CSDMS

COMMUNITY SURFACE DYNAMICS MODELING SYSTEM

2011 ANNUAL REPORT

NSF COOPERATIVE AGREEMENT 0621695

Executive Summary

CSDMS continues to gain momentum in 2011, a growth of 46%, with 220 new members (~700 members in total). CSDMS has become the international coordinator of open source surface dynamics models and modeling efforts, both nationally (142 institutions) and internationally (184 foreign institutions from 49 countries). The CSDMS Model Repository offers 191 open-source models (more than 4.85 million lines of code), directly addressing the historical lack of readily available models for research and application. This penetration of computational tools into the earth-science community should provide valuable future dividends. Visits to the CSDMS Web Portal grew by 267% with more than 5.45 million visits to become the "go to" site for models and CSDMS-related data and educational products including animations and images, modeling labs and lecture materials. There are presently 122 movies & animations on the CSDMS YouTube channel, generating more than 36,001 views and putting the CSDMS YouTube channel in the "Top 50 most viewed channels" in the "non profit" category. Use on a dedicated supercomputer is offered free to the CSDMS community and presently supports more than 166 users (a 66% growth). CSDMS continued to organize, host or sponsor CSDMS-related workshops and symposia, providing short courses and model clinics.

Year 1 and 2 focused on developing the architecture for model coupling. Year 3 was dedicated to advanced simulations through proof-of-concept projects. Year 4 and 5 finalized the standards for model interfaces and the wrapping tools to allow models to more easily be converted into plug and play components. With the rapid growth in membership, adjustments were made on how the community could best interact through annual meetings, including an ever increasing number of model training clinics. Getting models into the hands of scientists and engineers is not the same as providing members insight and instruction in the proper application of a model.

The 2011 Annual CSDMS Award winners are: 1) 2011 Best Poster — "Direct Numerical Simulation of Sediment Erosion" Zachary Borden (UC Santa Barbara), 2) 2011 Student award — "A reduced-complexity channel-resolving model for sedimentary delta formation" — Man Liang (SAFL, U Minnesota) and 3) Lifetime Achievement Award — Professor Rudy L Slingerland (Penn State).

This report outlines Year-5 progress and provides future goals and resource requirements needed to advance the CSDMS effort. The Annual Report documents community activity, management structure and plans, publications and presentations, meetings, models, membership, and provides budgetary details on income and expenditures. The report builds upon the Year-5 Semiannual Report and other CSDMS documents.

CSDMS 2011 Annual Report

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CSDMS Annual Report, Dec 31, 2011

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.

This Annual Report covers the period from January 1, 2011 to December 31, 2011, and provides anticipated progress through March 31, 2011.

2.0 CSDMS Management and Oversight.

Development priorities are guided through community meetings and online input from community members. CSDMS operates with a mature set of by-laws available at the CSDMS website. The following outlines the present organizational and governance structure

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

- Rudy Slingerland (April, 2007), Chair, CSDMS Steering Committee, Penn State Univ.
- Brad Murray (April, 2007), Chair, Coastal Working Group, Duke Univ.
- Pat Wiberg (April, 2007), Chair, Marine Working Group, Univ. of Virginia
- Greg Tucker (April, 2007), Chair, Terrestrial Working Group, CIRES, U. Colorado – Boulder
- Eckart Meiberg (Jan, 2009), Chair, Cyberinformatics & Numerics WG, U. California-Santa Barbara
- Irina Overeem (Oct, 2011), Chair, Education & Knowledge Transfer WG, U. Colorado – Boulder
- James Syvitski (*ex-officio),* CSDMS Executive Director, INSTAAR, University of Colorado - Boulder
- Scott Peckham (*ex-officio)* Chief Software Architect, CSDMS Integration Facility, U. 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. ExCom approves the business reports, management plan, budget, partner memberships, and other issues that arise in the running of CSDMS. ExCom met both in the spring and fall of 2011.

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

- Rudy Slingerland (April, 2007), Chair, CSDMS Steering Committee, Penn State Univ., University Park, PA
- Tom Drake (April, 2007), U.S. Office of Naval Research, Arlington, VA
- Bert Jagers (April, 2007), Deltares and OpenMI, Delft, The Netherlands
- Rick Sarg (April, 2007), Colorado School of Mines, Golden, CO
- Gary Parker (April, 2007), Univ. Illinois Urbana-Champaign, IL
- Dan Tetzlaff (April, 2007), Schlumberger Ltd, Cambridge, MA
- Dave Furbish (April, 2007), Vanderbilt University, Nashville, TN
- Chris Paola (Sept, 2009), NCED, U. Minnesota, Minneapolis, MN
- Cecilia DeLuca (Sept, 2009), ESMF, NOAA/CIRES, Boulder, CO
- Boyana Norris (Sept, 2009), Argonne National Lab, Argonne, IL
- 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 — joined fall 2010.

The CSDMS SC assesses the competing objectives and needs of the 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. The CSDMS SC met in the fall of 2011.

2.3 CSDMS Working and Focus Research Groups

The ~700 members represent 144 U.S. institutions (105 academic, 18 private, 21 federal) and 185 non-U.S. institutions from 49 countries (110 academic, 20 private, 55 government). Members are organized within 5 working groups (Terrestrial, Coastal, Marine, Education, Cyberinformatics) and 3 focus research groups (Hydrology, Carbonate, Chesapeake) as of 12/31/11:

Terrestrial	**328**
Coastal	**259**
Hydrology	**240**
Marine	**189**
Cyber	**104**
EKT	**101**
Carbonate	**55**
Chesapeake	**39**

Members provide model code and support tools, educational material, and data for model initialization, testing and benchmarking, and assessing contributed models. The semi-annual, annual and rolling Strategic Plans transparently reflect input from member. **Appendix 1** provides a listing of participating US academic institutions, foreign institutions, and government agencies. There are now ~**329** affiliated institutions.

2.4 The CSDMS Integration Facility (IF)

The CSDMS Integration Facility (IF) maintains the CSDMS Repositories, facilitates community communication and coordination, public relations, and product penetration. IF develops the CSDMS cyber-infrastructure (e.g. coupling framework, tools, services and software protocols), and provides software guidance to the CSDMS community. The IF maintains the CSDMS vision and supports cooperation between observational and modeling communities. CSDMS' IF is located at INSTAAR, University of Colorado-Boulder, csdms.colorado.edu/wiki/Contact_us. As of Dec 31, 2011, CSDMS IF staff included csdms.colorado.edu/wiki/Staff

- Executive Director, Prof. James Syvitski (April, 2007) — CSDMS & CU support
- Executive Assistant, Ms. Marlene Lofton (Aug. 2008) — CSDMS support
- Chief Software Engineer, Dr. Scott Peckham (April, 2007) — CSDMS & other NSF/NOAA support
- Software Engineer, Dr. Eric Hutton (April, 2007) — CSDMS & LASP & GSC support
- Computer Scientist, Jisamma Kallumadikal (Aug, 2009) — Industry, CSDMS & NOAA support
- Cyber Scientist Dr. Albert Kettner (July, 2007) — CSDMS, ConocoPhilips & other NSF/NASA support
- EKT Scientist Dr. Irina Overeem (Sept, 2007) — CSDMS, ConocoPhillips & other NSF support
- PDF Dr. Sagy Cohen (Aug, 2010) — NASA support
- Ph.D. GRA Stephanie Higgins (Sept, 2010) — Other NSF support
- Ph.D. GRA Fei Xing (July, 2010) — CSDMS & other NSF support
- Ph.D. GRA Ben Hudson (May, 2010) — NSF support
- Accounting Technician Mary Fentress (April, 2007) — multiple grant support
- Systems Administrator Chad Stoffel (April, 2007) — multiple grant support
- Director Dartmouth Flood Observatory, G Robert Brakenridge (Jan, 2010) — NASA support
- Senior Research Scientist Christopher Jenkins (Jan 2009) — NSF & other support

CSDMS Visiting Scientists and Students **since Jan 1, 2011:**

• Zuosheng Yang	Professor	Ocean U of China	2011 January
• Houjie Wang	Professor	Ocean U of China	2011 January
• Naishuang Bi	Professor	Ocean U of China	2011 January
• Reed Maxwell	Professor	Col. School of Mines	2011 February
• Tao Sun	Executive	ExxonMobil	2011 March
• Damian O'Grady	Executive	ExxonMobil	2011 March
• Kim Picard	Ph.D. student	GSC, Pacific	2011 March-April
• Mohamad Nasr-Azadani	Ph.D. student	UCSB *(& CSDMS Student Modeler 2010)*	2011 May
• Peter Burgess	Professor	Royal Holloway Univ. of London	2011 May
• Laurel Saito	Professor	Univ Nevada-Reno	2011 June-Oct
• Bert Jagers	Executive	Deltares	2011 June
• Kees Sloff	Executive	Deltares	2011 June
• Ron Tingook	Ph.D. student	U Alaska	2011 June
• Michael Barton	Director	Arizona State U	2011 June
• Liz Olhsson	Ph.D. student	UC Berkeley	2011 July
• Martin Perlmutter	Executive	Chevron	2011 July
• Michael Pyrcz	Executive	Chevron	2011 July
• Brian Willis	Executive	Chevron	2011 July
• Elchin Jafarov	Scientist	University of Alaska	2011 August
• Daekyo Cheong	Professor	Kangwon Nntl. Univ, Korea	2011 Aug-Dec
• Matthias Vanmaercke	Ph.D. student	K.U. Leuven, Belgium	2011 Aug-Oct
• James Verdin	Ph.D.	USGS	2011 August
• Kristine Verdin	Ph.D.	USGS	2011 August
• Phadrea Upton	Professor	GNS Science, New Zealand	2011 September
• Emilio Mayorga	Professor	University of Washington	2011 September
• Vladimir Smakhtin	Professor	IWMI	2011 October
• Benjamin Allan	Professor	Sandia National Labs	2011 October
• Hajo Eicken	Professor	University of Alaska-Fairbanks	2011 October
• Kim Picard	Ph.D. student	GSC, Pacific	2011 November
• Ruth Mugford	Scientist	Cambridge U	2011 November

2.5 Industrial Consortium

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 11% of CSDMS members are with industry (75 members — see Appendix 1 for details). CSDMS efforts were presented in separate meetings to Statoil, Exxon, Chevron, ConocoPhillips and Shell representatives. A wider community of practitioners was reached with presentation of an invited address to the Tulsa Geological Society (March 1st, 2011) made available through AAPG Search and Discovery website. Presentations at the Annual CSDMS meeting reflected participation of our industry and federal partners.

A strategic plan for a source-to-sink modeling toolbox has been further developed. These modeling concepts were presented at the AGU Chapman Conference on Source to Sink Modeling (January 2011). Conference presentations and posters have been collected and may be viewed through the CSDMS Educational Repository; the material forms the basis for online teaching resources related to an S2S system approach.

The stratigraphic model SedFlux has been made user-friendly through the CMT. At the CSDMS Annual Meeting, new functionality was presented during a clinic. The Carbonate Working Group is well connected to industry. CSDMS continues it out reach to engineering teams at Électricité de France (EDF) and Deltares. Both Telemac and Delft3D became models available through CSDMS and can be run on the CSDMS HPCC. The open-source community effort of the Delft3D model has been actively reaching out to CSDMS members through webinars. The CSDMS annual meeting featured a hands-on clinic on Delft3D.

2.6 CSDMS Interagency Committee

This group is comprised of the 21 US agencies (see Appendix 1 for details) and may host non-US government agencies. For 2011, the British Geological Survey participated as an observer. The committee coordinates their member's collaboration with and support of CSDMS efforts. For 2011 the focus was on how best to move models from research grade to operational grade level, avoiding duplication of effort. Most agencies use models to address practical applied problems, for example: operational forecasts; regulatory assessments, permitting, risk assessments, remedial action plans, emergency response, and outreach to stakeholders. Most agencies rely on models that are developed or are funded in-house, for reasons of quality control, specificity, familiarity (with the developers, agency users, and contractors), and cost of changing. Still, the CSDMS community and its products might offer agencies coupled models that these same agencies might like to see developed. However there is a long path from first successful coupled runs to acceptance and/or utility within agencies. In the near term, CSDMS can contribute to understanding of how to build and deploy coupled models. Individual agencies might be "early adopters" and leverage CSDMS to develop coupled models to address specific topics. A task force of the CSDMS Interagency Committee has agreed to explore early adoption strategies.

As a proof of concept, and with support of the **Marine Working Group**, CSDMS is providing help in coupling a high-resolution large-eddy-simulation (LES) turbidity current model (*TURBINS* to be upscaled at UCSB) to a coarser resolution Reynolds-averaged Navier-Stokes (RANS) ocean circulation model ROMS with the Community Surface Transport Model enabled. This LES-RANS model coupling will employ CMT and also couple with other data and model components. The project is being funded through a Rutgers U. cooperative agreement with the Bureau of Ocean Energy Management (BOEM), and CSDMS will use this opportunity as a proof-of-concept at getting academic (research grade) models into an operational workflow. Model runs will provide insights into areas most likely to be impacted by turbidity currents, and the factors that precondition or trigger the flow. The Gulf of Mexico has >3500 oil platforms and >28,000 miles of underwater pipes exposed to different types of structural damage, most of them associated with extreme oceanic and atmospheric events. About 5% of the pipelines are broken or damaged by sudden and violent cascading of sediments. Predicting the path and fate of spilled oil in the ocean is important for resource managers and spill responders.

2011 CSDMS Annual Meeting

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). Of the ~5 million lines-of-code held in the Repository, 44 projects are in Fortran, 70 in C or C++, 29 in Python, 15 in Matlab, with the remaining in C#, IDL, SAS, Java, or VB. About 70% are distributed through a central Repository; others are distributed through linkages to existing community efforts. Centralized downloads exceed 8000 and redirected download traffic to other sites is similarly high. The 168 projects noted below may involve more than one model.

Repository lines of code statistics as of Dec 2011: csdms.colorado.edu/wiki/Model_SLOC_Page

Language	Projects	Comment	Source	Total
Fortran 77/90/95+	44	941932	1943161	2885093
c/c++	70	319023	1020813	1339836
Python	29	97570	147709	245279
C#	1	29344	160373	189717
MATLAB	15	36150	52325	88475
IDL	5	38834	36954	75788
Statistical Analysis Software	1	2390	5796	8186
Java	2	2214	12851	15065
Visual Basic	1	537	8581	9118
Total	168	1467994	3388563	4856557

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

Domain	Models	Tools	Components
Terrestrial	77	44	33
Coastal	52	2	4
Marine	44	4	8
Hydrology	50	35	43
Carbonate	1	1	0
Climate	10	2	0

Models can be run on the CSDMS supercomputer without download and are not included in these statistics. Community models downloaded from other sites (e.g. ROMS, NearCOM) are also not counted. The top ten most downloaded models by version (Dec 2011):

	Model	No. Times	Topic
1.	**topotoolbox**	*953*	A set of Matlab functions for topographic analysis
2.	**child**	*711*	Landscape evolution model
3.	**topoflow**	*676*	Spatially-distributed, D8-based hydrologic model
4.	**sedflux**	*290*	Basin filling stratigraphic model
5.	**hydrotrend**	214	Climate driven hydrological transport model
6.	**2dflowvel**	*201*	Tidal & wind-driven coastal circulation routine
7.	**adi-2d**	*201*	Advection Diffusion Implicit method for 2D diffusion
8.	**bing**	*183*	Submarine debris flows
9.	**midas**	*171*	Coupled flow- heterogeneous sediment routing model
10.	**gc2d**	*140*	Glacier / ice sheet evolution model

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

Data Repository as of December 2011

Data Type	Databases		
Topography/bathy	15	Land cover	2
Climate	6	Substrates	3
Hydrography	5	Human Dimensions	2
River discharge	8	Sea level	1
Cryosphere	5	Oceanography	9
Soils	3	GIS Tools	12
		Network Extraction	7

3.3 CSDMS Education & Knowledge Transfer (EKT) Repository

The **Education Repository** offers undergraduate and graduate modeling courses, educational modules, modeling labs, and process and simulation movies.

Animations library csdms.colorado.edu/wiki/Movies_portal.

Climate & Oceanographic Animations	8	Marine Animations	9
Terrestrial Animations	16	Laboratory Movies	14
Coastal Animations	21	Real Event Movies	32

Image Library csdms.colorado.edu/wiki/Images_portal

Terrestrial Images	90
Coastal and Marine Images	49

Modeling Labs csdms.colorado.edu/wiki/Labs_portal

Modeling Labs are being designed to have a tiered approach. There are spreadsheet labs that emphasize quantitative skills, but address earth surface process questions/problems with reduced parameter space. These labs are focused on undergraduate education and include lesson plans and teacher material. Whereas CMT-based modeling labs offer additional complexity and simulations can be run with more freedom in complexity level. The EKT web pages point to members who have active online teaching resources.

Current available labs:

1. Glacio-Hydrological Modeling
2. River-Delta Interactions
3. Sediment Supply to the Global Ocean
4. Landscape Evolution Numerical Experiments
5. Earth Science Models for K6-12
6. Coastal Engineering Experiments
7. Hydrological Processes Exercises
8. Sinking Deltas
9. Stratigraphic Modeling with Sedflux
10. Coastal Stratigraphy Numerical Experiments

Modeling Lectures and Courses csdms.colorado.edu/wiki/Lectures_portal

1. Surface Dynamics Modeling with CMT — I Overeem & SD Peckham
2. Quantitative Earth-surface Dynamics Modeling — JPM Syvitski
3. 1D Sediment Transport — G Parker
4. Morphodynamics of Rivers — G Parker
5. Source to Sink Systems around the World — Keynote Chapman Lectures
6. Plug and Play Component Technology — JPM Syvitski and I Overeem
7. Geological Modeling — I Overeem

Modeling Textbooks csdms.colorado.edu/wiki/Modeling_Textbooks

1. Mathematical Modeling of Earth's Dynamical Systems *By: Slingerland, R., Kump, L.*
2. Geomorphology; the Mechanics and Chemistry of Landscapes *By: Anderson, R., Anderson, S.*
3. Quantitative Modeling of Earth Surface Processes *By: Pelletier, J.D.*
4. Simulating Clastic Sedimentary Basins: Physical Fundamentals and Computing Procedures *By: R.L. Slingerland, K. Furlong and J. Harbaugh*
5. 1D Sediment Transport Morphodynamics with applications to Rivers and Turbidity Currents *By: G Parker*

3.4 CSDMS Experimental Supercomputer csdms.colorado.edu/wiki/HPCC_information

The CSDMS High Performance Computing Cluster has operational issues during the Spring period causing periodic shutdowns. These issues have been addressed by SGI. Over 160 CSDMS members now have accounts on the system and have met the use criteria:

- Running a CSDMS model(s) to advance science
- Developing a model that will ultimately become part of the CSDMS model repository.
- Developing a new data systems or visualizations in support of CSDMS models.

CSDMS High Performance Computing Cluster (HPCC) System *Beach* is an SGI Altix XE 1300 with 88 compute nodes (704 cores, 3.0 GHz Harpertown processors) (≈8 Tflops). 64 nodes have 2 GB of memory per core, 16 nodes have 4 GB of memory per core. Internode communication is accomplished through 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). Power management employs APC UPS with 30 minutes of uptime at 50% load. *Beach* head-nodes are backed-up by a separate UPS system. *Beach* is supported by the CU ITS Managed Services (UnixOps) under contract to CSDMS.

The *Janus* supercomputing cluster, funded in part by NSF under Grant CNS-0821794, is now online and available for use by CSDMS members that have accounts on beach. This provides CSDMS members with 16,416 computational cores and 32TB of memory. Users are allowed 50,000 core-hours by default and must submit an allocation request for more computational time. The CSDMS high-performace computing cluster, *Beach* is connected to the *Janus* cluster through a private 10 Gb/s network. This enables *Beach* users to quickly and easily share large data sets between the two clusters and use *Janus* 1PB lustre file system.

The Janus system consists of 1368 nodes, each containing two 2.8 GHz Intel Westmere processors with six cores each (16,416 cores total) and 24 GB of memory (2 GB/core) per node. Nodes are connected using a fully non-blocking quad-data rate InfiniBand interconnect, and the system's initial deployment will provide about 1 PB of parallel temporary disk storage. This system will be available to CU-Boulder researchers and collaborators. Additionally, CRC provides of a small "Analytics and Visualization" cluster where each node will has 48 cores and 0.5 TB of memory for data intensive applications and pre- and post-processing.

Projects that significantly use the HPCC http://csdms.colorado.edu/wiki/HPCC_projects

Some CSDMS member's scientific projects heavily rely on the CSDMS High Performance Computing Cluster, e.g.:

1. Coupling fluvial discharge and coastal evolution models (*Ashton, Kettner, Xing*)
2. Hydrodynamics and Sediment-Transport in the Poverty Bay Portion of the Waipaoa Sedimentary System (*Harris, McNinch*)
3. Investigating valley spacing regularity on evolving mountain fronts (*Capolongo, Refice, Lovergine, Ranaldo*)
4. Linking climate model output with landscape evolution models (*Ward, Galewsky*)
5. Lithology Image Strips Extraction for the Ocean Drilling Program (*Jenkins*)

6. Niger Delta Project (*Hannon, Kettner, Syvitski, Peckham*)
7. Numerical Modeling of Permafrost Dynamics in Alaska using a High Spatial Resolution Dataset (*Marchenko, Jafarov*)
8. Numerical simulations of turbidity and gravity currents interacting with complex topographies (*Nasr-Azadani, Radhakrishnan*)
9. Repeat glacier elevation and velocity maps from multi-view stereophotography (*Welty*)
10. Surface Process Modeling Using CMT Course (Instructors: *Overeem*)
11. The BQARTwbm distributed sediment flux model (*Cohen, Kettner, Syvitski, Fekete*)
12. The impact of thermocline induction on decadal variability of the North Atlantic carbon sink (*Lovenduski*)
13. Using Neighborhood-Algorithm Inversion to Test and Calibrate Landscape Evolution Models (*Perignon*)

3.5 CSDMS WEB PORTAL STATISTICS csdms.colorado.edu/wiki/Special:Statistics

Content Pages	1,057	Page Edits	52,978
Total Pages	4,809	Registered Users	678
Upload Files	2,343	View Statistics	5,456,792

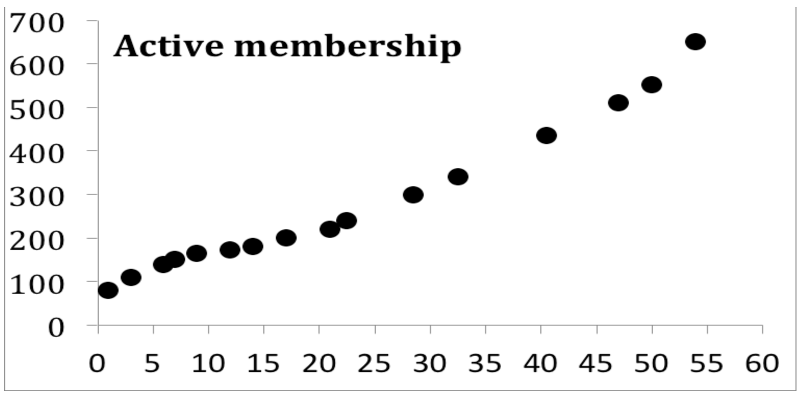


Fig. 1 Growth in CSDMS membership (y-axis) in months since April 2007 (x-axis).

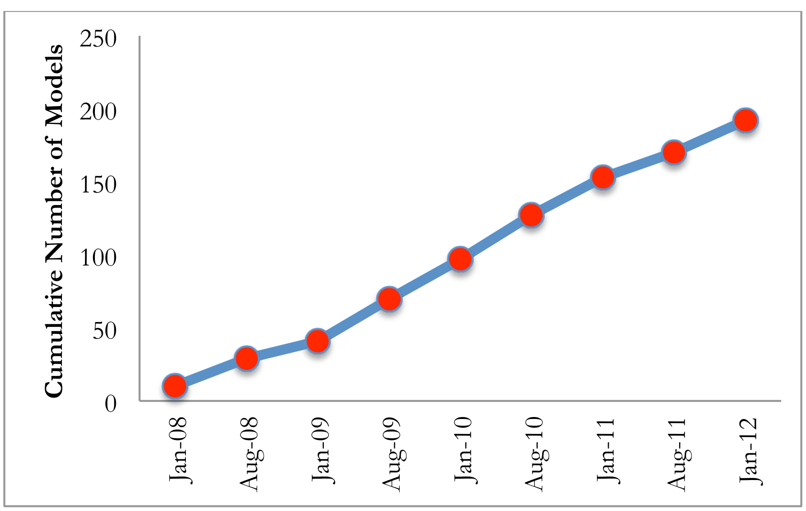


Fig. 2 Model contributions contributed by the community to the CSDMS Model Repository

Achievements on Year 5 Goals

4.1 Goal 1) CSDMS Web Gateway and Portal in Aid of Community Involvement

The CSDMS website is evolving at a rapid pace, maturing to become the portal for open source surface dynamics models, almost always ranking number one for Google searches on specific model names, and now number one when searching for CSDMS. Several new content management developments have taken place over the last year to become and stay *the* portal for open source surface dynamics models. Listed below are this year major achievements to serve our community.

4.1.1 Community input on the transitions of models into fully integrated components.

An online voting system is developed to give the members of the community the opportunity to prioritize modules that they would like to see incorporated as component into the CSDMS component modeling tool (CMT). So far the community has given their vote to 27 programs (23 models and 4 tools). Through the online voting systems, members can give their one vote anonymous per model. The given vote is made public in real time for other viewers. The vote can be changed by the member at any time up to the point where CSDMS-IF personal or a member decides to start integrating the specific model into the CMT. The online voting system is used and can be combined with feedback from CSDMS community meetings to prioritize model integration into the CMT.

Links:

- Voting guidelines: http://csdms.colorado.edu/wiki/Why_vote_for_model_incorporation
- Voting results: http://csdms.colorado.edu/wiki/Models_all
- Example voting box: http://csdms.colorado.edu/wiki/Model:ADCIRC

4.1.2 CSDMS development tracking: Roadmap to component status

A roadmap displaying duration, tasks and person responsible is automatically generated and tracked by IF staff and or model owner once it is decided to be incorporated as a model into the CMT. The roadmap is constructed such that it is easy to get a quick overview of the status of the project and contains the option for each of the task owners as well as for the project owner to incorporate links containing detailed information regarding specific tasks. Three milestones, including their status are also displayed: executable, standalone component and coupled component. A green checkmark is placed when a task is fulfilled; a red cross is displayed when a task could not be executed. A task is displayed as light gray in cases where this task will not be fulfilled within the scope of the project; not every model will be configured as a component that can be coupled. The roadmap informs membership about the status of a model to become a CMT component and provide detailed information of each of the involved tasks and which person to contact in case members have specific questions.

Links: Roadmap example: http://csdms.colorado.edu/wiki/Roadmap:Flexure

4.1.3 The CSDMS YouTube channel for educational movies, tutorial and model animations.

CSDMS has ported all of its contributed animations and movies to YouTube to enlarge the impact of the community and expose the public to some of the community gained insights. Detailed description of each of the movies remain on the CSDMS website, under the educational section (http://csdms.colorado.edu/wiki/Movies_portal), and can also be found at the meeting portal (http://csdms.colorado.edu/wiki/Past_Meetings). While movies will still play from the CSDMS website they are hosted from the 'CSDMSmovies YouTube channel' (http://www.youtube.com/user/CSDMSmovie). The channel incorporates 8 playlists: Coastal animations (*21*), Environmental animations (*8*), Laboratory movies (*14*), Marine animations (*9*), Real event movies (*32*), Terrestrial animations (*16*), Meeting movies (*22*), and CSDMS tutorials (*4*). In 2011, the University of Colorado started to encourage departments and institutes to provide animations and movies to the university media page as well. CSDMS contributed all its movies to CU to further enlarge the exposure to the public. There are presently 122 movies & animations on the CSDMS YouTube channel, generating more than 36,001 views.

Table 1: Top 10 views of CSDMSmovies YouTube channel:

Movie / animation description	Nr. of views for 2011
Global circulation	10,394
Delta formation	2,613
Spit evolution	1,653
Lauren tide Ice Sheet evolution	1,143
Floodplain Evolution	977
Sand ripples	949
Jokulhlaup over Sandur Iceland	943
Sand boil behind levee	729
Arctic coastal erosion 2010	662
Meandering river	638

The goal to enlarge the impact of the community by making the movies more accessible is successful. **The CSDMS movies YouTube channel has been highlighted several times for being in the "Top 50 most viewed channel" of the "non profit" category. Furthermore there is a steady increase in the number of average views (from 17 to over 25 views per movie per month (Fig. 3).**

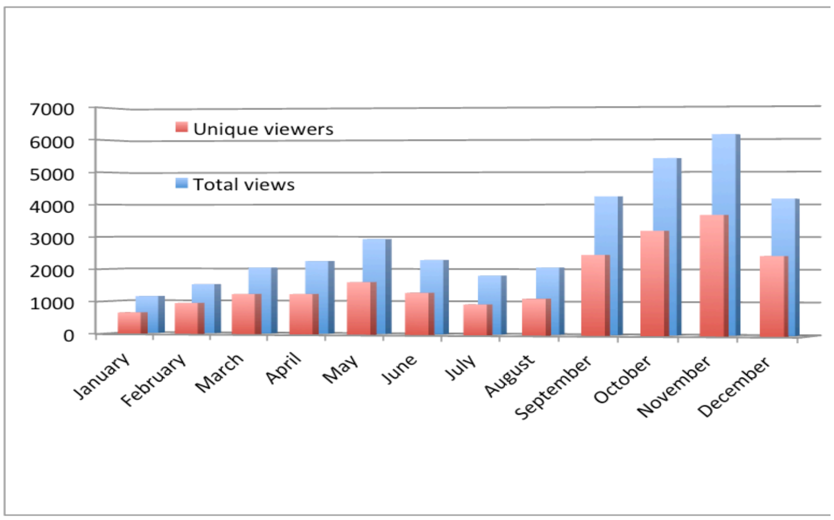


Figure 3. Monthly total views of all CSDMS movies on YouTube (blue) and the number of unique viewers for each month (red).

Links:

- Movie descriptions: http://csdms.colorado.edu/wiki/Movies_portal
- CSDMS YouTube channel: http://www.youtube.com/user/CSDMSmovie
- Univ. of Colorado YouTube channel: http://www.youtube.com/user/univcoloradoboulder#p/c/0A49CA0F0E6D8EDA

4.1.4 Tools for repository downloads are embedded into the website are now in place.

Significant changes have been made to the backside of the model repository to accommodate community members desire to: 1) store and retrieve all source code of modules that are in the CSDMS database from a single place, 2) track basic information of who is downloading what module from the CSDMS database and 3) monitor how often a module is downloaded from the CSDMS database. All source code is now only stored in Subversion. People who download a module access subversion automatically through the website, select the desired version of the source code of a module, which then is automatically zipped before the download process starts. We do solicit each downloaders email address and name. This collected information (name and email) will be provided to the original developer annually by the end of December or at any time on request.

Monthly download statistics are presented on the model metadata webpage as soon as a module is downloaded once (Fig. 4). Complete download statistics of the model repository are provided as well (see links below).

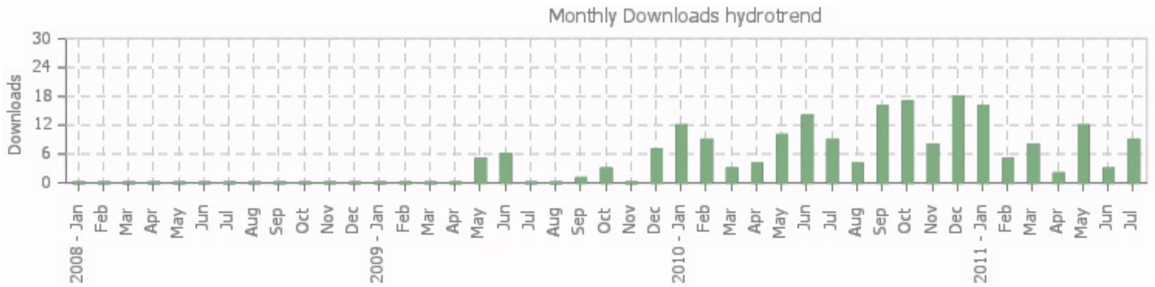


Figure 4. Model download menu example where you can select the desired version of a model as well as provide basic information. *http://csdms.colorado.edu/wiki/Special:ExtensionDistributor*

Links:

- Download a model: http://csdms.colorado.edu/wiki/Download_models
- Monthly overview of a model download e.g.: http://csdms.colorado.edu/wiki/Model:SIBERIA
- Complete download report: http://csdms.colorado.edu/wiki/Model_download_Page

4.1.5 CSDMS HPCC (*Beach*) usage is open-access

CSDMS uses Ganglia, a scalable distributed monitoring system, to monitor beach, the high-performance cluster of CSDMS. Real-time monitoring information is of key value for cluster operators but can also be very relevant for its users. Therefore CSDMS integrates key output parameters of ganglia into the CSDMS website. Visitors can monitor status and activity of the cluster as a whole as well as of each of the nodes (Fig. 5). A ganglia summary is posted real-time on the front CSDMS website under 'Supercomputing stats' as well.

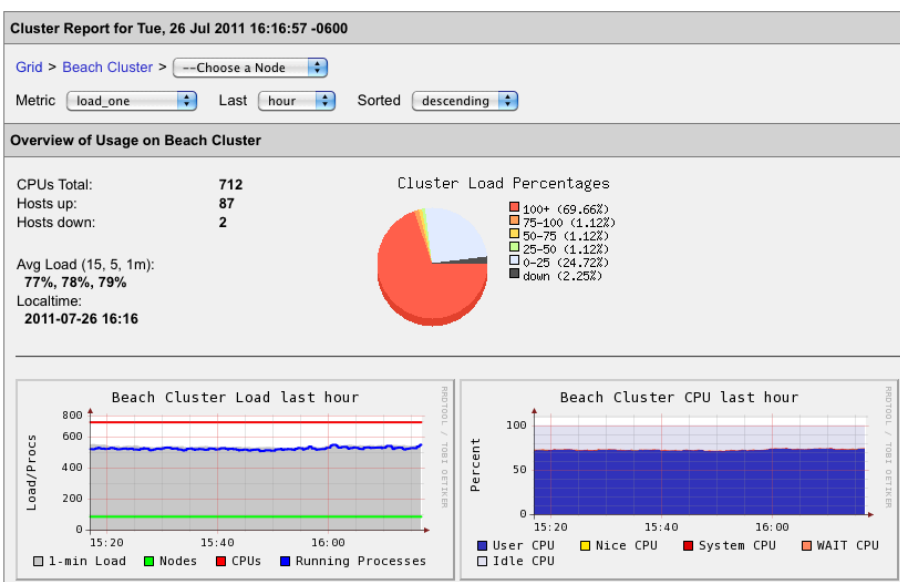


Figure 5. Snapshot in time of the use of Beach, provided by Ganglia. *http://csdms.colorado.edu/wiki/HPCC_current_use*

Links:

- Integrated ganglia page: http://csdms.colorado.edu/wiki/HPCC_current_use
- Summary of ganglia on front page: http://csdms.colorado.edu

4.1.6 Video tutorials on topics related to modeling with the CSDMS Modeling Tool (CMT).

CSDMS members are exposed to a lot of content that at a first glance seems difficult or time consuming to achieve comprehension. Topics are well explained in written documents and posted on the community website, but have been either difficult to find if the user doesn't know where to look for them, or the user simply does not have the time to read all instructions, which eventually results in reduced participation of the community. To increase participation, four video tutorials are developed to make CSDMS processes more comprehensible for our members: 1) How to connect to the CSDMS HPC, 2) How to contribute to the CSDMS repositories, 3) How to use the model repository, and 4) How to become a member (Fig. 4).

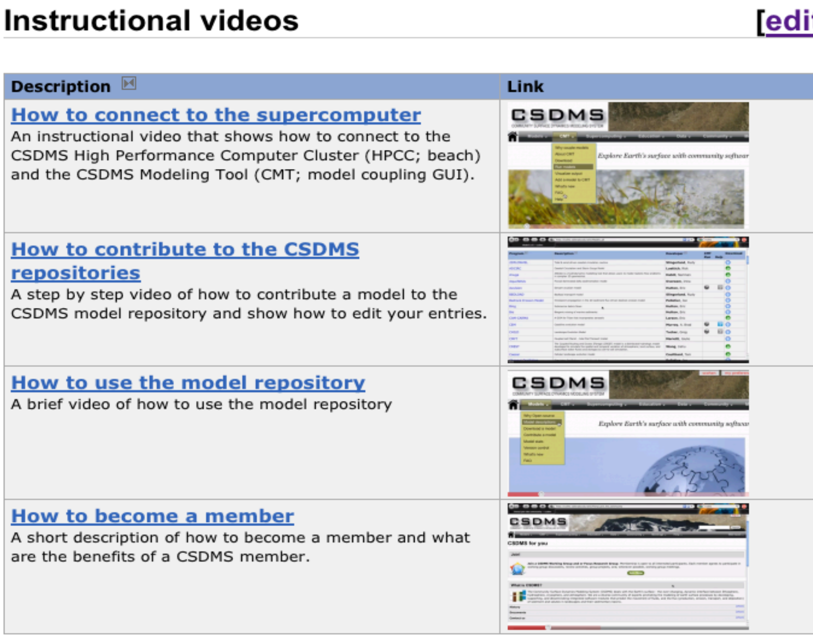


Figure 6. Tutorial videos. http://csdms.colorado.edu/wiki/Help:How_to_videos

The tutorial videos (posted on the CSMDS YouTube channel) are embedded in the CSDMS website and are between 2.5 and 8 minutes long, taking the user step by step through a particular process. The videos are featured under the "Help" menu on the main menu bar of the website as well as embedded on pages that describe a specific process.

Links:
- How to videos: http://csdms.colorado.edu/wiki/Help:How_to_videos
- CSDMS movie channel: http://www.youtube.com/user/CSDMSmovie

4.1.7 New model or science in the spotlight as highlighted on the CSDMS front page.
CSDMS launched its new web portal December 2010. The new web portal aims to enthuse, inform and engage end-users by more frequent updates on CSDMS science and new discoveries. Two sections, 'Model highlight' and 'Science in the spotlight' are embedded at the front page of the CSDMS website for this purpose. Each section provides a summary of a topic with a link to the full article. So far 11 topics (See table 2) have been featured generating (up to Jan 12th) in total 8,905 hits.

Table 2: Recent Model highlights and Science in the Spotlight topics

Model highlight (*4,689 views*)	Science in the spotlights (*4,216 views*)
TopoFlow	Boom-and-bust cycles of barrier island retreat
TURBINS: An immersed boundary, Navier-Stokes code for the simulation of gravity and turbidity currents	Retreating Arctic Coasts
Delft3D	Where do Salmon thrive
SedBerg	Irreversible Peatland Subsidence
SPARROW	New Modeling Textbook
SNAC	StGermaiN Analysis of Continua

Links:

- Entrance page CSDMS: http://csdms.colorado.edu
- Model highlight history: http://csdms.colorado.edu/wiki/Model_highlight
- Science in the spotlight history: http://csdms.colorado.edu/wiki/Science_spotlights

4.1.8 CSDMS actively share news through social networking Twitter

CSDMS is sending tweets since December 2010. People can sign up to follow the CSDMS tweets like following any normal twitter account. The tweets are fully incorporated in the CSDMS web as well, so people can read and brows old tweets as desired.

Links:

- Twitter page of CSDMS: http://twitter.com/#!/CSDMS
- Integrated twitter page in the CSDMS website: http://csdms.colorado.edu/wiki/Tweets

4.1.9 Google Analytics used to monitor key web-use parameters

Google Analytics content management monitoring software informs on how people touch upon and explore the CSDMS website. With this information we analyze which pages are most often viewed, how people reached those pages, which pages are more buried and hard to find by the user, and where we should place content that needs visibility. The monitoring software has been integrated within the CSDMS website since 2010. Results are shared with users by integrating key parameters monitored by Google Analytics into the CSDMS website.

4.1.10 CSDMS Communication Strategy & Transparency of Governance

CSDMS works to continually increase its profile within relevant research, educational and industrial communities both nationally and internationally. CSDMS has a diverse membership and works to develop targeted communication with each audience. CSDMS continually interacts with its community to address community needs (i.e. model and component repository, education repository), to provide a leading edge in Earth surface dynamics modeling. Through the methods below, we gather and distribute strategic information to and from our community and adapt our services to meet their needs to the best of our ability and within our budgetary and time constraints.

CSDMS Interactive Website Examples

- CSDMS website profiles our models, member scientists and their work (model highlights)
- CSDMS website posts jobs available within the community
- CSDMS website profiles upcoming meetings within the community
- CSDMS website highlights relevant science (science in the spotlight)
- Video tutorials on how to use CSDMS wiki website and interact with CSDMS model repository

CSDMS Meetings.

- Working Group (WG) and Focus Research Group (FRG) Workshops Each group has a Chairperson who corresponds to his/her membership via telephone, meetings, and mail lists. The WG and FRG Chairperson and CSDMS IF staff conduct polls of the WG and FRG membership to prioritize the work of CSDMS, which helps to prioritize CSDMS operations budget allocation.
- Annual Meeting: "Impact of Time and Process Scales" held October 28-30, 2011 in Boulder, CO. This meeting allowed CSDMS members to share their feedback with CSDMS during the meeting, on presentations, question and answer sessions, clinics, email, and feedback survey forms. The feedback was consolidated and suggestions were incorporated into the format/content of future meetings.
- CSDMS Inter-Agency Meeting. CSDMS provides updates to U.S. agencies.

Personal Interviews with Key Personnel

- CoG Interviews**.** The Commodity Governance (*Introducing commodity governance into community Earth science modeling)* or COG is a type II NSF/CDI project to research communication strategies and built software tools to enable virtual organizations in the Earth Sciences like CSDMS to scale to massive interdisciplinary "communities of communities." COG interviews were held with CSDMS staff and with volunteer scientists, government users and students within the larger CSDMS community. The results are being compiled and analyzed with a goal towards publication to provide further insight into how best to communicate and strategize for a diverse community that mainly interacts via the virtual world (i.e., wiki website, teleconferences, email lists, discussion forums).

Analysis of Member Use and Contributions

- Encouraging volunteerism among CSDMS members to provide and adapt metadata and model code to be sufficiently standardized for coupling is crucial to building an integrated community modeling system. In 2011 we analyzed data on community contributions and novice user engagement and evaluated the effectiveness of CSDMS' strategies towards these two challenges over the first 5 years of our project based on member and user data, surveys, computing logs and web log analysis. Analysis shows that sponsored member participation in annual meetings (~30%) is relatively high. Direct CSDMS governance relies on ~4% of members. About 15% of members contributed code and metadata, and a similar 15% use the common supercomputing resources. Technological development and documentation lies predominantly in hands of the funded members, and a small number of others (~3% together). Potential new users are trained in clinics and courses, with positive effects on self-efficacy and recruitment of new advanced developers.

Survey on newly launched web portal

- CSDMS IF staff requested feedback on scope, clarity, content, useability and navigation, and aesthetics of the newly launched CSDMS wiki from web professionals and science institute data managers, students, as well as from the EKT Working Group Chair and key members of the CSDMS steering committee in January-February 2011. Responses were overwhelmingly positive and suggested additional changes have mostly been implemented by July 2011.

CSDMS Integration Facility Staff publications and presentations

- CSDMS IF staff promote CSDMS and stay current with the latest industry information by conducting research published in leading venues (publications list provided above) and providing key educational presentations and mini-courses (world-wide) and at CSDMS co-sponsored meetings (meetings list included above)

CSDMS Student Modeler-of-the-Year Contest

- The **CSDMS Student Modeler Award** is an annual competitive award for graduate students from Earth and computer sciences who have completed an outstanding research project involved in developing an Earth science model (terrestrial, coastal, marine or biogeochemistry), a modeling tool or model linking technology. Entries are judged by a panel of experts in the field on the basis of ingenuity, applicability, and contribution towards the advancement of geo-science modeling. This award increases the recognition of CSDMS within the graduate student population and their institutions. Winners receive a funded visit to the CSDMS Integration Facility in Boulder, Colorado, to learn and work with CSDMS scientists to develop their model into a CSDMS component.

Missives from the Executive Director

- Missives from the Executive Director of CSDMS are sent to every member highlighting progress, news, and membership events. Once quarterly, these missives have decreased to 2 - 3 times a year, in lieu of increased social and wiki communication. Email is an overused communication forum

Social Marketing

- CSDMS has a presence on Twitter

4.2 Goal 2) Componentizing the CSDMS Model Repository

BMI and CMI. A key CSDMS achievements of the past year is the development of an innovative, two-level wrapping process (BMI/CMI) that greatly simplifies the process of converting contributed models into interoperable, plug-and-play components. Model contributors are asked to make relatively small changes and additions (e.g. functions that describe their model's attributes in a standard way) to their source code to provide a Basic Model Interface or BMI. BMI implementation is noninvasive and straightforward --- it requires no calls to CSDMS code and no knowledge of CSDMS framework concepts or protocols. By design, BMI provides all of the model information (grid type, information on input and output variables, etc.) that is needed by a second-level wrapper that converts the model to a CSDMS component. The second-level wrapper provides a Component Model Interface or CMI that enables coupling to other CSDMS components and automatically calls service components when needed to accommodate numerous differences between models such as programming language, computational grid, time-stepping scheme, variable names and units. Service components provide additional added value such as output to NetCDF files, unit conversion and spatial regridding. By design, BMI allows the same CMI wrapper to be used for every model written in a given language. This greatly simplifies and reduces maintenance associated with the wrapping process and reduces the burden on code contributors.

Sharing Components Between Frameworks. Another benefit of the BMI/CMI approach is that it provides a mechanism for sharing models between frameworks. There is nothing framework-related in a BMI-enabled model and yet the BMI interface allows a caller to retrieve anything it needs for deployment in a framework. It is therefore straightforward to wrap a BMI-enabled model to provide an interface other than CMI, as would be needed for use in another framework like OpenMI or OMS.

Regional Ocean Modeling System (ROMS). ROMS is a top priority for the Marine and Coastal Working Groups, and the Chesapeake and Carbonate Focus Research Groups. The ***ROMS Builder*** and new ***ROMS Compiler*** components were completed to each create a "cppdefs.h" file (https://www.myroms.org/wiki/index.php/cppdefs.h) and then compile a new instance of the ROMS model with those CPP options. ROMS Builder additionally creates a CSDMS component for the new ROMS model that appears in the CSDMS Modeling Tool (CMT) palette. Each has a tabbed-dialog GUI. Each new ROMS component created with ROMS Builder has a tabbed dialog GUI (with 10 tabs and over 135 input variables) that creates the ROMS input file called "ocean.in" (https://www.myroms.org/wiki/index.php/ocean.in) and launches ROMS.

ROMS Builder has been used to create CSDMS components for four different instances of ROMS: (a) CBOFS2, (b) UMCES, (c) Upwelling example and (d) ChesROMS. For each of these ROMS versions, all associated input data and grids were collected on the CSDMS high-performance cluster and "BLD files" were created that allow CMT users to select and run those ROMS versions with that data. Each new ROMS component created with ROMS Builder gets a CSDMS BMI (Basic Model Interface) that includes many additional functions, including getters and setters. A CMI wrapper for Fortran models was also created and used to wrap BMI-enabled versions of both ROMS and LTRANS (Lagrangian Transport model). Due to these enhancements, ROMS is now a CSDMS component that can be dynamically coupled to other CSDMS components, as demonstrated through direct (runtime) coupling to LTRANS.

LTRANS- In the wake of the BP oil spill, CSDMS staff surveyed existing models for oil spill tracking and discovered there were no open-source models of this type available. CSDMS staff worked on an NSF RAPID grant with E. North, C. Sherwood and others to create an open-source model to fulfill this need. LTRANS version 1 (Larval TRANSport) was augmented with oil droplet physics to create LTRANS version 2 (Lagrangian TRANSport) that includes the ability to track oil droplet transport for a large region such as the Gulf of Mexico. It was also provided with a BMI interface and a tabbed-dialog GUI and is now available as a plug-and-play component through the CMT. LTRANS v.2 was released in January 2012. Within the CSDMS framework, LTRANS can be used as a stand-alone model that reads input from a ROMS history file, or can be coupled directly to ROMS (i.e. not through files) and run in tandem. See http://northweb.hpl.umces.edu/LTRANS.htm for more information.

FORTRAN BMI/CMI – CSDMS developed the code necessary to implement the BMI and CMI interfaces for Fortran models and applied it and tested it on both ROMS and LTRANS. This includes a new, unified approach to providing the required getter and setter functions for FORTRAN models.

Flexure. This flexural and non-flexural isostasy model provides 1D and 2D solutions. Flexure is the first model submitted by a new graduate student, who fully committed to help bring the model code online as a component in the CMT. Flexure has been refactored to provide the BMI interface and is very close to appearing as a plug-and-play component in the CMT. It will have many coupling options in both the terrestrial model projects as well as in the coastal and marine model projects. This model has strong interest from CSDMS industry partners to allow coupling applications with stratigraphic models.

Bioenergetics. This is a biological model with a large user base that was originally developed by Paul Hanson of the University of Wisconsin Center for Limnology. It uses an energy balance formulation to compute the growth potential of different fish species as a function of environmental variables such as water temperature. CSDMS member Laurel Saito (and developer of open-source extensions to the model) has recently obtained permission to provide the full model and its documentation as a set of plug-and-play components.

ParFlow. ParFlow is an open-source, object-oriented, parallel watershed flow model. It includes fully-integrated overland flow, the ability to simulate complex topography, geology and heterogeneity and coupled land-surface processes including the land-energy budget, biogeochemistry and snow. ParFlow uses a TCL framework to integrate its various components. CSDMS is studying the source code to determine whether its engine (a Richards equation solver) can be provided as a separate plug-and-play component. Some code changes by the developer may be necessary to achieve this.

Grid generator/editor. Several models in the CSDMS repository require a computational mesh for the area to be modeled but they rely on external software for this preliminary step. CSDMS has surveyed existing, open-source software for grid generation. GridGen and Triangle appear to meet our needs and we have identified an interactive, graphical front-end for GridGen written in Java (but not yet complete). CSDMS will determine if it is feasible to provide this within the CMT.

Erode3 Components. During this past year, four new components from the NSF-CMG project were made available to the CSDMS community through the CMT. These include (1) **D8_Global***:* fills depressions in a DEM, creates a D8 flow grid and contributing area grid, (2) **DEM Smoother**: modifies an existing DEM so that all of its elevation profiles vary smoothly downstream (with smoothly decreasing and nonzero slopes), (3) **Erode_Global**: a landscape evolution model that uses "global", adaptive timesteps and (4) **Erode_Local** a new (and much more efficient) landscape evolution model that uses an innovative new "local timestepping" algorithm. Erode_Global and Erode_Local each use a new stability condition and natural, transport-based depression filling. Note that the CHILD and MARSSIM landscape evolution models are also available as components within the CMT.

CUAHSI HydroModeler Suite. This collection of hydrologic process modules is mostly written in C#, which though similar to Java is not a Babel-supported language. The CUAHSI HydroDesktop team has recently received funding to continue their work on this effort and their current plan is to convert the C# code to Python with BMI interfaces and contribute them to CSDMS. CSDMS will continue to work with them in support of this effort.

Carbonate Workbench. Members of the Carbonate Focus Research Group have completed 3 new forms of a Carbonate Model. CarboCAT is a cellular automaton model of facies geometries. CarboCELL is a cellular model of organism competition and growth for scales of 1 to 100 meters. CarboLOT is a multispecies population model based in Lotka-Volterra methods. The models build carbonate facies for periods of time as long as 100ky incorporating environmental and biological forcing events. Papers are being prepared and the model source code will be placed with CSDMS as soon as the papers are submitted.

AquaTellUs. This model aims at modeling floodplain sedimentary architecture on a timescale of 100-100's of years, it is potentially couplable to river and delta models and to other stratigraphic models. AquaTellUs now has a complete IRF structure, and a compatible basic modeling interface (BMI). Tabbed dialogues have been designed and implemented and this first version of AquaTellus has been published in CMT in 11/2011. Additional development on floodplain modeling algorithms and further improvements to the BMI coupling to other components are funded through efforts in 2012-2013.

4.3 Goal 3) Advancing the Working Groups & Focus Research Groups

As described in the previous section, significant progress has been made in converting the specific models identified by the working groups as CSDMS plug-and-play components.

We recognize that development team needs to guide individual interested developers with clear and efficient protocols for coupling their code. CSDMS has now defined a Basic Model Interface or BMI that is to be provided by model developers and a Component Model Interface or CMI for model coupling that is provided by CSDMS. CSDMS IF Staff continue to improve its automated tools that wrap BMI-compliant models with the CMI interface. CSDMS has produced documentation that describes these two interfaces in detail with specific examples for C and Python; other examples for the other Babel-compatible languages are far along, especially Fortran. In addition, a paper has been accepted a special issue of Computers and Geosciences that describes the inner workings and rationale of the CSDMS design (Peckham et al., in press 2012, Computers & Geosciences). We further presented these protocols in the clinic on CMT during the Annual Meeting in October 2011.

CSDMS now provides a THREDDS Data Server that provides members with convenient web access to various data sets including, for example, the netCDF history files (model output) for the ROMS ocean model. This resource is currently being used to archive and share data from the U.S. Integrated Ocean Observing System (IOOS, ioos.gov) Modeling Testbed project.

CSDMS further advanced the coupled river-waves-delta modeling project; it now includes the components HydroTrend-AVULSE-WAVES and CEM as well as number of service components. This CMT project has been tested thoroughly by IF facility graduate students and by 32 participants in a graduate modeling course at NCED in Summer 2011. This project is documented in detail both in the online CMT Help system as well as in journal paper (Ashton et al., in press 2012, Computers & Geosciences).

CSDMS EKT Working Group had in 2010 prioritized teaching modules appropriate for undergraduate teaching, and emphasized the importance of posting material with complete lesson plans, and teacher guidance. Whereas CMT will provide his functionality in future, at present we have posted labs in two tiers; simpler spreadsheet labs designed in 2011 associated with more complex CMT labs allowing a progressive track through a curriculum.

4.4 Goal 4) Conferences, Meetings, and the 2nd CSDMS Special Issue

4.4.1 Staff Participation — Conferences & Meetings

*01/2011	AGU Chapman Conf. Source to Sink	Oxnard, CA	(Overeem, Syvitski)
01/2011	Community for Integrated Env. Modeling (CIEM)	teleconferences	(Peckham)
02/2011	EPSCoR Climate IWG	McCall, Idaho	(Peckham)
02/2011	IASC Network for Arctic Glaciology	Winter Park, CO	(Overeem)
02/2011	WHOI Geodynamics Lecture	Woods Hole, MA	(Syvitski)
02/2011	ONR Delta Meeting	Arlington, VA	(Syvitski, Brakenridge)
02/2011	IGBP SC Meeting	Washington, DC	(Syvitski)
02/2011	Community for Integrated Env. Modeling (CIEM)	teleconferences	(Peckham)
02/2011	IWMI Delta 2011: Deltas under climate change	Hanoi, Vietnam	(Syvitski)
03/2011	Tulsa Geological Society Presentation	Tulsa, OK	(Overeem)
03/2011	CUAHSI CHyMP Meeting	Irvine, CA	(Peckham)
03/2011	41st Arctic Workshop at Universite de Quebec	Montreal, Canada	(Hudson)
03/2011	CU Hydrological Symposium	Boulder, CO	(Hannon, Xing)
03/2011	Hydrologic Model Intercomparison Workshop	Golden, CO	(Peckham)
03/2011	BOEMRE teleconference	Boulder, CO	(Arango, Harris, Meiburg, Syvitski)
04/2011	European Geosciences Union (EGU)	Vienna, Austria	(Kettner)
04/2011	Deltares OS Collaboration meeting	Delft, Netherlands	(Kettner, Overeem)
04/2011	CSDMS Modeling Course, KORDI, KOPRI, KNU	Korea	(Syvitski)
04/2011	Community for Integrated Env. Modeling (CIEM)	teleconferences	(Peckham)
05/2011*	Chesapeake FRG Mtg at SERC	Baltimore, MD	(Peckham)
05/2011	Lamont-Doherty Colloquium	Palisades, New York	(Syvitski)

05/2011	British Geol. Society: The Anthropocene	London, UK	(Syvitski)
05/2011	11th International Coastal Symposium	Szczecin, Poland	(Syvitski)
05/2011	CSDMS Executive Committee Meeting	Boulder, CO	(CSDMS IF Staff)
05/2011	BOEMRE Teleconference	Boulder, CO	(Arango, Harris, Meiburg, Syvitski)
06/2011	Geochemistry of the Earth Surface	Boulder, CO	(Syvitski)
06/2011	DeltaNet: Impacts of Global change	Ainsa, Spain	(Syvitski)
06/2011	Commodity Governance Meeting at NOAA	Boulder, CO	(Syvitski, Overeem)
06/2011*	CCMP Hydrodynamic Model Wkshp (SERC)	Edgewater, MD	(Peckham)
06/2011	BOEMRE teleconference	Boulder, CO	(Arango, Harris, Meiburg, Syvitski)
07/2011	CBP Modeling Quarterly Review Mtg	Annapolis, MD	(Peckham)
07/2011	BOEMRE Teleconference	Boulder, CO	(Arango, Harris, Meiburg, Syvitski)
08/2011	NCED Summer Course	Minneapolis, MN	(Overeem, Kallumadikal)
08/2011	Earthcube Webinar	webinar	(Syvitski)
09/2011	7th IAHR RCEM Symposium	Beijing, China	(Syvitski)
09/2011	Lecture on CSDMS at Nanjing University	Nanjing, China	(Syvitski)
09/2011	LOICZ Open Science Conference 2011	Yantai, China	(Syvitski)
10/2011*	CSDMS Meeting 2011: Impact of Time and Process Scales	Boulder, CO	(CSDMS IF Staff & 101 Members)
10/2011*	CSDMS Steering Committee Meeting	Boulder, CO	(Syvitski, Lofton)
10/2011*	CSDMS Executive Committee Meeting	Boulder, CO	(Syvitski, Lofton, Peckham, Overeem)
10/2011	AIMES SSC Meeting	Boulder, CO	(Syvitski)
11/2011*	CSDMS Inter-Agency Meeting	Washington, DC	(Syvitski)
11/2011	Earthcube Meeting	Washington, DC	(Peckham)
11/2011	Model Fusion Meeting	London, UK	(Peckham)
12/2011	AGU Conference	San Francisco, CA	(Syvitski, Peckham, Kettner, Cohen, Xing)

** CSDMS co-sponsored meeting*

4.4.2 CSDMS Annual Meeting 2011: Impact of Time and Process Scales

The second all hands meeting: "Impact of time and process scales" (10/28/2011 – 10/30/2011) was attended by 101 CSDMS members (http://csdms.colorado.edu/wiki/CSDMS_meeting_2011). The annual meeting offered 1) insights on time and space issues and how this is addressed in the software subtleties that is at the heart of all surface dynamic modeling efforts — whether landscape-evolution, morphodynamics or transport of material, 2) hands on clinics on a variety of models for beginners as well as advanced users, 3) hands on clinics on the use of the CSDMS component modeling tool and visualization software as well as for parallel programming, and 4) time for the Working Groups and Focus Research Groups to review their strategic plans. In addition to well-attended poster sessions (34 posters in total were presented; most of them can be found on the CSDMS web: http://csdms.colorado.edu/wiki/CSDMS_meeting_2011), the meeting featured:

Keynote lectures

All keynote lectures were filmed and presentations are made available on the CSDMS YouTube channel as well as on the CSDMS web (http://csdms.colorado.edu/wiki/CSDMS_meeting_2011).

1. Bridging surface dynamics to tectonic modeling with SNAC *Choi (Lamont-Doherty Earth Observatory, NY)*
2. Applications of Rule-based Models and Geostatistics. *Pyrcz* (Chevron Energy Technology Company, Houston)
3. Feedbacks between surface processes and flexural isostasy: a motivation for coupling models. *Wickert* (University of Colorado)
4. Glacier hydrological modeling. *Anderson* (INSTAAR, University of Colorado)
5. Morphodynamics and river modeling. *Abad* (University of Pittsburgh)
6. Quantitative modeling and education. *Manduca* (Carlton College, Minnesota)
7. GlobalNEWS - C & Nutrient Transport Modeling. *Seitzinger* (IGBP, Sweden)
8. Scaling marine sediment transport. *Wiberg* (University of Virginia)
9. Tidal channels and estuarine dynamics. *Canestrelli* (Boston University)
10. A reduced-complexity channel-resolving model for sedimentary delta formation. *Liang* (SAFL, U. Minnesota)

11. XBeach modeling at a range of temporal and spatial scales. *Reniers* (RSMAS - Miami)
12. A simple model for oxygen dynamics in Chesapeake Bay. *Scully* (Old Dominion University)
13. The Telemac system, from small scale processes to large scale applications. *Villaret* (EDF, France)
14. Global hydrology. *Fekete* (The City College of New York)
15. High resolution surface process modeling in a GRASS GIS environment. *Barton* (Arizona State University)
16. Modeling the glacial-interglacial impact of the Pacific trade wind inversion on the geomorphology and hydrology of the Big Island of Hawai'i. *Ward* (University New Mexico)
17. Modeling permafrost - a CMT component. *Jafarov* (University of Alaska)
18. Integrated modeling & data access - CUAHSI HIS hydroModeler. *Goodall* (University of South Carolina)
19. Towards a complete description of the hydrologic cycle: Large scale simulations with the open-source, parallel, ParFlow hydrologic model. *Maxwell* (Colorado School of Mines)
20. Direct Numerical Simulation (DNS) modeling and upscaling. *Meiberg* (University of California-Santa Barbara)

Clinics

1. Topoflow *Peckham* (CSDMS IF)
2. CEM *Murray & Ashton* (Duke University & WHOI)
3. Sedflux *Hutton & Overeem* (CSDMS IF)
4. Deriving Dynamic Earth System Models *Slingerland* (Penn State University)
5. CHILD *Tucker, Gasparine & Lancester* (University of Colorado, Tulane University & Oregon State University)
6. Delft3D *Jagers & Edmonds* (Deltares, The Netherlands & Boston College)
7. Cyclopath & CarboCAT *Burgess* (Royal Holloway University of London)
8. VisIt *Pugmire* (ORNL, Tennessee)
9. TauDEM *Tarboton* (Utah State University)
10. ROMS CSTMS *Sherwood* (USGS)
11. CMT *Overeem* (CSDMS IF)
12. HPCC *Hauser* (University of Colorado)

Appendix 2 provides the abstract volume for the CSDMS 2011 annual meeting.

4.4.3 CSDMS Special Issue of 'Computers and Geosciences'

1. *Ashton, A.D., Hutton, E.W.H., Kettner, A.J., Xing, F., Giosan, L.* Progress in Coupling Coastline and Fluvial Dynamics. *****
2. *Burgess, P.* In Press, Corrected Proof. CarboCAT: A Cellular Automata Model of Heterogeneous Carbonate Strata. doi:10.1016/j.cageo.2011.08.026
3. *Campbell, K., Overeem, I., and Berlin, M.* In Press, Corrected Proof. Taking it to the Streets: the Case for Modeling in the Geosciences Undergraduate Curriculum. doi:10.1016/j.cageo.2011.09.006
4. *Cohen, S., Kettner, A.J., Syvitski, J.P.M., and Fekete, B.M.* In Press, Corrected Proof. WBMsed: a distributed global-scale riverine sediment flux model: Model description and validation. doi:10.1016/j.cageo.2011.08.011
5. *Dunlap, R., Rugaber, S., and Mark, L.* In Press, Corrected Proof. A Feature Model of Coupling Technologies for Earth System Models. doi:10.1016/j.cageo.2011.10.002
6. *Hutton, E.W.H., Syvitski, J.P.M., and Watts, A.* Isostatic Flexure of a Finite Slope Due to Sea-Level Rise and Fall. ******
7. *Lorenzo-Trueba, J., Voller, V.R., and Paola, C.* A geometric model of sediment delta dynamics under base-level change. *****
8. *Matell, N., Anderson, R.S., Overeem, I., Wobus, C., Urban, F.E., and Clow, G.D.* In Press, Corrected Proof. Modeling the subsurface thermal impact of Arctic thaw lakes in a warming climate. doi:10.1016/j.cageo.2011.08.028
9. *Murray, B., Gopalakrishnan, S., McNamara, D.E. and Smith, M.D.* In Press, Corrected Proof. Progress in coupling Models of Human and Coastal Landscape Change. doi:10.1016/j.cageo.2011.10.010
10. *Nasr-Azadani, M. M., Hall, B., and Meiburg, E.* In Press, Corrected Proof. Polydisperse turbidity currents propagating over complex topography: Comparison of experimental and depth-resolved simulation results. doi:10.1016/j.cageo.2011.08.030

11. *Peckham, S.D., and Goodall, J.L.* Driving plug-and-play models with data from web services: A demonstration of interoperability between CSDMS and CUAHSI-HIS. **
12. *Peckham, S.D., Hutton, E., and Norris, B.* A Component-Based Approach to Integrated Modeling in the Geosciences: The Design of CSDMS. **
13. *Upton, P., Kettner, A.J., Gomez, B., Orpin, A.R., Litchfield, N., and Page, M.J.* Simulating post-LGM riverine fluxes to the coastal zone: The Waipaoa catchment, New Zealand. **
14. *Villaret, C., Hervouet, J.-M., Kopmann, R., Merkel, U., and Davies, A.G.* In Press, Corrected Proof. Morphodynamic modeling using the Telemac finite-element system. doi:10.1016/j.cageo.2011.10.004
15. *Viparelli, E., Lauer, J.W., Belmont, P., and Parker, G.* In Press, Corrected Proof. A Numerical Model to Develop Long-term Sediment Budgets Using Isotopic Sediment Fingerprints. doi:10.1016/j.cageo.2011.10.003
16. *Yeh, T.-H., and Parker, G.* Matlab-based Software for Evaluating Sediment-Induced Stratification in Open-Channel Flows. **

* *Not all reviews have been received by the main author yet.*

** *Submission is in revision.*

4.5 Goal 5) Technical Advances in the CSDMS Cyber-Infrastructure

The CSDMS integration facility has developed a suite of tools that extends the CCA bocca utility. Included in this collection is bocca-clone, a command-line utility that wraps a model as a CSDMS-CCA component for use within the CSDMS-CCA modeling framework. The model must expose the appropriate BMI interface (along with value getters and/or setters), with details of the model's interface and how it has been installed on the target platform described in a configuration file (eg. lists of exchange items, names of interface functions, paths to shared libraries, etc.). The bocca-clone tool has been tested for use with C and C++ components but has yet to be used with the remaining CCA-supported languages.

Links: Subversion repository: http://csdms.colorado.edu/viewvc/bocca_tools/trunk/scripts/

Through the CSDMS Component Modeling Tool (CMT), users are now able to run components that themselves create new components. As proof-of-concept, these so-called component factories have been used to create new components based on a Regional Ocean Modelling System (ROMS) component. To create the new component, the component factory downloads, compiles, and installs a new version of the model on the CSDMS cluster, *beach*. The model is built to the specifications of the user as provided by configuration menus in the CMT. The component factory then goes on to auto-generate the wrapping code necessary to create a usable component within the CSDMS modeling framwork. Following this process, the user now is able to use this new component within the CMT.

Links: Subversion repository: http://csdms.colorado.edu/viewvc/component_builder/trunk

In support of Milestone 2, and described above, the CSDMS IF has created a component that is able to download, compile, and install software on the CSDMS HPC cluster for use outside of the CSDMS modeling framework.

The CSDMS IF has created several new service classes that equip components with tools to manage common tasks such as the printing of output data, CMI-port management, and grid mapping.

CMIPortQueue. The CMIPortQueue class manages the CMI uses-ports of a component. This service class manages the connection and disconnection of a component's CMI ports, controls the exectution of each port's initialize, run and finalize functions, as well as grid mapping of the get_value functions.

PrintQueue. The PrintQueue class manages the printing of uniform rectilinear and non-uniform gridded data. The class writes uniform rectilinear grids to NetCDF files (the NCRasterFile class), and non-uniform meshes to VTK files (the VTKFile class). The service class also manages printing intervals for components when these intervals may not be the same as a component's time step.

ESMFRegrid. The ESMF field regridding operation moves data between fields that lie on different grids for the purpose of model coupling through a sparse matrix multiply interpolation between source field and destination grid. The ESMF regridding module has been componentized and will work as a service component within CMT. An algorithm for automating parallel partitioning unstructured mesh of randomly distributed triangulars has been implemented and tested to improve regridding performance.

CSMDSGridMapper. Written in Python and wrapped as a CCA class, the new CSDMS grid mapping tools are capable of mapping structured and unstructured meshs between CMI components. Currently, these tools are able to map point data to cell data, cell data to point data, and point data to point data. The mapping of cell data to cell data is not yet complete but is scheduled for completion by the end of 2012. In addition, a Python API for these tools is available for use outside of the CSDMS modeling framework.

Links:

- CSDMS components:
  - http://csdms.colorado.edu/viewvc/components/trunk/import/csdms/components/edu.csdms.tools.CMIPortQueue/
  - http://csdms.colorado.edu/viewvc/components/trunk/import/csdms/components/edu.csdms.tools.PrintQueue/
  - http://csdms.colorado.edu/viewvc/components/trunk/import/csdms/components/edu.csdms.tools.CSDMSGridMapper/
- Python modules:
  - http://csdms.colorado.edu/viewvc/cmt_py_utils/trunk/cmt/port_queue.py
  - http://csdms.colorado.edu/viewvc/cmt_py_utils/trunk/cmt/print_queue.py
  - http://csdms.colorado.edu/viewvc/cmt_py_utils/trunk/cmt/mapper.py

Components provided by the above goals are able to be used through the CSDMS Component Modeling Tool. The CSDMS IF developed a command-line tool, CMTCL, that enables users to connect, configure, and run coupled components from the command line. This provides many of the same functions as the CMT but allows for easy scripting of batch jobs through either Python or shell scripts. Using a CMT resource file as input, CMTCL configures and connects components, sets up the users environment as necessary, and submits the resulting job to the CSDMS HPC cluster.

Links: Subversion repositories:

- http://csdms.colorado.edu/viewvc/ccafe_gui/trunk/CMT
- http://csdms.colorado.edu/viewvc/cmt/trunk

4.6 Goal 6) Educational and Knowledge Transfer

In 2011 we continue work on two overarching EKT goals, firstly to create and test tutorials and a help system for the CSDMS Modeling Tool, and secondly to improve the CSDMS Educational Repository. To advance these two overarching goals in 2011 we: 1) standardized and improved the CMT Help System with detailed descriptions of model equations. We posted our first instructional videos on a newly launched CSDMS YouTube Channel; 2) continued to post model animations, new spreadsheet labs for undergraduate students and more advanced modeling labs in the educational repository.

Accomplishments and Highlights: Every model in the CSDMS Model repository has 5 or more key reference papers listed to make informed model use straightforward. We standardized the look and feel of the Help System of the CMT and improved the CMT Help System with detailed descriptions of model equations for 53 components. No user has to experience CMT components as a black box --- core model equations are only a single-click away. These help pages are by design shared through the CSDMS wiki, which allows the original model developers to improve and intermittently update documentation.

The EKT repository has progressed in presentation and content. We now share our documented educational movies and animations through a YouTube CSDMS science and technology channel, and have received >42,000 views since December 29th, 2010. Real-world earth surface processes movies are collected and brought online with documentation during large earth surface dynamics events, such as the Japan tsunami, March 2011, and Mississippi flooding, May 2011. Quantitative modeling resources for undergraduate teaching are developed as complete sets of student labs, spreadsheet exercises, instructor notes and overarching lesson plans.

Transparency and usability of the CSDMS component modeling tool-CMT

The CSDMS Modeling Tool (CMT) is one of the key products of the CSDMS project; it allows earth scientists with little prior modeling experience to use and couple models for surface dynamics research and education on the CSDMS computing cluster. In 2011 we continued to improve the transparency and usability of the CMT.

Portal and Help System

CMT has it own portal on the wiki website: http://csdms.colorado.edu/wiki/CMT_portal

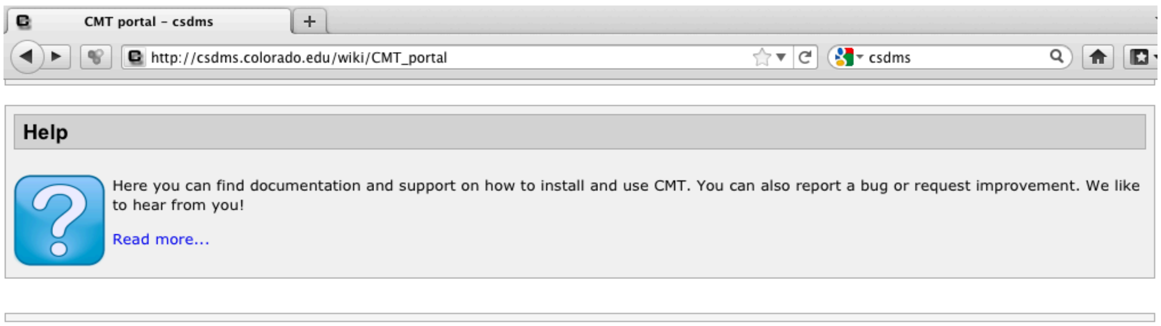


Figure 7. *The CSDMS Component Modeling Tool has a new web portal with a Help System. The Help System refers to navigating and using the CMT, to concise tutorials on starting and running components and to more detailed component help.*

We standardized and further improved the 'CMT Help System' with detailed descriptions of model equations for 53 components. The Help system mirrors tabbed-dialogue user-driven menus in the models themselves. No user has to experience CMT components as a black box, core model equations are only a single-click away for any arbitrary model component. These help pages are intentionally shared through both the CMT directly and through the CSDMS wiki, which allows the original model developers to improve and continuously update documentation.

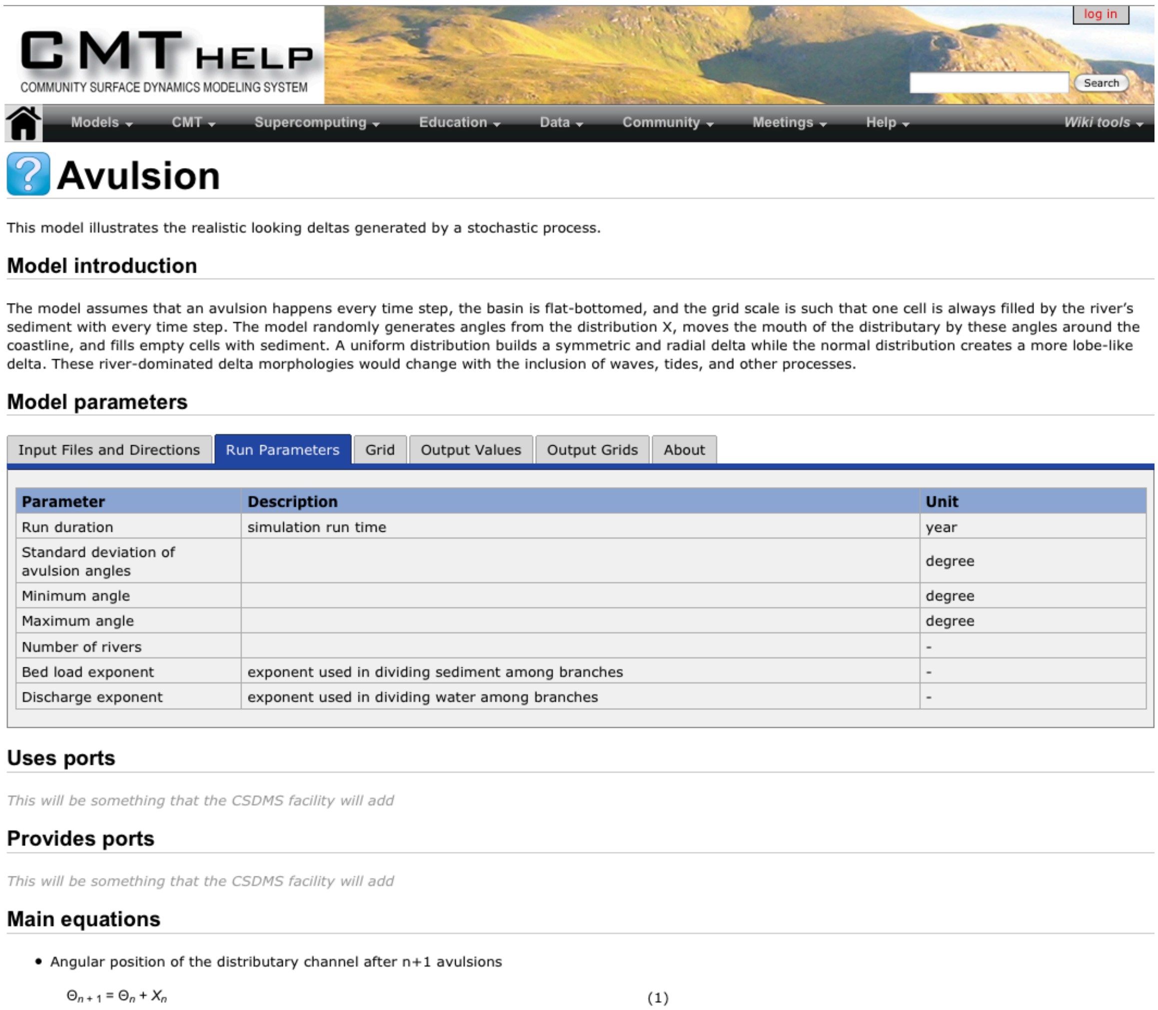
Instructional Videos on CSDMS YouTube channel

We developed a first set of web-based video tutorials that show 1) the vision of the CMT, 2) a beginning user how to install the required software, 3) how to get an account on the supercomputer. More instructional movies will be created and posted in 2011.

Project Governance and Feedback from CMT Users

We value transparency in our CMT software development project. For those CSDMS members that want to monitor progress of development we created a wiki-based progress and workflow-mapping tool. We call this tool a 'component roadmap'; its purpose is to explicitly show what steps a model has to go through before coming online as a CMT component, it also lists the developer or scientist responsible for the steps and sets an approximate timeline.

One more direct feedback option for advanced users is the "Report a bug" option, which allows feedback through the CSDMS Track page. Active tickets are created and posted and are accessible for all stakeholders. Selecting the "Report a bug" option opens a dialog box, in which users may choose whether to create a new ticket for the bug they have discovered, or to view all active tickets.



CMT HELP
COMMUNITY SURFACE DYNAMICS MODELING SYSTEM

log in

Search

Models CMT Supercomputing Education Data Community Meetings Help Wiki tools

Avulsion

This model illustrates the realistic looking deltas generated by a stochastic process.

Model introduction

The model assumes that an avulsion happens every time step, the basin is flat-bottomed, and the grid scale is such that one cell is always filled by the river's sediment with every time step. The model randomly generates angles from the distribution X, moves the mouth of the distributary by these angles around the coastline, and fills empty cells with sediment. A uniform distribution builds a symmetric and radial delta while the normal distribution creates a more lobe-like delta. These river-dominated delta morphologies would change with the inclusion of waves, tides, and other processes.

Model parameters

Input Files and Directions | Run Parameters | Grid | Output Values | Output Grids | About

Parameter	Description	Unit
Run duration	simulation run time	year
Standard deviation of avulsion angles		degree
Minimum angle		degree
Maximum angle		degree
Number of rivers		-
Bed load exponent	exponent used in dividing sediment among branches	-
Discharge exponent	exponent used in dividing water among branches	-

Uses ports

This will be something that the CSDMS facility will add

Provides ports

This will be something that the CSDMS facility will add

Main equations

- Angular position of the distributary channel after n+1 avulsions

$$\Theta_{n+1} = \Theta_n + X_n \quad (1)$$

Figure 8. *Users have single-click access to the model equations behind CMT components. This functionality helps prevent users of experiencing components as a black box --- core model equations are only a single-click away for any arbitrary model component.*

Educational Repository 2011

Growing database of documented animations and movies

The EKT repository has further grown to include 94 documented animation and movies. We now share our documented educational movies and animations through a YouTube CSDMS science and technology channel, and have received >42,000 views since December 29th, 2010. Real-world earth surface processes movies are collected and brought online with documentation during large earth surface dynamics events, such as the Japan tsunami, March 2011, and Mississippi flooding, May 2011. This 'rapid response' approach provoked a large number of views: during the May 2011 Mississippi floods the 'CSDMSmovies' YouTube channel had the largest number of views for a not-for-profit science and technology channel.

We intentionally focus on surface dynamics process aspects of these world events. As an example, CSDMS posted a rare movie to explain the concept of a sand boil near a river levee as a result of flood discharge and pressure gradients between the river channel and the surrounding floodplain.

Movies from the educational repository were picked up in early 2011 by the North Carolina Museum of Natural Sciences for video exhibits in their Nature Research Center, as well as by the Oregon Public Broadcasting for their NASA funded educational website on Carbon connections focused on teaching resources on climate science.

Figure 9. Instructional videos were launched on the CSDMS YouTube channel; topics include 'How to become a CSDMS member, connecting to the CSDMS HPCC and CMT, Contributing to CSDMS repositories and others. These videos will be expanded in 2012.

Figure 10 CSDMS YouTube movie to explain the concept of a sand boil near a river levee as a result of flood discharge and pressure gradients between the river channel and the surrounding floodplain. Posted during the May 2011 Mississippi floods.

Tiered approach to quantitative modeling: High-school & undergraduate-graduate level teaching resources

The EKT working group proposed to develop the educational repository such that there are different levels of teaching resources on surface process modeling; simple spreadsheet modeling, web-based relatively simple 'slider' models with limited parameter space, and more advanced modeling with CMT. CSDMS EKT specialist and CSDMS graduate students now have posted a number of spreadsheet exercises with special focus on teaching quantitative skills. The exercises all include student notes, instructor notes, a lesson plan highlighting topical content and which general quantitative skills are being taught. Downloadable labs as of August 1st, 2011 include hydrological processes (e.g. Evaporation, Infiltration and Interception), Delta Evolution (e.g. Sinking Deltas), Glacio-fluvial Processes (e.g. River Discharge Measurements), and a source-to-sink exercise on Sediment Supply and Human Influences. CSDMS established contacts with new scientists and groups who developed online interactive models. As of 2011, we link to a Coastal Engineering Toolbox (Prof. Dalrymple, University of Delaware) and to the Phet Earth Science Simulations.

Summer Institute on Earth-Surface Dynamics (NCED/CSDMS): This two-week institute combines lectures with practical experiences in the laboratory and the field. SIESD' topic in 2011 was 'Coastal Processes and the Dynamics of Deltaic Systems', the course was successfully held from August 10-19, University of Minnesota. Two days in the summer institute are specially dedicated to use of numerical modeling and quantitative techniques in research and teaching. A selection of the CMT and spreadsheet exercises was further tested and evaluated for teaching purposes during this 2-day part of the SIESD course for students, teaching assistants and teaching faculty. This two-week institute combines lectures with practical experiences in the laboratory and the field and now newly expanded with modeling clinics.

Concepts of Supercomputing for Middle School Students: CSDMS scientists and software engineers participated in the INSTAAR Open House 2011. The INSTAAR Open House hosted over 195 middle school students who participated in hands-on science measurements and activities. The CSDMS Integration Facility team set out to teach concepts of super-computing. To illustrate parallel processing, versus fast-processing students raced to perform tasks as 'fast processors' or cluster teams' and gained insights on basic supercomputing strategies. Students played a science game that pitted different computing methods—parallel processors vs. single processors—against each other, using Duplo blocks to perform tasks. Scott Peckham the chief software architect at the Community Surface Dynamics Modeling System conducted the games. "It was interesting—right away the students came up with refinements that mirror stuff we do in programming," Peckham said.

L) Zachery Borden Best 2011 Poster R) Man Liang 2011 Student Modeler Award

2011 CSDMS Annual Meeting

5.0 Year 6 (2012) Integration Facility Goals and Resources

5.1 Goal 1) CSDMS Web Gateway and Portal in Aid of Community Involvement

We envision the CSDMS website as THE portal for those engaged or interested in modeling earth surface processes. The CSDMS content management system now serves: i) community expertise for networking; ii) models, model data and metadata, iii) model education products, and iv) model tools, v) access to the CSDMS HPCC for running CSDMS models and components, vi) best coding protocols, and vii) assorted community contributions. By fully integrating the Semantic MediaWiki (SMW) plugin, CSDMS databases allow for powerful and flexible web query and dynamically display of content. We therefore will expand the use of SMW information fields to support complex query algorithms. Query algorithms allow: i) side-by-side comparison of models; ii) access by drilling down to input, benchmark & test datasets, key simulations, and metadata and educational material available for a particular model; and iii) search for all papers written for a specific model or by a specific author.

CSDMS strives to provide comprehensive information on models and their simulations (e.g. http://csdms.colorado.edu/wiki/Model_help:Acronym1). We will enhance model metadata and transparency through new capabilities such as the visualization of functions applied in models. The major equations used to simulate key processes are presently provided for each model component. As these equations can be sometimes non-intuitive, we will incorporate a web tool named MathML to help users visualize key model functions within pop-up graphs. To highlight model processes we will host model animations of key processes within a model.

DOI's or Digital Object Identifier is a widely used system established since the late 90's for identifying content objects in a digital environment. DOI names are used to provide current information, including where the object can be found in the World Wide Web [http://www.doi.org/]. Over 50 million DOI names have been currently assigned to digital information ["DOI® News, April 2011: 1. DOI System exceeds 50 million assigned identifiers"] of which probably the most well known usage are publishers who appoint a DOI name to a scientific publication. Studies have shown that search results for publications with DOIs were 5 times more likely to deliver active links to the digital content than titles without DOIs [*Sieck, S., 2004. Economic Benefits of Digital Object Identifier Applications in content Marketing: II. Using the DOI to Improve Profitability In Content Distribution, An EPS White Paper Series. 18p, DOI: http://dx.doi.org/10.1220/eps2.*]. We propose to assign DOI names to the metadata information of each open source model in the CSDMS model repository, which always contains a link to the actual source code. DOI names will *guaranty* that the digital content, in our case the meta data information of a model, can be found on the web, even if the actual URL chances if information is moved to e.g. different servers.

Only a handful of CSDMS models contain data files. However, data files, input files as well as output files, are extremely important to e.g. test if a model compilation is done properly. Once data files are available, compilations checks can be done where received output files can be compared with newly generated output files (based on the identical input file) to identify if there are any differences in the output data. This compile check will benefit 1) the person who downloads the open source code of a model, 2) as well as scientist who would like to run any available model on the CSDMS HPCC, as CSDMS-IF can check the compiled software for this group.

Milestones: Expand the use of SMW information fields to include all 3 repositories as well as the meeting pages. Set up system that makes side-by-side comparison of models possible. Start actively contacting model owners to gather benchmark & test datasets as well as key simulations to add to the data and model repository. Integration of MathML into the CSDMS content management system. We will start to incorporate the model help pages to include the MathML; and further extend to incorporate MathML to other workspaces as well. **Resources**: 0.6 FTE WebSpecialist.

5.2 Goal 2) Service Components and other Technical Advances

Framework Service Components: Models contributed to CSDMS are wrapped to provide them with a calling interface that allows them to be used as plug-and-play components in the CSDMS model-coupling framework (Syvitski et al 2010). The CSDMS framework is based on the Common Component Architecture (CCA, www.cca-forum.org) and therefore provides a mechanism by which any component can be promoted to the role of service component. Service components are very similar to model components but they can have a different calling interface and they are automatically instantiated by a CCA framework when it starts up. Service components are therefore ideal for encapsulating low-level tools or utilities and making them available to all of the model components without requiring any action from a user. The services or methods provided by these components are then called framework services. Unlike other components (e.g. model process components), which users may assemble graphically into larger applications, users do not interact with service components directly. However, a component developer can make calls to the methods of service components through service ports. The use of service components allows developers to maintain code for a shared functionality in a single place and to make that functionality available to all components regardless of the language they are written in (or which address space they are in).

CSDMS has experimented with service components for (1) spatial regridding (interpolation between two different computational grids) and (2) writing output data to netCDF files. For the current proposal, we intend to create a suite of service components that will automatically provide CSDMS model components with greatly enhanced, noninvasive functionality (or added value), without requiring any action from the model contributors. Based on our experiences with many different open-source models, we propose to develop the following set of service components. Our system is designed so that these are called from the component wrapper interface and not from within a contributed model, which makes them noninvasive.

Spatial Regridding: Models contributed to CSDMS use many different types of computational grid, including structured meshes (e.g. rectilinear and orthogonal curvilinear) and unstructured meshes (e.g. Voronoi cells and triangles). When two models with different meshes need to share data, spatial regridding is required. CSDMS incorporates a fast, open-source, multi-processor regridding tool that was developed for the ESMF (Earth System Modeling Framework) project (Syvitski et al 2011b).

Time Interpolation: Models contributed to CSDMS may use either fixed or adaptive time-steps and time-step size can vary widely between models (e.g. a river model and a glacier model). We propose to build a general tool with a variety of interpolation options including none, linear and spline.

File Writer: Contributed models write output files in a variety of formats, but netCDF is currently the clear frontrunner among scientific data formats. The purpose of this service component will be to retrieve data from a model component at specified times and write it to a netCDF file that follows the CF conventions and that is compatible with visualization software such as VisIt.

File Reader: Contributed models are generally written to ingest data from particular file formats. This service component will provide existing and new components with the ability to read input data from additional file formats.

Unit Conversion: Different models may use different units for the same physical quantity (e.g. km or meters). If a component that is requesting data from another component uses different units, this conversion will be performed before passing the data.

Name Lookup: Different models often use different names (as strings) for the same physical quantity (e.g. "streamflow" and "discharge"). There are a number of large projects working on this issue of ontology and semantics. Some examples are: MMI (Marine Metadata Interoperability, marinemetadata.org), SWEET (Semantic Web for Earth and Environmental Terminology, sweet.jpl.nasa.gov) and the CF conventions (cf-pcmdi.llnl.gov/documents/cf-conventions). We propose to use the products of these efforts to create automatic lookup tables to make sure variables are passed correctly.

Model Calibration: For hydrologic models, there is an open-source parameter estimation package called Shuffled Complex Evolution (SCE/SCEM-UA) that is considered the gold standard (see Vrugt et al. (2003)). DREAM (DiffeRential Evolution Adaptive Metropolis) is a related package designed for distributed computing and available in Matlab, R, Python and C. For more information see: http://jasper.enj.uci.edu/software.html

Stopping Condition: Every model has at least one "stopping condition" that determines when the model should stop. However, there are many possibilities, such as (1) fixed number of time-steps, (2) fixed model timespan, (3) until some state variable reaches steady-state and (4) until some state variable produces a NaN (not a number), usually due to an instability. We propose to develop a general service component that can provide contributed models with a richer variety of stopping conditions.

Data Simulation: It is frequently useful, especially for testing, to create or simulate data to satisfy the input data requirements of a model component. The simulated data may represent a scalar, a time series, a grid or a grid sequence. Values may be constant, ramp-like, or random (perhaps will some type of structure or correlation). For example, random cascade algorithms may be used to simulate space-time rainfall fields and the midpoint replacement algorithm is often used to create an initial surface for a fluvial landscape evolution model. We propose to develop a general service component that can provide numerous options such as these.

Milestones: We will begin working on these service components in Year 6 but we do not expect them all to be finished at the end of Year 6. Milestones will include completion of the Spatial Regridding, Time Interpolation, Unit Conversion, and Stopping Condition service components by mid-year. **Resources:** 0.5 FTE Software Engineer.

5.3 Goal 3) Education and Knowledge Transfer

Development of Online CSDMS Earth Surface Process Modeling Course: When a researcher or a student downloads a CSDMS models and the CSDMS Component Modeling Tool (CMT), they use a suite of associated interactive modules to allow an efficient and informed startup of their surface processes modeling projects. We envision an online course to combine mini-tutorial movies with lecture notes hosted on the CSDMS wiki, along with online hands-on modeling projects using the CSDMS HPCC. Each working group domain will have their own targeted online course component with relevant examples; i.e. terrestrial, hydrology, coastal, and marine models. The online course material will be linked to Q&A sections, and threaded discussion forums on the CSDMS wiki, moderated by CSDMS EKT specialist and experts. This online course material will streamline the existing 'Help system' of the CSDMS component modeling system, and integrate it firmly with the material now available in the educational repository. We propose to teach such a course with CSDMS community members particularly graduate students enrolling online. The course will involve several CSDMS experts engaged during the course with short web demos of resources and skills. Each web-based demo will be set up as a webinar and allow for additional direct contact between the enrolled students and the instructors.

We will further the existing CMT components and provide those modeling project with wiki-based examples, and exercises, moving on from current more 'static' documentation of labs. The wiki-based exercises will be outfitted with discussion forums for student use and online forums.

In addition in 2012, we will focus on technical design of one currently missing element in the modeling 'stack'; simplified 'playground' models that students can interact with and explore limited parameters space. Such models should teach core disciplinary ideas and address common misconceptions. The models/modules will be based on current CSDMS CMT technology and CMT-web, but exercises will be entirely pre-wired and with greatly simplified tabbed dialogues of input parameters and generated output. Quantitative data generated by these model simulations have the potential to engage students in sophisticated analyses of time-series and statistics.

Resources: 0.6 FTE EKT Specialist.

5.4 Goal 4) Component Modeling Tool (CMT) on other platforms

The CMT client is available to all CSDMS members as a means to run models or create new ensemble models on the CSDMS HPC cluster (Beach). We propose to expand the CMT server code for installation on a wider range of machines. In this way, users can run the client to connect to a selection of servers. CMT server relies on compilation of the CCA tool chain, model components, and all of the models that the components wrap. To accomplish this we will create an installation method that builds each of these elements and their dependencies on a range of platforms and compilers. When installed on another cluster, the CMT server will support the job scheduler used by that specific cluster. Server-specific configuration will be provided through key/value configuration files.

Deploying CMT to another platform(s) would provide increased stability and sustainability of the modeling tool. We would build CCA and CSDMS tools on the Front-Range NSF/CU High Performance Computer Janus. The result would be a CMT client able to connect to multiple servers. Installation scripts that automate the build process would enable nightly testing of the CSDMS tools and model repository. This product would extend the usability, accessibility, and sustainability of the CMT and CSDMS tools/models as described in the original proposal, and add longevity to the products of the original proposal.

Milestones: Build and install the CSDMS software stack on another HPC cluster (e.g. Janus) with low-volume beta testing of the software stack; Begin building CSDMS contributed models on several platforms and operating systems; Report builds and test results on the CSDMS website; Design the graphical interface and construct a CMTweb prototype. **Resources**: 0.5 FTE Software Engineer.

5.5 Goal 5) Community Activities

CSDMS by-laws require important operational activities for the Integration Facility staff: i) supporting ongoing working and focus research group activities, including workshops and symposia; ii) providing community-targeted short courses and clinics; iii) supporting CSDMS-directed research engaged by the community; iv) growing the community Model Repository, including model metadata and test data; v) improving the CSDMS-HPCC test bed experience and reliability for running models; vi) growing the EKT Repository (student labs, courses, lectures, meeting presentations, real-event movies, laboratory movies, model animations); and the time-consuming vii) conversion of evermore models into "plug-and-play" components. Models that expose the BMI functions become CSDMS components when wrapped with a CMI wrapper. We will automate of this wrapping process to allow evermore legacy code in the Repository to become plug-and-play components.

Each integration staff member liaises with one or more of the 5 working and 3 focus research groups. Each year IF staff effort is apportioned to support group activities. To further improve CSDMS' scope and capabilities, the community has expressed a desire to liaise with other environmental scientists within the larger earth surface community**.** CSDMS as an organization will begin to explore new partnerships with scientists in the fields of ecology, geodynamics, global sustainability, coastal vulnerability, continental margin dynamics, and the Critical Zone Observatories.

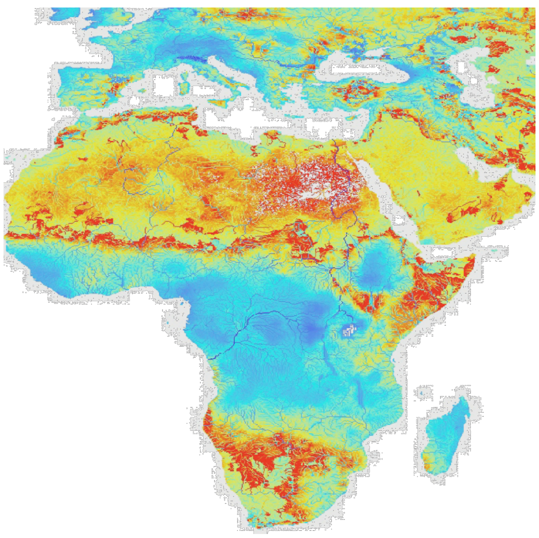
CSDMS is a contributing member of the NSF Frontiers of Earth System Dynamics **Delta Dynamics Collaboratory** (DDC) that will develop and test high-resolution, quantitative models incorporating morphodynamics, ecology, and stratigraphy to predict river delta dynamics over engineering to geologic time-scales, and to address questions of system dynamics, resiliency, and sustainability. This DDC opportunity will see a suite of 1D (reduced complexity) to 3D (ecogeomorphodynamic flow and sediment transport) models be developed as a DeltaMod toolbox using existing CMT components and components developed in the course of that research. CSDMS will also contribute to developing a **"fingerprinting" system** able to identify hot spots of key delta systems as they respond to environmental stressors, under contemporary societal vulnerabilities and future threats (NASA funding). Here integrated modeling within the CSDMS framework coupled to satellite data will be used to assess delta vulnerabilities from a geophysical and social-science perspectives. The two projects are mutually supportive, with the latter providing a geographically global perspective.

CSDMS will continue to provide support for coupling the high-resolution large-eddy-simulation (LES) turbidity current model (TURBINS) to a coarser resolution Reynolds-averaged Navier-Stokes (RANS) ocean circulation model ROMS with the Community Surface Transport Model enabled. This LES-RANS model coupling will employ CMT and also couple with other data and model components. The project is funded through a Rutgers U. cooperative agreement with the Bureau of Ocean Energy Management (BOEM), and CSDMS will use this opportunity as a proof-of-concept at getting academic (research grade) models into an operational workflow. Model runs will provide insights into areas most likely to be impacted by turbidity currents, and the factors that precondition or trigger the flow.

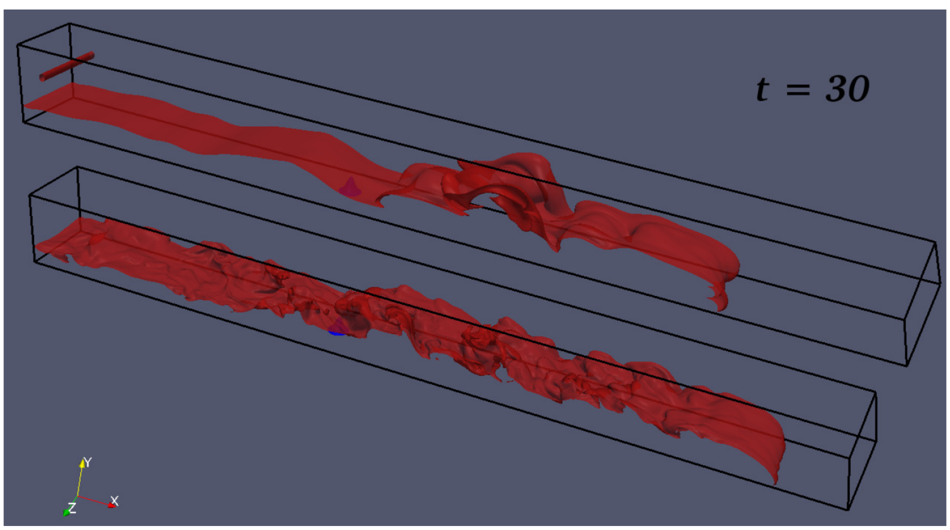
NSF's Critical Zone Observatories or **CZO**s are environmental laboratories fostering a renaissance in the interdisciplinary study of earth's near-surface environment. The CZO effort involves increasing use of models that cross disciplinary boundaries. There is important synergy between participants in CZO and CSDMS (e.g. the Chair of the CSDMS Terrestrial Working Group is an active participant in the Boulder Creek CZO). To foster communication between these two cyber efforts, a CZO Focus Research Group with co-sponsorship with the CZO National Program Office will be initiated.

To help with model prioritization and how geodynamics model best couple to surface process models, we will act on plans to create a Geodynamics Focus Research Group. Several geodynamics models in the Repository appear suitable to be CSDMS components (*Flexure, Isostasy, Lithflex1, Lithflex2, PrattAiry, SNAC, Subside, TAo, TISC*). Together these models would allow geodynamic-generated tectonics to be used by landscape evolution models such as *CHILD, Erode and MARSSIM* that are currently available as CSDMS components.

Resources: 0.5 FTE Software Engineer, 0.25 FTE Director and PI, 1.0 FTE support staff.



WBMsed: a distributed global-scale riverine sediment flux model (Cohen et al., Computers & Geosciences, in press) run on the CSDMS High Performance Computing Cluster. The model run had extreme memory requirements for a 50 yr global run of daily discharge and sediment transport.



Upper) DNS gravity current at Reynolds number of 1000 compared with LES gravity current at Reynolds number of 200,000 generated from simulations run on the CSDMS HPCC (Meiberg, & Radhakrishnan)

6.0 Integration Facility 2010 Publications & Abstracts

CSDMS IF PUBLICATIONS since Jan 1, 2011:

Book Chapters, Journal papers and Newsletters:

Submitted:

Ashton, A.D., Hutton, E.W.H., Kettner, A.J., Xing, F., Kallumadikal, J., Neinhuis, J., Giosan, L. Progress in Coupling Coastline and Fluvial Dynamics. *Computers & Geosciences*.

Brakenridge, G.R., Syvitski, J.P.M., Overeem, I., Higgins, S.A., Kettner, A.J., Stewart-Moore, J.A., and Westerhoff, R. Global Mapping of Storm Surges and the Assessment of Delta Vulnerability. *Natural Hazards*.

Chen, Y., Syvitski, J.P.M., Gao, S., Overeem, I., and Kettner, A.J. Socio-economic Impacts on Flooding: a 4000 year History of the Yellow River, China. *AMBIO*.

Hutton, E.W.H., Syvitski, J.P.M., and Watts, A.B. Isostatic Flexure of a Finite Slope Due to Sea-Level Rise and Fall. *Computers & Geosciences*.

Kettner, AJ and Syvitski, JPM (Eds). Modeling for Environmental Change *A CSDMS Special Issue of 'Computers and Geosciences'*.

Upton, P., Kettner, A.J., Gomez, B., Orpin, A.R., Litchfield, N., and Page, M.J. Application of CSDMS codes to Source-to-Sink studies in New Zealand: The Waipaoa and the Waitaki catchments. *Computers & Geosciences*.

Accepted:

Chen, Y., Overeem, I., Syvitski, J.P.M., Gao, S., and Kettner, A.J. Controls of levee breaches on the Lower Yellow River during the years 1550-1855. *IAHS* Publ.

De Winter, I., Storms, J., and Overeem, I. Glacial valley sediment budgets during deglaciation: A numerical sediment source module. *Geomorphology*.

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Peckham, S.D. and Goodall, J.L. Driving plug-and-play models with data from web services: A demonstration of interoperability between CSDMS and CUAHSI-HIS, *Computers and Geoscience*.

Peckham, S.D., Hutton, E.W.H., and Norris., B. A component-based approach to integrated modeling in the geosciences: The design of CSDMS, *Computers & Geosciences*.

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Slingerland, R., and Syvitski, J.P.M. Community Approach to Modeling Earth- and Seascapes. *Treatise on Geomorphology*, in press

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Wobus, C., R.S. Anderson, I. Overeem, N. Matell, F. Urban, G. Clow, and C. Holmes. Calibrating thermal erosion models along an Arctic coastline. *Arctic Antarctic and Alpine Research*.

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Cohen, S., Kettner, A.J., and Syvitski, J.P.M., Oct., 28-30, 2011. Improved water discharge predictions in WBMsed, a Blobal riverine Sediment Flux model. CSDMS annual meeting, Boulder, CO, USA.

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Kettner, A.J., Xing, F., Ashton, A., Hannon, M., Ibanez, C., and Giosan, L., April 2011. Unraveling the impact of humans versus climate on the morphological evolution of the Ebro Delta, Spain. EGU, Vienna, Austria.
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Peckham, S.D., July 2011. Component-based ocean modeling with the Community Surface Dynamics Modeling System (CSDMS), Chesapeake Bay Program (CBP) Modeling Quarterly Review Meeting, Annapolis, MD.
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Vanmaercke, M., Kettner, A.J., Van Den Eeckhaut, M., Poesen, J., Govers, G., Mamaliga, A., Verstraeten, G., and Radoane, M., Oct., 28-30, 2011. Predicting sediment yields from undisturbed catchments: the dominant role of

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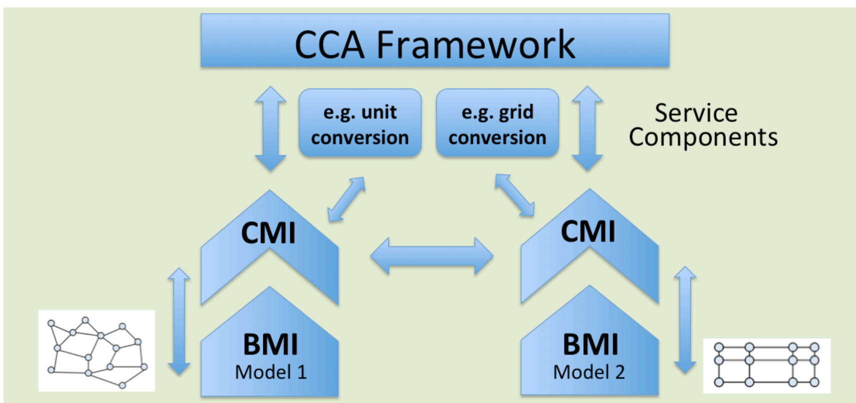
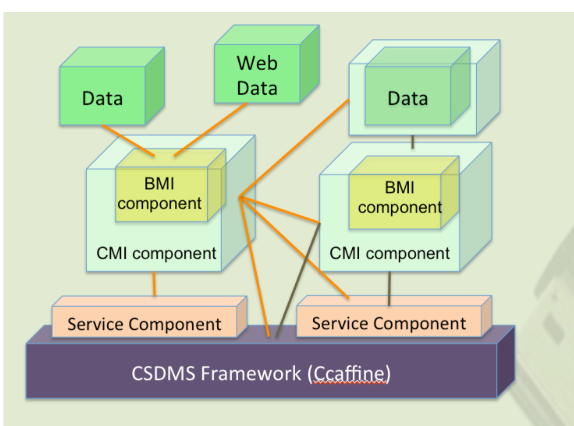


BMI CSDMS "Basic Model Interface" is a set of public functions *for developers*

CMI CSDMS "Component Model Interface" provides BMI components with CMT services for coupling models written in different: 1) programming languages, 2) computational grids, 3) time-stepping, 4) variable names, 5) units; or 6) to run models on HPCC, or to 6) write output to NetCDF files, or 7) etc



BMI component + CMI wrapping + Babel = CMI component

CSDMS Component Modeling Tool or CMT offers a **"plug and play"** programming environment that increases the performance of contributed models, increases their ease of maintenance and use, their flexibility, stability, portability, and future proofing.

7.0 CSDMS Priorities and Management of Its Resources

Year 1 saw the CSDMS governance established; Committees and Working Groups populated; the Integration Facility set-up; communication systems for the community developed; outreach and coordination with US Federal Labs and Agencies, industry, and to the broader surface dynamic community; and the hosting of a variety of scientific Workshops.

Year 2 saw refinements in the CSDMS communication systems with greater community activity; establishment of a CSDMS Interagency Committee established; the Industry Consortium finalized; and outreach to the broader surface dynamic community continued through scientific Workshops and Meetings. The CSDMS high-performance computer was installed and launched as a community-open system, and further advances in the CSDMS cyber-infrastructure was achieved. Computer service costs spiked in Year 2 with the new CSDMS HPC coming on line. A software engineer was hired to help with the Proof-of-concept Projects in Model Coupling.

Year 3 was focused on advanced simulations through proof-of-concept projects where six models, written by six authors, in four computer languages, three different grids, and two levels of granularity were coupled in an alpha-version of the CSDMS Modeling Tool *CMT*. Year 3 also saw the hiring of new staff as the NSF cooperative agreement reached its first year of full funding.

Year 4 witnessed rapid growth and advances in community products, including: 1) revised web portal and services, 2) the first official release of the CSDMS model-coupling tool, 3) evermore models made into components within the CMT tool, 4) an alpha-version of the CSDMS Domain Architecture *SedGrid*, 5) new data handling abilities, 6) the first all-hands conference *Modeling for Environmental Change*, and 7) numerous pedagogically-tested educational modules, clinics, and courses.

In Year 5, CSDMS gained momentum with a 46% growth in membership, a 22% growth in models and components, a 41% growth in model code, a 66% growth in CSDMS HPCC users, and a 267% growth in visits to the CSDMS web resources. These 5.45 million visits indicate that CSDMS has become the "go to" site for models and CSDMS-related data and educational products including animations and images, modeling labs and lecture materials. There are presently 122 movies & animations on the CSDMS YouTube channel, generating more than 36,001 views and putting the CSDMS YouTube channel in the "Top 50 most viewed channels" in the "non profit" category. CSDMS continued to organize, host or sponsor workshops, symposia and meetings, providing short courses and model clinics. The CSDMS budget resources can be roughly divided into four components: 1) 25% supporting middleware development (e.g. CMT plug-and-play environment, BMI and CMI interface standards, support services), 2) 25% supporting networking, capacity building and working group activities (e.g. developing the model repository, metadata), 3) 25% supporting CSDMS support services (e.g. HPCC operations, model simulations, data handling, and other modeling services), and 4) 25% supporting education and knowledge products (e.g. model algorithms, numerical techniques, clinics, and short courses). This division of resources is considered optimal for the CSDMS mission and plans are to continue these allocations in Year 6.

CSDMS Integration Facility Staff continues to juggle the competing demands of an actively engaged and ever-growing CSDMS Community. CSDMS staff will continue their community interactions at both national and international venues. Expenditures related to the Integration Facility staff, travel expenses related to CSDMS governance, operations and workshop participation costs are provided below in Section 8.0. Priorities for Year 6 will continue to be responsive to the active CSDMS communities. This includes focusing on developments in the social dynamics of operating a large community effort, getting more contributed models able to work within CMT, producing a well-vetted CSDMS state-of-the-art special issue of C&G, streamlining the component wrapping process for model developers, and further develop educational tools and products for advancing computational approaches to earth-surface dynamics.

8.0 NSF Revenue & Expenditure (in thousands ($K) with rounding errors)

	Actual Year 1	Actual Year 2	Actual Year 3	Actual Year 4	Estimated Year 5
A. Salaries and Wages					
Executive Director:	$48	$52	$52	$52	$53
Software Engineers:	$97	$113	$211	$225	$220
Communication Staff**	$17	$73	$90	$89	$89
Admin Staff***	$48	$63	$81	$84	$83
Total Salaries	**$210**	**$300**	**$434**	**$450**	**$445**
B. Fringe	**$49**	**$81**	**$121**	**$138**	**$150**
D. Travel					
Center Staff:	$23	$28	$29	$24	$26
Steering Committee	$2	$7	$8	$7	$5
Executive Com.	$5	$12	$6	$5	$5
Total Travel	**$30**	**$47**	**$42**	**$36**	**$36**
E. Workshop Participation					
	$37	**$76**	**$68**	**$60**	**$60**
F. Other Direct Costs					
Materials & Suppl	$1	$6	$4	$3	$3
Publication Costs	$6	$6	$6	$2	$4
Computer Services:	$6	$13	$14	$20	$21
Non Capital Equipment	$0	$0	$7	$2	$2
Communications	$2	$3	$3	$6	$5
Total	**$15**	**$29**	**$34**	**$30**	**$35**
G. Total Direct Costs	**$341**	**$533**	**$700**	**$714**	**$726**
H. Indirect Cost	$140	$233	$326	$313	$319
I. Total Costs	**$489**	**$766**	**$1,026**	**$1,027**	**$1,045**

Notes:
1) Year 5 estimates include salaries projected out 3 months to the end of the CSDMS fiscal year.
2) ** Communication Staff includes Cyber Scientist + EKT Scientist.
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.

9.1 Additional Funds Received by CSDMS IF Staff and Associates (compare with Section 2.4)

Year 1:

Office of Naval Research: Hydrologic and morphodynamic modeling of Deltas: $150K
NASA: Modeling framework to detect and analyze changes in land-to-coastal fluxes: $70K
ConocoPhillips: Cold-climate sedimentary environments: Sedimentary architecture, GIFT $50K
NSF: Modeling river basin dynamics: Parallel computing and advanced numerical methods $220K
NOPP: Toward a predictive model of Arctic coastal retreat in a warming climate $32K
University of Colorado: Salary and Capital support for the CSDMS Integration Facility: $50K
ExxonMobil: CSDMS GIFT $30K

Year 2:

Office of Naval Research: Hydrologic and morphodynamic modeling of Deltas: $110K
NASA: Modeling framework to detect and analyze changes in land-to-coastal fluxes: $70K
ConocoPhillips: Cold-climate sedimentary environments: Sedimentary architecture, GIFT $100K
NSF: Modeling river basin dynamics: Parallel computing and advanced numerical methods $220K
NOPP: Toward a predictive model of Arctic coastal retreat in a warming climate $32K
University of Colorado: Salary and Capital support for the CSDMS Integration Facility: $220K

Year 3:

Office of Naval Research: Hydrologic and morphodynamic modeling of Deltas: $107K
NASA: Modeling framework to detect and analyze changes in land-to-coastal fluxes: $70K
ConocoPhillips: CSDMS, GIFT $30K
NSF: Modeling river basin dynamics: Parallel computing and advanced numerical methods $220K
NOPP: Toward a predictive model of Arctic coastal retreat in a warming climate $32K
University of Colorado: Salary and Capital support for the CSDMS Integration Facility: $220K
StatOil: CSDMS GIFT $50K
NSF: Greenland Ice Sheet Inverse Plume modeling and observations: $80K
USGS: UPS for the CSDMS HPCC: $40K

Year 4:

Office of Naval Research: Vietnam Oceanography site visit $8K
NASA: Modeling framework to detect and analyze changes in land-to-coastal fluxes: $70K
ConocoPhillips: CSDMS, GIFT $30K
ConocoPhillips: Floodplain morphology and dynamics, GIFT $45K
NSF: Modeling river basin dynamics: Parallel computing and advanced numerical methods $220K
NSF: CDI Type II: Scaling Up: Introducing Community Governance into Community Earth Science Meeting $90K
NOPP: Toward a predictive model of Arctic coastal retreat in a warming climate $10K
University of Colorado: Salary and Capital support for the CSDMS Integration Facility: $180K
StatOil: CSDMS GIFT $50K
NSF: Greenland Ice Sheet Inverse Plume modeling and observations: $80K
USGS: HPCC support for additional processors: $110K

Year 5:

NASA: Modeling framework to detect and analyze changes in land-to-coastal fluxes: $70K
ConocoPhillips: Floodplain morphology and dynamics, GIFT $45K
NSF: CDI Type II: Scaling Up: Introducing Community Governance into Community Earth Science Meeting $90K
University of Colorado: Salary for the CSDMS Integration Facility: $80K
StatOil: CSDMS GIFT $50K
NSF: Greenland Ice Sheet Inverse Plume modeling and observations: $80K
BOEM: CSDMS Annual meeting $5K
SHELL: CSDMS Annual meeting $10K
Canadian Natural Resources: Mackenzie Delta Modeling Effort $14.5K

Appendix 1: Institutional Membership — those in marked in blue have joined CSDMS in 2011. There are now more than 326 affiliated institutions.

U.S. Academic Institutions

1. Arizona State University
2. Auburn University, Alabama
3. Binghamton University, New York
4. Boston College
5. Boston University
6. Brigham Young University, Utah
7. California State University - Long Beach
8. Carleton College, Minneapolis
9. Center for Applied Coastal Research, Delaware
10. Chapman University, California
11. City College of New York, City University of New York
12. Coastal Carolina University, South Carolina
13. Colorado School of Mines,
14. Colorado State University
15. Columbia/LDEO, New York
16. Conservation Biology Institute, Oregon
17. CUAHSI, District of Columbia
18. Desert Research Institute, Nevada
19. Duke University, North Carolina
20. Florida Gulf Coast University
21. Florida International University
22. Franklin & Marshall College, Pennsylvania
23. George Mason University, VA
24. Georgia Institute of Technology, Atlanta
25. Harvard University
26. Idaho State University
27. Indiana State University
28. Iowa State University
29. John Hopkins University, Maryland
30. Louisiana State University
31. Massachusetts Institute of Technology
32. Michigan Technological University
33. Monterey Bay Aquarium Research Inst.
34. North Carolina State University
35. Northern Arizona University
36. Northern Illinois University
37. Nova Southeastern University, Florida
38. Oberlin College
39. Ohio State University
40. Old Dominion University, Virginia
41. Oregon State University
42. Penn State University
43. Purdue, Indiana
44. Rutgers University, New Jersey
45. Scripps Institution of Oceanography, CA
46. South Dakota School of Mines, South Dakota
47. Stanford, CA
48. State University (Virginia Tech), VA
49. Syracuse University, New York
50. Texas A&M, College Station, TX
51. Tulane University, New Orleans
52. University of Alabama-Huntsville
53. University of Alaska Fairbanks
54. University of Arizona
55. University of California - Irvine
56. University of California - San Diego
57. University of California -Santa Barbara
58. University of California – Berkeley
59. University of California – Santa Cruz
60. University of Colorado – Boulder
61. University of Connecticut
62. University of Delaware
63. University of Florida
64. University of Houston
65. University of Idaho
66. University of Illinois-Urbana-Champaign
67. University of Iowa
68. University of Kansas
69. University of Maryland
70. University of Memphis
71. University of Miami
72. University of Michigan
73. University of Minnesota – Minneapolis
74. University of Minnesota – Duluth
75. University of Nebraska – Lincoln
76. University of Nevada – Reno
77. University of New Hampshire
78. University of New Mexico
79. University of New Orleans
80. University of North Carolina
81. University of Oklahoma
82. University of Oregon
83. University of Pennsylvania – Pittsburgh
84. University of Rhode Island
85. University of South Carolina
86. University of South Florida
87. University of Southern California
88. University of Texas – San Antonio
89. University of Texas – El Paso
90. University of Texas – Arlington
91. University of Texas – Austin
92. University of Virginia
93. University of Washington
94. University of Wyoming
95. Utah State University
96. Vanderbilt University
97. Virginia Institute of Marine Science (VIMS)
98. Virginia Polytechnic Institute, VA
99. Washington State University
100. Western Carolina University
101. Wichita State University

102. William & Mary College, VA
103. Woods Hole Oceanographic Inst.

U.S. Federal Labs and Agencies

1. Argonne National Laboratory (ANL)
2. Bureau of Ocean Energy Management (BOEM)
3. Idaho National Laboratory (IDL)
4. National Aeronautics & Space Administration (NASA)
5. National Center for Atmospheric Research (NCAR)
6. National Forest Service (NFS)
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 (NRL)
12. Oak Ridge National Laboratory (ORNL)
13. Sandia National Laboratories (SNL)
14. The National Science Foundation (NSF)
15. U.S. Army Corps of Engineers (ACE)
16. U.S. Army Research Office (ARO)
17. U.S. Department of the Interior – Bureau of Reclamation
18. U.S. Dept of Agriculture (USDA)
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

1. Aquaveo LLC, Provo, Utah
2. Chevron Energy Technology, Houston, TX
3. ConocoPhillips, Houston, TX
4. Deltares, USA
5. Dewberry, Virginia,
6. Everglades Partners Joint Venture (EPJV), Florida
7. ExxonMobil Research and Engineering, Houston, TX
8. Idaho Power, Boise
9. Minerals Management Service, National Center for Biotechnology Information (NCBI)
10. PdM Calibrations, LLC, Florida
11. Philip Williams and Associates, Ltd., California
12. Schlumberger Information Solutions, Houston, TX
13. Science Museum of Minnesota, St. Paul, MN
14. Shell USA, Houston, TX
15. URS–Grenier Corporation, Colorado
16. Warren Pinnacle Consulting, Inc., Warren, VT
17. The Von Braun Center for Science & Innovation, Inc.
18. UAN Company

Foreign Membership 101 new members in 2011 (51 countries outside of the U.S.A.: Argentina, Australia, Austria, Bangladesh, Belgium, Bolivia, Brazil, Bulgaria, Cambodia, Canada, Chile, China, Cuba, Denmark, Egypt, France, Germany, Ghana, Greece, Hong Kong, Hungary, India, Indonesia, Iran, Ireland, Italy, Japan, Kenya, Malaysia, Myanmar, New Zealand, Nigeria, Norway, Pakistan, Peru, Poland, Portugal, Republic of Korea, Scotland, Singapore, South Korea, Spain, Sweden, Switzerland, Taiwan, The Netherlands, UK, United Arab Emirates, Uruguay, Venezuela, Việt Nam).

1. Aberystwyth University, UK
2. Adam Mickiewicz University (AMU) Poznan, Poland
3. Aerospace Company, Taiwan
4. Agency for Assessment and Application of Technology, Indonesia
5. AgroCampus Ouest, France
6. Aix-Marseille University, France
7. Anna University, India
8. Aristotle University of Thessaloniki, Greece
9. ASR Ltd., New Zealand
10. Australian Commonwealth Scientific and Industrial
11. Bakosurtanal, Indonesia
12. Baltic Sea Research Inst. Warnemuende (IOW), Germany
13. Bedford Institute of Oceanography, Canada
14. BG Energy Holdings Ltd., UK
15. BG Group, UK
16. Birbal Sahni Institute of Palaeobotany, India
17. Bonn University, Germany
18. British Geological Survey, UK
19. Bundesanstalt fur Gewasserkunde, Germany
20. Cambodia National Mekong Committee (CNMC), Cambodia
21. Cambridge Carbonates, Ltd., France
22. Cardiff University, UK
23. CETMEF/LGCE, France
24. China University of Geosciences- Beijing, China
25. Chinese Academy of Sciences – Cold and Arid Regions Environmental and Engineering Research Institute
26. Chinese Academy of Sciences – Institute of Mountain Hazards and Environment, China
27. Chinese Academy of Sciences – Institute of Tibetan Plateau Research (ITPCAS), China
28. Christian-Albrechts-Universitat (CAU) zu Kie, Germany
29. CNRS / University of Rennes I, France
30. Consiglio Nazionale delle Ricerche (CNR), Italy

31. Cracow University of Technology, Poland
32. Darmstadt University of Technology, Germany
33. Delft University of Technology, Netherlands
34. Deltares, Netherlands
35. Digital Mapping Company, Bangladesh
36. Dongguk University, South Korea
37. Ecole Nationale Superieure des Mines de Paris, France
38. Ecole Polytechnique, France
39. Energy & Environment Modeling, ENEA/UTMEA, Italy
40. Environnement Illimite, Inc., Canada
41. FCEFN-UNSJ-Catedra Geologia Aplicada II, Argentina
42. Federal Ministry of Environment, Nigeria
43. Federal University of Itajuba, Brazil
44. Federal University of Petroleum Resources, Nigeria
45. Free University of Brussels, Belgium
46. French Agricultural and Environmental Research Institute (CEMAGREF)
47. French Research Institute for Exploration of the Sea (IFREMER), France
48. Fugro-GEOS, UK
49. Geological Survey of Canada (Atlantic), Nova Scotia
50. Geological Survey of Canada, Atlantic
51. Geological Survey of Canada, Pacific
52. Geological Survey of Japan (AIST), Japan
53. GNS Science, New Zealand
54. Group-T, Myanmar
55. Grupo DIAO, C.A., Venezuela
56. Haycock, UK
57. Hong Kong University, Hong Kong
58. IANIGLA, Unidad de Geocriologia, Argentina
59. Imperial College of London, UK
60. India Institute of Technology – Delhi, India
61. India Institute of Technology – Kanpur, India
62. India Institute of Technology – Mumbai, India
63. Indian Institute of Science – Bangalore, India
64. InnovationONE, Nigeria
65. Institut de Physique de Globe de Paris, France
66. Institut Francais du Petrole (IFP), France
67. Institute for Computational Science and Technology (ICST), Viet Nam
68. Institute of Earth Sciences (ICTJA-CSIC), Spain
69. Instituto Nacional de Hidraulica (INH), Chile
70. Instituto Nazionale di Astrofisica, Italy
71. Intl. Geosphere Biosphere Programme (IGBP), Sweden
72. Italy National Research Council (CNR), Italy
73. IUEM: Institut Univ. Europeen de la Mer, France
74. Japan Agency for Marine-Earth Science Technology
75. Karlsruhe Institute of Technology (KIT), Germany
76. Katholieke Universiteit Leuven, KUT, Belgium
77. Kenya Meteorological Services, Kenya (JAMSTEC), Japan
78. King's College London, UK
79. Korea Ocean Research and Development Institute (KORDI), South Korea
80. Korea Water Resources Corporation, South Korea
81. Lab Domaines Oceanique IUEM/UBO France
82. Laboratoire de Sciences de la Terre, France
83. Lanzhou University, China
84. Loughborough University, UK
85. Marine Sciences For Society, France
86. McGill University, Canada
87. Ministry of Earth Sciences, India
88. MUC Engineering, United Arab Emirates (UAE)
89. Mulawarman University, Indonesia
90. Nanjing Hydraulics Research Institute, China
91. Nanjing University of Information Science & Technology (NUIST), China
92. Nanjing University, China
93. National Institute for Space Research, INPE, Brazil
94. National Institute of Oceanography, India
95. National Institute of Water and Atmosphere (NIWA), New Zealand
96. National Marine Environmental Forecasting Center (NMEFC), China
97. National University of Sciences & Technology, (NUST), Pakistan
98. Natural Resources, Canada
99. Northwest University of China, China
100. Ntnl. Space Research & Development Agency, Nigeria
101. Ocean University of China, China
102. Padua University, Italy
103. Peking University, China
104. Petrobras, Brazil
105. Riggs Engineering, Ltd., Canada
106. Royal Holloway University of London, UK
107. Senckenberg Institute, Germany
108. SEO Company, Indonesia
109. Seoul National University, South Korea
110. Shell, Netherlands
111. Shenzhen Inst. of Advanced Technology, China
112. Shihezi University, China
113. Singapore-MIT Alliance for Research and Technology (SMART), Singapore
114. Sriwijaya University, Indonesia
115. SRM University, India
116. Statoil, Norway
117. Stockholm University, Sweden
118. Tarbiat Modares University, Iran
119. The Leibniz Institute for Baltic Sea Research, Germany
120. The Maharaja Sayajirao University of Baroda, India
121. Tianjin University, China
122. Tsinghua University, China
123. UNESCO-IHE, Netherlands

124. Universidad Agraria la Molina, Peru
125. Universidad Complutense de Madrid, Spain
126. Universidad de Granada, Spain
127. Universidad de Oriente, Cuba
128. Universidad Nacional de San Juan, Argentina
129. Universidad Politecnica de Catalunya, Spain
130. Universidade de Madeira, Portugal
131. Universidade Federal do Rio Grande do Sul (FRGS), Brazil
132. Universit of Bulgaria (VUZF), Bulgaria
133. Universita "G. d'Annunzio" di Chieti-Pescara, Italy
134. Universite Bordeaux 1, France
135. Universite de Rennes (CNRS), France
136. Universite du Quebec a Chicoutimi (UQAC), Canada
137. Universite Montpellier 2, France
138. Universiteit Gent, Ghent, Belgium
139. Universiti Teknologi Mara (UiTM), Mayalsia
140. University College Dublin, Ireland
141. University of Bari, Italy
142. University of Basel, Switzerland
143. University of Bergen, Norway
144. University of Bremen, Germany
145. University of Brest, France
146. University of Bristol, UK
147. University of British Columbia, Canada
148. University of Calgary, Canada
149. University of Cambridge, UK
150. University of Copenhagen, Denmark
151. University of Dundee, UK
152. University of Edinburgh, Scotland
153. University of Edinburgh, UK
154. University of Exeter, UK
155. University of Ghana, Ghana
156. University of Guelph, Canada
157. University of Kashmir, India
158. University of Lethbridge, Canada
159. University of Milano-Bicocca, Italy
160. University of Natural Resources & Life Sciences, Vienna, Austria
161. University of New South Wales, Australia
162. University of Newcastle upon Tyne, UK
163. University of Newcastle, Australia
164. University of Nigeria Nsukka, Nigeria
165. University of Padova, Italy
166. University of Pavia, Italy
167. University of Queensland (UQ), Australia
168. University of Rome (INFN) "LaSapienza", Italy
169. University of Southampton, UK
170. University of St. Andrews, UK
171. University of Sydney, Australia
172. University of the Republic, Uruguay
173. University of Warsaw, Poland
174. University of West Hungary - Savaria Campus, Hungary
175. University of Western Australia, Australia
176. Utrecht University, Netherlands
177. Vision on Technology, VITO, Belgium
178. Vrije Universiteit, Netherlands
179. VU University, Amsterdam, Netherlands
180. Wageningen University, Netherlands
181. World Weather Information Service (WMO), Cuba
182. Xi-an University of Architecture & Technology, China
183. York University, Canada

Independent Researchers (both U.S. and Foreign)

15 members self-identify as independent researchers.

Appendix 2 CSDMS 2011 Meeting Abstracts

CHARACTERISTIC TIMESCALES OF SHOREFACE RESPONSE TO SEA-LEVEL RISE

Ashton, Andrew[1]; Ortiz, Alejandra[2]; Lane, Phil[2]; Donnelly, Jeffrey[2]
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[2]Woods Hole Oceanographic Institution, Massachusetts

The response of the wave-dominated coasts to sea-level rise is dominated not by inundation, but rather by the dynamic response of sediment transport processes to perturbations of the sea level. In a regime of sea level change, the predominant response of the wave-dominated shoreface depends upon the time-dependent response of the shoreface itself to changes in sea level as well as the potential changes to the shoreline. Sediment transport processes on the shoreface remain poorly understood, complicating predictions of equilibrium shoreface shapes and even net sediment transport directions. However, presuming equilibrium geometry, energetics-based, time-averaged relationships for cross-shore sediment transport provide a framework to understand the characteristic rates and types of shoreface response to perturbations to either the sea level or the shoreline boundary. In the case of a sea-level rise, we find that the dominant perturbation for a barrier system is not the sea-level rise itself, but rather the movement of the shoreline by overwash. The characteristic response time of the shoreface itself increases significantly at depth, suggesting that the lower shoreface response to a sea level change can be significantly delayed. To study the interactions between the characteristic timescales of shoreface evolution and barrier overwash, we apply a numerical model of barrier profile evolution that couples shoreface evolution with barrier overwash. This integrated model provides a tool to understand the response of barrier systems to changes in sea level over the late Holocene to the modern. The model also investigates the potential behavior of barrier systems as they (and their human occupants) respond to predicted increased rates of sea-level rise over the coming centuries.

MODELING THE RATE AND STYLE OF ARCTIC COASTAL RETREAT ALONG THE BEAUFORT SEA, ALASKA

Barnhart, Katherine[1]; Anderson, Robert[2]; Overeem, Irina[2]; Wobus, Cameron[3]; Clow, Gary[4]; Urban, Frank[4]; LeWinter, Adam[5]; Stanton, Timothy[6]
[1]University of Colorado - INSTAAR and Dept. of Geology, Colorado; katy.barnhart@gmail.com
[2]University of Colorado - INSTAAR, Colorado
[3]Stratus Consulting Inc Boulder, Colorado
[4]USGS, Colorado
[5]CRREL, New Hampshire
[6]Naval Postgraduate School, California

"In Arctic landscapes, modern surface warming has significantly altered geomorphic process rates. Along the Beaufort Sea coastline bounding Alaska's North Slope, the mean annual coastal erosion rate has doubled from ~7 m/yr for 1955-1979 to ~14 m/yr for 2002-2007. Locally the erosion rate reaches 30 m/yr. A robust understanding of the processes that govern the rate of erosion is required in order to predict the response of the coast and its adjacent landscape to a rapidly changing climate, with implications for sediment and carbon fluxes, oilfield infrastructure, and animal habitat.

On the Beaufort Sea coast, bluffs in regions of ice-rich silt-dominated permafrost are abundant. This type of coast is vulnerable to rapid erosion due to its high ice content and the small grain size of bluff sediment. The bluff material at our study site near Drew Point is 64% ice, making the bluff susceptible to thermal erosion. Liberated sediment is removed from the system in suspension and does not form sheltering beaches or barrier islands which would provide a negative feedback to erosion. During the sea ice-free season, relatively warm waters abut the bluff and ocean water melts a notch into the 4-m tall bluffs. The bluffs ultimately fail by the toppling of polygonal blocks bounded by mechanically weak ice-wedges that are spaced roughly 10-20 m apart. The blocks then temporarily armor the coast against further attack.

We document the style and the drivers of coastal erosion in this region through simultaneous measurements of the oceanic and atmospheric conditions, and time-lapse imagery. We extract proxies for erosion rate from time-lapse imagery of both a degrading block and a retreating bluff from the summer of 2010, and compare the proxy record with environmental conditions and melt rate models. These observations verify that the dominant process by which erosion occurs is thermal insertion of a notch, toppling of blocks, and subsequent melting of the ice in the block. The annual retreat rate is governed by the length of the sea ice-free season, water and air temperatures, and the water level history, including both storm surge and wave height.

Motivated by these observations, we developed a numerical model to capture the evolution of the permafrost bluffs on the North Slope. We honor the high ice content of the bluff materials and the role of the toppled block in temporarily armoring the coast. We employ a positive degree day algorithm to drive subaerial melt, and a modified iceberg melting algorithm to determine rate of notch incision. Our model is first applied to the 2010 coastal retreat history, and is then

used to address field and remote sensing observations over a variety of timescales. Finally, we employ the model to explore expected changes in coastal retreat rates in a range of climate scenarios that include increases in the duration of sea-ice free conditions, warming ocean temperatures, and changes in storm frequencies.

HIGH RESOLUTION SURFACE PROCESS MODELING IN A GRASS GIS ENVIRONMENT

Barton, Michael[1]; Ullah, Isaac[2]; Mitasova, Helena[3]
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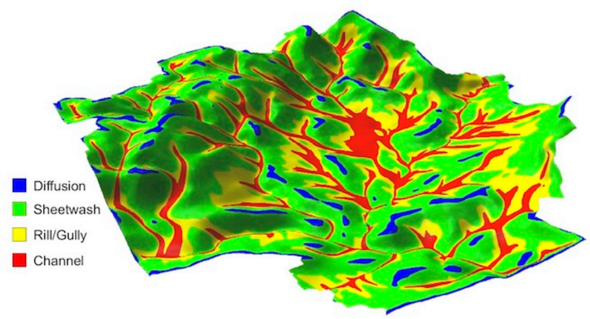
[2]Arizona State University, Arizona
[3]North Carolina State University Raleigh, North Carolina



r.landscape_evol.py model results for landscape in Mediterranean Spain

As part of the Mediterranean Landscape Dynamics (MedLand) project to create a modeling laboratory for human-landscape interaction, we have developed a suite of landscape evolution tools in the GRASS GIS environment. The core of this tool set is a Python script to estimate sediment transport for hillslopes, gullies/rills, and small channels, and simulate resulting terrain change for high-resolution 3D digital landscapes. Because it takes advantage of raster-optimized routines in GRASS, it is very fast on normal desktop systems, making it ideal for simulating long-term landscape change resulting from human activity, climate change, or other drivers. We provide examples of how this landscape evolution model is being used in the MedLand project.

DIRECT NUMERICAL SIMULATION OF SEDIMENT EROSION

Borden, Zachary[1]; Meiburg, Eckart[2]; Glinsky, Michael[3]; Kanarska, Yuliya[4]
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[2]UC Santa Barbara, California
[3]Commonwealth Scientific and Industrial Research Organization, Australia
[4]Lawrence Livermore National Laboratory, California

Any code that attempts to simulate large scale geophysical flows and their effect on topography needs a way to couple local flow properties to a rate of sediment erosion or deposition. However, the mechanisms responsible for a particle's entrainment into a flow are poorly understood. Early erosional models setup a force balance between the fluctuating hydrodynamic forces acting on a particle and the adhesive forces holding a particle to the substrate. Later researchers eschewed this force balance in favor of an energy balance. They claim that a particle is constantly receiving energy from turbulent fluctuations in the flow near the surface, and that a particle will become entrained when it receives a critical amount of energy.

Despite all the work that has gone into deriving an erosion model based on theory, the most popular, and most accurate erosion model used in geophysical codes is the Garcia-Parker model, which is a simple fit to several sets of experimental data. But because their model is empirical, it's impossible to know under what circumstances the model can and cannot be reasonably applied. A theoretical model would be much more desirable for precisely this reason.

Our goal is to better understand the mechanisms of particle entrainment through the use of direct numerical simulation. We are using a code developed at Lawrence Livermore National Laboratory, which solves the incompressible Navier-Stokes equations and uses a Lagrange multiplier method to enforce the correct boundary condition on the surface of the particles within the computational domain. With this method, we are able to accurately simulate the motion of thousands, or even tens of thousands of particles in an external flow in two or three dimensions. With this code, we can study in detail the coupling between local flow structures and the forces on a particle, which will hopefully lead to a better, theoretically based model for erosion.

INSTABILITIES IN PARTICLE-LADEN SYSTEMS

Burns, Peter[1]; Meiburg, Eckart[2]
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[2]UC Santa Barbara, California

When a layer of particle-laden fresh water is placed above clear, saline water, both Rayleigh-Taylor and double-diffusive instabilities may arise. In the absence of salinity, the dominant parameter is the ratio of the particle settling velocity to the viscous velocity scale. As long as this ratio is small, particle settling has a negligible influence on the instability growth. However, when the particles settle more rapidly than the instability grows, the growth rate decreases inversely proportional to the settling velocity. In the presence of a stably stratified salinity field, this picture changes dramatically. An important new parameter is the ratio of the height of the nose region that contains both salt and particles to the thickness of the salinity interface. If this ratio is small (large) the dominant instability mechanism will be double-diffusive (Rayleigh-Taylor) dominant. In contrast to situations without salinity, particle settling can have a destabilizing effect and significantly increase the growth rate. Scaling laws obtained from the linear stability results are seen to be consistent with experimental observations and theoretical arguments put forward by other authors.

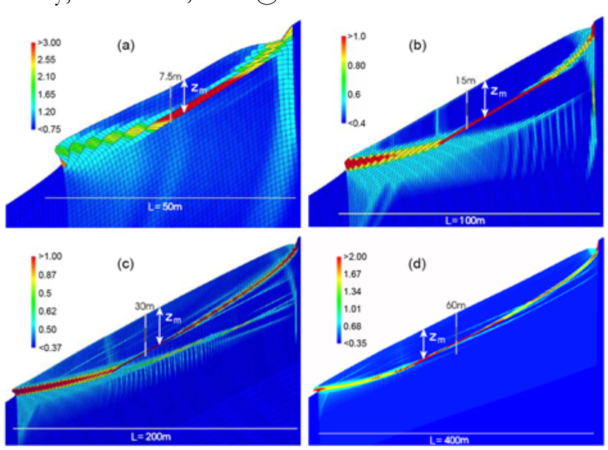
RELATIONSHIPS BETWEEN SEDIMENT CALIBER AND DELTA SHORELINE GEOMETRY AND STRATIGRAPHY

Burpee, Alexander[1]; Slingerland, Rudy[2]; Edmonds, Doug[3]
[1]Geosciences, Pennsylvania State University, State College, Pennsylvania; apb5160@psu.edu
[2]Geosciences, Pennsylvania State University, State College, Pennsylvania
[3]Geology & Geophysics, Boston College, Minnesota

Recent morphodynamic modeling of non-uniform turbulent transport and deposition of sediment in a standing body of water devoid of tides and waves shows that sediment caliber plays a major role in determining the shapes, cumulative number of distributaries, and wetland areas of river-dominated deltas. In this study we introduce metrics for quantifying delta shoreline rugosity and foreset dip (clinoform) variability, and explore their variation with sediment caliber. Delta shoreline rugosity is calculated using the isoperimetric quotient, IP = 4 pi A / P2, where a circle has a value of one. Clinoform complexity is calculated using the uniformity test in circular statistics wherein clinoform dip direction uniformity is the sum of the deviations of dip azimuths from a theoretical uniform distribution. Analysis of fifteen simulated deltas shows that IP increases from 0.1 to 0.5 as the normalized shear stress for re-erosion of cohesive sediment, τ_n, increases from 0.65 to 1. Clinoform dip azimuth uniformity decreases from 300 to 130 with increasing τ_n. Preliminary analysis of data from outcrops of the Cretaceous Ferron Delta and ground penetrating radar data of the Pleistocene Weber and Brigham City Deltas are consistent with these trends. These results imply that changes in sediment caliber delivered to a deltaic coastal system will profoundly change its wetland area, bathymetric hypsometry, ecological function, and interior stratigraphy.

LANDSLIDE RUPTURE AND LENGTH-DEPTH SCALING

Choi, Eunseo[1]
[1]Lamont-Doherty Earth Observatory, New York; echoi@ldeo.columbia.edu



Simulated landslide geometries and model plastic strain (colors): (a) L = 50 m, (b) L = 100 m, (c) L = 200 m, (d) L = 400 m.

Landslides are often assumed to exhibit self-similarity in their failure geometry, and thus a linear scaling between slip depth and rupture length. This assumption has important implications for the prediction of large landslide volumes and for the estimation of erosion budgets by mass-wasting. Nevertheless, some field data indicate a break from self-similarity and imply that, in some circumstances, landslide depth may scale non-linearly with length. Here we test the simple scaling hypothesis by numerical experiment. Modeling is performed with SNAC (StGermaiN Analysis of Continua), a 3D community code originally designed to model viscoelastoplastic deformation on a crustal scale and newly adapted to treating hillslope failure. SNAC employs a parallelized, Lagrangian, explicit finite-difference scheme and dynamic relaxation to solve static, quasi-static and steady-state problems. Landslide rupture is treated as emergent shear localization under strain-weakening Mohr-Coulomb plasticity. We model only the initial slip and early motion of a landslide; granular flow during the runout phase is not considered. A set of 2+1D simulations of failures spanning lengths of 50–400m suffice to vindicate cross-sectional self-similarity—absent any dominant depth scale or trend in the variation of cohesion—and a depth-length ratio of 11–15% is recorded. An interesting by-product of the choice of experimental geometry is some unanticipated complexity in the evolution of the slip plane. Failure initiates at the toe, propagates upslope, and asymptotically parallels the planar upper boundary. However, a connected failure surface is only achieved once a secondary rupture has propagated downwards into this slip plane from the upper breakaway zone. The broader outcome of our numerical experiments is a demonstration of how 3D continuum modeling of soil and rock-slope failure, and the study of their rich behavior, is now feasible using non-commercial code on supercomputing platforms.

IMPROVED WATER DISCHARGE PREDICTIONS IN WBMSED, A GLOBAL RIVERINE SEDIMENT FLUX MODEL

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WBMsed is a spatially and temporally explicit global riverine model predicting suspended and bedload sediment fluxes based on the WBMplus water balance and transport model (part of the FrAMES biogeochemical modeling framework). The model incorporates climate input forcings to calculate surface and subsurface runoff for each grid cell. The prediction of fluvial sediment fluxes is highly dependent on how well its transport medium, riverine water, is simulated. Our analyses indicate that average water discharges are well predicted by the WBMplus model. However, daily freshwater predictions are often over or under predicted by up to an order of magnitude, significantly affecting the accuracy of sediment flux simulation capabilities of WBMsed and indicating that certain hydrological processes are less captured within the model. One of these processes could be temporal storage of water discharge on floodplains, dampening the water hydrograph significantly. In WBMsedv2.0 we incorporate a floodplain reservoir component to improve daily water discharge simulations. The Floodplain reservoir component is used in WBMsedv2.0 to store overbank water flow which are refurbished back to the river once its water level has subsided. Here we compare two methods for determining overbank flow: (1) the log-Pearson III (flood frequency analysis) 5-year maximum discharge recurrence and (2) an empirical relationship between mean river discharge and river width and bank height.

DEPTH-AVERAGED TWO DIMENSIONAL MODEL USING CARTESIAN CUT-CELL APPROACH

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A two-dimensional numerical model was developed for simulating free surface flow. The model is based on the solutions of two-dimensional depth averaged Navier-Stokes equations. A finite volume method is applied such that mass conservation is satisfied both locally and globally. The model adopted the two-step, high resolution MUSCL-Hancock scheme. This Godunov type scheme is used together with the approximate Riemann solver. The boundary cells are treated as cut-cells in order to accommodate arbitrarily geometries of natural rivers. There are sixteen types of cut-cells depending on the slope of the boundary intersection with the cell. A cell merging technique is incorporated in the model that combines small cells with neighboring cells to create a larger cell, helps keeping the CFL condition. The cut-cells approach permits a fully boundary-fitted mesh without implementing a complex mesh generation procedure for irregular geometries. The model is verified by several laboratory experiments including unsteady flow passing through cylindrical piers and dam break flow in a rectangular channel. The model is also applied to simulate a 100-year flood event occurred at the Huron Island reach of the Mississippi River, where flow paths in the island formed a complex channel network as flood propagates.

A NEW WAY TO ACCESS DIGITAL ELEVATION MODELS

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NOAA's National Geophysical Data Center (NGDC) develops and publicly distributes a wide variety of topographic and integrated bathymetric-topographic digital elevation models (DEMs), ranging from the global ETOPO1 and GLOBE, to high-resolution (~10-m cell size) coastal DEMs to support NOAA's tsunami forecast and warning efforts. We have developed a prototype online tool, using an underlying THREDDs catalog, to view and extract the square-cell models in their native resolution and datums, subset by user extents, and output in netCDF, geotiff, xyz, or ESRI Arc ASCII formats. We have also implemented a command-line get request that bypasses the browser interface. Current models include the 1-minute ETOPO1, 30-second GLOBE topography, the 3 arc-second U.S. Coastal Relief Model (CRM) and Great Lakes Bathymetry, and the 24 arc-second Southern Alaska CRM. In the future, we will be expanding the catalog to include all of NGDC's public DEMs, and are investigating ways to in-fill gaps between higher-resolution DEMs with data from coarser models.

NUMERICAL MODELING OF THE IMPACT OF WETLANDS ON HURRICANE STORM SURGE IN COASTAL BAYS

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Texas has historically faced severe hurricanes with Ike being the most recent major storm example. It is believed that coastal wetlands might reduce the impact of the storm surge on coastal areas, acting as a natural protection against hurricane flooding, especially for small hurricanes and tropical storms. Numerical analysis is an important instrument for predicting and simulating the flooding extent and magnitude in coastal areas. In recent years, improvements on the understanding of the physics of storm surges have led to the development of physically based numerical models capable of reasonably representing the storm surges caused from hurricanes. Wetlands are represented in the numerical model through their influence on the frictional resistance proprieties and bathymetric changes. To characterize the wetland types and their spatial distribution along the coast, we used six different land use databases from the National Land Cover Dataset (NLCD) (1992, 2001), the National Wetlands Inventory (NWI) (1993) and the Coastal Change Analysis Program (C-CAP) (1996, 2001, 2006). The analyses was conducted for Corpus Christi Bay using a pre-validated, physically based, hydrodynamic model (ADCIRC) and a wind and pressure field model (PBL) representing the physical properties of historical hurricane Bret. The calculations were performed using an unstructured numerical grid with 3.3 million nodes covering part of the Atlantic Ocean and the entire Gulf of Mexico (resolution from 2000 km to 50 meters at the coast). Considering the expected rise in the mean sea level, wetland composition and spatial distribution are also expected to change as the environmental conditions change along the coast. We analyzed a range of Intergovernmental Panel on Climate Change (IPCC) projections for sea level rise (SLR) to simulate wetland alterations and evaluate their impact on hurricane storm surge. The wetland degradation by SLR was spatially simulated using empirical relations for water levels/tides and ecosystem resilience. The choice of wetland database resulted in surge variations of less than 0.1 m in locations inside Corpus Bay. Preliminary studies considering IPCC scenarios (B1, A1F1, B1FI) for 2030 and 2080 plus predicted local subsidence showed that, although the SLR scenarios for 2030 did not affect surge considerably inside the bay (SLR increase removed after simulation), the greater degradation of the wetlands caused by SLR on the 2080 scenarios (0.80 m SLR + subsidence) resulted in surges on the order of 0.3 m higher for Hurricane Bret in selected locations. Future work includes performing analyses using different storm conditions (forward speed, central pressure and storm radius), additional and less conservative SLR scenarios, damage assessment and also include the effects of waves using the coupled version of ADCIRC with UNSWAN.

RESULTS OF THE US IOOS TESTBED FOR COMPARISON OF HYDRODYNAMIC MODELS OF THE CHESAPEAKE BAY

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Through funding provided by the US Integrated Ocean Observing System, five open source 3-D hydrodynamic models for Chesapeake Bay have been compared to each other and to EPA monitoring data for hindcasts of the years 2004 and 2005. The aim of this project is to provide NOAA, EPA, other government agencies, and the larger modeling community meaningful guidance on the relative accuracy, efficiency, complexity and likely utility for federal operational and scenario modeling of a suite of community models available for simulating hydrodynamics and oxygen dynamics in Chesapeake Bay. The focus of the present paper is on the hydrodynamic comparison of:

1. the ChesROMS model (http://ches.communitymodeling.org/models/ChesROMS/index.php)
2. the CBOFS2 model (http://cedb.asce.org/cgi/WWWdisplay.cgi?265616)
3. the CH3D model (http://www.chesapeakebay.net/publication.aspx?publicationid=55318)
4. the EFDC model (http://smig.usgs.gov/SMIC/model_pages/efdc.html)
5. the UMCES ROMS model (http://ciceet.unh.edu/news/releases/springReports/pdf/ming-li.pdf)

These models represent a range of resolutions (from ~5,000 to ~50,000 wetted cells). The models do similarly well in reproducing 3-D, time-dependent temperature fields. Bottom salinity is significantly improved with increases in horizontal resolution that better capture the structure of narrow, deep channels. Seasonal variation in density stratification is surprisingly difficult for all the models to capture well, and density stratification is not found to be especially sensitive to horizontal or vertical resolution within the range of resolutions considered. The hydrodynamics in general are not particularly sensitive to refinements in offshore climatological forcing, nor to refinements in riverine input, nor to refinements in spatial resolution of wind forcing. Lateral and longitudinal advection is sensitive, however, to seasonal changes in wind velocity and direction, suggesting that typical seasonal changes in wind forcing may be more important than seasonal changes in local stratification in controlling transfer of oxygen to deep channels susceptible to hypoxia.

USING A THREE-DIMENSIONAL COUPLED SEDIMENT – HYDRODYNAMIC MODEL TO EXPLORE FEEDBACKS BETWEEN ERODIBILITY AND SEDIMENT TRAPPING IN A PARTIALLY MIXED ESTUARY, YORK RIVER, VA.

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The MUltiDisciplinary Benthic Exchange Dynamics (MUDBED) program explored the impact of physical and biological processes on turbidity and sediment properties in a muddy estuary. Hydrodynamics, settling velocity, and erodibility influence suspended sediment concentrations. In turn, flux convergence and divergence modify suspended sediment and seabed properties, thereby impacting Estuarine Turbidity Maxima (ETM). In partially mixed estuaries like the York River, VA variations in stratification and sediment trapping respond to tides, discharge, and winds, and produce a Secondary Turbidity Maxima (STM) that appears seasonally downstream of the main ETM.

A hydrodynamic and sediment-transport model of the York River was developed to examine feedbacks between sediment flux convergence, erodibility, and settling velocity. The Regional Ocean Modeling System (ROMS) was coupled to the Community Sediment Transport Modeling System (CSTMS). The model included bed consolidation by representing critical shear stress for erosion as increasing with depth in the bed and with time since deposition. Multiple grain types were used having settling velocities from 0.1 – 2.5 mm/s. Calculations of turbidity and erodibility showed similar patterns to observations and exhibited high spatial variability in both the along and across channel directions. Sediment trapping in the model led to the development of an erodible pool of sediment near the observed STM. Enhanced erodibility elevated suspended sediment concentrations in that area for some time after sediment convergence processes diminished. This poster will explore the behavior of the model and evaluate the use of the simplified bed consolidation model within a full three-dimensional numerical model.

THE NEED FOR SYSTEM SCALE STUDIES IN POLAR REGIONS

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The understanding of Polar Regions has advanced tremendously in the past two decades and much of the improved insight into our knowledge of environmental dynamics is due to multidisciplinary and interdisciplinary studies conducted by coordinated and collaborative research programs supported by national funding agencies. Although much remains to be learned with respect to component processes, many of the most urgent scientific, engineering and social questions can only be addressed through the broader perspective of studies on system scales. Questions such as quantifying feedbacks, understanding the implications of sea ice loss to adjacent land areas or society, resolving future predictions of ecosystem evolution or population dynamics all require consideration of complex interactions and interdependent linkages among system components. Research that has identified physical controls on biological processes, or quantified impact/response relationships in physical and biological systems is critically important, and must be continued; however we are approaching a limitation in our ability to accurately project how the Arctic and the Antarctic will respond to a continued warming climate. Complex issues, such as developing accurate model algorithms of feedback processes require higher level synthesis of multiple component interactions. Several examples of important questions that may only be addressed through systems analyses will be addressed.

COMBINING MODIS IMAGERY AND PLUME MODELING TO ESTIMATE DISCHARGE OF FRESHWATER FROM THE GREENLAND ICE SHEET TO THE COAST

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Very few in-situ measurements of runoff from the Greenland Ice Sheet (GrIS) exist, though melt water runoff from the GrIS is important to global eustatic sea level, ocean salinity, thermohaline circulation and sea ice dynamics and the transport of sediment and nutrients to fjords and the ocean. We continue to develop the use of NASA MODIS imagery to gauge river discharge of sediment and freshwater into fjords hydrologically linked to the GrIS.
Essential to this remote sensing proxy are accurate models of fjord and plume dynamics. We compare Hutton and Syvitski's PLUME model results to in situ oceanographic and sedimentological measurements of Greenlandic river sediment/freshwater plumes towards the end goal of exploring the suitability of inverting the PLUME model and combining it with remotely sensed MODIS imagery to estimate river discharge.
Within our study fjords a range of estuarine conditions present a robust test for our plume method, and in turn conditions present a range of complexities to test the suitability of inverting the PLUME model. Fjord conditions range from ocean to river dominated. Some plumes mix very quickly from fresh to near full ocean salinities (22 – 28 PSU). Other plumes maintain low salinities (0 – 10 PSU) to depths exceeding six meters and down fjord over 65 km. Fjord geometries, tidal range, and other conditions impact sediment plume dynamics. These dynamics must be accounted for to link plume imagery to discharge into fjords.

TEMPORAL-SPATIAL FEATURES OF BIOLOGICALLY-BASED CARBONATE MODELING

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A new class of models based on population ecology, nutrient-geochemistry, and sedimentology is able to simulate carbonate accretion in reef and shelf environments. Unlike previous models for carbonates, they produce very detailed simulations of facies variabilities in space and time. With adjustments to the model runs the range of variabilities can be explored and described statistically. We look at comparisons of the statistics from the models and in outcrops/drillcores of carbonate rocks and ecological transects of present-day seabed areas.

MODELING GRAVEL BED RIVER MORPHODYNAMICS USING A STEP-LENGTH BASED APPROACH

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Understanding gravel bed river morphology over decadal to centennial timescales is vital to making informed stream management and restoration decisions. Factors such as land use change and climate shifts over such timescales may drastically alter river evolution – with major implications for in-channel and riparian habitat. Given these longer timescales of influence, field-based studies may be unable to fully capture such morphologic shifts. Scenario-based morphodynamic modeling is emerging as a means of quantifying gravel bed river evolution, yet current models are unable to predict changes in stream morphology over the timescales in question and with adequate spatial resolution, a problem due largely to the computational overhead they require. Since the computational overhead required to drive sediment transport has hindered previous modeling efforts, field-based research suggests a potential improvement, in that sediment is often mobilized downstream with characteristic step-lengths. Here we introduce a morphodynamic model which drives sediment transport using a step-length based approach. Such a technique negates the need for frequent recalculation of sediment dynamics in the flow, and correspondingly reduces computational overhead. Upon application of this model to the River Feshie (UK), we observe that it accurately reproduces many bed morphologies observed during annual high-resolution topographic surveys. By employing step-length based sediment transport distributions, the formation and preservation of bed morphologies can be accurately predicted with less computational overhead than was available in previous morphodynamic models. Using this new model, a better understanding of gravel-bed river morphodynamics over longer-term timescales (decades to centuries) may aid in the management of gravel bed streams under shifting discharge and sediment regimes.

SEA-LEVEL RISE, DEPTH-DEPENDENT CARBONATE GROWTH, AND THE PARADOX OF DROWNED PLATFORMS

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A mathematical model of carbonate platform sedimentation is presented in which the depth-dependent carbonate growth rate determines the depositional rate of a platform top responding to relative sea-level rise. This model predicts that carbonate platform evolution is primarily controlled by the initial water depth and the sediment production rate at the initial depth, rather than by the maximum potential production rate and imposed rate of relative sea-level rise. A long-standing paradox in the understanding of drowned carbonate platforms in the geological record is based on comparing relatively slow long-term rates of relative sea-level rise with maximum growth potentials of healthy platforms. The model presented here demonstrates that a carbonate platform could be paradoxically drowned by a constant relative sea-level rise when the rate is still less than the maximum carbonate production potential. This does not require other external controls of environmental change, such as nutrient supply or siliciclastic sedimentation. If the rate of relative sea-level rise is higher than the production rate at the initial water depth, the top of the carbonate platform gradually drops below the active photic zone and drowns even if the rate of relative sea-level rise is lower than the maximum carbonate accumulation growth potential. This result effectively resolves the paradox of a drowned carbonate platform. Test runs conducted at bracketed rates of relative sea-level rise have determined how fast the system catches up and maintains the "keep-up" phase, which is a measure of the time necessary for the basin to respond fully to the external forcing. The duration of the "catch-up" phase of platform response (termed carbonate response time) scales with the initial seawater depth and the platform-top aggradation rate. The catch-up duration can be significantly elongated with an increase in the rate of relative sea-level rise. The transition from the catch-up to the keep-up phases can also be delayed by a time interval associated with ecological reestablishment after platform flooding. The carbonate model here employs a logistic equation to model the colonization of carbonate-producing marine organisms and captures the initial time interval for full ecological reestablishment. The increase in delay time due to the carbonate response time and self-organized processes associated with biological colonization, implies a greater likelihood of autogenic origin for high-frequency cyclic strata than has been previously estimated.

A VELOCITY-DEPENDANT FRICTION LAW FOR FLEXIBLE VEGETATION IN A 2D HYDRODYNAMIC MODEL.

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The tidal flats of Roberts Bank in British Columbia, Canada contain large areas of the intertidal zone that are vegetated with eelgrass (Zostera Marina and Zostera Japonica). This vegetation has a variable influence on the flow of tidal waters passing over the tidal flats, which we aim to describe in a large-scale 2D hydrodynamic model.

Vegetation on the surface of the tidal flats causes an increase in the roughness that modifies the flow properties. For submerged vegetation, this roughness is most strongly related to the height of the plants in the water; however, for very flexible plants such as eelgrass, the plant height changes with flow velocity since the plants bend with the currents. The roughness is therefore dependent both on flow depth and flow velocity.

Existing studies concerning the effect of flexible vegetation on flow are mostly focused on the small-scale properties of the velocity and turbulence profiles. Such results cannot be directly incorporated into 2D hydrodynamic models. 3D hydrodynamic modeling is computationally demanding and is therefore less appropriate for large-scale studies and engineering applications over large areas. In order to resolve this computational challenge we developed an integrated formulation of the effects of flexible vegetation on the flow, with the following approach: The roughness is represented through an equivalent Manning's coefficient, which depends on both the water depth and the flow velocity.

Simulations are performed with the Telemac2d model, which has been modified to incorporate the velocity-dependent friction law. Preliminary results show that the proposed law is able to account for qualitative modifications in the tidal flow. In particular, the simulation provides an asymmetric flow pattern that correctly predicts the slower ebb velocities as compared to flood velocities, as observed in the field.

USING THE FLOOD EARLY WARNING SYSTEM WITH OCEAN MODELING DATA

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The Flood Early Warning System (FEWS) was designed as a hydrologic forecasting and warning system. A major design philosophy of FEWS is to use an open infrastructure to facilitate data import, manipulation, and export from a wide – and expanding – number of data sources. The same can be said of the models that FEWS communicates with. This open infrastructure allows FEWS to be used with novel data sources and models. Given its proven history in hydrologic forecasting, this makes FEWS well suited to modeling and forecasting fluvial influence on coastal and marine systems.

Here we present an example of how FEWS can be extended to use oceanographic data. Our example forecasts stage in the Potomac River, where storm surges, especially during hurricanes, can cause flooding in a densely populated area. We use gridded data from the Integrated Ocean Observing System (IOOS). Data from the Chesapeake Bay Regional Ocean

Modeling System (ChesROMS), posted to an OpenDAP server, were accessed from within FEWS. FEWS was used to manipulate the ChesROMS data. For example, the ChesROMS data are disaggregated to produce a time step consistent with available discharge time series, and point data are extracted from the ChesROMS grid at river monitoring sites. The model HEC-RAS is then used to forecast water heights given inputs of stage and discharge. This example illustrates the flexibility of FEWS, and its ability to be used in new areas.

A NEW CHANNEL-RESOLVING REDUCED-ROMPLEXITY MODEL FOR SEDIMENTARY DELTA FORMATION

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Sedimentary delta formation varies over a wide range of time and space scales. Reduced-complexity models offer a worthwhile means of retaining key dynamics and phenomena in delta morphodynamics through employing approximate but physically reliable descriptions of governing transport equations. To that end, we developed a cellular rule-based model, using a "directed" random-walk to determine the flow field, coupled with empirically based sediment transport schemes, following an Exner equation combining bedload and suspended load. Preliminary results provide physically reasonable 3-dimensional topographical features, as well as dynamic processes like channel avulsions and bifurcations. Stratigraphy is also recorded. The flexibility of the modeling framework makes each building block to be updated separately, which will allow for the ready extension to include additional phenomena such as waves and tides.

A MODEL FRAMEWORK FOR FLUVIAL-DELTA EVOLUTION THAT ACCOUNTS FOR THE ACCUMULATION OF ORGANIC SEDIMENT

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The evolution of fluvial deltas involves a complex web of processes, many of which are yet poorly understood. In particular, the role of organic matter (peat) accumulation on delta dynamics still remains elusive. Here, we present a simple geometric prism model that couples the evolution of the delta plain with the accumulation of organic-rich sediment. The model is able to explain the observed coupling between the accommodation/peat accumulation ratio and the quality of buried peat/coal deposits in the delta plain. Similarly to multiple modern and ancient organic-rich sedimentary environments, the model preserves the maximum volume fraction of organic sediment in the delta plain when the overall accommodation rate approximately equals the rate of peat accumulation. Further analysis of the model under simple scenarios of base-level rise and pivot subsidence shows that organic matter accumulation can either enhance or alleviate shoreline transgression.

TOWARDS A COMPLETE DESCRIPTION OF THE HYDROLOGIC CYCLE: LARGE SCALE SIMULATIONS WITH THE OPEN-SOURCE, PARALLEL, PARFLOW HYDROLOGIC MODEL

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Integrated hydrologic models are growing in application and show significant promise in unraveling connections between the surface, subsurface, land-surface and lower atmospheric systems. Recent advances in numerical methods, coupled formulation and computing power have all enabled these simulation advances. Here, I will discuss the modeling platform ParFlow, an integrated hydrologic model that has been coupled to land surface and atmospheric models. I will then discuss a recent application of this model to a large, Continental-Scale domain in North America at high resolution that encompasses both the Mississippi and Colorado watersheds. Details will include techniques for model setup and initialization, in addition to results that focus on understanding fluxes, feedbacks and systems dynamics. Additional anthropogenic complications such as the effects of pumping, irrigation and urbanization will be discussed and a path forward for integrated simulations of the hydrologic cycle will be presented.

MODELING A CONTINUOUS PERMAFROST BASIN ON THE NORTH SLOPE OF ALASKA

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GEOtop 1.145 is used to model the thermal and hydrological state of the subsurface in the Kuparuk basin, Alaska. GEOtop is a distributed hydrological model with coupled water and energy budgets. The surface energy balance scheme includes sensible, latent and radiative heat fluxes at the air-soil or air-snow interface. The subsurface represents heat

fluxes in the vertical and water fluxes in the vertical and horizontal directions. The ERA-Interim atmospheric reanalysis product, which is used to force the model, is compared to meteorological and radiation data from the Kuparuk Basin and other stations on the North Slope of Alaska. The use of ERA-Interim reanalysis to force GEOtop enables large-scale simulations to be performed over areas where in situ meteorological data is sparse, such as the North Slope of Alaska. Model simulations forced by ERA-Interim reanalysis data are validated using borehole observations of soil temperature. Model results will be presented demonstrating the interactions between soil properties, snow cover, vegetation and climate.

DON'T UPSCALE THE COASTLINE; SCALES OF CUMULATIVE CHANGE EMERGE

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Analyzing patterns of shoreline change between repeated LIDAR surveys reveals disparate styles of behavior on different temporal and spatial scales (Lazarus and Murray, GRL 2007; Lazarus, Ashton, Murray, Tebbens, and Burroughs, in review). We use wavelet analysis to investigate the mean variance (or spectral power) of cross-shore shoreline change, as well as the alongshore locations exhibiting high variance, across a range of scales. The time spans between surveys range from one to 12 years. On scales of a kilometer and less, the variance of shoreline change does not increase with the length of time between surveys. On these spatial scales, significant changes in shoreline location tend to occur in localized zones, and these zones shift from one time period to another rather than accumulating. Incidentally, the variance across these scales also exhibits a power-law behavior, even though different processes are known to dominate shoreline change on different scales within the range from 10-103 m. However, on scales larger than a kilometer, a peak in the variance appears, and both the magnitude of the variance and the alongshore scale of maximum variance increases over time; on these scales of a few to ten kilometers, shoreline changes do accumulate.

We interpret these observations as follows: On scales of a kilometer and less, each wave event creates an alongshore-heterogeneous pattern of shoreline change, with the alongshore locations of accentuated shoreline change depending on the characteristics of the waves (height, period, deep-water approach angle) and how those waves interact with heterogeneities on the seafloor—bathymetric features on the inner continental shelf are associated with shoreline change on the kilometer scale (List REFSXXX), and those in the surf zone and swash zones produce changes with alongshore scales on the order of one hundred meters and ten meters, respectively . Repeating such shoreline changes over many wave events superimposes essentially independent patterns of change, with effectively no memory of previous changes. The cumulative changes on scales of a few to ten kilometers, in contrast, suggest a diffusion of plan-view coastline shape; the relationship between the length scales of the variance peak over different time scales are consistent with diffusion, given estimates of effective diffusivity for this coastline (REF ANDREW, JORDAN). Apparently, on large alongshore length scales, the residual alongshore sediment flux that emerges from the many disparate wave events and associated complicated smaller scale patterns of sediment transport can be treated as related to shoreline orientation (the gradient in shoreline location)—the way that a long-term, large-scale, gradient-related flux of soil creep on hillslopes emerges from the complicated smaller-scale patterns of tree throw, gopher burrows, etc.

TURBINS: A COMPUTATIONAL TOOL FOR THREE-DIMENSIONAL, HIGH-RESOLUTION SIMULATIONS OF PARTICLE-LADEN FLOWS

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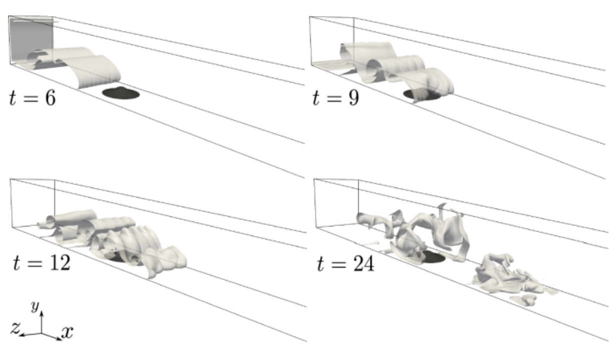

Time evolution of the c = 0.1 concentration isosurface for a lock-exchange turbidity current interacting with a Gaussian bump for Re = 2,000. The suspension contains a mixture of two particle sizes, with nondimensional settling velocities equal to u_c = 0.035 and u_f = 0.0035$, and initial mass fractions of 90% and 10%, respectively.

An accurate, three-dimensional Navier–Stokes based immersed boundary code called TURBINS has been developed, validated and tested, for the purpose of simulating density-driven gravity and turbidity currents propagating over complex topographies. The code is second order accurate in space and third order in time, uses MPI, and employs a domain decomposition approach for parallelism. It makes use of multigrid preconditioners and Krylov iterative solvers for the systems of linear equations obtained by the finite difference discretization of the governing equations. Various boundary conditions on the complex geometry are imposed via the direct forcing variant of the immersed boundary approach, utilizing a stable interpolation method. Bi- and trilinear interpolations are employed in such a way that the original discretization accuracy is retained with no additional restriction on the time step. Weak and strong scaling tests were performed for a uniform flow over array of spheres. We obtain very good scaling results as expected for multigrid solvers. We perform convergence tests via uniform flow over cylinder. Both skin friction and pressure coefficients show very good agreement with results reported by other authors.

Subsequently, a computational investigation was conducted of mono-, bi- and polydisperse lock-exchange turbidity currents interacting with complex bottom topography. Our simulation results are compared against laboratory experiments of other authors. Several features of the flow such as deposit profiles, front location, suspended mass and runout length are discussed. For a monodisperse lock-exchange current propagating over a flat surface, we investigate the influence of the boundary conditions at the streamwise and top boundaries, and we generally find good agreement with corresponding laboratory experiments. However, we note some differences with a second set of experimental data for polydisperse turbidity currents over flat surfaces. A comparison with experimental data for bidisperse currents with varying mass fractions of coarse and fine particles yields good agreement for all cases except those where the current consists almost exclusively of fine particles. For polydisperse currents over a two-dimensional bottom topography, significant discrepancies are observed. Potential reasons are discussed, including erosion and bedload transport.

Finally, we investigate the influence of a three-dimensional Gaussian bump on the deposit pattern of a bidisperse current. The suspension includes two particle sizes with a settling velocity ratio of 10. As the current travels over the bottom topography, we record instantaneous deposit profiles and wall shear stress contours. As the current impinges on the obstacle, it becomes strongly three-dimensional (see Fig. 1). Comparison of the final deposit profiles near the Gaussian bump against the case of a flat surface shows a smaller influence of the topography on the fine particles than on the coarse ones. Due to lateral deflection, deposition generally decreases near the bump, while increasing away from it. Some distance downstream of the obstacle, the deposit profiles lose their memory of the bump and become nearly uniform again. Instantaneous wall shear stress profiles are employed in order to estimate the critical conditions at which bedload transport and/or particle resuspension can occur in various regions.

FLOODPLAIN DEPOSITION MODELING: TIME AND SPATIAL SCALE ISSUES

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Floodplain deposition maintains and builds up low-lying lands along rivers and in deltas. Floodplain aggradation processes and patterns determine how vulnerability of low-lying land changes over timescales of decades to hundreds of years. Over the long term, floodplain deposition and channel migration determine the depositional architecture with impacts on groundwater and hydrocarbon reservoirs.

We build and enhanced a 3D floodplain architecture model, AquaTellUs. AquaTellUs uses a nested model approach; a 2D longitudinal profile, embedded as a dynamical flowpath in a 3D grid-based space. A main channel belt is modeled as a 2D longitudinal profile that responds dynamically to changes in discharge, sediment load and sea level. Sediment flux is described with a modified Exner equation by separate erosion and sedimentation components. Erosion flux along the main flowpath depends on river discharge and channel slope, and is independent of grain-size. Depositional flux along the channel path as well as in the lateral direction into the floodplain depends on the local stream velocity, and on grainsize-dependant settling rates. Multiple grainsize classes are independently tracked. Floodplain deposition is an event-driven system, only peak discharge events cause overbanking, flooding and perhaps channel avulsion. The computational architecture of AquaTellUs preserves stratigraphy by event, allowing for preservation of information of depositional layers of variable thickness and composition.

We here present experiments that show the pronounced effect of different probability density functions for river discharge and sediment load, i.e. flooding recurrence times, on the stratigraphic architecture.

USING NEIGHBORHOOD-ALGORITHM INVERSION TO TEST AND CALIBRATE LANDSCAPE EVOLUTION MODELS

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Landscape evolution models use mass transport rules to simulate the development of topography over timescales too long for humans to observe. The ability of models to reproduce various attributes of real landscapes must be tested against natural systems in which driving forces, boundary conditions, and timescales of landscape evolution can be well constrained over millennia. We test and calibrate a landscape evolution model by comparing it with a well-constrained natural experiment using a formal inversion method to obtain best-fitting parameter values.
Our case study is the Dragon's Back Pressure Ridge, a region of elevated topography parallel to the south central San Andreas Fault that serves as a natural laboratory for studying how the timing and spatial distribution of uplift affects topography. We apply an optimization procedure to identify the parameter ranges and combinations that best account for the observed topography. Direct-search inversion models can be used to convert observations from such natural systems into inferences of the processes that governed their formation through the use of repeat forward modeling. Simple inversion techniques have been used before in landscape evolution modeling, but these are imprecise and computationally expensive. We present the application of a more efficient inversion technique, the Neighborhood Algorithm (NA), to optimize the search for the model parameters values that are most consistent with the formation of the Dragon's Back Pressure Ridge through repeat forward modeling using CHILD.
Inversion techniques require the comparison of model results with direct observations to evaluate misfit. For our target landscape, this is done through a series of topographic metrics that include hypsometry, slope-area curves, and channel concavity. NA uses an initial Monte Carlo simulation for which misfits have been calculated to guide a second iteration of forward models. At each iteration, NA uses n-dimensional Voronoi cells to explore the parameter space and find the zones of best-fit, from which it selects new parameter values for the forward models. As it proceeds, the algorithm concentrates sampling around the cells with the best-fit models. The resulting distribution of forward models and misfits in multi-parameter space can then be analyzed to obtain probability density distributions for each parameter.
Preliminary results suggest that, when combined with robust algorithms for the calculation of the misfit, NA quickly centers the parameter search around values that capture the key features of the observed topography. The ability of NA to provide probability distributions for parameter values gives an indication of uncertainty in each, and can be used to guide field measurements for model testing. This application of advanced inversion techniques for landscape evolution modeling is a significant step towards the use of more formal mathematical methods in geomorphology that are already applied by other disciplines in the geosciences.

THE COMPLEXITY OF MODELING A GLACIATED SHELF USING SEDFLUX

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The present study uses the Sedflux stratigraphic model to simulate the Late Pleistocene evolution of the Eastern Beaufort Continental Shelf, Canadian Arctic. During this period, the proximity and the dynamics of the Laurentide Ice Sheet created a complex glacial environment. Modeling such environments thus presents challenges. Modules and input parameters have to be able to simulate major fluctuations in sea-level and sediment supply, an ever evolving source of sediments, a large outwash plain, sudden outburst floods, permafrost aggradation, glacial isostasy, etc. In addition, detailed understanding of glacially-influenced environments in general and the glacial history of the local region specifically make it difficult to estimate parameters such as sediment supply. This poster thus presents the challenges and the potential solutions in using SEFLUX to simulate the stratigraphy of a glaciated shelf such as the Beaufort Shelf.

A KNOWLEDGE BASE SUPPORTING BIOLOGICALLY-BASED CARBONATE MODELING

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Marine carbonates are created by the metabolism, growth, death and skeletal accumulations of a diverse array of benthic organisms (e.g. corals, bryozoa, molluscs, foraminifera, calcareous algae, and micro-organisms), but carbonate accretion requires a positive net balance among biological growth processes, processes of biological erosion (mainly by fishes, urchins, polychaetes, molluscs, sponges, algae and micro-organisms), and physical processes of destruction, suspension, transport, deposition and cementation. We are creating a knowledge base (KB) containing empirical quantitative data

about individual, population and community properties of major calcifying and bio-eroding species to capture the ecological variation inherent in all biological processes, both spatial (e.g. latitude, longitude, habitat, climate, oceanography, depth) and temporal (e.g. diurnal, seasonal, interannual). The KB will provide realistic values for input to a "virtual aquarium" of characteristic organisms at the center of biologically-based carbonate models describing the initiation, growth and maturation through ecological to geological timescales of such formations as shallow and deep-sea coral reefs, Halimeda beds, bryozoan reefs, and maerl deposits.

MODELING SEDIMENT TRANSPORT PROCESSES AND RESIDENCE TIMES IN THE SHALLOW COASTAL BAY COMPLEX OF THE VIRGINIA COAST RESERVE

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Patterns of sediment transport and particle residence times influence the morphology and ecology of shallow coastal bays in important ways. The Virginia Coast Reserve (VCR), a barrier island-lagoon-marsh system on the Eastern Shore of Virginia, is typical of many shallow coastal bay complexes that lack a significant fluvial source of freshwater and sediment. Sediment redistribution within the bays in response to storms and sea-level rise, together with the dynamics of marsh and lagoon-bottom plants, largely governs the morphological evolution of this system. There are also important feedbacks between sediment and ecosystem dynamics. This is particularly true in the VCR, which is relatively unaffected by human activities. As a step towards evaluating the impact of hydrodynamics on sediment and ecological processes in the VCR, we employ a single unified model that accounts for circulation, surface waves, wave-current interaction, and sediment processes. This three-dimensional unstructured grid finite-volume coastal ocean model (FVCOM) is validated with field observations of wind- and tide-induced water flow (water level and current velocities) in Hog Island Bay, centrally located within the VCR. We present here the resulting patterns of sediment transport and particle residence times over event and seasonal time scales. Water and particle exchange within the VCR and between the VCR and the ocean is examined with the Lagrangian particle-tracking module in FVCOM. We focus on 3 bays with strongly varying bathymetry and coastline geometry, which are also located along a gradient of nitrogen input to the system. The results indicate that residence time of particles within the system vary greatly depending on the location of particle release, bay morphology, and wind conditions. The implications for morphologic evolution and ecosystem response to climate and land-use changes are evaluated.

STRATIGRAPHIC MODELING IN ROMS

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The stratigraphic record is the product of sedimentary processes acting over time. The Regional Ocean Modeling System (ROMS) includes algorithms for the processes of erosion, deposition, and mixing of both non-cohesive (sandy) and cohesive (muddy) sediment, and routines capable of tracking the evolution of event-scale stratigraphy with layers as fine as a few grain diameters thick. Thus ROMS allows users to relate process with product over time scales ranging from a few seconds to years, over vertical space scales of 0.1 mm to meters, and over horizontal space scales of meters to hundreds of kilometers. ROMS requires users to specify the number of bed layers to be tracked at compile time. This improves model efficiency on parallel systems, but complicates the task of tracking stratigraphic evolution. In addition to the number of layers, users can control the minimum and maximum layer thickness and the initial stratigraphy. The effect of these choices and the success of the stratigraphy routines is demonstrated with models of idealized estuaries, deltas, and continental shelves.

LANDSCAPE RESPONSE TO CLIMATE CHANGE: INSIGHTS FROM AN EXPERIMENTAL MODEL

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A series of controlled laboratory experiments were conducted at the St. Anthony Falls laboratory of the University of Minnesota to study the effect of changing precipitation patterns on landscape evolution over long-time scales. High resolution digital elevation (DEM) both in space and time along with instantaneous sediment transport rates were measured over a range of rainfall and uplift rates. These experiments were designed to develop a complete drainage network by growth and propagation of erosional instabilities in response to tectonic uplift. We focus our study to the investigation of how changes in the frequency and magnitude of large-scale rainfall patterns (e.g. monsoonal variability) might influence the development of mountainous landscapes. Preliminary analysis suggests that the statistics of

topographic signatures, for example, evolution of drainage network, slopes, curvatures, etc., show dependence on both rainfall patterns and uplift rate. The implications of these results for predictive modeling of landscapes and the resulting sediment transport are discussed.

PREDICTING SEDIMENT YIELDS FROM UNDISTURBED CATCHMENTS: THE DOMINANT ROLE OF TECTONICS

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A major issue, hampering our understanding about the human impacts on sediment fluxes is our limited knowledge about the magnitude and controlling factors of catchment sediment yields (SY, t km^{-2} y^{-1}) under ‘baseline’ conditions, i.e. the SY that could be expected from a catchment if it was unaffected by human impacts. To address this problem, a dataset was set up with measured SY-data from 146 catchments in Europe that are little or not affected by humans in terms of land use and have no significant reservoirs, lakes, impoundments or glaciers in their upstream area. The considered catchments span a wide range in catchment areas (0.3 – 4,000km^2) and observed SY-values (0.5 – 3,100 t km^{-2} y^{-1}). Analyses of these data indicate that climate exerts little control on the observed range of SY-values. However, strong correlations were found between SY and average catchment slope, lithology and tectonic activity (as derived from a globally available earthquake hazard map). Based on these findings, a regression model was developed that allows predicting baseline SY. Model calibration and validation results indicate that this model is able to provide robust approximations of the baseline SY, with >95% of predictions deviating less than one order of magnitude from the measured SY-values. This model can therefore significantly improve our understanding about the controlling factors of SY and their sensitivity to human impacts. However, it is also the first model that explicitly considers the effect of tectonic activity on catchment SY. Despite the relatively limited tectonic activity in many of these catchments, differences in earthquake sensitivity alone were found to explain already more than 40% of the observed variation in SY. Our results therefore illustrate that tectonic activity has a strong, but hitherto largely neglected, influence on SY.

MODELING THE GLACIAL-INTERGLACIAL IMPACT OF THE PACIFIC TRADE WIND INVERSION ON THE GEOMORPHOLOGY AND HYDROLOGY OF THE BIG ISLAND OF HAWAII

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The interaction of the subsiding, subtropical limb of the Hadley circulation and the easterly North Pacific trade winds establishes a persistent thermal inversion about halfway up the eastern flank of the Big Island of Hawaii. This restricts convective rainfall to the lower elevations, resulting in stream channels that cross an order-of-magnitude rainfall gradient, active ephemerally above the inversion and perennially below it. Above the inversion–capped cloud layer, precipitation is on the order of 400 mm/yr, and the landscape features thin, weakly-developed soils, gentle hillslopes, and ephemeral, shallowly incised bedrock streams and grassland gullies. Below the inversion, where rainfall is >3000 mm/yr, the perennial streams run through 50- to 100-m-deep gulches, with steep forested walls covered by thick tropical soils that are prone to landsliding. Meter- to 50-meter waterfalls are common downstream of the inversion layer, and incision of the deep gulches may proceed by upstream migration of these knickpoints from the coast. The positions of these knickpoints likely reflect the history of lava flows in these catchments, base level changes due to landsliding at the coast, and the statistics of water and sediment discharge above and below the trade inversion and through time.

This landscape has evolved entirely in the last 0.3 Ma, and thus under conditions of glacial-interglacial climate oscillations. During glacial periods, the inversion’s average elevation was likely depressed, although the magnitude of this depression is not well-constrained. An ice cap that was present on Mauna Kea altered the hydrology of the upper slopes of the mountain, providing a continuous source of meltwater to channels that, in the modern setting, are active only during winter storms and rare hurricane strikes. The frequency and intensity of such storms during glaciations are also not well-known.

To quantify these effects, we would like to use climate models to inform landscape evolution models. A key difficulty in coupling these types of models is the separation of time and spatial scales involved. Global climate models typically run on grids of 1 degree or more, at temporal resolution of seconds and run lengths of years to decades. Landscape evolution models (LEMs) reside at the other end of both dimensions, with typical spatial resolutions of meters to km

and temporal resolutions of years or decades. The entire duration of a climate model run may be shorter than the timestep of a typical LEM.

We report initial results from our efforts to bridge the relevant scales by downscaling large-scale climate model output for last-glacial and modern times with NCAR's regional-scale Weather Research and Forecasting (WRF) model. The predicted precipitation fields are input to a hydrologic model to generate realistic discharge statistics useful for landscape modeling. This modeling chain may be validated for the modern climate using atmospheric observations, including the modern distribution of inversion height, and USGS stream gauge data. For glacial periods, the ability of the weather model to correctly predict snowlines on Mauna Kea provides a first-order point of calibration.

FEEDBACKS BETWEEN SURFACE PROCESSES AND FLEXURAL ISOSTASY: A MOTIVATION FOR COUPLING MODELS

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Answers to scientific questions often involve coupled systems that lie within separate fields of study. An example of this is flexural isostasy and surface mass transport. Erosion, deposition, and moving ice masses change loads on the Earth surface, which induce a flexural isostatic response. These isostatic deflections in turn change topography, which is a large control on surface processes. We couple a landscape evolution model (CHILD) and a flexural isostasy model (Flexure) within the CSDMS framework to understand interactions between these processes. We highlight a few scenarios in which this feedback is crucial for understanding what happens on the surface of the Earth: foredeeps around mountain belts, rivers at the margins of large ice sheets, and the "old age" of decaying mountain ranges. We also show how the response changes from simple analytical solutions for flexural isostasy to numerical solutions that allow us to explore spatial variability in lithospheric strength. This work places the spotlight on the kinds of advances that can be made when members of the broader Earth surface process community design their models to be coupleable, share them, and connect them under the unified framework developed by CSDMS. We encourage Earth surface scientists to unleash their creativity in constructing, sharing, and coupling their models to better learn how these building blocks make up the wonderfully complicated Earth surface system.

EXPLORING RIVER - WAVE DOMINATED DELTA EVOLUTION APPLYING A MODEL-COUPLING APPROACH

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Deltas are the important interface between continents and oceans, providing home to over half a billion people. The unique environment supports a wide variety of diverse ecosystems and is highly susceptible to a broad spectrum of interacting forces. Therefore it is critical to understand its current and future changes, especially against the background of climate change and human impact, something that could be explored by studying its historical evolution process. Delta evolution is mainly governed by: a) sediment load supply from its contributing river, and b) ocean dynamics (e.g. waves, tides). Fluvial sediment supply to a delta fluctuates over time either e.g. due to shifts in climate or, on shorter time scales, due to human interference (e.g. deforestation which could increase sediment supply or the emplacement of dams and reservoirs that reduces the sediment supply). How does this affect the morphology of a delta? Waves interact on deltas by dispersing fluvial sediment, reshaping its shoreline, how will it be illustrated in delta's shape and morphology?

To study this, we explored hypothetical delta evolution scenarios given the following boundary conditions: a medium size upstream drainage basin (~80,000km^2) with, as base case, a typical Mediterranean climate. The analysis is done through coupling two numerical models, HydroTrend and CEM. HydroTrend, a climate-driven hydrological transport model, is applied to replicate freshwater and sediment flux to the delta, and subsequently a coastline evolution model (CEM) is applied to simulate the according changes in the delta's coastline morphology. A component-modeling tool (CMT) developed by CSDMS, is used to couple the models for this study. Several scenarios are considered that take into account: 1) stepwise increasing fluvial sediment supply, to the delta and 2) the release time of these stepwise sediment increases by changing the storm intensity for periods of time.

Preliminary model experiments will be presented demonstrating: 1) the capability of the CMT to couple models that represent different process domains and were developed and designed independently (i.e. without the intentions of such coupling), 2) the impact of changes in fluvial sediment on deltas.

A WAVELET-BASED DEM REGULARIZATION METHODOLOGY AIMED AT IMPROVING DISTRIBUTED RAINFALL-RUNOFF MODELING

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In this study, a methodology based on a multi-resolution wavelet analysis is introduced to extract a regularized topographic index (TI) distribution from a high-resolution DEM (digital elevation model). The methodology is a promising method to deal with common problems in hydrological applications of high-resolution DEMs, which usually contain noise, pits and redundant information. Formation of several unconnected saturated zones is a particular case of such problems when TOPMODEL is employed for simulation of hydrological processes within a basin. The proposed method includes four steps. The first two steps are used for smoothing and de-noising purposes and include decomposition of the original DEM into multi-level sub-signals by 2-dimentional discrete wavelet transform (DWT) and thresholding of the wavelet coefficients. In the next step, the original smoothed and filtered DEM is reconstructed using inverse DWT. Finally, the TI distribution and its information content are computed. The computed information content is used as a metric to identify an optimal TI distribution which contains reasonable topography information in the absence of noise and redundancy. Application of the procedure to 1-m resolution LiDAR (light detection and ranging) DEM of the Elder Creek River watershed via the TOPMODEL framework indicates its filtering ability to smooth and connect the saturated areas during the hydrological process. In addition to the rainfall-runoff modeling, the proposed pre-processing technique may be applied wherever a high-resolution DEM is employed for distributed simulation of hydro-environmental processes.

Appendix 3. CSDMS Model Repository

Component **(C)**/Program, Description, Developer

(1) 2DFLOWVEL, Tidal & wind-driven coastal circulation routine, Slingerland, Rudy
(2) ADCIRC, Coastal Circulation and Storm Surge Model, Luettich, Rick
(3) ADI-2D, Advection Diffusion Implicit (ADI) method for solving 2D diffusion equation, Pelletier, Jon
(4) AlluvStrat, Rules-based model to generate a 2-dimensional cross section of alluvial stratigraphy based on fluvial processes, Wickert, Andrew
(5) **(C)** Acronym1, E-book: program for computing bedload transport in gravel rivers., Parker, Gary
(6) **(C)** Acronym1D, E-book: program for computing bedload transport in gravel rivers over time., Parker, Gary
(7) **(C)** Acronym1R, E-book: program for computing bedload transport in gravel rivers with a Manning-Strickler relation for flow resistance., Parker, Gary
(8) **(C)** AgDegBW, E-book: Calculator for aggradation and degradation of a river reach using a backwater formulation., Parker, Gary
(9) **(C)** AgDegNormGravMixPW, E-book: calculator for aggradation and degradation of sediment mixtures in gravel-bed streams, Parker, Gary
(10) **(C)** AgDegNormGravMixSubPW, E-book: calculator for evolution of upward-concave bed profiles in rivers carrying sediment mixtures in subsiding basins., Parker, Gary
(11) **(C)** AgDegNormal, E-book: illustration of calculation of aggradation and degradation of a river reach using the normal flow approximation., Parker, Gary
(12) **(C)** AgDegNormalFault, E-book: Illustration of calculation of aggradation and degradation of a river reach using the normal flow approximation; with an extension for calculation of the response to a sudden fault along the reach., Parker, Gary
(13) **(C)** AgDegNormalGravMixHyd, E-book: A module that calculates the evolution of a gravel bed river under an imposed cycled hydrograph., Parker, Gary
(14) **(C)** AgDegNormalSub, E-book: Program to calculate the evolution of upward-concave bed profiles in rivers carrying uniform sediment in subsiding basins., Parker, Gary
(15) Anuga, ANUGA is a hydrodynamic modelling tool that allows users to model realistic flow problems in complex 2D geometries., Habili, Nariman
(16) AquaTellUs, Fluvial-dominated delta sedimentation model, Overeem, Irina
(17) Area-Slope Equation Calculator, Pixel scale Area-Slope equation calculator, Cohen, Sagy
(18) **(C)** Avulsion, Stream avulsion model, Hutton, Eric
(19) BEDLOAD, Bedload transport model, Slingerland, Rudy
(20) **(C)** BackwaterCalculator, E-book: program for backwater calculations in open channel flow, Parker, Gary
(21) **(C)** BackwaterWrightParker, E-book: calculator for backwater curves in sand-bed streams, including the effects of both skin friction and form drag due to skin friction, Parker, Gary
(22) Bedrock Erosion Model, Knickpoint propagation in the 2D sediment-flux-driven bedrock erosion model, Pelletier, Jon
(23) Bedrock Fault Scarp, This is a two-dimensional numerical model that computes the topographic evolution of the facet slope in the footwall of an active normal fault, Tucker, Greg
(24) **(C)** BedrockAlluvialTransition, E-book: calculator for aggradation and degradation with a migrating bedrock-alluvial transition at the upstream end., Parker, Gary
(25) Bing, Submarine debris flows, Hutton, Eric
(26) Bio, Biogenic mixing of marine sediments, Hutton, Eric
(27) CAM-CARMA, A GCM for Titan that incorporates aerosols, Larson, Eric
(28) **(C)** CEOFS2, The Second Generation Chesapeake Bay Operational Forecast System (CBOFS2): A ROM-Based Modeling System, Lanerolle, Lyon
(29) **(C)** CEM, Coastline evolution model, Murray, A. Brad
(30) **(C)** ChesROMS, Chesapeake Bay ROMS Community Model (ChesROMS), special case of ROMS, Long, Wen
(31) **(C)** CHILD, Landscape Evolution Model, Tucker, Greg
(32) CMFT, Coupled salt Marsh - tidal Flat Transect model, Mariotti, Giulio
(33) CREST, The Coupled Routing and Excess STorage (CREST) model is a distributed hydrologic model developed to simulate the spatial and temporal variation of atmospheric, land surface, and subsurface water fluxes and storages by cell-to-cell simulation., Wang, Jiahu
(34) Caesar, Cellular landscape evolution model, Coulthard, Tom
(35) Channel-Oscillation, Simulates Oscillations in arid alluvial channels, Pelletier, Jon
(36) Compact, Sediment compaction, Hutton, Eric
(37) Coupled1D, Coupled 1D bedrock-alluvial channel evolution, Pelletier, Jon
(38) CrevasseFlow, The module calculates crevasse splay morphology and water discharge outflow of a crevasse splay., Chen, Yunzhen
(39) Cyclopath, A 2D/3D model of carbonate cyclicity, Burgess, Peter
(40) DELTA, Simulates circulation and sedimentation in a 2D turbulent plane jet and resulting delta growth, Slingerland, Rudy
(41) DHSVM, DHSVM is a distributed hydrologic model that explicitly represents the effects of topography and vegetation on water fluxes through the landscape., DHSVM, Administrator
(42) DR3M, Distributed Routing Rainfall-Runoff Model--version II, U.S., Geological Survey
(43) Delft3D, 3D hydrodynamic and sediment transport model, Delft3D, Support
(44) **(C)** DeltaBW, E-book: Calculator for evolution of long profile of a river ending in a 1D migrating delta, using a backwater formulation., Parker, Gary
(45) **(C)** DeltaNorm, E-book: Calculator for evolution of long profile of a river ending in a 1D migrating delta, using the normal flow approximation., Parker, Gary
(46) **(C)** DepDistTotLoadCalc, E-book: Illustration of calculation of depth-discharge relation, bed load transport, suspended load transport and total bed material load for a large, low-slope sand-bed river., Parker, Gary
(47) Detrital Thermochron, Code for estimating long-term exhumation histories and spatial patterns of short-term erosion from the detrital thermochronometric data, Avdeev, Boris
(48) Diffusion, Diffusion of marine sediments due to waves, bioturbation, Hutton, Eric

(49) DLBRM, Distributed Large Basin Runoff Model, Croley, Thomas
(50) **(C)** DredgeSlotBW, E-book: calculator for aggradation and degradation of sediment mixtures in gravel-bed streams subject to cyclic hydrographs., Parker, Gary
(51) ENTRAIN, Simulates critical shear stress of median grain sizes, Slingerland, Rudy
(52) ENTRAINH, Simulates critical shields theta for median grain sizes, Slingerland, Rudy
(53) Eolian Dune Model, Werner's model for eolian dune formation and evolution, Pelletier, Jon
(54) **(C)** Erode, Fluvial landscape evolution model, Peckham, Scott
(55) FLDTA, Simulates flow characteristics based on gradually varied flow equation, Slingerland, Rudy
(56) FTCS1D-NonLinear, Forward Time Centered Space (FTCS) method for 1D nonlinear diffusion equation, Pelletier, Jon
(57) FTCS2D, Forward Time Centered Space (FTCS) method for 2D diffusion equation, Pelletier, Jon
(58) FTCS2D-TerraceDiffusion, Forward Time Centered Space (FTCS) method for 2D Terrace diffusion, Pelletier, Jon
(59) FUNWAVE, Fully Nonlinear Boussinesq Wave Model, Kirby, Jim
(60) FVCOM, The Unstructured Grid Finite Volume Coastal Ocean Model, Chen, Changsheng
(61) **(C)** FallVelocity, E-book: Particle fall velocity calculator, Parker, Gary
(62) FillinPitsFlatsDEM, Filling in pits and flats in a DEM, Pelletier, Jon
(63) Flex1D, Fourier filtering in 1D while solving the flexure equation, Pelletier, Jon
(64) Flex2D, Fourier filtering in 2D while solving the flexure equation, Pelletier, Jon
(65) Flex2D-ADI, Solving the flexure equation applying Advection Diffusion Implicit (ADI) method, Pelletier, Jon
(66) Flexure, Direct 2D finite difference solution of lithospheric plate flexure, Wickert, Andy
(67) Fourier-Bessel-integration, Numerical integration of Fourier-Bessel terms, Pelletier, Jon
(68) FractionalNoises1D, 1D fractional-noise generation with Fourier-filtering method, Pelletier, Jon
(69) FractionalNoises2D, 2D Gaussian fractional-noise generation with Fourier-filtering method, Pelletier, Jon
(70) FVshock, Finite Volume two-dimensional shock-capturing model, Canestrelli, Alberto
(71) GEOMBEST, Geomorphic Model of Barrier, Estuarine, and Shoreface Translations, Stolper, David
(72) GEOtop, Distributed hydrological model, water and energy budgets, Rigon, Riccardo
(73) GIPL, GIPL(Geophysical Institute Permafrost Laboratory) is an implicit finite difference one-dimensional heat flow numerical model, Jafarov, Elchin
(74) Glimmer-CISM, Dynamic thermo-mechanical ice sheet model, Hagdorn, Magnus
(75) GNE, Set of biogeochemical sub-models that predicts river export, Seitzinger, Sybil
(76) GOLEM, Landscape evolution model, Tucker, Greg
(77) **(C)** GSDCalculator, E-book: Calculator for statistical characteristics of grain size distributions., Parker, Gary
(78) **(C)** Gc2d, Glacier / ice sheet evolution model, Kessler, Mark
(79) **(C)** GravelSandTransition, E-book: Calculator for evolution of long profile of river with a migrating gravel-sand transition and subject to subsidence or base level rise., Parker, Gary
(80) GSFLOW, Ground-water and Surface-water FLOW model, Markstrom, Steve
(81) HSPF, a comprehensive package for simulation of watershed hydrology and water quality for both conventional and toxic organic pollutants, Bicknell, Bob
(82) **(C)** HydroTrend, Climate driven hydrological transport model, Kettner, Albert
(83) Hyper, 2D Turbidity Current model, Imran, Jasim
(84) Ice-sheet-Glacier-reconstruction, Sandpile method for ice-sheet and glacier reconstruction, Pelletier, Jon
(85) Iceages, Stochastic-resonance subroutine of Pleistocene ice ages, Pelletier, Jon
(86) Inflow, Steady-state hyperpycnal flow model, Hutton, Eric
(87) Isotasy, Multiple solution methods for lithospheric flexure and isostasy, Wickert, Andy
(88) LEMming, LEMming landscape evolution model: a 2-D, regular-grid, rules-based, hybrid finite-difference / cellular automaton model that is designed to explore the effect of multiple rock types on landscape evolution, Ward, Dylan
(89) LITHFLEX1, Lithospheric flexure solution, Furlong, Kevin
(90) LITHFLEX2, Lithospheric flexure solution for a broken plate, Furlong, Kevin
(91) LOADEST, Software for estimating constituent loads in streams and rivers, Runkel, Rob
(92) LOGDIST, Logrithmic velocity distribution solution, Slingerland, Rudy
(93) LONGPRO, Dynamic evolution of longitudinal profiles, Slingerland, Rudy
(94) LavaFlow2D, 2D radially symmetric lava flow model, Pelletier, Jon
(95) LTRANS, The Larval TRANSport Lagrangian model (LTRANS) is an off-line particle-tracking model that runs with the stored predictions of a 3D hydrodynamic model, specifically the Regional Ocean Modeling System (ROMS), North, Elizabeth
(96) **(C)** MARSSIM, Landform evolution model, Howard, Alan
(97) MFDrouting, Multiple Flow Direction (MFD) flow routing method, Pelletier, Jon
(98) MFDrouting-Successive, Successive flow routing with Multiple Flow Direction (MFD) method, Pelletier, Jon
(99) MIDAS, Coupled flow- heterogeneous sediment routing model, Slingerland, Rudy
(100) MITgcm, The MITgcm (MIT General Circulation Model) is a numerical model designed for study of the atmosphere, ocean, and climate., Lovenduski, Nicole
(101) MODFLOW, MODFLOW is a three-dimensional finite-difference ground-water model, Barlow, Paul
(102) ModelParameterDictionary, Tool written in Python for reading model input parameters from a simple formatted text file, Tucker, Greg
(103) Mrip, Mrip is a self-organization type model for the formation and dynamics of megaripples in the nearshore, Gallagher, Edith
(104) NearCoM, Nearshore Community Model, Kirby, James
(105) NEXRAD-extract, Extract data from NEXRAD Doppler Radar NetCDFs, Wickert, Andrew
(106) OTEQ, One-Dimensional Transport with Equilibrium Chemistry (OTEQ): A Reactive Transport Model for Streams and Rivers, Runkel, Rob
(107) OTIS, One-Dimensional Transport with Inflow and Storage (OTIS): A Solute Transport Model for Streams and Rivers, Runkel, Rob
(108) PIHM, PIHM is a multiprocess, multi-scale hydrologic model., Duffy, Christopher
(109) PIHMgis, Tightly coupled GIS interface for the Penn State Integrated Hydrologic Model, Duffy, Christopher
(110) ParFlow, Parallel, high-performance, integrated watershed model, Maxwell, Reed
(111) Pllcart3d, 3D numerical simulation of confined miscible flows, Oliveira, Rafael
(112) Plume, Hypopycnal sediment plume, Hutton, Eric

(113) Point-Tidal-flat, Point Model for Tidal Flat Evolution model, Fagherazzi, Sergio
(114) PrattyAiry, Simple isostatic compensation, Wickert, Andy
(115) Princeton Ocean Model (POM), POM: Sigma coordinate coastal & basin circulation model, Ezer, Tal
(116) PRMS, Precipitation-Runoff Modeling System, Leavesley, George
(117) PsHIC, Pixel-scale Hypsometric Integral Calculator, Cohen, Sagy
(118) QUAL2K, A Modeling Framework for Simulating River and Stream Water Quality, Chapra, Steve
(119) REF-DIF, Phase-resolving parabolic refraction-diffraction model for ocean surface wave propagation., Kirby, James
(120) RHESSys, Regional Hydro-Ecologic Simulation System, Tague, christina
(121) **(C)** ROMS, Regional Ocean Modeling System, Arango, Hernan G.
(122) **(C)** ROMSBuilder, ROMSBuilder is a CCA-CSDMS Modeling Tool (CMT) compliant component that creates another CMT compliant ROMS component. The new ROMS component is built as per the C-preprocessing options that defines a particular ROMS application, Kallumadikal, Jisamma
(123) **(C)** RecircFeed, E-book: calculator for approach to equilibrium in recirculating and feed flumes, Parker, Gary
(124) **(C)** RiverWFRisingBaseLevelNormal, E-book: Calculator for disequilibrium aggradation of a sand-bed river in response to rising base level., Parker, Gary
(125) **(C)** RouseVanoniEquilibrium, E-book: Program for calculating the Rouse-Vanoni profile of suspended sediment., Parker, Gary
(126) SETTLE, Partical settling velocity solution, Slingerland, Rudy
(127) SIBERIA, SIBERIA simulates the evolution of landscapes under the action of runoff and erosion over long times scales., Willgoose, Garry
(128) SPARROW, The SPARROW Surface Water-Quality Model, Alexander, Richard
(129) SPHYSICS, Smoothed Particle Hydrodynamics code, Dalrymple, Robert
(130) STORM, Windfield simulator for a cyclone, Slingerland, Rudy
(131) STVENANT, 1D gradually varied flow routine, Slingerland, Rudy
(132) STWAVE, Steady-State Spectral Wave Model, Smith, Jane
(133) SUSP, Suspended load transport subroutine, Slingerland, Rudy
(134) SVELA, Shear velocity solution associated with grain roughness, Slingerland, Rudy
(135) SWAN, SWAN is a third-generation wave model, SWAN, Team
(136) SWAT, SWAT is a river basin scale model developed to quantify the impact of land management practices in large, complex watersheds., Arnold, Jeff
(137) SWMM, Storm Water Management Model, Rossman, Lewis
(138) Sakura, 3 Equation hyperpycnal flow model, Kubo, Yusuke
(139) SBM, Sorted Bedform Model, Murray, A. Brad
(140) SedBerg, An iceberg drift and melt model, developed to simulate sedimentation in high-latitude glaciated fjords., Mugford, Ruth
(141) **(C)** Sedflux, Basin filling stratigraphic model, Hutton, Eric
(142) Sedtrans05, Sediment transport model for continental shelf and estuaries, Neumeier, Urs
(143) SNAC, An updated Lagrangian explicit finite difference code for modeling a finitely deforming elasto-visco-plastic solid in 3D, Choi, Eunseo
(144) Spirals1D, 1D model of spiral troughs on Mars, Pelletier, Jon
(145) **(C)** SteadyStateAg, E-book: calculator for approach to equilibrium in recirculating and feed flumes, Parker, Gary
(146) StreamPower, Modeling the development of topographic steady state in the stream-power model, Pelletier, Jon
(147) **(C)** Subside, Flexure model, Hutton, Eric
(148) **(C)** SubsidingFan, E-book: calculator for evolution of profiles of fans in subsiding basins, Parker, Gary
(149) **(C)** SuspSedDensityStrat, E-book: Module for calculating the effect of density stratification on the vertical profiles of velocity and suspended sediment., Parker, Gary
(150) Symphonie, 3D primitive equation ocean model, Marsaleix, Patrick
(151) TAo, tAo is a software designed to model the interplay between lithosphere flexure and surface transport (erosion/sedimentation), particularly during the formation of orogens and foreland sedimentary basins (see details)., Garcia Castellanos, Daniel
(152) TISC, TISC integrates quantitative models of lithospheric flexure, fault deformation, and surface mass transport (erosion/transport/sedimentation) along drainage networks., Garcia Castellanos, Daniel
(153) TOPOG, TOPOG is a terrain analysis-based hydrologic modelling package, Silberstein, Richard
(154) TURB, Gausian distribution calculator of instantaneous shear stresses on the fluvial bed, Slingerland, Rudy
(155) TauDEM, A suite of Digital Elevation Model (DEM) tools for the extraction and analysis of hydrologic information from topography as represented by a DEM. TauDEM 5 is a new version implemented to take advantage of parallel processing, Tarboton, David
(156) TELEMAC, A powerful integrated modeling tool for use in the field of free-surface flows, Hervouet, Jean-Michel
(157) ThawLake1D, 1-D numerical model of permafrost and subsidence processes, Matell, Nora
(158) **(C)** TopoFlow, Spatially-distributed, D8-based hydrologic model, Peckham, Scott
(159) **(C)** TopoFlow-Channels-Diffusive Wave, Diffusive Wave process component for flow routing in a D8-based, spatial hydrologic model, Peckham, Scott
(160) **(C)** TopoFlow-Channels-Dynamic Wave, Dynamic Wave process component for flow routing in a D8-based, spatial hydrologic model, Peckham, Scott
(161) **(C)** TopoFlow-Channels-Kinematic Wave, Kinematic Wave process component for flow routing in a D8-based, spatial hydrologic model., Peckham, Scott
(162) TopoFlow-Data-HIS, The CUAHSI Hydrologic Information System, Peckham, Scott
(163) **(C)** TopoFlow-Diversions, Diversions component for a D8-based, spatial hydrologic model., Peckham, Scott
(164) **(C)** TopoFlow-Evaporation-Energy Balance, Evaporation process component (Energy Balance method) for a D8-based, spatial hydrologic model, Peckham, Scott
(165) **(C)** TopoFlow-Evaporation-Priestley Taylor, Evaporation process component (Priestley-Taylor method) for a D8-based, spatial hydrologic model, Peckham, Scott
(166) **(C)** TopoFlow-Evaporation-Read File, Evaporation process component (read from file method) for a spatially-distributed hydrologic model., Peckham, Scott
(167) **(C)** TopoFlow-Infiltration-Green-Ampt, Infiltration process component (Green-Ampt method) for a D8-based, spatial hydrologic model, Peckham, Scott

(168) **(C)** TopoFlow-Infiltration-Richards 1D, Infiltration process component (Richards 1D method) for a D8-based, spatial hydrologic model, Peckham, Scott
(169) **(C)** TopoFlow-Infiltration-Smith-Parlange, Infiltration process component (Smith-Parlange method) for a D8-based, spatial hydrologic model, Peckham, Scott
(170) **(C)** TopoFlow-Meteorology, Meteorology process component for a D8-based, spatial hydrologic model, Peckham, Scott
(171) **(C)** TopoFlow-Saturated Zone-Darcy Layers, Saturated Zone process component (Darcy's law, multiple soil layers) for a D8-based, spatial hydrologic model, Peckham, Scott
(172) **(C)** TopoFlow-Snowmelt-Degree-Day, Snowmelt process component (Degree-Day method) for a D8-based, spatial hydrologic model, Peckham, Scott
(173) **(C)** TopoFlow-Snowmelt-Energy Balance, Snowmelt process component (Energy Balance method) for a D8-based, spatial hydrologic model, Peckham, Scott
(174) TopoToolbox, A set of Matlab functions for topographic analysis, Schwanghart, Wolfgang
(175) UMCESroms, Chesapeake Bay Application, special case of Regional Ocean Modeling System (ROMS), Li, Yun
(176) VIC, VIC (Variable Infiltration Capacity) is a macroscale hydrologic model that solves full water and energy balances, originally developed by Xu Liang at the University of Washington., Lettenmaier, Dennis
(177) WACCM Dust-Sulfur, Whole atmosphere module of sulfate aerosols., Neely, Ryan
(178) WACCM-CARMA, atmospheric/aerosol microphysical model, English, Jason
(179) WACCM-EE, GCM for deep paleoclimate studies, Wolf, Eric
(180) WAVEREF, Wave refraction routine, Slingerland, Rudy
(181) WAVEWATCH III ^TM, Spectral wind wave model, Tolman, Hendrik
(182) WBMsed, Global sediment flux and water discharge model, Cohen, Sagy
(183) WBM-WTM, Water Balance/Transport Model, Fekete, Balazs
(184) WILSIM, Landscape evolution model, Luo, Wei
(185) WINDSEA, Deep water significant wave height and period simulator during a hurricane routine, Slingerland, Rudy
(186) **(C)** WPHydResAMBL, E-book: Implementation of the Wright-Parker (2004) formulation for hydraulic resistance combined with the Ashida-Michiue (1972) bedload formulation., Parker, Gary
(187) WRF, Weather Research and Forecasting Model, Skamarock, Bill
(188) WSGFAM, Wave and current supported sediment gravity flow model, Friedrichs, Carl
(189) WDUNE, GUI implementation of the Werner (1995) cellular automata aeolian dune model, Barchyn, Tom
(190) XBeach, Wave propagation sediment transport model, Roelvink, Dano
(191) YANGs, Fluvial sediment transport model, Slingerland, Rudy
(192) Zscape, A simple parallel code to demonstrate diffusion, Connor, Chuck

Appendix 4. Professor Rudy L Slingerland - 2011 CSDMS Lifetime Achievement Award

At the 2011 CSDMS Annual Meeting Banquet, Professor Rudy L Slingerland was honored with the 2011 Lifetime Achievement Award. His former students Professor Greg Tucker (UCB) and Professor Doug Edmonds (Boston College) provided the dedication. Professor James Syvitski handed off the award, a unique art piece that honors Professor Slingerland as being one of the greats.

"Rudy has operated with fabulous success in all key CSDMS domains (Landscape Evolution Modeling, Transport Modeling, and Morphodynamics Modeling). The award is completely independent of the support Rudy has shown the Earth Science Community for his leadership roles in NCED, CSDMS, MARGINS, but does entrain his leadership efforts in starting the field of Quantitative Dynamic Stratigraphy. By predicting on how sediment grains of different density, move across the landscape, Professor Slingerland has changed our understanding on connectedness of sediment process, in a source to sink approach. Expressing our knowledge in terms of the fundamental equations that govern the movement of sediment and fluids, as represented by the work and inspiration of Dr. Slingerland, allows us to understand what we know, what we do not know, and how to go about and experimentally move forward with our understanding. Rudy Slingerland is able to bridge between disciplines: 1) engineering and science, and has published in both venues; 2) physics/geophysics and geology, through his field-based computational science; 3) hydrology and geology, through his landmark research on rivers; 4) sedimentology and geomorphology, particularly his work on fold and thrust belts; 5) mathematics and geology, with his leading efforts at bringing quantitative science to an a historically descriptive field; and finally 6) oceanography and geology, particularly his work on the Western Interior Seaway. Much kudos and love go to Professor Slingerland." --- *J Syvitski*