Personalized Itinerary Planner and Abstract Book

AGU-FM13

December 07 - 13, 2013

To make changes to your intinerary or view the full meeting schedule, visit http://agu-fm13.abstractcentral.com/itin.jsp

Saturday, December 07, 2013

You have nothing scheduled for this day

Sunday, December 08, 2013

You have nothing scheduled for this day

Monday, December 09, 2013

Time	Session Info
8:00 AM-12:20 PM, Hall A-C (Moscone South), **A11C. Emissions and Impacts of Short-lived Climate Forcers I Posters (cosponsored by AMS)**	
8:00-8:00 AM	**A11C-0059. Evolution of biomass burning aerosol over the Amazon: airborne measurements of aerosol chemical composition, microphysical properties, mixing state and optical properties during SAMBBA** W. Morgan; J.D. Allan; M. Flynn; E. Darbyshire; A. Hodgson; D. Liu; S. O'Shea; S. Bauguitte; K. Szpek; B. Johnson; J. Haywood; K. Longo; P. Artaxo; H. Coe
8:00 AM-12:20 PM, Hall A-C (Moscone South), **B11A. Biogeodynamics and Earth System Sciences I Posters**	
8:00-8:00 AM	**B11A-0367. The Secret Gardener: Vegetation and the Emergence of Bio-geomorphic Patterns in Tidal Environments** M. Marani; C. Da Lio; A. D'Alpaos
8:00 AM-12:20 PM, Hall A-C (Moscone South), **B11C. Linking Geomorphology to Biogeochemistry and Nutrient Cycles I Posters [SWIRL_GS]**	
8:00-8:00 AM	**B11C-0391. Geomorphic controls on mineral weathering, elemental transport, and production of mineral surface area in a schist bedrock weathering profile, Piedmont Pennsylvania** B. Wenell; K. Yoo; A.K. Aufdenkampe; J.B. Mahoney; L. Lepak
8:00 AM-12:20 PM, Hall A-C (Moscone South), **C11A. Himalayan Glacier Dynamics I Posters**	
8:00-8:00 AM	**C11A-0647. Glacier sensitivity to climate change in the Nepalese Himalaya quantified using higher-order modelling** A.V. Rowan; D.L. Egholm; N.F. Glasser; D.J. Quincey
8:00 AM-12:20 PM, Hall A-C (Moscone South), **H11E. Innovation in Hydrology Through the Design, Development, and Use of Community Technologies and Resources Posters**	
8:00-8:00 AM	**H11E-1195. Modeling of hydrological and hydraulics problems using OpenFOAM® platform: From physics to mathematical models to computer codes** ***(Invited)*** X. Liu

8:00-8:00 AM	**H11E-1204. A New Open Data Open Modeling Framework for the Geosciences Community** ***(Invited)*** X. Liang; D. Salas; M. Navarro; Y. Liang; W.L. Teng; R.P. Hooper; P.J. Restrepo; J.D. Bales
8:00-8:00 AM	**H11E-1206. HydroDesktop as a Community Designed and Developed Resource for Hydrologic Data Discovery and Analysis** D.P. Ames
8:00 AM-12:20 PM, Hall A-C (Moscone South), **H11F. Managed Aquifer Recharge: Challenges, Approaches, and Applications Posters**	
8:00-8:00 AM	**H11F-1212. Heat Tracing Percolation in Managed Aquifer Recharge Facilities using Fiber Optic Distributed Temperature Sensing** M. Becker; W. Ellis; B. Bauer; A. Hutchinson
8:00 AM-12:20 PM, Hall A-C (Moscone South), **H11H. Regional Groundwater Systems: Advances in Modeling, Characterization, and Applications I Posters**	
8:00-8:00 AM	**H11H-1245. Evaluation of groundwater resources of the Chesapeake Bay Watershed using an integrated hydrologic model** A. Seck; C. Welty; R.M. Maxwell
8:00 AM-12:20 PM, Hall A-C (Moscone South), **H11I. Saturated and Unsaturated Flow in Structurally Variable Pathways Posters [SWIRL_GS]**	
8:00-8:00 AM	**H11I-1256. Flow paths inside a hillslope** ***(Invited)*** W.E. Dietrich; D.M. Rempe; J. Oshun; R. Salve
8:00 AM-12:20 PM, Hall A-C (Moscone South), **IN11A. Information Model Driven Architectural Components for Science Data Repositories and Archives Posters**	
8:00-8:00 AM	**IN11A-1510. HydroShare: An online, collaborative environment for the sharing of hydrologic data and models** ***(Invited)*** D.G. Tarboton; R. Idaszak; J.S. Horsburgh; D. Ames; J.L. Goodall; L.E. Band; V. Merwade; A. Couch; J. Arrigo; R.P. Hooper; D.W. Valentine; D.R. Maidment
8:00 AM-12:20 PM, Hall A-C (Moscone South), **IN11B. Near Real Time Data for Earth Science and Space Weather Applications I Posters**	
8:00-8:00 AM	**IN11B-1534. A Statewide Private Microwave Wide Area Network for Real-time Natural Hazard Monitoring** M.C. Williams; G. Kent; K.D. Smith; G. Plank; D. Slater; J. Torrisi; R. Presser; K. Straley
8:00 AM-12:20 PM, Hall A-C (Moscone South), **NG11A. Statistical Geophysics: Natural Hazards and Fracking I Posters [SWIRL_CM.CU]**	
8:00-8:00 AM	**NG11A-1579. Scaling of peak flows in large European river basins: new results on meteorological and channel network controls** S. Zanardo; L. Nicotina; A.G. Hilberts
8:00 AM-12:20 PM, Hall A-C (Moscone South), **PP11A. Paleoceanography and Paleoclimatology General Contributions I Posters**	

8:00-8:00 AM	**PP11A-1804. Out of Africa: the importance of rivers as human migration corridors** J.A. Ramirez; T.J. Coulthard; M. Rogerson; N. Barton; T. Bruecher
8:00 AM-10:00 AM, 3014 (Moscone West), **C11C. Remote Sensing of the Cryosphere I: Surface Mass Balance**	
8:30-8:45 AM	**C11C-03. Sub-meter Commercial Imagery Coverage for the Earth's Polar Regions** P.J. Morin; K. Peterman
8:00 AM-10:00 AM, 3001 (Moscone West), **GC11F. Translating Science into Action: Innovative Services for the Geo- and Environmental- Sciences in the Era of Big Data I**	
9:15-9:30 AM	**GC11F-06. Precipitation Downscaling Products for Hydrologic Applications *(Invited)*** E.D. Gutmann; T. Pruitt; C. Liu; M.P. Clark; L.D. Brekke; J. Arnold; D.A. Raff; R. Rasmussen
8:00 AM-10:00 AM, 2003 (Moscone West), **EP11A. Thresholds in Soil Response to Global Change I [SWIRL_GS]**	
9:30-9:45 AM	**EP11A-07. Climate warming and eco-hydrology of forested watersheds in the California Sierra *(Invited)*** C. Tague; K. Son; T. Brandt; A.L. Dugger
8:00 AM-10:00 AM, 309 (Moscone South), **ED11F. Preparation for the Geoscience Workforce: Programs and Projects That Increase Students' Employability I**	
9:45-10:00 AM (Conflict)	**ED11F-08. Preparing the Next Generation of Earth Scientists: An Examination of 25 Federal Earth Science Education Programs** A.M. Linn; A. Goldstein; C.A. Manduca; E.J. Pyle; P.M. Asher; L.D. White; E.M. Riggs; S. Cozzens; D. Glickson
8:00 AM-10:00 AM, 3018 (Moscone West), **H11O. Water, Energy and Society in Urban Systems I [SWIRL_US]**	
9:45-10:00 AM (Conflict)	**H11O-08. Evaluation of the impacts of urban development on groundwater storage at the regional scale** A.S. Bhaskar; C. Welty; R.M. Maxwell; A.J. Miller
10:20 AM-12:20 PM, 3020 (Moscone West), **H12A. Advances in Hydrometeorological Predictions and Applications II**	
10:20-10:35 AM	**H12A-01. CONDITIONAL MONTHLY WEATHER RESAMPLING PROCEDURE FOR OPERATIONAL SEASONAL WATER RESOURCES FORECASTING** J. Beckers; A. Weerts; E. Tijdeman; E. Welles; A. McManamon
10:20 AM-12:20 PM, 3001 (Moscone West), **GC12B. Climate Change Adaptation and Mitigation I [SWIRL_CS]**	

10:35-10:50 AM (Conflict)	**GC12B-02. Future Extreme Heat Scenarios to Enable the Assessment of Climate Impacts on Public Health over the Coterminous U.S.** D.A. Quattrochi; W.L. Crosson; M.Z. Al-Hamdan; M.G. Estes Jr
10:20 AM-12:20 PM, 3022 (Moscone West), **H12B. Advances in Understanding Land-Atmosphere Interactions II [SWIRL_GS]**	
10:40-11:00 AM (Conflict)	**H12B-02. Assessing latent heat flux estimates from the Community Land Model using GRACE and FLUXNET-MTE data.** S.C. Swenson; D.M. Lawrence
10:20 AM-12:20 PM, 2020 (Moscone West), **IN12A. Data Curation, Credibility, Preservation Implementation, and Data Rescue to Enable Multi-source Science II**	
10:50-11:05 AM (Conflict)	**IN12A-03. Rescue of Long-Tail Data from the Ocean Bottom to the Moon** L. Hsu; K.A. Lehnert; S.M. Carbotte; V. Ferrini; J.W. Delano; J.B. Gill; M. Tivey
10:20 AM-12:20 PM, 2011 (Moscone West), **SA12A. GNSS/GPS Based Ionospheric Space Weather Monitoring I**	
10:55-11:10 AM (Conflict)	**SA12A-04. Day-fo-day Monitoring of the Comparisons Between UHF Scintillation Forecasts and GNSS Observations** D.N. Anderson; Y. Morton; Y. Jiao; R.J. Redmon
10:20 AM-12:20 PM, 3008 (Moscone West), **A12B. From Air Pollution to Climate Changes in Asia II [SWIRL_DA] (cosponsored by AMS)**	
11:05-11:20 AM (Conflict)	**A12B-04. Contributions of Asian SO2 Pollution to the Upper Troposphere and Lower Stratosphere** R.R. Neely; P. Yu; K.H. Rosenlof; O.B. Toon; J.S. Daniel; S. Solomon; H.L. Miller
10:20 AM-12:20 PM, 2006 (Moscone West), **B12C. Emerging Frontiers in Biogeosciences II**	
11:05-11:20 AM (Conflict)	**B12C-04. Impact of diffuse mortality in a terrestrial biosphere model: stress, succession, and disease** ***(Invited)*** M. Dietze
10:20 AM-12:20 PM, 3020 (Moscone West), **H12A. Advances in Hydrometeorological Predictions and Applications II**	
11:50-12:05 PM (Conflict)	**H12A-07. Integrated hydrometeorological predictions with the fully-coupled WRF-Hydro modeling system in western North America** D.J. Gochis; W. Yu
10:20 AM-12:20 PM, 3014 (Moscone West), **H12E. Nonpoint Source Fluxes in the Vadose Zone and Groundwater I**	
11:50-12:05 PM (Conflict)	**H12E-07. Transferrable Lessons about Non-Point-Source Gas Transport from the Amargosa Desert** D.A. Stonestrom; B.J. Andraski; R.J. Baker; S. Maples; M.A. Walvoord; C.T. Green; B. Thomas; W. Luo; M.B. Young; R.L. Michel

1:40 PM-6:00 PM, Hall A-C (Moscone South), **A13F. Tropical and Midlatitude Convective Storm Systems and Their Roles in Weather and Climate III Posters (cosponsored by AMS)**	
1:40-1:40 PM	**A13F-0285. Potential Vorticity diagnosis of the binary interaction between Typhoon Tembin(2012, 14th) and Bolaven(2012, 15th)** J. Hwang; H. Cheong; J. LEE
1:40 PM-6:00 PM, Hall A-C (Moscone South), **B13G. Soil Erosion, Transport and Deposition and Their Control Over Biogeochemical Cycling of Essential Elements I Posters**	
1:40-1:40 PM	**B13G-0605. Whole Watershed Quantification of Net Carbon Fluxes by Erosion and Deposition within the Christina River Basin Critical Zone Observatory** A.K. Aufdenkampe; D.L. Karwan; R.E. Aalto; J. Marquard; K. Yoo; B. Wenell; C. Chen
1:40 PM-6:00 PM, Hall A-C (Moscone South), **ED13B. Climate Literacy: Beyond Climate Literacy — Toward Effective Responses to Global Change III Posters**	
1:40-1:40 PM	**ED13B-0779. ‘EXPERIMENTING WITH A SMALL PLANET’ AS AN EXPERIMENT** W.W. Hay
1:40 PM-6:00 PM, Hall A-C (Moscone South), **ED13C. Preparation for the Geoscience Workforce: Curriculum, Department, and Program Reform Strategies III Posters**	
1:40-1:40 PM	**ED13C-0784. Geoscience and the 21st Century Workforce** C.A. Manduca; T.J. Bralower; D. Blockstein; C.M. Keane; K.B. Kirk; D. Schejbal; C.E. Wilson
1:40 PM-6:00 PM, Hall A-C (Moscone South), **EP13A. Coastal Geomorphology and Morphodynamics I Posters**	
1:40-1:40 PM	**EP13A-0828. Connecting bathymetry, the flow field, and bathymetric evolution on the Wax Lake Delta, coastal Louisiana, USA** J.B. Shaw; D.C. Mohrig
1:40-1:40 PM	**EP13A-0837. Feedbacks Between Wave Energy And Declining Coral Reef Structure: Implications For Coastal Morphodynamics** A.E. Grady; C.J. Jenkins; L.J. Moore; D.C. Potts; P.M. Burgess; C.D. Storlazzi; E. Elias; M.A. Reidenbach
1:40-1:40 PM	**EP13A-0838. Short and long term evolution of deep giant submarine dunes in continental shelf environment: the example of the “Banc du Four” (Western Brittany, France)** M. Franzetti; P. Le Roy; T. Garlan; C. Delacourt; R. Thibaud; R. Cancouet; D. Graindorge; C. Prunier; A. Sukhovich; A. Deschamps
1:40-1:40 PM	**EP13A-0848. Understanding the effects of bathymetry, wave climate, and coastline shape on wave energy delivery to rocky coastlines using machine learning** E.B. Goldstein; P.W. Limber; A. Murray; P.N. Adams

1:40-1:40 PM	**EP13A-0852. The effects of breaking wave turbulence on suspended sand transport in the nearshore - a 3D numerical investigation** Z. Zhou; X. Liu; T. Hsu; J. Sangermano
1:40-1:40 PM	**EP13A-0856. Exploring a morphodynamic modeling framework for reef island evolution under sea-level rise** J. Lorenzo Trueba; A.D. Ashton; J.P. Donnelly
1:40-1:40 PM	**EP13A-0857. Impact of vegetation on the hydrodynamics and morphological changes of the Wax Lake Delta during hurricanes** F. Xing; A.J. Kettner; J.P. Syvitski; Q. Ye; A. Bevington; R. Twilley; J.H. Atkinson
1:40-1:40 PM	**EP13A-0861. Generating synthetic wave climates for coastal modelling: a linear mixed modelling approach** C. Thomas; R.M. Lark
1:40 PM-6:00 PM, Hall A-C (Moscone South), **EP13C. Thresholds in Soil Response to Global Change II Posters [SWIRL_GS]**	
1:40-1:40 PM	**EP13C-0881. Snowmelt and rain in a marginal snowpack watershed: Amount and duration of water input controls runoff** S.P. Anderson; N. Rock
1:40 PM-3:40 PM, 3003 (Moscone West), **GC13E. Natural- and Human-Induced Changes in the Global Water Cycle from Observations and Model Simulations and Implications for Water Resources**	
1:40-1:55 PM (Conflict)	**GC13E-01. Impacts of Large-Scale Water Management on Terrestrial Hydrology and Climate** ***(Invited)*** J.S. Famiglietti
1:40 PM-3:40 PM, 3007 (Moscone West), **OS13D. Ice-Ocean-Seabed Interactions in Fjords II**	
1:40-1:55 PM (Conflict)	**OS13D-01. Evaluating competing forces constraining glacial grounding-line stability** ***(Invited)*** R.D. Powell
1:40 PM-6:00 PM, Hall A-C (Moscone South), **MR13A. Advances in Rock Physics and Rock Mechanics — From Faults to Reservoirs I Posters**	
1:40-1:40 PM	**MR13A-2224. Flow and Geometry Control the Onset of Jamming in Fractures with High Solid-Fraction Fluids** R. Medina; J.E. Elkhoury; L.J. Shannon; R.L. Detwiler; J. Morris; R. Prioul; J. Desroches
1:40 PM-6:00 PM, Hall A-C (Moscone South), **T13D. Seismology, Active Tectonics and Geomorphology in South and East Asia II: Central and SE Asia Posters**	
1:40-1:40 PM	**T13D-2566. GPS Velocity Field in Bangladesh: Delta Subsidence, Seasonal Water Loading and Shortening Across the Burma Accretionary Prism and Shillong Massif.** M.S. Steckler; D.R. Mondal; S.L. Nooner; S.H. Akhter; L. Seeber; S.V. Bettadpur; C. Sazedul Karim; M. Howe; F. Masson; T. Maurin; C. Rangin

1:40 PM-3:40 PM, 2006 (Moscone West), **B13M. Model Intercomparisons: Syntheses That Inform Scientific Understanding II [SWIRL_CU]**	
2:40-2:55 PM	**B13M-05. Global net land carbon sink: Results from the Multi-scale Synthesis and Terrestrial Model Intercomparison Project (MsTMIP)** D.N. Huntzinger; C.R. Schwalm; A.M. Michalak; R.B. Cook; A.R. Jacobson; K.M. Schaefer; A. Dasgupta; J. Poco
4:00 PM-6:00 PM, 307 (Moscone South), **NH14A. Advances in Analysis and Prediction of Rock Falls, Rock Slides, and Rock Avalanches I**	
4:00-4:15 PM	**NH14A-01. Landslide dynamics from seismology and satellite remote sensing** ***(Invited)*** C.P. Stark; G. Ekstrom; C. Hibert; J. Allen
4:00 PM-6:00 PM, 3002 (Moscone West), **PA14A. Hydraulic Fracturing: Knowns, Unknowns, and Communication to the Public I [SWIRL_CU] (Virtual Option)**	
4:15-4:25 PM	**PA14A-02. Water Resource Impacts During Unconventional Shale Gas Development: The Pennsylvania Experience** S.L. Brantley; D. Yoxtheimer; S. Arjmand; P. Grieve; R. Vidic; J.D. Abad; C.A. Simon; J. Pollak
4:00 PM-6:00 PM, 300 (Moscone South), **ED14C. Games, Interactive Simulations, and Virtual Labs for Science Teaching and Learning II [SWIRL_CM]**	
4:45-5:00 PM	**ED14C-04. Web-based Interactive Landform Simulation Model - Grand Canyon** W. Luo; J.D. Pelletier; K. Duffin; C.J. Ormand; W. Hung; E.A. Iverson; D. Shernoff; X. Zhai; A. Chowdary
4:00 PM-6:00 PM, 2020 (Moscone West), **IN14A. Near Real Time Data for Earth Science and Space Weather Applications III**	
5:15-5:30 PM	**IN14A-06. Assimilation of NASA MODIS Flood Mapping Product into Operational Flash Flood Warning Systems** A.J. Posner; K.P. Georgakakos; E. Shamir
4:00 PM-6:00 PM, 3001 (Moscone West), **GC14B. Understanding and Assessing Natural and Societal Impacts of Decadal Climate Variability II**	
5:30-5:45 PM (Conflict)	**GC14B-07. The Florida Water and Climate Alliance: A Collaborative Working Group for the Development of Climate Predictions for Improved Water Management, Operations and Planning.** ***(Invited)*** W.D. Graham; S. Hwang; A. Adams
4:00 PM-6:00 PM, 307 (Moscone South), **NH14A. Advances in Analysis and Prediction of Rock Falls, Rock Slides, and Rock Avalanches I**	
5:30-5:45 PM (Conflict)	**NH14A-07. Cosmogenic beryllium-10 exposure dating of probable earthquake-triggered rock avalanches in Yosemite Valley, California** J.A. Thompson; G.M. Stock; D. Rood; K.L. Frankel
6:15 PM-7:15 PM, 304 (Moscone South), **TH15D. Critical Zone Science and Observatories**	

6:15-6:15 PM	**TH15D-01. Critical Zone Science and Observatories** S.L. Brantley; T.S. White; S.P. Anderson; R.C. Bales; J. Chorover; W.H. McDowell

Tuesday, December 10, 2013

Time	Session Info
8:00 AM-12:20 PM, Hall A-C (Moscone South), **A21C. From Air Pollution to Climate Changes in Asia Posters V [SWIRL_DA] (cosponsored by AMS)**	
8:00-8:00 AM	**A14B-03. High Black Carbon Concentrations and Atmospheric Pollution Around Indian Coal Fired Thermal Power Plants** R.P. Singh; A.K. Singh; S. Kumar; T. Takemura
8:00 AM-12:20 PM, Hall A-C (Moscone South), **B21D. Vulnerability of Permafrost Carbon to Climate Change IV Posters [SWIRL_GS]**	
8:00-8:00 AM	**B21D-0513. Improved estimates of the permafrost carbon feedback** E.E. Jafarov; K.M. Schaefer; J. Watts; T. Zhang
8:00 AM-12:20 PM, Hall A-C (Moscone South), **C21B. Improved Glacier Mass Balance Assessment and Projection: Methods and Modeling I Posters**	
8:00-8:00 AM	**C21B-0631. Improving global observation and assessment of glacier contributions to sea level rise** ***(Invited)*** W.T. Pfeffer
8:00 AM-12:20 PM, Hall A-C (Moscone South), **C21D. Remote Sensing of the Cryosphere IV Posters**	
8:00-8:00 AM	**C21D-0666. Surface Roughness Impact on the Sea Ice Thickness Measurements Based on LIDAR/Radar Altimetry** L. Li; D. Truesdale; P. Posey; R. Allard; J.M. Gardner; J.M. Brozena; J. Richter-Menge
8:00-8:00 AM	**C21D-0673. Snow and Ice Climatology of the Western United States and Alaska from MODIS** K.E. Rittger; T.H. Painter; C.A. Mattmann; F.C. Seidel; A. Burgess; M. Brodzik
8:00-8:00 AM	**C21D-0685. Influence of the sea-ice edge on the Arctic nearshore environment** K.R. Barnhart; I. Overeem; R.S. Anderson
8:00 AM-10:00 AM, 2003 (Moscone West), **EP21A. Coastal Geomorphology and Morphodynamics: Beaches and Barrier Islands II**	
8:00-8:15 AM	**EP21A-01. Barriers on the Brink? Interactions Between Biological and Physical Processes Lead to Bistability and the Potential for Rapid Response to Gradually Changing Conditions** ***(Invited)*** L.J. Moore; O. Duran Vinent
8:00 AM-12:20 PM, Hall A-C (Moscone South), **GC21B. Advances in Reservoir Modeling and Monitoring from Regional to Global Scales I Posters**	

8:00-8:00 AM	**GC21B-0831. Lake Storage Measurements For Water Resources Management: Combining Remotely Sensed Water Levels and Surface Areas** G.R. Brakenridge; C.M. Birkett
8:00 AM-12:20 PM, Hall A-C (Moscone South), **GC21C. Climate Change and Wildfire: Drivers, Interactions and Consequences I Posters**	
8:00-8:00 AM	**GC21C-0847. Modeling wildfire and hydrologic response to global climate change using the Landlab modeling environment** J.M. Adams; N.M. Gasparini; G.E. Tucker; E. Istanbulluoglu; E. Hutton; D.E. Hobley; S. NUDURUPATI
8:00 AM-12:20 PM, Hall A-C (Moscone South), **H21C. Advances in Understanding Land-Atmosphere Interactions Posters IV [SWIRL_GS]**	
8:00-8:00 AM	**H21C-1057. Ensemble Kalman Filter data assimilation for the TerrSysMP fully-coupled hydrologic – land surface – atmospheric modeling system** J.L. Williams; P. Shrestha; M. Sulis; C. Simmer
8:00 AM-12:20 PM, Hall A-C (Moscone South), **H21D. Anomalous Transport: Experimental and Mathematical Studies Posters**	
8:00-8:00 AM	**H21D-1091. Anomalous Sediment Mixing by Bioturbation** K.R. Roche; A.F. Aubeneau; M. Xie; A.I. Packman
8:00 AM-12:20 PM, Hall A-C (Moscone South), **H21H. Uncertainty in Water Management, Part I: Uncertainty Quantification, Sensitivity Analysis and Experimental Design I Posters [SWIRL_CU]**	
8:00-8:00 AM	**H21H-1156. Monitoring Network Design for Discriminating and Reducing Models in Bayesian Model Averaging Paradigm** F.T. Tsai; H.V. Pham
8:00 AM-12:20 PM, Hall A-C (Moscone South), **H21I. Uncertainty in Water Management, Part 2: Risk Analysis, Decision Support and Law, With Special Focus on Hydrometeorological Scaling From Continents to Watersheds II Posters [SWIRL_CU]**	
8:00-8:00 AM	**H21I-1182. Rainfall and temperature estimation for a data sparse region** D. Yu; R.L. Wilby
8:00 AM-12:20 PM, Hall A-C (Moscone South), **H21J. Water, Energy and Society in Urban Systems III Posters [SWIRL_US]**	
8:00-8:00 AM	**H21J-1199. DOES STORMWATER MANAGEMENT MAKE A DIFFERENCE?** A.J. Miller; C. Welty; G.A. Lindner
8:00 AM-12:20 PM, Hall A-C (Moscone South), **OS21A. Ocean Sciences General Contributions II Posters**	
8:00-8:00 AM	**OS21A-1599. Coring Methane Hydrate by using Hybrid Pressure Coring System of D/V Chikyu** Y. Kubo; Y. Mizuguchi; F. Inagaki; N. Eguchi; K. Yamamoto

8:00-8:00 AM	**OS21A-1620. Capillary effects on gas hydrate three-phase stability in marine sediments** X. Liu; P.B. Flemings
8:00 AM-12:20 PM, Hall A-C (Moscone South), **P21B. Planetary Atmospheres and Evolution I Posters [SWIRL_DA]**	
8:00-8:00 AM	**P21B-1736. Investigating Climate at an Inland Sea During Snowball Earth** A.J. Campbell; C.M. Bitz; S.G. Warren; E.D. Waddington
8:00 AM-12:20 PM, Hall A-C (Moscone South), **PA21B. Why Should We Talk About What We Don't Know? Implications of Communicating Scientific Uncertainty I Posters [SWIRL_CU]**	
8:00-8:00 AM	**PA21B-1870. Deterministic or Probabilistic - Robustness or Resilience: How to Respond to Climate Change?** H. Plag; D. Earnest; S. Jules-Plag
8:00-8:00 AM	**PA21B-1875. What can decision makers achieve from computer simulations of environmental systems?** M.C. Hill; D. Kavetski; M.P. Clark; M. Ye; M. Arabi; D. Lu; L. Foglia; S. Mehl
8:00 AM-12:20 PM, Hall A-C (Moscone South), **T21B. Continental Rifts and Rifted Margins VI Posters**	
8:00-8:00 AM	**T21B-2545. Geodynamic modeling of the Mid-Continental Rift System: Is a mantle plume required?** R. Moucha; T.O. Rooney; S.A. Stein; E. Brown
8:00 AM-12:20 PM, Hall A-C (Moscone South), **V21A. Examining Soil Salts in Hyper-arid Environments on Earth and Mars Posters [SWIRL_GS]**	
8:00-8:00 AM	**V21A-2698. Salt Profile in Sedimentary Deposits: an archive of past climate and tectonics** T. Sun; H. Bao; M. Reich
8:00 AM-12:20 PM, Hall A-C (Moscone South), **V21B. Investigating Volcanic Conduits and Related Processes Through Experiments, Numerical Modelling and Observations III Posters (cosponsored by EGU-GMPV)**	
8:00-8:00 AM	**V21B-2718. Timescales of magma ascent recorded by H2O zonation in clinopyroxene** A.S. Lloyd; T.A. Plank; P. Ruprecht; E.H. Hauri; W.I. Rose
8:00 AM-10:00 AM, 2003 (Moscone West), **EP21A. Coastal Geomorphology and Morphodynamics: Beaches and Barrier Islands II**	
8:15-8:30 AM	**EP21A-02. Punctuated events and long-term barrier evolution in a rising-sea-level world** ***(Invited)*** A.D. Ashton; A.C. Ortiz; J. Lorenzo Trueba; J.P. Donnelly; R.L. Evans
8:00 AM-10:00 AM, 3022 (Moscone West), **H21K. Assessing Land Use Change Effects on Hydrological Processes and Feedbacks II**	
8:30-8:45 AM	**H21K-03. Assessing Resilience of Intensively Managed Landscapes through Feedbacks** A.E. Goodwell; P. Kumar

8:00 AM-10:00 AM, 103 (Moscone South), **ED21B. Climate Literacy: Achieving Widespread Climate Literacy Through Innovative Engagement Strategies, Effective Partnerships, and Large-Scale Networks III (Virtual Option)**	
9:00-9:15 AM	**ED21B-05. Aiding cities in their work on climate change adaptation** P. Hamilton
8:00 AM-10:00 AM, 2002 (Moscone West), **B21G. Linking Landscape and Watershed Processes with Aquatic Ecosystem Functions, Services, and Sustainability II**	
9:15-9:30 AM	**B21G-06. A general framework for incorporating heterogeneity of aquatic ecosystems into aquatic network models to understand biogeochemical fluxes *(Invited)*** W.M. Wollheim; R. Stewart; K.R. Sheehan
8:00 AM-10:00 AM, 2003 (Moscone West), **EP21A. Coastal Geomorphology and Morphodynamics: Beaches and Barrier Islands II**	
9:30-9:45 AM	**EP21A-07. Terrestrial laser scanning of anthropogenic beach berms for urban flood defense** B.F. Sanders; J. Schubert; T. Gallien; M. Shakeri Majd
8:00 AM-10:00 AM, 3002 (Moscone West), **H21N. Hydrological Change and Water Systems: Feedbacks, Prediction, and Experimental Management I (Virtual Option)**	
9:45-10:00 AM	**H21N-08. From Hydroclimatic Prediction to Negotiated and Risk Managed Water Allocation and Reservoir Operation *(Invited)*** U. Lall
10:20 AM-12:20 PM, 3009 (Moscone West), **OS22B. Regime Changes in Estuarine and Coastal Systems II**	
10:20-10:40 AM (Conflict)	**OS22B-01. Assessment of the Correlation of Long-Term Hydrodynamic Variations and Dissolved Oxygen in the Chesapeake Bay *(Invited)*** J. Shen
10:20 AM-12:20 PM, 304 (Moscone South), **T22E. Seismology, Active Tectonics and Geomorphology in South and East Asia V: Structure/Tectonics**	
10:20-10:35 AM (Conflict)	**T22E-01. On the extent and significance of Oligocene mountain building in eastern Tibet *(Invited)*** E. Kirby; K.P. Furlong; K.L. Cook; W.B. Ouimet; X. Shi; E. Wang; P.J. Kamp; K.V. Hodges
10:20 AM-12:20 PM, 2003 (Moscone West), **EP22A. Coastal Geomorphology and Morphodynamics: Nearshore Systems III**	
10:50-11:05 AM (Conflict)	**EP22A-03. Potential Cascading Failures of Long-term Shoreline Stabilization in a Coupled Morphoeconomic Coastline Evolution Model** K.D. Ells; D. McNamara; A. Murray
10:20 AM-12:20 PM, 310 (Moscone South), **T22C. Investigating Marine Records of Climate-Tectonic Interactions in Active Orogens: Southern Alaska and Other Convergent Margins I**	

10:50-11:05 AM (Conflict)	**T22C-03. The Impact of Neogene Climate and Tectonics on Sediment Dispersal and Accumulation on a Glaciated Continental Margin: IODP Expedition 341 Southern Alaska** J.M. Jaeger; S.P. Gulick
10:20 AM-12:20 PM, 2020 (Moscone West), **IN22A. Enabling Better Science Through Improving Science Software Development Culture I**	
11:05-11:20 AM (Conflict)	**IN22A-04. Pipe dream? Envisioning a grassroots Python ecosystem of open, common software tools and data access in support of river and coastal biogeochemical research *(Invited)*** E. Mayorga
10:20 AM-12:20 PM, 2010 (Moscone West), **EP22B. Path-Dependence and Hysteresis in Earth-Surface Dynamics I [SWIRL_CU]**	
11:10-11:25 AM (Conflict)	**EP22B-03. Numerical simulations of inherited sinuosity and valley entrenchment in mixed alluvial- and bedrock-banked meandering rivers** A. Limaye; M.P. Lamb
10:20 AM-12:20 PM, 2020 (Moscone West), **IN22A. Enabling Better Science Through Improving Science Software Development Culture I**	
11:20-11:35 AM (Conflict)	**IN22A-05. HydroShare: Applying professional software engineering to a new NSF-funded large software project** R. Idaszak; D.G. Tarboton; D. Ames; J.A. Saleem Arrigo; L.E. Band; A. Bedig; A.M. Castronova; L. Christopherson; J. Coposky; A. Couch; P. Dash; T. Gan; J. Goodall; K. Gustafson; J. Heard; R.P. Hooper; J.S. Horsburgh; S. Jackson; H. Johnson; D.R. Maidment; P. Mbewe; V. Merwade; B. Miles; S. Reeder; T. Russell; C. Song; A. Taylor; S. Thakur; D.W. Valentine; T.L. Whiteaker
10:20 AM-12:20 PM, 2003 (Moscone West), **EP22A. Coastal Geomorphology and Morphodynamics: Nearshore Systems III**	
11:35-11:50 AM (Conflict)	**EP22A-06. Time Series Observations of Seafloor Roughness in the Northern Gulf of Mexico 1: Sediment Transport** J. Calantoni; K. Eldredge; T. Staples; A. Sheremet; A. Penko
10:20 AM-12:20 PM, 3003 (Moscone West), **GC22A. Water, Climate Variability, and the Anthropocene I**	
11:35-11:50 AM (Conflict)	**GC22A-06. Interactions between climate change impacts on forest productivity and mortality and stream water quality in the US Western Mountains *(Invited)*** C. Tague; J. Zhu
10:20 AM-12:20 PM, 2010 (Moscone West), **EP22B. Path-Dependence and Hysteresis in Earth-Surface Dynamics I [SWIRL_CU]**	
11:40-11:55 AM (Conflict)	**EP22B-05. Hysteresis in hillslope morphology records landscape growth and decay** M.D. Hurst; S.M. Mudd; M. Attal; G.E. Hilley
10:20 AM-12:20 PM, 3003 (Moscone West), **GC22A. Water, Climate Variability, and the Anthropocene I**	

11:50-12:05 PM (Conflict)	**GC22A-07. Early Anthropogenic Transformation of the Danube-Black Sea System: From Records to Causes *(Invited)*** L. Giosan; M. Coolen
10:20 AM-12:20 PM, 2010 (Moscone West), **EP22B. Path-Dependence and Hysteresis in Earth-Surface Dynamics I [SWIRL_CU]**	
11:55-12:20 PM (Conflict)	**EP22B-06. The role of temporally varying erodibility in hysteresis in fine-grained coastal systems** P. Wiberg; J.A. Carr
10:20 AM-12:20 PM, 2000 (Moscone West), **B22C. Dynamics of Global Forests Under a Changing Climate I**	
12:05-12:20 PM (Conflict)	**B22C-08. Fires, invasives, migrations, oh my! Scaling spatial processes into earth system models and global change projections. *(Invited)*** M. Dietze
12:30 PM-1:30 PM, 2007 (Moscone West), **TH22G. InTeGrate:Interdisciplinary Teaching of Geoscience for a Sustainable Future**	
12:30-12:30 PM	**TH22G-01. InTeGrate: InTeGrate: Interdisciplinary Teaching of Geoscience for a Sustainable Future** C.A. Manduca; A.E. Egger; J.J. Taber
1:40 PM-6:00 PM, Hall A-C (Moscone South), **GC23C. Water, Climate Variability, and the Anthropocene II Posters**	
1:40-1:40 PM	**GC23C-0939. Anthropogenic effects on global riverine sediment and water discharge - a spatially explicit analysis** S. Cohen; A.J. Kettner; J.P. Syvitski
1:40-1:40 PM	**GC23C-0948. Expansive Tidal Marshes on the North American Eastern Seaboard: Relics of Colonial Deforestation?** A. Murray; M. Kirwan
1:40 PM-6:00 PM, Hall A-C (Moscone South), **H23A. Advances in Hydrometeorological Predictions and Applications IV Posters**	
1:40-1:40 PM	**H23A-1227. Hydrologic modeling using topographically corrected NARR and NARCCAP climate data: Tucannon River, Washington** S.J. Praskievicz; P.J. Bartlein
1:40 PM-6:00 PM, Hall A-C (Moscone South), **H23C. Eco-hydrology in a Changing Environment VI Posters**	
1:40-1:40 PM	**H23C-1277. Simulating stand-level water and carbon fluxes in beetle-attacked conifer forests in the Western U.S.** S.D. Peckham; B.E. Ewers; D.S. Mackay; E.G. Pendall; J.M. Frank; W.J. Massman
1:40 PM-6:00 PM, Hall A-C (Moscone South), **H23E. High Resolution Hydrologic Modeling: Challenges and Avenues for Development II Posters [SWIRL_CM]**	

1:40-1:40 PM	**H23E-1317. Evaluating the Performance of a Coupled Distributed Hydrologic – Hydraulic Model for Flash Flood Modeling Using Multiple Precipitation Data Sources** P. Nguyen; S. Sorooshian; K. Hsu; A. AghaKouchak; B.F. Sanders
1:40 PM-6:00 PM, Hall A-C (Moscone South), **NH23C. Planning and Mitigation for Natural Hazards Through Specialized Remote Sensing Techniques II Posters**	
1:40-1:40 PM	**NH23C-1540. Hydrologic Severity-based Forecast System for Road Infrastructure Monitoring** F. Hernandez; L. Li; S. Lochan; X. Liang; Y. Liang; W.L. Teng
1:40 PM-3:40 PM, 2007 (Moscone West), **P23G. Planetary Atmospheres and Evolution II [SWIRL_DA]**	
1:40-1:55 PM	**P23G-01. Is the faint young Sun paradox solved?** E.T. Wolf; O.B. Toon
1:40 PM-6:00 PM, Hall A-C (Moscone South), **PP23C. Water Isotope Systematics: Improving our Palaeoclimate Interpretations III Posters**	
1:40-1:40 PM	**PP23C-1991. The impact of differing physical assumptions on a water isotope climatology simulated by an isotope-enabled version of the NCAR Community Atmosphere Model Version 5 (CAM5).** J.M. Nusbaumer; C. Bardeen; E.C. Brady; T. Wong; D.C. Noone
1:40 PM-3:40 PM, 3018 (Moscone West), **H23I. Advances in Spatial Scaling of Hydrological and Biogeochemical Processes II**	
1:55-2:10 PM	**H23I-02. Quantifying the imprint of geologic controls on river network topology and scaling in hydrologic response** ***(Invited)*** M. Danesh Yazdi; A. Longjas; S. Zanardo; E. Foufoula-Georgiou
1:40 PM-3:40 PM, 2003 (Moscone West), **EP23A. Coastal Geomorphology and Morphodynamics: Rivers, Deltas and Marshes IV**	
2:40-2:55 PM (Conflict)	**EP23A-05. The Statistical Signal of Morphological Process in Stratigraphy** C.R. Esposito; K.M. Straub
1:40 PM-3:40 PM, 2008 (Moscone West), **EP23B. The Imprint of Past Climate Change on Landscapes I**	
2:40-2:55 PM (Conflict)	**EP23B-05. Climatic and paleoclimatic forcing of erosion in the southern Central Andes and the northwestern Himalaya** ***(Invited)*** B. Bookhagen; M.R. Strecker
1:40 PM-3:40 PM, 2003 (Moscone West), **EP23A. Coastal Geomorphology and Morphodynamics: Rivers, Deltas and Marshes IV**	
2:55-3:10 PM	**EP23A-06. Statistical characterization of wind-wave induced sediment resuspension events in shallow tidal basins** A. D'Alpaos; L. Carniello; A. Rinaldo

1:40 PM-3:40 PM, 3011 (Moscone West), **H23L. Mixing and Reaction in Hydrological Systems: From Experiment to Theory and Back I**	
2:55-2:55 PM	**H23L-06. Mineral Spatial Distribution in Determining Rates: When does it matter?** L. Li; F. Salehikhoo; S.L. Brantley
1:40 PM-3:40 PM, 3005 (Moscone West), **H23N. The Flow Below: Defining, Quantifying, and Understanding Baseflow II**	
3:25-3:40 PM (Conflict)	**H23N-08. Examining the concept of baseflow using end-member mixing analysis *(Invited)*** R.P. Hooper
1:40 PM-3:40 PM, 3022 (Moscone West), **H23O. Uncertainty in Water Management, Part I: Uncertainty Quantification, Sensitivity Analysis and Experimental Design II [SWIRL_CU]**	
3:25-3:40 PM (Conflict)	**H23O-08. A New Computationally Frugal Method For Sensitivity Analysis Of Environmental Models** O. Rakovec; M.C. Hill; M.P. Clark; A. Weerts; R. Teuling; E. Borgonovo; R. Uijlenhoet
4:00 PM-6:00 PM, 3016 (Moscone West), **H24G. Water Resources and Water Quality under Changing Climate and Land Use III**	
4:00-4:30 PM (Conflict)	**H24G-01. Regional climate variability and patterns of urban development - Impacts on the urban water cycle and nutrient export *(Invited)*** C. Welty; E. Bou-Zeid; E. Doheny; A. Gold; P.M. Groffman; M. Grove; S. Kaushal; A. Klaiber; E. Irwin; A.J. Miller; D. Newburn; J.A. Smith; C. Towe
4:00 PM-6:00 PM, 306 (Moscone South), **T24A. Collision, Accretion, Slab-Windows and Oroclines: The Evolution of Congested Subduction Zone II**	
4:15-4:30 PM (Conflict)	**T24A-02. Dynamics of Continental Accretion** L.N. Moresi; P.G. Betts; M.S. Miller
4:00 PM-6:00 PM, 2008 (Moscone West), **EP24B. Morphodynamics of Mixed Bedrock-Alluvial River Systems I**	
4:30-4:45 PM (Conflict)	**EP24B-03. Testing bedrock incision models: Holocene channel evolution, High Cascades, Oregon** K.E. Sweeney; J.J. Roering; M.A. Fonstad
4:00 PM-6:00 PM, 3011 (Moscone West), **H24D. Mixing and Reaction in Hydrological Systems: From Experiment to Theory and Back II**	
4:30-4:45 PM (Conflict)	**H24D-03. High mountain water fluxes, a trans-Himalayan base-flow perspective** C. Andermann; T.C. Stieglitz; N. Hovius; R. Sharma; T. Labasque
4:00 PM-6:00 PM, 3007 (Moscone West), **OS24A. Geodynamic, Sedimentary, and Oceanographic Processes of the South China Sea III**	

4:45-5:00 PM (Conflict)	**OS24A-04. Modern sediment dispersal pattern and sediment budget on the continental shelf off the Mekong River delta, South China Sea** W. Szczucinski; R. Jagodzinski; T. Hanebuth; K. Stattegger; A. Wetzel; M. Mitrega; D. Unverricht; P. Van Phach
4:00 PM-6:00 PM, 304 (Moscone South), **T24C. Seismology, Active Tectonics and Geomorphology in South and East Asia VII: Geomorphology**	
4:45-5:00 PM (Conflict)	**T24C-04. Geomorphic evidence for a major discontinuity in the Main Himalayan Thrust in west Nepal** J.E. Harvey; D.W. Burbank; B. Bookhagen
4:00 PM-6:00 PM, 2003 (Moscone West), **EP24A. Glacier Processes on the Scales of Mountains and Orogens I**	
4:55-5:15 PM (Conflict)	**EP24A-04. Modeling subglacial hydrology and what that may tell us about erosion *(Invited)*** M.A. Werder; G.E. Flowers
4:00 PM-6:00 PM, 3003 (Moscone West), **GC24B. Environmental, Socio-Economic and Climatic Changes in Northern Eurasia and their Feedbacks to the Global Earth System III**	
5:00-5:15 PM (Conflict)	**GC24B-05. On the weighting of CMIP5 multimodel ensembles in temperature simulation over Eurasia** C. Miao; Q. Duan
4:00 PM-6:00 PM, 2007 (Moscone West), **P24B. Planetary Atmospheres and Evolution III [SWIRL_DA]**	
5:15-5:30 PM	**P24B-06. Conservation of Total Escape from Hydrodynamic Planetary Atmospheres** F. Tian
4:00 PM-6:00 PM, 2008 (Moscone West), **EP24B. Morphodynamics of Mixed Bedrock-Alluvial River Systems I**	
5:30-5:45 PM	**EP24B-07. Numerical Model of Turbulence, Sediment Transport, and Sediment Cover in a Large Canyon-Bound River** L.V. Alvarez; M.W. Schmeeckle
4:00 PM-6:00 PM, 2003 (Moscone West), **EP24A. Glacier Processes on the Scales of Mountains and Orogens I**	
5:45-6:00 PM (Conflict)	**EP24A-07. Relative importance of fluvial and glacial erosion in shaping the Chandra Valley, western Himalaya, India** P. Eugster; D. Scherler; R.C. Thiede; A. Codilean; M.R. Strecker
4:00 PM-6:00 PM, 2008 (Moscone West), **EP24B. Morphodynamics of Mixed Bedrock-Alluvial River Systems I**	
5:45-6:00 PM (Conflict)	**EP24B-08. Modelling Incision in Mixed Bedrock-Alluvial Rivers: The Role of Sediment Waves *(Invited)*** G. Parker; L. Zhang; C.P. Stark; E. Viparelli; X. Fu

Wednesday, December 11, 2013

Time	Session Info
8:00 AM-12:20 PM, Hall A-C (Moscone South), **C31B. Integration of International Arctic Research Programs and Data Streams From Polar Observatories, User Facilities, Data Collection Networks, and Field Campaigns I Posters**	
8:00-8:00 AM	**C31B-0649. Observation Platforms and Data Streams of the Arctic Next Generation Ecosystem Experiment (NGEE-Arctic)** L.D. Hinzman; S.D. Wullschleger; D.E. Graham; S.S. Hubbard; R.J. Norby; A. Rogers; M.S. Torn; C.J. Wilson
8:00 AM-12:20 PM, Hall A-C (Moscone South), **EP31A. Deltas: A Multi-trillion Dollar Global Problem I Posters**	
8:00-8:00 AM	**EP31A-0818. Linking shoreline displacement to environmental conditions in the Wax Lake Delta, USA** N. Geleynse; M.R. Hiatt; H. Sangireddy; P. Passalacqua
8:00-8:00 AM	**EP31A-0829. NUMERICAL MODELING OF MIXING OVER DUNE BEDS UNDER LOW AND HIGH TIDE CONDITIONS** J. Imran; K. Abdo; A. Cantelli
8:00-8:00 AM	**EP31A-0830. Modeling Floodplain Dynamics: Can the Ganges-Brahmaputra Delta keep pace with 21st Century Sea Level Rise?** K.G. Rogers; I. Overeem
8:00-8:00 AM	**EP31A-0835. Holocene evolution of a wave-dominated fan-delta: Godavari delta, India** Y. Saito; K. Nageswara Rao; K. Nagakumar; G. Demudu; A. Rajawat; S. Kubo; Z. Li
8:00-8:00 AM	**EP31A-0847. Geomorphology and Landscape Evolution Model for the natural and human-impacted regions of the Ganges-Brahmaputra-Meghna Delta** C. Wilson; S.L. Goodbred; L. Wallace Auerbach; K. Ahmed; C. Paola; M.D. Reitz; J. Pickering
8:00 AM-12:20 PM, Hall A-C (Moscone South), **G31A. Recent Advances in the Application of InSAR and High-Resolution Geodetic Data for Crustal Deformation Research I Posters**	
8:00-8:00 AM	**G31A-0932. Space geodetic observations and modeling of postseismic deformation due to the 2005 M7.6 Kashmir (Pakistan) earthquake** K. Wang; Y.A. Fialko
8:00-8:00 AM	**G31A-0952. Decadal strain along creeping faults in the Needles District, Paradox Basin Utah determined with InSAR Time Series Analysis** K. Kravitz; M. Furuya; K.J. Mueller
8:00 AM-12:20 PM, Hall A-C (Moscone South), **GC31A. Magnitudes and Mechanisms of Ice Sheet Melt, Sea-Level Changes, and Coastal Inundation: Past and Future I Posters**	

<table>
<tr><td>8:00-8:00 AM</td><td>GC31A-1018. Minimizing Uncertainty in Coastal Digital Elevation Models B. Eakins; J. Danielson; S.J. McLean</td></tr>
<tr><td colspan="2">8:00 AM-12:20 PM, Hall A-C (Moscone South), H31H. Water Resources and Water Quality under Changing Climate and Land Use IV Posters</td></tr>
<tr><td>8:00-8:00 AM</td><td>H31H-1315. The Implication of Water Resources Development and Climate Change on Tropical Lakes and Rivers S. Setegn</td></tr>
<tr><td colspan="2">8:00 AM-12:20 PM, Hall A-C (Moscone South), IN31A. Data Management Strategies for Airborne Science Data Posters</td></tr>
<tr><td>8:00-8:00 AM</td><td>IN31A-1499. Increasing the Impact of High-Resolution Lidar Topography Through Online Data Access and Processing C.J. Crosby; V. Nandigam; C. Baru; R. Arrowsmith</td></tr>
<tr><td colspan="2">8:00 AM-12:20 PM, Hall A-C (Moscone South), DI31A. State of the Art in Computational Geoscience I Posters [SWIRL_CM.CU]</td></tr>
<tr><td>8:00-8:00 AM</td><td>DI31A-2208. TerraFERMA: The Transparent Finite Element Rapid Model Assembler for multi-physics problems in the solid Earth sciences M.W. Spiegelman; C.R. Wilson; P.E. Van Keken</td></tr>
<tr><td colspan="2">8:00 AM-12:20 PM, Hall A-C (Moscone South), T31B. Evolution of the Northern Tibetan Plateau: Lithospheric Geodynamics, Plateau Uplift, and Links to Climate Change II Posters</td></tr>
<tr><td>8:00-8:00 AM</td><td>T31B-2505. A numerical model of continental topographic evolution integrating thin sheet tectonics, river transport, and climate D. Garcia-Castellanos; I. Jimenez-Munt</td></tr>
<tr><td colspan="2">8:00 AM-10:00 AM, 2010 (Moscone West), EP31D. Connecting Natural Landscapes to Experimental and Numerical Models of Earth and Planetary Surface Evolution I</td></tr>
<tr><td>8:15-8:30 AM</td><td>EP31D-02. Creative Computing with Landlab: Open-Source Python Software for Building and Exploring 2D Models of Earth-Surface Dynamics G.E. Tucker; D.E. Hobley; N.M. Gasparini; E. Hutton; E. Istanbulluoglu; S. NUDURUPATI; J.M. Adams</td></tr>
<tr><td>8:30-8:45 AM</td><td>EP31D-03. VALIDATION OF A PARCEL-BASED REDUCED-COMPLEXITY MODEL FOR RIVER DELTA FORMATION (Invited) M. Liang; N. Geleynse; P. Passalacqua; D.A. Edmonds; W. Kim; V.R. Voller; C. Paola</td></tr>
<tr><td>9:15-9:30 AM
(Conflict)</td><td>EP31D-06. Is a Dendritic Drainage Basin Inevitable? (Invited) G. Parker; M. Domanski; S. Weiss; N. Moller; J. Kwang; L. Zhang; X. Fu</td></tr>
<tr><td colspan="2">8:00 AM-10:00 AM, 3020 (Moscone West), H31M. Hydropedology: Synergistic Integration of Soil Science and Hydrology in the Critical Zone II [SWIRL_GS]</td></tr>
<tr><td>9:25-9:40 AM
(Conflict)</td><td>H31M-06. A spatial scaling relationship for soil moisture in a semiarid landscape, using spatial scaling relationships for pedology G.R. Willgoose; M. Chen; S. Cohen; P.M. Saco; G.R. Hancock</td></tr>
</table>

8:00 AM-10:00 AM, 2010 (Moscone West), **EP31D. Connecting Natural Landscapes to Experimental and Numerical Models of Earth and Planetary Surface Evolution I**	
9:30-9:45 AM (Conflict)	**EP31D-07. Scaling the Morphology of Sapping and Pressurized Groundwater Experiments to Martian Valleys** W.A. Marra; M.G. Kleinhans
8:00 AM-10:00 AM, 3007 (Moscone West), **OS31D. Dynamics of the Equatorial Oceans and Atmosphere I**	
9:45-10:00 AM	**OS31D-08. The Seasonal Circulation and Dynamics of the South China Sea (SCS) and the Indonesian Throughflow (ITF) Region** D. Xu; P.M. Rizzoli
10:20 AM-12:20 PM, 2010 (Moscone West), **EP32B. Connecting Natural Landscapes to Experimental and Numerical Models of Earth and Planetary Surface Evolution II**	
10:50-11:05 AM	**EP32B-03. Increased complexity modeling provides new physical understanding of landscape-forming processes** ***(Invited)*** M.W. Schmeeckle
11:05-11:20 AM	**EP32B-04. Probability-Based Model of Sediment Transport During Extreme Flood Events in Mountain Catchments** M.C. Perignon; G.E. Tucker
10:20 AM-12:20 PM, 3016 (Moscone West), **H32F. Remote Sensing Applications for Water Resources Management II: Groundwater Monitoring, Data Integration and Modeling**	
11:20-11:35 AM (Conflict)	**H32F-05. Utilizing Multi-Sensor Data Products and high-resolution flood model in Analyzing North African Hydrological Processes** K. Thengumthara; F. Policelli; S. Habib; J.L. David; K.A. Melocik; G.J. Huffman; M.C. Anderson; A.B. Ali; S. Bacha
10:20 AM-12:20 PM, 2020 (Moscone West), **IN32A. Emerging Technologies in Earth and Space Science Informatics (ESSI) I**	
11:20-11:35 AM (Conflict)	**IN32A-05. Use of natural user interfaces in water simulations** G. Donchyts; F. Baart; A. van Dam; B. Jagers
10:20 AM-12:20 PM, 3016 (Moscone West), **H32F. Remote Sensing Applications for Water Resources Management II: Groundwater Monitoring, Data Integration and Modeling**	
11:35-11:50 AM	**H32F-06. Global Water Maps** D.R. Maidment; F. Salas; W.L. Teng
10:20 AM-12:20 PM, 2010 (Moscone West), **EP32B. Connecting Natural Landscapes to Experimental and Numerical Models of Earth and Planetary Surface Evolution II**	
12:05-12:20 PM	**EP32B-08. Hydrodynamic controls on floodplain construction over years to millennia** A.P. Nicholas; R.E. Aalto; A. Schwendel; G. Sambrook Smith
12:30 PM-1:30 PM, 2005 (Moscone West), **TH32D. Building a Sediment Experimentalist Network**	

12:30-12:30 PM	**TH32D-01. Building a Sediment Experimentalist Network** L. Hsu; W. Kim; R.L. Martin; B.J. McElroy
1:40 PM-6:00 PM, Hall A-C (Moscone South), **B33F. Land Use and Climate Change Impacts on Water-Related Ecosystem Services II Posters**	
1:40-1:40 PM	**B33F-0553. Identification of anthropogenic nitrogen sources using stable isotopes and reactive hydrologic modeling** M.T. O'connell; S.A. Macko; Y. Fu
1:40 PM-6:00 PM, Hall A-C (Moscone South), **C33A. Climate Change and Cryospheric Systems V Posters**	
1:40-1:40 PM	**C33A-0691. Climatology and Changes in the Timing and Duration of Surface Soil Freeze/Thaw Status from 1956-2006 over China** K. Wang; T. Zhang
1:40 PM-6:00 PM, Hall A-C (Moscone South), **C33B. Glacier, Ice Cap, and Ice Sheet Hydrology I Posters**	
1:40-1:40 PM	**C33B-0715. In Situ Data Suggest Supra-, En- and/or Subglacial Meltwater Retention in Southwest Greenland** A.K. Rennermalm; A.B. Mikkelsen; D. van As; I. Overeem; L.C. Smith; V. Chu; P.W. Nienow; A. Tedstone
1:40-1:40 PM	**C33B-0716. Fast flow of Jakobshavn Isbræ and its subglacial drainage system** M.A. Werder; I.R. Joughin
1:40-1:40 PM	**C33B-0720. Hydrometeorology and basal sliding on the Kennicott Glacier, Alaska, USA: Evidence for seasonal, diurnal, and event-scale glacier velocity fluctuations due to varying meltwater inputs and precipitation events** W.H. Armstrong; R.S. Anderson; E.C. Pettit; H. Rajaram
1:40-1:40 PM	**C33B-0728. Physical and chemical characteristics of the Subglacial Lake Whillans sediment cores, Whillans Ice Stream, West Antarctica** T.O. Hodson; R.D. Powell
1:40-1:40 PM	**C33B-0730. River Channel Expansion Reveals Ice Sheet Runoff Variations** I. Overeem; B.D. Hudson; E. Welty; A. LeWinter; A.B. Mikkelsen
1:40-1:40 PM	**C33B-0732. Estimating Freshwater Discharge from the Greenland Ice Sheet with MODIS** B.D. Hudson; I. Overeem; A.B. Mikkelsen; D. McGrath; J.P. Syvitski
1:40 PM-6:00 PM, Hall A-C (Moscone South), **EP33A. Connecting Natural Landscapes to Experimental and Numerical Models of Earth and Planetary Surface Evolution III Posters**	
1:40-1:40 PM	**EP33A-0857. From Fractal Trees to Deltaic Networks** D. Cazanacli; M.A. Wolinsky; Z. Sylvester; A. Cantelli; C. Paola

1:40-1:40 PM	**EP33A-0858. A New Hydrologic-Morphodynamic Model for Regolith Formation and Landscape Evolution** Y. Zhang; R.L. Slingerland; C. Duffy
1:40-1:40 PM	**EP33A-0859. Exploring controls on valley spacing in higher order fluvial channels with the CHILD Model** J. Han; N.M. Gasparini; J.P. Johnson
1:40-1:40 PM	**EP33A-0861. Quantifying the role of channel width in transient bedrock river evolution over geologic timescales** B.J. Yanites
1:40-1:40 PM	**EP33A-0862. River Capture in Disequilibrium Landscapes** S.W. McCoy; J. Perron; S. Willett; L. Goren
1:40-1:40 PM	**EP33A-0863. Modeling post-wildfire fluvial incision and terrace formation** F.K. Rengers; G.E. Tucker
1:40-1:40 PM	**EP33A-0867. Landlab Ecohydrology: A component-based computational environment for ecohydrologic modeling and its illustrations through model building** S. NUDURUPATI; E. Istanbulluoglu; J.M. Adams; N.M. Gasparini; G.E. Tucker; E. Hutton; D.E. Hobley
1:40-1:40 PM	**EP33A-0868. Modeling impact cratering as a geomorphic process using the novel landscape evolution model Landlab** D.E. Hobley; G.E. Tucker; J.M. Adams; N.M. Gasparini; E. Hutton; E. Istanbulluoglu; S. NUDURUPATI
1:40-1:40 PM	**EP33A-0869. Influence of sediment cohesion on stratigraphic architecture** Q. Li; W. Benson; K.M. Straub
1:40-1:40 PM	**EP33A-0870. What can a numerical landscape evolution model tell us about the evolution of a real landscape? Two examples of modeling a real landscape without recreating it.** N.M. Gasparini; K.X. Whipple; J. Willenbring; B.T. Crosby; G.Y. Brocard
1:40-1:40 PM	**EP33A-0876. The Influence of Laboratory-Generated Tides on Experimental Deltas** S.E. Baumgardner; A. Abeyta; D. Cazanacli; C. Paola
1:40-1:40 PM	**EP33A-0878. An Experimental Study of Submarine Canyon Evolution on Continental Slopes** S.Y. Lai; T.P. Gerber; D. Amblas
1:40 PM-6:00 PM, Hall A-C (Moscone South), **EP33B. Exploring the Interplay Between Solid Earth Tectonics and Surface Processes From Mountains to the Sea I Posters**	
1:40-1:40 PM	**EP33B-0889. Reconstructing the formation and in-filling of Lake Manuherikia, Otago: Linking geodynamics and surface processes** P. Upton; G. Duclaux; D. Craw; T.B. Salles; R. Walcott

1:40-1:40 PM	**EP33B-0890. Decadal to millennial deformation in the Pamir – Tian Shan collision zone, NW China and surface expression of active tectonics.** A. Bufe; B. Bookhagen; D.W. Burbank; D.P. Bekaert; E. Hussain
1:40-1:40 PM	**EP33B-0893. A comprehensive view of Late Quaternary fluvial sediments and stratal architecture in a tectonically active basin: Influence of eustasy, climate, and tectonics on the Bengal Basin and Brahmaputra River system** R. Sincavage; S.L. Goodbred; L.A. Williams; J. Pickering; C. Wilson; M.S. Steckler; L. Seeber; M.D. Reitz; S. Hossain; S.H. Akhter; D.R. Mondal; C. Paola
1:40-1:40 PM	**EP33B-0905. Quantifying Holocene Coastal Retreat From River Morphology in Southern England and Wales** M. Attal; S.M. Mudd; M.D. Hurst; B.A. Crickmore
1:40-1:40 PM	**EP33B-0908. Using the stratigraphic record to document tectonic-geomorphologic interactions in a foreland basin setting: outcrop study of the Ainsa Basin, Spain** D.R. Pyles; J. Moody; G. Gordon; M. Hoffman; A. Moss-Russell; H. Silalahi; P. Setiawan; J. Clark; B. Bracken; C. Guzofski
1:40 PM-6:00 PM, Hall A-C (Moscone South), **EP33C. Morphodynamics of Mixed Bedrock-Alluvial River Systems II Posters**	
1:40-1:40 PM	**EP33C-0916. A theoretical framework for quantifying the relative importance of dissolution and mechanical erosion in soluble bedrock channels** M.D. Covington; F. Gabrovšek; J.D. Gulley
1:40-1:40 PM	**EP33C-0926. Morphodynamics and anabranching patterns generated in the Madeira River, Brazil.** E.M. Latrubesse; C. Bonthius; J.D. Abad; J. Stevaux; N. Filizola ; C.E. Frias
1:40 PM-3:40 PM, 2005 (Moscone West), **EP33D. Deltas: A Multi-trillion Dollar Global Problem II**	
1:40-1:55 PM (Conflict)	**EP33D-01. Ganges-Brahmaputra Delta: Balance of Subsidence, Sea level and Sedimentation in a Tectonically-Active Delta** ***(Invited)*** M.S. Steckler; S.L. Goodbred; S.H. Akhter; L. Seeber; M.D. Reitz; C. Paola; S.L. Nooner; S. DeWolf; E.K. Ferguson; J. Gale; S. Hossain; M. Howe; W. Kim; C.M. McHugh; D.R. Mondal; A.L. Petter; J. Pickering; R. Sincavage; L.A. Williams; C. Wilson; M.A. Zumberge
1:40 PM-6:00 PM, Hall A-C (Moscone South), **G33A. 4D Topography: Detecting Changes to the Earth's Surface With Multi-temporal, High-Resolution Topographic Data II Posters**	
1:40-1:40 PM	**G33A-0966. Using High-temporal-resolution, Repeat Terrestrial LiDAR to Compare Topographic Change Detection Methods and to Elucidate the Hydrometeorologic Controls on the Retreat Rate and Form of the Selawik Retrogressive Thaw Slump, Northwest Alaska** T.B. Barnhart; B.T. Crosby; D.R. Derryberry; J.C. Rowland

1:40-1:40 PM	**G33A-0973. Erosion and Channel Incision Analysis with High-Resolution Lidar** J. Potapenko; B. Bookhagen
1:40-1:40 PM	**G33A-0979. Quantifying geomorphic change and characterizing uncertainty in repeat aerial lidar over an enormous area: Blue Earth County, MN** K.R. Schaffrath; P. Belmont; J.M. Wheaton
1:40 PM-6:00 PM, Hall A-C (Moscone South), **H33A. Advances in Ecohydraulics and Biogeomorphology: Coupling System Processes Posters [SWIRL_CU]**	
1:40-1:40 PM	**H33A-1329. Modeling the gopher-meadow eco-geomorphic system on montane hillslopes** E.W. Winchell; D.F. Doak; R.S. Anderson
1:40-1:40 PM	**H33A-1334. Modeling the Channel/Floodplain Interface: The Influence of Riparian Vegetation on Mass and Momentum Exchange** M.C. Stone
1:40-1:40 PM	**H33A-1338. Reciprocal Vegetation-Flow Feedbacks Driving Early-Stage Landscape Evolution in a Restored Wet Meadow** L. Larsen; D.J. Merritts; R.C. Walter; D. Watts
1:40 PM-3:40 PM, 3011 (Moscone West), **H33L. Pore Structure, Fluid Flow, and Mass Transport in Porous Media II [SWIRL_CM]**	
1:40-1:55 PM (Conflict)	**H33L-01. Water-Organic-Rock Reactions Recorded in Pores in Shales from the Marcellus and Rose Hill Formations *(Invited)*** S.L. Brantley; L. Jin; G. Rother; D.R. Cole; x. gu; V.N. Balashov
1:40 PM-3:40 PM, 2020 (Moscone West), **IN33C. Future of Earth Science Informatics in Access, Visualization, and Analysis of Large-Scale Data II**	
1:40-1:55 PM (Conflict)	**IN33C-01. Smart Frameworks and Self-Describing Models: Model Metadata for Automated Coupling of Hydrologic Process Components *(Invited)*** S.D. Peckham
1:40 PM-6:00 PM, Hall A-C (Moscone South), **NH33A. Mechanisms, Vulnerability, Hazard, and Risk: From Shallow to Deep Seated Slope Deformation III Posters**	
1:40-1:40 PM	**NH33A-1629. Model Building Strategies for Predicting Multiple Landslide Events** L. Lombardo; M. Cama; M. Märker; L. Parisi; E. Rotigliano
1:40 PM-3:40 PM, 302 (Moscone South), **T33E. Geodynamic Modeling of Lithosphere Deformation: Advances and Challenges II [SWIRL_CM]**	
1:40-1:55 PM (Conflict)	**T33E-01. Underworld: What we set out to do, How far did we get, What did we Learn ? *(Invited)*** L.N. Moresi
1:40 PM-3:40 PM, 2005 (Moscone West), **EP33D. Deltas: A Multi-trillion Dollar Global Problem II**	
1:55-2:10 PM (Conflict)	**EP33D-02. Slope-mediated and Deltaic Avulsions on the Huanghe River, China** V. Ganti; Z. Chu; H.J. Hassenruck-Gudipati; M.P. Lamb

1:40 PM-3:40 PM, 2003 (Moscone West), **EP33E. Fluvial Sediment Budgets: Can We Do Better? I [SWIRL_CU]**	
1:55-2:10 PM (Conflict)	**EP33E-02. Better budgeting by redundancy, context, and coupling of coarse and fine sediment dynamics** ***(Invited)*** P. Belmont
1:40 PM-3:40 PM, 2005 (Moscone West), **EP33D. Deltas: A Multi-trillion Dollar Global Problem II**	
2:10-2:25 PM (Conflict)	**EP33D-03. Modeling delta growth and channel geometry on Wax Lake Delta, Louisiana. Preliminary results** E. Viparelli; M.J. Czapiga; C. Li; J.B. Shaw; G. Parker
1:40 PM-3:40 PM, 2020 (Moscone West), **IN33C. Future of Earth Science Informatics in Access, Visualization, and Analysis of Large-Scale Data II**	
2:10-2:25 PM (Conflict)	**IN33C-03. Leveraging the DataNet Federation Consortium (DFC) to Support Regional-Scale Hydrologic Modeling** ***(Invited)*** J.L. Goodall; M.M. Billah; B. Essawy; U. Narayan; V. Lakshmi; A. Rajasekar; R. Moore
1:40 PM-3:40 PM, 300 (Moscone South), **NG33B. Pattern Formation and Nonlinear and Scaling Geoprocesses: From Microscale to the Climate I [SWIRL_CM.CU]**	
2:10-2:25 PM (Conflict)	**NG33B-03. The Shape of Patterns to Come** ***(Invited)*** A. Murray; E.B. Goldstein; G. Coco
1:40 PM-3:40 PM, 2005 (Moscone West), **EP33D. Deltas: A Multi-trillion Dollar Global Problem II**	
2:25-2:40 PM (Conflict)	**EP33D-04. Three dimensional numerical modeling of shallow jets: importance of frictional effects on the morphodynamics of river mouth bars and levees** A. Canestrelli; W. Nardin; D.A. Edmonds; S. Fagherazzi; R.L. Slingerland
1:40 PM-3:40 PM, 2020 (Moscone West), **IN33C. Future of Earth Science Informatics in Access, Visualization, and Analysis of Large-Scale Data II**	
2:25-2:40 PM (Conflict)	**IN33C-04. GEOSS Water Services for Data and Maps** D.K. Arctur; D.R. Maidment; R.G. Lawford
2:40-2:55 PM	**IN33C-05. Design and Implementation of Hydrologic Process Knowledge-base Ontology: A case study for the Infiltration Process** M. Elag; J.L. Goodall
1:40 PM-3:40 PM, 2005 (Moscone West), **EP33D. Deltas: A Multi-trillion Dollar Global Problem II**	
2:55-3:10 PM	**EP33D-06. Left Behind: Effects of marine reworking and sea-level rise on deltas of the 21st century** ***(Invited)*** A.D. Ashton; J. Nienhuis; A.C. Ortiz; J. Lorenzo Trueba; L. Giosan

3:25-3:40 PM	**EP33D-08. Maintenance of large deltas through channelization** L. Giosan; S. Constatinescu; F. Filip
4:00 PM-6:00 PM, 2005 (Moscone West), **EP34B. Deltas: A Multi-trillion Dollar Global Problem III**	
4:00-4:15 PM	**EP34B-01. DELTAS: A new Global Delta Sustainability Initiative *(Invited)*** E. Foufoula-Georgiou
4:15-4:30 PM	**EP34B-02. A global deltas typology of environmental stress and its relation to terrestrial hydrology** Z.D. Tessler; C.J. Vorosmarty; K.C. McDonald; R. Schroeder; M. Grossberg; I. Gladkova; H. Aizenman
4:00 PM-6:00 PM, 307 (Moscone South), **ED34A. From Pole to Pole: Experiences Educating About the Polar Regions II**	
4:30-4:45 PM	**ED34A-03. Using high-resolution satellite imagery to engage students in classroom experiences which meld research, the nature of science, and inquiry-based instruction.** J. Pennycook; M. LaRue; B. Herried; P.J. Morin
4:00 PM-6:00 PM, 2007 (Moscone West), **EP34A. Climatic and Glaciological Significance of Glacial Landforms and Landscape Evolution I**	
4:45-5:00 PM (Conflict)	**EP34A-04. The effect of interannual variability on the moraine record: A new perspective on paleoclimate estimation in glacial landscapes** L.S. Anderson; G. Roe; R.S. Anderson
4:00 PM-6:00 PM, 2003 (Moscone West), **EP34C. Fluvial Sediment Budgets: Can We Do Better? II [SWIRL_CU]**	
4:45-5:00 PM (Conflict)	**EP34C-04. The Sensitivity of Sediment Path-Lengths to Channel Morphology: Results from Physical Models of Braided Rivers** A. Kasprak; P. Ashmore; S. Peirce; J.M. Wheaton
4:00 PM-6:00 PM, 3014 (Moscone West), **H34B. Information and Uncertainty in Data and Models: Toward a Common Framework for Model Building and Prediction III [SWIRL_CU]**	
5:00-5:15 PM (Conflict)	**H34B-05. Spatiotemporal variability of rainfall extremes in monsoonal climates – examples from the South American Monsoon and the Indian Monsoon Systems *(Invited)*** B. Bookhagen; N. Boers; N. Marwan; N. Malik; J. Kurths
4:00 PM-6:00 PM, 309 (Moscone South), **NH34A. Interdisciplinary Approaches to Natural Hazards: Environmental, Economical, and Societal Significance II**	
5:00-5:15 PM (Conflict)	**NH34A-05. Recovery of coastal ecosystems after large tsunamis in various climatic zones - review of cases from tropical, temperate and polar zones *(Invited)*** W. Szczucinski
4:00 PM-6:00 PM, 2005 (Moscone West), **EP34B. Deltas: A Multi-trillion Dollar Global Problem III**	

5:30-5:45 PM (Conflict)	**EP34B-07. Sinking Coastlines: Land Subsidence at Aquaculture Facilities in the Yellow River Delta, China, measured with Differential Synthetic Aperture Radar (D-InSAR)** S. Higgins; I. Overeem; A. Tanaka; J.P. Syvitski
4:00 PM-6:00 PM, 305 (Moscone South), **DI34B. State of the Art in Computational Geoscience II [SWIRL_CM.CU]**	
5:30-5:45 PM (Conflict)	**DI34B-07. Computational Hydrology: simulating the integrated water cycle using high performance computing *(Invited)*** R.M. Maxwell

Thursday, December 12, 2013

Time	Session Info
8:00 AM-12:20 PM, Hall A-C (Moscone South), **C41B. Advances in Monitoring, Measuring, and Modeling of Snow, Snow-Vegetation and Avalanche Processes I Posters**	
8:00-8:00 AM	**C41B-0607. Using Forest Radiation Model (FoRM) to Quantify the Role of Canopy Coverage on Net Snow Cover Radiation** B. Seyednasrollah; M. Kumar
8:00-8:00 AM	**C41B-0621. Are weather models better than gridded observations for precipitation in the mountains? *(Invited)*** E.D. Gutmann; R. Rasmussen; C. Liu; K. Ikeda; M.P. Clark; L.D. Brekke; J. Arnold; D.A. Raff
8:00-8:00 AM	**C41B-0633. Combining remotely-sensed snow water equivalent with in-situ measurements to produce a real-time SWE product** D. Schneider; N.P. Molotch
8:00 AM-12:20 PM, Hall A-C (Moscone South), **EP41B. Glacier Processes on the Scales of Mountains and Orogens II Posters**	
8:00-8:00 AM	**EP41B-0799. Variations in Glacial Erosion over Multiple Glacial-Interglacial Cycles** R.M. Headley; T.A. Ehlers
8:00 AM-12:20 PM, Hall A-C (Moscone South), **EP41C. The Imprint of Past Climate Change on Landscapes II Posters**	
8:00-8:00 AM	**EP41C-0805. Landslide statistics reveal a transient response and annealing of a landscape as it emerges from LGM conditions** M.A. Ellis; M.D. Hurst; K.R. Royse; K.A. Lee; K. Freeborough
8:00-8:00 AM	**EP41C-0807. A 50-ky record of climate, ecosystem, and erosion rate change in the Oregon Coast Range** J.A. Marshall; J.J. Roering; D.E. Granger; D.G. Gavin
8:00 AM-12:20 PM, Hall A-C (Moscone South), **H41F. Hydrologic Controls on Biogeochemical and Ecosystem Processes at the Land-Sea Interface III Posters**	

8:00-8:00 AM	**H41F-1297. The Significance of Ultra-Refracted Ocean Waves to Sediment Dynamics and Water Quality in Sheltered Areas, With Application to Crissy Field Marsh, San Francisco** D.M. Hanes
8:00 AM-12:20 PM, Hall A-C (Moscone South), **H41H. Overcoming Remediation Barriers and Improving the Understanding of Processes Controlling Contaminant Transport III Posters**	
8:00-8:00 AM	**H41H-1352. Smouldering Combustion for Soil Remediation: Two-dimensional Experiments and Modelling** T. Hasan; J.I. Gerhard; R. Hadden; P. Pironi; G. Rein
8:00 AM-12:20 PM, Hall A-C (Moscone South), **IN41A. Emerging Concepts for Cyberinfrastructure in the Geosciences I Posters**	
8:00-8:00 AM	**IN41A-1600. Evaluation of the Earth System CoG Infrastructure in Supporting a Model Intercomparison Project** J.C. Wallis; R.B. Rood; S. Murphy; L. Cinquini; C. DeLuca
8:00 AM-12:20 PM, Hall A-C (Moscone South), **NS41A. Geophysical Methods for Groundwater Evaluation and Management II Posters**	
8:00-8:00 AM	**NS41A-1778. Control of in-situ Q by stress and water saturation, for shallow (m), unconsolidated sand.** J.M. Lorenzo; J.M. Crane; J. Shen
8:00 AM-12:20 PM, Hall A-C (Moscone South), **OS41D. Thirty Years of ENSO Research: Dynamics, Predictability, Modeling, Impacts IV Posters**	
8:00-8:00 AM	**OS41D-1861. Testing for orbital and solar forcing of the ENSO system during the Holocene** H. Grist; T.M. Marchitto; A.O. Parker; J.D. Ortiz; A. van Geen
8:00 AM-12:20 PM, Hall A-C (Moscone South), **DI41A. Multidisciplinary Constraints on the Nature and Scale of Mantle Heterogeneities II Posters**	
8:00-8:00 AM	**DI41A-2327. Iron Oxidation State and Compressional Behaviors of Al,Fe-rich Mantle Silicate Perovskite up to 90 GPa** Q. Zhang; S. Shim; Y. Meng; V. Prakapenka; E.E. Alp
8:00 AM-12:20 PM, Hall A-C (Moscone South), **V41A. Geochemistry of Geologic Carbon Sequestration III Posters [SWIRL_CS] (cosponsored by EGU-GMPV and MSA)**	
8:00-8:00 AM	**V41A-2742. Controls on CO2 Mineralization in Volcanogenic Sandstone Reservoir Rocks** S. Zhang; D.J. DePaolo; T. Xu; M. Voltolini
8:00 AM-10:00 AM, 3005 (Moscone West), **C41E. Glacier Monitoring From In-situ and Remotely Sensed Observations II**	
8:20-8:40 AM (Conflict)	**C41E-02. Millennial scale ice dynamics and the spatial partition of Greenland mass change *(Invited)*** W.T. Colgan; W. Abdalati; J.E. Box; B.M. Csatho; R.S. Fausto; X. Fettweis; S.B. Luthcke; T.A. Scambos; D. van As; J.M. Wahr; H. Zwally

8:00 AM-10:00 AM, 2005 (Moscone West), **EP41E. New Concepts in River Mapping and Analysis I**	
8:30-8:45 AM (Conflict)	**EP41E-03. Automated Derivation of Fish Habitat, Geomorphic Units & Transition Zones from Topography** ***(Invited)*** J.M. Wheaton; S.G. Bangen; P. Bailey; N. Bouwes; J.A. McKean
8:00 AM-10:00 AM, 2003 (Moscone West), **EP41D. Morphodynamic Characteristics of Non-normal Flow Conditions II**	
9:00-9:15 AM (Conflict)	**EP41D-05. Validity of the quasi-steady assumption for bed forms under time-varying flows in rivers** ***(Invited)*** R.L. Martin; D.J. Jerolmack
8:00 AM-10:00 AM, 3022 (Moscone West), **H41L. Biophysical Functions and Process Dynamics in Soil I**	
9:00-9:15 AM (Conflict)	**H41L-05. The Catchment Isoscape: Theory and Experimental Evidence for the Isotopic Age of Water in a Critical Zone Observatory** ***(Invited)*** C. Duffy; E. Thomas; P.L. Sullivan; G. Bhatt; X. Yu
8:00 AM-10:00 AM, 2005 (Moscone West), **EP41E. New Concepts in River Mapping and Analysis I**	
9:30-9:45 AM (Conflict)	**EP41E-07. NEAR-BANK FLOW AND FLOOD INDUCED BANK EROSION PROCESSES REVEALED BY APPLICATION OF ADVANCED ACOUSTIC TECHNIQUES ON A MEGA-RIVER** J. Leyland; D.R. Parsons; S.E. Darby; C.R. Hackney; J. Best; R.E. Aalto; A.P. Nicholas
8:00 AM-10:00 AM, 309 (Moscone South), **NH41C. Integrated Approach to the Extreme Natural Hazard Events and Global Environmental Change Assessment I**	
9:30-9:45 AM (Conflict)	**NH51C-1632. Disaster Risks Reduction for Extreme Natural Hazards** H. Plag; S. Jules-Plag
10:20 AM-12:20 PM, 102 (Moscone South), **U42A. Hydrometeorological Research at the Computational Frontier: Data-Intensive Prediction and Social Impact Assessment of Natural Disasters (Virtual Option)**	
11:20-11:50 AM	**U42A-03. A call for a community strategy to the "Essential Terrestrial Variables" necessary for catchment modeling anywhere in the US** ***(Invited)*** C. Duffy; L.N. Leonard
10:20 AM-12:20 PM, 3020 (Moscone West), **H42C. Hydrologic Data Assimilation I**	
11:50-12:05 PM	**H42C-07. Estimating Passive Microwave Brightness Temperature over Snow-covered Land in North America Using a Land Surface Model and a Support Vector Machine** B.A. Forman; R.H. Reichle
1:40 PM-6:00 PM, Hall A-C (Moscone South), **A43B. Cloud, Convection, Radiation, Water and Energy Cycles I Posters**	

1:40-1:40 PM	**A43B-0250. Interactions between clouds and radiation on Arctic present and future climates using CMIP5 models** J.M. English; A. Gettelman; J.E. Kay
1:40 PM-6:00 PM, Hall A-C (Moscone South), **EP43B. Fluvial Sediment Budgets: Can We Do Better? III Posters [SWIRL_CU]**	
1:40-1:40 PM	**EP43B-0850. Experimental Study on Sediment Transport in Meandering Channels** D. Chen; L. He; J. Liu
1:40-1:40 PM	**EP43B-0853. A Progressive Black Top Hat Transformation Algorithm for Estimating Valley Volumes from DEM Data** W. Luo; T. Pingel; J. Heo; A.D. Howard
1:40 PM-6:00 PM, Hall A-C (Moscone South), **EP43D. Source to Sink: Earth-Surface-Process Connections From Mountains to Margins I Posters**	
1:40-1:40 PM	**EP43D-0879. Understanding Coupled Earth-Surface Processes through Experiments and Models *(Invited)*** I. Overeem; W. Kim
1:40-1:40 PM	**EP43D-0880. Building a Bridge to Deep Time: Sedimentary Systems Across Timescales** B. Romans; S. Castelltort; J.A. Covault; J.P. Walsh
1:40-1:40 PM	**EP43D-0885. Source-To-Sink Perspectives On The Mississippi River System, Miocene To Present, Mountain To Abyss** S.J. Bentley; M.D. Blum
1:40-1:40 PM	**EP43D-0887. Humans, Tectonics and Climate, Changing S2S Systems over Time: Waipaoa River Margin Example** S.A. Kuehl; C.R. Alexander; D.R. Corbett; C.K. Harris; A.S. Ogston; A.R. Orpin; J.P. Walsh
1:40-1:40 PM	**EP43D-0896. A record of Yarlung-Tsangpo river reorganization since the middle Miocene: evidence for a Himalayan-Tibetan connection** K.A. Lang; K.W. Huntington
1:40-1:40 PM	**EP43D-0901. Architecture and Channel-Belt Clustering in the Fluvial lower Wasatch Formation, Uinta Basin, Utah.** J.R. Pisel; D.R. Pyles; B. Bracken; C.D. Rosenbaum
1:40 PM-6:00 PM, Hall A-C (Moscone South), **H43A. Groundwater-Surface Water Interactions: Physical, Biological, and Chemical Relevance VI Posters**	
1:40-1:40 PM	**H43A-1432. Estimates of riparian evapotranspiration using diurnal monitoring of groundwater regime in desert environments** P. Wang; S.P. Pozdniakov; S. Grinevsky; J. Yu
1:40 PM-6:00 PM, Hall A-C (Moscone South), **H43B. Impacts of Climatic and Environmental Change on Stream Carbon Loadings Posters**	
1:40-1:40 PM	**H43B-1440. Redistribution of Carbon During Forest Blowdowns** E.E. Wohl

1:40 PM-6:00 PM, Hall A-C (Moscone South), **H43H. Transformative Measurements to Understand the Geosphere: Zip-Ties, Arduinos, Novel Sensors, and Twitter Posters**	
1:40-1:40 PM	**H43H-1574. Inexpensive Open-Source Data Logging in the Field** A.D. Wickert
1:40 PM-6:00 PM, Hall A-C (Moscone South), **NH43A. Innovations in Tsunami Hazard Analysis, Mitigation, and Preparedness II Posters**	
1:40-1:40 PM	**NH43A-1735. Time-Reverse Imaging for the Tsunami Source** J. Hossen; P.R. Cummins
1:40 PM-6:00 PM, Hall A-C (Moscone South), **PP43A. Miocene Climate II Posters**	
1:40-1:40 PM	**PP43A-2068. Sea-level and climate forcing of the Sr isotope composition of marginal basins in the late Miocene Mediterranean Basin** T.F. Schildgen; D. Cosentino; G. Frijia; F. Castorina; F.O. Dudas; A. Iadanza; P. Cipollari; A. Caruso; S.A. Bowring; M.R. Strecker
1:40 PM-6:00 PM, Hall A-C (Moscone South), **SM43A. Integrating Theories and Observations of the Earth's Inner Magnetosphere IV Posters**	
1:40-1:40 PM	**SM43A-2262. Comparison of EMIC wave observation and modeling under different geomagnetic activities** D. Lee; E. Kim; H. Kim; J. Johnson; M. Lessard; M.J. Engebretson; H.J. Singer; E. Valeo; C. Phillips
1:40 PM-6:00 PM, Hall A-C (Moscone South), **MR43A. Constraints and Uncertainties on the Composition, Structure, and Dynamics of the Earth's Lithosphere, Upper Mantle, and Transition Zone From Multidisciplinary Studies III Posters**	
1:40-1:40 PM	**MR43A-2364. High Resolution Global Electrical Conductivity Variations in the Earth's Mantle** A. Kelbert; J. Sun; G.D. Egbert
1:40 PM-3:40 PM, 3016 (Moscone West), **H43O. Water Resources Management and Policy in a Changing World II: Tackling Water Problems Around the Globe**	
1:47-2:02 PM	**H43O-01. Averting a Disaster with Groundwater Depletion in India: The General Case of Water Management Principles and Development *(Invited)*** U. Lall
1:40 PM-3:40 PM, 2003 (Moscone West), **EP43E. Exploring the Interplay Between Solid Earth Tectonics and Surface Processes From Mountains to the Sea II**	
2:10-2:25 PM	**EP43E-03. Tectonics, erosion, and climate in the Miocene Mediterranean: a mechanistic approach to the Messinian Salinity Crisis *(Invited)*** D. Garcia-Castellanos
2:55-3:10 PM (Conflict)	**EP43E-06. River avulsions in the presence of tectonic tilting, and the Ganges-Brahmaputra Delta** M.D. Reitz; M.S. Steckler; C. Paola; S.L. Goodbred; A.L. Petter; J. Pickering; L.A. Williams

1:40 PM-3:40 PM, 2005 (Moscone West), **EP43F. From Grains to Landscapes: Understanding the Links Between Surface Topography, Fluid Mechanics, and Sediment Transport I [SWIRL_CU]**	
2:55-3:10 PM (Conflict)	**EP43F-06. Turbulence- and particle-resolving model of sediment transport and the formation of bedforms under waves and unidirectional currents** M.W. Schmeeckle; J.M. Nelson
3:10-3:25 PM	**EP43F-07. Simulation of River Bluffs and Slip-Off Slopes With a Discrete Particle-Based Model** S.T. Lancaster; J.P. Zunka; G.E. Tucker
4:00 PM-6:00 PM, 2005 (Moscone West), **EP44B. From Grains to Landscapes: Understanding the Links Between Surface Topography, Fluid Mechanics, and Sediment Transport II [SWIRL_CU]**	
4:00-4:15 PM	**EP44B-01. The role of probabilistic formulations of sediment transport aimed at describing the behavior of soil-mantled hillslopes over geomorphic timescales** ***(Invited)*** D.J. Furbish; J.J. Roering
4:15-4:30 PM	**EP44B-02. Are grain packing and flow turbulence the keys to predicting bedload transport in steep streams?** ***(Invited)*** E. Yager; A. Monsalve Sepulveda; H.J. Smith; A. Badoux
4:00 PM-6:00 PM, 302 (Moscone South), **T44C. Linking Earth Surface Dynamics and Deep Tectonic Processes III**	
4:30-4:45 PM	**T44C-03. Quantifying landscape evolution response to changes in dynamic topography** ***(Invited)*** R. Moucha; G.A. Ruetenik; J. Braun; F. Guillocheau; G.D. Hoke
4:00 PM-6:00 PM, 2003 (Moscone West), **EP44A. Exploring the Interplay Between Solid Earth Tectonics and Surface Processes From Mountains to the Sea III**	
5:15-5:30 PM	**EP44A-06. Feedbacks Between Topographic Stress and Drainage Basin Evolution** J. Perron; S.J. Martel; K. Singha; M.I. Slim
5:30-5:45 PM	**EP44A-07. Crustal strength anisotropy influences landscape form and longevity** S.G. Roy; P.O. Koons; P. Upton; G.E. Tucker
5:45-6:00 PM (Conflict)	**EP44A-08. Linking Earth and Atmosphere at Higher Frequencies with the Failure Earth Response Model** ***(Invited)*** P.O. Koons; P. Upton; S.G. Roy; G.E. Tucker
4:00 PM-6:00 PM, 2005 (Moscone West), **EP44B. From Grains to Landscapes: Understanding the Links Between Surface Topography, Fluid Mechanics, and Sediment Transport II [SWIRL_CU]**	
5:45-6:00 PM (Conflict)	**EP44B-08. Tracer waiting times and the steady-state evolution of a granular bed** R.L. Martin; P.K. Purohit; D.J. Jerolmack
4:00 PM-6:00 PM, 3014 (Moscone West), **H44D. Hydrogeophysical Data Integration and Joint Inversion I [SWIRL_CM]**	

5:45-6:00 PM (Conflict)	**H51G-1284. Hydrogeophysical Cyberinfrastructure For Real-Time Interactive Browser Controlled Monitoring Of Near Surface Hydrology: Results Of A 13 Month Monitoring Effort At The Hanford 300 Area** R.J. Versteeg; T. Johnson; A. Henrie; D. Johnson

Friday, December 13, 2013

Time	Session Info
8:00 AM-12:20 PM, Hall A-C (Moscone South), **B51H. Remote Sensing of Northern High-Latitude Terrestrial and Aquatic Ecosystems II Posters**	
8:00-8:00 AM	**B51H-0403. Characterization of an Active Thermal Erosion Site, Caribou Creek, Alaska** R. Busey; W.R. Bolton; J.E. Cherry; L.D. Hinzman
8:00 AM-12:20 PM, Hall A-C (Moscone South), **EP51A. Numerical Modeling of River Fluxes Under Changing Environmental Conditions I Posters**	
8:00-8:00 AM	**EP51A-0696. Modeling bed material transport through colonial-age mill dam impoundments, northern Delaware** A. Pearson; J.E. Pizzuto
8:00-8:00 AM	**EP51A-0698. Three dimensional numerical modeling of Hydrodynamics and sediment transport in the Mississippi River Diversion at West Bay** K.M. Sadid; E.A. Meselhe; B. Roth; M.A. Allison
8:00-8:00 AM	**EP51A-0700. Modeling mud flocculation using variable collision and breakup efficiencies** K. Strom; A. Keyvani
8:00-8:00 AM	**EP51A-0704. A probabilistic sediment cascade model of sediment transfer through a mountain basin.** G.L. Bennett; P. Molnar; B.W. McArdell; S.N. Lane; P. Burlando
8:00 AM-12:20 PM, Hall A-C (Moscone South), **EP51B. Using Predictive Models to Inform River Management and Restoration I Posters**	
8:00-8:00 AM	**EP51B-0711. Estimation of Daily Stream Temperatures in a Mountain River Network** M. Sohrabi; R.M. Benjankar; D. Isaak; S. Wenger; D. Tonina
8:00 AM-12:20 PM, Hall A-C (Moscone South), **H51F. Hydrogeophysical Characterization of the Critical Zone II Posters [SWIRL_GS]**	
8:00-8:00 AM	**H51F-1266. Soil temperature and water dynamics on contrasting aspects in the rain-snow transition zone** T.E. Link; M.S. Seyfried; S. Bryden; J.P. McNamara; P.Z. Klos
8:00 AM-12:20 PM, Hall A-C (Moscone South), **H51G. Hydrogeophysical Data Integration and Joint Inversion II Posters [SWIRL_CM]**	

8:00-8:00 AM	**H51G-1276. Conversion of Highly Complex Faulted Hydrostratigraphic Architectures into MODFLOW Grid for Groundwater Modeling** H.V. Pham; F.T. Tsai
8:00 AM-12:20 PM, Hall A-C (Moscone South), **H51K. Large-Scale Field Experimentation and Networks I Posters**	
8:00-8:00 AM	**H51K-1347. Investigating Snowmelt Infiltration Dynamics in the Western U.S. Using the SNOTEL Network** A.A. Harpold; N.P. Molotch
8:00 AM-10:00 AM, 3014 (Moscone West), **H51S. Remote Sensing and Modeling of Groundwater Variability I**	
8:00-8:15 AM (Conflict)	**H51S-01. Diagnosing scaling behavior of groundwater with a fully-integrated, high resolution hydrologic model simulated over the continental US *(Invited)*** R.M. Maxwell; L.E. Condon; S.J. Kollet
8:00 AM-10:00 AM, 2010 (Moscone West), **IN51C. Adopting Cloud Computing for Environmental Decision Support Systems I [SWIRL_CM]**	
8:00-8:15 AM (Conflict)	**IN51C-01. Decision Support for Active Water Management *(Invited)*** D.R. Maidment; F. Salas; B.S. Minsker
8:00 AM-12:20 PM, Hall A-C (Moscone South), **P51D. Rapid Environmental Change and the Fate of Planetary Habitability II Posters**	
8:00-8:00 AM	**P51D-1756. Simulating Fine grained Alluvial Fan Sedimentation on Mars** A.M. Morgan; A.D. Howard; J.M. Moore; R.A. Beyer
8:00 AM-12:20 PM, Hall A-C (Moscone South), **T51B. New Frontiers in Asia Pacific Earth Sciences II Posters**	
8:00-8:00 AM	**T51B-2460. Subsurface Evidence for Late Mesozoic Extension in Western Mongolia: Tectonic and Petroleum Systems Implications** C.L. Johnson; K. Constenius; A. Payton; S.A. Graham; G.N. Mackey
8:00 AM-12:20 PM, Hall A-C (Moscone South), **V51D. Volcanic Flow and Magma Properties: Field, Laboratory and Hazard Assessment III Posters (cosponsored by EGU-GMPV and MSA)**	
8:00-8:00 AM	**V51D-2704. Numerical investigation of the morphological transition of submarine lava flow due to slope change** E. Choi; M. Tominaga; M.G. Baker; D. May; E. Fujita; T. Kozono
8:00 AM-10:00 AM, 3009 (Moscone West), **OS51C. From Mountains to the Ocean: Physical, Chemical and Microbial Impacts on Carbon Fluxes I**	
8:15-8:30 AM	**OS51C-02. The Dynamic Watershed and the Coastal Ocean: Biogeochemical Linkages and Interannual Variability** E. Olhsson; T.M. Powell
8:00 AM-10:00 AM, 2003 (Moscone West), **EP51C. Influence of Climate and Climate Variability on Landscape Form and Function II**	

8:45-9:00 AM (Conflict)	**EP51C-04. High-resolution regional paleoclimate simulations of Lake Bonneville and its influence on geomorphic processes in the Uinta Mountains during the Last Glacial Maximum** ***(Invited)*** J. Galewsky
8:00 AM-10:00 AM, 2010 (Moscone West), **IN51C. Adopting Cloud Computing for Environmental Decision Support Systems I [SWIRL_CM]**	
8:45-9:00 AM (Conflict)	**IN51C-04. Using the cloud to speed-up calibration of watershed-scale hydrologic models** ***(Invited)*** J.L. Goodall; M.B. Ercan; A.M. Castronova; M. Humphrey; N. Beekwilder; J. Steele; I. Kim
8:00 AM-10:00 AM, 2005 (Moscone West), **EP51D. Source to Sink: Earth-Surface-Process Connections From Mountains to Margins II**	
9:00-9:15 AM	**EP51D-05. Sink to source: The effects of offshore dynamics on upstream processes** A. Abeyta; C. Paola; J.B. Swenson
8:00 AM-10:00 AM, 3006 (Moscone West), **A51M. New Particle Formation I (cosponsored by AMS)**	
9:30-9:45 AM (Conflict)	**A51M-07. Photo-chemical reduction of iodate (IO3-) in sea-water leading to the emission of iodine (I2) in the atmosphere** R. Kumar
8:00 AM-10:00 AM, 2005 (Moscone West), **EP51D. Source to Sink: Earth-Surface-Process Connections From Mountains to Margins II**	
9:30-9:45 AM (Conflict)	**EP51D-07. Climate and Tectonics Need Not Apply: Transient Erosion Driven by Drainage Integration, Aravaipa Creek, AZ** M. Jungers; A.M. Heimsath
10:20 AM-12:20 PM, 2005 (Moscone West), **EP52B. Source to Sink: Earth-Surface-Process Connections From Mountains to Margins III**	
10:20-10:35 AM (Conflict)	**EP52B-01. Flood Deposition Patterns and Channel Migration due to a 10-year flood event: the case of the Indus River flood 2010** A.J. Kettner; J.P. Syvitski; I. Overeem; G.R. Brakenridge
10:20 AM-12:20 PM, 3009 (Moscone West), **OS52A. Sediment Transport by Turbidity Currents: Simulation and Observation I (cosponsored by IAS)**	
10:20-10:35 AM (Conflict)	**OS52A-01. Visualizing the internal structure of subaqueous, high-concentration sediment-laden flows: implication of rheology to flow structure.** M.M. Perillo; J. Buttles; D.C. Mohrig; I. Kane; A. Pontén; D. Brown; B.W. Minton
10:20 AM-12:20 PM, 2003 (Moscone West), **EP52A. Influence of Climate and Climate Variability on Landscape Form and Function I**	
10:35-10:50 AM	**EP52A-02. Solar radiation signature manifested on the spatial patterns of modeled soil moisture, vegetation, and topography using an ecohydro-geomorphic landscape evolution model** O. Yetemen; J.H. Flores Cervantes; E. Istanbulluoglu; E.R. Vivoni

11:05-11:20 AM (Conflict)	**EP52A-04. Climatic controls on mechanical rock strength and channel incision due to bedrock weathering, Kohala Peninsula, Hawaii** B.P. Murphy; J.P. Johnson; N.M. Gasparini; L.S. Sklar
10:20 AM-12:20 PM, 3009 (Moscone West), **OS52A. Sediment Transport by Turbidity Currents: Simulation and Observation I (cosponsored by IAS)**	
11:05-11:20 AM (Conflict)	**OS52A-04. Insights into the linked dynamics of channel networks on shelf-edge deltas and submarine slopes from physical experiments and high-resolution seismic data** A.M. Fernandes; K.M. Straub
10:20 AM-12:20 PM, 3016 (Moscone West), **H52G. Water Resources Management and Policy in a Changing World V: Dealing with Flow and Climate Variability**	
11:25-11:40 AM	**H52G-05. Assessing Applicability of CMIP5 Climate Projections for Water Resources and Environmental Planning** I.M. Ferguson; L.D. Brekke; J. Scott; M.A. Alexander
10:20 AM-12:20 PM, 2022 (Moscone West), **SM52A. Decadal Challenges for Solar and Space Physics I (Virtual Option: On-Demand Only)**	
11:51-12:03 PM	**SM52A-08. A future Chinese mission proposed to investigate the coupling of the Earth's magnetoshpere, ionosphere and thermoshpere** Y. Liu; C. Wang; J. Xu
10:20 AM-12:20 PM, 2003 (Moscone West), **EP52A. Influence of Climate and Climate Variability on Landscape Form and Function I**	
12:05-12:20 PM	**EP52A-08. Landscape re-organization under changing climatic forcing** A. Singh; L. Reinhardt; E. Foufoula-Georgiou
1:40 PM-6:00 PM, Hall A-C (Moscone South), **C53A. Hydrological Response to Climate Change in Permafrost Regions II Posters**	
1:40-1:40 PM	**C53A-0550. Increased Groundwater Upwelling from Changes in Permafrost as a Control on River Ice Thickness** C. Jones; K. Kielland; L.D. Hinzman
1:40 PM-6:00 PM, Hall A-C (Moscone South), **C53B. Modeling of the Cryosphere: Glaciers and Ice Sheets III Posters**	
1:40-1:40 PM	**C53B-0553. Constitutive Models for Debris-bearing Ice Layers** P.L. Moore
1:40 PM-6:00 PM, Hall A-C (Moscone South), **EP53A. Earth and Planetary Surface Processes General Contributions Posters**	
1:40-1:40 PM	**EP53A-0720. Draix multidisciplinary observatory for water and sediment processes** C. Le Bouteiller; N. Mathys; F. Liébault; S. Klotz

1:40-1:40 PM	**EP53A-0725. BED FORMS MODULATING TEMPORAL PEAKS ON NEAR-BANK SHEAR STRESSES, THE WABASH RIVER CASE** J.D. Abad; C.E. Frias; E.J. Langendoen; J. Best; B.L. Rhoads; K.M. Konsoer; M.H. Garcia
1:40-1:40 PM	**EP53A-0737. Recent developments in cosmogenic nuclide production rate scaling** N.A. Lifton
1:40-1:40 PM	**EP53A-0746. A New Method of Assessing the Extent of Topographic Equilibrium at Different Spatial Scales** R. Walcott
1:40-1:40 PM	**EP53A-0757. Scaling up debris-flow experiments on a centrifuge** C. Hung; H. Capart; T.J. Crone; E. Grinspum; L. Hsu; D. Kaufman; L. Li; H. Ling; M.D. Reitz; B. Smith; C.P. Stark
1:40-1:40 PM	**EP53A-0764. 10-year Field Measurement Program of Post-Wildfire Tree Root Decay, Kootenay National Park, British Columbia** Y.E. Martin; E.A. Johnson; S. Kroeker
1:40-1:40 PM	**EP53A-0774. Early Cretaceous continental sedimentation in the Coastal Cordillera (Atajaña Formation), Northern Chile** G. Fuentes; M. Garcia; F. Sepulveda; P. Vasquez
1:40-1:40 PM	**EP53A-0775. Thickness of the oligo-neogene sedimentary cover in the Central Depression, northern Chile (Pampa del Tamarugal, 20°45’ -21°30’S), based on seismic reflection** M. Garcia; Y. Simicic; E. Contreras Reyes; R. Charrier
1:40-1:40 PM	**EP53A-0779. Influence of Shear History on the Growth Rate and Equilibrium Size of Mud Flocs** A. Keyvani; K. Strom
1:40-1:40 PM	**EP53A-0786. A multi-resolution analysis of lidar-DTMs to identify geomorphic processes from characteristic topographic length scales** H. Sangireddy; P. Passalacqua; C.P. Stark
1:40 PM-6:00 PM, Hall A-C (Moscone South), **EP53B. From Grains to Landscapes: Understanding the Links Between Surface Topography, Fluid Mechanics, and Sediment Transport III Posters [SWIRL_CU]**	
1:40-1:40 PM	**EP53B-0822. Steady-state unsteadiness: drainage network reorganization triggered by bedrock river meandering in the Oregon Coast Range** K.N. Johnson; N.J. Finnegan
1:40-1:40 PM	**EP53B-0824. Mapping bathymetry in a large meandering river above and below a significant sediment input** S.A. Kelly; P. Belmont
1:40-1:40 PM	**EP53B-0831. A comparison of hydrology and channel hydraulics in headwater streams of the Central Oregon Cascades** L.A. Hempel; G. Grant; S. Lewis
1:40-1:40 PM	**EP53B-0833. Physicochemical effects of temperature and water chemistry on cohesive channel erosion** T. Wynn-Thompson; S. Hoomehr; O. Parks; M. Eick

1:40-1:40 PM	**EP53B-0839. Fluid Dynamical Control of Spacing and Symmetry Breaking in Orbital Wave Ripples** J. Nienhuis; J. Perron; J.C. Kao; P. Myrow
1:40 PM-6:00 PM, Hall A-C (Moscone South), **EP53C. Influence of Climate and Climate Variability on Landscape Form and Function III Posters**	
1:40-1:40 PM	**EP53C-0851. Topographic and Genetic Markers of Landscape Change: Landslides and Isolated Fish Populations Demarcating Basin -wide Erosional Waves Above the Cascadia Subduction Zone** N.J. Lyons; K.W. Wegmann; M. Raley
1:40 PM-3:40 PM, 2003 (Moscone West), **EP53E. Numerical Modeling of River Fluxes Under Changing Environmental Conditions II**	
1:40-1:55 PM (Conflict)	**EP53E-01. Morphodynamic modeling of the river pattern continuum *(Invited)*** A.P. Nicholas
1:40 PM-6:00 PM, Hall A-C (Moscone South), **H53D. Global Floods: Satellite Observation, Modeling and Socioeconomic Response II Posters [SWIRL_CM]**	
1:40-1:40 PM	**H53D-1447. Multi-scale Evaluation of a Real Time Multi-satellite Precipitation Forced Global Hydrological Modeling System** Y. Zhang; Y. Hong; H. Gao; X. Xue; J.J. Gourley
1:40 PM-3:40 PM, 3018 (Moscone West), **H53I. Chemical, Isotopic, and Chronologic Tracers to Understand the Fate and Transport of Nutrients in Watersheds II**	
1:40-1:55 PM (Conflict)	**H53I-01. Insights on Biogeochemistry from the Triple Isotope System of Nitrate *(Invited)*** T. Meixner; G.M. Michalski; N. Dejwahk; K.M. Riha; K.A. Lohse; E.L. Gallo; J.C. McIntosh; P.D. Brooks
1:40 PM-6:00 PM, Hall A-C (Moscone South), **P53D. Titan- A Solar System Enigma II Posters**	
1:40-1:40 PM	**P53D-1892. Orographic forcing of dune forming winds on Titan** E.J. Larson; O.B. Toon; A.J. Friedson
1:40 PM-6:00 PM, Hall A-C (Moscone South), **PP53A. Environmental Change in High-Altitude Lakes II Posters**	
1:40-1:40 PM	**PP53A-1984. High lake levels at Siling Co, central Tibet, during MIS 5e - 6** X. Shi; E. Kirby; K.P. Furlong; K. Meng; S. Marrero; E. Wang; Y. Asmerom; R.A. Robinson; V.J. Polyak; F.M. Phillips
1:40 PM-3:40 PM, 2003 (Moscone West), **EP53E. Numerical Modeling of River Fluxes Under Changing Environmental Conditions II**	
1:55-2:10 PM	**EP53E-02. New Possibilities in Global Hydrology and Sediment Transport *(Invited)*** J.P. Syvitski; S. Cohen; A.J. Kettner; G.R. Brakenridge

2:10-2:25 PM	**EP53E-03. Towards a consistent modeling framework across scales** B. Jagers
2:40-2:55 PM	**EP53E-05. A (fast) "precipiton" method to calculate river hydrodynamics with applications to landscape evolution models as well as flood prediction** P. Davy
1:40 PM-3:40 PM, 3003 (Moscone West), **GC53D. Challenges in Attribution and Assessment of Climate Impacts II**	
2:58-3:11 PM (Conflict)	**GC53D-07. Rising to the Challenge of Climate Impact Assessment in the Arctic *(Invited)*** L.D. Hinzman
1:40 PM-3:40 PM, 3011 (Moscone West), **H53M. Persistent Problems and Modern Approaches in Multiphase Flow in Porous Media: From Pore to Laboratory and Field-Scale II**	
3:10-3:25 PM (Conflict)	**H53M-07. A Non-classical Hydrostatic Equation for Unsaturated Porous Media** J. Wang; R.L. Bras; T.H. Illangasekare; T. Sakaki; R.L. Detwiler
1:40 PM-3:40 PM, 2003 (Moscone West), **EP53E. Numerical Modeling of River Fluxes Under Changing Environmental Conditions II**	
3:25-3:40 PM	**EP53E-08. A theoretical and field-based study on the formation and shape of fluvial levees** D.A. Edmonds; E.A. Hajek
4:00 PM-6:00 PM, 2003 (Moscone West), **EP54A. Using Predictive Models to Inform River Management and Restoration II**	
5:35-5:55 PM	**EP54A-07. Questioning the Faith – Models and Prediction in Stream Restoration *(Invited)*** P. Wilcock

Final ID: A11C-0059

Evolution of biomass burning aerosol over the Amazon: airborne measurements of aerosol chemical composition, microphysical properties, mixing state and optical properties during SAMBBA

W. Morgan; [1]; *J. D. Allan;* [1, 2]; *M. Flynn;* [1]; *E. Darbyshire;* [1]; *A. Hodgson;* [1]; *D. Liu;* [1]; *S. O'Shea;* [1]; *S. Bauguitte;* [7]; *K. Szpek;* [3]; *B. Johnson;* [3]; *J. Haywood;* [3, 4]; *K. Longo;* [5]; *P. Artaxo;* [6]; *H. Coe;* [1];

1. Centre for Atmospheric Science, University of Manchester, Manchester, United Kingdom.
2. National Centre for Atmospheric Science, University of Manchester, Manchester, United Kingdom.
3. Met Office, Exeter, United Kingdom.
4. College of Engineering, Mathematics and Physical Sciences, University of Exeter, Exeter, United Kingdom.
5. National Institute for Space Research (INPE), Sao Paulo, Brazil.
6. University of Sao Paulo, Sao Paulo, Brazil.
7. Facility for Airborne Atmospheric Measurement, Cranfield, United Kingdom.

Body: Biomass burning represents one of the largest sources of particulate matter to the atmosphere, resulting in a significant perturbation to the Earth's radiative balance coupled with serious impacts on public health. On regional scales, the impacts are substantial, particularly in areas such as the Amazon Basin where large, intense and frequent burning occurs on an annual basis for several months. Absorption by atmospheric aerosols is underestimated by models over South America, which points to significant uncertainties relating to Black Carbon (BC) aerosol properties.

Initial results from the South American Biomass Burning Analysis (SAMBBA) field experiment, which took place during September and October 2012 over Brazil on-board the UK Facility for Airborne Atmospheric Measurement (FAAM) BAe-146 research aircraft, are presented here. Aerosol chemical composition was measured by an Aerodyne Aerosol Mass Spectrometer (AMS) and a DMT Single Particle Soot Photometer (SP2). The physical, chemical and optical properties of the aerosols across the region will be characterized in order to establish the impact of biomass burning on regional air quality, weather and climate.

The aircraft sampled a range of conditions including sampling of pristine Rainforest, fresh biomass burning plumes, regional haze and elevated biomass burning layers within the free troposphere. The aircraft sampled biomass burning aerosol across the southern Amazon in the states of Rondonia and Mato Grosso, as well as in a Cerrado (Savannah-like) region in Tocantins state. This presented a range of fire conditions, in terms of their number, intensity, vegetation-type and their combustion efficiencies. Near-source sampling of fires in Rainforest environments suggested that smouldering combustion dominated, while flaming combustion dominated in the Cerrado. This led to significant differences in aerosol chemical composition, particularly in terms of the BC content, with BC being enhanced in the Cerrado region compared with the Rainforest environment. This was reflected in the single scattering albedo of the regional smoke haze, with values of 0.9 observed in the Rainforest environments compared with a value of 0.8 in the Cerrado region. This contrast results in a net cooling and warming respectively in terms of the aerosol direct radiative effect.

BC-containing particles were found to be rapidly coated in the near-field, with little evidence for additional coating upon advection and dilution. This is consistent with organic aerosol mass being approximately constant when accounting for dilution both close to source and on the regional scale. However, the bulk organic aerosol composition became increasingly oxidised with distance from source. Such properties have important implications for the life cycle and formation of particulate material, which governs its subsequent impacts. Biomass burning layers were observed aloft in the free troposphere, which has potential implications for atmospheric stability profiles and cloud formation.

The results presented enhance our knowledge of biomass burning aerosol in a sensitive region of the globe, where relatively few measurement campaigns have taken place previously.

Final ID: B11A-0367

The Secret Gardener: Vegetation and the Emergence of Bio-geomorphic Patterns in Tidal Environments

M. Marani; [1, 2]; *C. Da Lio;* [3]; *A. D'Alpaos;* [4];
1. Duke University, Durham, NC, United States.
2. Dept. ICEA, University of Padova, Padova, Italy.
3. CNR - ISMAR, Venice , Italy.
4. Dept. of Geosciences, University of Padova, Padova, Italy.

Body: The presence and continued existence of tidal morphologies, and in particular of salt marshes, is intimately connected with biological activity, especially with the presence of halophytic vegetation. Here we show how the presence of multiple competing stable states arising from a two-way feedback between biomass productivity and topographic elevation regulates the intertidal landscape dynamics. Through the analysis of previous and new results on spatially-extended biogeomorphological systems, we show that multiple stable states constitute a unifying framework explaining emerging patterns in tidal environments from the local to the system scale. Furthermore, in contrast
with traditional views we propose that biota in tidal environments is not just passively adapting to morphological features prescribed by sediment transport, but rather it is 'The Secret Gardener', fundamentally constructing the tidal landscape. The proposed framework allows to identify the observable signature of the biogemorphic feedbacks underlying tidal landscapes and to explore the response and resilience of tidal biogeomorphic patterns to variations in the forcings, such as the rate of relative sea level rise.

Final ID: B11C-0391

Geomorphic controls on mineral weathering, elemental transport, and production of mineral surface area in a schist bedrock weathering profile, Piedmont Pennsylvania

B. Wenell; [1]; *K. Yoo;* [1]; *A. K. Aufdenkampe;* [3]; *J. B. Mahoney;* [2]; *L. Lepak;* [2];
1. University of Minnesota, St. Paul, MN, United States.
2. Geology, University of Wisconsin-Eau Claire, Eau Claire, WI, United States.
3. Stroud Water Research Center, Avondale, PA, United States.

Body: We assess a deep chemical weathering profile in the context of geomorphic evolution in the Laurels Schist, a late proterozoic greenschist formation in the Christina River Basin Critical Zone Observatory located in the Piedmont region in southeastern Pennsylvania. Two 21-meter deep rotosonic drill cores were sampled at the ridge top and footslope positions in a first-order, forested watershed. The top meter was sampled at high-resolution in a soil pit adjacent to each drill core and along a hillslope transect to assess geomorphic controls on the weathering profile. Weathering processes in soil and saprolite were examined by observing changes in mineralogy, including the emergence of secondary phyllosilicate and oxide minerals; measuring specific surface area of bulk soil and saprolite; and by quantifying elemental mass changes of major and minor rock-forming elements. Mineral profiles were assessed using clay and bulk XRD, and reveal that kaolinite, a common secondary phyllosilicate, is present above 1.5 meters in the weathering profile. Specific surface area (SSA) values decrease with increasing depth to a critical depth around 2 meters, where the values of untreated (carbon-loaded) and muffled (carbon removed by heating) mineral grains converge to baseline SSA values below 10 m2g-1, indicating that carbon is sorbed with mineral surface area in the upper 2 meters. Immobile element concentrations decrease with increasing depth up to 3 meters, indicating that the preferential removal of mobile elements extends beyond the depth of C-mineral adsorption. Variability of immobile elements in the deep weathering profile reveal variations that could be the result of weathering in fractures but are more likely inherited by the rock composition and particle size of pre-metamorphosed parent rock.

Final ID: C11A-0647

Glacier sensitivity to climate change in the Nepalese Himalaya quantified using higher-order modelling

A. V. Rowan; [1]; *D. L. Egholm;* [2]; *N. F. Glasser;* [1]; *D. J. Quincey;* [3];

1. Department of Geography and Earth Sciences, Aberystwyth University, Aberystwyth, United Kingdom.
2. Department of Earth Sciences, University of Aarhus, Aarhus, Denmark.
3. School of Geography, University of Leeds, Leeds, United Kingdom.

Body: Recent studies of glaciers in the eastern Himalaya have identified rapid changes in ice volume with small changes in climate indicating that these glaciers are highly sensitive to primary climate variables (e.g. daily variations in air temperature and monsoon precipitation). However, quantifying Himalayan glacier sensitivity to climate change is challenging due to: (1) a lack of information about how glaciological and geomorphological factors influence the balance of large debris-covered glaciers; (2) the local modification of meteorological variables by the interaction of high topography with regional atmospheric circulation systems; and (3) the simple representation of ice dynamics in many numerical glacier models which limits their usefulness in regions with steep terrain. To quantify the sensitivity of Himalayan glaciers to climate change we apply the integrated second-order shallow ice approximation (iSOSIA) [Egholm et al. 2011, Journal of Geophysical Research-Earth Surface] to large debris-covered glaciers on the southern slopes of Mt. Everest in the Khumbu Himal, Nepal. iSOSIA considers both the longitudinal and transverse stresses that drive mountain glacier flow in regions with steep terrain—a more suitable approach for Himalayan glaciers than those models based on approximations developed for shallow ice sheets. We apply iSOSIA at a 100-m resolution on a regular grid using a daily timestep to Nepalese glaciers including Khumbu, Ngozumpa and Lhotse. Our mass balance model development has focused on the dynamic representation of snow avalanching onto the glacier surfaces as this accounts for up to 75% of accumulation.

We investigate Himalayan glacier sensitivities to primary climatological, glaciological and geological variables including air temperature, supraglacial debris cover, and catchment hypsometry. Furthermore, we aim to improve the representation of climate in glacier models for the Himalaya by testing a range of methods to describe these variables: (1) simple elevation-dependent rates for accumulation and ablation with empirical values for melt along a flow line beneath supraglacial debris; (2) climate–elevation relationships derived from local automatic weather stations in the Khumbu valley; and (3) 3-D surface energy balance calculations using regional meteorological data. Once we have described glacier–climate sensitivities in the Khumbu Himal, we will use these results to predict the likely magnitude and timescales of glacier mass loss under IPCC future climate change scenarios, and quantify the uncertainties associated with these predictions. Future work will consider: how glacier hydrology modifies variations in ice dynamics; how the spatial distribution of supraglacial debris modifies glacier balance sensitivity; how rock debris is transported within and on these glaciers; and how rates of rock debris delivery from hillslopes affects glacier balance and dynamics. Fieldwork in Nepal is planned for 2014 to collect data from debris-covered Khumbu Glacier with which to validate our numerical model.

URL: http://www.aber.ac.uk/en/iges/staff/research/anr34/

Final ID: H11E-1195

Modeling of hydrological and hydraulics problems using OpenFOAM® platform: From physics to mathematical models to computer codes ***(Invited)***

X. Liu; [1];
1. Department of Civil and Environmental Engineering, University of Texas at San Antonio, San Antonio, TX, United States.

Body: The talk will showcase some modeling work for hydrological and hydraulics problems using the open source computational physics platform OpenFOAM®. It has been about ten years since OpenFOAM entered the public domain. The user base has grown tremendously evidenced by the active online community and the increasing publications. This platform is essentially a computational toolbox which solves mathematical models (partial differential equations, PDEs) using finite volume method. OpenFOAM solves the PDEs in an automatic fashion and yet provides sufficient user controls on almost all aspects of the numerics, for example discretization schemes. Parallel computation based on domain decomposition is also automatic since the mechanism is built into the lower level of the code structure. Upper level users do not need to know the details. It liberates the researchers from the burden of extensive computer coding and makes it possible for them to focus on the physics. From the abstraction of physical processes to mathematical models, and to implement them in OpenFOAM and see the results, a proficient user probably only needs several hours. Our research group has used it for a variety of applications, including porous media flows, river hydraulics, sedimentation, buoyant plumes, etc. Examples will be shown.

Final ID: H11E-1204

A New Open Data Open Modeling Framework for the Geosciences Community ***(Invited)***

X. Liang; [1]; *D. Salas;* [1]; *M. Navarro;* [2]; *Y. Liang;* [2]; *W. L. Teng;* [3]; *R. P. Hooper;* [4]; *P. J. Restrepo;* [5]; *J. D. Bales;* [6];

1. Department of Civil and Environmental Engineering, University of Pittsburgh, Pittsburgh, PA, United States.
2. Department of Computer and Information Science, Indiana Univ.-Purdue Univ. , Indianapolis, IN, United States.
3. NASA Goddard Earth Sciences Data and Information Services Center (ADNET), Greenbelt, MD, United States.
4. Consortium of Universities for the Advancement of Hydrologic Science, Medford, MA, United States.
5. NOAA/NWS North Central River Forecast Center, Chanhassen, MN, United States.
6. U.S. Geological Survey, Reston, VA, United States.

Body: A prototype Open Hydrospheric Modeling Framework (OHMF), also called Open Data Open Modeling framework, has been developed to address two key modeling challenges faced by the broad research community: (1) accessing external data from diverse sources and (2) execution, coupling, and evaluation/intercomparison of various and complex models. The former is achieved via the Open Data architecture, while the latter is achieved via the Open Modeling architecture. The Open Data architecture adopts a common internal data model and representation, to facilitate the integration of various external data sources into OHMF, using Data Agents that handle remote data access protocols (e.g., OPeNDAP, Web services), metadata standards, and source-specific implementations. These Data Agents hide the heterogeneity of the external data sources and provide a common interface to the OHMF system core. The Open Modeling architecture allows different models or modules to be easily integrated into OHMF. The OHMF architectural design offers a general many-to-many connectivity between individual models and external data sources, instead of one-to-one connectivity from data access to model simulation results. OHMF adopts a graphical scientific workflow, offers tools to re-scale in space and time, and provides multi-scale data fusion and assimilation functionality. Notably, the OHMF system employs a strategy that does not require re-compiling or adding interface codes for a user's model to be integrated. Thus, a corresponding model agent can be easily developed by a user. Once an agent is available for a model, it can be shared and used by others. An example will be presented to illustrate the prototype OHMF system and the automatic flow from accessing data to model simulation results in a user-friendly workflow-controlled environment.

Final ID: H11E-1206

HydroDesktop as a Community Designed and Developed Resource for Hydrologic Data Discovery and Analysis

D. P. Ames; [1];
1. Brigham Young University, Provo, UT, United States.

Body: As has been seen in other informatics fields, well-documented and appropriately licensed open source software tools have the potential to significantly increase both opportunities and motivation for inter-institutional science and technology collaboration. The CUAHSI HIS (and related HydroShare) projects have aimed to foster such activities in hydrology resulting in the development of many useful community software components including the HydroDesktop software application. HydroDesktop is an open source, GIS-based, scriptable software application for discovering data on the CUAHSI Hydrologic Information System and related resources. It includes a well-defined plugin architecture and interface to allow 3rd party developers to create extensions and add new functionality without requiring recompiling of the full source code. HydroDesktop is built in the C# programming language and uses the open source DotSpatial GIS engine for spatial data management. Capabilities include data search, discovery, download, visualization, and export. An extension that integrates the R programming language with HydroDesktop provides scripting and data automation capabilities and an OpenMI plugin provides the ability to link models. Current revision and updates to HydroDesktop include migration of core business logic to cross platform, scriptable Python code modules that can be executed in any operating system or linked into other software front-end applications.

URL: http://www.hydrodesktop.org

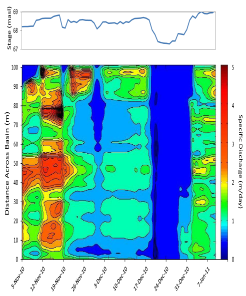
Final ID: H11F-1212

Heat Tracing Percolation in Managed Aquifer Recharge Facilities using Fiber Optic Distributed Temperature Sensing

M. Becker;[1]; *W. Ellis;*[1]; *B. Bauer;*[1]; *A. Hutchinson;*[2];
1. Cal State Long Beach, Long Beach, CA, United States.
2. Orange County Water District, Anaheim, CA, United States.

Body: Percolation rates in Managed Aquifer Rechage (MAR) facilities, such as recharge basins and stream channels, can vary widely through both time and space. Natural variations in sediment hydraulic conductivity can create “dead zones” in which percolation rates are negligible. Clogging is a constant problem, leading to decays in facility percolation rates . Measuring percolation rate variations is important for management, maintenance, and remediation of surface MAR facilities

We have used Fiber Optic Distributed Temperature Sensing (FODTS) to monitor percolation in two very different recharge facilities. The first is a small (2 ha) nearly round recharge basin of homogeneous sediment type in which water balance can be closely monitored. The second is a long narrow river channel separated from an active river by a levee. The alluvial sediment in the river channel varies widely in texture and water balance is difficult to monitor independently. Both facilities were monitored by trenching in fiber optic cable and measuring the propagation rate of the diurnal temperature oscillations carried downward with infiltrating water. In this way, heat was used as a tracer of percolation rates along the section defined by the trenched cable (400 and 1600 m, respectively). We were able to confirm the FODTS measurements of percolation in the recharge basin and demonstrate its wide applicability in the river channel. Results from the measurements have been used to understand both the hydraulic behavior of percolation in the facilities and to make management decisions regarding facility operations and the potential need for additional surface sediment remediation.



Estimation of specific discharge (m/day) through the basin using the wavelet method. Basin stage is shown above

Final ID: H11H-1245

Evaluation of groundwater resources of the Chesapeake Bay Watershed using an integrated hydrologic model

A. Seck; [1]; *C. Welty;* [1]; *R. M. Maxwell;* [2];
1. Department of Chemical, Biochemical and Environmental Engineering, University of Maryland Baltimore County, Baltimore, MD, United States.
2. Department of Geology and Geological Engineering, Colorado School of Mines, Golden, CO, United States.

Body: We present results from a distributed integrated hydrologic model of the Chesapeake Bay Watershed using ParFlow-CLM. The model covers an area of 400,000 km2 spanning five physiographic provinces, discretized at a horizontal resolution of 2 km and vertical resolution of 5 m. Synthesis of published hydrogeologic data as well as analysis of well completion reports from state agencies were used to construct a hydrogeologic model framework. The model was run for the period of 2003-2004 using National Land Data Assimilation System (NLDAS) meteorological forcing. Model output captures seasonal and spatial variability in subsurface storage and surface storage, and produces water table depths consistent with the topography, meteorological forcing, and hydrogeological setting. Model results show spatial variability in evaporation fluxes correlated to land cover at higher resolution than either NLDAS outputs or the EPA Chesapeake Bay Watershed Model Phase 5.3. Comparison with USGS streamflow data at selected stream gages shows good agreement in daily discharge timing and fluxes for high and average flows, whereas the model does not perform as well for low flows during summer and dry periods. Analysis of groundwater stores and fluxes showed marked variability across physiographic provinces. Highest groundwater stores were expectedly found in the Coastal Plain, while the Blue Ridge physiographic province had the lowest stores. The Appalachian Plateau was characterized by the highest net recharge rates. The highest discharge rates were found in the Valley and Ridge, Piedmont and Coastal Plain. The construction of this model constitutes a step forward in understanding the groundwater system in the Chesapeake Bay Watershed and its role in solute delivery to the Chesapeake Bay.

Final ID: H11I-1256

Flow paths inside a hillslope *(Invited)*

W. E. Dietrich; [1, 2]; *D. M. Rempe;* [1]; *J. Oshun;* [1]; *R. Salve;* [2];

1. Earth and Planetary Science, University of California Berkeley, Berkeley, CA, United States.
2. Earth Sciences Division, Lawrence Berkeley National Laboratory, Berkeley, CA, United States.

Body: Although limited direct measurements exist, soil-mantled hillslopes appear to be commonly underlain by weathered fractured bedrock of enhanced porosity and permeability compared to deeper, fresh bedrock. This conductive zone, inside the hillslope, may vary systematically with topography, becoming thicker towards the hillslope divide in many cases. Geomorphic evolution gives rise to a structured heterogeneity that strongly influences flow paths, moisture availability, solute loading, and erosion processes. Systematic changes in permeability, porosity, and structure occur between the soil and the weathered bedrock zone, but the soil- bedrock boundary may be insignificant hydrologically: all infiltrating water can pass into the bedrock. In this deeper zone, observations are difficult, but field data suggest strongly structured flow paths matter. Here we describe measurements at a heavily instrumented, forested ~30 degree hillslope (Rivendell) in the Angelo Coast Range Reserve along the Eel River in northern California. The site is underlain by vertically dipping mudstone (with a sandstone layer forming a local ridge) with a weathering front into it that varies from 4 m thick near the channel to 24 m at the divide. A thin (<50 cm) gravelly soil caps the weathered rock zone, and at the interface is a variably thick saprolite. This saprolite, which has soil-like texture but retains a relict rock structure, may play an important role in establishing a relatively rapid deep delivery of storm precipitation. Even the first light rains of the wet season (13 mm in 4.5 hours -2009, 19 mm in 13 hours-2010) penetrate past the soil and into the saprolite in a few locations. The first major storm (134 mm in 43 hours-2009; 220 mm in 41 hours in 2010) penetrates rapidly through the soil and more slowly through the saprolite, but before the wetting front reaches about 1 m below the surface, the groundwater at depths of 18 m below the surface responds. The storm in 2010 caused the water content in the weathered bedrock (the rock moisture) to increase down to depths of 6 m, but below that level no moisture change was detected despite the perched water table on the underlying fresh bedrock locally rising and falling nearly 7 m. Our observations suggest that rapid delivery of water to depth occurs via fracture flow, causing deep penetration before general progressive wetting up of the upper layers. The water retention of the saprolite coupled with its residual fractured structure may contribute to water being directed to rapid fracture pathways that descend into deeper, less weathered bedrock. The systematically greater depth to fresh bedrock towards the hillslope divide introduces a significant delay in hillslope response such that in short, intense storms, runoff is dominated by the shallower, lower portion of the hillslope. These findings combined with observations elsewhere suggest a runoff path that is not shallow and directed by the soil-bedrock boundary, nor deep and controlled by slow groundwater flow processes, but instead is fed by fracture flow and is perched at the weathered-fresh bedrock boundary and capable of delivering storm runoff as well as sustained summer baseflow.

Final ID: IN11A-1510

HydroShare: An online, collaborative environment for the sharing of hydrologic data and models ***(Invited)***

D. G. Tarboton; [1]; *R. Idaszak;* [2]; *J. S. Horsburgh;* [1]; *D. Ames;* [3]; *J. L. Goodall;* [4]; *L. E. Band;* [5]; *V. Merwade;* [6]; *A. Couch;* [7]; *J. Arrigo;* [8]; *R. P. Hooper;* [8]; *D. W. Valentine;* [9]; *D. R. Maidment;* [10];

1. Civil and Environmental Engineering, Utah State Univ, Logan, UT, United States.
2. RENCI, University of North Carolina, Chapel Hill, NC, United States.
3. Civil and Environmental Engineering, Brigham Young University, Provo, UT, United States.
4. Civil and Environmental Engineering, University of Virginia, Charlottesville, VA, United States.
5. Geography, University of North Carolina, Chapel Hill, NC, United States.
6. School of Civil Engineering , Purdue, West Lafayette, IN, United States.
7. Computer Science, Tufts University, Boston, MA, United States.
8. CUAHSI, Boston, MA, United States.
9. San Diego Supercomputer Center, University of California, San Diego, CA, United States.
10. Center for Research in Water Resources, University of Texas, Austin, TX, United States.

Body: HydroShare is an online, collaborative system being developed for sharing hydrologic data and models. The goal of HydroShare is to enable scientists to easily discover and access data and models, retrieve them to their desktop or perform analyses in a distributed computing environment that may include grid, cloud or high performance computing model instances as necessary. Scientists may also publish outcomes (data, results or models) into HydroShare, using the system as a collaboration platform for sharing data, models and analyses. HydroShare is expanding the data sharing capability of the CUAHSI Hydrologic Information System by broadening the classes of data accommodated, creating new capability to share models and model components, and taking advantage of emerging social media functionality to enhance information about and collaboration around hydrologic data and models. One of the fundamental concepts in HydroShare is that of a Resource. All content is represented using a Resource Data Model that separates system and science metadata and has elements common to all resources as well as elements specific to the types of resources HydroShare will support. These will include different data types used in the hydrology community and models and workflows that require metadata on execution functionality. HydroShare will use the integrated Rule-Oriented Data System (iRODS) to manage federated data content and perform rule-based background actions on data and model resources, including parsing to generate metadata catalog information and the execution of models and workflows. This presentation will introduce the HydroShare functionality developed to date, describe key elements of the Resource Data Model and outline the roadmap for future development.

URL : http://www.hydroshare.org

Final ID: IN11B-1534

A Statewide Private Microwave Wide Area Network for Real-time Natural Hazard Monitoring

M. C. Williams; [1]; *G. Kent;* [1]; *K. D. Smith;* [1]; *G. Plank;* [1]; *D. Slater;* [1]; *J. Torrisi;* [1]; *R. Presser;* [1]; *K. Straley;* [1];
1. Nevada Seismological Laboratory, University of Nevada, Reno, Reno, NV, United States.

Body: The Nevada Seismological Laboratory (NSL) at the University of Nevada, Reno, operates the Nevada Seismic Network, a collection of ground motion instruments installed throughout Nevada and California, for the purposes of detecting, locating, and notifying the public of earthquakes in the state. To perform these tasks effectively, NSL has designed and built a statewide wireless microwave wide-area network (WAN) in order to receive ground motion data in near real-time. This network consists of radio access points, backhauls, and backbone communication sites transmitting time-series, images, and datalogger diagnostics to our data center servers in Reno. This privately managed communication network greatly reduces the dependence on third-party infrastructure (e.g. commercial cellular networks), and is vital for emergency management response and system uptime.

Any individual seismograph or data collection device is networked through a wireless point-to-multipoint connection to a remote access point (AP) using a low-cost radio/routerboard combination. Additional point-to-point connections from AP's to radio backhauls and/or mountaintop backbone sites allow the Data Center in Reno to communicate with and receive data directly from each datalogger. Dataloggers, radios, and routers can be configured using tablets on-site, or via desktop computers at the Data Center. Redundant mountaintop links can be added to the network and facilitate the re-routing of data (similar to a meshed network) in the event of a faulty, failing, or noisy communication site. All routers, radios, and servers, including those at the Data Center, have redundant power and can operate independently in the event of a grid power or public Internet outage. A managed server room at the Data Center processes earthquake data for notifications and acts as a data source for remote users.

Consisting of about 500 hosts, and spanning hundreds of miles, this WAN provides network operators access to each router and datalogger in our seismic network not only for data collection, but also for maintenance and quality control. This has resulted in several partnerships with other agencies. In addition to our seismic station network for earthquake monitoring, we currently manage ~400 more channels of data (many running at 500 Hz) for the National Center for Nuclear Security (NCNS) Source Physics Experiments, a series of chemical explosions at the Nevada National Security Site. Some of our mountaintop stations have been experimentally equipped with near-infrared high-definition fire cameras for wildfire monitoring, and have recently recorded the Bison and Pedlar fires in northwest Nevada. Data for the Nevada EPSCor climate program also utilizes the NSL WAN. Real-time access to data for these experiments greatly reduces the effort required for data archival, quality control, and monitoring equipment failures. Future plans include increasing density of stations in urban areas such as Reno and Las Vegas, and expanding coverage to Tahoe and eastern Nevada.

URL: http://www.seismo.unr.edu/

Final ID: NG11A-1579

Scaling of peak flows in large European river basins: new results on meteorological and channel network controls

S. Zanardo; [1]; *L. Nicotina;* [1]; *A. G. Hilberts;* [1];
1. Flood group, RMS Ltd, London, United Kingdom.

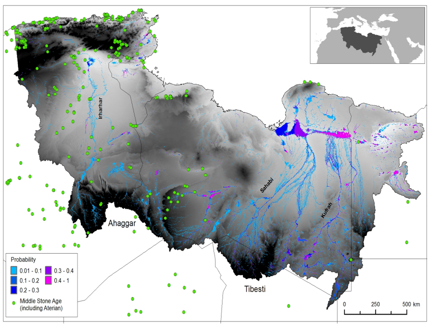
Body: The spatial scaling of geophysical fluxes has been often observed in a variety of studies and disciplines. This process characteristic, usually referred to as “scale invariance”, arises from the non-linear interaction of different components of a geophysical system. An outstanding and very popular example of scale invariance in hydrology is represented by the observed power law relationship between discharge and drainage area. A number of studies have focused on the scaling of flow quantiles and, more recently, of peak flow events, with drainage area, reporting the existence of scale invariance in many cases of interest. The objective of these studies has often been to relate the two scaling coefficients of the discharge-area relationship (i.e., the area exponent and the intercept), to regional characteristics, in order to make predictions for ungauged basins. In this study we analyse flow data collected at approximately 700 stations across Europe, over a time period spanning between 30 and 146 years. Based on these data we extract flow-area relationships for a number of European regions and show that for many of them scale invariance exists for both flow quantiles and individual flow events. Scaling coefficients are shown to be statistically different between regions as well as between events and quantiles, however, within many regions, their variability is relatively small. In order to explore how these coefficients are related to regional characteristics, we apply a distributed rainfall-runoff model to a set of synthetic river networks with different topological characteristics, and we force it with different rainfall patterns. Preliminary results show that the scaling coefficients, and in particular the area exponent, are significantly more affected by rainfall patterns than by the topology of river networks and the water routing parameters. Even though further analyses are necessary to understand how meteorological patterns influence the scaling of river discharge, the current results demonstrate the importance of the scaling theory for a better understanding of climate change impacts on flood hydrology.

Final ID: PP11A-1804

Out of Africa: the importance of rivers as human migration corridors

J. A. Ramirez; [1]; *T. J. Coulthard;* [1]; *M. Rogerson;* [1]; *N. Barton;* [2]; *T. Bruecher;* [3];
1. Geography, Environment and Earth Sciences, University of Hull, Hull, United Kingdom.
2. Archaeology, University of Oxford, Oxford, United Kingdom.
3. Meteorology, Max-Planck-Institut für Meteorologie, Hamburg, Germany.

Body: The route and timing of Homo sapiens exiting Africa remains uncertain. Corridors leading out of Africa through the Sahara, the Nile Valley, and the Red Sea coast have been proposed as migration routes for anatomically modern humans 80,000-130,000 years ago. During this time climate conditions in the Sahara were wetter than present day, and monsoon rainfall fed rivers that flowed across the desert landscape. The location and timing of these rivers may have supported human migration northward from central Africa to the Mediterranean coast, and onwards to Europe or Asia. Here, we use palaeoclimate rainfall and a hydrological model to spatially simulate and quantitatively test the existence of three major rivers crossing the Sahara from south to north during the time of human migration. We provide evidence that, given realistic underlying climatology, the well-known Sahabi and Kufrah rivers very likely flowed across modern day Libya and reached the coast. More unexpectedly an additional river crossed the core of the Sahara through Algeria (Irharhar river) and flowed into the Chotts basin. The Irharhar river is unique, because it links locations in central Africa experiencing monsoon climates with temperate coastal Mediterranean environments where food and resources were likely abundant. From an ecological perspective, this little-known corridor may prove to be the most parsimonious migration route. Support for the Irharar as a viable migration corridor is provided by its geographic proximity to middle Stone Age archaeological artefacts found in North Africa. Our new, highly novel approach provides the first quantitative analysis of the likelihood that rivers occurred during the critical period of human migration out of Africa.



Simulated probability of surface water in North Africa during the last interglacial and the location of tools and ornaments from the Middle Stone Age.

Final ID: C11C-03

Sub-meter Commercial Imagery Coverage for the Earth's Polar Regions

P. J. Morin; [1]; *K. Peterman;* [2];
1. Polar Geospatial Center, St Paul, MN, United States.
2. National Geospatial-Intellegence Agency, Springfield, VA, United States.

Body: A complete, high resolution satellite imagery view of the Earth’s Polar Regions is important to understand a wide variety of scientific, logistical and geospatial problems. To address this need, near complete sub-meter licensed commercial imagery coverage of the Earth’s Polar Regions and all ice on earth is now available to US federal employees and US federally funded researchers with a US federal purpose through the NGA Commercial Imagery Program and the Polar Geospatial Center. Included are historical sub-meter mono and stereo imagery from DigitalGlobe, Inc.’s IKONOS, Geoeye-1, and Quickbird as well as historical imagery and new collects from Worldview-1 and 2. The imagery is available in both “unprocessed” and orthorectified formats. The orthos are both image strips and mosaics. An orthomosaic of the earth became available in August. Additionally, multispectral imagery is aquired by NGA from WV-2 (8 band) and IKONOS (4 band) with every pan shot.

The Polar Geospatial Center has developed the capacity to process as many as 5000 scenes or approximately one third of the US lower 48 states a day. This enables researchers to request imagery for large geographic areas to be custom processed to their specifications.

To make this imagery more easily accessible for researchers, the Polar Geospatial Center has developed an imagery mosaic, viewer and web services for 60% of Antarctica, 80% of Greenland and 50% of Alaska. Areas are updated as new imagery is collected. We will discuss data access requirements and limitations, current capabilities, and future direction.

URL: http://www.pgc.umn.edu/

Final ID: GC11F-06

Precipitation Downscaling Products for Hydrologic Applications *(Invited)*

E. D. Gutmann; [1]; *T. Pruitt;* [2]; *C. Liu;* [1]; *M. P. Clark;* [1]; *L. D. Brekke;* [2]; *J. Arnold;* [3]; *D. A. Raff;* [3]; *R. Rasmussen;* [1];

1. RAL, NCAR, Boulder, CO, United States.
2. Bureau of Reclamation, Denver, CO, United States.
3. US Army Corps of Engineers, Philadelphia, PA, United States.

Body: Hydrologists and engineers require climate data on high-resolution grids (4-12km) for many water resources applications. To get such data from climate models, users have traditionally relied on statistical downscaling techniques, with only limited use of dynamic downscaling techniques. Statistical techniques utilize a variety of assumptions, data, and methodologies that result in statistical artifacts that may impact hydroclimate representations. These impacts are often pronounced when downscaling precipitation. We will discuss four major statistical downscaling techniques: Bias Corrected Constructed Analogue (BCCA), Asynchronous Regression (AR), and two forms of Bias Corrected Spatial Disaggregation (BCSD.) The hydroclimate representations within many statistical methods often have too much drizzle, too small extreme events, and an improper representation of spatial scaling characteristics. These scaling problems lead some statistical methods substantially over estimate extreme events at hydrologically important scales (e.g., basin totals.) This can lead to large errors in future hydrologic predictions. In contrast, high-resolution dynamic downscaling using the Weather Research and Forecasting model (WRF) provides a better representation of precipitation in many respects, but at a much higher computational cost. This computational constraint prevents the use of high-resolution WRF simulations when examining the range of possible future scenarios generated as part of the Coupled Model Intercomparison Project (CMIP.) Finally, we will present a next generation psuedo-dynamical model that provides dynamic downscaling information for a fraction of the computational requirements. This simple weather model uses large scale circulation patterns from a GCM, for example wind, temperature and humidity, but performs advection and microphysical calculations on a high-resolution grid, thus permitting topography to be adequately represented. This model is capable of generating changes in spatial patterns of precipitation related to atmospheric processes in a future climate. The pseudo-dynamical model may provide both the opportunity to better represent precipitation as well as being efficient in application to utilize a range of potential futures in a manner that would support water resources planning and management in the future.

Final ID: EP11A-07

Climate warming and eco-hydrology of forested watersheds in the California Sierra *(Invited)*

C. Tague; [1]; *K. Son;* [1]; *T. Brandt;* [1]; *A. L. Dugger;* [1];
1. UC Santa Barbara, Santa Barbara, CA, United States.

Body: Coupled models of hydrologic and ecosystem biogeochemical cycling are key tools used to generalize results from field based analysis at the CZO to other watersheds and future climate and land management scenarios. The CZO continues to provide an excellent opportunity to assess the performance of coupled models and highlight strategies for improvement and/or situations where model limitations or specific parameterization approaches are likely to alter eco-hydrologic predictions. At the Sierra CZO we have used RHESSys (the Regional Hydro-Ecologic Simulation System) as a modeling framework to look at interactions among climate variability and change, and vegetation dynamics and hydrology at daily, and seasonal to inter-annual time scales. Geophysical information provides a template that influences these interactions through topography, flowpath distributions, and soil properties. We present an implementation of RHESSys. We use the model to examine spatial-temporal patterns in the sensitivity of snow-dominated systems to climate warming and show how earlier snowmelt alters not only hydrology, but also forest carbon and nutrient cycling. Model results emphasize the importance of accounting for feedbacks between climate driven changes in hydrology and ecosystem responses.

Final ID: ED11F-08

Preparing the Next Generation of Earth Scientists: An Examination of 25 Federal Earth Science Education Programs

C. A. Manduca; [5]; *A. M. Linn;* [1]; *A. Goldstein;* [2]; *E. J. Pyle;* [6]; *P. M. Asher;* [3]; *L. D. White;* [8]; *E. M. Riggs;* [7]; *S. Cozzens;* [4]; *D. Glickson;* [1];

1. Natl Research Council, Washington, DC, United States.
2. Bridgewater State University, Bridgewater, MA, United States.
3. American Geophysical Union, Washington, DC, United States.
4. Georgia Institute of Technology, Atlanta, GA, United States.
5. Carlton College, Northfield, MN, United States.
6. James Madison University, Harrisonburg, VA, United States.
7. Texas A&M University, College Station, TX, United States.
8. University of California Museum of Paleontology, Berkeley, CA, United States.

Body: Federal agencies play a key role in educating the next generation of earth scientists, offering programs that attract students to the field, support them through formal education, and provide training for an earth science career. In a time of reduced budgets, it is important for federal agencies to invest in education programs that are effective. A National Research Council committee examined 25 federal earth science education programs and described ways to evaluate the success of these programs and opportunities for leveraging federal education resources. Although the programs cover a wide range of objectives and audiences, they are part of a system of opportunities and experiences that attract individuals to the field and prepare them for employment. In this conceptual framework, individuals become aware of earth science, then engage in learning about the Earth and the nature of earth science, and finally prepare for a career by acquiring specialized knowledge, skills, and expertise and by exploring different employment options.

The federal education programs considered in this report provide a range of opportunities for raising awareness of earth science (e.g., USDA 4-H Club), nurturing that interest to engage students in the field (e.g., USGS Youth Internship Program), and preparing students for earth science careers (NSF Research Experiences for Undergraduates, DOE Science Undergraduate Laboratory Internships). These efforts can also contribute toward the development of a robust earth science workforce by connecting programs and providing pathways for students to move through informal and formal education to careers. The conceptual framework shows how the various education opportunities fit together and where connections are needed to move students along earth science pathways. The framework can also be used by federal agencies to identify gaps, overlaps, and imbalances in existing programs; to identify potential partners in other agencies or organizations; and to inform program evaluation for individual projects.

Final ID: H11O-08

Evaluation of the impacts of urban development on groundwater storage at the regional scale

A. S. Bhaskar;[1, 2]; *C. Welty;*[1, 2]; *R. M. Maxwell;*[3]; *A. J. Miller;*[4, 1];
1. Center for Urban Environmental Research and Education, University of Maryland, Baltimore County, Baltimore, MD, United States.
2. Department of Chemical, Biochemical and Environmental Engineering, University of Maryland, Baltimore County, Baltimore, MD, United States.
3. Department of Geology and Geological Engineering, Colorado School of Mines, Golden, CO, United States.
4. Department of Geography and Environmental Systems, University of Maryland, Baltimore County, Baltimore, MD, United States.

Body: Urban development results in a myriad of changes to the natural environment; these changes can give rise to a range of effects on the groundwater system. We have used the integrated subsurface – surface – land surface hydrologic model ParFlow.CLM to evaluate and isolate the impacts of urban development on groundwater storage at the regional scale. We have applied the model to the 13,216 sq km Baltimore metropolitan area at a 500 m horizontal and 5 m vertical discretization, incorporating realistic estimates of anthropogenic fluxes (lawn watering, leakage from water supply pipes, infiltration into sewer pipes, withdrawals for water supply) as well as any available hydrogeologic data. We developed a base-case model, where all urban fluxes and features are incorporated, followed by model scenarios in which urban features were modified one-at-a time to evaluate the effects of each feature. The scenarios presented are: (1) the vegetated city, in which urban land is represented as natural vegetation mosaic in the land surface model; (2) the pervious city, in which low hydraulic conductivity values representing impervious surfaces are replaced with higher soil hydraulic conductivities; (3) the intact-sewer scenario, in which infiltration and inflow (I/I) of groundwater and stormwater into wastewater sewer pipes is removed; and (4) the no-anthropogenic- discharge-and-recharge scenario, in which all anthropogenic input and output fluxes are removed. We compared the subsurface storage of these scenarios to the base case model. We found that the pervious city subsurface storage was slightly greater than the subsurface storage in the base case, which is expected due to additional infiltration associated higher hydraulic conductivity values. The magnitude of this increase in subsurface storage was surprisingly small compared to changes found in other scenarios. The intact-sewer scenario eliminated the large quantity of groundwater infiltrating into wastewater pipes in the separate sanitary and storm sewer system of Baltimore. This led to an increase and the largest change in subsurface storage of all scenarios. The no anthropogenic-recharge-or-discharge scenario removed lawn irrigation and water supply pipe leakage as well as infiltration into wastewater pipes and all human-induced discharges. The subsurface storage for this scenario was less than that for the intact sewer scenario because the total recharge removed (lawn irrigation and pipe leakage) outweighed the net effect of the discharge removed. The vegetated city scenario led to less subsurface storage during high evapotranspirative periods compared to the base case. Future work includes modeling the impacts of scenarios of urban growth.

Final ID: H12A-01

CONDITIONAL MONTHLY WEATHER RESAMPLING PROCEDURE FOR OPERATIONAL SEASONAL WATER RESOURCES FORECASTING

E. Welles; [3]; *J. Beckers;* [1]; *A. Weerts;* [1, 2]; *E. Tijdeman;* [2]; *A. McManamon;* [4];

1. Inland Water Systems, Deltares, Delft, Netherlands.
2. Hydrology and Quantitative Water Management Group, Wageningen University, Wageningen, Netherlands.
3. Deltares USA Inc, Silver Spring, MD, United States.
4. Weather and Streamflow Forecasting, Bonneville Power Administration, Portland, OR, United States.

Body: To provide reliable and accurate seasonal streamflow forecasts for water resources management several operational hydrologic agencies and hydropower companies around the world use the Extended Streamflow Prediction (ESP) procedure. The ESP in its original implementation does not accommodate for any additional information that the forecaster may have about expected deviations from climatology in the near future. Several attempts have been conducted to improve the skill of the ESP forecast, especially for areas which are affected by teleconnetions (e,g. ENSO, PDO) via selection (Hamlet and Lettenmaier, 1999) or weighting schemes (Werner et al., 2004; Wood and Lettenmaier, 2006; Najafi et al., 2012). A disadvantage of such schemes is that they lead to a reduction of the signal to noise ratio of the probabilistic forecast. To overcome this, we propose a resampling method conditional on climate indices to generate meteorological time series to be used in the ESP. The method can be used to generate a large number of meteorological ensemble members in order to improve the statistical properties of the ensemble. The effectiveness of the method was demonstrated in a real-time operational hydrologic seasonal forecasts system for the Columbia River basin operated by the Bonneville Power Administration. The forecast skill of the k-nn resampler was tested against the original ESP for three basins at the long-range seasonal time scale. The BSS and CRPSS were used to compare the results to those of the original ESP method. Positive forecast skill scores were found for the resampler method conditioned on different indices for the prediction of spring peak flows in the Dworshak and Hungry Horse basin. For the Libby Dam basin however, no improvement of skill was found. The proposed resampling method is a promising practical approach that can add skill to ESP forecasts at the seasonal time scale. Further improvement is possible by fine tuning the method and selecting the most informative climate indices for the region of interest.

Final ID: GC12B-02

Future Extreme Heat Scenarios to Enable the Assessment of Climate Impacts on Public Health over the Coterminous U.S.

D. A. Quattrochi; [1]; *W. L. Crosson;* [2]; *M. Z. Al-Hamdan;* [2]; *M. G. Estes Jr;* [2];
1. Earth Science Office, NASA, Huntsville, AL, United States.
2. Universities Space Research Association, National Space Science & Technology Center, Huntsville, AL, United States.

Body: In the United States, extreme heat is the most deadly weather-related hazard. In the face of a warming climate and urbanization, which contributes to local-scale urban heat islands, it is very likely that extreme heat events (EHEs) will become more common and more severe in the U.S. This research seeks to provide historical and future measures of climate-driven extreme heat events to enable assessments of the impacts of heat on public health over the coterminous U.S. We use atmospheric temperature and humidity information from meteorological reanalysis and from Global Climate Models (GCMs) to provide data on past and future heat events. The focus of research is on providing assessments of the magnitude, frequency and geographic distribution of extreme heat in the U.S. to facilitate public health studies. In our approach, long-term climate change is captured with GCM outputs, and the temporal and spatial characteristics of short-term extremes are represented by the reanalysis data.
Two future time horizons for 2040 and 2090 are compared to the recent past period of 1981-2000. We characterize regional-scale temperature and humidity conditions using GCM outputs for two climate change scenarios (A2 and A1B) defined in the Special Report on Emissions Scenarios (SRES). For each future period, 20 years of multi-model GCM outputs are analyzed to develop a 'heat stress climatology' based on statistics of extreme heat indicators. Differences between the two future and the past period are used to define temperature and humidity changes on a monthly time scale and regional spatial scale. These changes are combined with the historical meteorological data, which is hourly and at a spatial scale (12 km) much finer than that of GCMs, to create future climate realizations. From these realizations, we compute the daily heat stress measures and related spatially-specific climatological fields, such as the mean annual number of days above certain thresholds of maximum and minimum air temperatures, heat indices, and a new heat stress variable developed as part of this research that gives an integrated measure of heat stress (and relief) over the course of a day. Comparisons are made between projected (2040 and 2090) and past (1990) heat stress statistics. Outputs are aggregated to the county level, which is a popular scale of analysis for public health interests. County-level statistics are made available to public health researchers by the Centers for Disease Control and Prevention (CDC) via the Wide-ranging Online Data for Epidemiologic Research (WONDER) system. This addition of heat stress measures to CDC WONDER allows decision and policy makers to assess the impact of alternative approaches to optimize the public health response to EHEs. Through CDC WONDER, users are able to spatially and temporally query public health and heat-related data sets and create county-level maps and statistical charts of such data across the coterminous U.S.

Final ID: H12B-02

Assessing latent heat flux estimates from the Community Land Model using GRACE and FLUXNET-MTE data.

S. C. Swenson; [1]; *D. M. Lawrence;* [1];
1. NCAR, Boulder, CO, United States.

Body: The land component of the Community Earth System Model (CESM), the Community Land Model (CLM), determines the surface fluxes that return moisture and energy to the atmosphere. Recent land cover change experiments have shown that, contrary to expectation, CLM simulations in which vegetation has been replaced by bare soil actually exhibit higher evaporative fluxes. In this study, we show that this behavior is partly due to the formulation of the soil evaporative resistance. Using a new soil evaporative resistance function, we show that model simulations agree better with both GRACE satellite water storage estimates and FLUXNET-MTE gridded latent heat flux estimates.

Final ID: IN12A-03

Rescue of Long-Tail Data from the Ocean Bottom to the Moon

L. Hsu; [1]; *K. A. Lehnert;* [1]; *S. M. Carbotte;* [1]; *V. Ferrini;* [1]; *J. W. Delano;* [2]; *J. B. Gill;* [3]; *M. Tivey;* [4];

1. Lamont-Doherty Earth Observatory, Palisades, NY, United States.
2. Dept. of Atmospheric and Environmental Sciences, University at Albany, State University of New York, Albany, NY, United States.
3. Earth & Planetary Sciences, University of California, Santa Cruz, Santa Cruz, CA, United States.
4. Geology & Geophysics, Woods Hole Oceanographic Institution, Woods Hole, MA, United States.

Body: IEDA (Integrated Earth Data Applications, www.iedadata.org), the NSF facility that operates EarthChem, the Marine Geoscience Data System, and the System for Earth Sample Registration, launched a Data Rescue Initiative in 2013 to advance preservation and re-use of valuable legacy datasets that are in danger of being lost. As part of this initiative, IEDA established a competition for Data Rescue Mini-Awards that provide modest funds to investigators to properly compile, document, and transfer legacy data sets to IEDA. Applications from late-career and near-retirement investigators were specifically encouraged. Awardees were given approximately six months to complete their data rescue activities. Three projects were awarded in 2013: (1) Geochemistry of Lunar Glasses: assembly of major element, trace element, volatile element, and isotope ratio data for lunar volcanic glasses and lunar impact glasses, (2) Geochemical and Geochronological data from Fiji, Izu-Bonin-Marianas, and Endeavor segment: assembly of published and unpublished data and metadata from large rock sample collections, and (3) Near-bottom Magnetic Data: curation and archival of 35 years of high-resolution, near-bottom magnetic field data from deeptowed platforms, submersibles, and ROVs. IEDA is working closely with the awardees to guide and support the data rescue effort and to assist with specific challenges related to outdated storage media or technology, diversity of platforms over decades of research, and the lack of established standards for data documentation. In this contribution we describe procedures and tools used for each project, summarize lessons learned and best practices, and present the final output of each data rescue project. Depending on the experiences of this first year and the availability of funds, we plan to continue the competition in future years.

URL: http://www.iedadata.org/datarescue

Final ID: SA12A-04

Day-fo-day Monitoring of the Comparisons Between UHF Scintillation Forecasts and GNSS Observations

D. N. Anderson; [1]; *Y. Morton;* [2]; *Y. Jiao;* [2]; *R. J. Redmon;* [3];

1. CIRES, Boulder, CO, United States.
2. Univ. of Miami, Oxford, OH, United States.
3. NGDC, NOAA, Boulder, CO, United States.

Body: When trans-ionospheric radio waves propagate through an irregular ionosphere with plasma depletions or “bubbles”, they are subject to sporadic enhancement and fading which is referred to as scintillation. Communication and navigation systems may be subject to these detrimental effects if the scintillation is strong enough. It is critical to have knowledge of the current ionospheric conditions so that system operators can distinguish between the natural radio environment and system-induced failures. In this paper, we present and describe a proven technique for forecasting UHF scintillation activity in the equatorial region after sunset and compare these forecasts with observed global navigation satellite systems (GNSS) L-band scintillation activity at Jicamarca, Peru, on a night-to-night basis. The UHF scintillation forecasting technique is described in a paper by Redmon et al. (Space Weather, Vol 8, 2010) entitled “A Forecasting Ionospheric Real-time Scintillation Tool (FIRST).” The technique utilizes the observed characteristic parameter h’F from a ground-based, ionospheric sounder near the magnetic equator. This paper demonstrated that there exists an excellent correlation (R2 ~ 0.91) between h’F (1930LT) and the pre-reversal enhancement in vertical ExB drift velocity after sunset which is the prime driver for creating plasma depletions and bubbles. In addition, there exists a “threshold” in the h’F value at 1930 LT, h’Fthr, such that, on any given evening if h’F is significantly above h’Fthr then scintillation activity is likely to occur and if it is below h’Fthr, scintillation activity is unlikely to occur. The digital sounder at Jicamarca, Peru provides the h’F values between 1830 and 2000 LT. A multi-constellation GNSS receiver at Jicamarca provides 50Hz navigation signal observables continuously since December 2012. S4 index and detrended carrier phase standard deviation, two commonly used amplitude and phase scintillation indices are computed from these observables during the equinox months in 2013. An unprecedented number of open signals from GPS, GLONASS, Galileo, Beidou, and SBAS satellites are included in the observations, providing high spatial and temporal resolution of scintillation indices measurements. In addition to the statistical analysis between the UHF scintillation forecast and observed GNSS receiver S4 index values, detailed quantitative relationships between the vertical ExB drift velocity, prompt penetration magnetic storm disturbances, and the intensity, duration, and spatial distributions of amplitude and phase scintillation will be presented.

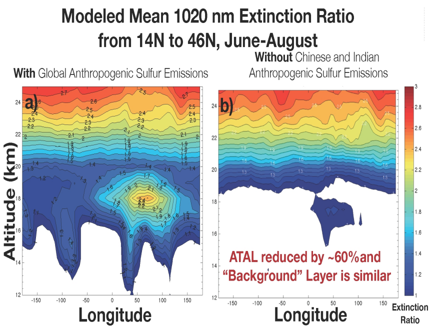
Final ID: A12B-04

Contributions of Asian SO2 Pollution to the Upper Troposphere and Lower Stratosphere

R. R. Neely; [1, 2]; *P. Yu;* [4, 5]; *K. H. Rosenlof;* [3]; *O. B. Toon;* [4, 5]; *J. S. Daniel;* [3]; *S. Solomon;* [6]; *H. L. Miller;* [2];

1. Advanced Study Program, National Center for Atmospheric Research, Boulder, CO, United States.
2. Cooperative Institute for Research in Environmental Sciences, Boulder, CO, United States.
3. Earth System Research Laboratory, NOAA, Boulder, CO, United States.
4. Atmospheric and Oceanic Sciences, University of Colorado, Boulder, CO, United States.
5. Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, CO, United States.
6. Earth, Atmospheric and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, MA, United States.

Body: Recent observations reveal a seasonally occurring layer of aerosol located from 0° to 100°E, 20°N to 45°N and extending vertically from about 13 km to 18 km. Termed the Asian Tropopause Aerosol Layer (ATAL), its existence is closely associated with the Asian monsoonal circulation. Recent observational studies argued that the source of the ATAL must be anthropogenic, as the layer was not observed by satellite prior to 1998. Here we test this hypothesis using a global climate model coupled to an aerosol microphysical model. The model examines the impact of global and regional sulfur dioxide (SO2) sources on the ATAL and the importance of non-sulfate constituents in its composition. We conclude that while the ATAL is of anthropogenic origin, it is not solely due to emissions from Asia. We find that model results of the ATAL match well with current satellite observations of backscatter and extinction, and the vertical distribution of composition agrees with in situ measurements at other locations. Further model experiments indicate that the ATAL is not created solely from emissions near the monsoon region as previously suggested but likely originates from a wider range of source regions. At year 2000 levels, Chinese and Indian SO2 emissions contribute only 30% of the sulfate aerosol extinction in the ATAL during volcanically quiescent periods. This is proportional to the emissions from this region compared to the total global emission of SO2 . The remaining contribution of sulfate aerosol originates from anthropogenic SO2 emissions in other regions. Curiously, we also find that the sulfate in the North American Tropopause Aerosol Layer (NATAL) may have a modest (15%) contribution from Asian emissions. The model results also suggest that sulfates are more important in the stratospheric part of the ATAL than particles coming from other sources, such as BC, SOA and dust, as sulfates make up over 70% of the aerosol extinction burden above the tropopause while the opposite is true in the upper troposphere.



Modeled representation of ATAL. Panels a) and b) are the JJA mean 1020 nm extinction ratio averaged from 15 N to 45 N to match the representation of SAGE II observations in Figures 9 and 10 in Thomason and Vernier [2013]. Panel a represents the baseline model run with year 2000 levels of global SO2 emissions. Panel b is the exact same as Panel a) but excludes emissions from China and India. The white line in each panel represents the mean model tropopause over the same region.

Final ID: B12C-04

Impact of diffuse mortality in a terrestrial biosphere model: stress, succession, and disease ***(Invited)***

M. Dietze; [1];
1. Boston University, Boston, MA, United States.

Body: Small changes in background mortality rate can have large impacts on forest composition, structure, and biogeochemical cycles. Despite this high sensitivity, the effects of mortality are absent from most ecosystem models and poorly constrained in the few models that explicitly represent mortality. Herein we explore the representation and uncertainties in diffuse mortality in the Ecosystem Demography model, a height- and successionally-structured terrestrial biosphere model. Modeled mortality is based on contributions from density independent effects, carbon balance effects, and frost effects. We also introduce a novel conceptual model for the representation of both diffuse (endemic) and epidemic forest pests and pathogens in earth system models.

The sensitivity of forest mortality rates and carbon balance to different environmental factors is explored for eastern US forests and compared to national Forest Inventory and Analysis patterns. Specifically we assess the impacts of temperature, precipitation, CO2, elevation, slope, aspect, soil texture, lateral hydrology, successional status, tree size, and competitive interactions. Mortality was found to have the highest sensitivity to successional status, tree size, elevation, temperature, and CO2. Modeled sensitivity shows a strong correspondence with mortality patterns from forest inventory data. We also explore the dynamics of our conceptual disease model to represent forest responses to different disease classes, including phloem feeders, defoliators, cankers & wilts, stem rot, and root rot

Final ID: H12A-07

Integrated hydrometeorological predictions with the fully-coupled WRF-Hydro modeling system in western North America

D. J. Gochis;[1]; *W. Yu;*[1];
1. RAL, NCAR, Boulder, CO, United States.

Body: Prediction of heavy rainfall and associated streamflow responses remain as critical hydrometeorological challenges and require improved understanding of the linkages between atmospheric and land surface processes. Streamflow prediction skill is intrinsically liked to quantitative precipitation forecast skill, which emphasizes the need to produce mesoscale predictions of rainfall of high fidelity. However, in many cases land surface parameters can also exert significant control on the runoff response to heavy rainfall and on the formation or localization of heavy rainfall as well. A new generation of integrated atmospheric-hydrologic modeling systems is emerging from different groups around the world to meet the challenge of integrated water cycle predictions. In this talk the community WRF-Hydro modeling system will be presented. After a brief reviewing the architectural features of the WRF-Hydro system short-term forecasting and regional hydroclimate prediction applications of the model from western North America will be presented. In these applications, analyses will present results from observation-validated prediction experiments where atmospheric and terrestrial hydrologic model components are run in both a fully coupled mode and separately without two-way interactions. Emphasis is placed on illustrating an assessment framework using an initial state perturbation methodology to quantify the role of land-atmosphere energy and moisture flux partitioning in controlling precipitation and runoff forecast skill. Issues related to experimental design of fully-coupled model prediction experiments will also be discussed as will issues related to computational performance.

Final ID: H12E-07

Transferrable Lessons about Non-Point-Source Gas Transport from the Amargosa Desert

D. A. Stonestrom; [1]; *B. J. Andraski;* [2]; *R. J. Baker;* [4]; *S. Maples;* [2]; *M. A. Walvoord;* [3]; *C. T. Green;* [1]; *B. Thomas;* [1]; *W. Luo;* [5]; *M. B. Young;* [1]; *R. L. Michel;* [1];

1. USGS, Menlo Park, CA, United States.
2. USGS, Carson City, NV, United States.
3. USGS, Lakewood, CO, United States.
4. USGS, West Trenton, NJ, United States.
5. Portland State University, Portland, OR, United States.

Body: Diffuse mass fluxes of radionuclides and other contaminants are being investigated at the U.S. Geological Survey's Amargosa Desert Research Site (ADRS), adjacent to the Nation's first commercial disposal facility for low-level radioactive waste. Gases containing trace quantities of tritium, radiocarbon, and over 60 different organic compounds are migrating through a 110-m thick unsaturated zone from unlined trenches that received waste from 1962 to 1992. Observations of diffuse plume dynamics began in 1995. Transferrable lessons about non-point-source contaminant transport through the unsaturated zone include the unexpectedly large importance of (1) stratigraphic controls on long-range transport, (2) advective terms including barometric fluctuations, and (3) compound-specific interactions with soil moisture.

Final ID: A13F-0285

Potential Vorticity diagnosis of the binary interaction between Typhoon Tembin(2012, 14th) and Bolaven(2012, 15th)

J. Hwang; [1]; *H. Cheong;* [1]; *J. LEE;* [1];
1. Pukyong National University, Busan, Korea, Republic of.

Body: Typhoon Tembin (2012, 14th) and Supertyphoon Bolaven (2012, 15th) are analyzed through potential vorticity (PV) diagnosis in quasi-geostrophic insight of tropical cyclone to investigate binary interaction between two typhoons as well as the effect of environmental flow. Preliminary results show that the movement of Tembin and Bolaven is mainly governed by environmental flow except for the time when they interacted with each other. During binary interaction, however, Typhoon Tembin showed abnormal cyclonic ‘α’ shaped track caused by binary interaction between Tembin and Bolaven. Due to the flow associated with Bolaven, Tembin has passed along unusual track. With the use of piecewise PV inversion, the binary interaction between two typhoons is quantitatively evaluated to show how the unusual cyclonic loop in the track of Tembin occured. The centroid-relative track is plotted to easily explain how two typhoons affected one another with time. Furthermore, the impact of environmental flow fields on the motions of Tembin and Bolaven is discussed to elucidate the difference of what depends on the existence of binary interaction. Such an analysis will help produce better prediction of binary interaction in typhoons.

Final ID: B13G-0605

Whole Watershed Quantification of Net Carbon Fluxes by Erosion and Deposition within the Christina River Basin Critical Zone Observatory

A. K. Aufdenkampe; [1]; *D. L. Karwan;* [2, 1]; *R. E. Aalto;* [3]; *J. Marquard;* [3]; *K. Yoo;* [2]; *B. Wenell;* [2]; *C. Chen;* [4];
1. Stroud Water Rsch Ctr, Avondale, PA, United States.
2. University of Minnesota, St. Paul, MN, United States.
3. University of Exeter, Exeter, United Kingdom.
4. University of Delaware, Newark, DE, United States.

Body: We have proposed that the rate at which fresh, carbon-free minerals are delivered to and mix with fresh organic matter determines the rate of carbon preservation at a watershed scale (Aufdenkampe et al. 2011). Although many studies have examined the role of erosion in carbon balances, none consider that fresh carbon and fresh minerals interact. We believe that this mechanism may be a dominant sequestration process in watersheds with strong anthropogenic impacts. Our hypothesis – that the rate of mixing fresh carbon with fresh, carbon-free minerals is a primary control on watershed-scale carbon sequestration – is central to our Christina River Basin Critical Zone Observatory project (CRB-CZO, http://www.udel.edu/czo/). The Christina River Basin spans 1440 km2 from piedmont to Atlantic coastal plain physiographic provinces in the states of Pennsylvania and Delaware, and experienced intensive deforestation and land use beginning in the colonial period of the USA.

Here we present a synthesis of multi-disciplinary data from the CRB-CZO on materials as they are transported from sapprolite to topsoils to colluvium to suspended solids to floodplains, wetlands and eventually to the Delaware Bay estuary. At the heart of our analysis is a spatially-integrated, flux-weighted comparison of the organic carbon to mineral surface area ratio (OC/SA) of erosion source materials versus transported and deposited materials. Because source end-members – such as forest topsoils, farmed topsoils, gullied subsoils and stream banks – represent a wide distribution of initial, pre-erosion OC/SA, we quantify source contributions using geochemical sediment fingerprinting approaches (Walling 2005). Analytes used for sediment fingerprinting include: total mineral elemental composition (including rare earth elements), fallout radioisotope activity for common erosion tracers (beryllium-7, beryllium-10, lead-210, cesium-137), particle size distribution and mineral specific surface area, in addition to organic carbon and nitrogen content with stable isotope (13C, 15N) and radiocarbon (14C) abundance to quantify OC/SA and organic carbon sources and mean age. We then use multivariate mixing model analysis to quantify the fractional contribution of each source end-member to each sample of suspended or deposited sediments. Last, we calculate a predicted OC/SA based on source end-member mixing and compare to the measured OC/SA to quantify net change in mineral complexed carbon.

Aufdenkampe, A.K. et al. Riverine coupling of biogeochemical cycles between land, oceans, and atmosphere. Frontiers Ecol. Environ. 9, 53-60 (2011).
Walling, D. E. Tracing suspended sediment sources in catchments and river systems. Sci. Total Environ. 34, 159-184 (2005).

Final ID: ED13B-0779

'EXPERIMENTING WITH A SMALL PLANET' AS AN EXPERIMENT

W. W. Hay; [1];

1. Geological Sciences, University of Colorado, Boulder, CO, United States.

Body: Communicating science to the American public is difficult. The book 'Experimenting with a Small Planet' is a radical but sucessful departure from tradition.

My background has been in study of the warm climate of the Cretaceous using numerical climate models — not directly with modern climate change. The Arctic sea-ice meltback of 2007 was a startling event; it wasn't expected before the end of this century. Earth had gone past a tipping point toward an ice-free pole condition.

I decided to try to write a book for the general public explaining the basics of climate and the significance of what is happening to our planet. Over 50 years I had written more than 200 technical papers in the peer-reviewed literature. I had also written 27 annual reviews on Geology for the high-school level World Book Encyclopedia. I had experience in communicating with the general public as Director of the University of Colorado Museum.

Using my retirement community neighbors (businessmen, hedge fund manager, rancher, doctors, engineer, grade school teacher) as initial reviewers, I learned that: 1) the metric system is totally foreign and unintelligible - metric measurements must also be given in US feet, pounds, Fahrenheit temperatures, etc.; 2) readers stop if they encounter references to papers scattered in the text; 3) mathematics beyond arithmetic is feared; 4) scientific terminology is unknown; as is 5) the history of how we have come to understand physics, chemistry, biology, and geology.

The average level of scientific knowledge of a successful retired American today is at best that of about 40 years ago; of our pubic school teachers, about 20 years old. Members of the US Congress have mostly law degrees, and at best took a few freshman-level courses in science when they were in college 30 years or more ago. Most Americans believe in the dogma of some religion, not in science.

I discovered that most geologists know nothing about climatology, and most climatologists know next-to-nothing about Earth history. The book "Experimenting with a Small Planet - A Scholarly Entertainment" assumes that the reader knows nothing except how to read. The 900 + pages have over 400 illustrations to break up the text into short self-contained segments. Through informal storytelling it builds up the background necessary to understand our sophisticated science. It introduces mathematics, Newtonian and quantum physics, chemistry, and some basic biology, then goes on to explain how the atmosphere, ocean and climate system work, and how human activies are affecting them.

Each of the chapters on science is followed by an 'Intermezzo' of personal stories from my life experiences, covering topics such as being present when the Berlin Wall went up, assisting in the defection of an important scientist from a communist country, becoming a close friend of Nikita Khrushchev's science advisor, and my involvement in scientific ocean drilling since its inception.

To my great surprise, the book, intended for the general public, is being used as a college text at both the undergraduate and graduate level - in Europe as well as in the US. The publisher, Springer Verlag, was very cooperative in helping to bring out this innovative approach to science education.

Final ID: ED13C-0784

Geoscience and the 21st Century Workforce

C. A. Manduca; [1]; *T. J. Bralower;* [2]; *D. Blockstein;* [3]; *C. M. Keane;* [4]; *K. B. Kirk;* [1]; *D. Schejbal;* [5]; *C. E. Wilson;* [4];

1. Carleton College, Northfield, MN, United States.
2. Department of Geosciences, Pennsylvania State University , State College, PA, United States.
3. Education and Public Outreach, National Council for Science and the Environment, Washington, DC, United States.
4. American Geosciences Institute, Washington, DC, United States.
5. Continuing Education, Outreach and E-Learning, University of Wisconsin-Extension, Madison, WI, United States.

Body: Geoscience knowledge and skills play new roles in the workforce as our society addresses the challenges of living safely and sustainably on Earth. As a result, we expect a wider range of future career opportunities for students with education in the geosciences and related fields. A workshop offered by the InTeGrate STEP Center on 'Geoscience and the 21st Century Workforce' brought together representatives from 24 programs with a substantial geoscience component, representatives from different employment sectors, and workforce scholars to explore the intersections between geoscience education and employment.

As has been reported elsewhere, employment in energy, environmental and extractive sectors for geoscientists with core geology, quantitative and communication skills is expected to be robust over the next decade as demand for resources grow and a significant part of the current workforce retires. Relatively little is known about employment opportunities in emerging areas such as green energy or sustainability consulting. Employers at the workshop from all sectors are seeking the combination of strong technical, quantitative, communication, time management, and critical thinking skills. The specific technical skills are highly specific to the employer and employment needs. Thus there is not a single answer to the question 'What skills make a student employable?'. Employers at this workshop emphasized the value of data analysis, quantitative, and problem solving skills over broad awareness of policy issues. Employers value the ability to articulate an appropriate, effective, creative solution to problems. Employers are also very interested in enthusiasm and drive.

Participants felt that the learning outcomes that their programs have in place were in line with the needs expressed by employers. Preparing students for the workforce requires attention to professional skills, as well as to the skills needed to identify career pathways and land a job. This critical work takes place both inside and outside of the classroom and occurs as a progression throughout the course of study. Professional skills were recognized as an area where outcomes could be strengthened.

The challenge faced by geoscience programs is developing pathways into the workforce for students who bring different skills and interests to their studies. Workforce data suggest that in the past only 30% of undergraduate graduates have remained in the geosciences indicating that geoscience programs are playing an important role in developing the workforce beyond the geosciences. A collection of program descriptions describes what is known about career pathways from the programs represented at the workshop.

URL: http://serc.carleton.edu/integrate/workshops/workforce2013/index.html

Final ID: EP13A-0828

Connecting bathymetry, the flow field, and bathymetric evolution on the Wax Lake Delta, coastal Louisiana, USA

J. B. Shaw; [1]; *D. C. Mohrig;* [2];
1. Geology and Geophysics, University of Wyoming, Laramie, WY, United States.
2. , Austin, TX, United States.

Body: Fluid flow on river deltas transitions from being focused in discrete, self-formed channels to being more evenly distributed on the sub-aqueous delta front. This flow pattern dictates sediment transport and therefore the growth patterns of river deltas, but has rarely been measured on a field-scale delta. We quantify flow patterns, bathymetry and bathymetric evolution for 23 km^2 of the subaqueous delta front immediately downstream of two distributary channels on the Wax Lake Delta (WLD), an ~80 km^2 delta prograding into Atchafalaya Bay in coastal Louisiana. The flow direction field is measured using streaklines of organic detritus traceable in aerial photography collected during high discharge (4800 m^3 s^{-1}) in November 2009. Distributary channels extend 2-6 km beyond the shoreline where channel banks fall below sea level. Over this reach, channels have adverse bed slopes, shallowing in the downstream direction. Horizontal flow divergence is concentrated within 0.5-1.5 km (2-4 channel widths) of the subaqueous channel margins, and persists just 0.4 km (1.6 channel widths) beyond channel tips. This pattern of horizontal flow spreading in close proximity to the extant channel network differs from existing models of, turbulent, jet-flow pattern postulated for the WLD, where all spreading occurs beyond the channel terminus. We conclude that the pattern of flow at the delta front is controlled by bathymetry that includes sub-aqueous channel margins and adverse bed slopes rather than by jet advection and mixing associated with turbulent entrainment of still basin water.

Final ID: EP13A-0837

Feedbacks Between Wave Energy And Declining Coral Reef Structure: Implications For Coastal Morphodynamics

A. E. Grady; [1]; *C. J. Jenkins;* [2]; *L. J. Moore;* [3]; *D. C. Potts;* [4]; *P. M. Burgess;* [5]; *C. D. Storlazzi;* [6]; *E. Elias;* [7]; *M. A. Reidenbach;* [1];

1. Department of Environmental Sciences, University of Virginia, Charlottesville, VA, United States.
2. INSTAAR, University of Colorado, Boulder, CO, United States.
3. Department of Geological Sciences, University of North Carolina, Chapel HIll, NC, United States.
4. Department of Ecology and Evolutionary Biology, University of California - Santa Cruz, Santa Cruz, CA, United States.
5. Department of Earth Sciences, University of London, Surrey, United Kingdom.
6. Coastal and Marine Geology Program, U.S. Geological Survey, Santa Cruz, CA, United States.
7. Deltares, Delft, Netherlands.

Body: The incident wave energy dissipated by the structural complexity and bottom roughness of coral reef ecosystems, and the carbonate sediment produced by framework-building corals, provide natural shoreline protection and nourishment, respectively. Globally, coral reef ecosystems are in decline as a result of ocean warming and acidification, which is exacerbated by chronic regional stressors such as pollution and disease. As a consequence of declining reef health, many reef ecosystems are experiencing reduced coral cover and shifts to dominance by macroalgae, resulting in a loss of rugosity and thus hydrodynamic roughness. As coral reef architecture is compromised and carbonate skeletons are eroded, wave energy dissipation and sediment transport patterns—along with the carbonate sediment budget of the coastal environment—may be altered.

Using a Delft3D numerical model of the south-central Molokai, Hawaii, fringing reef, we simulate the effects of changing reef states on wave energy and sediment transport. To determine the temporally-varying effects of biotic and abiotic stressors such as storms and bleaching on the reef structure and carbonate production, we couple Delft3D with CarboLOT, a model that simulates growth and competition of carbonate-producing organisms. CarboLOT is driven by the Lotka-Volterra population ecology equations and niche suitability principles, and accesses the CarboKB database for region-specific, carbonate-producing species information on growth rates, reproduction patterns, habitat suitability, as well as organism geometries.

Simulations assess how changing reef states—which alter carbonate sediment production and reef morphology and thus hydrodynamic roughness—impact wave attenuation and sediment transport gradients along reef-fronted beaches. Initial results suggest that along fringing reefs having characteristics similar to the Molokai fringing reef, projected sea level rise will likely outpace coral reef accretion, and the increased residual wave energy transported to the coast may result in the alteration of alongshore sediment transport gradients and substantial changes to coastal morphology.

Final ID: EP13A-0838

Short and long term evolution of deep giant submarine dunes in continental shelf environment: the example of the "Banc du Four" (Western Brittany, France)

C. Delacourt; [1]; *M. Franzetti;* [1]; *P. Le Roy;* [1]; *T. Garlan;* [2]; *R. Thibaud;* [3]; *R. Cancouet;* [1]; *D. Graindorge;* [1]; *C. Prunier;* [1]; *A. Sukhovich;* [1]; *A. Deschamps;* [1];

1. UBO-IUEM, Brest, France.
2. SHOM, Brest, France.
3. Ecole Navale, Brest, France.

Body: The deep sandwave dynamics is still in debate. Understanding the migration processes and the resulting evolution of their 3D internal architecture are scientifically challenging. To address these questions we realized two swath bathymetry surveys complemented with seismic reflection across the large sandwaves field named "Banc du Four". It is located offshore the Western Brittany and is composed of more 500 dunes. Some of the dunes' wavelengths and heights exceed 1000m and 30m respectively placing them among the largest dunes ever described. Equilibrium laws obtained from our morphological analysis are not completely in agreement with those described in previous studies of similar structures in shallow waters. Relatively high migration velocities on deep continental shelves (from 3 to 20m.yr-1) attest of their still present dynamical equilibrium. Internal-external morphological and kinematical analyses show the existence of two different dynamic regimes. Interpretation of the seismic reflection data allowed reconstructing long-term evolution of the sandbank and the establishment of progressive connections between stepped submarine channels and tidal dynamics during the last sea-level rise.

Final ID: EP13A-0848

Understanding the effects of bathymetry, wave climate, and coastline shape on wave energy delivery to rocky coastlines using machine learning

E. B. Goldstein; [1]; *P. W. Limber;* [2, 1]; *A. Murray;* [1]; *P. N. Adams;* [2];
1. Earth and Ocean Sciences, Duke University, Durham, NC, United States.
2. Geological Sciences, University of Florida, Gainesville, FL, United States.

Body: Coastal headlands protruding seaward modify the incoming wave field. Notably, wave refraction over bathymetry associated with a subaerial headland results in the focusing of wave energy on headlands, hypothesized to be a primary mechanism of headland erosion and a control on planform coastline evolution. In this contribution we examine the factors that control wave energy delivery, specifically the impact of mean seabed slope, headland amplitude and wave climate (i.e. height, period, offshore wave direction). This study is a direct extension of a recently developed analytical model of rocky coastline evolution (Limber et al., submitted; Limber and Murray, submitted). We utilize a wave ray tracing model to determine the mean wave power density delivered to protruding rocky headlands of various size over a range of wave conditions. With this large model data set, we employ genetic programming (a machine learning technique) to develop a predictive equation for mean wave power delivered to a headland as a function of the wave climate and headland size. Preliminary results from the coupled wave ray-machine learning analysis show headland averaged wave power density scales linearly with cross-shore headland amplitude and is proportional to offshore wave energy density, wave period, and the offshore wave approach angle. However, relative to headland amplitude, the wave characteristics exert significantly stronger control on power delivery.
The new relationship can be modified to reflect an ‘effective’ wave climate that describes the long-term wave energy delivery to the coast. This term can be estimated using historic wave buoy data. From purely dimensional grounds, previous work suggested that wave power density and the erosion rate of cliffed margins are linearly related. The constant that links power density and cliff retreat, however, is difficult to quantify. On coasts with known erosion rates, we will use the effective long-term wave energy delivery to determine the range of values for the constant that scales wave power to erosion rate, which allows observed sea cliff retreat rates to be related to the offshore wave conditions.

Limber, P.W., Murray, A.B., Adams, P.N., and Goldstein, E.B., Unraveling the dynamics that control cross-shore headland amplitude on rocky coastlines, Part 1: Model development. Submitted to J. Geophys. Res. – Earth Surface.
Limber, P.W., and Murray, A.B., Unraveling the dynamics that control cross-shore headland amplitude on rocky coastlines, Part 2: Model results and comparisons to nature. Submitted to J. Geophys. Res. – Earth Surface.

Final ID: EP13A-0852

The effects of breaking wave turbulence on suspended sand transport in the nearshore - a 3D numerical investigation

X. Liu; [2]; *Z. Zhou;* [1]; *T. Hsu;* [1]; *J. Sangermano;* [1];
1. University of Delaware, Newark, DE, United States.
2. Civil and Environmental Engineering, University of Texas at San Antonio, San Antonio, TX, United States.

Body: To better understand the effects of wave-breaking-induced turbulence on sand transport in the nearshore , a 3D Large-Eddy Simulation (LES) study has been carried out. Using a turbulence-resolving approach, our specific objective is to investigate how wave-breaking-induced turbulent coherent structures, known as the obliquely descending eddies (ODEs), may interact with the bed and enhance suspended sand transport. The numerical model is implemented in an open-source computational fluid dynamics platform OpenFOAM®, In this model, the incompressible 3D filtered Navier-Stokes equations for the water and the air phases are solved with a finite volume scheme. The free surface is resolved using a volume of fluid (VOF) method. Using the dynamic Smagorinsky closure, the numerical model has been validated with wave flume experiments of solitary wave breaking over a 1/50 sloping beach (Ting 2006, Coastal Eng., 53, 441-462). The generation and evolution of turbulent coherent structures are shown to be similar to the measured data. More importantly, simulation results show that many turbulent coherent structures are sufficiently intense to reach the bed and enhance the bottom stress by a factor of 2~3. The implication for sediment transport is obvious. The numerical model has recently been extended with a suspended sediment transport module and the numerical simulations are extended to study periodic wave breaking over a slope. Hence, the role of ODEs in determining the direction and amount of suspended sand transport under different breaker types is investigated.

Final ID: EP13A-0856

Exploring a morphodynamic modeling framework for reef island evolution under sea-level rise

J. Lorenzo Trueba; [1]; *A. D. Ashton;* [1]; *J. P. Donnelly;* [1];
1. Woods Hole Oceanographic Institution, Woods Hole, MA, United States.

Body: Global sea-level rise rates have increased over the last century, with dramatic rate increases expected over the coming century and beyond. Not only are rates projected to approach those of the previous deglaciation, the actual increase in elevation by the end of the century (potentially 1m or more) will be significant in terms of the elevations of low-lying coastal landforms. Coral reef islands, often called “cays” or “motus”, which generally comprise the subaerial portion of atolls, are particularly sensitive to sea-level rise. These landforms are typically low-lying (on the order of meters high), and are formed of wave-transported detrital sediment perched atop coralline rock. As opposed to barrier islands that can be supplied by offshore sediment from the shoreface, breakdown of corals and the shallow offshore lithology can serve as a source of sediment to reef islands, which can help build these islands as sea level rises. Here, we present a morphodynamic model to explore the combined effects of sea-level rise, sediment supply, and overwash processes on the evolution of reef islands.
Model results demonstrate how reef islands are particularly sensitive to the offshore generation of sediment. When this onshore sediment supply is low, islands migrate lagoonward via storm overwash, Islands migrate over the proximal lagoonward regions, which tend to include a shallow (~2m) platform, until they reach the edge of a typically very deep lagoon (up to 60m or more). At the lagoon edge, reef islands stop their migration and eventually drown overwash sediment flux is lost to the lagoon. In contrast, a high sediment supply of offshore sediment can bulwark reef islands before reaching the lagoon edge. One possibility is that the island attains a ‘static equilibrium’ in which the overwash flux fills the top-barrier accommodation created by sea-level rise, and the island surface area is maintained. When the sediment supply is very high, however, the island can undergo rapid increases in surface area, and only portions of the island are able to keep up with sea level in the long term. Overall, the morphodynamic model presents rich behaviors that cannot be captured by geometric models that have previously been applied to these landforms.
As reef islands are often located in the middle of ocean basins, locally, shorelines face different dominant forcing conditions depending on the local orientation. This affects not only the local profile response, but the system response as each island reach is coupled with its alongshore neighbors through littoral transport. Coupling dynamic profiles alongshore allows us to investigate these rich coupled dynamics. Overall, our results highlight the dependence of reef evolution on overwash processes, and motivates a better understanding of the timing, magnitude, and morphological effect of low-frequency, high-energy events.

Final ID: EP13A-0857

Impact of vegetation on the hydrodynamics and morphological changes of the Wax Lake Delta during hurricanes

F. Xing; [1]; *A. J. Kettner;* [1]; *J. P. Syvitski;* [1]; *Q. Ye;* [3]; *A. Bevington;* [2]; *R. Twilley;* [2]; *J. H. Atkinson;* [4];
1. CSDMS, INSTAAR, Boulder, CO, United States.
2. Department of Oceanography and Coastal Sciences, Louisiana State University, Baton Rouge, LA, United States.
3. Deltares, Delft, Netherlands.
4. ARCADIS, Boulder, CO, United States.

Body: Coastal wetlands are natural barriers for storms, but have become more vulnerable especially when considering sea level rise and intensification of hurricanes due to global climate change. We use the numerical model Delft3D, which incorporates a newly developed vegetation routine to analyze the impact of natural vegetation on the morphological changes of coastal wetlands. The vegetation routine takes into account: 1) the influence of vertically oriented stems of plants as well as horizontally oriented stems (bent or broken but still attached to the belowground roots and rhizomes) on the flow turbulence as well as flow momentum, and 2) the influence of plant roots on the submerged soil strength. The model is applied to the Wax Lake Delta, a river-dominated delta that is part of the larger Mississippi River Delta system, during extreme events (hurricane Katrina and Rita (2005)).
Hydrodynamic components as well as waves and salinity are included in the Delft3D model simulation. Results reveal that the submerged aboveground plant stems significantly decrease flow velocity and protect the wetland from erosion. When flow velocity exceeds a critical value, plant stems start to orient horizontally and lie on the bed, which changes the 3D vertical flow structure to free water condition (log profile), and also increases the bed roughness on the wetlands. Roots help to increase the soil strength, reducing erosion of the wetlands. However, roots can also intensify erosion if they got pulled out of the soil during storm events. Typically the whole root system of plants will be pulled out together, leading to a mat of soil that is eroded. This process has been observed for some parts of the Mississippi Delta during severe hurricanes like hurricane Katrina. Storm surges generated by hurricanes can push a large amount of saline water into the freshwater wetlands. The high salinity water increases flocculation and therefore sedimentation.
Overall, plants have a complex impact on the hydrodynamic and morphological changes of coastal wetlands, which are not yet fully understood. This study shows that plants have to be taken into consideration when studying morphological processes of wetlands, especially during extreme events, such as hurricanes.

Final ID: EP13A-0861

Generating synthetic wave climates for coastal modelling: a linear mixed modelling approach

C. Thomas; [1]; *R. M. Lark;* [2];
1. Climate & Landscape Change, British Geological Survey, Edinburgh, United Kingdom.
2. Environmental Modelling, British Geological Survey, Keyworth, Nottingham, United Kingdom.

Body: Numerical coastline morphological evolution models require wave climate properties to drive morphological change through time. Wave climate properties (typically wave height, period and direction) may be temporally fixed, culled from real wave buoy data, or allowed to vary in some way defined by a Gaussian or other pdf. However, to examine sensitivity of coastline morphologies to wave climate change, it seems desirable to be able to modify wave climate time series from a current to some new state along a trajectory, but in a way consistent with, or initially conditioned by, the properties of existing data, or to generate fully synthetic data sets with realistic time series properties. For example, mean or significant wave height time series may have underlying periodicities, as revealed in numerous analyses of wave data. Our motivation is to develop a simple methodology to generate synthetic wave climate time series that can change in some stochastic way through time. We wish to use such time series in a coastline evolution model to test sensitivities of coastal landforms to changes in wave climate over decadal and centennial scales.

We have worked initially on time series of significant wave height, based on data from a Waverider III buoy located off the coast of Yorkshire, England. The statistical framework for the simulation is the linear mixed model. The target variable, perhaps after transformation (Box-Cox), is modelled as a multivariate Gaussian, the mean modelled as a function of a fixed effect, and two random components, one of which is independently and identically distributed (iid) and the second of which is temporally correlated. The model was fitted to the data by likelihood methods. We considered the option of a periodic mean, the period either fixed (e.g. at 12 months) or estimated from the data. We considered two possible correlation structures for the second random effect. In one the correlation decays exponentially with time. In the second (spherical) model, it cuts off at a temporal range. Having fitted the model, multiple realisations were generated; the random effects were simulated by specifying a covariance matrix for the simulated values, with the estimated parameters. The Cholesky factorisation of the covariance matrix was computed and realizations of the random component of the model generated by pre-multiplying a vector of iid standard Gaussian variables by the lower triangular factor. The resulting random variate was added to the mean value computed from the fixed effects, and the result back-transformed to the original scale of the measurement. Realistic simulations result from approach described above.

Background exploratory data analysis was undertaken on 20-day sets of 30-minute buoy data, selected from days 5-24 of months January, April, July, October, 2011, to elucidate daily to weekly variations, and to keep numerical analysis tractable computationally. Work remains to be undertaken to develop suitable models for synthetic directional data.

We suggest that the general principles of the method will have applications in other geomorphological modelling endeavours requiring time series of stochastically variable environmental parameters.

Final ID: EP13C-0881

Snowmelt and rain in a marginal snowpack watershed: Amount and duration of water input controls runoff

S. P. Anderson;[1, 2]; N. Rock;[1];
1. INSTAAR, University of Colorado, Boulder, CO, United States.
2. Dept. of Geography, University of Colorado, Boulder, CO, United States.

Body: Snowmelt predictably delivers a concentrated pulse of water to watersheds, and therefore structures ecosystems and human water management. The deep irrigation from snowmelt also delivers water effectively to the base of the critical zone in water-limited climates, and hence controls the advance of the weathering front. Changes in snowmelt therefore stand as a prominent concern for the impacts of future climate warming. We use a headwater watershed in the Colorado Front Range to explore the impacts of varying delivery of rain and snow on runoff.
Gordon Gulch, a 2.7 km^2 forested watershed at 2650 m elevation in the Colorado Front Range, is drained by a small first order stream. A snowpack builds on north-facing slopes, while snow comes and goes on south-facing slopes. In water years 2010-2012, total precipitation ranged from 480 to 560 mm. Total runoff, which ranged from 55 to 102 mm, does not correlate with annual precipitation. Over half of the total annual discharge occurs in a period of a few weeks each year; in two of the study years, peak discharge occurred in spring following snowmelt. In one year, peak discharge was entirely rain driven.
In 2010 and 2011, discharge peaked during late spring (May) storms after the snow pack melted. The highest annual runoff, and longest duration high discharge period, occurred in water year 2010. In that year, ablation of most of a ~70 cm snowpack (on N-facing slopes; S facing slopes were bare) was followed by a 25 day stormy period in which ~130 mm of mixed rain and snow fell. Two discharge maxima occurred in response to precipitation events during this wet, post-snowpack period. In total, discharge remained high for ~6 weeks. In water year 2011, a smaller snowpack (max. ~30 cm), and drier spring produced a much more compact high runoff season of ~2 weeks. Although water year 2011 had ~10% more total precipitation, it produced 30% less runoff than water year 2010. A greater proportion of the 2011 precipitation fell in summer, but with little effect on runoff.
Summer rain produced the discharge maximum in water year 2012. The snowpack ablated by April 1, a month earlier than in the biggest annual discharge year of 2010. Only 50 mm of precipitation fell in the ensuing two months. However, a series of storms over a four-day period in early July brought 137 mm of rain (almost 30% of the annual precipitation that water year) and produced ~1.5 weeks of high discharge. The highest instantaneous discharge of all three years occurred one day after the highest single day rain total (67 mm) on July 8, the 3rd day in the storm sequence. Intense summer rains are not uncommon in the Colorado, but summer storms that produce sustained high flow are. The 2012 storm sequence was marked by both its high intensity and long duration. These observations highlight the importance of antecedent moisture, from snow or from rain, on runoff production.

URL: http://criticalzone.org/boulder/

Final ID: GC13E-01

Impacts of Large-Scale Water Management on Terrestrial Hydrology and Climate *(Invited)*

J. S. Famiglietti; [1];
1. Univ California Irvine, Irvine, CA, United States.

Body: Large-scale water management practices, including reservoir storage, groundwater mining for irrigation, wetland drainage and river diversions, are known to often influence regional hydrology and climate, though their impacts are poorly understood. The NASA GRACE mission can help characterize water storage changes associated with such management, many of which have the potential to feed back to atmospheric and oceanic processes. Here, the affects of groundwater pumping, regional–scale irrigation, reservoir storage and continental discharge, observed or derived from GRACE, on interactions with the atmosphere and the ocean, are quantified. Results suggest the occurrence of regional-scale circulations and positive feedbacks that can strengthen the regional hydrologic cycle, either in the immediate vicinity or remotely.

URL : http://ucchm.org

Final ID: OS13D-01

Evaluating competing forces constraining glacial grounding-line stability ***(Invited)***

R. D. Powell; [1];

1. Geology & Environmental Geosciences, Northern Illinois Univ., De Kalb, IL, United States.

Body: Stability of grounding lines of marine-terminating glaciers and ice sheets is of concern due to their importance in governing rates of ice mass loss and consequent sea level rise during global warming. Although processes are similar at tidewater and floating grounding zones their relative magnitudes in terms of their influence on grounding-line stability vary between these two end members. Processes considered Important for this discussion are ice dynamics, ice surface melting and crevassing, ocean dynamics, subglacial sediment and water dynamics, and subglacial bed geometries. Models have continued to improve in their representation of these complex interactions but reliable field measurements and data continue to be hard earned and too few to properly constrain the range of boundary conditions in this complicated system. Some data will be presented covering a range of regimes from Alaska, Svalbard and Antarctica. Certainly more data are required on subglacial sediment/water dynamics and fluxes to fully represent the spectrum of glacial regimes and to assess the significance of grounding-zone sediment systems in counteracting the other processes to force grounding-line stability. Especially important here is constraining the duration of the stability that could be maintained by sediment flux – present data appear to show that it is likely to be a limited period.

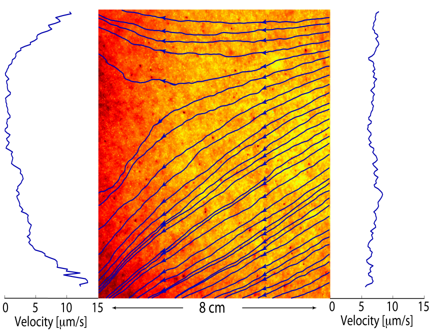
Final ID: MR13A-2224

Flow and Geometry Control the Onset of Jamming in Fractures with High Solid-Fraction Fluids

R. Medina; [1]; *J. E. Elkhoury;* [1]; *L. J. Shannon;* [1]; *R. L. Detwiler;* [1]; *J. Morris;* [2]; *R. Prioul;* [2]; *J. Desroches;* [3];

1. Civil and Environmental Engineering, University of California, Irvine, Irvine, CA, United States.
2. Schlumberger Doll Research , Cambridge, MA, United States.
3. Services Pétroliers Schlumberger, La Défense Cedex, France.

Body: Fluids containing a large fraction of suspended solids are common in the subsurface. Examples include fluids used for environmental remediation, hydraulic fracturing fluids and magma. These fluid-solid mixtures behave as non-Newtonian fluids where interactions between fluid, suspended solids, and pore walls can lead to jamming of the suspended solids. Jamming causes the velocity of the solid to decrease locally to zero causing a rapid decrease in permeability as the fluid is forced to flow through the pore space within the immobilized solid. Here we present results from experiments that quantify the flow of non-Newtonian suspensions in an analog parallel-plate fracture (transparent 15cm x 15cm with ~3-mm aperture) and explore the dependence of jamming on flow conditions, fracture geometry, and the action of gravity. We used guar gum mixed with water (0.75%) as the fluid and added 50% by volume of crushed silica (< 300μm). Flow rates ranged from 0.2ml/min to 6.0ml/min, cell orientation varied from horizontal to vertical (bottom to top) flow and a transducer provided continuous measurement of differential pressure across the cell. A strobed LED panel backlit the cell and a high-resolution CCD camera captured frequent (0.2 Hz) images during all experiments. Particle image velocimetry (PIV) yielded measurements of the evolving velocity field during experiments (see Figure). In the vertical orientation during the initial period of high flow rate, outflow decreased rapidly and the differential pressure increased indicating jamming within the cell. Subsequent efforts to flush solids from the cell suggested that jamming occurred at the inlet of the cell. This was likely due to settling of solids within the flow field indicating that the time scale associated with settling was shorter than the time scale of advection through the cell. In the horizontal orientation, localized jamming occurred at the lowest flow rate in a region near the outlet. This suggests that when settling and advection are not competing, localized regions of low velocity within the cell trigger jamming. Subsequent increases in flow rate did not remobilize the jammed region demonstrating that the jamming process is at least hysteretic, if not irreversible.



Light absorbance image from a sub-region adjacent to the outlet of the fracture for a flow rate of 0.2 ml/min. Flow was from right to left. The PIV-derived streamlines show divergence of the flow field around the jammed region adjacent to the outlet. Velocity profiles from the inlet and outlet of this region clearly show that the velocity field is near-uniform at the inlet but that jamming leads to a region along the outlet with zero velocity.

Final ID: T13D-2566

GPS Velocity Field in Bangladesh: Delta Subsidence, Seasonal Water Loading and Shortening Across the Burma Accretionary Prism and Shillong Massif.

M. S. Steckler; [1]; *D. R. Mondal;* [2]; *S. L. Nooner;* [3]; *S. H. Akhter;* [4]; *L. Seeber;* [1]; *S. V. Bettadpur;* [6]; *C. Sazedul Karim;* [5]; *M. Howe;* [1]; *F. Masson;* [7]; *T. Maurin;* [8]; *C. Rangin;* [9];

1. Lamont-Doherty Earth Observatory, Columbia University, Palisades, NY, United States.
2. Queens College, The City University of New York, Flushing, NY, United States.
3. University of North Carolina, Wilmington, NC, United States.
4. University of Dhaka, Dhaka, Bangladesh.
5. Bangladesh Water Development Board, Dhaka, Bangladesh.
6. Center for Space Research, University of Texas, Austin, TX, United States.
7. Institut de Physique du Globe de Strasbourg, Université de Strasbourg, Strasbourg, France.
8. GeoAzur, Université Nice Sophia Antipolis, Valbonne, France.
9. EGERIE, College de France, Aix en Provence, France.

Body: We installed a suite of 25 GPS receivers between 2003 to 2012 covering the deltaic country of Bangladesh, which lies near the junction of the Indian Shield, the Himayalan collision belt and the Indo-Burman wedge. The crust of the Indian Shield thins southeastward in Bengal Basin across the hinge zone of an Early Cretaceous continental margin. The thin continental and/or oceanic crust of the Bengal Basin beyond the hinge zone is overlain by the southwest prograding Ganges-Brahmaputra Delta (GBD) creating a total sediment thickness of ≥16 km. The GBD is formed by the convergence of these great rivers which together supply >1GT/y of sediment. Their flow, the second largest on earth, is strongly seasonal and causes widespread flooding during the summer monsoon. The heavily-sedimented GBD is being overridden from the north by the Shillong Massif, a 2-km high basement-cored anticlinorium exposing Indian Shield, and from the east by the accretionary prism of the Indo-Burma wedge. The soft, oblique collision of the Burma platelet with the Bengal Basin and the GBD has built a large accretionary prism that widens northwards to 250-300 km. The prism extends westward up to half way across the GBD. The outer folds and thrust front are blind due to burial by the rapid sedimentation of the GBD. The GPS data in Bangladesh cover the frontal region of this unusual subaerial accretionary prism, while observations from India and Myanmar provide velocities for more internal parts of the system.

The GPS velocities provide data on multiple processes taking place in the region. The vertical component shows both long-term and seasonal signals. The horizontal components quantify the shortening and lateral motion between the GBD and both the Indo-Burman wedge and Shillong Massif. The Indo-Burman convergence is oblique and partitioned into multiple strike-slip faults and a large number of thrust folds, presumably rooted into a basal megathrust.. The velocity gradients across the accretionary prism indicate E-W shortening at ~17 mm/y and N-S dextral shear at ~45 mm/y. Most of the shear occurs on the Sagaing Fault in Myanmar and the Churachandpur-Mao Fault in India, with only ~5 mm/y in Bangladesh. The shortening is consistent with elastic deformation above a locked, shallowly dipping megathrust. A small amount of the shortening could be accommodated by a backthrust on the eastern side of the Indo-Burman Ranges. Despite uncertainties from merging the Indian and Bangladeshi GPS surveys, the Shillong Massif is consistent with elastic deformation above a locked blind thrust fault dipping at ~30° at 7-8 mm/y. The seasonal signal of up to 5-6 cm is due to elastic deformation from the weight of >100GT water impounded during the monsoon. Most of the delta yields a Young's modulus (E) of ~80 GPa, however the two stations landward of the hinge zone yield larger values indicative of cratonic lithosphere. Long-term subsidence of NW Bangladesh landward of the hinge zone marking the edge of the Indian craton is <1 mm/y. The Sylhet Basin, the foredeep of Dauki-Shillong thrust-anticline is sinking at 7-12 mm/y, while the coastal belt subsides at 3-7 mm/y. Dhaka subsides at 12 mm/y due to

groundwater pumping. The foldbelt shows variable uplift and subsidence congruent with the structural position of the GPS sites.

URL: http://www.BanglaPIRE.org

Final ID: B13M-05

Global net land carbon sink: Results from the Multi-scale Synthesis and Terrestrial Model Intercomparison Project (MsTMIP)

D. N. Huntzinger;[1, 2]; *C. R. Schwalm;*[1]; *A. M. Michalak;*[3]; *R. B. Cook;*[4]; *A. R. Jacobson;*[5, 6]; *K. M. Schaefer;*[6, 7]; *A. Dasgupta;*[8]; *J. Poco;*[9];

1. School of Earth Sciences and Environmental Sustainability, Northern Arizona University, Flagstaff, AZ, United States.
2. Department of Civil Engineering, Construction Mgmt., and Environmental Engineering, Northern Arizona University, Flagstaff, AZ, United States.
3. Department of Global Ecology, Carnegie Institution for Science, Stanford, CA, United States.
4. Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN, United States.
5. Earth System Research Laboratory, National Oceanic and Atmospheric Administration, Boulder, CO, United States.
6. Cooperative Institute for Research in Environmental Sciences, University of Colorado, Boulder, CO, United States.
7. National Snow and Ice Data Center, Boulder, CO, United States.
8. DataONE, University of New Mexico, Albuquerque, NM, United States.
9. Computer Science and Engineering, New York University - Polytechnic, Brooklyn, NY, United States.

Body: The Multi-scale Synthesis and Model Intercomparison Project (MsTMIP) is a formal model intercomparison effort focused on improving the diagnosis and attribution of carbon exchange at regional and global scales. Here we present results from the terrestrial biospheric models participating in the MsTMIP effort, focusing on global and regional model estimates of the net land carbon sink. When compared to estimates of the residual net land sink inferred from atmospheric CO2 observations (i.e., fossil fuel emission + land use land cover change - atmospheric increase - ocean uptake), MsTMIP models predict, on average, a weaker global net land uptake of carbon. There is a large spread in MsTMIP estimates of the net land sink (e.g., -2.5 to 5.0 Pg C/yr in 2010, where a negative flux represents a net release to the atmosphere). Some models consistently show the land surface as a net source of carbon to the atmosphere, which is inconsistent with the atmospheric record. In addition, we examine how model estimates of the cumulative global net sink diverge over the period 1900 to 2010, and the degree to which model sensitivity to forcing factors and fundamental differences in model formulation contribute to this divergence. We link differences in estimates of the cumulative land sink back to each model's sensitivity to key forcing factors including climate variability, CO2 fertilization, nitrogen limitation, and land cover / land-use change. For example, the strength of carbon uptake in most models appears to be strongly coupled with atmospheric CO2 concentrations (CO2 fertilization effect). The strength of this relationship, however, varies across models with some models exhibiting a very strong CO2 fertilization effect (e.g., ORCHIDEE), while others not so (e.g., CLM). To inform the comparison across models, structural differences (i.e., which processes are included and how those processes are parameterized) among the participating models are evaluated using hierarchical cluster diagrams or dendrograms. Dendrograms are also used to compare model estimates, testing whether models with similar structural attributes produce similar estimates of net terrestrial carbon sink with time.

Final ID: NH14A-01

Landslide dynamics from seismology and satellite remote sensing ***(Invited)***

C. P. Stark; [1]; *G. Ekstrom;* [1]; *C. Hibert;* [1]; *J. Allen;* [2];

1. Lamont-Doherty Earth Observatory, Columbia Univ, Palisades, NY, United States.
2. NASA Earth Observatory, Greenbelt, MD, United States.

Body: Each year, a half-dozen or more kilometer-scale landslides strike mountain regions around the world. Each involves the acceleration and deceleration of millions of tons of debris at bulk rates of 1-3m/s^2, generating peak bulk-averaged forces well in excess of 10GN and exciting seismic waves whose long-period components are detectable at distances exceeding 1000km. We have studied around 40 such teleseismogenic (but not earthquake-triggered) landslides for the period 1980-2013, focusing mainly on inverting the long-period waveforms to infer time-series of landslide dynamical properties (the landslide force history or LFH; [1]), and recently extending our analysis to consider high-frequency seismicity recorded for well-instrumented events. It is now feasible to detect, measure and roughly geolocate >50GN, Msw>4.7 landslide events within a few hours of their occurrence, even if the landslides strike in very remote areas. Each rapid LFH inversion generates a good estimate of the runout geometry, which, for remote events, turns out to be very useful when trying to confirm and precisely locate the landslide occurrence in satellite imagery. With the advent of Landsat 8 it is now feasible to make such a confirmation within a week or so, weather permitting. A recent example is the rapid detection of a ~40Mt landslide in the Wrangell Mountains of Alaska that struck on 2013-07-25: the event was detected and roughly located with a few hours; within a few days, an LFH inversion gave its scale and runout path; the inversion and correlative short-period waveform analysis generated a sharper estimate for its location; a Landsat 8 image over the area was acquired within 8 days, and the new landslide scar was spotted shortly thereafter. This event extends our catalog of landslide source inversions and corroborates our general conclusions from this work, which are: (i) the glaciated mountains of Alaska, notably the St Elias Range and its neighbors, are the most catastrophic-landslide-prone in the world; (ii) remote measurements can be made of bulk landslide dynamics and runout geometry; (ii) when analyses of this kind are aggregated, a set of empirical scaling behaviors become clear [1]. Implications for landslide physics will be discussed further during the presentation.

[1] Ekström G. and Stark C. P. (2013), Science, 339: 1416-1419. DOI: 10.1126/science.1232887.

Final ID: PA14A-02

Water Resource Impacts During Unconventional Shale Gas Development: The Pennsylvania Experience

S. L. Brantley; [1]; *D. Yoxtheimer;* [1]; *S. Arjmand;* [2]; *P. Grieve;* [1]; *R. Vidic;* [2]; *J. D. Abad;* [2]; *C. A. Simon;* [2]; *J. Pollak;* [3];

1. Penn State Univ, University Park, PA, United States.
2. University of Pittsburgh, Pittsburgh, PA, United States.
3. CUAHSI, Medford, MA, United States.

Body: The number of unconventional Marcellus shale wells in PA has increased from 8 in 2005 to more than 6000 today. This rapid development has been accompanied by environmental issues. We analyze publicly available data describing this Pennsylvania experience (data from www.shalenetwork.org and PA Department of Environmental Protection, i.e., PA DEP). After removing permitting and reporting violations, the average percent of wells/year with at least one notice of violation (NOV) from PA DEP is 35 %. Most violations are minor. An analysis of NOVs reported for wells drilled before 2013 revealed a rate of casing, cement, or well construction issues of 3.4%. Sixteen wells were given notices specifically related to migration of methane. A similarly low percent of wells were contaminated by brine components. Such contamination could derive from spills, subsurface migration of flowback water or shallow natural brines, or contamination by drill cuttings. Most cases of contamination of drinking water supplies with methane or brine components were reported in the previously glaciated part of the state. Before 2011, flowback and production water was often discharged legally into streams after minimal treatment, possibly increasing dissolved Br concentrations in some rivers. The rate of large spills or releases of gas-related industrial wastes in the state peaked in 2009 but little evidence of spills has been found in publicly available surface water chemistry data. The most likely indicators of spillage or subsurface release of flowback or production waters are the dissolved ions Na, Ca, and Cl. However, the data coverage for any given analyte is generally spatially and temporally sparse. Publicly available water quality data for before and after spills into Larrys Creek and Bobs Creek document the difficulties of detecting such events. An observation from the Pennsylvania experience is that the large number of people who have complained about their water supply (~1000 letters investigated by state regulators) and the media attention during the fast start in PA may have led to better management practices. Maintaining online databases of observations could similarly drive shale-gas practice to become even more environmentally protective.

Final ID: ED14C-04

Web-based Interactive Landform Simulation Model - Grand Canyon

W. Luo; [1]; *J. D. Pelletier;* [2]; *K. Duffin;* [1]; *C. J. Ormand;* [3]; *W. Hung;* [1]; *E. A. Iverson;* [3]; *D. Shernoff;* [1]; *X. Zhai;* [4]; *A. Chowdary;* [1];

1. Northern Illinois Univ, De Kalb, IL, United States.
2. University of Arizona, Tucson, AZ, United States.
3. Carleton College, Northfield, MN, United States.
4. College of Lake County, Grayslake, IL, United States.

Body: Earth science educators need interactive tools to engage and enable students to better understand how Earth systems work over geologic time scales. The evolution of landforms is ripe for interactive, inquiry-based learning exercises because landforms exist all around us. The Web-based Interactive Landform Simulation Model – Grand Canyon (WILSIM-GC, http://serc.carleton.edu/landform/) is a continuation and upgrade of the simple cellular automata (CA) rule-based model (WILSIM-CA, http://www.niu.edu/landform/) that can be accessed from anywhere with an Internet connection. Major improvements in WILSIM-GC include adopting a physically based model and the latest Java technology. The physically based model is incorporated to illustrate the fluvial processes involved in land-sculpting pertaining to the development and evolution of one of the most famous landforms on Earth: the Grand Canyon. It is hoped that this focus on a famous and specific landscape will attract greater student interest and provide opportunities for students to learn not only how different processes interact to form the landform we observe today, but also how models and data are used together to enhance our understanding of the processes involved. The latest development in Java technology (such as Java OpenGL for access to ubiquitous fast graphics hardware, Trusted Applet for file input and output, and multithreaded ability to take advantage of modern multi-core CPUs) are incorporated into building WILSIM-GC and active, standards-aligned curricula materials guided by educational psychology theory on science learning will be developed to accompany the model. This project is funded NSF-TUES program.

URL: http://serc.carleton.edu/landform/

Final ID: IN14A-06

Assimilation of NASA MODIS Flood Mapping Product into Operational Flash Flood Warning Systems

A. J. Posner; [1]; *K. P. Georgakakos;* [1]; *E. Shamir;* [1];
1. Hydrologic Research Center, San Diego, CA, United States.

Body: Regional operational systems that support forecasters for the real-time warning of flash flood events have been implemented worldwide in the last decade. These systems provide hydrological and meteorological agencies the tools to make possible timely alerts and warnings for flash floods in small basins (area of order of 100 km2). The output of the model consists of indices that estimate the amount of rain of a certain duration that is needed over a given small basin in order to cause minor flooding (bankfull flow) at its outlet. These indices are adjusted and used with local available data and nowcast products by forecasters and enable the generation of prompt flash flood warnings and alerts.

Soil moisture is the principal state variable in estimating the rainfall-runoff relationship in a given catchment. Antecedent soil moisture conditions directly impact the ability of additional precipitation to infiltrate, rather than becoming surface runoff. In the operational systems the focus is on the water balance over the flash-flood prone small watersheds. Backwater catchment inundation from swollen rivers or regional groundwater inputs is not significant over the spatial and temporal scales for the majority of the upland flash flood prone basins, and as such, these effects are not considered. However, some lowland areas and flat terrain near large rivers experience standing water long after local precipitation has ceased as a result of phenomena outside of local forcing. The NASA Office of Applied Science is producing an experimental product from the MODIS instrument on the Terra and Aqua satellites that detects standing water, beyond reference water, at a daily time interval and with a 250m resolution. This presentation discusses the potential utility of this product to adjust the soil water estimates of the operational systems for flash flood prone basins in low lying areas to improve local flash flood warnings.

Given that a portion of the catchment area is inundated, the total volume of the upper soil water content of the catchment can be expressed with respect to the proportion of inundated area, and with respect to the modeled soil saturation fraction and its error. These relations are used to derive an error estimate for the modeled soil saturation fraction; whereby, the soil saturation fraction model state can be updated given the availability of observed inundation. At its limit, the difference between modeled soil saturation fraction estimates and unity, representing full inundation, for those basin-days experiencing full inundation was found to be nearly normally distributed. In order to represent uncertainty in error estimates, conditional sampling was used to generate an ensemble of model error estimates for a given range of modeled upper soil water. Those error estimates were used in the context of Monte Carlo ensemble forecasting of soil water and flash flood potential. Numerical experiments with six months of data (July 2012 – December 2012) showed that MODIS inundation data, when assimilated to correct soil moisture estimates, increased the likelihood that bankfull flow would occur, over non-assimilated modeling, at catchment outlets for approximately 44% of basin-days during the study time period. For these basins this is a significant reduction of the bias that leads forecasters to underestimate local flash flood threat.

URL: http://www.hrc-lab.org/

Final ID: GC14B-07

The Florida Water and Climate Alliance: A Collaborative Working Group for the Development of Climate Predictions for Improved Water Management, Operations and Planning. ***(Invited)***

W. D. Graham; [1]; *S. Hwang;* [1]; *A. Adams;* [2];
1. Water Institute, University of Florida, Gainesville, FL, United States.
2. Tampa Bay Water, Clearwater, FL, United States.

Body: The Florida Water and Climate Alliance (FloridaWCA) is a stakeholder-scientist partnership focused on increasing the relevance of climate science data and tools for water resource planning and supply operations in Florida. To date the FloridaWCA has (1) developed a collaborative working group comprised of public water suppliers, water resource managers, climate scientists, and hydrologic scientists focused on understanding how climate variability/change may impact planning and operations of Florida's public water supply utilities, (2) identified the appropriate spatio-temporal scales, climatic indices, and events that drive utilities' and water managers' decisions, (3) evaluated the accuracy of statistically and dynamically downscaled General Circulation Model (GCM) predictions for the region, and (4) used the downscaled climate model predictions in Working Group members' hydrologic models to evaluate the usefulness of these data for minimizing current and future risks associated with climate variability/climate change.

This presentation will highlight technical results that show the variable accuracy with which alternative statistical and dynamic downscaling techniques reproduce the small-scale spatiotemporal variability of precipitation in Florida, and the importance of this small-scale variability for predicting hydrologic response to changes in climatic forcing. The implications of uncertainty produced by alternative future scenarios, GCM projections, and downscaling techniques for water resource decision-making will be explored. The benefits of convening scientists and practitioners in an iterative process of knowledge co-production will be discussed, and lessons learned that may be applicable to other groups involved in multi-stakeholder process development will be presented.

URL : http://www.floridawca.org/

Final ID: NH14A-07

Cosmogenic beryllium-10 exposure dating of probable earthquake-triggered rock avalanches in Yosemite Valley, California

J. A. Thompson; [1, 2]; *G. M. Stock;* [1]; *D. Rood;* [3]; *K. L. Frankel;* [4];

1. National Park Service, Yosemite National Park, El Portal, CA, United States.
2. Earth Science, UC Santa Barbara, Santa Barbara, CA, United States.
3. SUERC, East Kilbride, United Kingdom.
4. Earth & Atmospheric Sciences, Georgia Institute of Technology, Atlanta, GA, United States.

Body: In Yosemite Valley, rock falls commonly originate from the glacially-steepened walls. Deposition of the smaller rock falls, from hundreds up to tens of thousands of cubic meters, is typically limited to the active talus slopes beneath the cliffs. The floor of Yosemite Valley, however, preserves at least seven extremely large rock fall deposits, here termed rock avalanches, up to several million cubic meters in volume. These deposits extend far beyond the base of active talus slopes onto the valley floor, and have occurred since the retreat of Last Glacial Maximum glaciers circa 15-17 ka. Using airborne LiDAR data that resolves individual boulders, we mapped the rock avalanche deposits in the field and in ArcGIS. Minimum exposed volumes range from hundreds of thousands to several million cubic meters. To assess the frequency of rock avalanche occurrence, we employed cosmogenic beryllium-10 surface exposure dating of large (>4 cubic meters) boulders embedded within the deposits. These deposits are ideal targets for cosmogenic 10Be exposure dating, as they are instantaneous events that excavate deep-seated quartz-rich granitic rocks, and once deposited, are essentially immune to post-depositional erosion or modification. Mean exposure ages indicate that failures occurred at 1.0, 1.8, 2.3, 3.7, 4.4, 6.4, and 11.6 ka. At least three of the deposits appear to represent two or more failures, separated in time by hundreds to thousands of years. Synchronous rock avalanches (within the uncertainty of the exposure ages (<200 yrs)) at different locations within the valley appear to have occurred at 3.7 ka, and possibly at 2.3 ka, suggesting possible coseismic triggering. Age correlations from paleoseismic work tentatively identify large earthquakes originating from the eastern Sierra Nevada or western Nevada as possible triggers for at least half of the rock avalanches. These unique and robust age data provide key information for accurately mapping rock avalanches in Yosemite Valley and for quantifying their recurrence intervals.

Final ID: TH15D-01

Critical Zone Science and Observatories

S. L. Brantley; [1]; *T. S. White;* [1]; *S. P. Anderson;* [2]; *R. C. Bales;* [3]; *J. Chorover;* [4]; *W. H. McDowell;* [5];
1. Earth & Environmental Systems Institute, Penn State University, University Park, PA, United States.
2. Geography, University of Colorado-Boulder, Boulder, CO, United States.
3. School of Engineering, University of California-Merced, Merced, CA, United States.
4. Institute of the Environment, University of Arizona, Tucson, AZ, United States.
5. Natural Resources and the Environment, University of New Hampshire, Durham, NH, United States.

Description: Critical Zone Observatories (CZOs) are natural laboratories for investigating Earth surface processes by monitoring streams, climate and groundwater. CZOs are instrumented for hydrogeochemical measurements of soil, canopy and bedrock. The US CZO network grew to 9 observatories in 2013. The cross-disciplinary teams use field and theoretical approaches, and include education and outreach such as the townhall.

Final ID: A14B-03

High Black Carbon Concentrations and Atmospheric Pollution Around Indian Coal Fired Thermal Power Plants

R. P. Singh; [1, 2]; *A. K. Singh;* [3]; *S. Kumar;* [3]; *T. Takemura;* [4];

1. S University, NCR GN, India.
2. Chapman University, Orange, India.
3. Atmospheric Research Lab., Banaras Hindu University, Varanasi, India.
4. Research Institute for Applied Mechanics, Kyushu University 6-1 , Kyushu , Japan.

Body: Emissions from coal-fired Thermal Power Plants (TPPs) are among major sources of black carbon (BC) aerosols in the atmosphere and air quality degradation. Knowledge of BC emissions from TPPs is important in characterizing regional carbonaceous particulate emissions, associated with regional climate forcing as well as effects on human health. Furthermore, elevated BC concentrations, over the Indo-Gangetic Plains (IGP) and the Himalayan foothills, has emerged as an important subject to estimate effects of deposition and atmospheric warming of BC on the accelerated melting of snow and glaciers in the Himalaya. For the first time, this study reports BC concentrations and aerosol characterization near coal-fired power plants in the IGP. Coal-fired TPPs are also recognized as major point-sources of other atmospheric pollutants such as high NO_2 hotspots in the IGP, as evident from the OMI Aura satellite observations. In-situ measurements were carried out in Kanpur (central IGP) and Singrauli (eastern IGP), during January and March 2013. We show detailed spatial variability of BC within ~10 km from TPPs, that indicate BC variations up to 95 μg/m3, with strong diurnal variations associated with BC concentration peaks during early morning and evening hours. BC concentrations were measured to be significantly higher in close proximity to the coal-fired TPPs (as high as 200μg/m3), compared to the outside domain of our study region. Co-located ground-based sunphotometer measurements of aerosols also show significant spatial variability around the TPPs, with aerosol optical depth (AOD) in the range 0.38-0.58, and the largest AOD of 0.7 - 0.95 near the TPPs (similar to the peak BC concentrations). Additionally, the Angstrom Exponent was found to be in the range 0.4 – 1.0 (maximum in the morning time) and highest in the vicinity of TPPs (~1.0) suggesting abundance of fine particulates, whereas lowest recorded over the surrounding coal mining fields. We also inter-compare global model simulations of BC over our study region, that indicate substantial underestimate against observations in the IGP. Results from this detailed observational study provide an insight into carbonaceous aerosol characteristics in complex and mesoscale environments of coal-fired TPPs, which are major emission sources in the IGP.

Final ID: B21D-0513

Improved estimates of the permafrost carbon feedback

E. E. Jafarov; [1]; *K. M. Schaefer;* [1]; *J. Watts;* [2]; *T. Zhang;* [1];
1. National Snow and Ice Data Center, University of Colorado, Boulder, CO, United States.
2. Flathead Lake Biological Station, University of Montana, Polson, MT, United States.

Body: The Permafrost Carbon Feedback (PCF) is an amplification of surface warming due to the release of CO2 and CH4 from thawing permafrost. Currently, there is substantial uncertainty in estimates of future CO2 release. Studies show that the extensive northern wetlands (>30N) contribute up to 25% of global CH4 emission, whereas 2.3% of CH4 emissions occurs from thawing permafrost in these regions. To improve estimates of the PCF we added prognostic organic layer to the Simple Bioshpere/Carnegie-Ames-Stanford (SIBCASA) Terrestrial Carbon Cycle Model and quantified CO2 and CH4 fluxes resulting from changes in terrestrial carbon storage in permafrost affected soils. Model simulations spanning 1801 to 2010 were driven using Climatic Research Unit-National Centers for Environmental Prediction (CRUNCEP) reanalysis, atmospheric CO2, and land use change information as modified by the Multi-Scale Terrestrial Model Intercomparison Project (MsTMIP). From 2011 to 2300, multiple projections of CO2 and CH4 emissions and changes in PCF were evaluated by scaling the CRUNCEP data using trends in weather data derived from the Fifth Coupled Model Intercomparison Project (CMIP5) for all Representative Concentration Pathway (RCP) scenarios. Implementation of the dynamic organic layer into the model lowered the effective thermal conductivity between the soil and the atmosphere and increased the resilience of permafrost to climate warming and decreased permafrost seasonal thawing depth. The ensemble mean for each RCP is our best estimate of CO2 and CH4 emissions from degrading permafrost and the standard deviation is a measure of uncertainty.

Final ID: C21B-0631

Improving global observation and assessment of glacier contributions to sea level rise *(Invited)*

W. T. Pfeffer; [1, 2];
1. INSTAAR, University of Colorado, Boulder, CO, United States.
2. Civil, Environmental, and Architectural Engineering, University of Colorado, Boulder, CO, United States.

Body: Despite the small volume of land ice contained in glaciers (less than 1% of the total, including the Greenland and Antarctic ice sheets) observations show that glaciers are presently significant sea level rise contributors, with aggregate rates of mass loss estimated to be ca. 40% greater than the combined loss from the ice sheets during the period 1993-2010 and ca. 32% less than the ice sheets over the past decade. Glaciers are expected to continue to be significant contributors in the near term (decades to century), accounting for as much as 30% of total sea level rise by 2100 according to a variety of model projections. Glaciers are also significant sources of uncertainty in sea level projections on decades-to-century time scales, when reductions in uncertainty are of greatest value for policy decisions regarding sea level rise. Despite their acknowledged significance, our capacity to observe, analyze, and model global glacier changes is very weak. The Randolph Glacier Inventory has been a major improvement in the basic information needed to assess present and project future global glacier mass balance changes, but other crucial information is still needed. This includes better observations of regions with high rates of change but minimal observations, such as Alaska and the Himalayas, and a first-order assessment of the capacity for glaciers to undergo rapid dynamic changes. I review the current state of global glacier observation, assessment and modeling, some of the relative uncertainties in the cryospheric components of sea level rise, and options for developing our observational and modeling capacity in the future.

Final ID: C21D-0666

Surface Roughness Impact on the Sea Ice Thickness Measurements Based on LIDAR/Radar Altimetry

L. Li; [1]; *D. Truesdale;* [1]; *P. Posey;* [2]; *R. Allard;* [2]; *J. M. Gardner;* [3]; *J. M. Brozena;* [3]; *J. Richter-Menge;* [4];

1. Remote Sensing Division, Naval Research Lab, Washington, DC, United States.
2. Oceanography Division, Naval Research Laboratory, Stennis Space Center, MS, United States.
3. Marine Geosciences Division, Naval Research Lab, Washington, DC, United States.
4. Terrestrial and Cryospheric Sciences Branch, ERDC-Cold Regions Research and Engineer (CRREL), Hanover, NH, United States.

Body: The Radar and/or LIDAR measurements of sea ice freeboard provide an indirect approach to infer sea ice thickness via isostasy. The underlying assumption is that the LIDAR signal returns at the air/snow interface and radar signal at the snow/ice interface. Thus the surface roughness at the air, snow and ice interface has a significant impact on the LIDAR/Radar returns, which can lead to very significant errors in the ice thickness retrievals. Recent Cryosat-2 validation results suggest that its altimetry-based technique is very effective in mapping hemispheric sea ice thickness. However, in some cases significant bias exists in the Cryosat-2 data product. To understand the performance of those data depends on our skills in quantifying the impacts of the secondary parameters, such as surface roughness of snow and ice surfaces and the penetration depth of the snow/ice by the radar. To this end, we analyze airborne radar and lidar altimeter data collected during a Cryosat-2 under-flight by the NRL and the NASA IceBridge missions, as well as the in-situ data from the coordinated CRREL/NRL field campaign. In this presentation we will show some surface roughness data from airborne LIDAR for leveled and deformed first year ice, and ice pressure ridges. Their impacts on radar returns and sea ice thickness retrieval will be presented.

Final ID: C21D-0673

Snow and Ice Climatology of the Western United States and Alaska from MODIS

K. E. Rittger; [1, 2]; *T. H. Painter;* [1]; *C. A. Mattmann;* [1]; *F. C. Seidel;* [1]; *A. Burgess;* [3]; *M. Brodzik;* [4];
1. JPL, Pasadena, CA, United States.
2. Earth Research Institute, Univ. of California, Santa Barbara, CA, United States.
3. Geography, Univ. of Utah, Salt Lake City, UT, United States.
4. Univ. of Colorado, Boulder, CO, United States.

Body: The climate and hydroclimate of the Western US and Alaska are tightly coupled to their snow and ice cover. The Western US depends on mountain snowmelt for the majority of its water supply to agriculture, industrial and urban use, hydroelectric generation, and recreation, all driven by increasing population and demand. Alaskan snow and glacier cover modulate regional climate and, as with the Western US, dominate water supply and hydroelectric generation in much of the state. Projections of climate change in the Western US and Alaska suggest that the most pronounced impacts will include reductions of mountain snow and ice cover, earlier runoff, and a greater fraction of rain instead of snow.

We establish a snow and ice climatology of the Western US and Alaska using physically based MODIS Snow Covered Area and Grain size model (MODSCAG) for fractional snow cover, the MODIS Dust Radiative Forcing in Snow model (MODDRFS) for radiative forcing by light absorbing impurities in snow, and the MODIS Permanent Ice model (MODICE) for annual minimum exposed snow. MODSCAG and MODDRFS use EOS MOD09GA historical reflectance data (2000-2012) to provide daily and 8-day composites and near real time products since the beginning of 2013, themselves ultimately composited to 8-day products. The compositing method considers sensor-viewing geometry, solar illumination, clouds, cloud shadows, aerosols and noisy detectors in order to select the best pixel for an 8-day period. The MODICE annual minimum exposed snow and ice product uses the daily time series of fractional snow and ice from MODSCAG to generate annual maps.

With this project we have established an ongoing, national-scale, consistent and replicable approach to assessing current and projected climate impacts and climate-related risk in the context of other stressors. We analyze the products in the Northwest, Southwest, and Alaska/Arctic regions of the National Climate Assessment for the last decade, the nation’s hottest on record. In the Northwest we use the observations to investigate earlier snowmelt, in the Southwest drought, and in Alaska to measure the change in glacier area. We compare the MODIS retrievals to a time series of AVIRIS retrievals at higher spatial resolution spanning 289km^2 and 61km^2 in the California’s Sierra Nevada and Colorado’s Senator Beck Basin. We continue to nest specific investigations of regions and topics that have high priority due to existing or anticipated climate stresses, generally in the context of a variety of other concerns.

Final ID: C21D-0685

Influence of the sea-ice edge on the Arctic nearshore environment

K. R. Barnhart;[1, 2]; *I. Overeem;*[2]; *R. S. Anderson;*[1, 2];
1. Department of Geological Sciences, University of Colorado-Boulder, Boulder, CO, United States.
2. INSTAAR, University of Colorado at Boulder, Boulder, CO, United States.

Body: Coasts form the dynamic interface of the terrestrial and oceanic systems. In the Arctic, and in much of the world, the coast is a zone of relatively high population, infrastructure, biodiversity, and ecosystem services. A significant difference between Arctic and temperate coasts is the presence of sea ice. Sea ice influences Arctic coasts in two main ways: (1) the length of the sea ice-free season controls the length of time over which nearshore water can interact with the land, and (2) the sea ice edge controls the fetch over which storm winds can blow over open water, resulting in changes in nearshore water level and wave field. The resulting nearshore hydrodynamic environment impacts all aspects of the coastal system. Here, we use satellite records of sea ice along with a simple model for wind-driven storm surge and waves to document how changes in the length and character of the sea ice-free season have impacted the nearshore hydrodynamic environment.

For our sea ice analysis we primarily use the Bootstrap Sea Ice Concentrations from Nimbus-7 SMMR and DMSP SSM/I-SSMIS. We make whole-Arctic maps of sea ice change in the coastal zone. In addition to evaluating changes in length of the sea ice-free season at the coast, we look at changes segmented by azimuth. This allows us to consider changes in the sea ice in the context of the wind field.

For our storm surge and wave field analysis we focus on the Beaufort Sea region. This region has experienced some of the greatest changes in both sea ice cover and coastal erosion rates in the Arctic and is anticipated to experience significant change in the future. In addition, the NOAA ESRL GMD has observed the wind field at Barrow since extends to 1977. In our past work on the rapid and accelerating coastal erosion, we have shown that one may model storm surge with a 2D numerical bathystrophic model, and that waves are well represented by the Shore Protection Manual methods for shallow-water fetch-limited waves. We use these models to explore the effect of increasing fetch on water level set up and wave generation. As increasing the fetch is one of the main effects of the changing sea ice cover, this allows us to connect changes in the sea ice cover to changes in the nearshore hydrodynamic environment. The long wind record allows for us to investigate changes in extreme wind and associated storm events.

Preliminary analysis of Barrow and Drew Point indicate that at Drew Point the sea ice-free season has expanded by ~17 days/decade while at Barrow it has expanded by ~22 days/decade. We find the increase in the number of days when the sea ice edge is far away from the coast makes up a large proportion of the total increase in the duration of the sea ice-free season. For these days the sea ice edge does not provide a limit on the fetch over which water level set up and waves are generated.

Final ID: EP21A-01

Barriers on the Brink? Interactions Between Biological and Physical Processes Lead to Bistability and the Potential for Rapid Response to Gradually Changing Conditions ***(Invited)***

L. J. Moore; [1]; *O. Duran Vinent;* [2];
1. Department of Geological Sciences, University of North Carolina-Chapel Hill, Chapel Hill, NC, United States.
2. MARUM—Center for Marine Environmental Sciences, University of Bremen, Bremen, Germany.

Body: Barrier islands and their habitats are especially sensitive to changing environmental conditions. As sea level rises, storm intensity increases and plant species composition changes, interactions among biological and physical processes will play a critical role in determining how barrier islands will evolve. Within a new conceptual framework, islands tend to exist in one of two primary states. “Low-elevation” islands have little relief above sea level and are dominated by external processes, responding quickly on short time scales to changes in forcing (e.g., storms, sea level rise, etc.), migrating rapidly and generally being low in ecological diversity and productivity. In contrast, “high-elevation” islands are less vulnerable to storms, tend to be dominated by internal processes (e.g., sand trapping by vegetation), require long time periods to respond to changes in forcing, migrate slowly (if at all) and host a range of plant species and morphological environments including shrubs, small trees and vegetated secondary and tertiary dunes with intervening swales. The continued existence of barrier island landforms will depend on the degree to which islands can maintain elevation above sea level while also responding to changes in forcing by migrating landward.

Using a new model that simulates the co-evolution of island topography and vegetation, we demonstrate that barrier islands can undergo rapid deterioration in response to gradual changes in forcing. Model simulations indicate that once the ratio between the time required for island vegetation to re-establish after a storm and the time between storms becomes greater than 1, barrier islands become bistable. Simulations and observations indicate that once islands enter this regime, strong storms can trigger a shift from a high-elevation state (resistant to storms) to a low-elevation state (prone to storm overwash). At this point, the probability of returning to the high-elevation state decreases exponentially as a function of increasing storm frequency, rising sea level and physical and biological factors that slow dune formation. Such rapid—and potentially permanent—shifts in island state have the potential to initiate changes across the broader coastal system via connections to adjacent marsh and bay environments.

Final ID: GC21B-0831

Lake Storage Measurements For Water Resources Management: Combining Remotely Sensed Water Levels and Surface Areas

G. R. Brakenridge; [1]; *C. M. Birkett;* [2];
1. CSDMS/INSTAAR, University of Colorado, Boulder, CO, United States.
2. ESSIC, University of Maryland, College Park, MD, United States.

Body: Presently operating satellite-based radar altimeters have the ability to monitor variations in surface water height for large lakes and reservoirs, and future sensors will expand observational capabilities to many smaller water bodies. Such remote sensing provides objective, independent information where in situ data are lacking or access is restricted. A USDA/NASA (http://www.pecad.fas.usda.gov/cropexplorer/global_reservoir/) program is performing operational altimetric monitoring of the largest lakes and reservoirs around the world using data from the NASA/CNES, NRL, and ESA missions. Public lake-level products from the Global Reservoir and Lake Monitor (GRLM) are a combination of archived and near real time information. The USDA/FAS utilizes the products for assessing international irrigation potential and for crop production estimates; other end-users study climate trends, observe anthropogenic effects, and/or are are involved in other water resources management and regional water security issues. At the same time, the Dartmouth Flood Observatory (http://floodobservatory.colorado.edu/), its NASA GSFC partners (http://oas.gsfc.nasa.gov/floodmap/home.html), and associated MODIS data and automated processing algorithms are providing public access to a growing GIS record of the Earth's changing surface water extent, including changes related to floods and droughts. The Observatory's web site also provide both archival and near real time information, and is based mainly on the highest spatial resolution (250 m) MODIS bands. Therefore, it is now possible to provide on an international basis reservoir and lake storage change measurements entirely from remote sensing, on a frequently updating basis. The volume change values are based on standard numerical procedures used for many decades for analysis of coeval lake area and height data. We provide first results of this combination, including prototype displays for public access and data retrieval of water storage volume changes. Ground-based data can, in some cases, test the remote sensing accuracy and precision. Data accuracy requirements vary for different applications: reservoir management for flood control, agriculture, or power generation may need more accurate and timely information than (for example) regional assessments of water and food security issues. Thus, the long-term goal for the hydrological sciences community should be to efficiently mesh both types of information and with as extensive geographic coverage as possible.

Final ID: GC21C-0847

Modeling wildfire and hydrologic response to global climate change using the Landlab modeling environment

J. M. Adams; [1]; *N. M. Gasparini;* [1]; *G. E. Tucker;* [2]; *E. Istanbulluoglu;* [3]; *E. Hutton;* [4]; *D. E. Hobley;* [2]; *S. NUDURUPATI;* [3];

1. Department of Earth and Environmental Sciences, Tulane University, New Orleans, LA, United States.
2. CIRES and Department of Geological Sciences, University of Colorado, Boulder, CO, United States.
3. Department of Civil and Environmental Engineering, University of Washington, Seattle, WA, United States.
4. Commununity Surface Dynamics Modeling System (CSDMS), University of Colorado, Boulder, CO, United States.

Body: Climate change presents new challenges in modeling surface processes across landscapes that are prone to wildfire. Historical recurrence intervals of wildfire and precipitation must be adapted to account for changes in climate. Warming temperatures have already been linked to shorter winters, smaller volumes of snowmelt, and lower soil moisture content, all of which can contribute to more frequent fires. As fire and precipitation distributions change, the magnitude of fluvial erosion in burned landscapes may change dramatically. Fluvial erosion driven by large precipitation events post-fire can threaten property, infrastructure and human life in the short-term, and potentially impact long-term landscape evolution. Understanding post-fire landscape response across multiple time scales can be accomplished through numerical modeling of fire and rainfall events and the resulting stream flow across a landscape. This study uses the Landlab modeling environment to explore possible fire and precipitation scenarios that could lead to significant post-fire landscape change. Landlab is a plug-and-play model that is designed to be highly flexible in order to address a wide range of scientific questions. This study links together a stochastic fire generator, stochastic storm generator, and overland flow module to explore scenarios that may cause significant flow in the one-year period following a high-severity fire. Post-fire landscapes have been observed to be particularly vulnerable to fluvial erosion during this period. The parameters in the fire and rainfall generator are varied to test whether erosion-inducing precipitation events will increase in frequency and severity as climate changes. We analyze potential scenarios in which fire and storm recurrence change with the climate. Three test cases are explored: increasing fire recurrence while holding the parameters of the precipitation distribution constant; increasing the recurrence of precipitation events while holding the fire recurrence parameter constant; and increasing both event frequencies. In all cases, we explore the number of times in a 100-year period that flow events large enough to cause significant fluvial erosion occur in the critical one-year post-fire period. We test the scenarios on the topography of the Spring Creek watershed, which experienced significant erosion following the 1996 Buffalo Creek fire.

Final ID: H21C-1057

Ensemble Kalman Filter data assimilation for the TerrSysMP fully-coupled hydrologic – land surface – atmospheric modeling system

J. L. Williams; [1]; *P. Shrestha;* [1]; *M. Sulis;* [1]; *C. Simmer;* [1];

1. Meteorological Institute, University of Bonn, Bonn, Germany.

Body: Research in hydrometeorology has demonstrated repeatedly that atmospheric models benefit from detailed formulations of the land surface. By treating the land surface not simply as a boundary condition, but as a dynamic coupled system, a weather model can generate better forecasts. Further improvements to a regional weather model forecast can be realized by periodically incorporating observed data into the model's calculations. There are several methods available for assimilating observations into forecast models including the Ensemble Kalman Filter (EnKF), a statistical technique using an error covariance matrix derived from a model ensemble to dynamically adjust the model to observations as it advances. For this work, we apply the EnKF functionality included in the Data Assimilation Assimilation Research Testbed (DART), a collection of data assimilation tools maintained at the National Center for Atmospheric Research, to the TerrSysMP system, an integrated modeling system which couples the COSMO regional weather forecasting and climate model with the Community Land Model and the ParFlow hydrologic model. This generalized data assimilation tool allows observations of variables in any component of the subusurface – land surface – atmosphere system to be incorporated into the overall error covariance matrix thus guiding the development of quantities that define the model state. Two sets of verification tests are used to evaluate the effects of assimilating individual observation types through the TerrSysMP-DART system in idealized simulations. In the first set, synthetic observations of soil moisture, latent heat flux and temperature show how assimilation of data in one component of the system affect model outputs in another. In the second, precipitation observations are assimilated to evaluate the effectiveness of constraining a highly uncertain variable on improving the forecast as a whole.

Final ID: H21D-1091

Anomalous Sediment Mixing by Bioturbation

K. R. Roche; [1]; *A. F. Aubeneau;* [2]; *M. Xie;* [1]; *A. I. Packman;* [1];
1. Civil and Environmental Engineering, Northwestern University, Evanston, IL, United States.
2. Civil and Environmental Engineering, University of Notre Dame, South Bend, IN, United States.

Body: Bioturbation, the reworking of sediments by animals and plants, is the dominant mode of sediment mixing in low-energy environments, and plays an important role in sedimentary biogeochemical processes. Mixing resulting from bioturbation has historically been modeled as a diffusive process. However, diffusion models often do not provide a sufficient description of sediment mixing due to bioturbation. Stochastic models, such as the continuous time random walk (CTRW) model, provide more general descriptions of mixing behavior that are applicable even when regular diffusion assumptions are not met.

Here we present results from an experimental investigation of anomalous sediment mixing by bioturbation in freshwater sediments. Clean and heavy-metal-contaminated sediments were collected from Lake DePue, a backwater lake of the Illinois River. The burrowing worm species Lumbriculus variegatus was introduced to homogenized Lake DePue sediments in aerated aquaria. We then introduced inert fine fluorescent particles to the sediment-water interface. Using time-lapse photography, we observed the mixing of the fluorescent particles into the sediment bed over a two-week period. We developed image analysis software to characterize the concentration distribution of the fluorescent particles as a function of sediment depth, and applied this to the time-series of images to evaluate sediment mixing. We fit a one-dimensional CTRW model to the depth profiles to evaluate the underlying statistical properties of the mixing behavior.

This analysis suggests that the sediment mixing caused by L. variegatus burrowing is subdiffusive in time and superdiffusive in space. We also found that heavy metal contamination significantly reduces L. variegatus burrowing, causing increasingly anomalous sediment mixing. This result implies that there can be important feedbacks between sediment chemistry, organism behavior, and sediment mixing that are not considered in current environmental models.

Final ID: H21H-1156

Monitoring Network Design for Discriminating and Reducing Models in Bayesian Model Averaging Paradigm

H. V. Pham; [1]; *F. T. Tsai;* [1];

1. Civil and Environmental Engineering, Louisiana State University, Baton Rouge, LA, United States.

Body: Bayesian model averaging (BMA) is often adopted to quantify model prediction and uncertainty using multiple models generated from various sources of uncertainty. Due to the lack of data and knowledge, the number of models with non-dominant posterior model probabilities can be overwhelming. Conducting prediction and uncertainty analysis using a great deal of computationally intensive simulation models (e.g., groundwater models) can become intractable under the BMA framework. Moreover, prediction results using the BMA can be useless when prediction uncertainty is very high.

This study implements a monitoring network design under the BMA framework to discriminate groundwater models and in turn reduce the number of models. The posterior model probabilities are re-evaluated by using BMA prediction as “future observation data” and historical data. Given a design criterion of posterior model probability (e.g. 85%), the monitoring network design aims to find the optimal number and location of monitoring wells at existing wells for continuous observation. If using existing wells cannot achieve the design criterion, then exploration of new monitoring well location is necessary. Once the design criterion is met, other models will be discriminated from the best model. Between-model variance will be significantly reduced.

We use the monitoring network design to discriminate 18 complex groundwater models that include the “1,200-foot”, “1,500-foot”, and “1,700-foot” sands in the Baton Rouge area, southeastern Louisiana. The sources of uncertainty that creates the groundwater models are from hydrostratigraphic architecture, fault permeability architecture, and boundary conditions. To speed up model calibration, we develop a parallel version of CMA-ES and implement it to SuperMike II cluster at Louisiana State University.

Results show that in the model calibration period from 1975 to 2010, eleven models have posterior model probabilities ranging from 3.5% to 17.4%. The purpose of the current monitoring network design is to determine optimal locations to collect monthly groundwater head data from 2011 to 2015 in order to maximize the posterior model probability of the best model given a number of existing USGS monitoring wells. Considering only two USGS monitoring wells, EB-918 and WBR-5 are found to be the two best wells, and the best model has posterior model probability of 39.6%. The second best model has posterior model probability of 22.9%. Considering five USGS monitoring wells, EB-782B, EB-917, EB-918, EB-807A and WBR-5 are found to be the best wells. The posterior model probability for the best model increases to 57.6%. By using all 21 USGS monitoring wells, the best model has posterior model probability of 85.9%, which dominates that of 9.4% and 3.6% for the second and the third best model, respectively.

In conclusion, the proposed monitoring network design is able to discriminate and reduce groundwater models as well as reduce prediction uncertainty under the BMA framework.

Final ID: H21I-1182

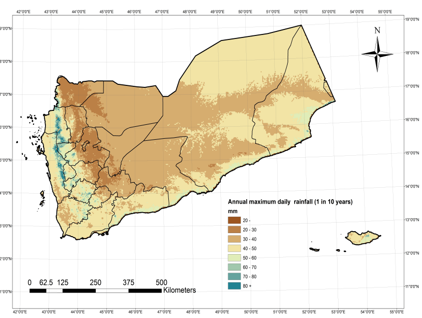
Rainfall and temperature estimation for a data sparse region

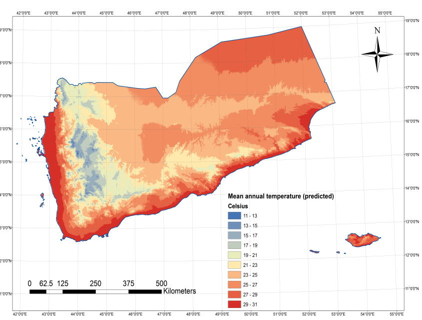
D. Yu; [1]; *R. L. Wilby;* [1];
1. Loughborough University, Loughborough, United Kingdom.

Body: Development agencies often face difficult decisions about where and how to prioritise climate risk reduction measures. These tasks are especially challenging in data sparse regions with few meteorological stations, complex topography and extreme weather events. At the same time, these regions are also often highly vulnerable to climate risks.

In this study, we blend surface meteorological observations, remotely sensed (TRMM and NDVI) data, physiographic indices, and regression techniques to produce gridded maps of annual mean precipitation and temperature, as well as parameters for site-specific, daily weather generation in Yemen. Maps of annual means were cross-validated and tested against independent observations. These replicated known features such as peak rainfall totals in the Highlands and western escarpment, as well as maximum temperatures along the coastal plains and interior. The weather generator reproduced daily and annual diagnostics when run with parameters from observed meteorological series for a test site at Taiz. However, when run with interpolated parameters, the frequency of wet-days, mean wet-day amount, annual totals and variability were underestimated. Stratification of sites for model calibration improved representation of growing season rainfall totals.

We conclude that local terrain and remotely sensed variables can be used to infer annual mean temperature and precipitation across the most populous, south-west area of Yemen. Important features of the daily and seasonal weather can also be simulated at the site scale, but more rigorous validation is ultimately constrained by lack of data. Future work should focus on a wider range of model inputs to better discriminate controls exerted by different landscape units.





Final ID: H21J-1199

DOES STORMWATER MANAGEMENT MAKE A DIFFERENCE?

A. J. Miller; [1, 3]; *C. Welty;* [2, 3]; *G. A. Lindner;* [1, 3];
1. Geography & Environmental Systems, UMBC, Baltimore, MD, United States.
2. Chemical, Biochemical and Environmental Engineering, UMBC, Baltimore, MD, United States.
3. CUERE, UMBC, Baltimore, MD, United States.

Body: The fundamental purpose of stormwater management (SWM) is to “bend” the flow duration curve, i.e. to redistribute the arrival times of runoff such that flashy peak flows induced by urban development will be reduced in magnitude and frequency, with corresponding augmentation of base flow. Because there are so many variables that affect watershed hydrologic response to precipitation events, it is difficult to determine the extent to which SWM is truly effective at the watershed scale. The approach of this study is to compare the hydrologic behavior of small urban watersheds that are located in close proximity to one another, with comparable drainage area, geology, and percent impervious cover and with significant differences in the percent of drainage area controlled by SWM facilities. The Gwynns Falls watershed in the Baltimore metropolitan area offers several opportunities for comparative analysis of gaged watersheds with accompanying precipitation records. Scotts Level (drainage area = 8.6 km2, 32.9% impervious, 10.5% SWM) and Gwynns Falls near Delight (drainage area = 10.5 km2, 28.5% impervious, 42.7% SWM) are located in close proximity with similar geology. We also compare three small headwater tributaries in the Dead Run watershed (DR1: 1.2 km2, 67% impervious, 48.1% SWM; DR2: 1.9 km2, 49.1% impervious, 30.5% SWM; DR5: 1.6 km2, 45.9% impervious, 2.9% SWM) and two intermediate-scale tributaries (DR3: 5.8 km2, 55.2% impervious, 38.4% SWM; DR4: 5.1 km2, 47.8% impervious, 7.5% SWM).

Analyses include paired-watershed comparisons of cumulative monthly runoff and precipitation; flow duration curves for unit runoff rates; and quickflow hydrographs associated with individual precipitation events, as well as characteristic shape of unit hydrograph response to short-duration pulse rainfall. Preliminary results suggest that runoff ratios are more sensitive to percent impervious cover than to percent control by SWM. Flow duration curves show greater separation between paired watersheds at low flow than at higher flow; some comparisons suggest that SWM may augment base flow but others do not. In some cases the differences at the high-flow end of the spectrum are consistent with the anticipated effects of SWM coverage but differences among flow duration curves at the 1% and 0.1% exceedence probability do not suggest that SWM exerts a controlling influence on watershed response. Timing and magnitude of peak flow response to precipitation events also do not appear highly sensitive to watershed percent SWM control. These findings may be specific to the more traditional types of SWM dominant in the study watersheds. The presentation will include comparison with other sites where newer, advanced SWM structures are used to divert most surface runoff to infiltration.

Final ID: OS21A-1599

Coring Methane Hydrate by using Hybrid Pressure Coring System of D/V Chikyu

Y. Kubo; [1]; *Y. Mizuguchi;* [1]; *F. Inagaki;* [2]; *N. Eguchi;* [1]; *K. Yamamoto;* [3];
1. CDEX, JAMSTEC, Yokohama, Japan.
2. KCC, JAMSTEC, Kochi, Japan.
3. JOGMEC, Tokyo, Japan.

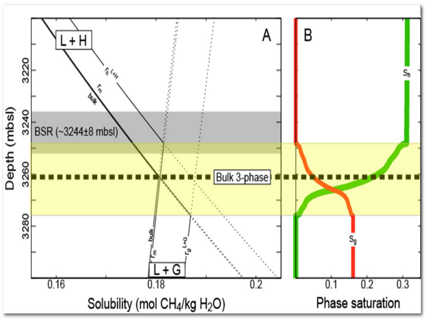
Body: Pressure coring is a technique to keep in-situ conditions in recovering sub-seafloor sediment samples, which are potentially rich in soluble or hydrated gas. In regular core sampling, gas fractions are easily lost through the changes in the pressure and temperature during core recovery, and it has significant impact on the chemical components of the sample. Rapid degassing may also cause critical damages of original structures. To study original characteristics of gaseous sub-seafloor sediment, a new Hybrid Pressure Coring System (Hybrid PCS) was developed for the D/V Chikyu operation by adapting some of the existing pressure sampling technologies. Hybrid PCS is composed of three main parts: top section for the wireline operation, middle section for the accumulator and pressure controlling system, and the bottom section for the autoclave chamber. The design concept is based on that of Pressure Core Sampler used in Ocean Drilling Program, and of Pressure Temperature Core Sampler (PTCS) and Non-cooled PTCS of Japan Oil, Gas and Metals National Corporation (JOGMEC). Several modifications were made including that on the ball valve, which operates to close the autoclave after coring. The core samples are 51 mm in diameter and up to 3.5 m in length. The system is combined with the Extented Shoe Coring System on the Chikyu and best suited for coring of semi-consolidated formation up to about 3400 m from the sea level. Sample autoclave is compatible with Pressure Core Analysis and Transfer System (PCATS) of Geotek Ltd for sub-sampling and analysis under in-situ pressure. The analysis in PCATS includes X-ray CT scan and core logging with P-wave velocity and gamma density. Depressurization provides accurate volume of gas and its sub-sampling.
Hybrid PCS was first tested during the Chikyu Exp. 906 at a submarine mud-volcano in the Nankai Trough. A 0.9 m of hydrate rich material was recovered from the summit (water depth: 2000 m) and the intact hydrate structure was observed by X-ray CT scan. Hybrid PCS was also used in the following JOGMEC methane hydrate cruise, resulting in the good recovery of methane hydrate-bearing cores (approx. 69%).

Final ID: OS21A-1620

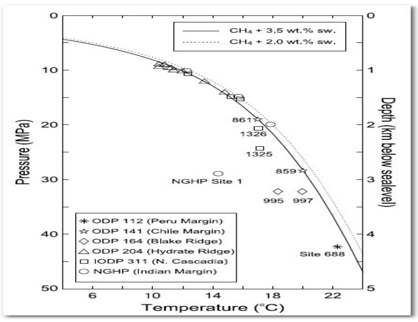
Capillary effects on gas hydrate three-phase stability in marine sediments

X. Liu; [1]; *P. B. Flemings;* [2];
1. Anadarko Petroleum Corporation, The Woodlands, TX, United States.
2. Jackson School of Geosciences, The University of Texas at Austin, Austin, TX, United States.

Body: We study the three-phase (Liquid + Gas + Hydrate) stability of the methane hydrate system in marine sediments by considering the capillary effects on both hydrate and free gas phases. The aqueous CH4 solubilities required for forming hydrate (L+H) and free gas (L+G) in different pore sizes can be met in a three-phase zone. The top of the three-phase zone shifts upward in sediments as the water depth increases and the mean pore size decreases. The thickness of the three-phase zone increases as the pore size distribution widens. The top of the three-phase zone can either overlie the three-phase stability depth at deepwater Blake Ridge or underlie the three-phase stability depth at Hydrate Ridge in shallow water. Our model prediction is compatible with worldwide observations that the bottom-simulating reflector is systematically shifted upward relative to the bulk equilibrium depth as water depth (pressure) is increased.



The gas hydrate and free gas saturations of the three-phase zone at Blake Ridge



Comparison of the globally compiled BSR temperatures with the three-phase equilibrium curves for the systems of pure CH4 + 3.5 wt.% seawater (solid line) and pure CH4 + 2.0 wt.% seawater (dotted line). The discrepancies between the observed BSR temperature and the calculated three-phase temperature are systematically larger in deep water than in shallow water.

Final ID: P21B-1736

Investigating Climate at an Inland Sea During Snowball Earth

A. J. Campbell; [1]; *C. M. Bitz;* [2]; *S. G. Warren;* [1, 3]; *E. D. Waddington;* [1];
1. Department of Earth and Space Sciences, University of Washington, Seattle, WA, United States.
2. Department of Atmospheric Sciences, University of Washington, Seattle, WA, United States.
3. Astrobiology Program, University of Washington, Seattle, WA, United States.

Body: During the Neoproterozoic, the Earth's oceans may have been completely covered with thick ice, during periods commonly called Snowball Earth events. The Snowball Earth environment would seemingly have prohibited the survival of photosynthetic eukaryotic algae; however, these organisms were alive immediately prior to and immediate subsequent to these periods. Where on a Snowball Earth, or a Snowball-like exoplanet, could photosynthetic eukaryotic algae survive? Recent research, in attempt to reconcile this paradox, has demonstrated that narrow channels connected the ocean, called inland seas, could have provided refugia for photosynthetic eukaryotic algae during Snowball Earth events. Narrow channels could have restricted the flow of ocean-derived ice, called sea glaciers, diminishing sea-glacier penetration into these channels. Provided certain climate conditions and channel geometries, this diminished sea-glacier penetration would have allowed for either open water or thin sea ice, at the far end of these channels. A channel with open water or thin sea ice would provide the conditions needed for survival of photosynthetic eukaryotic algae.

Here we test whether the climate needed to prevent sea-glacier penetration, could have existed in the special inland sea environment. Previous climate modeling of Snowball Earth has shown that tropical regions would have likely been warmer than the global average and would have experienced net sublimation at the surface. An inland sea located in the tropics would be surrounded by land that is bare and free from snow, while the inland sea itself would be either ice-covered or open water. With these conditions the inland sea would likely have a high albedo, while the surrounding bare land, would have a lower albedo. This albedo contrast could cause the climate over an inland sea to be warmer than the climate over the ice-covered ocean at the same latitude. We calculate the surface temperature and sublimation rate at an inland sea using the Community Earth System Model. By using idealized continent configurations and surface conditions and by adjusting the position and size of the inland sea, we establish the range and probability of achievable inland-sea climates in order to determine if inland seas could have been viable refugia for photosynthetic eukaryotic algae during Snowball Earth Events.

Final ID: PA21B-1870

Deterministic or Probabilistic - Robustness or Resilience: How to Respond to Climate Change?

H. Plag; [1]; *D. Earnest;* [2]; *S. Jules-Plag;* [3];
1. Climate Change and Sea Level Rise Initiative, Old Dominion Univ, Norfolk, VA, United States.
2. Political Science and International Studies, Old Dominion University, Norfolk, VA, United States.
3. School of Architecture and Planning, University of the Witwatersrand, Johannesburg, South Africa.

Body: Our response to climate change is dominated by a deterministic approach that emphasizes the interaction between only the natural and the built environment. But in the non-ergodic world of unprecedented climate change, social factors drive recovery from unforeseen Black Swans much more than natural or built ones. Particularly the sea level rise discussion focuses on deterministic predictions, accounting for uncertainties in major driving processes with a set of forcing scenarios and public deliberations on which of the plausible trajectories is most likely. Science focuses on the prediction of future climate change, and policies focus on mitigation of both climate change itself and its impacts.

The deterministic approach is based on two basic assumptions: 1) Climate change is an ergodic process; 2) The urban coast is a robust system. Evidence suggests that these assumptions may not hold. Anthropogenic changes are pushing key parameters of the climate system outside of the natural range of variability from the last 1 Million years, creating the potential for environmental Black Swans. A probabilistic approach allows for non-ergodic processes and focuses more on resilience, hence does not depend on the two assumptions.

Recent experience with hurricanes revealed threshold limitations of the built environment of the urban coast, which, once exceeded, brought to the forefront the importance of the social fabric and social networking in evaluating resilience. Resilience strongly depends on social capital, and building social capital that can create resilience must be a key element in our response to climate change. Although social capital cannot mitigate hazards, social scientists have found that communities rich in strong norms of cooperation recover more quickly than communities without social capital. There is growing evidence that the built environment can affect the social capital of a community, for example public health and perceptions of public safety. This suggests an intriguing hypothesis: disaster risk reduction programs need to account for whether they also facilitate the public trust, cooperation, and communication needed to recover from a disaster.

Our work in the Hampton Roads area, where the probability of hazardous flooding and inundation events exceeding the thresholds of the infrastructure is high, suggests that to facilitate the paradigm shift from the deterministic to a probabilistic approach, natural sciences have to focus on hazard probabilities, while engineering and social sciences have to work together to understand how interactions of the built and social environments impact robustness and resilience. The current science–policy relationship needs to be augmented by social structures that can learn from previous unexpected events. In this response to climate change, science does not have the primary goal to reduce uncertainties and prediction errors, but rather to develop processes that can utilize uncertainties and surprises to increase robustness, strengthen resilience, and reduce fragility of the social systems during times when infrastructure fails.

Final ID: PA21B-1875

What can decision makers achieve from computer simulations of environmental systems?

M. C. Hill; [1]; *D. Kavetski;* [2]; *M. P. Clark;* [3]; *M. Ye;* [4]; *M. Arabi;* [5]; *D. Lu;* [4]; *L. Foglia;* [6]; *S. Mehl;* [7];
1. USGS, Boulder, CO, United States.
2. University of Adelaide, Adelaide, SA, Australia.
3. National Center for Atmospheric Research, Boulder, CO, United States.
4. Florida State University, Tallahassee, FL, United States.
5. Colorado State University, Fort Collins, CO, United States.
6. Technical University of Darmstadt, Darmstadt, Germany.
7. California State University, Chico, CA, United States.

Body: For scientists and decision-makers to understand model predictions and their limitations, models need to be as transparent and refutable as possible. This is achieved by evaluating model fit to data, estimated parameter values, sensitivities, and uncertainty. This talk illustrates methods for evaluating model accuracy, identifying important parameters and observations, quantifying uncertainty, and identifying potential new observations. We also point out some important challenges. First, advances in computing power notwithstanding, computational runtimes remain a major constraint as environmental models become more complicated in an attempt to better capture realistic complexity, heterogeneity and non-stationarity. This constraint is often particularly restrictive given the continuing push towards computationally intensive analysis methods requiring 10,000s or more model runs. In environmental fields, where models can take a week or more per forward run, such methods are burdensome and often infeasible. Second, the relationships between the various model analysis methods and metrics in current use and in research are yet to be clearly established. This makes it difficult for research managers – and even researchers themselves – to develop strategic insights from the enormous ongoing effort to model environmental systems. In our strategy for navigating these difficulties, we suggest viewing the plethora of methods and metrics based on their objectives and computational demand, and making clear links between methods pursuing the same objectives despite starkly different theoretical backgrounds. The strategy emphasizes practical solutions as embodied in the proposed integrated use of methods that range from being computationally frugal (typically local) to demanding (typically global). We identify inexpensive diagnostics to distinguish between cases where frugal methods provide adequate and efficient insights into complex, high-dimensional models and enable systematic comparison of many alternative models and hypotheses, versus cases where more general but less computationally efficient methods are needed. Applied systematically, such an approach will eventually provide the insight needed to model environmental systems more strategically, better serving the needs of resource managers and public policy.

URL: http://wwwbrr.cr.usgs.gov/projects/GW_ModUncert/

Final ID: T21B-2545

Geodynamic modeling of the Mid-Continental Rift System: Is a mantle plume required?

R. Moucha; [1]; *T. O. Rooney;* [2]; *S. A. Stein;* [3]; *E. Brown;* [4];
1. Department of Earth Sciences, Syracuse University, Syracuse, NY, United States.
2. Department of Geological Sciences, Michigan State University, East Lansing, MI, United States.
3. Department of Earth and Planetary Sciences, Northwestern University, Evanston, IL, United States.
4. Department of Geology, Portland State University, Portland, OR, United States.

Body: The Mid-Continent Rift System (MCRS) is a 2000-km long trace of a massive igneous event that nearly split North America 1.1 billion years ago. The MCRS offers a snapshot of continental rifting and rift failure. The rift started, evolved, and terminated via a complex and not-yet-understood interplay of mantle dynamics, magmatism, and extension. In particular, details of the processes surrounding melt formation and the associated depletion of the lithospheric mantle, and re-thickening of the extended crust remain poorly constrained. To help unravel the complex history of the MCRS, we present a new geodynamic model for late Proterozoic rifting and compare a number of different extension scenarios in an effort to answer the following question: can the volume of magmas preserved in the MCRS be explained by extensional processes in the absence of a thermo-chemical mantle plume anomaly?

In the late Proterozoic, inherently higher mantle potential temperatures may have permitted rifting at lower stress levels and favored more melt formation. Therefore, the inferred volume of magma in the MCRS may not have required a plume. To explore this idea, we compare models for the evolution of a rift under different ambient mantle temperatures and radiogenic heating conditions, i.e. Phanerozoic vs. Proterozoic, and in the absence or presence of a thermal-chemical plume. Our geodynamic model of the MCRS includes a temperature dependent visco-elasto-plastic rheology in the presence of partial melt that is dynamically determined according to given rock-type, pressure and temperature. The models include a “sticky air” layer to mimic a free surface that is coupled to a surface processes model to account for erosion and sedimentation. The numerical method we use is based on the primitive variable particle-in-cell finite-difference method developed by Taras Gerya and others (e.g. Gerya, 2010). The advantage of this approach is that specific material properties are inherently traced through time negating the need for numerous high-resolution grids. Moreover, melt-extraction and the formation of a crust along with depletion and fertilization are also easily tracked.

Final ID: V21A-2698

Salt Profile in Sedimentary Deposits: an archive of past climate and tectonics

T. Sun; [1]; *H. Bao;* [2]; *M. Reich;* [3];
1. NASA Johnson Space Center, Houston, TX, United States.
2. Geology and geophysics, Louisiana State University, Baton Rouge, LA, United States.
3. Geology, Universitys of Chile, Santiago, Chile.

Body: In hyper-arid environments, paleoclimatic and paleoenvironmental studies typically evaluate paleosol-based proxies such as morphology, variation of remnant vegetations, and geochemical and isotopic signatures of minerals to reveal the plaeoclimatic changes. Limited works utilized geochemical/isotopic approaches in sedimentary deposits which barely experience pedogenic processes. The objectives of this work are to evaluate the isotopic systematics and total chemistry of salts as function of depth within unsolidated sediments in an effort to reconstruct paleoclimatic conditions of Atacama Desert. Results of this work will demonstrate techniques that can also be applied in other hyper-arid environments (e.g., Antarctica, Mars).

We report a study on a ~75 meter thick core from alluvial sedimentary deposits (Atacama Gravels) in the eastern margin of the central depression of Atacama desert, North Chile. This work combines mineralogical/geochemical/isotopic approaches to decipher the depositional conditions and the climatic conditions during and between sedimentation events. Our main focus is on the soluble sulfate, nitrate, chloride profiles through the sediments. These salt deposits likely originated from seasalts, atmospherically produced salts and/or salts from nearby evaporite deposits. The sources of salts are likely affected by offshore oceanic currents that may vary the seasalt input, or by regional tectonic or orogenic changes that may vary the terrestrial sources and their ratio with seasalt input. The outflux of the salts in these deposits are mainly due to groundwater drainage, and microbial facilitated salt consumption (e.g. sulfate reduction, denitrification), both of which are indicative of paleoclimatic conditions. Thus, the salt profile within the sediments records regional paleo-climate, global oceanic current setting, and regional tectonic activity.

Morphological and mineralogical studies show that the target "gravel" consists of two main suites of sediments with a top layer (~35 meters) of alluvial deposits with no sign of standing water, and a bottom layer (~40 meters) of possible fluvial deposits. Salt concentration profiles indicate that interaction between salt inventories in these two suites were negligible. The multiple isotope compositions (D17O, δ34S and δ18O) of sulfates show distinct depth dependent pattern with all three parameters within top layer close to those of modern surface materials, and with decreasing D17O , δ34S, and increasing δ18O within bottom layer. Furthermore, with age constraint by dating a volcanic ash layer imbedded in a top layer, the isotope data indicate that the current level of hyper-aridity of the eastern margin of the central depression has been present since at least 10Ma.

Our study and future modeling work may provide an analog for the study of martian environments, e.g. the Aeolis Mons in the center of Gale Crater, where salt enriched alluvial or aeolian deposits are likely to have been deposited under hyper-arid conditions.

Final ID: V21B-2718

Timescales of magma ascent recorded by H2O zonation in clinopyroxene

A. S. Lloyd; [1]; *T. A. Plank;* [1]; *P. Ruprecht;* [1]; *E. H. Hauri;* [2]; *W. I. Rose;* [3];

1. Dept Earth & Env Sci, Lamont Doherty Earth Obs., New York, NY, United States.
2. Dept Terrestrial Magnatism, Carnegie Inst Washington, Washington, DC, United States.
3. Dept Geological Eng & Sciences, Michigan Technological Univ, Houghton, MI, United States.

Body: Magma ascent prior to explosive eruptions occurs on timescales of minutes to hours, and so requires exceptionally fast chronometers to quantify. One promising approach involves the diffusion of water in clinopyroxene (cpx), given laboratory measurements of diffusivities on the order of 10-9.5 to 10-11.5 at temperatures appropriate for mafic magmas [1]. Previous studies have observed H2O zonation in cpx grains but this was accompanied by major element zonation, leaving open the possibility for crystal growth zonation instead of diffusive loss of water [2]. We report SIMS and EMP analyses for three cpx phenocrysts from ash samples collected in situ during the Oct 17, 1974 sub-plinian eruption of Volcán de Fuego. Concentration profiles were assessed by 5-6 measurements along ~350-450 µm transects measured perpendicular to glassy rims. The maximum H2O measured in the cores of the cpx ranges from 230-320 ppm; whereas, the measurements closest to the rim range from 80-170 ppm. Importantly, we chose grains with limited major element zonation (i.e., Mg# and Al2O3 remain relatively constant or do not co-vary with H2O concentrations).

Based on a temperature-dependent parameterization for the partition coefficient of H2O between cpx and melt that accounts for tetrahedrally coordinated Al3+ [3], cores and rims of these cpx are in equilibrium with a melt containing 2.0-2.7 wt% (core) and 0.7-1.6 wt% (rim). The maximum H2O concentration measured in olivine-hosted melt inclusions (~4.2 wt% H2O) erupted on the same day as the cpx phenocrysts [4] suggests that the cpx are not in equilibrium with the melt inclusions. The Mg# of the cpxs (73-77) fall within the range of that for the olivines (72-78) indicating that cpx and olivine were co-crystalizing and that H+ loss by diffusion has potentially occurred. Utilizing the same melt inclusion data to constrain the degassing path for the ascending magma under Fuego, we used forward models to estimate the decompression rate needed to create the observed H2O concentration profiles. Assuming that the diffusivity of water for these evolved, Fe-rich cpx is on the order of the fastest experimental measurements (10-9.5 to 10-10 m2/s [1]), we calculate decompression rates of 0.3 to 0.07 MPa/s, equivalent to an average ascent rate of 12 to 2 m/s (from 8 km depth). Varying the initial concentration of H2O in the cpx (equivalent to varying the initial depth) had no effect on the calculated decompression or ascent rates as the shorter ascent times were compensated by the shallower starting depths. These estimates are similar to those previously reported for Fuego based on H reequilibration in melt inclusions and diffusion along melt embayments [5], demonstrating the coherence of three independent chronometers that record 10-30 minutes of magma ascent prior to eruption.

[1] Woods et al, AmMin, 2000 [2] Wade et al, Geol, 2008 [3] O'Leary et al, EPSL, 2010 [4] Lloyd et al, CMP, 2013 [5] Lloyd et al, AGU, 2012

Final ID: EP21A-02

Punctuated events and long-term barrier evolution in a rising-sea-level world ***(Invited)***

A. D. Ashton; [1]; *A. C. Ortiz;* [1]; *J. Lorenzo Trueba;* [1]; *J. P. Donnelly;* [1]; *R. L. Evans;* [1];
1. Geology and Geophysics, WHOI, Woods Hole, MA, United States.

Body: Barrier coasts, both developed and undeveloped, face historically unprecedented rates of sea-level rise over the coming century—sustained rates not seen since the last deglaciation. Understanding the future trajectory of barriers requires an integrated accounting of three key sediment transport pathways: alongshore transport gradients, on-offshore sediment transport across the wave-affected shoreface, and onshore sediment transport, generally by storm overwash. Recent modeling results suggest that long-timescale interactions between overwash and the deeper shoreface can explain two mechanisms of barrier drowning: height drowning where overwash fails to maintain barrier height and width drowning, where rapid overwash results in excessive roll-over and abandonment of the shoreface. Furthermore, a more complex mode of discontinuous barrier retreat can arise even with constant system forcing, characterized by rapid barrier roll-over and in-place aggradation. These findings, however, are based on an assumption of long-term sustained overwash processes, and while this morphodynamic model captures fundamental system feedbacks absent from morphokinematic models, it overlooks the role of storms on coastal evolution.
Our approach begins with application of classic geomorphic analysis of the frequency and magnitude of morphologically significant events, focusing on sites along the Gulf and Atlantic coasts of the US. Analyzing 20-year hindcast of wave data, we find that storms are not dominant agents of alongshore sediment transport, and, although infrequent high-energy events can play a significant role in cross-shore transport, the return interval of morphologically significant events is typically less than two years. Overwash generally depends on storms, and statistically characterizing the frequency and magnitude of hurricane events requires longer data series; using synthetic data sets of tens of thousands of storm strikes allows us to characterize the far less frequent morphologically significant hurricane events. As high-impact events often occur with return intervals greater that once a decade or century, modeling centennial-scale barrier evolution requires a stochastic approach coupled with a mechanistic understanding of long-term shoreface evolution. With characteristic timescales and process rates resolved, we update a model of long-term barrier evolution to include storm-driven overwash and apply general results to characteristic environments with varied forcing regimes. These range from Gulf coast sites with limited storm wave effects but significant storm overwash, to Atlantic coast sites whose wave and overwash regimes are both affected by intermittent storms. Ensemble model results can then be used to understand a potential range of future barrier evolution for different sea-level rise scenarios. We find that preexisting barrier geometries play a significant role in storm response; accordingly, coupling profiles alongshore allows us to investigate the role of alongshore variability on long-term barrier evolution.

Final ID: H21K-03

Assessing Resilience of Intensively Managed Landscapes through Feedbacks

A. E. Goodwell; [1]; *P. Kumar;* [1];
1. University of Illinois at Urbana-Champaign, Urbana, IL, United States.

Body: Intensively managed landscapes such as those of the United States agricultural Midwest are hypothesized to be on a different trajectory than natural landscapes in terms of ecosystem processes and landscape evolution. Process networks provide a method to analyze system states as patterns of couplings and feedbacks. It has been shown using FLUXNET data that variables such as precipitation, soil temperature, soil moisture, latent heat flux, and net ecosystem exchange may exhibit synchronized relationships, time-lagged forcing behavior, or feedbacks. The strength of these couplings weakens or breaks down with environmental extremes such as drought. This study compares couplings in measured fluxes observed using a process network approach with couplings of modeled ecohydrological variables. MLCan is a multi-layer canopy-air exchange model that uses FLUXNET tower climate and flux data as input to simulate leaf uptake, stomatal conductance, photosynthesis, soil hydrology, and other descriptors of ecosystem state. This model has been used to assess vegetation acclimation to climate change, altered hydrology due to biofuel crops, and root hydraulic redistribution in different ecosystems. For this study, MLCan is used to simulate conditions for the 2005 growing season at the location of the Bondville, IL flux tower. A process network is defined with nodes representing key measured and simulated variables including streamflow at a nearby gage, precipitation, radiation, soil moisture, leaf uptake, and nutrient fluxes. Couplings are identified using mutual information and transfer entropy statistics. This study effectively validates whether simulated ecosystem state variables demonstrate information flow to the same extent as measured data. The inclusion of streamflow introduces a spatial element to the process network approach that begins to link processes with topography and land use in the watershed. Analysis of coupling types and strengths can be applied to assess resilience characteristics of intensively managed versus natural landscapes.

Final ID: ED21B-05

Aiding cities in their work on climate change adaptation

P. Hamilton; [1];
1. Science Museum of Minnesota, St Paul, MN, United States.

Body: Urban areas around the world are at the frontlines of climate change because of their enormous aggregate populations and because of their vulnerability to multiple climate change stressors. Half of our planet's 7.1 billion inhabitants currently reside in cities with six billion people projected to call cities home by 2050. In the U.S. and much of the rest of the world, cities are warming at twice the rate of the planet. Superimposed on urban climate changes driven by global warming are the regional effects of urban heat domes driven by large differences in land use, building materials, and vegetation between cities and their rural surroundings. In megacities – those with populations exceeding 10 million people – such as Tokyo – urban heat domes can contribute to daytime temperatures that soar to more than 11°C higher than their rural surroundings. In addition, the localized warming can alter patterns of precipitation in metropolitan regions and perhaps even influence the frequency and severity of severe weather.

Municipal officials need to accelerate their efforts to prepare and implement climate change adaptation strategies but what are the institutions that can help enable this work? Informal science education centers can play vital roles because they are overwhelmingly in urban settings and because they can act as 'competent outsiders.' They are neither responsible for conducting climate change research nor accountable for implementing public policies to address climate change. They instead can play an essential role of ensuring that solid science informs the formulation of good practices and policies. It is incumbent, therefore, for informal science education centers to accelerate and enhance their abilities to help translate scientific insights into on-the-ground actions. This session will explore the potential roles of informal science education centers to advance climate change adaptation through a review of the urban climate change education initiatives for municipal officials that the Science Museum of Minnesota has implemented over the past two years.

Final ID: B21G-06

A general framework for incorporating heterogeneity of aquatic ecosystems into aquatic network models to understand biogeochemical fluxes *(Invited)*

W. M. Wollheim; [1, 2]; *R. Stewart;* [2]; *K. R. Sheehan;* [1, 2];

1. Natural Resources and the Environment, Univ New Hampshire, Durham, NH, United States.
2. Earth Systems Research Center, Univ New Hampshire, Durham, NH, United States.

Body: Aquatic networks comprise a range of aquatic ecosystem types linked by flowing water. Quantifying how entire aquatic networks function in the landscape requires an understanding of the abundance, size, distribution, linkages and dominant biological processes in each. Models accounting for each of these factors at network scales are only in their infancy. We propose a broad modeling framework that can be applied to integrate aquatic heterogeneity to explore biogeochemical questions at various spatial scales. The framework applies the concept of two transient storage zones embedded within an advective channel network, where heterogeneity is accounted for by parameterizing the surface transient storage according to whether side pools, backwaters, fluvial wetlands, floodplains, ponds, or lakes are present within elements of a topological river network. A parsimonious set of parameters that describe connectivity and reactivity is needed to account for the varying role of each aquatic ecosystem type. Identification of these parameters, and the sensitivities that each exert on network scale processes, could help prioritize field research and reporting of results in order to inform the modeling community. We present an example that explores nitrogen removal by entire aquatic networks, but the approach is applicable for aquatic processes in general, including carbon respiration and metabolism.

Final ID: EP21A-07

Terrestrial laser scanning of anthropogenic beach berms for urban flood defense

B. F. Sanders; [1]; *J. Schubert;* [1]; *T. Gallien;* [2]; *M. Shakeri Majd;* [1];
1. Univ California Irvine, Irvine, CA, United States.
2. Scripps Institution of Oceanography, La Jolla, CA, United States.

Body: Globally, over 20 million people reside below present high tide levels and as many as 200 million are vulnerable to flooding during extreme events. In California, coastal flooding is driven by a combination of factors such as high astronomical tides, waves, storm surge, and other fluctuations such as those caused by the El Nino Southern Oscillation (ENSO), and climate change is likely to exacerbate those factors testing the limits of coastal flood defenses. Beaches provide natural flood protection during storms by mitigating the effects of high water levels and wave runup, and a process known as beach berming can be used to temporarily enhance the ability of beaches to withstand overtopping. In cases where beaches serve as primary protection for development, anthropogenic berms may represent an attractive management option for temporarily addressing future flood hazards.

Terrestrial laser scanning (TLS) or lidar has emerged as a valuable technology for capturing the three dimensional geometry of complex surfaces and objects, and in the context of coastal flood prediction mobile TLS could prove invaluable by quickly mapping beach topography before an imminent flood threat and reducing associated uncertainties in coastal flood forecasting systems. The research presented here highlights the results of a field campaign to document the initial conditions and dynamic erosion of anthropogenic berms using TLS. On three occasions in February and March of 2012, a prototype berm was constructed on the foreshore of the city of Newport Beach, CA at low tide, and was scanned to document its initial shape, and then scanned in near-continuous fashion with the rising tide to characterize its subsequent erosion. The purpose is two-fold: (1) to measure the performance of the TLS system relative to accuracy and assess strengths and drawbacks that are likely to bear on the suitability of this technology to support flood prediction as described above, and (2) to develop a better understanding of how typical southern California berms respond to hydrodynamic stresses (rising tides and waves). Near continuous scanning leads to a 4D model (3 spatial coordinates plus time) of the berm that documents its gradual erosion, including a characterization of how the berm crest and volume change over time, which offers primary data on how anthropogenic berms can be expected to perform during a flood event.

Results reveal that TLS, when referenced to a temporary bench mark leveled to within 1.5 cm by RTK-GPS, achieves an absolute vertical accuracy of less than 3 cm (VRMSE) with a scan resolution of 10 cm or finer. In regards to berm morphodynamics, a near-linear increase in tide elevation over two hours caused a non-linear lowering of the berm crest with time, characterized first by a gradual and then by a rapid change. The overall erosion of the berm correlates best with the swash elevation in relation to the berm toe elevation. Across the three berm experiments, erosion begins when the swash elevation is about 13% below the toe of the berm, relative to the initial berm height, and the berm is overtopped when the swash elevation is 25-30% of the initial berm height and the berm is 70-75% eroded by volume.
URL: sanders.eng.uci.edu

Final ID: H21N-08

From Hydroclimatic Prediction to Negotiated and Risk Managed Water Allocation and Reservoir Operation ***(Invited)***

U. Lall; [1];
1. Earth & Env Eng, Columbia Univ, New York, NY, United States.

Body: The availability of long lead climate forecasts that can in turn inform streamflow, agricultural, ecological and municipal/industrial and energy demands provides an opportunity for innovations in water resources management that go beyond the current practices and paradigms.
In a practical setting, managers seek to meet registered demands as well as they can. Pricing mechanisms to manage demand are rarely invoked. Drought restrictions and operations are implemented as needed, and pressures from special interest groups are sometimes accommodated through a variety of processes. In the academic literature, there is a notion that demand curves for different sectors could be established and used for "optimal management". However, the few attempts to implement such ideas have invariably failed as elicitation of demand elasticity and socio-political factors is imperfect at best.
In this talk, I will focus on what is worth predicting and for whom and how operational risks for the water system can be securitized while providing a platform for priced and negotiated allocation of the resources in the presence of imperfect forecasts. The possibility of a national or regional market for water contracts as part of the framework is explored, and its potential benefits and pitfalls identified.

Final ID: OS22B-01

Assessment of the Correlation of Long-Term Hydrodynamic Variations and Dissolved Oxygen in the Chesapeake Bay *(Invited)*

J. Shen;[1];
1. , Williamsburg, VA, United States.

Body: The extent, duration, and severity of summer bottom hypoxia in the Chesapeake Bay depend on both biochemical and physical processes. Variations in physical forcings resulting in changes of estuarine stratification, gravitational circulation, and vertical exchange processes highly control the severity of the summer hypoxia. We recently developed a conceptual model to describe the low DO condition in the Bay based on transport timescales of estuarine gravitational circulation and vertical exchange, and the timescale of the total oxygen consumption rate of the biochemical processes, which enable us to decouple the influences of physical and biochemical processes on dissolved oxygen (DO) and diagnose the modulation of external forcings on bottom DO. The transport timescales introduced provide a linkage between the dynamic and biochemical processes and can be used directly to evaluate the influence of a change of these dynamics on hypoxia in the Bay. The long-term transport timescales of the Chesapeake Bay have been computed using a 3D model with respect to the freshwater and wind forcing variations over a 30-year period. Coupling with a timescale of the biochemical oxygen consumption, the correlation of change of dynamics and hypoxic conditions in the bottom waters in the Chesapeake Bay can be examined. The changes of wind forcing and freshwater over a 30-year period and the resultant change of transport timescale are examined, and the influence of external forcing on long-term variation of summer bottom hypoxia is discussed. By using filtering to remove the modulation of physical processes on DO, the change of biochemical processes can be isolated and examined.

Final ID: T22E-01

On the extent and significance of Oligocene mountain building in eastern Tibet *(Invited)*

E. Kirby; [1, 2]; *K. P. Furlong;* [1]; *K. L. Cook;* [4]; *W. B. Ouimet;* [3]; *X. Shi;* [1]; *E. Wang;* [5]; *P. J. Kamp;* [6]; *K. V. Hodges;* [7];

1. Pennsylvania State Univ, University Park, PA, United States.
2. College of Earth Ocean and Atmospheric Science, Oregon State University, Corvallis, OR, United States.
3. University of Connecicut, Storrs, CT, United States.
4. GFZ, Potsdam, Germany.
5. Chinese Academy of Sciences, Beijing, China.
6. University of Waikato, Hamilton, New Zealand.
7. Arizona State University, Tempe, AZ, United States.

Body: High topography in the region north and east of the Indo-Asian collision zone is typically considered to have developed in Miocene time, potentially in response to outward flow of weak lower crust from beneath the Tibetan Plateau. Much of the evidence for an increase in surface elevation in eastern Tibet is inferential and relies on the onset of rapid cooling and deep exhumation in the great river valleys along the plateau margin as recorded in low-temperature thermochronometers. Recently, detailed reconstruction of thermal/exhumational histories along the Longmen Shan, adjacent to the Sichuan Basin, reveals a pre-Miocene phase of mountain building (Wang et al., 2012). However, whether this event is confined to the Longmen Shan or whether it reflects widespread mountain building in the region remains unknown. Here, we synthesize emerging thermochronologic evidence from studies that utilize higher-temperature systems which are sensitive to deeper exhumation and that span various regions of the plateau margin. In the western Longmen Shan, late Oligocene – early Miocene zircon (U-Th)/He (zHe) ages from the summit of the Xuelongbao Massif (~5500m) require that mountain building was well underway along this margin by Oligocene time. In the Danba region, farther south, biotite and muscovite 40Ar/39Ar ages of samples from both fault zones and the surrounding rocks indicate that the faults were active at about 25- 30 Ma. Combined with structural and regional thermochronology data, this suggests that folding and exhumation of the Danba Anticlinorium began in mid-Tertiary time. Even farther south, along the Yalong River, biotite 40Ar/39Ar ages and zHe ages along an age-elevation transect reveal that the onset of rapid exhumation began around the same time, at ca. 30 Ma. Our results, in conjunction with existing data on the timing of deformation along the Aliao-Shan/Red River shear zone, implies that the onset of mountain building in eastern Tibet was widespread in late Oligocene time. These data appear to require reconsideration of both the processes that built high topography in eastern Tibet as well as the linkages between plateau growth and sediment delivery to east Asian marginal basins.

Final ID: EP22A-03

Potential Cascading Failures of Long-term Shoreline Stabilization in a Coupled Morphoeconomic Coastline Evolution Model

K. D. Ells;[1]; *D. McNamara;*[2]; *A. Murray;*[1];
1. Division of Earth and Ocean Sciences, Duke University, Durham, NC, United States.
2. Department of Physics and Physical Oceanography, UNC Wilmington, Wilmington, NC, United States.

Body: Systems with many interconnected parts can be susceptible to a cascade of failures, where the failure of one or more constituents can trigger the failure of others. This phenomenon has received significant attention in various applications of complex networks, but for many environmental systems the component parts and extent of their connectivity are not readily evident. Recent modeling work has shown that the evolution of many large-scale coastline shapes can be understood by the directional distribution of waves reaching the coast from offshore (i.e. wave climate), and that coastal communities responding to erosion with long-term shoreline stabilization (e.g. beach nourishment or seawalls) may perturb patterns of shoreline change far from their own locality. Economic strategies for shoreline stabilization – historically a spatially decentralized practice – are subject to constraints ranging from the scarcity of nourishment sand to coastal property values and locally observed erosion rates. Initial investigations into the coupling between large-scale coastline morphology and coastal economies along a cuspate cape coastline (similar to the Carolina capes, USA) have shown that long-term beach nourishment can become unsustainable due to the depletion of a finite sand reservoir, and that the spatial dynamics of abandonment depend on the distribution of both erosion rates and property values. Here we extend this analysis to consider: 1) how the abandonment of beach nourishment in one location may induce increased nourishment rates and potential abandonment in other locations alongshore, and 2) the consequences of hard-structured alternatives to beach nourishment (e.g. seawalls). The potential for cascading effects may be most significant along coastlines with subtle curvature and wave climates dominated by low-angle waves, broadly similar to much of the New Jersey and Delmarva coasts, USA, a region with a complex history of shoreline stabilization.

Final ID: T22C-03

The Impact of Neogene Climate and Tectonics on Sediment Dispersal and Accumulation on a Glaciated Continental Margin: IODP Expedition 341 Southern Alaska

J. M. Jaeger; [1]; *S. P. Gulick;* [2];
1. Univ Florida, Gainesville, FL, United States.
2. University of Texas Institute for Geophysics, Austin, TX, United States.

Body: Addressing the linkages between global climate change, modification of surficial processes, and subsequent tectonic responses requires integrated studies of orogenic systems. One end-member system is the glaciated St. Elias Orogen in southern Alaska, where Integrated Ocean Drilling Program Expedition 341 recovered >3 km of high-quality core placed in a chronostratigraphic context and coupled with nested-resolution seismic profiles. A fundamental hypothesis tested in Exp. 341 is that the onset and presence of erosive temperate glaciers can radically alter mass fluxes within an orogenic wedge, which creates an out-of-equilibrium tectonic setting leading to a positive exhumation feedback response. Shipboard chronostratigraphy highlights the high-resolution sedimentary record from Exp. 341 that allows for testing this hypothesis and provides an opportunity to examine late Miocene to present paleoceanography, regional tectonics, and marine sedimentary environment through key climatic transitions including the late Miocene-Pliocene warm period, the early Pleistocene intensification of northern Hemisphere glaciation (INHG), as well as the mid-Pleistocene transition (MPT).

A remarkable expedition discovery is the substantial sediment volume accumulating on the shelf, slope, and fan since the INHG and more significantly since the MPT. Stratal lithofacies span from biogenic oozes, ashes, to clast-rich diamict, indicating a dynamic Neogene depositional environment. Lithofacies are interpreted shipboard as reflecting deposition from suspension fall out, sediment gravity flows, large-scale mass wasting, ice rafting, variation in organic productivity, and volcanic eruptions. Pleistocene strata are dominated by glacigenic sediments. The retrieval at slope and fan sites of Holocene interglacial sediments and microfossils provides a means to identify comparable interstadial periods in the deeper sedimentary record. An exceptional shipboard paleomagnetic chronology, as well as biosiliceous and calcareous biostratigraphy provide a temporal framework to guide future analyses of particular glacial-interglacial periods. Shipboard analyses indicate that sedimentation at slope and fan sites corresponds with major global Pleistocene climate patterns. A notable discovery of the expedition at Site U1418 is that proximal deepwater sediment depocenters can contain an expanded record of fjord-like glacimarine facies during periods of maximum glacigenic sediment accumulation. Site U1420 demonstrated the potential for extremely thick Pleistocene depocenters in shelf settings where accommodation space can be maintained; consequently individual glacial advance-retreat facies cycles can be seismically mapped. Post-cruise analyses of sediment provenance will constrain this locus of erosion linking it back to onshore patterns of exhumation to ultimately test whether rapid erosion has the potential to lead to a positive feedback in exhumation in an active orogen.

URL: http://iodp.tamu.edu/scienceops/expeditions/alaska_tectonics_climate.html

Final ID: IN22A-04

Pipe dream? Envisioning a grassroots Python ecosystem of open, common software tools and data access in support of river and coastal biogeochemical research *(Invited)*

E. Mayorga; [1];
1. University of Washington, Seattle, WA, United States.

Body: Practical, problem oriented software developed by scientists and graduate students in domains lacking a strong software development tradition is often balkanized into the scripting environments provided by dominant, typically proprietary tools. In environmental fields, these tools include ArcGIS, Matlab, SAS, Excel and others, and are often constrained to specific operating systems. While this situation is the outcome of rational choices, it limits the dissemination of useful tools and their integration into loosely coupled frameworks that can meet wider needs and be developed organically by groups addressing their own needs.

Open-source dynamic languages offer the advantages of an accessible programming syntax, a wealth of pre-existing libraries, multi-platform access, linkage to community libraries developed in lower level languages such as C or FORTRAN, and access to web service infrastructure. Python in particular has seen a large and increasing uptake in scientific communities, as evidenced by the continued growth of the annual SciPy conference.

Ecosystems with distinctive physical structures and organization, and mechanistic processes that are well characterized, are both factors that have often led to the grass-roots development of useful code meeting the needs of a range of communities. In aquatic applications, examples include river and watershed analysis tools (River Tools, Taudem, etc), and geochemical modules such as CO2SYS, PHREEQ and LOADEST.

I will review the state of affairs and explore the potential offered by a Python tool ecosystem in supporting aquatic biogeochemistry and water quality research. This potential is multi-faceted and broadly involves accessibility to lone grad students, access to a wide community of programmers and problem solvers via online resources such as StackExchange, and opportunities to leverage broader cyberinfrastructure efforts and tools, including those from widely different domains. Collaborative development of such tools can provide the additional advantage of enhancing cohesion and communication across specific research areas, and reducing research obstacles in a range of disciplines.

Final ID: EP22B-03

Numerical simulations of inherited sinuosity and valley entrenchment in mixed alluvial- and bedrock-banked meandering rivers

A. Limaye; [1]; *M. P. Lamb;* [1];
1. California Inst. of Technology, Pasadena, CA, United States.

Body: Highly sinuous rivers inset in bedrock canyons have long piqued the interest of geomorphologists because this sinuous morphology evokes comparisons to more actively migrating rivers with relatively weak sediment banks. An extensive literature debates the degree to which meandering rivers in bedrock valleys have inherited their sinuosity from previous alluvial states, or instead actively maintain sinuosity through bank migration at a rate sensitive to environmental characteristics (e.g., climate and lithology). This distinction is essential to evaluating whether bedrock channel sinuosity and valley morphology can be used to infer regional base-level and climate history, or instead reflect initial conditions. Previous work has considered sinuosity inheritance to occur by river vertical incision directly translating the form of a meandering channel from its alluvial state to a bedrock-bound state, yet the rate of vertical incision required to cause this state transition is uncertain. Here we explore the hypothesis that feedbacks between channel lateral migration and vertical incision, communicated through the composition of the channel banks, may influence channel planform geometry during an alluvial-to-bedrock transition. We use a numerical model to evaluate the transient morphologic and kinematic response of an alluvial river to different vertical incision histories and initial valley configurations. The model uses a vector-based framework for bank-material tracking to precisely model feedbacks between channel lateral migration and bank strength. Model results suggest that the tendency for a channel to remain highly laterally mobile depends on the vertical incision rate, but also on the width of the valley formed by lateral channel migration: bedrock valley floors are more easily bevelled by channel sweeping within narrow valleys than for wide valleys. For cases in which the channel cannot bevel across the initial valley width, lateral variations in bank strength cause more frequent cutoffs, which reduces channel sinuosity, stalls channel migration, and confines the channel to bedrock banks. Resultant channel morphology is less sinuous under cases of steady vertical incision than for cases with a rapid pulse of vertical incision (e.g., due to climate change). These results suggest that a channel's planform morphology may hold clues to its vertical incision history, and may assist in discriminating hypotheses for the evolution of bedrock river valleys. We use these insights to reevaluate potential dynamical histories of several bedrock rivers, including the San Juan River, Utah.

Final ID: IN22A-05

HydroShare: Applying professional software engineering to a new NSF-funded large software project

R. Idaszak; [1]; *D. G. Tarboton;* [2]; *D. Ames;* [3]; *J. A. Saleem Arrigo;* [4]; *L. E. Band;* [5]; *A. Bedig;* [6]; *A. M. Castronova;* [7]; *L. Christopherson;* [1]; *J. Coposky;* [1]; *A. Couch;* [6]; *P. Dash;* [2]; *T. Gan;* [2]; *J. Goodall;* [7]; *K. Gustafson;* [1]; *J. Heard;* [1]; *R. P. Hooper;* [4]; *J. S. Horsburgh;* [2]; *S. Jackson;* [8]; *H. Johnson;* [1]; *D. R. Maidment;* [8]; *P. Mbewe;* [9]; *V. Merwade;* [10]; *B. Miles;* [5]; *S. Reeder;* [2]; *T. Russell;* [1]; *C. Song;* [10]; *A. Taylor;* [1]; *S. Thakur;* [1]; *D. W. Valentine;* [11]; *T. L. Whiteaker;* [8];

1. RENCI, University of North Carolina at Chapel Hill, Chapel Hill, NC, United States.
2. Utah State University, Logan, UT, United States.
3. Brigham Young University, Provo, UT, United States.
4. CUAHSI, Boston, MA, United States.
5. University of North Carolina at Chapel Hill, Chapel Hill, NC, United States.
6. Tufts University, Medford, MA, United States.
7. University of Virginia, Charlottesville, VA, United States.
8. University of Texas at Austin, Austin, TX, United States.
9. University of South Carolina, Columbia, SC, United States.
10. Purdue University, West Lafayette, IN, United States.
11. San Diego Supercomputing Center, University of California San Diego, San Diego, CA, United States.

Body: HydroShare is an online, collaborative system being developed for sharing hydrologic data and models as part of the NSF's Software Infrastructure for Sustained Innovation (SI2) program (NSF collaborative award numbers 1148453 and 1148090). HydroShare involves a large software development effort requiring cooperative research and distributed software development between domain scientists, professional software engineers (here "professional" denotes previous commercial experience in the application of modern software engineering), and university software developers. HydroShare expands upon the data sharing capabilities of the Hydrologic Information System of the Consortium of Universities for the Advancement of Hydrologic Sciences, Inc. (CUAHSI) by broadening the classes of data accommodated, expanding capability to include the sharing of models and model components, and taking advantage of emerging social media functionality to enhance information about and collaboration around hydrologic data and models. With a goal of enabling better science concomitant with improved sustainable software practices, we will describe our approach, experiences, and lessons learned thus-far in applying professional software engineering to a large NSF-funded software project from the project's onset.

URL: http://www.cuahsi.org/HydroShare.aspx

Final ID: EP22A-06

Time Series Observations of Seafloor Roughness in the Northern Gulf of Mexico 1: Sediment Transport

J. Calantoni; [1]; *K. Eldredge;* [2]; *T. Staples;* [3]; *A. Sheremet;* [3]; *A. Penko;* [1];

1. Marine Geosciences Division, Naval Research Laboratory, Stennis Space Center, MS, United States.
2. Naval Research Enterprise Internship Program, Naval Research Laboratory, Stennis Space Center, MS, United States.
3. Department of Civil and Coast Engineering, University of Florida, Gainesville, FL, United States.

Body: Two instrumented quadpods were deployed offshore of Panama City, Florida in 7.5 m (shallow site) and 20 m (deep site) water depths, respectively, from 20 April – 23 May 2013. The four-legged stainless steel structures were adjusted to a height of 2.3 m at the shallow site and to a height of 3.3 m at the deep site. Each quadpod housed a suite of instrumentation to measure hydrodynamic and sedimentological properties. A high frequency (1 MHz) sector scanning sonar imaged a small area of the seafloor (~15 square meters) every 12 minutes for the entire deployment around each quadpod. The scans provided high-resolution observations of ripple growth, decay, and reorientation under a wide range of forcing conditions. During the passage of an atmospheric front, 5 – 7 May 2013, approximately 20 cm of sediment accretion was observed around the quadpod at the shallow site. However, no sediment accretion was observed around the quadpod located at the deep site. Divers took push cores during the deployment around each quadpod that were brought back to the laboratory for analysis. Observed sedimentation and changes in seafloor roughness correlated well with the measured hydrodynamics. The time series observations will be used to test and calibrate the first generation of a new operational forecasting model for seafloor roughness (NSEA). Preliminary modeling results will be presented.

Final ID: GC22A-06

Interactions between climate change impacts on forest productivity and mortality and stream water quality in the US Western Mountains *(Invited)*

C. Tague; [1]; *J. Zhu;* [1];
1. UC Santa Barbara, Santa Barbara, CA, United States.

Body: In the snow-dominated mountains of the Western US, climate change is likely to alter forest productivity, water use and nutrient uptake. The consequence of changes in forest structure and function will have impacts on both water quality and water quantity. Warmer temperatures, reduced snow accumulation and earlier melt, elevated CO2 and increased frequency and severity of drought all influence forest productivity, sometimes in opposing ways. In the complex topography of mountain environments, whether forest productivity increases or decreases is likely to vary along gradients between water and energy limited systems. Implications for forest structure also vary along these gradients, and include the impact of disturbances such as fire and pests. We build on earlier work that used a coupled eco-hydrologic model to show how forest water use changes with increasing temperatures and how these changes are distributed along elevational gradients for a snow-dominated site within the California Sierra. We extend this analysis to investigate associated changes in forest structure and nutrient uptake with temperature warming, along an elevational gradient. We compare results for sites in the California Sierra and the wetter Pacific Northwest. Results show that for wetter sites, forest productivity is likely to increases with associated declines in stream nutrient export. For drier sites, however, forest productivity may decline leading to reduced forest nutrient uptake. This decline in uptake is combined with shifts to more winter rainfall that together may facilitate greater flushing of nutrients. We use these results to define scenarios where we would expect forest productivity to decline and lead to increase nitrate leaching to stream and groundwater.

Final ID: EP22B-05

Hysteresis in hillslope morphology records landscape growth and decay

M. D. Hurst; [1, 2]; *S. M. Mudd;* [1]; *M. Attal;* [1]; *G. E. Hilley;* [3];

1. School of Geosciences, The University of Edinburgh , Edinburgh, United Kingdom.
2. British Geological Survey, Nottingham, United Kingdom.
3. Department of Geological and Environmental Sciences, Stanford University, Stanford, CA, United States.

Body: The Earth's surface archives the history of tectonic-driven uplift and subsidence, and climate-driven erosion, sediment transport and deposition. Hillslopes that have adjusted to their local base-level are predicted to exhibit morphology which reflects the rate of base-level fall, which may be equated to surface uplift when channel response times are short. In this study, hillslope morphology was analysed along the tectonically active Dragon's Back Pressure Ridge (DBPR), adjacent to the San Andreas Fault (SAF) in California, USA, to assess whether uplift history can be inferred using measurable attributes of hillslope features. The DBPR comprises a series of south-west trending valleys (< 400 m length) roughly perpendicular to the SAF. Here, the relief is generated as dextral fault motion carries the Pacific plate over a region of uplift which is pinned to the North American plate. The DBPR topography is inferred to reflect rejuvenation during passage through the zone of uplift and subsequent relaxation after uplift ceases. This facilitates a space-for-time substitution and generation of a time series of hillslope evolution in response to active uplift and erosion and subsequent landscape relaxation. Hillslope morphological properties such as slope, length and hilltop curvature have been measured using 1-m resolution LiDAR data. Comparison of these measurements to predictions by a nonlinear diffusion rule for steady-state hillslope reveals systematic deviations in morphology from those expected at steady-state. This deviation has path-dependency such that hilltop curvature lags behind relief development for hillslopes responding to base-level fall, whilst hilltop curvature and relief decline gradually and in concert during landscape relaxation. A one-dimensional model for hillslope evolution was developed in order to infer the most likely history of baselevel fall at DBPR from the observed hillslope morphology. Comparison of this inferred history to the known distribution of uplift provides constraint on the response time of the channel system and supports our finding of path-dependency in hillslope morphology. This study demonstrates that hillslope morphology can be used to distinguish between growing and decaying landscapes,, with potential applications such as distinguishing active faults in remote settings, quantifying the distribution of fault-related uplift and delineating zones with high landslide risk.

Final ID: GC22A-07

Early Anthropogenic Transformation of the Danube-Black Sea System: From Records to Causes *(Invited)*

L. Giosan; [1]; *M. Coolen;* [2];
1. Geology and Geophysics, Woods Hole Oceanographic Inst, Woods Hole, MA, United States.
2. Marine Chemistry and Geochemistry, Woods Hole Oceanographic Institution, Woods Hole, MA, United States.

Body: Over the last century humans have altered the export of fluvial materials leading to significant changes in morphology, chemistry, and biology of the coastal ocean. We present sedimentary, paleoenvironmental and paleogenetic evidence to show that the Black Sea, a nearly enclosed marine basin, was affected by land use long before the changes of the Industrial Era. Although watershed hydroclimate was spatially and temporally variable over the last ~3000 years, surface salinity dropped systematically in the Black Sea. Sediment loads delivered by Danube River, the main tributary of the Black Sea, significantly increased as land use intensified in the last two millennia, which led to a rapid expansion of its delta. Lastly, proliferation of diatoms and dinoflagellates over the last five to six centuries, when intensive deforestation occurred in Eastern Europe, points to an anthropogenic pulse of river-borne nutrients that radically transformed the food web structure in the Black Sea.

We discuss potential avenues for fingerprinting historical land use type and intensity based on sedimentary proxies as well as novel strategies to disentangle climate from anthropogenic variables with potential application to other systems outside the Danube and Black Sea.

Final ID: EP22B-06

The role of temporally varying erodibility in hysteresis in fine-grained coastal systems

P. Wiberg; [1]; *J. A. Carr;* [1];
1. Environmental Sciences, University of Virginia, Charlottesville, VA, United States.

Body: Sediment transport rates are typically expressed as some function of excess shear stress, the difference between the fluid shear stress at the sediment surface and the shear stress needed to initiate transport of the sediment comprising the surface. While a great deal of research has addressed questions related to temporal and spatial variations in the fluid stresses driving transport and deposition, considerably less has focused on temporal and spatial variations in sediment erodibility. Most sediment transport relationships involved a critical shear stress that is at most a function of grain size and density for non-cohesive sediment or a function of depth for cohesive sediment. Such simple characterizations of erodibility are frequently inadequate for representing sediment dynamics in fine-grained coastal and shallow marine environments where a wide range of processes, including consolidation, biofilm production and bioturbation can cause dramatic temporal and spatial (horizontal and vertical) variations in erodibility. For example, flood deposits of mud on the continental shelf can initially be highly erodible, facilitating the formation of wave-supported gravity flows, but quickly (days-weeks) consolidate to the point where they can become relatively resistant to resuspension by large storm waves – well above traditional notions of “storm wave base”. On the other hand, loss of protection by primary producers – such as a die off of seagrasses or biofilms – can release large quantities of previously stable sediment into a coastal system. In this talk we explore the importance of temporal variations in erodibility on coastal and shallow marine systems in producing path-dependence and hysteresis in fine-grained coastal systems.

Final ID: B22C-08

Fires, invasives, migrations, oh my! Scaling spatial processes into earth system models and global change projections. ***(Invited)***

M. Dietze; [1];
1. Boston University, Boston, MA, United States.

Body: Spatial processes often drive ecosystem processes, biogeochemical cycles, and land-atmosphere feedbacks at the landscape-scale. Long-term responses of ecosystems to climate change requires dispersal and species migrations. Climate-sensitive disturbances, such as fire, pests, and pathogens, often spread contagiously across the landscape. Land-use change has created a highly fragmented landscape with a large fraction of 'edge' habitat that alters the surface energy dynamics and microclimate. These factors all interact, with fragmentation creating barriers for fire and migrations while creating corridors for rapid invasion. While the climate-change implications of these factors are often discussed, none of these processes are incorporated into earth system models because they occur at a spatial scale well below model resolution.

Here we present a novel second-order spatially-implicit scheme for representing the spatial adjacencies of different vegetation types and edaphic classes. Adjacencies direct affect dispersal, contagious disturbance, radiation, and microclimate. We also demonstrate a means for approximating the size distribution of spatially contagious disturbances, such as fire, insects, and disease. Finally, we demonstrate a means for dynamically evolving spatial adjacency through time in response to disturbance and succession. This scheme is tested under a range of dispersal, disturbance, and land-use scenarios in comparison to a spatially explicit and conventional non-spatial alternatives. This scheme lays the ground for a more realistic global-scale exploration of how spatially-complex and heterogenous landscapes interact with climate-change drivers.

Final ID: TH22G-01

InTeGrate: InTeGrate: Interdisciplinary Teaching of Geoscience for a Sustainable Future

C. A. Manduca; [1]; *A. E. Egger;* [2]; *J. J. Taber;* [3];

1. Science Education Resource Center, Carleton College, Northfield, MN, United States.
2. Geological Sciences and Science Education, Central Washington University , Ellensburg, WA, United States.
3. Education and Public Outreach, IRIS, Washington, DC, United States.

Description: InTeGrate is an NSF-funded community project to improve geoscience literacy and build a workforce that can make use of geoscience to address societal issues. At this town hall you can learn about newly published teaching materials and opportunities to be involved in materials development teams, implementation programs, and workshops in the upcoming year, and give input on future directions for the project.

Final ID: GC23C-0939

Anthropogenic effects on global riverine sediment and water discharge - a spatially explicit analysis

S. Cohen;[1]; *A. J. Kettner;*[2]; *J. P. Syvitski;*[2];
1. Geography, University of Alabama, Tuscaloosa, AL, United States.
2. CSDMS, INSTAAR, University of Colorado, Boulder, CO, United States.

Body: Changes in global riverine water discharge and suspended sediment flux over a 50-year period, 1960-2010 are studied, applying a new version of the WBMsed (WBMsed v.2.0) global hydrological water balance model. A new floodplain component is introduced to better represent water and sediment dynamics during periods of overbank discharge. Validated against data from 16 globally distributed stations, WBMsed v.2.0 simulation results show considerable improvement over the original model. Anthropogenic impact on sediment and water discharge is evaluated by comparing global scale simulations with and without human drivers and parameters (agricultural land use, water intake form aquifers and rivers, sediment trapping in reservoirs, and human-induced soil erosion). The results show that, on average, global riverine sediment flux is reduced by approximately 25% by anthropogenic activities (almost exclusively due to trapping in reservoirs) while water discharge is reduced by about 2%. These results correspond to previous analysis by other research groups. Substantial global and intra-basin variability is observed (see Figure 1) for the first time. In some regions an opposite anthropogenic effect on sediment and water discharge was predicted (e.g. west Mississippi Basin, Rio Grande River, Indian subcontinent). We discuss the western part of the Mississippi Basin as an example of this intriguing anthropogenic impact.

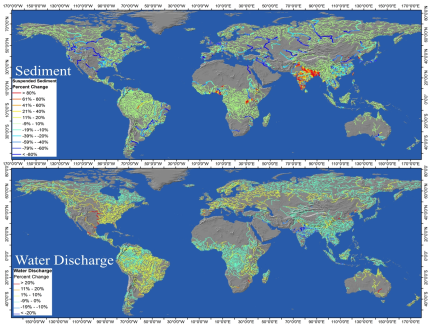


Figure 1. Percent change between disturbed and pristine simulations (with and without human footprint respectively) for sediment flux (top) and water discharge (bottom).

Final ID: GC23C-0948

Expansive Tidal Marshes on the North American Eastern Seaboard: Relics of Colonial Deforestation?

A. Murray; [1]; *M. Kirwan;* [2];
1. Division of Earth and Ocean Sciences, Nicholas School of the Environment; Center for Nonlinear and Complex Systems, Duke University, Durham, NC, United States.
2. Virginia Institute of Marine Sciences, College of William and Mary, Gloucester Point, VA, United States.

Body: Experiments using a numerical model of tidal marsh ecomorphodynamic evolution suggest that changes in sediment supply (suspended sediment concentrations) reaching tidal marshes can play a role as strong as sea-level-rise rate in determining the extent and elevation of coastal wetlands. Testing a model-generated hypothesis, sediment coring and radiocarbon dating in the Plum Island Estuary marshes, Massachusetts, USA, suggested that marshes prograded rapidly and substantially following colonial deforestation (Kirwan et al., Geology, 2011). This controversial claim has been questioned, in part because historical maps from 1780 and 1830 show that the marsh had already attained most of its modern extent by that time—which is earlier than some of the of the radiocarbon mid-point dates (Priestas et al., Geology Forum, Dec. 2012). However, given the uncertainties in the radiocarbon dates, and in identifying the earliest marsh-derived layers in sediment cores, the maps and the dating are broadly consistent (Kirwan and Murray, Geology Forum, Dec. 2012).

In addition, previous studies have shown that considerable land-use change had already occurred in this small coastal watershed by the late 17th Century, with local laws against tree cutting in place by 1660, and evidence for regional deforestation by 1700. Our field evidence, combined with the historical maps, indicates that this early colonial development lead to an expansion of marshes by approximately 50 percent within the studied area. Given the widespread and pervasive nature of subsequent land-use changes on the Eastern Seaboard from colonial through civil war periods, many of the currently expansive marshes on the East Coast may be relict. Numerical modeling suggests that when sediment concentrations fall below the values required to form a marsh, the marsh will be metastable, with vegetation feedbacks able to maintain the relict morphology and ecology, but susceptible to irreversible loss in response to disturbances. Thus, the field investigations in one location may have wide reaching implications for explaining and mitigating observed marsh degradation.

Final ID: H23A-1227

Hydrologic modeling using topographically corrected NARR and NARCCAP climate data: Tucannon River, Washington

S. J. Praskievicz; [1]; *P. J. Bartlein;* [1];
1. Geography, University of Oregon, Eugene, OR, United States.

Body: An emerging approach to downscaling the projections from General Circulation Models (GCMs) to scales relevant for basin hydrology is to use lateral boundary conditions supplied by GCMs to force higher-resolution Regional Climate Models (RCMs). With spatial resolution often in the tens of kilometers, however, even these RCM outputs fail to resolve local topography that may be climatically significant in high-relief basins. Here we develop and apply an approach to downscaling RCM output using local topographic lapse rates. We calculate monthly local topographic lapse rates for the northwestern United States from the 800-m Parameter-elevation Regressions on Independent Slopes Model (PRISM) dataset, which is based on regressions of observed climate against location and topographic variables. The maximum temperature lapse rates are mostly negative, with temperatures decreasing with increasing elevation, which is the expected relationship. In the winter months, positive lapse rates in some valleys in the northeastern part of the study region indicate the presence of temperature inversions. A narrow band of positive lapse rates can also be seen along the coast in the summer, when temperatures increase with distance from the ocean. The minimum temperature lapse rates, which were created from a smaller search window, are more spatially variable than those for maximum temperature, and the winter temperature inversions are more pronounced. Precipitation lapse rates are mostly positive, with precipitation increasing with increasing elevation, but with some areas of negative lapse rates on the leeward side of mountain ranges. We then use these lapse rates to elevationally correct two types of simulated regional-scale climate data: the North American Regional Reanalysis (NARR), a retrospective dataset produced from regional forecasting models constrained by observations, and a range of baseline climate scenarios from the North American Regional Climate Change Assessment Program (NARCCAP), which is produced by a series of RCMs driven by GCMs. In comparison to a simple bilinear interpolation of the regional climate data to the PRISM grid, the topographically-corrected data exhibit finer-scale spatial variability, including the resolution of some individual topographic features such as major mountain peaks and river valleys. For all three climate variables, the initial uncorrected NARR bilinear interpolation is systematically biased relative to the observed station data. The NARR timeseries that have been topographically corrected using lapse rates are less biased than the uncorrected NARR. Finally, the downscaled and bias-corrected NARR timeseries are very close to the observed station data. By running a calibrated and validated hydrologic model, the Soil and Water Assessment Tool (SWAT), using observed station data and topographically corrected NARR and NARCCAP output, we are able to determine the sensitivity of the output of a hydrologic model to the choice of the dataset used to drive the model. Topographic correction of regional climate data is a promising method for modeling the hydrology of mountainous basins for which no weather station data are available or for simulating hydrology under past or future climates.

Final ID: H23C-1277

Simulating stand-level water and carbon fluxes in beetle-attacked conifer forests in the Western U.S.

S. D. Peckham; [1]; *B. E. Ewers;* [1]; *D. S. Mackay;* [2]; *E. G. Pendall;* [1]; *J. M. Frank;* [1, 3]; *W. J. Massman;* [3];
1. University of Wyoming, Laramie, WY, United States.
2. SUNY, Buffalo, NY, United States.
3. US Forest Service, Fort Collins, CO, United States.

Body: In recent decades, forest mortality due to bark beetle infestation in conifer forests of western North America has reached epidemic levels, which may have profound effects on both present and future water and carbon cycling. The responses of evaporation, transpiration, and net photosynthesis to changing climate and disturbance are a major concern as they control the carbon balance of forests and the hydrologic cycle in a region that relies on water from montane and subalpine forest systems. Tree mortality during bark beetle infestation in this region is due to hydraulic failure resulting from fungal infection spread by the beetles. We modified the terrestrial regional ecosystem exchange simulator (TREES) model to incorporate xylem-occlusion effects on hydraulic conductance to simulate beetle attack over the period 2005-2012 in a subalpine conifer forest at the Glacier Lakes Ecosystem Experiment Site (GLEES) and over 2008-2012 at a lodgepole pine dominated site in southeast Wyoming. Model simulations with and without beetle effects were compared to eddy-covariance and sap-flux data measured at the sites. The simulations were run at a 30-minute time step and covered the pre- to post-beetle infestation period. Simulated NEE at GLEES ranged from 200 to -625 g C m-2 yr-1, annual ET ranged from 250 to 800 mm yr-1 over the seven years and standard error in predicted half-hourly NEE was <3 μmol CO2 m-2 s-1 and <2e-05 mm s-1 for ET. The stand transitioned from a C sink to C source during the beetle attack and our modified model captured this dynamic, while simulations without the beetle effect did not (i.e. continued C sink). However, simulated NEE was underestimated compared to flux data later in the infestation period (2011) by over 100 g C m-2 yr-1. ET decreased during beetle attack in both the observed and simulated data, but the modified model underestimated ET in the later phase of attack (2010-2011). These results suggest that ET and NEE in these conifer forests may not simply scale with canopy or tree basal area impacted by beetles and that factors such as root gaps, increased growth of surviving trees, or understory could be compensating. Thus, inclusion of explicit hydraulic mechanisms in TREES captured the effects of forest mortality on C and H2O fluxes, but additional ecosystem-level responses related to vegetation succession may be needed to more accurately simulate forest response to disturbance.

Final ID: H23E-1317

Evaluating the Performance of a Coupled Distributed Hydrologic – Hydraulic Model for Flash Flood Modeling Using Multiple Precipitation Data Sources

P. Nguyen; [1]; *S. Sorooshian;* [1]; *K. Hsu;* [1]; *A. AghaKouchak;* [1]; *B. F. Sanders;* [1];
1. Civil and Environmental Engineering, University of California Irvine, Irvine, CA, United States.

Body: Flash floods are considered one of the most hazardous natural disasters, which kills thousands of people and causes billions of US dollar economic damages annually world-wide. Forecasting flash floods to provide accurate warnings in a timely manner is still challenging. At the Center for Hydrometeorology and Remote Sensing (CHRS) at the University of California, Irvine, we have been developing a coupled high resolution distributed hydrologic-hydraulic system for flash flood modeling which has been successfully tested for some selected areas in the U.S. and has potential to be implemented in global scale. The system employs the National Weather Service's distributed hydrologic model (HL-RDHM) as a rainfall-runoff generator, and a high-resolution hydraulic model (BreZo) for simulating the channel and flood-plain flows realistically.

In this research, we evaluate the system for flash flood warning using multiple precipitation sources (gauge, radar and satellite and forecast). A flash flood event occurring on June 11, 2010 in the Upper Little Missouri River watershed in Arkansas is used as a case study. The catchment was delineated into 123 sub-catchments based on the 10m Digital Elevation Model (DEM) topography data from USGS. From HL-RDHM surface runoff, 123 hydrographs can be derived and connected as inputs to BreZo. The system was calibrated using NEXRAD Stage IV radar-based rainfall by tuning the roughness parameter in BreZo to best match the USGS discharge observation at the catchment outlet. The results show good agreement with the USGS gauge flow measurement (Nash-Sutcliffe coefficient = 0.91) when using Stage IV data. The system is under investigation with satellite-based precipitation data, rain gauge and Global Forecast System (GFS) data and will be reported in the presentation.

Final ID: NH23C-1540

Hydrologic Severity-based Forecast System for Road Infrastructure Monitoring

X. Liang; [1]; *F. Hernandez;* [1]; *L. Li;* [1, 3]; *S. Lochan;* [2]; *Y. Liang;* [2]; *W. L. Teng;* [4];

1. Department of Civil and Environmental Engineering, University of Pittsburgh, Pittsburgh, PA, United States.
2. Department of Computer and Information Science, Indiana Univ.-Purdue Univ. Indianapolis, Indianapolis, IN, United States.
3. State Key Laboratory of Hydraulics and Mountain River Engineering, Sichuan University, Chengdu, Sichuan, China.
4. Goddard Earth Sciences Data and Information Services Center (ADNET), NASA, Greenbelt, MD, United States.

Body: The state departments of transportation in the U.S. are responsible for responding to weather- and hydrology-related emergencies affecting the transportation infrastructure, such as heavy rain, flooding, scouring of bridge structures, icing, and fog. These emergency response actions often require significant amount of effort to identify, inspect, and manage, e.g., potentially compromised bridges due to scouring. An online Hydrologic Disaster Forecasting and Response (HDFR) system is being developed for the Pennsylvania Department of Transportation (PennDOT), to provide more accurate estimates on current road infrastructure conditions. The HDFR system can automatically access satellite data from NASA data centers, NOAA radar rainfall measurements, and meteorological and hydrometeorological station observations. The accessed data can be fused, using an extended multi-scale Kalman smoother-based (MKS-based) algorithm to provide enhanced data products. The fused information is then contrasted with historical data, to assess the severity of the weather and hydrological conditions and to provide more accurate estimates of those areas with a high likelihood of being affected by similar emergencies. The real- and near-real-time data, as well as weather forecasts, are input to a multi-scale hydrological simulator. The HDFR system will be able to generate stream flow predictions at road-level scales, allowing for the monitoring of a complex and distributed infrastructure, with less computational resources than those previously required. Preliminary results will be presented that show the advantages of the HDFR system over PennDOT's current methods for identifying bridges in need of inspection.

Final ID: P23G-01

Is the faint young Sun paradox solved?

E. T. Wolf; [1, 2]; *O. B. Toon;* [1, 2];
1. Atmospheric and Oceanic Sciences, University of Colorado, Boulder, CO, United States.
2. Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, CO, United States.

Body: How did the early Earth remain warm despite weak solar luminosity? The faint young Sun paradox has stubbornly resisted a self-consistent solution since it was first introduced by Sagan and Mullen [1] over four decades ago. However, recent revisions to expected paleo-ocean temperatures [2, 3] along with new results from three-dimensional climate models [4] may allow this long standing problem to be finally put to rest. Here we use a modified version of the Community Atmosphere Model version 3 from the National Center for Atmospheric Research to study early climate. We find that resolving the faint young Sun paradox becomes less problematic when viewing a full representation of the climate system. For the late Archean climate (80% solar constant), relatively modest amounts of CO_2 ($\leq$0.02 bar) and CH_4 (0.001 bar) yield surface temperatures equal to the present day with no other alterations to climate. Cooler climates with large ice caps but with temperate tropical regions can be supported with considerably smaller greenhouse gas burdens. The incorporation of systematic climate system elements expected for the Archean such as fewer cloud condensation nuclei (CCN) [5], reduced land albedos [5], and an increased atmospheric inventory of N_2 [6], can provide a combined 10 to 20 K of additional surface warming given reasonable assumptions. With the inclusion of 0.001 bar of CH_4, 2 PAL of N_2, reduced land albedos, and reduced CCN, present day mean surface temperatures can be maintained for the earliest Archean (75% solar constant) with only ~0.01 bar of CO_2. However, lower requirements for atmospheric CO_2 may imply that photochemical hazes were frequent during the Archean.

[1] Sagan, C., & Mullen, G. Science 177, 52 (1972)
[2] Hren, M.T., Tice, M.M., & Chamberlin, C.P. Nature 462, 205 (2009)
[3] Blake. R.E., Chang, S.J., & Lepland, A. Nature 464, 1029 (2010)
[4] Wolf, E.T., & Toon, O.B. Astrobiology 13(7), 1 (2013)
[5] Rosing, M.T., Bird, D.K., Sleep, N.H., & Bjerrum, C.J. Nature 464, 744 (2010)
[6] Goldblatt, C., Claire, M.W., Lenton, T.M., Matthews, A.J., Watson, A.J. Nature Geoscience 2, 891 (2009)

Final ID: PP23C-1991

The impact of differing physical assumptions on a water isotope climatology simulated by an isotope-enabled version of the NCAR Community Atmosphere Model Version 5 (CAM5).

J. M. Nusbaumer; [1, 2]; *C. Bardeen;* [3]; *E. C. Brady;* [4]; *T. Wong;* [5, 2]; *D. C. Noone;* [1, 2];

1. Atmospheric and Oceanic Sciences, University of Colorado, Boulder, CO, United States.
2. Cooperative Institute for Research in Environmental Sciences, University of Colorado, Boulder, CO, United States.
3. ACD, NCAR, Boulder, CO, United States.
4. CGD, NCAR, Boulder, CO, United States.
5. Applied Math, University of Colorado, Boulder, CO, United States.

Body: Water isotope-enabled Global Climate Models (GCMs) provide a framework to test the hypotheses used to invert isotope proxy records to obtain historical estimates of different geophysical variables, such as temperature or precipitation amount. They also provide the capability of forward modeling isotope proxies, eliminating the need to invert the proxy data and potentially increasing the confidence in reconstructions of past climates. However, all GCMs must make simplifying assumptions, such as what physical processes should be included, and how those processes are actually represented. These choices and assumptions can have a large impact on the simulation of water isotopes in a GCM, and could confound efforts to interpret the isotopic results from these models. This study examines the simulation of water isotopes in a new isotope-enabled version of NCAR's Community Atmosphere Model (CAM5). In particular, this study evaluates how assumptions in the cloud parameterizations can influence the water isotopes predicted by the model, including choices regarding phase changes and the assumed temperature during fractionation. CAM5 is also coupled to different surface models, including a simplified isotopic land surface model and an isotope-enabled ocean model (iPOP2) in order to determine their impact on the overall atmospheric isotope climatology. Findings suggest that cloud process assumptions do influence the isotope ratios in precipitation, and that coupling to surface models can have a substantial impact on isotopic values at a regional or local scale. These results will help determine to what processes stable water isotopes are sensitive, and thus where efforts should be placed in climate model development in order to generate the most useful guidance for proxy record evaluation.

Final ID: H23I-02

Quantifying the imprint of geologic controls on river network topology and scaling in hydrologic response ***(Invited)***

E. Foufoula-Georgiou; [1]; *M. Danesh Yazdi;* [1]; *A. Longjas;* [1]; *S. Zanardo;* [1];
1. Saint Anthony Falls Laboratory, University of Minnesota, Minneapolis, MN, United States.

Body: River network topology has been at the core of relating geomorphologic and hydrologic properties of landscapes, specifically in developing scaling frameworks of hydrologic fluxes. Recent studies have suggested that the topological structure of river networks might carry the signature of the underlying climatic and/or geologic controls of landscape evolution with implications for regionalization studies and network-based predictive frameworks of hydrologic response. In this study, the drainage networks of 12 sub-watersheds within the Minnesota River Basin (MRB), extracted from the National Hydrography Dataset (NHD), are analyzed in terms of statistical self-similarity in geomorphologic, topologic, and hydrologic attributes. The MRB offers a unique setting for studying fundamental processes of landscape evolution as its geologic history has left behind a still evolving landscape with propagating knickpoints, steep bluffs, strath terraces, and an impressive spatial heterogeneity in river network topology. Preliminary analysis of the MRB sub-watersheds reveals that they do not follow some of the statistical self-similarity relationships usually found in river networks such as the scaling of slopes and lengths with respect to stream order. In addition, the Tokunaga self-similarity analysis shows a wider variability of the higher-order branching parameter c ranging from 1.3 to 2.7, relative to the first-order branching parameter a, which ranges from 0.9 to 1.6. Also, as the Horton-Strahler order of the sub-watersheds increases, a different topology with more regular drainage patterns is observed with lower c values, revealing important connections between geology and network topology. We investigate the hypothesis that sub-watersheds with steeper and still actively incising channels exhibit a pronounced higher-order branching, reflected visually in highly “feathered” networks and quantitatively in higher values of the Tokunaga parameter c. The frequency of knickpoints, which are described as locations in a river where there is a sharp change in channel slope, is examined using high-resolution digital elevation models to provide a better understanding of the quantitative relationship between landscape geomorphic features, drainage patterns and scaling in hydrologic response.

Final ID: EP23A-05

The Statistical Signal of Morphological Process in Stratigraphy

C. R. Esposito; [1]; *K. M. Straub;* [1];
1. Tulane University, New Orleans, LA, United States.

Body: The most widely used classification of river delta morphologies, Galloway's ternary diagram, holds that the surface characteristics of a delta, including the distribution of depositional environments, and shoreline shape, can be predicted by the relative strengths of the fluvial and marine processes that influence the delta. Though almost 40 years old, Galloway's diagram of wave, river, and tide dominated deltas is still widely referred to in textbooks and in literature as a way of describing the relationship between morphological processes and the distribution of depositional environments over a single delta "event" such as the progradation of one delta lobe. However, there is no complimentary classification scheme that addresses the ways in which deltaic stratigraphy under varying forcing conditions is preserved over sequences of many such events. Such sequences operating over a range of time scales set the architecture of sedimentary basins, so a method of classifying the stratigraphic result is an important goal. In this study, we use Delft3D to examine the autogenic behavior of thick packages of simulated deltaic stratigraphy (>10 channel depths) under the influence of a range of wave, tide, and flood-dominated conditions, as well as a variety of sedimentary inputs. We quantify the strength and type of autogenic behavior by measuring stratigraphic completeness and compensation index. Both metrics have been observed to vary systematically in field scale systems, and in experimental deltas deposited under a range of river dominated conditions. This work will extend that range into deltas with significant wave, tide, and flood influence.

Final ID: EP23B-05

Climatic and paleoclimatic forcing of erosion in the southern Central Andes and the northwestern Himalaya *(Invited)*

B. Bookhagen;[1]; *M. R. Strecker;*[2];
1. Geography, UC Santa Barbara, Santa Barbara, CA, United States.
2. Institut für Erd- und Umweltwissenschaften, Uni Potsdam, Potdam, Germany.

Body: The windward flanks of the tectonically active southern Central Andes and the NW Himalaya are characterized by steep climatic, tectonic, and topographic gradients. The first windward topographic rise of these mountain ranges constitutes a significant orographic barrier resulting in high orographic rainfall causing some of the wettest places on Earth. However, the higher-elevation areas of the windward flanks of both regions become progressively drier, until arid conditions are attained in the orogen interiors (i.e., the Altiplano-Puna and Tibet plateaus). Both areas have experienced significant paleoclimatic changes with deeper penetration of moisture into the orogen and thus an orogenward shift of the climate gradient. Some of the world's largest rivers with high sediment loads emerge from these mountain belts, and understanding the relation between climate and erosion is key in predicting mass fluxes, assessing the impacts of climate variability, and long-term climate forcing of erosion on landscape evolution. Here, we quantify the impact of the climatic gradients and their spatial shifts during the late Pleistocene and Holocene. We rely on sedimentary archives, digital topography, and cosmogenic inventories of river sands (10Be) and bedrock-erosion rates (10Be and 26Al) from the Puna Plateau in NW Argentina and the interior of the western Himalaya in NW India. We make three key observations that underline the importance of present-day climatic parameters and paleoclimatic changes on the effiency of surface processes in both areas: (1) First-order spatial erosion patterns follow the climatic gradient and catchment-mean erosion rates vary by three orders of magnitude from the wet mountain fronts to the dry orogen interior. In NW Argentina, our measurements represent the fluvial transport rates and indicate very low fluvial activity in the interior of the Puna Plateau during the Late Pleistocene; (2) the spatial distribution of erosion rates can be explained by a specific stream power (SSP) model that explicitly accounts for discharge through calibrated satellite-derived rainfall rates. The relation between SSP and catchment-mean erosion rates indicates that erosion (E) scales with E ~ SSP^2 on cosmogenic-nuclide time scales; (3) in the Puna Plateau interior, eolion erosion rates determined on wind-polished surfaces are at least one order of magnitude higher than fluvial erosion rates. Rates increase from the eastern margin of the Puna Plateau to its center.

Late Pleistocene and Holocene sedimentary archives (lacustrine sediments related to landslide damming of river valleys) from both regions furnishes valuable information on the temporal variation of erosion rates. These records reveal that the arid sectors of both environments, which are presently characterized by low present-day and millennial-scale erosion rates, may have increased sediment flux by an order of magnitude during wetter periods on longer time scales in the past. Overall, our findings underscore (1) the fundamental importance of climate-driven processes in the long-term landscape evolution of tectonically active mountain belts; (2) the importance of climatic forcing on sediment production, mass transfer, and permanent vs. transient sediment storage in orogens; and (3) the importance of climate variability in intensifying erosion and sediment-flux rates on millennial time scales.

Final ID: EP23A-06

Statistical characterization of wind-wave induced sediment resuspension events in shallow tidal basins

A. D'Alpaos; [1]; *L. Carniello;* [2]; *A. Rinaldo;* [2, 3];
1. Geosciences, University of Padova, Padova, Italy.
2. Civil, Environmental, and Architectural Engineering, University of Padova, Padova, Italy.
3. 3Laboratory of Ecohydrology, ECHO/IEE/ENAC, EPFL, Lausanne, Switzerland.

Body: Wind-wave induced erosion processes play a critical role on the morphodynamic evolution of shallow tidal landscapes. Both in the horizontal and in the vertical planes, patterns of wind-induced bottom shear stresses contribute to control the morphological and biological features of the tidal landscape, through the erosion of tidal-flat surfaces and of salt-marsh margins, the disruption of the polymeric microphytobenthic biofilm, and the increase in suspended sediment concentration which affects the stability of intertidal ecosystems. Towards the goal of developing a synthetic theoretical framework to represent wind wave-induced resuspension events and account for their erosional effects on the long-term biomorphodynamic evolution of tidal systems, we have employed a complete, coupled finite element model accounting for the role of wind waves and tidal currents on the hydrodynamic circulation in shallow basins. Our analysis of the characteristics of combined current and wave-induced exceedances in bottom shear stress over a given threshold for erosion, suggest that wind wave-induced resuspension events can be modeled as a marked Poisson process. Moreover, the analysis of wind-wave induced resuspension events for different historical configurations of the Venice Lagoon shows that the interarrival times of erosion events have decreased through the last two centuries, whereas the intensities of erosion events have increased. This allows us to characterize the threatening erosion and degradation processes that the Venice Lagoon has been experiencing since the beginning of the last century.

Final ID: H23L-06

Mineral Spatial Distribution in Determining Rates: When does it matter?

L. Li; [1, 3]; *F. Salehikhoo;* [1]; *S. L. Brantley;* [2, 3];
1. Dept. Energy & Mineral Engineering, The Pennsylvania State University, University Park, PA, United States.
2. Dept. of Geosciences, The Pennsylvania State University, University Park, PA, United States.
3. Earth and Environmental Systems Institute, The Pennsylvania State University, University Park, PA, United States.

Body: This abstract summarizes several years' work on exploring the largely unknown effects of mineral spatial distribution on dissolution rates using columns packed with the same magnesite mass but with different distributions within a quartz matrix. Variables include the spatial distribution of the reactive mineral magnesite, orientation of the magnesite zone to the main flow direction, length scale, flow rates, and size contrast between magnesite and quartz grains. The columns with lengths varying from 5 to 20 cm were flushed with acidic solutions (pH 4.0) at flow velocities varying from 0.015 to 7.2 m/d. The largest rate difference was observed between a "Mixed" column containing uniformly distributed magnesite and a "One-zone" column containing magnesite in one cylindrical zone in the center of the column ("flow-parallel One-zone" column). Breakthrough data show that the zonation in the One-zone columns, especially when the grain sizes of magnesite are smaller than that of the quartz, limits magnesite dissolution by a factor of 1.5 – 4.0 compared to the Mixed column. The magnitude of the rate difference increases with increasing flow rates. Under low flow rate conditions, the porefluids reach chemical equilibrium and reaction kinetics does not play an important role. For those conditions, the mineral distribution does not make a difference. Under high flow conditions, however, the effects of the mineral distribution are maximized because column-scale rates exhibit kinetic control due to low residence times. The rate differences between the Mixed and the flow-parallel One-zone cases are much larger than the 14% maximum difference observed between the Mixed column and the "flow-perpendicular One-zone" column.

Two-dimensional reactive transport modeling revealed that local pore-scale dissolution rates vary by orders of magnitude under almost all conditions. In particular, in the flow-parallel one-zone columns, the transverse dispersivity at the quartz-magnesite interface controls mass transport and the column-scale rates. A large portion of the magnesite grains reaches local equilibrium and does not dissolve under various flow and heterogeneity conditions. We therefore define the "effective" surface area as the surface area of the magnesite that is under far-from-equilibrium conditions. The effective surface area essentially determines the column-scale dissolution rates and is a function of flow conditions, length scale, and mineral spatial distribution. The effective surface area can then unify the rates under different flow and heterogeneity conditions. These are the first experimental results that systematically document the significant effects of mineral spatial distribution on their dissolution rates in the subsurface. The work identifies general principles that govern how to predict dissolution rates of minerals in heterogeneous porous media. It will advance our models of the multi-component geochemical reactions in natural, heterogeneous porous media and will provide valuable insights on the laboratory-field rate discrepancy.

Final ID: H23N-08

Examining the concept of baseflow using end-member mixing analysis ***(Invited)***

R. P. Hooper;[1];
1. CUAHSI, Medford, MA, United States.

Body: Baseflow represents the condition a catchment returns to after storm events and is often used as a reference point in mixing models of an unforced state. Frequently baseflow samples are considered indicative of an “old water” or ground water end member. To test the assumptions, 28 storms at the Panola Mountain Research Watershed, near Atlanta, GA, were examined using a three-component chemical mixing model to determine the relative contributions of end members at baseflow and during storms. A discriminant analysis indicated that a 6-month humidity index, precipitation volume, and storm duration were significant in determining the pattern of end-member contributions during these storms.
The results indicate that baseflow varies markedly across seasons and is a mixture of varying proportions of two “groundwater” (i.e., saturated zone) end members. The only consistent finding is that vadose water did not contribute to baseflow. More broadly, the change in concentration between baseflow and stormflow was far more predictable for those solutes whose vadose zone concentration was outside the range of concentration defined by the two groundwater endmembers because there was a consistent direction of change during a storm; if the end member concentration of the vadose water lay between the groundwater end members, the chemical response of the stream depends on the baseflow composition at the start of the storm. This finding explains why it is difficult to define a simple concentration-discharge function to explain both baseflow and storm samples across many storms. Therefore, the concept of baseflow is valid as a reference point for a given storm, but should not be considered a single reference state across seasons.

Final ID: H23O-08

A New Computationally Frugal Method For Sensitivity Analysis Of Environmental Models

M. C. Hill; [2]; *O. Rakovec;* [1]; *M. P. Clark;* [3]; *A. Weerts;* [4, 1]; *R. Teuling;* [1]; *E. Borgonovo;* [5]; *R. Uijlenhoet;* [1];

1. Hydrology and Quantitative Water Management Group, Wageningen University, Wageningen, Netherlands.
2. U.S. Geological Survey - Water Resources Division, Boulder, CO, United States.
3. Research Applications Laboratory, National Center for Atmospheric Research, Boulder, CO, United States.
4. Deltares, Delft, Netherlands.
5. Department of Decision Sciences, Bocconi University, Milan, Italy.

Body: Effective and efficient parameter sensitivity analysis methods are crucial to understand the behaviour of complex environmental models and use of models in risk assessment. This paper proposes a new computationally frugal method for analyzing parameter sensitivity: the Distributed Evaluation of Local Sensitivity Analysis (DELSA). The DELSA method can be considered a hybrid of local and global methods, and focuses explicitly on multiscale evaluation of parameter sensitivity across the parameter space. Results of the DELSA method are compared with the popular global, variance-based Sobol' method and the delta method. We assess the parameter sensitivity of both (1) a simple non-linear reservoir model with only two parameters, and (2) five different "bucket-style" hydrologic models applied to a medium-sized catchment (200 km^2) in the Belgian Ardennes. Results show that in both the synthetic and real-world examples, the global Sobol' method and the DELSA method provide similar sensitivities, with the DELSA method providing more detailed insight at much lower computational cost. The ability to understand how sensitivity measures vary through parameter space with modest computational requirements provides exciting new opportunities.

Final ID: H24G-01

Regional climate variability and patterns of urban development - Impacts on the urban water cycle and nutrient export *(Invited)*

C. Welty; [1]; *E. Bou-Zeid;* [2]; *E. Doheny;* [3]; *A. Gold;* [4]; *P. M. Groffman;* [5]; *M. Grove;* [6]; *S. Kaushal;* [7]; *A. Klaiber;* [8]; *E. Irwin;* [8]; *A. J. Miller;* [1]; *D. Newburn;* [7]; *J. A. Smith;* [2]; *C. Towe;* [7];

1. UMBC, Baltimore, MD, United States.
2. Princeton University, Princeton, NJ, United States.
3. US Geological Survey, Baltimore, MD, United States.
4. University of Rhode Island, Providence, RI, United States.
5. Cary Institute of Ecosystem Studies, Millbrook, NY, United States.
6. USDA Forest Service, Baltimore, MD, United States.
7. University of Maryland, College Park, MD, United States.
8. Ohio State University, Columbus, OH, United States.

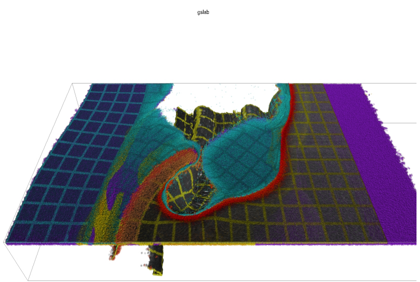
Body: The goal of this work is to evaluate the interactions between urban development patterns and the hydrologic cycle and its associated nutrient cycles, within the context of regional and local climate variability. More specifically, our objective is to create a modeling system capable of simulating the feedback relationships that control urban water sustainability. Core elements include spatial modeling of urban development patterns and individual land use and location processes at parcel and neighborhood scales and for different policy scenarios; three-dimensional modeling of coupled surface water-groundwater and land surface-atmospheric systems at multiple scales (including consideration of the engineered water system), where development patterns are incorporated as input; and field work and modeling aimed at quantifying flow paths and fluxes of water and nitrogen in this system. The project team is evaluating linkages among (1) how human locational choices, water-based ecosystem services, and regulatory policies affect the supply of land and patterns of development over time; (2) how the changing composition and variability of urbanizing surfaces affect local and regional climate; and (3) how patterns of development (including the engineered water system) and climate variability affect fluxes, flow paths and storage of water and nitrogen in urban areas. The Baltimore Ecosystem Study LTER (http://beslter.org) serves as a platform for place-based research to carry out this work.

Final ID: T24A-02

Dynamics of Continental Accretion

L. N. Moresi; [1]; *P. G. Betts;* [1]; *M. S. Miller;* [2];
1. Monash University, Clayton, Australia.
2. Department of Earth Sciences, University of Southern California, Los Angeles, CA, United States.

Body: Subduction zones become congested when they try to swallow buoyant exotic crust. Accretionary mountain belts (orogens) that form at these convergent plate margins are the principal sites of lateral continental growth through Earth’s history. Modern examples of accretionary margins are the North and South American Cordilleras and southwest Pacific. The geologic record is riddled with accretionary orogens, such as the Tasmanides along the eastern margin of the supercontinent Gondwana and the Altaides that formed on the southern margin of Laurasia. Both the modern and ancient examples are characterised by episodic switches between extension and shortening associated with transitions from collision of exotic crust and subduction related rollback. We present three-dimensional dynamic models that show for the first time how accretionary margins evolve from the initial collision, through a period of plate margin instability, to re-establishment of a stable convergent margin. The models illustrate how significant curvature of the orogenic system develops, as well as the mechanism for tectonic escape of the back arc region. The complexity of the morphology and evolution of the system are driven by lateral rollback of a tightly arcuate trench migrating parallel to the plate boundary and orthogonal to the convergence direction. We find geological and geophysical evidence for this process in the Tasmanides of eastern Australia, but infer that this is a global phenomena throughout Earth’s evolution.



Final ID: EP24B-03

Testing bedrock incision models: Holocene channel evolution, High Cascades, Oregon

K. E. Sweeney; [1]; *J. J. Roering;* [1]; *M. A. Fonstad;* [1];
1. University of Oregon, Eugene, OR, United States.

Body: There is abundant field evidence that sediment supply controls the incision of bedrock channels by both protecting the bed from incision and providing tools to incise the bed. Despite several theoretical models for sediment-dependent bedrock abrasion, many investigations of natural channel response to climatic, lithologic, or tectonic forcing rely on the stream power model, which does not consider the role of sediment. Here, we use a well-constrained fluvial channel cut into a Holocene lava flow in the High Cascades, Oregon to compare incision predictions of the stream power model and of the full physics of theoretical models for saltation-abrasion incision by bedload and suspended load. The blocky andesite of Collier lava flow erupted from Collier Cone ~1500 years ago, paving over the existing landscape and erasing fine-scale landscape dissection. Since the eruption, a 6 km stream channel has been incised into the lava flow. The channel is comprised of three alluvial reaches with sediment deposits up to 2 m thick and two bedrock gorges with incision of up to 8 m, with larger magnitude incision in the upstream gorge. Abraded forms such as flutes are present in both gorges. Given the low magnitude and duration of modern snowmelt flow in the channel, it is likely that much of the incision was driven by sediment-laden outburst floods from the terminus of Collier Glacier, which is situated just upstream of the lava flow and has produced two outburst floods in the past 100 years. This site is well suited for comparing incision models because of the relatively uniform lithology of the lava flow and our ability to constrain the timing and depth of incision using the undissected lava surface above the channel as an initial condition.

Using a simple finite difference scheme with airborne-Lidar-derived pre-incision topography as an initial condition, we predict incision in the two gorges through time with both stream power and sediment-dependent models. Field observations and previous studies of Collier Glacier give a likely range of values for grain size, sediment supply and water discharge; we use a 1D energy equation to calculate channel shear stress. Our results from the stream power model show that the incision patterns in both gorges are not well predicted by a single value of the stream power coefficient K, but can be matched relatively well by decreasing K by a factor of two in the lower gorge. This result implies lower erosional efficacy in the lower gorge but does not discriminate among the many mechanisms that may lead to a lower K (asynchronous incision, discharge variability, etc.). Using the mechanistic formulation of the saltation-abrasion model, we explore the implications of factors that may control incision along the channel such as (1) rare, high-magnitude outburst floods, (2) asynchronous incision of the two gorges and (3) hydraulic and sediment transport relationships specific to steep mountain streams (e.g., slope-dependent critical Shields stress). Our initial runs of the saltation-abrasion models underpredict the magnitude of incision, given a reasonable range of inputs. Hence, though the morphology of the gorges indicates that some abrasion has occurred, we suggest that erosion due to plucking also played a significant role in channel evolution.

Final ID: H24D-03

High mountain water fluxes, a trans-Himalayan base-flow perspective

C. Andermann;[1]; *T. C. Stieglitz;*[2]; *N. Hovius;*[1]; *R. Sharma;*[3]; *T. Labasque;*[4];

1. Section 5.1, Geomorphology, GFZ German Research Centre for Geosciences, Potsdam, Germany.
2. TropWater & School of Engineering & Physical Sciences, James Cook University, Townsville, QLD, Australia.
3. Department of Hydrology and Meteorology DHM, Kathmandu, Nepal.
4. Géosciences Rennes, UMR-6118, Université de Rennes 1, Rennes, France.

Body: Large scale hydrological processes in mountain areas underlain by bedrock are not well constrained. Groundwater is commonly considered to be of little importance in the mountain water balance, with direct runoff, snow and ice melt thought to be the principal hydrological buffer. We present new insights into hydrological fluxes between major reservoirs and their associated time scales in a trans-Himalayan catchment. The study area is the Kali Gandaki catchment, rising in the dry Tibetan interior, carving through the high Himalayas and draining the full width of the foothills to the Ganges foreland. The catchment has a well-defined monsoon climate, with pronounced annual wet and dry seasons and a clear separation of windward and lee regions. From December to end of March rainfall is minimal. This offers an opportunity to resolve the spatial contribution of hydrological fluxes, other than direct runoff to river discharge, using geochemical tracers. In February 2013 we have sampled the river over its full 350 km length at ~10 km intervals, all main tributaries and several springs in each lithological unit. We have measured major element abundances, CFC's and noble gases for age determination, trace elements and stable isotopes. We also measured 222Rn in situ, as a tracer for groundwater contribution. These measurements are placed in a context of topographic analyses and continuous discharge and precipitation measurements.

We have observed large variations of chemical fluxes over several orders of magnitude, showing a systematic downstream dilution trend for most major elements. High initial concentrations derive from evaporite deposits in the uppermost part of the catchment, constituting a large scale, natural salt tracer experiment. The well-defined decline of solute concentrations along the main river, paired with constraints on the composition of lateral water inputs downstream allows the calculation of the spatial distribution of additional hydrological fluxes, by applying dilution equations. Radon and trace element measurements show that groundwater contributions are primarily associated with the main structures of the Himalayan range, but also concentrate on the steep southern mountain front, and that groundwater outflow from the Lesser Himalayas is limited. The residence times and recharge temperature (= region of recharge) will be estimated from CFC and noble gas measurements.

Our results highlight the volumetric importance of a high mountain deep-groundwater storage compartment for the well constrained dry base flow season.

Final ID: OS24A-04

Modern sediment dispersal pattern and sediment budget on the continental shelf off the Mekong River delta, South China Sea

W. Szczucinski; [1]; *R. Jagodzinski;* [1]; *T. Hanebuth;* [2]; *K. Stattegger;* [3]; *A. Wetzel;* [4]; *M. Mitrega;* [1]; *D. Unverricht;* [3]; *P. Van Phach;* [5];

1. Adam Mickiewicz University in Poznan, Poznan, Poland.
2. MARUM – Center for Marine Environmental Sciences, University of Bremen, Bremen, Germany.
3. Institute of Geosciences, Kiel University, Kiel, Germany.
4. Institute of Geology and Paleontology, Basel University, Basel, Switzerland.
5. Institute of Marine Geology and Geophysics, Vietnam Academy of Science and Technology, Hanoi, Viet Nam.

Body: The Mekong River is one the major suppliers of sediments to the ocean resulting in the formation of one of the largest river deltas. A major portion of the supplied sediments is accumulated in the subaqueous part of the delta which progrades directly off the river mouths as well as forms in an area next to Camau Peninsula, more than 200 km westward of these mouths.

This study shows evidence for the existence of a Mekong-fed prodelta further offshore and provides a first quantitative estimate of the modern fate of fluvial-derived sediments and of the dispersal pattern of sediments transported further offshore to the subaqueous prodelta, to the outer continental shelf and to the deep South China Sea basin. The study is based on 96 surface sediment samples and five short sediment cores which were analyzed for grain-size composition, carbonate and total organic carbon contents, sedimentary structures (X-ray radiographs), clay mineralogy and bulk geochemistry, as well as 210Pb and 137Cs-based sediment accumulation rates.

According to these results, the shelf environment is divided into three zones. Westward and southward of Camau Peninsula, the subaqueous prodelta (water depth < 32 m) appears as mud-dominated, organic-rich, high-accumulation (up to 1.5 cm yr-1) zone. South of the river mouths, a wide zone is dominated by terrigenous sands, probably representing the sink for river-supplied bedload sediments. The third, most offshore zone is dominated by muddy sands rich in biogenic carbonate. Evidence for redeposition, event deposition and changing sedimentary conditions is found in each of these zones reflecting the combined effects of tides, changing monsoonal current and wind regimes as well as of episodic tropical storms.

The sediment budget calculation reveals that the subaqueous delta front stores about 50% of the fine-grained sediments supplied by the Mekong River. Roughly one fourth of the sediments is retained in the subaerial part of the delta (including the Tonle Sap lake) and about 25% accumulates on the shelf around Camau Peninsula mainly in the form of prodelta deposits. These results do not suggest a significant export of fine-grained sediments into the deep part of South China Sea.

Final ID: T24C-04

Geomorphic evidence for a major discontinuity in the Main Himalayan Thrust in west Nepal

J. E. Harvey; [1]; *D. W. Burbank;* [1]; *B. Bookhagen;* [1];
1. UCSB, Santa Barbara, CA, United States.

Body: In central and eastern Nepal, an abrupt rise in elevation from the foothills to the high Himalaya (known colloquially as PT2) has been interpreted as the southern margin of a belt of rapid rock uplift. Although the mechanisms driving uplift are debated, there is broad agreement that some component of the uplift results from overthrusting over a mid-crustal ramp in the Main Himalayan Thrust (MHT). The presence of the uplift gradient is evidenced by mineral cooling ages, river incision rates, and geodetic observations, which show that uplift and erosion rates north of PT2 are on the order of 1-7 mm/yr faster than to the south. Analysis of digital topography reveals that the zone of rapid uplift is manifest as a belt of elevated hillslope gradient, stream steepness index, and topographic relief. Thus it appears that in the Himalaya, these topographic metrics can serve as a crude proxy for uplift rates within the orogen.

To the west of well-studied central Nepal, the conspicuous band of elevated topographic metrics bifurcates into two bands; one tracks the retreat of the High Himalaya to the north in a broad embayment, and the other, more subtle, lies along strike of PT2. Between the two belts lies a low-relief relict landscape. We interpret the northern step as a northward bend in the MHT ramp and the southern step as the surface expression of a ramp in the floor thrust of a duplex growing in the footwall of the MHT. Recent reactivation of the duplex likely led to the uplift of the relict landscape to its present elevation. This neotectonic model is supported by a recently described dextral shear zone that crosscuts the range, spatial patterns of microseismicity, and a tectonic reconstruction that infers the presence of ramps beneath the two uplift belts.

Our interpretations stand in contrast to the standard tectonic model for central Nepal, which is often projected along strike with little regard for lateral variations in tectonic structures. However, west Nepal represents a zone where oblique transport over a mid-crustal ramp and out-of-sequence duplexing operate in tandem to define the first-order topography of the range. This transition zone represents an important discontinuity in the MHT and exemplifies an increasingly complex pattern of strain distribution, related seismicity, and large-scale tectonic structure in the central Himalaya.

Final ID: EP24A-04

Modeling subglacial hydrology and what that may tell us about erosion ***(Invited)***

M. A. Werder; [1]; *G. E. Flowers;* [2];
1. University of Bristol, Bristol, United Kingdom.
2. Simon Fraser University, Burnaby, BC, Canada.

Body: Subglacial hydrology can influence erosion directly through plucking, by changing the water pressure, and indirectly through abrasion, by modulating the sliding velocity of glaciers. Further, water flow can erode, deposit and transport sediments. Thus, subglacial hydrology may play a key role in shaping typical glacial landforms like deep troughs and overdeepenings. In this context, one of the important physical properties of water is the pressure dependence of its melting point which decreases with pressure. This leads to enhanced water flow into troughs and overdeepenings and inhibited water flow out of them.

Here we present a model study of the hydrology of synthetic glaciers lying in deep troughs with or without overdeepenings. We use the 2D glacier drainage system model GlaDS which simulates both distributed and channelized drainage at the ice-bed interface. Notably this model generates the channel system as part of the solution.

We find that side channels descending into the trough are abundant due to the enhanced melt inside them. This leads to an equalization of the hydraulic potential and effective pressure across the glacier. At steep adverse bed slops at the end of overdeepenings, the channel system shuts down due to freeze-on at channels walls. However, the critical adverse slope along the thalweg is larger than previously thought as channels will do a "traversing ascent" to lessen the slope. There is a region of negative effective pressure at the onset of steep enough adverse bed slopes and generally a reduced effective pressure throughout overdeepenings. We will discuss how these findings tie in with the genesis and preservation of deep troughs and overdeepenings.

Final ID: GC24B-05

On the weighting of CMIP5 multimodel ensembles in temperature simulation over Eurasia

C. Miao; [1]; *Q. Duan;* [1];
1. Beijing Normal University, Beijing, China.

Body: Outputs from Global Circulation Models (GCMs) form the main scientific basis for several climate change assessment reports sponsored by the Intergovernmental Panel on Climate Change (IPCC) and are widely used in global change research. GCMs can be used to simulate present-day and project future climate conditions under different scenarios, and hence inform decision makers regarding policy making such as potential mitigation measures and adaptation strategies. Because single models are over-confident, multi-model ensembles contain the information from all participating models and embrace distinctly different physical parameterizations and consequently moderate the uncertainties arising from different parameterizations and dynamical cores in the different GCMs. Consequently, use of multi-model ensembles from global climate models to simulate current and future climate change has flourished as a research topic during recent decades. With the Climate Model Intercomparison Projection Phase 5 (CMIP5) near completion, it is necessary to evaluate whether the outputs from CMIP5 GCMs are able to represent fully the observed climate trend and statistical features in the 20th century. Meanwhile, the future trends of temperature for different scales and emission scenarios are projected based on the posterior model probabilities estimated by multi-models ensemble methods. This study uses different weighting multimodel approach to study the trend in temperature change in Eurasia using climate simulations from the CMIP5. Observed data from 1901-2005 are used for this study. The trend is estimated based on change in decadal scale. Bayesian weights are computed for each 10-year period. The change in weights is analyzed. The suitability of using the weights computed from the past data to predict temperature in the future is evaluated.

Final ID: P24B-06

Conservation of Total Escape from Hydrodynamic Planetary Atmospheres

F. Tian;[1, 2];
1. NAOC, Beijing, China.
2. CESS-THU, Beijing, China.

Body: Atmosphere escape is one key process controlling the evolution of planets. However, estimating the escape rate in any detail is difficult because there are many physical processes contributing to the total escape rate. Here we show that as a result of energy conservation the total escape rate from hydrodynamic planetary atmospheres where the outflow remains subsonic is nearly constant under the same stellar XUV photon flux when increasing the escape efficiency from the exobase level, consistent with the energy limited escape approximation. Thus the estimate of atmospheric escape in a planet's evolution history can be greatly simplified.

URL: http://arxiv.org/abs/1308.0511

Final ID: EP24B-07

Numerical Model of Turbulence, Sediment Transport, and Sediment Cover in a Large Canyon-Bound River

L. V. Alvarez; [1]; *M. W. Schmeeckle;* [1];

1. School of Geographical Sciences, Arizona State University, Tempe, AZ, United States.

Body: The Colorado River in Grand Canyon is confined by bedrock and coarse-grained sediments. Finer grain sizes are supply limited, and sandbars primarily occur in lateral separation eddies downstream of coarse-grained tributary debris fans. These sandbars are important resources for native fish, recreational boaters, and as a source of aeolian transport preventing the erosion of archaeological resources by gully extension. Relatively accurate prediction of deposition and, especially, erosion of these sandbar beaches has proven difficult using two- and three-dimensional, time-averaged morphodynamic models. We present a parallelized, three-dimensional, turbulence-resolving model using the Detached-Eddy Simulation (DES) technique. DES is a hybrid large eddy simulation (LES) and Reynolds-averaged Navier Stokes (RANS). RANS is applied to the near-bed grid cells, where grid resolution is not sufficient to fully resolve wall turbulence. LES is applied further from the bed and banks. We utilize the Spalart-Allmaras one equation turbulence closure with a rough wall extension. The model resolves large-scale turbulence using DES and simultaneously integrates the suspended sediment advection-diffusion equation. The Smith and McLean suspended sediment boundary condition is used to calculate the upward and downward settling of sediment fluxes in the grid cells attached to the bed. The model calculates the entrainment of five grain sizes at every time step using a mixing layer model. Where the mixing layer depth becomes zero, the net entrainment is zero or negative. As such, the model is able to predict the exposure and burial of bedrock and coarse-grained surfaces by fine-grained sediments. A separate program was written to automatically construct the computational domain between the water surface and a triangulated surface of a digital elevation model of the given river reach. Model results compare favorably with ADCP measurements of flow taken on the Colorado River in Grand Canyon during the High Flow Experiment (HFE) of 2008. The model accurately reproduces the size and position of the major recirculation currents, and the error in velocity magnitude was found to be less than 17% or 0.22 m/s absolute error. The mean deviation of the direction of velocity with respect to the measured velocity was found to be 20 degrees.

Large-scale turbulence structures with vorticity predominantly in the vertical direction are produced at the shear layer between the main channel and the separation zone. However, these structures rapidly become three-dimensional with no preferred orientation of vorticity. Surprisingly, cross-stream velocities, into the main recirculation zone just upstream of the point of reattachment and out of the main recirculation region just downstream of the point of separation, are highest near the bed. Lateral separation eddies are more efficient at storing and exporting sediment than previously modeled. The input of sediment to the eddy recirculation zone occurs near the reattachment zone and is relatively continuous in time. While, the export of sediment to the main channel by the return current occurs in pulses. Pulsation of the strength of the return current becomes a key factor to determine the rates of erosion and deposition in the main recirculation zone.

Final ID: EP24A-07

Relative importance of fluvial and glacial erosion in shaping the Chandra Valley, western Himalaya, India

P. Eugster; [1]; *D. Scherler;* [2]; *R. C. Thiede;* [1]; *A. Codilean;* [3]; *M. R. Strecker;* [1];

1. Institute of Earth and Environmental Science, University of Potsdam, Potsdam, Germany.
2. Division of Geological and Planetary Sciences, California Institute of Technnology, Pasadena, CA, United States.
3. GFZ German Research Centre for Geosciences, Potsdam, Germany.

Body: In deeply incised, high-elevation orogens, such as the Himalaya, it is challenging to quantify the contribution of glaciers to long-term erosion and exhumation due to vigorous fluvial erosion and mass wasting. This is especially true for the humid sectors of the orogen. In the Himalaya, the majority of studies has been conducted in internal arid sectors of the orogen, where present-day ice coverage is low and glacial landforms and deposits are well preserved. The Chandra Valley of the greater Lahul area (NW-Himalaya), situated between the southern front of the range (bulk precipitation during summer) and the more arid Trans-Himalaya to the north (most precipitation during winter) is sensitive to fluctuations of the Indian Summer Monsoon and the Westerlies. In this region we intend to determine spatial and temporal variations in valley incision through fluvial and glacial erosion on different timescales by combining information obtained from cosmogenic radionuclide (CRN) dating of glacially-carved and striated surfaces, low-temperature thermochronometers, field mapping and morphometric analysis. A prominent feature in the upper Chandra Valley, also the headwater region of the Chenab River, is a large knickpoint in the present-day channel profile of the Chandra/Chenab River at an elevation of ~3900 m asl. This knickpoint spatially coincides with (1) a pronounced change in AFT ages along the course of the valley; (2) the joining of a tributary where one of the largest glaciers in the entire area is found; (3) a significant lithological break; and (4) a steep climatic gradient that accompanies the northward turn of the valley. Further knickpoints were found in tributary valleys of the Chandra Valley at approximately the same elevation of ~3900 m asl. Our field observations and preliminary CRN data suggest extensive glacial coverage of the upper Chandra Valley. Based on field evidence the minimum ice thicknesses for the main trunk glacier in the Chandra Valley must have been at least 700 m above the present-day valley bottom until ~15 ka. Our data confirm previous glacial chronological work in this area that also proposed that deglaciation of the Chandra Valley must have been rapid and accomplished within 15 ka, but additionally shows that the late glacial ice cover in the upper Chandra was more extensive than previously thought and also reached the Spiti Valley. Combining all preliminary results and observations, we hypothesize that glacial carving has been the first-order erosional agent during the Quaternary of all regions in Lahul above an elevation of 4100 m asl. Apatite fission-track ages suggest slower erosional exhumation in the more arid upper Chandra Valley. In this context a former blocking of the valley by the Bara Shigri glacier is possible and glacial processes may have outpaced fluvial erosion in the upper part of the Chandra Valley.

Final ID: EP24B-08

Modelling Incision in Mixed Bedrock-Alluvial Rivers: The Role of Sediment Waves *(Invited)*

G. Parker; [1, 2]; *L. Zhang;* [3]; *C. P. Stark;* [4]; *E. Viparelli;* [5]; *X. Fu;* [3];

1. Dept. of Civil & Environmental Engineering, University of Illinois Urbana-Champaign, Urbana, IL, United States.
2. Dept. of Geology, University of Illinois Urbana-Champaign, Urbana, IL, United States.
3. Dept. of Hydraulic Engineering, Tsinghua University, Beijing, Beijing, China.
4. Lamont-Doherty Earth Observatory, Columbia University, Palisades, NY, United States.
5. Dept. of Civil & Environmental Engineering, University of South Carolina, Columbia, SC, United States.

Body: The delineation of the Sklar-Dietrich (S-D) model for bedrock incision due to wear has allowed modeling to move beyond phenomenological models to treatments with both measurable and physically interpretable input parameters. The S-D model assumes that incision is due to abrasion caused by bedload particles striking the bedrock surface, and that the ratio of the bedload supply rate to the capacity transport rate controls the areal fraction of bed surface available for abrasion. The model does not, however, route the alluvium itself downstream. As such, it cannot track the spatiotemporal evolution of downstream-migrating sediment waves created by such episodic events such as landslides and debris flows. The passage of these waves can cause complete alluviation of the bed, thus shutting down incision. The absence of these events can also shut down incision due to a paucity of tools. We introduce a new model which ties an “Exner” equation for mass balance of bedrock with an Exner equation for conservation of alluvium. As a first step, we apply the model to a 1D configuration with temporally varying sediment input at the upstream end. Model results illustrate the competing roles of advection (which causes deviation from the results of S-D) and diffusion (which drives the process toward S-D). The model is adaptable to a) 2D meandering channels and b) distributed landscape evolution models.

Final ID: C31B-0649

Observation Platforms and Data Streams of the Arctic Next Generation Ecosystem Experiment (NGEE-Arctic)

L. D. Hinzman; [1]; *S. D. Wullschleger;* [2]; *D. E. Graham;* [2]; *S. S. Hubbard;* [3]; *R. J. Norby;* [2]; *A. Rogers;* [4]; *M. S. Torn;* [3]; *C. J. Wilson;* [5];

1. University of Alaska Fairbanks, Fairbanks, AK, United States.
2. Oak Ridge National Laboratory, Oak Ridge, TN, United States.
3. Lawrence Berkeley National Laboratory, Berkeley, CA, United States.
4. Brookhaven National Laboratory, Upton, NY, United States.
5. Los Alamos National Laboratory, Los Alamos, NM, United States.

Body: The goal of the Arctic Next Generation Ecosystem Experiment (NGEE-Arctic) is to deliver a process-rich ecosystem model, extending from bedrock to the top of the vegetative canopy, in which the evolution of Arctic ecosystems in a changing climate can be modeled at the scale of a high resolution Earth System Model grid cell. Increasing our confidence in climate projections for high-latitude regions of the world requires a coordinated set of observation platforms that target improved process understanding and model representation of important ecosystem-climate feedbacks. The Next-Generation Ecosystem Experiments (NGEE Arctic) seeks to address this challenge by quantifying the physical, chemical, and biological behavior of terrestrial ecosystems in Alaska. Initial research has focused upon the highly dynamic landscapes of the North Slope (Barrow, Alaska) where thaw lakes, drained thaw lake basins, and ice-rich polygonal ground offer distinct land units for investigation and modeling. This vision includes mechanistic studies in the field and in the laboratory; modeling of critical and interrelated water, nitrogen, carbon, and energy dynamics; and characterization of important interactions from molecular to landscape scales that drive feedbacks to the climate system. To complete these investigations, an integrated program of field monitoring has been initiated. These include observations of meteorological, hydrological, ecological and geophysical processes. These data streams are intended to supplement and extend existing polar data sets to advance our understanding of the Arctic environment and its response to a rapidly changing climate.

URL: http://ngee-arctic.ornl.gov/

Final ID: EP31A-0818

Linking shoreline displacement to environmental conditions in the Wax Lake Delta, USA

N. Geleynse; [1, 2]; *M. R. Hiatt;* [3]; *H. Sangireddy;* [3]; *P. Passalacqua;* [3];

1. National Center for Earth-Surface Dynamics, University of Minnesota, Minneapolis, MN, United States.
2. Jackson School of Geosciences, University of Texas At Austin, Austin, TX, United States.
3. Department of Civil, Architectural, and Environmental Engineering and Center for Research in Water Resources, University of Texas At Austin, Austin, TX, United States.

Body: The dynamics of river deltas are not well-understood in part because of scarcity of historical data that document the growth or retreat of their channel networks, islands and shorelines. In particular, the mapping of deltaic shorelines is not trivial, however recent developments allow for their extraction from satellite and aerial imagery.

Here, we present an analysis of environmental data and Landsat imagery of the Wax Lake Delta, a naturally-developing river delta in the shallow Atchafalaya Basin, Gulf of Mexico, USA. The image-based shoreline corresponds to the hydrodynamic shoreline, that is, the boundary of the subaerial and subaqueous portions of the delta, however, can be related to a morphodynamically-relevant shoreline by application of our method [Geleynse et al., 2012] to bathymetric-topographic data. Moreover, the effect of tides, river floods, wind, and vegetation cover on the extracted shorelines of the Wax Lake Delta can be identified.

Final ID: EP31A-0829

NUMERICAL MODELING OF MIXING OVER DUNE BEDS UNDER LOW AND HIGH TIDE CONDITIONS

J. Imran; [1]; *K. Abdo;* [1]; *A. Cantelli;* [2];
1. Univ South Carolina, Columbia, SC, United States.
2. Shell Exploration and Production Company, Houston, TX, United States.

Body: Mixing in estuaries is controlled by the interaction fresh water discharge and tidal cycle. Recent field studies have shown that the presence of bedforms can also significantly affect the interfacial mixing between fresh water and salt wedges and generate internal waves. In the present work, numerical modeling is done to study the flow field in the estuarine environment under low and high tide as well as low and high fresh water discharge conditions. Conservation equations of mass, momentum, and salt concentration are solved using a finite volume method. Turbulence is modeled using the k-ε model and the free surface is tracked using the volume of fluid method. Fixed bedforms of different amplitudes are considered. Internal Froude numbers are computed from simulation results to characterize disturbances. The results show that (i) lower river discharge results in increased salt entrainment in the upper water column while higher discharge suppresses the mixing and migration of the salt wedge, (ii) mixing increases with dune amplitude, (iii) presence of dunes significantly affects the free surface slope due to increased resistance to the flow, (iv) flow disturbances over the dune are found to be in the subcritical zone during the high tide as a result of the significant increase in the salt wedge thickness, (v) during the low tide, the type of disturbance changes from subcritical to partially blocked to supercritical as the river flow or the tidal amplitude increases.

Final ID: EP31A-0830

Modeling Floodplain Dynamics: Can the Ganges-Brahmaputra Delta keep pace with 21st Century Sea Level Rise?

K. G. Rogers; [1]; *I. Overeem;* [1];

1. University of Colorado, Boulder, CO, United States.

Body: The low-lying Ganges-Brahmaputra (G-B) Delta in Bangladesh is densely populated (~1200 people/km2) and could be flooded within the next century by rapid sea level rise and increased monsoonal rains. The G-B Rivers currently transport 1*109 tons of sediment from their basins in the Himalaya Mountains to the delta each year, with ~90% of the annual sediment load delivered during the Asian summer monsoon. Sediment distribution across the delta's surface by floods and coastal storms has kept pace with the rate of relative sea level rise along the Bengal coast, enabling the delta to maintain a positive elevation. However, ensemble Community Climate System Model experiments predict 11% higher monsoonal rainfall for the next century, potentially leading to extreme flooding events in the delta. Stratigraphic reconstructions show that sedimentation in the upper G-B floodplain was more than doubled under the Early Holocene enhanced monsoonal regime, suggesting that the delta may withstand an increase in monsoon intensity, flooding, and tropical cyclones that are currently predicted. Whether the G-B floodplains and coastal areas will ultimately drown under predicted sea level rise and monsoon intensification depends on a balance of aggradation, eustatic sea level rise and subsidence. To improve predictions of climatic forcing on aggradation rates in the lower G-B floodplain and coastal plain, direct sedimentation measurements collected in 2008 and 2012 in the lower delta are paired with a series of model components coupled within the Community Surface Dynamics Modeling System (CSDMS) Modeling Tool (CMT). We use three separate numerical models to simulate river basin sediment flux, floodplain sedimentation, and tidal-plain aggradation. The model inputs are based on available 20Th century climate and river gauge data, and outputs are compared to modern sedimentation rates within the G-B tidal delta and highly cultivated central coastal plain. The models are then used to test the response of the G-B sediment dispersal system under various climate scenarios and anthropogenic influences, including: increased precipitation and coastal water levels; changes in glacial coverage in the Himalayas; and greater sediment storage within man-made reservoirs. This quantitative modeling approach will help assess the process-response mechanisms of the G-B sediment dispersal system, better constraining the impact of flooding dynamics on basin sediment production and aggradation within the highly populated delta plain.

Final ID: EP31A-0835

Holocene evolution of a wave-dominated fan-delta: Godavari delta, India

Y. Saito; [1]; *K. Nageswara Rao;* [2]; *K. Nagakumar;* [2]; *G. Demudu;* [2]; *A. Rajawat;* [3]; *S. Kubo;* [4]; *Z. Li;* [5];
1. Geological Survey Japan / AIST, Tsukuba Ibaraki, Japan.
2. Andhra University, Visakhapatnam, India.
3. Space Applications Centre, Ahmedabad, India.
4. Waseda University, Tokyo, Japan.
5. East China Normal University, Shanghai, China.

Body: The Godavari delta is one of the world's largest wave-dominated deltas. The Godavari River arises in the Western Ghats near the west coast of India and drains an area of about 3.1x10^5 km^2, flowing about 1465 km southeast across the Indian peninsula to the Bay of Bengal. The Godavari delta consists of a gentle seaward slope from its apex (12 m elevation) at Rajahmundry and a coastal beach-ridge plain over a distance of about 75 km and covers ~5200 km^2 as a delta plain. The river splits into two major distributary channels, the Gautami and the Vasishta, at a barrage constructed in the mid-1800s. The coastal environment of the deltaic coast is microtidal (~1 m mean tidal range) and wave-dominated (~1.5 m mean wave height in the June–September SW monsoon season, ~0.8 m in the NE monsoon season). Models of the Holocene evolution of the Godavari delta have changed from a zonal progradation model (e.g. Nageswara Rao & Sadakata, 1993) to a truncated cuspate delta model (Nageswara Rao et al., 2005, 2012). Twelve borehole cores (340 m total length), taken in the coastal delta plain during 2010–2013, yielded more than 100 C-14 dates. Sediment facies and C-14 dates from these and previous cores and remote-sensing data support a new delta evolution model. The Holocene coastal delta plain is divided into two parts by a set of linear beach ridges 12–14 km landward from the present shoreline in the central part of the delta. The location of the main depocenter (lobe) has shifted during the Holocene from 1) the center to 2) the west, 3) east, 4) center, 5) west, and 6) east. The linear beach ridges separate the first three from the last three stages. These lobe shifts are controlled by river channel shifts near the apex. Just as the current linear shoreline of the central part of the delta and the concave-up nearshore topography are the result of coastal erosion of a cuspate delta, the linear beach ridges indicate a former eroded shoreline. An unconformity within the deltaic sediments also indicates erosional environments during the formation of the linear shoreline. We interpret this unconformity as a wave-ravinement surface in a regressive delta succession reflecting the decrease of sediment supply due to lobe shifts (or avulsion), and not as a marine erosion surface due to forced regression. Similar erosion surface is recognized in the Yellow River delta (Saito et al., 2000). Discrimination of either surface for ancient sediments and rocks in a wave-dominated setting will be important in sequence-stratigraphic interpretation.
Coastal erosion and deposition have occurred in wave-dominated deltas naturally on centennial to millenneial time scales, resulting in delta progradation during the Holocene. However recent decrease of sediment discharge due to dam construction and irrigation on decadal time scales has been exacerbating coastal erosion significantly, resulting in delta shrinking in the Godavari delta.

Nageswara Rao, K., Sadakata, N.: In Kay, R. (Ed.), Deltas of the World. American Society of Civil Engineers, New York, 1-15, 1993.
Nageswara Rao, K. et al.: In Bhattacharya, J.P., Gioson, L. (Eds.), River Deltas--Concepts, Models and Examples: SEPM Special Publication 83, 435-451, 2005.
Nageswara Rao, K. et al.: Geomorphology 175-176, 163¬-175, 2012.
Saito, Y. et al.: J Asian Earth Sci. 18, 489–497, 2000.

Final ID: EP31A-0847

Geomorphology and Landscape Evolution Model for the natural and human-impacted regions of the Ganges-Brahmaputra-Meghna Delta

C. Wilson; [1]; *S. L. Goodbred;* [1]; *L. Wallace Auerbach;* [1]; *K. Ahmed;* [3]; *C. Paola;* [4]; *M. D. Reitz;* [2]; *J. Pickering;* [1]
;

1. Dept of Earth and Environmental Sciences, Vanderbilt University, Nashville, TN, United States.
2. Lamont-Doherty Earth Observatory, Columbia University, Palisades, NY, United States.
3. Dept. of Environmental Sciences, Khulna University, Khulna, Bangladesh.
4. St. Anthony Falls Laboratory, University of Minnesota, Minneapolis, MN, United States.

Body: The Ganges-Brahmaputra-Meghna delta (GBMD) in south Asia is generally considered a tide-dominated system, but much of the subaerial delta plain is geomorphically similar to river-dominated systems such as the Mississippi River delta, with a well-developed distributary network separated by low-lying, organic-rich interdistributary basins. By contrast, the lower GBMD is dominated by tidal processes and comprises a 100-km wide coastal plain with dense, interconnected tidal channels that are amalgamated to the seaward edge of the river-dominated portion of the delta. These distinct river- and tide-dominated geomorphic regions are simultaneously sustained by the enormous sediment load of the GBM rivers and its efficient dispersal via the distributary channel network and onshore advection by tides. Together these processes have resulted in the ability of the GBMD to keep pace with sea-level rise throughout the Holocene, with comparatively little shoreline transgression. However, topographic data from the Shuttle Radar Topography Mission (SRTM) highlight low-lying regions of the delta that are located at the interface of the river- and tide-dominated portions of the delta, where the transport energy of small distributaries and the upper tidal zone go to zero. As a result, these are the most sediment-starved regions of the delta and those most at risk to flooding by the summer monsoon and storm surges. Compounding the slow rates of sedimentation and high local organic content, these regions have been strongly affected by the construction of embankments (polders) that artificially de-water the soils and accelerate organic decomposition during the dry season, and further starve the land surface of sediment. Here, we present an integrated conceptual model for the geomorphic evolution of the GBMD that incorporates river- and tide-dominated regions in conjunction with channel-avulsion processes and delta-lobe construction. Each of these is also overprinted by tectonic deformation and human-landscape modifications. A key goal of this model is to explain the wide-scale distribution of coarse-grained river-borne sediment (predominantly sand) that forms the underlying architecture of the GBMD, with only localized preservation of fine-grained (silt and clay) deposits. Finally, analysis of the channel networks in the tidal delta plain reveal that constructed embankments have significantly decreased the density of naturally functioning tidal channels, inducing locally rapid bank migration and affiliated changes in sinuosity. These rapid landscape changes suggest that there has been a resultant change in hydrodynamics of the tidal delta plain following widespread construction of the embankments. With concern to assess landscape vulnerabilities to environmental change and renewed efforts to rehabilitate and stabilize the embankments, this information is needed to support the successful outcome of coastal defense initiatives.

Final ID: G31A-0932

Space geodetic observations and modeling of postseismic deformation due to the 2005 M7.6 Kashmir (Pakistan) earthquake

K. Wang; [1]; *Y. A. Fialko;* [1];
1. Institute of Geophysics and Planetary Physics, Scripps Institution of Oceanography, University of California San Diego, La Jolla, CA, United States.

Body: We analyze the L-band ALOS and C-band ENVISAT Interferometric Synthetic Apetrure data from the epicentral area of the 2005 magnitude 7.6 Kashmir (Pakistan) earthquake that occurred on the south-western edge of Himalaya. ENVISAT data are available from both the descending and ascending orbits, and span a time period of 3 years immediately following the earthquake (2005-2008), with monthly acquisitions. However, the ENVISAT data are highly decorrelated due to high topography and snow cover. ALOS data are available from the ascending orbit, and span a time period of ~2.5 years between 2007-2009, over which they remain reasonably well-correlated. We derive the mean line-of-sight (LOS) postseismic velocity maps in the epicentral area of the Kashmir earthquake using persistent scatterer method for ENVISAT data, and selective stacking for ALOS data. LOS velocities from all data sets indicate an uplift in the hanging wall of the earthquake rupture over the entire period of SAR observations (2005-2009). Models of poroelastic relaxation predict uplift of both the footwall and the hanging wall, while models of viscoelastic relaxation below the brittle-ductile transition predict subsidence of both the footwall and the hanging wall. Therefore the observed pattern of surface velocities suggests that the early several years of postseismic deformation were dominated by afterslip on the fault plane. Kinematic inversions of InSAR data, as well as forward models of stress-driven creep confirm that the observed deformation is consistent with afterslip, primarily downdip of the seismic asperity. We use the InSAR data and modeling results to place contraints on the effective viscosity of the ductile substrate in the study area. We show that in order to prevent surface subsidence, the effective viscosity has to be greater than 10^19 Pa s. The data also appear to require lateral heterogeneities in the rate-state frictional properties of the fault at the bottom of the seismogenic zone and/or and below the brittle-ductile transition.

Final ID: G31A-0952

Decadal strain along creeping faults in the Needles District, Paradox Basin Utah determined with InSAR Time Series Analysis

K. Kravitz; [1]; *M. Furuya;* [2]; *K. J. Mueller;* [1];
1. Geological Sciences , University of Colorado, Boulder, CO, United States.
2. Natural History Sciences, Hokkaido University, Sapporo, Japan.

Body: The Needles District, in Canyonlands National Park in Utah exposes an array of actively creeping normal faults that accommodate gravity-driven extension above a plastically deforming substrate of evaporite deposits. Previous interferogram stacking and InSAR analysis of faults in the Needles District using 35 ERS satellite scenes from 1992 to 2002 showed line-of-sight deformation rates of ~1-2 mm/yr along active normal faults, with a wide strain gradient along the eastern margin of the deforming region. More rapid subsidence of ~2-2.5 mm/yr was also evident south of the main fault array across a broad platform bounded by the Colorado River and a single fault scarp to the south. In this study, time series analysis was performed on SAR scenes from Envisat, PALSAR, and ERS satellites ranging from 1992 to 2010 to expand upon previous results. Both persistent scatterer and small baseline methods were implemented using StaMPS. Preliminary results from Envisat data indicate equally distributed slip rates along the length of faults within the Needles District and very little subsidence in the broad region further southwest identified in previous work. A phase ramp that appears to be present within the initial interferograms creates uncertainty in the current analysis and future work is aimed at removing this artifact. Our new results suggest, however that a clear deformation signal is present along a number of large grabens in the northern part of the region at higher rates of up to 3-4 mm/yr. Little to no creep is evident along the single fault zone that bounds the southern Needles, in spite of the presence of a large and apparently active fault. This includes a segment of this fault that is instrumented by a creepmeter that yields slip rates on the order of ~1mm/yr. Further work using time series analysis and a larger sampling of SAR scenes will be used in an effort to determine why differences exist between previous and current work and to test mechanics-based modeling of extension in the region.

Final ID: GC31A-1018

Minimizing Uncertainty in Coastal Digital Elevation Models

B. Eakins; [1]; *J. Danielson;* [2]; *S. J. McLean;* [3];
1. Cooperative Institute for Research in Environmental Sciences, University of Colorado, Boulder, CO, United States.
2. Earth Resources Observation and Science Center, U.S. Geological Survey, Sioux Falls, SD, United States.
3. National Geophysical Data Center, National Oceanic and Atmospheric Administration, Boulder, CO, United States.

Body: Digital elevation models (DEMs) have inherent uncertainties in their values that impact the accuracies of coastal inundation studies that utilize them. Sources of DEM uncertainty include: uncertainty of source data, gridding interpolation to fill data gaps, and morphologic change after data collection. These uncertainties are propagated into modeling results such that the modeling of coastal inundation cannot be more accurate than the source DEMs they rely upon. We describe some of the major challenges in building coastal DEMs—those that integrate bathymetry and topography at the coast—and how to recognize errors and minimize model uncertainties. We also discuss procedures for building DEMs, and the efforts of NOAA and USGS to develop high-resolution DEMs of coastal areas impacted by Hurricane Sandy in October 2012.

Final ID: H31H-1315

The Implication of Water Resources Development and Climate Change on Tropical Lakes and Rivers

S. Setegn;[1];
1. Florida International Universi, North Miami, FL, United States.

Body: Assessing future water-availability and developing new management strategies in the presence of climate change is an important challenge in water resources planning and management. A major effect of climate change is likely to be alterations in hydrologic cycles and changes in water availability. Increased evaporation, combined with changes in precipitation, has the potential to affect runoff, the frequency and intensity of floods and droughts. The objective of this study is to assess the vulnerability of water resources for the changing climate and appropriate adaptation strategies. Assessing the impact of climate change on hydrology and water resources essentially involves taking projections of climatic variables at a global scale, downscaling global-scale climatic variables to local-scale hydrologic variables, and computing hydrological components for water resources variability and risk of hydrologic extremes. Time serious climate projections were generated by modifying the historical datasets to represent the changes in the GCM climatologies for three future time windows. Changes in streamflows and other hydrological components were investigated using the downscaled changes in temperature and precipitation. The direction of streamflow change followed mainly the direction of changes in rainfall. Many of the models show statistically-significant declines in mean annual flow for the different time-periods and scenarios. Climate change has the potential to cause shortage of agricultural water resources that contribute to a great agricultural drought. Appropriate adaptation strategies should be designed in order to avoid extreme disasters. The results from this study can contribute information to planers and policy makers, to assist them to appropriately design relevant adaptation strategy.

Final ID: IN31A-1499

Increasing the Impact of High-Resolution Lidar Topography Through Online Data Access and Processing

C. J. Crosby; [1]; *V. Nandigam;* [2]; *C. Baru;* [2]; *R. Arrowsmith;* [3];
1. UNAVCO, Boulder, CO, United States.
2. San Diego Supercomputer Center, University of California, San Diego, La Jolla, CA, United States.
3. School of Earth and Space Exploration, Arizona State University, Tempe, AZ, United States.

Body: Topography data acquired with lidar (light detection and ranging) technology are revolutionizing the way we study the Earth's surface and overlying vegetation. These data, collected from satellite, airborne, tripod, or mobile-mounted scanners have emerged as a fundamental tool for research on topics including earthquake hazards, hillslope processes, and cyrosphere change.

The U.S. National Science Foundation-funded OpenTopography (OT) Facility (http://www.opentopography.org) is a web-based system designed to democratize access to earth science-oriented lidar topography data. OT provides free, online access to lidar data in a number of forms, including the point cloud and associated geospatial-processing tools for customized analysis. The point cloud data are co-located with on-demand processing tools to generate digital elevation models, and derived products and visualizations which allow users to quickly access data in a format appropriate for their scientific application. The OT system is built using a service-oriented architecture (SOA) that leverages cyberinfrastructure resources at the San Diego Supercomputer Center at the University of California San Diego to allow users, regardless of expertise, to access these massive lidar datasets and derived raster data products for use in research and teaching.

OT hosts over 600 billion lidar returns covering more than 120,000 km2. These data are provided by a variety of partners under joint agreements and memoranda of understanding with OT. Partners include national facilities such as the NSF-funded National Center for Airborne Lidar Mapping (NCALM), as well as non-governmental organizations and local, state, and federal agencies. OT has become a hub for high-resolution topography resources. Datasets hosted by other organizations, as well as lidar-specific software, can be registered into the OT catalog, providing users a "one-stop shop" for such information. OT is also a partner on the NASA Lidar Access System (NLAS) project, collaborative research funded by the NASA ACCESS program, that makes NASA airborne and space based laser altimetry data (GLAS and LVIS) available through OT using federated web services.

With several thousand active users, OT is an excellent example of a cyberinfrastructure-based airborne science data system that is enabling access to challenging data for research, education and outreach. OT has demonstrated that by democratizing access to lidar topography, the impact of these expensive research datasets is greatly increased, through reused in research, education, and commercial applications beyond their original scope.

This presentation will highlight the OT system and lessons learned during its development. We will also highlight ongoing work related to creation of a more flexible and scalable high-performance environment for processing of large datasets; creation of a "pluggable" infrastructure for third-party programs and algorithms to be run against the OT data holdings; and interoperability of OT with other earth science data systems.

URL: http://www.opentopography.org/

Final ID: DI31A-2208

TerraFERMA: The Transparent Finite Element Rapid Model Assembler for multi-physics problems in the solid Earth sciences

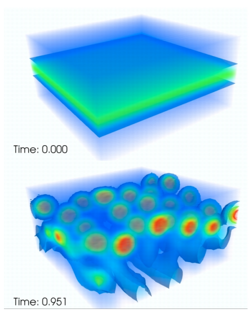
M. W. Spiegelman; [1, 2]; *C. R. Wilson;* [1]; *P. E. Van Keken;* [3];
1. LDEO, Columbia University, Palisades, NY, United States.
2. Applied Physics/Applied Math, Columbia University, New York, NY, United States.
3. Geological Sciences, University of Michigan, Ann Arbor, MI, United States.

Body: We announce the release of a new software infrastructure, TerraFERMA, the Transparent Finite Element Rapid Model Assembler for the exploration and solution of coupled multi-physics problems. The design of TerraFERMA is driven by two overarching computational needs in Earth sciences. The first is the need for increased flexibility in both problem description and solution strategies for coupled problems where small changes in model assumptions can often lead to dramatic changes in physical behavior. The second is the need for software and models that are more transparent so that results can be verified, reproduced and modified in a manner such that the best ideas in computation and earth science can be more easily shared and reused.

TerraFERMA leverages three advanced open-source libraries for scientific computation that provide high level problem description (FEniCS), composable solvers for coupled multi-physics problems (PETSc) and a science neutral options handling system (SPuD) that allows the hierarchical management of all model options. TerraFERMA integrates these libraries into an easier to use interface that organizes the scientific and computational choices required in a model into a single options file, from which a custom compiled application is generated and run. Because all models share the same infrastructure, models become more reusable and reproducible. TerraFERMA inherits much of its functionality from the underlying libraries. It currently solves partial differential equations (PDE) using finite element methods on simplicial meshes of triangles (2D) and tetrahedra (3D).

The software is particularly well suited for non-linear problems with complex coupling between components. We demonstrate the design and utility of TerraFERMA through examples of thermal convection and magma dynamics. TerraFERMA has been tested successfully against over 45 benchmark problems from 7 publications in incompressible and compressible convection, magmatic solitary waves and Stokes flow with free surfaces. We have been using it extensively for research in basic magma dynamics, fluid flow in subduction zones and reactive cracking in poro-elastic materials. TerraFERMA is open-source and available as a git repository at bitbucket.org/tferma/tferma and through CIG.

URL: bitbucket.org:/tferma/tferma



Instability of a 1-D magmatic solitary wave to spherical 3D waves calculated using TerraFERMA

Final ID: T31B-2505

A numerical model of continental topographic evolution integrating thin sheet tectonics, river transport, and climate

D. Garcia-Castellanos; [1]; *I. Jimenez-Munt;* [1];
1. Inst. Ciencias de la Tierra Jaume Almera, Barcelona, Spain.

Body: How much does the erosion and sedimentation at the crust's surface influence on the patterns and distribution of tectonic deformation? This question has been mostly addressed from a numerical modelling perspective, at scales ranging from local to orogenic. Here we present a model that aims at constraining this phenomenon at the continental scale. With this purpose, we couple a thin-sheet viscous model of continental deformation with a stream-power surface transport model. The model also incorporates flexural isostatic compensation that permits the formation of large sedimentary foreland basins and a precipitation model that reproduces basic climatic effects such as continentality and orographic rainfall and rain shadow. We quantify the feedbacks between these 4 processes in a synthetic scenario inspired by the India-Asia collision. The model reproduces first-order characteristics of the growth of the Tibetan Plateau as a result of the Indian indentation. A large intramountain basin (comparable to the Tarim Basin) develops when predefining a hard inherited area in the undeformed foreland (Asia). The amount of sediment trapped in it is very sensitive to climatic parameters, particularly to evaporation, because it crucially determines its endorheic/exorheic drainage. We identify some degree of feedback between the deep and the surface processes occurs, leading locally to a <20% increase in deformation rates if orographic precipitation is account for (relative to a reference model with evenly-distributed precipitation). These enhanced thickening of the crust takes place particularly in areas of concentrated precipitation and steep slope, i.e., at the upwind flank of the growing plateau. This effect is particularly enhanced at the corners of the indenter (syntaxes). We hypothesize that this may provide clues for better understanding the mechanisms underlying the intriguing tectonic aneurisms documented in the syntaxes of the Himalayas.

URL: https://sites.google.com/site/daniggcc/research-interests/high-plateaus

Final ID: EP31D-02

Creative Computing with Landlab: Open-Source Python Software for Building and Exploring 2D Models of Earth-Surface Dynamics

G. E. Tucker; [1]; *D. E. Hobley;* [1]; *N. M. Gasparini;* [3]; *E. Hutton;* [2]; *E. Istanbulluoglu;* [4]; *S. NUDURUPATI;* [4]; *J. M. Adams;* [3];

1. Cooperative Institute for Research in Environmental Sciences (CIRES) and Department of Geological Sciences, University of Colorado, Boulder, CO, United States.
2. CSDMS Integration Facility, INSTAAR, University of Colorado, Boulder, CO, United States.
3. Department of Earth and Environmental Sciences, Tulane University, New Orleans, LA, United States.
4. Department of Civil and Environmental Engineering, University of Washington, Seattle, WA, United States.

Body: Computer models help us explore the consequences of scientific hypotheses at a level of precision and quantification that is impossible for our unaided minds. The process of writing and debugging the necessary code is often time-consuming, however, and this cost can inhibit progress. The code-development barrier can be especially problematic when a field is rapidly unearthing new data and new ideas, as is presently the case in surface dynamics. To help meet the need for rapid, flexible model development, we have written a prototype software framework for two-dimensional numerical modeling of planetary surface processes. The Landlab software can be used to develop new models from scratch, to create models from existing components, or a combination of the two. Landlab provides a gridding module that allows you to create and configure a model grid in just a few lines of code. Grids can be regular or unstructured, and can readily be used to implement staggered-grid numerical solutions to equations for various types of geophysical flow. The gridding module provides built-in functions for common numerical operations, such as calculating gradients and integrating fluxes around the perimeter of cells. Landlab is written in Python, a high-level language that enables rapid code development and takes advantage of a wealth of libraries for scientific computing and graphical output. Landlab also provides a framework for assembling new models from combinations of pre-built components. This capability is illustrated with several examples, including flood inundation, long-term landscape evolution, impact cratering, post-wildfire erosion, and ecohydrology. Interoperability with the Community Surface Dynamics Modeling System (CSDMS) Model-Coupling Framework allows models created in Landlab to be combined with other CSDMS models, which helps to bring frontier problems in landscape and seascape dynamics within closer theoretical reach.

Final ID: EP31D-03

VALIDATION OF A PARCEL-BASED REDUCED-COMPLEXITY MODEL FOR RIVER DELTA FORMATION ***(Invited)***

M. Liang; [1]; *N. Geleynse;* [2]; *P. Passalacqua;* [1]; *D. A. Edmonds;* [3]; *W. Kim;* [2]; *V. R. Voller;* [4]; *C. Paola;* [5];

1. Civil, Architectural and Environmental Engineering, University of Texas at Austin, Austin, TX, United States.
2. Geological Sciences, University of Texas at Austin, Austin, TX, United States.
3. Geological Sciences, Indiana University at Bloomington, Bloomington, IN, United States.
4. Civil Engineering, University of Minnesota, Twin Cities, Minneapolis, MN, United States.
5. Earth Sciences, University of Minnesota, Twin Cities, Minneapolis, MN, United States.

Body: Reduced-Complexity Models (RCMs) take an intuitive yet quantitative approach to represent processes with the goal of getting maximum return in emergent system-scale behavior with minimum investment in computational complexity. This approach is in contrast to reductionist models that aim at rigorously solving the governing equations of fluid flow and sediment transport. RCMs have had encouraging successes in modeling a variety of geomorphic systems, such as braided rivers, alluvial fans, and river deltas. Despite the fact that these models are not intended to resolve detailed flow structures, questions remain on how to interpret and validate the output of RCMs beyond qualitative behavior-based descriptions.

Here we present a validation of the newly developed RCM for river delta formation with channel dynamics (Liang, 2013). The model uses a parcel-based “weighted-random-walk” method that resolves the formation of river deltas at the scale of channel dynamics (e.g., avulsions and bifurcations). The main focus of this validation work is the flow routing model component. A set of synthetic test cases were designed to compare hydrodynamic results from the RCM and Delft3D, including flow in a straight channel, around a bump, and flow partitioning at a single bifurcation. Output results, such as water surface slope and flow field, are also compared to field observations collected at Wax Lake Delta. Additionally, we investigate channel avulsion cycles and flow path selection in an alluvial fan with differential styles of subsidence and compare model results to laboratory experiments, as a preliminary effort in pairing up numerical and experimental models to understand channel organization at process scale. Strengths and weaknesses of the RCM are discussed and potential candidates for model application identified.

Final ID: EP31D-06

Is a Dendritic Drainage Basin Inevitable? ***(Invited)***

G. Parker;[1, 2]; *M. Domanski;*[1]; *S. Weiss;*[3]; *N. Moller;*[1]; *J. Kwang;*[1]; *L. Zhang;*[4]; *X. Fu;*[4];

1. Dept. of Civil & Environmental Engineering, University of Illinois Urbana-Champaign, Urbana, IL, United States.
2. Dept. of Geology, University of Illinois Urbana-Champaign, Urbana, IL, United States.
3. Dept. of Chemical and Biomolecular Engineering, University of Illinois Urbana-Champaign, Urbana, IL, United States.
4. Dept. of Hydraulic Engineering, Tsinghua University, Beijing, Beijing, China.

Body: Channel networks in drainage basins take dendritic forms in the absence of structural controls. It has been known for over 20 years that simple numerical models based on a cellular discretization, and starting from a randomized surface that is subject to rainfall and uplift, spontaneously yield dendritic channel networks. Such numerical landscapes usually reach a steady-state configuration, after which uplift and denudation are in balance and the network no longer evolves. Changed initial randomization is expected to yield a steady state that is different in details, but statistically the same. It has been argued that the dendritic nature of the network is a response to various optimality conditions. Optimality, however, requires one or more parameters to deviate from their extremal values were the steady-state equilibrium to be perturbed. Here we study a) an unchannelized steady state, including incision and hillslope diffusion, b) the effect of perturbing this unchannelized state, and c) the effect of continuously perturbing both a channelized "steady state" and a non-dendritic network. The results provide the ability to study the stability of dendritic networks to infinitesimal and finite-amplitude perturbations, and this to provide a tool for determining in more detail what might be optimal about dendritic drainage basins.

Final ID: H31M-06

A spatial scaling relationship for soil moisture in a semiarid landscape, using spatial scaling relationships for pedology

G. R. Willgoose; [1]; *M. Chen;* [1, 4]; *S. Cohen;* [3]; *P. M. Saco;* [1]; *G. R. Hancock;* [2];

1. Civil, Surveying and Environmental Engineering, The University of Newcastle, Callaghan, NSW, Australia.
2. Environmental and Life Sciences, The University of Newcastle, Callaghan, NSW, Australia.
3. Geography, The University of Alabama, Tuscaloose, AL, United States.
4. Hydraulic and Environmental Engineering, Three Gorges University, Yichang, Hubei, China.

Body: In humid areas it is generally considered that soil moisture scales spatially according to the wetness index of the landscape. This scaling arises from lateral flow downslope of ground water within the soil zone. However, in semi-arid and drier regions, this lateral flow is small and fluxes are dominated by vertical flows driven by infiltration and evapotranspiration. Thus, in the absence of runon processes, soil moisture at a location is more driven by local factors such as soil and vegetation properties at that location rather than upstream processes draining to that point. The “apparent” spatial randomness of soil and vegetation properties generally suggests that soil moisture for semi-arid regions is spatially random. In this presentation a new analysis of neutron probe data during summer from the Tarrawarra site near Melbourne, Australia shows persistent spatial organisation of soil moisture over several years. This suggests a link between permanent features of the catchment (e.g. soil properties) and soil moisture distribution, even though the spatial pattern of soil moisture during the 4 summers monitored appears spatially random. This and other data establishes a prima facie case that soil variations drive spatial variation in soil moisture. Accordingly, we used a previously published spatial scaling relationship for soil properties derived using the mARM pedogenesis model to simulate the spatial variation of soil grading. This soil grading distribution was used in the Rosetta pedotransfer model to derive a spatial distribution of soil functional properties (e.g. saturated hydraulic conductivity, porosity). These functional properties were then input into the HYDRUS-1D soil moisture model and soil moisture simulated for 3 years at daily resolution. The HYDRUS model used had previously been calibrated to field observed soil moisture data at our SASMAS field site. The scaling behaviour of soil moisture derived from this modelling will be discussed and compared with observed data from our SASMAS field sites.

Final ID: EP31D-07

Scaling the Morphology of Sapping and Pressurized Groundwater Experiments to Martian Valleys

W. A. Marra; [1]; *M. G. Kleinhans;* [1];

1. Universiteit Utrecht, Utrecht, Netherlands.

Body: Various valleys exist on Mars, which shows the former existence of fluvial activity and thus liquid water at the surface. Although these valleys show similarities with some valleys on Earth, many morphological features are unique for Mars or are very rare on Earth. Therefore, we lack knowledge about the formative processes of these enigmatic valleys. In this study, we explored possible groundwater scenarios for the formation of these valleys using flume experiments, as there are no pure Earth analogues for these systems. We aim to infer their formative processes from morphological properties.

A series of flume experiments were carried out in a 4x6x1 m experimental setup, where we observed the valley formation as result from seeping groundwater by both local and distal groundwater sources and by pressurized groundwater release. Time-lapse imagery and DEMs of the experiments show the morphological development, associated processes, and landscape evolution. Indicators of the processes where we particularly looked at were changes in valley slope, cross-sectional shape, the relations between valley dimensions, and regional landscape properties as drainage density and valley size distributions. Hydrological modelling assists in scaling the observed experimental features to real-world systems. Additionally, we looked at valleys on Earth in the Atacama Desert, at Box canyon in Idaho, valleys around Kohala on Hawaii and Apalachicola bluffs in Florida to test the applicability of our methods to real-world systems.

In the seeping groundwater valleys, valleys develop due to a combination of mass-wasting failures, mudflows and fluvial flow. The latter two processes are expressed in the final morphology by a break in slope. The mass wasting processes result in U-shaped valleys, which are more pronounced in distal groundwater cases. However, in real-world cases of similar shaped valleys, the cross-sectional shape seems strongly influenced by the strength of the material as well. Groundwater flow piracy of multiple valleys within one system are characterized by equal ratios of width and length development, a property that is absent in case of a local groundwater source which does not induce flow piracy.

In case of pressurized groundwater release, the sediment surface in the source area fractured and pits developed due to high groundwater pressure. The resulting valley head consisted of feather-shaped converging flow features. Scaling of the non-fluvial features that relate to groundwater pressure is possible by using hydrological modelling of groundwater pressure and geophysical modelling of the behaviour of the material under such pressures.

Our results on sapping valley formation, combined with insights from multiple terrestrial sites of similar valleys contribute to the discussion of some enigmatic valleys on Mars. We provide several quantitative morphological measures, which directly relate to the formative process, which is valuable in linking morphology to the formative process. Our results on pressurized groundwater release prove a long-standing hypothesis on the formation on some of the largest valleys observed in our solar system. In both cases, the insights in the formative processes enable us to quantify the amount of water required for the formation of groundwater-induced Martian valleys.

Final ID: OS31D-08

The Seasonal Circulation and Dynamics of the South China Sea (SCS) and the Indonesian Throughflow (ITF) Region

D. Xu; [1]; *P. M. Rizzoli;* [2];
1. Center for Environmental Sensing and Modeling (CENSAM), Singapore-MIT Alliance for Research and Technology (SMART), Singapore, Singapore.
2. Department of Earth, Atmospheric and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, MA, United States.

Body: The upper layer, wind-driven circulation of the South China Sea (SCS) and the Indonesian Throughflow (ITF) are simulated using a high resolution model, FVCOM (Finite Volume Coastal Ocean Model) in a regional domain comprising the Maritime Continent.

The seasonal variability of the wind-driven circulation produced by the monsoon system is realistically simulated. In the SCS the dominant driving force is the monsoon wind and the surface circulation reverses accordingly, with a net cyclonic tendency in winter and anticyclonic in summer. The SCS circulation in the 90s is weaker than in the 60s because of the weaker monsoon system in the 90s. In the upper 50 m the interaction between the SCSTF and ITF is very important. The southward ITF can be blocked by the SCSTF at the Makassar Strait during winter. In summer, part of the ITF feeds the SCSTF flowing into the SCS through the Karimata Strait. The ITF is primarily controlled by the sea level difference between the western Pacific and eastern Indian Ocean. The ITF flow, consistently southwestward below the surface layer, is stronger in the 90s.

The volume transports for winter, summer and yearly are estimated from the simulation through all the interocean straits. On the annual average, there is a ~ 5.6 Sv of western Pacific water entering the SCS through the Luzon Strait and ~ 1.4 Sv exiting through the Karimata Strait into the Java Sea. Also, ~ 2 Sv of SCS water enters the Sulu Sea through the Mindoro Strait, while ~ 2.9 Sv flow southwards through the Sibutu Strait merging into the ITF. The ITF inflow occurs through the Makassar Strait (up to ~ 62%) and the Lifamatola Strait (~ 38%). The annual average volume transport of the ITF inflow from the simulation is ~ 15 Sv in the 60s and ~ 16.6 Sv in the 90s, very close to the long term observations. The transport estimates of the simulation at all the straits are in rather good agreement with the observational estimates.

We analyze the thermal structure of the domain in the 60s and 90s and assess the simulated temperature patterns against the SODA reanalysis product, with special focus on the shallow region of the SCS. The SODA dataset clearly shows that the yearly averaged temperatures of the 90s are overall warmer than those of the 60s in the surface, intermediate and some of the deep layers and the decadal NCEP net heat flux differences (90s-60s) indicate that the overall warming of the SCS interior is a local effect. In the simulation the warm trend from the 60s to the 90s in well reproduced in the surface layer.

Final ID: EP32B-03

Increased complexity modeling provides new physical understanding of landscape-forming processes *(Invited)*

M. W. Schmeeckle;[1];
1. Arizona State University, Tempe, AZ, United States.

Body: Supercomputer resources are increasingly available and affordable to geomorphologists. Significant computational time on a supercomputer is often less expensive than a single trip to a research conference. Perhaps more importantly, massively-parallel, open source codes for solving fluid and particle mechanics and surface evolution, albeit with some modification, are available at no expense. Complex, reductionist modeling approaches, resolving a large range of scales while conserving mass, momentum, and energy, are under-utilized within the surface processes research community. Highly-resolved models provide a richness of data that generally cannot be gained from field or laboratory experiments. Fluid pressure, for example, is difficult to measure except at a few discrete points. The data richness of resolved models can provide physical insight that is not otherwise possible. In such circumstances, lab and field experiments can be designed to validate new physics. Validation itself is a challenge when the primary goal is to confirm new physical insight rather than to compare predicted and actual outcomes. Monte Carlo simulation of sampling distributions is quite useful for statistical inference in such situations where fields are almost always correlated in space and time.

A number of highly-resolved modeling efforts of landscape forming processes, the physical insights learned, and attempts to validate them will be presented. Turbulence- and particle-resloving simulations of bedload and suspended sediment transport in water will be presented. New physical insights from this model involve direct computation of the suspended sediment boundary condition, stratification effects on momentum and mass diffusivity, a new understanding of bedload entrainment by turbulence, and a reduced importance of bedload saltation relative to other motions. Turbulence-resolving simulations of flow and suspended sediment transport in meander bends and lateral separation eddies in rivers reveal the importance of large-scale turbulence structures produced because of secondary circulation and flow separation. Turbulence-resolving and Reynolds-averaged models of flow and formation of aeolian dunes on earth and in Martian craters, and a water, air, and particle model of raindrop impacts will also be briefly presented.

Final ID: EP32B-04

Probability-Based Model of Sediment Transport During Extreme Flood Events in Mountain Catchments

M. C. Perignon; [1, 2]; *G. E. Tucker;* [1, 2];

1. Department of Geological Sciences, University of Colorado Boulder, Boulder, CO, United States.
2. Cooperative Institute for Research in Environmental Sciences (CIRES), University of Colorado Boulder, Boulder, CO, United States.

Body: The impacts that large floods have on the morphology of river networks are strongly dependent on river type and layout, duration and magnitude of overbank flooding, spatial heterogeneity of the sediment supply, and the recent flooding history of the site. Even with detailed knowledge of these initial and boundary conditions, simulations of extreme precipitation-driven floods in mountain catchments created with deterministic morphodynamic models will allow only for a limited understanding of the range of potential responses of the landscape to these rare but potentially highly influential events. We present an example of a probability-based model that predicts the distribution of possible behaviors and characteristics of the sediment carried by the flow as it travels through a mountain catchment, emerges onto a low-slope surface and deposits on the landscape.

Using the 1976 Big Thompson Canyon flood in Colorado as a test scenario, we predict the possible sources of sediment within the catchment, the probable transport times and distances for both the sediment and the flow, the likely particle-size distribution of the material in transport as it travels through the river network, and the probability of sediment accumulation across the landscape and the composition of those deposits after the flow emerges onto the plains. This probability-based model calculates the sediment transport probabilities for a continuum of grain sizes from the flow dynamics simulated by the hydrodynamic model ANUGA driven by spatially-varied precipitation over complex topography. We test the sensitivity of our probability-based model to the boundary conditions by contrasting simulations using the reconstructed precipitation patterns of the 1976 flood as well as other distributions of rainfall intensity and duration, and by comparing the predictions of the model when different spatial distributions of sediment supply are allowed.

The use of probability-based models of sediment transport instead of deterministic morphodynamics for quantifying landscape change during extreme precipitation events captures a full range of potential geomorphic responses instead of only those resulting from a particular combination of model parameters and reduces the influence that spatial and temporal heterogeneity of boundary conditions can have on the simulation results.

Final ID: H32F-05

Utilizing Multi-Sensor Data Products and high-resolution flood model in Analyzing North African Hydrological Processes

K. Thengumthara; [2, 1]; *F. Policelli;* [1]; *S. Habib;* [1]; *J. L. David;* [2, 1]; *K. A. Melocik;* [2, 1]; *G. J. Huffman;* [1]; *M. C. Anderson;* [3]; *A. B. Ali;* [4]; *S. Bacha;* [4];

1. NASA Goddard Space Flight Center, Greenbelt, MD, United States.
2. Science Systems and Applications Inc. (SSAI), Lanham, MD, United States.
3. USDA-ARS Hydrology and Remote Sensing Laboratory, Beltsville, MD, United States.
4. Regional Centre for Remote sensing (CRTEAN), CNCT & DGRE, Tunis, Tunisia.

Body: North Africa is an arid region characterized by isolated extreme events such as floods and droughts. Our present understanding of hydrological processes over North Africa is limited due to low rainfall, mixed response of evaporation to temperature and soil moisture gradients, and lack of high-resolution ground measurements. Remote sensing is an excellent way to obtain near real- time data of high spatial and temporal resolution. Satellite estimates of rainfall and evapotranspiration (ET) have uncertainties due to topography, land-sea contrast, complex weather, and climate variability for high-elevated regions. Generally for arid regions, the satellite precipitation instruments are sensitive to soil moisture and land surface geometry.

This study analyzes different components of hydrological processes over North Africa based on remote sensing data such as precipitation (NASA-TMPA, CMORPH and PERSIANN), evaporation (ALEXI and MODIS), and elevation (SRTM) along with ground measurements and model simulations. Here we use the Coupled Routing and Excess STorage (CREST) hydrological model-version 2.0, which was originally developed by NASA-GSFC and the University of Oklahoma [Wang J et al., 2011]. The model is driven by real time TMPA and climatological PET, interpolated to model grids. The flexible simulation and calibration enables the model to provide high-resolution runoff and water depth at each time step. Our study mainly focuses on two major basins such as Medjerda over Tunisia and the Sebou basin of Morocco.

Case studies of flood events over North Africa were analyzed based on CREST model simulations with respect to ground measurements. The floods are mainly modulated by rainfall associated with synoptic frontal and tropical plumes and orographic mesoscale systems. Occurrences of peak floods simulated by CREST are comparable with diagnostics such as vertically integrated moisture convergence, stratiform and convective precipitation from ECMWF reanalysis. These were also checked with AMSRE-River Watch and MODIS flood maps and uncertainties among different tools will be discussed. The performance of TMPA and ET is also evaluated based on model-simulated runoff and actual ET in comparison with their respective ground measurements.

In general, the model is able to simulate the streamflow and flood fairly well with acceptable statistical efficiency limits for some gauge stations, though it has shown considerable sensitivity to fine resolution elevation data of less than 1km and TMPA of different versions. TMPA rainfall and the simulated runoff have shown large bias and inconsistent trends in some months with respect to gauge measurements; however, better correlation were noted for monthly and yearly aggregation with their respective gauges.

Our analysis recommends the following steps to improve the model performance. (i) correcting TMPA against gauge observations (ii) using high resolution ET from satellite based ALEXI instead of using climatological mean (iii) obtaining more accurate DEMs and (iv) perform model calibration with long term gauge data to ensure that the model is independent of grid scaling.

Final ID: IN32A-05

Use of natural user interfaces in water simulations

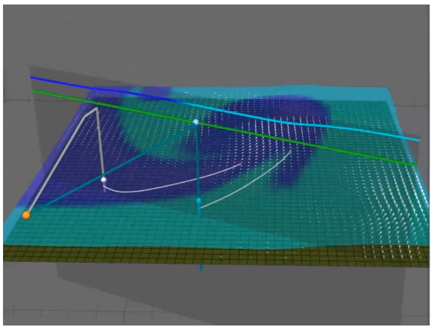
G. Donchyts; [1]; F. Baart; [1]; A. van Dam; [1]; B. Jagers; [1];
1. Deltares, Delft, Netherlands.

Body: Conventional graphical user interfaces, used to edit input and present results of earth science models, have seen little innovation for the past two decades. In most cases model data is presented and edited using 2D projections even when working with 3D data.

The emergence of 3D motion sensing technologies, such as Microsoft Kinect and LEAP Motion, opens new possibilities for user interaction by adding more degrees of freedom compared to a classical way using mouse and keyboard.

Here we investigate how interaction with hydrodynamic numerical models can be improved using these new technologies. Our research hypothesis (H1) states that properly designed 3D graphical user interface paired with the 3D motion sensor can significantly reduce the time required to setup and use numerical models.

In this work we have used a LEAP motion controller combined with a shallow water flow model engine D-Flow Flexible Mesh.



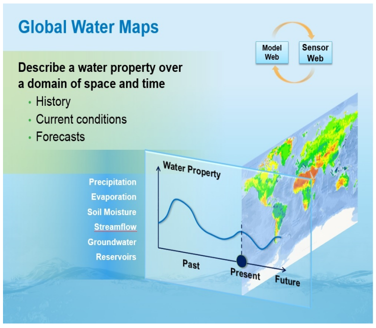
Interacting with numerical model using hands

Final ID: H32F-06

Global Water Maps

D. R. Maidment; [1]; *F. Salas;* [1]; *W. L. Teng;* [2, 3];
1. Center for Research in Water Resources, University of Texas at Austin, Austin, TX, United States.
2. GES DISC, GSFC NASA, Greenbelt, MD, United States.
3. ADNET Systems, Inc., , Rockville, MD, United States.

Body: A global water map is a coverage of the earth that describes the state of water circulation in a phase of the hydrologic cycle. This information can be published as a map showing the state of the water variable at a particular point in time, or charted as a time series showing the temporal variation of that variable at a point in space. Such maps can be created through the NASA Land Data Assimilation System (LDAS) for precipitation, evaporation, soil moisture, and other parameters describing the vertical exchange of water between the land and atmosphere, through a combination of observations and simulation modeling. Point observations of water variables such as precipitation and streamflow are carried out by local hydrologic measurement agencies associated with a particular area. These point observations are now being published as web services in the WaterML language and federated using the Global Earth Observing System of Systems to enable the publication of water observations maps for these variables. By combining water maps derived from LDAS with those from federated point observations, a deeper understanding of global water conditions and movement can be created. This information should be described in a Hydrologic Data Book that specifies the information content of each of these map layers so that they can be appropriately used and combined.



Final ID: EP32B-08

Hydrodynamic controls on floodplain construction over years to millennia

A. P. Nicholas; [1]; *R. E. Aalto;* [1]; *A. Schwendel;* [1]; *G. Sambrook Smith;* [2];
1. Geography, University of Exeter, Exeter, United Kingdom.
2. Geography, University of Birmingham, Birmingham, United Kingdom.

Body: Floodplain construction involves the interplay between channel belt sedimentation and avulsion, overbank deposition of fines, and sediment reworking by channel migration. Each of these processes is controlled, in part, by within-channel and/or overbank hydraulics. However, while spatially-distributed hydrodynamic models are used routinely to simulate floodplain inundation and overbank sedimentation during individual floods, most existing models of long-term floodplain construction and alluvial architecture do not account for flood hydraulics explicitly. Instead, floodplain sedimentation is typically modeled as an exponential function of distance from the river, and avulsion thresholds are defined using topographic indices (e.g., lateral:downstream slope ratios or metrics of channel belt super-elevation). Here we examine the importance of incorporating a physically-based representation of flooding within models of long-term floodplain construction. We combine a simple model of meander migration, cutoff and avulsion with a 2D grid-based model of flood hydrodynamics and overbank sedimentation. The latter involves a finite volume solution of the shallow water equations and an advection-diffusion model for suspended sediment transport. We evaluate model realism over annual to multi-decadal time periods using data quantifying floodplain evolution along the Rio Beni, Bolivia. The Beni is a large (width ~500 m), meandering sand-bed river characterized by very high rates of channel migration (locally >100 m per year) and rapid floodplain sedimentation (~5 cm per year on average adjacent to the channel). We utilise information on planform channel change obtained from satellite imagery, and measurements of floodplain deposit grain size characteristics and overbank sedimentation rates over the past century derived from Pb-210 analysis of floodplain sediment cores. Following model evaluation, we carry out a series of numerical experiments to quantify hydrodynamic controls on long-term floodplain construction for a range of flood regimes, sediment supply scenarios, floodbasin geometries, and subsidence rates.

Final ID: TH32D-01

Building a Sediment Experimentalist Network

L. Hsu; [1]; *W. Kim;* [2]; *R. L. Martin;* [3]; *B. J. McElroy;* [4];
1. Lamont Doherty Earth Obs, Palisades, NY, United States.
2. University of Texas, Austin, TX, United States.
3. University of California, Los Angeles, Los Angeles, CA, United States.
4. University of Wyoming, Laramie, WY, United States.

Description: Join us in building the new Sediment Experimentalist Network (SEN). We will present plans for practical tools to aid you in sharing and organizing your experimental data and methods on Earth-surface process and stratigraphy. We also seek community feedback in the areas of a Knowledge Base, initiation of Education and Data Standards, and coordination of Experimental Collaboratories. Students and early career investigators are encouraged to attend.

Final ID: B33F-0553

Identification of anthropogenic nitrogen sources using stable isotopes and reactive hydrologic modeling

M. T. O'connell; [1]; *S. A. Macko;* [1]; *Y. Fu;* [2];
1. Environmental Sciences, University of Virginia, Charlottesville, VA, United States.
2. Triad Engineering Application, Inc, Ashburn, VA, United States.

Body: The Najinhe watershed is a topographically diverse, heavily agricultural region in northeastern China that provides opportunities for identification of the impact of land use on nitrogen cycling. In addition to agricultural soil amendments, seasonal variation in atmospheric flow introduces dry and wet deposition from urban and desert sources. Both agricultural amendments and atmospheric sources are significant inputs of reactive N, at estimated annual rates of 450 kg/ha and 30 kg/ha respectively in the nearby North China Plain.
Both historic and current land use has influenced the biological processing of nitrogen in a particular area. Soil conditions, including moisture, texture, and organic content, control the capacity of a parcel for processing reactive nitrogen. Compounds derived from natural and anthropogenic sources exhibit characteristic stable isotopes of nitrogen and oxygen that serve as tracers of origin as well as integrators of biological processes. Analysis of bulk soils (including both organic and inorganic N contents) in the system shows $\delta^{15}N$ ranging from 1.3 – 8.6 ‰ suggesting varying influence of anthropogenic inputs, fertilizers, soil organic nitrogen, and atmospheric sources based on land use.
A distributed hydrologic model coupled with one focusing on reactive transport is able to help determine locations with the highest impact on the dissolved N in this system. Spatial statistical methods are employed to determine the biogeochemical influence of model locations whereas $\delta^{18}O$ on soil NO_3^- and $\delta^{15}N$ measurements on NO_3^- and NH_4^+ in surface water and soil extracts are used to calibrate and validate model predictions based on measured precipitation and streamflow values. Sources are integrated using a Bayesian mixing model to determine likely fate and transport parameters for various N inputs to the watershed.
The application of the coupled hydrologic and transport models to a landscape scale catchment suggests integration and expansion to larger watersheds on the basin scale is possible. Identification of sensitive parcels on multiple spatial scales can direct targeted land management efforts to mitigate ecological and health effects of reactive N in surface waters.

Final ID: C33A-0691

Climatology and Changes in the Timing and Duration of Surface Soil Freeze/Thaw Status from 1956-2006 over China

K. Wang; [1]; *T. Zhang;* [2, 3];

1. Research School of Arid Environment and Climate Change, LZU Lanzhou University, Lanzhou, China.
2. College of Earth and Environmental Sciences, Lanzhou University, Lanzhou, China.
3. National Snow and Ice Data Center, University of Colorado at Boulder, Boulder, CO, United States.

Body: This study investigated the climatology and changes in the surface soil freeze-thaw status across China. We used the observed daily surface soil temperature data from 845 stations over a period from 1956 to 2006. We investigated the spatial and temporal changes in the first and last date of te near surface soil (~5 cm) freezing, duration and number of freezing days, as well as number of freeze/thaw cycles in the near-surface soils. The climatology for each parameter was based on the base period of 1971-2000. The preliminary results showed that the near-surface soil freeze/thaw status was correlated with latitudes and elevations. We found that boundaries of permafrost zones are coincided with regions where the numbers of freezing days were more than 220 days per year. Using the mean number of 15 days of the near surface soil freezing as a criterion, we found that the southern boundary of seasonally frozen ground was about 25°N, and the regions south of 22°N were essentially unfrozen regions. Changes in surface soil freeze/thaw status represented clear temporal trends under the changing climate over China. The number of freezing day and duration of the near-surface soil freezing have decreased by approximately 11 days from 1956 to 2006. The timing of soil freeze/thaw has also changed significantly. There was a trend toward later in the first date of the near-surface soil freezing by about 5 days and earlier in the last date of the near surface soil freezing by 7 days over the period 1956-2006. These changes was accelerated since the 1990s with the linear slope up to -1.4 days per year. Changes in the number of near-surface soil freezing were in a negative correlation with air temperature, i.e., the number of near-surface soil freezing days decreased with increase in air temperature.

Final ID: C33B-0715

In Situ Data Suggest Supra-, En- and/or Subglacial Meltwater Retention in Southwest Greenland

A. K. Rennermalm; [1]; *A. B. Mikkelsen;* [2]; *D. van As;* [3]; *I. Overeem;* [4]; *L. C. Smith;* [5]; *V. Chu;* [5]; *P. W. Nienow;* [6]; *A. Tedstone;* [6];

1. Geography, Rutgers University New Brunswick, Piscataway, NJ, United States.
2. Geography and Geology, University of Copenhagen, Copenhagen, Denmark.
3. Geological Survey of Denmark and Greenland, Copenhagen, Denmark.
4. INSTAAR, University of Colorado Boulder, Boulder, CO, United States.
5. Geography, University of California Los Angeles, Los Angeles, CA, United States.
6. Geography, University of Edinburgh, Edinburgh, United Kingdom.

Body: To accurately determine the Greenland ice sheet contribution to raising global sea levels, a better understanding of how much surface meltwater is retained is needed. It is possible to calculate catchment meltwater retention from land-terminating outlet glaciers with an input/output method. In this paper, this method is used to determine meltwater retention within the large Watson River catchment in Southwest Greenland using runoff calculated with a surface energy balance model relying on input data from three on-ice automatic weather stations, and river discharge datasets from three nested ice sheet catchments (60 – 9750 km2) for 2008 - 2012. By using data from three nested basins of different sizes, an understanding of spatial distribution can be obtained. This analysis indicates that meltwater retention in supra-, en-, and/or subglacial environments may take place both below 800 m a.s.l, near the margin, and above 800 m a.s.l, in the interior region of the ice sheet.

Final ID: C33B-0716

Fast flow of Jakobshavn Isbræ and its subglacial drainage system

M. A. Werder; [1]; *I. R. Joughin;* [2];
1. University of Bristol, Bristol, United Kingdom.
2. University of Washington, Seattle, WA, United States.

Body: Jakobshavn Isbræ and many other outlet glaciers of present and past ice sheets lie in deep troughs which often have several overdeepened sections. The subglacial drainage system of such glaciers is heavily influenced by two effects caused by the pressure dependence of the melting point of water. The melting point decreases with increasing water pressure, this enhances wall-melt in downward sloping channels and diminishes wall-melt in upward sloping channels. Thus the first effect is the well known shutdown of channels on steep adverse bed slopes of overdeepenings and the associated high water pressure/low effective pressure. The second effect is a 2D effect and has not received much/any attention so far: the orientation of a channel will be deflected from the direction of the (negative) hydraulic potential gradient (which drives the water flow) towards the steepest slope of the bed. This leads to the enhanced formation of side channels dipping into the trough at about a 45° angle. This efficient connection between the margin and the trough equalizes the hydraulic potential, again leading to higher water pressure in the trough.

We investigate these two effects with the 2D subglacial drainage system model GlaDS using Jakobshavn Isbræ as an example. We compare model runs with the pressure melt term disabled and enabled. With the term disabled the main channel situated in the trough is continuous and produces a large depression in the hydraulic potential and consequently high effective pressure in the trough (1-2MPa). Conversely, with the term enabled the main channel becomes discontinuous on steep adverse bed slopes and many side channels form on the margins of the trough. This leads to a hydraulic potential in the trough which is higher than in the surrounding area and consequently the effective pressure is low (0-1MPa).

Low effective pressure leads to reduced basal drag and thus to more basal sliding. The modeled large decrease of effective pressure in the trough due to the pressure dependence of the melting point of water suggests that basal drag will be small and that sliding speeds are large. Thus, this may be one of the leading causes for the fast flow of Jakobshavn Isbræ and other glaciers in deep troughs.

Final ID: C33B-0720

Hydrometeorology and basal sliding on the Kennicott Glacier, Alaska, USA: Evidence for seasonal, diurnal, and event-scale glacier velocity fluctuations due to varying meltwater inputs and precipitation events

W. H. Armstrong; [1, 2]; *R. S. Anderson;* [1, 2]; *E. C. Pettit;* [3]; *H. Rajaram;* [4];
1. Institute for Arctic and Alpine Research, University of Colorado at Boulder, Boulder, CO, United States.
2. Department of Geological Sciences, University of Colorado at Boulder, Boulder, CO, United States.
3. Department of Geology and Geophysics, University of Alaska Fairbanks, Fairbanks, AK, United States.
4. Department of Civil, Environmental and Architectural Engineering, University of Colorado at Boulder, Boulder, CO, United States.

Body: We examine GPS-derived glacier ice surface velocities along with on- and near-glacier hydrometeorologic data to investigate the linkage between subglacial hydrology and basal sliding on the Kennicott Glacier in southeastern Alaska. Connections between ice dynamics and glacier hydrology remain poorly understood, yet are critical for understanding and forecasting modern sea level rise. In addition, basal sliding is an important process in glacial erosion and, therefore, alpine landscape evolution. We differentially process 30-second GPS data at four monuments along the glacier centerline over the 2012 and 2013 melt seasons. In addition, we overwinter one GPS monument on the glacier, allowing us to observe glacier behavior through a full annual cycle. We monitor stage on ice-marginal lakes, supraglacial streams, and the outlet river with pressure transducers and timelapse cameras. In both years we observe complex early season hydrologic behavior, with a ice-marginal lake draining and filling many times before emptying for the season. This likely records the interplay between varying melt inputs and the evolution of the glacier's ability to transmit flow subglacially. Concurrent with these stage variations, we observe large diurnal velocity fluctuations superimposed on a sustained increase in glacier velocity, likely reflecting the glacier's sensitivity to melt inputs in the early season. In 2012, we observe glacier velocity during the annual outburst flood of Hidden Creek Lake, which drains ~25×10^{6} m^{3} of water beneath the Kennicott Glacier. The flood hydrograph from an ice-marginal lake shows remarkable consistency from year to year despite differences in the timing of the flood and meteorology leading up to the jökulhlaup. As the flood wave passes through the glacier, ice surface velocity increases from ~0.3 m d^{-1} to ~1.5 m d^{-1} for a short time. We see speedups of a similar magnitude in autumn 2012 that appear to correlate precipitation events.
In addition, we analyze ten years of high-resolution (~0.5 m pixel) satellite imagery to identify and characterize the evolution of moulins, which serve as point inputs to the glacier hydrologic system. We validate a number of satellite-identified moulins with field observations and characterize the diurnal cycle of meltwater inputs into one moulin via salt dilution discharge estimates. We extract glacier surface velocity fields from these satellite images, which provide a context for our GPS-derived point velocities. We investigate this suite of data in light of radar estimates of ice thickness and bed topography to better understand the importance and effect of glacier hydrology on basal sliding of the Kennicott Glacier.

Final ID: C33B-0728

Physical and chemical characteristics of the Subglacial Lake Whillans sediment cores, Whillans Ice Stream, West Antarctica

T. O. Hodson; [1]; *R. D. Powell;* [1];
1. Department of Geology and Environmental Geoscience, Northern Illinois University, DeKalb, IL, United States.

Body: Sediment recovered from Subglacial Lake Whillans (SLW) is well-homogenized, structureless diamict; typical subglacial till. Based on theoretical estimates, the basal ice above SLW should be below the pressure melting point preventing melt-out of debris from basal ice. Therefore, the lake floor diamict likely formed through deformation while the ice stream was grounded at the drill site. Using satellite altimetry, Fricker, et al. (2007) inferred that SLW experiences short (~7 month) discharge events, lowering the ice surface and lake water level by between 1 and 4 m. The lake “lowstands” are separated by longer periods of gradual recharge, but over the period of a lowstand the ice stream is suspected to touch down and couple with the lake floor, potentially shearing new till into the lake. The lack of sorted sediment or erosional lags indicates water flow during discharge/recharge events has had a low current velocity with quiescent conditions in the lake. The most notable variability in the cores is a uniformly weak, critical porosity horizon extending to ~50 cm depth above more consolidated till. We interpret the weak upper horizon as the product of shear deformation and decreasing effective pressure experienced during the final stages of grounding prior to a lake recharge event (see generally, the undrained plastic bed model of Tulaczyk et al. (2000)). The presence of this weak layer illustrates the importance of hydrology in modulating till rheology and is an example of how subglacial sediments can preserve archives of hydrologic conditions at the glacial bed.

Fricker, H.A., T. Scambos, R. Bindschadler and L. Padman. 2007. An active subglacial water system in West Antarctica mapped from space. Science, 315(5818), 1544–1548.

Tulaczyk S, Kamb WB, Engelhardt HF. 2000. Basal mechanics of Ice Stream B, West Antarctica. 2. Undrained plastic bed model. J. Geophys. Res. 105:483–94.

Final ID: C33B-0730

River Channel Expansion Reveals Ice Sheet Runoff Variations

I. Overeem; [1]; *B. D. Hudson;* [1]; *E. Welty;* [1]; *A. LeWinter;* [2]; *A. B. Mikkelsen;* [3];
1. INSTAAR, University of Colorado, Boulder, CO, United States.
2. Cold Regions Research and Engineering Laboratory, Hanover, NH, United States.
3. Universiy of Copenhagen, Copenhagen, Denmark.

Body: The Greenland Ice Sheet has been rapidly melting over the last decades. To quantify its contribution to global sea-level rise, we urgently need to understand flux of meltwater into proglacial rivers. Direct measurements of river runoff at the Greenlandic coast are sparse due to the dynamic braided channels with unstable banks, which makes in-situ discharge monitoring challenging.

Here, we explore the use of 'inundation-discharge' relationships through analysis of both time-lapse camera imagery and MODIS remote-sensing reflectance data to provide us with a proxy record of river discharge for proglacial systems. We utilize MODIS band6 (mid IR 1628 – 1652 nm). Light in this band is strongly absorbed by water, and reflectance is not sensitive to sediment suspended in the water, making it an appropriate proxy for river braidplain inundation. Our focus is on two Greenlandic river systems; the Watson River near Kangerlussuaq and the Naujat Kuat River near Nuuk, to track band6 reflectance characteristics over all cloud-free days for the summers of 2000-2012. For validation, a ground-based inundation record is assembled from time-lapse imagery overlooking the Watson River for 2012.

Exponential inundation-discharge relationships were established using our in-situ discharge records for the Watson River near Kangerlussuaq (2007-2012, R2=0.55) and the Naujat Kuat River near Nuuk (2011-2012, R2 = 0.42). Using these relationships to predict total annual river discharge proves reasonably accurate for most years of the observational record (varying between 96-86%). Interestingly, the extreme melt year of 2012 was not reliably predicted using the established relationship. We compared these predictions against an inundation record from the in-situ time-lapse camera and found that a ground-based observations track extreme discharge events more reliably (R2 = 0.60).

This methodology allows us to extend existing river records back beyond the 5 or 2 years of in-situ observations. Whereas direct calibration is essential to establish total annual volumes, intra-annual variation of river runoff can be mapped for proglacial river systems along the Greenland margin.

Final ID: C33B-0732

Estimating Freshwater Discharge from the Greenland Ice Sheet with MODIS

B. D. Hudson; [1, 2]; *I. Overeem;* [1, 2]; *A. B. Mikkelsen;* [3]; *D. McGrath;* [4]; *J. P. Syvitski;* [2, 1];
1. Institute of Arctic and Alpine Research, University of Colorado, Boulder, CO, United States.
2. Community Surface Dynamics Modeling System, University of Colorado, Boulder, CO, United States.
3. University of Copenhagen, Copenhagen , Denmark.
4. Cooperative Institute for Research in Environmental Sciences, University of Colorado, Boulder, CO, United States.

Body: Freshwater discharge from the Greenland Ice Sheet (GrIS) has significant ecological importance, impacts ocean circulation and represents a major contribution to global sea level rise. Despite these factors, only one river in Greenland (accounting for less than one percent of land terminating river outlets) has a published discharge record. Due to logistical constrains future efforts to directly gauge river discharge will likely remain ad hoc.

To overcome this deficiency, we developed a remote sensing technique that utilizes observations of sediment plume geometry as a proxy for freshwater discharge from the ice sheet. We use MODIS (Moderate Resolution Imaging Spectroradiometer) imagery, validated with a suite of oceanographic measurements from four fjords in southwest Greenland during the 2008, 2010, 2011 and 2012 summer seasons. From surface water samples collected during these campaigns we develop a robust retrieval algorithm for suspended sediment concentrations based on MODIS band one and two reflectance values (r^2 =.84). This relationship allows us to accurately map sediment plume geometry of numerous river-fjord systems on all cloud-free days during the summer season. We then use in situ river discharge records from the Watson River at Kangerlussuaq (a six year record), ‘Pakitsuup South’ River near Illulisat (a two year record) and Naujat Kuat River near Nuuk (a three year record) to derive an empirical relationship between plume geometry and discharge volume. These fjords provide a robust test for this method, as fjord salinity for these locations span a continuum of river-dominated low salinity to ocean-dominated high salinity cases.

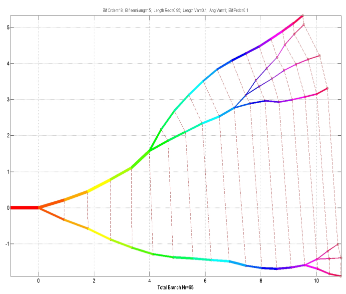
We find high interannual stability in these relationships for individual sites, suggesting that this method may be suitable for estimating historical river discharges back to 2000 when Terra, the first satellite carrying MODIS was launched. Despite promise, variability in the empirical relationships found precludes reconstructions for additional river-fjord systems without in situ observations.

Final ID: EP33A-0857

From Fractal Trees to Deltaic Networks

D. Cazanacli; [1]; *M. A. Wolinsky;* [2]; *Z. Sylvester;* [2]; *A. Cantelli;* [2]; *C. Paola;* [1];
1. Earth Sciences, University of Minnesota, Minneapolis, MN, United States.
2. Shell Technology Center, Houston, TX, United States.

Body: Geometric networks that capture many aspects of natural deltas can be constructed from simple concepts from graph theory and normal probability distributions. Fractal trees with symmetrical geometries are the result of replicating two simple geometric elements, line segments whose lengths decrease and bifurcation angles that are commonly held constant. Branches could also have a thickness, which in the case of natural distributary systems is the equivalent of channel width. In river- or wave-dominated natural deltas, the channel width is a function of discharge. When normal variations around the mean values for length, bifurcating angles, and discharge are applied, along with either pruning of "clashing" branches or merging (equivalent to channel confluence), fractal trees start resembling natural deltaic networks, except that the resulting channels are unnaturally straight.
Introducing a bifurcation probability fewer, naturally curved channels are obtained. If there is no bifurcation, the direction of each new segment depends on the direction the previous segment upstream (correlated random walk) and, to a lesser extent, on a general direction of growth (directional bias). When bifurcation occurs, the resulting two directions also depend on the bifurcation angle and the discharge split proportions, with the dominant branch following the direction of the upstream parent channel closely. The bifurcation probability controls the channel density and, in conjunction with the variability of the directional angles, the overall curvature of the channels. The growth of the network in effect is associated with net delta progradation. The overall shape and shape evolution of the delta depend mainly on the bifurcation angle average size and angle variability coupled with the degree of dominant direction dependency (bias). The proposed algorithm demonstrates how, based on only a few simple rules, a wide variety of channel networks resembling natural deltas, can be replicated.



Network Example

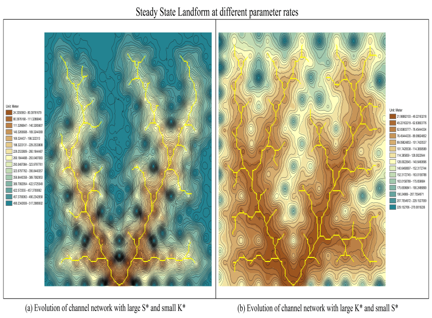
Final ID: EP33A-0858

A New Hydrologic-Morphodynamic Model for Regolith Formation and Landscape Evolution

Y. Zhang; [1, 2]; *R. L. Slingerland;* [2]; *C. Duffy;* [1];
1. Department of Civil and Environmental Engineering, The Pennsylvania State University, STATE COLLEGE, PA, United States.
2. Department of Geoscience, The Pennsylvania State University, STATE COLLEGE, PA, United States.

Body: Abstract

Feedbacks between regolith formation and removal and accompanying hydrological processes require a landscape evolution model coupling vertical uplift, soil production by bedrock weathering, and regolith transport with a hydrologic model. Here we present a new version of the Penn State Integrated Hydrologic Model (PIHM) that computes the feedbacks among infiltration, recharge, groundwater and surface water runoff, creation of regolith and its erosion by streams, and downslope movement by tree-throw. The equation set is solved using the semi-discrete finite volume method. The groundwater table evolves during deposition and erosion of regolith and tree-throw. Three non-dimensional parameters govern the behavior of the system: 1) W*=Po/U, the ratio of the weathering rate of bare bedrock to the rock uplift rate; 2) K*=K/UL, the ratio of hillslope diffusivity to rock uplift rate times a system lengthscale; and 3) S*=D/UL, the ratio of overland sediment transport diffusivity to uplift rate times a system lengthscale. Steady-state landforms of an artificial watershed possess convex and smooth channel profiles if K* relative large and S* is small, whereas S* dominant landscapes possess concave and sharp channel and mountain profiles. The set of analysis also reveal that even though the ratios are the same, higher uplift rate accelerates the time to steady state.



Steady State Landforms at Different Parameter Rates

Final ID: EP33A-0859

Exploring controls on valley spacing in higher order fluvial channels with the CHILD Model

J. Han; [1]; *N. M. Gasparini;* [1]; *J. P. Johnson;* [2];
1. Department of Earth and Environmental Sciences, Tulane University of Louisiana, New Orleans, LA, United States.
2. Department of Geological Sciences, The University of Texas at Austin, Austin, TX, United States.

Body: Across a wide range of landscapes the ratio between the width of a mountain and the distance separating trunk channels exiting the mountain front (generally termed the valley spacing ratio) has been observed to be fairly constant, but the reasons for its uniformity are not well understood. Recent work also suggests that the ratio between the spacing of valleys and the characteristic length, or distance from the divide to where hillslopes transition to fluvial channels, (here termed the characteristic length ratio) is relatively constant in first order channels. We propose that the characteristic length ratio of higher order channels is a primary control on the valley spacing ratio. We explore how these ratios are linked together and the variables that may affect both of these ratios using the CHILD numerical landscape evolution model. Previous studies observed a linear relationship between valley spacing and characteristic length in first order channels, and we find that the relationship remains linear in higher order channels, demonstrating that the competition between hillslope and fluvial processes influences landscape morphology at all scales. Moreover, we also find that the characteristic length ratio for a given order channel is fairly robust and does not appear to be impacted by model initial conditions (such as initial topography) and precipitation patterns (such as orographic precipitation).

For a fixed domain in our model, although the characteristic length may vary, the valley spacing ratio remains in the range observed in real landscapes. The ratio of mountain width to valley spacing remains relatively constant because the order of trunk channels varies with the characteristic length. In other words, for a given domain size (or mountain range width), a larger characteristic length can produce lower order trunk channels but with the same spacing value as higher order trunk channels with a smaller characteristic length. This competition between channel order and characteristic length may be one of the reasons why the valley spacing ratio is relatively constant across diverse natural settings. However, our model results also show that initial and boundary conditions may affect the maximum stream order in a domain, even though they do not affect valley spacing. As a result, the valley spacing ratio is more variable than the characteristic length ratio. For example, we find that more pronounced orographic precipitation patterns, or much steeper initial surfaces, can lead to more linear streams, less tributary branching and lower order trunk channels. In this case, the ratio between valley spacing and characteristic length remains the same, whereas the ratio between mountain width and valley spacing increases, but still remains within the observed range in natural landscapes. Finally, DEM analysis of three study areas supports our numerical results.

Final ID: EP33A-0861

Quantifying the role of channel width in transient bedrock river evolution over geologic timescales

B. J. Yanites; [1];
1. Geological Sciences, University of Idaho, Moscow, ID, United States.

Body: The evolution of rivers in tectonically active landscapes plays a key role in determining mountain relief and modulating the interaction between climate and tectonics. Recent field, theoretical, and numerical studies have revealed that channel width may play an important, yet often overlooked, role in controlling the dynamics of bedrock river systems. Channel width appears to be especially important when bedload sediment transport processes are an important factor influencing the rate of erosion. Here I present a new method for modeling the influence of channel width on river profile evolution. In this model, channel widening or narrowing occurs based on river shear stress and an assumed river widening/narrowing parameter. The channel widening parameter is chosen such that the rate of channel width change is capable of producing multiple river terraces over an ~10 ky timescale. This is consistent with the observation that many tectonically active landscapes contain at least one, and in many instances multiple, Holocene river terraces. The direction of channel width change (i.e. narrowing versus widening) is dictated by an assumption of optimization of river geometry for maximum bedrock erosion. With this model set-up, vertical river erosion can operate based on any number of river erosion models, such as a simple shear stress (e.g. detachment-limited), full saltation-abrasion model, or sediment cover-shear stress hybrid models. Using this set-up I model the evolution of river profiles under various steady-state and transient scenarios to explore how channel width and slope evolve in various environments. For example, one transient simulation shows that channel width initially widens by 300% and the river steepens by 200% in response to an increase in bedload sediment supply (from 0% to 30% of total load) over 1 My. Moreover, I explore how predictions in channel slope and width change depending on which vertical erosion model is used. This experiment compares the evolution of width and slope in three modeled rivers undergoing a 5-fold increase in rock uplift after reaching an initial steady state. Each of the three simulated rivers has a different assumed vertical erosion model. We then rerun this experiment but hold channel width steady through the transient evolution of the rivers. The detachment-limited model exhibits little difference when ignoring the potential for channel width adjustments; however, both the sediment cover-shear stress and saltation abrasion models exhibit drastically different behaviour when channel width is held static. Channel adjustment time, variations in erosion rate, and differences in relief are quantified for each numerical model and presented. The model results imply that channel width adjustments must be properly accounted for when modeling river dynamics in systems where bed load sediment transport influences vertical bedrock erosion. For example, not accounting for channel width adjustments could lead to an over prediction in the response of orogen scale relief to a change in rock-uplift. Given the prevalence of coarse sediment in rivers in tectonically active regions, quantifying channel width dynamics is central to quantifying topographic response to tectonic or climatic changes.

Final ID: EP33A-0862

River Capture in Disequilibrium Landscapes

S. W. McCoy;[1]; *J. Perron;*[1]; *S. Willett;*[2]; *L. Goren;*[2];
1. Massachusetts Institute of Technology, Cambridge, MA, United States.
2. ETH, Zurich, Switzerland.

Body: The process of river piracy or river capture has long drawn interest as a potential mechanism by which drainage basins large and small evolve towards an equilibrium state. River capture transfers both drainage area and drainage lines from one river basin to another, which can cause large, abrupt shifts in network topology, drainage divide positions, and river incision rates. Despite numerous case studies in which river capture has been proposed to have occurred, there is no general, mechanistic framework for understanding the controls on river capture, nor are there quantitative criteria for determining if capture has occurred. Here we use new metrics of landscape disequilibrium to first identify landscapes in which drainage reorganization is occurring. These metrics are based on a balance between an integral of the contributing drainage area and elevation. In an analysis of rivers in the Eastern United States we find that many rivers are in a state of disequilibrium and are experiencing recent or ongoing area exchange between basins. In these disequilibrium basins we find widespread evidence for network rearrangement via river capture at multiple scales. We then conduct numerical experiments with a 2-D landscape evolution model to explore the conditions in which area exchange among drainage basins is likely to occur as discrete capture events as opposed to continuous divide migration. These experiments indicate that: (1) capture activity increases with the degree of disequilibrium induced by persistent spatial gradients in tectonic forcing or by temporal changes in climate or tectonic forcing; (2) capture activity is strongly controlled by the initial planform drainage network geometry; and (3) capture activity scales with the fluvial incision rate constant in the river power erosion law.

Final ID: EP33A-0863

Modeling post-wildfire fluvial incision and terrace formation

F. K. Rengers; [1]; *G. E. Tucker;* [1];
1. University of Colorado, Boulder, CO, United States.

Body: Wildfires often lead to rapid erosion, sedimentation, and morphologic change. One of the challenges in developing quantitative models of post-fire landscape dynamics is a lack of high-quality datasets that document fluvial system evolution in the years to decades following a destructive fire. This study takes advantage of a natural experiment in post-fire fluvial incision to explore how the magnitude and timing of large flow events following a wildfire can change fluvial channel patterns. The study site is the Spring Creek watershed located in the foothills of central Colorado approximately 26 miles southwest of Denver, Colorado. The site burned during the Buffalo Creek wildfire, which was contained in May 1996. Within the Spring Creek watershed, 79% of the basin was burned and 63% of the burned area was considered high severity (Moody and Martin, 2001). In July 1996 a large rain storm hit the burned watershed and 110 mm of rain fell in one hour (Jarrett, 2001). This storm was larger than the estimated 100-year rainfall intensity of 60 mm/hr. Due to the increased surface erodibility after the wildfire, rapid erosion occurred within the watershed, while the main valley of Spring Creek aggraded with up to 2 m of sediment after this storm. Spring Creek has been incising through this post-wildfire sediment since the 1996 storm, and the terraces from this initial storm are still prevalent and identifiable along the valley. Repeated measurements of valley cross-sections since 1996 provide a comprehensive dataset for testing models of fluvial-system evolution on a decadal time scale.

We hypothesize that the current channel pattern results from the specific sequence of rain events that occurred within the four years after the initial 1996 storm filled the valley with sediment. This hypothesis was tested using a two-dimensional coupled model of shallow-water flow, sediment transport, and topographic evolution. Discharge data were obtained from a stream gage installed at Spring Creek in 1997, with records from April 1997 to October 2000. The initial channel topography was constructed by extrapolating the 1996 terraces across the channel. Thus the initial condition for the model is the aggradation after the 1996 storm. We calibrated the model using observed measured discharges and actual closely spaced (10-50 m) cross-sections that were measured before and after large discharges from 1997-2000.

Model sensitivity tests are used to explore how the channel evolution might have differed under alternative discharge sequences. For example, the natural discharge from the study site showed three large floods in 1997, two in 1998, one in 1999, and none in 2000. We ran models that varied this sequence to identify the degree to which storm sequence, magnitude, and duration influence the tempo and nature of channel evolution. Early results show that the sequence of storms is indeed important in shaping the overall channel geomorphology.

Final ID: EP33A-0867

Landlab Ecohydrology: A component-based computational environment for ecohydrologic modeling and its illustrations through model building

S. NUDURUPATI; [1]; *E. Istanbulluoglu;* [1]; *J. M. Adams;* [2]; *N. M. Gasparini;* [2]; *G. E. Tucker;* [3]; *E. Hutton;* [3]; *D. E. Hobley;* [3];

1. Univ of Washington, Seattle, WA, United States.
2. Tulane, University, LA, United States.
3. University of Colorado, University, CO, United States.

Body: Ecohydrology seeks to understand the commanding role of water and climate in the ecological patterns and processes at a range of scales. Ecohydrologic dynamics are tightly coupled with biogeochemical cycles, land surface atmosphere interactions, the geomorphic phenomena, and landscape evolution. Therefore, ecohydrology plays a central role in understanding and predicting the consequences of global change for the landscape system. Models encapsulate the scientific community's quantitative understanding to make testable predictions, and foster exploratory hypothesis testing. Most modelers build their ecohydrology models from the ground up, re-coding the basic building blocks of the hydrologic system before they can explore new ideas. The Landlab project creates a component-based environment in which scientists can build a numerical landscape model without having to code all of the individual components. We present a component-based design of ecohydrologic modeling using the Landlab environment. In Landlab, components interface with each other, and access and modify a model grid in which topographic attributes and ecohydrologic state variables are stored. We briefly present the existing ecohydrologic components of Landlab, and illustrate the use of components through examples of building model applications to explore hypotheses. These include the implementation of a solar radiation component to explore the role of aspect on soil moisture, sensitivity of soil moisture and plant biomass to climate variability, and the impact of vegetation change on runoff erosion. These applications illustrate the easy-to-use nature of the Landlab environment and potential use cases of Landlab for the ecohydrology and geomorphology communities.

Final ID: EP33A-0868

Modeling impact cratering as a geomorphic process using the novel landscape evolution model Landlab

D. E. Hobley; [1]; *G. E. Tucker;* [1]; *J. M. Adams;* [3]; *N. M. Gasparini;* [3]; *E. Hutton;* [2]; *E. Istanbulluoglu;* [4]; *S. NUDURUPATI;* [4];

1. CIRES/Dept. of Geological Sciences, University of Colorado, Boulder, CO, United States.
2. INSTAAR, University of Colorado, Boulder, CO, United States.
3. Dept. of Earth & Environmental Sciences, Tulane University, New Orleans, LA, United States.
4. Civil & Environmental Engineering, University of Washington, Seattle, WA, United States.

Body: Many problems in the planetary sciences depend on understanding the way in which impact craters modify planetary surfaces. The geomorphometry of the resulting surfaces hold great promise in providing complementary tools alongside traditional crater counting to constrain relative cratering rates and distributions back through time. Through such constraints, we can attack a number of longstanding problems—such as the nature of the Late Heavy Bombardment, impact gardening and surface turnover rates and processes, variations in past impactor populations, and surface dating—from new angles.

To address these issues from a theoretical viewpoint, we have built a component to model a landscape undergoing impact cratering for Landlab. Landlab is a new, open-source, modular, Python-based land surface dynamics model. It has been designed for maximum user-friendliness, and to allow efficient model development and use in a Matlab-like, interactive Python environment (e.g., iPython). The design is based around a set of components, each of which simulates a different surface process (e.g., runoff, creep, fluvial erosion). These components can operate independently, or can be readily coupled together in various combinations to simulate more complex natural environments. Our cratering component is designed to simulate the impact of very large numbers ($>10^6$) of bolides, and produces craters that follow known empirical relations between shape metrics. In particular, the model explicitly treats asymmetry in ejecta patterns induced by impacts at oblique angles to the surface. We are using this computational framework to understand the degradation of cratered surfaces by further impacts, initially seeking in particular to quantify how, and at what scales, impact cratering can produce the apparently diffusive behavior characteristic of many lunar landscapes. We demonstrate the importance of declining impactor fluxes and sizes with time in producing smoothly rounded hillslopes on the Moon.

Final ID: EP33A-0869

Influence of sediment cohesion on stratigraphic architecture

Q. Li; [1]; *W. Benson;* [1]; *K. M. Straub;* [1];
1. Tulane University of Louisiana, New Orleans, LA, United States.

Body: Recent experimental and numerical modeling studies show that sediment cohesion, which is controlled by grain size and vegetation, promotes channelization on delta-tops and increases the magnitude and time scales of internally generated (autogenic) processes. These autogenic processes have been shown to produce stratigraphic products that mimic patterns produced by tectonics, climate, and eustatic change (allogenic processes). We use numerical models and laboratory experiments to quantify the influence of sediment cohesion on autogenic dynamics that operate over basin filling time-scales. In a cohesive delta laboratory experiment, we use a polymer that increases substrate strength and critical shear stress for erosion. Data from this experiment is used to quantify how the compensation index (κ), which describes the tendency for sediment transported by channelized flow to be deposited in topographic lows, is influenced by sediment cohesion. Initial results suggest that sediment cohesion reduces channel mobility which results in an increase in the persistence of depositional trends as quantified with κ. For the first time, we document sedimentation patterns with persistence of deposition in excess of that expected from random processes. In addition, unlike results from deltas built from non-cohesive sediment, we see little reduction in κ from delta source to sink. These observations are consistent with results from a reduced complexity numerical model of channel avulsion used to explore the influence of sediment cohesion on morphodynamics. This study advances our understanding of sediment cohesion and its implications for the filling of alluvial basins and our ability to recover paleo-surface dynamics from subsurface stratigraphy.

Final ID: EP33A-0870

What can a numerical landscape evolution model tell us about the evolution of a real landscape? Two examples of modeling a real landscape without recreating it.

N. M. Gasparini; [1]; *K. X. Whipple;* [2]; *J. Willenbring;* [3]; *B. T. Crosby;* [4]; *G. Y. Brocard;* [3];

1. Tulane University, New Orleans, LA, United States.
2. Arizona State University, Tempe, AZ, United States.
3. University of Pennsylvania, Philadelphia, PA, United States.
4. Idaho State University, Pocatello, ID, United States.

Body: Numerical landscape evolution models (LEMs) offer us the unique opportunity to watch a landscape evolve under any set of environmental forcings that we can quantify. The possibilities for using LEMs are infinite, but complications arise when trying to model a real landscape. Specifically, numerical models cannot recreate every aspect of a real landscape because exact initial conditions are unknown, there will always be gaps in the known tectonic and climatic history, and the geomorphic transport laws that govern redistribution of mass due to surface processes will always be a simplified representation of the actual process. Yet, even with these constraints, numerical models remain the only tool that offers us the potential to explore a limitless range of evolutionary scenarios, allowing us to, at the very least, identify possible drivers responsible for the morphology of the current landscape, and just as importantly, rule out others.

Here we highlight two examples in which we use a numerical model to explore the signature of different forcings on landscape morphology and erosion patterns. In the first landscape, the Northern Bolivian Andes, the relative imprint of rock uplift and precipitation patterns on landscape morphology is widely contested. We use the CHILD LEM to systematically vary climate and tectonics and quantify their fingerprints on channel profiles across a steep mountain front. We find that rock uplift and precipitation patterns in this landscape and others can be teased out by examining channel profiles of variably sized catchments that drain different parts of the topography. In the second landscape, the South Fork Eel River (SFER), northern California, USA, the tectonic history is relatively well known; a wave of rock uplift swept through the watershed from headwaters to outlet, perturbing the landscape and sending a wave of bedrock incision upstream. Nine millennial-scale erosion rates from along the mainstem of the river illustrate a pattern of downstream increasing erosion rate. Similarly, the proportion of the landscape that has adjusted to the tectonic perturbation increases from upstream to downstream. We use the CHILD LEM to explore whether the relationship between erosion rates and proportion of adjusted landscape is unique to the tectonic history of the SFER and if this relationship can be used as a fingerprint to identify the nature of tectonic perturbations in other locations. In both study sites, we do not try to recreate the exact morphology of the real landscape. Rather, we identify patterns in erosion rates and the morphology of the numerical landscape that can be used to interpret the tectonic history, climatic history, or both in these and other real landscapes.

Final ID: EP33A-0876

The Influence of Laboratory-Generated Tides on Experimental Deltas

S. E. Baumgardner; [1, 2]; *A. Abeyta;* [1, 2]; *D. Cazanacli;* [1, 2]; *C. Paola;* [1, 2];

1. Department of Earth Sciences, University of Minnesota Twin Cities, Minneapolis, MN, United States.
2. St. Anthony Falls Laboratory, University of Minnesota Twin Cities, Minneapolis, MN, United States.

Body: Due to their ecological and economic importance, deltas are widely studied but the controls on the processes that create and shape them are incompletely understood. The most prominent downstream control on a delta is the input of basinal energy from (wind-driven) waves and tides. Studies of the response of field-scale deltas to changing basinal energy conditions are limited by their large size and long response time. Laboratory-generated deltas allow control over upstream inputs (sediment and water) and base level, and enable the generation of a high-resolution record of topography and planform morphology of the deposit throughout the experiment.

We include the effects of tides by imposing cyclic changes in base level with a period that is long compared to ordinary gravity waves but short compared to time scales of morphologic evolution; here we used periods of < 120 seconds, and amplitudes of <2.5 cm. These fluctuations led to the development of sinuous, headward cutting channels. Preliminary analysis of overhead imagery suggests that the addition of tides to the experimental deltas changed the grain-size distribution on the topset, increased channel occupancy times, and altered the size and frequency of mouth bars, point bars and mid-channel bars. The mechanisms of these changes were found to differ between cohesive and non-cohesive deltas: in non-cohesive deltas, tides interrupted channel backfilling, suppressing avulsion, while in cohesive deltas, tides generated knickpoints, which led to channel deepening. These results suggest that basinal energy can affect deltaic processes far upstream of the coastline.

We introduce waves to the system through the use of a generator; this generator produces waves with a single, user-defined period (here, ~1-2 seconds) and amplitude (2-3 cm) . The orientation of the incoming wave crests is set by the position of the generator. The addition of wave energy led to rapid shoreline retreat and straightening and the formation and migration of shore parallel barrier bars similar to what is observed in wave-influenced field-scale systems. Analysis of overhead imagery shows that wave transport of sediment occurs over a much shorter timescale than tidally-driven transport, leads to the formation of a continuous, coarse berm parallel to the shoreline and plays a major role in determining the configuration of channel mouths.

Final ID: EP33A-0878

An Experimental Study of Submarine Canyon Evolution on Continental Slopes

S. Y. Lai; [1]; *T. P. Gerber;* [2]; *D. Amblas;* [3];

1. Hydraulic and Ocean Engineering, National Cheng Kung University, Tainan, Taiwan.
2. Statoil, Research Center Austin, Austin, TX, United States.
3. GRC Geociències Marines, Facultat de Geologia, Universitat de Barcelona, Barcelona, Spain.

Body: Submarine canyons define the morphology of many continental slopes and are conduits for the transport of sediment from shallow to deep water. Though the origin and evolution of submarine canyons is still debated, there is general agreement that sediment gravity flows play an important role. Here we present results from a simple, reduced-scale sandbox experiment designed to investigate how sediment gravity flows generate submarine canyons. In the experiments, gravity flows were modeled using either sediment-free or turbid saline currents. Unconfined flows were released onto an inclined bed of sand bounded on the downstream end by a movable floor that was incrementally lowered during the course of an experiment to produce an escarpment. This design was developed to represent the growth of relief across the continental slope. To monitor canyon evolution on the slope, we placed an overhead DSLR camera to record vivid time-lapse videos. At the end of each experimental stage we scanned the topography by imaging a series of submerged laser stripes, each projected from a motor-driven transverse laser sheet, onto a calibrated Cartesian coordinate system to produce high resolution bathymetry without draining the ambient water. In areas unaffected by the flows, we observe featureless, angle-of-repose submarine slopes formed by retrogressive breaching processes. In contrast, areas influenced by gravity flows cascading across the shelf break are deeply incised by submarine canyons with well-developed channel networks. Our results show that downslope gravity flows and submarine falling base level are both required to produce realistic canyon morphologies at laboratory scale. Though our mechanism for generating relief may be a rather crude analogue for the processes driving slope evolution, we hope our novel approach can stimulate new questions about the coevolution of canyons and slopes and motivate further experimental work to address them.

Final ID: EP33B-0889

Reconstructing the formation and in-filling of Lake Manuherikia, Otago: Linking geodynamics and surface processes

P. Upton; [1]; *G. Duclaux;* [2]; *D. Craw;* [3]; *T. B. Salles;* [2]; *R. Walcott;* [4];
1. GNS Science, Lower Hutt, New Zealand.
2. Earth Science and Resource Engineering, CSIRO, Sydney, NSW, Australia.
3. Geology Department, University of Otago, Dunedin, New Zealand.
4. National Museums Scotland, Edinburgh, United Kingdom.

Body: The Miocene geography of Central Otago, New Zealand was dominated by a long-lived region of subsidence culminating in an orogen-scale large lake complex that existed for at least 10 Ma. Subsidence was terminated by uplift of orogen-perpendicular ranges with orogen-parallel subsidiary ranges infilling of the lake and coincident major drainage reorientation. We used a combination of a 3D numerical model with geophysical and geological observations to show that the subsidence is a predictable consequence of the lithospheric structure and tectonic history of the region. A weak lower crust beneath Otago, bounded along strike by two stronger regions, subjected to dextral strike-slip tectonics produces characteristic topography including uplift to the north and subsidence to the south. Second-order features such as pre-existing faults influenced local topography and regional drainage reorientation.

We then model the Pliocene in-filling of Lake Manuherikia using a surface dynamics code in which we constrain uplift rates, precipitation, underlying structure (pre-existing faults) and track Plio-Pleistocene sediments. As the Central Otago ranges shed coarse sediment into the lake eventually drowning it, the dominant river system shifted from draining southwest to draining to the east. Fault zones, cored by weak gouge zones, facilitated erosion through the uplifting ranges and allowed the Clutha River to incise a path from the Main Divide to the south-eastern Otago coast.

To unravel the complex topographic evolution of the region since the early Miocene, it is essential to constrain our surface process models with information about the underlying lithosphere. In this situation, the rheology of the lower crust is important for the first order topographic development while the pre-existing structure controls second order features such as river incision and local topography.

Final ID: EP33B-0890

Decadal to millennial deformation in the Pamir – Tian Shan collision zone, NW China and surface expression of active tectonics.

A. Bufe; [1]; *B. Bookhagen;* [2]; *D. W. Burbank;* [1]; *D. P. Bekaert;* [3]; *E. Hussain;* [3];
1. Department of Earth Sciences, UC Santa Barbara, Santa Barbara, CA, United States.
2. Department of Geography, UC Santa Barbara, Santa Barbara, CA, United States.
3. Department of Earth and Environment, University of Leeds, Leeds, United Kingdom.

Body: The collision between the Pamir and the Tian Shan is a type example of intracontinental collision. GPS studies show that in Northwest China, at the junction between the Tarim basin, the Pamir and the Tian Shan, 7-9 mm/y of north-south shortening are presently accommodated across the boundary between the two orogens. Here, the deformation has mostly stepped out from the high mountain front into the foreland and has formed a complex array of compressional structures. We compare rates of decadal deformation in the area with 104- to 106-year estimates and investigate the extent to which stream profiles and topography reflect the active tectonics in this setting.
A dataset of decadal deformation rates around the Tarim-Tian Shan-Pamir junction in Northwest China is obtained from Interferometric Synthetic Aperture Radar (InSAR) time-series analysis. We use the StaMPS/MTI package to combine small-baseline and persistent-scatterer techniques and obtain results that show no significant residual topographic phase correlation. Our data show that deformation has stepped away from the high mountain front and is concentrated on a few structures in the foreland of the Pamir and Tian Shan. Line-of-sight deformation of up to 2-4 mm/y on the Pamir Frontal Thrust (PFT) and the Kashi detachment anticline are observed. No significant displacement of the Main Pamir Thrust can be detected. Within error, the modern deformation rates agree with previously published millennial to million-year estimates along the PFT. However, decadal deformation rates deviate from million-year shortening and rock-uplift rates of anticlines in the foreland of the Tian Shan. It remains unclear whether the discrepancy arises from a recent change to a new persistent uplift rate, or merely from short timescale fluctuation of uplift rate, for example within an earthquake cycle. In an additional step, we extract stream profiles and normalized steepness index (ksn) values for rivers with drainage areas larger than 9 km2 using an SRTM Digital Elevation Model (DEM). Stream profiles of large catchments (drainage area of > 1000 km2) draining the Pamir and the Tian Shan are straight or slightly convex across the entire foreland with consequent downstream increases in ksn values. However, no significant changes in stream profiles or ksn values are observed where channels cross presently active structures in the foreland. We note exceptions from this observation at locations of strong litholgic contrasts. The analysis of many small streams with headwaters in the active structures is limited by the resolution of the DEM. A few channels that are large enough to be resolved do not consistently have higher ksn values than equivalently sized streams on presently inactive structures. Our observations, therefore, show that the stream profiles and steepness indices of streams with drainage areas > 9 km2 do not clearly indicate the locus of active deformation in this area despite rock-uplift rates of 1-4 mm/y. Possible reasons for this result include the dry climate of the Tarim basin leading to an overestimation of contributing drainage area in the foreland, the rapid erosion of weak lithologies exposed in many of the active structures, and the possible role of sediment load in rivers and aggradation in the foreland in smoothing of any steepening that was due to uplift.

Final ID: EP33B-0893

A comprehensive view of Late Quaternary fluvial sediments and stratal architecture in a tectonically active basin: Influence of eustasy, climate, and tectonics on the Bengal Basin and Brahmaputra River system

R. Sincavage; [1]; *S. L. Goodbred;* [1]; *L. A. Williams;* [1]; *J. Pickering;* [1]; *C. Wilson;* [1]; *M. S. Steckler;* [2]; *L. Seeber;* [2]; *M. D. Reitz;* [2]; *S. Hossain;* [3]; *S. H. Akhter;* [3]; *D. R. Mondal;* [4]; *C. Paola;* [5];

1. Department of Earth and Environmental Science, Vanderbilt University, Nashville, TN, United States.
2. Lamont-Doherty Earth Observatory, Columbia University, Palisades, NY, United States.
3. Department of Geology, University of Dhaka, Dhaka, Bangladesh.
4. School of Earth and Environmental Sciences, CUNY Queens College, Flushing, NY, United States.
5. National Center for Earth-surface Dynamics, University of Minnesota, Minneapolis, MN, United States.

Body: More than 130 closely-spaced (~3-5 km) boreholes have been drilled along five transects in the upper Bengal Basin, providing the first detailed record of the stratigraphic architecture and provenance of the entire Late Quaternary fluviodeltaic sedimentary succession of the Ganges-Brahmaputra-Meghna Delta (GBMD). This effort is part of BanglaPIRE, an interdisciplinary, multi-institutional research effort aimed at unraveling the history and mechanisms of river-tectonic-basin interactions in the GBMD and Bengal basin, around which three tectonic plates converge. Following the Younger-Dryas, the onset of a strong summer monsoon coincident with continued eustatic sea-level rise initiated construction of the modern delta and rapid development of a thick (up to 80 m) succession of fluvial and deltaic sediments. These deposits illustrate several (3-4) avulsions and asymmetric occupations of the Brahmaputra River in the tectonically active Sylhet Basin. We hypothesize that the longer occupation periods (10^3 years) may be classified as major river avulsions driven by autogenic fluvial processes, whereas shorter occupation periods (10^2 years) reflect minor distributive events that may have been initiated by allogenic forcing via floods or earthquakes. Subsidence rates in Sylhet Basin, driven by an active foredeep, are relatively high (~5 mm/yr); however, the Brahmaputra River does not regularly migrate towards this side of the delta. Annual widespread flooding of Sylhet Basin may negate the potential topographic attraction for the system to be steered in this direction. Furthermore, a gentle westward topographic tilt of the active thrust front of the Tripura fold belt appears to have forced lateral steering of the Brahmaputra River and initiated erosion of a bench-cut terrace into an adjacent Pleistocene landform. Tectonic effects over longer timescales (10^3 years) are revealed by the presence of sediment with a unique provenance at the core of regional anticlines, which suggest a strong link between the basinward advance of the tectonic deformation front and re-organization of the fluvial channel network within the GBMD. These observations and other evidence for river-tectonic-basin interactions will provide fundamental insights into the coupling between sedimentation and tectonics in one of the world’s most densely populated regions.

Final ID: EP33B-0905

Quantifying Holocene Coastal Retreat From River Morphology in Southern England and Wales

M. Attal; [1]; *S. M. Mudd;* [1]; *M. D. Hurst;* [2, 1]; *B. A. Crickmore;* [1];
1. School of GeoSciences, University of Edinburgh, Edinburgh, United Kingdom.
2. British Geological Survey, Keyworth, United Kingdom.

Body: Southern England and Wales have been undergoing subsidence since the end of the Last Glacial Maximum, with average rates varying between 0.5 and 1.2 mm/yr over the last 10 ka (Shennan and Horton, 2002). Rivers typically respond to subsidence by aggrading (e.g., Ishihara et al., 2012), yet many English and Welsh rivers incise into bedrock at their outlet and exhibit river profiles convexities typical of systems experiencing a drop in base level (e.g., Snyder et al., 2002; Attal et al., 2011). Scientists have proposed that coastal erosion could result in such river morphology (Snyder et al., 2002; Leyland & Darby, 2008, 2009). We combine modelling with topographic analysis of a series of basins along the coast of Southern England and Wales to test whether coastal erosion could explain the occurrence of rivers incising into bedrock at the coast. We further assess whether the distribution of such rivers and the shape of river profiles could be used to constrain amounts of coastal erosion during the Holocene.

Within zones characterized by similar lithologies and coastal exposure (i.e. the orientation of the coast and the type of water body it faces), we find that rivers with the smallest basins incise into bedrock at their mouth while rivers with the largest basins experience aggradation. The transition between these two types of basins occurs at a consistent basin size. This signal conforms to model predictions, assuming that the slope of rivers at the coast decreases with increasing basin size. Whereas rivers in basins comprising igneous and/or metamorphic rocks tend to be steeper than rivers flowing on sedimentary bedrock, we find that the critical drainage area does not vary significantly with varying lithology, suggesting that other factors such as spatial variations in coastal retreat exert a stronger control on the spatial distribution of the two types of rivers throughout the study area. Reconstruction of river profiles prior to base level rise allows estimates of minimum coastal retreat to be made but the uncertainty is high due to presence of multiple convexities in the river profiles.

Attal, M. et al. (2011) Testing fluvial erosion models using the transient response of bedrock rivers to tectonic forcing in the Apennines, Italy. J. Geophys. Res., 116, F02005, doi:10.1029/2010JF001875.
Ishihara, T. et al. (2012) Fluvial response to sea-level changes since the latest Pleistocene in the near-coastal lowland, central Kanto Plain, Japan. Geomorphology, 147-148, 49–60, doi:10.1016/j.geomorph.2011.08.022.
Leyland, J. and Darby, S.E. (2008) An empirical-conceptual gully evolution model for channelled sea cliffs. Geomorphology, 102, 419-434, doi:10.1016/j.geomorph.2008.04.017.
Leyland, J. and Darby, S.E. (2009) Effects of Holocene climate and sea-level changes on coastal gully evolution: insights from numerical modelling. Earth Surf. Proc. and Land., 34, 1878-1893, doi:10.1002/esp.1872.
Shennan, I. and Horton, B. (2002) Holocene land- and sea-level changes in Great Britain. J. Quat. Sc., 17, 511-526, doi:10.1002/jqs.710.
Snyder, N.P. et al. (2002) Interactions between onshore bedrock-channel incision and nearshore wave-base erosion forced by eustasy and tectonics. Basin Res., 14, 105–127.

Final ID: EP33B-0908

Using the stratigraphic record to document tectonic-geomorphologic interactions in a foreland basin setting: outcrop study of the Ainsa Basin, Spain

D. R. Pyles;[1]; *J. Moody;*[1]; *G. Gordon;*[1]; *M. Hoffman;*[4]; *A. Moss-Russell;*[3]; *H. Silalahi;*[3]; *P. Setiawan;*[6]; *J. Clark;*[2]; *B. Bracken;*[2]; *C. Guzofski;*[5];

1. Colorado School of Mines, Golden, CO, United States.
2. Chevron Energy Technology Company, Chevron, San Ramon, CO, United States.
3. Chevron, Chevron, Bakersfield, CA, United States.
4. Chevron, Chevron, New Orleans, LA, United States.
5. Chevron, Chevron, Houston, TX, United States.
6. Chevron, Chevron, Jakarta, Indonesia.

Body: Eocene strata of the Ainsa Basin (Spain) contain clastic and carbonate strata deposited in a relatively small (100 km^2), structurally active piggyback foreland basin. The basin is bounded by the Mediano Anticline to the east and the Boltana Anticline to the west. Clastic strata were sourced by an eastern fluvial-deltaic system whereas carbonate strata were sourced from shallow-water carbonate systems that rimmed the southern and western margins of the basin. Four time-stratigraphic units, which form an upward transect through the basin-fill succession, were studied in detail: Ainsa, Morillo, Guaso, Sobrarbe-Escanilla. The study uses the stratigraphic record to document linkages between progressive uplift of the basin-bounding structures, spatial-temporal changes in the amount and location of subsidence, and temporal changes in the landscape.

The Ainsa unit contains submarine channels that entered the basin from the east and exited the basin to the northwest, although some channels locally transfer to lobes near the northwest end of the basin. The Morillo unit contains submarine channels that entered the basin from the east, dispersed onto the basin floor, then converged at the western end of the basin where they continued onto the longitudinally adjacent Jaca Basin. The Guaso unit contains submarine channels that entered the basin from the east and transfer to a ponded distributive submarine fan at the center of the basin. The Escanilla-Sobrarbe unit contains a linked shelf-to-basin system that prograded from south to north and records the final filling of the basin. Four lines of evidence collectively support the basin-fill succession was deposited during structural growth. First, the depocenter, which is interpreted to reflect the position of maximum subsidence during deposition, of the systems systematically shifted westward as the basin filled. Second, the axial part of the clastic sediment systematically shifted southward as the basin filled. Third, the stratigraphic units are locally separated by progressive unconformities at the Mediano Anticline. Forth, carbonate-clast, sediment-gravity flow deposits were continually sourced off of the Boltana Anticline. The upward succession generally records a shallowing of the basin through time indicating that sediment supply exceeded the rate at which accommodation was created.

Final ID: EP33C-0916

A theoretical framework for quantifying the relative importance of dissolution and mechanical erosion in soluble bedrock channels

M. D. Covington; [1]; *F. Gabrovšek;* [3]; *J. D. Gulley;* [2];
1. University of Arkansas, Fayetteville, AR, United States.
2. Geological and Mining Engineering and Sciences, Michigan Technological University, Houghton, MI, United States.
3. Karst Research Institute ZRC SAZU, Postojna, Slovenia.

Body: Models of erosion in surface streams typically assume that the rates of stream incision via dissolution are negligibly small in comparison to mechanical erosion rates. On the contrary, numerical models of the formation and evolution of cave channels in karst landscapes have not typically considered mechanical processes. The disconnect in the assumptions made by these two communities is indicative of a switch in the importance of these two types of processes as channels grow. However, the parameters that control this switch, and the typical settings in which chemical or mechanical incision will dominate are unknown. Here we construct a theoretical framework to allow a systematic study of the role of climatic and lithological factors in controlling the relative importance of dissolution and mechanical processes in channels in highly soluble rock. We begin by characterizing the relationship between saturation state and discharge in a wide variety of streams using data from the USGS Water Quality database. Using this characterization, we have developed a stochastic model for dissolution in streams that enables calculation of rates averaged over all discharges. This model is compared against similar models for mechanical erosion that employ a stream power erosion law. The model shows that at sufficiently high discharges, or shear stresses, mechanical erosion dominates. Similarly, channel dissolution is relatively insensitive to extreme events. However, at low discharges, significant dissolution can occur if the stream is undersaturated. Consequently, the average saturation state of the stream, the critical threshold for the onset of mechanical erosion, and the time distribution of discharges all play crucial roles. We conclude with a preliminary examination of the distribution of characteristic chemical and mechanical erosion features within soluble bedrock channels as a function of lithological, hydraulic, chemical, and sediment properties.

Final ID: EP33C-0926

Morphodynamics and anabranching patterns generated in the Madeira River, Brazil.

J. D. Abad; [2]; E. M. Latrubesse; [1]; C. Bonthius; [1]; J. Stevaux; [3]; N. Filizola ; [4]; C. E. Frias; [2];
1. University of Texas at Austin, Austin, TX, United States.
2. University of Pittsburgh , Pittsburgh , PA, United States.
3. UNESP- Rio Claro , Rio Claro , Brazil.
4. Universidade Federal do Amazonas, Manaus , Brazil.

Body: The Madeira River is the largest tributary in water discharge and sediment transport of the Amazon River. At present, this river is at the center of a controversial political discussion because the Brazilian government is building two hydroelectric plants on the Bolivia-Brazil border, flooding a long reach from near Cachuela Esperanza in the tributary Beni River, close to the Brazil-Bolivia border, up to Porto Velho. We present results from three field expeditions carried out in July-August 2011, December 2012 and March 2013. The main scope of this article is to disseminate the environmental threat suffered by the Madeira from regulation/disruption, and to present preliminary results on the geomorphologic characteristics of the Madeira channel and floodplain.
Using historical radar and satellite imagery, the floodplain morpho-sedimentary units and morphology of the channel were assessed and quantified. Sediment bed and bank sampling, bathymetric surveys and velocity measurements were recorded using a single beam echo sounder and an acoustic Doppler current profiler (ADCP), respectively. Velocity data were analyzed using TRDI's WinRiverII and a MATLAB-based software package Velocity Mapping Tool. We consider that the Madeira River offers some ideal conditions to provide information on critical conditions and geomorphologic thresholds in mega-rivers. The Madeira River has been classified as a simple to moderate anabranching low-sinuosity river. The Madeira flows through a relatively simple pattern, alternating straight reaches with others that exhibit an incipient tendency to anabranch. Single beam and ADCP data yields insight into the bathymetry and flow characteristics in the channel through straight, pseudo-meandering, and anabranching stretches. We studied in detail three selected three reaches zones where three primary mechanisms for anabranching were identified: a) branches upstream and downstream in box shape pseudo-meanders; b) simple branch patterns developing downstream a straight single channel reach; and c) branches in sinuous-second order lateral channels. Velocity maps and an analysis of secondary currents provide information on the three-dimensional flows of water within the channel indicating that bed and channel morphology affect hydraulic characteristics. Several cross sections present unusually deep pools up to ~80m depth in the outer bank and significant increases in the local water slope. These are related to geological constraints, which manifest in the over deepening from the preferentially downwards secondary flow, exacerbating erosion. The anabranching patterns in large rivers such as the Madeira are not just controlled by intrinsic morphodynamics and hydraulic geometry variables but though a variety of interactions with the architecture of the floodplain and the control exerted by older fluvial geomorphological units.

Final ID: EP33D-01

Ganges-Brahmaputra Delta: Balance of Subsidence, Sea level and Sedimentation in a Tectonically-Active Delta *(Invited)*

M. S. Steckler; [1]; *S. L. Goodbred;* [2]; *S. H. Akhter;* [3]; *L. Seeber;* [1]; *M. D. Reitz;* [1]; *C. Paola;* [4]; *S. L. Nooner;* [5]; *S. DeWolf;* [6]; *E. K. Ferguson;* [1]; *J. Gale;* [1]; *S. Hossain;* [3]; *M. Howe;* [1]; *W. Kim;* [1]; *C. M. McHugh;* [7, 1]; *D. R. Mondal;* [7]; *A. L. Petter;* [4]; *J. Pickering;* [2]; *R. Sincavage;* [2]; *L. A. Williams;* [2]; *C. Wilson;* [2]; *M. A. Zumberge;* [6];

1. Lamont-Doherty Earth Obs, Palisades, NY, United States.
2. Vanderbilt University, Nashville, TN, United States.
3. Dhaka University, Dhaka, Bangladesh.
4. University of Minnesota-TC, Minneapolis, MN, United States.
5. University of North Carolina, Wilmington, NC, United States.
6. Scripps Institute of Oceanography, UCSD, San Diego, CA, United States.
7. Queens College, The City University of New York, Flushing, NY, United States.

Body: Bangladesh is vulnerable to a host of short and long-term natural hazards – widespread seasonal flooding, river erosion and channel avulsions, permanent land loss from sea level rise, natural groundwater arsenic, recurrent cyclones, landslides and huge earthquakes. These hazards derive from active fluvial processes related to the growth of the delta and the tectonics at the India-Burma-Tibet plate junctions. The Ganges and Brahmaputra rivers drain 3/4 of the Himalayas and carry ~1 GT/y of sediment, 6-8% of the total world flux. In Bangladesh, these two great rivers combine with the Meghna River to form the Ganges-Brahmaputra-Meghna Delta (GBMD). The seasonality of the rivers' water and sediment discharge is a major influence causing widespread flooding during the summer monsoon. The mass of the water is so great that it causes 5-6 cm of seasonal elastic deformation of the delta discerned by our GPS data. Over the longer-term, the rivers are also dynamic. Two centuries ago, the Brahmaputra River avulsed westward up to 100 km and has since captured other rivers. The primary mouth of the Ganges has shifted 100s of km eastward from the Hooghly River over the last 400y, finally joining the Brahmaputra in the 19th century. These avulsions are influenced by the tectonics of the delta. On the east side of Bangladesh, the >16 km thick GBMD is being overridden by the Burma Arc where the attempted subduction of such a thick sediment pile has created a huge accretionary prism. The foldbelt is up to 250-km wide and its front is buried beneath the delta. The main Himalayan thrust front is <100 km north, but adjacent to the GBMD is the Shillong Massif, a 300-km long, 2-km high block of uplifted Indian basement that is overthrusting and depressing GBMD sediments to the south. The overthrusting Shillong Massif may represent a forward jump of the Himalayan front to a new plate boundary. This area ruptured in a ~M8 1897 earthquake. Subsidence from the tectonics and differential loading also influences the river patterns and avulsion rates of the delta. We are beginning to unravel these interactions through sampling and numerical modeling. One advantage for geologic research in Bangladesh is that the rapid sediment accumulation preserves a detailed structural and stratigraphic archive. We have been tapping into these records using the combination of a local, low-cost drilling method, resistivity imaging and MCS seismics, while GPS, seismology and other geophysical methods are helping to unravel GBMD dynamics. Five transects of >130 wells are illuminating the Holocene shifts of the Brahmaputra River and subsidence patterns. Very high resolution MCS seismics on the rivers shows deformation by subsidence and compaction. Resistivity is further mapping surfaces warped by the anticlinal folds. GPS geodesy is quantifying the rates of overthrusting and differential subsidence across the delta. Optical fiber strain meters installed in well nests are constraining sediment compaction rates. Seismology is imaging the tectonics in and around Bangladesh, while structural geology maps the tectonic deformation exposed on the margins of the delta. Numerical modeling is beginning to integrate all these results. I will present an overview of the GBMD and our growing research into the dynamics of the delta. A comprehensive view of these processes and their interaction is critical for

understanding human impact and the future evolution of the delta.

URL : http://BanglaPIRE.org

Final ID: G33A-0966

Using High-temporal-resolution, Repeat Terrestrial LiDAR to Compare Topographic Change Detection Methods and to Elucidate the Hydrometeorologic Controls on the Retreat Rate and Form of the Selawik Retrogressive Thaw Slump, Northwest Alaska

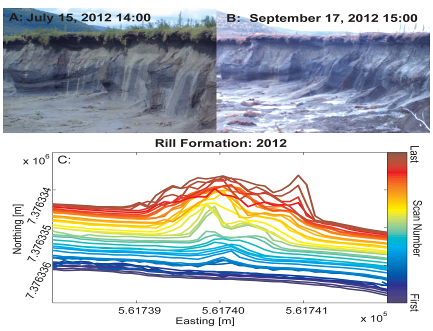
T. B. Barnhart; [1, 2]; *B. T. Crosby;* [2]; *D. R. Derryberry;* [3]; *J. C. Rowland;* [4];

1. Institute for Arctic and Alpine Research / Department of Geography, University of Colorado Boulder, Boulder, CO, United States.
2. Department of Geosciences, Idaho State University, Pocatello, ID, United States.
3. Department of Mathematics, Idaho State University, Pocatello, ID, United States.
4. EES-14, Los Alamos National Laboratory, Los Alamos, NM, United States.

Body: Retrogressive thaw slumps (RTS), a type of catastrophic thermokarst indicative of permafrost degradation, are forecast to increase in frequency and magnitude with a warming climate. RTS flux a disproportionate amount of sediment and nutrients to downstream ecosystems with the potential for adverse impacts. Characterizing the processes and hydrometeorologic drivers through which these features grow is necessary to better understand how these features may behave in the future. The Selawik RTS initiated in 2004 and has grown at a rate of 7-20 m/yr. In 2012, the feature was 200 m wide with a vertical headwall ~20 m high at its apex. We utilize a 58 scan repeat, ground based LiDAR data set collected over the summers of 2011 and 2012 and interval camera imagery to: (1) compare two topographic change detection methods, cloud to mesh (C2M) and the Multiscale Model to Model Cloud Comparison (M3C2) algorithm, (2) compare the error analysis techniques used with C2M and M3C2, (3) describe RTS mass loss processes, and (4) investigate the drivers of RTS retreat rate and form.

We found that C2M reports higher magnitude topographic change over short time periods (~12 hours) and lower magnitude topographic change over long time periods (~20 days) when compared to M3C2. The spatially variable error analysis protocol used with M3C2 better accounts for the sources of uncertainty in point cloud data sets used for topographic change detection than C2M. TLS data from 2011 show a diel pattern in the mean retreat rate of the feature while data from 2012 show a more mixed signal. These differences are likely due to the warm, dry conditions experienced in 2011 verses the cool, wet conditions experienced in 2012. Statistical modeling indicates that RTS retreat rate and form are most sensitive to net radiation (R^2 27.4%, pVal: 0.001 and R^2 82.0%, pVal: <0.001, respectively). We interpret this to indicate that spallation-type mass loss processes, driven by elevated net radiation, are most effective at removing material from interstitial ice dominated RTS features. Furthermore, we find that hydrologic pathways in the tundra upslope of the feature control the cuspate form the Selawik RTS headwall.

URL: http://theobarnhart.host-ed.me/research.html

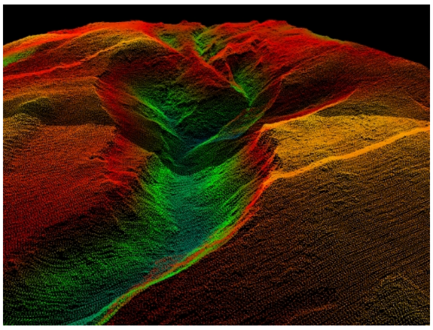


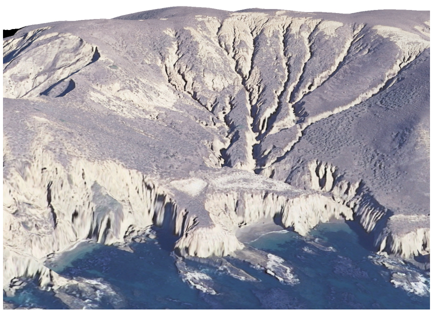
Final ID: G33A-0973

Erosion and Channel Incision Analysis with High-Resolution Lidar

J. Potapenko; [1]; *B. Bookhagen;* [1];
1. Geography, UCSB, Santa Barbara, CA, United States.

Body: High-resolution LiDAR (LIght Detection And Ranging) provides a new generation of sub-meter topographic data that is still to be fully exploited by the Earth science communities. We make use of multi-temporal airborne and terrestrial lidar scans in the south-central California and Santa Barbara area. Specifically, we have investigated the Mission Canyon and Channel Islands regions from 2009-2011 to study changes in erosion and channel incision on the landscape. In addition to gridding the lidar data into digital elevation models (DEMs), we also make use of raw lidar point clouds and triangulated irregular networks (TINs) for detailed analysis of heterogeneously spaced topographic data. Using recent advancements in lidar point cloud processing from information technology disciplines, we have employed novel lidar point cloud processing and feature detection algorithms to automate the detection of deeply incised channels and gullies, vegetation, and other derived metrics (e.g. estimates of eroded volume). Our analysis compares topographically-derived erosion volumes to field-derived cosmogenic radionuclide age and in-situ sediment-flux measurements. First results indicate that gully erosion accounts for up to 60% of the sediment volume removed from the Mission Canyon region. Furthermore, we observe that gully erosion and upstream arroyo propagation accelerated after fires, especially in regions where vegetation was heavily burned. The use of high-resolution lidar point cloud data for topographic analysis is still a novel method that needs more precedent and we hope to provide a cogent example of this approach with our research.





Final ID: G33A-0979

Quantifying geomorphic change and characterizing uncertainty in repeat aerial lidar over an enormous area: Blue Earth County, MN

K. R. Schaffrath; [1]; *P. Belmont;* [1]; *J. M. Wheaton;* [1];
1. Utah State University, Logan, UT, United States.

Body: High-resolution topography data (lidar) are being collected over increasingly larger geographic areas. These data contain an immense amount of information regarding the topography of bare-earth and vegetated surfaces. Repeat lidar data (collected at multiple times for the same location) enables extraction of an unprecedented level of detailed information about landscape form and function and provides an opportunity to quantify volumetric change and identify hot spots of erosion and deposition. However, significant technological and scientific challenges remain in the analysis of repeat lidar data over enormous areas (>1000 square kilometers), not the least of which involves robust quantification of uncertainty.

Excessive sedimentation has been documented in the Minnesota River and many reaches of the mainstem and tributaries are listed as impaired for turbidity and eutrophication under the Clean Water Act of 1972. The Blue Earth River and its tributaries (Greater Blue Earth basin) have been identified as one of the main sources of sediment to the Minnesota River. Much of the Greater Blue Earth basin is located in Blue Earth County (1,982 square kilometers) where airborne lidar data were collected in 2005 and 2012, with average bare-earth point densities of 1 point per square meter and closer to 2 points per square meter, respectively. One of the largest floods on record (100-year recurrence interval) occurred in September 2010. A sediment budget for the Greater Blue Earth basin is being developed to inform strategies to reduce current sediment loads and better predict how the basin may respond to changing climate and management practices.

Here we evaluate the geomorphic changes that occurred between 2005 and 2012 to identify hotspots of erosion and deposition, and to quantify some of the terms in the sediment budget. To make meaningful interpretations of the differences between the 2005 and 2012 lidar digital elevation models (DEMs), total uncertainty must be accounted for between and within DEMs. We identified, quantified, and corrected for a systematic vertical bias of 6 cm between the two DEMs. We compared elevation differences using the control points used to ground-truth and from points digitized in areas outside channels where we did not expect geomorphic change over time. Digitized points were stratified by geography and flight lines to determine if the bias was spatially distributed. To evaluate horizontal bias, we digitized points at the corners of buildings throughout each DEM. For each set of points, we compared the direction and magnitude of differences and did not detect a systematic horizontal bias. A new uncertainty model was developed and applied to each DEM that accounts for uncertainty due to vegetation interference and topographic complexity relative to sampling. These uncertainty models were propagated into the change detection estimates to establish a probabilistically thresholded estimate of elevation change and estimates of volume eroded or deposited. Results will be presented of the spatial patterns of net erosion and deposition and their contribution to the overall sediment budget being developed.

Final ID: H33A-1329

Modeling the gopher-meadow eco-geomorphic system on montane hillslopes

E. W. Winchell; [1]; *D. F. Doak;* [2]; *R. S. Anderson;* [1];
1. Department of Geological Sciences and INSTAAR, University of Colorado, Boulder, CO, United States.
2. Environmental Studies Program, University of Colorado, Boulder, CO, United States.

Body: On montane hillslopes of Colorado's Front Range, the transport of soil by gophers can dominate the modern geomorphic system in meadows. Qualitative observations reveal that gophers prefer to forage in meadows over forests, that seedling roots are consumed by gophers, and that trees commonly occupy the rocky crests of hills overlooking open meadow hillslopes. This motivates a numerical model of gopher-mediated transport of soil and the long-term evolution of the coupled ecological-geomorphic system through quantitative observations from a manipulative experiment on meadow-centered plots in the Boulder Creek CZO in the Colorado Front Range montane forest.

The ecological and geomorphic processes in the coupled system we wish to model must include: seedling establishment and damage, gopher tunneling geometries and resulting mound generation, mound material transport driven by rain and hail and by ungulate trampling, vegetative lock-down of mound material, and resulting changes in the soil depth and rockiness of the landscape. We must therefore have algorithms to capture the feedback mechanisms between gopher activity and the growth and potential death of trees, the casting of seeds and their likelihood of germination, and the spatial distribution of plants. The ecological component interacts with the soils/critical zone layer through feedbacks that include the dependence of gopher activity on root density, depth, and size, undergrowth availability, and the dependence of the rate of change of soil thickness on gradients in gopher-mediated transport.

Results of a preliminary cellular automaton model which captures the essence of these geomorphic-ecological feedbacks can readily address the role of gophers in limiting the encroachment of trees into meadow patches. The bioturbation of the meadows, and the downslope transport of soil within them, is much more efficient than that in the forest, which sees little to no gopher activity. These geomorphic transport hotspots will persist on timescales of meadow duration.

Final ID: H33A-1334

Modeling the Channel/Floodplain Interface: The Influence of Riparian Vegetation on Mass and Momentum Exchange

M. C. Stone; [1];
1. University of New Mexico Main Campus, Albuquerque, NM, United States.

Body: The objective of this research was to improve understanding of the impacts of riparian vegetation on mass and momentum flux between the main channel and the floodplain. Numerical investigations were carried out on five sites within three rivers in New Mexico, USA. Vegetation characteristics were varied to represent different riparian scenarios ranging from no vegetation to dense understory. The sedimentation and river hydraulics in two dimensions (SRH-2D) model was applied to simulate hydrodynamic conditions. The model was modified to include two algorithms for simulating a dynamic hydraulic roughness in the riparian zone. Thus resistive forces were represented as a function of vegetation characteristics and hydrodynamic condition. The results provide insights into the processes of mass and momentum transfer at the channel/floodplain interface. As expected, an increase in vegetation density produced enhanced momentum exchange. However, a threshold was reached beyond which the momentum exchange peaked and then dropped. This threshold was the results of low floodplain velocities producing very little resistive force due to low drag. Future work will focus on unsteady investigations and laboratory and field verification studies.

Final ID: H33A-1338

Reciprocal Vegetation-Flow Feedbacks Driving Early-Stage Landscape Evolution in a Restored Wet Meadow

L. Larsen; [1]; *D. J. Merritts;* [2]; *R. C. Walter;* [2]; *D. Watts;* [1];
1. University of California, Berkeley, CA, United States.
2. Franklin and Marshall College, Lancaster, PA, United States.

Body: Just as taxonomic classification has improved understanding in biology, ecogeomorphologists would benefit from a functional classification of biota based on the biophysical feedbacks that they engage in. Early stages of landscape development following disturbance provide a unique opportunity to delineate and understand these feedback processes, as the diversity in functional morphotypes (a.k.a. "ecomorphs," to expand on a concept from terrestrial ecology) is high and the potential for self-organization of landscape pattern strong. We used the opportunity of a stream restoration that reset its floodplain to "initial conditions" to perform a suite of biophysical measurements designed to delineate the classes of feedback that influence landscape evolution in distinct ways. The Big Spring Run restoration (Lancaster, PA), completed in November 2011, involved removal of 15,000 t of legacy sediment from the valley bottom to expose a Holocene hydric layer and reestablish wet meadow hydrology and biota.

By performing repeat biogeomorphic surveys within a study grid, we tested the hypothesis that distinct ecomorphs determine the persistence and location of channel and microtopographic features. The qualitatively distinct patch types surveyed included carpet-forming mat vegetation, tussock-forming vegetation, sparsely vegetated mudflats, benthic algal mats, mixed herbaceous communities, grasses, and clonal emergent vegetation. Within each sampling location, changes in vegetation community architecture, grain size distribution, critical shear stress for sediment entrainment, and topography were monitored over time, and flow resistance was measured. An overbank flow event that completely filled the floodplain provided an additional opportunity to measure vegetation-flow-sediment interactions. Once emergent vegetation was bent over by flow, vegetation had a negligible influence on flow velocity—in contrast to most other wetlands—but continued to shelter the bed from sediment entrainment and promote the deposition of fines. In the two years of the study, distinct biogeomophic succession trajectories associated with different ecomorphs emerged: 1) Stabilization of sediment by benthic algae, followed by occupation by mat-forming vegetation and ultimately by grasses 2) incipient channel formation around clonal emergents or trees, which induced topographic steering of flow, and 3) replacement of clonal emergents with grasses in areas not immediately adjacent to the channel or sustained by groundwater seeps. Principal component analyses allowed for rigorous quantitative identification of ecomorphs, and long-term feedbacks of those ecomorphs on landscape evolution are presently being evaluated by modeling. Overall, landscape dynamics in this restored wet meadow-floodplain are driven by deterministic succession trajectories but are influenced by stochastic elements: the spatial distribution of groundwater seeps and the initial colonization of patch types that remain upright during high flow. However, whereas hydrology might respond quickly to restoration change, biological, geological, and hydrological feedbacks might take a decade or more to stabilize.

Final ID: H33L-01

Water-Organic-Rock Reactions Recorded in Pores in Shales from the Marcellus and Rose Hill Formations ***(Invited)***

S. L. Brantley; [1]; *L. Jin;* [2]; *G. Rother;* [3]; *D. R. Cole;* [4]; *x. gu;* [1]; *V. N. Balashov;* [1];
1. Geosciences/EESI, Penn State University, University Park, PA, United States.
2. Geological Sciences, University of El Paso, TX, El Paso, TX, United States.
3. Oak Ridge National Laboratory, Oak Ridge, TN, United States.
4. School of Earth Sciences, Ohio State University, Columbus, OH, United States.

Body: The porosity of shales varies depending upon such attributes as the mineralogy, grain size, organic content, depth and duration of burial, and extent of water-rock reaction. Today, shales are being exploited when they contain significant natural gas, and the connectivity of pores are important toward controlling both recovery of gas after hydrofracking. In fact, the fine-scale nature of the pores controls aspects of release of natural gas and brines during hydrofracturing and gas exploitation.

Despite the importance of shale as a source rock for natural gas and petroleum, it remains difficult to quantify and image porosity in shales because of their fine-scale nature. We are using neutron scattering, FIB SEM, CT microtomography, and other techniques to understand pores in a black (Marcellus) and a grey shale (Rose Hill formation) sampled in Pennsylvania. Samples were recovered both from outcrop and from depth in wellbores. We also report a new approach for investigating pores in shales by using neutron scattering before and after removal of organic matter.

Pores in the two shales are observed to be isotropic (i.e. in the plane of bedding) or anisotropic (i.e. perpendicular to bedding), as expected for sediments that have been compacted after burial. Some nanometer-sized pores are observed in the organic matter of the Marcellus to be spherical; other pores are observed to be present in pyrite framboids and among silicate grains in that rock. We have no evidence that significant porosity is present in the organic matter in the Rose Hill formation, a relatively organic-poor shale, but pores are observed between and in clay particles.

We also investigate how progressive water-rock reaction changes the primary porosity in the shales by investigating weathering samples. FIB SEM images document that organic matter is oxidized and removed significantly from the weathering Marcellus before the rock turns to soil, leaving behind porosity. Pyrite oxidation and dissolution also creates pores in the Marcellus bedrock before it turns to soil. Only the latter process is significant in the Rose Hill shale. Unlike other weathering rocks (granites, diabase, basalt), the pores in the shales comprise surface fractals both before and after weathering. Understanding how water enters and transforms pores in shales at depth and near surface will increase our ability to protect our water and soil resources, as well as inform our methods of gas recovery.

Final ID: IN33C-01

Smart Frameworks and Self-Describing Models: Model Metadata for Automated Coupling of Hydrologic Process Components *(Invited)*

S. D. Peckham;[1];
1. University of Colorado, Boulder, CO, United States.

Body: Model coupling frameworks like CSDMS (Community Surface Dynamics Modeling System) and ESMF (Earth System Modeling Framework) have developed mechanisms that allow heterogeneous sets of process models to be assembled in a plug-and-play manner to create composite "system models". These mechanisms facilitate code reuse, but must simultaneously satisfy many different design criteria. They must be able to mediate or compensate for differences between the process models, such as their different programming languages, computational grids, time-stepping schemes, variable names and variable units. However, they must achieve this interoperability in a way that: (1) is noninvasive, requiring only relatively small and isolated changes to the original source code, (2) does not significantly reduce performance, (3) is not time-consuming or confusing for a model developer to implement, (4) can very easily be updated to accommodate new versions of a given process model and (5) does not shift the burden of providing model interoperability to the model developers, e.g. by requiring them to provide their output in specific forms that meet the input requirements of other models.

In tackling these design challenges, model framework developers have learned that the best solution is to provide each model with a simple, standardized interface, i.e. a set of standardized functions that make the model: (1) fully-controllable by a caller (e.g. a model framework) and (2) self-describing. Model control functions are separate functions that allow a caller to initialize the model, advance the model's state variables in time and finalize the model. Model description functions allow a caller to retrieve detailed information on the model's input and output variables, its computational grid and its timestepping scheme. If the caller is a modeling framework, it can compare the answers to these queries with similar answers from other process models in a collection and then automatically call framework service components as necessary to mediate the differences between the coupled models.

This talk will first review two key products of the CSDMS project, namely a standardized model interface called the Basic Model Interface (BMI) and the CSDMS Standard Names. The standard names are used in conjunction with BMI to provide a semantic matching mechanism that allows output variables from one process model to be reliably used as input variables to other process models in a collection. They include not just a standardized naming scheme for model variables, but also a standardized set of terms for describing the attributes and assumptions of a given model. To illustrate the power of standardized model interfaces and metadata, a smart, light-weight modeling framework written in Python will be introduced that can automatically (without user intervention) couple a set of BMI-enabled hydrologic process components together to create a spatial hydrologic model. The same mechanisms could also be used to provide seamless integration (import/export) of data and models.

URL : http://csdms.colorado.edu/wiki/BMI_Description

Final ID: NH33A-1629

Model Building Strategies for Predicting Multiple Landslide Events

L. Lombardo; [1, 2]; *M. Cama;* [1]; *M. Märker;* [4]; *L. Parisi;* [3]; *E. Rotigliano;* [1];

1. DiSTeM, Università degli Studi di Palermo, Palermo, Italy.
2. Geographisches Institut , Eberhard Karls Universität Tübingen, Tübingen, Germany.
3. School of Environmental Sciences, University of East Anglia, Norwich, United Kingdom.
4. Dipartimento Scienze della Terra, Università degli Studi di Firenze, Firenze, Italy.

Body: A model building strategy is tested to assess the susceptibility for extreme climatic events driven landslides. In fact, extreme climatic inputs such as storms typically are very local phenomena in the Mediterranean areas, so that with the exception of recently stricken areas, the landslide inventories which are required to train any stochastic model are actually unavailable. A solution is here proposed, consisting in training a susceptibility model in a source catchment, which was implemented by applying the binary logistic regression technique, and exporting its predicting function (selected predictors regressed coefficients) in a target catchment to predict its landslide distribution. To test the method we exploit the disaster that occurred in the Messina area (southern Italy) on the 1st of October 2009 where, following a 250mm/8hours storm, approximately 2000 debris flow/debris avalanches landslides in an area of 21km2 triggered, killing thirty-seven people, injuring more than one hundred, and causing 0.5M euro worth of structural damage. The debris flows and debris avalanches phenomena involved the thin weathered mantle of the Varisican low to high grade metamorphic rocks that outcrop in the eastern slopes of the Peloritan Belt. Two 10km2 wide stream catchments, which are located inside the storm core area were exploited: susceptibility models trained in the Briga catchment were tested when exported to predict the landslides distribution in the Giampilieri catchment. The prediction performance (based on goodness of fit, prediction skill, accuracy and precision assessment) of the exported model was then compared with that of a model prepared in the Giampilieri catchment exploiting its landslide inventory. The results demonstrate that the landslide scenario observed in the Giampilieri catchment can be predicted with the same high performance without knowing its landslide distribution: we obtained in fact a very poor decrease in predictive performance when comparing the exported model (AUC=0.824) to the native random partition based model (AUC=0.844).

Final ID: T33E-01

Underworld: What we set out to do, How far did we get, What did we Learn ? *(Invited)*

L. N. Moresi; [1];
1. Monash University, Clayton, Australia.

Body: Underworld was conceived as a tool for modelling 3D lithospheric deformation coupled with the underlying / surrounding mantle flow. The challenges involved were to find a method capable of representing the complicated, non-linear, history dependent rheology of the near surface as well as being able to model mantle convection, and, simultaneously, to be able to solve the numerical system efficiently.

Underworld is a hybrid particle / mesh code reminiscent of the particle-in-cell techniques from the early 1960s. The Underworld team (*) was not the first to use this approach, nor the last, but the team does have considerable experience and much has been learned along the way.

The use of a finite element method as the underlying "cell" in which the Lagrangian particles are embedded considerably reduces errors associated with mapping material properties to the cells. The particles are treated as moving quadrature points in computing the stiffness matrix integrals.
The decoupling of deformation markers from computation points allows the use of structured meshes, efficient parallel decompositions, and simple-to-code geometric multigrid solution methods. For a 3D code such efficiencies are very important.

The elegance of the method is that it can be completely described in a couple of sentences. However, there are some limitations: it is not obvious how to retain this elegance for unstructured or adaptive meshes, arbitrary element types are not sufficiently well integrated by the simple quadrature approach, and swarms of particles representing volumes are usually an inefficient representation of surfaces. This will be discussed !

(*) Although not formally constituted, my co-conspirators in this exercise are listed as the Underworld team and I will reveal their true identities on the day.

Final ID: EP33D-02

Slope-mediated and Deltaic Avulsions on the Huanghe River, China

V. Ganti; [1]; *Z. Chu;* [2, 1]; *H. J. Hassenruck-Gudipati;* [1]; *M. P. Lamb;* [1];
1. Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, CA, United States.
2. Key Laboratory of Submarine Geosciences and Prospecting Techniques, Ministry of Education, Ocean University of China, Qingdao, China.

Body: River avulsions, which occur because of a topographic slope-break or as a result of dynamic backwater effects, set the fundamental length scale of alluvial fans and deltas, respectively. Several theories have been proposed to predict the location and frequency of river avulsions, though testing these theories in an evolving system have been difficult owing to the large timescales of river avulsions. The Huanghe river system in China provides a rare opportunity to test these theories because of its exceptionally high sediment loads and also because the Huanghe river displays both these types of river avulsions, which we term as ‘slope-mediated’ and ‘deltaic’ avulsions. We show that the slope-mediated avulsion node of the Huanghe river is pinned to the topographic slope-break over the last ~5000 years (~8 river avulsions), which occurs at the location where the river drains out of the Loess plateau. Further, we show that the deltaic avulsion node of the Huanghe River migrated seaward over the past 150 years (~13 river avulsions) in sync with the prograding shoreline and the computed backwater length accurately predicts the location of this avulsion node. We show that the frequency of the slope-mediated river avulsions is accurately predicted by the channel-filling timescale. However, the frequency of the deltaic avulsions are over-predicted by the channel-filling timescale indicating that water discharge variability may play an additional role in setting the frequency of deltaic avulsions. Preliminary results from controlled physical experiments designed to reproduce deltaic avulsions provide insights into how backwater hydrodynamics, discharge variability, and seal level interplay to control the morphodynamics of deltaic evolution.

Final ID: EP33E-02

Better budgeting by redundancy, context, and coupling of coarse and fine sediment dynamics *(Invited)*

P. Belmont; [1];
1. Department of Watershed Sciences, Utah State University, Logan, UT, United States.

Body: The core principles of sediment budgeting are simple, involving a careful accounting of sediment sources and sinks over a specified spatial extent and time period. However, a long history of sediment budgeting has shown that such numbers are difficult to constrain due to uncertainty in measurements and immense variability in water and sediment fluxes in time and space. As a result, many budgets compiled at the reach or watershed scales are indeterminate with respect to net erosion or deposition. Further, budgets can be highly sensitive to bias if critical processes or contingencies in the landscape are not considered. Over the past decade many new tools and techniques have been developed that can be used to constrain sediment budgets, including software for analysis of high resolution topography data and imagery, in situ monitoring instrumentation, geochemical fingerprinting and particle tracking devices, and increasingly sophisticated models that describe erosion, transport, and deposition in a physically meaningful way. These approaches have the potential to substantially advance budgeting capabilities by providing multiple, redundant sources of information that must be reconciled within the hard constraint of a mass balance. Each independent source of information can add to the level of certainty with which the budget can inform our understanding of sediment inputs, outputs and net change in storage. However, a key technical challenge lies in developing meaningful estimates of uncertainty for each approach. Once developed, rigorous estimates of uncertainty can serve as scaling factors to close the budget in a transparent and parsimonious manner. More broadly, two key conceptual challenges for the future of sediment budgeting include a) placing the components of the budget into the appropriate landscape context with a focus on identifying critical locations where erosion and deposition processes may be amplified or dampened, and b) linking the dynamics of coarse and fine sediment within a sediment routing model. Here we focus on recent theoretical advances for overcoming these challenges, with examples from the Upper Mississippi River and Columbia River watersheds.

Final ID: EP33D-03

Modeling delta growth and channel geometry on Wax Lake Delta, Louisiana. Preliminary results

E. Viparelli; [1]; *M. J. Czapiga;* [2]; *C. Li;* [2]; *J. B. Shaw;* [4]; *G. Parker;* [3];

1. Civil and Environmental Engineering, university of South Carolina, columbia, SC, United States.
2. Civil and Environmental Engineering, University of Illinois, Urbana-Champaign, IL, United States.
3. Civil and Environmental Engineering and Geology, University of Illinois, Urbana-Champaign, IL, United States.
4. Geology and Geophysics, university of Wyoming, Laramie, WY, United States.

Body: A numerical model of delta growth, in which the distributary channels are assumed to have self-constructed their cross sections, is validated on Wax Lake Delta, Louisiana. As in previous laterally averaged models of delta growth, the delta is divided in a low slope delta top, a steep delta front and a low slope basement. The flow on the delta top is assumed steady, and a backwater formulation is implemented. Since one or more channels can actively transport water and sediment on the delta top during floods, we simplify the problem by assuming that the bed material is transported in one rectangular channel, with width and depth roughly equal to the sum of the active channel widths, and to the average depth of the active channels. The problem is characterized by one equation (i.e. the backwater equation) in two unknowns, the channel width and depth. Another equation is thus needed to close the problem. Under the assumptions that 1) the system is at bankfull flow, and 2) the Shields number in the channels is equal to its channel formative value, our closure relation is a channel-formative criterion. In particular, a recently derived relation to estimate the formative (bankfull) Shields number as a function of the friction slope is implemented. Recent field work on Wax Lake Delta shows that the distributary channels are incising into a relatively stiff basement. In our model we do not attempt to directly model channel incision, but we implicitly account for it with a modified formulation to compute the shoreline migration rate. In this formulation the bed material at the shoreline is trapped in the non-channelized portion of the delta front only. Measured and numerical shoreline migration rates, longitudinal profiles of delta elevation, and channel geometry, i.e. width and depth, are compared. In the relatively near future we plan to 1) use our model to estimate land-building potential of engineered diversions of the Mississippi River, and 2) couple the present model with a formulation to predict the ecological succession on the delta top.

Final ID: IN33C-03

Leveraging the DataNet Federation Consortium (DFC) to Support Regional-Scale Hydrologic Modeling *(Invited)*

J. L. Goodall; [1, 2]; *M. M. Billah;* [3]; *B. Essawy;* [1]; *U. Narayan;* [4]; *V. Lakshmi;* [5]; *A. Rajasekar;* [6]; *R. Moore;* [6];

1. Civil and Environmental Engineering, University of Virginia, Charlottesville, VA, United States.
2. Civil and Environmental Engineering, University of South Carolina, Columbia, SC, United States.
3. Bureau of Water, South Carolina Department of Health & Environmental Control, Columbia, SC, United States.
4. Signal Data Corporation, New York, NY, United States.
5. Earth & Ocean Sciences, University of South Carolina, Columbia, SC, United States.
6. Information and Library Science, University of North Carolina, Chapel Hill, NC, United States.

Body: There are significant data management challenges associated with modeling regional-scale hydrologic systems. Locating, accessing, and transforming publically available datasets to prepare the necessary inputs for hydrologic models is a time consuming process. The lack of tools for automating these steps limits researchers' ability to reproduce the work of others, and to build from past work. This research focuses on the use of the DataNet Federation Consortium (DFC) cyberinfrastructure to overcome these challenges of locating, accessing, and transforming datasets associated with performing hydrologic model simulations. The DFC is built on the integrated Rule Oriented Data Management System (iRODS), which allows processing on data resources within a data grid. Datasets can be distributed across many machines, and processing these datasets can occur remotely near data providers to distribute the computational load and reduce network data transfers. Moreover, the data processing rules document steps required for creating model inputs, making it easier to reproduce model runs. This approach is demonstrated using the hydrologic model VIC for the Carolinas to analyze a period of drought within the region.

Final ID: NG33B-03

The Shape of Patterns to Come ***(Invited)***

A. Murray; [1]; *E. B. Goldstein;* [1]; *G. Coco;* [2];
1. Division of Earth and Ocean Sciences, Nicholas School of the Environment; Center for Nonlinear and Complex Systems, Duke University, Durham, NC, United States.
2. Environmental Hydraulics Institute, “IH Cantabria”, Universidad de Cantabria, Santandur, Spain.

Body: Many studies focus on the emergence and development of rhythmic patterns in Earth surface systems. In this contribution we explore the different behaviors found in pattern evolution; the trajectories and behaviors that patterns exhibit as they transit from infinitesimal-amplitude perturbation to a statistically steady state. The variety of behaviors observed, either through field and laboratory experiments or numerical modeling, can be reduced to four classes: a) simple stabilization where predictions based on the initial growth of infinitesimal perturbations (e.g., Linear Stability Analyses) corresponds with the characteristics of patterns observed in nature; b) significant pattern coarsening en route to saturated wavelength, where nonlinear interactions between finite-amplitude pattern elements change the geometric properties of a pattern as it approaches steady-state; c) perpetual coarsening where the wavelength associated with the emerging pattern continues to grow over time and is only limited by physical boundaries or external constrains; d) slow evolution toward a different attractor, a novel behavior observed in numerical modeling that involves profound temporal changes in the pattern characteristics. Within these classes we also observe generalizable nonlinear behaviors: dependence on initial conditions, the role played by emergent pattern variables such as pattern defects, and the presence of multiple stable states. Predicting the shape of patterns to come remains a challenge–one that we suggest requires a range of modeling approaches to address both initial instabilities and the emergent properties of evolving patterns, which involve disparate forms of nonlinear interactions. Consideration of generic system behaviors at the pattern scale could enhance future pattern formation studies, facilitating appropriate pairings of analysis approaches and pattern-evolution modes.

Final ID: EP33D-04

Three dimensional numerical modeling of shallow jets: importance of frictional effects on the morphodynamics of river mouth bars and levees

A. Canestrelli; [1]; *W. Nardin;* [3, 2]; *D. A. Edmonds;* [3]; *S. Fagherazzi;* [2]; *R. L. Slingerland;* [1];
1. Department of Geosciences, PSU, State College, PA, United States.
2. Department of Earth Sciences, Boston University, Boston, MA, United States.
3. Department of Geological Sciences and Center for Geospatial Data Analysis, Indiana University, Bloomington, IN, United States.

Body: In this work a three-dimensional numerical model (Delft3D) has been used to assess the hydrodynamic and morphodynamic behaviour of a river jet debouching in a large quiescent water body. We show that the stability number S, function of friction and river mouth aspect ratio, and the mouth Reynolds number ReB are the two parameters that describe the stable/unstable character of the jet. From a morphodynamic point of view, a stable jet always tends to form an emerging mouth bar. However, a decrease of the stability number together with jet instability increase the delivery of sediments to the jet margins, favoring the formation of subaerial levees and elongated channels. Therefore, importance of frictional effects in setting depositional patterns at the river mouth (e.g. the distance at which the mouth bar becomes stagnant) is comparable to or larger than other variables (i.e. momentum of the jet and potential vorticity) and therefore should be considered in the design of restoration schemes for deltaic land.

Final ID: IN33C-04

GEOSS Water Services for Data and Maps

D. K. Arctur; [1, 2]; *D. R. Maidment;* [1]; *R. G. Lawford;* [3];
1. University of Texas at Austin, Austin, TX, United States.
2. Open Geospatial Consortium (OGC), Boston, MA, United States.
3. Morgan State University, Baltimore, MD, United States.

Body: The Global Earth Observation System of Systems (GEOSS) has a Water Strategic Target, which is “to produce comprehensive sets of data and information products to support decision-making for efficient management of the world's water resources, based on coordinated, sustained observations of the water cycle on multiple scales.” This target is intended to be reached by 2015.

In support of this target, and activities of the Integrated Water Cycle Observations (IGWCO) Community of Practice, work began in 2012 on a GEOSS Architecture Implementation Pilot called GEOSS Water Services that will provide additional operational capability for in situ water observations, as a federated resource in GEOSS. The scope of this project is to provide a global registry of water data, mapping tools, and modeling services catalogued using the standards and procedures of the Open Geospatial Consortium and the World Meteorological Organization. This registry will be open to all participants and institutions from any country or level of government, and applies to any type of water information, although the initial focus will be on physical hydrology.

This presentation will introduce the project team and objectives, and show results achieved.

Final ID: IN33C-05

Design and Implementation of Hydrologic Process Knowledge-base Ontology: A case study for the Infiltration Process

M. Elag; [1]; *J. L. Goodall;* [2];
1. Civil and Environmental, University of Illinois at Urbana Champaign, Urbana, IL, United States.
2. Civil and Environmental, University of South Carolina, Columbia, IL, United States.

Body: Hydrologic modeling often requires the re-use and integration of models from different disciplines to simulate complex environmental systems. Component-based modeling introduces a flexible approach for integrating physical-based processes across disciplinary boundaries. Several hydrologic-related modeling communities have adopted the component-based approach for simulating complex physical systems by integrating model components across disciplinary boundaries in a workflow. However, it is not always straightforward to create these interdisciplinary models due to the lack of sufficient knowledge about a hydrologic process. This shortcoming is a result of using informal methods for organizing and sharing information about a hydrologic process. A knowledge-based ontology provides such standards and is considered the ideal approach for overcoming this challenge. The aims of this research are to present the methodology used in analyzing the basic hydrologic domain in order to identify hydrologic processes, the ontology itself, and how the proposed ontology is integrated with the Water Resources Component (WRC) ontology. The proposed ontology standardizes the definitions of a hydrologic process, the relationships between hydrologic processes, and their associated scientific equations. The objective of the proposed Hydrologic Process (HP) Ontology is to advance the idea of creating a unified knowledge framework for components' metadata by introducing a domain-level ontology for hydrologic processes. The HP ontology is a step toward an explicit and robust domain knowledge framework that can be evolved through the contribution of domain users. Analysis of the hydrologic domain is accomplished using the Formal Concept Approach (FCA), in which the infiltration process, an important hydrologic process, is examined. Two infiltration methods, the Green-Ampt and Philip's methods, were used to demonstrate the implementation of information in the HP ontology. Furthermore, a SPARQL service is provided for semantic-based querying of the ontology.

Final ID: EP33D-06

Left Behind: Effects of marine reworking and sea-level rise on deltas of the 21st century ***(Invited)***

A. D. Ashton; [1]; *J. Nienhuis;* [1]; *A. C. Ortiz;* [1]; *J. Lorenzo Trueba;* [1]; *L. Giosan;* [1];
1. WHOI, Woods Hole, MA, United States.

Body: The 21st century will represent a time of punctuated change for the morphology of the world's deltas as they face the doubled-edged impacts of sediment reduction during reservoir infilling and submergence by rising sea levels. This research focuses on the controls on the evolution of deltas strongly affected by marine processes, namely wind waves, with a particular emphasis on reworking. Our objective is to apply process-based quantitative means to advance our observational knowledge of how changes in sediment supply and accommodation growth through sea-level rise manifest through delta reworking and the delta cycle.

Building upon previous research highlighting how the angle of approaching waves can leave a fingerprint on a delta's shape, we investigate how the coastal conditions prior to sediment cessation can be used to predict the morphologic shape of the ensuing reworked shore along and adjacent to the former delta, including the potential for forming spits and other features indicative of lobe abandonment. In general, reworking results in rapid retreat near the mouth, but tends to be mass conservative, with eroded shoreface-compatible sediment deposited distally along the shoreline. Sediment cessation stops growth, but does not necessarily mean a delta plain will shrink. This marine reworking can be better understood using analogues of wave-influenced delta lobes that have been subjected to large-scale avulsions over the late Holocene, such as the Ebro, Danube, and Volta deltas.

While the effects of sediment reduction will tend to be focused around active river mouths, a rising sea will, in a manner, "sink all coasts". Although models of stratigraphic delta evolution typically focus on the active depositional phase of profile evolution, with the wave-affected shoreface acting as a conduit of sediment basinwards, passive coasts demonstrate that coastal systems can remain intact during rising sea level and without sediment sources. As such, passive margin environments, such as those found throughout the eastern US coast, may provide apt analogues of the effect of sea-level rise on wave-influenced deltas. We apply the results of models of both the on- and offshore transport of clastic sediment within the upper shoreface to the problem of delta response to sea-level rise. As delta plains flood, marine processes will likely sculpt protective barriers whose evolution and responses to sea-level rise are strongly affected by the process of overwash. Coupling the alongshore and cross-shore dimensions allows a more detailed picture of the fate of many deltas over the next century and beyond.

Final ID: EP33D-08

Maintenance of large deltas through channelization

L. Giosan; [1]; *S. Constatinescu;* [2]; *F. Filip;* [3];
1. Geology & Geophysics, Woods Hole Oceanographic Inst, Woods Hole, MA, United States.
2. Geography, University of Bucharest, Bucharest, Romania.
3. FAD Smart Technology , Bucharest, Romania.

Body: A new paradigm for delta restoration is currently taking shape using primarily Mississippi delta examples. Here we propose an alternative for delta maintenance primarily envisioned for wave-influenced deltas based on Danube delta experiences.

Over the last half century, while the total sediment load of the Danube dramatically decreased due to dam construction on tributaries and its mainstem, a grand experiment was inadvertently run in the Danube delta: the construction of a dense network of canals, which almost tripled the water discharge toward the interior of the delta plain.

We use core-based and chart-based sedimentation rates and patterns to explore the delta transition from the natural to an anthropogenic regime, to understand the effects of far-field damming and near-field channelization, and to construct a conceptual model for delta development as a function sediment partition between the delta plain and the delta coastal fringe.

We show that sediment fluxes increased to the delta plain due to channelization, counteracting sea level rise. In turn, the delta coastal fringe was most impacted by the Danube's sediment load collapse. Furthermore, we show that morphodynamic feedbacks at the river mouth are crucial in trapping sediment near the coast and constructing wave-dominated deltas or lobes or delaying their destruction.

As a general conclusion, we suggest that increased channelization that mimics and enhances natural processes may provide a simple solution for keeping delta plains above sea level and that abandonment of wave-dominated lobes may be the most long term efficient solution for protecting the internal fluvial regions of deltas and provide new coastal growth downcoast.

Final ID: EP34B-01

DELTAS: A new Global Delta Sustainability Initiative ***(Invited)***

E. Foufoula-Georgiou; [1];

1. Civil Engineering, University of Minnesota, Minneapolis, MN, United States.

Body: Deltas are economic and environmental hotspots, food baskets for many nations, home to a large part of the world population, and hosts of exceptional biodiversity and rich ecosystems. Deltas, being at the land–water interface, are international, regional, and local transport hubs, thus providing the basis for intense economic activities. Yet, deltas are deteriorating at an alarming rate as “victims” of human actions (e.g. water and sediment reduction due to upstream basin development), climatic impacts (e.g. sea level rise and flooding from rivers and intense tropical storms), and local exploration (e.g. sand or aggregates, groundwater and hydrocarbon extraction). Although many efforts exist on individual deltas around the world, a comprehensive global delta sustainability initiative that promotes awareness, science integration, data and knowledge sharing, and development of decision support tools for an effective dialogue between scientists, managers and policy makers is lacking. Recently, the international scientific community proposed to establish the International Year of Deltas (IYD) to serve as the beginning of such a Global Delta Sustainability Initiative. The IYD was proposed as a year to: (1) increase awareness and attention to the value and vulnerability of deltas worldwide; (2) promote and enhance international and regional cooperation at the scientific, policy, and stakeholder level; and (3) serve as a launching pad for a 10-year committed effort to understand deltas as complex socio-ecological systems and ensure preparedness in protecting and restoring them in a rapidly changing environment. In this talk, the vision for such an international coordinated effort on delta sustainability will be presented as developed by a large number of international experts and recently funded through the Belmont Forum International Opportunities Fund. Participating countries include: U.S., France, Germany, U.K., India, Japan, Netherlands, Norway, Brazil, Bangladesh, Vietnam, and Canada. Key components of the DELTAS Sustainability Initiative are: integrated research on deltas as coupled socio-ecological systems undergoing change (Delta-SRES), a global delta data depository (Delta-DAT), a suite of open access delta risk assessment and decision support modeling tools (Delta-RADS), and the coordinated demonstration of these activities in deltas around the world (Delta-ACT).

Final ID: EP34B-02

A global deltas typology of environmental stress and its relation to terrestrial hydrology

Z. D. Tessler;[1]; *C. J. Vorosmarty;*[1]; *K. C. McDonald;*[1]; *R. Schroeder;*[1]; *M. Grossberg;*[2]; *I. Gladkova;*[2]; *H. Aizenman;*[2];

1. Environmental CrossRoads Initiative, City College of New York, New York, NY, United States.
2. Department of Computer Science, City College of New York, New York, NY, United States.

Body: River delta systems around the world are under varying degrees of environmental stress stemming from a variety of human impacts, both from upstream basin based activities and local impacts on the deltas themselves, as well as sea level rise. These stresses are known to affect rates of relative sea level rise by disrupting the delivery or deposition of sediment on the delta. We present a global database of several of these stresses, and investigate patterns of stress across delta systems. Several methods of aggregating the environmental stressors into an index score are also investigated. A statistical clustering analysis, which we refer to as a "global delta fingerprinting system", across the environmental stresses identifies systems under similar states of threat. Several deltas, including the Nile, are in unique clusters, while regional patterns are evident among deltas in Southeast Asia. These patterns are compared with observed surface inundation derived from SAR, NDVI from MODIS, river discharge estimates from the WBMplus numerical model, and ocean wave activity from WAVEWATCH III. Delta inundation sensitivity to river and coastal forcings are observed to vary with environmental stress and social indicators including population density and GDP.

Final ID: ED34A-03

Using high-resolution satellite imagery to engage students in classroom experiences which meld research, the nature of science, and inquiry-based instruction.

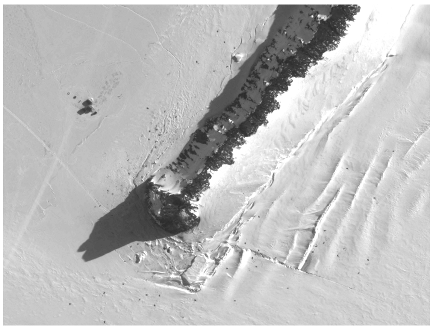
P. J. Morin;[2]; *J. Pennycook;*[1]; *M. LaRue;*[2]; *B. Herried;*[2];
1. Penguin Science, Fresno, CA, United States.
2. Polar Geospatial Center, St. Paul, MN, United States.

Body: Recognizing the need to bridge the gap between scientific research and the classroom, we have developed an exciting activity which engages students in grades 5-12 using high-resolution satellite imagery to observe Weddell seal populations in Antarctica. Going beyond the scope of the textbook, students experience the challenge researchers face in counting and monitoring animal populations in the field.

The activity is presented in a non-expert, non-technical exercise enriched for students, with background information, tutorials, and satellite imagery included. Teachers instruct their class in how to use satellite imagery analysis techniques to collect data on seal populations in the McMurdo Sound region of the Ross Sea, Antarctica. Students participate in this inquiry-based, open-ended exercise to evaluate changes in the seal population within and between seasons. The activity meets the New Generation Science Standards (NGSS) through inquiry-based, real-world application and supports seven Performance Expectations (PE) for grade 5-12. In addition, it offers students a glimpse into the work of a field biologist, promoting interest in entering the STEM career pipeline. As every new Antarctica season unfolds, new imagery will be uploaded to the website allowing each year of students to add their counts to a growing long-term dataset for the classroom.

The activity files provide 1) a tutorial in how to use the images to count the populations, 2) background information about Weddell seals in the McMurdo Sound region of the Ross Sea for the students and the teachers, and 3) collections of satellite imagery for spatial and temporal analysis of population fluctuations. Teachers can find all activity files to conduct the activity, including student instructions, on the Polar Geospatial Center's website (http://z.umn.edu/seals).

URL: http://z.umn.edu/seals



Satellite image, Big Razorback Island, Antarctica

Weddell seals,Tent Island, Antarctica

Final ID: EP34A-04

The effect of interannual variability on the moraine record: A new perspective on paleoclimate estimation in glacial landscapes

L. S. Anderson;[1]; *G. Roe;*[2]; *R. S. Anderson;*[1];
1. Geological Sciences and INSTAAR, University of Colorado, Boulder, CO, United States.
2. Earth and Space Sciences, University of Washington, Seattle, WA, United States.

Body: Glacier moraines are commonly used to infer mean climate conditions (annual precipitation (*P*) and melt-season temperature (*T*)). However, recent research has demonstrated that, even in steady climates, kilometer-scale fluctuations in glacier length occur in response to ever present, stochastic, year-to-year (interannual) variability in mass balance (Figure 1). Moraines can be 1) formed by interannual variability forced advances or 2) formed by advances forced by a combination of a climate change component and an interannual variability component. We address this issue for eleven Last Glacial Maximum (LGM) glaciers (56 to 1 km^2) in the Colorado Front Range, USA. Using a linear glacier model that allows thorough exploration of parameter uncertainties, supplemented by a shallow-ice flowline model, our analyses suggest that individual LGM terminal moraines were formed by a combination of climate change and interannual variability forced advances and may hold important implications for the long-term pattern of glacial erosion.

We also evaluate the importance of parameter selection and interannual variability in the estimation of paleoclimate from moraines. Interannual variability reduces estimates of climate change by 10-15%. Paleoclimate estimates are most sensitive to the selection of the near-surface lapse rate: small, reasonable changes in the near-surface lapse rate reduce estimates of paleoclimate change by 20-25%. We test if modern near-surface lapse rates are comparable to LGM near-surface lapse rates using Paleoclimate Inter-comparison Modeling Project (PMIP 2 and 3) global circulation model output. Potential changes in lapse rate from the modern to LGM climates are then used to test if modern near-surface lapse rates can produce viable estimates of paleo *T* and *P*. Our results suggest that LGM paleoclimate estimates derived from glacier modeling are 40% too extreme.

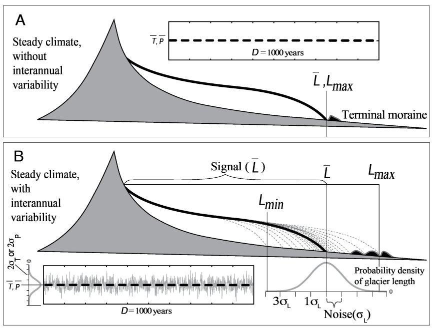


Figure 1. (A) A glacier forced only by the long-term average of annual precipitation (*P* bar) and the long-term average of mean melt-season temperature (*T* bar) over time period, *D*, leads to a steady ice profile (bold black line) at the mean glacial length (*L* bar). (B) A glacier forced by the same *P* bar and *T* bar as in (A) but with interannual variability included results in a terminus position that fluctuates around *L* bar and is shown by the gray dashed ice profiles.

Final ID: EP34C-04

The Sensitivity of Sediment Path-Lengths to Channel Morphology: Results from Physical Models of Braided Rivers

A. Kasprak; [1]; *P. Ashmore;* [2]; *S. Peirce;* [2]; *J. M. Wheaton;* [1];
1. Watershed Sciences, Utah State University, Logan, UT, United States.
2. Geography, University of Western Ontario, London, ON, Canada.

Body: The travel distances of coarse sediment in gravel-bed rivers during floods, or their path-lengths, exhibit strong dependencies on the arrangement of geomorphic units they are sourced from, routed through or around, and finally deposited on. Despite previous research on both braiding and single-thread meandering streams, a coherent rule set which relates particle path lengths to morphology remains elusive; such a rule set has the potential to vastly simplify models which seek to predict sediment transport or morphodynamics in these channels. Here we seek to understand the sensitivity of particle path-length distributions to morphology via a physical model of a braided stream, by using fluorescent tracer particles to track sediment path-lengths. These flume experiments provide a rich dataset composed of before-and-after bed photogrammetry, along with high-resolution photography and high-speed video documentation of particle deposition and mobility. Initial analyses indicate a strong coupling between particle path-length and the spatial arrangement of in-channel geomorphic units, with bar heads and point bars frequently acting as sink locations for tracer particles. This is interesting as it suggests that morphodynamics are in part contingent on morphology with strong positive feedbacks on hydraulics, deposition and negative feedbacks on path-length. Several mechanisms of braiding were captured in the simulations as erosional source processes for the tracers, including chute cutoff of point bars, bank erosion, channel incision, and bar edge trimming. These results may help inform the development of morphodynamic models for braided rivers which rely on particle path-lengths to simplify sediment transport algorithms, and such relations between channel morphology and path-length hold the potential to benefit numerous other modeling efforts, as well as provide a heuristic framework with which to understand fluvial morphodynamics.

Final ID: H34B-05

Spatiotemporal variability of rainfall extremes in monsoonal climates – examples from the South American Monsoon and the Indian Monsoon Systems *(Invited)*

B. Bookhagen; [1]; *N. Boers;* [2]; *N. Marwan;* [2]; *N. Malik;* [3]; *J. Kurths;* [2];

1. Geography, UC Santa Barbara, Santa Barbara, CA, United States.
2. Potsdam Institute for Climate Impact Research, Potsdam, Germany.
3. Department of Mathematics, University of North Carolina at Chapel Hill, Chapel Hill, NC, United States.

Body: Monsoonal rainfall is the crucial component for more than half of the world's population. Runoff associated with monsoon systems provide water resources for agriculture, hydropower, drinking-water generation, recreation, and social well-being and are thus a fundamental part of human society. However, monsoon systems are highly stochastic and show large variability on various timescales. Here, we use various rainfall datasets to characterize spatiotemporal rainfall patterns using traditional as well as new approaches emphasizing nonlinear spatial correlations from a complex networks perspective.

Our analyses focus on the South American (SAMS) and Indian (ISM) Monsoon Systems on the basis of Tropical Rainfall Measurement Mission (TRMM) using precipitation radar and passive-microwave products with horizontal spatial resolutions of ~5x5 km^2 (products 2A25, 2B31) and 25x25 km^2 (3B42) and interpolated rainfall-gauge data for the ISM (APHRODITE, 25x25 km^2). The eastern slopes of the Andes of South America and the southern front of the Himalaya are characterized by significant orographic barriers that intersect with the moisture-bearing, monsoonal wind systems. We demonstrate that topography exerts a first-order control on peak rainfall amounts on annual timescales in both mountain belts. Flooding in the downstream regions is dominantly caused by heavy rainfall storms that propagate deep into the mountain range and reach regions that are arid and without vegetation cover promoting rapid runoff. These storms exert a significantly different spatial distribution than average-rainfall conditions and assessing their recurrence intervals and prediction is key in understanding flooding for these regions. An analysis of extreme-value distributions of our high-spatial resolution data reveal that semi-arid areas are characterized by low-frequency/high-magnitude events (i.e., are characterized by a 'heavy tail' distribution), whereas regions with high mean annual rainfall have a less skewed distribution. In a second step, an analysis of the spatial characteristics of extreme rainfall synchronicity by means of complex networks reveals patterns of the propagation of extreme rainfall events. These patterns differ substantially from those obtained from the mean annual rainfall distribution. In addition, we have developed a scheme to predict rainfall extreme events in the eastern Central Andes based on event synchronization and spatial patterns of complex networks. The presented methods and result will allow to critically evaluate data and models in space and time.

Final ID: NH34A-05

Recovery of coastal ecosystems after large tsunamis in various climatic zones - review of cases from tropical, temperate and polar zones ***(Invited)***

W. Szczucinski; [1];
1. Adam Mickiewicz University in Poznan, Poznan, Poland.

Body: Large tsunamis cause significant changes in coastal ecosystems. They include modifications in shoreline position, sediment erosion and deposition, new initial soil formation, salination of soils and waters, removal of vegetation, as well as direct impact on humans and infrastructure. The processes and rate of coastal zone recovery from large tsunamis has been little studied but during the last decade a noteworthy progress has been made.
This study focus on comparison of recovery processes in various climatic zones, namely in monsoonal-tropical, temperate and polar zone. It is based on own observation and monitoring in areas affected by 2004 Indian Ocean Tsunami in Thailand, 2011 Tohoku-oki tsunami in Japan and 2000 Paatuut landslide-generated tsunami in Vaigat Strait (west Greenland), as well as on review of published studies from those areas. The particular focus is on physical and biological recoveries of beaches, recovery of coastal vegetation, new soil formation in eroded areas and those covered by tsunami deposits, marine salt removal from soils, surface- and groundwater, as well as landscape adjustment after the tsunamis.
The beach zone - typically the most tsunami-eroded zone, has been recovered already within weeks to months and has been observed to be in the pre-tsunami equilibrium stage within one year in all the climate zones, except for sediment-starved environments. The existing data on beach ecosystems point also to relatively fast recovery of meio- and macrofauna (within weeks to several months).
The recovery of coastal vegetation depends on the rate of salt removal from soils or on the rate of soil formation in case of its erosion or burial by tsunami deposits. The salt removal have been observed to depend mainly on precipitation and effective water drainage. In tropical climate with seasonal rainfall of more 3000 mm the salt removal was fast, however, in temperate climate with lower precipitation and flat topography the salinities still exceeded the recommended concentrations for freshwater plants after one year. The new soil formation and vegetation recovery depends mainly on the rate of biological production. In tropical climate the vegetation largely recovered already after the first rainy season and supported the new soil formation. In temperate climate this process was much slower, in particular in flat lying areas and on coastal dunes with poor sandy soils. In polar climate only limited vegetation recovery (mainly of Salix species) has been observed after 12 years and vegetation withered due to salt stress still marked the tsunami inundation limit and the new soil formation was very slow and focused on low lying, wet areas buried with thin tsunami deposits cover.
The post-tsunami recovery processes may be grouped into climate-related (vegetation recovery, removal of salts from soils) and non climate-related (e.g. beach recovery) or modified by climatic and local factors (for instance, the rate of tsunami deposits reworking and thus new soil formation). The rate of recovery varies from days / weeks as in case of beach recovery to several decades as in case of new soil formation on tsunami deposits.
The study was partly funded by Polish National Science Centre grant No. 2011/01/B/ST10/01553. The review results from studies in collaboration with number of researchers from Australia, Japan, Poland, Thailand, United Kingdom and United States to whom I express sincere thanks.

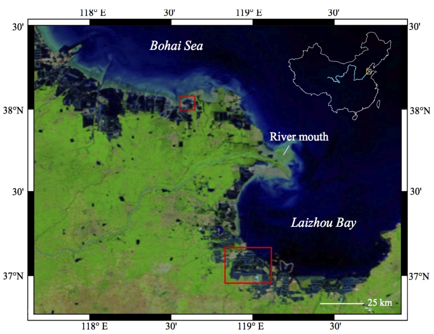
Final ID: EP34B-07

Sinking Coastlines: Land Subsidence at Aquaculture Facilities in the Yellow River Delta, China, measured with Differential Synthetic Aperture Radar (D-InSAR)

S. Higgins;[1, 3]; *I. Overeem;*[2, 3]; *A. Tanaka;*[4]; *J. P. Syvitski;*[2, 3];

1. Geological Sciences, University of Colorado Boulder, Boulder, CO, United States.
2. Institute of Arctic and Alpine Research, University of Colorado Boulder, Boulder, CO, United States.
3. Community Surface Dynamics Modeling System, University of Colorado Boulder, Boulder, CO, United States.
4. Geological Survey of Japan, AIST, Tsukuba, Japan.

Body: Land subsidence in river deltas is a global problem. It heightens storm surges, salinates groundwater, intensifies river flooding, destabilizes infrastructure and accelerates shoreline retreat. Measurements of delta subsidence typically rely on point measures such as GPS devices, tide gauges or extensometers, but spatial coverage is needed to fully assess risk across river deltas. Differential Interferometric Synthetic Aperture Radar (D-InSAR) is a satellite-based technique that can provide maps of ground deformation with mm to cm-scale vertical resolution. We apply D-InSAR to the coast of the Yellow River Delta in China, which is dominated by aquaculture facilities and has experienced severe coastal erosion in the last twenty years. We extract deformation patterns from dry land adjacent to aquaculture facilities along the coast, allowing the first measurements of subsidence at a non-urban delta shoreline. Results show classic cones-of-depression surrounding aquaculture facilities, likely due to groundwater pumping. Subsidence rates are as high as 250 mm/y at the largest facility on the delta. These rates exceed local and global average sea level rise by nearly two orders of magnitude. If these rates continue, large aquaculture facilities in the area could induce more than a meter of relative sea level rise every five years. Given the global explosion in fish farming in recent years, these results also suggest that similar subsidence and associated relative sea level rise may present a significant hazard for other Asian megadeltas.



False-color MODIS image of the Yellow River delta in September 2012. Water appears dark blue, highlighting the abundance of aquaculture facilities along the coast. Green land is primarily agricultural; brown is urban. Red boxes indicate locations of aquaculture facilities examined in this study. Figure from Higgins, S., Overeem, I., Tanaka, A., & Syvitski, J.P.M., (2013), Land Subsidence at Aquaculture Facilities in the Yellow River Delta, Geophysical Research Letters, in press.

Final ID: DI34B-07

Computational Hydrology: simulating the integrated water cycle using high performance computing *(Invited)*

R. M. Maxwell; [1];
1. Colorado School of Mines, Golden , CO, United States.

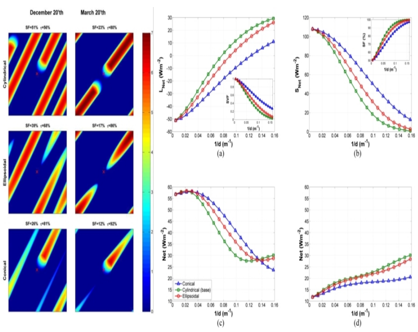
Body: The hydrologic cycle is comprised of many coupled processes, yet it is often simulated with disconnected models. Increasingly, efforts are being made to integrate these components into a single computational platform. Application of these integrated models spans physical and computational disciplines where a range of complex spatial and temporal scales provide numerical challenges for efficient solution. Here, I present a multi-physics, parallel hydrological platform that extends from bedrock to the top of the atmosphere. The development of this new framework allows for large-scale, high-resolution simulations of much of the continental United States. The computational and applied mathematics challenges behind these simulations are a specific focus of this work and range from efficient preconditioners that enable good parallel performance to big-data storage of model input and output. With the development of these integrated models, the concept of Computational Hydrology is discussed as an increasing important subdiscipline that provides an additional path towards understanding terrestrial water cycle.

Final ID: C41B-0607

Using Forest Radiation Model (FoRM) to Quantify the Role of Canopy Coverage on Net Snow Cover Radiation

B. Seyednasrollah; [1]; *M. Kumar;* [1];
1. Nicholas School of the Environment, Duke University, Durham, NC, United States.

Body: In snow-fed forested areas, the rate and timing of snowmelt is influenced by net snowcover radiation reaching the floor. In order to understand and predict the impact of natural or anthropogenic changes in vegetation density on snow energetics, it is important to first quantify the relationship between canopy structure and net snowcover radiation. Here, we evaluate the net radiation on the forest floor and its variability with vegetation density using a physically-based, spatially distributed forest radiation model (FoRM). The results show that for clear sky conditions, net radiation on the horizontal forest floor frequently exhibits a non-monotonic decreasing then increasing trend with increasing vegetation density. The relationship turns monotonically increasing when cloudiness is considered. We also explore the effects of tree morphometric characteristics on the variation of net snowcover radiation with vegetation density. Taller trees, larger and denser crowns, and cylindrical shaped crowns are found to exhibit lower net snowcover radiation on the forest floor at intermediate vegetation densities and larger radiation at high vegetation densities. In clear sky conditions, trees with smaller crown dimensions show tendency for a monotonically decreasing trend in radiation with increasing vegetation density. In contrast, larger crown dimensions lead to a radiation minima at an intermediate vegetation density. Interspersed cloudy conditions however result in a monotonically increasing radiation with increasing vegetation density. Coupled with Light Detection and Ranging (LiDAR) data, the FoRM could be used to guide forest management strategies to modulate net radiation in snow dominated forested watersheds and for inter-comparison of snowmelt rates from forests with different vegetation densities.



Left)
Path length of solar beam through canopy for different crown shapes

Right)
Effect of crown shape on snow cover radiation: (a) Longwave radiation, (b) Shortwave radiation and (c) Net radiation in clear sky conditions and (d) Net radiation when cloudiness is considered.

Final ID: C41B-0621

Are weather models better than gridded observations for precipitation in the mountains? *(Invited)*

E. D. Gutmann; [1]; *R. Rasmussen;* [1]; *C. Liu;* [1]; *K. Ikeda;* [1]; *M. P. Clark;* [1]; *L. D. Brekke;* [2]; *J. Arnold;* [3]; *D. A. Raff;* [3];

1. NCAR, Boulder, CO, United States.
2. Bureau of Reclamation, Denver, CO, United States.
3. US Army Corps of Engineers, Alexandria, VA, United States.

Body: Mountain snowpack is a critical storage component in the water cycle, and it provides drinking water for tens of millions of people in the Western US alone. This water store is susceptible to climate change both because warming temperatures are likely to lead to earlier melt and a temporal shift of the hydrograph, and because changing atmospheric conditions are likely to change the precipitation patterns that produce the snowpack. Current measurements of snowfall in complex terrain are limited in number due in part to the logistics of installing equipment in complex terrain. We show that this limitation leads to statistical artifacts in gridded observations of current climate including errors in precipitation season totals of a factor of two or more, increases in wet day fraction, and decreases in storm intensity. In contrast, a high-resolution numerical weather model (WRF) is able to reproduce observed precipitation patterns, leading to confidence in its predictions for areas without measurements and new observations support this. Running WRF for a future climate scenario shows substantial changes in the spatial patterns of precipitation in the mountains related to the physics of hydrometeor production and detrainment that are not captured by statistical downscaling products. The stationarity in statistical downscaling products is likely to lead to important errors in our estimation of future precipitation in complex terrain.

Final ID: C41B-0633

Combining remotely-sensed snow water equivalent with in-situ measurements to produce a real-time SWE product

D. Schneider; [1]; *N. P. Molotch;* [1];
1. University of Colorado/Institute of Arctic and Alpine Research, Boulder, CO, United States.

Body: Snowmelt is the primary water source in the Western United States and mountainous regions globally. Forecasts of streamflow and water supply rely heavily on snow measurements from sparse observation networks that may not provide adequate information during abnormal climatic conditions. To address this issue we developed a real-time spatially distributed snow water equivalent (SWE) product for the Upper Colorado River Basin that merges previous years SWE patterns derived from a reconstruction model, with interpolations of real-time situ measurements. The approach uses a multiple linear regression to model SWE in which physiography and reconstructed SWE are treated as independent variables and observed SNOTEL SWE the dependent variable. Using a drop-1 approach, the years 2000 - 2011 (Mar 1, Apr 1, and May 1) consistently find reconstructed SWE to be a significant predictor and the explained variability of the model is improved between 0.1 and 0.5 (mean= 0.23) compared to a model just based on physiographics. Independent validation in the Front Range, CO produces mean absolute errors (MAE) between 0.13 and 0.18 m, with significant improvements between 0.03 and 0.09 m over both reconstructed SWE and physiographic SWE ($p<0.05$). Geostatistical interpolation techniques (IDW, kriging) are used to blend the regression residuals onto the regression surface to incorporate regional effects within the modeling domain. However, MAE is only marginally reduced (~0.01) with blending. Improved analysis of past SWE distribution can provide valuable information for modeling efforts to predict, e.g. hydrologic impacts due to climate change and disturbances. Future validation is planned in additional locations within the modeling domain and a real-time product is in development that uses this ensemble of past patterns of SWE to estimate SWE in the current water year.

Final ID: EP41B-0799

Variations in Glacial Erosion over Multiple Glacial-Interglacial Cycles

R. M. Headley; [1, 2]; *T. A. Ehlers;* [2];

1. Geosciences Department, University of Wisconsin-Parkside, Kenosha, WI, United States.
2. Department of Geosciences, Universität Tübingen, Tübingen, Germany.

Body: Glacial erosion plays an important role in the construction and development of many mountain ranges. When modeling orogenic development, the choice of ice-flow physics can have an influence on developing topography, though many simple models can still produce the distinctive geomorphological features associated with glaciated topography. However, detailed comparisons at orogenic-time and length scales hold potential for quantifying the influence of glacial physics in landscape evolution models.

Within a modified version of the ICE-Cascade landscape evolution model, we present results from a comparison between two different numerical models of glacial flow. This orogenic model calculates not only glaciological processes but also hillslope and fluvial erosion, sediment transport, isostasy, and temporally and spatially variable orographic precipitation. Over single and multiple glaciations and in a variety of climate scenarios, glacial erosion rates and topographic evolution are analyzed. We compare the predicted erosion patterns using a modified SIA as well as a nested, 3D Stokes-flow model calculated using COMSOL Multiphysics. The time-averaged erosion rates differ between the two models of ice physics. In addition, these results and the amount of variation between the models are sensitive to the climate and the ice temperature. For warmer climates with more sliding, the higher-order model leads to larger erosion rates, by almost an order of magnitude, also with more variance. Additionally, as the erosion, basal topography and the ice deformation are all interconnected through the glacial dynamics, comparisons of large-scale and glacier-wide properties can also be instructive. For these properties, particularly the ice thickness and extent, the higher-order glacial model can lead to variations between the ice flow models that are greater than 30%, again with larger differences for temperate ice. When compared after multiple glaciations and long-time scales, these results suggest that consideration of higher-order glacial physics may be necessary, particularly in regions with extensive temperate or polythermal glaciers.

Final ID: EP41C-0805

Landslide statistics reveal a transient response and annealing of a landscape as it emerges from LGM conditions

M. A. Ellis; [1]; *M. D. Hurst;* [1]; *K. R. Royse;* [1]; *K. A. Lee;* [1]; *K. Freeborough;* [1];
1. Climate and Landscape Change, British Geological Survey, Nottingham, Notts, United Kingdom.

Body: We develop and interpret the statistical properties of a secular landslide inventory in the context of the emergence of the landscape from last glacial maximum (LGM) conditions and through the Holocene to the present-day. The landslide inventory consists of mapped landslide deposits and their underlying lithology across the UK, and it is assumed to represent a representative sample of landslides that have occurred throughout the UK since approximately LGM (~27 ky).

The statistical behavior of landslide size distribution is typically characterized by a power-law relationship for medium-large landslides (>104 – 105 m2) with an inflection ('roll-over') for smaller landslides. The occurrence of landslides is expected to be influenced by the material properties of rock and/or regolith in which failure occurs, as well as the external forcing. A geologically recent secular inventory of the sort examined here likely experienced variable external forcing related to climate change and human activities as well as variable material properties related to ice-sheet retreat and thawing soil-regolith.

The magnitude-frequency distribution of this secular inventory exhibits an inflected power law relationship similar to single-event triggered inventories, well approximated by an inverse Gamma or double Pareto model, with a scaling exponent for the power-law relationship is $\alpha = -1.76$. Power-law scaling varies as a function of lithology, with 'harder' substrates (i.e. igneous or metamorphic rocks) having lower α than 'softer' material such as landslides in superficial deposits or fine grained sedimentary rock. The small-event rollover occurs at landslide sizes approximately an order of magnitude larger than observed in single-event landslide records. We interpret this finding as evidence of "landscape annealing" at these relatively short length-scales, with the implication that a secular dataset is likely to underestimate the frequency of small landslides. This is supported by a subset of data where a complete landslide inventory was recently mapped. Large landslides appear to be under-represented relative to model predictions, which we interpret as a transient response due to more frequent landslides as the UK emerged from the LGM and through relatively volatile conditions (including significant land clearance during Neolithic times) toward a generally more stable late Holocene climate.

Final ID: EP41C-0807

A 50-ky record of climate, ecosystem, and erosion rate change in the Oregon Coast Range

J. A. Marshall; [1]; *J. J. Roering;* [1]; *D. E. Granger;* [2]; *D. G. Gavin;* [3];
1. Department of Geological Sciences, University of Oregon, Eugene , OR, United States.
2. Department of Earth and Atmospheric Sciences, Purdue Univesity, Bloomington, IN, United States.
3. Department of Geography, University of Oregon, Eugene, OR, United States.

Body: In unglaciated landscapes, quantifying landscape response to millennial-scale climate fluctuations is often restricted to temporally and spatially limited archives such as terrace deposits. In addition, mechanistic explanations for landscape response to climate change are lacking. Specifically it is unclear how climate controls the vigor and rate of soil production and transport, as processes in modern ecosystems (e.g. bioturbation such as tree throw) tend to bias our interpretations of landscape evolution. Here, we present results coupling a 50-ky paleo-environmental record with cosmogenic ^{10}Be-derived paleo-erosion rates spanning non-glacial, glacial, and inter-glacial intervals from a 63m sediment archive in the Oregon Coast Range (OCR). At Little Lake, our landslide-dammed lake study site, we refined previous records of paleo-climate to better constrain paleo-temperature and thus the likelihood of frost-driven vs. biotic erosional processes prior to the Holocene. The presence of *Picea sitchensis* (Sitka spruce) and *Abies lasiocarpa* (subalpine fir) in the core during the Last Glacial Maximum (LGM) imply mean annual temperatures of ~ 1 °C and January mean temperatures of ~ -7 °C. This contrasts sharply with modern temperatures of 11 °C and 5 °C respectively. Using ^{14}C (n=21) and OSL (n=3), we constructed a chronology for our sediment archives that spans the non-glacial (50-26 ka) and glacial intervals (26- 16 ka) and the late Holocene (3 ka to present). Our depth-age model shows that sediment accumulation rates increased 5x from the non-glacial to the glacial interval, coincident with a transition from finely laminated clays and sands to coarse blue-grey sands.

We extracted 25 samples for ^{10}Be analysis from the core over an average interval of 1500 years. Preliminary ^{10}Be-derived erosion rates show increasing erosion rates from 0.06 ± 0.02 mm/yr (48 ka) to 0.18 ± 0.02 mm/yr (28 ka) during the non-glacial interval as temperatures cooled and the forest transitioned from a temperate to montane forest and then a cold and dry sub-alpine grassland setting. During the LGM, erosion rates remain constant around 0.19 ± 0.01 mm/yr (mean ± sd). From 20 ka to the present, erosion rates steadily decline, with present-day upstream catchment erosion rates averaging 0.07 ± 0.03 mm/yr (mean ± sd). Given the presence of species found in periglacial settings, increased sediment accumulation, an abrupt increase in grain size, and increased erosion rates, we conclude that frost-cracking conditions may have persisted during the LGM. Our results suggest that in the OCR climate modulates erosion rates by dictating the dominance of tree throw or frost cracking soil production mechanisms. Importantly these shifting erosion mechanisms over millennial timescales challenge the widely held assumption that uplift rates and erosion rates in the OCR are broadly consistent over the timescale of landscape recovery from perturbations (~ 40 ky). Thus, we suggest that steady-state process models developed using present-day calibration parameters from the OCR may not adequately represent landscape evolution in mid-latitude unglaciated soil-mantled regions.

Final ID: H41F-1297

The Significance of Ultra-Refracted Ocean Waves to Sediment Dynamics and Water Quality in Sheltered Areas, With Application to Crissy Field Marsh, San Francisco

D. M. Hanes; [1];
1. Earth and Environmental Sciences, Saint Louis Unversity, Saint Louis, MO, United States.

Body: Crissy Field Marsh (CFM; http://www.nps.gov/prsf/planyourvisit/crissy-field-marsh-and-beach.htm) is a small, restored tidal wetland located in the entrance to San Francisco Bay just east of the Golden Gate. The marsh is fairly typical of many such restored wetlands worldwide. The marsh is hydraulically connected to the bay and Pacific Ocean by a narrow sandy channel. The channel often migrates and sometimes closes completely, which effectively blocks the tidal connection to the ocean and disrupts the hydraulics and ecology of the marsh. Field measurements of ocean waves and tides have been examined in order to evaluate the conditions responsible for the intermittent closure of the marsh entrance. The most important factor found to bring about the entrance channel closure is the occurrence of large, offshore, ocean waves. These waves undergo radical changes in their direction due primarily to refraction as they propagate over the ebb tidal delta and through the golden gate straights. The tidal records during closure events show no strong relationship between closures and tides, other than that closures tend to occur during periods with successively increasing high tides. It can be inferred from these findings that the most important process to the intermittent closure of the entrance to CFM is littoral sediment transport driven by the influence of ocean swell waves breaking along the CFM shoreline at oblique angles. During periods of large, oblique, waves the littoral transport of sand likely overwhelms the scour potential of the tidal flow in the entrance channel.

Final ID: H41H-1352

Smouldering Combustion for Soil Remediation: Two-dimensional Experiments and Modelling

T. Hasan; [1]; *J. I. Gerhard;* [1]; *R. Hadden;* [1]; *P. Pironi;* [1]; *G. Rein;* [2];

1. Civil and Environmental Engineering, Western University, London, ON, Canada.
2. Mechanical Engineering, Imperial College London, London, United Kingdom.

Body: Smouldering combustion is an innovative approach that has significant potential for the remediation of soils contaminated with Non-Aqueous Phase liquids (NAPLs). Sustaining Treatment for Active Remediation (STAR) is a novel technology which is based upon the concept of liquid smouldering, in which NAPLs embedded in a porous medium are progressively destroyed via an exothermic oxidation reaction which propagates in a self-sustaining manner through the contaminated material. The In Situ Smouldering Model (ISSM), developed to simulate the propagation of STAR as a function of NAPL content and local air velocity, was calibrated for a suite of one-dimensional experiments (MacPhee et al., 2010). However, STAR application at field sites involves propagation of a smouldering front in multiple directions simultaneously. This study presents the further development and validation of the model against experiments for two-dimensional (2D) smouldering propagation. 2D STAR experiments were conducted to explore the simultaneous vertical (upwards), lateral (horizontal) and opposed (downwards) front propagation rates and final extent of remediation as a function of air injection rate in coal tar-contaminated sand. The model was then calibrated to the base case experiment and predictive simulations demonstrated strong agreement with the remaining experiments. This work provides some of the first evidence of multidimensional smouldering under forced, complex air flow fields and provides confidence in a tool that will be useful for designing STAR soil remediation schemes at the field scale.

Final ID: IN41A-1600

Evaluation of the Earth System CoG Infrastructure in Supporting a Model Intercomparison Project

J. C. Wallis; [1]; *R. B. Rood;* [2]; *S. Murphy;* [3]; *L. Cinquini;* [3]; *C. DeLuca;* [3];

1. School of Information, University of Michigan, Ann Arbor, MI, United States.
2. School of Engineering, University of Michigan, Ann Arbor, MI, United States.
3. University of Colorado, Boulder, CO, United States.

Body: Earth System CoG is a web-based collaboration environment that combines data services with metadata and project management services. The environment is particularly suited to support software development and model intercomparison projects. CoG was recently used to support the National Climate Predictions and Projections Platform (NCPP) Quantitative Evaluation of Downscaling (QED-2013) workshop. QED-2013 was a workshop with a community approach for the objective, quantitative evaluation of techniques to downscale climate model predictions and projections. This paper will present a brief introduction to CoG, QED-2013, and findings from an ethnographic evaluation of how CoG supported QED-2013.

The QED-2013 workshop focused on real-world application problems drawn from several sectors, and contributed to the informed use of downscaled data. This workshop is a part of a larger effort by NCPP and partner organizations to develop a standardized evaluation framework for local and regional climate information. The main goals of QED-2013 were to a) coordinate efforts for quantitative evaluation, b) develop software infrastructure, c) develop a repository of information, d) develop translational and guidance information, e) identify and engage key user communities, and f) promote collaboration and interoperability.

CoG was a key player in QED-2013 support. NCPP was an early adopter of the CoG platform, providing valuable recommendations for overall development plus specific workshop-related requirements. New CoG features developed for QED-2013 included: the ability to publish images and associated metadata contained within XML files to its associated data node combine both artifacts into an integrated display. The ability to modify data search facets into scientifically relevant groups and display dynamic lists of workshop participants and their interests was also added to the interface. During the workshop, the QED-2013 project page on CoG provided meeting logistics, meeting materials, shared spaces and resources, and data services.

The evaluation of CoG tools was focused on the usability of products rather than metrics, such as number of independent hits to a web site. We wanted to know how well CoG tools supported the workshop participants and their tasks. For instance, what workshop tasks could be performed within the CoG environment? Were these tasks performed there or with alternative tools? And do participants plan to use the tools after the workshop for other projects? Ultimately, we wanted to know if CoG contributed to NCPP's need for a flexible and extensible evaluation platform, and did it support the integration of dispersed resources, quantitative evaluation of climate projections, and the generation and management of interpretive information.

Evaluation of the workshop and activity occurred during, at the end of, and after the workshop. During the workshop, an ethnographer observed and participated in the workshop, and collected short, semi-structured interviews with a subset of the participants. At the end of the workshop, an exit survey was administered to all the participants. After the workshop, a variety of methods were used to capture the impact of the workshop.

Final ID: NS41A-1778

Control of in-situ Q by stress and water saturation, for shallow (m), unconsolidated sand.

J. M. Lorenzo; [1]; *J. M. Crane;* [1]; *J. Shen;* [1];
1. Dept. Geology and Geophysics, Louisiana State University, Baton Rouge, LA, United States.

Body: Field investigations into the simultaneous effects of water saturation and stress on seismic attenuation are scarce. However, seismic attenuation may be used to place constraints on water saturation with depth, at least for homogenous, porous media. We use a publicly available seismic dataset [Lorenzo et al., 2013] collected in a mid-size sand tank (~6 x 9 x 0.44 m) for open evaluation of these relationships. In the presence of large Q gradients the assumed equivalency of Q between the raypaths of the reference and measured signals can lead to false Q estimates (e.g., < 0). We employ a modified spectral ratio method to estimate in-situ Q so that the average Q along the measured and reference ray paths differ.
We estimate local Q values from average raypath Q values, penetration depths, and travel times. Local Q values (Qint) increase the most with depth ($dQ/dz = 43\ m^{-1}$) and stress ($dQ/d\sigma = 0.0025/Pa$) in dry sand and the least in partially saturated sand ($dQ/dz = 10\ ^{-1}m$ and $dQ/d\sigma = 0.0013/Pa$) where attenuation created by local fluid flow reaches a maximum. Anomalous Q deviations outside this range can be explained by a divergence in effective stress, attenuation mechanism, or lithology.

Final ID: OS41D-1861

Testing for orbital and solar forcing of the ENSO system during the Holocene

H. Grist; [1, 2]; *T. M. Marchitto;* [1, 2]; *A. O. Parker;* [3]; *J. D. Ortiz;* [4]; *A. van Geen;* [5];

1. Dept. of Geological Sciences, University of Colorado at Boulder, Boulder, CO, United States.
2. Institute of Arctic and Alpine Research, University of Colorado at Boulder, Boulder, CO, United States.
3. Texas A&M University, College Station, TX, United States.
4. Kent State University, Kent, OH, United States.
5. Lamont-Doherty Earth Observatory of Columbia University, Palisades, NY, United States.

Body: The El Niño-Southern Oscillation (ENSO) system has been shown to vary on both orbital and millennial timescales during the late Quaternary. Proxy records of Mg/Ca-derived sea surface temperature (SST) and climate models show an increased temperature gradient across the Pacific corresponding to a more La Niña-like state during the early-mid-Holocene. This may be attributed to an 'ocean dynamical thermostat' whereby increased boreal summer/fall insolation enhances the easterlies and intensifies the Pacific cold tongue. Previous measurements on *Globigerina bulloides* from the Soledad Basin off the coast of Baja California Sur (Marchitto et al., 2010) confirm orbital scale cooling during the early-mid-Holocene (10-4 ka). Millennial scale cold intervals between 11-7 ka correspond to solar maxima suggesting that the ocean dynamical thermostat also operates on millennial timescales. However Marchitto et al. could not rule out local upwelling as a driver of *G. bulloides* temperature variations since this species lives near the surface during the upwelling season. We aim to resolve the source of the temperature signal observed in Soledad Basin by analyzing two other species for Mg/Ca.

Globigerinoides ruber lives in the surface mixed layer during summer months. We expect *G. ruber* to have experienced the early-mid Holocene shoaling of the thermocline as recorded by *G. bulloides*. If not, we must attribute some or all of the *G. bulloides* signal to an upwelling season response to direct solar insolation.

Neogloboquadrina incompta lives at the deep chlorophyll maximum, and the depth of its habitat changes little as the thermocline shoals or deepens allowing Mg/Ca reconstructions to track changes in thermocline depth. Preliminary results from *N. incompta* across several millennial-scale coolings show temperature changes of similar magnitudes to those found in G. bulloides, indicating that the coolings are indeed due to La Niña-like shoaling of the thermocline.

Final ID: DI41A-2327

Iron Oxidation State and Compressional Behaviors of Al,Fe-rich Mantle Silicate Perovskite up to 90 GPa

Q. Zhang; [1]; *S. Shim;* [1]; *Y. Meng;* [2]; *V. Prakapenka;* [3]; *E. E. Alp;* [2];
1. Arizona State University, Tempe, AZ, United States.
2. Argonne National Laboratory, Argonne, IL, United States.
3. University of Chicago, Chicago, IL, United States.

Body: Magnesium silicate perovskite, the dominant lower-mantle phase, may contain much more Al and Fe in the subducting oceanic crust than in the normal mantle. Therefore, it is important to understand the physical properties of Al,Fe-rich mantle silicate perovskite.

We have synthesized Fe,Al-rich mantle silicate perovskites from two different starting materials [$Mg_2FeAl_2Si_3O_{12}$ (Alm33) and $Mg_{2.5}Fe_{0.5}Al_2Si_3O_{12}$ (Alm17)] and conducted in-situ synchrotron X-ray diffraction (GSECARS and HPCAT) and Mössbauer spectroscopy (Sector 3) in the laser heated diamond-anvil cell at Advanced Photon Source. The garnet starting materials were synthesized in the multi-anvil press at Arizona State University. The starting materials were mixed with 10 wt% Au powder (internal pressure standard) and loaded with an Ar or Ne pressure medium in the diamond-anvil cell for X-ray diffraction measurements. Pure starting materials are loaded in the diamond-anvil cell with an Ne or KCl pressure medium for synchrotron Mössbauer measurements. In synchrotron Mössbauer spectroscopy, we obtained pressure from the unit-cell volumes of pressure media combined with their equations of state.

During the laser heating of the Alm33 starting material at ~66 GPa and ~2300 K, perovskite was synthesized with a small amount of stishovite. For the same starting material, pure perovskite was synthesized at 90 GPa and ~2300 K. For the Alm17 starting material, perovskite was synthesized with a small amount of stishovite at 65-92 GPa and ~2200K. Between 60 and 90 GPa, the unit-cell volumes of the Alm33 and Alm17 perovskites are only slightly higher (0.3-0.6%) than that of Mg-end member perovskite and are comparable to that of $(Mg_{0.85}Fe_{0.15})SiO_3$ perovskite, indicating higher density of the Al,Fe-rich perovskite in subducting oceanic crust than surrounding mantle. Both Al,Fe-rich perovskites show a steep increase in unit-cell volume during decompression between 60 and 40 GPa, suggesting either spin transition or metastability at the pressure range. We successfully quenched both Al,Fe-rich perovskites and measured the unit-cell volumes at 1 bar: 166.3±0.1 $Å^3$ for Alm17 perovskite, and 165.0±0.2 $Å^3$ for Alm33 perovskite. Our direct measurements indicate that the combined effects of Fe and Al on the unit-cell volume is much greater at lower pressures (~2%) than those observed at higher pressure (0.3-0.6%). The preliminary spectral fitting of synchrotron Mössbauer data indicates that 50~80% of iron is Fe^{3+} in both Al,Fe-rich pervoskites, suggesting that similar degree of charge disproportionation reaction occurs in Al-rich mantle silicate perovskite. This result is in disagreement with a recent thermodynamic prediction by Nakajima et al. (2012, JGR) that Fe^{3+} concentration may be very low (near zero) in Al-rich perovskite.

Final ID: V41A-2742

Controls on CO2 Mineralization in Volcanogenic Sandstone Reservoir Rocks

S. Zhang; [1, 2]; *D. J. DePaolo;* [2, 1]; *T. Xu;* [2]; *M. Voltolini;* [2];
1. UC Berkeley, Berkeley, CA, United States.
2. Lawrence Berkeley National Lab, Berkeley, CA, United States.

Body: We proposed to use volcanogenic sandstones for CO2 sequestration. Such sandstones with a relatively high percentage of volcanic rock fragments (VRF) could be a promising target for CO2 sequestration in that they have a sufficient percentage of reactive minerals to allow substantial mineralization of injected scCO2, which provides the most secure form of CO2 storage, but can also be porous and permeable enough to allow injection at acceptable rates. Modeling results from reactive transport code TOUGHREACT show that as much as 80% CO2 mineralization could occur in 1000 years in rocks with 10-20% volcanic rock fragments and still allow sufficient injectivity so that ca. 1 megaton of CO2 can be injected per year per well. The key to estimating how much CO2 can be injected and mineralized is the relationship between permeability (or injectivity) and reactive mineral content. We have sampled examples of volcanogenic sandstones from Miocene Etchegoin Formation, central California to examine these relationships. Characterizations of these samples by SEM, XRF and XRD show that they are rich in reactive minerals with around 32% plagioclase, 10% clinopyroxene, 2% diopside, and 1% ilmenite. Porosities range from 10% to 20%, and permeabilities range from 10 mD to 1000 mD. Batch experiments are also in progress to obtain realistic reactivity estimates.

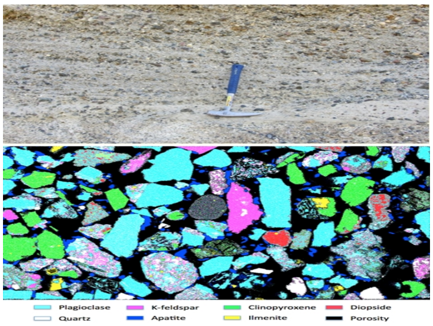


Figure 1. Outcrop photo and photomicrograph showing volcanic mineralogy and abundant pore space from Miocene Etchegoin Formation, central California

Final ID: C41E-02

Millennial scale ice dynamics and the spatial partition of Greenland mass change *(Invited)*

W. T. Colgan; [1]; *W. Abdalati;* [2]; *J. E. Box;* [1]; *B. M. Csatho;* [3]; *R. S. Fausto;* [1]; *X. Fettweis;* [4]; *S. B. Luthcke;* [5]; *T. A. Scambos;* [2]; *D. van As;* [1]; *J. M. Wahr;* [2]; *H. Zwally;* [5];

1. Geological Survey of Denmark and Greenland, Copenhagen, Denmark.
2. University of Colorado, Boulder, CO, United States.
3. State University of New York, Buffalo, NY, United States.
4. University of Liege, Liege, Belgium.
5. Goddard Space Flight Center, NASA, Greenbelt, MD, United States.

Body: We present a hybrid gravimetry/altimetry (GRACE/ICESat) cryospheric mass change product for all ice-covered areas in Greenland over the 2003 to 2010 period. This hybrid mass change product is generated by Monte Carlo inversion of satellite gravimetry observations within a framework that includes additional independent information of fractional ice coverage (Randolph Glacier Inventory) and the spatial distribution of mass changes (ICESat elevation changes). By virtue of introducing this independent information, the hybrid mass change product reproduces the input GRACE-derived spherical harmonic representation of cryospheric mass change, while also constraining mass changes to occur within irregularly shaped ice-covered areas, and reproducing a spatial distribution of mass changes that is consistent with observed surface elevation changes. By eliminating signal leakage between non- and ice-covered areas, as well as distributing on-ice mass changes to be consistent with satellite altimetry observations, we suggest that this hybrid product is representative of total cryospheric mass change at a given location, within ensemble-derived uncertainty bounds. We difference MAR-modelled surface mass balance over the same period from this total mass change in order to resolve the magnitude and spatial distribution of the instantaneous horizontal divergence of flux (or the "ice dynamic") component of mass change. This essentially solves the transient glacier continuity equation at 26 km nominal resolution over the 2003 to 2010 period.

We suggest that subtle millennial scale dynamic thickening, due to the ongoing advection and replacement of Wisconsin ice (deposited prior to 10 kaBP) with more viscous Holocene ice of larger crystal size and lower impurity content, should be considered as an independent term when spatially partitioning contemporary cryospheric mass change. Failure to account for this millennial scale dynamic thickening forces the residual horizontal divergence of flux field to take on implausible values, indicative of net convergence, over a spatially limited high elevation area of North Greenland. We constrain the magnitude of high elevation dynamic thickening associated with the Wisconsin-Holocene transition using two independent approaches that assimilate in situ (velocity stake/flux gate), remotely sensed (GRACE mascon), and modelled (MAR surface mass balance) data, during the 1961 to 1990 and 2003.5 to 2005.5 periods. These approaches constrain millennial scale ice dynamic thickening to 4.0±2.8 cm/a across the ice sheet area above 2000 m elevation. Applying this dynamic correction eliminates implausible net convergence values from the residual horizontal divergence of flux field in North Greenland. We review the evidence for potentially analogous, but difficult-to-constrain, millennial scale ice dynamic signals in the smaller ice caps of the Canadian Arctic.

Final ID: EP41E-03

Automated Derivation of Fish Habitat, Geomorphic Units & Transition Zones from Topography *(Invited)*

J. M. Wheaton; [1]; *S. G. Bangen;* [1]; *P. Bailey;* [2]; *N. Bouwes;* [1]; *J. A. McKean;* [3];

1. Watershed Sciences, Utah State University, Logan, UT, United States.
2. North Arrow Research, Vancouver, BC, Canada.
3. Rocky Mountain Research Station, US Forest Service, Boise, ID, United States.

Body: Despite the growing availability of high resolution topography and imagery in fluvial environments, a systematic and coherent framework for the automated derivation of geomorphic units from topography alone does not exist. Coherent morphometric models of hillslope and upland topography have been around for some time. However, in fluvial environments the topographic derivation of geomorphic units is complicated by the stage dependence of features as well as inconsistent nomenclature and definitions. Moreover, defining fish habitat and geomorphic units in the absence of full hydraulic model solutions remains a challenge. A new tiered classification of geomorphic/habitat units is presented in which the tiers are tied to specific geoprocessing steps that can be readily confirmed or validated with simple field observations. The four tiers are i) detrended stage relative to bankfull, ii) shape/type (e.g. convexities, concavities, planar features, margins), iii) position (e.g. bank-attached, mid-channel, channel spanning) and iv) specific morphology (e.g. diagonal bar, plunge pool, rapid). The cell-by-cell raster-based workflow involves deriving a suite of different evidence rasters from raw DEMs, and using transform functions to translate these evidence rasters into a priori and conditional probabilities. These probabilities are then combined using Bayes Theorem and for every category a probability that a given cell is each category is produced. To produce a mutually exclusive mapping of geomorphic units and habitat from this probabilistic representation, each category is thresholded at a confidence interval (e.g. 90% probability) and then transition zones between unit types emerge. These transition zones often are hot-spots of biotic activity and are also some of the most important zones from a geomorphic change perspective from repeat topographic surveys. Examples of application from a diverse array of habitats throughout the Columbia Basin will be highlighted where the workflow has been put to the test on over 500 sites from the CHaMP (Columbia Habitat Monitoring Program). The tools will be made available to the community through the River Bathymetry Toolkit.

URL : http://fluvialhabitatscenter.org

Final ID: EP41D-05

Validity of the quasi-steady assumption for bed forms under time-varying flows in rivers *(Invited)*

R. L. Martin; [1, 2]; *D. J. Jerolmack;* [2];
1. Atmospheric and Oceanic Sciences, University of California, Los Angeles, Los Angeles, CA, United States.
2. Earth and Environmental Science, University of Pennsylvania, Philadelphia, PA, United States.

Body: Bed forms adjust their dimensions in response to changes in river discharge. When the rate of discharge change is sufficiently slow, we may make the "quasi-steady" assumption; that is, bed form dimensions are in equilibrium with the simultaneous flow conditions. However, the quasi-steady assumption is violated when discharge changes too rapidly, due to the lagged nature of bed form adjustment. Based on experiments that reveal the distinctive patterns of bed form growth and decay, we derive geometrical models that predict minimal discharge adjustment time scales for the quasi-steady bed form assumption to hold. Laboratory and field examples show that hysteresis in bed form dimensions – i.e. smaller bed forms for equivalent discharge on the rising than on the falling limb of a flood – occur when this minimal time scale exceeds the duration of discharge change.

Final ID: H41L-05

The Catchment Isoscape: Theory and Experimental Evidence for the Isotopic Age of Water in a Critical Zone Observatory *(Invited)*

C. Duffy; [1]; *E. Thomas;* [1]; *P. L. Sullivan;* [1]; *G. Bhatt;* [1]; *X. Yu;* [1];
1. , State College, PA, United States.

Body: This paper deals with the theoretical controls for the “Age” of water in upland watershed flow systems and present comprehensive experimental evidence to support the theory using stable isotopes of and at the Susquehanna/Shale Hills Critical Zone Observatory (SSH_CZO). In this context “age” is defined as the time since water entered the watershed as precipitation. The paper first examines the theoretical basis for direct simulation of “age” for environmental tracers in the unsaturated zone subject to dynamic flow and transport processes with mobile and immobile flow considered. The theory demonstrates that the residence time and age of an environmental tracer can be directly modeled without knowledge of the form of the underlying residence time distribution function and without adding any new parameters. On the physical side, the theory is applied to the apparent rapid attenuation of event and seasonal isotopic ratios with depth in the soil at the SSH_CZO. Comparison of the age model to experimental data provides evidence for the role of macropore-matrix flow partitioning during the non-growing cold season and root uptake from the immobile store during the growing season via transpiration and evaporation. Flow path changes during storm events are also inferred by comparing the distribution of groundwater and streamflow isotope histories.

Final ID: EP41E-07

NEAR-BANK FLOW AND FLOOD INDUCED BANK EROSION PROCESSES REVEALED BY APPLICATION OF ADVANCED ACOUSTIC TECHNIQUES ON A MEGA-RIVER

J. Leyland; [1]; *D. R. Parsons;* [2]; *S. E. Darby;* [1]; *C. R. Hackney;* [1]; *J. Best;* [3]; *R. E. Aalto;* [4]; *A. P. Nicholas;* [4];
1. Geography and Environment, University of Southampton, Southampton, United Kingdom.
2. Geography, Environment and Earth Sciences, University of Hull, Hull, United Kingdom.
3. Geology, University of Illinois, Champaign, IL, United States.
4. Geography, University of Exeter, Exeter, United Kingdom.

Body: Bank erosion processes are a key component of river morphodynamics, controlling rates of channel shift and ultimately governing floodplain system dynamics and sedimentology. Near-bank flow fields and the interactions of turbulent fluid flows in the near-bank zone with mechanisms of bank failure and erosion styles are presently poorly understood. Recent research has suggested that bank erosion and the type of failure mechanism can play an important role in protecting the bank toe from further erosion, notably through increased near-bank roughness and the resultant reduction in near-bank flow velocity and shear stress. An improved understanding of these interactive near-bank processes is essential if we are to improve our ability to predict bank erosion and channel morphodynamics.

In this study we present a series of high-resolution multibeam sonar repeat near-bank surveys and acoustic Doppler profiles (acquired as part of the NERC funded STELAR-S2S project: www.stelar-s2s.org), from the monsoonal Mekong River in SE Asia. These data are the first to simultaneously capture detailed bank topography and near-bank flow processes of a mega-river during high flow conditions. Data is presented from a range of channel morphologies and includes a variety of geotechnical bank failure styles. The results show how systematic quantification of bank roughness over bank lengths of several channel widths can be used to quantify hydraulic roughness and how such information can be used to parameterise bank erosion models. Furthermore, the evolution and role of slumped material at the bank toe is also examined during the monsoonal flood. The methods, estimates of error and implications of the results for the morphodynamic function of large river systems will be discussed.

URL: http://www.stelar-s2s.org/

Final ID: NH51C-1632

Disaster Risks Reduction for Extreme Natural Hazards

H. Plag; [1]; *S. Jules-Plag;* [2];
1. Old Dominion Univ, Norfolk, VA, United States.
2. Tiwah, Inc, Reno, NV, United States.

Body: Mega disasters associated with extreme natural hazards have the potential to escalate the global sustainability crisis and put us close to the boundaries of the safe operating space for humanity. Floods and droughts are major threats that potentially could reach planetary extent, particularly through secondary economic and social impacts. Earthquakes and tsunamis frequently cause disasters that eventually could exceed the immediate coping capacity of the global economy, particularly since we have built mega cities in hazardous areas that are now ready to be harvested by natural hazards. Unfortunately, the more we learn to cope with the relatively frequent hazards (50 to 100 years events), the less we are worried about the low-probability, high-impact events (a few hundred and more years events). As a consequence, threats from the 500 years flood, drought, volcano eruption are not appropriately accounted for in disaster risk reduction (DRR) discussions.

Extreme geohazards have occurred regularly throughout the past, but mostly did not cause major disasters because exposure of human assets to hazards was much lower in the past. The most extreme events that occurred during the last 2,000 years would today cause unparalleled damage on a global scale and could worsen the sustainability crisis. Simulation of these extreme hazards under present conditions can help to assess the disaster risk.

Recent extreme earthquakes have illustrated the destruction they can inflict, both directly and indirectly through tsunamis. Large volcano eruptions have the potential to impact climate, anthropogenic infrastructure and resource supplies on global scale. During the last 2,000 years several large volcano eruptions occurred, which under today's conditions are associated with extreme disaster risk. The comparison of earthquakes and volcano eruptions indicates that large volcano eruptions are the low-probability geohazards with potentially the highest impact on our civilization.

Integration of these low-probability, high-impact events in DRR requires an approach focused on resilience and antifragility, as well as the ability to cope with, and recover from failure of infrastructure and social systems. Resilience does not primarily result from the robustness of infrastructure but mainly is a function of the social capital. While it is important to understand the hazards (the contribution of geosciences), it is equally important to understand the processes that let us cope with the hazards, or lead to failure (the contribution of social sciences and engineering). For the latter, we need a joint effort of social sciences and engineering and a revised science-policy relationship. Democratizing knowledge about extreme geohazards is very important in order to inform deliberations of DRR through increased resilience and reduced fragility. The current science-society dialog is not fully capable of supporting deliberative governance. Most scientific knowledge is created independent of those who could put it to use, and a transition to co-design and co-development of knowledge involving a broad stakeholder base is necessary for DRR, particularly for extreme events. This transition may have the consequence of more responsibility and even liability for science.

Final ID: U42A-03

A call for a community strategy to the “Essential Terrestrial Variables” necessary for catchment modeling anywhere in the US *(Invited)*

C. Duffy; [1]; *L. N. Leonard;* [1];
1. Penn State University, State College, PA, United States.

Body: Water is an essential human resource and an agent of earth system processes that is playing an increasing role in global environmental and political issues (NRC 2004). As such there is a national need to provide seamless and fast access to essential geo-spatial/geo-temporal data to support the physics-based numerical models necessary to understand, predict and manage the nations surface and groundwater resources. The heterogeneity of data sources and access methods for data sources across multiple agencies has resulted in a lack of interoperability between data repositories required to support integrative data-intensive computation that addresses national and continental scale water problems.

In this paper we review the existing national data sets necessary to support catchment models that resolve upland stream features (hillslopes, 1st, 2nd and 3rd order streams), and make the case for a community adoption of the “Essential Terrestrial Variables” (ETV) necessary to support hydrologic modeling supported by national data anywhere in the US. The concept of ETV’s evolves from the WMO’s adoption of Essential Climate Variables.

We argue for a community approach for an integrated system of data sources that provides seamless access to the ETV data required to support water models at multiple scales across the continent (WMO, 2011). We envisage collaborative data access arrangements with Federal and other data providers coupled to workflows to parse and repackage data into a form ready for use by models in near real time for retrospective investigation and for scenario development of climate and landuse change impacts.

Final ID: H42C-07

Estimating Passive Microwave Brightness Temperature over Snow-covered Land in North America Using a Land Surface Model and a Support Vector Machine

B. A. Forman; [1]; *R. H. Reichle;* [2];
1. Civil and Environmental Engineering, University of Maryland, College Park, MD, United States.
2. Global Modeling and Assimilation Office, NASA GSFC, Greenbelt, MD, United States.

Body: Recent research by Forman et al. [2013, IEEE] demonstrated the ability of an artificial neural network (ANN) to predict passive microwave (PMW) brightness temperatures (Tb) over snow-covered land as measured by the Advanced Microwave Sounding Radiometer (AMSR-E). The eventual goal is to use the ANN as an observation operator within an ensemble-based data assimilation framework where model estimates are merged with AMSR-E Tb measurements in order to improve snow water equivalent (SWE) estimates at regional and continental scales. The results from this current study suggest an alternative form of machine learning – the support vector machine (SVM) – outperforms the ANN for all frequencies and polarizations evaluated. During SVM development, the NASA Catchment Land Surface Model is used to define snowpack properties. The SVM is then trained on a split-sample of PMW Tb measurements from AMSR-E. Improvements in the SVM predictions (relative to the ANN) were found in both forested and non-forested regions as well as in regions where the snowpack is relatively thin and ephemeral. Additionally, the SVM predictions (relative to the ANN) captured much more of the daily temporal variability present in the AMSR-E Tb observations. These finding suggest a SVM could serve as an effective observation operator within a land data assimilation framework.

Final ID: A43B-0250

Interactions between clouds and radiation on Arctic present and future climates using CMIP5 models

J. M. English; [1]; *A. Gettelman;* [1]; *J. E. Kay;* [1];
1. NCAR, Boulder, CO, United States.

Body: The Arctic is warming faster than the global average, and this "Arctic amplification" is projected to continue. Arctic cloud amount and phase partitioning strongly affects Arctic climate, and differences in modeled cloud processes is a key contribution to the large spread in climate model projections of Arctic climate. In particular, most climate models predict insufficient cloud liquid which in turn causes biases in radiative fluxes. Detailed comparisons between observations of Arctic radiative fluxes and clouds to a coupled earth system model (the Community Earth System Model) indicate insufficient cloud fraction and cloud liquid as well as snow and ice albedo biases contributing to radiative flux biases. We extend this analysis to other earth system models that are part of the Coupled Model Intercomparison Project 5 (CMIP5) and investigate how variations in CMIP5 cloud and surface albedo parameterizations affect radiative fluxes and sea ice extent for both current and future climates.

Final ID: EP43B-0850

Experimental Study on Sediment Transport in Meandering Channels

D. Chen; [1]; *L. He;* [1]; *J. Liu;* [2, 1];
1. Chinese Academy of Sciences, Beijing, China.
2. North China University of Water Resources and Electric Power, Zhengzhou, China.

Body: To study sediment transport in spiral flow structures and the consequent bed deformation in curved channels, a series of experiments is carried out in two sine-generated laboratory channels, representing “mildly” and “highly”sinuous channels respectively. The velocities are measured using ADV. The bed is paved with 2mm uniform sand particles. Those particles are painted with various colors according to their original position. Amounts of particles transporting longitudinally and transversely in the curved channels are counted by using an image processing software. The topography is found mainly created by the gradient of the primary flow rather than the secondary currents.

Final ID: EP43B-0853

A Progressive Black Top Hat Transformation Algorithm for Estimating Valley Volumes from DEM Data

W. Luo; [1]; *T. Pingel;* [1]; *J. Heo;* [2]; *A. D. Howard;* [3];

1. Northern Illinois Univ, De Kalb, IL, United States.
2. Yonsei University, Soeul, Korea, Republic of.
3. University of Virginia, Charlottesville, VA, United States.

Body: The amount of valley incision and valley volume are important parameters in geomorphology and hydrology research, because they are related to the amount erosion (and thus the volume of sediments) and the amount of water needed to create the valley. This is not only the case for terrestrial research but also for planetary research as such figuring out how much water was on Mars. With readily available digital elevation model (DEM) data, the Black Top Hat (BTH) transformation, an image processing technique for extracting dark features on a variable background, has been applied to DEM data to extract valley depth and estimate valley volume. However, previous studies typically use one single structuring element size for extracting the valley feature and one single threshold value for removing noise, resulting in some finer features such as tributaries not being extracted and underestimation of valley volume. Inspired by similar algorithms used in LiDAR data analysis to separate above ground features and bare earth topography, here we propose a progressive BTH (PBTH) transformation algorithm, where the structuring elements size is progressively increased to extract valleys of different orders. In addition, a slope based threshold was introduced to automatically adjust the threshold values for structuring elements with different sizes. Connectivity and shape parameters of the masked regions were used to keep the long linear valleys while removing other smaller non-connected regions. Preliminary application of the PBTH to Grand Canyon and two sites on Mars has produced promising results. More testing and fine-tuning is in progress. The ultimate goal of the project is to apply the algorithm to estimate the volume of valley networks on Mars and the volume of water needed to form the valleys we observe today and thus infer the nature of the hydrologic cycle on early Mars. The project is funded by NASA's Mars Data Analysis program.

Final ID: EP43D-0879

Understanding Coupled Earth-Surface Processes through Experiments and Models *(Invited)*

I. Overeem; [1]; *W. Kim;* [2];
1. Univ Colorado, Boulder, CO, United States.
2. University of Texas, Austin, TX, United States.

Body: Traditionally, both numerical models and experiments have been purposefully designed to 'isolate' singular components or certain processes of a larger mountain to deep-ocean interconnected source-to-sink (S2S) transport system. Controlling factors driven by processes outside of the domain of immediate interest were treated and simplified as input or as boundary conditions. Increasingly, earth surface processes scientists appreciate feedbacks and explore these feedbacks with more dynamically coupled approaches to their experiments and models.

Here, we discuss key concepts and recent advances made in coupled modeling and experimental setups. In addition, we emphasize challenges and new frontiers to coupled experiments.

Experiments have highlighted the important role of self-organization; river and delta systems do not always need to be forced by external processes to change or develop characteristic morphologies. Similarly modeling f.e. has shown that intricate networks in tidal deltas are stable because of the interplay between river avulsions and the tidal current scouring with both processes being important to develop and maintain the dentritic networks. Both models and experiment have demonstrated that seemingly stable systems can be perturbed slightly and show dramatic responses.

Source-to-sink models were developed for both the Fly River System in Papua New Guinea and the Waipaoa River in New Zealand. These models pointed to the importance of upstream-downstream effects and enforced our view of the S2S system as a signal transfer and dampening conveyor belt. Coupled modeling showed that deforestation had extreme effects on sediment fluxes draining from the catchment of the Waipaoa River in New Zealand, and that this increase in sediment production rapidly shifted the locus of offshore deposition.

The challenge in designing coupled models and experiments is both technological as well as intellectual. Our community advances to make numerical model coupling more straightforward through common interfaces and standardization of time-stepping, model domains and model parameters. At the same time major steps forward require an interdisciplinary approach, wherein the source to sink system contains ecological feedbacks and human actors.

Final ID: EP43D-0880

Building a Bridge to Deep Time: Sedimentary Systems Across Timescales

B. Romans; [1]; *S. Castelltort;* [2]; *J. A. Covault;* [3]; *J. P. Walsh;* [4];
1. Virginia Tech, Blacksburg, VA, United States.
2. Earth Sciences, University of Geneva, Geneve, Switzerland.
3. Chevron Energy Technology Co., Houston, TX, United States.
4. Geological Sciences and Institute for Coastal Science and Policy, East Carolina University, Greenville, NC, United States.

Body: It is increasingly important to understand the complex and interdependent processes associated with sediment production, transport, and deposition at timescales relevant to civilization (annual to millennial). However, predicting the response of sedimentary systems to global environmental change across a range of timescales remains a significant challenge. For example, a significant increase in global average temperature at the Paleocene-Eocene boundary (55.8 Ma) is interpreted to have occurred over millennial timescales; however, the specific response of sedimentary systems (e.g., timing and magnitude of sediment flux variability in river systems) to that forcing is debated. Thus, using such environmental perturbations recorded in sedimentary archives as analogs for ongoing/future global change requires improved approaches to bridging across time. Additionally, the ability to bridge timescales is critical for addressing other questions about sedimentary system behavior, including signal propagation and signal versus ‘noise’ in the record.

The geologic record provides information that can be used to develop a comprehensive understanding of process-response behavior at multiple timescales. The geomorphic ‘snapshot’ of present-day erosional and depositional landscapes can be examined to reconstruct the history of processes that created the observable configurations. Direct measurement and monitoring of active processes are used to constrain conceptual and numerical models and develop sedimentary system theory. But real-time observations of active Earth-surface processes are limited to the very recent, and how such processes integrate over longer timescales to transform into strata remains unknown. At longer timescales (>10^6 yr), the stratigraphic record is the only vestige of ancient sedimentary systems. Stratigraphic successions contain a complex record of sediment deposition and preservation, as well as the detrital material that originated in long since denuded orogenic belts. Moreover, as the timescale of the duration of the process-response behavior and/or system age increase, additional aspects must be considered (e.g., significant tectonic regime change, rare but significant events, non-periodic global change, etc.). In this presentation we discuss several examples of sedimentary system analysis at different timescales with the goal of highlighting various approaches at one timescale and how they can (or cannot) be applied for questions at different timescales. Examples include: (1) brief review of decadal to centennial sediment budgets; (2) land-to-sea sediment budget reconstructions from southern California at millennial to multi-millennial timescales, and (3) sedimentary system response to climatic and tectonic forcings at ≥10^5 yr timescales.

Final ID: EP43D-0885

Source-To-Sink Perspectives On The Mississippi River System, Miocene To Present, Mountain To Abyss

S. J. Bentley; [1]; *M. D. Blum;* [2];
1. Coastal Studies Institute and Dept of Geology and Geophysics, Louisiana State University, Baton Rouge, LA, United States.
2. ExxonMobil Upstream Research Company, Houston, TX, United States.

Body: . The objective of this study is to present a synthesis of the Mississippi River source-to-sink system, from montane source to abyssal sink, to elucidate specific geomorphic components and boundaries in the system, controls on mass transfer, and resultant geomorphic and statigraphic development. The Mississippi River source-to-sink system constitutes one of the largest sources, conduits, and depocenters of sediment on Earth, extending from elevations of 3.7 km in the Rocky Mountains to the Gulf of Mexico abyssal plain. Despite being one of the most intensely studied fluvial-marine systems in the world, comprehensive understanding and management of the system's resources remain a challenge. The system is valuable in many ways: it provides navigation and water to the heart of North America, and sustains extensive marine fisheries. The river has built a delta that is home to millions of people and yet is subsiding rapidly. Ancestral Mississippi fluvial-marine deposits continue to yield high-value petroleum resources to exploration. To address the range of temporal and spatial scales over which the system has developed and continues to evolve, we will focus on three geological time spans that display contrasting geologic forcing and response: Miocene, Pleistocene, and late Holocene. The present configuration of source, conduit, and sink were established during the Miocene epoch, when tectonics (via the uplifting southern Rockies, and later the rejuvenated Appalachians) and climate (wet in the east and dry in the west) provided abundant water and sediment to prograde the shelf margin and initiate deep-sea fan growth. Pleistocene continental glaciation, eustasy, and catastrophic drainage events further sculpted the alluvial valley, and extended the shelf margin, and fan. Studies of Modern processes and Holocene delta development have provided keys to both the delta's past and future evolution, in terms of cyclic autogenic lobe-switching, mass-transport events, storm-driven sediment delivery to canyon heads, and allogenic/anthropogenic controls on sediment supply and subsidence.

Final ID: EP43D-0887

Humans, Tectonics and Climate, Changing S2S Systems over Time: Waipaoa River Margin Example

S. A. Kuehl; [1]; *C. R. Alexander;* [2]; *D. R. Corbett;* [3]; *C. K. Harris;* [1]; *A. S. Ogston;* [4]; *A. R. Orpin;* [5]; *J. P. Walsh;* [3];
1. College William & Mary, Gloucester Point, VA, United States.
2. Skidaway Institute of Oceanography, Savannah, GA, United States.
3. East Carolina University, Greenville, NC, United States.
4. University of Washington, Seattle, WA, United States.
5. National Institute of Water & Atmospheric Research Ltd., Wellington, New Zealand.

Body: Recent interdisciplinary studies of the Waipaoa River margin, New Zealand North Island, provide a clear picture of human and natural signal propagation and preservation in Holocene and contemporary sedimentary sequences of the continental shelf and slope. This active margin setting presents both extraordinary high sediment yields and high sediment accommodation which are controlled, in part, by tectonic uplift and deformation. Unlike many passive margins, the resulting sediment deposits on the Waipaoa shelf and slope provide a high-resolution record of changing climate and landscape since the Last Glacial Maximum (LGM). Giant piston cores collected using the Marion Dufresne reveal definitive textural and carbon isotopic downcore trends that clearly reflect the transgressive and regressive phases of relative sea-level since the LGM. Moreover, A distinct coarsening in sediment texture around 3ka reflects the intensification of the El Nino Southern Oscillation in the western Pacific Ocean at that time, either through increased landsliding caused by enhanced precipitation, or by higher significant wave heights and resuspension that may have accompanied increased cyclonic storm activity. A distinct signature of fine sediment in the upper sections of the Marion Dufresne cores is thought to herald the Anthropocene period, reflecting deforestation and an increase both in sediment load and the release of fine sediment from the catchment from runaway gully formation. Sediment budgets indicate that whereas the continental shelf off the Waipaoa was a very efficient sediment trap during much of the Holocene, the Anthropocene is marked by the dominance of off- and along-shelf sediment escape. Contemporary sediment transport studies, seabed observations and modeling suggest a strong disconnect with average Holocene dispersal patterns, with much sediment currently escaping along the shelf to the north. It appears that this dramatic shift in sediment dispersal on the Waipaoa margin has occurred, at least in part, because of human changes to the landscape that have significantly altered the composition and quantity of riverine material discharged to the coastal ocean.

Final ID: EP43D-0896

A record of Yarlung-Tsangpo river reorganization since the middle Miocene: evidence for a Himalayan-Tibetan connection

K. A. Lang; [1]; *K. W. Huntington;* [1];
1. University of Washington, Seattle, WA, United States.

Body: Late Cenozoic deformation of the easternmost margin of the Himalayan orogen dramatically modified the drainage patterns of the Yarlung-Tsangpo, Lohit and Irrawaddy river networks. Today, these distorted drainage basins reflect this accumulated strain, and proximal sedimentary basins record the time and sequence of distinct river capture and reversal events. We establish a sequential record of the reorganization of these river networks since 10-12 Ma using detrital zircon U-Pb provenance data from the eastern Himalayan foreland basin. We present new data from the most proximal areas of the basin, doubling the size of published basin U-Pb provenance data and completing the basin-wide sedimentary archive to discriminate between existing models of river reorganization. Specifically, we evaluate competing models disputing the capture of the Tibetan Yarlung-Tangpo river by a headward eroding Himalayan drainage as a mechanism to generate the Tsangpo Gorge, an enigmatic knickpoint dropping ~2 km through the eastern Himalaya. Our data show that such a Tibetan connection through the eastern Himalaya was present since the mid-late Miocene, favoring models of an antecedent Yarlung-Tsangpo river since “dragged” into a distorted configuration by active crustal-scale structures. Furthermore, the young (<30 Ma) anatectic zircons observed in modern river sediments to be exclusively derived from source rocks within the Tsangpo Gorge, are absent in the entire ~12-2 Ma proximal sedimentary record. This absence demonstrates that despite a long-lived Tibetan connection through the eastern Himalaya, surface exhumation of these source rocks did not occur until after ~2 Ma. These results suggest that glaciation and associated erosional processes active in the Quaternary may have played a substantial role in triggering rapid, recent erosion of the Tsangpo Gorge generating anomalously steep local relief. Our findings quantify the variability in sedimentary provenance data with proximity to source areas, highlighting the importance of a basin-wide dataset for the interpretation of river network reorganization. Beyond models of continental-scale drainage reorganization, our findings have significant implications for models relating surface erosion to upper crustal tectonic processes, and more broadly for the interpretation of distal basin sedimentary archives used for continental-scale climatic and tectonic reconstructions.

Final ID: EP43D-0901

Architecture and Channel-Belt Clustering in the Fluvial lower Wasatch Formation, Uinta Basin, Utah.

J. R. Pisel; [1]; *D. R. Pyles;* [1]; *B. Bracken;* [2]; *C. D. Rosenbaum;* [1];

1. Geology and Geological Engineering - Chevron Center of Research Excellence, Colorado School of Mines, Golden, CO, United States.
2. Chevron Energy Technology Company, San Ramon, CA, United States.

Body: The Eocene lower Wasatch Formation of the Uinta Basin contains exceptional outcrops of low net-sand content (27% sand) fluvial strata. This study quantitatively documents the stratigraphy of a 7 km wide by 300 meter thick strike-oriented outcrop in order to develop a quantitative data base that can be used to improve our knowledge of how some fluvial systems evolve over geologic time scales. Data used to document the outcrop are: (1) 550 meters of decimeter to half meter scale resolution stratigraphic columns that document grain size and physical sedimentary structures; (2) detailed photopanels used to document architectural style and lithofacies types in the outcrop; (3) thickness, width, and spatial position for all channel belts in the outcrop, and (4) directional measurements of paleocurrent indicators.

Two channel-belt styles are recognized: lateral and downstream accreting channel belts; both of which occur as either single or multi-story. Floodplain strata are well exposed and consist of overbank fines and sand-rich crevasse splay deposits. Key upward and lateral characteristics of the outcrop documented herein are the following. First, the shapes of 243 channels are documented. The average width, thickness and aspect ratios of the channel belts are 110 m, 7 m, and 16:1, respectively. Importantly, the size and shape of channel belts does not change upward through the 300 meter transect. Second, channels are documented to spatially cluster. 9 clusters are documented using a spatial statistic. Key upward patterns in channel belt clustering are a marked change from non-amalgamated isolated channel-belt clusters to amalgamated channel-belt clusters. Critically, stratal surfaces can be correlated from mudstone units within the clusters to time-equivalent floodplain strata adjacent to the cluster demonstrating that clusters are not confined within fluvial valleys. Finally, proportions of floodplain and channel belt elements underlying clusters and channel belts vary with the style of clusters and channel belts laterally and vertically within the outcrop.

Final ID: H43A-1432

Estimates of riparian evapotranspiration using diurnal monitoring of groundwater regime in desert environments

P. Wang; [1]; *S. P. Pozdniakov;* [2]; *S. Grinevsky;* [2]; *J. Yu;* [1];
1. Key Laboratory of Water Cycle & Related Land Surface Processes, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing, China.
2. Department of hydrogeology, Moscow State University, Moscow, Russian Federation.

Body: Shallow groundwater is mainly discharged by phreatophytes in many riparian ecosystems of arid and semiarid environment, while estimation of groundwater evapotranspiration in these regions still remains a challenge for regional water resources assessment. In this study, a simple relationship between the average standard deviation of diurnal groundwater level fluctuations and the daily evapotranspiration over relatively short periods (days or weeks) was developed for estimating groundwater consumption by phreatophytes in arid/semi-arid areas. Our approach allows estimating groundwater evapotranspiration using stable statistical characteristics of diurnal groundwater fluctuation, and it is useful for analyzing large amounts of data obtained from digital groundwater level monitoring sensors. The developed methodology was applied to two phreatophyte-dominated riparian areas (Populus euphratica and Tamarix ramosissima) in a typical Gobi desert region of northwest China to demonstrate the usefulness of the technique.

Final ID: H43B-1440

Redistribution of Carbon During Forest Blowdowns

E. E. Wohl; [1];
1. Colorado State Univ, Fort Collins, CO, United States.

Body: Numerous blowdowns in subalpine and montane forests of the Southern Rocky Mountains during the winter of 2011-12 present an opportunity to evaluate how this type of disturbance affects the distribution of organic carbon. Patch blowdowns covering 0.1 to 33 ha are an episodic event with an unknown recurrence interval. Blowdowns influence carbon partitioning in a forested ecosystem by transferring live to dead biomass and exposing soil on uprooted trees. Wood recruited to streams via blowdowns can cause channel-spanning jams that enhance overbank flows and channel avulsion in wider valley segments. This can lead to a multithread channel planform and increased floodplain storage of carbon, as well as altered stream metabolism and animal (insect and fish) production. This talk examines a 33-ha blowdown that occurred along Glacier Creek in Rocky Mountain National Park, Colorado during February 2012. Estimated carbon redistribution ranged as high as 308 Mg C/ha in high-severity patches to 106 Mg C/ha in low-severity patches. Volumes of carbon redistributed from living to dead biomass at high-severity sites are close to average total biomass in subalpine forests in the region. Blowdowns are likely to increase under a warming climate as part of an accelerated disturbance regime involving intense storms and wind, wildfire, and insect infestations. The consequences for carbon partitioning across the landscape, and for riverine ecosystems, depend partly on geomorphic setting, which creates path-dependence and hysteresis. In wider valley segments, downed trees (carbon transferred to dead biomass by blowdowns) may enhance retention of carbon in transport within the stream, facilitating both burial in sedimentary reservoirs and uptake by stream organisms.

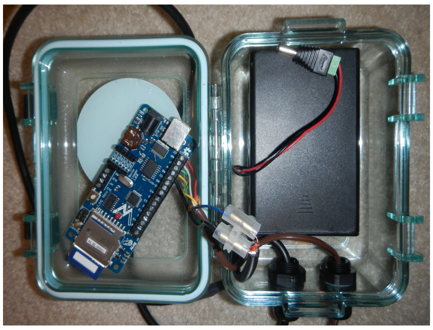
Final ID: H43H-1574

Inexpensive Open-Source Data Logging in the Field

A. D. Wickert; [1, 2];
1. Northern Widget LLC, Saint Paul, MN, United States.
2. INSTAAR and Geological Sciences, University of Colorado Boulder, Boulder, CO, United States.

Body: I present a general-purpose open-source field-capable data logger, which provides a mechanism to develop dense networks of inexpensive environmental sensors. This data logger was developed as a low-power variant of the Arduino open-source development system, and is named the ALog ("Arduino Logger") BottleLogger (it is slim enough to fit inside a Nalgene water bottle) version 1.0. It features an integrated high-precision real-time clock, SD card slot for high-volume data storage, and integrated power switching. The ALog can interface with sensors via six analog/digital pins, two digital pins, and one digital interrupt pin that can read event-based inputs, such as those from a tipping-bucket rain gauge. We have successfully tested the ALog BottleLogger with ultrasonic rangefinders (for water stage and snow accumulation and melt), temperature sensors, tipping-bucket rain gauges, soil moisture and water potential sensors, resistance-based tools to measure frost heave, and cameras that it triggers based on events. The source code for the ALog, including functions to interface with a a range of commercially-available sensors, is provided as an Arduino C++ library with example implementations. All schematics, circuit board layouts, and source code files are open-source and freely available under GNU GPL v3.0 and Creative Commons Attribution-ShareAlike 3.0 Unported licenses. Through this work, we hope to foster a community-driven movement to collect field environmental data on a budget that permits citizen-scientists and researchers from low-income countries to collect the same high-quality data as researchers in wealthy countries. These data can provide information about global change to managers, governments, scientists, and interested citizens worldwide.

URL: http://www.northernwidget.com



Watertight box with ALog BottleLogger data logger on the left and battery pack with 3 D cells on the right. Data can be collected for 3-5 years on one set of batteries.

Final ID: NH43A-1735

Time-Reverse Imaging for the Tsunami Source

J. Hossen; [1]; *P. R. Cummins;* [1];
1. Research School of Earth Sciences, Australian National University, Canberra, ACT, Australia.

Body: Many tsunami source inversion techniques have already been developed to derive source models with the assumption that tsunami generation is due to slip on a single large fault. Therefore, these inversion techniques cannot determine to what extent subsidiary phenomena - such as submarine landslides, block movement, or slip on splay faults - have contributed to the tsunami generation. We are proposing a new method that can be used to derive source models without requiring the assumption of slip on a fault of pre-determined geometry, but rather inverts directly for sea surface displacement. The proposed method is based on "Time Reverse Imaging (TRI)" technique, which has been used in underwater acoustic and medical imaging. We have applied TRI to recover the initial sea surface displacement associated with the tsunami source. This approach requires observations with good azimuthal coverage around the source area. It also requires a numerical model that will be run backward with a collection of point sources that coincide with observation locations. Synthetic numerical experiments show that if a good enough coverage of observations is available, TRI yields a good approximation to the spatial distribution of the initial source model. To show the application of this method we have chosen the tsunami triggered by the March 11, 2011 Tohoku-Oki earthquake, for which an unprecedented number of high-quality observations are available. We use both near- and far-field tsunami observations in our study. We will compare the findings of the TRI result with other more conventional methods of source inversion.

Final ID: PP43A-2068

Sea-level and climate forcing of the Sr isotope composition of marginal basins in the late Miocene Mediterranean Basin

T. F. Schildgen; [1]; *D. Cosentino;* [2]; *G. Frijia;* [1]; *F. Castorina;* [3]; *F. O. Dudas;* [5]; *A. Iadanza;* [2]; *P. Cipollari;* [2]; *A. Caruso;* [4]; *S. A. Bowring;* [5]; *M. R. Strecker;* [1];

1. Department of Earth and Environmental Science, University of Potsdam, Potsdam, Germany.
2. Dipartimento di Scienze Geologiche, Roma III University, Rome, Italy.
3. Dipartimento di Scienze della Terra, Sapienza University Rome, Rome, Italy.
4. Instituto di Scienze della Terra e del Mare, Università Palermo, Palermo, Italy.
5. Department of Earth, Atmospheric and Planetary Science, Massachusetts Institute of Technology, Cambridge, MA, United States.

Body: Sr isotope records from marginal marine basins track the mixing between sea water and local continental runoff. Because changes in sea level determine the amount of mixing between global marine and continental water, and climate affects the amount of continental runoff, both sea-level and climate changes can potentially be recorded in marine fossil Sr isotope composition. Our 128 new 87Sr/86Sr analyses on 73 oyster, foraminifera, and coral samples from eight late Miocene stratigraphic sections in southern Turkey, Crete, and Sicily show that 87Sr/86Sr in Mediterranean marginal basins started to depart from global ocean values several million years before the Messinian Salinity Crisis (MSC), with sub-basin 87Sr/86Sr commonly dropping 0.000100 below contemporaneous global ocean values. The marked departure coincided with tectonic uplift and basin shallowing along the margins of the Mediterranean Basin. In contrast, centrally-located basins within the Mediterranean (e.g., Cyprus, Sicily, Crete) only record departures during the MSC.

Besides this general trend, our 57 new 87Sr/86Sr analyses from the astronomically tuned Lower Evaporite unit deposited during the MSC in the central Apennines (Italy) allow us to explore in detail the effect of sea-level and humidity changes on 87Sr/86Sr . Most of the variation in 87Sr/86Sr that we observe can be explained by changes in eustatic sea level, with greatest departures from global ocean values (with differences up to 0.000150) occurring during sea-level lowstands, which were characterized by relatively arid conditions in the Mediterranean. However, in a few cases, the greatest 87Sr/86Sr departures (up to 0.000300) occur during sea-level highstands, which are marked by more humid conditions. Because the correlations between peaks in Sr departures and highstands (humid conditions) occur only after episodes of prolonged aridity, variations of residence time of continental water (particularly groundwater) could have affected its Sr concentration, and hence the degree to which continental water could perturb 87Sr/86Sr in marine sub-basins.

Although our results demonstrate that the forcing behind variations in Sr isotope composition in marginal marine basins is more complex than what is typically included in Sr isotope box models, they also imply that high-resolution records, particularly when combined with independent information on sea-level or climate changes, could offer unique insights into local tectonic, climatic, and sea-level variations.

Final ID: SM43A-2262

Comparison of EMIC wave observation and modeling under different geomagnetic activities

D. Lee;[1, 2]; *E. Kim;*[2]; *H. Kim;*[3]; *J. Johnson;*[2]; *M. Lessard;*[4]; *M. J. Engebretson;*[5]; *H. J. Singer;*[6]; *E. Valeo;*[2]; *C. Phillips;*[2];

1. Kyung Hee Univ, Gyeonggi, Korea, Republic of.
2. Plasma Physics Laboratory, Princeton University, Princeton, NJ, United States.
3. Virginia Tech, Blacksburg, VA, United States.
4. University of New Hampshire, Durham, NH, United States.
5. Augsburg College, Minneapolis, MN, United States.
6. NOAA-Space Weather Prediction Center, Boulder, CO, United States.

Body: Electromagnetic (EMIC) waves are known to be excited by the cyclotron instability associated with hot and anisotropic ion distributions in the equatorial region of the magnetosphere during geomagnetic storms and substorms. Over the years, many studies have investigated EMIC waves and their relationship with geomagnetic storms, focusing on when, where, and under what conditions EMIC waves are detected. However, previous ground based studies have primarily focused only on when EMIC waves are detected. We address here both where and under what conditions EMIC waves are observed at the ground. We present space-ground conjunction events that show EMIC wave occurrence peaks around 12 MLT at the ground while peaking 16 MLT at geosynchronous orbit. It is also shown that EMIC waves were less likely to propagate into the ionosphere with higher Kp indices. We compare these observations with wave full solutions employing a finite element code developed at the Princeton Plasma Physics Laboratory. The code describes a three-dimensional wave structure including mode conversion when ULF, EMIC, and whistler waves are launched in a two-dimensional axisymmetric background plasma with general magnetic field topology. By adopting a realistic magnetospheric and ionospheric density structure, we examine the spatial and temporal features of EMIC waves in the inner magnetosphere. Using the model, we examine how EMIC waves propagate in the magnetosphere and reach the ionosphere after the waves are launched in space where they are typically observed. We also investigate how changes in the He+ and/or O+ density that result from the ion outflows would affect the accessibility of the waves to the ground.

Final ID: MR43A-2364

High Resolution Global Electrical Conductivity Variations in the Earth's Mantle

A. Kelbert; [1]; *J. Sun;* [1, 2]; *G. D. Egbert;* [1];
1. Oregon State University, Corvallis, OR, United States.
2. ETH, Zurich, Switzerland.

Body: Electrical conductivity of the Earth's mantle is a valuable constraint on the water content and melting processes. In Kelbert et al. (2009), we obtained the first global inverse model of electrical conductivity in the mantle capable of providing constraints on the lateral variations in mantle water content. However, in doing so we had to compromise on the problem complexity by using the historically very primitive ionospheric and magnetospheric source assumptions. In particular, possible model contamination by the auroral current systems had greatly restricted our use of available data.

We have now addressed this problem by inverting for the external sources along with the electrical conductivity variations. In this study, we still focus primarily on long period data that are dominated by quasi-zonal source fields. The improved understanding of the ionospheric sources allows us to invert the magnetic fields directly, without a correction for the source and/or the use of transfer functions. It allows us to extend the period range of available data to 1.2 days – 102 days, achieving better sensitivity to the upper mantle and transition zone structures. Finally, once the source effects in the data are accounted for, a much larger subset of observatories may be used in the electrical conductivity inversion.

Here, we use full magnetic fields at 207 geomagnetic observatories, which include mid-latitude, equatorial and high latitude data. Observatory hourly means from the years 1958-2010 are employed. The improved quality and spatial distribution of the data set, as well as the high resolution modeling and inversion using degree and order 40 spherical harmonics mapped to a 2x2 degree lateral grid, all contribute to the much improved resolution of our models, representing a conceptual step forward in global electromagnetic sounding.

We present a fully three-dimensional, global electrical conductivity model of the Earth's mantle as inferred from ground geomagnetic observatory data, and use additional constraints to interpret these results in terms of mantle processes and compositional variations.

Final ID: H43O-01

Averting a Disaster with Groundwater Depletion in India: The General Case of Water Management Principles and Development *(Invited)*

U. Lall; [1];
1. Earth & Env Eng, Columbia Univ, New York, NY, United States.

Body: Many countries, including the USA, China, and India are experiencing chronic groundwater depletion. In part this unsustainable water use results from climatic factors that reduce surface water availability and also the recharge to the aquifer system. However, a more critical factor is uncontrolled use for agriculture and energy and mineral processing. Interestingly in places such as India endowments have been politically created that lead to ever increasing use, through the provision of free energy for pumping. Reversing the situation is considered politically challenging, and the concept of metering and payment for what is essentially economic use of water is also considered difficult to apply.

In this talk I use the Indian situation as a general example and discuss the role central planning strategies for demand and resource management can play recognizing the private action by millions of users as an inevitable tool that needs to be leveraged without necessarily the high transaction costs that come with monitoring and fee collection for monitored use. Specifically, targeting and stimulating potential cropping strategies and on farm water and energy management emerge as a choice in a difficult management environment. In a broader development context, I argue that the role of private sector aggregators in developing farm to market procurement strategies can play a role in both improving rural economies and providing a trajectory for more efficient water use through technology and crop choice.

Final ID: EP43E-03

Tectonics, erosion, and climate in the Miocene Mediterranean: a mechanistic approach to the Messinian Salinity Crisis *(Invited)*

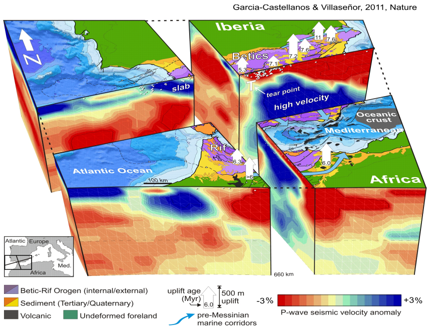
D. Garcia-Castellanos; [1];
1. Inst. Ciencias de la Tierra Jaume Almera, Barcelona, Spain.

Body: The Messinian salinity crisis (MSC) was an extreme case of interaction between tectonic and climatic processes that lead to the isolation of the Mediterranean Sea about 6 million years ago. In less than a few hundred thousand years, 6-10% of the salt of the global ocean was captured by precipitation at the Mediterranean seafloor. Both the timing and the processes involved in these events remain controversial. There is an agreement that global sea level changes and the tectonic uplift of the connecting corridors across the Gibraltar Arc were key players. But there is no full consensus, for example, on whether a kilometric evaporative drawdown ever took place, when during the MSC would it have happened, or whether it may have occurred in multiple occasions intercalated by an equal number of floods refilling the Mediterranean.

I will show results from a simple forward numerical model based on 1D mathematical approaches to water-flow and erosion on a seaway. Salt precipitation in the isolated side of the seaway is computed as a function of the salt concentration imposed by varying rates of evaporation, precipitation and seaway uplift. The results show that the erosion exerted on the seaway by the Atlantic inflowing water allows a long-term connection of a few tens of meters by reaching a dynamic equilibrium with tectonic uplift, even if the global sea level fluctuates with larger amplitude. The predicted uplift rates required to block the inflow of Atlantic water are consistent with the present altitude of uplifted marine sediments and with geodynamic models of a proposed lithospheric slab detachment under the Gibraltar Arc. A minor increase in tectonic uplift rate or a large, rapid ocean level drop of a few tens of meters can lead to the full disconnection and the emergence of the seaway, upon which the Mediterranean drops to an equilibrium level of 1.1-2.5 km by evaporation. This is consistent with the restored depth of Messinian erosion surfaces (the M reflector) visible in seismic imaging in areas as the Rhone and the Ebro deltas.

Finally, the same model is used to estimate the water discharge and the duration of the flood that refilled the Mediterranean at the end of the MSC, assuming that this is mainly controlled by the feedback between water inflow and erosion across the Gibraltar Strait. The results suggest a very rapid flooding that could explain the 200-800-m deep erosion trough documented in the Alborán Sea.

URL : https://sites.google.com/site/daniggcc/research-interests/messinian



Geology and mantle structure of the Gibraltar area.

Final ID: EP43E-06

River avulsions in the presence of tectonic tilting, and the Ganges-Brahmaputra Delta

M. D. Reitz; [1]; *M. S. Steckler;* [1]; *C. Paola;* [2]; *S. L. Goodbred;* [3]; *A. L. Petter;* [2]; *J. Pickering;* [3]; *L. A. Williams;* [3];
1. Division of Marine Geology and Geophysics, LDEO, Columbia University, Palisades, NY, United States.
2. Department of Earth Sciences, University of Minnesota, Minneapolis, MN, United States.
3. Department of Earth and Environmental Sciences, Vanderbilt University, Nashville, TN, United States.

Body: In Bangladesh, the set of active rivers of the Ganges-Brahmaputra Delta overlie a landscape that is being continually modified by tectonics. The response of rivers to a surface being altered by tectonic tilting or other causes of spatially variable subsidence is generally understood to be a preferred path direction toward regions of higher subsidence. Quantifying the magnitude of the effect of variable subsidence on the timescale and path direction of channel avulsion remains, however, an open question. Recent experimental work has suggested an equilibrium-slope explanation for the timescale and conditions for avulsion, which provides a way forward on understanding how varied subsidence conditions would affect the avulsion process. Here we adapt this model for avulsion to the context of variable subsidence, developing a new framework to quantify its effect on channel avulsions. We find that variable subsidence results in two effects: differing timescales between avulsions on different parts of the delta, and differing frequencies of avulsion to these locations. Regions of higher subsidence both draw avulsions more frequently, and result in longer channel residence times in these locations. We also describe the effect of incision or aggradation due to sea level changes within this framework: incisional events lengthen avulsion timescales everywhere on the delta, while periods of sea-level rise drive the timescales back toward their minimum values. Finally, we apply this theory to the Ganges-Brahmaputra Delta, where we use a map of regional variable subsidence that we derived from GPS and published stratigraphic data, to predict the variation in avulsion timescale and frequency for the Brahmaputra River due to this variable subsidence. We make estimates for two different tectonic history interpretations, and for the cases with or without the estimated incision from the most recent sea-level fall. Comparison between our predictions and our stratigraphy-derived estimates of avulsion timescale shows encouraging consistency. The work presented here represents the first quantitative, general framework for the influence of variable tectonics or subsidence on large-scale nodal avulsion timescale and path direction.

Final ID: EP43F-06

Turbulence- and particle-resolving model of sediment transport and the formation of bedforms under waves and unidirectional currents

M. W. Schmeeckle; [1]; *J. M. Nelson;* [2];
1. Arizona State University, Tempe, AZ, United States.
2. Geomorphology and Sediment Transport Laboratory, United States Geological Survey, Golden, CO, United States.

Body: Turbulence and bedload sediment transport over evolving bedforms are directly simulated by a coupled large eddy simulation (LES) of the fluid and the discrete element method (DEM) for every sediment grain. The LES and DEM models are fully coupled in momentum. Information from the LES is used to specify forces on the DEM particles, and those particle forces are given in an equal and opposite direction in the filtered and discretized Navier-Stokes equations at each grid cell in the finite volume LES. This modeling system directly calculates the motion of all grains by resolved turbulence structures. LES-DEM simulations of bedload transport of initially flat beds has shown that the penetration of the bed by smaller intense vortical structures within a broader sweep structure are largely responsible for sediment entrainment. To validate the model we compare our simulations with previous synchronous measurements of flow and transport in an oscillatory flow duct and downstream of a negative step. LES-DEM simulations in an oscillatory boundary layer of the formation of ripples from an initially flat bed will be presented. Unidirectional LES-DEM simulations over an initially rippled bed will also be presented, and simulations of the formation of bedforms from flat beds under unidirectional flow are ongoing.

Flow separation over bedforms produces large scale structures with primarily a cross-stream orientation of the vorticity vector. Traveling downstream, these structures rapidly transform into structures with a random direction of vorticity. The point of reattachment is not stable, moving upstream and downstream. At, and downstream of, the point of reattachment many of the structures produced in the shear layer impinge on the bed. LES-DEM simulations over ripples show that the penetration of large scale structures downstream of flow reattachment bring high downstream momentum fluid into the bed and create localized, episodic bursts of entrainment. Particles entrained near the point of reattachment often have a significant vertical component of motion due to strong positive vertical fluid motion. Further downstream, near the bedform crest, large-scale, episodic fluid penetration and consequent entrainment of the bed is reduced, even though the time-mean downstream velocity is higher. This can result in a peak in transport between the point of reattachment and bedform crest. In such a case, the bedform continues to grow until the near-bed velocity at the crest is large enough to produce a transport rate greater than upstream of the crest.

Previous successful numerical simulations of the formation of ripples and dunes by water have relied on sediment transport formulations that do not specify a monotonic relationship between boundary stress and sediment flux. Rather , they often include a gravitational correction, specification of pickup and disentrainment, and/or a saturation length formulation. The simulations herein suggest that, at the very least, future parameterizations should incorporate the large temporal variance of bed stress near the point of reattachment that decreases further downstream. Although, this approach is not complete because it does not consider the effects of strong vertical fluid motions on grain trajectories.

Final ID: EP43F-07

Simulation of River Bluffs and Slip-Off Slopes With a Discrete Particle-Based Model

S. T. Lancaster; [1]; *J. P. Zunka;* [1]; *G. E. Tucker;* [2];
1. College of Earth, Ocean, and Atmospheric Sciences, Oregon State University, Corvallis, OR, United States.
2. Department of Geological Sciences, University of Colorado, Boulder, CO, United States.

Body: A discrete particle-based model simulates evolution of two-dimensional valley cross sections similar to those produced by bedrock meandering rivers and thereby suggests that characteristic features such as overhanging cliffs and talus slopes are dependent on specific relationships among process rates. Discrete coordinates on a gridded cross-section define locations of particles of intact bedrock, sediment (loose material with half the bulk density of bedrock), water, or air on that grid, and each particle of rock or sediment has a unique (or zero) concentration of terrestrial cosmogenic nuclides (TCNs). Stochastic processes determine both the possible locations of process actions and the results of those actions. Stochastic discharges generate boundary shear stresses, calculated by an approximation to the ray-isovel model, that determine removal probabilities for candidate particles of bedrock or sediment from the boundary of a self-formed channel. An asymmetric probability distribution governs the selection of candidate particles on the wetted perimeter and drives asymmetric fluvial erosion and transport that can undermine adjacent slopes, so that the channel migrates laterally. Sediment is produced from intact bedrock by weathering and rock fall. The latter acts only on candidate bedrock particles that are undermined and exposed at the surface. Weathering produces two sediment particles from one of bedrock, and thereby inflates the surface, when slope-normal random walks from candidate sites on the surface end at bedrock particles, so that the sediment-bedrock interface is irregular and discontinuous. Diffusive transport moves candidate particles on random walks in random directions along the surface, where transition probabilities depend on local topography. TCNs are produced when the randomly situated and oriented random walks of cosmic rays end at bedrock or sediment, and not water, particles. The model produces asymmetric channels and valley cross sections, where the two slopes have contrasting bedrock lowering rates, regolith thicknesses, TCN concentrations, and gradients. In simulated valleys, talus-mantled slopes grade smoothly into steep outer channel banks at the bases of overhanging cliffs, all with small TCN concentrations, and thickly mantled slip-off slopes grade smoothly into shallow inner banks similar to point bars, all with large TCN concentrations. Dimensional analysis suggests, and simulations confirm, relationships that can be tested in the field: cliffs form when bedrock lowering due to weathering is small relative to fluvial bedrock and weathering rate is small relative to fluvial transport capacity; for a given slope length, smaller rock-fall rates produce greater cliff heights; and greater fluvial transport capacity relative to sediment production by bedrock lowering produces thinner talus.

URL: http://www.geo.oregonstate.edu/~lancasts/

Final ID: EP44B-01

The role of probabilistic formulations of sediment transport aimed at describing the behavior of soil-mantled hillslopes over geomorphic timescales *(Invited)*

D. J. Furbish; [1]; *J. J. Roering;* [2];
1. Earth and Environmental Sciences, Vanderbilt University, Nashville, TN, United States.
2. Department of Geological Sciences, University of Oregon, Eugene, OR, United States.

Body: Recent discussions of local versus nonlocal sediment transport on hillslopes offer a lens for considering uncertainty in formulations of transport rates that are aimed at characterizing patchy, intermittent sediment motions in steeplands. Here we describe a general formulation for transport that is based on a convolution integral of the factors controlling the entrainment and disentrainment of sediment particles on a hillslope. In essence, such a formulation represents a 'flux' version of the Master equation, a general probabilistic (kinematic) formulation of mass conservation. As such, with the relevant physics invoked to represent entrainment and disentrainment, a nonlocal formulation quite happily accommodates local transport (and looks/behaves like a local formulation), as well as nonlocal transport, depending on the characteristic length scale of particle motions relative to the length scale at which the factors controlling particle transport are defined or measured. Nonetheless, nonlocal formulations of the sediment flux have mostly (but not entirely) outpaced experimental and field-based observations needed to inform the theory. At risk is bringing to bear a sophisticated mathematics that is not supported by our uncertain understanding of the processes involved. Experimental and field-based measurements of entrainment rates and particle travel distances are difficult to obtain, notably given the intermittency of many hillslope transport processes and the slow rates of change in hillslope morphology. A 'test' of a specific nonlocal formulation applied to hillslope evolution must therefore in part rest on consistency between measured hillslope configurations and predicted (i.e., modeled) hillslope configurations predicated on the proposed nonlocal formulation, assuming sufficient knowledge of initial and boundary conditions. On the other hand, because of its probabilistic basis, the formulation is in principle well suited to the task of describing transport relevant to geomorphic timescales — in view of the stochastic nature of the transport processes occurring over these timescales and the uncertainty of our understanding of the physics involved. Moreover, in its basic form, the nonlocal formulation of the sediment flux is such that appropriate physics can be readily embedded within it as we learn more. And, the formulation is space-time averaged in a way that accommodates discontinuous (patchy, intermittent) sediment motions.

Final ID: EP44B-02

Are grain packing and flow turbulence the keys to predicting bedload transport in steep streams? ***(Invited)***

E. Yager; [1]; *A. Monsalve Sepulveda;* [1]; *H. J. Smith;* [2]; *A. Badoux;* [3];
1. Civil Engineering, Center for Ecohydraulics Research, University of Idaho, Boise, ID, United States.
2. Water Resources, Center for Ecohydraulics Research, University of Idaho, Boise, ID, United States.
3. Swiss Federal Research Institute WSL , Birmensdorf, Switzerland.

Body: Bedload transport rates in steep mountain channels are often over-predicted by orders of magnitude, which has been attributed to a range of processes from grain jamming, roughness drag, changes in fluid turbulence and a limited upstream sediment supply. We hypothesize that such poor predictions occur in part because the grain-scale mechanics (turbulence, particle arrangements) of sediment transport are not well understood or incorporated into simplified reach-averaged calculations. To better quantify how turbulence impacts sediment movement, we measured detailed flow velocities and forces at the onset of motion of a single test grain with a fixed pocket geometry in laboratory flume experiments. Of all measured parameters (e.g. flow velocity, shear stress), the local fluid drag force had the highest statistical correlation with grain motion. Use of flow velocity or shear stress to estimate sediment transport may therefore result in erroneous predictions given their relatively low correlation to the onset of sediment motion.

To further understand the role of grain arrangement on bedload transport, we measured in situ grain resisting forces to motion (using a force sensor) for a range of grain sizes and patch classes in the Erlenbach torrent, Switzerland (10% gradient). Such forces varied by over two orders of magnitude for a given grain weight and were statistically greater than those calculated using empirical equations for the friction angle. In addition, when normalized by the grain weight, the resisting forces declined with higher grain protrusion above the surrounding bed sediment. Therefore, resisting forces from grain packing and interlocking are substantial and depend on the amount of grain burial. The onset of motion may be considerably under-estimated when calculated solely from measured grain sizes and friction angles. These packing forces may partly explain why critical Shields stresses are higher in steep channels.

Such flow and grain parameters also spatially vary in steep streams because of boulder steps and patches of different grain size distributions. To determine if this spatial variation is important for bedload transport, we incorporated probability density functions of flow turbulence and patch grain size distributions into a simple bedload transport equation. Predicted bedload fluxes were significantly improved when distributions of these parameters, rather than single reach-averaged values, were used.

Final ID: T44C-03

Quantifying landscape evolution response to changes in dynamic topography *(Invited)*

R. Moucha; [1]; *G. A. Ruetenik;* [1]; *J. Braun;* [2]; *F. Guillocheau;* [3]; *G. D. Hoke;* [1];

1. Department of Earth Sciences, Syracuse University, Syracuse, NY, United States.
2. Institut des Sciences de la Terre, Universite Joseph Fourier, Grenoble, France.
3. Geosciences Rennes, Universite de Rennes 1, Rennes, France.

Body: Earth’s topography is a convolution of complex interactions of the mantle, the crust and surface processes, where the latter are controlled by the dynamics of the atmosphere and sea level change. An outstanding problem in landscape evolution and continental dynamics is the delineation of mantle convective flow induced topography (termed dynamic topography) from the geological record. Therefore, to unravel this record, we need to first understand the complex landscape evolution response to long-term dynamic forcing from the mantle in a controlled study. Recent advances in landscape evolution modeling have overcome a previous limitation in spatial and temporal scales making modeling the effects of large-scale long-term features such as dynamic topography, possible. In this study, we utilize FastScape (Braun and Willett, 2013) to quantify the effect of changes in dynamic topography of Africa on landscape evolution and sediment supply to its margins. We utilize a novel iterative approach that uses backward in time advected models of dynamic topography as the initial drivers of uplift/subsidence in the landscape evolution model. Subsequently, with the margins’ sedimentary record acting as constraints we refine the changes in topography as a function of time. Our goal is to obtain a geodynamically and geologically consistent model of African topography throughout the late Cenozoic.

Final ID: EP44A-06

Feedbacks Between Topographic Stress and Drainage Basin Evolution

J. Perron; [1]; *S. J. Martel;* [2]; *K. Singha;* [3]; *M. I. Slim;* [1];

1. Department of Earth, Atmospheric & Planetary Sciences, MIT, Cambridge, MA, United States.
2. Department of Geology & Geophysics, University of Hawaii, Honolulu, HI, United States.
3. Hydrologic Science and Engineering Program, Colorado School of Mines, Golden, CO, United States.

Body: Theoretical calculations imply that stresses produced by gravity acting on topography may be large enough in some scenarios to fracture rock. Predicted stress fields beneath ridges and valleys can differ dramatically, which has led several authors to hypothesize feedbacks between topographic stress, rock fracture and landscape evolution. However, there have been few attempts to explore these feedbacks. We use a coupled model to identify possible feedbacks between topographic stress and drainage basin evolution. The domain is a cross-section of a valley consisting of a bedrock channel and adjacent soil-mantled hillslopes. The bedrock surface evolves due to channel incision, soil production, and rock uplift, and soil thickness evolves due to soil production and transport. Plane stresses at and below the bedrock surface are calculated with a boundary element method that accounts for both ambient tectonic stress and topographic stress. We assume that the stress field experienced by rock as it is exhumed influences the likelihood that it will develop fractures, which make the rock more susceptible to weathering, disaggregation and erosion. A measure of susceptibility to shear fracture, the most likely failure mode under regional compression, serves as a proxy for rock damage. We couple the landscape evolution model to the stress model by assuming that rock damage accelerates the rates of soil production and channel incision, with two endmember cases: rates scale with the magnitude of the damage proxy at the bedrock surface, or with cumulative damage acquired during rock exhumation. The stress-induced variations in soil production and channel incision alter the soil thickness and topography, which in turn alter the stress field.

Comparing model simulations with and without these feedbacks, we note several predicted consequences of topographic stress for drainage basin evolution. Rock damage is typically focused at or near the foot of hillslopes, which creates thicker soils near the valley bottom than near the ridgetop. This gradient in soil thickness is largest, and the thickest soil furthest downslope, if most rock damage is assumed to occur near the surface. Ambient tectonic stress also has a strong effect on hillslopes, with more compressive horizontal stress steepening the soil thickness gradient and displacing the thickest soil farther downslope. Rock damage in the valley bottom scales with valley depth, creating a positive feedback between relief and channel incision. This produces higher relief during transient channel incision, but steady-state relief is insensitive to stress effects because the positive feedback is limited by reduction of the channel slope. However, the fact that valleys are typically deepest in the middle of a drainage basin implies that channel profiles will be more concave if stresses enhance channel incision. Observational tests of these qualitative predictions will help evaluate the significance of suspected feedbacks between topographic stress and landscape evolution.

Final ID: EP44A-07

Crustal strength anisotropy influences landscape form and longevity

S. G. Roy; [1]; *P. O. Koons;* [1]; *P. Upton;* [2, 1]; *G. E. Tucker;* [3];
1. Earth and Climate Sciences, University of Maine, Orono, ME, United States.
2. GNS Science, Lower Hutt, New Zealand.
3. CIRES & Geological Sciences, UC Boulder, Boulder, CO, United States.

Body: Lithospheric deformation is increasingly recognized as integral to landscape evolution. Here we employ a coupled orogenic and landscape model to test the hypothesis that strain-induced crustal failure exerts the dominant control on rates and patterns of orogenic landscape evolution. We assume that erodibility is inversely proportional to cohesion for bedrock rivers host to bedload abrasion. Crustal failure can potentially reduce cohesion by several orders of magnitude along meter scale planar fault zones. The strain-induced cohesion field is generated by use of a strain softening upper crustal rheology in our orogenic model. Based on the results of our coupled model, we predict that topographic anisotropy found in natural orogens is largely a consequence of strain-induced anisotropy in the near surface strength field. The lifespan and geometry of mountain ranges are strongly sensitive to 1) the acute division in erodibility values between the damaged fault zones and the surrounding intact rock and 2) the fault zone orientations for a given tectonic regime. The large division in erodibility between damaged and intact rock combined with the dependence on fault zone orientation provides a spectrum of rates at which a landscape will respond to tectonic or climatic perturbations. Knickpoint migration is about an order of magnitude faster along the exposed cores of fault zones when compared to rates in intact rock, and migration rate increases with fault dip. The contrast in relative erosion rate confines much of the early stage fluvial erosion and establishes a major drainage network that reflects the orientations of exposed fault zones. Slower erosion into the surrounding intact rock typically creates small tributaries that link orthogonally to the structurally confined channels. The large divide in fluvial erosion rate permits the long term persistence of the tectonic signal in the landscape and partly contributes to orogen longevity. Landscape morphology and channel tortuosity together provide critical information on the orientation and spatial distribution of fault damage and the relevant tectonic regime. Our landscape evolution models express similar mechanisms and produce drainage network patterns analogous to those seen in the Southern Alps of New Zealand and the Himalayan Eastern Syntaxis, both centers of active lithospheric deformation.

Final ID: EP44A-08

Linking Earth and Atmosphere at Higher Frequencies with the Failure Earth Response Model ***(Invited)***

P. O. Koons; [1]; *P. Upton;* [2, 1]; *S. G. Roy;* [1]; *G. E. Tucker;* [3];
1. Univ Maine, Orono, ME, United States.
2. GNS Science, Lower Hutt, New Zealand.
3. CIRES & Geological Science, Univ. Colorado, Boulder, CO, United States.

Body: Feedback among atmospheric and silicate circulation systems is dominated at the macroscale by advection/rheological relationships that influence whole lithosphere and that are relatively well characterized by current tectonic/landscape theory. At the meso- and micro-scales of faults, rivers, glaciers and coasts, however, cooperation in the coupled silicate/atmospheric system is obscured in standard landscape theory by inconsistencies inherent in the employment of multiple Earth response laws, in which the Earth model used depends on the ambient surface process regime. Here we introduce an alternative formulation for coupled tectonic and landscape evolution that unifies the description of the silicate Earth response to both tectonic and geomorphic forcings within a single framework: the Failure Earth Response Model (FERM). FERM is constructed on the two, basic assumptions about the three-dimensional stress state and rheological memory:

I.)Material displacement, whether tectonic or geomorphic in origin, at or below Earth's surface, is driven by local forces overcoming local resistance, and

II.) Large displacements, whether tectonic or geomorphic in origin, irreversibly alter Earth material properties enhancing a long term strain memory mapped into the topography.

In addition to the gathering of stresses generated by far field tectonic processes, topography and the inertial surface processes into a single stress state for every point, FERM allows explicit consideration of the contributions to the evolving landscape of pore pressure fluctuations, seismic accelerations, and fault damage. Incorporation of these in the FERM model leads to highly heterogeneous and anisotropic stress and strength patterns, largely predictable from knowledge of mantle kinematics, that strongly couple with landscape evolution at the meso- and micro- scales. Here we focus on the FERM description of knickpoint migration to illustrate the high frequency cooperation among tectonic, slope, and fluvial processes in the evolution of actively deforming orogens.

Final ID: EP44B-08

Tracer waiting times and the steady-state evolution of a granular bed

R. L. Martin; [1, 2]; *P. K. Purohit;* [3]; *D. J. Jerolmack;* [2];
1. Atmospheric and Oceanic Sciences, University of California, Los Angeles, Los Angeles, CA, United States.
2. Earth and Environmental Science, University of Pennsylvania, Philadelphia, PA, United States.
3. Mechanical Engineering and Applied Mechanics, University of Pennsylvania, Philadelphia, PA, United States.

Body: In bed load sediment transport, particles follow trajectories that alternate between motion and rest. Knowing the distribution of waiting times – the durations of particles in the resting phase – is vital for relating particle tracer studies to bulk sediment motion and bed evolution. Here, we report on laboratory experiments to determine the origin of the tracer waiting time distribution. In the experiments, we tracked the evolution of a bed of glass spheres, contained within a confined (two-dimensional) channel, that were driven by a steady fluid stress and particle flux. We show that the granular bed evolution resembles an Ornstein-Uhlenbeck (O-U) process; i.e. an advection-diffusion process with tendency to revert to a central value. Monte-Carlo simulations of the O-U process yield bed surface return times that closely follow the power-law bed particle waiting time distribution. The O-U process is determined by two parameters. The diffusion parameter increases linearly with particle flux, while the advection parameter is roughly constant for all experiments in our system.

Final ID: H51G-1284

Hydrogeophysical Cyberinfrastructure For Real-Time Interactive Browser Controlled Monitoring Of Near Surface Hydrology: Results Of A 13 Month Monitoring Effort At The Hanford 300 Area

R. J. Versteeg; [1]; *T. Johnson;* [2]; *A. Henrie;* [1]; *D. Johnson;* [1];

1. Subsurface Insights, Hanover, NH, United States.
2. Pacific Northwest National Laboratory, Richland, WA, United States.

Body: The Hanford 300 Area, located adjacent to the Columbia River in south-central Washington, USA, is the site of former research and uranium fuel rod fabrication facilities. Waste disposal practices at the site included discharging between 33 and 59 metric tons of uranium over a 40 year period into shallow infiltration galleries, resulting in persistent uranium contamination within the vadose and saturated zones. Uranium transport from the vadose zone to the saturated zone is intimately linked with water table fluctuations and river water driven by upstream dam operations.

Different remedial efforts have occurred at the site to address uranium contamination. Numerous investigations are occurring at the site, both to investigate remedial performance and to increase the understanding of uranium dynamics. Several of these studies include acquisition of large hydrological and time lapse electrical geophysical data sets.

Such datasets contain large amounts of information on hydrological processes. There are substantial challenges in how to effectively deal with the data volumes of such datasets, how to process such datasets and how to provide users with the ability to effectively access and synergize the hydrological information contained in raw and processed data. These challenges motivated the development of a cloud based cyberinfrastructure for dealing with large electrical hydrogeophysical datasets. This cyberinfrastructure is modular and extensible and includes datamanagement, data processing, visualization and result mining capabilities. Specifically, it provides for data transmission to a central server, data parsing in a relational database and processing of the data using a PNNL developed parallel inversion code on either dedicated or commodity compute clusters. Access to results is done through a browser with interactive tools allowing for generation of on demand visualization of the inversion results as well as interactive data mining and statistical calculation.

This infrastructure was used for the acquisition and processing of an electrical geophysical timelapse survey which was collected over a highly instrumented field site in the Hanford 300 Area. Over a 13 month period between November 2011 and December 2012 1823 timelapse datasets were collected (roughly 5 datasets a day for a total of 23 million individual measurements) on three parallel resistivity lines of 30 m each with 0.5 meter electrode spacing. In addition, hydrological and environmental data were collected from dedicated and general purpose sensors.

This dataset contains rich information on near surface processes on a range of different spatial and temporal scales (ranging from hourly to seasonal). We will show how this cyberinfrastructure was used to manage and process this dataset and how the cyberinfrastructure can be used to access, mine and visualize the resulting data and information.

URL: http://www.subsurfaceinsights.com

Final ID: B51H-0403

Characterization of an Active Thermal Erosion Site, Caribou Creek, Alaska

R. Busey; [1]; *W. R. Bolton;* [1]; *J. E. Cherry;* [1]; *L. D. Hinzman;* [1];
1. Univ Alaska, Fairbanks, AK, United States.

Body: The goal of this project is to estimate volume loss of soil over time from this site, provide parameterizations on erodibility of ice rich permafrost and serve as a baseline for future landscape evolution simulations.

Located in the zone of discontinuous permafrost, the interior region of Alaska (USA) is home to a large quantity of warm, unstable permafrost that is both high in ice content and has soil temperatures near the freezing point. Much of this permafrost maintains a frozen state despite the general warming air temperature trend in the region due to the presence of a thick insulating organic mat and a dense root network in the upper sub-surface of the soil column. At a rapidly evolving thermo-erosion site, located within the Caribou-Poker Creeks Research Watershed (part of the Bonanza Creek LTER) near Chatanika, Alaska (N65.140, W147.570), the protective organic layer and associated plants were disturbed by an adjacent traditional use trail and the shifting of a groundwater spring. These triggers have led to rapid geomorphological change on the landscape as the soil thaws and sediment is transported into the creek at the valley bottom. Since 2006 (approximately the time of initiation), the thermal erosion has grown to 170 meters length, 3 meters max depth, and 15 meters maximum width. This research combines several data sets: DGPS survey, imagery from an extremely low altitude pole-based remote sensing (3 to 5 meters above ground level), and imagery from an Unmanned Aerial System (UAS) at about 60m altitude.

Final ID: EP51A-0696

Modeling bed material transport through colonial-age mill dam impoundments, northern Delaware

A. Pearson; [1]; *J. E. Pizzuto;* [1];
1. Geological Sciences, University of Delaware, Newark, DE, United States.

Body: Two hundred –year old colonial mill dam impoundments of the White Clay and Red Clay Creeks in northern Delaware are barely 20% “filled” with sediment. Field evidence suggests that gravel-sized bed material supplied from upstream is able to pass through these impoundments, implying that the impoundment morphology has reached an equilibrium morphology controlled by the prevailing hydraulic regime. We assess this hypothesis using backwater modeling to compute local boundary shear stresses and the Wilcock-Crowe sediment transport equation to determine bed material transport rates in a representative impoundment with a ~ 2 m high dam and a 1.5 km-long impoundment. While previous conceptual models suggest that cobbles could only be transported through impoundments during catastrophic storm events or after impoundments had completely filled, our analysis demonstrates that transport rates of cobbles during the 2 year flow are significant. Even smaller discharges can be effective: the 0.5 year discharge moves coarse-grained bed material (11.2 – 32 mm) at moderate rates outside the impoundment and at low rates within the impoundment, suggesting net accumulation. Larger flows (5-25 year) transport material at similar rates both outside and within the impoundment. Averaged over time, this regime would keep the bed of the stream in quasi-equilibrium, with lower flows filling the impoundment and higher flows removing the accumulated sediment. This behavior is reminiscent of the response and recovery cycle described for quasi-equilibrium stream channels, suggesting that these impounded channels behave as graded streams with a reduced slope rather than as stagnant quasi-lacustrine systems incapable of transporting the sediment supplied from upstream. The current morphology (only 20% filled by sand and gravel) may not have existed in the past. Cores from floodplains adjacent to the impoundments reveal deposits of laminated mud suggesting a former fine-grained impoundment fill that has subsequently been eroded. Changes in land use and spillway operation have likely altered the discharge regime, sediment supply, and hydraulics of the impoundment, creating a different impoundment morphology. Our study suggests that the morphology of impoundment streams adjusts through time to achieve a quasi-equilibrium morphology controlled by the prevailing sediment supply and hydraulic regime.

Final ID: EP51A-0698

Three dimensional numerical modeling of Hydrodynamics and sediment transport in the Mississippi River Diversion at West Bay

K. M. Sadid; [1]; *E. A. Meselhe;* [1]; *B. Roth;* [1]; *M. A. Allison;* [1];
1. The Water Institute of the Gulf, Baton Rouge, LA, United States.

Body: The coastal wetlands of Louisiana have been experiencing high rates of land subsidence and erosion for decades. Anthropogenic alterations to the hydrology and geology, powerful hurricanes, and relative sea level rise have caused major coastal land loss in Louisiana. After years of research and discussions, the use of sediment diversions from the Mississippi River to adjacent embayment areas were proposed and further authorized as a solution for land building. To this end, the West Bay diversion (WBD) was constructed in 2003 to restore approximately 9,831 acres of wetlands in the West Bay area under the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA). The WBD is located along the right-descending bank of the Mississippi River south of Venice, LA near River Mile (RM) 4.7. The initial size of the channel post-construction was designed to convey 20,000 cubic feet per second (cfs), and over time it was anticipated to support a maximum of 50,000 cfs. This sediment diversion provides an opportunity to examine and analyze the impact of such diversion on the morphology of the river channel, and the retention characteristics and rate of delta growth in the receiving basin. Additionally, the WBD serve as analogue to fully validate morphologic models that could consequently be used to model proposed land building sediment diversions in the Lower Mississippi River.

In this study a three-dimensional numerical model is developed for the WBD which includes the main channel of the Mississippi River as well as the receiving basin. The model is being calibrated and validated for hydrodynamics and morphology using detailed field observations. Since 2003 regular monitoring has taken place as per the CWPPRA project guidelines. This includes bathymetric surveys of the receiving basin from 2002 (pre-construction), 2003, 2006, and 2009. A recent monitoring survey has been completed and will be available in the near future. In addition to this monitoring data, the U.S. Army Corps of Engineers (USACE) has conducted a study of the diversion to assess the impact on sedimentation within the Pilottown Anchorage Area and the navigation channel.

This model will provide quantitative information regarding the sediment load and size distribution diverted through the WBD and deposited in the receiving basin, as well as that deposited within river channel. Further, the WBD model will provide great insights on the morphological response of the river and the receiving basin to such diversions. The validated WBD model will help to establish the appropriate parameterizations for other Delft3D models that will analyze and predict the morphological development within the receiving basins of the proposed diversions located along the lower Mississippi River. These models will be used not only to assess the performance of individual diversions, but also to evaluate the effects of multiple diversions operating simultaneously along the River.

Keywords: Three Dimensional Numerical Modeling, West Bay, Sediment Diversions, Lower Mississippi River, Delft3D

Final ID: EP51A-0700

Modeling mud flocculation using variable collision and breakup efficiencies

K. Strom; [1]; *A. Keyvani;* [1];
1. University of Houston, Houston, TX, United States.

Body: Solution of the Winterwerp (1998) floc growth and breakup equation yields time dependent median floc size as an outcome of collision driven floc growth and shear induced floc breakage. The formulation is quite nice in that it is an ODE that yields fast solution for median floc size and can be incorporated into sediment transport models. The Winterwerp (1998) floc size equation was used to model floc growth and breakup data from laboratory experiments conducted under both constant and variable turbulent shear rate (Keyvani 2013). The data showed that floc growth rate starts out very high and then reduces with size to asymptotically approach an equilibrium size. In modeling the data, the Winterwerp (1998) model and the Son and Hsu (2008) variant were found to be able to capture the initial fast growth phase and the equilibrium state, but were not able to well capture the slow growing phase. This resulted in flocs reaching the equilibrium state in the models much faster than the experimental data. The objective of this work was to improve the ability of the general Winterwerp (1998) formulation to better capture the slow growth phase and more accurately predict the time to equilibrium. To do this, a full parameter sensitivity analysis was conducted using the Winterwerp (1998) model. Several modifications were tested, including the variable fractal dimension and yield strength extensions of Son and Hsu (2008, 2009). The best match with the in-house data, and data from the literature, was achieved using floc collision and breakup efficiency coefficients that decrease with floc size. The net result of the decrease in both of these coefficients is that floc growth slows without modification to the equilibrium size. Inclusion of these new functions allows for substantial improvement in modeling the growth phase of flocs in both steady and variable turbulence conditions. The improvement is particularly noticeable when modeling continual growth in a decaying turbulence field similar to what might be experienced in a river mouth jet. Inclusion of the functions does, however, result in problems with capturing rapid floc breakage due to a stepwise increase in turbulent shear.

References

Keyvani, A. (2013). Flocculation processes in river mouth fluvial to marine transitions. Ph.D. dissertation, University of Houston.

Son, M. & Hsu, T.J. (2008). Flocculation model of cohesive sediment using variable fractal dimension. Environmental Fluid Mechanics, 8(1), 55-71.

Son, M. & Hsu, T.J. (2009). The effect of variable yield strength and variable fractal dimension on flocculation of cohesive sediment. Water Research, 43(14), 3582 - 3592.

Winterwerp, J. C. (1998). A simple model for turbulence induced flocculation of cohesive sediment. Journal of Hydraulic Research, 36(3), 309-326.

Final ID: EP51A-0704

A probabilistic sediment cascade model of sediment transfer through a mountain basin.

G. L. Bennett; [1]; *P. Molnar;* [2]; *B. W. McArdell;* [3]; *S. N. Lane;* [4]; *P. Burlando;* [2];
1. University of Oregon, Eugene, OR, United States.
2. ETH Zurich, Zurich, Switzerland.
3. Swiss Federal Institute of Forest, Snow and Landscape Research, Birmensdorf, Switzerland.
4. Univerisity of Lausanne, Lausanne, Switzerland.

Body: Mountain basin sediment discharge poses a significant hazard to the downstream population, particularly in the form of debris flows. The importance and sensitivity of snow and ice melt processes in mountain basins along with their rapid rainfall-runoff response makes mountain basin sediment discharge particularly responsive to climate change. It is important to understand and model sediment transfer through mountain basins to be able to predict sediment discharge under a changing climate. We developed a probabilistic sediment cascade model, SedCas, to simulate sediment transfer in a mountain basin (Illgraben, Switzerland) where sediment is produced by hillslope landslides and exported out of the basin by debris flows and floods. We present the model setup, the calibration of the model for the period 2000 – 2009 and the application of SedCas to model sediment discharge in the Illgraben over the 19th and 20th centuries.

SedCas conceptualizes the fluvial system as a spatially lumped cascade of connected reservoirs representing hillslope and channel storages where sediment goes through multiple cycles of storage and remobilization by surface runoff. Sediment input is drawn from a probability distribution of slope failures produced for the basin from a time series of DEMs and the model is driven by observed climate. The model includes all relevant hydrological processes that lead to runoff in an Alpine basin, such as snow cover accumulation, snowmelt, evapotranspiration, and soil water storage. Although the processes of sediment transfer and debris flow generation are described in a simplified manner, SedCas produces highly complex sediment discharge behavior which is driven by the availability of sediment and antecedent moisture (system memory) as well as triggering potential (climate).

The model reproduces the first order properties of observed debris flows over the period 2000-2009 including their probability distribution, seasonal timing and probability of occurrence for a given rainfall event magnitude. Experiments with different sediment input procedures suggest that the stochastic element of sediment input is important to reproduce realistic sediment storage and ultimately the distribution of sediment discharge. Sediment supply plays a key role in simulated sediment discharge events, limiting their occurrence and sediment concentrations. The model allows us to explicitly quantify this division into transport and supply-limited events (debris flows, debris floods and floods). SedCas demonstrates the importance of considering antecedent moisture and sediment storage as well as climatic triggering for debris flow prediction.

The reproduction of observations of landslide and debris flow frequency in the Illgraben and wider European Alps over the 19th and 20th centuries further suggests that the model captures the main processes of sediment transfer in the Illgraben. Although this application was developed for the Illgraben we believe the findings have general implications for fluvial systems that can be schematized into sediment cascades and where the supply of sediment and triggering of events is largely stochastic. Additionally, the parsimonious nature of the model enables it to be used for climate impact assessments in the future.

Final ID: EP51B-0711

Estimation of Daily Stream Temperatures in a Mountain River Network

M. Sohrabi; [1]; *R. M. Benjankar;* [1]; *D. Isaak;* [2]; *S. Wenger;* [2]; *D. Tonina;* [1];
1. Center for Ecohydraulics Research, University of Idaho, Boise, ID, United States.
2. Rocky Mountain Research Station, U.S. Forest Service, Boise, ID, United States.

Body: Stream temperature plays an important role in aquatic ecosystems. Concentrations of dissolved oxygen, water and spawning habitat quality, growth of fish populations are functions of stream temperature. Therefore, accurate estimates of daily stream temperatures can provide beneficial information for water resource managers and decision makers. Here, we develop a model for precise daily water temperature estimates that is applicable even in places lacking various meteorological and hydrological data. The water temperature model in this study is a piecewise model that considers both linear and non-linear relationships between dependent and independent variables including maximum and minimum temperature (meteorological derivers) and precipitation (hydrological deriver). We demonstrated the model in the Boise River Basin, in central Idaho, USA. The hydrology of this basin is snow-dominated and complex due to the mountainous terrain. We predicted daily stream temperature at 34 sites using 12 weather and Snowtel stations for deriving variables. Results of the stream temperature model indicate average Root Mean Square Error of 1.28 degree of Celsius along with average 0.91 of Nash-Sutcliffe coefficient for all stations. Comparison of the results of this study to Mohseni et al.'s model (1998), which is widely applied in water temperature studies, shows better performance of the model presented in this study. Our approach can be used to provide historical reconstructions of daily stream temperatures or projections of stream temperatures under climate change scenarios in any location with at least one year of daily stream temperature observations and with contemporaneous regional air temperature and precipitation data.

Final ID: H51F-1266

Soil temperature and water dynamics on contrasting aspects in the rain-snow transition zone

T. E. Link; [1]; *M. S. Seyfried;* [2]; *S. Bryden;* [1]; *J. P. McNamara;* [3]; *P. Z. Klos;* [1];
1. University of Idaho, Moscow, ID, United States.
2. ARS Northwest Watershed Research Center, Boise, ID, United States.
3. Boise State University, Boise, ID, United States.

Body: Understanding how complex terrain affects ecohydrological and biogeochemical processes in the critical zone has become increasingly important as the global climate changes. Soils modulate both fluxes and are therefore central to this understanding. We are particularly interested in soil temperature and water content because they exert strong controls on hydrologic and biogeochemical fluxes and ecological processes. We measured soil water (θ) and temperature (Ts) profiles at three paired locations in mountainous, complex terrain in SW Idaho, USA (~43°latitude). Each pair consisted of a soil profile of temperature and water content from a depth of 5 cm to bedrock (50 to 110 cm) on opposing north and south facing slopes at the same elevation. The sites are located near the rain/snow transition elevation for the area (1600 m) on steep slopes (25 to 40°) with sparse vegetative cover. We measured dramatic differences between the two slopes, with a difference of 9°C (at 50 cm) in August. Differences between slopes were smaller in winter, about 4° C. The Ts difference between two opposing slopes at identical elevations that we measured is practically the same as the difference between Ts measured on nearly level ground but separated by 1000 m in elevation. This implies that we need to consider two snowmelt seasons within a given watershed based on aspect. We expected θ on north facing soils to decline more slowly and later in the year the south facing soils due to the evaporative demand differential. We did not observe this and, in fact, θ on the two slopes responded similarly during spring and early summer. This is attributed to two factors. First, spring rains were sufficient to maintain relatively high soil water storage on both slopes. Second, the denser vegetative cover on the north-facing slopes counters the lesser evaporative demand. Results suggest that as climate warms, south facing slopes will be the first to transition from a five hydrologic season system characterized by a seasonal dry, transitional wetting, wet low-flux, wet high flux, and transitional drying to a four phase system lacking the wet low-flux phase. Collection of detailed datasets such as this can be used to elucidate important 3-dimensional variations in critical zone patterns and processes in complex terrain.

Final ID: H51G-1276

Conversion of Highly Complex Faulted Hydrostratigraphic Architectures into MODFLOW Grid for Groundwater Modeling

H. V. Pham; [1]; *F. T. Tsai;* [1];
1. Civil and Environmental Engineering, Louisiana State University, Baton Rouge, LA, United States.

Body: The USGS MODFLOW is widely used for groundwater modeling. Because of using structured grid, all layers have to be continuous throughout the model domain. This makes it difficult to generate computational grid for complex hydrostratigraphic architectures including thin and discontinuous layers, interconnections of sand units, pinch-outs, and faults. In this study, we present a technique for automatically generating MODFLOW grid for complex aquifer systems of strongly sand-clay binary heterogeneity.

To do so, an indicator geostatistical method is adopted to interpolate sand and clay distributions in a gridded two-dimensional plane along the structural dip for every one-foot vertical interval. A three-dimensional gridded binary geological architecture is reconstructed by assembling all two-dimensional planes. Then, the geological architecture is converted to MODFLOW computational grid by the procedures as follows. First, we determine bed boundary elevation of sand and clay units for each vertical column. Then, we determine the total number of bed boundaries for a vertical column by projecting the bed boundaries of its adjacent four vertical columns to the column. This step is of importance to preserve flow pathways, especially for narrow connections between sand units. Finally, we determine the number of MODFLOW layers and assign layer indices to bed boundaries. A MATLAB code was developed to implement the technique. The inputs for the code are bed boundary data from well logs, a structural dip, minimal layer thickness, and the number of layers. The outputs are MODFLOW grid of sand and clay indicators. The technique is able to generate grid that preserves fault features in the geological architecture. Moreover, the code is very efficient for regenerating MODFLOW grid with different grid resolutions.

The technique was applied to MODFLOW grid generation for the fluvial aquifer system in Baton Rouge, Louisiana. The study area consists of the “1,200-foot” sand, the “1,500-foot” sand, the “1,700-foot” sand, and the “2,000-foot” sand and includes the east-west trending Baton Rouge fault and Denham Springs-Scotlandville fault. 288 electric well logs in East and West Baton Rouge Parishes were analyzed to construct the aquifer system, which was discretized into 93 rows, 137 columns and 76 layers of MODFLOW grid. Each computation cell has a size of 200 m by 200 m. The cell thickness varies from 3.0 m to 12.8 m. The constructed grid was used to develop a regional groundwater model that includes the “1,200-foot”, “1,500-foot”, and “1,700-foot” sands and the two faults. A parallel version of CMA-ES was developed in high performance computing to calibrate the complicated groundwater model and estimate model parameters.

The result of the case study demonstrates the capability of the technique that exactly converts complex hydrostratigraphic architectures including faults into MODFLOW grid. The code ensures that all narrow sand connections including those through the faults are preserved. Using the complex grid, the error of groundwater model structure can be significantly reduced.

Final ID: H51K-1347

Investigating Snowmelt Infiltration Dynamics in the Western U.S. Using the SNOTEL Network

A. A. Harpold; [1]; *N. P. Molotch;* [1];
1. University of Colorado, Boulder, CO, United States.

Body: The melt of seasonal snowpacks from mountainous regions is critical to maintaining ecosystem services and managing downstream water resources in the Western U.S. Climate models predict warming temperatures will decrease growing season water availability by increasing the ratio of rain to snow and advancing the timing of snowmelt. These changes in precipitation and snowmelt will likely alter the timing and magnitude of soil water storage. Thus, this study evaluates the sensitivity of the timing and magnitude of peak soil moisture (SM) to variability in snowmelt timing. Data from 260 Snow Telemetry (SNOTEL) stations, where snow water equivalent (SWE) and SM were both measured, were used to explore these sensitivities. The majority (51%) of the 2348 station-years had peak SM preceding snowpack disappearance by >7 days, 19% had peak moisture trailing snowpack disappearance by >7 days, and 30% had peak SM within 7 days of snowpack disappearance. Stations with average snow seasons lasting after May 15 had significantly ($p<0.05$) shorter lag times between peak SM and snow disappearance, as compared to stations with snow seasons ending before May 15 (5.5 days and 23.5 days prior to snow disappearance, respectively). There were also clear differences in the snowmelt infiltration regimes between eight hydroclimatic regions identified. For example, peak SM preceded snow disappearance by an average of 33 days in the Cascade Mountains and lagged an average of 2 days in the Northern Rocky Mountains. The potential for colder, high elevation sites in the Rocky Mountains to shift towards a peak SM regime occurring prior to snow disappearance (typical of the Cascade Mountains) could have implications for the partitioning of water (e.g. runoff versus ET) and energy (e.g. latent versus sensible) at the land-surface.

Final ID: H51S-01

Diagnosing scaling behavior of groundwater with a fully-integrated, high resolution hydrologic model simulated over the continental US *(Invited)*

R. M. Maxwell;[1]; *L. E. Condon;*[1]; *S. J. Kollet;*[2];
1. Colorado School of Mines, Golden , CO, United States.
2. FZ-Jülich, Jülich, Germany.

Body: Groundwater is an important component of the hydrologic cycle yet its importance is often overlooked. Aquifers are a critical water resource, particularly in irrigation, but also participates in moderating the land-energy balance over the so-called critical zone of 2-10m in water table depth. Yet,the scaling behavior of groundwater is not well known. Here, we present the results of a fully-integrated hydrologic model run over a 6.3M km2 domain that covers much of North America focused on the continental United States. This model encompasses both the Mississippi and Colorado River watersheds in their entirety at 1km resolution and is constructed using the fully-integrated groundwater-vadose zone-surface water-land surface model, ParFlow. Results from this work are compared to observations (both of surface water flow and groundwater depths) and approaches are presented for observing of these integrated systems. Furthermore, results are used to understand the scaling behavior of groundwater over the continent at high resolution. Implications for understanding dominant hydrological processes at large scales will be discussed.

Final ID: IN51C-01

Decision Support for Active Water Management *(Invited)*

D. R. Maidment; [1]; *F. Salas;* [1]; *B. S. Minsker;* [2];
1. Center for Research in Water Resources, University of Texas, Austin, TX, United States.
2. Dept of Civil Engineering, University of Illinois, Urbana, IL, United States.

Body: Active water management refers to real-time adjustment of water management decisions based on observation and modeling of current water conditions. A case study is presented of a decision-support system for active water management in the San Antonio and Guadalupe basins using web services and cloud computing to create at the University of Texas a repository of observations, forecasts and model simulations from federal, state and regional water agencies and academia. Each day, National Weather Service river flow forecasts at 47 points in the basin are densified to create corresponding flows in 5500 river reaches using the RAPID river flow model operated in "Model as a Service" mode at the University of Illinois. These flows are adjusted by using the "Declarations of Intent" to pump water compiled by the Texas Commission for Environmental Quality which is the WaterMaster for all surface water withdrawals in the basin. The results are viewed through web maps that convey both maps of the spatial pattern of flow at a particular point in time, and charts of time series of flows at particular points in space.

Final ID: P51D-1756

Simulating Fine grained Alluvial Fan Sedimentation on Mars

A. M. Morgan; [1]; *A. D. Howard;* [1]; *J. M. Moore;* [2]; *R. A. Beyer;* [2];

1. Dept. of Environmental Sciences, University of Virginia Main Campus, Charlottesville, VA, United States.
2. NASA Ames Research Center, Moffett Field, CA, United States.

Body: The alluvial fans on Mars date to as late as the Hesperian Period and may be representative of the last major episode of widespread fluvial modification to the red planet's surface. These fans lie within enclosed crater basins, and are characterized by their large size (tens of km in length) and gentle gradient (less than 1-3°). The fans generally feature a network of channel distributaries floored with coarser sediment and what we have interpreted to be fine grained overbank deposits that comprise the bulk of the fan material [1].

We have developed a landform evolution model based on the approach of [2] to simulate the growth of these fans in order to answer several questions about their formation, including: (1) what are the characteristics of water discharge (flow magnitude and duration) and sediment supply (quantity and grain size); and (2) what are the associated implications for the responsible climatic environment (e.g. amount and frequency of precipitation sourcing the fans).

The model combines discharge and sediment deposition with channel avulsion and abandonment, allowing for an analysis of both the micro and macro scale processes concerning fan formation. Water and sediment is routed through a distributary network that can branch, recombine, and avulse. The model simulates deposition of both coarse-grained bedload and a fine-grained suspended load material that can be deposited overbank during flood events. The model records the stratigraphy of the deposited material in terms of the relative proportions of coarse and fine-grained sediment.

Using measures such as channel width, relative proportions of channel versus overbank deposited sediment, and frequency of channel branching, output is statistically compared with digital elevation models that have been produced from high-resolution CTX and HiRISE stereo pairs.

Initial results suggest fans formed from hundreds of flow events over many thousands of years. Fan formation processes appear to be similar to those active in terrestrial fans in northern Chile's Atacama Desert. Additional model runs will simulate fan development under different patterns of precipitation (uniform over the fan versus an orographic pattern of greater precipitation on upper crater walls) and variations in sediment size distribution.

References: [1] Morgan, A. M., Howard, A. D., Hobley, D. E. J., Moore, J. M., Dietrich, W. E., Williams, R. M. E., Burr, D. M., Grant, J. A., Wilson, S. A., and Matsubara, Y. (in review) Sedimentology and Climatic Environment of Alluvial Fans in the Martian Saheki Crater and a Comparison with Terrestrial Fans in the Atacama Desert [2] Sun, T., C. Paola, G. Parker, and P. Meakin (2002), Water Resour. Res., 38, no.8, 10.

URL: http://alexmorgan.us/agu2013/

Final ID: T51B-2460

Subsurface Evidence for Late Mesozoic Extension in Western Mongolia: Tectonic and Petroleum Systems Implications

C. L. Johnson; [1]; *K. Constenius;* [2]; *A. Payton;* [2]; *S. A. Graham;* [3]; *G. N. Mackey;* [1];
1. Univ of Utah, Salt Lake City, UT, United States.
2. Consultant, Tucson, AZ, United States.
3. Stanford University, Stanford, CA, United States.

Body: The late Mesozoic extensional province of eastern China and Mongolia continued west into the Gobi Altai region of western Mongolia, based on new seismic data, core evaluation, and recent outcrop studies. New seismic reflection profiles from the Tugrug basin of western Mongolia (petroleum block 5) demonstrate the existence of preserved late Mesozoic extensional basins by imaging listric normal faults, syn-rift growth strata, and partially inverted grabens. Several new core holes from this region include one core of ~1600 continuous meters of Upper Jurassic – Lower Cretaceous (Kimmeridgian-Berriasian) syn-rift and Tertiary post-rift strata overlying Late Triassic volcanic basement. The cored stratigraphic section is dominated by lacustrine and marginal lacustrine deposition ranging from stratified lacustrine to subaqueous fan and delta to subaerial alluvial-fluvial environments. These units are located on the flexural margin of a partially inverted graben with a strongly folded and reactivated master listric normal fault. Strike-slip faulting certainly postdates extension as documented by late Cenozoic transpression, however late Mesozoic basins may also have experienced a transtensional component. Prospective petroleum source and reservoir intervals are documented, as well as multiple unconformities representing pre-, syn- and post-rift basin evolution. Ties to correlative outcrop sections underscore that in general, this basin appears to share a similar tectono-stratigraphic evolution with other petroliferous basins in eastern Mongolia and China. Nevertheless, some interesting apparent contrasts to these other basins are noted, including comparatively high source rock maturity, distinct sandstone provenance, and younger (Cenozoic) inversion structures. The Tugrug basin and related areas in the Gobi Altai occupy an important paleogeographic position between late Mesozoic contractile and extensional provinces, and could represent an accommodation zone, perhaps with a Mesozoic strike-slip component, and/or a rapid temporal shift from orogenic thickening to gravitational collapse in the Late Jurassic. Key conventional petroleum systems components are documented, particularly source and reservoir facies and the likelihood of thermal maturity, with implications for future exploration in the region.

Final ID: V51D-2704

Numerical investigation of the morphological transition of submarine lava flow due to slope change

E. Choi; [1]; *M. Tominaga;* [2]; *M. G. Baker;* [2]; *D. May;* [3]; *E. Fujita;* [4]; *T. Kozono;* [4];

1. Center for Earthquake Research and Information, University of Memphis, Memphis, TN, United States.
2. Dept. of Geological Sciences, Michigan State University, East Lansing, MI, United States.
3. NIED, Tsukuba, Japan.
4. Department of Earth Sciences, ETH Zürich, Zürich, Switzerland.

Body: We numerically investigate the effects of variations in slope angle on the morphological transition of submarine lava flow. GALE, an open-source code for long-term geodynamic modeling, has been adapted to submarine lava flow simulations. Using the adapted GALE, we first numerically reproduce pillow lavas as accumulated tubular flows, the dominant formation process observed in nature. We then test whether an increase in slope angle causes the sheet-to-pillow transition. This specific morphological transition has been observed while the existing theory and analogue models for lava flow morphology predict the opposite. The combined effects of a slope angle change and other lava source parameters (e.g., effusion rate) on lava morphology are also modeled. Finally, the model results and performance of the adapted GALE are benchmarked against LavaSIM, a mature code with a track record in lava flow simulations as well as pTatin3d, a finite element marker-and-cell based library developed for studying large deformation processes of very viscous fluids.

Final ID: OS51C-02

The Dynamic Watershed and the Coastal Ocean: Biogeochemical Linkages and Interannual Variability

E. Olhsson; [1]; *T. M. Powell;* [1];
1. University of California Berkeley, Berkeley, CA, United States.

Body: What is the fate of riverine nutrients in the coastal ocean? To what extent does the timing and magnitude of river discharge influence coastal primary productivity? What mechanisms link biological variability to changes within a given watershed? And how might climate change alter these relationships? To test the advantages of using regional scale model coupling to explore these questions, an example river was selected for study: the Eel River.

The Eel River discharges into the North Pacific at 40° 38.5' in Northern California. Its annual discharge (~200 m3/s) is about 1% that of the Mississippi, but its sediment yield (15 million tons/yr) is the highest for its drainage area (9500 km2) in the entire continental US. It is an advantageous choice for a test case to model because its annual behavior is dramatic and potentially very sensitive to changes in climate. Driven by the Mediterranean climate of northern California, it is characterized by low flow during the long dry season. Then, each winter and spring, storm events flush sediments, nutrients, organic matter and organisms down the river to the ocean, in large pulses. The storm flows are out of phase with the other major nutrient input to local coastal biology: late spring and summer upwelling of cold, nutrient-rich ocean water to the photosynthetically active surface. The timing and magnitude of these storm events, and thus of Eel riverine nutrient delivery, have a great deal of interannual variability and may be altered by climate change. Furthermore, satellite ocean color imagery suggests that the fluxes from the Eel River may contribute to phytoplankton blooms offshore, demonstrating spatial, seasonal and interannual variability of ocean color, north and south of the Eel River's mouth. This study constructs a detailed modeling framework to examine the connections between variability in weather (modulated, slowly, by climate trends), river nutrient delivery to the ocean, and coastal phytoplankton productivity.

In the coupled modeling framework, the watershed is represented with the lumped empirical watershed model HydroTrend, which can generate high-frequency water and sediment time series in relatively unstudied basins. The hindcast atmosphere (2002-2010) is represented by the NCEP North American Regional Reanalysis and the ECMWF ERA Interim Reanalysis. The ocean is represented with the Regional Ocean Modeling System, a powerful, modular, physically distributed model that can efficiently solve fine-scale resolution grids. Transforming HydroTrend’s output into a form suitable to force the ocean and biology models required a coupling interface physically input at the ROMS boundary. The Eel plume under storm flood conditions is a supercritical, non-diffusive plume that forms turbulent coastal jets, and the coupling interface thus provides boundary velocity forcings that assumes this formation takes place, beginning with a plug flow in the zone of flow establishment at the river mouth/ROMS boundary that is then affected by turbulent mixing with the ocean. The modeling framework uses an Iron-Limited Nitrogen-Phytoplankton-Zooplankton-Detritus biological model to analyze spatial and temporal variability in coastal ocean productivity. The nutrient load within the Eel River is estimated from a climatology of USGS Eel River nutrient data.

Final ID: EP51C-04

High-resolution regional paleoclimate simulations of Lake Bonneville and its influence on geomorphic processes in the Uinta Mountains during the Last Glacial Maximum ***(Invited)***

J. Galewsky; [1];

1. University of New Mexico, Albuquerque, NM, United States.

Body: Reconstructed equilibrium line altitudes (ELAs) for alpine glaciers in the Uinta Mountains at the Last Glacial Maximum (LGM) increase with distance from the shoreline of pluvial Lake Bonneville, an effect that has been linked at least in part to enhanced precipitation derived from Lake Bonneville. While this result is broadly consistent with relatively large-scale climate modeling studies, the precise meteorological mechanisms by which Lake Bonneville may have influenced the glacial geomorphology of the Uinta Mountains remain poorly understood. New, high resolution (4km grid spacing) quasi-idealized regional paeoclimate simulations of the LGM computed with the Weather Research and Forecast (WRF) model provide new insights into these processes. Preliminary results indicate that moisture derived from Lake Bonneville likely would not have exerted a significant impact on regional precipitation unless the lake temperature exceeded about 4 degrees C. However, an ice-free Lake Bonneville would have likely exerted a modest (at least 1-2C) local warming, with associated impacts on precipitation and snowpack development. While the overall snowfall amounts do not appear to be greatly affected by the presence of a cold, ice-free lake, the presence of such a lake does appear to influence precipitation extremes throughout the region. These results suggest that the local temperature influence of pluvial lakes on regional glaciation may be of similar magnitude to the effects of enhanced evaporation from those lakes.

Final ID: IN51C-04

Using the cloud to speed-up calibration of watershed-scale hydrologic models ***(Invited)***

J. L. Goodall; [1, 2]; *M. B. Ercan;* [2]; *A. M. Castronova;* [2]; *M. Humphrey;* [3]; *N. Beekwilder;* [3]; *J. Steele;* [3]; *I. Kim;* [3];

1. Civil and Environmental Engineering, University of Virginia, Charlottesville, VA, United States.
2. Civil and Environmental Engineering, University of South Carolina, Columbia, SC, United States.
3. Computer Science, University of Virginia, Charlottesville, VA, United States.

Body: This research focuses on using the cloud to address computational challenges associated with hydrologic modeling. One example is calibration of a watershed-scale hydrologic model, which can take days of execution time on typical computers. While parallel algorithms for model calibration exist and some researchers have used multi-core computers or clusters to run these algorithms, these solutions do not fully address the challenge because (i) calibration can still be too time consuming even on multicore personal computers and (ii) few in the community have the time and expertise needed to manage a compute cluster. Given this, another option for addressing this challenge that we are exploring through this work is the use of the cloud for speeding-up calibration of watershed-scale hydrologic models. The cloud used in this capacity provides a means for renting a specific number and type of machines for only the time needed to perform a calibration model run. The cloud allows one to precisely balance the duration of the calibration with the financial costs so that, if the budget allows, the calibration can be performed more quickly by renting more machines. Focusing specifically on the SWAT hydrologic model and a parallel version of the DDS calibration algorithm, we show significant speed-up time across a range of watershed sizes using up to 256 cores to perform a model calibration. The tool provides a simple web-based user interface and the ability to monitor the calibration job submission process during the calibration process. Finally this talk concludes with initial work to leverage the cloud for other tasks associated with hydrologic modeling including tasks related to preparing inputs for constructing place-based hydrologic models.

Final ID: EP51D-05

Sink to source: The effects of offshore dynamics on upstream processes

A. Abeyta; [1]; *C. Paola;* [1]; *J. B. Swenson;* [2];
1. Department of Earth Sciences, University of Minnesota, Minneapolis, MN, United States.
2. Department of Geological Sciences, University of Minnesota, Duluth, MN, United States.

Body: Often, when we model fluvial sedimentation on large space and timescales, we focus on local controls (e.g. sediment and water supply), as well as the effects of relative sea level change. Shoreline often provides a boundary condition, which implies that offshore processes are merely acting as a passive sink for sediment accumulation. However, over long time scales, coastal rivers are strongly coupled to offshore and slope transport systems via the clinoform geometries typical of prograding sedimentary bodies. Here, we adopt a “sink to source” view of sediment mass balance on coastal-plain rivers. We identify a variety of effects by which offshore processes influence the state of coastal rivers. For example, the toe of the clinoform represents a critical point that controls net deposition upstream of itself. Mechanisms that increase sediment transport at the toe or along the foreset reduce sedimentation in the fluvial system, reducing the shoreline progradation rate and increasing sedimentation in more distal regions. Results from two experimental studies give examples of how the dynamics of the offshore can control fluvial bypass and progradation. First, results of a 1D flume study show that progradation over pre-existing basin topography combined with overpassing turbidity currents can “unlock” the clinoform toe, reducing sedimentation in the fluvial system and directing sediment to more distal offshore regions. Second, a 3D study using cohesive sediment that produces complex foreset dynamics, such as mass failure, shows that such failures are expressed in the topset, through land loss, shoreline retreat, and upstream-migrating erosion. These are just two examples of how dynamics in the offshore can influence fluvial sedimentation with no change in upstream supply or base level.

Final ID: A51M-07

Photo-chemical reduction of iodate (IO_3^-) in sea-water leading to the emission of iodine (I_2) in the atmosphere

R. Kumar; [1];

1. Department of Chemistry, Multanimal Modi (Postgraduate) College, Modinagar (UP), PIN-201204, Uttar Pradesh, India.

Body: Iodine exists in open seawaters mainly in the inorganic forms iodate (IO3-) and iodide (I-). While the concentration of IO3- predominates in deep water, I- concentrations increase toward the surface. The primary precursor for iodine oxide particle (IOP) formation in the coastal marine boundary layer (MBL) is iodine (I2) originating from exposed macroalgae. In contrast, recent field measurements of IO above the open ocean suggest that biogenic organic-iodine emissions cannot account for the observed levels. Thus, the alternative mechanisms include the reduction of IO3- to I- in seawater which in turn is converted to, and emitted as I2 to the atmosphere which may contribute to observed levels of I2 in the MBL.

In this study a series of laboratory investigations of the photo-chemical reduction of iodate (IO3-) to both aqueous iodide (I-) and a bound, soluble iodinated organic form have been conducted to investigate three potentially important processes likely to participate in the recycling of I2 from seawater in the presence of sunlight: (i) the role of dissolved organic materials (i.e. humic acid), (ii) the effect of salinity (Cl- concentration) and (iii) deposition and uptake of O3.

The experiments involved the initial photolysis of IO3- solutions with either humic acid or Cl- added. The formation of I- in solution (due to IO3- reduction) was detected using time-resolved UV-Vis spectroscopy. Oxidation of iodide ions to I2 formation in the solutions and release to the gas-phase was confirmed indirectly by the detection of iodine oxide particles (IOPs) generated by the photo-oxidation of the gas-phase I2 released from solution using a coupled differential mobility analyser (DMA) and Faraday cup electrometer (FCE) system.

The results indicate a constant fraction of ~ 20% of reduced iodate is in the form free iodide (I-) and by difference, ~ 80% of reduced iodate is most likely in an iodinated humic acid. Iodine (I2) is emitted by the uptake of ozone on iodide (I-) solution at the sea surface with an uptake coefficient (γ) of $(7.0 \pm 0.2) \times 10^{-7}$ at a temperature of 293 K which could potentially be a source of I2 to the atmosphere.

URL: www.mmcollegemodinagar.org

Final ID: EP51D-07

Climate and Tectonics Need Not Apply: Transient Erosion Driven by Drainage Integration, Aravaipa Creek, AZ

M. Jungers; [1]; *A. M. Heimsath;* [1];
1. School of Earth and Space Exploration, Arizona State University, Tempe, AZ, United States.

Body: Periods of transient erosion during landscape evolution are most commonly attributed to fluvial systems' responses to changes in tectonic or climatic forcing. Dramatic changes in base level and sudden increases in drainage area associated with drainage reorganization can, however, drive punctuated events of incision and erosion equal in magnitude to those driven by tectonics or climate. In southeastern Arizona's Basin and Range, a mature portion of the North American physiographic province, the modern Gila River system integrates a network of previously internally drained structural basins. One basin in particular, Aravaipa Creek, is the most recent to join the broader Gila River fluvial network. Following drainage integration, Aravaipa Creek rapidly incised to equilibrate with its new, much lower, base level. In doing so, it carved Aravaipa Canyon, excavated a large volume of sedimentary basin fill, and captured drainage area from the still internally drained Sulphur Springs basin. Importantly, this dramatic episode of transient incision and erosion was the result of drainage integration alone. We hypothesize that the adjustment time for Aravaipa Creek was shorter than the timescale of any climate forcing, and regional extensional tectonics were quiescent at the time of integration. We can, therefore, explicitly quantify the magnitude of transient incision and erosion driven by drainage reorganization.

We use remnants of the paleo-basin surface and modern landscape elevations to reconstruct the pre-drainage integration topography of Aravaipa Creek basin. Doing so enables us to quantify the magnitude of incision driven by drainage reorganization as well as the volume of material eroded from the basin subsequent to integration. Key control points for our landscape reconstruction are: (1) the inferred elevation of the spillover point between Aravaipa Creek and the San Pedro River; (2) Quaternary pediment-capping gravels above Aravaipa Canyon (3) perched remnants of late stage sedimentary basin fill that preserve the slope of the pre-incision piedmonts of the Galiuro Mountains and Santa Teresa Mountains; and (4) the paleo-drainage divide between Aravaipa Creek and Sulphur Springs Valley, approximately 6 km northwest of the modern divide. The pre-incision basin surface sloped from the Sulphur Springs divide (1370 m) to its intersection with the point of integration (1100 m) between Aravaipa Creek and the San Pedro River, 50 km to the northwest. Maximum incision of 450 m occurred in the vicinity of Aravaipa Canyon, and more than 50 cubic kilometers of material have been eroded from Aravaipa Creek basin. Finally, cosmogenic nuclide burial dates for latest stage sedimentary basin fill enable us to constrain the timing of drainage integration and place first-order constraints on paleo-erosion rates.

Final ID: EP52B-01

Flood Deposition Patterns and Channel Migration due to a 10-year flood event: the case of the Indus River flood 2010

A. J. Kettner; [1]; *J. P. Syvitski;* [1]; *I. Overeem;* [1]; *G. R. Brakenridge;* [1];
1. University of Colorado, Boulder, CO, United States.

Body: Fluvial geomorphological processes evolve the landscape and are often referred to as processes that act for hundred to thousands of years before making a noticeable change in landforms. For the Indus River, landscape evolution has been intensified due to human interference. Failure in repairing its levees from previous floods led in July 2010 during a not exceptional discharge event (~10 year recurrence interval) to a large avulsion and flooding disaster that caused ~2,000 fatalities. Examining pre- and post flood maps by analyzing MODIS and ASTER-A1 data allowed us to determine the extent of sandy flood deposits and to quantify channel migration patterns.

The typical pattern of inner bend deposition (due to helical flow) and outer bend erosion were less pronounced. We hypothesize that when flow exceeds bankfull conditions, deposition is more uniform and no longer constrained by the streambed geometry. We observe that the inner and the outer river bend receive similar amounts of sandy deposits (43% versus 57% respectively). Crevasse splaying was widespread and appeared to occur as a flow stripping process again both upon the point bars as well as in river outer bends.

Channel activity (defined as the areal shift of the pre- and post river centerline), sinuosity, slope and lateral sediment deposition were determined for 50km river stretches. Analyzes reveal that flood deposits extend generally less than 2 km from the main channel axis. Furthermore, channel activity correlates negatively with channel sinuosity and lateral distance of sediment deposition and positively with slope. The river channel migrated over 100's of meters during the July 2010 flood event. Lateral migration averaged ~340m along a 1000km stretch of the Indus River over a period of just 52 days.

Although this discharge event was not exceptional, lateral migration was significant and deposition impacts the active river floodplain. Remarkably, most sediments are deposited downstream the large avulsion (85%). No significant amount of sediment reaches the Indus Delta (2%); which was also less significantly affected by channel migration.

Final ID: OS52A-01

Visualizing the internal structure of subaqueous, high-concentration sediment-laden flows: implication of rheology to flow structure.

M. M. Perillo; [1]; *J. Buttles;* [1]; *D. C. Mohrig;* [1]; *I. Kane;* [2]; *A. Pontén;* [3]; *D. Brown;* [1]; *B. W. Minton;* [1];
1. Jackson School of Geosciences, Univ of Texas Austin, Austin, TX, United States.
2. Statoil ASA, Research Centre Bergen, Bergen, Norway.
3. Statoil ASA, Research Centre Rotvoll, Trondheim, Norway.

Body: Subaqueous sediment-laden flows are thought to be the main mechanism transporting sediments to the deep sea. Understanding the processes governing these flows is crucial to building predictive models of flow behaviour, sediment transport and deposition and is applicable to a wide range of disciplines. Physical modelling using a wide range of experimental facilities and measurement techniques has significantly advanced our understanding of these sediment-laden flows and their ability to erode, transport and deposit sediments. However, for the case of high-sediment concentration flows, measuring flow and depositional properties is still a challenge. Here, we present results from an acoustic reflection technique that allows for direct and noninvasive visualization of the internal structure of high concentration, clay-rich, sand-laden flows with a range of initial yield strengths (0-26 Pa). As the acoustic signal travels through the sediment-laden flow, it encounters zones of varying acoustic impedance that are due to temporal and spatial changes in sediment concentration, grain size and sorting, and flow mixing. The reflected signal is processed and interpreted using seismic techniques developed in exploration geophysics. The ultrasonic reflection data captured two distinct flow stages, an active stage and a post-depositional creeping stage. The clay-rich sand-laden flows showed stratification expressed by three clear vertical zones: (a) an upper relatively dilute turbulent zone, (b) a zone with high sediment concentration and significantly reduced mixing and (c) an aggrading bed of static grains.

Final ID: EP52A-02

Solar radiation signature manifested on the spatial patterns of modeled soil moisture, vegetation, and topography using an ecohydro-geomorphic landscape evolution model

O. Yetemen; [1]; *J. H. Flores Cervantes;* [1]; *E. Istanbulluoglu;* [1]; *E. R. Vivoni;* [2, 3];

1. Department of Civil and Environmental Engineering, University of Washington, Seattle, WA, United States.
2. School of Earth and Space Exploration, Arizona State University, Tempe, AZ, United States.
3. School of Sustainable Engineering and the Built Environment, Arizona State University, Tempe, AZ, United States.

Body: The role of solar radiation on ecohydrologic fluxes, vegetation dynamics, species composition, and landscape morphology have long been documented in field studies. However a numerical model framework to integrate a range of ecohydrologic and geomorphic processes to explore the integrated ecohydro-geomorphic landscape response have been missing. In this study, our aim is to realistically represent flood generation and solar-radiation-driven echydrologic dynamics in a landscape evolution model (LEM) to investigate how ecohydrologic differences caused by differential irradiance on opposing hillslopes manifest themselves on the organization of modeled topography, soil moisture and plant biomass. We use the CHILD LEM equipped with a spatially-distributed solar-radiation component, leading to spatial patterns of soil moisture; a vegetation dynamics component that explicitly tracks above- and below-ground biomass; and a runoff component that allows for runoff-runon processes along the landscape flow paths. Ecohydrological component has been verified using a detailed data gathered from Sevilleta National Wildlife Refuge in central New Mexico, and Walnut Gulch Experimental Watershed in southern Arizona. LEM scenarios were designed to compare the outcomes of spatially distributed versus spatially uniform solar radiation forced with a constant climate and variable uplift. Modeled spatial patterns of soil moisture confirm empirical observations at the landscape scale and other hydrologic modeling studies. The spatial variability in soil moisture is controlled by aspect prior to the wet season (North American Monsoon, NAM), and by the hydraulic connectivity of the flow network during NAM. Aspect and network connectivity signatures are also manifested on plant biomass with typically denser vegetation cover on north-facing slopes than south facing slopes. Over the long-term, CHILD gives slightly steeper and less dissected north-facing slopes more dissected south facing slopes and an overall asymmetry in the modeled morphology of valleys. The model simulations show how subtle differences in biomass and soil moisture dynamics at annual scale lead to distinct geomorphic differences at both hillslope and catchment scales.

Final ID: EP52A-04

Climatic controls on mechanical rock strength and channel incision due to bedrock weathering, Kohala Peninsula, Hawaii

B. P. Murphy; [1]; *J. P. Johnson;* [1]; *N. M. Gasparini;* [2]; *L. S. Sklar;* [3];
1. The University of Texas at Austin, Austin, TX, United States.
2. Tulane University , New Orleans, LA, United States.
3. San Francisco State University, San Francisco, CA, United States.

Body: Orographic precipitation gradients are prevalent in mountainous terrains, and climate-dependent bedrock weathering may play an important role in the incision of bedrock channels and the evolution of landscapes. Kohala Peninsula on the big island of Hawaii presents a unique natural setting for exploring climate sensitivity of landscape erosion, with over an order of magnitude variation in mean annual precipitation, a landscape composed entirely of weatherable basalt, and systematic variations in fluvial incision and resulting topography across the climate gradient. We hypothesize that increases in local mean annual precipitation will promote long-term channel incision rates due to increases in bedrock weathering, but measurements of rock strength within bedrock channels will be greatly influenced by the efficient removal of weathered rock by fluvial erosion. Mechanical properties of bedrock were measured at a total of 13 sites across two watersheds that vary in local mean annual precipitation from 0.27 – 2.25 m/yr. In situ strength measurements were collected using a Schmidt hammer with a pseudo-random sampling method along transects parallel to stream direction and just above the channel thalweg. Tensile strength and elastic moduli were also measured in the laboratory on cores collected from a subset of the same transects. Long-term channel incision rates were independently constrained from the local valley relief and the ages of mapped basalt units that form the relatively unmodified volcanic shield of Kohala. When strength data comes from sites of low long-term incision, we find strong power-law relationships between both rock strength measurements and local mean annual precipitation. However, for sites with high precipitation rate and variable erosion rates, we find significant variability in the rock strength. We interpret this to reflect the removal of weathered rock by erosion. In order to interpret the influence of climate in our dataset, we made a normalized "climate-incision index" by dividing local precipitation rate (m/yr) by the local erosion rate (m/yr). When rock strength is plotted against this climate-incision index the data nicely collapses into consistent power-law relationships. Therefore, by removing the influence of local long-term incision from the data, the relationship between decreasing rock strength and increasing local mean annual precipitation becomes clear. Identifying this relationship may help explain the varied patterns of incision observed across the Kohala peninsula. Finally, if changes in mechanical rock strength are representative of weathering patterns across the landscape, this result may also suggest an influence on other key fluvial characteristics, such as sediment supply in channels. While Kohala may be an ideal site to isolate these trends, influences of bedrock weathering may be important for landscape evolution across many other orographic precipitation gradients.

Final ID: OS52A-04

Insights into the linked dynamics of channel networks on shelf-edge deltas and submarine slopes from physical experiments and high-resolution seismic data

A. M. Fernandes;[1]; *K. M. Straub;*[1];
1. Earth and Environmental Sciences, Tulane University, New Orleans, LA, United States.

Body: Continental margin deposits provide the most complete record on Earth of paleo-landscapes and paleo-landscape dynamics, in addition to hosting water and hydrocarbon reservoirs. As a result of high Holocene sea-level rise rates, most modern deltas are far from the continental shelf-edge, making it difficult to study sediment routing past coastlines and into the deep ocean in real time. Motivated by observations from acoustically–imaged shelf-edge deltaic systems offshore Brunei and in the Gulf of Mexico, we use physical experiments to explore the key boundary conditions that affect dynamics of sub-aqueous slope channels linked to deltaic channels. We will discuss how: a) the ratio of sediment discharge to water discharge (Q s:Q w), b) the fraction of coarse sediment in the input grain-size distribution, and c) shoreline rugosity of shelf-edge deltas affect the development and longevity of sub-aqueous slope channels and the lateral extent of sediment deposition on the slope. In a high Q s:Q w ratio experiment with a uni-modal grain-size distribution in the silt regime, delta-top flow was sheet-like and highly mobile, shorelines were smooth and arcuate, subaqueous channels were transient and poorly defined, and slope sedimentation was diffuse. In contrast, in a low Q s:Q w ratio experiment, with a bimodal grain size distribution (one part by weight sand to 9 parts silt), delta top flow was channelized and less mobile, shore-lines were rugose, slope channels were well-defined and persistent through time and deposition on the slope occurred along restricted fairways.

Final ID: H52G-05

Assessing Applicability of CMIP5 Climate Projections for Water Resources and Environmental Planning

I. M. Ferguson; [1]; *L. D. Brekke;* [1]; *J. Scott;* [2]; *M. A. Alexander;* [3];

1. US Bureau of Reclamation, Denver, CO, United States.
2. Physical Sciences Division, NOAA/CIRES/ESRL , Boulder, CO, United States.
3. Physical Sciences Division, NOAA, Earth System Research Laboratory, Boulder, CO, United States.

Body: Recent changes in Federal agency directives and programmatic mandates require Federal managers to consider climate change in water resources and environmental planning. As a result, resource managers are now required to make judgments regarding which aspects of climate projection information are applicable to a given decision, including decisions to modify system operations, invest in new or improved infrastructure, and establish long-term management objectives. Here we present results from an interagency collaboration to evaluate the reliability, relevance, and applicability of CMIP5 climate projections for use in water and environmental resources planning, focusing on a case study of the Central Valley Project and State Water Project systems in California. Reliability of climate projection information is assessed through detailed evaluation of climate model skill in simulating 20th century climate conditions, whereas relevance is assessed by evaluating the sensitivity of water resources system performance to changes in climate. Information on reliability and relevance is then combined into a common framework to assess the applicability of climate projection information to a given water resources or environmental planning context. Outcomes of this collaborative study will inform agency discussions regarding the use of climate projection information in long-term resource planning, including decisions to invest in adaptation measures.

Final ID: SM52A-08

A future Chinese mission proposed to investigate the coupling of the Earth's magnetoshpere, ionosphere and thermoshpere

Y. Liu; [1]; *C. Wang;* [1]; *J. Xu;* [1];
1. State Key Laboratory of Space Weather, National Space Science Center, Beijing, Beijing, China.

Body: Under the support of Chinese Strategy Pioneer Program for space science, we are developing a mission to investigate a key question for space weather. The Earth’s magnetosphere, ionosphere and thermosphere (MIT) are crucial regions for the space and they are coupling together through exchange of energy, momentum and mass. The mission, named as MIT, focuses on the polar upflow ions which are vital for the understanding of the physical processes relating to the MIT coupling. The mission plans a constellation composed of four spacecrafts, each spacecraft has its own orbit and crosses the polar region at the nearly the same time but at different altitude. With particles detectors, field detectors and imagers onboard each spacecraft, we will be able to track the polar upflow ions and study the acceleration mechanism at different altitude. Currently we have determined the orbits, the payloads for each the spacecraft and the expected lunch time is 2019 to 2020.

Final ID: EP52A-08

Landscape re-organization under changing climatic forcing

A. Singh; [1]; *L. Reinhardt;* [2]; *E. Foufoula-Georgiou;* [1];
1. Department of Civil Engineering and St. Anthony Falls Laboratory, University of Minnesota, Minneapolis, MN, United States.
2. Geography, College of Life and Environmental Sciences, University of Exeter, Cornwall, United Kingdom.

Body: Understanding how landscapes respond to changes in climate in terms of macro-scale (relief) and micro-scale (drainage network structure) re-organization is an issue of timely interest in view of climatic trends in many regions of the world. Although several studies have addressed the large-scale response, studies that focus on the smaller-scale drainage pattern re-organization and quantification of landscape vulnerability to the timing, magnitude, and frequency of the changing forcing are lacking. The reason is the absence of data for such an analysis. To that goal, a series of controlled laboratory experiments were conducted at the St. Anthony Falls laboratory of the University of Minnesota to study the effect of space-time variable and changing precipitation patterns on landscape evolution at the short and long-time scales. High resolution digital elevation models (DEM) both in space and time along with the instantaneous sediment transport rates were measured for a range of rainfall patterns and uplift rates. These experiments were designed to create an evolving and self-organized drainage network by the growth and propagation of erosional instabilities in response to external forcing, such as, tectonic uplift and rainfall dynamics. Results from our study show distinct signatures of extreme climatic fluctuations on the statistics of topographical features which are evident in widening and deepening of channels, change in drainage patterns within a basin and change in the probabilistic structure of hot-spots of change contributing to mass-wasting events, such as, landslides and debris flows. Understanding and quantifying these signatures is important as the underlying processes developing these landscapes exhibit complex dynamics and nonlinear behavior to the timing, frequency, and magnitude of the changing forcing, which needs to be understood for predicting landscape vulnerability to future climatic change.

Final ID: C53A-0550

Increased Groundwater Upwelling from Changes in Permafrost as a Control on River Ice Thickness

C. Jones; [1]; *K. Kielland;* [2]; *L. D. Hinzman;* [1];
1. Int. Arctic Research Center, Univ. of Alaska Fairbanks, Fairbanks, AK, United States.
2. Institute of Arctic Biology, Univ. of Alaska Fairbanks, Fairbanks, AK, United States.

Body: The Tanana River flows through interior Alaska, a region characterized by discontinuous permafrost. Studies link degrading permafrost to increased winter river discharge due to increasing groundwater input. In winter, interior Alaskan rivers are exclusively fed by groundwater, which serves as an external source of heat. In fact, some portions of rivers fed by groundwater maintain thin ice throughout the winter, or remain altogether ice-free, despite very cold air temperatures. These ice conditions represent a significant danger to winter travellers who use rivers for wintertime travel, particularly in this largely roadless area.

We developed a deterministic model to explore how fluctuations in groundwater discharge control ice thickness on the Tanana River. The model allows us to examine how local changes in groundwater characteristics affect ice dynamics by addressing two questions: 1) What are the dominant factors controlling seasonal ice dynamics on the Tanana River? 2) What are the rates of change in ice thickness resulting from observed and projected changes in these factors?

Ice melt is amplified by increased hydraulic gradients, increased groundwater upwelling, increased air temperature, increased groundwater temperature, or increased snow depth. A warming climate in regions with discontinuous permafrost is expected to increase groundwater input into rivers, decrease the temperature gradient between the atmosphere and the ice/water interface, and increase snow depths. All these changes contribute to decreased ice thickness and thus more hazardous conditions for winter travellers. The model illustrates the physical mechanisms which corroborate reports from Alaskans that ice conditions have become more dangerous in the spring, and further suggests that permafrost degradation could contribute to the degradation of river ice in a warming climate.

Final ID: C53B-0553

Constitutive Models for Debris-bearing Ice Layers

P. L. Moore; [1];
1. Iowa State University, Ames, IA, United States.

Body: Rock debris is incorporated within many glaciers and ice sheets, particularly in basal ice layers and englacial debris bands. Field observations and laboratory experiments have shown that debris inclusions can both strengthen and weaken ice by as much as two orders of magnitude compared to debris-free ice under the same conditions. Nevertheless, models of glacier flow usually neglect any effect of debris-bearing layers. Where debris-bearing ice is present, proper treatment of its deformation could profoundly impact model results.

A three-phase mechanical model is presented that reproduces many of the key observations of debris-bearing ice rheology. First order variables in the model are limited to debris concentration, particle size, solute concentration and temperature. At low debris concentrations (less than about 40% by volume), the mixture is treated under the framework of a dispersion-strengthened metal alloy but with a fluidity that is enhanced by premelted water at ice-debris interfaces. While debris strengthens the ice by interfering with the motion of dislocations, thermally-activated detachment can reduce the effect at temperatures close to melting. At these warm temperatures, recovery aided by unfrozen interfacial water acts to weaken the mixture, an effect that is further ehnanced by the presence of solutes at particle surfaces. Whether the debris-bearing ice is stronger or weaker than debris-free ice in the model depends strongly on the specific surface area of the debris and on a parameter that describes the thermal detachment of dislocations. As debris concentrations exceed about 40%, dispersion-strengthened ice flow still governs bulk deformation but the effective viscosity is further increased by enhanced strain rates in the ice "matrix" as the average inter-particle distance declines.

At still higher concentrations (greater than about 52% by volume for sand), deformation is primarily frictional. The mixture is thus treated as a dilatant Coulomb-plastic material with long term strength equal to the residual strength of the ice-free debris in the local stress state. Strength of the mixture at low strains, however, is a superposition of the strengths due to interparticle friction, pore-ice creep or yield, and debris-ice adhesion. Adhesive strength scales inversely with the thickness of interfacial water films, and thus with temperature. Higher initial debris concentrations (lower initial porosity) heighten the importance of dilatancy, thereby increasing the contribution of temperature and rate-dependent pore ice and adhesive strengths. Peak strengths can thereby be orders of magnitude larger than the residual strength.

This model reproduces many of the key observations from laboratory and field studies and highlights how the behavior of an ice-debris mixture can vary widely as a function of a small number of key independent variables. Example applications are discussed for the impact of debris-bearing ice on strain distribution and structural instabilities in heterogeneous ice masses.

Final ID: EP53A-0720

Draix multidisciplinary observatory for water and sediment processes

C. Le Bouteiller; [1]; *N. Mathys;* [1]; *F. Liébault;* [1]; *S. Klotz;* [1];
1. IRSTEA (UR Erosion Torrentielle, Neige et Avalanches), Saint-Martin d'Heres, France.

Body: Over the last decades, much progress has been done in the modeling and conceptualizing of surface processes. Testing theories and models requires field data, and possibly long-term time series. Here we present a 30-year old field observatory dedicated to water and sediment fluxes in the French Alps.

Draix observatory is located in a badland area of the French Alps (shale lithology), and includes several subcatchments which differ in size (0.001 to 1 km2) and vegetation coverage (bare soil or forest). Climate is mountainous and Mediterranean, characterized with summer storm-induced floods and winter frost.

Data collected includes climatic data (rainfall, temperature) and water and sediment fluxes (discharge at the outlet of each subcatchment, suspended load and bedload fluxes). High frequency monitoring (minute/hour) is used to capture flood dynamics. Some soil hydraulic and geophysical properties, lidar scans and vegetation maps are also available.

The combination of an erodible badland morphology and tough climatic conditions induces very high erosion rates and sediment yield (up to 70 tons/ha/yr). Observed erosion processes include landslides, small-scale debris flows, gully formation, weathering on the slopes and in the riverbeds, hyperconcentrated flows and in-transport sediment abrasion. The sediment response is highly non-linear with a strong seasonal pattern of storage and scour in the bed.

Current research on Draix observatory is multidisciplinary and involves hydraulic engineers, hydrologists, geomorphologists, soil scientists and restoration ecologists. Fast rates of geomorphic changes, well-constrained sediment budgets and long data series are some of the advantages of this site for the study of earth surface processes. Our data is available for the community and we welcome everyone who is interested in collaborating on it.

Final ID: EP53A-0725

BED FORMS MODULATING TEMPORAL PEAKS ON NEAR-BANK SHEAR STRESSES, THE WABASH RIVER CASE

J. D. Abad; [1]; *C. E. Frias;* [1]; *E. J. Langendoen;* [3]; *J. Best;* [2]; *B. L. Rhoads;* [2]; *K. M. Konsoer;* [2]; *M. H. Garcia;* [2];
1. University of Pittsburgh , Pittsburgh, PA, United States.
2. University of Illinois at Urbana-Champaign, Urbana, IL, United States.
3. United States Department of Agriculture, Oxford, MS, United States.

Body: There is a great body of experimental work showing how bed forms modulate bed roughness, flow field structure, and sediment transport rates in straight flumes. Recently, it was observed that migrating bed forms produce temporal and spatial peaks of shear stresses along the outer bank of an experimental meandering channel. These stresses are about 50% larger than the shear stresses exerted by the mean near-bank flow. As fluvial erosion bank erosion rates are typically linearly related to applied shear stress, the migration rate of the bend may be significantly increased. However, this hypothesis has never been tested in the field, where bed forms could be more complex than those found in experimental cases. Herein, only fluvial erosion is considered, while geotechnical processes occurring at the outer bank are not accounted for.
Detailed measurements of hydrodynamics (using acoustic Doppler profiler), bed morphology (using multibeam and RTK GPS) and bank morphology (using laser scanner) were conducted at two bends on the Wabash River along the Illinois and Indiana Stateline. The bed morphology exhibited different scales of bed forms, ranging from dunes to ripples. Using Wavelet analysis to discriminate the bed morphology it was possible to separate the ripples and dunes structures resulting in a bed without bed forms, which shows the typical erosion (outer bank)/deposition (inner bank) arrangement in meandering channels.
Using a fully three-dimensional Reynolds-Averaged Navier-Stokes (RANS) numerical model, two cases are simulated: [1] bend with bed forms, and [2] bend without bed forms to test the above hypothesis. The results show that the three-dimensional flow field is compares well to that observed for both scenarios. Further, peaks in shear stresses along the outer bank are indeed observed, which are correlated to the location of the bed forms with respect to the bend. Further conclusion and its importance for long-term morphodynamics of meandering channels are described.

Final ID: EP53A-0737

Recent developments in cosmogenic nuclide production rate scaling

N. A. Lifton; [1, 2];
1. Dept of Earth, Atmospheric, and Planetary Sciences, Purdue University, West Lafayette, IN, United States.
2. Dept of Physics, Purdue University, West Lafayette, IN, United States.

Body: A new cosmogenic nuclide production rate scaling model based on analytical fits to Monte Carlo simulations of atmospheric cosmic ray flux spectra (both of which agree well with measured spectra) enables identification and quantification of the biases in previously published models (Lifton, N., Sato, T., Dunai, T., in review, *Earth and Planet. Sci. Lett.*). Scaling predictions derived from the new model (termed LSD) suggest two potential sources of bias in the previous models: different energy responses of the secondary neutron detectors used in developing the models, and different geomagnetic parameterizations. In addition, the particle flux spectra generated by the LSD model allow one to generate nuclide-specific scaling factors that reflect the influences of the flux energy distribution and the relevant excitation functions (probability of nuclide production in a given nuclear reaction as a function of energy). Resulting scaling factors indicate ^{3}He shows the strongest positive deviation from the flux-based scaling, while ^{14}C exhibits a negative deviation. These results are consistent with previous studies showing an increasing ^{3}He/^{10}Be ratio with altitude in the Himalayas, but with a much lower magnitude for the effect. Furthermore, the new model provides a flexible framework for exploring the implications of future advances in model inputs. For example, the effects of recently updated paleomagnetic models (e.g. Korte et al., 2011, *Earth and Planet Sci. Lett.* **312**, 497-505) on scaling predictions will also be presented.

Final ID: EP53A-0746

A New Method of Assessing the Extent of Topographic Equilibrium at Different Spatial Scales

R. Walcott; [1, 2];
1. National Museums Scotland, Edinburgh, United Kingdom.
2. School of Geoscience, University of Edinburgh, Edinburgh, United Kingdom.

Body: The Earth's surface represents the current resultant state of the interaction between forces working to lower topography and those working to resist this, or to raise topography. A diversity of processes generate these forces and in some cases coupled feedbacks allow a dynamic equilibrium to emerge at certain spatial and temporal scales. Dynamic equilibrium is typically expressed by distinctive geometries (e.g., regular catchment shapes, first order geometry of an orogen, constant thickness of a soil horizon over space). However, the presence of stochastic surface and tectonic processes also means that regular geometries are rarely observed at all scales. Determining the scale and temporal range over which topography can be considered to be in equilibrium can be difficult and expensive, requiring a large range of spatially distributed data, and/or data that spans significant time periods. Here we present a new morphometric method that focuses on the product of erosive competition between catchments, that is the geometry of drainage divide intersections. We use this method to show that stable areas, with minimal tectonic disturbance and homogeneous rock types have distinctive drainage divide geometry (e.g. Eastern USA) which differs from the geometry of drainage divide intersections in other environments (e.g. tectonically active regions such as the South Island of New Zealand). With a few caveats, this method could be used to predict areas prone to drainage divide migration and river network reconfiguration.

Final ID: EP53A-0757

Scaling up debris-flow experiments on a centrifuge

C. Hung; [1, 2]; *H. Capart;* [1]; *T. J. Crone;* [2]; *E. Grinspum;* [4]; *L. Hsu;* [2]; *D. Kaufman;* [4]; *L. Li;* [3]; *H. Ling;* [3]; *M. D. Reitz;* [2]; *B. Smith;* [4]; *C. P. Stark;* [2];

1. Civil Engineering, National Taiwan University, Taipei, Taiwan.
2. Lamont-Doherty Earth Observatory, Columbia University, New York, NY, United States.
3. Dept. of Civil Engineering and Engineering Mechanics, Columbia University, New York, NY, United States.
4. Dept. of Computer Science, Columbia University, New York, NY, United States.

Body: Boundary forces generated by debris flows can be powerful enough to erode bedrock and cause considerable damage to infrastructure during runout. Formulation of an erosion-rate law for debris flows is therefore a high priority, and it makes sense to build such a law around laboratory experiments. However, running experiments big enough to generate realistic boundary forces is a logistical challenge to say the least [1]. One alternative is to run table-top simulations with unnaturally weak but fast-eroding pseudo-bedrock, another is to extrapolate from micro-erosion of natural substrates driven by unnaturally weak impacts; hybrid-scale experiments have also been conducted [2]. Here we take a different approach in which we scale up granular impact forces by running our experiments under enhanced gravity in a geotechnical centrifuge [3]. Using a 40cm-diameter rotating drum [2] spun at up to 100g, we generate debris flows with an effective depth of over several meters. By varying effective gravity from 1g to 100g we explore the scaling of granular flow forces and the consequent bed and wall erosion rates. The velocity and density structure of these granular flows is monitored using laser sheets, high-speed video, and particle tracking [4], and the progressive erosion of the boundary surfaces is measured by laser scanning. The force structures and their fluctuations within the granular mass and at the boundaries are explored with contact dynamics numerical simulations that mimic the lab experimental conditions [5]. In this presentation we summarize these results and discuss how they can contribute to the formulation of debris-flow erosion law.

[1] Major, J. J. (1997), Journal of Geology 105: 345-366, doi:10.1086/515930

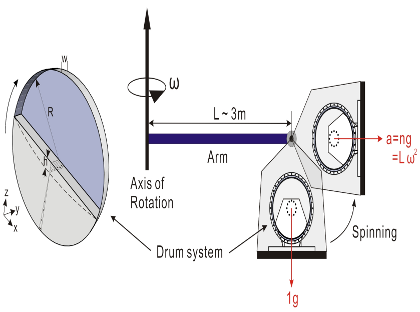
[2] Hsu, L. (2010), Ph.D. thesis, University of California, Berkeley

[3] Brucks, A., et al (2007), Physical Review E 75, 032301, doi:10.1103/PhysRevE.75.032301

[4] Spinewine, B., et al (2011), Experiments in Fluids 50: 1507-1525, doi: 10.1007/s00348-010-1009-7

[5] Smith, B., et al (2012), ACM Transactions on Graphics 314:106, doi:10.1145/2185520.2185602

URL: http://www2.ce.ntu.edu.tw/~mh/index.html



Final ID: EP53A-0764

10-year Field Measurement Program of Post-Wildfire Tree Root Decay, Kootenay National Park, British Columbia

Y. E. Martin; [1, 2]; *E. A. Johnson;* [3, 2]; *S. Kroeker;* [1, 2];
1. Geography, University of Calgary, Calgary, AB, Canada.
2. Biogeosciences Institute, University of Calgary, Calgary, AB, Canada.
3. Biological Sciences, University of Calgary, Calgary, AB, Canada.

Body: Tree population dynamics in subalpine forests of the Canadian Rockies are dominated by wildfire disturbance (Gallaway et al., 2009), with wildfire return intervals most often being shorter than the potential lifespan of trees. These crown wildfires kill all trees, resulting in a gradual decline of tree root strength in shallow soils in the immediate post-wildfire years. Tree root networks have been shown to provide mechanical reinforcement of shear strength in shallow soils (Schmidt et al., 2001; Roering et al., 2003). Therefore, decreases in tree root reinforcement in post-wildfire years may result in increased debris slide and debris flow activity during this time period (e.g., Benda and Dunne, 1997; Martin, 2007; Jackson and Roering, 2009). To our knowledge, our study is the first that has measured tree root strength annually for 10 years following a crown wildfire to document the nature and timing of tree root decay. Suggestions have been made that studies documenting the decay of tree roots following timber harvesting provide a reasonable analogue for post-wildfire tree root decay; drainage basin modeling studies considering hillslope erosion resulting from episodic wildfires have had to rely on this assumption (e.g., Benda and Dunne, 1997; Martin, 2007).

Herein, we present our annual field measurements of post-wildfire tree root strength made over the past 10 years at a post-wildfire site in Kootenay National Park, Canadian Rockies. The episodic nature of crown wildfire occurrence over time in these forests results in periods of tree root decay in the immediate post-fire years, and an associated susceptibility for mass wasting during these time periods. In July 2003, two large crown fires were ignited by lightning in Kootenay National Park, British Columbia, Canada and merged to burn approximately 17 000 hectares. Our field measurements were made in the subalpine forest of Hawk Creek drainage basin, Kootenay National Park. Measurements of tree root characteristics in a total of 15 soil pits, covering 5 slope gradient classes, were made in each year from 2004 to the present year. Within each soil pit, tensile force at breakage for all tree roots, as well as vertical rooting depth and root diameter, were measured. For this study, analyses include: depth vs. diameter of tree roots (analyzed for each year), diameter vs. strength of tree roots (analyzed for each year), changes in distribution of tree root sizes over time, changes in total tree root strength over time. Data were also analyzed to see if tree root characteristics are affected by slope gradient. The key contribution of this paper is the meticulous 10-year field documentation and quantification of the gradual decay in tree root strength over time.

Final ID: EP53A-0774

Early Cretaceous continental sedimentation in the Coastal Cordillera (Atajaña Formation), Northern Chile

M. Garcia;[1, 2]; *G. Fuentes;*[1, 2]; *F. Sepulveda;*[3]; *P. Vasquez;*[3];
1. Advanced Mining Technology Center, Universidad de Chile, Santiago, Metropolitana, Chile.
2. Geología, Universidad de Chile, Santiago, Metropolitana, Chile.
3. Servicio Nacional de Geología y Minería, Santiago, Metropolitana, Chile.

Body: Early Cretaceous continental sedimentation development at the Coastal Cordillera of northern Chile has been described in a broad sense. The Atajaña Formation represents this continental sedimentation, south of Arica (18°30S), where it exposes mostly as an elongated swath oriented N70°E, forming a 20 km long and 8 km wide area of outcrop. Northward, these deposits occur as isolated outcrops at the bottom of Chiza, Camarones, Vitor and Azapa valleys.

The Atajaña succession was deposited in apparent angular unconformity over Cuya Formation (Middle-Late Jurassic) and Chiza Formation (Bajocian-Oxfordian). The Atajaña Formation is overlain, conformable and transitional, by the Blanco Formation (Aptian-Albian) and overlain in erosion unconformity by the Suca Formation (upper Early Cretaceous). Angular unconformity contact between Atajaña Formation and Cenozoic units (Azapa Formation and alluvial deposits) is exposed at previously named valleys. In the Camarones valley, the Atajaña Formation unconformably overlies Middle to Late Jurassic intrusive rocks.

In this work, the Atajaña Formation is divided in three facies associations, exposed close to Atajaña hill and Chiza valley (Kia1, Kia2 y Kia2a). Reddish conglomerates and sedimentary breccias facies (Kia1) consists of an up to 850 m thick. These rocks are massive, polymictic and poorly-sorted, and form laterally extensive beds. Clasts are mostly composed by diorites, monzodiorites, grayish fine sandstones, fine calcareous sandstones, limestones, volcarenites and porphyric andesites. Facies Kia1 includes interbedded red calcareous sandstones and siltstones, some of them displaying low-angle cross bedding. Facies Kia2 consists of an up to 570 m thick of red sandstone and siltstone, interbedded with conglomerates. This well stratified succession, parallel bedded and minor cross bedded, form continuous beds with subrounded and well-sorted clasts. Previous authors described dessication cracks in the red siltstones. Locally, unit Kia2 contains andesite lava flows interbedded (Kia2a) exposed in Chiza valley, south of Caleta Chica and southwestern of Atajaña hill.

The age of the Atajaña Formation, near to Atajaña hill, obtained from relationship contacts with the Blanco Formation, is Berriasian to Aptian. Besides, two new ages zircon U-Pb of 105.8±1.3 Ma and 107 Ma (best average between four population ages) obtained on the overlying rhyodacitic tuffs (Suca Formation), in the Chiza and Camarones valleys respectively. These data allow place the Atajaña Formation in the Lower Cretaceous (Barresian-Albian). This indicate a northward extension of continental sedimentation until Albian times, as well as a Blanco Formation wedging in the same direction. Southward, the Atajaña Formation can be stratigraphically correlated with Punta Barranco Formation, close to Iquique (20°S), and chrono-stratigraphically with Caleta Coloso Formation, near to Antofagasta (24°S).

According to the facies descriptions, the Atajaña Formation corresponds to a succession accumulated in alluvial, fluvial and locally lacustrine continental environment. South to the Atajaña hill, marine incursion is evidenced by the Blanco Formation during Aptian-Albian times. Northward (Chiza valley), continental sedimentation would have continued, in a volcanic environment, until Albian times.

Final ID: EP53A-0775

Thickness of the oligo-neogene sedimentary cover in the Central Depression, northern Chile (Pampa del Tamarugal, 20°45'-21°30'S), based on seismic reflection

M. Garcia; [3, 1]; *Y. Simicic;* [3, 1]; *E. Contreras Reyes;* [2]; *R. Charrier;* [1, 4];

1. Geología, Universidad de Chile, Santiago, Chile.
2. Geofísica, Universidad de Chile, Santiago, Chile.
3. Advanced Mining Technology Center, Universidad de Chile, Santiago, Chile.
4. Ciencias de la Tierra, Universidad Andrés Bello, Santiago, Chile.

Body: The estimation of the Pampa de Tamarugal oligo-neogene sedimentary cover thickness from seismic interpretation is crucial for scientific and applied subjects, such as placing aquifers traps and Mesozoic-Paleogene basement top location for mining exploration drilling. The Chilean National Petroleum Company (ENAP) has explored hydrocarbon resources in the area, raising several reflection seismic lines and drilling some wells. Previous studies used the paper seismic data by determining the cover geometry and defining the basement-cover boundary. We have obtained directly SGY digital files, which allow a better definition and modeling of stratigraphy and cover thickness. This thickness was estimated by the travel time in the seismic reflection lines and the value of the p-wave propagation velocity (0.91 to 1.97 km/s for cover). The last value was obtained by density measurements of field samples, which resulted from 1,895 to 2,065 g/cm3. In the central-south part of the Pampa del Tamarugal, immediately south of Cerro Challacollo, the west-east-oriented 99_7 seismic line shows a "basement high" whose top is at 100 m from the surface. The basement was uplift by a north-trend west-verging reverse fault and separates two sub-basins of 9.5 km and 13.8 km wide, and maximum cover thicknesses of 600 and 850 m, west and east respectively. To the north of Cerro Challacollo, the subparallel 99_6 line shows a similar geometry, and increasing the depth of the basement high top up to 350 m in the central part of the section. For seismic lines south of Cerro Challacollo, the basement high disappears and the cover thickness increases. To improve the accuracy of the cover thickness estimations, we will test directly measurements of p-wave propagation velocity in field samples of basement and cover (instead of approximations from the density measurements).

Final ID: EP53A-0779

Influence of Shear History on the Growth Rate and Equilibrium Size of Mud Flocs

A. Keyvani; [1]; *K. Strom;* [1];

1. Civil and Environmental Engineering, University of Houston, Houston, TX, United States.

Body: Effects of repeated exposure to multiple cycles of high and low turbulent shear rate on the floc growth pattern and equilibrium size were investigated through a laboratory study on a suspension of mud. The specific research questions examined are: (1) does repeated cycles of flocculation and deflocculation change the equilibrium floc size from one cycle to another?; and (2) do these repeated cycles impact the floc growth rate and path to equilibrium? For the experiments, a mixture of kaolinite and montmorillonite clay was sonicated and introduced to a mixing chamber to allow for flocculation under a mean turbulent shear rate of 35 s-1. Floc size time series, floc circularity index, and time series of the number of flocs were measured using a camera system and image processing routines. After the flocs reached an equilibrium size, the sample was deflocculated with vigorous turbulent mixing (400 s-1) for 15 hours, and then reflocculated by returning the shear rate to the initial value of 35 s-1. This procedure was repeated seven consecutive times. Results show that the different initial states of particles after sonication and after intense shearing had almost no effect on the equilibrium floc size, but that the initial state did significantly impact the floc growth pattern before the equilibrium was reached. With each repeated deflocculation and reflocculation cycle, the rate of floc growth decreased. Each of the seven reflocculation growth cycles were modeled with the Winterwerp (1998) equation for the mean floc size by calibrating the collision and breakup efficiency coefficients for each cycle. To obtain a good fit to the data, both the collision and breakup efficiency coefficients had to be reduced further with each successive cycle; the modeling suggests that flocs become stronger and less reactive with each repeated cycles of flocculation and defloccualtion. These results indicate that inclusion of shear history and initial condition impacts on mud flocs in natural estuarine, deltaic, and coastal systems is not important for steady-state conditions where flocs are at their equilibrium size. However, the initial primary particle state and time history of shear that a suspension has experienced could be important in modeling time accurate floc properties, and hence mud settling rates, in dynamic shear zones since flocculation rate appears to be dependent on shear history.

Final ID: EP53A-0786

A multi-resolution analysis of lidar-DTMs to identify geomorphic processes from characteristic topographic length scales

H. Sangireddy; [1]; *P. Passalacqua;* [1]; *C. P. Stark;* [2];
1. Civil, Architectural and Environmental Engineering, University of Texas at Austin, Austin, TX, United States.
2. Lamont-Doherty Earth Observatory, Columbia University, Palisades, NY, United States.

Body: Characteristic length scales are often present in topography, and they reflect the driving geomorphic processes. The wide availability of high resolution lidar Digital Terrain Models (DTMs) allows us to measure such characteristic scales, but new methods of topographic analysis are needed in order to do so. Here, we explore how transitions in probability distributions (pdfs) of topographic variables such as (log(area/slope)), defined as topoindex by *Beven and Kirkby*[1979], can be measured by Multi-Resolution Analysis (MRA) of lidar DTMs [*Stark and Stark*, 2001; *Sangireddy et al.,*2012] and used to infer dominant geomorphic processes such as non-linear diffusion and critical shear. We show this correlation between dominant geomorphic processes to characteristic length scales by comparing results from a landscape evolution model to natural landscapes.

The landscape evolution model MARSSIM *Howard*[1994] includes components for modeling rock weathering, mass wasting by non-linear creep, detachment-limited channel erosion, and bedload sediment transport. We use MARSSIM to simulate steady state landscapes for a range of hillslope diffusivity and critical shear stresses. Using the MRA approach, we estimate modal values and inter-quartile ranges of slope, curvature, and topoindex as a function of resolution. We also construct pdfs at each resolution and identify and extract characteristic scale breaks. Following the approach of *Tucker et al.,*[2001], we measure the average length to channel from ridges, within the GeoNet framework developed by *Passalacqua et al.,*[2010] and compute pdfs for hillslope lengths at each scale defined in the MRA. We compare the hillslope diffusivity used in MARSSIM against inter-quartile ranges of topoindex and hillslope length scales, and observe power law relationships between the compared variables for simulated landscapes at steady state. We plot similar measures for natural landscapes and are able to qualitatively infer the dominant geomorphic processes. Also, we explore the variability in hillslope length scales as a function of hillslope diffusivity coefficients and critical shear stress in natural landscapes and show that we can infer signatures of dominant geomorphic processes by analyzing characteristic topographic length scales present in topography.

References:

Beven, K. and Kirkby, M. J.: A physically based variable contributing area model of basin hydrology, Hydrol. Sci. Bull., 24, 43–69, 1979
Howard, A. D. (1994). A detachment-limited model of drainage basin evolution.Water resources research, 30(7), 2261-2285.
Passalacqua, P., Do Trung, T., Foufoula Georgiou, E., Sapiro, G., & Dietrich, W. E. (2010). A geometric framework for channel network extraction from lidar: Nonlinear diffusion and geodesic paths. Journal of Geophysical. Research: Earth Surface (2003–2012), 115(F1).
Sangireddy, H., Passalacqua, P., Stark, C.P.(2012). Multi-resolution estimation of lidar-DTM surface flow metrics to identify characteristic topographic length scales, EP13C-0859: AGU Fall meeting 2012.
Stark, C. P., & Stark, G. J. (2001). A channelization model of landscape evolution. American Journal of Science, 301(4-5), 486-512.
Tucker, G. E., Catani, F., Rinaldo, A., & Bras, R. L. (2001). Statistical analysis of drainage density from digital terrain

data. Geomorphology, 36(3), 187-202.

Final ID: EP53B-0822

Steady-state unsteadiness: drainage network reorganization triggered by bedrock river meandering in the Oregon Coast Range

K. N. Johnson; [1]; *N. J. Finnegan;* [1];
1. Earth and Planetary Sciences, University of California, Santa Cruz, Santa Cruz, CA, United States.

Body: In most landscapes, vertical incision of bedrock stream networks transmits base-level signals into the landscape interior, and is thus the primary control on landscape evolution. Some bedrock channels, however, also have the capacity to move laterally within a landscape via active bedrock meandering. This is common in diverse lithologies including many sedimentary rocks (e.g. California and Oregon Coast Ranges, Colorado Plateau) and basalt (e.g. Columbia River Flood Basalt, Hawaiian Islands). If active meandering of the main stem channel occurs, rates of base-level lowering at the mouth of tributary watersheds will fluctuate over time, even if the base-level lowering rate at the mouth of the main stem channel is constant over time. This is because lateral migration of the main stem channel causes elongation or truncation of the lower reaches of tributaries, which in turn changes slopes and thus tributary incision rates. In addition, as meander bends along the main stem channel grow, they can capture tributaries from other main stem reaches, causing sudden drainage network reorganization and impulsive base-level lowering. Thus a landscape with steady tectonic and climatic forcing may nevertheless experience significant unsteadiness because of the process of meandering itself.

Here we test our conceptual model that active meandering of a main stem channel exerts a fundamental control on the relative base-level lowering of tributary watersheds throughout the landscape. To this end, we analyze high resolution LiDAR elevation data from the Smith River, in the Oregon Coast Range, argued to be a classic example of a “steady state” landscape.

We find that tributary junctions are concentrated on the outside of active meander bends, consistent with the hypothesis that actively growing meander bends “collect” tributaries as they propagate into the landscape. In addition, we find that longitudinal profiles of these tributaries are not consistent with a “steady state” condition in which rates of river incision are constant throughout the watershed over time. Rather, where meander bend growth truncates tributaries that join the main stem channel on the outside of bends, profiles are generally steeper, and often have pronounced convexities. In contrast, where meander bend growth stretches tributaries that join the main stem channel on the inside of bends, tributary long profiles are generally less steep and more concave.

This study suggests that meandering provides a source of “noise” in eroding landscapes, and in particular distorts tributary base-level signals and triggers continual reorganization of tributary drainage networks. Transience driven by this reorganization may obfuscate evidence for tectonic and climatic forcing. Thus models of landscape evolution for systems where channels meander must incorporate active bedrock meandering, its control on tributary base-level forcing, and its continual reorganization of the drainage network as boundary conditions.

Final ID: EP53B-0824

Mapping bathymetry in a large meandering river above and below a significant sediment input

S. A. Kelly; [1]; *P. Belmont;* [1];

1. Watershed Sciences, Utah State University, Logan, UT, United States.

Body: Accurate representations of river bathymetry are essential for understanding channel morphodynamics and sediment routing. Repeat surveys of channel topography using sophisticated technology can elucidate where depositional surfaces occur and whether they are acting as net accumulation zones or places of transient sediment exchange. In this study, we used an Acoustic Doppler Current Profiler (ADCP) coupled with a real-time-kinematic GPS to collect bathymetry data upstream and downstream of a critical tributary junction where the Blue Earth River joins the Minnesota River, near Mankato, MN, USA. The Blue Earth River represents a considerable point source of coarse and fine sediment, much of which is stored within the channel and floodplain of the actively aggrading Minnesota River. This junction therefore represents a rare opportunity to study how a significant increase in sediment supply influences the form and evolution of in-channel topography. We surveyed 33 river km over 6 days in June 2013, achieving an average point density of 3.2 points/100 m2. River bathymetry is generally more variable in the transverse than the streamwise direction, so we used anisotropic interpolation techniques to construct digital elevation models (DEMs) of the surveyed channel. We transformed Cartesian coordinates to curvilinear orthogonal coordinates and generated DEMs using Hutchinson's spline, anisotropic ordinary kriging, and elliptical inverse distance weighting statistical interpolation techniques. To evaluate the performance of each interpolation method we created DEMs from a subset of the surveyed points and calculated the root mean square error between reference points in each DEM. We observed alternate bars in straight reaches downstream of the tributary junction, while straight reaches upstream were planar bed. Point bars and cutoffs were observed in meandering reaches above and below the tributary junction. Channel geometry significantly differs downstream of the Blue Earth River confluence. Average channel width increases 1.5x, the width to depth ratio nearly doubles, and bed slope decreases. We will continue to survey the Minnesota River for the next three years to quantify changes in the form and organization of channel topography.

Final ID: EP53B-0831

A comparison of hydrology and channel hydraulics in headwater streams of the Central Oregon Cascades

L. A. Hempel; [1]; *G. Grant;* [1, 2]; *S. Lewis;* [1, 2];
1. CEOAS, Oregon State University, Corvallis, OR, United States.
2. USDA Forest Service, Corvallis, OR, United States.

Body: Streams with distinctly different flow regimes can be found within close proximity of each other in the Central Oregon Cascades due to the unique hydrogeology of the region. Spring-fed streams with stable discharge regimes tend to have rectangular cross-sections, uniform grain sizes, and frequent channel-spanning wood. In contrast, flashier surface-runoff channels tend to have more variable cross-sections, a wider grain-size distribution, and woody debris accumulations along channel margins. To examine differences in channel hydraulics, we collected high-resolution 3-D maps of 12 channel reaches from tributaries of the McKenzie and Metolius Rivers, OR. Stream channel maps were then used to run a 2-D channel stability model (MD_SWMS). We also compared stream hydrology using 10+ years of stream gage data. We expect bed particles are mobilized more frequently in spring-fed systems, but the opportunity for channel form development— which occurs when sediment is mobile and when flow reaches or exceeds the active channel flow—is higher in surface-runoff channels. Therefore, each channel-type is characterized by a unique set of hydraulic processes that lead to observed differences in channel form.

Final ID: EP53B-0833

Physicochemical effects of temperature and water chemistry on cohesive channel erosion

T. Wynn-Thompson; [1]; *S. Hoomehr;* [2]; *O. Parks;* [3]; *M. Eick;* [4];

1. Biological Systems Engineering, Virginia Tech, Blacksburg, VA, United States.
2. Leonard Jackson Associates, Pomona, NY, United States.
3. Penfield & Smith, Santa Barbara, CA, United States.
4. Crop and Soil Environmental Sciences, Virginia Tech, Blacksburg, VA, United States.

Body: One potential unforeseen consequence urbanization and climate change is accelerated stream channel erosion due to increased stream temperatures and changes in stream chemistry, which affect the surface potential and hence the stability of soil colloids. Summer thunderstorms in urban watersheds can increase stream temperature more than 7 degC and the impact of global warming on average stream temperature is already evident in some stream systems. The goal of this research was to evaluate the impact of changes in stream chemistry commonly observed in urban watersheds, and expected to occur due to climate change, on the fluvial erosion of cohesive streambank soils. We hypothesized that increases in stream temperature and changes in stream pH and salt concentrations alter the surface potential of clay particles, affecting soil erodibility. We tested this hypothesis by measuring the erosion rate of two riparian soils dominated by different common phyllosilicate clays in a recirculating hydraulic flume. Two pH levels (6, 8), three water temperatures (10 degC, 20 degC, 30 degC), and two NaCl concentrations (5 mg/l, 5 g/l) were analyzed. Velocity profiles and the distance to the soil sample were measured using a Sontek Vectrino II acoustic Doppler profiler. Additionally, zetapotential was measured to determine if erosion rates were correlated to changes in clay surface potential due to varying water chemistry. Initial study results indicated significant increases in erosion rates for both clay types with decreasing pH and increasing water temperature; temperature effects were more significant than pH effects. Changes in erosion rates with salt concentration were only significant for the soil with montmorillonite clay. While the research is ongoing, these initial results could have wide-ranging implications for climate change and urban stormwater management. Assuming climate change will result in higher stream temperatures and lower stream pH, streambank erosion could accelerate in currently stable stream systems with cohesive banks. Additionally, new stormwater management and urban design techniques may be needed to manage runoff temperature and pH, in addition to current techniques for reducing runoff peak flow and volume from developed lands.

Final ID: EP53B-0839

Fluid Dynamical Control of Spacing and Symmetry Breaking in Orbital Wave Ripples

J. Nienhuis; [1]; *J. Perron;* [1]; *J. C. Kao;* [1]; *P. Myrow;* [2];
1. Earth, Atmospheric and Planetary Sciences, MIT, Cambridge, MA, United States.
2. Geology, Colorado College, Colorago Springs, CO, United States.

Body: Sand ripples in coastal environments and the rock record are a ubiquitous signature of the interaction of flows, bed topography and sediment transport. A common class of ripples, orbital wave ripples, exhibits a well-known linear relationship between the wavelength of the ripple pattern and the amplitude of wave-generated oscillatory flow. Based on this relationship, the ripple wavelength is often used as a paleoenvironmental indicator; and the height and spacing of modern ripples are major controls on bed roughness. However, the mechanism that selects the observed ratio of ripple wavelength to flow amplitude has not been explained.

Orbital wave ripples are sustained by zones of reversed flow on the lee side of the crest that moves sand upslope toward the crest. Using a lattice Boltzmann numerical flow model to simulate two-dimensional flow over a rippled bed, we demonstrate a coupling of flow and ripples that leads to the observed equilibrium: if the ratio between the orbital diameter (double the flow amplitude) and ripple wavelength is 0.65 – the equilibrium ratio observed in laboratory experiments and in the field – the maximum length of the separation zone downstream of a ripple crest is exactly equal to the ripple wavelength. Longer separation zones, with vortices advected further, will erode the neighboring crest. Shorter separation zones will not be able to erode the adjacent troughs.

In addition to this equilibrium morphology, orbital wave ripples display characteristic patterns as they evolve in response to changes in wave conditions. Multiple experiments have shown that large-scale symmetry is lost during adjustment to a new equilibrium. When the wave orbital diameter is shortened sufficiently, two new crests appear in every trough. Of these two, one decays, while the other keeps growing. Interestingly, the same side (right or left) is observed to “win” in every trough. When the orbital diameter is lengthened, a “bulging” instability occurs, in which select ripple crests become increasingly sinuous before breaking up. The origins of these transient phenomena are not yet understood.

We extracted side-looking 1D-profiles from field-scale laboratory experiments in a wave tank to study the incipient response of ripples to a step change in wave conditions, and used the numerical flow model to calculate stresses over the evolving bed. Combining these calculations with real-time video and time-lapse imagery, we tracked the hydrodynamic and morphodynamic evolution of individual ripples.

When the wave orbital diameter is shortened, incipient secondary crests act as “speed bumps,” shortening the separation zone and encouraging the growth of crests on the next flank. This feedback appears to be the mechanism that systematically favors incipient crests on the same side of each trough. When the orbital diameter is lengthened, the nearly straight crests of equilibrium ripples become unstable: crests migrate preferentially towards the nearest adjacent crest that is closer, which amplifies crest sinuosity and may lead to the observed bulging instability.

Understanding the mechanisms of ripple adjustment provides insight into bedform dynamics and paleoenvironmental reconstructions, and should aid in the development of reduced-complexity morphodynamic models by providing a basis for parameterizing complicated flow effects.

Final ID: EP53C-0851

Topographic and Genetic Markers of Landscape Change: Landslides and Isolated Fish Populations Demarcating Basin-wide Erosional Waves Above the Cascadia Subduction Zone

N. J. Lyons; [1]; *K. W. Wegmann;* [1]; *M. Raley;* [2];
1. Department of Marine, Earth, and Atmospheric Sciences, North Carolina State University, Raleigh, NC, United States.
2. Genomics and Microbiology Laboratory, North Carolina Museum of Natural Sciences, Raleigh, NC, United States.

Body: A cascade of geomorphic and biotic responses to river incision can be modulated by glacial-interglacial cycles. Prior investigations have revealed the complex fluvial responses to climate and tectonic uplift above the Cascadia margin. Reduced sediment supply or increased stream discharge during interglacials is responsible for incision and preservation of terraces, whose basal strath unconformities were formed during glacial periods. A river incision record is provided by a flight of well-preserved stream terraces in the Clearwater River basin of the Olympic Mountains.

Using numerical modeling and field observations, we will present analyses of stream topography and geometry, knickpoint location and age, and landslide frequency to assess hillslope and stream coupling in response to millennium-scale stream incision in the Clearwater River basin. We hypothesize that incision into a late Pleistocene terrace initiated a wave of erosion that is now expressed as increased landslide frequency on hillslopes, and as knickpoints on streams. Hillslopes are steepened to critical landslide thresholds as the erosional wave propagates through the basin. Aerial photographs and landslide inventories reveal that landslide scars cluster along the lower hillslopes below a network of stream knickpoints present in many Clearwater tributaries.

Also within the premise of this hypothesis, aquatic organisms would become isolated above knickpoints once waterfalls reach an impassable height. Knickpoints then block upstream passage of fish, which instigates genetic drift and decreases population genetic variation. Introduction of alleles—alternative forms of a gene—to fish populations upstream of knickpoints is then limited to mutations, which along with the genetic mutation rate of a species, operates as a “molecular clock” that records the time since knickpoint formation. We collected and analyzed DNA from Cutthroat trout (*Oncorhynchus clarkii*) specimens above knickpoints to assess the genetic distance of subpopulations and to estimate the time since these populations were connected. Establishing the diversity of trout in the Clearwater system has implications for the resiliency of small isolated populations, the transmission of erosion through basins, and the far-reaching effects of climate.

Final ID: EP53E-01

Morphodynamic modeling of the river pattern continuum ***(Invited)***

A. P. Nicholas; [1];

1. University of Exeter, Exeter, United Kingdom.

Body: Numerical models provide valuable tools for integrating understanding of fluvial processes and morphology. Moreover, they have considerable potential for use in investigating river responses to environmental change and catchment management, and for aiding the interpretation of alluvial deposits and landforms. For this potential to be realised fully, such models must be capable of representing diverse river styles and the spatial and temporal transitions between styles that are driven by changes in environmental forcing. However, while numerical modeling of rivers has advanced considerable over the past few decades, this has been accomplished largely by developing separate approaches to modeling single and multi-thread channels. Results are presented here from numerical simulations undertaken using a new model of river and floodplain co-evolution, applied to investigate the morphodynamics of large sand-bed rivers. This model solves the two-dimensional depth-averaged shallow water equations using a Godunov-type finite volume scheme, with a two-fraction representation of sediment transport, and includes the effects of secondary circulation, bank erosion and floodplain development due to the colonization of bar surfaces by vegetation. Simulation results demonstrate the feasibility of representing a wide range of fluvial styles (including braiding, meandering and anabranching channels) using relatively simple physics-based models, and provide insight into the controls on channel pattern diversity in large sand-bed rivers. Analysis of model sensitivity illustrates the important role of upstream boundary conditions as a control on channel dynamics. Moreover, this analysis highlights key uncertainties in model process representation and their implications for modelling river evolution in response to natural and anthropogenic-induced river disturbance.

Final ID: H53D-1447

Multi-scale Evaluation of a Real Time Multi-satellite Precipitation Forced Global Hydrological Modeling System

Y. Zhang;[1, 2]; *Y. Hong;*[1, 2]; *H. Gao;*[3]; *X. Xue;*[1, 2]; *J. J. Gourley;*[4];

1. CEES, University of Okalahoma, Norman, OK, United States.
2. ARRC, University of Okalahoma, Norman, OK, United States.
3. Texas A&M University, College Station, TX, United States.
4. National Severe Storms Laboratory, Norman, OK, United States.

Body: A Global Hydrological Modeling System (GHMS), with its core part of a physical based distributed hydrological model called Coupled Routing and Excess STorage (CREST), has been established and applied for real time global flood monitoring thus providing early warning for decision makers and stakeholders. The updated Version 7 Near Real Time TRMM Multi-satellite Precipitation Analysis (TRMM-RT) with the potential to apply for real time flood prediction without gauge adjustment especially beneficial to those regions sparsely covered by gauge networks, was used to force the CREST model with the spatial resolution of 1/8 degree from 50N to 50S quasi-globally (http://eos.ou.edu) for a retrospective period (2002-2012). The simulated hydrological variables (e.g. runoff depth and streamflow) were compared with Global Runoff Data Center (GRDC) observations in terms of gridded global runoff climatology (mm/yr), the selected basins based annual mean and seasonality of streamflow prediction, daily and monthly scale based streamflow prediction skills over different continents, etc. At global scale, the TRMM RT derived gridded global runoff climatology (mm/yr) and model simulated annual streamflow mean over selected basins are in general agreement with GRDC observation, though with performance variation over different continents (e.g. Africa shows relatively poorer performance due to the sparsely in-situ networks for TMPA RT algorithm development). The results also indicate that the modeling performance is better with a larger basin size and a location near the equator. Given the global availability of satellite-based precipitation in near real-time, this study demonstrates the opportunities and challenges that exist for the real time flood prediction on basis of GHMS, which is particularly useful for the vast ungauged regions of the globe.

Final ID: H53I-01

Insights on Biogeochemistry from the Triple Isotope System of Nitrate ***(Invited)***

T. Meixner; [1]; *G. M. Michalski;* [2]; *N. Dejwahk;* [1]; *K. M. Riha;* [2]; *K. A. Lohse;* [3]; *E. L. Gallo;* [1]; *J. C. McIntosh;* [1]; *P. D. Brooks;* [1];

1. Hydrology and water Resources, University of Arizona, Tucson, AZ, United States.
2. Earth and Atmospheric Science, Purdue University, West Lafayette, IN, United States.
3. Biological Sciences, Idaho State University , Pocatello, ID, United States.

Body: Given its central role in biogeochemistry, its multiple valences and the reactive and unreactive gaseous forms, the nitrogen cycle has long proven a difficult biogeochemical system to unravel. The oxidized form of nitrogen, nitrate, has been of particular interest due to its hydrologic mobility and role as a common groundwater contaminant. While the use of $\delta^{15}N$ and $\delta^{18}O$ of nitrate have long helped us over the last decade to distinguish sources of contaminant and biogeochemical processes, such as nitrate reduction, the addition of $\Delta^{17}O$ (the triple isotope approach) has quantified the variability and importance of atmospheric contributions of nitrate, as well as the fate and transport of nitrate in natural environments. In the process of following this atmospherically sourced nitrate through hydrologic systems we have been further able to elucidate the loss and transformation processes that influence nitrate of all origins in the environment. Here, we will highlight the utility of the triple isotope system in a semi-arid system with reference to studies in other settings. The Tucson basin has four main sources of nitrogen- atmospheric deposition, terrestrial N fixation, anthropogenic fertilizer, and sewage effluent. The triple isotope system enabled the identification of denitrification as a major loss pathway after effluent discharge. We were also able to quantify the contribution of atmospheric nitrate directly to the regional groundwater system, and identify spatial patterns in surface water and groundwater. By bringing additional nitrogen budget and tracer data to bear we were able to constrain the biogeochemical cycling of N in the Tucson basin. This study offers lessons for those working on the N cycle in other settings and the triple isotope system offers a unique tool to help isolate the different processes that influence nitrate concentrations in natural waters.

URL : http://tmeixner.faculty.arizona.edu/

Final ID: P53D-1892

Orographic forcing of dune forming winds on Titan

E. J. Larson; [1]; *O. B. Toon;* [1]; *A. J. Friedson;* [2];
1. University of Colorado, Boulder, CO, United States.
2. Jet Propulsion Laboratory, Pasadena, CA, United States.

Body: Cassini has observed hundreds of dune fields on Titan, nearly all of which lie in the tropics and suggest westerly (from west to east) winds dominate at the surface [1,2]. Most GCMs however have obtained easterly surface winds in the tropics, seemingly contradicting the wind direction suggested by the dunes. This has led to an active debate in the community about the origin of the dune forming winds on Titan and their direction and modality. This discussion is mostly driven by a study of Earth dunes seen as analogous to Titan [1,2,3]. One can find examples of dunes on Earth that fit several wind regimes. To date only one GCM, that of Tokano [4,5], has presented detailed analysis of its near surface winds and their dune forming capabilities. Despite the bulk of the wind being easterly, this GCM produces faster westerlies at equinox, thus transporting sand to the east. Our model, the Titan CAM [6], is unable to reproduce the fast westerlies, although it is possible we are not outputting frequently enough to catch them. Our GCM has been updated to include realistic topography released by the Cassini radar team. Preliminary results suggest our tropical wind regime now has net westerly winds in the tropics, albeit weak. References: [1], Lorenz, R. et al. 2006. Science, 312, 724-727. [2], Radebaugh, J. et al. 2008. Icarus, 194, 690-703. [3] Rubin, D. and Hesp, P. 2009. Nature Geoscience 2, 653-658. [4] Tokano, T. 2008. Icarus 194, 243–262. [5] Tokano, T. 2010. Aeolian Research 2, 113-127. [6] Friedson, J. et al. 2009. Planetary Space Science, 57, 1931-1949.

Final ID: PP53A-1984

High lake levels at Siling Co, central Tibet, during MIS 5e - 6

X. Shi; [1]; *E. Kirby;* [1]; *K. P. Furlong;* [1]; *K. Meng;* [2]; *S. Marrero;* [3]; *E. Wang;* [2]; *Y. Asmerom;* [4]; *R. A. Robinson;* [5]; *V. J. Polyak;* [4]; *F. M. Phillips;* [3];

1. Geosciences, The Pennsylvania State University, University Park, PA, United States.
2. Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing, China.
3. Earth and Environmental Science, New Mexico Tech, Socorro, NM, United States.
4. Earth and Planetary Sciences, University of New Mexico, Albuquerque, NM, United States.
5. Earth Sciences, University St Andrews, St Andrews, Scotland, United Kingdom.

Body: Flights of well-preserved paleoshorelines around lakes atop the Tibetan plateau reflect paleoclimatic conditions in this highest region in the world and provide important constraints on the history of hydrologic change. Regionally, previous studies have shown that many Tibetan lakes achieved highstand levels during the Late Pleistocene – Early Holocene transition. Whether similar extents were reached in the geologic past, however, remains uncertain due to sparse dating of ancient shoreline features. Here we focus on exposures of relict, high shorelines around Siling Co, in central Tibet. Previous study of a well-preserved sequence of shorelines suggest that lake levels during the Late Pleistocene - Early Holocene reached ~ 64 m above present lake level (referenced to 1976). We determined ages of even higher shorelines (up to ~76 m above present lake level) using a combination of U-series dating of tufa deposits, 36Cl depth profiles of beach ridges, and optically stimulated luminescence (OSL) of beach sand. We obtained a 36Cl depth profile age of 113 ka from a tombolo in central peninsula of Siling Co, 66 m above present level; an OSL age from this deposit, however, yielded an age of ~ 43 ka and probably reflects saturation of the OSL signal. U-Th ages of tufa deposits range from 145 - 159 ka and place minimum constraints on lake levels during MIS 6 of 65 - 76 m above present level. Finally, an even older 36Cl age of 178 ka was obtained from a high spit shoreline (~ 62 m above present level). Collectively, our results provide evidence that lake levels at Siling Co reached or exceeded the Early Holocene highstand during the MIS 5e (Eemian) interglacial, suggesting that paleohydrologic conditions were similar during these time periods. Moreover, the preservation of higher shorelines developed during MIS 6 suggest the presence of an even larger lake during the penultimate glacial stage. Comparison of our results with available δ18O records of an ice core in northern Tibet, cave stalagmites in central Tibet and East China and insolation curve at 65°N, suggests that high lake levels may have developed in response to enhanced precipitation during the Eemian interglacial (as has been claimed for extensive Early Holocene lakes) or in response to deglaciation. However, high lake levels during the MIS 6 glacial probably require enhanced precipitation and/or reduced evaporative loss. Finally, our new shoreline chronology does not support the hypothesis of a single, integrated lake system (the putative “East Qiangtang Lake”) during the Late Pleistocene on the Tibetan Plateau.

Final ID: EP53E-02

New Possibilities in Global Hydrology and Sediment Transport ***(Invited)***

J. P. Syvitski; [1]; *S. Cohen;* [1]; *A. J. Kettner;* [1]; *G. R. Brakenridge;* [1];
1. Univ Colorado, Boulder, CO, United States.

Body: Global hydrological models have advanced over the last decade, from runoff predictions at 1° spatial resolution and one year time steps, to simulating runoff at 6 arc minutes and daily resolution (WBM model). In this model, flow routing employs a cell-tree topology and a semi-implicit finite difference solution to the Muskingum-Cunge equation using a diffusive wave solution to the St. Venant equations. Bankfull discharge is monitored for each pixel using a floodplain schema as described by Yamazaki et al. (2011) to simulate overbank flooding. Irrigational water demand is modelled with withdrawal from small reservoirs, shallow groundwater, nearby rivers, and unsustained deep aquifers. WBMsed takes into account landscape properties and landuse practices to simulate sediment load, sediment concentration, and sediment yield within the global river networks. Model implementation involves matching input resolution (time and space) with model resolution for global air temperature and precipitation, and appropriate boundary conditions (e.g. soil parameters, crop land, vegetation, bedrock lithology reservoirs, irrigation parameters, ice cover, population). Simulations provide both a continental view of the coupling between climate dynamics and the landscape, and the response from individual rivers. Human impacts on fluvial fluxes can also be quantified. The next decade should see improvements in both time and space resolution but will require new approaches in flow routing (kinematic or dynamic wave formulations), and higher resolution flow grids as well as refining sediment flux simulations by incorporating earthquake activity, more accurate land use changes, and improvements in simulating spatial bedload. Research possibilities are abundant: contributions to river characterizations and assessments, better understanding of coastal dead zones, and realistic coupling of climate dynamics to river morphology. Model compatibility to data from present and future satellite missions will further improve these efforts.

Final ID: EP53E-03

Towards a consistent modeling framework across scales

B. Jagers; [1];
1. Deltares, Delft, Netherlands.

Body: The morphodynamic evolution of river-delta-coastal systems may be studied in detail to predict local, short-term changes or at a more aggregated level to indicate the net large scale, long-term effect. The whole spectrum of spatial and temporal scales needs to be considered for environmental impact studies. Usually this implies setting up a number of different models for different scales. Since the various models often use codes that have been independently developed by different researchers and include different formulations, it may be difficult to arrive at a consistent set of modeling results. This is one of the reasons why Deltares has taken on an effort to develop a consistent suite of model components that can be applied over a wide range of scales. The heart of this suite is formed by a flexible mesh flow component that supports mixed 1D-2D-3D domains, a equally flexible transport component with an expandable library of water quality and ecological processes, and a library of sediment transport and morphology routines that can be linked directly to the flow component or used as part of the process library. We will present the latest developments with a focus on the status of the sediment transport and morphology component for running consistent 1D, 2D and 3D models.

URL: http://oss.deltares.nl/web/delft3d

Final ID: EP53E-05

A (fast) “precipiton” method to calculate river hydrodynamics with applications to landscape evolution models as well as flood prediction

P. Davy;[1];

1. Geosciences Rennes, Rennes Cedex, France.

Body: Particle-based methods have been popular to develop models of landscape evolution able to reproduce complex features such as dynamical braided patterns. Such a high-resolution high-frequency geomorphical structures are beyond the scope of simple landscape evolution model, whose hydrodynamics description is much too rudimentary, and hardly modeled with sophisticated CFD models because of computational time. Solving hydrodynamics remains however a major issue for the particle-based models, which may cast doubt on the relevance of the modeled dynamics.

The “precipiton” method consists in routing elementary water volumes (i.e. precipitons) on top of topography with erosive and deposition actions. The basic method assumes that precipitons move down the steepest descent slope of topography, which is a very crude approximation of the river hydrodynamics. Here we present an original way to calculate both river depth and velocity, from a method that remains intimately embedded into the precipiton framework. The method consists in solving water depth from a differential equation where the water depth is increased by a constant (small) quantity at each precipiton passage, and decreased by a mass balance 1st-order differential equation, where the flux is related to water depth from a Manning-type flow resistance equation. The precipiton are then routed on top of the water surface so calculated, towards lowest zones. The method is applicable even if the precipitons are routed one by one, i.e. independently of each others. It is not subject to the classical drying-wetting issue.

The method has been applied to a large number of geomorphic cases including lake filling, circular channels, flow over topographic bumps, flow over vegetation patches and river banks, dam gate, or real cases with high resolution LIDAR topography. In all cases, the method is very fast to find a solution for water depths, which fits the shallow water solution without inertia. For real topographies, the model has been used to calculate the areas flooded for different hydraulic conditions. Further developments are in progress to incorporate the inertia terms of the shallow water equation that makes possible the modeling of countercurrents or return flows.

When coupled with erosion/deposition rules, the model is able to simulate the birth and development of the braiding instability without any dependency to the grid size.

Final ID: GC53D-07

Rising to the Challenge of Climate Impact Assessment in the Arctic *(Invited)*

L. D. Hinzman; [1];
1. International Arctic Research Center, University of Alaska Fairbanks, Fairbanks, AK, United States.

Body: The environmental changes ongoing in Arctic Regions have clearly demonstrated the climate is changing however assessing and predicting the impacts upon the physical and biological systems remains an important research challenge. To truly understand the evolution of the environment in response to a warming climate, we cannot investigate single components in isolation. We must change our perspective to include the dynamic linkages and feedbacks among system components, including physical and biological processes and in some cases societal interactions. The land areas of the Arctic are changing rapidly. The permafrost is degrading, lakes are draining, soils are getting drier, plant and animal species are migrating northward, snow is melting earlier and returning later. The marine system is also experiencing marked changes, most notably loss of sea ice, warming of deeper layers, changes in cloudiness and weather, acidification and migration of species. Trends of decreasing sea ice and increased open-water fetch, combined with warming air and ground temperatures, result in higher wave energy, increased seasonal thaw, and accelerated coastal retreat along large parts of circum-Arctic coast. All of these changes are having a significant impact upon local environment, but these changes are occurring over such a large area, they are beginning to affect regional and perhaps even global climate. We will not be able accurately forecast the impacts of changing climate conditions until we can accurately incorporate the processes of those dynamics in the integrated system.

Final ID: H53M-07

A Non-classical Hydrostatic Equation for Unsaturated Porous Media

J. Wang; [1]; *R. L. Bras;* [1]; *T. H. Illangasekare;* [2]; *T. Sakaki;* [3]; *R. L. Detwiler;* [4];
1. GA Ins of Tech-Civil & Env Eng, Atlanta, GA, United States.
2. Colorado School of Mine, Golden, CO, United States.
3. National Cooperative for the Disposal of Radioactive Waste, Wettingen, Switzerland.
4. University of California, Irvine, CA, United States.

Body: The classical hydrostatic equation (CHE) of a liquid fluid in unsaturated porous media is critically re-examined vis-a-vis Newton's first law, the principle of minimum potential energy, and the principle of virtual work. We found that the CHE is inconsistent with these fundamental principles. A non-classical hydrostatic equation (NCHE), derived based on Newton's first law and the principle of minimum potential energy, includes an extra term as a nonlinear function of tension and liquid content. The NCHE makes four quantitative and experimentally verifiable predictions that are inconsistent with the CHE: 1) tension head is a nonlinear function of elevation (nonlinearity); 2) the vertical profile of equilibrium liquid content extends within a finite distance bounded by “edges” (discontinuity); 3) equilibrium profiles of liquid content and tension head may decrease or increase with elevation (non-monotonicity); and 4) opposite horizontal equilibrium distribution of liquid content to that according to the CHE (lateral reversion). Preliminary laboratory experiments have confirmed nonlinearity and provided suggestive evidence consistent with discontinuity. In addition, an analytical expression of areal liquid content as a function of liquid content in terms of retention curve was obtained for the first time. This study provides an alternative explanation of flow and transport in unsaturated porous media deviating from Darcy’s law or Richards’ equation, and may be a starting point of formulating revised Darcy’s and Richards’ equation.

Final ID: EP53E-08

A theoretical and field-based study on the formation and shape of fluvial levees

D. A. Edmonds; [1]; *E. A. Hajek;* [2];
1. Geological Sciences, Indiana University, Bloomington, IN, United States.
2. Geosciences, Penn State University, University Park, PA, United States.

Body: The natural levees that form on channel margins are important features because they influence sediment transfer between channel and floodplain, and modulate the floodplain accretion rate. Despite this importance, we do not have basic models that predict levee formation or shape. Here we present a coupled theoretical and field-based study on formation and shape of levees. We developed a 1D morphodynamic channel-floodplain model for levee growth. Our model starts from the simplifying assumption of a straight channel and floodplain, each with a uniform width. The model solves conservation of mass for water and sediment along a cross-section perpendicular to the channel and is coupled to an analytical solution of the Navier-Stokes equations that solves for the downstream flood velocity and accounts for turbulent momentum exchange between the channel and floodplain.

Model results predict that the necessary conditions for levee formation depend non-linearly on the ratio of channel depth to floodplain depth, and the floodplain Rouse number. If the necessary conditions for levee formation are met, the shape of the levee is controlled by the Peclet-Rouse number. Wider levees form in advection-dominated floodplains (high Peclet number) with easily suspendable grains (low floodplain Rouse number). Diffusion has two important effects on levee width. Firstly, increasing the diffusivity directly increases diffusive sediment transport into the floodplain, which increases levee width. Secondly, increasing diffusivity causes additional turbulent diffusion of momentum from the main channel to the floodplain, which increases the width of the shear layer. A wider shear layer increases the near-channel downstream velocity, which creates more suspended transport and wider levees.

We compare our model predictions to levees on reaches of the White River and Muscatatuck River, Indiana, USA. We chose these rivers because the sediment load of the White River is ~5% silt, whereas it is ~80% silt for the Muscatatuck River. Consistent with model predictions, we find that levees on the coarser-grained White River are narrower and much less prevalent compared to the Muscatatuck.

Final ID: EP54A-07

Questioning the Faith – Models and Prediction in Stream Restoration ***(Invited)***

P. Wilcock;[1];
1. Johns Hopkins Univ, Baltimore, MD, United States.

Body: River management and restoration demand prediction at and beyond our present ability. Management questions, framed appropriately, can motivate fundamental advances in science, although the connection between research and application is not always easy, useful, or robust. Why is that? This presentation considers the connection between models and management, a connection that requires critical and creative thought on both sides. Essential challenges for managers include clearly defining project objectives and accommodating uncertainty in any model prediction. Essential challenges for the research community include matching the appropriate model to project duration, space, funding, information, and social constraints and clearly presenting answers that are actually useful to managers. Better models do not lead to better management decisions or better designs if the predictions are not relevant to and accepted by managers. In fact, any prediction may be irrelevant if the need for prediction is not recognized. The predictive target must be developed in an active dialog between managers and modelers. This relationship, like any other, can take time to develop. For example, large segments of stream restoration practice have remained resistant to models and prediction because the foundational tenet – that channels built to a certain template will be able to transport the supplied sediment with the available flow – has no essential physical connection between cause and effect. Stream restoration practice can be steered in a predictive direction in which project objectives are defined as predictable attributes and testable hypotheses. If stream restoration design is defined in terms of the desired performance of the channel (static or dynamic, sediment surplus or deficit), then channel properties that provide these attributes can be predicted and a basis exists for testing approximations, models, and predictions.