CSDMS

COMMUNITY SURFACE DYNAMICS MODELING SYSTEM

ANNUAL REPORT

AUG 2015

NSF COOPERATIVE AGREEMENT 0621695

CSDMS

COMMUNITY SURFACE DYNAMICS MODELING SYSTEM

Executive Summary

The Community Surface Dynamics Modeling System (CSDMS) is a NSF-supported, international and community-driven program that seeks to transform the science and practice of earth-surface dynamics modeling. CSDMS, now in its 8th year, integrates a diverse community of 1323 members representing 176 U.S. institutions (129 academic, 26 private, 21 federal) and 315 non-U.S. institutions (210 academic, 31 private, 74 government) from 67 countries. CSDMS distributes 246 Open Source models and modeling tools, provides access to high performance computing clusters in support of developing and running models, and offers a suite of products for education and knowledge transfer. The CSDMS architecture employs frameworks and services that convert stand-alone models into flexible "plug-and-play" components to be assembled into larger applications. CSDMS activities are supported through multiple NSF funding units: GEO/OCE Marine Geology and Geophysics, GEO/EAR Geoinformatics, GEO/EAR Geomorphology and Land-use Dynamics, GEO/EAR Sedimentary Geology and Paleontology, GEO/EAR Education and Human Resources, GEO/EAR Hydrological Sciences, BIO/DEB Macrosystems Biology, and BIO/DEB Ecosystem Studies. This report highlights web portal developments, model uncertainty support services, and the CSDMS Web Modeling Tool (WMT), the web-based successor to the desktop Component Modeling Tool that allows users to build and run coupled Earth system models on a high-performance computing cluster (HPCC) from a web browser. Reports from each of the six CSDMS Working Groups (including the newly reformed Interagency Working Group) and seven Focus Research Groups (including the recently launched Ecosystems Dynamics FRG) are provided. We outline past achievements and their plans to implement the CSDMS Strategic Plan. This Annual Report covers the period from August 2014 to July 2015.

Table of Contents: CSDMS 2.0 2015 Annual Report

CSDMS 2.0 2015 Annual Report

1.0 CSDMS Mission

The Community Surface Dynamics Modeling System (CSDMS) catalyzes new paradigms and practices in developing and employing software to understand the earth's surface — the ever-changing dynamic interface between lithosphere, hydrosphere, cryosphere, and atmosphere. CSDMS focuses on the movement of fluids and the sediment and solutes they transport through landscapes, seascapes and sedimentary basins. CSDMS supports the development, integration, dissemination and archiving of community open-source software that reflects and predicts earth-surface processes over a broad range of temporal and spatial scales.

2.0 CSDMS Management and Oversight

2.1 The CSDMS Executive Committee (ExCom) is comprised of organizational chairpersons:

- **Patricia Wiberg** (Apr. 2012—), Chair, CSDMS Steering Committee, Univ. of Virginia, VA
- **Christopher Sherwood** (Sept. 2014—), Chair, CSDMS Interagency Working Group, USGS, Woods Hole, MA
- **Greg Tucker** (Apr. 2007—), Chair, Terrestrial WG, CIRES, U. Colorado – Boulder, CO
- **Brad Murray** (April 2007—), Chair, Coastal Working Group & Coastal Vulnerability Initiative, Duke Univ., NC
    - *Chris Thomas (May 2014 —), Vice Chair, Coastal WG, British Geological Society, Edinburgh, UK*
    - *Hans-Peter Plag (May 2014—), Vice Chair, Coastal Vulnerability Initiative, Old Dominion U., Norfolk, VA*
- **Courtney Harris** (Apr. 2012—), Chair, Marine WG & Continental Margin Initiative, VIMS, VA
- **Eckart Meiburg** (Jan. 2009—), Chair, Cyberinformatics & Numerics WG, U. California-Santa Barbara, CA
    - *Scott Peckham (Dec. 2013—) Vice Chair, Cyberinformatics & Numerics WG, U. Colorado – Boulder*
- **Samuel Bentley** (Sept. 2012—), Chair, Education & Knowledge Transfer WG, LSU, LA
- **Brian Fath** (Nov. 2014—), Chair, Ecosystem Dynamics FRG, Towson University, Towson, MD & International Institute for Applied Systems Analysis, Laxenburg, Austria
- **Peter Burgess** (Sept. 2008—), Chair, Carbonate Focus Research Group, Royal Holloway, U. London, UK
- **Carl Friedrichs** (Apr. 2009-Jul. 2014), Chair, FRG, VIMS, VA
- **Raleigh Hood** (Jul. 2014—), Chair, Chesapeake FRG, U. of Maryland, Cambridge, MD
- **Jonathan Goodall** (Nov, 2010—), Chair, Hydrology FRG, U. of Virginia, Charlottesville, VA
- **Chris Duffy** (Mar. 2013—), Co-Chair, Critical Zone FRG, Penn State U., PA
- **Alejandro Flores** (Oct. 2014—), Co-Chair, Critical Zone FRG, Boise State U., ID
- **Mark Rounsevell** (Nov. 2014 —), Co-Chair, Human Dimensions FRG, University of Edinburgh, UK
- **Kathleen Galvin** (Jan. 2013—), Co-Chair, Human Dimensions FRG, Colorado State University, Ft. Collins, CO
- **Phaedra Upton** (Mar. 2013—), Co-Chair, Geodynamics FRG, GNS, Lower Hutt, New Zealand
- **Mark Behn** (Mar. 2013—), Co-Chair, Geodynamics Focus Research Group, WHOI, MA
- **James Syvitski** *(ex-officio),* CSDMS Executive Director, INSTAAR, University of Colorado - Boulder

The Executive Committee is the primary decision-making body of CSDMS, and ensures that the NSF Cooperative Agreement is met, oversees the Bylaws & Operational Procedures, and sets up the annual science plan. The ExCom approves the business reports, management plan, budget, partner memberships, and other issues that arise in the running of CSDMS.

2.2 The CSDMS Steering Committee (SC) includes representatives of U.S. Federal Agencies, Industry, and Academia:

- **Patricia Wiberg** (Sept. 2012—), Chair, CSDMS Steering Committee, Univ. of Virginia, VA
- **Tom Drake** (April 2007—), U.S. Office of Naval Research, Arlington, VA
- **Bert Jagers** (April 2007—), Deltares, Delft, The Netherlands
- **Marcelo Garcia** (Dec. 2012—), Univ. Illinois at Urbana-Champaign, IL
- **Chris Paola** (Sept. 2009—), NCED, U. Minnesota, Minneapolis, MN
- **Cecilia DeLuca** (Sept. 2009—), ESMF, NOAA/CIRES, Boulder, CO
- **Boyana Norris** (Sept. 2009—), University of Oregon, Eugene, OR
- **Guillermo Auad** (Jan. 2013—), Bureau of Ocean and Energy Management, Herndon, VA
- **Martin Perlmutter** (Jan. 2014 —), Chevron, Exploration Technology Company, Houston, TX
- **James Syvitski** (*ex-officio*), CSDMS Executive Director, INSTAAR, CU-B, Boulder, CO
- **Bilal Haq** (*ex-officio),* National Science Foundation
- **Paul Cutler** *(ex-officio),* National Science Foundation

The CSDMS SC assesses the competing objectives and needs of CSDMS, assesses progress in terms of science, outreach and education, advises on revisions to the 5-year strategic plan, and approves the Bylaws and its revisions.

2.3 CSDMS Working and Focus Research Groups

There are currently 1323 members representing 176 U.S. institutions (129 academic, 26 private, 21 federal) and 315 non-U.S. institutions (210 academic, 31 private, 74 government) from 67 countries. Members are organized within 6 working groups (Terrestrial, Coastal, Marine, Education and Knowledge Transfer, Cyberinformatics and Numerics, and Interagency) and 7 focus research groups (Human Dimensions, Carbonate, Hydrology, Critical Zone, Geodynamics, Chesapeake, and Ecosystem Dynamics).

Terrestrial	622	Geodynamics	91
Coastal	498	Carbonate	87
Hydrology	479	Chesapeake	62
Marine	322	Critical Zone	53
Cyber	189	Human Dimensions	45
EKT	198	Ecosystem Dynamics	30

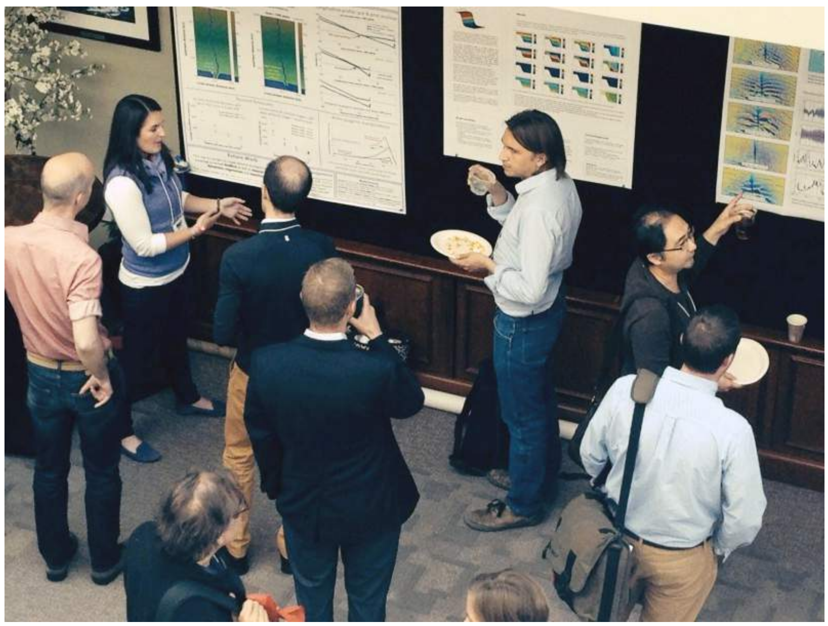
2.4 The CSDMS Integration Facility (IF)

The CSDMS Integration Facility (IF) maintains the CSDMS repositories and facilitates community communication and coordination, public relations, and product penetration. The IF develops the CSDMS cyber-infrastructure, provides software guidance to the CSDMS community, maintains the CSDMS vision, and supports cooperation between observational and modeling communities. As of July 2015, CSDMS IF staff includes:

- Executive Director, Prof. James Syvitski (April, 2007—) - CSDMS & CU support
- Executive Assistant, Lauren Borkowski (Jan. 2014 —) - CSDMS support
- Senior Software Engineer, Dr. Eric Hutton (April 2007—) - CSDMS support
- Software Engineer, Dr. Mark Piper (Oct. 2013—) - CSDMS & other NSF support
- Cyber Scientist, Dr. Albert Kettner (July 2007—) - CSDMS & other NSF & NASA support
- EKT Scientist, Dr. Irina Overeem (Sept. 2007—) - CSDMS & other NSF & NASA support
- Research Scientist, Dr. Kimberly Rogers (March 2012—) - Other NSF support
- Postdoctoral Researcher, Dr. Stephanie Higgins (Sept. 2010—)- NASA & Belmont Forum Support

• Research Associate, Dr. Mariela Perignon (June 2015 —) -Other NASA & NSF support
• Research Associate, Dr. Elchin Jafarov (June 2015 —) -Other NSF support
• Systems Administrator, Chad Stoffel (April 2007—) - multiple grant support
• Accounting Technician, Chrystal Pochay (July 2013 —) - multiple grant support
• Director, Flood Observatory, Dr. G Robert Brakenridge (Jan. 2010—) – NASA, World Bank support
• Senior Research Scientist, Dr. Christopher Jenkins (Jan. 2009—) – NSF, BOEM & other support

Departures
• Ph.D. GRA Ben Hudson (May 2010- Dec. 2014) - Other NSF support
• Ph.D. GRA Fei Xing (July 2010-April 2015) - Other NSF support



CSDMS Annual Meeting 2015 Poster Session

2.5 CSDMS Industrial Partners

Industry partners (csdms.colorado.edu/wiki/Industry_partners) play an important role in contributing to the success of CSDMS through their financial or in-kind contributions. Sponsorship supports the CSDMS effort and thus the next generation of researchers working to develop innovative approaches towards modeling complex earth-surface systems. CSDMS consortium members: 1) demonstrate corporate responsibility and community relations; 2) contribute to the direction of CSDMS research and products; 3) access the latest CSDMS products and information; and 4) join an association of diverse scientists, universities, agencies, and industries. Approximately 12% of CSDMS member institutions are with the private sector.

3.0 JUST THE FACTS

3.1 CSDMS Model Repository

The CSDMS Model Repository hosts open-source models, modeling tools, and plug-and-play components, including: i) Cryospheric (e.g. glaciers, permafrost, icebergs), ii) Hydrologic, from reach to global scale, iii) Marine (e.g. ocean circulation), iv) River, coastal and estuarine morphodynamics, v) Landscape or seascape evolution, vi) Stratigraphic, and vii) Affiliated domains (e.g. weather & climate models). About 70% of the models are distributed through a central Repository hosted at GitHub (https://github.com/csdms-contrib); others are distributed through linkages to existing community efforts. The newly implemented centralized model repository at GitHub makes source code version control, contributions, sharing, down loading and managing individual code repositories easier with more control for the code developer (See also section 4.10). The GitHub repository reduces the overhead time for CSDMS-IF staff as managing and maintaining a local source code version control server is no longer needed. The abundance of different ways to share source code through GitHub makes it impossible to present download statistics. We hope to be able to present this information in future annual reports. The table below represents the total number of source code projects (246) per domain where one model project could be in multiple domains; numbers in italic are contributions made over the last year.

Models, Tools by Environmental Domain http://csdms.colorado.edu/wiki/Main_Page

Domain	Models	Tools
Terrestrial	92 (*11*)	52 (*3*)
Coastal	58 (*5*)	4 (*1*)
Marine	51 (*7*)	5 (*1*)
Hydrology	58 (*4*)	40 (-)
Carbonate	3 (-)	2 (*1*)
Climate	10 (-)	2 (-)
Total	187	59

Over last year the following new models were either submitted to the Model repository or source code was made available through external sites (http://csdms.colorado.edu/wiki/Models_all#All_models):

Model	Description	Developer
GreenAmptInfiltrationModel	The Green-Ampt method of infiltration estimation.	Peishi Jiang
GeoClaw	Depth-averaged fluid dynamics for modeling geophysical flows and wave propagation.	Randall LeVeque
PHREEQC	PHREEQC version 3 is a computer program written in the C and C++ programming languages that is designed to perform a wide variety of aqueous geochemical calculations	David Parkhurst
GEOMBEST-Plus	2D cross-shore geomorphological model of barrier island and marsh response to sea level rise.	David Walters
OceanWaves	Calculate wave-generated bottom orbital velocities from surface wave parameters	Patricia Wiberg

Coastal Dune Model	Evolution of Coastal Foredunes	Orencio Durán Vinent
FineSed3D	A turbulence-resolving numerical model for fine sediment transport in bottom boundary layer	Zhen Cheng
MARM5D	Landscape-scale soil evolution model	Sagy Cohen
Cliffs	Numerical model to compute tsunami propagation and runup on land in the shallow-water approximation	Elena Tolkova
SLEPIAN Delta	Analysis of time-variable gravity from the GRACE satellite mission using spherical harmonics and spherical Slepian functions	Christopher Harig
SLEPIAN Charlie	Spectral estimation problems using spherical harmonics and spherical Slepian functions	Frederik Simons
SLEPIAN Bravo	Linear inverse problems using spherical harmonics and spherical Slepian functions	Frederik Simons
SLEPIAN Alpha	Computation of spherical harmonics, Slepian functions, and transforms	Frederik Simons
TwoPhaseEulerSedFoam	A four-way coupled two-phase Eulerian model for sediment transport	Zhen Cheng
GullyErosionProfiler1D	This model is designed to simulate longitudinal profiles with headward advancing headcuts.	Francis Rengers
IceFlow	2D semi-implicit shallow ice approximation glacier model	Andy Wickert

Over last year the following new tools were either submitted to the Model repository or source code was made available through an external sites (http://csdms.colorado.edu/wiki/Models_all#All_tools):

Tool	**Description**	**Developer**
OrderID	A method to test for order in a vertical succession of strata	Peter Burgess
Hilltop flow routing	Algorithm for directly measuring hillslope length from high resolution topographic data	Stuart Grieve
SurfaceRoughness	Quantifies surface roughness with high-resolution topographic data by analyzing the local variability of surface normal vectors	David Milodowski

CSDMS is tracking papers, books, chapters, or reports that describe or apply single or multiple models that are currently listed in the CSDMS model repository. So far CSDMS is managing references to 586 papers. Last year, 25 references were added to the model reference database.

3.2 CSDMS Data Repository csdms.colorado.edu/wiki/Data_download

Data Repository as of July 2015

Data Type	Databases	Data Type	Databases
Topography/bathy	19	Land cover	5
Climate	6	Life Forms	1
Hydrography	6	Substrates	4
River discharge	9	Human Dimensions	2
Cryosphere	5	Sea level	1
Surface Properties	5	Oceanography	11
		GIS Tools	12

3.3 CSDMS Education & Knowledge Transfer (EKT) Repository

Developed Educational and Knowledge Transfer materials are made available through the CSDMS online repository. Material is open source and organized in several tiers: 1) basic educational resources such as movies, animations and imagery, 2) Science on a Sphere datasets, 3) CSDMS course lectures, 4) teaching labs using models and the CSDMS HPCC including model development teaching labs.

Movie repository

Feedback from CSDMS members and consistent traffic to the CSDMS YouTube channel (reported in section 3.6) indicates substantial use of documented movies and model animations. In response, we have expanded the number of earth-surface processes "real-world" movies and model animation over 2014-2015 to approximately 140 movies.

http://csdms.colorado.edu/wiki/Movies_portal

In total 32 movies (a 24% increase) were collected, described and added to the educational repository. Movies are a powerful medium to use for educational purposes, to highlight certain landscape forming processes, or to indicate how well models capture natural processes. Below is a list of movies added over the last year and the type of movie each presents: a) an 'Animation', simulated by model; b) a 'Laboratory', lab experiment that is filmed; or c) a 'Real event', footage of a natural process.

Submitted movies over the last year	Movie type
Wave heights in Gulf of Mexico due to Rita	Animation (Delft3D)
Water level in Gulf of Mexico during Hurricane Rita	Animation (Delft3D)
Water level in Wax lake delta due to winter storms	Animation (Delft3D)
Wax Lake Sedimentation for a cold Front	Animation (Delft3D)
Wax Lake Salinity during strong cold front	Animation (Delft3D)
Wax Lake Salinity during hurricane Ike	Animation (Delft3D)
Sedimentation in Wax lake during Rita	Animation (Delft3D)
Wave height in vegetated Wax Lake during Rita	Animation (Delft3D)
Wave height in Wax Lake during Rita	Animation (Delft3D)
Waterlevel in Wax Lake during Rita	Animation (Delft3D)
Ocean Waves during Hurricane Sandy 2012	Animation (Delft3D)
Wave heights during hurricane Katrina 2005	Animation (Delft3D)
Global Wave Power 2012	Animation (WaveWatch III ®)
Global Wave heights 2012	Animation (WaveWatch III ®)

Bioturbation by Worms	Laboratory
Debris Flow Nepal	Real event
Driftwood Simulation	Animation (1RICNaysCUBE 3D solver)
Density Current	Laboratory
Arctic Permafrost Coastal Erosion Simulation	Animation (-)
Arctic Coastal Erosion- Melting Block 2010	Real event
Rio Puerco 2006 Sedimentation Simulation	Animation (Anuga)
Rio Puerco Flood 2006 Simulation	Animation (Anuga)
Sand bed River Bar Migration	Animation (HSTAR)
Sandbed River Evolution	Animation (HSTAR)
Tree fall uprooting soil	Real event
Landslide Swiss Alps	Real event
Rio Puerco Flood damage in San Francisco	Real event
Rio Puerco Flood over HW66 in 2013	Real event
Rio Puerco Flood 2013	Real event
Flood of Lefthand Creek 2013	Animation (Anuga)
Flood of Boulder Creek 2013	Animation (Anuga)
Global Dams Development 1800-2010	Animation (-)

Science on a Sphere

The EKT repository now highlights the CSDMS contributions to NOAA's 'Science on a Sphere' data repository. The developed datasets are listed (See Table 1 and Appendix 10) and quick links to the NOAA data catalogue and teaching materials are provided. These new teaching resources are advertised on the CSDMS web portal front page and we solicite further contributions from CSDMS members. CSDMS provides flyers to explain what SOS is, and offers essential information for future SOS dataset contributions. CSDMS IF staff have visited 4 SOS installations within the U.S. and internationally (Fig. 1), and discussed data set requirements and efficacy with the museum educators. Appendix 10 provides details of this effort and reports on the use of the datasets in museums worldwide.

*Table 1. CSDMS contributions to Science on a sphere dataset catalogue (*data maintained by DFO and CSDMS)*

Data Set Title	ID	Web link
Dams and Reservoirs 1800-2010	472	http://sos.noaa.gov/Datasets/dataset.php?id=472
Dams and Reservoirs Mississippi River 1800-2010	476	http://sos.noaa.gov/Datasets/dataset.php?id=476
Dams and reservoirs Yangtze River 1800-2010	477	http://sos.noaa.gov/Datasets/dataset.php?id=477
Rivers Daily Discharge	555	http://sos.noaa.gov/Datasets/dataset.php?id=555
Flood Events 2000-2009*	109	http://sos.noaa.gov/Datasets/dataset.php?id=109
Wave Heights 2012	488	http://sos.noaa.gov/Datasets/dataset.php?id=488
Wave Power 2012	487	http://sos.noaa.gov/Datasets/dataset.php?id=487
Wave heights Hurricane Katrina 2005	490	http://sos.noaa.gov/Datasets/dataset.php?id=490
Wave heights Hurricane Sandy 2012	489	http://sos.noaa.gov/Datasets/dataset.php?id=489
A closer look at El Nino & La Nina	Live Program	http://sos.noaa.gov/Datasets/dataset.php?id=563

Fig. 1 CSDMS IF staff visits Science on a Sphere installation at the Jiangsu Provincial Meteorological Bureau in Nanjing, China. We discussed with museum educators a dataset on development of reservoirs with exclusive focus on dams within the Yangtze River basin, including the famous Three Gorges Dam.

Basic Modeling Labs and Spreadsheet Exercises for Highschool Students and Undergraduate Students

These exercises are designed for ease of use and to teach basic concepts in surface processes. The labs consist partly of spreadsheet labs and web-based models developed at the CSDMS Integration Facility, and include many contributions from the wider CSDMS community.

- *Earth Science Models for K6-12 (17 animations with teacher notes, developed by PhET).*
- *Hydrological Processes Spreadsheet Exercises (includes labs on precipitation, evapotranspiration and infiltration, all have both topical learning objectives as well as quantitative modeling and data skills objectives, 4 labs total).*
- *WILSIM (web-based landscape evolution modeling with special focus on the Grand Canyon, and WILSIM cellular automata on general landscape evolution processes, 2 codes, both developed by Wei Luo)*
- *Coastal Processes Labs (web-based coastal engineering models, including waves, seiche, storm surge and many others, 22 codes total, contributed by Robert Dalrymple).*
- *Sinking Deltas (on sea level rise and land subsidence processes, all have both topical learning objectives as well as quantitative modeling and data skills objectives, 2 labs).*
- *Flow Routing (on modeling of flow over a raster DEM, random walk, steepest descent, D8, Dinf theory, web-based, 1 lab, 1 activity).*
- *River Flow and Sediment Transport and Impacts of Vegetation (concepts of river discharge, flow velocity, critical shear stress, impacts of vegetation, including Mannings equation and a web-based interactive model of vegetation and flow velocity), material developed for Teacher Workshop in August 2015).*

Advanced Modeling Labs for Senior Undergraduate and Graduate Students

Advanced labs are now fully updated and tightly integrated with the newly released CSDMS Web Modeling

Tool. We have migrated to use new visualization software for classroom use. The software package, Panoply NetCDF, HDF and GRIB Data Viewer, is developed at NASA. It is an open-source package and works cross platform to plot georeferenced as well as non-referenced data (i.e. theoretical model outputs). A new tutorial on the use of Panoply for WMT users builds basics skills with this package.

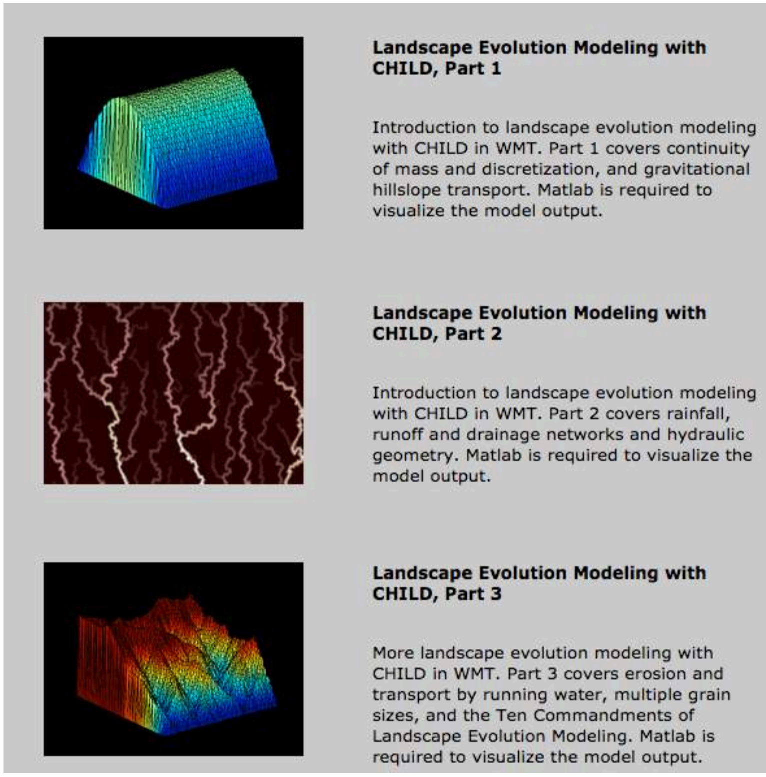


Fig. 2 Course on Landscape Evolution Modeling in three parts using CHILD, original course material contributed by Greg Tucker, and now fully adapted to be run through the CSDMS Web Modeling Tool.

List of Labs using the Web Modeling Tool and ran through the CSDMS HPCC system

1. *Get Started with WMT (basic skills working with WMT)*
2. *Visualize NetCDF Output from WMT (basic skills working with WMT)*
3. *River Sediment Supply Modeling (with HydroTrend)*
4. *Future Sediment Flux of the Ganges River (with HydroTrend)*
5. *Modeling River Plumes (with PLUME)*
6. *Longshore Sediment Transport and Barrier Coastlines (with CEM and Waves)*
7. *River-Delta Interactions (with coupled Avulsion, Waves and CEM)*
8. *Modeling Stratigraphy in 2-D cross-sections (with Sedflux)*
9. *Modeling of Delta Stratigraphy in 3-D (with Sedflux)*
10. *Landscape Evolution Modeling Part 1 (with CHILD)*
11. *Landscape Evolution Modeling Part 2 (with CHILD)*
12. *Landscape Evolution Modeling Part 3 (with CHILD)*

A number of developed teaching labs relied on the previous generation of the CSDMS modeling tool (i.e. Glacial modeling with GC2D, Hydrological Processes with TOPOFLOW, and simple landscape modeling and flow routing with ERODE). These labs are temporarily made 'invisible', but will be modified and become newly available upon release of these components in 2015-2016.

3.4 CSDMS Experimental Supercomputer

Over the last year 114 individuals were given a new account on the CSDMS High-Performance Computing Cluster, ***beach***. This represents a 30% increase in the total number of researchers using beach in a single year—our highest increase to date.

To obtain an account on ***beach*** users meet the following criteria:

- Run a CSDMS model(s) to advance science
- Develop a model that will ultimately become part of the CSDMS model repository
- Develop a new data systems or visualization in support of the CSDMS community

The CSDMS High Performance Computing Cluster (HPCC) System ***beach*** (Syvitski is PI) is an SGI Altix XE1300 with 88 compute nodes (704 cores, 3.0 GHz Harpertown processors ≈ 8 Tflops). 64 nodes have 16 GB of memory each; 16 nodes have 32 GB of memory each. Internode communication uses a non-blocking InfiniBand fabric. Each compute node has 250 GB of local temporary storage and can access 72TB (raw) of RAID storage through NFS. Beach provides GNU and Intel compilers as well as their MPI counterparts (mvapich2, mpich2, and openmpi). ***Beach*** is supported by the CU ITS Managed Services (UnixOps) under contract to CSDMS.

In November of 2014 ***beach*** was moved to its new home in the SPSC Data Center at the University of Colorado. This new data center provides support for 100 racks of up to approximately 12kW per rack. Features of the new data center include:

- Electrical system redundancy and reliability exceeding UTI Tier 1
- UPS and generator backup
- High-speed network connectivity
- Physical security and restricted access, 24/7
- Remote hands for performing routine tasks
- Cooling system that uses air-side economization, an efficiency model that takes advantage of Colorado's favorable climate

Top beach users since 1 December 2014

Investigator	Institution	Processor Days
Jim McElwaine	University of Cambridge	17491
Theodore Barnhart	University of Colorado	1274
Mark Piper	University of Colorado	495
Fei Xing	University of Colorado	366
Doug Edmonds	Indiana University	154
Gregory Ruetenik	Syracuse University	154
Xiujuan Liu	China University of Geosciences	124
Bartho Schulte	University of Santa Barbara	106
Raphael Ouillon	University of Santa Barbara	74
Frances Dunn	University of Southampton	67

The larger Janus supercomputing cluster (Syvitski is Co-PI) consists of 1368 nodes, each containing two 2.8 GHz Intel Westmere processors with six cores each (16,416 cores total) and 24GB of memory (2 GB/core) per node. Nodes are connected using a non-blocking quad-data rate InfiniBand interconnect, and 1 PB of parallel temporary disk storage. Beach is connected to the Janus cluster through a private 10 Gb/s network. The system enables Beach to quickly share large data sets using the Janus 1PB lustre file system. The Janus system CU Research Computing manages Janus. CPU Utilization rates on Beach average 70%.

3.5 CSDMS Web Portal Statistics csdms.colorado.edu/wiki/Special:Statistics

Content Pages	1,585
Total Pages	8,992
Upload Files	3,499
Page Edits	265,327
Registered Users	1,290
Page views last year	166,105

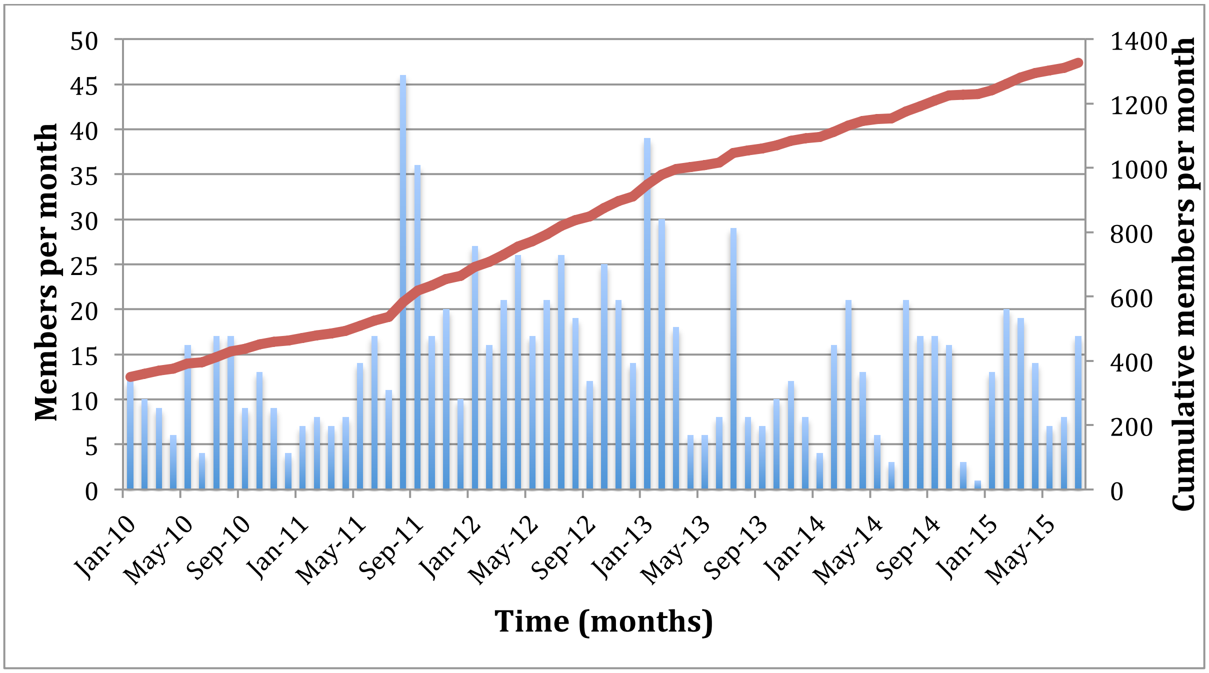


Fig. 3 Active membership per month as of January 2010. CSDMS has 1323 members as of July 13th, 2015 (an increase of 163 members since last annual report).

Fig. 4 Spatial representation of all CSDMS members as of July 2015 (interactive version is available through the CSDMS web portal: https://csdms.colorado.edu/wiki/All_CSDMS_members_spatial).

3.6 CSDMS YouTube Statistics http://www.youtube.com/user/CSDMSmovie

CSDMS YouTube channel (introduced in December 2010) hosts its (model) animations, laboratory experiments, real events and conference talks. Close to 175 people have now subscribed to the channel to stay informed about new uploads (45 new subscribers since previous annual report). The channel contains 228 short movies, which in total have been viewed 232,260 times. Over the last year the CSDMS YouTube channel had 54,422 new views, totaling ~46 days of CSDMS content viewing time. CSDMS started this channel to make people aware of how illustrative and sophisticated model simulations or associated movies can be. The movies on the CSDMS YouTube channel are integrated into the CSDMS website, and can be viewed through the CMSDS movie portal: http://csdms.colorado.edu/wiki/Movies_portal or directly through YouTube: http://www.youtube.com/user/CSDMSmovie.

Top 10 most viewed CSDMS YouTube movies:

Of the viewers of the top 10 most viewed movies, most came from the United States (59%), followed by the UK (11%) and Canada (8%). The table below shows the total views as of December 2010 (*Total*) as well as views over the last year (*Last yr*).

Movie title:	*Total:*	*Last yr:*	*link:*
Global circulation	85,196	21,457	http://www.youtube.com/watch?v=qh011eAYjAA
Laurentide Ice Sheet	18,791	5,449	http://www.youtube.com/watch?v=wbsURVgoRD0
World dams since 1800	9,113	2,773	http://www.youtube.com/watch?v=OR5IFcSsaxY
Sand Ripples	8,187	2,413	http://www.youtube.com/watch?v=rSzGOCo4JEk
Bedload sedim. transpo.	4,149	1,629	https://www.youtube.com/watch?v=is-qcxrKKBI
Spit Evolution	6,909	1,235	http://www.youtube.com/watch?v=N_LBeJPWqFM
Delta formation	8,207	1,196	http://www.youtube.com/watch?v=eVTxzuaB00M
Barrier Island	4,354	1,065	http://www.youtube.com/watch?v=VCX_SzPydsw
Jokulhlaup over Sandur	3,644	916	http://www.youtube.com/watch?v=gKRFtm5Z8DM
Allier river meander	3,998	903	http://www.youtube.com/watch?v=i0KByNRGv_8

4.0 CSDMS 2.0 Year 3

4.1 CSDMS software stack on other HPC clusters

The CSDMS IF continues to build the complete CSDMS software stack on different operating systems, which include Darwin (Mac), and several flavors of Linux (CentOS, RedHat, and Ubuntu). The software stack provides the tools necessary for:

- Building C, C++, Fortran, and Python bindings for BMI models, regardless of their source language.
- Wrapping BMI models so that they can be incorporated into the CSDMS modeling framework.
- Running coupled model simulations, including grid mapping as provided by the ESMF.
- Executing coupled simulations generated with the CSDMS Web Modeling Tool.
- Uploading model results to the Web Modeling Tool server.

As the software stack consists of many components and, in turn, their dependent packages, the CSDMS IF has automated the installation process to make building the software on new platforms as easy as possible. Primarily written in Python, the CSDMS installer makes use of existing OS-specific package managers such as Homebrew for Mac and RPM or APT for Linux.

The software stack has been installed on large high-performance computing clusters such as ***Beach*** (CSDMS), ***Janus*** (Research Computing - University of Colorado), and ***Yellowstone*** (NCAR-Wyoming Supercomputing Center). At the same time, we continue to test these tools on single-processor personal computers. The CSDMS IF has started working with Sam Bentley and Jim Chen of LSU to install the CSDMS software stack on the HPC@LSU systems (http://www.hpc.lsu.edu). Professor Bentley plans to use WMT as a teaching tool in his classes.

The source code for the CSDMS Coupling Framework is hosted on GitHub at https://github.com/csdms/wmt-exe. The installer for the CSDMS software stack can be found in this repository at https://github.com/csdms/wmt-exe/blob/master/scripts/install.

4.2 The CSDMS Web Modeling Tool (WMT)

The CSDMS Web Modeling Tool (WMT) is now fully operational. WMT will be officially released at version 1.0 before the end of this funding year. The release will be announced on the CSDMS portal, newsletter, and social media channels. Additionally, to generate more exposure for WMT, an abstract has been submitted for a poster presentation on WMT at the 2015 AGU Fall Meeting.

Since the introduction of WMT at the 2014 CSDMS annual meeting, there have been

- 156 unique usernames registered;
- 560 models created by users (Irina Overeem has the most, with 65);
- 604 jobs submitted.

Additionally, CSDMS IF has received substantial feedback on the behavior and usability of WMT. Some of this feedback can be quickly implemented in WMT. Feedback that requires more thought, and more development time, has been collected into issues tracked on GitHub; e.g., https://github.com/csdms/wmt-client/issues.

WMT continues to be actively developed. Since the 2014 CSDMS annual meeting, there have been

- 380 commits to GitHub,

- 38 issues reported (17 of which have been closed), and
- 5000+ lines of code added.

To make it easier to develop and maintain WMT, the CSDMS IF has split WMT development into three GitHub repositories:

- **wmt**, the database and data servers
- **wmt-exe**, the execution server
- **wmt-client**, the web client

These repositories, each open-sourced under the MIT License, can be found under the CSDMS organization on GitHub, https://github.com/csdms. We encourage CSDMS members to fork these projects to add their own features, enhancements, and improvements, and then create pull requests to merge them back into the original CSDMS projects.

The CSDMS IF has written a new Web API that will function as the backend for WMT. The Web API provides a RESTful server-side interface to CSDMS models and model metadata. Communication with the API is done through the Hypertext Transfer Protocol (HTTP) with the usual HTTP verbs (GET, POST, PUT, PATCH, DELETE) used by typical web browsers. This API provides an interface to the following database of resources:

- Standard names: Get collections of standard names, parse standard names into their constituent parts (object, quantity, operators, etc.), query which models use which names.
- Components: Get information about CSDMS model components (author, version, etc.), what input and output variables they use, what other components they can connect to.
- Parameters: Query the entire list of input parameters used by models in the database.
- Input files: Query and construct model input files based on sets of parameters.

In addition, through the API users are able to submit model simulations (either a set of coupled components or a standalone model) that are then run on the CSDMS cluster, ***Beach***. Although written for the use by WMT, the web service is available for use by any user or even another program. The official WMT Web Service will become active before the end of this funding year. The Web API source code is available at https://github.com/csdms/wmt-api.

Several improvements have been made to the WMT client since its introduction at the 2014 CSDMS annual meeting.

- A sign-in screen has been added (see Figure 5). Users must login with an email address and a password to access WMT functionality. Links provide information to new users and password help.
- A 12-minute YouTube video (http://youtu.be/hbfmxHRYbtA) has been created to demonstrate how to use the WMT client. A link to the video is provided on the sign-in screen.
- A configuration file has been included with the client. It allows several client settings (e.g., the address of the HPC host) to be modified by an administrator without rebuilding the client.
- When opening a saved model, the owner and creation date are shown in the "Open Model" dialog. By default, users can now only see models that they own. However, if they set the **public** label on a model they own, it can be viewed, and run, by others. Likewise, when opening a model, selecting the **public** label allows a user to see public models created by other users. A user can't modify a public model that they don't own. They can, however, save a copy of the model with their username; the **public** label is automatically removed from the copy.

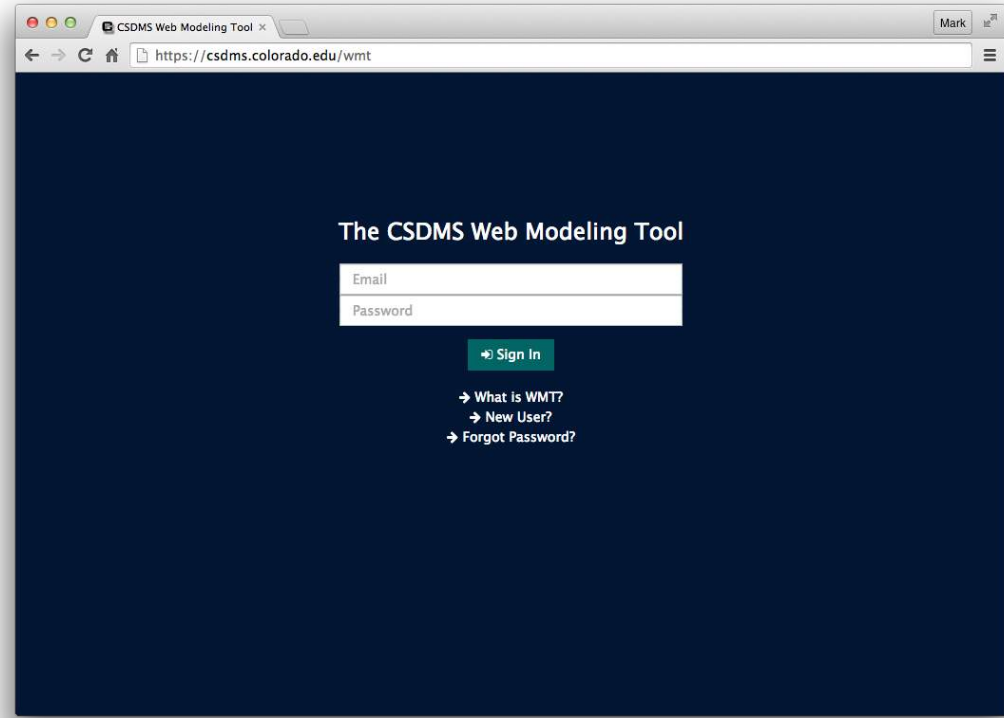


Fig. 5 The WMT sign-in screen. Links provide instructions to new users, password help, and a demonstration of WMT functionality on YouTube.

4.3 Automated 'wrapping' for moving BMI to CMI components

Before a BMI model can be run within the CSDMS modeling framework (or any other modeling framework), two things must be done:

- The BMI implementation must provide the necessary language bindings (Python, in the case of the CSDMS modeling framework)
- Provide the necessary interface for the particular modeling framework (a slightly modified version of BMI, in the case of the CSDMS modeling framework)

In the past, these two steps were done by hand, which made the process difficult to maintain, was time consuming, led to errors, and made it difficult to update any part of the workflow that brings a model into the CSDMS modeling framework. To remedy this, and make a more robust and sustainable product, the CSDMS IF automated this process.

Model BMI metadata now accompanies the BMI source code in the form of a YAML-formatted text file. Required metadata includes:

- Description of the model: Author(s), web page, version, license, etc.
- List of the input parameters and files
- Description of the steps needed to build the library

With this information, the automated wrapper is able to fetch the model source code, build it, create Python language bindings, decorate it in the BMI so that the CSDMS model-coupling framework can use it, and finally import it into the framework. For BMI projects that are hosted on GitHub, authors need only provide the metadata in a folder with the name *.bmi*. This identifies the project as one that provides a BMI and so can be automatically built. The source code for this project is available at https://github.com/bmi-forum/bmi-babel.

4.4 New Components

The CSDMS IF continues to add models with a BMI to the CSDMS modeling framework. The following components will be added to the CSDMS framework and made available in WMT by the end of the current funding year:

- **ChannelsKinWave**: The kinematic wave method is the simplest method for modeling flow in open channels. This method combines mass conservation with the simplest possible treatment of momentum conservation, namely that all terms in the general momentum equation (pressure gradient, local acceleration and convective acceleration) are negligible except the friction and gravity terms. For these flows the water surface slope, energy slope and bed slope are all equal.
- **ChannelsDiffWave**: This component uses the diffusive wave method to compute flow velocities for all channels in a D8-based river network. This method is similar to the kinematic wave method for modeling flow in open channels, but instead of a simple balance between friction and gravity, this method includes the pressure gradient that is induced by a water-depth gradient in the downstream direction. This means that instead of using bed slope in Manning's equation or the law of the wall, the water-surface slope is used. One consequence of this is that water is able to move across flat areas that have a bed slope of zero. Local and convective accelerations in the momentum equations are still neglected, just as is done in the kinematic wave method.
- **ChannelsDynamWave**: The dynamic wave method is the most complete and complex method for modeling flow in open channels. This method retains all of the terms in the full 1D momentum equation, including the gravity, friction and pressure gradient terms, as well as local and convective acceleration terms. It is assumed that the flow directions are static and given by a D8 flow grid.
- **Diversions** and **DiversionsFraction**: These components provide three different types of flow diversions: sources, sinks and canals. Sources are locations such as natural springs where water enters the watershed. Similarly, sinks are point locations where water leaves the watershed. Canals are generally man-made reaches that transport water from one point to another, typically without following the natural gradient of the terrain.
- **EvapEnergyBalance** and **EvapPriestleyTaylor**: These components use the energy balance and Priestley-Taylor methods, respectively, of estimating losses due to evaporation. The **EvapReadFile** component provides a way to read in files containing parameters used to model the evaporation process.
- **GC2D**: GC2D is a two-dimensional finite difference numerical model that is driven by a calculations of glacier mass balance (snow precipitation - melt rate). The model calculates ice surface elevations above a two-dimensional terrain by solving equations for ice flux and mass conservation using explicit methods.
- **InfilGreenAmpt** and **InfilSmithParlange**: These components model infiltration using the Green-Ampt and Smith-Parlange techniques, respectively. These methods are based on the infiltrability-depth approximation or IDA, which uses the cumulative infiltrated depth as a replacement for time. These methods are not well-suited to modeling redistribution between events or drying of surface layers by evaporation. They are best used for single events.

- **InfilRichards1D**: This component models infiltration by computing the time evolution of 1D (vertical, subsurface) profiles for soil moisture θ, pressure head ψ, hydraulic conductivity K and vertical flow rate v. These equations can be combined into one nonlinear, parabolic, second-order PDE known as the one-dimensional Richards' equation.
- **Meteorology**: This component computes meteorological variables such as vapor pressure, net shortwave radiation, net longwave radiation, and emissivity, using calculations based on celestial mechanics and widely-used empirical relationships.
- **SatZoneDarcyLayers**: This component models horizontal subsurface groundwater flow in the saturated zone via Darcy's Law.
- **SnowDegreeDay** and **SnowEnergyBalance**: These components calculate snow melt rate, snow depth, snow water equivalent, and cold content using degree day and energy balance techniques, respectively.
- **TopoFlow**: TopoFlow is a spatially distributed hydrologic model that evolved from the merger of a previous rainfall-runoff model based on DEM-derived D8 flow grids and a model called ARHYTHM that was designed and tested for modeling Arctic watersheds. It offers sophisticated methods for modeling temperature-dependent processes such as snowmelt, evaporation, infiltration (frozen ground) and shallow subsurface flow. TopoFlow is highly modular and was designed to be user-extensible.

4.5 Automated BMI Generation

To aid the building of a BMI model (either new or existing), the CSDMS IF has built a tool that auto-generates template code necessary to implement a BMI in the CSDMS supported languages. This tool, *bmi-builder*, reads metadata (as YAML-formatted text) that describes the new BMI and generates a series of files with boilerplate code that contains stubs for the developer to fill in based on their specific model.

By automating this process, the *bmi-builder* not only makes writing a new BMI easier but also more:

- Accurate: The generated BMI is guaranteed to satisfy the latest BMI specification.
- Maintainable: If there are changes to either the BMI specification or the model, the boilerplate code can easily be regenerated.

Currently the new BMI builder works with C and C++. However, before the end of this year the CSDMS IF will add a Python generator. The *bmi-builder* source is hosted on GitHub at https://github.com/bmi-forum/bmi-builder.

4.6 BMI Updates

Community interest in the CSDMS-designed Basic Modeling Interface (BMI) has grown over the last year. A BMI Forum GitHub organization (https://github.com/bmi-forum) has been created for groups interested in contributing to BMI. Included in the repository are adapters so that BMI-enabled models can be used as a component in other major modeling frameworks and BMI-related tools. The organization also provides a forum for people to discuss BMI-related issues.

Over the past year CSDMS has hosted researchers wanting to wrap their existing models with the Basic Model Interface. While at CSDMS, visiting scientists work one-on-one with CSDMS software engineers to implement a BMI for a wide variety of models. Visits typically last one or two days with collaboration continuing remotely.

Visitors to CSDMS looking for help with BMI implementation

Researcher	Institution	Topic
Pat Limber	USGS	Coastline Evolution Model
Pat Wiberg	VIMS	Ocean Waves
Brad Murray, Katherine Ratliff	Duke University	Coupling Coastline Evolution Model with river avulsion
Randy Leveque	University of Washington	GeoClaw - Geophysical waves and flows
Architha Reddy	Colorado State University	The Open Modeling System (hydrology and argriculture)
Mike Steckler	Lamont-Doherty	Sequence (Evolution of continental margins)
Fedor Baart	Deltares	SWAN, Delft3D
Landlab Team	Tulane University, University of Washington, University of Colorado	Landlab (Earth-Surface dynamics modeling)
Harutyun Shahumyan	University of Maryland	SESYNC (socio-environmental systems)
Wei Yu, David Gochis	UCAR	Weather Research and Forecasting Model (WRF)

Based on feedback from users, the BMI specification continues to evolve. Working directly with model developers, CSDMS updated the BMI to simplify the interface, making it easier for developers to implement and models to use, and make it more extensible to the wider range of models and grids. One major change is the ability of the BMI to interface with models that define their variables on multiple grids. A complete description of the latest BMI can be found on the BMI documentation page: http://bmi-forum.readthedocs.org.

During CSDMS's 2015 Annual Meeting, CSDMS software engineers conducted a well attended two-hour tutorial titled, "Wrapping Existing Models with the Basic Modeling Interface", that described the BMI and the process needed to wrap a model with a BMI. The hands-on clinic explained the key concepts of BMI (and CSDMS Standard Names), and demonstrated, through an example, how to implement a BMI for an already existing model. The clinic also included an overview of the CSDMS Standard Names, which provide a uniform way to map input and output variable names between component models.

The CSDMS IF worked with the EarthCube-funded Earth System Bridge project, which seeks to link several existing modeling frameworks using the BMI as a common target for each of the frameworks. CSDMS designed the BMI to be framework agnostic, allowing it to become a hub for connecting to a range of other projects. Existing modeling frameworks that are using BMI as a bridge include:

- NUOPC/ESMF: http://www.nws.noaa.gov/nuopc
- OMS: http://www.javaforge.com/project/oms
- OpenMI: http://www.openmi.org
- Pyre/St. Germain: https://github.com/bmi-forum/bmi-pyre

4.7 Analysis of Model Uncertainty

To support model uncertainty studies at CSDMS, version 6.1 of the Dakota iterative systems analysis toolkit (https://dakota.sandia.gov/) has been installed on the CSDMS HPCC, ***beach***. Dakota has a file-based command-line interface, available to all ***beach*** users, for communicating with computational models. This interface was tested with several sensitivity analyses and uncertainty quantification experiments using

HydroTrend and Delft3D; for example, Figure 6 shows a result from an uncertainty quantification study performed with Dakota by Fei Xing in her PhD research.

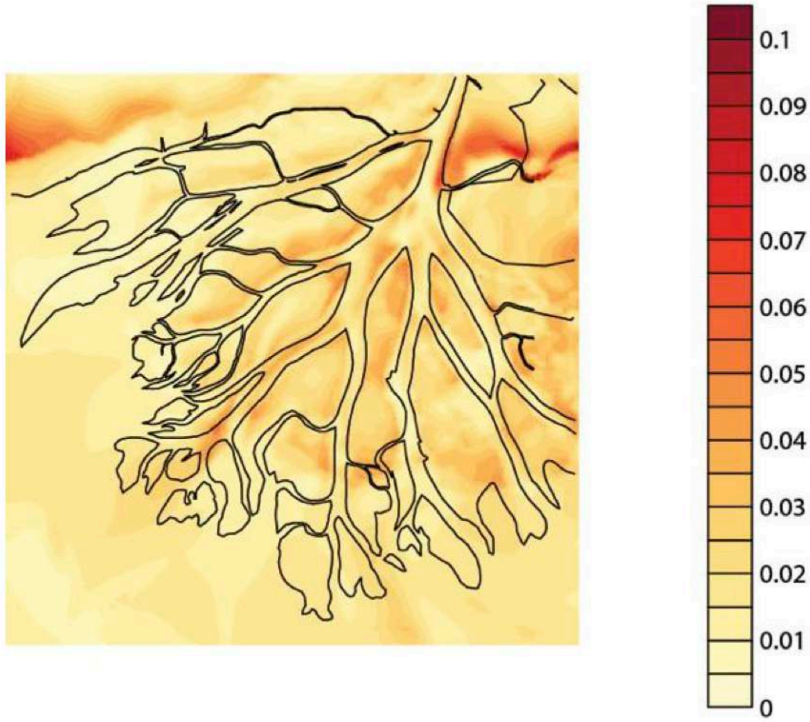


Fig. 6 Spatial uncertainty of surface elevation, characterized by its standard deviation (meters), in the Wax Lake Delta in the aftermath of Hurricane Rita, from 81 Delft3D simulations. Excerpted from Fei Xing's PhD dissertation.

To streamline access to the Dakota command-line interface, the CSDMS IF has developed a Python framework (https://github.com/csdms/dakota) within which Dakota analysis methods and CSDMS models can be wrapped. The framework currently includes code to call one CSDMS model, HydroTrend, as well as three Dakota analysis methods: the vector, centered, and multidimensional parameter studies. The framework can be extended to include other Dakota analysis methods and CSDMS models by adding new classes that describe the keywords of the analysis method or the inputs and outputs of the model. Documentation for the framework can be found at http://csdms-dakota.readthedocs.org. Because it doesn't call the BMI of the CSDMS model, the framework does not currently allow for coupling with CSDMS components; however, it does provide a foundation on which a coupleable service component will be constructed.

CSDMS IF has created a working prototype for using Dakota in WMT, available at https://csdms.colorado.edu/wmt-dakota, and previewed in Figure 7. The prototype uses the Python framework described above, and hence allows experiments to be created with HydroTrend and the three currently implemented Dakota analysis methods.

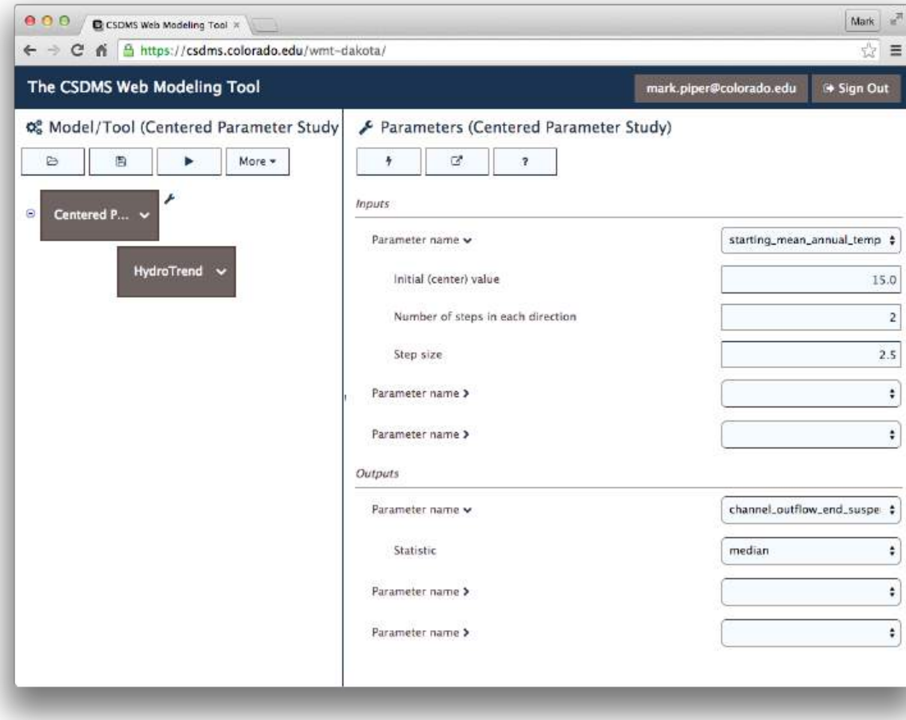


Fig. 7 A screenshot of the development prototype for using Dakota in WMT.

A tutorial on using the Dakota command-line interface, the CSDMS Python framework, and the WMT prototype was developed for the 2014 CSDMS annual meeting, and is available for download on GitHub at https://github.com/mdpiper/dakota-tutorial.

4.8 Model Benchmarking & Model Inter-comparison

Model inter-comparison and benchmarking is of key importance to understanding the strength and weaknesses of a particular numerical model, as well as a suite of comparable models or modeling frameworks. As models are increasingly used in predictive manner or for scenario modeling to guide policy-making, the importance of benchmarking individual models and comparison of models and modeling frameworks becomes paramount. Large modeling frameworks often are used in larger ensembles of other models to investigate internal model dynamics. Model benchmarking and inter-comparison projects are prevalent in some domains of the surface processes modeling community and much less practiced in others. CSDMS aims to instill a culture of practice in consistent model benchmarking through analytical solutions and standard, consistent test cases. Knowledge transfer efforts of CSDMS aim to provide CSDMS members with examples of best practices on model benchmarking and inter-comparison.

As one example of such best practices in 2015, CSDMS highlighted the model contribution of Dr. Elena Tolkova, a tsunami modeler with NorthWest Research Associates. She had recently published and contributed her tsunami model, CLIFFS, to the CSDMS model repository. The model code is well-documented, and maintained in a Github repository, but in addition it explicitly included benchmark datasets which were assembled for the May 2011 National Tsunami Hazard Mitigation Program Workshop. These benchmark data, which include theoretical problems, wave tank experiments, and a field case, were archived and are available through Github (https://github.com/rjleveque/nthmp-benchmark-problems).

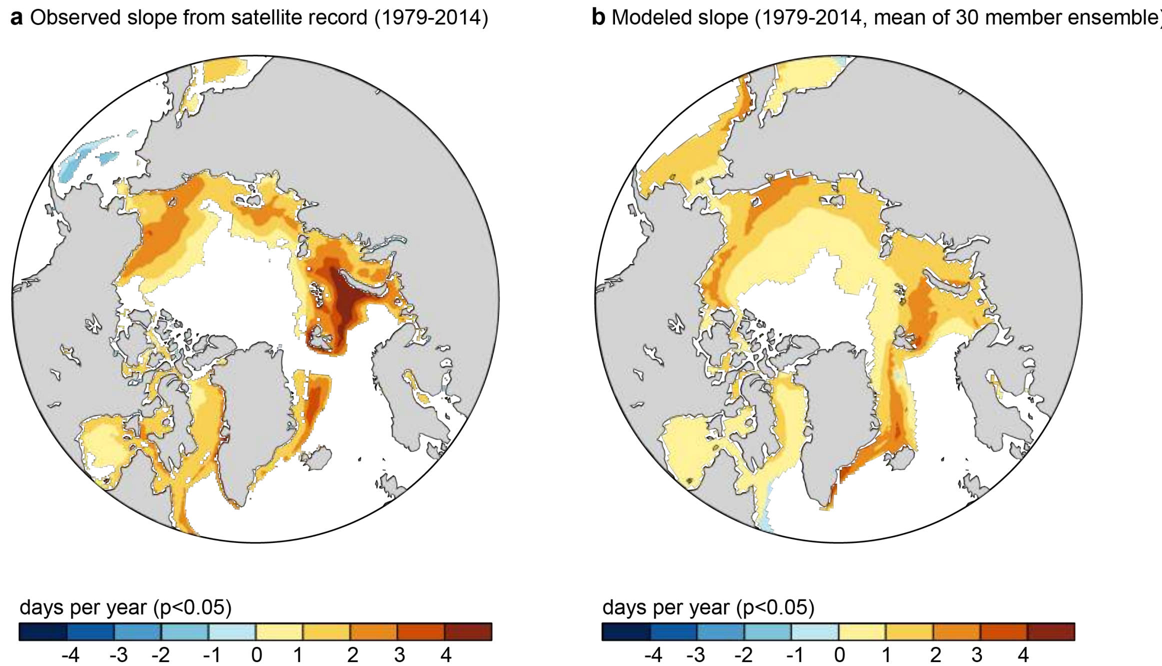


Fig. 8 Example of CSDMS surface process modelers analyzing the Community Earth System Model -Large Ensemble simulations for sea ice free days as an important control on Arctic coastal processes (Barnhart et al., in rev). Panel A shows the changes in sea ice free conditions from observed data, panel B shows the mean changes in sea ice free conditions over 30 model simulations.

To further educate our community on ongoing model benchmarking and inter-comparison efforts, the CSDMS Annual Meeting 2015 featured 'Models meet Data, Data meet Models' as a theme. The CSDMS Annual Meeting 2015 facilitated breakout groups discussing the needs of modelers from the data community. Three keynote talks focused explicitly on model benchmarking and model inter-comparison efforts in the terrestrial, hydrology and coastal/marine modeling domains:

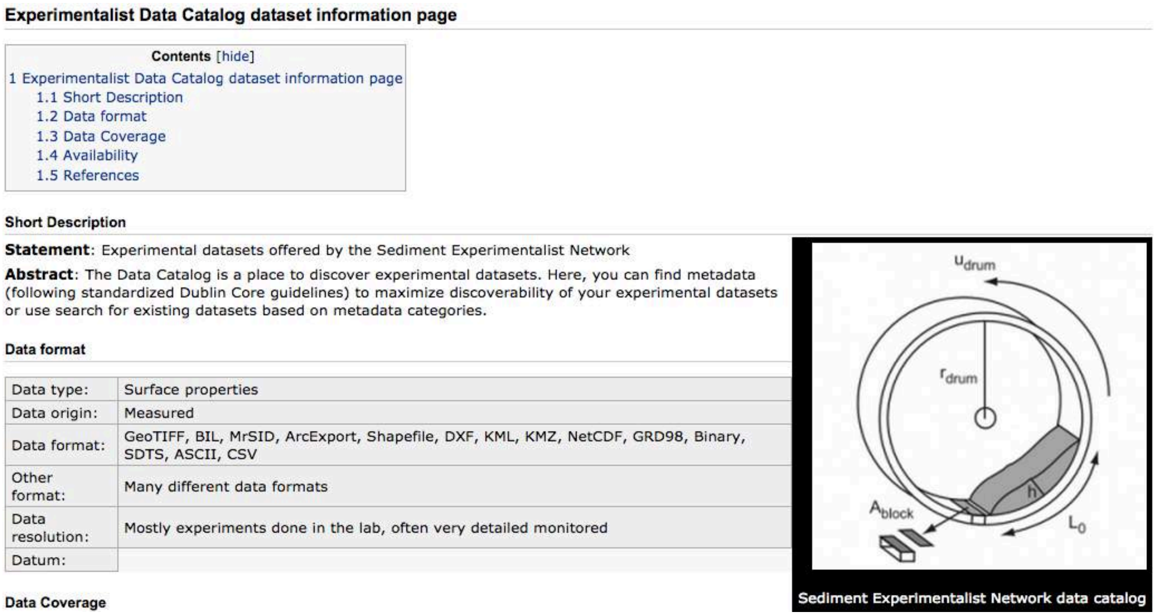
- Forrest M. Hoffman, *International Land Model Benchmarking Project*
- Mary Hill, *Testing model analysis frameworks*
- Randy LeVeque, *The GeoClaw Software*

CSDMS also targets to develop and contribute data sets that can be used for model testing, validation, and/or inter-comparison. The CSDMS Cyberinformatics Working Group has initiated a CSDMS Model Solution Library, a collection of analytical or closed-form solutions to a variety of mathematical models, which are popular in the surface processes domain. The Library includes over 20 entries, and varies for more general processes to specific domains, and is still under development http://csdms.colorado.edu/wiki/Model_Solution_Library

The CSDMS community has recognized that tank experiments can function as model benchmark datasets. The most widely known examples are lock-release experiments. Documenting tank experiments for possible future use by numerical modelers for model testing is an important charge. CSDMS connects with the Sediment Experimentalists Network, through participation in their steering committee. CSDMS provides the modelers needs perspective in the design process of best practices for data collection and management. http://earthcube.org/group/sen

CSDMS IF staff participated in the 2014 meeting in The Netherlands, titled: *'Exploring the Life Cycle of Sedimentary Experiments'*. More info: http://earthcube.org/workspace/sen/sen-workshop-2014

CSDMS data catalogue directly links to the SEN Data catalogue.



Experimentalist Data Catalog dataset information page

Contents [hide]

Short Description

Statement: Experimental datasets offered by the Sediment Experimentalist Network

Abstract: The Data Catalog is a place to discover experimental datasets. Here, you can find metadata (following standardized Dublin Core guidelines) to maximize discoverability of your experimental datasets or use search for existing datasets based on metadata categories.

Data format

Data type:	Surface properties
Data origin:	Measured
Data format:	GeoTIFF, BIL, MrSID, ArcExport, Shapefile, DXF, KML, KMZ, NetCDF, GRD98, Binary, SDTS, ASCII, CSV
Other format:	Many different data formats
Data resolution:	Mostly experiments done in the lab, often very detailed monitored
Datum:	

Data Coverage

Fig. 9 More explicit linkages between the sediment experimentalists and the CSDMS Data catalogue are now in place http://csdms.colorado.edu/wiki/Data: Experimentalist_Data_Catalog

4.9 Semantic Mediation and Ontologies

The new CSDMS Web API provides an interface to a CSDMS Standard Names relational database. Through a RESTful interface the web service allows users to query the Standard Names database, parse names into their constituent parts, search by name or name-element and add new names. Coupled with the rest of the CSDMS Web Services, users can also query which models use or provide a particular name, or which names a particular model uses and provides.

The database of standard names has grown over the last year. As of July 2015 the database consists of 2653 names, which represents a 300% increase over last year. Groups that are using Standard Names have also increased over the last year and represent an increase in the breadth of represented disciplines. Over the last year the following projects have begun including CSDMS Standard Names into their work:

- EarthCube Building Blocks: Earth System Bridge: Spanning scientific communities with interoperable modeling frameworks, **NSF-1550966**, Peckham is lead PI.
- EarthCube Building Blocks: Collaborative Proposal: GeoSoft 2: Collaborative Open Source Software Sharing for Geosciences, **NSF-1552359**, Peckham is co-PI.
- EarthCube Building Blocks: Collaborative Proposal: A Geo-Semantic Framework for Integrating Long-Tail Data and Models, **NSF-1552158**, Peckham is co-PI.
- Marine Metadata Interoperability (MMI). John Graybeal
- National Socio-Environmental Synthesis Center (SESYNC). Rolf Moeckel, Harut Shahumyan

The Earth System Bridge project works with CUAHSI to create a crosswalk (or mapping) from the CUAHSI VariableName CV to the CSDMS Standard Names and from the CF Convention Standard Names to the CSDMS Standard Names. This project has made major contributions to the CSDMS Standard Names, including over 1000 new variable names (current total is 2653) including new names for river deltas, the new "tilde" delimiter, over 1000 standard assumption names, extensive updates to the wiki pages, and connections to the ISO International Standard of Quantities (ISO 80000). Teams from the above three Earth Cube projects are working to create an ontology for the CSDMS Standard Names, that can be extended/edited by others (via GitHub). This ontology will be available in OWL and RDF formats.

4.10 CSDMS Portal

From July 2014 – July 2015, the CSDMS website had an average of 455 page views per day, which was similar to last reporting year (with 1086 as maximum page views per day, which occurred the last day of the CSDMS annual meeting). Typically CSDMS has 1/3 returning viewers and 2/3 new viewers. The top 3 countries from where the CSDMS website is mostly visited are: United States (39%), followed by China (8%) and India (5%), of which the majority used a desktop (92.7%) and only a small percentage used mobile devises (5.4%) or a tablet (2.0%). The CSDMS website is the first to come up in a Google search, automatically displaying 6 site links, which are the most visited sections of the website (CSDMS annual meeting; Upcoming; CSDMS Model repository; Models; CSDMS Executive Committee, and About CSDMS). Site links are shown on privilege by Google (so not controllable in Google search) and are only shown for nr. 1-search hits, when pages' lifetime exceeds 2 years, and has a Google page rank of at least 2. Site links typically provide more exposure.

Last year, CSDMS became even more involved with the community by: 1) posting CSDMS related job opportunities (125); reporting upcoming events like symposia, conferences and workshops (30); and tweeting CSDMS related messages to 162 (47% increase since last year) of its followers (https://twitter.com/CSDMS).

Web improvements

a) Implemented new Search tool. The CSDMS website has adopted a new search engine: CirrusSearch, which heavily relies on Elastic Search. The previous search engine is left behind after implementing the latest Mediawiki 1.25.1 (the content management system that is used by CSDMS). The new search engine features two main improvements for CSDMS over the previous used search engine, namely: i) Faster updates to the search index, meaning changes to articles are reflected in search results much faster (near real time), ii) Expanding templates, meaning that all content from a template is now reflected in search results (templates contain text that can be embedded in multiple pages), and iii) Will come up with 'Did you mean' suggestions when you misspell a word or use an uncommon phrase.

b) Migration Model repository. GitHub, founded in 2008, is an online source code sharing service. It is free to use when contributing code in the public domain. GitHub uses an easy to use graphic interface. At its core is Git, a decentralized version control system that manages and stores revisions of source code projects. CSDMS used the predecessor SubVersion as a version control system on its own server for many years. Operating a version control system in house adds management and maintenance tasks. Although source code was downloaded abundantly, few code improvements were contributed outside the core development team of a source code project. By migrating from SubVersion to GitHub we made source code easier to: find, manage by its owners and CSDMS-IF staff, share, and contribute, all with less effort, and without losing version history of any of the models.

This is how GitHub works in a nutshell. The most used function in GitHub is 'forking'; copying source code from one account to another person's account. This enables the user to make changes to his or her version of the code. If changes are made and you would like to share those, you can send the original code developer a 'pull request'. That user can then almost instantly, with a click of a button, 'merge' the changes with the original source code. Those 3 commands, operated by a graphical interface over the web, are all it takes to contribute to a source code project. GitHub keeps track of who made what changes and adds that to a user profile as well, so GitHub can be used as some sort of coding resume. For those who want to keep it even simpler, any version of the source code can be easily downloaded as a zipped package on a machine; all you need is to be online. Additionally, you can setup GitHub with an integrated 3rd party DOI provider, making it possible to generate DOIs for source code in minutes (See item below: c) Migration of DOI agency). With the migration to GitHub, CSDMS lost some of its management capabilities of tracking who downloaded, when, and how often for a specific model. With the abundance of different options you have in GitHub to download, CSDMS is not yet able to track the number of downloads for each model, but it is our intension to integrate this functionality soon.

c) New DOI agency. CSDMS, the first organization that made it possible to assign a Digital Object Identifier (DOI) to source code that is physically part of the CSDMS repository, recently migrated from DOI providers. For many years CSMDS worked closely with IEDA (Integrated Earth Data Applications, hosted at the Lamont-Doherty Earth Observatory of Columbia University), a formal Publication Agent of the DOI system through the German National Library of Science and Technology, to assign DOIs to source code. The process would take a few days and involved some effort. With the adoption of GitHub, CSDMS can now assign DOIs to any of the CSDMS maintained source code projects on GitHub in minutes by making use of an integrated service provided by Zenodo. Zenodo, based at CERN Data Centre, builds and operates a simple and innovative service that enables researchers, institutions and scientists to share multidisciplinary research results that are not part of the existing institutional or subject-based repositories of the research communities. Quoting from the website: "Zenodo enables researchers, institutions and scientists to:

- Easily share the long tail of small research results in a wide variety of formats including text, spreadsheets, audio, video, and images across all fields of science.
- Display their research results and get credited by making the research results citable and integrate them into existing reporting lines to funding agencies like the European Commission.
- Easily access and reuse shared research results."

Source code DOIs generated by Zenodo are searchable through standard DOI websites like e.g. http://dx.doi.org/. The following models have been assigned a DOI over the last year:

Model	Developer	DOI
Coastal Dune Model	Orencio Durán Vinent	10.5281/zenodo.16161
GEOMBEST	Laura Moore	10.5281/zenodo.16576
GEOMBEST-Plus	David Walters	10.5281/zenodo.16687
GreenAmptInfiltrationModel	Peishi Jiang	10.5281/zenodo.18772
SLEPIAN Alpha	Frederik Simons	10.5281/zenodo.15704
SLEPIAN Bravo	Frederik Simons	10.5281/zenodo.15705
SLEPIAN Charlie	Frederik Simons	10.5281/zenodo.15706
SLEPIAN Delta	Christopher Harig	10.5281/zenodo.15707

A poster was presented during the CSDMS annual meeting, explaining how CSDMS can assist in setting up a model repository on GitHub and assigning DOIs.

d) Adding web authorization functionality. Unfortunately, CSDMS has to restrict functionality to some products or services. The entire CSDMS website is publically accessible as well as any of its material stored in the various repositories, but for example to add content to the CSDMS web portal we require any user to login. The CSDMS logins are provided for free but new requests are monitored thoroughly so to minimalize the impact of misuse or spam content on the CSDMS platforms. Currently, a user would have multiple different usernames and passwords to make fully use of all CSDMS products and services. CSDMS is currently in the process of integrating OAuth (open standard for authorization) to minimize the number of different usernames and passwords a member has to remember. OAuth provides client applications a secure delegated access to server resources on behalf of a resource owner without sharing credentials. CSDMS is in the process to let CSDMS website portal serve as a provider, allowing the WMT tool to login with the username and password used for the CSDMS website portal. Currently, CSDMS is testing the OAuth on a beta site to guarantee a smooth and secure integration. This effort will be finalized before the end of this project year.

Web maintenance

CSDMS cyber infrastructure uses the open software package Mediawiki (http://www.mediawiki.org) and numerous third-party extensions (60 extension as of now; a reduction of 1 compared to last year) to extend cyber infrastructure capability and to provide the latest cyber tools to web visitors to guarantee the easiest experience to interact through the web. At the same time CSDMS tries to reduce the dependency on third-party extensions as they could cause cyber infrastructure instabilities. About every year the core software (mediawiki) is significantly upgraded and with it most third party software extensions, to guarantee performance, security, and to incorporate new features. It is required by the University of Colorado (CU) to upgrade cyber infrastructure to a newer version when a security upgrade becomes available, to reduce possible cyber attacks directed to CU. CSDMS executed the latest major cyber infrastructure upgrade (upgraded to mediawiki v1.25.1, see http://csdms.colorado.edu/wiki/Special:Version) to conform to CU standards. Outdated extensions were replaced to guarantee functionality.

4.11 Developing a QSD Educational Toolbox

CSDMS has a defined EKT mission to enable computer model use and development for research in the earth surface processes. CSDMS strives to widen the use of quantitative techniques and numerical models and promote best coding practices. This key objective is met through CSDMS Framework development, making models easier to use through the Web Modeling Tool (addressed in section 4.2 of this report), and tight integration between the WMT and model theory, metadata, and help pages as an online resource.

CSDMS also aims to enable undergraduate and graduate students (and their instructors) to more easily use models. In 2014 we released the Web Modeling Tool (WMT) (addressed in section 4.2 of this report), and associated educational material and tutorials. The Quantitative Surface Dynamics Educational Toolbox combines educational material at different tiers but with crosscutting themes.

Complexity in teaching resources in the QSDE toolbox steps up from a basic level; real-world surface process movies and simple model animations, to small spreadsheet model exercises, to web-based models with few parameters to vary, to the most advanced level WMT teaching labs. The educational repository contains a suite of resources on each of these levels.

As one example, there are many real-event movies on river sediment transport and hillslope processes. There are over 15 model animations categorized in the terrestrial category relevant for landscape evolution, including model animations of CHILD. All these are hosted in a database structure to be searchable by cross-cutting theme as well as by intended level. At a basic conceptual model there is a stand-alone quantitative assignment on flow routing in rasterized grids, a key concept in any of the landscape evolution modeling. Educators who subsequently want to expose their students to a more hands-on modeling experience and built efficacy in scenario modeling can use WILSIM to explore landscape evolution general principles and/or theoretical concepts. WILSIM is entirely web-based and requires no installation of local software beyond basic web browser functionality.

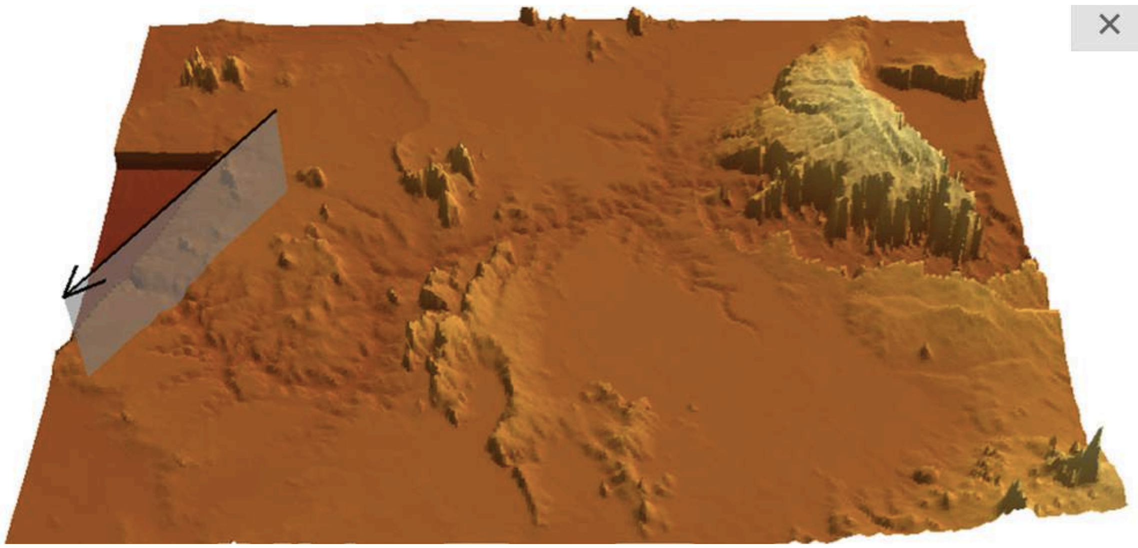


Fig. 10 Landscape Evolution of the Grand Canyon Region, as simulated with WILSIM, developed by Wei Luo. WILSIM is web-based and requires no additional installation of software. This is a big plus for courses with large participation.

At the most advanced level, three modeling labs explore hillslope processes and river sediment transport with CHILD through the CSDMS WMT. Each of these labs have a duration of approximately 4 hours, and are associated with much documentation and integrated into the Model Help system. In addition, these labs run on the CSDMS High Performance Computing System, and teach skills in working with common advanced file formats, i.e. NetCDF, and thus provide valuable exposure of learners to the numerical modelers community practices with simulation output and HPCC use. Whereas the EKT repository has model animation, model spreadsheets and WMT model teaching labs for all of the working group domains, further organizing of the resources is still a priority to make the progression of the material more evident.

4.12 Development of CSDMS Earth Surface Modeling Course Material

Two targeted CSDMS short courses on surface process were developed and taught in 2014.

- *'Surface Process Modeling' at the NCED Summer Institute on Earth System Dynamics, University of Minnesota, August 2014 (25 participants, 2 days, instructor Irina Overeem)*
- *'Source to Sink Modeling' at Nanjing University, Nanjing, China, October 2014 (14 participants, 4 days, instructors Albert Kettner and Irina Overeem)*

Both courses aim to familiarize earth sciences, coastal and oceanography and engineering graduate students with concepts of surface modeling and a number of numerical surface process models and hydrological models available through Community Surface Dynamics Modeling System. The course introduces participants to use of these software tools for their own research and teaching purposes. Participants learn about the following surface processes:

- River sediment supply
- Landscape evolution
- Coastal evolution and longshore transport and wave processes
- Stratigraphic modeling

At the end of these courses, students should be able to design and run simulations for independently designed research questions on sediment supply, landscape and coastline evolution and marine stratigraphic processes. In addition, students have learned basic skills of submitting modeling jobs to a High Performance Computing System, and for many this short course is their first exposure to remote access of a supercomputer.

Fig. 11 Participants in CSDMS short course at Nanjing University, China, present on their ongoing modeling efforts in coastal zone processes.

An additional targeted CSDMS short course on coastal and shallow marine sediment transport with 'ROMS-Lite' implemented through the CSDMS WMT has been designed in 2014-2015 in collaboration with Courtney Harris at VIMS. Labs have the following topics:

- Shallow marine sediment transport and waves
- Interactions of River Plume with waves
- Numerical modeling and the Boundary conditions

This lab needs final development and testing and will become available online by Fall 2015.

All course material is shared through the EKT repository lectures, and linked to the associated hands-on labs. http://csdms.colorado.edu/wiki/Source_to_Sink_Modeling_Lectures

4.13 Knowledge Transfer to Industry Partners and Government Agencies

CSDMS IF Staff has reached out to industry and governmental agencies and participated in meetings on more than 12 occasions over this reporting period 2014-2015 (see list of IF Staff meetings). Presentations on the CSDMS community, software protocols and modeling framework services, as well as educational resources were shared with most of these partners, including DOE, BOEM, USGS, AAPG/SEPM, NOPP, and Deltares as well as several organizations that reach out to future stakeholders of CSDMS modeling domains.

Whereas the transfer of ideas may be something that is hard to measure; CSDMS IF staff presented a stakeholder workshop on deltas and coastal zone management on CSDMS community protocols, data and model sharing best practices. These concepts have been straightforwardly adapted in a recent call for proposals in a large coastal engineering project funded by the World Bank.

In general, the tools developed in CSDMS support the surface processes research community. However, there is ongoing work to develop a prototype application of an open-access, science-based, integrative modeling framework. This is specifically done for delta systems at the CSDMS IF under separate funding of the Belmont Forum. The prototype is called the Delta Risk Assessment and Decision Support Tool. This tool is to be a service component on top of the CSDMS open-source modeling framework, i.e. the WMT. A prototype service component for Delta-RADS would help facilitate delta risk modeling. Such service components, described below, will shortly be incorporated into WMT and released as Delta-RADS after testing. These service components include a GIS modeling system to support quantitative mapping and definition of functional relationships of the biophysical environment of deltas as well as their social and economic dynamics, which is a long-term CSDMS goal and would be especially relevant to policy-makers. We now have developed tools to generate GeoTIFFs and shapefiles of relevant GIS based datasets for delta modeling, which users can download to use in other studies or convert into model input file formats for simulations in WMT.

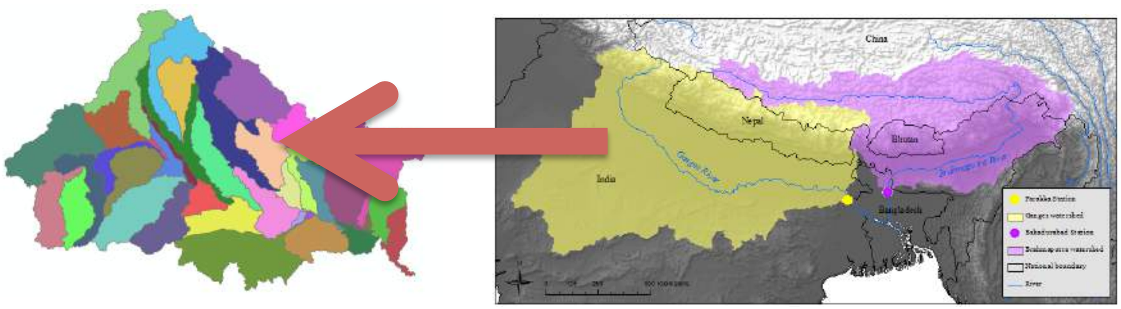


Fig. 12 Newly developed service component allows automatic generation of input files from GIS data and greaty simplifies the application of HydroTrend. Data on Ganges sub-basins: Pervez & Henebry (2014)

In 2015, CSDMS established new connections to the US Army Corps of Engineers Coastal and Hydraulics Laboratory. CHL personnel visited with the CSDMS Integration Facility and IF staff, and CHL engineers are exchanging ideas to contribute tools for state-of-the-art numerical solvers for moving boundary problems.

CSDMS IF is exploring linkages to the recently established NSF-funded STEPPE. STEPPE (Sedimentary Geology, Time, Environment, Paleontology, Paleoclimatology, Energy) is an NSF-supported consortium whose purpose is to promote multidisciplinary research and education on Earth's deep-time sedimentary crust. CSDMS members are amongst the first awardees of scoping workshops of the STEPPE project, and serve on the respective steering committee and board and thus ensure there will be a fruitful connection between future science endeavors of the two initiatives.

5.0 Conferences & Publications

5.1 CSDMS Staff Participation In Conferences & Meetings Aug 2014 to July 2015

08/2014	BOEM Gulf of Mexico Sediment Models	Reston, VA	(Syvitski)
08/2014	DOE Iowa National Lab, visit (Mark Byden)	Boulder, CO	(CSDMS staff)
08/2014	GeoRAMA Film Producer Nicolas Koutsikas	Boulder, CO	(Syvitski)
08/2014	NCED SIESD, University of Minn.	Minneapolis, MN	(Overeem)
09/2014	NSF HQ, CSDMS presentation & meetings	Washington D.C.	(Syv. & Hutton)
09/2014	CSDMS as a US resource, Nati'l Ocean Partnership Program HQ	Washington D.C.	(Syvitski)
09/2014	CSDMS Interagency Meeting	Washington D.C.	(Syvitski)
09/2014	NSF & Boise U, Roadmap for CMG++	Boise, ID	(Syvitski)
09/2014	DeltaRes, Delft University, The Netherlands	Delft, NL	(Overeem)
09/2014	Deltas in Times of Climate Change	Rotterdam, NL	(Overeem)
10/2014	AAPG/SEPM Hedberg Conf. on Latitudinal Controls On Stratigraphic Models & Sedimentary Concepts	Banff, Canada	(Syvitski)
10/2014	Southeastern U Research Association, SURA HQ	Washington D.C.	(Syvitski)
10/2014	ICS Anthropocene Working Group	Berlin, Germany	(Syvitski)
10/2014	IGBP & the Royal Swedish Academy	Stockholm, SW	(Syvitski)
10/2014	CSDMS S2S Modeling Course	Nanjing, China	(Kettner/Overeem)
11/2014	EuroCSDMS Meeting	Vienna, Austria	(Syvitski)
11/2014	Floodplain Dynamics, UIUC	Champagne, IL	(Syvitski)
11/2014	WSSSPE2	New Orleans, LA	(Hutton)
11/2014	Supercomputing 2014	New Orleans, LA	(Hutton)
11/2014	ROMS Course design, VIMS	Gloucester Pnt, VA	(Overeem)
12/2014	American Geophysical Union	San Francisco, CA	(CSDMS staff)
01/2015	Marine Environmental Sciences	Xiamen, China	(Syvitski)
01/2015	Terrestrial Hydrology in CESM, Lawrence NCAR	Boulder, CO	(Overeem)
03/2015	The Anthropocene, U Nebraska	Lincoln, NB	(Syvitski)
03/2015	Building Capacity in the Social Sciences (NSF)	Washington D.C.	(Syvitski)
03/2015	GEOSS Stakeholders & Technology	Norfolk, VA	(Syvitski)
04/2015	IDRC/DFID Deltas and Basins	London, UK	(Syvitski)
04/2015	Earth System Science (IGBP & IIASA)	Vienna, Austria	(Syvitski)
04/2015	UCAR Software Engineering Assembly	Boulder, CO	(Hutton, Piper)
05/2015	GeoRAMA Floods	Boulder, CO	(Syvitski)
05/2015	NCAR- The Anthropocene	Boulder, CO	(Syvitski)
05/2015	2015 CSDMS Annual Meeting	Boulder, CO	(CSDMS staff)
06/2015	36th IAHR World Congress "Deltas"	Den Hague, Neth	(Syvitski)
06/2015	Future Deltas, U Utrecht	Utrecht, Neth	(Syvitski)
06/2015	DELTARES, Delft3D & EuroCSDMS	Delft, Netherlands	(Syvitski)
07/2015	UNAVCO HQ, Subsidence	Boulder, CO	(Syvitski)
07/2015	NREL: Food, Water, Energy	Denver, CO	(Syvitski)
07/2015	INQUA Congress: Deltas & the Anthropocene	Nagoya, Japan	(Syvitski)

5.2 Integration Facility Staff Book Chapters, Journal papers and Newsletters:

Submitted/in review August 2014 to July 2015: (IF Staff in bold)

Bai, X, van der Leeuw, S, O'Brien, K, Berkhout, F, Biermann, F, Broadgate, W, Brondizio, E, Cudennec, C, Dearing, J, Duraiappah, A, Glaser, M, Steffen, W, **Syvitski, JP**, *in revision*, Plausible and Desirable Futures in the Anthropocene. Global Environmental Change

Barnhart, K., Miller, C.R., **Overeem, I**., Kay. J., (in rev. 2015). Mapping the future expansion of Arctic open water. Nature Climate Change.

Barton, CM, LN Alessa, S Bankes, L Buja, E CoBabe-Ammann, JJ Feddema, K Galvin, S van der Leeuw, B Turner, M Alberti, R Axtell, DA Bennett, L Betencourt, SJ Breckler, E Brondizio, DG Brown, P Fox, R Groves, E Hackett, S Hofferth, JS Jackson, R Kassimir, M Levy, J Liu, E Moran, GC Nelson, W Rand, D Rogers, **J Syvitski**, S Wang submitted, Integrative Human Sciences. Science

Hutton, EWH, **Piper, MD**, **Peckham, SD, Overeem, I, Kettner, AJ**, and **Syvitski, JPM**, submitted: Building Sustainable Software - The CSDMS Approach, Journal of Open Research Software.

Rennermalm, A., Mikkelsen, A., **Overeem, I.,** Chu, V., Smith, L.C., van As, D., Mote, T., Hasholt, B., (in rev. 2015). Spatial variation of Greenland ice sheet meltwater export inferred from river discharge observations. Geophysical Research Letters.

Accepted/in press August 2014 to July 2015:

Hudson, B. Overeem, I, Syvitski, J (accepted 2015) A novel technique to detect turbid water and mask clouds in Greenland fjords. International Journal of Remote Sensing

Overeem, I., Hudson, B., Welty, E., Mikkelsen, A., Pedersen, D., LeWinter, A., Hasholt, B., (accepted 2015). River Inundation Suggests Ice Sheet Runoff Variations, Journal of Glaciology.

Tessler, Z., C. Vörösmarty, M. Grossberg, I Gladkova, H Aizenman, **J Syvitski** and E Foufoula-Georgiou, *in press*. Profiling Risk and Sustainability in Coastal Deltas of the World. Science

Verburg, P.H., J Dearing, **J Syvitski**, S van der Leeuw, S Seitzinger, P Matrai, W Steffen, *in press*, Modelling the Anthropocene: representing characteristics of the Anthropocene in models, Global Environmental Change

Published August 2014 to July 2015:

Barnhart, K., Anderson, R., **Overeem, I**., Wobus, C., Clow, G., Urban. F. 2014. Modeling erosion of ice-rich permafrost bluffs along the Alaskan Beaufort Sea coast. Journal of Geophysical Research Earth Surf., 119, doi:10.1002/2013JF002845.

Barnhart, K., **Overeem, I**., Anderson, R.S. 2014. The effect of changing sea ice on the physical vulnerability of Arctic coasts. The Cryosphere 8, 1777-1799.

Chen, Y., **Overeem, I**., **Kettner, A.J.,** Gao, S., **Syvitski, J.P.M.**, (2015). Modeling Flood Dynamics along the Super-elevated Channel Belt of the Yellow River over the Last 3,000 years. Journal of Geophysical Research.

Giosan, L., **Syvitski, J**, Constantinescu, S, Day, J, 2014, Protect the world's deltas, Nature 516: 31-33.

Higgins, S, Overeem, I, Steckler, MS, **Syvitski, JPM,** and Akhter, SH 2014, InSAR measurements of compaction and subsidence in the Ganges-Brahmaputra Delta, Bangladesh. Journal of Geophysical Research – Earth Surface 119: 1768-1781.

Hudson, B, Overeem, I, McGrath, D., **Syvitski, J,** Mikkelsen, A., Hasholt, B., (2014). MODIS observed increase in duration and spatial extent of sediment plumes in Greenland fjords. The Cryosphere. 8, 1161-1176.

Syvitski, JPM 2014. Looking Forward. *Nature Climate Change* 4: 856-857.

Syvitski, JPM, Cohen, S, Kettner, AJ, Brakenridge, GR, 2014, How Important and Different Are Tropical Rivers? — An Overview. *Geomorphology* 227: 5-17.

Syvitski, JPM, Hutton, EWH, MD Piper, I Overeem, AJ Kettner, SD Peckham, 2014, Plug and Play Component Modeling — The CSDMS2.0 Approach. International Environmental Modelling and Software Society (iEMSs) 7th Intl. Congress on Env. Modelling and Software, San Diego, CA, USA,

Daniel P. Ames, Nigel W.T. Quinn and Andrea E. Rizzoli (Eds.) http://www.iemss.org/society/index.php/iemss-2014-proceedings

Vanmaercke, M, **Kettner, AJ**, van den Eeckhaut, M, Poesen, J, Mamaliga, A, Verstraeten, G, Radoane, M, Obreja, F. Upton, P., **Syvitski, JPM** and Govers, G, 2014. Moderate seismic activity affects contemporary sediment yields. *Progress in Physical Geography* 38(2): 145-172.

Waters CN, **JPM Syvitski**, A Gałuszka, GJ Hancock, J Zalasiewicz, A Cearreta, J Grinevald, C Jeandel, JR McNeill, C Summerhayes and A Barnosky, 2015, Can nuclear weapons fallout mark the beginning of the Anthropocene Epoch? Bulletin of Atomic Scientists, 71(3) 46–57 DOI: 10.1177/0096340215581357

Zalasiewicz, J, CN Waters, AD Barnosky, A Cearreta, M Edgeworth, EC Ellis, A Gałuszka, PL Gibbard, J Grinevald, I Hajdas, J Ivar do Sul, C Jeandel, R Leinfelder, JR McNeill, C Poirier, A Revkin, D de B Richter, W Steffen, C Summerhayes, **JPM Syvitski**, D Vidas, M Wagreich, M Williams and AP Wolfe, 2015, Colonization of the Americas, 'Little Ice Age' climate, and bomb produced carbon: Their role in defining the Anthropocene, The Anthropocene Review 2(2) 117–127. DOI: 10.1177/2053019615587056

Zalasiewicz, J, CN Waters, M Williams, AD Barnosky, A Cearreta, P Crutzen, E Ellis, MA Ellis, IJ Fairchild, J Grinevald, PK Haff, I Hajdas, R Leinfelder, J McNeill, C Poirier, D Richter, W Steffen, C Summerhayes, **JPM Syvitski**, D Vidas, M Wagreich, SL Wing, AP Wolfe and A Zhisheng , *2014*. When did the Anthropocene begin? A mid-twentieth century boundary level is stratigraphically optimal. Quaternary International http://dx.doi.org/10.1016/j.quaint.2014.11.045

5.3 Abstracts *August 2014 to July 2015:*

Chen, Y, I Overeem, A Kettner, S Gao, **JPM Syvitski** 2014, Modeling Flood Dynamics Along the Super-Elevated Channel Belt of the Yellow River, China, over the Last 3,000 Years, EP44A-02, 2014 Fall Meeting, AGU, San Francisco, Calif., 15-19 Dec

Cohen, S., **Kettner, AJ, Syvitski, JPM**, Yamazaki, D 2014, Global-scale simulation of river-floodplain water and sediment exchange within a riverine modeling framework EP44A-06 Fall Meeting, AGU, San Francisco, Calif., 15-19 Dec

Higgins, S, Overeem, I, Syvitski, JPM, 2014, Monitoring delta subsidence with Interferometric Synthetic Aperture Radar (InSAR), GC21D-0574, 2014 Fall Meeting, AGU, San Francisco, Calif., 15-19 Dec

Higgins, S., **Overeem I**., and **Syvitski, J. P. M.** (2015) Potential impacts of Indian Rivers Inter-links on sediment transport to the Ganges-Brahmaputra Delta. Models Meet Data, Data Meet Models: Annual Meeting of the Community Surface Dynamics Modeling System (CSDMS), 26-28 May 2015,Boulder, CO, USA.

Hudson, B., Overeem, I., Syvitski, JPM, A Mikkelsen, B Hasholt, M, Morlighem 2014, Global-scale simulation of river-floodplain water and sediment exchange within a riverine modeling framework C14B-08 Fall Meeting, AGU, San Francisco, Calif., 15-19 Dec

Hutton, EWH, **Piper, MD**, Peckham, SD, **Overeem, I, Kettner, AJ**, and **Syvitski, JPM**, 2014: Building Sustainable Software - The CSDMS Approach, 2nd Workshop on Sustainable Software for Science: Practice and Experiences (WSSSPE2), http://arxiv.org/abs/1407.4106.

Overeem, I, 2015. Arctic Coastal Zone Processes Reflect Rapid Warming Polar Center, Applied Physics Lab, University of Washington, March 17th 2015.

Overeem, I, Higgins, S, Syvitski, JPM, Kettner, AJ, Brakenridge, RG, 2014, The Impacts of Armoring Our Deltas: Mapping and Modeling Large-Scale Deltaplain Aggradation, GC23G-02, 2014 Fall Meeting, AGU, San Francisco, Calif., 15-19 Dec

Overeem, I., 2014. Frozen Coasts Reflect Rapid Warming. Virginia Institute of Marine Sciences seminar, NASA Arctic Colors Meeting, Gloucester Point, VA, November 2014.

Overeem, I., 2014. Sedimentation in Fluvio-Deltaic Plains, Department of Coastal and Oceanography Science Seminar, Nanjing University, China.

Overeem, I., 2014. Sedimentation Rates in the Ganges-Brahmaputra Delta, Joint seminar for UNESCO-IHE and Deltares, Delft, The Netherlands.

Overeem, I., 2015. Greenlandic Rivers and Ice Sheet Melt. NSF-Office of Polar Programs, Washington DC, May 8th, 2015.

Overeem, I., **Borkowski, L., Kettner, A.J.**, Rusell, B., Peddicord, H., 2015. Bringing earth surface processes simulations to large audiences. CSDMS Annual Meeting, Boulder, CO, May 26th-28th, 2015.

Overeem, I., Higgins, S., Syvitski, J., Kettner, A.J., Brakenridge, R., 2014. The Impacts of Armoring Our Deltas: Mapping and Modeling Large-Scale Deltaplain Aggradation, AGU Fall Meeting, 2014, San Francisco, CA, December 15-19th, 2014.

Overeem, I., Hudson, B., 2014. The Response of Greenlandic Rivers to Ice Sheet Melt, IMAU, Utrecht University, The Netherlands, September 27th, 2014.

Overeem, I., Rogers, K., Goodbred, S., Passalacqua, P. 2014. Sedimentation in the Ganges-Brahmaputra Delta: natural mangrove forest and embanked polders. Deltas in times of Climate Change II, International Conference, Rotterdam, The Netherlands, 24-26th of September, 2014.

Syvitski, JPM & SA Higgins 2014, Subsidence and Relative Sea-level Rise in Threatened Deltas, H31L-01, 2014 Fall Meeting, AGU, San Francisco, Calif., 15-19 Dec

Syvitski, JPM, I Overeem, Brakenridge, RG, Hudson, B, Cohen, S., 2014, Arctic River Discharge and Sediment Loads --- an Overview, B34B-07, 2014 Fall Meeting, AGU, San Francisco, Calif., 15-19 Dec

6.0 CSDMS 2.0: Working Groups & Focus Research Groups

6.1 CSDMS Terrestrial Working Group

The Terrestrial Working Group (TWG) met during the 2015 All Hands meeting in a 90-minute breakout session. Topics discussed were (1) follow-up discussion on data needs, (2) potential new contributions to education and knowledge transfer, and (3) coupled modeling and the CSDMS Web Modeling Tool.

What do terrestrial modelers want from the data community?

The TWG identified four areas for improvement in data capabilities: documentation, data use in modeling, uncertainty analysis, and versioning.

<u>Documentation:</u> There is still ample room for improvement in data documentation and metadata. This seems to be an area of active research and development within the data science community.

<u>Data for modeling</u>: The group discussed ongoing difficulties in working with large datasets, either for purposes of ingesting data into a model program for use as an initial or boundary condition, or for comparison to model predictions. Greater standardization in formats and metadata would be helpful. Continued development of data semantics, such as CUAHSI's work on semantics in hydrology, is needed. There was some discussion of a "Basic Model Interface (BMI) for data." What might this look like? One possibility would be to develop code to implement a generic "data component" for the CSDMS Web Modeling Tool (WMT). Such a component would, like any component, expose a BMI. It would provide the ability for other components to query the properties of, and read data from, an underlying dataset. One approach to turning a particular dataset into a data component would be to encode information about the dataset in an XML (eXtensible Markup Language) file, which would include information about the contents of the data (using the emerging standard data semantics, including CSDMS Standard Names), their units, and their formatting (such as gridding information where applicable). Such an approach would allow model components to treat data sets in the same fashion that they treat other components. It would extend the capability of the WMT, which would have value not only for those who wish to couple models, but also for those who wish to run a single model using a particular dataset, without having to customize the data format or write their own data-reading routines. However, developing a data BMI would require significant effort, both on the part of CSDMS Integration Facility staff, and on the part of dataset providers (who would need to provide standardized metadata in a format that could be read by a data component "wrapper"). One possibility to consider would be a supplemental grant to support such an activity through a program such as EarthCube.

<u>Uncertainty analysis</u>: The group noted that very few datasets include estimates of uncertainty or confidence limits (one notable exception is the emerging global soil map, for which uncertainty estimates will be provided; Sanchez et al., 2009). Lack of such information makes it impossible to evaluate whether or not a calculated quantity lies within or beyond observational uncertainty. Lack of reported observational uncertainty also makes it impossible to propagate uncertainty in models that rely on input data for initialization, boundary conditions, or process parameters.

<u>Data versioning</u>: The group noted instances in which providers of large data sets upgraded the data, which then led to a change in the output of models that used the data as input. Clearly, there are good reasons to release different versions of data sets, as the data are processed and improved. On the other hand, when older versions "disappear" (i.e., are removed from public access) as a result, it becomes impossible to reproduce model calculations performed with these older versions. This issue highlights the need for systematic data "versioning" (assignment of unique version numbers to data sets, with accompanying metadata), and for archiving of older versions that have been used in model calculations.

Potential contributions to CSDMS Education and Knowledge Transfer activities

The Education and Knowledge Transfer (EKT) Working Group asked the TWG to identify potential contributions to the EKT Repository for two levels of instruction: undergraduate and graduate. The group discussed a number of ideas, noting that the "undergraduate level" can vary widely depending on the nature of the program; for example, some degree programs provide advanced undergraduate coursework in mathematical/numerical modeling, whereas in others, undergraduate exposure to modeling may be limited to simple spreadsheet calculations, or may not exist at all. Thus, in developing materials for undergraduates, it is useful to identify the necessary prerequisite skills.

The WMT provides a useful framework for student modeling exercises, because it provides a consistent, web-based interface. Students working with different types of models in WMT could therefore do so without having to learn multiple idiosyncratic interfaces. The WMT can provide a useful platform even for relatively simple exercises. Potential examples include a linear reservoir model as an analog for rainfall and runoff (and comparison to hydrograph data), a 1D diffusion model for erosional degradation of scarp landforms, and multiple-regression modeling of sediment yield (with WMT used to do forward-model calculations; one member volunteered to provide such an exercise to the EKT repository, based on one he currently uses).

Models are heavily used in professional practice, both for making predictions (engineering) and for studying nature (science). It is therefore important that students develop a basic understanding of uncertainties in model calculations. Use of Dakota through the WMT could provide a valuable basis for exercises in model uncertainty analysis; one possibility would be to build on the successful Dakota-WMT clinic that was presented at the 2015 meeting. The appeal of model-based exercises could potentially be enhanced by framing exercises as "games" in which students compete to seek, for example, the best fitting models for a particular data set.

Earth-science educators often make effective use of physical experiments in their classrooms (one set of examples for can be found at:
http://www.geology.um.maine.edu/geodynamics/AnalogWebsite/html_files/crustal dynamics.html).

Physical experiments could be combined with model exercises to provide training in the use and value of models in describing natural phenomena, as well as practice in model-data comparison and parameter fitting. Here again, the WMT could prove valuable in the classroom as a common entry point. In many cases, the necessary simple "exercise level" model codes would need to be written and tested first.

CSDMS EKT material also has potential value in professional-level teaching. Computing technology has advanced considerably in the decades since many of today's senior-level geoscience professionals and environmental regulators were trained. There is likely to be a need for professional training in topics such as model uncertainty analysis.

Coupled modeling and the CSDMS Web Modeling Tool

Those in the group who had used WMT felt that it represented a big enhancement from the original CMT in terms of usability. Although there were no heavy users of WMT in this particular discussion group, members expressed the view that the design had positively influenced their own modeling. There was a sense, in other words, that CSDMS is successfully leading the community by example in terms of cyber-infrastructure design and quality.

One obstacle to broader adoption of the WMT is the fact that relatively few models in the CSDMS repository are BMI-compliant to date (though the list is steadily growing). The group appreciated the BMI clinics, but some felt that additional, more extensive workshop-level training would also be helpful. The need for hydrologic models was particularly noted. It would be useful, for example, to have a BMI-compatible groundwater or surface-and-groundwater model, such as ParFlow, MODFLOW-Ohwm, or TOUGH. An agent-based model, such as Envision (http://envision.bioe.orst.edu/About.aspx), would also be a novel and useful element.

Status of the Landlab project

As noted in last year's annual report, a team of TWG members has developed a working prototype of Landlab. Landlab is a Python-language software library that supports rapidly building, coupling, and exploring two-dimensional numerical models. A clinic on Landlab was presented at the 2015 All Hands meeting. Clinic materials, including slides and iPython notebook tutorials, are now available on Landlab's GitHub website. A proposal to further develop Landlab was submitted to NSF's Software Infrastructure for Sustained Innovation (SI2) program in summer 2014; that proposal was recently recommended for funding. (Landlab is described in Appendix 12).

Contributions to the Model Repository

During the past project year, about 9 new terrestrial models were added to the CSDMS Model Repository. The contribution of MARM5D by developers Cohen and Willgoose adds a substantial new capability for modeling physical weathering and soil-surface armoring. The addition of PHREEQC brings geochemical modeling into the CSDMS Terrestrial fold. In addition, Randy LeVeque of the University of Washington, who presented a keynote talk at the 2015 meeting, contributed GEOCLAW, a sophisticated shallow-water hydrodynamics model that uses adaptive-mesh refinement.

Contributions to the Education and Knowledge Transfer Repository

About 14 new movies depicting terrestrial processes were added to the EKT Repository during the last project year. These deal with topics ranging from floods to landslides to bioturbation by worms.

References

Sanchez, P. A., et al. (2009). Digital soil map of the world. *Science*, *325*(5941), 680-681.

6.2 Coastal Working Group & Coastal Vulnerability Initiative

Because the goals and activities of the Coastal Working Group (WG) and the Coastal Vulnerability Initiative (CV) overlap, we report on the progress and plans for these two efforts jointly, with items especially relevant for CV in red.

Select research and modeling progress in the community: toward WG and CV goals

We focus here on select accomplishments most relevant for the community-defined WG and CV priorities in the CSDMS Strategic Plan:

Specific Science Goal 1 (SSG1) involves developing a medium-complexity suite of coupled models to explore "delta evolution on decadal to millennial time scales, as affected by couplings between terrestrial, fluvial, coastal, wetland, floodplain, subsidence, ecological and human processes (Figure 13)". Building a model component for dynamic river avulsions, to couple to existing delta-building models, represents the first key step toward this goal. Katherine Ratliff has completed such a module, performed an initial investigation of the upstream effects of maintaining artificial levees, and is working on the coupling stage with Eric Hutton. Collaborator Rebecca Lauzon is devising a delta vegetation/flow module. Complementary delta modeling efforts abound, including those of Doug Edmonds, William Nardin, and others using Delft3D; Man Liang using a reduced complexity model, Anthony Longjas and other using network models, Jaap Nienhuis and Andrew Ashton using CEM (and Delft3D), and Ehab Meselhe and others using the applied Integrated Compartment Model (posters and talks presenting most of these efforts available: http://csdms.colorado.edu/wiki/CSDMS_meeting_2015#Posters).

SSG2 addresses how the "morphology, ecology, and human components of sandy coastal environments co-evolve under different scenarios of changing storm climate, sea level rise, and human manipulation—including coastal environments ranging from urban to undeveloped." Laura Moore and Orencio Duran have developed the Coastal Dune Model (CDM) and used it to explore barrier island responses to changing climate (Duran and Moore, Nature Climate Change, 2015, in references Appendix), while Collaborator Laura Rogers and others have documented how different styles of coastal development affect overwash fluxes (e.g. Figure 14), and (with Jorge Lorenzo Trueba and Andrew Ashton) ultimately barrier survival (in review). A growing team of economists and geomorphologists (Marty Smith, Brad Murray, Dylan McNamara, Sathya Gopalakrishnan, Laura Moore, Andy Keeler, and Craig Landry) continue to address couplings between physical/ecological and socio-economic processes on developed sandy coastlines (McNamara et al., 2015; Smith et al., 2015, in references Appendix).

SSG3 involves modeling rocky and soft-cliff evolution, including the effects of human manipulations from river damming to coastal armoring. As part of these efforts, Pat Limber, Chris Thomas, Andy Barkwith, Andrew Ashton and others are working to unify a version of the Coastline Evolution Model (CEM) that can address rocky coastlines and beach-cliff interactions, as well as delta-related processes (and numerous other relatively new capabilities), and to apply a Basic Model Interface (BMI). Pete Adams, Pat Limber, Dylan McNamara and others have been using CEM, coupled to various wave-transformation models, to address rocky (and sandy) coastline evolution and response to changing storm/wave climate.

Science Facilitation Goals 1 and 3 (SFG 1, 3) involve adding models prioritized by the community to the CSDMS toolbox of coupled models. Prioritized models include the expanded version of CEM (above), the wave-transformation model SWAN, and XBeach. Pat Limber has been applying a BMI to the wave model SWAN, and coupling it to the new CEM, as part of the work related to SSG3. As part of the work related to SSG2, Nick Cohn and others have applied a BMI to XBeach.

SFG2 calls for model benchmarking and intercomparison projects. Tom Hsu reports that participants in a recent workshop tackled the intercomparison of a range of models capable to simulating swash dynamics, and that the results will be published soon.

Community engagement activities

To encourage input and engagement from a range of different coastal-science communities and disciplines, we have enlisted and appointed two Vice Chairs, and several Liaisons: Vice-Chair for Community Engagement, Chris Thomas (British Geological Society); Vice Chair for Coastal Vulnerability, Hans-Peter Plag (Old Dominion University); Liaisons to the CSDMS Integration Facility, Eric Hutton; to the Education and Knowledge Transfer (EKT) Working Group and the Belmont Forum deltas group, Irina Overeem; to laboratory delta modeling and stratigraphy, Kyle Straub; to the XBeach community, Ad Reneirs; to the Delft3D community and the Delta Dynamics Collaboratory, Doug Edmonds; and to the Ganges-Bramaputra research community, Mike Steckler.

To elicit active input and contributions from as many of the Working Group members as possible, Vice Chair Chris Thomas has instituted a Newsletter; every few months, Chris has asked the WG members, via email, to send him their modeling related success stories (papers published, noteworthy results) and opportunities (e.g. graduate or postdoc positions available). Chris then collates the information he receives and circulates it, again via email, to the community. (A cumulative list of the references circulated among the WG membership appears as an Appendix below.)

Select research and modeling plans: toward WG and CV goals

- SSG1: Couple the river-avulsion model initial to CEM, and next to a marsh module (Katherine Ratliff, Marco Marani). The community has identified large-scale, long-term fluvial floodplain deposition dynamics as a key knowledge (and modeling capability) gap.
- SSG2: Continue to build on the existing Coastal Dune Model (CDM), use it to identify which types of coastlines are most vulnerable (Laura Moore, Orencio Duran, Evan Goldstein, and others), and couple it to XBeach (Laura Moore, Orencio Duran, Evan Goldstein, Peter Ruggiero, Nick Cohn, Danno Roelvink, and others), and then potentially to ground-water and weather models (intertwined with the Interagency Working Group plans). Continue efforts to measure effects of development on storm-driven sediment fluxes, and model the long-term consequences for and feedbacks with the morphological and ecological evolution of sandy coastal environments.
- SSG3: Activities listed above are ongoing.
- SFG 1, 3: Develop BMIs for a marsh model (e.g. the D'Alpaos et al. model), and a barrier-island groundwater model (e.g. SEW-WAT); and couple the Tsunami model GEOCLAW with XBeach.

- Contribute to the EKT WG, as featured models to excite and educate a range of students, the Coastal Dune Model (CDM), preferably coupled to XBeach (SSG2), and the Tusnami model GEOCLAW.
- Strive to accomplish additional model-intercomparison projects, including those addressing: a) prediction of marsh accretion rates under specified scenarios for sea-level-rise rate, suspended sediment flux, etc.; b) the 'Sand Engine' project in the Netherlands, involving a well monitored mega-nourishment of a north sea coastline, already simulated by different hydrodynamics-resolving models, but not yet by simpler models; and c) beach/nearshore data sets from Duck (North Carolina) and NCEX (California) massive experiments. Seek funding for such model-intercomparison projects.
- Investigate WG/CV involvement in the Food-Water-Energy nexus.
- To further develop the CV Initiative, hold a joint meeting with the Human Dimensions Focus Research Group, and add further Liaisons relevant to CV (see Community engagement next steps below).

Community engagement next steps

- Add WG/CV Liaisons for: the iCOASST effort (Robert Nichols, also for the Belmont Forum deltas project); the Integrated Coastal Modeling project on the Mississippi Gulf (Ehab Meselhe); the USGS coastal vulnerability efforts (Hillary Stockdon); and the US Army Corps of Engineers (TBD).
- Build on the experience with the Newsletter, to try to increase the breadth of active participants and spur new collaborations and new ideas involving coupling between different environments or processes, by: a) turning the WG email list into a moderated list that members can use for timely, and brief communications of success stories, opportunities, and ideas; b) turn the Newsletter into a cumulative online archive of the successes (e.g. Appendix below), opportunities and ideas to circulate among the community (via the listserv); c) next, to facilitate a forum for more lengthy descriptions of ideas and calls for collaboration (from unknown potential partners), such as Webinars that can be archived through YouTube; d) to follow up on such postings with limited-time (e.g. two day) focused discussions online; and e) to alert broader communities to such postings and discussions with messages to other lists, such as the Gilbert Club and the Coastal List.

References gathered through Community Engagement activities

Allison, M., M. Ramirez, and E. Meselhe (2014), Diversion of Mississippi River Water Downstream of New Orleans, Louisiana, USA to Maximize Sediment Capture and Ameliorate Coastal Land Loss, *Water Resour Manage*, *28*(12), 4113-4126, doi:10.1007/s11269-014-0731-y.

Juan Baztan, Omer Chouinard, Bethany Jorgensen, Paul Tett, Jean-Paul Vanderlinden and Liette Vasseur. 2015. Coastal Zones: Solutions for the 21st Century. ISBN: 978-0-12-802748-6

Covault, J. A., S. Kostic, C. K. Paull, H. F. Ryan, and A. Fildani (2014), Submarine channel initiation, filling and maintenance from sea-floor geomorphology and morphodynamic modelling of cyclic steps, *Sedimentology*, *61*(4), 1031-1054, doi:10.1111/sed.12084.

Duran Vinent, O., and L. J. Moore (2015), Barrier island bistability induced by biophysical interactions, *Nature Clim. Change*, *5*(2), 158-162, doi:10.1038/nclimate2474

Johnson, J.M, L.J. Moore, K. Ells, A.B. Murray, P.N. Adams, R.A. MacKenzie III, and J.M. Jaeger, 2014, Recent Shifts in Coastline Change and Shoreline Stabilization Linked to Storm Climate Change, Earth Surface Processes and Landforms. DOI: 10.1002/esp.3650

Lanzoni, S., and A. D'Alpaos (2015), On funneling of tidal channels, J. Geophys. Res. Earth Surf., 120, doi:10.1002/2014JF003203.

Limber, P, and A.B. Murray, 2014, Sea stack formation and the role of abrasion on beach-mantled headlands, Earth Surface Processes and Landforms. DOI: 10.1002/esp.3667.

Limber, P. W., A. Brad Murray, P. N. Adams, and E. B. Goldstein (2014), Unraveling the dynamics that scale cross-shore headland relief on rocky coastlines: 1. Model development, *Journal of Geophysical Research: Earth Surface*, *119*(4), 2013JF002950, doi:10.1002/2013JF002950.

Limber, P. W., and A. B. Murray (2014), Unraveling the dynamics that scale cross-shore headland relief on rocky coastlines: 2. Model predictions and initial tests, *Journal of Geophysical Research: Earth Surface*, *119*(4), 2013JF002978, doi:10.1002/2013JF002978.

McNamara D.E., Gopalakrishnan S, Smith M.D. Murray A.B. 2015 Climate Adaptation and Policy-Induced Inflation of Coastal Property Value. PLoS ONE 10(3): e0121278. doi:10.1371/journal. pone.0121278

Moore, L. J., K. Patsch, J. H. List, and S. J. Williams (2014), The potential for sea-level-rise-induced barrier island loss: Insights from the Chandeleur Islands, Louisiana, USA, *Marine Geology*, *355*(0), 244-259, doi:http://dx.doi.org/10.1016/j.margeo.2014.05.022.

Murray, A.B., Coco, G., and Goldstein, E.B., 2014, Cause and Effect in Geomorphic Systems: Complex-Systems Perspectives, Geomorphology, 214, 1 – 9. DOI: 10.1016/j.geomorph.2014.03.001.

Murray, A.B., E. B. Goldstein, and G. Coco, 2014, The shape of patterns to come: from initial formation to long-term evolution, Earth Surface Processes and Landforms, 39, 62 – 70, DOI: 10.1002/esp.3487.

Pittaluga, M. B., N. Tambroni, A. Canestrelli, R. Slingerland, S. Lanzoni, and G. Seminara (2015),Where river and tide meet: The morphodynamic equilibrium of alluvial estuaries, J. Geophys. Res. Earth Surf., 120, doi:10.1002/2014JF003233.

Ratliff, K. M., and A. B. Murray, 2014, Modes and emergent time scales of embayed beach dynamics, Geophysical Research Letters, 41, 7270 – 7275, DOI: 10.1002/2014GL061680.

Samaras, A.G. and Koutitas, C.G. (2014). The impact of watershed management on coastal morphology: A case study using an integrated approach and numerical modeling. Geomorphology, 211, pp.52-63. Elsevier; ISSN: 0169-555X; DOI

Samaras, A.G. and Koutitas, C.G. (2014). Modeling the impact of climate change on sediment transport and morphology in coupled watershed-coast systems: A case study using an integrated approach. International Journal of Sediment Research, 29(3), pp.304-315. Elsevier; ISSN: 1001-6279; DOI

Smith, M. D., Murray, A. B., Gopalakrishnan, S., Keeler, A. G., Landry, C. E., McNamara, D., and Moore, L. J., 2015, Chapter 7 – Geoengineering Coastlines? From Accidental to Intentional, in *Coastal Zones, Solutions for the 21st Century,* Elsevier, doi: 10.1016/B978-0-12-802748-6.00007-3

Tolkova, E., H. Tanaka, and M. Roh (2015), Tsunami Observations in Rivers from a Perspective of Tsunami Interaction with Tide and Riverine Flow, *Pure Appl. Geophys.*, *172*(3-4), 953-968, doi:10.1007/s00024-014-1017-2.

Van Oyen, T., L. Carniello, A. D'Alpaos, S. Temmerman, P. Troch, and S. Lanzoni (2014), An approximate solution to the flow field on vegetated intertidal platforms: Applicability and limitations, *Journal of Geophysical Research: Earth Surface*, n/a-n/a, doi:10.1002/2013JF003064.

Walters, D., Moore, L.J., Duran, O., Fagherazzi, S., and Mariotti, G. 2014. Interactions between barrier islands and backbarrier marshes affect island system response to sea level rise: Insights from a coupled model. *Journal of Geophysical Research—Earth Surface.* DOI: 10.1002/2014JF003091

A

B

Fig. 13. Rearrangements to barrier island landscapes (and development) after a severe storm (Hurricane Sandy). A: Mantoloking, New Jersey (blog.ucsusa.org). B: One of the New Jersey locations studied by Rodgers et al. (in review) in their showing that development style drastically affects overwash fluxes.

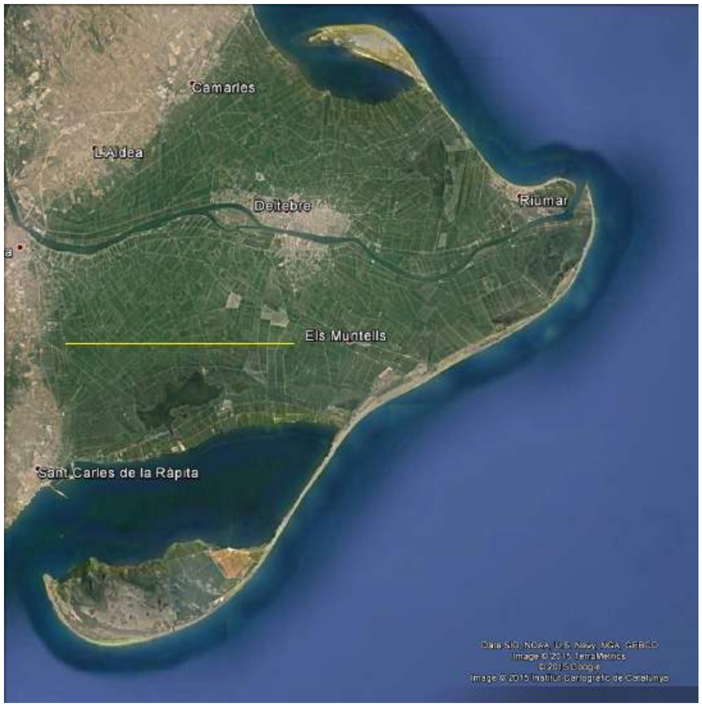


Fig. 14. The size and shape of the Ebro Delta in Spain have changed drastically as a result of land-use changes. Most of the world's major deltas are similarly affected by human land use in the watershed and on the delta (including manipulations of river processes). (Yellow scale bar shows 10 km.)

6.3 Marine Working Group

- A series of short-term (1-2 yr.) objectives outlined in the CSDMS Strategic Plan, including:
  - *Developing a set of models that can be coupled via BMI.*

    A BMI version of SWAN was developed and provided in 2013 via GitHub (https://github.com/SiggyF/chenopis). There are currently no plans to integrate this version back into the main SWAN development line of Delft University, however.

    Deltares is actively working on the development of a new hydro-morphodynamic engine Delft3D-FLOW Flexible Mesh, which is to be released in open source later this year. That version will include a BMI compatible interface, and other components will likely follow over time. However, project context to raise priority at Deltares for the development of a BMI interface for the current structured grid Delft3D-FLOW engine is currently lacking.

    Marine working group called for an atmospheric / wind model. No update.

    Patricia Wiberg (University of Virginia) has worked to add some tools to the CSDMS model repository to enable calculations of wave orbital velocity, surface wave characteristics, and bed shear stress.
  - *Providing a hydrodynamic model to the CSDMS that is easier to use.*

    An idealized continental shelf model has been provided that uses ROMS (the Regional Ocean Modeling System) to calculate hydrodynamics, salinity, and sediment transport fields for a planar-shaped continental shelf onto which a freshwater plume flows. A pre-compiled version of the model, with necessary input files, has been ported to the CSDMS supercomputer, *beach*. We are calling this implementation "riverplume2", or "ROMS-LITE". Working with the EKT group, members of the Marine Working Group are developing lesson plans appropriate for a graduate level course.

- The Marine Working Group has also discussed model intercomparison projects.
  - Examples of large, funded, model intercomparisons have been seen where the studies yielded interesting results and took advantage of quantitative metrics for skill assessment, and tools being developed within IOOS (the Integrated Ocean Observing System).
  - A true model intercomparison effort would require proposals, but other avenues for highlighting the potential of the various models exist including special journal volumes and special sessions at relevant conferences.
- Summary of Marine Working Group Resources:
  - The repository currently lists fifty-one marine models and 5 marine modeling tools.
  - Models that have BMIs and are allied with Marine Working Group interests including SWAN, SedFlux, OceanWaves, CEM, ROMS-Lite.

6.4 Education and Knowledge Transfer Working Group

The CSDMS EKT Working Group strives to develop and transfer CSDMS tools and knowledge to the following groups:

- Researchers with model and visualization tools
- Planners with decision-making tools to run scenarios
- Educators with pre-packaged models

For our educational materials, we strive to provide materials that help develop quantitative skills, and critical evaluation of model assumptions and outputs. Our principal education audiences are university students, professionals, teachers at the secondary school and college levels, and the general public. To document our progress, we provide a description of our short and longer-term goals and our progress towards those goals below.

1.0 Short-term action plan to achieve long-term goals 2013-2016:

1.1 CSDMS Course Materials

Call to CSDMS community for contribution of exercises and assignments with modeling focus at a range of educational levels, with goal of at least one contribution per group WG.

- Polish and post products
- Develop simple assessment rubrics
- Distribute to pilot team of at least one person per WG for classroom use, with assessment
- Compile results and experiences and prepare/submit paper to Journal of College Science Teaching, with plan authors and testers as co-authors
- Hold a clinic at CSDMS Annual Meeting: "Bringing CSDMS to the classroom"
- Promote development of web-enabled CMT environment to circumvent complications of getting large groups to use HPC
- Consider posting to Carleton College Earth Science Education website
- Implement high quality visualization for all products
- Consider uncertainty for all products

1.2 Education and research for non-specialists

Develop streamlined model packages for classroom and researcher use as binaries or simple CMT implementations

- Query CSDMS community to identify target models
- Componentize and/or prepare stable executables for offline use
- Prepare test cases submitted by user groups or developers
- Promote development of web-enabled CMT environment to circumvent complications of getting large groups to use HPC
- Implement high quality visualization for all products
- Consider uncertainty for all products
- Consider developing test cases for existing componentized models for educational use and tutorials for non-specialists (one or more per WG)

1.3 Year Two and farther out: Coupling between GIS and CMT.

- Seek out and advertise the existing proof-of-concept examples
- Develop tool to couple GIS based models or data and CMT
- Query end-users to identify key modeling tools and GIS environments for future implementation

2.0 Progress Toward Goals

The following is a summary of EKT activities towards long-term and short-term goals during the past year:

- Development of the WMT and wrapping of new models has greatly facilitated EKT activities
- During the CSDMS 2015 Annual Meeting, Irina Overeem (IF liaison to the ExCom) held a clinic on “Bringing CSDMS to the Classroom”
- IF personnel Kettner, Overeem, and Borkowski have developed multiple new packages for Science on a Sphere, accessible globally at >110 museum locations, viewed to date by >30 million visitors
- We have begun to install CSDMS stack at universities other than CU to mainframe access for large on-campus classes at non-CU campuses. Louisiana State University Center for Computation and Technology will be the first remote installation (supported by LSU coastal researcher Professor Jim Chen).
- We have begun developing CSDMS modeling modules for education, with goals for assessment and publication of results from educational deployment (details below and elsewhere in annual report).
- One of the major goals of CSDMS, via the EKT WG, is to help government agencies and other decision makers apply CSDMS tools to help agencies and decision makers reach programmatic objectives. Ongoing activities that demonstrate CSDMS progress in this realm include the following continuing collaborations: CSDMS collaboration with BOEM to study slope turbidite processes (Syvitski, Harris, Meinert) and delta front sedimentation processes (Bentley, Georgiou); redevelopment of Chesapeake Bay models to serve multiple agencies (Hood Chesapeake FRG).

New EKT lab modules under development by FRG and WG:

Hydrology FRG: TopoFlow, SWAT, MODFLOW via the WMT

Coastal WG: New CEM/WMT, with deltaic and non-deltaic lab examples; SWAN/WMT; GeoClaw; XBeach with a new sand dune module.

Marine WG: ROMS Lite; SedTrans05/Sedi1D; will also benefit from Coastal WG EKT labs

Terrestrial WG: WILSIM http://serc.carleton.edu/landform/index.html; CHILD; LandLab; simple 1D concept models via spreadsheets.

Carbonate FRG: CarboCAT

Geodynamics FRG: a simplified version of CHILD simplified version from Peter Koons

Crosscutting: WMT Dakota; Multiple regression techniques (e.g., BQART update via Sagy Cohen)

Human Dimension, Critical Zone, and Ecosystem Dynamics WGs are in consultation with their membership to identify candidate models.

Assessment templates are presently under development by Bentley and Overeem, which will be distributed during the 15/16 academic year for evaluation of the above modules in classroom environments.

6.5 Cyberinformatics and Numerics Working Group

The Cyberinformatics and Numerics Working Group has a membership of 189. At the 2015 CSDMS Annual Meeting in Boulder, the WG had useful discussions during the breakout sessions. The following projects have been successfully concluded over the last year:

- The Basic Model Interface (BMI) API documentation is now online at http://bmi-forum.readthedocs.org/en/latest
- The migration of the CSDMS model repository to GitHub has been successfully completed.

In addition, the discussions identified the following priorities for the future:

- There exists a need for a data repository for model validation, benchmarking, and intercomparisons.
- Any benchmarking projects should include efforts with regard to uncertainty quantification, cf. existing efforts for tsunami modeling.
- Stronger ties should be developed between CSDMS and EarthCube.
- The software Dakota needs a BMI to integrate with the CSDMS framework.

In addition, several WG members noticed that a large number of problems of interest to CSDMS members in all groups involve, in one form or another, the tracking of interfaces. This applies, for example, to the evolution of a coastline, the advancing or receding boundaries of a glacier or ice sheet, or the surface of a sediment bed on the seafloor. Frequently, current simulation approaches for such interface tracking problems employ very low-order, coarse numerical methods that may substantially reduce the accuracy of the underlying simulation model. Yet the scientific computing community in recent years has developed a novel class of numerical approaches that allows for much higher fidelity interface tracking algorithms. This approach is generally known under the broad terminology of 'level set methods' (S. Osher and R. Fedkiw 2002 Level Set Methods and Dynamic Implicit Surfaces, Springer Verlag). This approach has become quite mature in recent years, so that it may offer substantial advantages in the modeling of many problems of interest to the CSDMS community. It may be useful that for the 2016 CSDMS Annual Meeting, we should invite a speaker from the scientific computing community who could provide a broad introduction, and perhaps a clinic, on level set methods.

CSDMS publications & abstracts from C&N Vice-Chair, Scott Peckham

North, E.W., E.E. Adams, A.E. Thessen, Z. Schlag, R. He, S.A. Socolofsky, S.M. Masutani and S.D. Peckham (2015) The influence of droplet size and biodegradation on the transport of subsurface oil droplets during the

Deepwater Horizon spill: A model sensitivity study, *Environmental Research Lettters*, 10, 024016, doi:10.1088/1748-9326/10/2/024016.

Peckham, S.D. (2014) The CSDMS Standard Names: Cross-domain naming conventions for describing process models, data sets and their associated variables, Proceedings of the 7th Intl. Congress on Env. Modelling and Software, International Environmental Modelling and Software Society (iEMSs), San Diego, CA. (Eds. D.P. Ames, N.W.T. Quinn, A.E. Rizzoli), http://www.iemss.org/society/index.php/iemss-2014-proceedings.

Peckham, S.D. (2014) EMELI 1.0: An experimental smart modeling framework for automatic coupling of self-describing models, *Proceedings of HIC 2014*, 11th International Conf. on Hydroinformatics, New York, NY. http://www.hic2014.org/proceedings/handle/123456789/1705

Peckham, S.D., C. DeLuca, D. Gochis, J. Arrigo, R. Dunlap, A. Kelbert and E. Choi (2014) EarthCube – Earth System Bridge (ESB): Spanning scientific communities with interoperable modeling frameworks, *Eos Trans. AGU*, Fall Meet. Suppl., Abstract IN31D-3754.

Kelbert, A. and S.D. Peckham (2014) Metadata for numerical models of deep Earth and Earth surface processes, *Eos Trans. AGU*, Fall Meet. Suppl., Abstract IN31D-3721.

Choi, E., A. Kelbert and S.D. Peckham (2014) Linking tectonics and surface processes through SNAC-CHILD coupling: Preliminary results towards interoperable modeling frameworks, *Eos Trans. AGU*, Fall Meet. Suppl., Abstract T33B-4683.

June 2015. Peckham, S.D. (Invited) EarthCube - Earth System Bridge: Spanning scientific communities with interoperable modeling frameworks, EarthCube Architecture Workshop, Scripps Institution of Oceanography, UC San Diego, La Jolla, CA (June 19-20).

June 2015. Peckham, S.D. (Invited) Plug-and-play modeling: An overview of CSDMS and the Earth System Bridge project (guest lecture), Graduate-level course, GEOS 697 - Interdisciplinary Modeling: Water-related Issues and Changing Climate, Boise State University, Boise, ID (June 6-9).

May 2015. Peckham, S.D. EarthCube - Earth System Bridge: Spanning scientific communities with interoperable modeling frameworks (poster), EarthCube All Hands Meeting, Arlington, VA (May 27-29).

May 2015. Peckham, S.D. (Invited) Integrated plug-and-play modeling: An overview of CSDMS and the Earth System Bridge project, Integrated Modeling for Adaptive Management of Estuarine Systems Workshop, UC Davis, Davis, CA (May 21-22).

May 2015. Peckham, S.D. An overview of the Earth System Bridge project (and some background about CSDMS), EarthCube Earth System Bridge Workshop: Numerical Model Metadata for Solid Earth Sciences, Portland State University, Portland, OR (Apr. 30 to May 2)

Apr. 2015. Peckham, S.D. An overview of the Earth System Bridge project (and some background about CSDMS), 3rd Workshop on Coupling Technologies for Earth System Models, Manchester, UK (Apr. 20-22).

Apr. 2015. Peckham, S.D. A Semi-technical overview of the Earth System Bridge project, EarthCube Tech Hands Meeting, Scripps Institution of Oceanography, UC San Diego, La Jolla, CA (Apr. 8-10). Peckham was the lead organizer.

Mar. 2015. Peckham, S.D. Component-based, plug-and-play modeling: An overview of CSDMS, the Community Surface Dynamics Modeling System, EarthCube GeoSoft Early Career Advisory Committee Meeting, Information Sciences Institute (ISI), University of Southern California, Marina del Rey, CA (Mar. 11-13)

Feb. 2015. Peckham, S.D. (Invited) Sharing variables between models in a plug-and-play community modeling system like CSDMS: The semantic mediation problem and the CSDMS Standard Names, RDA (Research Data Alliance) Metadata Semantics Summit Workshop, IUPUI Campus, Indianapolis, IN (Feb. 23-25)

Feb. 2015. Peckham, S.D. Update on the CSDMS Standard Names and Model Coupling Metadata, EarthCube GeoSoft Kickoff Meeting, Marina del Rey, CA (Feb. 3-4)

Jan. 2015. Peckham, S.D. (Invited) An overview of CSDMS, the Community Surface Dynamics Modeling System and the Earth System Bridge project, SESYNC Model Integration Workshop: Development of a Prototype of an Integrated Modeling System for Socio-Economic and Environmental Analysis to Promote Sustainability at the Regional Level, NCSG (Natl. Center for Smart Growth Research and Education) and SESYNC (National Socio-Environmental Synthesis Center), Annapolis, MD (Jan. 21-23).

6.6 Interagency Working Group

The goal of the Interagency Working Group (IWG) is to build relationships between Federal and State agencies and CSDMS. CSDMS stands to benefit from these interactions directly through input of agency resources, and indirectly by demonstrating the utility of CSDMS science and technology. Agencies benefit by taking advantage of CSDMS technology and resources to advance their mission. Chris Sherwood (USGS, Woods Hole) was nominated as Chair of the IWG this year, and is working to strengthen ties between CSDMS and agencies. Based on discussions at the annual CSDMS meeting this year, the following strategy for IWG activities was developed.

Encourage existing relationships between CSDMS and agencies

There are several successful CSDMS research programs with significant agency involvement. The Sandia National Laboratories Dakota software has been installed on the CSDMS supercomputer with WMT access. BOEM continues to support work on a coupled model for turbidity flows in submarine canyons. The USGS is supporting the IWG, exploring the possibilities of wrapping coastal storm response model COSMOS in the WMT, and continuing work with MODFLOW.

Develop at least one, ideally two, new projects where agencies leverage CSDMS resources or infrastructure toward agency mission.

Ideas were solicited from both agency and CSDMS scientists and reported at the Annual meeting. Several promising opportunities have been identified, as follows.

- Use CSDMS model-coupling technology to develop a coupled model of coastal morphologic evolution that combines the recent advances in marine and coastal sediment transport (e.g., SWAN, XBeach) with terrestrial processes (wind transport, dune formation, bluff and cliff erosion, groundwater movement, terrestrial, wetland, and submerged vegetation ecology), possibly using either the Coastal Dune Model (CDM) or the LandLab framework. This model system would be used to evaluate short-term (event- to decadal time scales) evolution of coastal systems. Interested agencies might include ONR, USGS, BOEM, NPS, FWS, and USACOE.
- Develop a coupled modeling system for the physics and ecology of Chesapeake Bay, tributaries, and watershed to provide a modern, open-source alternative to the existing set of models used by the Chesapeake Bay Program. Use CSMDS tools to enable various combinations of alternative estuarine, watershed, and airshed models. Interested agencies might include EPA, USGS, and NOAA.
- Work with the US Army Corps of Engineers (USACOE) to post online model data from the North Atlantic Coast Comprehensive Study (NACCS). The study modeled storm winds, waves and water levels along the northeast coast affected by Hurricane Sandy and produced results for 1050 synthetic tropical events and 100 extratropical events at over three million computational locations. Making these model data searchable and useable with CSDMS support would provide opportunities for further analysis and modeling.

Conduct an Interagency Working Group Meeting in Washington this fall

The objective of this meeting would be to identify one or more target projects for agency participation and plan their implementation.

6.7 Carbonate Focus Research Group

Recent & current C-FRG activity includes:

- Development and sharing of the Carbo* organism knowledge base. This is an Excel based compilation of quantitative data on the growth rate, life habits and associated sediment accumulation rates for a range of modern carbonate-producing fauna. Current content is mostly modern corals, but the data format is very flexible and compatible with both modern and ancient fauna. An update of the content to include Miocene examples from the Mediterranean region is currently underway by a graduate student from Royal Holloway University of London. The OKB is available at http://csdms.colorado.edu/wiki/Data:Carbonate_Organisms

- Development of carbonate forward models under the C-FRG Carbo* framework is ongoing in University of Colorado, Boulder, Royal Holloway University of London, and NOVA Southeastern University, Florida. Most recent progress has been made by graduate students in Royal Holloway who are working on multi-scale carbonate models demonstrating how carbonate strata form on a basin scale in active extensional fault settings (Fig 15) and investigating feedbacks on a meter scale between microbial carbonate growth and sediment transport (Fig 16).

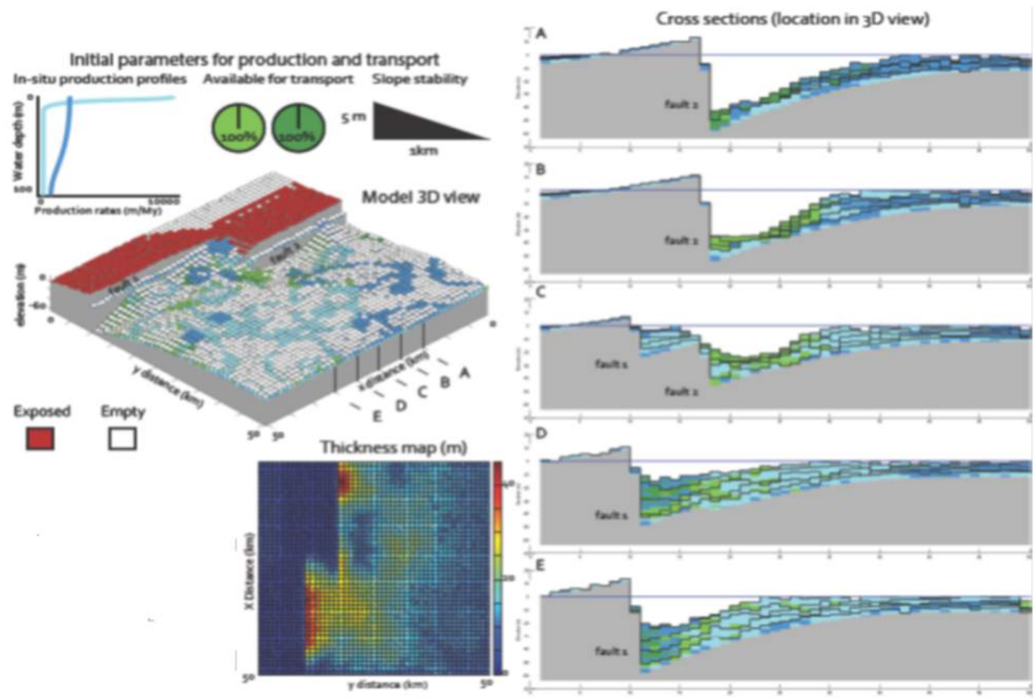


Fig. 15 Output from CarboCAT showing key parameters and output from a 100ky run with overlapping active extensional faults. Carbonate stratal thickness and stacking patterns vary along the strike of the faults in response to varying rates of differential subsidence.

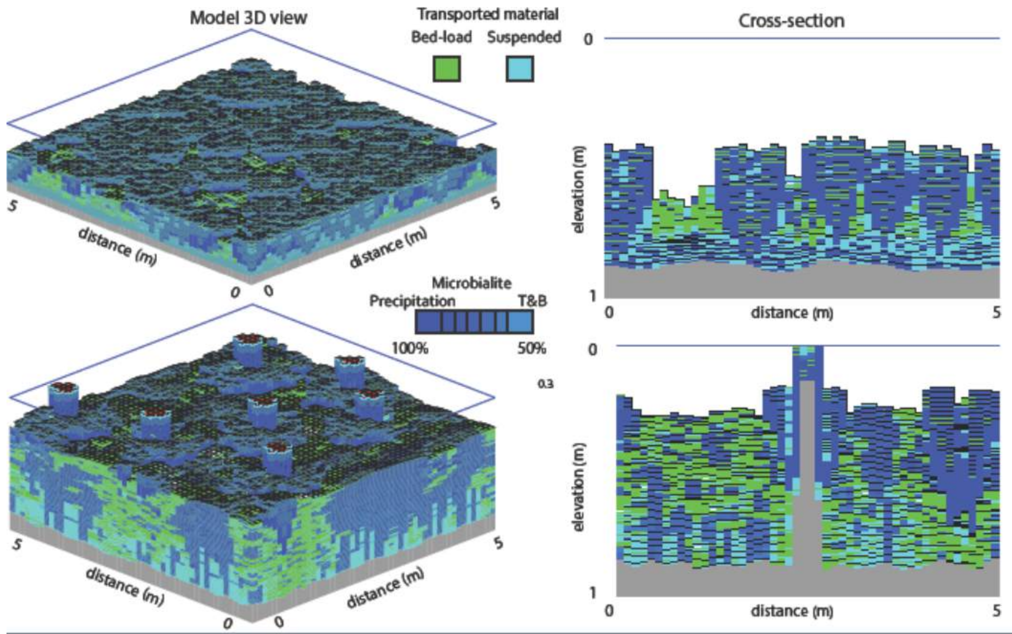


Fig. 16 Example output from Mounds3D showing how different forms of trapping and binding versus direct carbonate precipitation and sediment transport cause variations in microbial mound growth at the outcrop scale.

- Initial steps have been taken to componentize carbonate code by exporting a portion of CarboCAT code for inclusion into the Coastline Evolution Model. This will consist of in-situ production of carbonate sediment being available for transport onshore to form a carbonate or mixed siliciclastic-carbonate coastline. Integration of the CarboCAT code with existing CEM code and testing is required.
- At the May 2015 CSDMS annual meeting connections were established with the new Ecosystem Dynamics FRG; there are clear parallels given that the carbonate FRG modelling efforts involve a significant degree of ecosystem modelling

Plans for the future:

- C-FRG efforts are in progress to produce a componentized version of one of the Carbo* models within the Coastal Evolution Model and this will remain a focus for the next year
- An updated version of the CarboCAT code should be uploaded to the CSDMS model repository within the next few months
- The potential remains for a focus on biological modelling, for example with collaborators from the Life Sciences. The best way to facilitate this is most likely via developing of connections with the new CSDMS Ecosystem Dynamics FRG.

6.8 Human Dimensions Focus Research Group

Changing the name from Anthropocene FRG to Human Dimensions FRG was agreed upon by the group and voted on by the Executive Committee on 29 May 2015.

The HDFRG is planning a workshop, proposed for Spring 2016, on linking social science models and dynamic earth surface models. Social scientists have worked with ecologists for a while, but not extensively with earth scientists. We are now looking for funding sources and considering Boulder, CO for the meeting location. There was a general discussion of issues regarding human dimensions and earth system modeling. It is outlined below.

Potential Issues to be addressed in social science- earth system modeling?

- How to tackle temporal and spatial scaling issues
- What do we want to use these models for? Are they all predictive?
- How to handle uncertainty. Can DAKOTA be applied to integrated models?
- Addressing calibration and sensitivity
- Access to sensitive data and the importance of Metadata. How do you work with sensitive social data? How to protect or access sensitive data? How do you code sensitive data?
- How to build confidence in users of your models so that they trust your results.
- Communicating across disciplines. How do you determine and institute a common language?
- Social transformations, or: how to use model results to change things, and how to effectively introduce scenario results and modeled consequences to stakeholders
- How to take advantage of “technological leapfrogs”, i.e., sms technology in developing countries, internet
- How to co-produce model applications by involving stakeholders from the outset.

What should the outcome of model coupling be? What should we strive for?

- Collaborations; can CSDMS suggest solutions for linking these kinds of models?
- Building technical support (such as BMI, CSDMS wiki pages), also help with making social model codes BMI compliant
- Lessons learned about lessons learned? How to gain traction with ideas shared at the annual meetings and workshops (one suggestion is to involve stakeholders at the inception)
- Develop a database/list of funding mechanisms for coupled human-natural modeling projects. What are the sources of funding?
- What role can Future Earth can play in this?

What do we want?

- More Human Dimension models in the repository; standalone models and also surface dynamics models that can be linked to human dimension models
- Identify the kinds of parameters that may be useful for overlapping; add to standard names dictionary; list models in the repository by input data/output data;
- For CSDMS: make repository searchable by names or keywords; make it easier for users to search for appropriate models in the repository that they can link with (e.g. what kind of data will a model output? What kind of data is used for input?)
- Modeling priorities: How do we prioritize the kinds of models we want to couple?
- Temporal and Spatial scaling: How to resolve issues of scaling & how to talk about this
- Food Energy Water Nexus: great venue for applying coupled social-physical models, e.g. hydrological model (MODFLOW) linked with water rights model

- Need an agent based model in a language that can interface with CSDMS models; what language should these be created in?
- What are the models we can use for teaching? Are they stand alone or coupled?
- Ask members to visit CoMSES/OpenABM site and identify models that they would like to see couple-able. UrbanSim, ComSES.

Short-term goals

- Workshop
- More human dimensions model examples/talks/clinics at the annual CSDMS meeting
- Identify models that can be used for education

Long-term goals

- Co-production/coupling of models that address the numerous issues discussed above

6.9 Chesapeake Focus Research Group

The Chesapeake Focus Research Group (CFRG) currently has 62 members who are all active scientists and/or managers. The CFRG is integrated with the Chesapeake Community Modeling Program (CCMP), and so the CCMP Steering Committee provides oversight for both the CCMP and the CFRG. However, the CFRG has not been active over the past several years. Over the past year the CCMP/CFRG has convened a series of meetings aimed at reenergizing and crafting a vision for the CFRG.

Vision for a Reenergized CFRG (Working Together with the CCMP)

The current Chesapeake Bay Program's (CBP) modeling system that is used to inform management decisions and set TMDLs in Chesapeake Bay is based on the CMAQ (Community Multiscale Air Quality) airshed model; the phase 5 watershed model (which is based on the Hydrological Simulation Program – Fortan or HSPF), and the estuarine hydrodynamic and watershed models are based on CH3D (Curvilinear Hydrodynamics in 3 Dimensions) and ICM (Integrated Compartment Model) (Fig. 17). This modeling system, which was developed by the US Army Corp of Engineers, the EPA and the Chesapeake Bay Program, is not modern or modular, it is only marginally open source, and it employs models that are not widely used by the scientific community. *Our vision for the CFRG (working together with the CCMP) is to chart a course for the future of CBP modeling that revolves around the idea of using CSDMS (or similar) tools, philosophies and approaches to transform the Chesapeake Bay Program modeling system into a modern, modular, flexible, open-source modeling system for future management and scientific applications.*

This goal is consistent with CCMP objectives and the goals of the CSDMS Interagency Working Group. It is consistent with the recommendations of the CBP Modeling Laboratory Action Team and the STAC (Scientific and Technical Advisory Committee for the Chesapeake Bay Program)-endorsed goal of enabling the use of multiple/alternative models to inform management decisions. Moreover, something needs to be done to help the CBP reinvent and modernize its modeling system in the future. *A major challenge is getting the CBP/EPA to embrace this idea because there has been decades of investment in the current CBP modeling system.*

Alternative Open-Source Chesapeake Bay models:

There are now many alternative open-source models for doing estuarine, watershed and airshed modeling in Chesapeake Bay that could be included as part of a larger, modular, Chesapeake Bay modeling system. Some Alternative Open-Source Estuarine Hydrodynamic and Water Quality Models with structured grids include: ChesROMS-BGC/ECB[1], UMCESROMS-RCA[2] and CBOFS[3] (no BGC). Some unstructured grid models include: FVCOM-ICM, RCA[4], SCHISM-BGC[5] and SELFE-ICM[6].

Some Alternative Open-Source Watershed Models include: DLEM (large scale)[7], SWAT[8] (no full Chesapeake watershed implementation), PIHM[9] (no full Chesapeake watershed implementation), and Data (USGS Gauged Stations with nutrient and sediment load measurements).

Some Alternative Open-Source Airshed Models include: WRF[10] (ESSIC implementation, no atmospheric deposition), NARR[11] (no atmospheric deposition), Data (direct wind measurements from Thomas Point Light and other locations), Data (direct atmospheric deposition measurements).

Conclusions

The CFRG and CCMP have developed tentative plans to convene a workshop in conjunction with the CCMP Chesapeake Modeling Symposium (ChesMS16) in May of 2016 that will be focused on the idea of using CSDMS (or other) modeling tools to transition the CBP modeling system to a modular suite of models. Discussion about potential speakers and attendees for this workshop will commence at the next CCMP SC meeting on July 17, 2015 and will continue over the coming months. Some level of support from CSDMS will be requested, e.g., for sending CSDMS personnel to the workshop, etc. Imagine what we could do if we had the ability to couple all of the CBP models and use different combinations of them for both scientific and management applications.

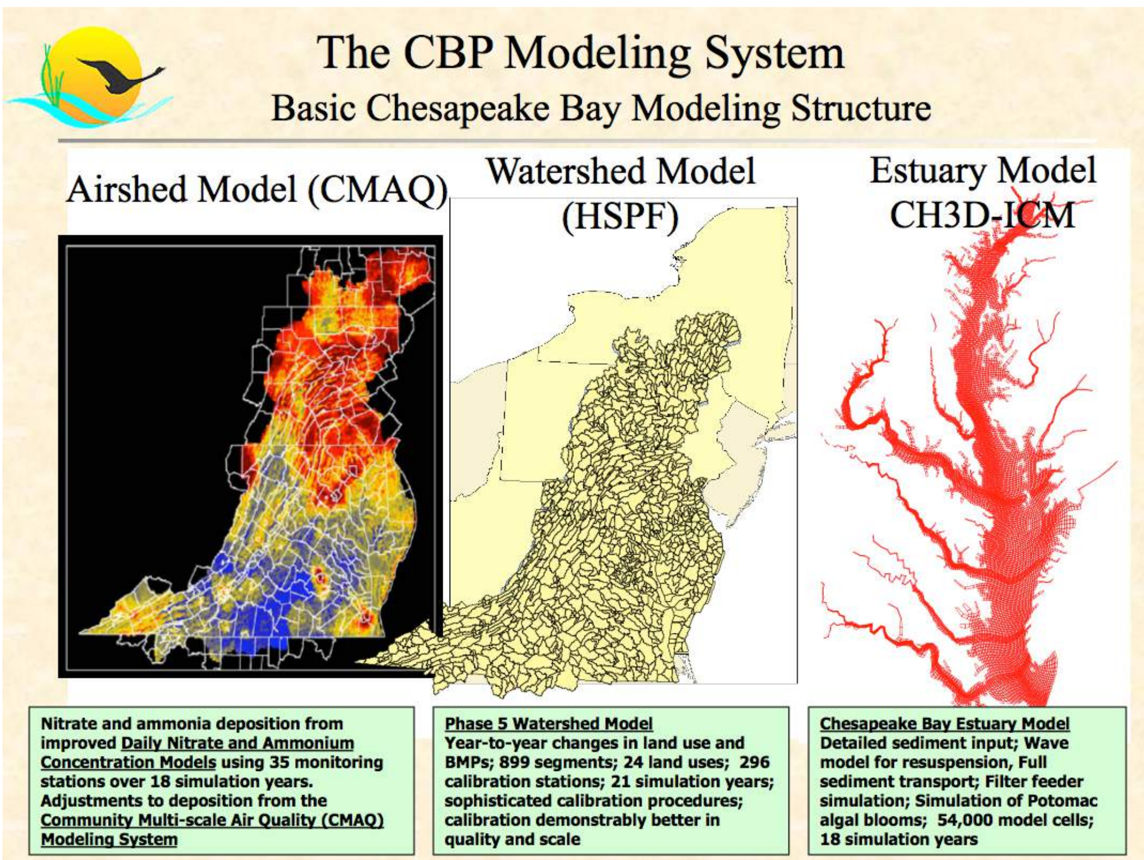


Fig. 17: The Chesapeake Bay Program modeling system core models: the CMAQ airshed model (left panel); the phase 5 watershed model based on HSPF (middle panel), and the estuarine hydrodynamic and watershed model based on CH3D and ICM (right panel).

Alternative Model Acronyms:

[1]ChesROMS-BGC/ECB: The Chesapeake Bay Regional Ocean Modeling System with biogeochemistry

[2]UMCESROMS-RCA: The University of Maryland Center for Environmental Science Regional Ocean Modeling System for Chesapeake Bay with the RCA (Row Column AESOP)

[3]CBOFS: The NOAA Chesapeake Bay Operational Forecast System

[4]FVCOM-ICM, RCA: Finite Volume Community Ocean Model with ICM or RCA

[5]SCHISM-BGC: Semi-implicit Cross-scale Hydroscience Integrated System Model based with biogeochemistry

[6]SELFE-ICM: A circulation model of oceans and estuaries with biogeochemistry

[7]DLEM: Dynamic Land Ecosystem Model

[8]SWAT: Soil and water assessment tool

[9]PIHM: Penn State Integrated Hydrologic Modeling System

[10]WRF: Weather Research Forecasting Model

[11]NARR: North American Regional Reanalysis

6.10 Geodynamics Focus Research Group

The Geodynamics Focus Research Group (FRG) currently has 91 members, several of whom where able to attend the recent CSDMS Annual Meeting.

Phaedra Upton gave the geodynamics keynote address at the Annual Meeting, which was focused around the theme "Models meet data, Earth Surface meet Geodynamics". Her presentation covered different approaches to coupling tectonics and landscape evolution modelling, mostly in convergent settings, and showcased some work being done through a collaboration between the University of Maine, the University of Colorado at Boulder, the University of Washington and GNS Science in New Zealand (Figure 18). In addition, Jean-Arthur Olive (MIT/WHOI) won the 2015 CSDMS student modeller prize and presented a talk on his research entitled, "Modes of extensional faulting controlled by surface processes" (Figure 19).

12 people attended the Geodynamics FRG break-out session at the Annual Meeting. Several topics were discussed, including:

- Coordination with the long-term tectonics community. Specifically, the possibility of putting together an NSF RCN (Research Coordination Network) proposal was discussed. CIG (Computation Infrastructure for Geodynamics) is currently putting in a bid for CIG–3 and so it was decided that we should wait for that process to be completed (likely in the Fall/Winter 2015) before we moved ahead with a RCN.
- Coordination with the shorter timeframe tectonics community. Processes such as earthquakes, interactions between climate cycles, and seismic cycles—are all systems with large complexities, incomplete linkages, and important societal implications. We discussed the possibility of linking tectonic models that included earthquake and climate cyclicity to LandLab in the future. We also discussed possible workshops and/or proposals.
- Mechanisms by which to attract more "tectonics" people to the CSDMS meeting? We discussed whether it is it too broad in scope to attract them, and if so, do we need to think about a more specific 2 or 3 day meeting? We will address these issues over the next year.
- The Education and Knowledge Transfer group requested models for education courses. The University of Maine has a simplified version of CHILD which they have volunteered.

In addition to activities at the annual meeting, SNAC was added to the model repository during the last year. At present SNAC remains the only geodynamic code available through the CSDMS site. One of the reasons for this may be that models in the geodynamics community tend to be much larger than many in the surface process community, encompassing multiple processes of crustal or mantle deformation. However, a clear need over the next several years is to add additional geodynamics codes to the CSDMS model repository to facilitate model inter-comparison.

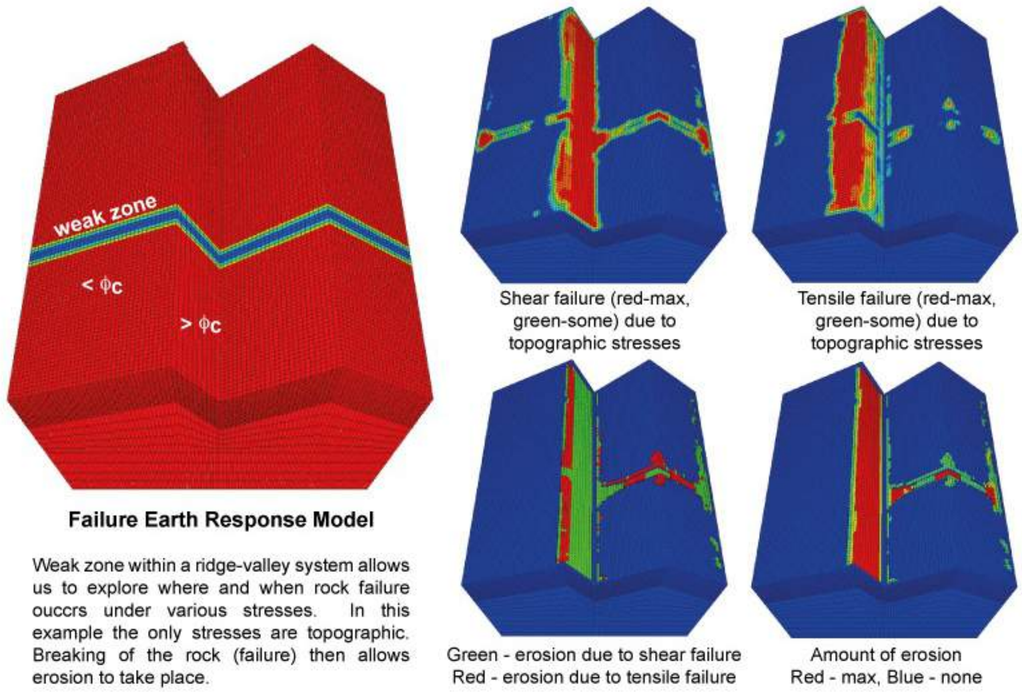


Fig. 18: From Phaedra Upton's keynote talk describing one component of the Failure Earth Response Model, a unifying theory coupling geodynamic and geomorphic processes being developed by Peter Koons, Phaedra Upton and others at the University of Maine and GNS Science.

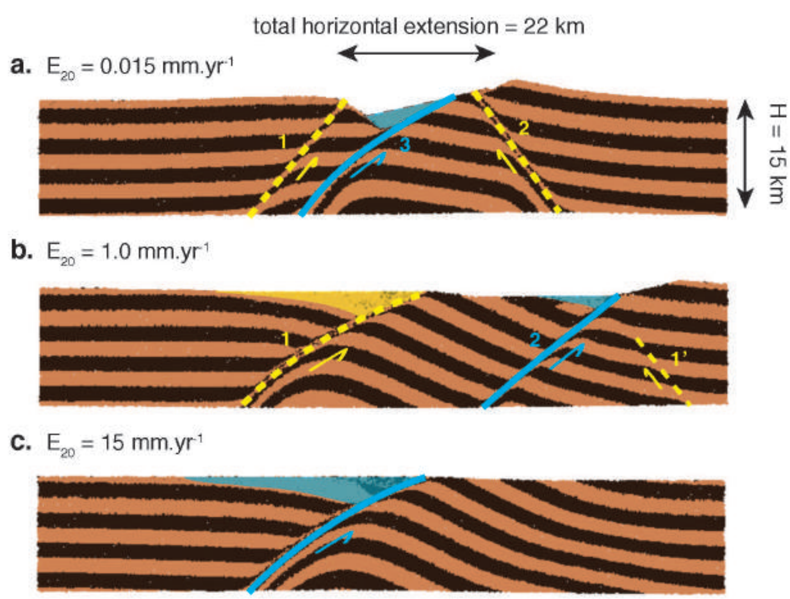


Fig. 19: From Jean-Arthur Olive's keynote talk illustrating the importance of erosion rates on fault life-span. Snapshots of numerical simulations after 22 km of extension in a 15 km thick layer extending at a half rate of 1 mm yr_1. In the 3 panels, surface topography is subjected to erosion rates of (b) 0.015, (c) 1.0, and (d) 15 mm yr_1. Yellow dashed lines indicate faults that have been abandoned in a sequence indicated by the numbers. Blue faults are actively growing at the time of the snapshot. Colored areas indicate the material that deposited while the fault of corresponding color was active.

6.11 Hydrology Focus Research Group

The CSDMS Hydrology Focus Research Group (FRG) is co-sponsored with the Consortium of Universities for the Advancement of Hydrologic Science, Inc. (CUAHSI). The group includes 479 members, making it the largest focus research group in CSDMS. The CSDMS model repository includes 58 hydrologic models and 40 hydrologic tools. Currently only 2 of the hydrologic models have been refactored in order to be compliant with the CSDMS Web Modeling Tool (WMT). A focus of the group in the coming year is to increase this number of hydrologic models available through WMT.

In terms of the goals established by the group in the CSDMS 2.0 Strategic Plan, we have made progress on many fronts. Here we briefly describe progress on a subset of our goals as an example.

- *Determine specific needs within the community for new tools, algorithms, or models.* This was a major focus of the All Hands meeting discussion for the Hydrology FRG looking specifically at the question of what models should be added to the CSDMS Web Modeling Tool (WMT). We identified two high-ranking priorities as described in the following section.
- *Lower barriers for hydrologists to participate in addressing important hydrologic challenges.* The ability to run models on the Web using tools like the CSDMS Web Modeling Tool (WMT) helps to achieve this goal. WMT allows hydrologists to execute models that may be challenging to install due to complicated software dependencies or due to a lack of compute resources required for performing tasks such as model uncertainty analysis. The inclusion of Dakota into WMT is helping our group move toward this goal.
- *Improve data management capabilities as they specifically relate to supporting hydrologic models.* Through related efforts funded by NSF including the CUAHSI HydroShare project, the NSF DataNet Federation Consortium (DFC) project, and many Earth Cube projects, our members are working on advancing data management capabilities for hydrologic modeling. Some of these challenges include semantic mediation between coupled models, metadata for sharing data and models, and workflows for data pre- and post-processing of hydrologic modeling data.
- *Foster culture shift in hydrologic modeling community toward collaborative and community-based model development.* Again, we believe online modeling tools like the WMT will be an important step toward this goal because it makes models accessible to a set of colleagues for collaboration and progress. Publishing data and model resources using systems such as CUAHSI HydroShare is another means for making progress toward this goal.

Discussion of Group Findings from the Annual Meeting

At this year's CSDMS annual meeting, the Hydrology FRG members met to discuss top priority models for inclusion in the CSDMS Web Modeling Tool. In the end, the group came to a general consensus on two priority items.

One priority should be to include hydrologic models that were once compliant with the now depreciated CSDMS Modeling Tool (CMT) into the newly created CSDMS WMT. One model in particular is TopoFlow. TopoFlow is a model currently within the CSDMS model repository as a stand-alone model, but also as a set of 14 process level model components. The ideal approach would be to include the 14 process level model components within WMT to take advantage of the model coupling capabilities in WMT. While these model components could be useful for researchers, we also discussed the specific advantage of these model components for education. Students learning hydrology and hydrologic modeling could build hydrologic models by linking together components in WMT and learning the details of model components rather than viewing hydrologic models as larger, often black-box systems.

A second priority should be to include more widely used hydrologic models within the CSDMS WMT. Two models emerged through the group's discussion as examples of these well-known and widely used hydrologic models: MODFLOW and SWAT. The group acknowledged that incorporating either of these models into the WMT using the current approach of first making the model compliant with the Basic Modeling Interface (BMI) interface would be challenging and time consuming. This is because the models are large and tightly coupled codes. While componentizing these models would certainly be a worthwhile long-term goal, a first step might be to integrate the stand-alone MODFLOW or SWAT model into WMT. While taking this approach would restrict the utility of WMT to simply running the model rather than coupling the model to other models within WMT, we noted that this stand-alone model would still be a great utility. Often model runs take time to run, and offloading the compute job to CSDMS compute resources would be helpful. This can be a useful resource for both research and education, especially for models that have complex software dependencies that may be difficult to install on classroom computer labs. Furthermore, the inclusion of the Dakota uncertainty analysis tool in WMT provides further motivation and benefit for including well known and widely used hydrologic models in WMT, even if these models have not been fully componentized.

Plans for the Future

The primary goal for the coming year is to have at least one hydrologic model, and hopefully more, added to the CSDMS Web Modeling Tool. We will also work toward the other goals defended by the group in the CSDMS 2.0 Strategic Plan document, focusing on growing the community of hydrologic modelers working on better defining and quantifying modeling skill, uncertainty, and interoperability. We will do this through CSDMS and our related projects and communities including CUAHSI. Another priority will be to convene sessions at conferences on CSDMS-related topics to foster collaboration and progress in these areas of research. Lastly, we will work to provide interoperability between CSDMS and the CUAHSI HydroShare system to benefit both of these two major cyberinfrastructure efforts that have synergistic aims and priorities.

6.12 Critical Zone Observatory Focus Research Group

Activities

In Fall 2014, the CSDMS leadership nominated Prof. Alejandro (Lejo) N. Flores (Boise State University) to the leadership team to serve as co-chair for the Critical Zone (CZ) Focus Research Group (FRG). Flores joins Christopher Duffy in leading the CSDMS CZ FRG.

The CZ breakout at the May 2015 CSDMS was attended by six, four faculty and two graduate students. Of the six attendees, two faculty members and one graduate student are currently being supported directly by the CZO program. These three attendees represented the Reynolds Creek and Shale Hills CZOs. Attendee Nicole Gasparini is directly supported by the LandLab project and, in support of that NSF grant, serves as the LandLab liaison to the CZO network.

Discussion within the CZ FRG breakout meeting revolved around identifying the mission of the CZ FRG and how it could play a role in facilitating: (1) better collaboration between modelers already involved in the CZO network, and (2) enhanced awareness of and access to the CZO network as a platform for advancing Critical Zone science and modeling. In particular, attendees identified the following three gaps and needs/opportunities for modelers seeking to engage in the CZO modeling community:

- The current lack of ability to assess, inventory, and access available datasets across multiple CZOs that would be needed to support CZ modeling work (particularly cross-CZO modeling work). This extends both the data to set up and run models at particular CZOs as well as to verify/validate/confirm model simulations of key environmental variables.
- Lack of communication channels to engage and collaborate with modelers already engaged in the CZO network. In particular, this is currently a barrier for the LandLab team that has resources to conduct workshop and training activities for the CZO network. Moreover, as was pointed out by an attendee not currently affiliated with a CZO, such a lack of a communication challenge creates difficulties in identifying potential collaborators when seeking to use the CZO network as a modeling platform, minimize potential duplication of modeling efforts, and identify potential areas for complementarity or comparison.

- A lack of a Critical Zone conceptual model developed by modelers and onto which existing and potential future CZO network modelers can map their modeling activities. Such a conceptual model – if it were formulated and widely available (e.g., via a publication) is also seen as an opportune vehicle to identify gaps in CZ modeling activities, illuminate potential opportunities for cross-CZO modeling efforts and model inter-comparisons, and contextualize potential or proposed modeling efforts.

These themes identified by attendees of the CZ FRG breakout occur against the backdrop of a CZO network that is in the incipient phases of organizing as a true research coordination network. As such, they both represent hurdles for the broader CZ network to overcome, as well as opportunities for the CZO network to grow and better engage with the broader modeling community.

Accomplishments

As a preliminary step in beginning to address the identified gaps and opportunities, after the CSDMS meeting, co-chair Flores began a preliminary effort to document the models currently reported as being used by investigators at US CZOs[1]. It is important to underscore that the models reported in Table 1 are only those that have been identified on the CZO webpage (http://criticalzone.org/national/). As such, the table may contain dated material and likely does not capture the totality of models being used within the CZOs.

Table 1: Models currently reported as being used within the CZO network

CZO	Investigator	Model	Model class	Spatially distributed
Southern Sierra	Naomi Tague	RHESSys	Ecohydrology	Yes
Boulder Creek	Greg Tucker	CHILD	Landscape evolution	Yes
Calhoun	Rafael Bras	tRIBS	Ecohydrology	Yes
Calhoun	Rafael Bras	CHILD	Landscape evolution	Yes
Catalina-Jemez	Peter Troch	hsB-SM	Hydrology	Semi
Catalina-Jemez	Guo-Yue Niu	TIMS	Ecohydrology	Yes
Christina	George Hornberger and others	FEMDOC_2D	Biogeochemistry	2D
Christina	Holly Michael	Fluid Exchange Model	Hydrodynamic and sediment transport	Yes
Christina	George Hornberger ++	IDOCM_1D	Biogeochemistry	1D
Christina	Chris Duffy	PIHM-X	Hydrology, biogeochemistry	Yes
Eel	Sally Thompson, Inez Fung	AWESOM	Atmospheric, Watershed, Ecological, Stream and Ocean Model	Yes
IML	Praveen Kumar, Thanos Papanicolaou	None yet		
Luquillo	Whendee Silver	CENTURY	Biogeochemistry	No
Luquillo	Fred Scatena*	GASH	Canopy moisture dynamics	Not known
Luquillo	Rafael Jimenez	PHREEQC	Geochemistry, reactive transport	No
Luquillo	Rafael Bras	tRIBS	Ecohydrology	Yes

[1] For sake of brevity and expedience only NSF-funded CZOs were included. This list will soon be expanded to include international CZOs that are affiliated with the CZO network.

Reynolds	Lejo Flores	Biome-BGC	Biogeochemistry	No*
Reynolds	Lejo Flores	WRF	Hydrometeorology	Yes
Reynolds	Lejo Flores	LandLab	Applied to landscape evolution	Yes
Reynolds	Gerald Flerchinger	SHAW	Coupled water energy cycles	No
Reynolds	Danny Marks	iSNOBAL	Snow mass and energy balance	Yes
Reynolds	Lejo Flores	ParFlow	Hydrology	Yes
Shale Hills	Chris Duffy, Ken Davis, Yuning Shi	Flux PIHM	Surface water and energy balance	Yes
Shale Hills	Chris Duffy	PIHM	Integrated hydrologic model	Yes
Shale Hills	Chris Duffy	PIHM-sed	Landscape evolution	Yes
Shale Hills	Li Li	PIHM-RT	Hydrology and reactive transport	Yes

Goals for the next year

In the coming year, co-chairs Flores and Duffy, in partnership with the CZO network and CSDMS, anticipate completing the following tasks:

3.1 **Expand and publicize the table above** to include modeling activities occurring at international CZOs, modeling activities that are leveraging CZOs as a modeling platform but not engaged with the CZO or CSDMS community, and engage ongoing modeling initiatives that potentially intersect with or complement CZO modeling activities. In the latter category, for instance, Dr. Garry Willgoose mentioned ongoing initiatives in the soil science community to improve models of pedogenesis and enhance data-driven pedometric techniques.

3.2 **Develop a vehicle to enable broader communication** among modelers in the CZO network and others modelers interested in engaging the CZO network and/or collaborating with ongoing modeling efforts within the CZO network. We will discuss both with Dr. Richard Yuretich (NSF CZO Program Manager) and the leadership of CSDMS about the specific mechanism that might best facilitate more open and robust communications. This communication vehicle will also be used to seek a more robust CZO presence at the CSDMS annual meeting.

3.3 **Develop a workshop proposal** that would seek to improve coordination among CZO modeling efforts. The proposed workshop would be an important occasion to (1) develop an overarching conceptual model of the critical zone, (2) characterize the ongoing modeling activities across the CZO network and place them within the context of the developed conceptual model, (3) outline opportunities to synthesize existing modeling studies and coordinate future modeling activities, and (4) identify the needs, existing infrastructure, and potential pathways to improve coordination among modelers and modeling activities to foster CZO network science. Particular topics that would be discussed with respect to supporting model-based CZ science would include: (1) reconciling modeling efforts being conducted across many orders of magnitude in spatiotemporal scale, and (2) vehicles to facilitate improved synthesis between models and data being collected at the CZOs. Flores has already had preliminary contact with CSDMS personnel and NSF Program Officers regarding this workshop proposal.

6.13 Ecosystem Dynamics Focus Research Group

The Ecosystem Dynamics Focus Research Group was launched in November 2015. The FRG, co-sponsored by the International Society for Ecological Modelling (ISEM - www.isemna.org), fills a gap in the existing

CSDMS expertise in ecological and biological modeling. To date, there are 30 members of the group representing 9 countries. The most members, 20, come from the United States.

Chair of the Ecosystem Dynamics FRG, Brian Fath, gave an invited presentation at the CSDMS annual meeting in May 2015. The talk provided a synopsis of the ongoing activities within ISEM as well as an overview of current research in Ecosystem Ecology Modeling. This was the first step to build a stronger bridge between the two societies, ISEM and CSDMS.

Roll out of the focus group was slow during the initial year but now is picking up steam. We are arranging to have information regarding the Ecosystem Dynamics FRG available at the website for the journal *Ecological Modelling*, which is the companion journal for ISEM. Furthermore, authors who have papers accepted in the journal now received the link to the Ecosystem Dynamics Group to get more information about CSDMS and hopefully consider joining and publishing models there. We are also in the process of adding the CSDMS link to the ISEM website. ISEM will be holding its next global meeting in May 2016 at Towson University and we are planning a coordinated event to promote CSDMS during the conference. James Syvitski, Executive Director of CSDMS, has been invited to present a keynote presentation at the conference, further establishing a tie between the communities.

7.0 CSDMS 2.0 Year 4 Priorities and Management of Resources

7.1 CSDMS 2.0 Year 4 Goals — CSDMS Portal

Develop community plaza tools

CSDMS has greatly expanded its products and resources over the years. However, not all users might be familiar with how to apply recommended standards, or how to best use certain products. By implementing better community plaza tools, we aim to facilitate mediums that will a) be easy to participate in for the community; and b) archive discussions, questions / answers so users can go back to view previous discussed topics.

A beta version of a technical plaza is setup, using GitHub functionality for the Basic Model Interface (BMI) development and implementation (see https://github.com/bmi-forum). In this example, several BMI related projects are shown. When selecting a project, you will be directed to the source code, where you can post questions, bug reports, or enhancement suggestions.

The GitHub platform is very well adapted in the model developer world, but may be less straightforward for model users. Therefore, we will utilize different platforms for the different communities and integrate them into the CSDMS web portal to guarantee easy access. A Thread plugin will be utilized on the CSDMS web portal as well.

Improve website data functionality

a) **Reform HPCC requests.** The HPCC, *beach*, is available to all members of CSDMS as long as the requested HPC time is justified by:

- Developing a model that will become part of the CSDMS model repository. In this case, before being given an account you must provide a description of your model, and provide the model's source code to the community under an open source license.
- Applying compliant CSDMS models developed by others within the CSDMS framework to help them advance their science.
- Experimenting with new data systems in support of CSDMS models, or to develop visualizations of model runs.
- Providing a course using CSDMS products or material from the CSMDS repositories.

These requirements are in place to limit the workload of the HPC. Currently we kindly ask members that request a HPC account to provide this information. Unfortunately it takes much time communicating what information is needed to grant an account (although described on the website). It can be a frustrating process for both the user and CSDMS-IF staff. Therefore, we suggest streamlining this process more by implementing a web based form for people to fill out. Only those forms that contain the required information will be given an account. This should also reduce the workload of the CSDMS HPC, as requirements can be better controlled, and will increase the source code contribution towards the CSDMS repository (as we can better enforce the requirement to get meta data of newly developed models).

b) **Develop query tools to substitute or extend the current repository lists.** The CSDMS web portal provides content lists of the various repositories. These lists are often categorized to narrow the search for viewers. For example, the model repository is categorized into Terrestrial, Coastal, Hydrological, Marine, Climate and Carbonate models. However, with growing numbers of models, even some of these categorized lists are getting too large to get a good overview of what models are available to accommodate a viewer's need. There are 92 terrestrial models, but you don't need to read up on all of them if you are only interested in, for example, the less than a dozen Landscape Evolution Models. Similar query tools will be built to query the publication database so people can find all publications of a specific model, or combination of models. The same will be done for the educational repository so people can find all simulation movies of a specific model. Emphasis has been on establishing repository databases in the recent years. Now we recommend developing easy to use search query pages to optimize search experiences of our community.

c) **Website maintenance.** The open software packages used for the CSDMS web portal require maintenance to guarantee performance and security. To conform University of Colorado standards, new upgrades and security patches will be installed when needed.

Milestones:

A) Further develop community plaza tools. Set up various media (e.g. GitHub Forms, educational blogs); advertise the plaza tools on the CSMDS web portal, twitter, etc. Integrate, where possible, the CSDMS website with the plaza tools.

B) Reform HPCC account requests. Create web form; integrate with model and user database. Add a status of request indicator per application.

C) Develop query tools to substitute or extend the current repository lists. Reformat some of the databases, develop query entrance portal on the website. Integrate some databases together to minimize duplication.

D) Website maintenance, installation of upgrades and security patches.

Resources: 0.5 FTE Web Specialist.

7.2 CSDMS 2.0 Year 4 Goals — Cyber Plans

In the coming year, the CSDMS IF software engineers will focus on four tasks:

1. Develop a coupleable model uncertainty component for WMT using the Dakota iterative systems analysis toolkit.
2. Continue to wrap models in the CSDMS repository with BMI and make them available in WMT.
3. Write basic technical documentation for the WMT client, database server, and execution server, as well as how to add a model with a BMI to WMT.
4. Implement OAuth login service in the WMT client.

Develop a coupleable model uncertainty service component. As reported in Section 4.7, CSDMS IF has developed a viable Python framework for accessing Dakota functionality. However, a deficiency of the framework in its present state is that it doesn't use BMI; for instance, for HydroTrend, the only model currently enabled in the framework, it calls the HydroTrend executable directly, then feeds data back into Dakota from the output text files produced by HydroTrend. The framework, therefore, doesn't allow for a true coupling between Dakota and a CSDMS component. In the coming budget year, CSDMS IF software engineers will implement a BMI for the Dakota-Python framework and update the framework to interface with any model that exposes inputs and outputs through a BMI. We will ensure that the framework can access not only HydroTrend, but also other CSDMS components currently available in WMT; for example, Avulsion, CEM, CHILD, etc. Finally, we will add the updated framework as a service component to the production instance of WMT at https://csdms.colorado.edu/wmt. This will require changes to the WMT client; for example, it will need to be able to dynamically build a parameter table from the inputs and outputs provided by the CSDMS component being analyzed by Dakota.

Milestones:

1. Implement a BMI for the existing Dakota-Python framework.
2. Modify the Dakota-Python framework to access the BMI of a model. Test with HydroTrend and other components available in WMT.
3. Add the ability to build parameter tables dynamically to the WMT client.
4. Add the Dakota-based model uncertainty service component to WMT.

Resources: 1.0 FTE software engineer.

Add CSDMS components to WMT. In a priority for the coming budget year, the CSDMS IF software engineers will continue to wrap models in the CSDMS repository with a BMI and add them as components to WMT. For instance, in the coming funding year, we are investigating adding:

- WRF,
- ROMS-Lite, and
- Storm

Milestones:

1. Identify a set of candidate models and write BMI wrappers for them.
2. Ensure the new components work in WMT.

Resources: 0.75 FTE software engineer.

Write basic technical documentation for WMT. In the interest of maintainability, portability and sustainability, the CSDMS IF software engineers will provide basic technical documentation on the architecture of WMT, including the database server, the execution server, and the client. Instructions will also be written for how to stand up a new instance of the CSDMS software stack, including WMT, and how to take a model with a BMI and add it to WMT.

Milestones:

1. Write basic documentation for the WMT database server.
2. Write basic documentation for the WMT execution server.
3. Write basic documentation for the WMT client.
4. Write basic documentation for how to install WMT.
5. Write basic documentation on how to add a model with a BMI to WMT.

Resources: 0.2 FTE software engineer.

Implement OAuth login service in the WMT client. As reported in Section 4.10, the CSDMS portal has been configured to provide an OAuth (http://oauth.net) authorization service. This service will allow CSDMS members to use the same login on the CSDMS website and WMT. Adopting this service will require modification of the current authorization system used when logging into the WMT client, as well as an update of the user database, since saved models in WMT are organized by username.

Milestones:

1. Modify the authorization system in the WMT client to use OAuth.
2. Ensure that saved models in WMT are transitioned to the new username of their owner.

Resources: 0.1 FTE software engineer.

Supplemental work plan -- Dakota extensions

CSDMS IF staff will expand upon the currently funded integration of Dakota with WMT by bringing additional Dakota analysis methods online in a thorough and sustainable way. We will provide expanded documentation and training to further educational objectives with respect to earth surface process modeling and uncertainty quantification. Our work includes three tasks:

1. Implement the following three Dakota analysis methods:
   i. sampling,
   ii. polynomial chaos, and
   iii. stochastic collocation

   as the obvious next useful resources for hydrology, earth surface, and geodynamics modelers. This class of algorithms will assist in the systematic exploration of uncertainty in model output.

   Resources: 0.4 FTE software engineer.

2. Generalize, harden and document the existing CSDMS Dakota-Python framework described in Section 4.7, including the additions described above. This framework allows modelers to run the implemented methods of Dakota with their own models, independent of WMT.

   Resources: 0.2 FTE software engineer.

3. Design online educational labs, hosted on the CSDMS portal, dedicated to these new uncertainty tools. These labs would document the new tools, provide a way of measuring the use of these tools, and expose a significant group of students to uncertainty and sensitivity in modeling.

   Resources: 0.1 EKT specialist.

In the process of completing these tasks, CSDMS IF will engage the Dakota development team at Sandia National Laboratory about techniques for efficiently building new software on their existing architecture. Further, we will invite the Dakota development team to teach a joint clinic at the 2016 CSDMS Annual Meeting.

Supplemental work plan -- SedGrid: A component for storing stratigraphy

The CSDMS IF staff will create a BMI component, SedGrid, that will be used to store stratigraphy generated by the erosion and deposition as a result of other component models. This new component will not be a model in and of itself but instead will connect to other components that provide sediment characteristics, as a *service component*. At regular intervals connected components will be able to either erode or deposit sediment into the SedGrid component that is saved and made available to other components.

As the basin-filling model, *sedflux*, already has such functionality, CSDMS has decided it to be a good, existing software element that can become the basis for such a component.

Milestones:

1. Implement a BMI for the sedflux model grid.
2. Build Python bindings for the BMI
3. Incorporate the component into the CSDMS modeling framework

Resources: 0.5 FTE software engineer.

7.3 CSDMS 2.0 Year 4 Goals — Education and Knowledge Transfer

EKT task 1 Enhance the Quantitative Surface Dynamics Toolbox

For year 4, we propose to further enhance the Quantitative Surface Dynamics Educational Toolbox, which combines educational material at different tiers but with cross-cutting themes. This includes a re-organization of the material on the CSDMS website, which better tags, improved search functionality and organization of material cross-cutting themes and concepts. Improvements will include testing of the teaching labs with teaching faculty at other universities (which is a major EKT Working Group Goal).

To make it possible to assess student learning, we also will develop Pre and Post Lab Survey Questions on the most advanced levels in the QSD Toolbox to allow rubrics for simple assessment.

Resources: 0.4 FTE Education and Knowledge Transfer Specialist, 0.1 FTE web specialist, 0.2 FTE Software engineer

EKT Task 2 Develop Educational Labs on concepts of model uncertainty and Dakota Tools in WMT

CSDMS has received support from the Software Reuse Venture Fund FY15 for further focus of development of tools to deal with model assessment and uncertainty quantification techniques. We propose to design extra online labs dedicated to the new uncertainty tools as a first phase contribution to this effort. These teaching labs would document the new tools in the WMT, would highlight key concepts in model assessments for new modelers and provide one way of measuring the use of these tools, and expose a significant group of students to uncertainty & sensitivity in modeling.

Resources: 0.1 FTE Education and Knowledge Transfer Specialist, 0.1 FTE Software engineer

EKT Task 3 Development of Science on a Sphere Datasets

We aim to continue to develop datasets for the NOAA Science on a Sphere System in collaboration with NOAA's educational specialists. Preliminary ideas for datasets have been solicited in the CSDMS community and include; world deltas, global sediment dynamics, tsunami model simulations, Arctic coastal sea ice dynamics, sea ice circulation, and others.

Resources: 0.1 FTE Education and Knowledge Transfer Specialist, 0.1 FTE Web Specialist

8.0: NSF Revenue & Expenditures ($K with rounding errors)

	~ $K Year 6	~ $K Year 7	~ $K Year 8
A. Salaries & Wages			
Executive Director:	$57	$56	$48
Software Engineers:	$144	$164	$164
Communication Staff*	$100	$100	$90
Admin Staff**	$72	$42	$62
Total Salaries	**$373**	**$362**	**$364**
B. Fringe	**$103**	**$100**	**$102**
D. Travel			
Center Staff:	$10	$15	$20
Steering Committee	$6	$10	$8
Executive Com.	$10	$15	$25
Total Travel	**$26**	**$40**	**$53**
E. Annual Meeting	**$70**	**$72**	**$72**
F. Other Direct Costs			
Materials & Supplies	$1	$1	$1
Publication Costs	$2	$1	$1
Computer Services:	$25	$20	$14
Non Capital Equipment	$2	$6	$5
Official Function,	$0	$1	$2
Total Other Costs	**$30**	**$29**	**$23**
G. Total Direct Costs	**$532**	**$531**	**$573**
H. Indirect Cost	**$277**	**$277**	**$298**
I. Total Costs	**$879**	**$880**	**$943**
J. Carry Over	**$21**	**$41**	**-$3**

Notes:
1) Estimates include salaries projected 3 months to the end of the CSDMS fiscal year.
2) * Communication Staff includes Cyber + EKT Scientists
3) ** Admin Staff includes Executive Assistant + System Administrator + Accounting Technician.
4) CU completes a preliminary estimate of expenditures after 60 days of a time marker. CU provides a finalization typically within 90 days of a fiscal year.

Additional Funds Received by CSDMS IF Staff and Associates (see Section 2.4)
Year 6:
NASA: Threatened River Delta Systems: $143K, Accelerating Changes in Arctic River Discharge $75K
BOEM: Shelf-Slope Sediment Exchange, N Gulf of Mexico: Numerical Models for Extreme Events $75K
NSF: 1) Governance in Community Earth Science $85K; 2) A Delta Dynamics Collaboratory $126K, 3) River plumes as indicators of Greenland Ice Sheet Melt $90K
U. Colorado: Salary support for the CSDMS Integration Facility: $73K

Year 7:
NASA: Threatened River Delta Systems: $143K, Accelerating Changes in Arctic River Discharge $75K
BOEM: Shelf-Slope Sediment Exchange, N Gulf of Mexico: Numerical Models for Extreme Events $75K
NSF: 1) A Delta Dynamics Collaboratory $126K, 2) River plumes as indicators of Greenland Ice Sheet Melt $90K
U. Colorado: Salary support for the CSDMS Integration Facility: $73K

Year 8:
NASA: Threatened River Delta Systems: $143K
BOEM: Shelf-Slope Sediment Exchange, N Gulf of Mexico: Numerical Models for Extreme Events $95K
NSF: 1) A Delta Dynamics Collaboratory $126K, 2) River plumes as indicators of Greenland Ice Sheet Melt $60K
U. Colorado: Salary support for the CSDMS Integration Facility: $83K

Appendix 1: Institutional Membership — those in marked in blue have joined CSDMS between August 2014 and July 2015.

U.S. Academic Institutions: Current total of 129 with 3 new members as of July 2015

1. Arizona State University
2. Auburn University, Alabama
3. Binghamton University, New York
4. Boston College, Massachusetts
5. Boston University, Massachusetts
6. Brigham Young University, Utah
7. California Institute of Technology, Pasadena
8. California State University - Fresno
9. California State University - Long Beach
10. California State University – Los Angeles
11. Carleton College, Minneapolis
12. Center for Applied Coastal Research, Delaware
13. Chapman University, California
14. City College of New York, City University of New York
15. Coastal Carolina University, South Carolina
16. Colorado School of Mines, Colorado
17. Colorado State University
18. Columbia/LDEO, New York
19. Conservation Biology Institute, Oregon
20. CUAHSI, District of Columbia
21. Desert Research Institute, Nevada
22. Duke University, North Carolina
23. Florida Gulf Coast University
24. Florida International University
25. Franklin & Marshall College, Pennsylvania
26. George Mason University, VA
27. Georgia Institute of Technology, Atlanta
28. Harvard University
29. Idaho State University
30. Indiana State University
31. Iowa State University
32. Jackson State University, Mississippi
33. John Hopkins University, Maryland
34. Louisiana State University
35. Massachusetts Institute of Technology
36. Michigan Technological University
37. Monterey Bay Aquarium Research Inst.
38. Murray State University, Kentucky
39. North Carolina State University
40. Northern Arizona University
41. Northern Illinois University
42. Northwestern University, Illinois
43. Nova Southeastern University, Florida
44. Oberlin College, Ohio
45. Ohio State University
46. Oklahoma State University
47. Old Dominion University, Virginia
48. Oregon State University
49. Pennsylvania State University
50. Portland State University, Oregon
51. Princeton University, New Jersey
52. Purdue University, Indiana
53. Rutgers University, New Jersey
54. San Jose State University, California
55. Scripps Institution of Oceanography, California
56. South Dakota School of Mines
57. Stanford University, CA
58. Virginia Polytechnic Institute and State University
59. Syracuse University, New York
60. Texas A&M, College Station
61. Texas Christian University
62. Towson University, Maryland
63. Tulane University, New Orleans
64. United States Naval Academy, Annapolis
65. University of Alabama - Huntsville
66. University of Alaska – Fairbanks
67. University of Arkansas
68. University of Arizona
69. University of California – Berkeley
70. University of California – Davis
71. University of California – Irvine
72. University of California – Los Angeles
73. University of California – San Diego
74. University of California – Santa Barbara
75. University of California – Santa Cruz
76. University of Colorado – Boulder
77. University of Colorado – Denver
78. University of Connecticut
79. University of Delaware
80. University of Florida
81. University of Houston
82. University of Idaho
83. University of Illinois-Urbana – Champaign
84. University of Iowa
85. University of Kansas

86. University of Louisiana – Lafayette
87. University of Maine
88. University of Maryland – Baltimore County
89. University of Memphis
90. University of Miami
91. University of Michigan
92. University of Minnesota – Minneapolis
93. University of Minnesota – Duluth
94. University of Nebraska – Lincoln
95. University of Nevada – Reno
96. University of New Hampshire
97. University of New Mexico
98. University of New Orleans
99. University of North Carolina – Chapel Hill
100. University of North Carolina – Wilmington
101. University of North Dakota
102. University of Oklahoma
103. University of Oregon
104. University of Pennsylvania – Pittsburgh
105. University of Pittsburgh
106. University of Rhode Island
107. University of South Carolina
108. University of South Florida
109. University of Southern California
110. University of Tennessee – Knoxville
111. University of Texas – Arlington
112. University of Texas – Austin
113. University of Texas – El Paso
114. University of Texas – San Antonio
115. University of Utah
116. University of Virginia
117. University of Washington
118. University of Wyoming
119. Utah State University
120. Vanderbilt University
121. Villanova University, Pennsylvania
122. Virginia Institute of Marine Science (VIMS)
123. Virginia Polytechnic Institute, VA
124. Washington State University
125. West Virginia University
126. Western Carolina University
127. Wichita State University
128. William & Mary College, VA
129. Woods Hole Oceanographic Inst.

U.S. Federal Labs and Agencies: 21 as of July 15

1. Argonne National Laboratory (ANL)
2. Idaho National Laboratory (IDL)
3. National Aeronautics & Space Administration (NASA)
4. National Center for Atmospheric Research (NCAR)
5. National Forest Service (NFS)
6. National Science Foundation (NSF)
7. National Oceanic & Atmospheric Administration (NOAA)
8. National Oceanographic Partnership Program (NOPP)
9. National Park Service (NPS)
10. National Weather Service (NWRFC)
11. Naval Research Laboratory
12. Oak Ridge National Laboratory (ORNL)
13. Sandia National Laboratories (SNL)
14. U.S. Army Corps of Engineers (ACE)
15. U.S. Army Research Office (ARO)
16. U.S. Department of Agriculture (USDA)
17. U.S. Department of the Interior – Bureau of Reclamation
18. U.S. Department of the Interior – Bureau of Ocean Energy Management (BOEM)
19. U.S. Geological Survey (USGS)
20. U.S. Nuclear Regulatory Commission (NRC)
21. U.S. Office of Naval Research (ONR)

U.S. Private Companies: 26 as with one new member as of July 2015

1. Airlink Communications, Hayward CA
2. Aquaveo LLC, Provo, Utah
3. ARCADIS-US, Boulder, CO
4. Chevron Energy Technology, Houston, TX
5. ConocoPhillips, Houston, TX
6. Deltares, USA
7. Dewberry, Virginia
8. DHI, Solana Beach, CA
9. Everglades Partners Joint Venture (EPJV), Florida
10. ExxonMobil Research and Engineering, Houston, TX
11. Geological Society of America Geocorps
12. Leonard Rice Engineers, Inc., Denver, CO
13. Idaho Power, Boise
14. PdM Calibrations, LLC, Florida
15. Philip Williams and Associates, Ltd., California

16. Schlumberger Information Solutions, Houston, TX
17. Science Museum of Minnesota, St. Paul, MN
18. Shell USA, Houston, TX
19. Straus Consulting, Boulder, CO
20. Stroud Water Research Center, Avondale, PA
21. Subsurface Insights, Hanover, NH
22. URS–Grenier Corporation, Colorado
23. The Von Braun Center for Science & Innovation, Inc.
24. UAN Company
25. Warren Pinnacle Consulting, Inc., Warren, VT
26. Water Institute of the Gulf, Baton Rouge, LA

Foreign Membership: Current total of 314 with 22 new members from August 2014 – July 2015 (**66** countries outside of the U.S.A.: Algeria, Argentina, Armenia, Australia, Austria, Bangladesh, Belgium, Bolivia, Brazil, Bulgaria, Cambodia, Canada, Chile, China, Colombia, Cuba, Denmark, Egypt, El Salvador, France, Germany, Ghana, Greece, Hungary, India, Indonesia, Iran, Iraq, Ireland, Israel, Italy, Japan, Jordan, Kenya, Malaysia, Mexico, Morocco, Myanmar, Nepal, Netherlands, New Zealand, Nigeria, Norway, Pakistan, Peru, Philippines, Poland, Portugal, Qatar, Romania, Russia, Saudi Arabia, Scotland, Singapore, South Africa, South Korea, Spain, Sweden, Switzerland, Thailand, Netherlands, Turkey, UK, United Arab Emirates, Uruguay, Venezuela, Việt Nam).

Foreign Academic Institutes: 210 with 20 new members as of July 2015

1. Aberystwyth University, Wales, UK
2. Adam Mickiewicz University (AMU) Poznan, Poland
3. AGH University of Science and Technology, Krakow, Poland
4. AgroCampus Ouest, France
5. Aix-Marseille University, France
6. Anna University, India
7. ANU College, Argentina
8. Architectural Association School of Architecture, UK
9. Aristotle University of Thessaloniki, Greece
10. Bahria University, Islamabad, Pakistan
11. Bangladesh University of Engineering and Technology, Dhaka, Bangladesh
12. Birbal Sahni Institute of Palaeobotany, India
13. Bonn University, Germany
14. Blaise Pascal University, Clermont, France
15. Brandenburg University of Technology (BTU), Cottbus, Germany
16. British Columbia Institute of Technology (BCIT), Canada
17. Cardiff University, UK
18. Carleton University, Canada
19. Chengdu University of Technology, China
20. China University of Geosciences- Beijing, China
21. China University of Petroleum, Beijing, China
22. Christian-Albrechts-Universitat (CAU) zu Kie, Germany
23. CNRS / University of Rennes I, France
24. Cracow University of Technology, Poland
25. Dalian University of Technology, Liaoning, China
26. Dankook University, South Korea
27. Darmstadt University of Technology, Germany
28. Delft University of Technology, Netherlands
29. Democritus University of Thrace, Greece
30. Diponegoro University, Semarang, Indonesia
31. Dongguk University, South Korea
32. Durham University, UK
33. Earth Sciences Federal University of Parana, Brazil
34. Ecole Nationale Superieure des Mines de Paris, France
35. Ecole Polytechnique, France
36. Eidgenossische Technische Hochschule (ETH) Zurich, Switzerland
37. Eötvös Loránd University, Hungary
38. FCEFN-UNSJ-Catedra Geologia Aplicada II, Argentina
39. Federal Ministry of Environment, Nigeria
40. Federal University of Itajuba, Brazil
41. Federal University of Petroleum Resources, Nigeria
42. Federal University Oye-Ekiti, Nigeria
43. First Institute of Oceanography, SOA,

China
44. Free University of Brussels, Belgium
45. Guanzhou University, Guanzhou, China
46. The Hebrew University of Jerusalem, Israel
47. Helmholtz-Zentrum University Gees
48. Heriot-Watt University, Edinburgh, UK
49. Hohai University, Nanjing, China
50. Hong Kong University, Hong Kong
51. IANIGLA, Unidad de Geocriologia, Argentina
52. Imperial College of London, UK
53. India Institute of Technology – Bhubaneswar, India
54. India Institute of Technology – Delhi
55. Indian Institute of Technology – Gandhinagar
56. India Institute of Technology – Kanpur
57. India Institute of Technology – Madras
58. India Institute of Technology – Mumbai
59. Indian Institute of Science – Bangalore
60. Indian Institute of Technology– Bombay
61. Institut Univ. Europeen de la Mer (IUEM), France
62. Institute of Engineering (IOE), Nepal
63. Institute of Geology, China Earthquake Administration
64. Instituto de Geociencias da Universidade Sao Paulo (IGC USP), Brasil
65. Kafrelsheikh University, Kafrelsheikh, Egypt
66. Karlsruhe Institute of Technology (KIT), Germany
67. Katholieke Universiteit Leuven, KUT, Belgium
68. King's College London, UK
69. King Fahd University of Petroleum and Mineral, Saudi Arabia
70. Kocaeli University, Izmit, Turkey
71. Lanzhou University, China
72. Leibniz-Institute fur Ostseeforschung Warnemunde (IOW)/Baltic Sea Research, Germany
73. Leibniz Universitat Hannover, Germany
74. Loughborough University, UK
75. Lund University, Sweden
76. McGill University, Canada
77. Mohammed V University-Agdal, Rabat,Morocco
78. Mulawarman University, Indonesia
79. Nanjing University of Information Science & Technology (NUIST), China
80. Nanjing University, China
81. National Cheng Kong University
82. National Taiwan University, Taipei, Taiwan
83. National University of Cordoba, Spain
84. National University (NUI) of Maynooth, Kildare, Ireland
85. National University of Sciences & Technology, Pakistan
86. National University of Sciences & Technology, (NUST), Pakistan
87. Natural Resources, Canada
88. Northwest University of China, China
89. Norwegian University of Life Sciences, Norway
90. Ocean University of China, China
91. Padua University, Italy
92. Paris Diderot University, France
93. Peking University, China
94. Pondicherry University, India
95. Pukyong National University, Busan, South Korea
96. Royal Holloway University of London, UK
97. RWTH Aachen University, Germany
98. Sejong University, South Korea
99. Seoul National University, South Korea
100. Shihezi University, China
101. Simon Fraser University, Canada
102. Singapore-MIT Alliance for Research and Technology (SMART), Singapore
103. Southern Cross University, United Arab Emirates (UAE)
104. Sriwijaya University, Indonesia
105. SRM University, India
106. Stockholm University, Sweden
107. Tarbiat Modares University, Iran
108. The Maharaja Sayajirao University of Baroda, India
109. Technical University, Hamburg, Germany
110. Tianjin University, China
111. Tsinghua University, China
112. Universidad Agraria la Molina, Peru
113. Universidad Complutense de Madrid, Spain
114. Universidad de Granada, Spain
115. Universidad de Guadalajara, Mexico

116. Universidad de la Republica, Uruguay
117. Universidad de Oriente, Cuba
118. Universidad de Zaragoza, Spain
119. Universidad Nacional Autónoma de México
120. Universidad Nacional de Catamarca, Argentina
121. Universidad Nacional de Rio Negro, Argentina
122. Universidad Nacional de San Juan, Argentina
123. Universidad Politecnica de Catalunya, Spain
124. Universidade de Lisboa, Lisbon, Portugal
125. Universidade de Madeira, Portugal
126. Universidade do Minho, Braga, Portugal
127. Universidade Federal do Rio Grande do Sul (FRGS), Brazil
128. Universit of Bulgaria (VUZF), Bulgaria Pescara, Italy
129. Universita "G. d'Annunzio" di Chieti-Pescara, Italy
130. Universitat Potsdam, Germany
131. Universitat Politecnica de Catalunya, Spain
132. Universitas Indonesia, Indonesia
133. Universite Bordeaux 1, France
134. Université de Bretagn Occidentale, France
135. Université de Grenoble, France
136. Universite de Rennes (CNRS), France
137. Universite du Quebec a Chicoutimi (UQAC), Canada
138. Universite Joseph Fourier, Grenoble, France
139. Universite Montpellier 2, France
140. Universiteit Gent, Ghent, Belgium
141. Universiteit Stellenosch University, South Africa
142. Universiteit Utrecht, Netherlands
143. Universiteit Vrije (VU), Amsterdam, Netherlands
144. Universiti Teknologi Mara (UiTM), Mayalsia
145. Universiti Malaysia Pahang, Malaysia
146. University College Dublin, Ireland
147. University of Bari, Italy
148. University of Basel, Switzerland
149. University of Bergen, Norway
150. University of Bremen, Germany
151. University of Brest, France
152. University of Bristol, UK
153. University of British Columbia, Canada
154. University of Calgary, Canada
155. University of Cambridge, UK
156. University of Cantabria, Spain
157. University of Concepcion, Chile
158. University of Copenhagen, Denmark
159. University of Dhaka, Bangladesh
160. University of Dundee, UK
161. University of Edinburgh, Scotland
162. University of Edinburgh, UK
163. University of Exeter, UK
164. University of Geneva, Switzerland
165. University of Ghana, Ghana
166. University of Guelph, Canada
167. University of Haifa, Israel
168. University of Ho Chi Minh City
169. University of Kashmir, India
170. University of Lethbridge, Canada
171. University of Manchester, UK
172. University of Malaya, Kuala Lumpur, Malaysia
173. University of Milano-Bicocca, Italy
174. University of Natural Resources & Life Sciences, Vienna, Austria
175. University of Newcastle, Australia
176. University of Newcastle upon Tyne, UK
177. University of New South Wales, Australia
178. University of Nigeria, Nsukka, Nigeria
179. University of Padova, Italy
180. University of Palermo, Italy
181. University of Pavia, Italy
182. University of Portsmouth, UK
183. University of Potsdam, Germany
184. University of Queensland (UQ), Australia
185. University of Reading, Berkshire, UK
186. University of Rome (INFN) "LaSapienza", Italy
187. University of Science Ho Chi Minh City, Viet Nam
188. University of Southampton, UK
189. University of St. Andrews, UK
190. University of Sydney, Australia
191. University of Tabriz, Iran
192. University of Tehran, Iran
193. University of the Philippines, Manila, Philippines
194. University of the Punjab, Lahore, Pakistan

195. University of Twente, Netherlands
196. University of Waikato, Hamilton, New Zealand
197. University of Warsaw, Poland
198. University of West Hungary - Savaria Campus, Hungary
199. University of Western Australia, Australia
200. University of Western Ontario, Canada
201. Victoria University of Wellington, New Zealand
202. VIT (Vellore Institute of Technology) University, Tamil Nadu, India
203. VUZF University, Bulgaria
204. Wageningen University, Netherlands
205. Water Resources University, Hanoi, Vietnam
206. Wuhan University, Wuhan, China
207. Xi-an University of Architecture & Technology, China
208. York University, Canada
209. Yuzuncu Yil University, Turkey
210. Zhejiang University, China

Foreign Private Companies: 31 with 1 new member as of July 2015

1. Aerospace Company, Taiwan
2. ASR Ltd., New Zealand
3. Bakosurtanal, Indonesia
4. BG Energy Holdings Ltd., UK
5. Cambridge Carbonates, Ltd., France
6. Deltares, Netherlands
7. Digital Mapping Company, Bangladesh
8. Energy & Environment Modeling, ENEA/UTMEA, Italy
9. Environnement Illimite, Inc., Canada
10. Excurra & Schmidt: Ocean, Hydraulic, Coastal and Environmental Engineering Firm, Argentina
11. Fugro-GEOS, UK
12. Geo Consulting, Inc., Italy
13. Grupo DIAO, C.A., Venezuela
14. Haycock Associates, UK
15. H.R. Wallingford, UK
16. IH Cantabria, Cantabria, Spain
17. InnovationONE, Nigeria
18. Institut de Physique de Globe de Paris, France
19. Institut Francais du Petrole (IFP), France
20. Jaime Illanes y Asociados Consultores S.A., Santiago, Chile
21. METEOSIM, Spain
22. MUC Engineering, United Arab Emirates (UAE)
23. Petrobras, Brazil
24. Riggs Engineering, Ltd., Canada
25. Risk Management Solutions Inc., India
26. Saipem (oil and gas industry contractor), Milano, Italy
27. Shell, Netherlands
28. SEO Company, Indonesia
29. Statoil, Norway
30. Tullow Oil, Ireland
31. Vision on Technology (VITO), Belgium

Foreign Government Agencies: 74 with 2 new members as of July 2015

1. Agency for Assessment and Application of Technology, Indonesia 2. Bedford Institute of Oceanography, Canada
2. Arpa-Emilia-Romagna, Italy
3. Bedford Institute of Oceanorgraphy, Canada
4. Bhakra Beas Management Board (BBMB), Chandigarh, India
5. British Geological Survey, UK
6. Bundesanstalt fur Gewasserkunde, Germany
7. Bureau de Recherches Géologiques et Minières (BRGM), Orleans, France
8. Cambodia National Mekong Committee (CNMC), Cambodia
9. Center for Petrographic and Geochemical Research (CRPG-CNRS), Nancy, France
10. CETMEF/LGCE, France
11. Channel Maintenance Research Institute

(CMRI), ISESCO, Kalioubia, Egypt
12. Chinese Academy of Sciences – Cold and Arid Regions Environmental and Engineering Research Institute
13. Chinese Academy of Sciences – Institute of Mountain Hazards and Environment, China
14. Chinese Academy of Sciences – Institute of Tibetan Plateau Research (ITPCAS), China
15. Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia
16. Consiglio Nazionale delle Ricerche (CNR), Italy
17. French Agricultural and Environmental Research Institute (CEMAGREF)
18. French Research Institute for Exploration of the Sea (IFREMER), France
19. Geological Survey of Canada, Atlantic
20. Geological Survey of Canada, Pacific
21. Geological Survey of Israel, Jerusalem, Israel
22. Geological Survey of Japan (AIST), Japan
23. Geosciences, Rennes France
24. GFZ, German Research Centre for Geosciences, Potsdam, Germany
25. GNS Science, New Zealand
26. GNU VNIIGiM , Moscow, Russia
27. Group-T, Myanmar
28. Helmholtz Centre for Environmental Research (UFZ), Germany
29. Indian National Centre for Ocean Information Services (INCOIS), India
30. Indian Space Research Organization
31. Institut des Sciences de la Terre, France
32. Institut National Agronomique (INAS), Algeria
33. Institut Teknologi Bandung (ITB), Indonesia
34. Institute of Atmospheric Sciences and Climate (ISAC) of Italian National Research Council (CNR), Italy
35. Institute for Computational Science and Technology (ICST), Viet Nam
36. Institute for the Conservation of Lake Maracaibo (ICLAM), Venezuela
37. Institute of Earth Sciences (ICTJA-CSIC), Spain
38. Instituto Hidrografico, Lisboa, Lisbon, Portugal
39. Instituto Nacional de Hidraulica (INH), Chile
40. Instituto Nazionale di Astrofisica, Italy
41. International Geosphere Biosphere Programme (IGBP), Sweden
42. Iranian National Institute for Oceanography (INIO), Tehran, Iran
43. Italy National Research Council (CNR), Italy
44. Japan Agency for Marine-Earth Science Technology (JAMSTEC), Japan
45. Kenya Meteorological Services, Kenya
46. Korea Ocean Research and Development Institute (KORDI), South Korea
47. Korea Water Resources Corporation, South Korea
48. Lab Domaines Oceanique IUEM/UBO France
49. Laboratoire de Sciences de la Terre, France
50. Marine Sciences For Society, France
51. Ministry of Earth Sciences, India
52. Nanjing Hydraulics Research Institute,China
53. National Institute of Water and Atmospheric Research (NIWA), Auckland, New Zealand
54. National Research Institute of Science and Technology for Environment and Agriculture, France
55. National Institute for Space Research (INPE), Brazil
56. National Institute of Oceanography (NIO), India
57. National Institute of Technology Rourkela, Orissa, India
58. National Institute of Technology Karnataka Surathkal, Mangalore, India
59. National Institute of Water and Atmosphere (NIWA), New Zealand
60. National Marine Environmental Forecasting Center (NMEFC), China
61. National Research Centre for Sorghum (NRCS), India
62. National Research Council (NRC), Italy
63. National Space Research & Development Agency, Nigeria
64. Qatar National Historic Environment

Project
65. Scientific-Applied Centre on hydrometeorology & ecology, Armstatehydromet, Armenia
66. Secretaria del Mar, Ecuador
67. Senckenberg Institute, Germany
68. Shenzhen Inst. of Advanced Technology, China
69. South China Sea Institute of Technology (SCSIO), Guanzhou, China
70. The European Institute for Marine Studies (IUEM), France
71. The Leibniz Institute for Baltic Sea Research, Germany
72. UNESCO-IHE, Netherlands
73. Water Resources Division, Dept. of Indian Affairs and Northern Development, Canada
74. World Weather Information Service (WMO), Cuba

Appendix 2: 2015 CSDMS Annual Meeting Abstracts (Keynotes and Posters)

CSDMS provided the capability to view the keynote presentations through a live stream. Additionally, all plenary keynote presentations and most clinics were recorded and provided through the CSDMS YouTube channel that is also embedded in the CSDMS web portal for people to view at their convenience.

2015 CSDMS Annual Meeting Abstracts (Keynotes and Posters)

RT-Flux-PIHM: A Coupled Hydrological, Land Surface, and Reactive Transport Model for Hydrogeochemical Processes at the Watershed Scale

Chen Bao, Penn State, University Park, Pennsylvania, USA. cub200@psu.edu, Li Li, Penn State, University Park, Pennsylvania, USA, Shi Yuning, Penn State, University Park, Pennsylvania, USA

The close coupling of hydrological and geochemical processes at the watershed scale requires an integrated approach to examine their interactions and impacts. Here we present the first model that couple hydrological, land surface, and reactive transport processes, RT-Flux-PIHM, a new addition to the PIHM (Penn State Integrated Hydrological Model) family. The reactive transport module explicitly simulates geochemical reactions, including aqueous complexation, mineral dissolution and precipitation, redox reaction, gas dissolution-exsolution, adsorption and cation exchange. The reactive transport module was coupled to land surface and hydrological model in a sequential non-iterative manner with special treatment to minimize errors associated with operator splitting. This new integrated model is applied at the Susquehanna Shale Hills Critical Zone Observatory (SSHCZO) to study the controls on stream water and soil water chemistry. The temporal concentration evolution of non-reactive tracer chloride and weathering-derived magnesium in the stream water simulated in the model agreed well with measurements in 2009 with the maximum total bias less than 17% and 8%, respectively. The integration of processes in this model also helped to explain the temporal and spatial variation in pore water chloride and magnesium concentration within the watershed. Furthermore, parameter sensitivity analysis showed the van Genuchten parameter α and β, clay dissolution rates, groundwater influx rate, magnitude of annual precipitation, dissolution surface area of clays and the cation exchange site density have strong controls on the stream magnesium concentration. In summary, RT-Flux-PIHM provides a unique integration tool to understand the hydrogeochemical processes and responses to climatic, hydrological, and anthropogenic forcing at the water shed scale.

Real-time integration of models

Getachew Belete, University of Twente, Enschede, Netherlands, Netherlands.

Integration of models requires establishing linkage, semantic mediation, and dataset conversion tasks between models. Conventionally model integration tasks are done during development time and users can only use model linkages which are already defined during development time. But as compared to very dynamic users' needs only few models are integrated and available for usage. What will happen when a user identifies the need to incorporate a 'new' model into the integrated system? Either the user himself has to develop the linkage or he has to find somebody who is willing and capable of doing it; which is mostly challenging and time consuming. But if users are provided with a tool that enables to link models at the time of usage, i.e. without requiring additional coding and debugging it will give users better opportunity towards meeting their requirements. Real-time integration can give users additional opportunity to simulate user defined scenarios. In this research we developed model integration framework that enables real-time linkage of 'simple' web service based models. The user can define how the models are linked, variable mapping, number of executions, time steps, etc. during the time of usage by using the GUI. The web service based models can be located anywhere and the user needs only the URL of those web service to bring them into the integration.

Landslide and denudational response to transient tectonic uplift in northern California: Lag times and a landslide buzz-saw

Georgie Bennett, University of Oregon, Oregon, USA. georgie.l.bennett@gmail.com, Scott Miller, Josh Roering, Corné Kreemer, David Schmidt.

Landsliding dominates the denudational response to uplift in mountainous regions around the world. In settings of steady uplift, it has been suggested that once slopes reach threshold gradients, landslide flux accommodates uplift and limits topographic development. The timescale and process linkages required for landscapes to become threshold slope-dominated, however, involve the consideration of multiple geomorphic lag times. Where channels respond to an increase in uplift rate via knickpoint propagation, we could expect to find a higher rate of landsliding along hillslopes flanking steep, rapidly incising reaches downstream of knickpoints. This is the model we sought to test in the northern Californian Coastal ranges, where the northward migration of the Mendocino Triple Junction causes crustal thickening and rapid uplift at the mouths of the Redwood, Mad and Eel catchments.

We manually mapped ~3000 earthflows and debris slides in the region from high-resolution, multi-temporal aerial photographs in Google Earth. The velocities of active earthflows were estimated by visually tracking features between sequential images. We mapped channel steepness from 10m NED DEMs in Topotoolbox 2 and developed a new tool to automatically define knickpoints along the channel network. We compare these datasets to geodynamically modeled and GPS derived uplift rates and cosmogenic nuclide erosion rates.

Swath-averaged landslide erosion rates match cosmogenic nuclide erosion rates and predicted exhumation rates well both in spatial pattern and magnitude, with a rapid increase proximal to the Mendocino triple junction and a gradual decline to the south. We find that landslides are clustered downstream of knickpoints of an estimated age of ~1.5 Ma. This corresponds to a maximum elevation of 1.5 km (or 1.5 Ma at an uplift rate of 1 mm yr^{-1}) observed for the onset of landslide erosion. Landslide erosion limits topographic growth beyond this elevation such that landsliding behaves as a buzz-saw on the landscape. The ongoing southward propagation of the landslide buzz-saw is limited by the rate of knickpoint propagation.

Changes in Southern Rocky Mountain Forests: Using Ecosystem Process Modelling to Project Critical Transitions

Megan Caldwell, CU Boulder/ INSTAAR, USGS, Colorado, USA. mcaldwell@usgs.gov

High elevation spruce-fir and lodgepole forests are widely distributed across the Rocky Mountains in the US and Canada, and represent high to mixed fire severity regimes. These forests contribute substantial ecosystem services in each category (supporting, provisioning, regulating and cultural) at multiple scales. Fire is a primary disturbance impacting these forests and subsequently, ecosystem services. Our research study area is the northern Colorado Rockies, dominated by high elevation forests. Colorado's climate has become substantially warmer over the past 30 years, where average temperatures have increased by 2.0°F and projections show further warming and precipitation variability. These changes raise concern about how future fires and related vegetation recovery will change, and how system drivers will change. The overall research objective this study focuses on how climate has influenced fires past and regeneration rates in the recent across high elevation forests, characterized previously by high to mixed-severity fire regimes. Greater predictive capacity and ecological understanding will come from dynamic ecosystem process modeling and systematic observations of past and present pattern. Critical transitions in regeneration patterns post-fire disturbance will be dependent upon the changes in biotic, abiotic and climatically drivers. This research both quantifies recent past and present heterogeneity in fire as well as fire recovery patterns. Recent conditions are quantified using the Burned Area Essential Climate Variable (BAECV) produced at USGS using an automated algorithm to detect burned areas from the Landsat archive. The BAECV product, Landsat NDVI, and high resolution temperature and precipitation data from the National Climate Data Center will be used to quantify heterogeneity in ecosystem response to higher temperatures. Using these data, a dynamic ecosystem process model (LANDIS) will be used to project future change to fire disturbances, recovery patterns and thresholds to critical transitions in ecosystem processes. Dynamic ecosystem modeling with new data provides insights complimentary to ecosystem recovery responses to increased temperatures and different precipitation regimes for adaptive land management to better manage forest ecosystems and ecosystem services.

Quantifying the Effects of Land Use Dynamics on Global Scale Fluvial Suspended Sediment Flux

Shawn Carter, University of Alabama, Alabama, USA. smcarter3@crimson.ua.edu, Sagy Cohen, University of Alabama, Alabama, USA, Albert Kettner, University of Colorado, Colorado, USA.

Quantifying fluvial suspended sediment flux discharged to the coastal oceans is a vital task in geomorphology. At the global scale, this task is hampered by a lack of sediment gauges and measured observations. Empirical models have attempted to overcome this deficiency by modeling fluvial suspended sediment as a function of geological, climatic, and limited anthropogenic factors. On of these models, the BQART model as implemented in the Water Balance Model (Sediment) (WBMsed) Framework, estimates global fluvial suspended sediment flux accurately, however, in its current form, the model lacks a spatially and temporally explicit parameter to describe the amount of sediment discharge created by human activities.

This poster will describe the process and results of modifying BQART and WBMsed to incorporate explicit global land use classifications and their impact on fluvial suspended sediment. This is the first step in incorporating a temporal and spatially explicit parameter describing human alteration of the landscape to understand past, current, and future impacts on a fundamental geomorphological process.

On the coherent structures generated by circular jets in shallow water

Yunxiang Chen, Pennsylvania State University, Pennsylvania, USA. yzc145@psu.edu, Xiaofeng Liu, Pennsylvania State U., Pennsylvania, USA, Tian-Jian (Tom) Hsu, University of Delaware, Delaware, USA.

The coherent structures generated by jet are ubiquitous in shallow water bodies (coasts, lakes, estuaries, etc.), posing considerable influences on the local mixing and transport processes of mass, momentum, and energy due to their large spatial scales and long decaying time. They are very common geophysical flow phenomena which play an important role in earth surface dynamics. This work studies the generation and evolution mechanisms of such coherent structures based on numerical simulations using OpenFOAM. The results indicate that the shallowness effects dominate the main features of the shallow coherent structures. Specifically, the bottom and the free surface confines the initial 3D vortex structure to be a quasi-2D (Q2D) coherent structure which is characterized by S~t^(2/3) with S denoting the length, radius, or circulation of the vortex structure. However, the shallowness effect caused by the free surface is weaker than the bottom, resulting a vertical spiral motion accompanied by the quasi-2D structure. The spiral motion (vorticity) can be seen on the free surface, and its strength is influenced by the jet momentum and water depth. One the other hand, Reynolds numbers also show influences on the generation and the evolution process. For laminar jets, the generated flow structures show more 3D features at lower Reynolds numbers while become more Q2D at higher Reynolds numbers. For turbulent jets, the flow structures is similar to that of laminar cases. However, there exists small scale 3D turbulence caused by bottom friction in the front region of the coherent structure. Another difference is that the orientation of the coherent structures becomes more random in turbulent jet cases. In conclusion, the above results imply that both the shallowness effects and the bottom friction contribute to the vertical transport of the fluid mass and momentum, and the interactions with the horizontal coherent structure, thus providing a useful clue to understand the vertical mass and momentum exchange in shallow water layers. In the future, sediment particles will be added into the jet and their transport in shallow water will be studied.

A Turbulence-resolving Eulerain Two-Phase Model for Sediment Transport Applications

Zhen Chen, Civil and Environmental Engineering, University of Delaware, Delaware, USA, Xiao Yu, University of Delaware, Delaware, USA., Tian-Jian (Tom) Hsu, University of Delaware, Delaware, USA.

Coastal morphological evolution is caused by a wide range of coupled cross-shore and alongshore sediment transport processes associated with short waves, infragravity waves, wave-induced currents. However, the fundamental transport mechanisms occur within bottom boundary layer dictated by turbulence-sediment interaction and inter-granular interactions. In the past decade, significant research efforts have been made in modeling sediment transport using Eulerian-Eulerian or Eulerian-Lagrangian two-phase flow approach. However, most of these models are limited to one-dimensional-vertical (1DV) formulation which is only applicable to Reynolds-averaged sheet flow condition. Therefore, complex processes such as turbulence-resolving features, momentary bed failure and bedform dynamics, cannot be investigated. The main objective of this study is to develop a multi-dimensional four-way coupled two-phase model for sediment transport that can be used for Reynolds-averaged study for large-scale applications or for turbulence-resolving simulations at small-scale.

Following the two-phase flow formulation for sediment transport of Hsu et al. (2004), the numerical model is developed using the open-source CFD toolbox, OpenFOAM by reviving the two-phase Eulerian flow solver of Rusche (2002). The Reynolds-averaged version of the present model has been validated with available laboratory data for sheet flow condition (Cheng et al., 2014) and disseminated as an open-source code via Community Surface Dynamics and Modeling System (CSDMS). This study further reports our ongoing effort to validate the 3D turbulence-resolving version of the two-phase model for sheet flow and to study sediment burst events often observed during flow reversal. Large eddy simulation (LES) concept is adopted in the present study. Figure 1 presents the 3D snapshots of iso-surface of sediment concentration during flow peak and flow reversal. In each panel, the blue iso-surface represents high sediment concentration of 30%, while the green iso-surface represents dilute concentration of 0.1%. We can see that during flow peak (Figure 1(a)), the distance between these two iso-surfaces is larger, suggesting a large sheet flow layer thickness. There is mild spatial variation due to turbulent eddies. On the other hand, during flow reversal (Figure 1(b)), the averaged distance between these two iso-surfaces becomes much smaller. However, we observe much significant spatial variation. Locally, we have sediment bursts penetrating upward for about 2~3 cm. Simulation results presented here are similar to a few oscillating water tunnel measurements where burst events are only observed during flow reversal for sufficiently fine sand (Dohmen-Janssen et al. 2002). More comprehensive model validation and model application for sediment transport will be discussed in the conference.

References:

Z. Cheng and T.-J. Hsu. A multi-dimensional two-phase eulerian model for sediment transport — twophaseeulersedfoam (version 1.0). Technical Report No. CACR-14-08, University of Delaware, August 2014.

Dohmen-Janssen, C. M., Hanes, D. M., Oct. 2002. Sheet flow dynamics under monochromatic nonbreaking waves. J. Geophys. Res. 107 (C10), 3149. doi:10.1029/2001JC001045, 2002.

Hsu, T.-J., Jenkins, J. T., Liu, P. L.-F., 2004. On two-phase sediment trans- port: sheet flow of massive particles. Proceedings of the Royal Society of London. Series A: Mathematical, Physical and Engineering Sciences 460 (2048), 2223–2250.

Rusche, H., 2002. Computational fluid dynamics of dispersed two-phase flows at high phase fractions. Ph.D. thesis, Imperial College London (University of London).

Three-dimensional modeling of a Chesapeake Bay tidal marsh ecosystem

Blake Clark, University of Maryland, Maryland, USA. bclark@umces.edu, Raleigh Hood, University of Maryland, Maryland, USA., Wen Long, PNNL, Washington, USA.

Biogeochemical processes on the fringes of estuaries are relatively unconstrained in coastal carbon budgets and, in particular, those associated with estuary-marsh exchanges. A three-dimensional biogeochemical simulation can be a valuable tool to augment the sparse observations on these exchanges and can provide insights into the carbon fluxes associated with them. The Finite Volume Community Ocean Model (FVCOM) coupled with the Integrated Compartment Model (ICM) for water quality is being adapted to simulate the physical and biological characteristics of the Rhode River, MD, a sub-estuary of Chesapeake Bay. Concurrent measurements of biogeochemical parameters and ongoing long-term observations are being used to inform the modeling effort. The model includes a module to simulate the drag imposed by marsh grasses that, along with the unstructured grid and the FVCOM wetting and drying treatment, provides a realistic representation of intertidal marsh hydrodynamics. Model output and observed data are compared for hydrodynamic model validation and small-scale circulation features are examined. A chromophoric dissolved organic matter (CDOM) module is being developed for inclusion into the water quality model. The DOM module explicitly defines CDOM independent of non-chromophoric DOM (NCDOM) allowing a dynamic simulation involving UV/visible light and microbial interactions in the water column and diagenesis of DOM in the sediments. The continued development of the Rhode River model will provide insights into carbon exchange across the marsh-estuary interface.

Spatially explicit modeling of particulate nutrient flux in global rivers

Sagy Cohen, University of Alabama, Alabama, USA. sagy.cohen@ua.edu, Albert Kettner, University of Colorado, INSTAAR, Colorado, USA., Emilio Mayorga, University of Washington, Washington, USA., John Harrison, Washington State University, Washington, USA.

Water, sediment, nutrient and carbon fluxes along river networks have undergone considerable alterations in response to anthropogenic and climatic changes, with significant consequences to infrastructure, agriculture, water security, ecology and geomorphology worldwide. However, in a global setting, these changes in fluvial fluxes and their spatial and temporal characteristics are poorly constrained, due to the limited availability of continuous and long-term observations. We present initial results from a new global-scale particulate modeling framework (WBMsedNEWS) that combines the Global NEWS watershed nutrient export model with the spatially distributed WBMsed water and sediment model. We compare the model predictions against multiple observational datasets. Early trials indicate that the model is able to accurately predict particulate nutrient (Nitrogen, Phosphorus and Organic Carbon) fluxes on an annual time scale. However, the model doesn't capture particulate flux dynamics at a higher temporal resolution (seasonal, monthly, weekly or daily). We show that discrepancies between measurements and model output can be attributed to temporal-scale incompatibility between the model and observations, the Global NEWS governing equations, and the WBMsed sediment predictions.

Towards assessing the coastal zone as an integrated system: the development of a coupled nearshore and aeolian dune model

N. Cohn, E.B. Goldstein, P. Ruggiero, L. J. Moore, O. Duran, J.A. Roelvink, B. Hoonhout

Coastal environments are complex because of the interplay between aeolian and nearshore processes. Waves, currents, tides, and winds drive significant short term (<weekly) changes to coastal landforms which augment longer term (> annual) geomorphic trends. Great strides have been made in recent years regarding our ability to model coastal geomorphic change in this range of societally relevant time scales. However, a great disparity exists in modeling coastal evolution because subaqueous and subaerial processes are typically assessed completely independent of one another. By neglecting the co-evolution of subtidal and supratidal regions within our current framework, we are precluded from fully capturing non-linear dynamics of these complex systems. This has implications for predicting coastal change during both fair weather and storm conditions, hindering our ability to answer important scientific questions related to coastal vulnerability and beach building.

Recognizing these historic limitations, here we present the outline for a coupled subaqueous (XBeach) and subaerial (Coastal Dune Model) morphodynamic modeling system that is in active development with the goal of exploring coastal co-evolution on daily to decadal timescales. Furthermore we present recently collected datasets of beach and dune morphology in the Pacific Northwest US that will be used to validate trends observed within the coupled model platform.

Improving ecosystem dynamic models in a semi-arid ecosystem by integrating different sources of remotely sensed data

Hamid Dashti, Boise State University, Idaho, USA. ahangar.hamid@gmail.com, Nancy Glenn, Boise State University, Idaho, USA., Lejo Flores, Boise State University, Idaho, USA., Nayani Ilangakoon, Boise State University, Idaho, USA., Jessica Mitchell, Appalachian State University, North Carolina, USA., Matt Masarik, Boise State University, Idaho, USA., Lucas Spaete, Boise State University, Idaho, USA., Qingtao Zhou, Boise State University, Idaho, USA., Aihua Allison, Boise State University, Idaho, USA.

The Western U.S. semi-arid ecosystems constitute more than 10% of global dryland ecosystems. Dryland ecosystems act as terrestrial carbon sinks as well as habitat for many wildlife. However, drylands have experienced significant degradation, and in particular, the sagebrush-steppe of the Western US. In this region, degradation has occurred due to disturbance from fire, climate, and land use. Monitoring these disturbance effects is ideally performed with remote sensing. Yet, these ecosystems are characterized by sparse vegetation, an abundance of targets with high albedo and non-linear spectral mixing. Moreover semi-arid plant reflectance recorded by airborne and satellite-based sensors are often attributed to canopy structure rather individual leaves. In this study our goal is to use vegetation structural parameters estimated from airborne laser scanning (ALS) and image spectroscopy as constraints in ecosystem models to predict ecosystem structure and fluxes in a semi-arid ecosystem. Our study area is Reynolds Creek Experimental Watershed (RCEW) located in southwestern Idaho, Great Basin. Novel fusion techniques will be used to estimate the vegetation structure products from full waveform ALS (Reigl LMS Q 1560 sensor) and hyperspectral (AVIRIS-ng) datasets collected in late summer 2014. Following a standard protocol, an extensive field campaign was conducted in early fall 2014 and vegetation parameters were measured in the field as well as in the lab for biochemical analysis. Moreover data from our previous experiments such as terrestrial laser scanning measurements (Riegl VZ-1000; 2011 and 2012), multispectral images (RapidEye, 2012) and ALS (Leica ALS50II, 2007) will help us with parameter retrieval. Estimated parameters shall be used to constrain the Ecosystem Demography (ED2) model to quantify ecosystem structures and fluxes. Results will be validated with a network of three eddy flux towers. This study will provide a basis for understanding feedback mechanisms related to changing climate and non-native plant invasion and its impact on wildfire. Our future prospect is to approach a data assimilation framework for integration of remote sensing data and ecosystem models.

Quo Vadis Ecosystem? Insights from Ecological Modelling and Systems Ecology

Brian Fath, Towson University; International Institute for Applied Systems Analysis, Laxenburg, Austria.

The question of ecosystem dynamics is relevant from a scientific and management perspective. Knowing the natural tendencies and trajectories of ecosystems will assist in planning for their development and restoration. One key feature is how the ecosystem uses the available energy flows to move further from thermodynamic equilibrium and increase its overall complexity in terms of total biomass, biodiversity, network connectivity, and information. In this presentation, I review some of the main concepts that have been used to identify these dynamic trajectories. Namely, it can be shown using network analysis that a number of ecological goal functions pertaining to energy, exergy, biomass, embodied energy, entropy, and information are complementary displaying various angles of the same general complexification phenomena

Coupled Human and Natural Systems: Testing the Impact of Agricultural Terraces on Landscape Evolution

Jennifer E. Glaubius and Xingong Li

Humans alter natural geomorphic systems by modifying terrain morphology and through on-going actions that change patterns of sediment erosion, transport, and deposition. Long-term interactions between humans and the environment can be examined using numerical modeling. Human modifications of the landscape such as land cover change and agricultural tillage have been implemented within some landscape evolution models, yet little effort has been made to incorporate agricultural terraces. Terraces of various forms have been constructed for millennia in the Mediterranean, Southeast Asia, and South America; in those regions some terraces have undergone cycles of use, abandonment, and reuse. Current implementations of terraces in existing models are as static objects that uniformly impact landscape evolution, yet empirical studies have shown that terrace impact depends upon whether they are maintained or abandoned. We previously tested a simple terrace model that included a single terrace wall on a synthetic hillside with 20% slope for the impacts of maintenance and abandonment. In this research we modify the terrace model to include a wider variety of terrace forms and couple it with a landscape evolution model to test the extent terraced terrain morphology is related to terrace form. We also test how landscape evolution, after abandonment of terraced fields, differs based on length of time the terraces were maintained. We argue that construction and maintenance of terraces has a significant impact on the spatial patterning of sediment erosion and deposition and thus landscape evolution modeling of terraced terrain requires coupling with a dynamic model of terrace use.

Modeling gravity-driven deposition on the East China Sea continental shelf

Zhuochen Han, Nanjing University, Nanjing, China. zhuochenhan@hotmail.com, Shu Gao, Nanjing University, NanJing, China.

Sediment gravity flows in relation to the clinoform formation associated with the Changjiang distal mud deposit on the inner shelf off the Zhejiang-Fujian coast, the East China Sea, are investigated using a process modeling approach. Different from the classic turbidity current and hyperpycnal flow theories, which rely on auto-suspension and high sediment load from rivers, respectively, the type of the gravity-driven, down-slope sediment transport in consideration is the movement of bottom turbid layers resulting from resuspension induced by tidal currents and waves. Compared with rapid down-slope movements of turbidity currents with a high sediment transport rate, the bottom turbid layer represents a small scale event; during such an event, only a short distance is covered by sediment movement. However, the cumulative effect of such frequent, short scale may produce large scale clinoforms, in response to repeated action of the bottom turbid layer. In our numerical experiments, both wave- and tidally-induced resuspension events are simulated; the critical Richardson number plays the key role in controlling the gravity-driven transport load. The results suggest that the modeled resuspension pattern is consistent with the in-situ observations undertaken in March 2014, off the Oujiang River mouth in the study area. Likewise, the gravity-driven deposition pattern obtained is supported by the seismic record which reveals parallel clinoforms within the distal mud. The simulation results support the hypothesis that the two types of clinoforms, i.e., convergence and parallel ones, are associated with settling and Bottom turbid layer processes, respectively.

Modeling Stream Capture in Strike-Slip Systems

Sarah Harbert, University of Washington, Washington, USA. harbert1@uw.edu

Rivers respond to tectonics and climate through both gradual and abrupt changes in slope, hydraulic geometry, and planform. At the fast end of the fluvial response spectrum is stream capture, a process by which drainage area, and therefore water and sediment, is rapidly diverted from one catchment into another. Stream capture modifies the topology of drainage networks and has implications for fluvial incision and deposition in sedimentary basins. Although stream capture is recognized as an important process in landscape evolution, the factors controlling its occurrence are not well understood. We use the Channel-Hillslope Integrated Landscape Development model (CHILD) to investigate the effects of stream size, sediment supply, drainage divide geometry, and rock uplift on stream capture. We model a scenario in which a strike-slip fault forces frequent stream captures by juxtaposing adjacent streams. In a simple scenario, stream captures should occur whenever two streams are juxtaposed, a frequency that depends on the drainage spacing and the fault slip rate. However, our models did not show such regularity. We found that river size and sediment supply both affect the likelihood of stream capture. In more than 90% of stream captures in our model runs, the capturing stream was larger (i.e. had more drainage area) than the captured stream. In model runs in which all of the streams were larger where they cross the fault, stream capture occurred almost twice as often. Finally, fewer stream captures happened when the fluvial system was detachment-limited; nearly twice as many stream captures occurred when fluvial sediment deposition was allowed in the system. Divide geometry also affected the occurrence of stream capture. We found that when the difference in elevations between the streams involved in a capture event is greater, the capture can occur from a greater horizontal distance. We interpret this relationship to mean that stream capture is "easier" when one stream is "perched" high above another. Finally, we test the role of differential uplift across a strike-slip fault by adding vertical motion to our models. These results indicate that stream capture is affected by many variables other than stream proximity. Comparing these results to field sites will help us to understand the prevalence of stream capture in real-world strike-slip systems and the resulting landscape signature of lateral faulting.

Storm-driven delivery of sediment to the continental slope: Numerical modeling for the northern Gulf of Mexico

Courtney Harris, Virginia Institute of Marine Sciences, Virginia, USA. ckharris@vims.edu

Few numerical models can estimate sediment transport from fluvial or coastal sources to deep-sea depositional sinks at the event timescale. Three-dimensional models have been developed to represent suspended sediment load on continental shelves, while separate turbidity current models have been used for continental slope environments. Shelf and slope sediment fluxes have rarely been coupled, however. To allow for interactions between them, a three-dimensional continental shelf sediment transport model for the northern Gulf of Mexico is being developed so that it can be linked to sediment-failure models. For sediment delivery to the shelf by riverine plumes and for sediment resuspension by energetic waves, sediment transport calculations were implemented within the Regional Ocean Modeling System (ROMS). The model domain represents the northern Gulf of Mexico including the Mississippi birdfoot delta and the Mississippi and DeSoto Canyons. To investigate the role of storms in driving down-slope sediment fluxes, model runs for the summer and fall of 2008 were analyzed, a time period that included the passage of two hurricanes (Ike and Gustav) over the study area. Preliminary results indicated that sediment delivery to the continental slope was triggered by the passage of these storm events, and focused at certain locations, such as submarine canyons.

Potential impacts of Indian Rivers Inter-links on sediment transport to the Ganges-Brahmaputra Delta

Stephanie Higgins, University of Colorado Boulder, Colorado, USA. stephanie.higgins@colorado.edu, Irina Overeem, University of Colorado Boulder, Colorado, USA, James Syvitski, University of Colorado Boulder, Colorado, USA.

The Indian Rivers Inter-link project is a proposal to link several of India's major rivers via a network of reservoirs and canals. If the Inter-link project moves forward, fourteen canals will divert water from tributaries of the Ganges and Brahmaputra rivers to areas in the west, where fresh water is needed in cities and agricultural areas. Here, we investigate the impacts of the proposed diversions on sediment transport to the Ganges-Brahmaputra Delta, Bangladesh. Changing watersheds are delineated using the Terrain Analysis Using Digital Elevation Models (TauDEM) Suite, developed by David Tarboton. Climate data comes from interpolation between 30 observed precipitation stations located in China, Nepal, India, Bhutan and Bangladesh (Pervez & Henebry, 2014). Changes in water discharge due to the proposed canals are simulated using HydroTrend, a climate-driven hydrological water balance and transport model that incorporates drainage area, discharge, relief, temperature, basin-average lithology, and anthropogenic influences (Kettner & Syvitski, 2008). Simulated river discharge is validated against observations from the Farakka and Bahadurabad gauging stations, where the Ganges and Brahmaputra rivers respectively enter Bangladesh (Fig. 1). HydroTrend is then used to investigate sediment transport changes that may result from the proposed canals. Preliminary results show that sediment loads to the delta will be reduced at both locations. Additional canals may also transport Himalayan sediments 500 km south to the Mahanadi delta and more than 1000 km south to the Godavari and Krishna deltas in India.

Testing model analysis frameworks

Mary Hill, University of Kansas, USA.

Model analysis frameworks specify ideas by which models and data are combined to simulate a system on interest. A given modeling framework will provide methods for model parameterization, data and model error characterization, sensitivity analysis (including identifying observations and parameters important to calibration and prediction), uncertainty quantification, and so on. Some model analysis frameworks suggest a narrow range of methods, while other frameworks try to place a broader range of methods in context. Testing is required to understand how well a model analysis framework is likely to work in practice. Commonly models are constructed to produce predictions, and here the accuracy and precision of predictions are considered.

The design of meaningful tests depends in part on the timing of system dynamics. In some circumstances the predicted quantity is readily measured and changes quickly, such as for weather (temperature, wind and precipitation), floods, and hurricanes. In such cases meaningful tests involve comparing predictions and measured values and tests can be conducted daily, hourly or even more frequently. The benchmarking tests in rainfall-runoff modeling, such as HEPEX, are in this category. The theoretical rating curves of Kean and Smith provide promise for high flow predictions. Though often challenged by measurement difficulties, short timeframe systems provide the simplest circumstance for conducting meaningful tests of model analysis frameworks.

If measurements are not readily available and (or) the system responds to changes over decades or centuries, as generally occurs for climate change, saltwater intrusion of groundwater systems, and dewatering of aquifers, prediction accuracy needs to be evaluated in other ways. For example, in recent work two methods were used to identify the likely accuracy of different methods used to construct models of groundwater systems (including parameterization methods): (1) results of complex and simple models were compared and (2) cross-validation experiments. These and other tests can require massive computational resources for any but the simplest of problems. In this talk we discuss the importance of model framework testing in these longer-term circumstances and provide examples of tests from several recent publications. We further suggest that for these long-term systems, the design and performance of such tests are essential for the responsible development of model frameworks, are critical for models of these environmental systems to provide enduring insights, and are one of the most important uses of high performance computing in natural resource evaluation.

International Land Model Benchmarking Project

Forrest Hoffman, Oak Ridge National Laboratory, USA, Jitendra Kumar, James T. Randerson, William J. Riley, David M. Lawrence, Damian M. Maddalena, Zachary L. Langford, and William W. Hargrove

Understanding and predicting the response of vegetated ecosystems to climate change and quantifying the resulting carbon cycle feedbacks requires a coherent program of field and laboratory experiments, data synthesis and integration, model development and evaluation, characterization of knowledge gaps, and understanding of ecosystem structure and function. The U.S. Department of Energy supports such a program, which produces community data, models, and analysis capabilities aimed at projecting the impacts of environmental change on future atmospheric carbon dioxide levels, predicting changes in extreme events, and assessing impacts on energy production and use. Two computational approaches--one for quantifying representativeness of field sites and one for systematically assessing model performance--will be presented.

Resource and logistical constraints limit the frequency and extent of observations, particularly in the harsh environments of the arctic and the tropics, necessitating the development of a systematic sampling strategy to maximize coverage and objectively represent variability at desired scales. These regions host large areas of potentially vulnerable ecosystems that are poorly represented in Earth system models (ESMs), motivating two new field campaigns, called Next Generation Ecosystem Experiments (NGEE) for the Arctic and Tropics, funded by the U.S. Department of Energy. We developed a Multivariate Spatio-Temporal Clustering (MSTC) technique to provide a quantitative methodology for stratifying sampling domains, informing site selection, and determining the representativeness of measurement sites and networks. We applied MSTC to model results and data for the State of Alaska to characterize projected changes in ecoregions and to identify field sites for sampling important environmental gradients.

As ESMs have become more complex, there is a growing need for comprehensive and multi-faceted evaluation, analysis, and diagnosis of model results. The relevance of model predictions hinges in part on the assessment and reduction of uncertainty in predicted biogeochemical cycles, requiring repeatable, automated analysis methods and new observational and experimental data to constrain model results and inform model development. The goal of the International Land Model Benchmarking (ILAMB) project is to assess and improve the performance of land models by confronting ESMs with best-available observational data sets. An international team of ILAMB participants is developing a suite of agreed-upon model evaluation metrics and associated data at site, regional, and global scales. We are developing Open Source software tools for quantifying the fidelity of model performance, allowing modeling groups to assess confidence in the ability of their models to predict responses and feedbacks to global change

Modeling the Chesapeake Bay

Raleigh Hood, University of Maryland, Maryland, USA.

In this presentation several modeling efforts in Chesapeake Bay will be reviewed that highlight how we can use 3-dimensional, time-dependent hydrodynamic models to provide insight into biogeochemical and ecological processes in marine systems. Two modeling studies will be discussed which illustrate the application of individual based modeling approaches to simulate the impact of 3-dimensional currents and mixing on pelagic organisms and how these interact with behavior to determine the fate of planktonic species. There are many applications of this approach related to fish and invertebrate (e.g., oyster) larvae transport and fate and also plankton that can be used to inform management efforts.

A long-term operational modeling project will be discussed that combines mechanistic and empirical modeling approaches to provide nowcasts and short-term forecasts of Sea Nettles, HAB, pathogen and also physical and biogeochemical properties for research, management and public uses in Chesapeake Bay. This is a powerful technique can be expanded to any marine system that has a hydrodynamic model and any marine organism for which the habitat can be defined.

Finally, a new research project will be reviewed where we are assessing the readiness of a suite of existing estuarine community models for determining past, present and future hypoxia events within the Chesapeake Bay, in order to accelerate the transition of hypoxia model formulations and products from academic research to operational centers. This work, which will ultimately provide the ability to do operational oxygen modeling in Chesapeake Bay (e.g., oxygen weather forecasts), can be extended to other coastal water bodies and any biogeochemical property.

Creating Educational Materials for Python and GIS

Shelley Jeltema, Michigan Technological University, Michigan, USA. sjeltema@mtu.edu

This project created a 15-week course to teach graduate students and GIS analysts/technicians how to use Python to extend the functionality of Geographical Information System (GIS) software. Using a combination of traditional college course and corporate training methods results in a modular course that can be taught in a traditional college setting, online, or as a custom course for specific business purposes. The class is comprised of lectures and labs where students will learn scripting, data processing with Python. Students will also learn how to create ArcGIS models with Python Script. The course contains base set of labs will focus on natural resource management and hydrology. Additional labs will cover different business scenarios to expand the audience to business, surveying, social science, and Peace Corps students. At the end of the course, students will have gained experience in scripting, data pre-processing, and modeling with Python and AcrGIS. They will also have frameworks for real world business scenarios. The requirements for this class are prior experience with ArcGIS and familiarity with modeling. Computer coding experience is suggested but not recommended. Future work includes continued refinement of this course to include more of the skills businesses. An advanced course will be created to look at more complex computer codes, creating ArcGIS tools, and working with GIS in a distributed computing environment where workload balancing is available.

Semantics-Enabled Paradigm for Model Integration

Peishi Jiang, University of Illinois at Urbana-Champaign, Illinois, USA. pjiang6@illinoise.edu, Mostafa Elag, University of Illinois at Urbana-Champaign, Illinois, USA, Praveen Kumar, University of Illinois at Urbana-Champaign, Illinois, USA.

Semantic Web technologies provide a networked-based information system and interface for publishing and discovering shared data, models, and services. Semantic Web technologies provide a better discovery method by exploiting the semantics attached to the shared objects. In this research, we develop a semantics-enabled approach to allow the integration and re-use of hydrology models across various related disciplines. The semantics-enabled approach requires that each model define a web service interface that allows it to be integrated with client, i.e. another model, and provide descriptive information about the model operation condition and attributes. This information is stored in a RDF graph database to allow the automatic reasoning on the dependencies between models. In this poster, we present an interface design to couple hydrology models as web services, ensure their semantic consistency, and demonstrate how it can correct the semantic mismatch in the attributes between hydrology models.

Considering holistic coastline response to climate-change induced shifts in natural processes and anthropogenic modifications

Margaret Jones, University of North Carolina, North Carolina, USA. mbj@live.unc.edu, Laura Moore, University of North Carolina, Chapel Hill, North Carolina, USA, Brad Murray, Duke University, North Carolina, USA, Dylan McNamara, University of North Carolina, Wilmington, North Carolina, USA.

While climate change and relative sea level rise can accelerate shoreline change rates, human modifications to the shoreline also have the ability affect large-scale patterns of change. Furthermore, there is a coupling between the natural shoreline dynamics and human response: increasing rates of shoreline change are likely to result in human modifications designed to protect shoreline investments and habitats, and these modifications, in turn, affect shoreline dynamics. Because management decisions affect not only those who implement them, but also neighboring stakeholders up and down the coast, it is beneficial to explore holistic coastline response within the coupled natural-human system. Coastal modeling is a powerful tool to help us understand these dynamics. As such, we are working to couple two previously described shoreline change models with the goal of exploring holistic shoreline change to management scenarios and climate change along a series of barrier islands on the Virginia coast where several different stakeholders have potentially competing coastal management goals.

The Barrier Island Model (BIM) describes barrier island, inlet, and dune response to storms and sea level rise (McNamara and Werner 2008). However, BIM does not account for the ability of gradients in alongshore sediment flux to produce complex shoreline shapes under high angle wave climates. Because our Virginia coast case study includes a cape-like feature (Fishing Point at the southern end of Assateague Island), we intend to use the Coastline Evolution Model (CEM; Ashton and Murray 2006) to asses how this coastline may respond to different wave climate scenarios. By coupling these two models and representing the effects of human manipulations (e.g. a commitment to nourish a specific section of beach; the construction of a seawall) and climate change scenarios (e.g. an increase in relative sea level; a change in the proportion of hurricane-generated waves) we will be able to assess the effects of the coupled natural-human system on shoreline dynamics.

CSDMS Tools to Promote Visibility of Open-source Model Code

Albert Kettner, Univ. of Colorado, INSTAAR, CSDMS, Colorado, USA. albert.kettner@gmail.co, Irina Overeem, CSDMS, INSTAAR, University of Colorado, Colorado, USA.

CSDMS encourages and supports the effort of developers to provide their numerical models as truly open source codes. CSDMS uses GitHub as their software version control system to provide access for those who want to share their model source code regardless of whether a model is still in development or for stable versions. GitHub keeps track of current and historical versions of source code, it allows for easy download, makes code highly visible, and permits for easy contributions, even from parties that are not directly associated with the developers core team. All one needs to contribute code to GitHub is a Git client version on your computer. Not every developer may be familiar with GitHub, therefore developers can provide source code to CSDMS and the Integration Facility will maintain the GitHub repository. Additionally if developers want to learn more about Git and GITHub, CSDMS has provided Git/GitHub software bootcamps and clinics in the past and envisions to provide such in upcoming annual meetings as well.

CSDMS promotes open source code as it reduces redundancy; it guarantees re-use and it makes research more replicable. At the same time CSDMS strives to ensure that model developers receive recognition for their work, even when code is submitted but not (yet) described in a scientific journal. Therefore CSDMS was one of the first organizations to adopt the Digital Object Identifier (DOI) system for source code. For this, we collaborated with IEDA (Integrated Earth Data Applications, hosted at the Lamont-Doherty Earth Observatory of Columbia University). Now that this practice is becoming more commonplace, we have switched to using the DOI service of Zenodo (CERN) as it has an easy to use and integrated tool through GitHub.

With the help of a brief model description form on the CSMDS portal, the developers can provide basic model information and indicate under which software license the model source code is available. Licensing software ensures the developer that models once made freely available will continue to be available for the community, even if others are 'upgrading' your code. At the same time appropriate open-source licenses protect the development team. CSMDS advises which software licenses to use. Finally, CSDMS promotes contributions of open source software by highlighting newly submitted models at the FrontPage of its website and through social media.

The GeoClaw Software

Randall LeVeque, University of Washington, USA.

GeoClaw is an open source Fortran/Python package based on Clawpack (conservation laws package), which implements high-resolution finite volume methods for solving wave propagation problems with adaptive mesh refinement. GeoClaw was originally developed for tsunami modeling and been validated via benchmarking workshops of the National Tsunami Hazard Mitigation Program for use in hazard assessment studies funded through this program. Current project include developing new tsunami inundation maps for the State of Washington and the development of new probabilistic tsunami hazard assessment (PTHA) methodologies. The GeoClaw code has also been extended to the study of storm surge and forms the basis for D-Claw, a debris flow and landslide code being developed at the USGS and recently used to model the 2014 Oso, Washington landslide, for example.

T-Flux-PIHM: A Coupled Hydrological, Land Surface, and Reactive Transport Model for Hydrogeochemical Processes at the Watershed Scale

Li Li, Penn State, University Park, Pennsylvania, USA lili@eme.psu.edu, Chen Bao, Penn State, University Park, Pennsylvania, USA, Shi Yuning, Penn State, University Park, Pennsylvania, USA.

The close coupling of hydrological and geochemical processes at the watershed scale requires an integrated approach to examine their interactions and impacts. Here we present the first model that couple hydrological, land surface, and reactive transport processes, RT-Flux-PIHM, a new addition to the PIHM (Penn State Integrated Hydrological Model) family. The reactive transport module explicitly simulates geochemical reactions, including aqueous complexation, mineral dissolution and precipitation, redox reaction, gas dissolution-exsolution, adsorption and cation exchange. The reactive transport module was coupled to land surface and hydrological model in a sequential non-iterative manner with special treatment to minimize errors associated with operator splitting. This new integrated model is applied at the Susquehanna Shale Hills Critical Zone Observatory (SSHCZO) to study the controls on stream water and soil water chemistry. The temporal concentration evolution of non-reactive tracer chloride and weathering-derived magnesium in the stream water simulated in the model agreed well with measurements in 2009 with the maximum total bias less than 17% and 8%, respectively. The integration of processes in this model also helped to explain the temporal and spatial variation in pore water chloride and magnesium concentration within the watershed. Furthermore, parameter sensitivity analysis showed the van Genuchten parameter α and β, clay dissolution rates, groundwater influx rate, magnitude of annual precipitation, dissolution surface area of clays and the cation exchange site density have strong controls on the stream magnesium concentration. In summary, RT-Flux-PIHM provides a unique integration tool to understand the hydrogeochemical processes and responses to climatic, hydrological, and anthropogenic forcing at the water shed scale.

Exploring the imprint of tectonics on sediment output from a small mountain watershed

Qi Li, Tulane University, Louisiana, USA. qli1@tulane.edu, Nicole Gasparini, Tulane University, Louisiana, USA, Kyle Straub, Tulane University, Louisiana, USA.

Changes in tectonics can affect erosion rates across a mountain belt, leading to non-steady sediment flux delivery to fluvial transport systems. This sediment flux record may eventually be recorded in a depositional basin. However, deciphering a tectonic signal from a sedimentary deposit may not be straightforward. Even at the outlet of an erosional watershed the sediment signal produced from time-varying tectonics can already be distorted. In this study, we use the Channel-Hillslope Integrated Landscape Development (CHILD) model to explore how the sediment flux delivered from a mountain watershed responds to non-steady uplift. The modeled uplift rate in each experiment varies between a high and low value. Between experiments we vary the duration of the high and low uplift intervals, but not the magnitude of the uplift rates. We observe that (1) sediment flux does not respond to a change in uplift rate immediately unless the erosional system has reached steady state, and in some cases the sediment flux is out of phase with the uplift rate; (2) the duration of the high or low uplift rate influences the amount of time it takes for the sediment flux to begin increasing (decreasing) after an increase (decrease) in uplift rate; (3) there are cases in which the sediment flux does not record changes in the uplift rate. All of these observations highlight the difficulty in accurately reconstructing the tectonic history from the sediment flux history, let alone from a sedimentary deposit. Results from this study will help to constrain what tectonic signals may be evident in the sediment flux delivered from an erosional system and therefore have the potential to be recorded in stratigraphy, ultimately improving our ability to interpret stratigraphy.

Reduced-Complexity Model (RCM) for River Delta Formation – Model Assessment and Application

Man Liang, University of Texas at Austin, Texas, USA. manliang@utexas.edu, Corey Van Dyk, University of Texas at Austin, Texas, USA, Paola Passalacqua, University of Texas at Austin, Texas, USA, Wonsuck Kim, University of Texas at Austin, Texas, USA.

Understanding deltaic channel dynamics is essential to acquiring knowledge on how deltas respond to environmental changes, as channels control the distribution of water, sediment, and nutrients. In recent years a variety of models have been developed, which provide the basis for the development of a quantitative framework to study deltaic channel dynamics. However, robust metrics are needed to effectively evaluate numerical models and extract relevant information.

In this work we use existing and new metrics, developed in the context of river delta formation, to assess the morphodynamic results of DeltaRCM, a reduced complexity model for delta formation and evolution. Model results are compared to theoretical predictions, field observations and physical experiments. We show that DeltaRCM captures: 1) the geometric growth characteristics of river-dominated deltas such as the fractal growth of channel network, 2) the temporal dynamics of channels at the level of autogenic timescales such as fluctuations in the fraction of wetted surface and loss of channel overlap with time. We also demonstrate how to use a new metric for subsurface structure, sedimentograph, to explore the radially-averaged distribution of coarse and fine sediment. Furthermore, we investigate how deltaic distributary channel networks respond to subsidence and sea-level rise. The results show that without coastal processes such as waves and tides, distributary channel networks exhibit intensified branching in response to continuous relative sea-level rise.

Modeling water and solute fluxes from terrestrial to aquatic ecosystems

Laurence Lin, University of Alabama, Alabama, USA. lhlin@crimson.ua.edu, Sagy Cohen, University of Alabama Tuscaloosa Alabama, USA, Lisa Davis, University of Alabama Tuscaloosa Alabama, USA.

Existing watershed models for hydrology and solute exports include physically-based models, empirical models and their hybrids. These models have been developed for different watershed sizes and different research interests. The Regional Hydro-Ecological Simulation System (RHESSys) is one of the physically-based models that have been widely used. It was developed to couple hillslope hydrology and forest ecosystem in small / medium catchments. The Soil and Water Assessment Tool (SWAT) is a hybrid model that contains physically-based hydrology and empirical biology. It is mostly used for medium / large agriculture and urban-developed catchments. The Water Balance Model (WBM) is an empirical-oriented model that estimates discharge and suspended sediment export in large drainage basins. In this study, we evaluated these three types of watershed models for catchments with various sizes. The models were initialized using the elevation, climate, and vegetation data and calibrated using discharge monitored by USGS or Long Term Ecological Research (LTER). The simulated daily patterns of water and solute fluxes from terrestrial to aquatic ecosystem along the main channel were compared among the models. We aimed to recommend appropriate models for estimating water and nitrogen fluxes from terrestrial to aquatic ecosystems given a certain size of catchment.

Vulnerability maps of deltas: quantifying how network connectivity modulates upstream change to the shoreline

Anthony Longjas, University of Minnesota, Minnesota, USA. alongjas@umn.edu, Alejandro Tejedor, University of Minnesota, Minnesota, Pennsylvania, USA, Ilya Zaliapin, University of Nevada, Nevada, USA, Efi Foufoula-Georgiou, University of Minnesota, Minnesota, USA.

The complex bifurcation and merging structure (called connectivity) of delta channel networks and the partitioning of fluxes at every junction determine the spatial flux distribution on the deltaic surface from the apex to the shoreline. Changes in any upstream part of the network will propagate downstream, and depending on the location of this change and the network connectivity, a particular perturbation will be attenuated to a different degree on its way to the shoreline. It is of interest to have a computationally efficient framework by which every channel in the delta network can be assigned a "vulnerability index" according to its potential to mitigate the propagation of the local change (e.g., a reduction of flux) to the shoreline. Here we present a framework for performing such an analysis by conceptualizing the network as a directed graph and using spectral graph theory to compute steady-state fluxes. We use the developed framework to construct vulnerability maps that quantify the relative change of sediment and water delivery to the shoreline outlets in response to possible perturbations in hundreds of upstream links. This enables us to evaluate which links (hotspots) and what management scenarios would most influence flux delivery to the outlets, paving the way for systematically examining how local or spatially distributed delta interventions can be studied within a systems approach for delta sustainability.

Web-based Interactive Landform Simulation Model - Grand Canyon (WILSIM-GC) and Its Advantages in Enhancing Students' Learning

Wei Luo, Northern Illinois University, Illinois, USA. wluo@niu.edu, John Pelletier, University of Arizona, Arizona, USA, Kirk Duffin, Northern Illinois University, Illinois, USA, Carol Ormand, Carleton College, USA, Wei-chen Chung, Northern Illinois University, Illinois, USA., Ellen Iverson, Carleton College, USA, David Shernouff, Rutgers University, USA., Xiaoming Zhai, College of Lake County, USA, Kyle Whalley, Northern Illinois University, Illinois, USA, Courtney Gallerher, Northern Illinois University, Illinois, USA, Walter Furness, Northern Illinois University, Illinois, USA.

The Web-based Interactive Landform Simulation Model – Grand Canyon (WILSIM-GC,http://serc.carleton.edu/landform/) is an educational tool designed to help students better understand the long term past geologic processes that shaped the landform we observe today. It is a continuation and upgrade of the simpler cellular automata (CA) rule-based model (WILSIM-CA, http://www.niu.edu/landform/). Major improvements in WILSIM-GC include adopting a physically based model that simulates bedrock channel erosion, cliff retreat, and base level change and utilizing the recent developments in Java technology (e.g., Java OpenGL, Trusted Applet, and multithreaded capability) that allows for fast computation and dynamic visualization. Students will be able to change the erodibility of the bedrock, contrast in erodibility between hard and soft rock layers, cliff retreat rate, and base level dropping rate. The impact and interaction of these changes on the landform evolution can be observed in animation from different viewing geometry. In addition, cross-sections and profiles at different time intervals can be saved for further quantitative analysis, such as computing channel incision rate, upstream knickpoint migration speed, etc.

WILSIM-GC was tested in an introductory physical geography lab course. Students were randomly assigned to a treatment group (using WILSIM-GC) or a control group (using traditional paper-based material) to learn the land-forming processes in the Grand Canyon. Pre- and post-tests were administered to measure students' understanding of the concepts and processes related to Grand Canyon formation and evolution. Results show that while both the interactive simulation and traditional paper-based approaches appeared to be effective in helping students learn landform evolution processes, there are several advantages and affordances of the simulation approach. The improvement effect from pre- to post-test scores was large for the treatment group, but small to moderate for the control group. In addition, for those questions requiring higher-level thinking, the percentage of students answering correctly was higher in the treatment group than in the control group. Furthermore, responses to the attitudinal survey indicate that students generally favor the interactive simulation approach. These advantages can be leveraged and integrated with traditional methods in designing better curricular materials, including materials for online or hybrid courses and flipped classrooms.

High resolution modeling of overland flow and sediment transport following wildfire

Luke McGuire, USGS Golden, Colorado, USA. lmcguire@usgs.gov, Jason Kean, USGS Golden, Colorado, USA, Dennis Staley, USGS Golden, Colorado, USA, Francis Rengers, USGS Golden, Colorado, USA.

Mountain watersheds that have been recently burned by wildfire often experience greater amounts of runoff, increased rates of sediment transport, and a significantly higher risk for debris flow generation relative to similar unburned areas. Previous work suggests that the redistribution of sediment within hillslope-channel systems by overland flow may play a key role in producing runoff-initiated debris flows, but the physical mechanisms by which water-dominated flows transition to a debris-flows are not well understood. In order to examine the connections between runoff, sediment transport, and debris flow initiation, we developed a numerical model that couples overland flow with sediment transport processes. We applied the model to study erosion from a single rainfall event that produced numerous debris flows within a small, recently burned drainage basin in the San Gabriel Mountains, CA. Input data for the numerical model was constrained by rain gauges, stage measurements at the basin outlet, soil moisture sensors, and soil particle size distribution analyses. Pre- and post-storm basin topography was obtained using high-resolution terrestrial laser scanner data. Numerical model results are quantitatively compared to post-event terrestrial laser scanner data and stage measurements recorded during the event. Our preliminary results show that the magnitude and spatial pattern of model-predicted erosion/deposition compare favorably with the measured topographic change throughout the study area. Additionally, the model predictions suggest that rain splash induced sediment transport was the dominant form of erosion throughout much of the watershed. Based on numerical model predictions, the failure of sediment piles that were generated by preferential deposition within the channel system likely contributed to repeated debris flow initiation throughout the event.

Coastal Eco-System Integrated Compartment Model (ICM)

Ehab Meselhe, The Water Institute of the Gulf, Baton Rouge, Louisiana, USA.

The Integrated Compartment Model (ICM) is a comprehensive and computationally efficient numerical tool that can be used to provide insights about coastal ecosystems and evaluate restoration and protection strategies. It includes physical and ecological processes, such as, hydrology, nutrients, vegetation, and morphology. The ICM can be used to estimate the individual and cumulative effects of restoration projects or strategies on the landscape and ecosystem and the level of impact/risk to communities. The ICM utilizes habitat suitability indices (HSIs) to predict broad spatial patterns of habitat change. It also provides input parameters to a more dynamic fish and shellfish community models to quantitatively predict potential changes in important fishery resources in the future.

The model is also used to examine the impact of climate change and future environmental scenarios (e.g. precipitation, Eustatic sea level rise, subsidence, nutrient loading, riverine runoff, storms, etc.) on the landscape and on the effectiveness of restoration or protection strategies. The ICM is publically accessible code and research groups in the coastal ecosystem restoration and protection field are encouraged to explore its utility as a computationally efficient tool to examine ecosystems' response to physical or ecological changes either due to future projections or to the implementation of restoration strategies.

Formation and establishment of forced sediment patches in high gradient channels

Angel Monsalve, University of Idaho, Idaho, USA. angelmonsalve@gmail.com, Elowyn Yager, University of Idaho, Idaho, USA.

Riverbeds in high gradient channels are often composed of sediment patches, which consist of distinct areas of the bed with relatively narrow grain size distributions and greater sorting compared to the reach. Field, laboratory and theoretical modeling have shown that the presence of sediment patches affects the dynamic of the sediment fluxes, for example patches generate large spatial and temporal variations in bed load composition and transport rates, which then induces changes in the flow and boundary shear stress field. This continuous feedback partially governs the bed surface evolution and can also have biological implications (i.e. salmon spawning). Although sediment-water interactions are affected by sediment patches, rarely are they explicitly included in bed load transport calculations, this is partly due to the fact that their formation and evolution are controlled by mechanisms that are highly temporal and spatially variable, such as shear stress field, hydrograph, turbulence, local grain sorting, and hiding effects. Little is known about how water and sediment adjust to form and establish patches of sediment and what conditions are needed to sustain them. It has been hypothesized, in particular for alternate bars, that shear stress divergence induced by topographic controls is the main driver for the existence of sediment patches. As a consequence of this divergence, the boundary shear stress field is matched by divergences in the sediment transport field, with a cross-stream sediment flux that is size-selective. However, the magnitude of the divergence that initiates the formation of sediment patches is unknown, as is the bed response to different shear stress divergences. We conducted a series of laboratory experiments to study the mechanisms that control the formation of forced patches. Starting from an identical condition, we provide different shear stress divergences (while maintaining the channel's averaged shear stress) to a bed that had a staggered configuration of immobile grains. Patches of sediment formed around these immobile grains and patch grain size distribution, elevation and area responded to the local shear stress field and immobile grain configuration. Patches formed at the upstream face of the immobile grains were coarser than the bed surface texture, while downstream patches were significantly finer. Here we present an analysis and results from a 3D numerical model comparing the flow and sediment transport field around a single immobile grain before and after the establishment of sediment patches. Comparisons between local surface grain size distributions are also presented for a range of shear stress divergences and immobile grain configurations.

GEOSS and its Common Infrastructure

Stefano Nativi, Institute of Atmospheric Pollution Research of the National Research Council of Italy (CNR-IIA)

Established in 2005, GEO (http://www.earthobservations.org/) is a voluntary partnership of governments and organizations that envisions "a future wherein decisions and actions for the benefit of humankind are informed by coordinated, comprehensive and sustained Earth observations and information." GEO Member governments include 96 nations and the European Commission, and 87 Participating Organizations comprised of international bodies with a mandate in Earth observations. Together, the GEO community is creating a Global Earth Observation System of Systems (GEOSS) that will link Earth observation resources world-wide across multiple Societal Benefit Areas - agriculture, biodiversity, climate, disasters, ecosystems, energy, health, water and weather - and make those resources available for better informed decision-making. Through the GEOSS Common Infrastructure (GCI), GEOSS resources, including Earth observation data (satellite, airborne, in situ, models), information services, standards and best practices, can be searched, discovered and accessed by scientists, policy leaders, decision makers, and those who develop and provide information services across the entire spectrum of users. The presentation will cover the GCI overall architecture and some possible future developments.

Integrating data and models with an ensemble Kalman filter to examine Mojave Desert ecohydrology

Crystal Ng, University of Minnesota, Minnesota, USA. gcng@umn.edu

Ecohydrological models that couple soil moisture and plant growth dynamics are needed to examine the vulnerability of desert ecosystems to climate change. However, models can be hindered by structural and parameter errors, and representing deserts is particularly challenging due to unique plant adaptations and marginal moisture conditions. Incorporating field observations with the model is critical for ensuring that simulations produce realistic dynamics. I present a coupled ecohydrological model based on NCAR's CLM4.0-CN [Olesen et al., 2010] that relies on hydrological and ecological data from a Mojave Desert study area to address structural and parameter uncertainty. A new multi-site implementation of the ensemble Kalman filter is developed to condition estimates of plant and soil parameters that are characteristic of the study area. A 50-year hindcast with the model makes it possible to extend the 3.5-year data record in time to examine multi-year relationship between rainfall and plant growth. The simulations also make it possible extend soil moisture data from two points to the full root zone to consider depth-dependent interactions. By combining data and model, we found that the perennial shrub Larrea tridentata (creosote bush) is uniquely adapted to desert conditions. Simulations for the study area show its growth is strongly controlled by ~3-year rainfall totals, which it mostly maintains by immediate uptake of moisture in the upper 80 cm of the soil, but also importantly by using more persistent moisture at 80 to 100 cm depth when available. These results highlighting the potential ecohydrological impact of interannual climate change would not have been possible with either the model or data alone.

Wavelength selection of tidally reversing mega-ripples, field observations and comparison with numerical flow modeling

Jaap Nienhuis, MIT-WHOI, Cambridge, Massachusetts, USA. jhn@mit.edu, Peter Traykovski, WHOI, Woods Hole, USA, Katie Samuelson, MIT-WHOI, Cambridge, Massachusetts, USA, Taylor Perron, MIT, Cambridge, Massachusetts, USA.

Ripples formed by waves and tides are ubiquitous in coastal environments. Recently, significant advances have been made to understand the basic controls of waves on ripple geometry. However, due to the difficulty of making field measurements and the long timescales over which tidal velocity amplitudes change, our understanding of the controls of tides on ripples has thus far been restricted. An improved understanding of the wave and tidal controls on ripple geometry can improve models of coastal sediment transport, and, through study of ripples preserved in the sedimentary archive, help to determine paleoenvironmental conditions. In this study, we combine field observations of ripples with a detailed numerical flow model to investigate tidal controls on ripple wavelength.

Using almost two months of continuous observations of ripples obtained offshore of Martha's Vineyard, we find a surprising dependence of ripple wavelength on tidal velocities. The wavelength during neap tide conditions is 0.4 m, when the maximum tidal velocities are 0.6 ms-1. At spring tide, with tidal currents of about

1 ms-1 close to the bed, the wavelength grows fivefold to more than 2 m. Because these ripples reverse every half-tidal cycle, and because the ripple wavelength is substantially longer than current ripples, we call these features tidally reversing mega-ripples. We have used a lattice Boltzmann model of turbulent flow across these features to study the influence of tidal currents on the flow separation zone downstream of the crest. For single ripples, flow velocities have a negligible influence on the separation vortices that develop. This is in agreement with flume observations and earlier numerical models of flow across bed forms. Surprisingly, however, when we place two ripples behind each other, we observe that vortices being shed off the upstream ripple increase the shear stress at the ripple crest downstream. We found that there exists a critical spacing at which the crest shear stress, and by extension, ripple migration rate, are equal for two subsequent ripples. This critical spacing coincides with our field observations of ripple wavelength during tidal conditions.

Landscape Evolution in Response to Laccolith Inflation: Insights from Numerical Modeling with Application to the Colorado Plateau

Daniel O'Hara, University of Oregon, Oregon, USA. dohara@uoregon.edu, Leif Karlstrom, University of Oregon, Oregon, USA, Benjamin Black, University of California, Berkeley California, USA, Kendra Murray, University of Arizona, Arizona, USA.

Laccoliths are shallow plutonic structures that uplift and deform overlying horizontal and near-horizontal strata, proposed to develop through short (possibly < 100 yr) episodic magmatic events. Numerous laccoliths ranging in age ~25-35 Ma occur around the rim of the Colorado Plateau. These structures provide a natural laboratory for studying localized dynamic topography that occurs on a smaller scale than typical drainage basin size. The coupling between initial river drainage geometry, laccolith emplacement rate and intrusion size on drainage development is poorly understood. Our research aims to understand the effect of an uplifting laccolith on pre-existing, steady state topography, both to constrain magmatic rates of processes and also the geometry of the paleo landscape.

Using a bedrock landscape evolution model, we vary initial drainage geometries, laccolith shapes and sizes, and laccolith emplacement timescales to study drainage response to topography. We analyze the underlying equations that govern bedrock landscape evolution, as well as characteristics of the resulting river networks such as drainage area, drainage divides, and channel orientations and longitudinal profiles. These are used to develop metrics that characterize the drainage disruption caused by the laccolith, the effect of initial drainage geometry on laccolith erosion, and the timescales of inflation and landscape erosional response. We then apply our results to the Colorado Plateau, in particular, Mt. Hillers (Henry Mountains, UT) and Navajo Mountain (UT) to understand their emplacement rate, landscape response to inflation, and paleo drainage networks.

Modes of extensional faulting controlled by surface processes

Jean-Arthur Olive, MIT / WHOI Joint Program in Oceanography, Massachusetts, USA., Mark D. Behn, WHOI, Woods Hole, Massachusetts, USA, Luca C. Malatesta, Caltech, Pasedena, California, USA.

We investigate the feedbacks between surface processes and tectonics in an extensional setting by coupling a 2-D geodynamical model with a landscape evolution law. Focusing on the evolution of a single normal fault, we show that surface processes significantly enhance the amount of horizontal extension a fault can accommodate before being abandoned in favor of a new fault. In simulations with very slow erosion rates, a 15 km- thick brittle layer extends via a succession of crosscutting short-lived faults (heave < 5 km). By contrast, when erosion rates are comparable to the regional extension velocity deformation is accommodated on long-lived faults (heave >10 km). Using simple scaling arguments, we quantify the effect of surface mass removal on the force balance acting on a growing normal fault. This leads us to propose that the major range-bounding normal faults observed in many continental rifts owe their large offsets to erosional and depositional processes.

Bringing earth surface processes simulations to large audiences

Irina Overeem, University of Colorado, INSTAAR, CSDMS, Colorado, USA. irina.overeem@colorado.edu, Lauren Borkowski, University of Colorado, INSTAAR, CSDMS, Colorado, USA, Albert Kettner, University of Colorado, INSTAAR, CSDMS, Colorado, USA, Beth Russell, NOAA, Colorado, USA, Hilary Peddicord, NOAA, Colorado, USA.

The Community Surface Dynamics Modeling System has a strong mandate to share state-of-the-art earth surface process modeling results with large audiences. One of the possible platforms to reach audiences much beyond the science community is through museum displays.

CSDMS has developed several model simulation datasets for the 'Science on a Sphere' system. 'Science on a Sphere' (SOS) consist of a large 4 ft diameter suspended globe on which global and regional simulations can be projected. SOS has been developed by NOAA and is now featured in over 100 locations worldwide, mostly in science museums and large research facilities. The SOS team at the Earth System Research Lab at NOAA estimates that >33 million people see these displays every year. In addition, the data catalogue features stand-alone downloadable movies and educational materials for teachers to use in their own class-rooms.

We contributed global simulations and datasets to the Science on a Sphere data catalogue. Examples include hydrological processes, coastal processes, and human interactions with the earth surface environment. Model simulations of a global hydrological and sediment transport model (WBM-SED) illustrate global river discharge patterns. WAVEWATCH III simulations have been specifically processed to show the impacts of hurricanes on ocean waves, with focus on hurricane Katrina and superstorm Sandy. A large world dataset of dams and reservoirs built over the last two centuries gives an impression of the profound influence of humans on water management.

Visualizations are developed with Python scripts and comply to well-published data submission protocols of NOAA, mostly the scripts are unique for each specific model dataset. Datasets story boards and teacher follow-up materials associated with the simulations are developed to address common core science standards. CSDMS contributions aim to familiarize large audiences with the use of coupled numerical modeling as a tool to create insight and understanding of environmental processes, and aim to explicitly educate about models as a predictive tool. This presentations showcases the CSDMS contributions to the Science on a Sphere data catalogue, shares insights on the workflow of getting simulations submitted to the SOS repository, and invites discussion and ideas from community members to develop new simulation datasets.

Extreme Floods as Agents of Landscape Evolution: Modeling the 2013 Front Range Flood, Colorado, USA

Mariela Perignon, University of Colorado, Colorado, USA. perignon@colorado.edu, Greg Tucker, University of Colorado, Colorado, USA.

In September 2013, five days of near-continuous precipitation across the northern Front Range of Colorado caused widespread flooding and triggered numerous debris flows within mountain catchments. Quantitative observations suggest that the hydrologic conditions and patterns of geomorphic activity varied dramatically, even between closely spaced basins. While the largest watersheds experienced very high discharges, many of the smaller ones suffered more significant landscape change and mobilized very large volumes of sediment.

We explore the temporal and spatial patterns of geomorphic activity across the region to identify the characteristics that determine the response of any given catchment to an extreme precipitation event. Understanding the mechanisms that govern their behavior during these single, intense events, is necessary for deciphering the processes that direct the evolution of the whole landscape over centuries to millennia.

We propose that the differences in their behavior result from the position of the basins relative to the spatial distribution of snowmelt and summer thunderstorm activity, as well as the size of the catchments compared to the footprint of summer thunderstorms.

We focused our analysis on five major basins along the northern Front Range of Colorado. We characterized the typical drivers of landscape evolution across the region by determining the relative importance of climatic drivers for runoff generation in sub-basins of all sizes. To understand the impact that this large event had on the landscape, we compiled hourly rainfall data for the week of the 2013 storm across the state and reconstructed the spatial and temporal patterns of precipitation over this period. We compared these results to long-term averages of summer and winter precipitation to infer the relative importance of this rare event in the short-term evolution of the landscape. To quantify the effects of this event on channel morphology, we simulated the generation and routing of this flood in each of the five major basins by driving the ANUGA hydrodynamic model with the reconstructed precipitation patterns. By calibrating the model results against real-world measurements of discharge at stream gages, we obtained an estimate of rainfall losses to infiltration and other processes. Finally, we used the reconstructions of streamflow and flooding patterns to infer the magnitude of sediment transport that would have been possible during this flood. By simulating the behavior of flow across the region during a rare and extreme precipitation event, we are able to extrapolate observations of modern-day geomorphic activity into a long-term history of the evolution of the landscape.

River-ocean interactions: Building a new morphodynamic delta model

Katherine Ratliff, Duke University, North Carolina, USA. k.ratliff@duke.edu, Brad Murray, Duke University, North Carolina, USA.

Deltas are among the most densely populated landscapes on earth, yet their morphology and inhabitants are increasingly susceptible to natural disasters, in part because of anthropogenic interactions with fluvial, coastal, and wetland processes. Humans have altered the natural course of many rivers via dams, channelization, and artificial levees, which can super-elevate the river above its floodplain. Rates of channel aggradation and backfilling increase as the relative sea-level rise rate (RSLRR) increases, potentially increasing the rate of flooding and avulsions. In order to investigate these effects on river and delta morphology, we have created a new river module based on steepest-decent methodology (Jerolmack and Paola, 2007) that incorporates floodplain deposition and avulsion processes. Preliminary results simulating anthropogenic manipulations of the river (e.g. inhibiting avulsions) show that the effects of artificial levees propagate hundreds of kilometers upstream. Results also indicate that avulsions reach farther upstream under higher RSLRR, and decreased subsidence rates result in more rapid avulsions. As a first step in developing a new 3D ecomorphodynamic delta model, we aim to couple this module with the 3D mode of Sedflux (Hutton and Syvitski, 2008). The new medium-detail model will be based on further model couplings, including vegetation, coastline, and human-dynamics modules. We plain to test, improve, and calibrate model and its parameterizations based on empirical data from the field and laboratory experiments.

Hutton, E, and J Syvitski (2008), Sedflux 2.0: An advanced process-response model that generates three-dimensional stratigraphy, Comput. Geosci. 34(10) 1319-1337.

Jerolmack, D, and C Paola (2007), Complexity in a cellular model of river avulsion, Geomorphology 91(3), 259-270.

Sediment Deposition in the Cretaceous North Sea – a Modelling Approach

Salik Anders Rosing, University of Copenhagen, Copenhagen, Denmark. salik@ign.ku.dk, Kresten Anderskouv, Centre for Cross-disciplinary Chalk Research and Institute of Geosciences and Natural Resources Management, University of Copenhagen, Denmark, Christian J. Bjerrum, Centre for Cross-disciplinary Chalk Research and Institute of Geosciences and Natural Resources Management, University of Copenhagen, Denmark, Courtney K. Harris, Virginia Institute of Marine Science, Virginia, USA.

The Upper Cretaceous (~100-66 Ma) of Northwest Europe is characterized by thick successions of chalk, a biogenic pelagic sediment consisting of shell fragments of coccolithophores, a group of haptophyte primary producers. These deposits serve as important reservoirs for hydrocarbons and ground water. In recent decades, it has become clear that these deposits were shaped by depth contour following currents and gravity flows, and not simply a result of uniformly vertical settling of coccoliths (Surlyk and Lykke-Andersen, 2006), leading to spatial variability in reservoir properties

It has been conjectured, that the warm Cretaceous Greenhouse climate and high sea level resulted in the breakdown of the oceanographic front at the continental shelf edge, as we know it today in mid-latitude areas (Hay, 2008)). Furthermore, the deep shelf conditions and very warm seasons most likely resulted in the continental shelf seas having a stratified structure similar to that of the open oceans, leading to a thinning of the surface Ekman layer. With warmer climate, evaporation on stratified continental shelf seas may have resulted in preconditioning of the waters where winter cooling may have caused cascading of dense, higher-salinity coastal waters. Such cascading may have resulted in significant oxygenation of deeper shelf waters and lead to depth contour following currents in the intermediate waters in and below the pycnocline.

Here we explore a modelling approach to assessing the quantitative physical basis for these conjectures. The 3D Regional Ocean Modeling System (ROMS) is coupled to a sediment transport module permitting assessment of the oceanographic processes influencing the chalk thickness variation as a function of idealized shelf bathymetry configurations. The numerical modeling grid is configured to represent the overall geometry of the paleo-North Sea during the Late Cretaceous. Model forcing for seasonal variations in winds, freshwater fluxes and temperature is informed by results from global climate models of the late Cretaceous, while the critical shear stress and settling velocity of chalk ooze is derived from experimental values.

Quantifying topographic anisotropy at multiple scales

Samuel Roy, University of Maine, Maine, USA. samuel.g.roy@umit.maine.edu, Peter Koons, University of Maine, Maine, USA, Bipush Osti, University of Maine, Maine, USA, Phaedra Upton, GNS, New Zealand, Gregory Tucker, CIRES, University of Colorado, Colorado, USA.

We present a method for quantifying orientation and scale dependence of topographic anisotropy to aid in differentiation of the fluvial and tectonic contributions to surface evolution. Using multi-directional variogram statistics to track the spatial persistence of elevation values across a landscape, we calculate anisotropy as a multiscale, direction-sensitive variance in elevation between two points on a surface. Tectonically derived topographic anisotropy is associated with the three-dimensional kinematic field, which contributes 1) differential surface displacement and 2) crustal weakening along shear zones, both of which amplify processes of surface erosion. Based on our analysis, tectonic displacements dominate the topographic field at the scale of mountain ranges, while a combination of the local displacement and strength fields are well represented at the ridge and valley scale. Drainage network patterns tend to reflect the geometry of underlying active or inactive tectonic structures due to the rapid erosion of faults and differential displacement across the fault. The persistence and complexity of correlated anisotropic signals depends on how the strain field evolves with time: new tectonic regimes can overprint the original topographic signal, or the signal can slowly recede as tectonism halts. Regions that have been largely devoid of strain, such as passive coastal margins, have predominantly isotropic topography with typically dendritic drainage network patterns. These methods can be used successfully to infer the settings of past or present tectonic regimes, and can be particularly useful in predicting the location and orientation of structural features that would otherwise be impossible to interpret in the field.

Development of hydrologic and water quality models for sustainable Integrated Water Resources Management

Shimelis Setegn, Florida International Univeirisity, Florida, USA. ssetegn@fiu.edu

Availability and distribution of freshwater resources to meet all consumptive and non-consumptive needs is a global challenge facing many nations. This challenge is further complicated at a time when demands for freshwater are increasing due to population growth and the need for more food production in the face of uncertainty of rainfall in a changing climate. The vulnerability of the Caribbean islands to natural and human-induced disasters and their inability to cope with the problem necessitates an understanding of the hydrological processes and responses of the watersheds to various stressors. Sustainable planning and management are essential for sustainability of fresh water resources in the watersheds. The main objective of this study is to develop a hydrological model and analyze the spatiotemporal variability of hydrological processes in selected watersheds of Haiti. The project will develop physically-based hydrologic and water quality models.

Challenges and a solution in coupling dissimilar models for complex planning policy analysis

Harutyun Shahumyan, University of Maryland, Maryland, USA. harut@umd.edu, Rolf Moeckel, University of Maryland, Maryland, USA.

Close model integration has become the mantra among model developers. New tools under development, such as CSDMS or OpenMI, promote tight integration of very different models and ease information transfer between the same. Continuously increasing computational capacities enable ever more comprehensive model integrations. From a technical perspective, the prospects of tight model integration are excellent. However, the research presented also exemplified limitations of model integration.

Python wrappers were developed to loosely couple land use, transportation and emission models developed in different environments. ArcGIS Model Builder was used to provide a graphical user interface and to present the models' links and workflow. With the use of Python wrappers, the implementation of the coupler is separated from the models' source codes. This gives an additional flexibility, which can help in terms of portability, performance and maintenance of the codes. Though some limitations, this system supports different types of components and links them under a single user interface without changing their original source codes. The integrated system calls automatically component models developed in Java, Cube script, MS Excel and C++ environments.

The suggested approach is especially efficient when the models are developed in different programming languages, their source code is not available or the licensing restrictions make other coupling approaches infeasible. Though this research focuses on dynamic spatial models that integrate transportation, land use and environmental impact models, the methodology is not limited to this type of systems. It can also be applied to other systems requiring consecutive implementation of standalone components including non-spatial models. Notwithstanding the ability to run complex model scenarios, the probably most important lesson learned of this research refers to the level of model integration. A key finding of this research is that model integration should depend on direction of information exchange and frequency of data flows. While this simple but robust loose integration method has satisfied the project's initial goals, further tighter integration within the CSDMS is currently explored in the view of enhancing the models performance and data exchange speed as well as to widen their scope of applications.

Comparing morphologic and stratigraphic field data from a tectonic basin on the Ganges-Brahmaputra River delta with results from a reduced-complexity model for river delta formation

Ryan Sincavage, Vanderbilt University, Tennessee, USA. ryan.s.sincavage@vanderbilt.edu, Carol Wilson, *Vanderbilt University, Tennessee, USA, Man Liang, University of Texas Austin Austin Texas, USA, Paola Passalacqua, University of Texas at Austin, Texas, USA, Steven Goodbred, Vanderbilt University, Tennessee, USA.*

Sylhet Basin in northeastern Bangladesh contains an archive of Holocene sediment deposited by the Brahmaputra River during episodic occupations of this subsiding basin. Geochemical and lithologic analyses of samples from more than 300 closely-spaced (3-5 km) boreholes have been used to delineate three discrete channel occupations confined to two sediment "fairways" within Sylhet Basin over the past ~10,000 years. A well-defined break in topography has been identified along these fairways, distinguishing a steeper (~10–4) upper fan delta from a lower gradient (~10–5) backwater-reach delta. This break in topography corresponds to a change from rapid to slow rate of downstream fining in Holocene sediments, perhaps representing the distal limit of mass extraction of bedload material. Furthermore, this break in slope roughly correlates with start of the backwater transition as calculated by a variety of methods. Stratigraphy along this reach of Sylhet Basin is characterized by 20-30 m thick early Holocene muds overlain by 30 m of amalgamated channel sands deposited during a prolonged (2-3 kyr) occupation of the basin during the mid Holocene. This stratigraphic succession is consistent with recent reduced-complexity model results of fluvial systems avulsing to infill an existing topographic basin. Similar model runs involving an actively subsiding basin (rate high enough to accommodate all incoming sediment) generate an attraction of channels towards the subsidence maximum not observed with the static basin. Based on modern sediment discharge of the Brahmaputra River, volume of the amalgamated channel sands (30 m thick x 80 km wide) formed during the mid-Holocene occupation of Sylhet basin is insufficient to account for the entire sediment budget, likely indicating bypass of the basin to its downstream outlet along the Meghna River, or that discharge was reduced during a the mid-late Holocene weakening of the monsoon. We therefore conclude that the subsidence rate of Sylhet Basin is sufficiently slow relative to sediment input such that the preserved stratigraphy and channel avulsion history are more characteristic of models exhibiting static basin topography than of active subsidence at rates comparable mass deposition. Future modeling scenarios will use the Sylhet Basin stratigraphic data to investigate the role of backwater on morphodynamic channel behavior and the resulting influence on downstream changes in net to gross values and stratal architecture.

Quantifying the influence of land use/land cover change on inland flooding occurrence and severity following hurricane events using a physically-based hydrology-hydraulics model

Monica Stone, University of Alabama, Alabama, USA. mhstone@crimson.ua.edu, Sagy Cohen, University of Alabama, Alabama, USA.

Tropical cyclones are the most severe rain events that impact the Southeast USA and often cause widespread flooding. These storms are the most costly weather hazards that occur in the USA, and the subsequent flooding is the leading cause of death from natural hazards in the USA. Most past research has focused on predicting storm surge following tropical cyclone events, but not much research has been conducted to study the affects of tropical cyclones on inland-river flooding in the Southeast USA, or how inland-river flooding following these storms is likely to change in the near future. Both the expected increase in tropical cyclone intensity with global climate warming, and future changes in land use/land cover are likely to alter flooding conditions following tropical cyclones. Here we present initial results from a study that aims to quantify the impact of increased precipitation, from tropical cyclone intensification, and changes in land use/land cover have on flooding magnitude and duration in 4 basins in the Southeast USA. This study utilizes the LISFLOOD model, a GIS hydrological rainfall-routing model, developed for flood forecasting and assessment of the effects of land use/land cover change and climate change on flooding conditions in a catchment. A sensitivity analysis was conducted using hypothetical land use/land cover scenarios in order to elucidate the influence of different land use/land cover types on tropical cyclone flooding magnitude and duration in the selected basins. Future efforts will focus on predicting hydrological conditions in the selected basins for 2100 given climate-induced tropical cyclone intensification, as well as possible land use/land cover change. The LISFLOOD model will be used again on the historical hydrological data for the selected basins: first just increasing precipitation rates during tropical cyclone events, second just changing the land use/land cover to that predicted for 2100, and third altering both the precipitation rates and the land use/land cover. While this research is still in progress, preliminary results suggest that tropical cyclone floods typically have a higher magnitude and a longer duration, and that this is likely to increase with both increased precipitation rates and increased urbanization in 2100. This study will help address the National Science Board's call for a "[prediction of]… inland flooding from hurricanes and tropical storms," and will hopefully help inform future mitigation and preparedness efforts.

Signals of Relative Sea Level perturbations: Defining the divide between autogenic signal shredding vs. preservation in the stratigraphic record

Kyle Straub, Tulane University, Louisiana, USA, Qi Li, Tulane University, Louisiana, USA. qli1@tulane.edu

Recent theoretical work suggests that autogenic processes in sediment transport systems have the capacity to shred signals of environmental and tectonic perturbations prior to transfer to the stratigraphic record. We view this theory as a major conceptual and quantitative breakthrough in long time scale Earth-surface processes and stratigraphy, but the general theory still needs to be adapted to deal with specific types of signals. Many argue that the tug of Relative Sea Level (RSL) change represents the most important boundary condition forcing affecting continental margin transport systems. However, we still lack quantitative theory to explain what properties RSL cycles must have to be stored in stratigraphy, thus limiting the usefulness of stratigraphy for defining paleo-environments. Results from our previously conducted laboratory experiments suggest that RSL cycles with amplitudes less than a channel depth and of periodicities less than the amount of time necessary to deposit, on average, one channel depth of stratigraphy over a delta-top are susceptible to signal shredding. Our hypothesis is supported using existing data sets and new numerical and physical experiments in which the surface process response and preserved record of RSL cycles of varying magnitudes and periodicities are constrained. Quantitative theory and predictions produced from this work is benchmarked against stratigraphy from the Late Miocene to Quaternary stratigraphy of the Mississippi Delta. During this time interval a significant change in the magnitude and periodicity of RSL cycles occurred. RSL cycles in the Late Miocene for the Mississippi Delta are predicted to be shredded, while more recent cycles are predicted to be preserved.

Secondary current simulations in open channels with different bed roughness configurations

Mahdad Talebpour, Penn State University State College Pennsylvania, USA. mxt982@psu.edu

Secondary current in open channels have been long recognized as an important mechanism to alter the path of sediment particle motion and consequently change the river and land surface evolution. Researchers have identified two different kinds of secondary current: the first kind due to curvature in a river bend and the second kind due to turbulence anisotropy. This paper deals with the second kind in a straight open channel. Despite the continuous research effort, the mechanism is still not fully understood. One of the intriguing features is that in natural channels, the co-evolution of the river and the bed, and more importantly the differential transport of sediment mixture, often result in the the non-homogeneous distribution of roughness on the channel bottom. The mutual influence of secondary current and bed roughness is of great interest to geologists and hydraulic engineering researchers. This paper aims to map the details of the flow field using a computational model equipped with a new nonlinear $k-\omega$ model. This nonlinear model is designed to take into account the anisotropy of turbulence and since it is written in $k-\omega$ formulation, it can be integrated all the way to the wall. Low-Reynolds number (LRN) form of the model also makes it unnecessary to use a wall-function, which breaks down in many cases. The roughness effect on the turbulence is through a simple relationship for the 'omega' boundary condition. The aim of this work is first to test the model in the context of riverine flows, and second to calibrate the model so it can be used with roughness patches. It is found the new turbulence model is capable to generate and maintain the secondary current. This paper will present the calibration result against classic experimental data. The results suggest the model is somewhat sensitive to the boundary condition on the bottom and less so to the free surface. As speculated in the many theories and observed in experiments, the simulation confirms that the secondary current above a non-homogeneous bed is mainly driven by the current generation near the bed and then a cellular motion is induced by the virtue of continuity. In other words, the anisotropy of turbulence near the free surface only plays a secondary role. The calibrated simulation results are further used for more detailed analysis on the momentum and vorticity budget.

Including fine-grained sediment processes within numerical representations of a partially-mixed estuary, the York River, Virginia

Danielle Tarpley, Virginia Institute of Marine Science, Virginia, USA. drtarpley@vims.edu, Courtney Harris, Virginia Institute of Marine Science, Virginia, USA, Carl Friedrichs, Virginia Institute of Marine Science, Virginia, USA, Kelsey Fall, Virginia Institute of Marine Science, Virginia, USA.

The Community Sediment Transport Modeling System (CSTMS) is being used to represent conditions in the York River, Virginia, a partially-mixed tidal tributary of Chesapeake Bay. Our modeling approach includes both an idealized two-dimensional longitudinal representation of the estuary, and a more realistic full three-dimensional model of the York River. Both have been implemented using versions of the Regional Ocean Modeling System (ROMS). Our modeling efforts have been motivated by a rich set of observation data from in-situ measurements made by acoustic Doppler velocimeters (ADVs), a pulse coherent acoustic Doppler profiler (PC-ADP), a laser in-situ scattering and transmissometry (LISST), and a particle imaging camera system (PICS). Additionally, water column and bed inventories of Beryllium-7 will be used to constrain the three-dimensional model parameters.

Within the full three-dimensional model, hydrologic conditions, physical forcing, and sediment characteristics are being used to examine spatial and temporal changes in sediment dynamics in the York River estuary. This version of the CSTMS accounts for suspended transport, erosion, deposition and cohesive processes via consolidation and swelling of the sediment bed, which change the critical shear stress of the seafloor in response to sedimentation. Adjustments to the open boundary conditions for salinity and wind forcing produced model estimates for the summer 2007 that show good agreement with observed sediment concentration, bed stress and other hydrological parameters. We analyzed the sensitivity of calculations of the total eroded mass to the bed consolidation time scale and the critical shear stress for erosion. Further analysis showed model sensitivities to the swelling time scale and the user defined initial and equilibrium critical shear stress profiles.

The idealized two-dimensional model is being developed within the Coupled Ocean-Atmosphere-Waves-Sediment Transport (COAWST) version of the ROMS model family. The idealized model represents a longitudinal section of a partially mixed estuary, accounting for a freshwater source, tides, and estuarine circulation, but neglecting across-channel variations. The impact of sediment-induced stratification and the flocculation of cohesive sediments on depositional patterns will be evaluated through the addition of these two processes into the two-dimensional model. This simplified model will be used as a platform for implementing code to account for sediment-induced stratification and flocculation processes within the CSTMS framework, including our three-dimensional CSTMS model of the York River estuary.

A graph-theoretic approach to Studying Deltaic Systems: Quantifying Complexity and Self-Organization.

Alejandro Tejedor, University of Minnesota, Minnesota, USA. alej.tejedor@gmail.com, Anthony Longjas, University of Minnesota, Minnesota, USA, Ilya Zaliapin, University of Reno, Nevada, USA, Efi Foufoula-Georgiou, University of Minnesota, Minnesota, USA.

River deltas are intricate landscapes with complex channel networks that self-organize to deliver water, sediment, and nutrients from the apex to the delta top and eventually to the coastal zone. Most of the deltas are subject to anthropogenic and natural perturbations causing topological and dynamical changes in the delta structure and function. Conceptualizing a delta channel network as a directed graph where channels are modeled by edges and junctions by vertices, we present a quantitative framework based on spectral graph theory within which a systematic study of the topology and transport dynamics of river deltas can be performed. Specifically, this framework allows us, from algebraic computations, to depict structural features of the delta system such as sub-networks (from apex to shoreline outlets), and contributing and nourishing areas. We also introduce metrics of topologic and dynamic complexity and define a multidimensional complexity space where each delta projects. The aim is to decode in this space the information stored in the delta connectivity as imprinted by the morphodynamic processes (e.g., river, tide, waved dominated) and other physical parameters of the system (e.g. sediment cohesiveness).

The Earth's surface is a boundary layer between internally-driven geodynamics and atmospheric forcing. In much of what we do as landscape modellers, our analysis of Earth surface can be enhanced by consideration and understanding of the substrate acted upon by hillslope, riverine and glacial processes. To explore the influence of crustal strength on patterns of fluvial incision, we use a conservative scaling rule to relate rock erodibility to field measurements of cohesive strength. In other models, grain sizes produced upon the erosion of rock are made a function of field measured fracture density values. By combining 3D geodynamic codes with landscape evolution models we are able to explore the sensitivity of surface processes to topographic and tectonic stresses, geological history, fault damage, seismic accelerations, pore pressures, and fluid flow. We present several examples where useful interpretations were made by integrating field, lab, and experimental data with geodynamic models, landscape evolution models, or a combination of both. Our examples are bias toward collisional settings – the Himalaya, the Southern Alps and Taiwan, but the approach is equally valid when considering strike-slip or extensional settings.

Models meet Data, Earth Surface meet Geodynamics

Phaedra Upton, GNS Science, New Zealand, Peter O. Koons, Sam G. Roy, Jamie D. Howarth, Dave Craw

The Earth's surface is a boundary layer between internally-driven geodynamics and atmospheric forcing. In much of what we do as landscape modellers, our analysis of Earth surface can be enhanced by consideration and understanding of the substrate acted upon by hillslope, riverine and glacial processes. To explore the influence of crustal strength on patterns of fluvial incision, we use a conservative scaling rule to relate rock erodibility to field measurements of cohesive strength. In other models, grain sizes produced upon the erosion of rock are made a function of field measured fracture density values. By combining 3D geodynamic codes with landscape evolution models we are able to explore the sensitivity of surface processes to topographic and tectonic stresses, geological history, fault damage, seismic accelerations, pore pressures, and fluid flow. We present several examples where useful interpretations were made by integrating field, lab, and experimental data with geodynamic models, landscape evolution models, or a combination of both. Our examples are bias toward collisional settings – the Himalaya, the Southern Alps and Taiwan, but the approach is equally valid when considering strike-slip or extensional settings.

Soil carbon in the Critical Zone: spinning up an ecohydrologic model using spatiotemporally distributed data records

Reggie Walters, Boise State University, Idaho, USA. reggiewalters@u.boisestate.edu, Alejandro Flores, Boise State University, Idaho, USA.

The Critical Zone is the region of the earth comprising all materials and processes from the top of the vegetative canopy to the top of the water table. Here, the fate of carbon (C) stored in soils is subject to appreciable uncertainty due to incomplete process understanding and representation in biogeochemical and earth system models. Since the size of the global soil C pool exceeds that of the atmospheric reservoir, this resource has considerable potential to act as either a source or a sink of CO2 under future scenarios, lending positive or negative feedbacks to climate change. This study applies a terrestrial water, C, and nitrogen model (Biome-BGC) across the Reynolds Creek Critical Zone Observatory (CZO), an experimental watershed (238 km^2) located in southwest Idaho, USA. Reynolds Creek Experimental Watershed (RCEW) is maintained by the USDA Agricultural Research Service (ARS) offering spatially and temporally extensive datasets that are invaluable for model forcing and parameterization. Model spin-up is performed using a 26-year distributed meteorological dataset in conjunction with site-specific soil and vegetation information. Methods and results for meteorological station spatial distribution are discussed along with preliminary equilibrium soil C state estimates for comparison with point field observations. Model parameter sensitivities are also explored with the goal of informing ongoing CZO field research and offering insight into the processes controlling soil C storage and turnover within this semi-arid region.

Bedload sediment modeling at a global scale based on the WBMsed model

Tong Wan, University of Alabama, Alabama, USA. twan@crimson.ua.edu, Cohen Sagy, University of Alabama, Alabama, USA.

River sediment dynamics is a key driver in fluvial and terrestrial research. Sediment indicators are often used in determining river change regime and sequentially river evolution. Since only a small fraction of global rivers are monitored for their sediment dynamics, our understanding of the processes and drivers affecting large global rivers is still lacking. Numerical modeling can remedy some of these observational deficiencies but remain a challenge, particularly at large, global scales. Bedload transport accounts for less than 10% of the fluvial sediment transferred from continental uplands to continental margins on a continental scale, however it is an important component of fluvial sediment budget for its important role in many fluvial processes and its key influence on river morphodynamics. Here we present a first-order global scale riverine bedload flux model. We are developing a bedload module within the WBMsed modeling framework based on existed bedload formulas. One of the key challenges in accurately solving bedload formulae at course spatial scales is accurate description of riverbed slope. Here we present a novel global riverine slope layer which we will use as input to the WBMsed model. Future work will include an extensive validation procedure based on observed data and global scale analysis of bedload flux dynamics.

Assessing the water balance of Dry Creek Experimental Watershed via an integrated modeling system

Katelyn Watson, Boise State University, Idaho, USA. katelynwatson@u.boisestate.edu, Miguel Aguayo, Boise State University, Idaho, USA, Alejandro Flores, Boise State University, Idaho, USA.

A significant limitation in many efforts to use physically based distributed hydrologic models, particularly in regions of complex terrain, is the complete lack of meteorologic forcing data at sufficiently fine spatial resolution approaching the correlation scales of meteorologic phenomena. Observational weather and climate data in mountainous regions are typically sparse, temporally discontinuous, and often poorly representative of the domain of interest. Increasingly, output from numerical weather prediction models is used as input to these hydrologic models. This approach, while computationally intensive, leads to internally and physically consistent environmental forcing variables distributed over the landscape at remote and ungauged areas. These data can then be used to feed sophisticated models of surface-subsurface hydrology. While an attractive alternative from the perspective of providing spatially and serially complete data, there are a number of unresolved issues associated with this “one-way” coupling of models. In order to explore some of the issues associated with this workflow, we are conducting a series of simulations to integrate an open-source, high spatial-resolution surface-subsurface hydrology model (ParFlow) with the Weather Research Forecasting (WRF) model. WRF is a sophisticated community regional weather and climate model that simulates environmental forcings required as input to the ParFlow model. We apply this modeling system to the Dry Creek Experimental Watershed located in the Boise foothills for the 2009 water year. Precipitation, snow and soil storage, and streamflows are evaluated using observational data from the experimental watershed to assess the performance of the modeling system. Performing these coupled model experiments in this high-relief experimental watershed will allow us to investigate not only the overall performance of the modeling system, but also the influence of varying the spatial resolution of WRF forcing information.

Quantifying the spatial distribution of bed properties in shallow coastal bays

Patricia Wiberg, University of Virginia, Virginia, USA. pw3c@virginia.edu, Joel Carr, University of Virginia, Virginia, USA, Ilgar Safak, University of Virginia, Virginia, USA.

Sediment resuspension and related increases in turbidity in shallow coastal bays are strongly controlled by local bed properties. However, knowledge of bed properties in coastal bays is typically sparse at best. In this study we developed a method to estimate the spatial distribution of bed properties in shallow coastal bays using a combination of bed sediment measurements and residence time calculations that requires neither extensive dedicated modeling nor extensive sampling. We found a strong relationship between water residence times derived from a coastal hydrodynamic model and observed bed grain size fractions in a system of coastal bays and used that relationship to transform maps of residence time to maps of grain size fractions throughout the bays. Because grain-size fractions are related to other bed properties such as organic fraction, permeability and cohesion, these maps provide valuable information for habitat studies as well as morphodynamic modeling.

Developing a soils-regolith evolution model for the design of covers for hazardous and nuclear waste containment facilities

Garry Willgoose, The University of Newcastle, Australia. garry.willgoose@newcastle.edu.au, Dimuth Welivitiya, The University of Newcastle, Australia, Greg Hancock, The University of Newcastle, Australia, Sagy Cohen, The University of Alabama, Alabama, USA.

Low-level nuclear waste and uranium mining tailings repositories are required to provide containment of waste for 10,000 years. This is sufficient for significant geomorphic evolution to have occurred and for materials in the containment facilities cover to change from as constructed. During the 1990's our group pioneered the use of landform evolution models for the design of such facilities. In the last decade our group has focused on the evolution of the material properties of the cover, typically some form of rocky artificial soil. This poster (and movies associated with) will highlight our models (mARM, SSSPAM) for regolith and soils evolution under the impacts of erosion and weathering over these timescales. These models are able to simulate the evolution of the grading of the soil profile with depth and over catchment scale using data from field and lab experiments. The specific focus of this poster will be current work on the dynamics of the soil evolution process and what are the dominant processes controlling profile development and spatial organisation. Results for the proposed tailings repository at Ranger Uranium Mine will be shown.

Exploring the Impacts of Hurricanes and Cold Fronts on the Morphological Evolution of the Wax Lake Delta, LA

Fei Xing, CSDMS, INSTAAR, University of Colorado, Colorado, USA. Fei.Xing@colorado.edu, James Syvitski, CSDMS, INSTAAR, Univ. of Colorado, Colorado, USA, Albert Kettner, CSDMS, INSTAAR, Univ. of Colorado, Colorado, USA, Ehab Meselhe, The Water Institute of the Gulf, Louisiana, USA.

Tropical cyclones (e.g. hurricane) and winter cold fronts are the two major weather systems influencing morphology of the coastal wetlands along the Gulf of Mexico. Delft3D is applied to the Wax Lake Delta (WLD), Louisiana, to study the impact of coastal storms with different magnitudes and frequencies on wetland morphology. Our simulations of a strong cold front (mean wind speed of 11.4 m/s) and a single hurricane event (Hurricane Ike, made landfall 337 km to the west of the WLD as a Category 2 Hurricane) demonstrate that although the hurricane event causes more sediment transport, many similarities exist between the two events: winds and waves significantly increase the amount of sediment transport; erosion occurs on islands; negative sediment balance for the WLD system (erosion). The simulations of 11 cold fronts between the 2008-2009 season show that cold fronts that cause significant water level variations produce stronger residual currents and move more sediment than events that causes minor water level variations, and that mean wind speeds are positively correlated with hourly averaged erosion and deposition caused by winds and waves (R2 of 0.94 for erosion, and 0.81 for deposition). The relationships are applied to 29 cold front events with available wind data (in total 41 events were recognized for the season), leading to a cumulatively erosion of 1,900,000 m3 on the WLD, higher than a single hurricane event such as Ike (412,000 m3). The results illustrate that cold fronts are more critical in determining deltaic morphology than a single hurricane event. Vegetation that grows in hurricane season significantly decreases the amount of erosion (from 412,000 m3 to 308, 000 m3 for hurricane Ike). Saline water intrusion threatens the survival of freshwater species on the WLD during hurricane events but would not influence the species during most of cold front events.

Morphological impact of large woody debris: Numerical and Experimental Modeling

Yuncheng Xu, Pennsylvania State University, Pennsylvania, USA. ycxu1990@gmail.com, Xiaofeng Liu, Department of Civil and Environmental Engineering, Institute of CyberScience, Pennsylvania State University, Pennsylvania, USA, Yong Lai, Technical Service Center, U.S. Bureau of Reclamation, Colorado, USA, David Smith, U. S. Army Corp of Engineers, Mississippi, USA, David Bandroski, Trinity River Restoration Program, U.S. Bureau of Reclamation, California, USA.

Sound decisions in stream restoration practices and eco-hydraulics should be based on solid quantitative analysis, either from carefully designed physical modeling or high fidelity computational study. Due to the complexity and uniqueness of each river and stream, realistic representation of the channel and the hydraulic structures in the modeling effort is of critical importance to the creditability of the quantitative analysis result. This paper presents a method to faithfully represent the geometries in both physical and computational modeling using 3D scanning and printing. Large woody debris (LWD) is one of the popular stream restoration designs and it is chosen as an example in this paper. The method demonstrated can be used for other structures too. The trees are first scanned using high accuracy laser scanner and the surface geometry is reconstructed. Then the trees are printed using a 3D printer. The printed trees are consequently placed in the flume to test the hydraulic performance and their effect on flow field, turbulence, air entrainment, etc. In particular, the flow velocity at specific locations around the trees will be measured using an acoustic Doppler velocimeter(ADV). The flow patterns around the trees will be also captured using colored tracer. In parallel, the scanned trees are imported into a 3D computational model that can simulate 3D open-channel flows around complex geometries. The computer model also has the capability to physically and realistically position the artificial trees in the flume. The numerical simulation uses large eddy simulation (LES) for turbulence, and with a combined Volume of Fluid(VOF) method and Level Set(LS) method for free surface. With the precise match of geometries in the physical test and computational model, the numerical results are compared with the experimental data. Ideally, the numerical model should match with the experiment since they are duplicates. Results from this rigorous mutual validation have high confidence level and provide accurate description of the physical process around the reintroduced trees.

Appendix 3: 2015 CSDMS Annual Meeting Clinic Abstracts

Modeling Coastal Sediment Transport Using OpenFOAM®

Zhen Cheng (Charlie) & Tian-Jian Hsu (Tom), University of Delaware, USA.

During a clinic session in the 2013 CSDMS annual meeting, the OpenFOAM®, an open source computational fluid dynamics (CFD) platform, was first introduced by Dr. Xiaofeng Liu (now at Penn State University) for modeling general earth surface dynamics. OpenFOAM® provides various libraries, solvers and toolboxes for solving various fluid physics via finite volume method. The objective of this clinic is to further discuss its recent development and applications to coastal sediment transport. The clinic will start with an overview of a range of coastal applications using OpenFOAM®. We will then focus on a recently released solver, SedFOAM, for modeling sand transport by using an Eulerian two-phase flow methodology. Specifically, we will focus on applying the model to study wave-driven sheet flows and the occurrence of momentary bed failure. The code can be downloaded via CSDMS code repository and participants will receive a hands-on training of the coding style, available numerical schemes in OpenFOAM®, computational domain setup, input/output and model result analysis. Knowledge of C++, object-oriented programming, and parallel computing is not required but will be helpful.

Accessing National Data and Distributed Models for Catchment Simulation

Gopal Bhatt, Pennsylvania State University, USA, Chris Duffy, Gopal Bhatt, Lorne Leonard

The objective of the clinic is: (1) to introduce the concept of essential terrestrial variables (ETVs) and HydroTerre1 as a continental scale ETV-repository for catchment modeling, and (2) to demonstrate the use of ETV's with the Penn State Integrated Hydrologic Model (PIHM) for simulating the catchment water cycle. PIHM2 is a multi-process, multi-scale hydrologic model where the hydrologic processes are fully coupled using the semi-discrete finite volume method. PIHMgis3 is an open source, platform independent, and extensible distributed modeling framework for setup, execute, and analyze model simulations. Through the procedural framework of PIHMgis, participants will be introduced to multiple data processing tools, and presented with a live demonstration of (i) accessing HydroTerre ETV service, (ii) ETV geodata translator for PIHM, (iii) automated ingestion of model parameters from national geospatial databases, (iv) conditional domain decomposition of the watershed into quality triangular mesh elements for numerical simulation, (v) performing multi-state distributed hydrologic model simulations on desktop, and (vi) visualization of model results as time-series plots and geo-spatial maps. In the clinic, an application is developed for a small-scale hillslope catchment Susquehanna-Shalehills Critical Zone Observatory (SSHCZO), which serves as a guided example of the desktop workflow, which is readily used to develop your own catchment simulation.

1. http://www.hydroterre.psu.edu/HydroTerre/Help/Ethos.aspx
2. http://www.pihm.psu.edu/index.html
3. http://www.pihm.psu.edu/pihmgis_home.html

Integrated Modeling Concepts

Jon Goodall, University of Virginia, USA.

This clinic is intended for early career researchers interested in gaining an understanding of basic integrated modeling concepts as they relate to modeling earth science systems. The class will present key literature in the field, core concepts and terminology, and different integrated modeling systems. Past, present, and future trends for designing integrating modeling systems will be discussed. Participants will also gain experience applying integrated modeling concepts using CSDMS for simplified integrated modeling examples.

Wrapping existing models with the Basic Model Interface

Eric Hutton & Mark Piper, CSDMS, University of Colorado, USA.

In order to simplify conversion of an existing model to a reusable, plug-and-play model component, CSDMS has developed a simple interface called the Basic Model Interface (BMI) that model developers are asked to implement. In this context, an interface is a named set of functions with prescribed function names, argument types and return types. By design, the BMI functions are straightforward to implement in C, C++, Fortran, Java and Python. Also by design, the BMI functions are noninvasive. A BMI-compliant model does not make any calls to CSDMS components or tools and is not modified to use CSDMS data structures. BMI therefore introduces no dependencies into a model and the model can still be used in a stand-alone manner.

Models that provide a BMI can be incorporated into a modeling framework, such as the CSDMS model coupling framework, where they gain new capabilities provided by the framework. The CSDMS framework allows coupling of models even if they differ in:

- programming language,
- variable names,
- variable units,
- time-stepping scheme or
- computational grid is different.

Framework models also gain the ability to write output variables to NetCDF files, a graphical user interface, and the ability to run within the CSDMS Web Tool. This clinic will explain the key concepts of BMI (and CSDMS Standard Names), and will demonstrate, through example, how to implement a BMI for an existing model. It will also include an overview of the CSDMS Standard Names, which provide a uniform way to map input and output variable names between component models as part of a BMI implementation. Participants are encouraged to read the associated CSDMS wiki pages in advance.

See
- BMI Description: http://csdms.colorado.edu/wiki/BMI_Description
- CSDMS Standard Names: http://csdms.colorado.edu/wiki/CSDMS_Standard_Names

Coastline Evolution Model (CEM)

Brad Murray & Andrew Ashton, Duke University & WHOI, USA, Irina Overeem, , CSDMS, INSTAAR, University of Colorado, USA

The Coastline Evolution Model (CEM) addresses coastline changes that arise from gradients in the net alongshore transport, over timescales that are long compared to storm cycles, and spatial scales that are larger than the cross-shore extent of the shoreface (kilometers on typical open ocean coasts). In the model, coastline morphodynamic feedbacks arise as coastline shapes determine spatial patterns of sediment flux, and gradients in that flux cause changes in shape. In this model system, waves approach from a wide range of directions, and the influences of the whole 'wave climate' combine to determine coastline changes and patterns. Wave shadowing—in which protruding coastline features change the local wave climates affecting other parts of the coastline—also plays a key role in coastline evolution in this model. A number of other processes or influences have been added to the model, including: river sediment input and delta evolution; effects of the composition of underlying rocks; two-way interactions between beach sediment and cliff erosion; and human shoreline stabilization.

This clinic will combine 1) explanations of model principles, assumptions, and limitations with 2) the opportunity for participants to gain some familiarity with running the model, by conducting their own simple model experiments.

Bringing CSDMS Models into the Classroom

Irina Overeem & Mark Piper, CSDMS, INSTAAR, University of Colorado, USA.

CSDMS has developed a Web-based Modeling Tool – the WMT. WMT allows users to select models, to edit model parameters, and run the model on the CSDMS High-Performance Computing System. The web interface makes it straightforward to configure different model components and run a coupled model simulation. Users can monitor progress of simulations and download model output.

CSDMS has developed educational labs that use the WMT to teach quantitative concepts in geomorphology, hydrology, coastal evolution. These labs are intended to be used by Teaching assistants and Faculty alike. Descriptions of 4-hr hands-on labs have been developed for HydroTrend, Plume, Sedflux, CHILD, ERODE and ROMS-Lite. These labs include instructions for students to run the models and explore dominant parameters in sets of simulations. Learning objectives are split between topical concepts, on climate change and sediment transport amongst many others, and modeling strategies, modeling philosophy and critical assessment of model results.

In this clinic, we will provide an overview of the available models and labs, and their themes and active learning objectives. We will discuss the requirements and logistics of using the WMT in your classroom. We will run some simulations hands-on, and walk through one lab in more detail as a demonstration. Finally, the workshop intends to discuss future developments for undergraduate course use with the participants.

WMT and the Dakota iterative systems analysis toolkit

Mark Piper & Eric Hutton, CSDMS, INSTAAR, University of Colorado, USA.

Dakota (https://dakota.sandia.gov) is an open-source software toolkit, designed and developed at Sandia National Laboratories, that provides a library of iterative systems analysis methods, including sensitivity analysis, uncertainty quantification, optimization, and parameter estimation. Dakota can be used to answer questions such as:

- What are the important parameters in my model?
- How safe, robust, and reliable is my model?
- What parameter values best match my observational data?

Dakota has been installed on the CSDMS supercomputer, beach.colorado.edu, and is available to all registered users. The full set of Dakota methods can be invoked from the command line on beach; however, this requires detailed knowledge of Dakota, including how to set up a Dakota input file and how to pass parameters and responses between a model and Dakota. To make Dakota more accessible to the CSDMS community, a subset of its functionality has been configured to run through the CSDMS Web Modeling Tool (WMT; https://csdms.colorado.edu/wmt). WMT currently provides access to Dakota's vector, centered, and multidimensional parameter study methods. In this clinic, we'll provide an overview of Dakota, then, through WMT, set up and perform a series of numerical experiments with Dakota on beach, and evaluate the results.

Exploring the influence of fault damage and fault slip on the patterns and rates of fluvial incision using CHILD and Matlab

Sam Roy (1), Phaedra Upton(2), Peter O. Koons(1) and Greg E. Tucker(3)
1. Department of Earth Sciences, University of Maine, Orono, ME, USA
2. GNS Science, Lower Hutt, New Zealand
3. CIRES and Department of Geological Sciences, University of Colorado, Boulder, CO, USA

The interplay between tectonics and surface processes has long been recognized and explored through field observations, laboratory studies, and analogue and numerical modeling. However, the dependencies that link tectonics and the surface are complex and often difficult to unravel and visualize with current methods and concepts. To address these difficulties, it is common to create predictive models with algorithms that simplify these natural processes and limit their dependencies on one another.

In this clinic, we share some simple methods for isolating two tectonic processes: fault damage and fault slip, and explore how they influence the rates and patterns of surface processes. These tectonic processes are introduced as 3D patterns of rock damage and kinematics in a landscape evolution model using Matlab and CHILD. First, we discuss methods for scaling rock damage to erodibility for use in a stream power model. The erodibility field is based on the generic 3D geometry of planar fault damage zones. Next, we include fault slip by using a 3D kinematic solution for dip-slip, oblique-slip, and strike-slip motion. These models include a single slip plane that divides a block of crust into fixed and mobile components. Finally, we combine the rock damage and kinematic fields to observe their combined influence. In these combined models, rock damage becomes a function of the amount of motion accommodated by the slip plane. Throughout the clinic we will explain our methods, interpret model results, discuss their limitations, and postulate ways to improve upon them. The simple methods we employ in this clinic lay a foundation of understanding that can be broadened by use of dynamic, fully coupled models.

Landlab: A Python library for building, exploring, and coupling 2D surface-process models

Gregory E. Tucker 1, Daniel E.J. Hobley 1, Jordan M. Adams 2, Sai S. Nudurupati 3, Eric Hutton 4, Nicole M. Gasparini 2, and Erkan Istanbulluoglu 3
1. CIRES and Department of Geological Sciences, University of Colorado at Boulder
2. Department of Earth and Environmental Sciences, Tulane University
3. Department of Civil and Environmental Engineering, University of Washington
4. CSDMS, University of Colorado at Boulder

Writing the software to implement a two-dimensional numerical model can be a daunting exercise, even when the underlying discretization and numerical schemes are relatively simple. The challenge is even greater when the desired model includes ``advanced features such as an unstructured grid, a staggered-grid numerical solver, or input/output operations on gridded data. Landlab is a Python-language programming library that makes the process of 2D model-building simpler and more efficient. Landlab's core features include: (1) a gridding engine that lets you create and configure a structured or unstructured grid in just a few lines of code, and to attach data directly to the grid; (2) a library of pre-built process components that saves you from having to re-invent the wheel with common geoscience algorithms (such as flow routing on gridded terrain, linear and nonlinear diffusion, and elastic plate flexure); (3) a mechanism for coupling components together to create integrated model; and (4) a suite of tools for input/output and other common operations. Although Landlab's components are primarily related to earth-surface dynamics (including geomorphology and hydrology), its basic framework is applicable to many types of geophysical system. This clinic provides a hands-on tutorial introduction to Landlab. Participants will learn about Landlab's capabilities, and how to use it to build and run simple 2D models. Familiarity with the Python language and the Numpy library is helpful but not critical.

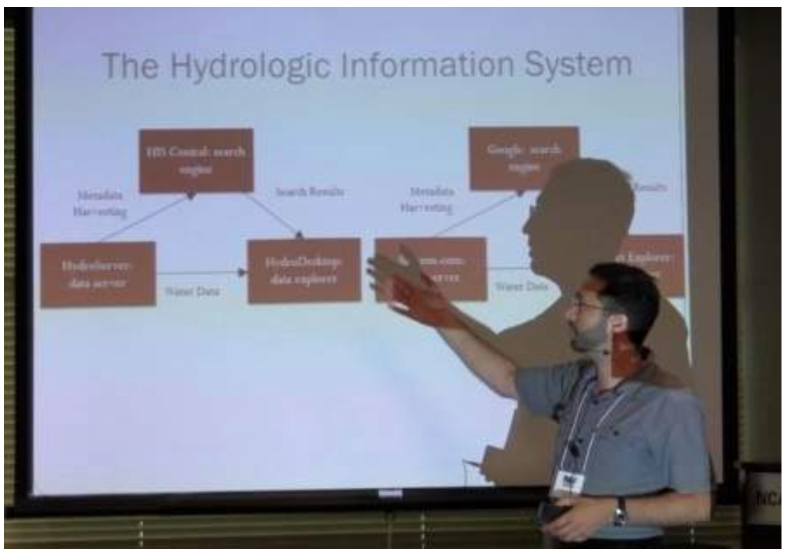
Data Access and Publication with the CUAHSI Water Data Center

Jon Pollak, CUAHSI, Jon Goodall, University of Virginia

The CUAHSI Water Data Center (WDC) is community governed, NSF funded facility that enables data access and publication through a web services oriented architecture. The WDC maintains the largest catalog of time series water data in the world, which includes data sources that range from global to local coverage and include data sets that describe climate, streams, and soil. This session will touch upon a number of functions of the WDC including:

• How can I use WDC services to fulfill NSF Data Management requirements?
• What data are available through the WDC?
• How can I access data?
• How can I write custom software that accesses data published with the WDC?

Participants should anticipate this information to be presented through slides and should expect to leave with a comprehensive understanding of the research support services offered by the WDC.



Jon Pollak presents the clinic, "Data Access and Publication with the CUAHSI Water Data Center," at the CSDMS Annual Meeting 2015

Appendix 4: 2015 CSDMS Annual Meeting Awards

The 2015 CSDMS Lifetime Achievement Award in Earth Surface Dynamics Modeling was presented to **Professor Chris Paola (University of Minnesota)** in Boulder, Colorado, as part of the 2015 CSDMS Annual Meeting. Presenters included Dr. Man Liang, Professor Brad Murray, Professor Charles Vorosmarty, and Professor James Syvitski.

Citation: "Professor Paola is both a pioneer and world leader on the subject of quantitative dynamic stratigraphy. Chris has enormously helped petroleum companies through consortia, in understanding how their fabulous 3D seismic data of basin fill can be better interpreted through 3D tank experiments. Chris has helped to organize the field of sedimentology, stratigraphy, and geomorphology through his service at NSF, AGU, GSA, and AAPG from within his position as National Co-Director of NCED and his long-term support for CSDMS. Chris is an over-achiever in bridging the domains of engineering and science, physics and geophysics, hydrology and geology, geomorphology and stratigraphy, and biology and geology. Chris has won numerous awards, including the Geological Society's Charles Lyell medal in 2011 and the SEPM's Laurence L. Sloss Award in 2014 for his studies of basin filling and controls on physical stratigraphy, braided streams, particle fractionation in depositional systems, bedform dynamics and self-organization in landscape evolution. His stellar 2000 review paper in Sedimentology on quantitative models of sedimentary basin filling has become a classic. Chris has mentored many fine students, many of whom have gone on to be honored as leaders in our field."

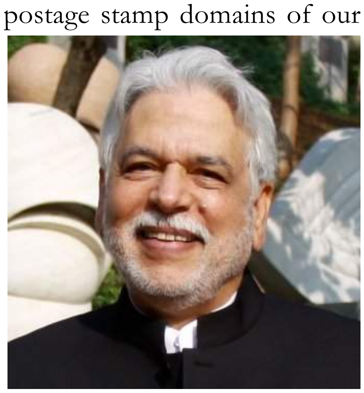
- Professor James Syvitski, CSDMS Executive Director

Professor Syvitski presents Professor Paola with the CSDMS Lifetime Achievement Award

The CSDMS Program Director's Award was given to Professor Bilal Haq

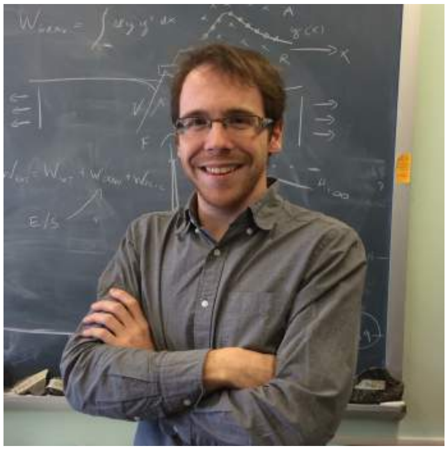
Citation: "The CSDMS community honors Bilal Haq for his service and leadership with the earth-surface dynamics community. I have a unique perspective. In 1996 trendsetters in siliciclastic sedimentology were called to participate in a special NSF-sponsored, international, think tank. Bilal urged participants to break out of their business-of-usual approach, where we tended to focus on postage stamp domains of our planet --- a shocking thing to say. Bilal outlined a path to get our community to the next level: by asking larger, integrative and quantitative earth science questions, to better organize and coordinate our community, and to stop needlessly criticizing each other's efforts. Few will ever remember that simple meeting that surely gave birth to the MARGINS Program, the National Center for Earth-surface Dynamics, and the Community Surface Dynamics Modeling System now coordinating scientists from more than 500 institutions in 67 countries. Our community thanks Professor Bilal Haq for his community vision and wish for him continued success in his new career activities."

-Professor James Syvitski, CSDMS Executive Director



Professor Bilal Haq

The 2014 CSDMS Student Modeler Award



Dr. Jean-Arthur Olive

Jean-Arthur Olive received the 2014 Student Modeler Award for his submission, "Modes of extensional faulting controlled by surface processes," which investigates the feedbacks between surface processes and tectonics in an extensional setting by coupling a 2-D geodynamical model with a landscape evolution law.

Dr. Olive earned his Ph.D. in Marine Geophysics from the Massachusetts Institute of Technology/Woods Hole Oceanographic Institution Joint Program in Oceanography in 2014.

The **Best Poster Award for the CSDMS Annual Meeting 2015** went to Katherine Ratliff for her submission, "River-ocean interactions: Building a new morphodynamic model." Professor Patricia Wiberg, CSDMS Steering Committee Chair, presented Ratliff with a Kindle Fire at the CSDMS Annual Meeting Banquet.

Professor Patricia Wiberg presents Katherine Ratliff with the Best Poster Award.

Appendix 5: What do modelers want from the data community? A discussion from the CSDMS Annual Meeting 2015

1.) Improved communication & greater collaboration is necessary

- There's a lack of overlap/communication across communities
  - Data collection is not informed by modelers
  - Multiple people need to be involved in the data collection process from the beginning (the PI, the data collection team, and the modeler). This will ensure that data is in the correct format and includes the correct metadata.

2.) Educational needs

- Beginning at the undergraduate level, students need to be trained in data processing and data management (scientific programming, Linux, R, Python, MATLAB, etc.)
- Many students feel they are working with a limited amount of data
- Students should get into the field, even if their work is completely model based
- Continuing education is necessary for everyone
- People in the field need to learn about model parameterization needs
- Everyone should consult with statisticians regarding comparing models and data
- Students need desktop stations
  - It is unreasonable for students to run a model and/or parse large datasets on personal laptops (CSDMS facilitating supercomputer access is helpful here)
- Direction is needed on how to standardize metadata
- Models should be simplified for teaching

3.) Other concerns regarding data and models

- Observationalists may not be collecting the right data
- There is a need for descriptions of how the data will be used
- Models may be lagging behind our understanding of the physics
- Scientists do not always release data in a timely fashion
  - Releasing data is easy when there is a system in place, but is difficult and time consuming if not
- Lack of metrics that extract information from data and/or models
  - Well defined metrics can be bridges to overcoming abstraction of models and build direct connection between model outputs and field-specific data sets
- Metadata standards are lacking and so are model code standards
- Code used to process or 'clean up' raw data should be made public
- Where is EarthCube data? There is still a lot of confusion regarding EarthCube's role in the modeling community
- Modeling almost always runs ahead of data availability
- Data access policies are a barrier
- Disagreement between model and data happens at subgrid processes
- Scaling experimental data to field-scale, which is necessary for models, can be difficult
- It can be difficult for data gathers to run models, which causes a disconnect
- Processed data is hard to get
- Raw data is there but takes lots of time/computer power to process
- Raw data is not enough
- Uncertainty is often missing for processed data

4.) Solutions and Suggestions

- Digital Object Identifiers are very helpful
- Data collectors need to publish data with metadata and DOIs; version control for data
- Datasets can be assigned a DOI
- Assigning data “asset” numbers allows it to be linked into Google Earth and downloaded
- Those collecting field data should collect as much information as possible, and could possibly create a permanent DOI for their field data
- The version of the data the DOI is pointing to should be documented so changes to the original dataset can be traced
- A metadata standard needs to be established for both data and models
- Data needs to be searchable in time and space
- Models should be easy to run
- Datasets need to come packaged with better parsing and processing tools (e.g. Python library)
- Data should come with uncertainties
- There needs to be a place for capturing input files
- Attach a license to data so others know how it can be used and how to properly attribute
- Need measurements that modelers can extract data from
- Need a way of resolving spatial and temporal scale differences between field data and the models
- Open-source standards and standard names are helpful
- Google and data.gov represent new way of archiving science data, replacing libraries and academic journals
- NIH data management plan created a plan for storing data
- NIH requires that data and papers are published with open access
- NSF data policies will be helpful
- In SEN, you can search and find all metadata (not all data is online yet because of storage limitations)
- PIs need to insist on collaboration between modelers and the data community
- CZO groups have a standardized procedure for collecting field data
- More effort is needed in creating and revising conceptual models
- The development of conceptual models should be prioritized
- We can leverage opportunities presented by new technology (radio tags, satellite instruments, drones for various sensors, etc.)
- Scaling methods need to be identified so that modelers can downscale their models to make them relevant for field-based validation
- Need more stringent requirements for controlling error propagation; assessing uncertainty
- Model code needs to evolve as our understanding of natural phenomena evolves
- More interdisciplinary initiatives are needed to encourage data collectors and modelers to collaborate
- Modelers must make it clear that data collection is critical for modeling
- Should we work toward a larger community-based cloud-computing engine that’s specifically focused on developing the capabilities of students?
- Case studies with models that show value in terms of collecting new data need to be documented and advertised
- Could agencies set standards for best practices in their fields?
- GEOSS is working on a document to define a list of essential variables. Users can identify which variables are essential.

5.) Specific data related needs from CSDMS discussion groups

- Long time series in geomorph and landscape
- Detailed surface dynamic data w/ time stamps
- High-resolution satellite data needs to be available in U.S.
- Long-term soil carbon data time records for various depths
- Age control for dating
- Uncertainty for processed data
- Measurements of size distributions and density of sediment
- A global lidar dataset with yearly updates
- Data from below ground surface (stratigraphy, groundwater)
- Social data/data measuring human impact needs to be gathered
- Monitoring of active faults (earthquake fault monitoring, landsliding, and river sediments)
  - E.g. Collection of pre-quake data from Nepal or Alpine faults

Appendix 6: CSDMS Software Bootcamp

In January 2014, CSDMS hosted a 3-day "bootcamp"-style training session for 40 graduate students at CU Boulder. The students came from five departments at CU: Environmental Engineering, Environmental Systems, Geology, Geography, and Atmospheric Sciences. All are conducting research that utilizes numerical modeling to study earth surface processes. Over the course of the workshop, students learned the fundamentals of software development, including programming best practices, unit testing, and version control with Git and Github. Instructors from the Software Carpentry organization and CSDMS also worked with students on their individual research projects, providing help with specific programming and modeling questions. Student research topics include hydrological modeling, ocean-atmosphere coupling, snowmelt partitioning between evapotranspiration and runoff, and tree species distribution under various climate change projections.

Appendix 7: CSDMS Visiting Scientists

Between August 2014 and July 2015, several scientists visited the CSDMS Integration Facility:

Date	Visitor
08/2014	Mark Bryden (Iowa State University and Ames Laboratory)
01/2015	Chris Kees, US Army Corps of Engineers' Coastal and Hydraulics Laboratory
01/2014 - 01/2015	Xiujuan Liu, China University of Geosciences
03/2015- 07/2015	Garry Willgoose, University of Newcastle
03/2015	Randy Leveque, University of Washington
05/2015	Konrad Hafen, Utah State University
06/2015	Randy LeVeque, Donsub Rim, and Scott Moe, University of Washington

07/2015 Mary Hill, University of Kansas

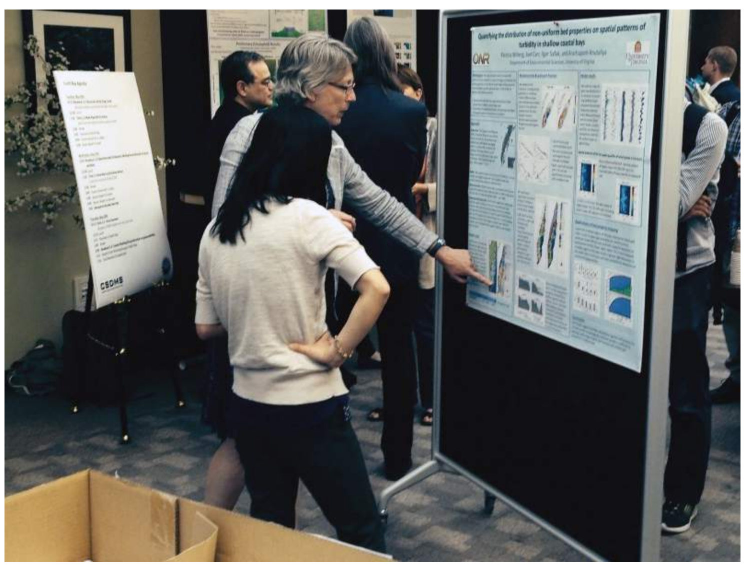
Appendix 8: CSDMS Diversity Efforts 2014-2015

The Community Surface Dynamics Modeling System is a national and international community of students, scientists and governmental employees from all parts of the world. As of July 2015, CSDMS members came from 176 U.S. universities, 21 U.S. Federal Labs, 22 U.S. corporations, and 315 foreign research institutions from more than 66 different countries. Members come mainly from the United States, but include many Asian, European and Latin-American nationals. There are not as many CSDMS members from the Middle East and Africa, but representation from these countries is increasing.

Diversity at the CSDMS Annual Meeting

CSDMS has not (yet) recorded data on diversity from their members or from meeting attendees. Overall, women and minorities are traditionally underrepresented in the STEM sciences, and form between 17-23% in the Geophysical Sciences (Rhodes, 2010; NSF Advisory Committee for Geosciences, 2014). We speculate that these numbers are likely even lower in the field of earth surface process modeling with emphasis on modeling and the analysis of "big data," and increasingly high performance computing.

CSDMS features a significantly higher representation of women in meeting attendees than the average published representation of women in the Geophysical Sciences. At our CSDMS Annual Meeting 2015, 30% of attendees were women, including women scientists at all career levels: students, PDFs, assistant professors, and full professors or senior scientists.



CSDMS Annual Meeting 2015

Engaging a diverse student population in the CSDMS Annual Meeting

CSDMS has reached out more widely than previous years to encourage students from all walks of life to participate in the CSDMS Annual Meeting 2015. CSDMS has awarded 3 student scholarships to underrepresented students with the explicit goal to increase diversity in the field of surface dynamics modeling. Stipends allowed these students to attend the entire annual meeting, May 26-28th, and present on their research.

We consulted about CSDMS strategies to broaden participation with Dr. Barbara Kraus, who is employed in the Colorado Diversity Initiative in Science, Math and Engineering. As a result of these interactions, we have posted announcements on the annual student scholarship to gateways typically used by underrepresented students to become familiar with targeted opportunities in the STEM sciences. These included:

2) NSF Alliances for Graduate Education and the Professoriate (AGEP), Institute for Broadening participation, its mission is: "*to increase diversity in the Science, Technology, Engineering and Mathematics (STEM) workforce. We design and implement strategies to increase access to STEM education, funding, and careers, with special emphasis on reaching underserved communities and diverse underrepresented groups.*"

www.PathwaysToScience.org *makes it easy for faculty and administrators to access resources that can assist them in their efforts to reduce barriers to participation, create environments rich in the positive factors that support student success on the STEM pathway, and conduct outreach to underserved communities and underrepresented groups by implementing recruitment and retention strategies that broaden participation and increase diversity.*"

2) AGEP listserv, especially for underrepresented groups at CU Boulder.
CSDMS asked student applicants how they would view their contribution to diversity, and has selected 3 students for stipends based on responses. For 2016, we plan to reach out to our members who teach at community colleges.

Diversity and representation in CSDMS leadership

Bell and Karsten (2004) found that of all employed PhD in the geosciences, only 13% were women. While this study is now a decade old, and representation may have improved over the last 10 years to 17-23% (Rhodes, 2010), it is likely still a valid estimate for women scientists in a career stage where they are called upon for leadership roles. Many of the CSDMS Working Groups and Focus Research Group chairs, and thus its executive committee, are women (21%). 33% of the CSDMS Steering Committee are women, and the Steering Committee is currently chaired by a woman. Overall, a broad participation of scientists and students from underrepresented groups remains a priority.

NSF Advisory Committee for Geosciences 2014. Dynamic Earth: GEO Imperatives & Frontiers 2015–2020 December 2014

Bell, R., Karsten, K., 2004. Righting the Balance: Gender Diversity in the Geosciences ADVANCE library Paper 47.

Rhodes, D.D., 2010., Changes in the demographic characteristics of AGU membership 2006-2010. AGU Fall Meeting 2010, abstract #ED31B-0666.

Appendix 9: CSDMS Special Issue

CSDMS Special Issue, "Model Uncertainty and Sensitivity," to be published in *Computers and Geosciences* is in the process of completion, generated from papers largely presented by participants of the CSDMS 2014 'Uncertainty and Sensitivity in Surface Dynamics Modeling' Meeting, May 20-22nd, 2014. A total of 15 manuscripts were accepted by February 15th 2015. The special issue is scheduled for publication early 2016 and will contain the following contributions:

1. *Fedor Baart, Maarten van Ormondt, Jaap van Thiel de Vries, Mark van Koningsveld* (under review). Lead time of morphological storm impact forecasts.
2. *Getachew F. Belete and Alexey Voinov* (under review). Exploring temporal and functional synchronization in integrating models: a sensitivity analysis.
3. *Zhen Cheng, Xiao Yu, Tian-Jian Hsu, and Sivaramakrishnan Balachandar* (under review). A numerical investigation of fine sediment resuspension in the wave boundary layer -- uncertainties in particle inertia and hindered settling.
4. *Greg Hancock, and Tom Coulthard* (under review). Predicting uncertainty in sediment transport and landscape evolution - the influence of initial surface conditions.
5. *Shawn R Harrison, Karin R Bryan, and Julia C Mullarney* (under review). Morphodynamic sensitivity of ebb-tidal shoal development using a semi-analytical jet model.
6. *Jennifer Jefferson, James Gilbert, Paul Constantine, and Reed Maxwell* (accepted). Active subspaces for sensitivity analysis and dimension reduction of an integrated hydrologic model.
7. *Eva M. Mockler, Fiachra E. O'Loughlin, and Michael Bruen* (under review). Understanding hydrological flow paths in conceptual catchment models using sensitivity analysis.
8. *A. Brad Murray, Nicole M Gasparaini, Evan B Goldstein, and Mick van der Wegen* (under review). Certain Uncertainties and Uncertain Uncertainties: It's easier to quantify uncertainty for some models than for others.
9. *Scott D. Peckham, Anna Kelbert, Mary Hill, and Eric Hutton* (under review). Model uncertainty and parameter estimation components in an Earth system modeling framework environment.
10. *Samuel G. Roy, Peter O. Koons, Bipush Osti, Phaedra Upton, and Gregory E Tucker* (under review). Multi-scale characterization of topographic anisotropy.
11. *S. Mostafa Siadatmousavi, Felix Jose, and Graziela M Silva* (under review). The Uncertainties in a Third Generation Phase-Averaged Wave Model.
12. *Arnaud J.A.M. Temme, and Tom Vanwalleghem* (under review). LORICA - A new model for linking landscape and soil profile evolution: development and sensitivity analysis.
13. *Catherine Villaret, Rebekka Kopmann, David Wyncoll, Jan Riehme, Uwe Merkel, and Uwe Naumann* (under review). First-order Uncertainty Analysis using Algorithmic Differentiation of the Telemac-2D/Sisyphe Morphodynamic Model.
14. *Kehui Xu, Rangley C. Mickey, Qin J. Chen, Courtney K. Harris, Robert Hetland, Kelin Hu, and Jiaze Wang* (under review). Shelf Sediment Transport during Hurricanes Katrina and Rita: Model Sensitivity to Erosional Rates and Settling Velocities.
15. *Xuan Yu, Anna Lamačová, Christopher Duffy, Pavel Krám, and Jakub Hruška* (accepted). Hydrological model uncertainty due to spatial evapotranspiration estimation methods.

Appendix 10: Bringing earth surface processes simulations to large audiences

Irina Overeem[1], Lauren Borkowski[1], Albert Kettner[1], Beth Russell[2] and Hilary Peddicord[2]
1. CSDMS Integration Facility, University of Colorado at Boulder, 80309 CO, USA
2. NOAA, Science on a Sphere, Earth System Research Lab, Boulder, 80305, CO, USA

Abstract
The Community Surface Dynamics Modeling System has a mandate to share state-of-the-art surface process modeling results with large audiences. One platform to reach audiences outside of the science community is through museum displays. CSDMS has developed model simulation datasets for the 'Science on a Sphere' (SOS) system. SOS consists of a 4 feet diameter suspended globe on which global and regional simulations can be projected. SOS has been developed by NOAA and is now featured in more than100 locations worldwide, mostly at science museums and large research facilities. The SOS team at the Earth System Research Lab estimates that over 33 million people see these displays every year. In addition, the data catalogue features stand-alone downloadable movies and educational materials for teachers to use in their own classrooms, further expanding the reach of these educational materials.

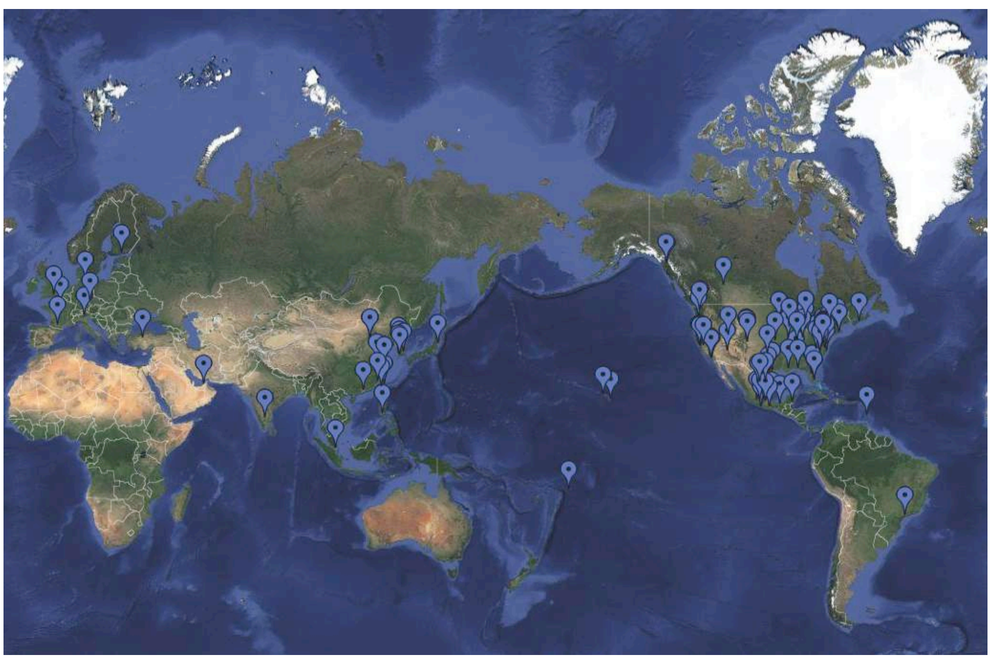
We contributed global simulations and datasets to the Science on a Sphere catalogue. Examples include hydrological processes, coastal processes, and human interactions with the environment. Model simulations of a global hydrological and sediment transport model (WBM-SED) illustrate global river discharge patterns. WAVEWATCH III simulations have been specifically processed to show the impacts of hurricanes on ocean waves, with focus on hurricane Katrina and superstorm Sandy. A large world dataset of dams built over the last two centuries gives an impression of the profound influence of humans on water management.

Visualizations are developed with Python scripts and comply with well-published data submission protocols of NOAA. Scripts are unique for each specific model dataset. Datasets story boards, and teacher follow-up materials associated with the simulations, are developed to address common core science K-12 standards. CSDMS contributions aim to familiarize large audiences with the use of numerical modeling as a tool to create understanding of environmental processes.

What is Science on a Sphere?
Science on a Sphere® is a giant globe, approximately 6ft in diameter, which is linked with computers and multiple projectors and can display data and animations on a sphere. It was developed by NOAA to better visualize Earth Science data.

The animated globes are installed in > 110 museums and research institutes worldwide. The Science on a Sphere team reports that > 33 million people see a SOS each year.

Example of Science on Sphere globe (image courtesy NOAA)



Worldwide location of Science on Sphere displays as of July 2015 (image courtesy NOAA)

CSDMS Education mission and Science on a Sphere

The Community Surface Dynamics Modeling System has a strong mandate to share state-of-the-art earth surface process modeling results with large audiences (Campbell et al, 2013), Science on a Sphere is suited to achieve this goal.

CSDMS strives to line up some of the key concepts in earth surface processes with 6th grade and high school science standards (CSE, 2009). The two most relevant science standards for the CSDMS domain dictate that students will become prepared to: "Apply an understanding that energy exists in various forms, and its transformation and conservation occur in processes that are predictable and measurable" and "Evaluate evidence that the Earth's geosphere, atmosphere, hydrosphere and biosphere interact as a complex system". Many CSDMS models allow for discussion of mass balance concepts and conservation of mass and energy, or provide illustration of the complex interactions of the atmosphere and geosphere, or of the hydrological cycle.

Numerical modeling in the earth surface processes has become an increasingly common tool, and visualization of model results are often sophisticated. However, it is still of importance to make our audiences aware of the fact that they look at model results, that underlying models have inherent assumptions and simplifications, and that limitations are known amongst others due to model resolution issues, and model uncertainty (Sarewitz and Pielke, 1999).

Documentation associated with Science on a Sphere datasets contributed by CSDMS clearly explains that the dataset on display originates from a numerical model, it identifies which model is, and provides links to more in-depth information on the models. Where appropriate some of the inquiry questions and teaching material compares model predictions to real-world observations.

Data Set Title	**ID**	**Web link**
Dams and Reservoirs 1800-2010	472	http://sos.noaa.gov/Datasets/dataset.php?id=472
Dams and Reservoirs Mississippi River 1800-2010	476	http://sos.noaa.gov/Datasets/dataset.php?id=476
Dams and reservoirs Yangtze River 1800-2010	477	http://sos.noaa.gov/Datasets/dataset.php?id=477
Rivers Daily Discharge	555	http://sos.noaa.gov/Datasets/dataset.php?id=555
Flood Events 2000-2009*	109	http://sos.noaa.gov/Datasets/dataset.php?id=109
Wave Heights 2012	488	http://sos.noaa.gov/Datasets/dataset.php?id=488
Wave Power 2012	487	http://sos.noaa.gov/Datasets/dataset.php?id=487
Wave heights Hurricane Katrina 2005	490	http://sos.noaa.gov/Datasets/dataset.php?id=490
Wave heights Hurricane Sandy 2012	489	http://sos.noaa.gov/Datasets/dataset.php?id=489
A closer look at El Nino & La Nina	Live Program	http://sos.noaa.gov/Datasets/dataset.php?id=563

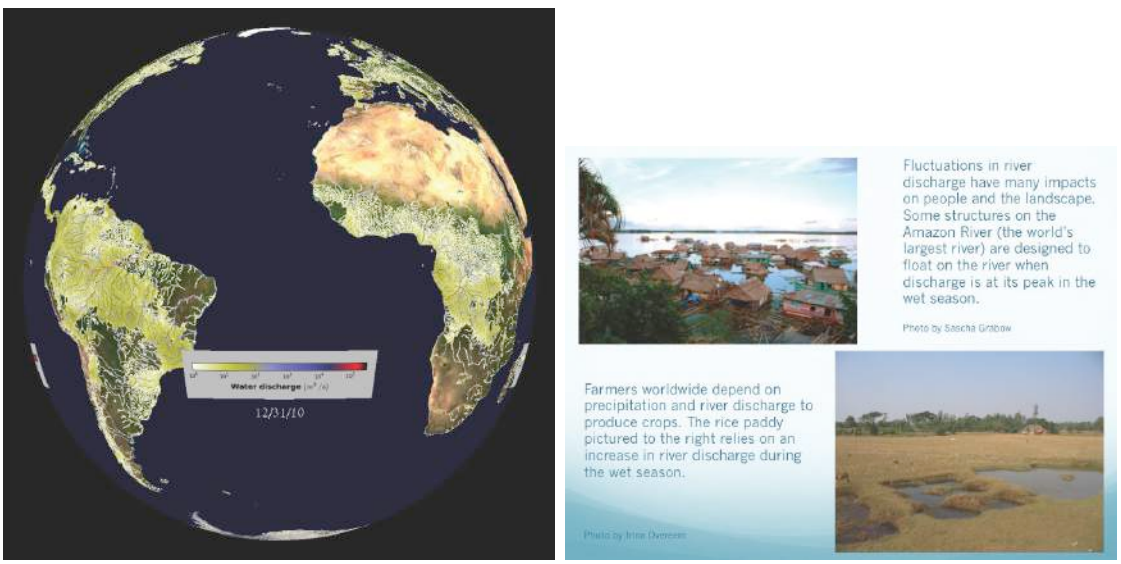
*Table 1. CSDMS contributions to Science on a sphere dataset catalogue (*data maintained by DFO and CSDMS)*

Global and Regional Models can be featured

The Science on a Sphere system is most conducive to global datasets and simulations, but regional datasets can be displayed as well. One example of a CSDMS dataset with a regional focus is the evolution of dam building in the Mississippi river basin. This river basin is large enough to be easily visible for the audience, and to resolve dams at different locations. Additionally, a dataset can have associated spatial information to indicate that the projection of the SOS globe should be tilted towards the region of interest.

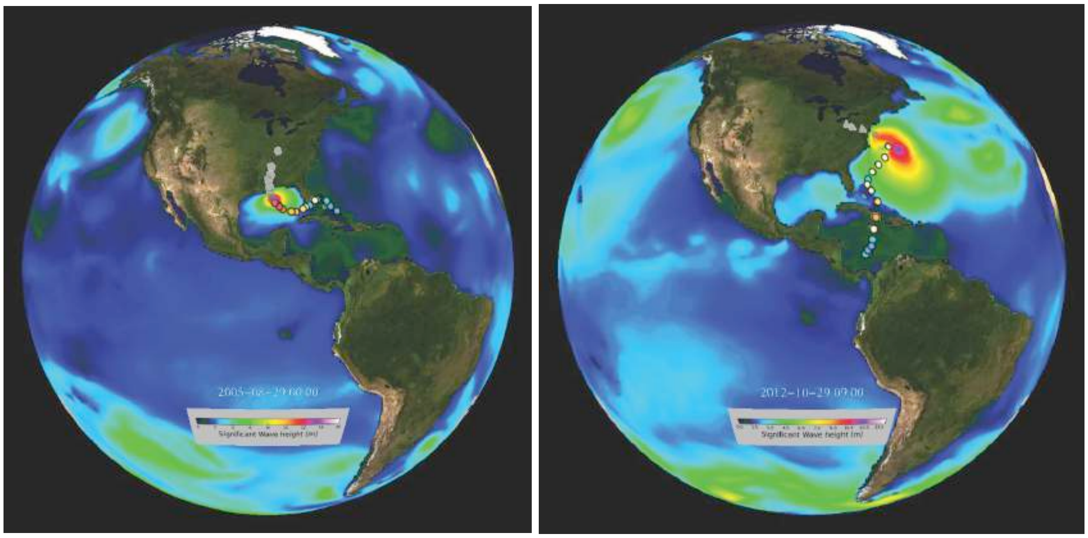
Datasets are played with associated presentations, typically 3 slides that will be on display on screens below the globe. Explanations on the key concepts, definitions of parameters being shown in the movie can be added. Slides can highlight people's adaptation to the earth surface processes of the movie, and enforce data interpretations skills (for example, read the graphs of river discharge over time while seeing a map view of river through a year). CSDMS lines up the movie descriptions, keywords, and lesson plans with 6th grade and high school science standards (CDE, 2009; 2014).

CSDMS EKT resources links to all the datasets and educational material through the CSDMS own web portal to provide and additional entry point to this resource.
http://csdms.colorado.edu/wiki/Science_on_a_Sphere



A. Global River Discharge as simulated with a gridded global Water Balance Model (WBM) (Cohen et al., 2013). B. Associated slide highlighting how local inhabitants have adapted to seasonal river flooding in the Amazon Basin and to monsoon-driven river flooding in the Ganges delta.

Data and Model Predictions of Natural Disasters



A. Significant wave height during hurricane Katrina, 2005. Simulations of the WaveWatch III model (3hr, global coverage). B. Significant wave height during superstorm Sandy, 2012. Simulations of the WaveWatch III model (3hr, global coverage).

Measuring Interest in Earth Surface Process Datasets

A subset of SOS reporting installations, i.e. 43 out of 102 installations, report data usage in an automated way to the main dataserver at NOAA. These data usage metrics are made available online and allow the contributors to evaluate the impact of their submissions. Standard parameters that are being reported on each dataset: number of plays; number of auto plays; and duration of plays.

CSDMS' top animation is global Wave Power of 2012, as calculated from WAVEWATCH III simulations. The animation has been played 5990 times, over 3 days and 11 hours cumulatively (Table 2, data retrieved and analyzed July, 2015).

Metrics on use of the online resources are being kept and can be useful, but for now there is no automized analysis tool associated with this particular use of the teaching resources.

Data Set Title	No of Plays	Total Duration (min)
Dams and Reservoirs 1800-2010	958	2433
Dams and Reservoirs Mississippi River 1800-2010	508	1208
Dams and reservoirs Yangtze River 1800-2010	507	1364
Rivers Daily Discharge	20	33
Flood Events 2000-2009	750	1832
Wave Heights 2012	5371	10976
Wave Power 2012	5990	4984
Wave heights Hurricane Katrina 2005	444	829
Wave heights Hurricane Sandy 2012	316	762
A closer look at El Nino & La Nina	n/a	n/a

Table 2. Usage of CSDMS Science on a Sphere datasets is monitored at 40% of SOS sites

References

- *Campbell, K., Overeem, I., Berlin, M., 2013. Taking it to the Streets: the Case for Modeling in the Geosciences Undergraduate Curriculum. Computers and Geosciences. 53, 123-128.*
- *Sarewitz, D, and Pielke,R.Jr. (1999) Prediction in science and policy. Technology In Society 21 (1999) 121–133.*
- *CDE, 2009. Colorado Academic Standards, 6th grade Science, 21p.*
- *CDE, 2014.Colorado Academic Standards, Highschool Science, 37p.*

Appendix 11: Projects that use the CSDMS Experimental Supercomputer

Based on account requests, a total of 25 research projects and 3 educational courses that have used during the last year, or are still using, the CSDMS HPCC ***beach***. The majority of those projects are part of Masters or PhD thesis work. Twelve projects are new, so have been started after last years annual report 2014.

Numerical Modeling of Permafrost Dynamics in Alaska using a High Spatial Resolution Dataset

Sergei Marchenko, University of Alaska, Elchin Jafarov, University of Colorado
Financial support provided by the National Science Foundation (projects 0520578; 0632400; 0856864) and the State of Alaska.

http://goo.gl/uImxNn

Permafrost is a lithospheric material where temperatures have remained at or below 0°C for a period of at least two consecutive years. Permafrost is one of the main components of the cryosphere in northern regions, which influences hydrological processes, energy exchanges, natural hazards and carbon budgets. Recent publications report a gradual increase of mean annual permafrost temperatures in Alaska (Romaniovsky et al., 2010 and Smith et al., 2010). Thawing of permafrost might cause the land to sink and collapse, damaging forests, homes, and infrastructure. Economists estimate that thawing permafrost will add billions of dollars in repair costs to public infrastructure (Larsen et al., 2008).

The nature of permafrost existence is complex enough and cannot be addressed based only on climatic data (Shur and Jorgenson, 2007). In this project we employed more sophisticated approach which includes all important factors affecting permafrost thermal regime such as snow, organic layer, soil physical properties and subsurface water content. We employ GIPL2-MPI transient heat flow model for the entire Alaska permafrost domain. As a climate forcing we used the composite of five IPCC Global Circulation Models that according to Scenarios Network for Alaska Planning (SNAP) performed the best in Alaska. Researchers from SNAP scaled down the outputs from these five models to 2 kilometers resolution using the PRISM model, which takes into account elevation, slope, and aspect. All derived values represent a single month within a given year for the five-model composite with A1B carbon emission scenario.

The original version of the model was developed by G. Tipenko and V. Romanovsky (2004). Later it was extended to the spatial case and first time applied for the entire Alaskan permafrost domain with 0.5° spatial resolution by Marchenko et al., (2008). To determine the social-economic impact of permafrost thaw on ecosystem and infrastructure higher spatial resolution is required. In order to employ the model to simulate the ground temperatures in higher spatial resolution we need make it parallel by distributing the amount of computational load between processors. The GIPL2-MPI is a modified parallel version of the GIPL2 spatial model used by Marchenko et al., (2008).

Glacier reconstruction in the Himalayas

Patricia Eugster, University of Potsdam

Funded by DFG

http://goo.gl/KWcIDL

The project is about the evolution of an orogeny and the possible impacts from climate and tectonics. The study area lies in the humid frontal segments of the Himalaya, where the present-day ice coverage is high but the evidence for extensive glaciations is limited. We want distinguish between fluvial and glacial erosion in the northwestern Himalayas and in this context if glaciers impede or accelerate erosion.

Understanding sediment delivery to deltas under environmental changes using WBMsed and HydroTrend

Frances Dunn, University of Southampton

Funded by University of Southampton, Southampton Marine and Maritime Institute (SMMI)

http://goo.gl/ksLW9m

This project is focused on increasing understanding of how environmental changes affect sediment flux to the world's more vulnerable deltas. Relative sea-level change is affected by sediment deposition (aggradation) along with subsidence, isostatic, and eustatic changes. This means that the sustainability of delta environments relies in part on the rates of aggradation, which in turn are affected by sediment delivery from catchments feeding deltas.

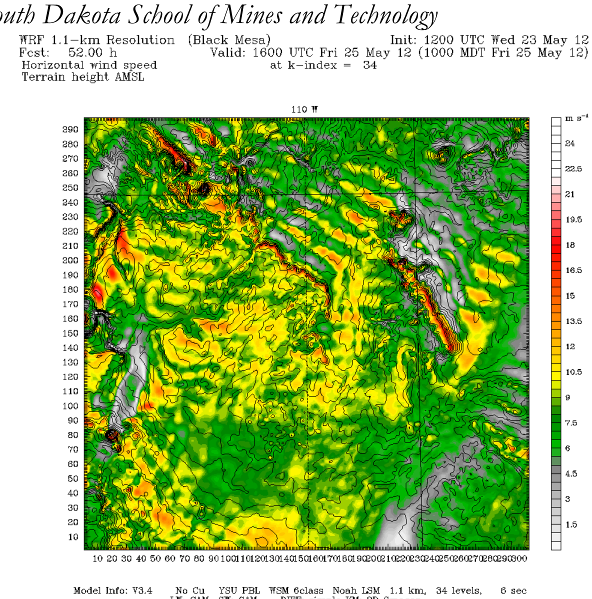
High-Resolution Regional Climate Modeling

Gary Clow, U.S. Geological Survey, John Stamm, U.S. Geological Survey, South Dakota School of Mines and Technology, Parker Norton, U.S. Geological Survey, South Dakota School of Mines and Technology

Funded by:

- Plains and Prairie Potholes Landscape Conservation Cooperative
- National Climate Change and Wildlife Science Center
- South Central Climate Science Center
- National Park Service
- U.S. Geological Survey
- U.S. Army Corps of Engineers

http://goo.gl/g5mKj7

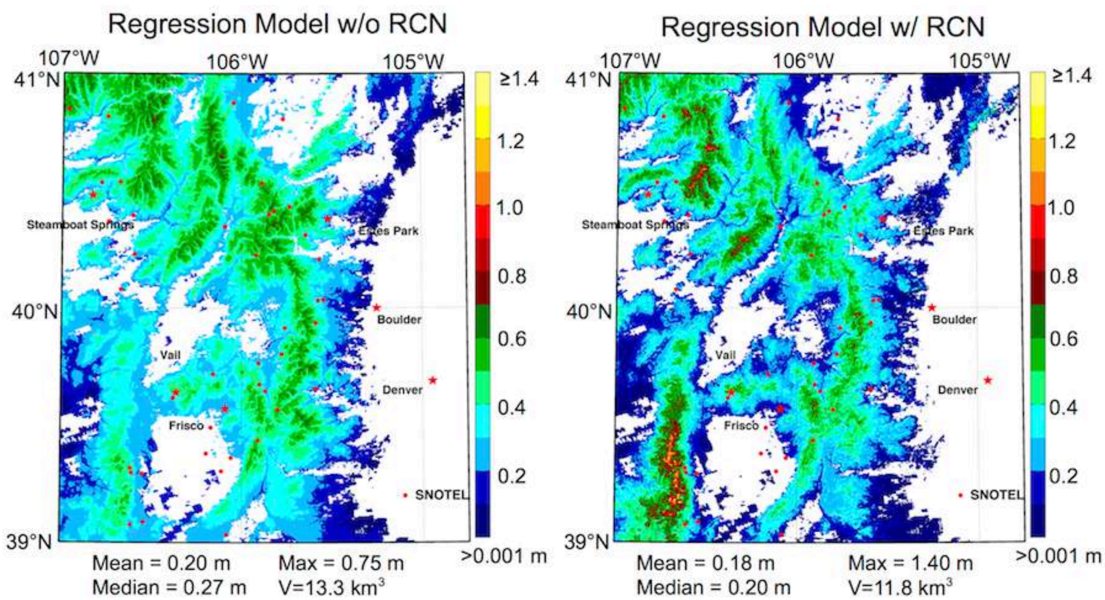


The High-Resolution Regional Climate Modeling project uses the Advanced Research Weather Research and Forecasting Model (ARW) to simulate projected climate based on Atmosphere-Ocean General Circulation Model (AOGCM) boundary and initial conditions. Regional solutions include much of North America and projections currently extend to 2050.

Combining a MODIS-based snow water equivalent product and statistical interpolation methods to estimate snowpack and streamflow conditions in the Colorado headwaters

Dominik Schneider, University of Colorado, Noah P. Molotch, University of Colorado
Funded by NOAA

http://goo.gl/fZuBSN



We are seeking to develop a SWE monitoring technique that can leverage both point scale measurements and spatially explicit patterns of SWE from remote sensing in near real-time. Current estimates of SWE distribution are frequently interpolated from point measurements based on physiographics with a observations of SCA occasionally used to constrain modeled values. Statistical models relating physiography and SNOTEL SWE only explain up to ~15% of the observed variability and thus these techniques provide limited credibility for water resource applications. Recent improvements in SWE estimates have been obtained using SWE reconstruction models whereby satellite data of SCA are coupled with fully distributed energy balance modeling to reconstruct peak snow mass. The first goal of this project is to combine a statistical interpolation model with remote-sensing based spatially distributed reconstructed SWE to augment resources available to water managers. The second goal of this project is to incorporate explicitly modeled patterns of SWE and use it as a spatial distribution field for winter precipitation in a streamflow modeling exercise. The intention is to examine the sensitivity and potential improvement in simulated streamflow timing and volume due to an improved representation of the physiographic distribution of SWE.

Simulation of Granular Flows

Jim McElwaine, University of Cambridge

Funded by University of Cambridge

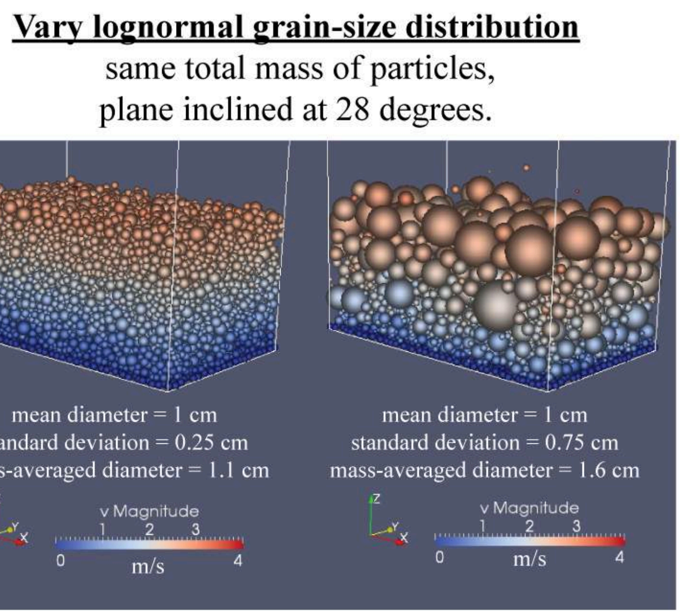
http://goo.gl/KCxvSX

Granular flows are ubiquitous in the environment. In some cases interaction with the ambient fluid is critical, for example debris flows, turbidity currents and powder snow avalanches. In other cases the flow dynamics are governed only by the dry granular material, for example, rock-slides and dense avalanches. In both cases accurate theories are necessary for the describing the granular material, but there is no known governing equation for granular matter in the way that the Navier-Stokes equations describes fluids. The aim of this project is to study granular systems by direct simulation using the Discrete Element Method (also known as Molecular Dynamics), in which the equation of motion for each individual grain in integrated in time accounting for solid contacts and interactions with the ambient fluid.

Investigating controls on bedrock erosion by granular flows using an open source discrete element model

Scott McCoy, University of Colorado, Greg Tucker, University of Colorado
This research was supported by the National Science Foundation (NSF) Graduate Fellowship, and NSF grants EAR 0643240 and EAR 0952247.

http://goo.gl/cEj0pW



Although steep valleys are ubiquitous in mountainous terrain and there is evidence that episodic scour by debris flows is an important erosional process in these valleys, there is no agreed upon mechanical framework to describe debris flow incision into bedrock. Hence our goal is formulate a defensible stochastic debris flow incision rule.

We hypothesize that the rate of bedrock incision will scale with the product of the intensity at which flow particles impact the bedrock channel floor (measured as impact force or energy) and the impact flux. We use grain-scale numerical experiments (discrete element method simulations) of free-surface, gravity-driven granular flows to quantify how impact intensity and impact flux, and hence the rate at which debris flows incise bedrock, change as a function of field measureable channel and flow properties such as grain size, flow depth, and channel slope.

Probability density of basal normal impact force from simulated monodispersed flows decayed rapidly and in an exponential manner with increasing force magnitude. Only when monodispersed flows were replaced by broad grain size distributions, characteristic of natural debris flows, did the distributions of simulated impact forces have a similar form to those measured beneath the natural flows. These results highlight the important role flow grain size can have on basal impact force.

As either bed inclination or flow depth was increased in the simulated flows, the mean and the spread of the impact force and impact energy distribution increased as well and in a nonlinear fashion. Bed impact flux was largely decoupled from the downstream flux of particles and was a linearly decreasing function of slope once slope increased beyond a threshold value. Incision rate, which should scale as the product of impact energy and impact flux, increased as a nonlinear function of slope. Steep landscapes in which millennial scale erosion rates have been quantified display a similar nonlinear relationship between erosion rate and channel gradient. This suggests that the grain-scale mechanics quantified here could place strong controls on steepland morphology that evolves over thousands to millions of years.

Coupled modelling of surface, subsurface hydrology and atmosphere in Jordan

Shadi Moqbel, Al-Isra Private University, Jordan

http://goo.gl/mFwG9r

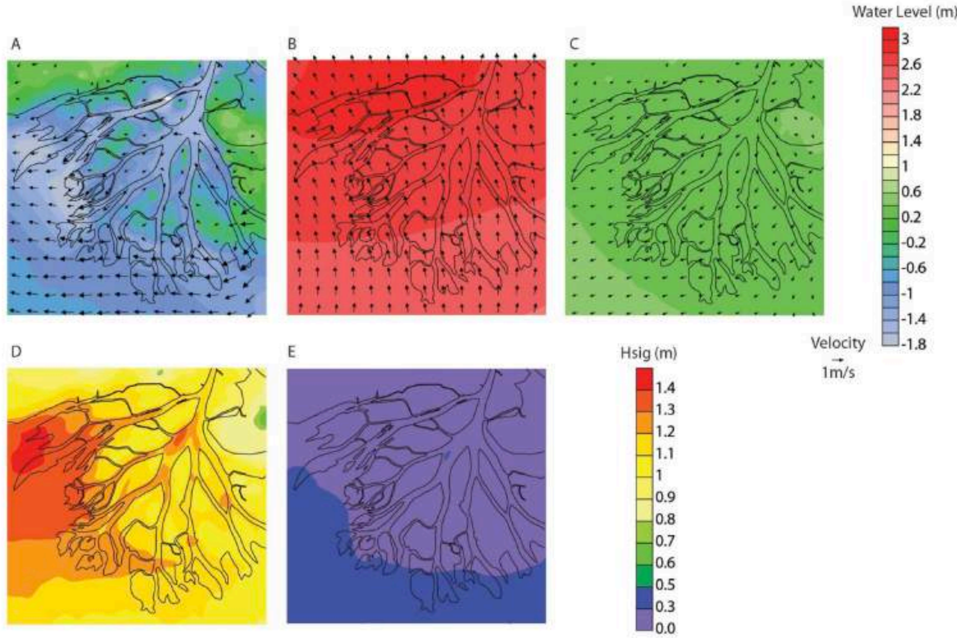
The project will study the effect of past and future climate changes on the eastern watersheds of Jordan. Watersheds under study will cover part of the desert and easter ridges of the mountainous area east of the Jordan valley.Project will evaluate water resources in the area, changes in the climate and its effect on the water storage and the expansion of the eastern desert of Jordan.

The impacts of vegetation on hydrodynamics and morphology of coastal wetlands, Wax Lake Delta during extreme events

Fei Xing, University of Colorado

NSF Award number 0952116 NSF Award number 1135427

http://goo.gl/rEykpA



The impacts of humans on natural systems are becoming more and more significant in modern times. The critical zone between ocean and land, the deltaic area, which is also the zone supporting most of population on the earth, is undergoing fast changes and becoming a high-risk zone for human society and ecosystem. Coastal Wetlands can slow down the flow velocity, dissipate wave energy, and increase soil critical shear strength, thus protect inland areas from increasing extreme events. This project mainly concentrates on hydrodynamics and morphological changes on the coastal wetlands during short-term extreme events (hurricanes, winter storms, and river floods), and also the river water and sediment changes for long-term period, which accounts for the formation of deltas.

Terrestrial Hydrology

Theodore Barnhart, University of Colorado, Noah P. Molotch, University of Colorado, Adrian Harpold, University of Colorado, John Knowles, University of Colorado, Suzanne Anderson, University of Colorado
Funded by:

- NSF EAR Boulder Creek CZO (DEB-9810218)
- USDA-NSF Water Sustainability and Climate Grant (2012-67003-19802)
- NSF Niwot Ridge LTER (DEB-1027341)
- NSF Hydrologic Sciences EAR (1141764)

http://goo.gl/ssNHxu

Snowmelt is the primary source of surface water in the western United States and many other regions on Earth. Climate warming is forecast to impact the amount of precipitation that falls as snow and forms the mountain snowpack. Climate change induced alterations to snowpack translate to changes in snowpack magnitude, the timing of snowmelt, and changes in snowmelt rate. We ask how these perturbations may impact how snowmelt is partitioned between evapotranspiration (ET) and runoff (R) at Como Creek, a snowmelt dominated catchment on the Colorado Front Range. Como Creek is a 4.5 km^2 headwater catchment spanning 2900-3560 m and is part of the Niwot Ridge Long Term Ecological Research Station and the Boulder Creek Critical Zone Observatory. We use observations of snow water equivalent (SWE), ET, and precipitation (P) from Niwot Ridge, CO, and discharge from Como Creek to explore relationships between snowpack dynamics and snowmelt partitioning. Measurements of ET are collected adjacent to Como Creek at the Niwot Ridge Ameriflux site and are assumed representative of the hydrologic fluxes in Como Creek. Analyses from point data show that years with higher peak SWE/P ratios partition proportionally more snowmelt to ET (pValue: 0.045). For example, water year (WY) 2005 has a peak SWE/P ratio of 0.49 and a growing season ET normalized by WY precipitation (ET/P) ratio of 0.48 while WY 2008 has a peak SWE/P ratio of 0.83 and an ET/P ratio of 0.82. Observations also show that years that experience later peak SWE (DOY=142) partition proportionally less snowmelt into ET (ET/P=0.42) compared to years that experience earlier peak SWE (DOY=86) and partition proportionally more snowmelt to ET (ET/P=0.56). Further point analyses also suggest that more rapid snowmelt results in proportionally less snowmelt partitioned to ET and more partitioned to runoff. To explore the underlying processes responsible for these relationships at the catchment scale we use the Regional Hydro-Ecologic Simulation System (RHESSys) to model how snowmelt is partitioned between ET and R under observed conditions and under a variety of climate change induced snowmelt timing, magnitude, and rate scenarios.

Improving Representations of Snow-Vegetation Interactions

Adrian Harpold

NSF EAR Postdoctoral Fellow (EAR#1144894)

http://goo.gl/zcPpwJ

Applying LiDAR-derived vegetation datasets to verify and improve snow-vegetation interactions in land surface models

Leif Anderson, University of Colorado and INSTAAR

National Science Foundation (NSF) grant DGE- 1144083 (GRFP)

http://goo.gl/cdeGRi

Valley glacier moraines are commonly used to infer past mean annual precipitation and mean melt-season temperature. However, recent research has demonstrated that, even in steady climates, multi-decadal, kilometer-scale fluctuations in glacier length occur in response to stochastic, year-to-year variability in mass balance. When interpreting moraine sequences it is important to include the effect of interannual weather variability on glacier length; moraines record advances that are forced either by interannual variability or by a combination of climate change and interannual variability. Our hope is to help establish the metrics needed to determine if a past glacier advance was caused by interannual variability or a climate change.

Landscape Evolution Modeling of Terrain Modified by Agricultural Terracing

Jennifer Glaubius, University of Kansas

http://goo.gl/bX0k8O

GPU-Accelerated Interactive Supercomputing for Climate Studies in the Northern Environment

Bipush Osti, University of Maine

http://goo.gl/uYE0RQ

The objective is to demonstrate the viability of a new GPU-accelerated and visually interactive supercomputing technique for human-in-the-loop investigation of the postglacial evolution of the Earth's surface since the Last Glacial Maximum via numeric modeling. The proposed interactive supercomputing provides runtime what-if analysis based on high-resolution graphics to achieve enhanced understanding of past and future climate change in the Northern Hemisphere.

Multiscale stratigraphic and statistical characterization of fluvial systems

Jesse Pisel, Colorado School of Mines, Chevron Center of Research Excellence, Rocky Mountain Association of Geologists, Colorado School of Mines, The Geological Society of America, Gulf Coast Section SEPM, Rocky Mountain Section SEPM, AAPG Grants in Aid

http://goo.gl/ALqJMr

Many different statistics are currently used to compare numerical and physical models of fluvial systems to outcrop datasets. This project focuses on evaluating the current methods and determining the most robust and accurate way to quantitatively compare models to outcrops.

A Geo-Semantic Framework for Integrating Long-Tail Data and Models

Peishi Jiang, University of Illinois at Urbana-Champaign

http://goo.gl/3zjUww

Our vision is to develop a decentralized knowledge-based platform that can be easily adapted across geoscience communities comprised of individual and small group researchers, to allow semantically heterogeneous system to interact with minimum human intervention. It will allow the automatic reference of data from data resources to model by: (i) leveraging the Semantic Web; (ii) developing an automated semantic mediation tool; and (iii) developing a semantic knowledge discovery system that can be used by long-tail models. The developed approach will be evaluated based on a case study of integrating two examples of long-tail modeling and data: the Community Surface Dynamic Modeling System (CSDMS) and Sustainable Environment Actionable Data (SEAD).

HAMSOM to South Atlantic

Joaquim Pereira Bento Netto Junior, Federal University of Parana

Phd scholarship from CNPq-DAAD program from Brazil

http://goo.gl/RQ50eF

Course: Numerical modeling of fluvial systems applying the Web Modeling Tool (WMT)

Albert Kettner, University of Colorado, Irina Overeem, University of Colorado

Funded in part by: NSF COOPERATIVE AGREEMENT 0621695

To familiarize earth sciences, coastal and oceanography and engineering graduate students with a resources and a number of numerical surface process models and hydrological models available through Community Surface Dynamics Modeling System and introduce them to use of these software tools for their own research and teaching purposes.To familiarize earth sciences and engineering graduate students with remote access to and use of the CSDMS supercomputer "Beach".

Learn about the following surface proceses:

- Sediment supply modeling: theory and HydroTrend Model
- Landscape evolution modeling theory and CHILD model
- Coastal evolution and longshore transport and wave processes and CEM
- Stratigraphic modeling and Sedflux model.

At the end of this course, students should be able to design and run simulations for independently designed research questions on sediment supply, landscape and coastline evolution and marine stratigraphic processes.

Modeling stream capture in strike-slip fault settings

Sarah Harbert, University of Washington

http://goo.gl/oHIo7M

Investigating the effect of stream size and sediment supply on stream capture.

Glacier Modeling

Leif Anderson, University of Colorado

National Science Foundation (NSF) grant DGE- 1144083 (GRFP)

http://goo.gl/ujjA1s

We are using a newly developed debris-covered glacier model to determine the effect of debris cover on glacier length. The model allows for fully transient advection of debris through and on top of the glacier. We are currently exploring the basic feedbacks between debris input location, erosion rate, mass balance parameterization, and glacier length.

Teaching basics of modeling in earth systems

Sarah Harbert, University of Washington

Funded by the University of Minnesota Office of Equity and Diversity

http://goo.gl/KkdneY

We are using CSDMS in a course offered at University of Minnesota Duluth titled 'Creative problem solving in earth science.' This is a project based course, focused on providing an overview of quantitative tools and models and how to start creating them.

CHESROMS BGC

Hao Wang, UMCES

Funded by NOAA COMT

http://goo.gl/520LdU

We are using ROMS to simulate the 3D salinity, temperature, dissolved oxygen, chlorophyll, NH4,NO3 for long term time period in Chesapeake Bay, to provide guidance for the public nutrient reduction and future operational work

Chesapeake Bay FVCOM-ICM

Blake Clark, UMCES

Funded by NASA

http://goo.gl/Q8K12r

I am working in collaboration with multiple institutions and PIs to model the coastal ocean carbon cycle, particularly with respect to marsh-estuary dynamics in Chesapeake Bay. We use FVCOM for 3d hydrodynamics and coupled offline to ICM for a carbon based biogeochemical model. A model to simulate SAV and sediment diagenesis is in development. The model developed here will be adapted for use in a broad range of coastal systems.

Estimation of sediment discharge in Mexican coastal basins larger than 500 km2, at high resolution

Miguel Angel Delgadillo-Calzadilla, Instituto de Ingeniería UNAM

http://goo.gl/F0HvK5

This research would estimate the sediment discharge, into coastal basins to evaluate the condition of sand beaches along the mexican littoral.

Hydraulic Bore into Shear

Zach Borden, University of Santa Barbara

http://goo.gl/JpfThm

We are expanding Zach Borden's work on the circulation model onto the case of hydraulic bores propagating into shear.

River plumes in Ecuadorian coast

Willington Renteria, Secretaria Techica del Mar, Ecuador

The project is funding by Secretaria del Mar, as an investment project from Ecuadorian Government

http://goo.gl/odCSAz

The project is focused in understand of the effect of river plumes in ecosystems of ecuadorian coast. A lot of nutrients are carried out by rivers to the marine-coastal ecosystems, some of them affecting the marine reserves in the coast. Moreover, the Humboldt current is present in the south of the coast also carrying out a lot of nutrients. The interaction between the Humboldt current and the river plumes is poorly understood, the focus of this project is try to quantify this interaction.

Course: Surface Process Modeling Using WMT

Irina Overeem

Funded in part by: NSF COOPERATIVE AGREEMENT 0621695

This course aims to familiarize earth sciences and engineering graduate students with a number of numerical surface process models and hydrological models available through the Community Surface Dynamics Modeling System (CSDMS) and sets students up to use these tools for your own research purposes.

Nearshore Currents

E. M. Yadhunath, National Institute of Oceanography, India

http://goo.gl/zihvY8

Studies in the nearshore region is a difficult task. Complex processes are associated at the near shore especially currents and wave breaking. I this work i am trying to model nearshore current pattern and morphological changes using given wave, tide and wind conditions. XBeach is the model using for this work.

Spatial Distribution of Solar Radiation as a Driver of Hillslope Asymmetry Across Latitudes

Omer Yeteman, University of Washington

This research is supported by NSF through grants: NSF-EAR 0963858, NSF-ACI 1148305.

Ecohydrologic roles of incoming solar radiation on landscape evolution in a semi-arid ecosystem are demonstrated by Yetemen et al. [2015] with CHILD (Channel-Hillslope Integrated Landscape Development) landscape evolution model. In this framework, the CHILD model which is equipped with a solar radiation-driven ecohydrologic vegetation dynamics model and a vegetation-modulated fluvial incision model, is sufficient to reproduce first-order characteristic of aspect-related observed vegetation distribution and hillslope and catchment-scale geomorphic patterns in New Mexico [Istanbulluoglu et al., 2008].

Poulos et al. [2012] investigated hillslope asymmetry across the American Cordillera from 60°N to 60°S latitude. They described hillslope asymmetry with an index, HAI (Hillslope Asymmetry Index) which is a comparison of median slope of different aspects (N versus S, or E versus W). They calculated HAI of N-to-S, HAIN-S through the American Cordillera based on 90-m DEM by using a 5 km by 5 km sliding window, the HAIN-S is nearly 0 at the equator, and systematically increases toward the North Pole which means steeper north-facing slopes than south-facing slopes, and systematically decreases toward the South Pole which means steeper south-facing slopes than north-facing ones. The absolute value of HAIN-S maximizes at mid-latitudes, and then begin to decreases toward the poles, finally sign changes further than 49°N and 40°N latitudes on the Northern and Southern Hemisphere, respectively.

In this project, we want to further explore the ecohydrologic role of solar radiation on landscape development at different latitudes, from 45°N to 45°S, for a range of semi-arid climatology, mean annual precipitation from 200 mm to 500 mm. To achieve this goal, the model will be adjusted based on required changes including the amount of incoming solar radiation, timing of wet season, and storm characteristics etc. At the end of this project, we will answer following questions: What is the role of solar radiation on landscape evolution at different latitudes? What is the role of mean annual precipitation on this role?

A Multi-model workflow to understand of the Influence of Hurricanes on Generating Turbidity Currents in the Gulf of Mexico

James Syvitski, University of Colorado, Hernan Arango, Rutgers University, Courtney Harris, College of William & Mary, Eckart Meiburg, University of Santa Barbara, Chris Jenkins, University of Colorado, Eric Hutton, University of Colorado, Guillermo Auad, Bureau of Ocean Energy Management, Tara Kniskern, College of William & Mary, Senthil Radhakrishnan, University of Santa Barbara
Funding: Bureau of Ocean Energy Management

The Gulf of Mexico (GOM) continental margin is a mature offshore oil and gas production area generating more than 1.7 million of barrels of oil per day, through more than 3,500 oil platforms. Currently the northern Gulf has 45,000+ km of underwater pipes exposed to structural damage from extreme oceanic and atmospheric events. Large waves may exceed 10m in wave height in deep water during the passage of a hurricane. Such waves can resuspend seafloor sediment and liquefy the seafloor, both being viable mechanisms for inducing sediment gravity flows, such as turbidity currents. Approximately 5% of the underwater pipes are broken or damaged by sudden powerful turbidity currents (BOEM). Leakage from offshore oil and gas reserves puts at risk about 40% of the USA's coastal and estuarine wetlands, vital to recreational, agricultural and a $1B/y seafood industry (Stone and McBride, 1998).

We model sediment fluxes from the inner continental shelf including fluvial sources to the continental slope. The workflow explores the conditions that trigger episodes of sediment flux on the continental slope where gas and oil infrastructure exist. Two hypotheses are tested: 1) episodic transport down the Mississippi Canyon is fed by sediment input at the canyon head from wave and current resuspension; and 2) turbidity currents can be triggered by continental slope failure when storm driven supply causes accumulation sediment to deep water.

Appendix 12: Landlab

The Landlab development team includes:

- Greg Tucker and Dan Hobley (University of Colorado),
- Eric Hutton (CSDMS),
- Nicole Gasparini and Jordan Adams (Tulane University),
- Erkan Istanbulluoglu and Sai Nudurupati (University of Washington).

Landlab is a Python-language software library that facilitates writing and coupling two-dimensional numerical models, with an emphasis on earth-surface dynamics models. The current prototype version of Landlab (0.24) was developed on behalf of CSDMS by a team of Terrestrial Working Group members, with support from NSF's SI2-SSE program.

The present version of Landlab provides three general capabilities. First, Landlab provides a *gridding engine*. A model grid is implemented as a data object, which means that a Landlab user can create and configure a grid in just one or a few lines of Python code. Landlab provides several grid types, including raster, hexagonal, Voronoi-Delaunay, and radial. Because the various grid types share the same fundamental data structures, users can change grid types quite easily, without needing substantial changes to their algorithms. A model developer can also attach *data fields* to the grid to represent state variables and boundary conditions. These fields then become part of the grid object, which makes it easy for individual components to share both the grid and a common set of data.

The grid data structures make it simple to associate state variables either with *grid nodes* (computational points associated with polygonal *cells*) or *grid links* (directed line segments that connect pairs of adjacent nodes). This configuration makes it easy to implement staggered-grid finite-difference and finite-volume schemes. For example, an application that simulates shallow water flow over topography could map scalar quantities (such as water depth) onto nodes, and vector quantities (such as flow velocity) onto links. The gridding engine also provides built-in functions to handle common numerical operations, such as calculation of gradients between pairs of adjacent cells.

A second Landlab capability is the coupling of *components*. A Landlab component, like a CSDMS component, is a piece of code that models a particular natural process. Landlab provides a simple architecture for coupling components, which share a common grid and its associated data fields. Components can query the grid to determine whether a particular data field (say, water depth at nodes) exists, and if not, create it. To facilitate sharing of data, each data field is given a name, using either CSDMS standard names or shorter variable names that can be mapped to their CSDMS equivalents. A Landlab user can create a coupled model by instantiating two or more components and running them sequentially.

Landlab version 0.24 includes several process components; these include, for example, components that model landscape evolution by soil creep and fluvial erosion, components that model shallow water flow over topography, and components that model soil moisture dynamics. Additional work is now underway to have components automatically inherit a BMI, such that any Landlab component can also function as a CSDMS component.

Finally, Landlab reduces model-development time by providing a set of utility functions to handle common software operations. These include, for example, reading parameter-input data from a formatted text file, reading and writing data to/from netCDF-format files, reading data in from ESRI ASCII files, and plotting user-selected data fields using the Matplotlib plotting library.

There is much more to be done to enhance Landlab's capabilities, documentation, and scope. Further development will be conducted over the next five years, through support from NSF's SI2-SSI program (beginning in August 2015). Landlab is publically available through a GitHub repository (http://github.com/landlab), and contributions from the community are highly encouraged.