CSDMS

COMMUNITY SURFACE DYNAMICS MODELING SYSTEM

ANNUAL REPORT

AUG 2013

NSF COOPERATIVE AGREEMENT 0621695

CSDMS
COMMUNITY SURFACE DYNAMICS MODELING SYSTEM

Executive Summary

The Community Surface Dynamic Modeling System (CSDMS) is an NSF-supported, international and community-driven program that seeks to transform the science and practice of earth-surface dynamics modeling. CSDMS now integrates a diverse community of more than 1000 members (as of 05/01/13) represent 166 U.S. institutions (123 academic, 22 private, 21 federal) and 275 non-U.S. institutions from 67 countries (177 academic, 28 private, 70 government). There are now **441** affiliated institutions plus another 30 private memberships. CSDMS distributes 217 Open Source models and modeling tools, provides access to high performance computing clusters in support of developing and running models, and offers a suite of products for education and knowledge transfer. The CSDMS architecture employs frameworks and services that convert stand-alone models into flexible "plug-and-play" components to be assembled into larger applications. After the first five years of CSDMS 1.0, CSDMS 2.0 activities begin through multiple NSF funding units: GEO/OCE Marine Geology and Geophysics, GEO/EAR Geoinformatics; GEO/EAR Geomorphology and Land-use Dynamics; GEO/EAR Sedimentary Geology and Paleontology; GEO/EAR Education and Human Resources; GEO/EAR Hydrological Sciences; BIO/DEB Macrosystems Biology; BIO/DEB Ecosystem Studies. This Report outlines developments of the CSDMS Modeling Framework, ever-increasing numbers of "plug-and-play" components, and model semantics. Three new community Focus Research Group have been launched: 1) a *Geodynamics Focus Research Group* to investigate the interplay among climate, geomorphology, and tectonic processes, and cosponsored with GeoPRISMS, 2) an *Anthropocene Focus Research Group* to incorporate mechanistic models of human influences, and cosponsored with IGBP and CoMSES, 3) a *Critical Zone Focus Research Group*, to develop compatibility between CSDMS architecture and protocols and Critical Zone Observatory-developed models and data. Two new initiatives have also been launched — 4) a *coastal vulnerability modeling initiative*, with emphasis on deltas and their multiple threats and stressors, and 5) a *continental margin modeling initiative*, to capture extreme oceanic and atmospheric events generating turbidity currents in the Gulf of Mexico, and cosponsored by BOEM. This Annual Report covers this supplemental period from Aug 2012 to July 2013, and provides an update since the last 2012 Report to NSF.

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CSDMS 2.0 2013 Annual Report

1.0 CSDMS Mission:

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

This Annual Report covers the period from Aug 2012 to July 2013.

2.0 CSDMS Management and Oversight.

2.1 The CSDMS Executive Committee (ExCom): organizational chairpersons:

- Pat Wiberg (April, 2012—), Chair, CSDMS Steering Committee, Univ. of Virginia, VA
- Brad Murray (April, 2007—), Chair, Coastal Working Group, Duke Univ., NC
- Courtney Harris (April, 2012—), Chair, Marine Working Group, VIMS, VA
- Greg Tucker (April, 2007—), Chair, Terrestrial Working Group, CIRES, U. Colorado – Boulder, CO
- Eckart Meiburg (Jan, 2009—), Chair, Cyberinformatics & Numerics WG, U. California-Santa Barbara, CA
- Samuel Bentley (Sept, 2012—), Chair, Education & Knowledge Transfer WG, LSU, LA
- Peter Burgess (Sept, 2008—), Chair, Carbonate Focus Research Group, Royal Holloway, U. London, UK
- Carl Friedrichs (April, 2009—), Chair, Chesapeake Focus Research Group, VIMS, VA
- Jonathan Goodall (Nov, 2010—), Chair, Hydrology Focus Research Group, U. South Carolina, Columbia SC
- Chris Duffy (Mar, 2013—), Chair, Critical Zone Focus Research Group, Penn State U., PA
- Michael Ellis (Jan, 2013—), Co-Chair, Anthropocene Focus Research Group, British Geol. Survey, UK
- Kathleen Galvin (Jan, 2013—), Co-Chair, Anthropocene Focus Research Group, Colorado State U, CO
- Phaedra Upton (Mar, 2013—), Co-Chair, Geodynamics Focus Research Group, GNS, New Zealand
- Mark Behn (Mar, 2013—), Co-Chair, Geodynamics Focus Research Group, WHOI, MA
- James Syvitski *(ex-officio),* CSDMS Executive Director, INSTAAR, University of Colorado - Boulder
- 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.

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

- Patricia Wiberg (Sept, 2012—), Chair, CSDMS Steering Committee, Univ. of Virginia, VA
- Tom Drake (April, 2007—), U.S. Office of Naval Research, Arlington, VA
- Bert Jagers (April, 2007—), Deltares, Delft, The Netherlands
- Marcelo Garcia (Dec, 2012—), Univ Illinois at Urbana-Champaign, IL
- Chris Paola (Sept, 2009—), NCED, U. Minnesota, Minneapolis, MN
- Cecilia DeLuca (Sept, 2009—), ESMF, NOAA/CIRES, Boulder, CO
- Boyana Norris (Sept, 2009—), 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
- Rudy Slingerland *(ex-officio, Past-Chair CSDMS SC 2007-2012),* Penn State Univ., PA

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

Figure 1 – New Chair Professor Patricia Wiberg (UVA) address the participants at the 2013 CSDMS Annual Meeting at NCAR, Boulder Colorado.

2.3 CSDMS Working and Focus Research Groups

There are over 1020 CSDMS members (56% U.S.) representing 166 U.S. institutions (123 academic, 22 private, 21 federal) and 275 non-U.S. institutions from 67 countries (171 academic, 22 private, 70 government). There are now ~443 affiliated institutions. Members are organized within 5 working groups (Terrestrial, Coastal, Marine, Education, Cyberinformatics) and 6 focus research groups. As of 03/23/2013, the three 3 new focus research groups (Critical Zone, Anthropocene, Geodynamics) were initiated (in blue) to add to the 3 original focus research groups (Hydrology, Carbonate, Chesapeake) in representing CSDMS membership interests:

Terrestrial	483	Carbonate	66
Coastal	368	Chesapeake	47
Hydrology	365	Critical Zone	11
Marine	251	Anthropocene	8
Cyber	159	Geodynamics	14
EKT	159		

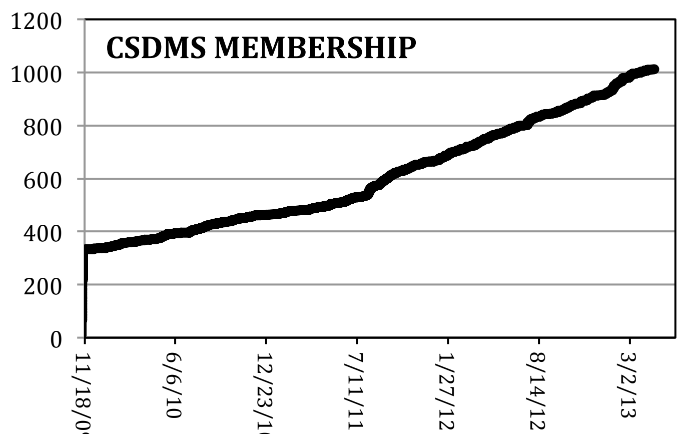

Figure 2 Growth in Active membership (y-axis) per day as of November 2009 (x-axis)

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 and provides software guidance to the CSDMS community. The IF maintains the CSDMS vision and supports cooperation between observational and modeling communities. As of July 2013, CSDMS IF staff includes:

• Executive Director, Prof. James Syvitski (April, 2007—) - CSDMS & CU support
• Executive Assistant, position open - CSDMS support
• Chief Software Engineer, Dr. Scott Peckham (April, 2007—) - CSDMS & other NSF/NOAA support
• Senior Software Engineer, Dr. Eric Hutton (April, 2007—) - CSDMS & other NSF support
• Cyber Scientist Dr. Albert Kettner (July, 2007—) - CSDMS & other NSF/NASA support
• EKT Scientist Dr. Irina Overeem (Sept, 2007—) - CSDMS & other NSF/NASA support
• PostDoc. Kimberly Rogers (March, 2012—) - Other NSF support
• Ph.D. GRA Stephanie Higgins (Sept, 2010—) - NASA support
• Ph.D. GRA Fei Xing (July, 2010—) - Other NSF support
• Ph.D. GRA Ben Hudson (May, 2010—) - Other NSF 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

Departures

• Accounting Technician Mary Fentress (2007-2013)
• PostDoc. Sagy Cohen (2010-2012)
• Executive Assistant, Ms. Marlene Lofton (Aug. 2008-2013)

2.5 CSDMS 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 14% of CSDMS member institutions are with the private sector. This last year saw formal interactions including presentations at STATOIL (Oslo), ConocoPhilips (Boulder), and Chevron (Houston and Boulder), and others at the American Association of Petroleum Geologists Annual Meeting.

2.6 CSDMS Interagency Committee

This group is comprised of the 21 US agencies (see Appendix 1 for details) and may include non-US government agencies. The committee coordinates their member's collaboration with and support of CSDMS efforts. For 2013 the focus was to appoint a more formal Chair of the Committee. The announcement of this search has yet to be revealed, as travel funding has been tied up with the U.S. Sequester decisions. 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. 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* UCSB) to a coarser resolution Reynolds-averaged Navier-Stokes (RANS) ocean circulation model ROMS with the Community Surface Transport Model enabled (Fig 3). 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. About 5% of the Gulf of Mexico 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.

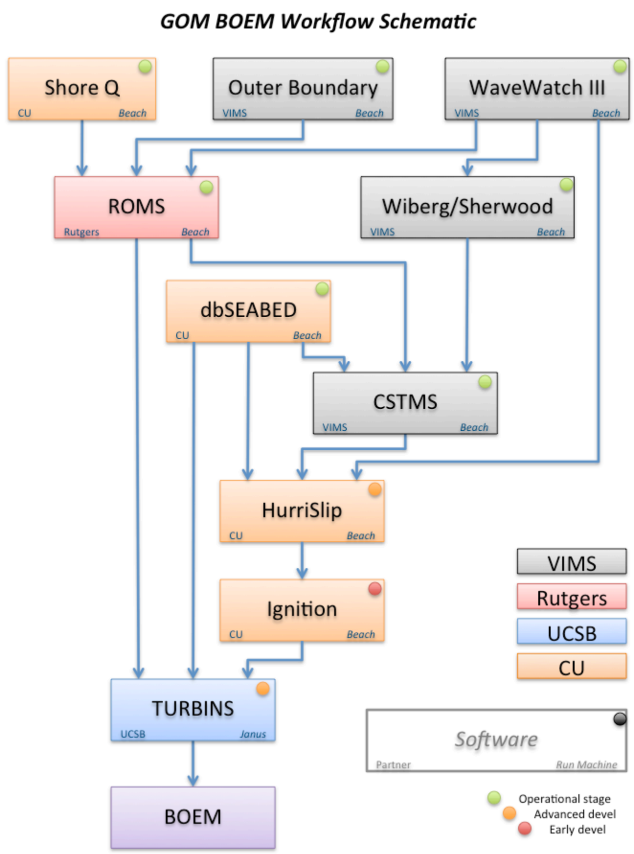

Figure 3: Schematic workflow for the BOEM funded project, in terms of software development. The color status-tabs (dots) refer to the development stage within the project, not to the packages in their native form.

3.0 Just the Facts

3.1 CSDMS Model Repository

The CSDMS Model Repository hosts open-source models, modeling tools, and plug-and-play components, including: i) Cryospheric (e.g. glaciers, permafrost, icebergs), ii) Hydrologic, from reach to global scale, iii) Marine (e.g. ocean circulation), iv) River, coastal and estuarine morphodynamics, v) Landscape or seascape evolution, vi) Stratigraphic, and vii) Affiliated domains (e.g. weather & climate models). About 70% of the models are distributed through a central Repository; others are distributed through linkages to existing community efforts. Centralized downloads exceed 10700 and redirected download traffic to other sites is similarly high. The 217 projects noted below may involve more than one model.

Repository lines of code statistics as of April 2013: csdms.colorado.edu/wiki/Model_SLOC_Page

Language	Projects	Comment	Source
Fortran 77/90/95+	61	1067184	2457617
c/c++	100	353465	1153207
Python	31	98933	149186
C#	1	29344	160373
MATLAB	17	39662	59157
IDL	5	38834	36954
Statistical Analysis Software	1	2390	5796
Java	2	2214	12851
Visual Basic	1	537	8581
Total	217	1632563	4043722

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

Domain	Models	Tools	Components
Terrestrial	76	45	33
Coastal	52	3	5
Marine	44	4	8
Hydrology	52	38	43
Carbonate	3	1	0
Climate	10	2	0

Not counting the community models downloaded from other sites (e.g. ROMS, NearCOM, DELT3D) are also not counted. The top ten most downloaded models by version (April 2013): (http://csdms.colorado.edu/wiki/Model_download_Page)

	Model	No. Times	Topic
1.	**topotoolbox**	1486	A set of Matlab functions for topographic analysis
2.	**child**	1096	Landscape evolution model
3.	**topoflow**	853	Spatially-distributed, D8-based hydrologic model
4.	**sedflux**	366	Basin filling stratigraphic model
5.	**hydrotrend**	292	Climate driven hydrological transport model
6.	**2dflowvel**	254	Tidal & wind-driven coastal circulation routine
7.	**bing**	239	Submarine debris flows
8.	**adi-2d**	226	Advection Diffusion Implicit method for 2D diffusion
9.	**cem**	216	Coastal evolution model
10.	**gc2d**	178	Glacier / ice sheet evolution model

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

Data Repository as of April 2013

Data Type	Databases
Topography/bathy	18
Climate	6
Hydrography	5
River discharge	8
Cryosphere	5
Surface Properties	5
Land cover	4
Substrates	3
Human Dimensions	2
Sea level	2
Oceanography	9
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.

Environmental Animations	8
Terrestrial Animations	21
Coastal Animations	22
Marine Animations	10
Laboratory Movies	14
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 Experiments with WILSIM
5. Landscape Evolution Modeling with ERODE
6. Earth Science Models for K6-12
7. Coastal Engineering Experiments
8. Hydrological Processes Exercises
9. Sinking Deltas
10. Stratigraphic Modeling with Sedflux
11. Get Started with CMT
12. Advanced Use of CMT
13. Modeling River Plumes
14. Simple Sediment Transport Experiments

15. 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 - applications to Rivers & Turbidity Currents *By: G Parker*

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

Over 180 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.

The CSDMS High Performance Computing Cluster (HPCC) System *Beach* (Syvitski is PI) is an SGI Altix XE 1300 with 88 compute nodes (704 cores, 3.0 GHz Harpertown processors ≈ 8 Tflops). 64 nodes have 16 GB of memory each; 16 nodes have 32 GB of memory each. Internode communication uses a non-blocking InfiniBand fabric. Each compute node has 250 GB of local temporary storage and can access 72TB (raw) of RAID storage through NFS. *Beach* provides GNU and Intel compilers as well as their MPI counterparts (mvapich2, mpich2, and openmpi). *Beach* is supported by the CU ITS Managed Services (UnixOps) under contract to CSDMS. The larger *Janus* supercomputing cluster (Syvitski is Co-PI) consists of 1368 nodes, each containing two 2.8 GHz Intel Westmere processors with six cores each (16,416 cores total) and 24 GB of memory (2 GB/core) per node. Nodes are connected using a non-blocking quad-data rate InfiniBand interconnect, and 1 PB of parallel temporary disk storage. *Beach* is connected to the *Janus* cluster through a private 10 Gb/s network. The system enables *Beach* to quickly share large data sets using the *Janus* 1PB lustre file system. The *Janus* system CU Research Computing manages *Janus*. CPU Utilization rates on *Beach* average 70%.

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

Content Pages	1,314
Total Pages	6,154
Upload Files	2,654
Page Edits	146,241
Registered Users	1013
View Statistics	14,316,150

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

CSDMS YouTube channel hosts its (model) animations, laboratory experiments, real events and conference talks. Close to 70 people have now subscribed to the channel to stay informed about new uploads. The channel contains 141 short movies, which in total have been viewed 112,605 times. CSDMS started this channel to make people aware of how illustrative and sophisticated model simulations or associated movies can be. This led to one simulation (World dams since 1800) to be used in a movie that came out in 2013: Damocracy (http://damocracy.org) by Todd Southgate. The movies on the CSDMS YouTube channel can be viewed through the CSDMS website: http://csdms.colorado.edu/wiki/Movies_portal or by visiting YouTube: http://www.youtube.com/user/CSDMSmovie.

Top 10 most viewed CSDMS YouTube movies:

Global circulation	39,455	http://www.youtube.com/watch?v=qh011eAYjAA
Laurentide Ice Sheet	7,604	http://www.youtube.com/watch?v=wbsURVgoRD0
Delta formation	5,596	http://www.youtube.com/watch?v=eVTxzuaB00M
Spit Evolution	4,358	http://www.youtube.com/watch?v=N_LBeJPWqFM
Sand Ripples	3,353	http://www.youtube.com/watch?v=rSzGOCo4JEk
Floodplain Evolution	3,304	http://www.youtube.com/watch?v=QqOfP3gVR4s
World dams since 1800	2,524	http://www.youtube.com/watch?v=OR5IFcSsaxY
Meandering river	2,267	http://www.youtube.com/watch?v=z3ub6_VwReY
Allier river meander	2,142	http://www.youtube.com/watch?v=i0KByNRGv_8
Barrier Island	1,919	http://www.youtube.com/watch?v=VCX_SzPydsw

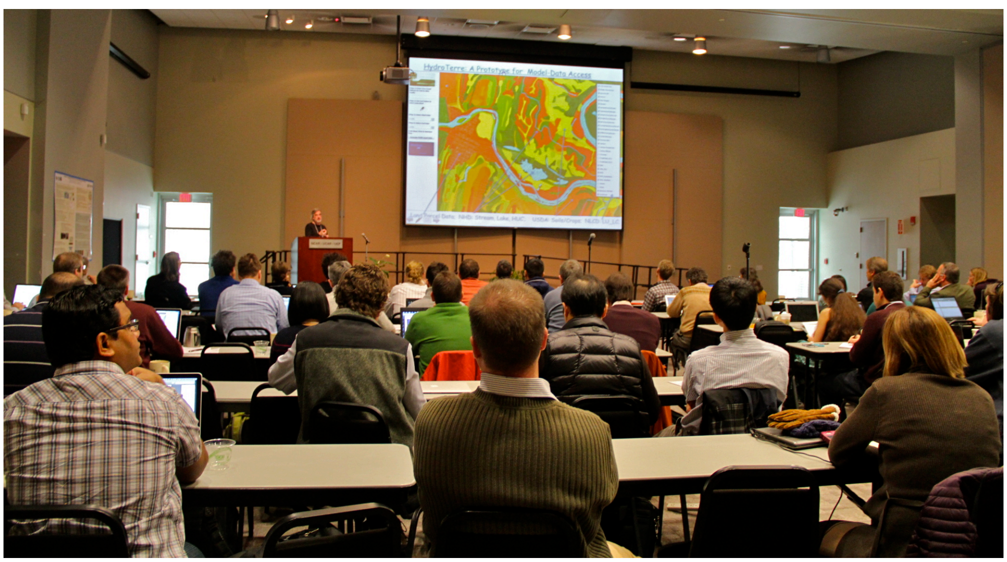

Figure 4. New Critical Zone Focus Research Group Chair, Chris Duffy (Penn State), provides a plenary keynote lecture at the 2013 CSDMS Annual Meeting.

4.0 CSDMS2.0 Year 1

4.1 CSDMS software stack on other HPC clusters

The CSDMS software stack, which is composed of more than two-dozen separate software packages, has been installed on the Janus supercomputer at the University of Colorado. However, the stack is not currently being maintained. Upon release of the next version of the CMT, which will be able to run jobs on Janus, the software stack will be reinstalled and more closely monitored.

Links — Janus: http://rc.colorado.edu/node/212

We have developed a plugin-based program, developed in Python, that automates the build process of the CSDMS software stack, and it's dependencies. Although not yet fully automated, our software stack builds with little human intervention. The CSDMS package builder, bob, is available as either a Python egg, or as source code. Both can be downloaded from the CSDMS website.

The bob package builder,

- SVN repository: https://csdms.colorado.edu/svn/bob/trunk
- Source-code: https://csdms.colorado.edu/tools/bob/bob-0.1.tar.gz
- Python egg: https://csdms.colorado.edu/tools/bob/bob-0.1-py2.7.egg

4.2 A web-based Component Modeling Tool (CMTweb)

Because of reliability, and maintenance issues the Component Modeling Tool (CMT) is being redesigned and largely rewritten. To this end, several of the backend tools have been rewritten and now provide a proof-of-concept command-line interface to a new CMT. These tools manage the communication between the client machine running CMT and the server on which the modeling projects are installed. They also are responsible for launching new instances of the CMT server, and running jobs of connected components.

CSDMS has developed a set of command-line utilities that allow users to connect and run component models within the CSDMS modeling framework. Users create CMT resource files that describe their collection of components and the manner in which the components are connected, as well as defining each model component's input parameters. This tool provides users who are more comfortable with a command-line environment with an easy to use and fast interface to the CSDMS Modeling Framework. In addition, it simplifies running ensembles of model simulations as batch jobs directly on the CSDMS High Performance Computing Cluster.

Links — Repository: http://csdms.colorado.edu/trac/csdms/browser

4.3 Automated 'wrapping' for moving BMI to CMI components

The CSDMS IF provides utilities that aid the migration of a model that merely exposes the Basic Modeling Interface (BMI), to a model-component that is a fully functioning component able to operate within the CSDMS Modeling Framework. For models that expose the complete BMI, these utilities are able to automatically wrap the BMI to expose the CSDMS Component Modeling Interface (CMI), which allows interaction with the CSDMS Modeling Framework framework. Because the BMI contains all of the information needed for model coupling, these tools (with some modifications) could be used in a similar way to wrap models for use in other frameworks as well.

The automated wrapping of models eliminates the time-consuming and error-prone method of hand-wrapping each model for use within the CSDMS Framework. In addition, models can easily be rewrapped for changes to their BMI implementation or to changes to the coupling framework itself. This will help ease some of the difficulty of maintaining component collections and deploying to new systems.

Models must be written in one of the following languages: C, C++, or Python. Wrapping tools for Java models is not yet complete. Because the CSDMS model repository is yet to contain a Java model, this has not been a high priority. The CSDMS IF is actively adding support for the automated wrapping of Fortran models.

Links

- Repository: http://csdms.colorado.edu/trac/csdms/browser/BoccaTools/trunk
- CMI Implementations:
  - C++: http://csdms.colorado.edu/trac/csdms/browser/CMI/trunk/cxx
  - C: http://csdms.colorado.edu/trac/csdms/browser/CMI/trunk/c
  - Python: http://csdms.colorado.edu/trac/csdms/browser/CMI/trunk/python
- BMI Description: http://csdms.colorado.edu/wiki/BMI_Description

4.4 Framework Service Components

FileWriter Component. The FileWriter service component writes model output variables that vary in time, including 0D (time series), 1D (profile series), 2D (grid stack) and 3D (cube stack) to NetCDF files that contain descriptive metadata (e.g. CF and CSDMS standard names) and which can be imported into the high-performance visualization software, VisIt. This component has been absorbed into the NCRasterfile class within the CSDMS PrintQueue component.

New Service Component API. CSDMS staff are working on a new API for CSDMS service components that will make it easier to integrate and/or replace them in the CSDMS Modeling Framework. The current approach, based on the PortQueue class, was developed before the two-level BMI/CMI approach to componentization was developed, so low-level changes are necessary to achieve this. This must be done carefully and then tested so as not to disrupt the existing functionality of the framework.

4.5 Time Interpolation Service Component

CSDMS Time Interpolator. Earth surface process models may use fixed or adaptive timestepping schemes, and two models to be coupled may use timesteps that are significantly different in size. An example would be a snowmelt model, with timesteps on the order of an hour coupled to a channelized flow model, with timesteps on the order of several seconds. It would clearly be inefficient to run the snowmelt model with timesteps appropriate to a channel model and the state variables of the snowmelt model vary much more slowly. However, it can be somewhat jarring to the channel model when a state variable it uses from the snowmelt model suddenly steps up to a new value that is then maintained without change for many channel timesteps. This issue is sometimes referred to as "temporal misalignment." In such cases it makes sense to fit a smooth interpolation function to each of the state variables in the model with the larger timestep. The model with the smaller timestep can then retrieve and use interpolated values that vary more smoothly and which can be updated (with every timestep) with very low computational cost.

CSDMS has experimented with a variety of methods to address time interpolation, starting with methods that required calling the time interpolator from within a model's source code and which utilized a simple "stair step" approach. However, with the advent of the two-level, BMI/CMI approach to componentization, CSDMS staff began work to design and implement a new time interpolation component that would be consistent with the BMI/CMI philosophy. That is, it was to be ***noninvasive*** (not called from within a model's source code) and automatically invoked (as a service component) when needed by the CSDMS framework (as determined from BMI function calls). The ultimate design ***automatically*** does the following: (1) uses CSDMS Standard Names to identify every output variable (that is actually used by another component) of every component in a set of components, (2) creates a class container that stores the interpolates and all interpolation parameters for every variable, at the CMI level, leaving BMI -level code and variables untouched, (3) calls each model's BMI update function whenever necessary to update the interpolation variables, (4) accommodates array variables of any rank and data type and (5) accommodates both fixed and adaptive time steps. Meeting all of these requirements (especially items 3 and 5) while providing multiple interpolation options was more difficult than expected and required a significant time investment. In addition, the use of cubic splines for "dynamic interpolation" or interpolation in time is nontrivial. Cubic splines do not simply fit a cubic polynomial using values of a state variable from four different times (i.e. using values at four "nodes" or "knots") over three adjacent time intervals. While both “stair step” and “linear” interpolation methods are supported, CSDMS is continuing to experiment with a dynamic cubic spline option. Note that while this new service component has been tested in a Python-based model coupling framework, deploying it within the CSDMS framework will require some changes (ongoing) to our current "port queue" approach.

4.6 Analysis of Model Uncertainty

As explained in the Work Package timeline table in the CSDMS 2.0 proposal, this goal will only be addressed in an exploratory way during Phase 1 (2012 to 2014). This Work Package also received a lower priority as a result of cuts to the original proposal budget. During the CSDMS Executive Committee meeting, every Working Group and Focus Research Group Chair acknowledged the importance of model benchmarking. This acknowledgement is reflected in the new long, midterm and short-term goals that are being developed for the 5-year strategic plan with input from members during the CSDMS annual meeting. CSDMS have started to learn more about the Dakota package, with a presentation at the CSDMS annual meeting and by reading online documentation. Dakota is a large and complex package that will require a significant time investment and this work will start to ramp up toward the end of 2013 and early 2014.

4.7 Model Benchmarking and Model Inter-comparison

As explained in the Work Package timeline table in the CSDMS 2.0 proposal, the goal for Phase 1 (2012 to 2014) is to design metadata standards and to begin alignment of similar models. Significant progress on ***standardized model metadata*** in support of this goal has already been made as explained in section 4.9 below. CSDMS staff have started to work on retro-fitting the landscape evolution models that have already been componentized (CHILD, MARSSIM, Erode-D8-Global and Erode-D8-Local) with CSDMS Standard Names (v. 0.7.1) in their BMI interfaces. CSDMS plans to do its first model benchmarking and inter-comparison project with these landscape evolution models in late 2013 or 2014.

4.8 Semantic Mediation and Ontologies

CSDMS Standard Names. Most models require input variables and produce output variables. In a component-based modeling framework like CSDMS, a set of components becomes a complete model when every component is able to obtain the input variables it needs from another component in the set. Ideally, we want a modeling framework to automatically:

1. Determine whether a set of components provides a complete model.

2. Determine whether a set of components have compatible assumptions and physics.

3. Connect each component that requires a certain input variable to another component in the set that can provide that variable as output.

However, this kind of automation requires a ***semantic matching mechanism*** for determining whether — ***and the degree to which*** — two variable names refer to the same quantity and whether they use the same units and are defined or measured in the same way.

CSDMS first began developing the CSDMS Standard Names in 2012 to provide a practical solution to this semantic mediation problem. It is a large, ongoing, cross-domain effort that is attracting the attention of several other cyber-infrastructure projects. While the CF Convention Standard Names that were introduced in the domain of ocean and atmosphere modeling have somewhat overlapping goals, the CSDMS Standard Names provide a more comprehensive set of naming rules and patterns for creating unique labels for model variables that are not specific to any particular modeling domain. These naming conventions consist of an extensive set of patterns that cover a wide variety of cases gleaned from models in the CSDMS repository as well as from the CF Standard Names. They were also designed to have many other nice features such as parsability and natural alphabetical grouping. CSDMS Standard Names always consist of an object part and a quantity/attribute part and the quantity part may also have an operation prefix that can consist of multiple operations. Unlike the CF Standard Names, assumptions and explanations are not included in the name itself; they are instead selected from a standardized list and specified with <assume> tags in a Model Metadata File (XML) that clarifies how a given model uses the name. The additional metadata in this file supports the names by including assumptions, units, equations used, boundary conditions, object name source, geo-referencing information (e.g. standard ellipsoid, datum and projection names), and so on, thereby fully describing the model and its associated input and output variables.

At the highest level, CSDMS Standard Names (v. 0.7.1) consist of Model Variable Names and Model Metadata Names. However, each of these consists of numerous supporting parts. ***Model Variable names*** are constructed from valid Object Names, Operation Names and Quantity Names, and the Quantity Names often include a Process Name. ***Model Metadata Names*** attempt to provide complete metadata for describing key attributes of a model other than the input and output variable names and are stored in Model Metadata Files. The Model Metadata Names include additional metadata to support the variable names, such as units, object name source and geo-referencing data (e.g. standard ellipsoid, datum and projection names) as well as many different types of Assumption Names. Each of these parts is fully documented on the CSDMS wiki.

Main Page:	http://csdms.colorado.edu/wiki/CSDMS_Standard_Names
Basic Rules:	http://csdms.colorado.edu/wiki/CSN_Basic_Rules
Object Names:	http://csdms.colorado.edu/wiki/CSN_Object_Templates
Operation Names:	http://csdms.colorado.edu/wiki/CSN_Operation_Templates
Quantity Names:	http://csdms.colorado.edu/wiki/CSN_Quantity_Templates
Process Names:	http://csdms.colorado.edu/wiki/CSN_Process_Names
Assumption Names:	http://csdms.colorado.edu/wiki/CSN_Assumption_Names
Metadata Names:	http://csdms.colorado.edu/wiki/CSN_Metadata_Names
Model Metadata Files:	http://csdms.colorado.edu/wiki/CSN_MMF_Example

The CSDMS Standard Names can be viewed as a ***lingua franca*** that provides a bridge for mapping variable names between models. They play an important role in the Basic Model Interface (BMI) developed by CSDMS. Model developers are asked to provide a BMI interface that includes a mapping of their model's internal variable names to CSDMS Standard Names and a Model Metadata File that provides model assumptions and other information. If widely adopted, this naming system could also provide other benefits, such as a better discovery mechanism for finding models on the web.

It is important to emphasize that model developers continue to use whatever variable names they want to in their code, but then "map" each of their internal variable names to the appropriate CSDMS standard name in their BMI implementation.

Building Links With Other Efforts: Meteorology Names. By invitation, CSDMS staff participated in regular telecons with the NUOPC (National Unified Operational Prediction Capability) consortium, which consists of representatives from the U.S. Navy, Air Force and NOAA focused mainly on meteorological models. They are currently evaluating various methods for providing semantic mediation in their Common Model Architecture (CMA), which is a set of conventions for implementing the ESMF (Earth System Modeling Framework) component interfaces. While ESMF has used a "field dictionary" of about 20 CF

Standard Names for some of its semantic mediation needs, the NUOPC CMA effort is interested in the more general and cross-domain approach offered by the CSDMS Standard Names. They are currently looking at ways to support both naming conventions in their system.

Building Links With Other Efforts: Hydrology Names. By invitation, CSDMS staff has participated in (and given WebEx presentations in) CUAHSI telecons to explain and promote the CSDMS Standard Names. Although CUAHSI currently has a controlled vocabulary for hydrologic variable names, it is quite limited and domain-specific. The recently NSF-funded HydroShare project considers the CSDMS Standard Names (both variable names and metadata names) to be a strong candidate for adoption by their project and certainly preferable to the CF Standard Names.

Building Links With Other Efforts: CF Standard Names. CSDMS staff made a point to meet with Bryan Lawrence (UK) at the 2nd Workshop on Coupling Technologies for Earth System Models held at NCAR in February 2013. Bryan chairs the committee that oversees the ongoing development of the CF Standard Names and expressed interest in the CSDMS Standard Names. CSDMS staff plans to follow up with future meetings to examine ways in which the two naming conventions can be made interoperable, perhaps through development of a lookup table of some kind.

Building Links With Other Efforts: Alignment with ESMF. CSDMS staff has written an NSF EarthCube Building Block proposal with funding support for aligning the semantic mediation tools of the ESMF (federal) and the CSDMS (academic) modeling frameworks.

Building Links With Other Efforts: Ocean Model Names. CSDMS staff has started working with Bert Jaegers of Deltares to develop a list of CSDMS Standard Names in support of ocean models.

Building Links With Other Efforts: Geodynamics Model Names. CSDMS staff has written an NSF EarthCube Building Block proposal with funding support for two early career scientists from the "deep earth process" and geodynamics community. The proposal includes funding for community meetings with the geodynamics community (including EarthScope, IRIS and CIG) to develop CSDMS Standard Names for that community. It also includes support for implementing the BMI interface on a selected set of geodynamics models.

4.9 CSDMS Portal

Digital Object Identifiers for models

Figure 5. An example of the Model info box (See http://csdms.colorado.edu/wiki/Model:SBM)

DOI, or Digital Object Identifier is a unique string to identify an object in a digital environment. The object could be a paper published in a scientific journal or a specific dataset. A DOI guaranties that an object can always be traced by simply resolving a web address that is constructed by a DOI search engine http://dx.doi.org/, combined by the unique identifier. The DOI contains metadata, including a URL that points to the specific object. Objects with a DOI are 5 times more likely to deliver active links to the digital content than objects without. To guaranty access to source code of numerical models CSDMS in close cooperation with Dr. K. Lehnert (Director of Integrated Earth Data Applications Research Group (IEDA)) and Dr. L. Hsu, both from Lemont-Doherty Earth Observatory, requested a DOI for each Model in the CSDMS repository. Despite over 50 million DOI strings, CSDMS is the first in history to request DOIs for numerical models. Only those models of which 1) the source code is submitted to the CSDMS repository, and 2) which are formally described in associated model metadata, will get a unique DOI. Numerical models in the DOI system will be treated similarly as data submissions. As of

April 2013, 67 numerical models that are within the centralized model repository have a DOI code as well as 42 tools. The DOI strings are provided on the model metadata page, as part of the model info box (Fig. 5). New DOI requests will be submitted to IEDA every half-year. Only significant updates of model source code, which involves a change in version number, will receive on request a new DOI string. For citing a model we suggest applying similar citation guidelines as are currently in place for data, which is the following: *ModelDeveloper (PublicationYear). ModelName, ModelVersion. Identifier* (for more detail http://csdms.colorado.edu/wiki/DOI_system_for_models). A list of all numerical models of the CSDMS model database that have a DOI together with limited metadata as well as the source code for each model is provided to IEDA as a backup to guaranty access to model information and its source code beyond the CSDMS program.

Web maintenance

CSDMS cyber infrastructure builds upon the open software package Mediawiki (http://www.mediawiki.org) and numerous third-party extensions (62 extension as of now) to extend cyber infrastructure capability and to provide the latest cyber tools to CSDMS web visitors to guaranty the easiest experience to interact through the web. About every year the core software (mediawiki) is significantly upgraded and with it most third party software extensions, to guaranty performance, security, and to incorporate new features. It is required by the University of Colorado (CU) to upgrade cyber infrastructure to a newer version when a security upgrade becomes available, to reduce possible cyber attacks directed to CU. CSDMS executed latest major cyber infrastructure upgrade (upgraded to mediawiki v1.20.6, see http://csdms.colorado.edu/wiki/Special:Version) conform CU standards. Additional effort were made to adapt the CSDMS website appearance (skin) to the latest version as well as making all extensions operable under the new core software. Were needed outdated extensions were replaced to guaranty functionality.

Web innovation

Forums: CSDMS incorporated discussion forums in its wiki website. A forum provides benefits to discussions as: 1) new users can see previous comments made to the forum, 2) comments to a forum will be archived, and 3) posts can be organized flexible, allowing to keep track of threads that are 'dead', and threads that are more active. Forums are currently tested and implemented to facilitate the working groups before, during and after the CSDMS 2013 annual meeting, e.g.: http://csdms.colorado.edu/wiki/Coastal_WG_Discussion (Fig. 6).

Figure 6. Forum example to support the Coastal Work Group in defining their long term coastal goals for the upcoming Five-Year Strategic Plan.

Select a model based on specific criteria: CSDMS is in the process to develop alternative ways to select a model or module of interest through the CSMDS web. Currently people can select a model based on a model domain, e.g. hydrology, coastal, marine or terrestrial. Once a domain has been defined a user gets list of models displayed and has to select a specific model to find out if the model is sufficient for his or her project. With this alternative way of searching and selecting a model the user can define multiple criteria to specify the needs. For example, what spatial dimensions are of interest for the user or is it of importance to exclude or include models that can run on multiple processors. In this regard keywords are added to each model such that e.g. all 'landscape evolution models' can be selected. A prototype with java interface has been implemented to analyze its capability and to test web performance (see: http://csdms.colorado.edu/wiki/Test4), Fig. 7.

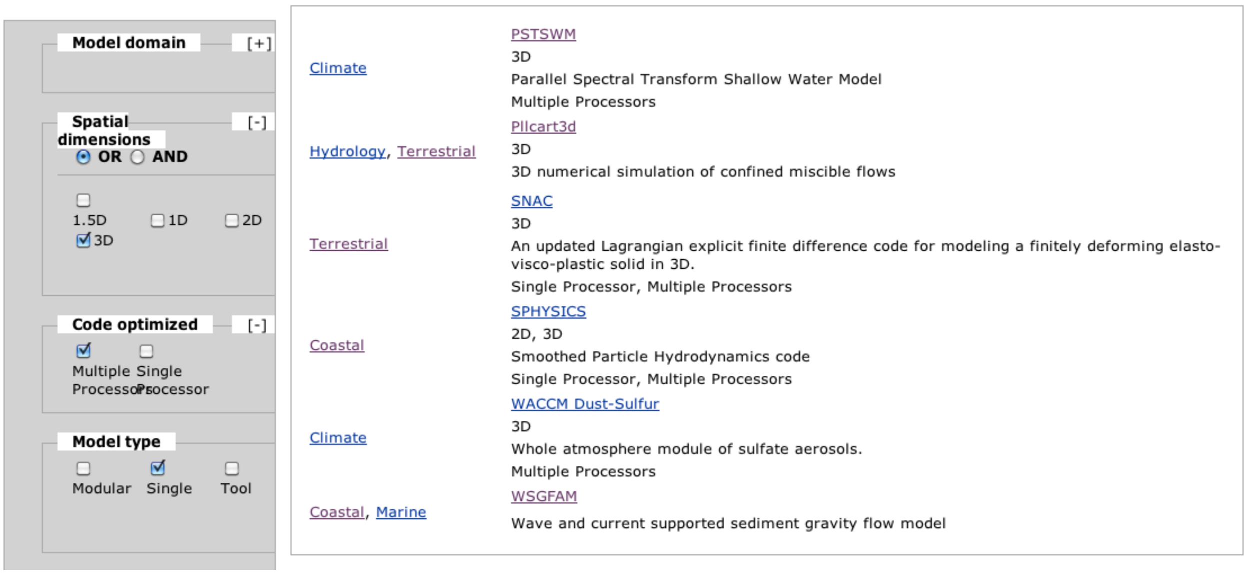

Figure 7. An example of how to select a model based on specific criteria

Reach out to the model developer's community: CSDMS tracks for each numerical model that is available in the CSDMS repository how often it is downloaded and publishes these statistics on a daily basis on the CSDMS web (http://csdms.colorado.edu/wiki/Model_download_Page). Besides these statistics a person who downloads a model is asked to provide name & email address. For 2012, this information was generated and provided by email to each of the main model developer of one or multiple numerical models. This is initiated on requests from the model developers community as an ability to contact their user group to provide information regarding bugs / upgrades or to identify if there are any requests for model upgrades or to discuss possible collaborations.

4.10 Developing a QSD Educational Toolbox

The Quantitative Surface Dynamics Toolbox envisions a learning progression; from 1) working with model output data and equations, to 2) quantitative numerical modeling for inexperienced modelers, to 3) more advanced numerical modeling on a high performance computing system. This approach was advocated in the CSDMS 2.0 to accommodate the variety of users in our community. This general approach aligns with the Next Generation Science Standards for K1-12, just published in May 2013: http://www.nextgenscience.org/next-generation-science-standards. A core idea of the NGS standards is the notion of learning as a developmental progression.

The educational repository contains close to 100 animations and documented movies, and a number of spreadsheet labs to support learners in phase 1. Beyond extensive use via web visits, we have received several requests of documentary filmmakers to incorporate key movies or animations into films and textbooks in 2012-2013. Examples include the documentary Damocracy (http://damocracy.org/), and the California Regional Office of American Rivers for the Wild and Scenic Film festival, as well as the Avian-Cetacean Press for incorporation of a barrier island migration animation into a textbook on hiking the Carolina Coast).

We initiated a set of topical resources on sediment transport for geology, geography, oceanography, hydrology and environmental engineering students. This set of modeling exercises is aimed at teaching students to build a model from a concept, while using first principles like conservation of mass. The resource is developed in collaboration with Prof. Greg Tucker and Prof. Bob Anderson (University of Colorado) and now contains four modeling assignments with posted example codes: http://csdms.colorado.edu/wiki/Labs_Sediment_Transport_Mechanics.

Over the spring semester of 2013, we have moved to wiki-based modeling labs for advanced undergraduates and graduate students. These students come with a variety of experience but we assume that they still need to build their modeling skills (phase 2). Whereas students and faculty used to download a single 'static' document with notes on labs, the labs are now entirely built on the wiki and contain lab notes, marked-up question sections, and contain more figures. Screenshots of CMT guide the learner with setting up their runs. The introductory labs emphasis building modeling skills (CMT functionality, job submission protocols, NetCDF files structure, how to visualize model output, how to find documentation on model equations and parameters), whereas the subsequent labs are more focused on model parameter exploration and processes. Labs are associated with downloadable introductory presentations focused on deepening physical process understanding and earth system behavior. References to more extensive literature are incorporated to further advance insight. The wiki functionality is interactive and allows learners to improve upon the documentation and to generate dynamic content. We have added (and improved) 6 labs, which are described in more detail in section 4.11.

We developed new documentation for more advanced modelers, who run simulations regularly, and are looking for improving the efficiency of their workflow beyond the basic graphical user interface of CMT. We document a system on the CSDMS wiki to enable fast submission of runs and rapid changing of run parameters through so-called 'rc-files' directly on the High Performance Computing Cluster. This system assumes basic familiarity with Unix commands and file transfer and editing skills in the Unix environment of the HPCC: http://csdms.colorado.edu/wiki/CMT_Command_Line_Tools

Graduate students that employed a variety of operating systems have tested the system. The students had > 40 hours of experience with running simulations through the more accessible CMT graphical user interface and still found this system to have a steep learning curve. However, once they gained proficiency several of the students preferred the more direct HPCC communication compared to less-transparent communication through the CMT-GUI.

4.11 Development of CSDMS Earth Surface Modeling Course Material

Over the spring semester of 2013, CSDMS IF staff designed and improved a series of combined lectures, labs and assignments for a special topics course on 'Surface Process Modeling'. The teaching material is posted in the CSDMS Educational Repository and was used and tested by 6 graduate students in 7 labs (each of 4 hours duration, with additional homework of about 4 hours). The course follows a source-to-sink topical progression: from hillslopes to rivers to landscape evolution to coastal processes and eventually marine stratigraphy.

1. Get Started with CMT: modeling runoff processes with TOPOFLOW
2. River Sediment Supply Modeling with HydroTrend
3. Landscape Evolution Modeling with ERODE
4. Landscape Evolution Modeling with CHILD
5. Plume Modeling
6. Modeling Stratigraphy in 2-D cross-sections with Sedflux

7. Final Assignment: is designed to be an independent modeling study on a unique problem with a relevant model or coupled models as chosen by students, so there is no instructor documentation.

4.12 Knowledge Transfer to Industry Partners

Interactions between industry partners and CSDMS were focused in the early part of 2012, and associated with the AAPG meeting, so there were few meetings in the current reporting period. IF Staff met with Conoco and Chevron representatives, in August 2012, and discussed the general use of CSDMS technology for industry. The discussions are ongoing and Chevron is supportive of CSDMS technology and model development. A team of industry representatives participated in the CSDMS annual meeting, March 2013. CSDMS invited a keynote speaker, John Atkinson of ARCADIS Consulting, to highlight the industry modeling efforts on Gulf of Mexico storm surges and coastal management. The talk was well received and an excellent example of applied modeling and model development to help guide managers and decision-makers.

5.0 Conferences & Publications

5.1 CSDMS Staff Participation In Conferences & Meetings *July 2012 to April 2013*

07/2012	World Climate Research Program JSC	Beijing, China	(Syvitski)
08/2012	Mathematical Problems in Environmental Science	Corvallis, OR (OSU)	(Peckham)
09/2012	Model frameworks IWRSS & NOAA-NWS-OHD	Silver Spring, MD	(Peckham)
10/2012	NSF EarthCube: PI Workshop #2, CIRES	Boulder, CO	(Peckham)
09/2012	3rd IGCP588 Conf Preparing for Coastal Change	Kiel Germany	(Syvitski)
10/2012	GEO S&T Workshop	Bonn Germany	(Syvitski)
11/2013	World Within Reach: From Science to Policy	Vienna Austria	(Syvitski)
12/2012	Frontiers in Computational Physics	Boulder, CO	(CSDMS Staff)
12/2012	AGU Annual Meeting	San Francisco, CA	(CSDMS Staff)
12/2012	Gilbert Club – Earth & Planetary Science	Berkley, CA	(Kettner)
12/2012	EarthCube Experimentalist Workshop	Austin, TX	(Kettner)
01/2013	NSF EarthCube: Digital Crust/GEO Domain	Fort Collins, CO	(Peckham)
01/2013	NSF EarthCube Critical Zone Workshop	Newark, DE	(Peckham, Syvitski)
02/2013	NSF EarthCube: Earth System Model Coupling	Irvine, CA	(Peckham)
02/2013	Workshop: Coupling Tech. for Earth System Models	Boulder, CO	(Peckham)
02/2013	PAGES Open Science Meeting,	Goa India	(Syvitski)
02/2013	ASLO Aquatic Sciences Meeting	New Orleans	(Syvitski)
03/2013	Reduced-Complexity Modeling Workshop	Boulder CO	(Overeem)
03/2013	CSDMS 2.0 Moving Forward	Boulder, CO	(CSDMS Staff)
03/2013	CSM Van Tuyl Lecture: Arctic Coastal Erosion	Golden, CO	(Overeem)
03/2013	Global Flood Monitoring & Modeling	College Park, MD	(Brakenridge)
03/2013	Flood Observatory Services For the World Bank	Washington DC	(Brakenridge)
04/2013	NSF EarthCube: Modeling Workshop for Geo	Boulder, CO	(Peckham)
04/2013	EarthCube BioGeoChemistry & Fluvial Sediment.	Boulder, CO	(Kettner)
04/2013	Intl Working Group for Satellite Emergency Resp.	Torino, Italy	(Brakenridge)
04/2013	Progress in Global Flood Detection System	Ispra, Italy	(Brakenridge)
04/2013	14th Swiss Global Change Day	Bern Switzerland	(Syvitski)

5.2 IF Staff Publications — Book Chapters, Journal papers and Newsletters:
Submitted/in review July 2012 to June 2013: (IF Staff in bold)

Cobourn, K.M., H. Lintz, S. **Peckham** and L. Saito (submitted 2013) A framework to understand and guide research and management in rangelands with ecological thresholds, *Rangeland Ecology and Management*

Cohen, S., Kettner, A.J., Syvitski, J.P.M., submitted. Global Suspended Sediment and Water Discharge Dynamics Between 1960-2010 based on the WBMsed v.2.0 Model. *Global and Planetary Change.*

Higgins, S. A., Overeem I., Tanaka, A., **Syvitski, J.P.M.**, (submitted 2013). Land Subsidence at Aquaculture Facilities in the Yellow River Delta, China. *Geophysical Research Letters.*

Hirpa, F.A., Hopson, T., De Groeve, T., **Brakenridge, G. R.,** and Restrepo. P.J., 2012, in review. Upstream satellite-derived flow signals for river discharge prediction downstream: application to major rivers in South Asia. *Remote Sensing of the Environment.*

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North, E.W., E.E. Adams, Z. Schlag, R. He, S. Socolofsky and S. **Peckham** (submitted 2013) Simulating the dispersal of degrading oil from the Deepwater Horizon spill: A model sensitivity study, *Geophysical Research Letters.*

Peckham, S.D. (submitted 2013) Manning's equation and power-law approximations to the logarithmic law of the wall.

Vanmaercke, M., **Kettner, A.J.,** van den Eeckhaut, M., Poesen, J., Govers, G., Mamaliga, A., Verstraeten, G., Radoane, M., and **Syvitski, J.P.M.** submitted. The neglected importance of tectonic activity in explaining catchment sediment yield. *Geology.*

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Foufoula-Georgiou, E., **Overeem, I.**, Saito, Y., et al., (accepted 2013). A vision for a coordinated international effort on delta sustainability. IAHS Extended Abstract, Gothenburg, Sweden, July 2013.

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Rogers, KG, Syvitski, JPM, Overeem, I, Higgins, S, & Gilligan, J, 2013, Farming Practices and Anthropogenic Delta Dynamics, *Proceedings of IAHS-IAPSO-IASPEI Assembly*, Gothenburg, Sweden. In press

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6.0 CSDMS 2.0: Group Plans

6.1 CSDMS and the Terrestrial World: Looking Back, Looking Forward

The primary roles of Terrestrial Working Group are:

- *Help GUIDE* CSDMS
- *CONTRIBUTE* to CSDMS
- *USE* CSDMS

Proposed Long-term goals

- Build the component library and advance science: Guide, contribute to, and use CSDMS in several particular thematic areas, such as fire, biogeochemistry, and model comparison/testing with "natural experiment" or "anthropogenic experiment" data sets.
- Build the library, part 2: Identify and contribute 5 fully CSDMS-capable models (one per year). (Note: can be new models, or BMI'ing models already in repository)
- Some kind of certification - like 'Implemented unit tests' from CSDMS. Need: It will give confidence for other people to connect with this model. Also update working status of models on repository (because people are simultaneously working on them).
- Development of CSDMS Datasets for model testing, validation, etc., organized by research area, and listed under two categories: 1) Existing data, properly formatted and documented; and 2) Desired data critical for CSDMS objectives, flagging up data products that should be obtained (either newly measured or distilled from existing field/lab datasets).
- Comparing models and data: Development of CSDMS Datasets for model testing, validation, etc., organized by research area, and listed under two categories: 1) Existing data, properly formatted and documented; and 2) Desired data critical for CSDMS objectives, flagging up data products that should be obtained (either newly measured or distilled from existing field/lab datasets). Includes populating CSDMS web site with data from natural or anthropogenic experiments in a common, consistent format.
- Understanding feedbacks between solid and fluid earth: use the CMF/CMT to implement a fully coupled model of 3D crustal deformation and surface landscape evolution.
- Benchmarking and model inter-comparison: (1) develop a culture of practice in robust, consistent model benchmarking through analytical solutions and standard, consistent test cases, (2) implement a model inter-comparison project for one or more thematic areas, such as landform evolution.
- Uncertainty analysis: improve our community's understanding and use of uncertainty analysis in surface dynamics modeling.

Proposed medium term goals

- Enhance tools/capabilities for uncertainty analysis
- Data: 1-3 examples of model-data comparison projects underway (e.g., papers submitted)
- Some proposals submitted and/or won by WG members in support of CSDMS-related science and engineering ("stuff should be happening")
- Contribute to education regarding modeling and related concepts by contributing materials to CSDMS educational repository
- Proportion of models integrated should increase; members increasingly provide BMI
- Nominate 2-3 models for "full" inclusion

- Develop a standard set of test inputs for at least one class of model

Proposed short-term goals

- Theme teams: Form small teams to collaborate, share, and advance particular topics, contributing to CSDMS and science along the way. Topics that have come up so far:
  - Wildfire: See our wiki, and feel free to edit/add things.
  - Soil
  - Biogeochemistry; note CZO connection
  - Soil erosion
  - Digital topography analysis - note potential Powell center symposium on feature extraction from digital topography / lidar analysis - good to engage with geomorphometry group
  - WRF coupling
  - Abrasion and grain-size dynamics in landscape evolution. Maybe also tracking mineral surface area?
  - Geodynamics Focus Research Group
  - Long term climate reconstruction - potentially landscape evolution time scales (already exist?)
  - Terrestrial depositional systems / stratigraphy; Source to sink signal transfer (links with coastal and marine)
  - Drought and flood hazards
  - Lithology, structure, and landform evolution <== could be in geodynamics
  - Climate change, weathering, vegetation/ecosystems, land-use, and landscape evolution <== CZO group related
  - Coupling between mountain building, erosion/weathering, carbon cycle, and climate
  - Paleotopography reconstruction (we build models and want to check)
  - Data coordination team / dark data rescue / data need articulators. Data opportunities & dark data rescue: develop and post on CSDMS website a list of natural and/or experimental data sets, such as terrestrial sediment transport in government-lab experiments. Take advantage of legacy data.

6.2 Coastal Working Group Goals and steps toward them

Overarching Goals

1 Improve the understanding of, and ability to forecast, how a broad range of coastal environments evolve, including the effects of: the dynamic feedbacks among physical, biological, and human processes; interactions between different environments along coastlines; and interactions among coastal, terrestrial, and marine environments--all under a range of climate and human management scenarios. (Initial goals for the next five years listed as 'specific science goals' below.)

2 Address societally relevant science questions, and assemble a set of model tools facilitating investigation of coastal impacts and vulnerability, and their variability-- and to enhance the ability of coastal managers and policy makers to use and interpret the modeling tools and results (in collaboration with the Education and Knowledge Transfer Working Group, key stakeholders, and decision makers).

Specific Science Goals (SSG's) Under these Umbrellas, and Steps Toward Them

SSG1: To improve understanding of and ability to hindcast/forecast past and possible future *delta evolution on decadal to millennial time scales, as affected by couplings between terrestrial, fluvial, coastal, wetland, floodplain, subsidence, ecological and human processes*. This could ultimately include coupling between 1) long- term changes in delta morphology/ecology and 2) storm-event impacts to morphology, vegetation, and human dynamics and infrastructure. Based on a recent Working Group Meeting report (as well as the CSDMS 2.0 proposal), the science questions that a suite of coupleable delta-evolution model components can be used to address include:

- *What are the fundamental controls on delta size, shape, and elevation?*
- *How might deltas change as dams are removed and sediment flux is restored to a pre-dam level?*
- *How do human manipulations of fluvial processes on deltas alter delta evolution?*
- *What determines the extent of wetlands, under various scenarios of human manipulations, relative sea-level rise (including subsidence) and upstream land-use changes?*
- *How do storm surge and flooding threats vary among different scenarios?*

Short Term Step (1 - 2 years)

- Begin to build on the coupling between CHILD and SEM (Seascape Evolution Model) to develop a suite of coupleable models to achieve the long-term delta-evolution goal. Specifically, construct a model component for dynamic river avulsions (requires community effort), and couple CEM to SEM (CSDMS Integration Facility effort).
- Discuss the possibility of establishing a particular site, or sites, for the community to focus study on, in addition to the Wax Lake Delta that the Delta Dynamics Collaboratory (an NSF Frontiers of Earth System Dynamics project). Desirable attributes for additional sites include the availability of data sets appropriate for model testing and inter-comparison, and conditions that contrast with those at the Wax Lake Delta, including more significant human presence and manipulation (possibilities include the Gambia Delta—please see the initial plans for the Coastal Vulnerability Initiative).

Medium Term Steps (3 + years)

- Add to the delta-evolution coupleable-component model suite a model (or models) of wetland and floodplain accretion, and couple the existing subsidence component (coupleable) to the others in the suite.
- Couple long term delta evolution with storm surge models; run a hydrodynamic model (e.g. ADCIRC) on the morphology resulting under various climate and human-manipulation scenarios to assess how storm impacts vary.
- Better determine the role of organic sediment accretion and vegetation dynamics in delta evolution.
- Improve our ability to reproduce delta morphology using hydro- and sediment-dynamic models (e.g. Deft3D) more realistically.
- Record the stratigraphic record of delta ecomorphodynamic evolution— e.g. under what conditions the stratigraphic signal is dominated by forests vs. topsets—under various climate, sea-level-rise, and human-forcing scenarios (the capability exists within SedFlux components).
- Add human-dynamics modeling components, ranging from traditional economic analytic approaches to agent-based models of how human react to changing coastline morphology and rates of change.

SSG2: To improve our understanding of and ability to forecast how the *morphology, ecology, and human components of sandy coastal environments co- evolve under different scenarios of changing storm climate, sea level rise, and human manipulation* --including coastal environments ranging from urban to undeveloped.

Short Term Steps (1 - 2 years)

- Identify what models should be included in the model suite to address sandy coastline eco-human-morphodynamics
- Decide on criteria that would determine which sites would be useful for benchmarking and intercomparison, after determining which models we want to test (possibilities for developed sites include the New Jersey Coast—please see the initial plans for the Coastal Vulnerability Initiative).

Medium Term Steps (3 + years)

- Investigate, using coupled hydrodynamic, eolian, ecological, and human- development models, how storm impacts and post storm recovery processes on sandy coastlines depend on ecomorphodynamic state and on human development patterns, and under what climate and human forcing scenarios thresholds may cause rapid and dramatic shifts in the morphologic/ecologic/development states.
- Improve our understanding of biological processes and interactions between biological and physical processes.
- Increase the involvement of social scientists in these investigations

SSG3: To improve our understanding of and ability to forecast how *rocky and soft-cliffed coastlines change over time, as human manipulations (e.g. river damming and coastal armoring) and changes in climate affect interactions between cliff erosion, sediment production, and sediment redistribution*-- and how these interactions affect coastal communities.

Short Term Steps (1 - 2 years)

- Identify what models should be included in the model suite to address rocky coastline human-morphodynamics, in addition to CEM Rocks (the version of CEM including lithological variations, cliffs, and nonlinear interactions between cliff erosion rate, sediment production, and beach sediment redistribution).

Medium Term Steps (3 + years)

- Add a BMI to CEM Rocks and other prioritized rocky-coastline models
- Conduct model experiments addressing rocky coastline evolution, and how it interacts with local engineering projects (including river damming, cliff defenses, jetties, groynes, and beach nourishment).

Science-Facilitation Goals (SFGs)--In Support of SSGs, and More Broadly

SFG 1: Provide open access to a toolbox of stand-alone and linkable models and modules that represent the scientific state of the art—while continually adding to it as knowledge and modeling capabilities improve.

a. enhance the efficiency of scientific advance, as individual scientists and research groups use the models in the toolbox, both stand-alone and linked, to address new intra- and inter-environment questions (with minimal need for new model development).

b. allow the broader community—including educators and environmental managers—to use state-of-the-art science and modeling capabilities (and animations) when addressing landscape and ecosystem evolution, global change (including direct human manipulations of landscapes as well as climate change) and exposure to natural hazards.

Short Term Steps (1 - 2 years)

- Update evaluation of present knowledge of processes in coastal environments (nearshore, inner shelf, barrier islands, sandy coastlines, rocky coastlines, estuaries, lagoons and marshes, eolian, deltas)— including the human component of those systems (i.e. direct couplings between human manipulations and landscape evolution in deltas and coastlines)—and identify the numerical models presently in use.
- Identify gaps in knowledge and areas where model development is needed—both poorly understood phenomena requiring basic research
  and exploratory modeling, and better understood systems for which model reliability should be improved.
- Continue to gather available models; reach out to researchers with useful models that are not yet contributed to the CSDMS, making them available to other scientists and the broader community.
- During year 1, prioritize MODEL X for the roadmap (community effort for BMI development, followed by Integration Facility effort for CMI; see below). Priority targets

include: SWAN; ADCIRC; and a simple fluvial avulsion component based on the Jerolmack/Paola model.
- Identify the models to add to the CSDMS coupleable-component toolbox (i.e. the next 'roadmap' models) in years 2 and 3, based partly on successes during year 1. Priorities in addition to those listed above under short-term steps may include a version of CEM including rocky-coastline dynamics, and the Barrier Island ecomorphodynamic model.

THE CSDMS 2.0 ROADMAP *to componentize a model:*

1. *Identify a community need*
2. *Identify a specific model.*
3. *Refactor model to comply with BMI standards (task of model developers). Documentation on CSDMS wiki http://csdms.colorado.edu/wiki/BMI_Description. CSDMS IF to offer support through Skype or work with developer(s) at the IF. BMI seminars will be given at meetings.*
4. *Generate XML– GUI file for component (developers & IF staff)*
5. *Provide input and output test data (developers)*
6. *Test stand alone component on CSDMS HPCC (IF staff)*
7. *Component help pages created (developers & IF staff)*
8. *Component tested for a coupled simulation.*
9. *Coupled run simulations lead parties to publishable paper*

Medium Term Steps (3 + years)

- Identify the models to add to the CSDMS coupleable-component toolbox (i.e. the next 'roadmap' models) in years 4 and 5.
- Encourage the coastal science community to propose to funding agencies scientific projects that will help fill gaps in knowledge and gaps in modeling capabilities.
- Persuade the modeling community to continue to adopt CSDMS protocols as new models and model components are developed, so that models can be more readily shared and in some cases linked to other models and components.
- Encourage the community to undertake the linking of specific models of different environments (within and beyond coastal environments); to broaden our thinking to include scientific questions we don't currently entertain, and to write proposals to address such questions involving multiple environments. Roadmap projects we identify will provide examples.
- Collaborate with the EKT WG (and end users/stakeholders) to facilitate future use of the toolbox, and interpretation of model results; for example, what information needs to be provided along with the model toolbox to help non-modelers understand various sources of uncertainty?

SFG 2: Increase model benchmarking and model intercomparison activities, by enhancing the accessibility of key data sets (targeted to model-testing needs), and groups of data sets (e.g. a range of variables measured in one region, or the same variables measured in a range of different environmental settings).

Short Term Steps (1 – 2 years)

- Determine the most appropriate data sets (and sets of data sets) form model testing (comparing models to nature) and intecomparison (comparing models to models)
- Discuss the most appropriate ways to test and compare models -- e.g. reproducing specific time/space changes (short term) vs. statistical comparisons (longer term morphodynamics and ecomorphodynamics)
- Seek out data rich sites involving significant perturbations to the background conditions, because the relatively rapid re-adjustments provide challenging targets for models to

reproduce. (One possible example: in the Netherlands, a recent massive beach nourishment project is being very closely monitored, providing data appropriate for testing coastline-change models.)

- Begin to gather data sets most needed to test, benchmark, and compare models
- Notify the community that the open-source GIS package GRASS can be useful for model testing, benchmarking and intercomparison, facilitating analysis of, for example, sediment volumes, or dune characteristics.

Medium Term Steps (3+ years)

- Evaluate and describe the uses, intended goals, and limitations of the available models. Which of them are designed to address abstract, basic science questions; which are designed to provide detailed and accurate simulations of processes and evolution in either specific locations or generic environment types; which fall between these end members; and how well do the models accomplish their goals (e.g. numerical fidelity and stability)? This large task will require significant community input, via the CSDMS wiki, as well as through peer-reviewed journal articles.
- Evaluate the uncertainty that results from stochastic initial and boundary conditions (i.e. suite of model runs using different initial, boundary, or forcing conditions will produce different results in detail), as well as that from parameter uncertainty, model imperfections, and forcing input error.
- Encourage the community to engage in model testing, benchmarking, and intercomparison activities.

SFG 3: Compile a set of coupleable, interchangeable process-oriented model components (tools) representing, for example, hydrodynamics, sediment dynamics, and ecological dynamics that can be used to address morphodynamic (and ecomorphodynamic) evolution in a range of contexts.

Short Term Steps (1 – 2 years)

- Target process-oriented models to add to this tool suite through the roadmap process. Initially prioritized candidates include a wave- transformation model (e.g. SWAN), a coastal hydrodynamic model (e.g. ADCIRC), and a generic bed-elevation model (may require significant model development).

Medium Term Steps (3 + years)

- Sequentially add more models to this suite, including vegetation-dynamics models (likely separate models for different vegetation types—e.g. seagrass, marsh grass, and dune grass).

6.3 Overarching Themes for Marine Working Group and CSDMS

The Marine Working Group deals with challenges of representing shelf, carbonate, slope, and deep marine environments within surface dynamics models, as well as linking oceanographic processes to surface dynamics in neighboring and coupled systems, like coastal, atmospheric, and fluvial systems. The working group recently identified the following large-scale goals and research issues for the coming decade.

- **Enable coupling of atmospheric, wave, ocean, sediment and biogeochemistry models.**
- **Develop an understanding of global variability** of shelf morphology, stratigraphy, and margin transfer processes as a function of external forcings (e.g., river discharge, coastal energy, etc.) under past and present and future conditions.
- **Produce tools for quantifying human impacts** to the global ocean and coastal regions (including estuaries) including ramifications of climate change, sea level rise, pollution and nutrient input.
- **Advance interdisciplinary models**, including multiple disciplinary inputs and expertise and their ramifications in ecosystems and biogeochemical processing.

- **Link models across time scales** as well as length scales. Develop methods for transferring information from models working at small scales into larger time and space scale models.

Intermediate – to – long-term goal:
A key advantage of CSDMS is the coupling it allows, and in the next phase of the program we should identify research problems where advances can be facilitated by ease of coupling. Now that CSDMS has reached some level of maturity, we encourage proposals that include investigators from multiple working groups. Toward this, the Marine Working Group should:

- Identify research issues that could most benefit from improved connections between the marine domain and other disciplines (coastal, terrestrial, carbonate, etc.).
- Encourage proposals involving Marine Working Group members and researchers from other working groups. The Carbonate Working Group, for example, expressed an interest in having access to a set of marine sediment transport modules.

Short Term Goals
Effort during 2008 – 2012 was expended to incorporate version(s) of the Regional Ocean Modeling System (ROMS) within CSDMS, with the idea that the Marine Working Group and other Working Groups would have available a marine hydrodynamic and sediment transport model within CSDMS. ROMS, however, has a steep learning curve and includes features that are not necessarily relevant to all CSDMS applications, including multiple advection schemes, data assimilation, etc. Additionally, ROMS is research code that continues to be updated. To capitalize on the previous effort and facilitate the use of a marine hydrodynamic / sediment transport model within CSDMS, the Marine Working Group recommends that

- CSDMS provide a stable version of a hydrodynamic model for research and teaching. This could be a simplified version of ROMS. CDMS should provide inputs and sample output for archetypal estuary and shelf configurations, which are available as ROMS test cases. Students and researchers should be able to quickly get the code, run it, modify model inputs, and generate reasonable hydrodynamic and sediment transport fields.
- A second ocean model be incorporated, perhaps a finite-volume model like FVCOM, or one with a large user base like Delft-3D., Another alternative would be a one-dimensional (vertical) model instead of a three-dimensional model. Candidates include Wiberg (1994) and the SEDTRANS code of Li, Amos, and colleagues.

Other short term goals include efforts that should benefit marine surface dynamics modeling efforts in general, aside from the choice of hydrodynamic model used. These include

- The CSDMS should provide a translate module from Matlab code to Python, because many marine reasearchers use Matlab for model development and processing of data.
- A wind model be added to the CSDMS repository, because coastal hydrodynamics are especially sensitive to wind forcing. Some suggested that the WRF (Weather Research and Forecasting) model would be an acceptable choice.

CSDMS can encourage the development of proposals and studies that involve Marine Working Group expertise, in concert with researchers from other disciplines. While the possibilities are endless, members of the Marine Working Group are especially excited by the following ideas for capitalizing on CSDMS capabilities to address compelling research questions.

- Evaluate coupling between land use practices and estuarine water quality. To study the feedbacks in such systems, a land-use model that predicts freshwater, sediment, and nutrient runoff could be coupled into a estuarine hydrodynamic / water quality model. The CSDMS Chesapeake Focus Research Group has expertise in this area and could work to link land use models to, for example, the ChesROMS community model.
- Subaqueous delta evolution involves feedbacks between fluvial discharge and shallow marine circulation, but many geomorphic and hydrodynamic models neglect this coupling. CSDMS

could be used to link shelf and river circulation and sediment transport to the evolution of subaqueous deltas.

- Sediment routing from fluvial and coastal sources to offshore sinks is poorly represented by models, and the processes that trigger transport episodes have not been decisively identified. To address this, CSDMS could provide a platform for coupling turbidite and / or contourite models to hydrodynamic circulation and sediment transport models.
- The evolution of carbonate systems respond strongly to conditions in their shallow marine environment, and likewise impact hydrodynamics and mixing there. To explore these feedbacks, the CSDMS could be used to link carbonate production and morphology to ocean circulation, turbidity, nutrients, light penetration, etc. using a hydrodynamic model coupled to a carbonate model.

Members attending the first Marine Working Group Meeting (March 8, 2008) identified the following processes as essential marine components in CSDMS. In 2013, the Marine Working Group revisited this list, and took stock of the degree to which research programs have focused on these issues.

- From this list, the community acknowledges that research programs in the CSDMS have focused on dynamics of muddy seabeds (including biological mixing and); dynamics of sandy seabeds (including bed form dynamics); dynamics of mixed sediment-size/composition beds; gravity-driven flows; bedload and suspended load transport (including nepheloid layers); isostasy; subsidence; and tectonics.
- Conversely, several topics that highlighted in 2008 do not seem to have received much research focus, and we encourage research in these areas in the near future: particle aggregation/disaggregation; dynamics of muddy seabeds (including irrigation, diagenesis); dynamics of carbonate sediments (including effects on porewater chemistry, seabed scour); and sediment-related ice dynamics.

6.4 Cyberinfrastructure and Numerics: Strategic Plan 2013-1017

Research interests of Cyber WG members for CSDMS 2.0

- Central scientific application around which our efforts can crystallize: Computational fluid dynamics and sediment transport
- Have available a suite of sophisticated computational codes to cover range of length scales: Grain-scale code (Biegert, Borden and Meiburg), Open Foam including particles (Schmeeckle, Liu, Hsu), TURBINS (Nasr-Azadani and Meiburg), TURBINS-LES (Radhakrishnan and Meiburg), Delft 3D (Jagers), ROMS (Arango).
- Expertise on Cyberinfrastructure: software componentization, coupling, interoperability, standards, semantics, algorithms, databases, social networks, hardware …
- Possible extension to ecology: coupling of fluid dynamics/sediment transport with vegetation, larvae transport, transport of nutrients and pollutants …

Key directions and long-term goals

- Make existing models accessible and useful to the widest possible community
- Create legacy databases that can benefit wide research community
- Develop nested models to address multiscale phenomena
- Help improve capabilities of reduced complexity models
- Uncertainty quantification
- Perform model inter-comparisons
- Develop strong ties with EarthCube (Scott Peckham, Boyana Norris, Anna Kelbert)

Medium term goals

1. Perform model inter-comparisons between TURBINS, Open Foam, LES, RANS models for a few canonical sediment transport problems
2. Target one or two of the above codes for creating demo examples of computational models and databases that address the needs of the community, such as:
    - Standardized way of accessing models/databases
    - Easy access even from developing countries (outreach)
    - Databases need to be interoperable ("internet of things")
    - Ability to query datasets for various quantities (velocities, sediment concentrations etc.) at arbitrary locations
    - Allow for easy visualization of databases
    - Accommodate large data files (bring model to the data, instead of the other way around?)
    - Searchable in automated fashion (semantics)
    - Ability to feed real-life data into ongoing simulations (such as updated rainfall statistics)
    - Employ social networking tools to build user communities, track user experience, create discussion forums (Google groups)
3. Continue to provide Python, MATLAB, Octave clinics, offer Q&A sessions, post on YouTube
4. Create systematic infrastructure for performing model comparisons

"Earth-on-a-Chip:" Advanced modeling concepts in support of the environment, water and energy resources

6.5 CSDMS EKT Draft Strategic Plan, 2013 Onward

What is the business of CSDMS EKT, and What Have We Accomplished?

We are in the business of developing and transferring CSDMS tools and knowledge to the following groups:

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

For our educational materials, we should provide materials that help develop quantitative skills, and critical evaluation of model assumptions and outputs. Our principal Education audiences are university students, professionals, teachers at the secondary school and college levels, and the general public.

Based on the questions above, here is one possible framework for considering EKT products:

- *Fundamental process models (perhaps 1D)*
- *Fundamental process models in space and time (multidimensional)*
- *Coupled processes in specific environments*
- *Processes and products linking surface environments*

Guiding questions for our considerations: 1) *What groups need which products? 2) Where do we stand with respect to product development and transfer to meet these general objectives?*

Where are we regarding our CSDMS 1.0 goals?

CMT: A CSDMS graduate Class has been taught 4 times, with summer clinic, using the CMT as a basis for instruction. However, CMT has a ways to go before it is ready for classroom use.

Non-CMT tools: We have had contributions of class materials from a number of individuals, but the collection is still limited. We need more applications for classroom use, more buy-in from other contributors.

Long-term goals for EKT group

Four directions: classroom education, research community, decision-makers, and government outreach programs (Science on a Sphere)

Education

Educational products could be steered towards distinct user groups:

1) For instructors who want to introduce students incrementally to applications of mathematics and code development: incremental stepping up of complexity in quantitative exercises, from chalkboard calculations to spreadsheets to simple code
2) For instructors who want to use packaged programs, or CMT components, to allow exploration of concepts and processes: executable packages that include CSDMS-required metadata, equation explanation, and help files. These executables, and CMT components, can also be used by researchers who are seeking relatively simplified versions of more complicated models, such as discussions of ROMS-Lite, in the Marine Group.

For both educational trajectories, important concepts and processes include (but are not limited to):

1. Conservation of Mass,
2. conservation of energy
3. diffusion, advection, reaction
4. Uncertainty: sources, types, and estimation
5. Parameter estimation
6. Feedbacks and complex systems
7. Sediment Transport laws (sediment, contaminants)
8. equilibrium
9. feedbacks
10. residence times
11. thresholds
12. kinetics
13. steady state v. dynamic
14. adsorption/desorption
15. redox reactions
16. ion exchange
17. flocculation/deposition
18. mud consolidation and associated changes in critical shear stress(i.e. mud vs. sand)
19. scaling relationships
20. self-similarity and organization, like channel bifurcation

Sources and Examples:

- Look to the hydrologists: create a EKT hydro toolbox (see Gary Parker's ebook)
- SERC geomorphology vignettes
- Carlton educational repository . Could link to relevant SERC vignettes to get more exposure. http://serc.carleton.edu/NAGTWorkshops/geomorph/vignettes.html
- Python wiki on CSDMS web site, that is presently hidden but searchable

Products for Decision Makers (government agencies, NGO's industry)
Primary requirement includes advanced visualization and GIS enablement. A major long-term goal would be to integrated complex, nested, and coupled models linked through CMT with open-source GIS
Two separate approaches:

1. Two-way coupling of open-source GIS and computational models, such as interaction of sediment transport, erosion, and deposition with DEM. This will allow adherence with CSDMS mandates for open source tools. One example of this is Andy Wickert's embedding of FLEXURE (Doi: 10.1594/IEDA/100123) in the GRASS openware GIS.
2. One-way coupling of models with GIS, using industry standard formats for model output, to allow use of GIS engines for visualization and communitcation (e.g., SHP, KMZ, etc.). This approach will acknowledge the widespread use of some proprietary formats and GIS environments (ESRI and SHP for example).

Elements to consider in these approaches:

- -Ensemble runs in a geospatially registered environment, running several scenarios using different perturbations then comparing outputs
- -Embed uncertainty
- -Reach out to other communities: i.e. landscape architects, regulatory managers, coastal management/deltaic community, to determine tools most in need.

Government Outreach Programs
Test case: Science on a Sphere
Several models are presently available for global implementation. Examples include:

-global river drainage basin/discharge
-Wavewatch 2 and 3
-temperature/climate of different regions around the globe
-watershed variability

Roadmap for componentizing models:

1. identify community need
2. identify specific model
3. refactor model to comply with CSDMS BMI standards (task for model developers), with documentation in WIKI
4. generate XML-gui file for component (developer and IF staff)
5. provide input and output files (developers)
6. test stand-alone component on CSDMS HPCC
7. create component help pages
8. text component for a coupled simulation
9. conduct coupled simulations for publishable paper

Short-term action plan to achieve long-term goals

Year One: CSDMS2.0 Course Materials — Call to CSDMS community for contribution of exercises and assignments with modeling focus at a range of educational levels, with goal of at least one contribution per group WG.

- Polish and post products
- Develop simple assessment rubrics
- Distribute to pilot team of at least one person per WG for classroom use, with assessment
- Compile results and experiences and prepare/submit paper to Journal of College Science Teaching, with plan authors and testers as co-authors
- Hold a clinic at CSDMS 2014: "Bringing CSDMS to the classroom".
- Promote development of web-enabled CMT environment, to circumvent complications of getting large groups to use HPC
- Consider posting to Carleton College Earth Science Education website
- Implement high quality visualization for all products
- Consider uncertainty for all products
- Promote development of web-enabled CMT environment, to circumvent complications of getting large groups to use HPC.

Years One-Two: education and research for non-specialists. Develop streamlined model packages for classroom and researcher use, as binaries or simple CMT implementations

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

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

- Seek out and advertise the existing proof-of-concept examples

- Develop tool to couple GRASS GIS and CMT
- Query end-users to identify key modeling tools and GIS environments for future implementation
- Promote development of web-enabled CMT environment, to circumvent complications of getting large groups to use HPC

6.6 Carbonate FRG in CSDMS 2.0 Strategy from 2013 onwards

Carbonate FRG Progress To Date

- Initial 60+ group currently represented by **only a few members actively coding and compiling data** with some NSF support
- Multiple carbonate models developed since 2008
- Database of rates for carbonate systems being populated, and able to be interrogated by developing models

Carbonate FRG Long-Term Goals

- Original group vision from 2008 remains valid – develop componentized “workbench” of carbonate models and encourage non-modellers to use them as default tools
- Ultimate goals are understanding of carbonate rock heterogeneity and 100 year prediction of carbonate response to environmental change, both from a suite of new next-generation components that more properly represent complex carbonate biology and chemistry
- What is unique in our style
    - Population dynamics
    - Spatial organization, mosaics, statistics
    - To-do trophics, water chemistry
    - Knowledge base
    - Real world runs

Carbonate FRG Long-Term Strategy: Specific Steps:

1. Develop BMI “wrapped” coupled carbonate model components that do all that the currently separately developed carbonate models (e.g. CarboCAT, CarboLOT, CarboCELL) do
    - Represents an evolution of the original Carbonate Workbench concept from 2008-2009
    - Components will represent both short time scale (decadal+) and long time scale processes (100Ky+) to satisfy the range of potential users
    - Will make extensive use of existing elements of SedFlux for representation of deposition as accumulated strata and for sediment transport elements. Non-relevant parts of SedFlux will be turned off
2. Complete development and population of a carbonate knowledge base and integrate it with carbonate model components
    - Currently lots of diverse rate data in an Excel spreadsheet, being developed by Chris and Don
    - Attracting lots of community interest, but not yet shared more widely, nor able to be interrogated by any models
3. Re-engage the wider “fizzhead” FRG community (the other 60 members) and grow the community by offering the developed components as a focal point for testing, benchmarking, further development and use as educational tools

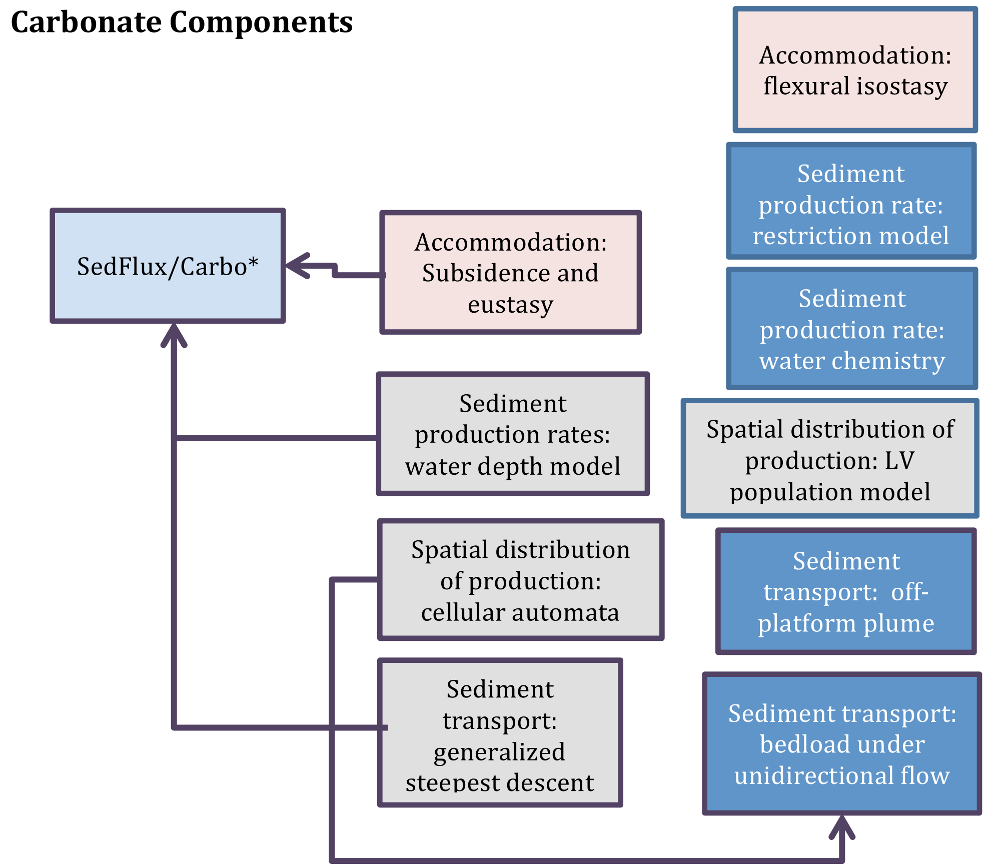

Figure 8 Proposed Carbonate Component Schema

Carbonate FRG Short to Medium-Term Strategy Summary plan:

1. Detailed plans to engage with industry, NSF Steppe and NGOs
   - Tasks defined for PhD students, possibly funded by NSF Steppe & direct industry funding
   - Engage with NGOs for prediction for coastal defence reef growth
2. Document and share the carbonate knowledge base in its current form and open it up to contributions from and development by the wider carbonate community
   - Document the existing parameters that are in the knowledge base
   - Share the knowledge base on Google documents
   - Publish via CSDMS web site as an online database product
3. Recruit more carbonate coders
   - Coding group is gradually growing
   - Actively seeking new people who can help us write component code e.g. PhD students and postdocs
4. Change of leadership if Euro-CSDMS progresses rapidly

6.7 CSDMS Hydrology Focus Research Group Breakout Sessions

Proposed Short-term Goals

- *Establish ways of collaborating between related activities that are currently happening within the hydrology community.* Have clear strategies for collaboration between existing community/grassroots efforts. Have the result of the collaboration be a force multiplier. Leverage currently funded projects and activities to contribute to CSDMS.

- *Identify mechanisms for getting hydrologists to participate in CSDMS.* Hydrology is a highly fragmented group. How can we keep this fragmentation but still encourage progress in community-based hydrologic modeling? Must acknowledge that in hydrology there is no single model in hydrology and the concept of a national water model will have pushback for this reason.
- *Propose a session on "Community Tools for Advancing Hydrologic Science" at the American Geophysical Union Fall Meeting.* The purpose of this meeting will be to engage the broader hydrology community (including but not limited to the current Hydrology FRG members) that are working in community hydrologic modeling and to provide an opportunity for this group to meet and network outside of the CSDMS Annual Meeting time. The session should be coordinated with related efforts, especially those organized through CUAHSI, in order to have broad participation in the session.

Proposed Mid-term Goals

- *Establish methods for model benchmarking and tests to assess model skill.* Benchmarks should assess minimum level of model capability while skill tests should assess model's range of application, as no model is skillful enough to address all questions posed by hydrologists. These benchmark and skill assessments should be standardized and well documented to allow for intermodal comparisons. The results of these tests will serve as an important model metadata metric that community members can use when selecting models for studies.
- *Determine specific needs within the community for new tools, algorithms, or models.* Have the community contribute specific computational needs and, potentially, also ask the community to rank the needs in order of importance. If there is insufficient engagement by the community in ranking the needs, then establish a committee to rank proposed needs to establish clear priorities for the community to contribute to through grant proposals.
- *Establish "challenge problems" that targeted specific needs of the community that are clearly articulated and of high priority.* Similar to how the X-Prize has encouraged innovation through competition, these "challenge problems" will engage the community in addressing community needs and be rewarded if their solution is selected as a prize winner. This approach should specifically target "next generation" scientists and engineers and should require the use of community tools (e.g., CSDMS) in their solution. In this way the H-Price would serve as a way to encourage the community participation in CSDMS.

Proposed Long-term Goals

- *Lower barriers for hydrologists to participate in addressing important hydrologic challenges.* A fundamental challenge in hydrologic modeling that cuts across most modeling activities is that too much time is spent on basic activities (data preprocessing) and this limits innovation in advancing hydrologic models. CSDMS should address this challenge as one component of the community modeling needs for hydrology.
- *Make hydrologic models more open and transparent for both scientific investigations and to support policy and decision makers.* Models in hydrology have grown so complex that modelers are often forced to treat the models as effectively black boxes because they are unable to understand the internal physical representations within the models. CSDMS can address this problem by breaking complex models into components that are easier to understand as a component within a larger modeling system. Likewise, CSDMS can improve this situation by encouraging model developers and model users with tools for quantifying the uncertainty of model predictions so that the models are more useful tools for decision makers.
- *Improve data management capabilities as they specifically relate to supporting hydrologic models.* Hydrology is a "big data" field and we need to work on techniques to more effectively handle the data we have now and the data we will have in the future for addressing hydrology research questions. Advance the science of model linking/coupling, which is a complex problem within itself. Advance the science of multiscale models, especially those that cross multiple communities within CSDMS.

- *Foster culture shift in hydrologic modeling community toward collaborative and community-based model development.* Encourage scientists to be more willing to contribute to a community effort. Have community agreed on and widely used standards for model and data sharing and integration. Specific efforts must be made to target the next generation of hydrologic scientists and researchers so that they "grow up" thinking about modeling frameworks, model coupling standards, HPC, big data, etc. as core tools for doing their research.

6.8 Overarching Themes for Chesapeake Focus Research Group and CSDMS

The Chesapeake Focus Research Group is a partnership between CSDMS and the Chesapeake Community Modeling Program (CCMP, http://ches.communitymodeling.org/), which is currently run by the Chesapeake Research Consortium (CRC). CCMP developed as the Chesapeake Bay research community came together with the common goal of cooperatively building an open source system of watershed and estuary models. Through support from CRC member institutions and the NOAA Chesapeake Bay Office, CCMP modelers have committed to developing a modeling framework that will enable free and open access to code specific to the Chesapeake Bay region. Together, CCMP and the Chesapeake FRG are striving to develop a comprehensive model system consisting of interchangeable individual modules covering diverse aspects of hydrodynamics, ecosystem dynamics, trophic exchanges, and watershed interactions.

Chesapeake FRG Progress To Date

- During CSDMS 1, the Chesapeake FRG co-hosted/co-sponsored three workshops in the Chesapeake region to help facilitate community awareness of CSDMS and its potential applications to Chesapeake related issues.
- As an outgrowth of the third of these three workshops, the Scientific and Technical Advisory Committee of the Chesapeake Bay Program produced a 28-page report (STAC Publication 11-04) entitled "Chesapeake Bay Hydrodynamic Modeling".
- In cooperation with the U.S. IOOS Coastal and Ocean Modeling Testbed, three ROMS-based 3D hydrodynamic models of the Chesapeake Bay have been added to CSDMS with BMI wrappers (CBOFS2, ChesROMS, and UMCESroms).

Chesapeake FRG Short-Term Term Goals

- Continue to populate the CSDMS with existing open-source Chesapeake Bay region models.
- Pursue avenues for group proposals including funding for full-time or nearly full-time Chesapeake FRG oriented personnel, such as a dedicated post-doc.
- Give priority to Chesapeake FRG related projects which focus on models with management implications, such as land use, water quality, ecosystem function, storm surge, etc.

Chesapeake FRG Intermediate Goals

- Train members of the Chesapeake FRG on use of CSDMS tools.
- Construct very simple land use and water quality box models for a Chesapeake FRG "sandbox" for members of the Chesapeake FRG to practice linking and implementing models within CSDMS.
- Post key common forcing data sets at CSDMS.

Chesapeake FRG Long-Term Goals

- Implement additional distinct, swappable land use models, hydrodynamic models, water quality models, ecosystem models, etc., in BMI format at CSDMS.
- Utilize CSDMS to make side-by-side comparisons of model performance and differences in output by systematically swapping model components.
- Utilize CSDMS to perform ensemble modeling (i.e., using multiple distinct models) of future Chesapeake environmental conditions under various management scenarios.

6.9 CSDMS – Geodynamics Focus Research Group

The Geodynamics FRG is new to CSDMS 2 and is co-sponsored by GeoPRISMS. It was formed with the aim of facilitating the understanding of the interplay between climatic, geomorphic, and geological/tectonic processes in governing Earth surface processes and landscape evolution. The Geodynamics FRG will move toward an integrated-coupled modeling suite that has the capability to account for paleo-topography, geology, substrate lithology, crustal deformation, climate, vegetation, runoff production, and ensuing sediment transport and storage. The FRG will be closely aligned to the CSDMS Terrestrial Working Group. Our road map for the next five years is:

1. Short-term goals focused on building up a community, determining key questions and identifying existing codes and how they might fit into the CSDMS framework;
2. Intermediate-term goals focused on building on existing codes and developing a robust coupled geodynamic-landscape evolution model(s);
3. Long-term goals will build a community around these model(s), benchmark models and train users.

Short-term goals (1-2 years, 2013-2015)

- Reach out to the geodynamic community through GeoPRISMS and CIG (Computational Infrastructure for Geodynamics). Seek feedback from the community on our goals and strategy for moving forward.
- Convene special sessions at large conferences such as AGU and run one or more workshops to engage the community. [One such session is planned for the 2013 Fall AGU and co-sponsored with GeoPRISMS.]
- Evaluate state-of-the-art understanding and modeling of coupled geodynamic and geomorphic systems. This includes identifying existing models, their potential for inclusion into CSDMS, research needs, and areas where models, datasets, and understanding of key processes are missing.
- Identify potential proof-of-concept applications and data sets. Develop a set of criteria for proof-of-concept applications. Where coupling is not seen as feasible in the short term, these criteria should address the barriers to that feasibility.
    - Include a component of both surface dynamics and solid earth deformation
    - Well-constrained boundary conditions

  Proof-of-concept applications could include:
    - Modeling how one (or a system) of growing normal fault(s) evolve while simultaneously exposed to surface processes (erosion and deposition) or;
    - Modeling simple two-sided mountain ranges such as Taiwan or the Southern Alps
- Evaluate available codes and their potential for inclusion in BMI (Basic Model Interface) and CMT (Component Modeling Tool).
- Define and prioritize education needs/training within the CSDMS framework.

Intermediate-term goals (3-4 years, 2015-2017)

- Stimulate proposals from the community for projects that will address important science questions while completing steps necessary for realizing the overall goals of CDSMS, including (1) developing and improving software for CSDMS, (2) developing proof-of-concept modeling applications, and/or

(3) developing strategies to test model predictions. In particular, encourage proposals that integrate a landscape evolution model and a geodynamic model within the CSDMS framework.

- Identify one or two models to focus development efforts and work with the Integration Staff to refactor the code with a BMI. Add code to the CMT.
- Implement proof-of-concept application(s) identified above. The application(s) will include a component of both surface dynamics and solid earth deformation, well-constrained boundary conditions, be testable by field or experimental data, and (ideally) will be used for model benchmarking and inter-comparison.
- Begin model benchmarking and model inter-comparison. The way we go about this will depend on which models we have decided to focus on as well as what proof-of-concept applications we have chosen. Model benchmarking will assist users when determining which model/set of models to use for their research problem by highlighting the strengths and weaknesses of each model/set of models.
- Make modeling tools available for educational use. Including the contribution of simple model animations to the Quantitative Surface Dynamics Educational Toolbox.

Long-term goals (5 years and beyond, 2017-)

- Develop (as in couple in CMT or outside CMT) and test a fully coupled geomorph/geodynamic problem. A framework problem would potentially include:
    - Underlying geology and structure
    - Tectonic boundary conditions
    - Surface processes e.g., runoff production and ensuing sediment transport and storage
- Contribute to the EKT (Education and Knowledge Transfer) program with the aim of seeing a new generation of computationally literate graduate students, versed in how to take maximum advantage of CSDMS tools and capability, begin to join the research community.
- Continue contributing to the Quantitative Surface Dynamics Educational Toolbox with animations, 'Concept to Model' exercises, simplified models for students to 'play' with, and more complex models for students to explore dynamic coupling problems.
- Consider running hands-on training courses to build community involvement with specific codes and coupled modeling systems.

6.10 Coastal Vulnerability Initiative Launch: Initial Plans and Directions

Scope

We discussed the definition of 'coastal vulnerability', and agreed that for us, this term refers to both the vulnerability of human coastal infrastructure and habitation to coastal processes that can impact them, and to the vulnerability of coastal ecosystems, which provide critical ecosystem services to society.

We discussed the relationship between the Coastal Working Group and the Coastal Vulnerability Initiative. Clearly, because the discussions in the Coastal WG included substantial and enthusiastic suggestions for WG goals that address human and ecosystem vulnerability in coastal environments, a subset of the current Coastal WG goals apply to the new Coastal Vulnerability Initiative—those involving the impacts of coastal processes on human infrastructure and activities, as well as the reverse. (Below we include the main goals articulated by the Coastal WG, with highlights showing which aspects apply to the Coastal Vulnerability Initiative.)

Discussion in the initial break out session focused on how the CSDMS community can most effectively contribute to addressing issues of coastal vulnerability and sustainability. Clearly, through modeling of storm impact using detailed hydrodynamic and sediment-dynamic models, we can contribute to the ability to forecast the effectiveness of alternative coastal- management policies, and associated engineering efforts, in protecting coastal infrastructure. Coupling state of the art models in the CSDMS toolbox will facilitate such assessments.

However, this group can also offer unique contributions to our understanding of how the long-term evolution of coastal environments depends on human actions, from land-use changes to coastal policy decisions. Typically, engineering interventions to protect or enhance human use of coastal environments is undertaken and evaluated in the context of impacts on scales up to kilometers and years. The relatively small-scale engineering interventions, however, alter the landscape-forming processes, and therefore the long-term, large-scale trajectories of landscape evolution (including ecological and human-development states).

Human decisions regarding coastal management and defense of coastal infrastructure, in turn, depend on how coastal environments change—ranging from rates of coastline erosion to flooding frequencies and the severity of storm impacts. Therefore, human dynamics and coastal dynamics are intimately intertwined. The CSDMS modeling community is uniquely capable of evaluating the long-term (decades to centuries), large-scale consequences of alternative engineering and coastal management approaches.

Given this thorough coupling between the long-term evolution of human actions and coastal morphology and ecology, the Coastal Vulnerability Initiative is also clearly linked with the Anthropocene Focused Research Group.

Geographical Scope

We agreed that this initiative should clearly focus on studies of delta environments, as well as sandy coastlines, and possibly rocky coasts as well. In each case, human decisions help shape the future of coastal environments and the future set of hazards human coastal habitation faces.

We agreed that the idea of concentrating community efforts on the study of a small number of case-study regions, raised initially in Coastal WG Breakout sessions, makes especially good sense in the Coastal Vulnerability context. For example, the Gambia Delta, already the focus of World Bank attention, could provide a highly relevant case study to test coupled-model studies of delta and human dynamics against. In addition, the Netherlands coast offers the combination of intensive coastal defense efforts (specifically beach nourishment) and intensive monitoring of the results. The New Jersey coast, in the wake of superstorm Sandy, offers clear advantages for studying how coastal development density and style affects storm impacts, and in in the longer term barrier island morphological evolution—and therefore future human habitation. As the shape of the Coastal Vulnerability Initiative emerges, we should discuss the most appropriate case-study regions.

Partners Scope

How the Coastal Vulnerability Initiative will evolve in the coming months will depend on the fate of several pending proposals. This includes multiple Belmont Forum consortia (multi- national, interdisciplinary efforts involving physical and social scientist as well as a strong component of end-user involvement), Coastal SEES (NSF Science, Engineering and Education for Sustainability call for proposals), and FESD (NSF Frontiers of Earth Surface Dynamics call for proposals). The currently funded Delta Dynamics Collaboratory FESD project should certainly be involved in this initiative. In addition, we several USGS personnel should be asked to join this Initiative.

We clearly need to engage a growing number of social scientists (e.g. economists and anthropologists) in the studies of couplings between landscape/ecosystem changes and human dynamics. Along with helping us investigate coupled human/landscape evolution, social scientists can help evaluate the costs/benefits associated with alternative management strategies.

Intended Stakeholder/Decision-Maker Audience Scope

We disused what level of government entity would be most likely to make use of the information we could help provide, and agreed that community level planners were less likely to be interested in longer-term, larger-scale consequences of local actions than are than region- scale entities (governmental, NGOs, and corporate—including insurance and re-insurance). On the other hand, reaching out to stake holders at the household level, for example with interactive games showing the long-run consequences of alternative management policies, could help create a better informed constituency. In any case, effectively reaching out to stakeholders likely requires the involvement of social scientists and/or specialists in science communication, which we will lobby for the Education and Knowledge Transfer Working Group to focus more directly on, in collaboration with those involved in this initiative.

Selected Coastal Working Group goals (5 years +), with Coastal Vulnerability overlap highlighted

Overarching Goals

1. Improve the understanding of, and ability to forecast, how a broad range of coastal environments evolve, including the effects of: the dynamic feedbacks among physical, biological, and human processes; interactions between different environments along coastlines; and interactions among coastal, terrestrial, and marine environments--all under a range of climate and human management scenarios. (Initial goals for the next five years listed as 'specific science goals' below.)

2. Address societally relevant science questions, and assemble a set of model tools facilitating investigation of coastal impacts and vulnerability, and their variability--and to enhance the ability of coastal managers and policy makers to use and interpret the modeling tools and results (in collaboration with the Education and Knowledge Transfer Working Group, key stakeholders, and decision makers).

Specific Science Goals (SSG's) Under these Umbrellas, and Steps Toward Them

SSG1 To improve understanding of and ability to hindcast/forecast past and possible future *delta evolution on decadal to millennial time scales, as affected by couplings between terrestrial, fluvial, coastal, wetland, floodplain, subsidence, ecological and human processes*, ultimately including coupling between 1) long- term changes in delta morphology/ecology and 2) storm-event impacts to morphology, vegetation, and human dynamics and infrastructure.

SSG2 To improve our understanding of and ability to forecast how the *morphology, ecology, and human components of sandy coastal environments co- evolve under different scenarios of changing storm climate, sea level rise, and human manipulation* --including coastal environments ranging from urban to undeveloped.

SSG3 To improve our understanding of and ability to forecast how *rocky and soft-cliffed coastlines change over time, as human manipulations (e.g. river damming and coastal armoring) and changes in climate affect interactions between cliff erosion, sediment production, and sediment redistribution*--and how these interactions affect coastal communities.

7.0 CSDMS2.0 Year 2 Priorities and Management of Resources

The CSDMS budget resources are roughly divided into four components:

1) 25% supporting middleware development (e.g. CMT plug-and-play environment, BMI and CMI interface standards, semantics, support services),

2) 25% supporting community 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.

CSDMS Integration Facility Staff continue to juggle the competing demands of an actively engaged and ever-growing CSDMS Community. CSDMS staff continues 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 7 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.

7.1 CSDMS2.0 Year 2 Goals — CSDMS Portal

1. Database structure

The CSDMS portal has proven itself to be the 'go to' site when it comes to modeling surface processes. The CSDMS website ends almost always in the top 10 Google search results when searching for, for example a specific surface numerical model. Over the last year, the CSDMS website is viewed on average 166 times a day of which 62.4% are new visitors (first time visitors). So not only those who are familiar with the CSDMS project will visit the CSDMS website, also people who are less familiar with CSDMS will find the website, which is also reflected in the ever-growing number of members (as of June 2013, 1020 members).

While among other the content of the 3 core repositories (Models, Data, EKT) is increasing every year, the challenge to stay the 'go to' website for modeling surface processes will be to ensure that the content is always up-to-date. With over 6,000 webpages this is not a trivial task for a small group of people. Member website participation is therefore of utmost importance. Especially as the group of members that contributed numerical code, datasets or educational material in the past, are likely most familiar with any upgrades or new additional material that should be hosted as well. To encourage members to participate more to the CSDMS website we want to engage them more in web activity by easy to use tools (forms) that will increase e.g. the visibility of the scientific achievements of a member, like publications. Therefore CSDMS will construct a publication database that can be queried such that e.g.: a) all publications of a model will be presented, or b) all publications of a CSDMS member will be listed. Needless to say, these publication lists can be automatically integrated to e.g. a specific model or set of models or CSDMS member pages, etc.

2. Improve website data functionality

a) Making specific model data input as well as output available to the community is as important as providing model source code to the community. This to e.g. 1) being able to see if a model does function once source code is locally downloaded and compiled, and 2) to check if generated model output is similar to suggested output by developer. Therefore CSMDS will actively contact those model developers that have not submitted any model input – output datasets, to seek model data as well as metadata files, and build up a model data database that is open source.

b) It is of importance to model users to have clear insights into the strengths and weaknesses of similar models to guide their choice of running simulations for a specific problem. In this regard a benchmark data collection system will be set up within the CSMDS content management system, where data suppliers (e.g. the experimental community) can easy upload and describe their datasets or use data warehouses that are already developed for this purpose. Collaboration is initiated and will be further developed with Dr. Wonsuck Kim, University of Texas, Austin and Kerstin Lehnert, IEDA, Palisades. Our goal is to get work together with the experimentalist community to generate a few tank experiment parameters datasets in combination with model input – output datasets that mimic these tank experiments.

3. Visualization of model functions

CSDMS strives to provide comprehensive information on models and their simulations to help new users better understand key functions of models. Of each of the model components in the CMT, a help page is constructed, providing key equations entered as TeX or LaTex by incorporating Math. A next step would be to incorporate web functionality to visualize model functions. JSXGraph is a cross-browser library for interactive geometry, function plotting and data visualization in a web browser. One of the advantages of incorporating JSXGraph is that it is browser independent, no plug-ins are required and it uses only minimal bandwidth, making it a fast dynamic mathematics visualization tool. As a first prove of concept, JSXGraph will be integrated within the CSDMS content management system and applied to some of the labs that are currently posted in the educational repository

Milestones: *A*) Create user submit and search query capability forms for publications as well as a full integration of publication lists to the various pages (model, user, movies, etc); populate the publication database, starting with model publications listed on the CSDMS web. ***B***) Contact each model developer to seek model input – output files, *C*) Develop a benchmark dataset submission system within the web content management system. Involving the community through WG and FRG chairs to design intercomparison experiments together with input from the experimental community. *D*) Integrate JSXGraph, a model function visualization tool to the content management system and apply JSXGraph as a prove of concept to a number of labs in the educational repository. **Resources:** 0.6 FTE Web Specialist.

7.2 CSDMS2.0 Year 2 Goals — Cyber Plans

The CSDMS software engineers will mainly focus their time in the coming year to developing the new CSDMS model coupling tool and related software.

New CSDMS Component Modeling Tool

In year 2 of the CSDMS-2.0 project, the CSDMS IF will build a new graphical user interface for that allows users to interact with the CSDMS modeling framework. This tool will replace the existing (java-based) CMT. The CMT redesign will result in a more *stable*, more *reliable*, and more *maintainable* interface to our modeling community.

Redesign: To ensure stability, and responsiveness of the new Component Modeling Tool, a redesign of the communication structure between the CMT client and server is necessary. Unnecessary communication between client and server will be reduced to a minimum, which will allow users to work with CMT in "offline" mode. Only once a user has set up their coupled simulation will the client communicate to a server of their choice (initially only the CSDMS HPC cluster, beach.colorado.edu) to actually run the simulation.

Backend and Command-Line Tools: Behind the scenes the new CMT GUI will rely on scripts and software that, among other things, will:

- Manage communication,
- Build project descriptions,
- Build simulation descriptions and
- Execute coupled model simulations on remote servers.

These tools will serve as both the foundation of the graphical user interface as well as a means for advanced users to use the CSDMS framework through command-line utilities.

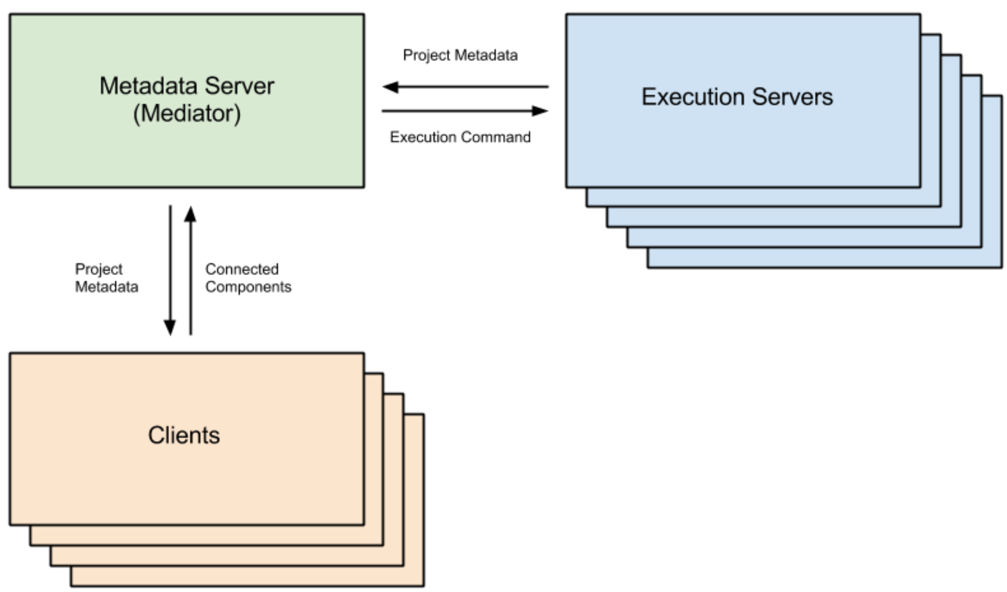

Figure 9- Communication between the client and execution servers will take place through a separate mediator. The mediator will run on a publically accessible server that supplies project metadata to connected clients and sends simulation metadata to one of a series of clusters that will run the simulation.

Graphical User Interface: Once a foundation is built, a graphical user interface to the model-coupling technology will be built. Written in Python, the client-side GUI will be platform independent, and easily installed on end-users' personal computers. The software will allow users to visually:

- Connect components
- Run coupled simulations
- Access model help and metadata, and
- Provide model coupling guidance

Milestones

Design:

- Description of the new communication design.

- Format specification for descriptions of model-coupling projects.
- Release version of tools used to create and describe model coupling projects.

Backend tools:

- Release version of tools that communicate between client and server.
- Release version of the job launcher

Client GUI:

- Graphical design of the new grahical user interface.
- A release version of a Python-based graphical user interface for connecting project components.

Model Build Automation:
The CSDMS model repository houses hundreds of thousands of lines of source code for numerical models contributed by the surface dynamics modeling community. When a model developer contributes their source code to the repository it is checked to see if it compiles on the CSDMS cluster and, optionally, if some simple test cases complete. This initial build is done only on one platform and is done only at the time the model was contributed.

In the coming year the CSDMS IF will work to set up a framework that will enable automatic compilation, testing and distribution of models within our repository. We will not ensure that each model compiles properly on every platform/compiler combination. Instead, the framework will provide a report that details on which environments a particular model can be built and results of any tests that may come with the model. When possible, we will offer binary distributions of models for the various build environments for which they were successfully built. We will initially concentrate on models used as components within the CMT and then expand by including other models within the CSDMS repository.

7.3 CSDMS2.0 Year 2 — EKT Goals

General

The EKT Working Group met at the CSDMS annual Meeting 2013 and confirmed the overarching mission of developing and transferring CSDM tools and knowledge to: 1) researchers who use and develop models, 2) planners who use scenario-modeling, 3) government outreach programs to the public such as 'Science on a Sphere', 4) educators who use lesson plans and pre-packaged models.

CSDMS 2.0's EKT grand challenge remains to provide our community with tools that can be used to prepare students and citizens in the STEM (Science, Technology, Engineering and Mathematics) disciplines with an emphasis on surface processes. Our students should gain quantitative skills sufficient to enter Earth Science graduate programs, compete in the workforce, become careful consumers of science information, and engage in public discussions about science and technology. CSDMS-EKT aims to meet this challenge by transferring modeling science, quantitative skills, and critical evaluation skills of models and model assumptions to high school and university undergraduate students and to policy-makers.

Earth science models are interactive tools; students show significant learning gains when they work with inquiry-based modules and receive instantaneous feedback. The EKT working group agrees that this idea remains a cornerstone of EKT efforts in 2014. We proposed to develop an online Quantitative Surface Dynamics Educational Toolbox that will allow learners at all levels to work with CSDMS models. The envisioned toolbox will consist of modules hosted on the CSDMS wiki, designed to allow a progressive topical track through the curriculum.

Quantitative Surface Dynamics Educational Toolbox

While there will be ongoing efforts at all levels of the proposed toolbox (i.e. increase of number of animations, teaching on an advanced graduate student level at our annual meeting and through the Student Modeler Award program). Specific focus for the educational working group and CSDMS EKT specialist for 2014 will be on two levels in the overall progressive track:

1) Submitting the first **CSDMS model animations to the NOAA's 'Science on a Sphere'** team and prepare educational material for the SOS displays (34 locations worldwide, including major science museums in the US, SOS: http://sos.noaa.gov). We propose to work with our community to submit simulations and datasets to visualized a global history of dam building, a global river runoff model and global wave simulations.
2) **Expand the current EKT repository with additional simplified models that students can 'play' with**. The educational working group proposed in the CSDMS annual meeting 2013 to prioritize and solicit one educational model contribution per working group. These models teach core disciplinary ideas and address common misconceptions. The models 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.

The toolbox will incorporate state-of-the-art research on efficient learning. Modules in the toolbox will have linked material posted; lesson plans, lesson learning objectives, documentation and proposed classroom laboratories or exercises.

Instructor-Training & Clinic on Educational Resources at CSDMS Annual Meeting 2014

In the CSDMS 2.0 proposal we acknowledged the tremendous influence that teachers and faculty have on student learning; not everything can be done online, and learning is driven by good teachers. The EKT Working Group enforced the goal of assembling a pilot team of members who will be early adopters of the educational toolbox to help evaluate the products from the earliest stages. At the CSDMS meeting 2014 we plan to further present these existing online modeling labs and resources to our entire community in a clinic "Bringing CSDMS to the classroom". Members for the pilot team will be recruited from the different CSDMS WG's.

We propose to organize two webinars in year 2 to design and provide modeling labs for teaching to this small pilot team. The labs should be polished and relatively straightforward to be used and will be accompanied of simple assessment rubrics. Our pilot team will test the labs and the proof-of-concept evaluation mechanisms in the Fall 2014 semester. Once tested and proven these can be organized in the longterm through forms in our wiki web system, so that learning objectives can be assessed in a more structured way with pre-test and post-test assessments as well as with formative assessments.

We will compile experiences after completion of the academic year 2014 and plan to prepare a paper to the Journal of College Science Teaching as a joint contribution of the entire pilot team.

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

	Est. $K Year 6
A. Salaries & Wages	
Executive Director:	$57
Software Engineers:	$144
Communication Staff*	$100
Admin Staff**	$72
Total Salaries	**$373**
B. Fringe	**$113**
D. Travel	
Center Staff:	$10
Steering Committee	$6
Executive Com.	$10
Total Travel	**$26**
E. Annual Meeting	**$70**
F. Other Direct Costs	
Materials & Suppl	$1
Publication Costs	$2
Computer Services:	$25
Non Capital Equipment	$2
Communications	$3
Total Other Costs	**$33**
G. Total Direct Costs	**$615**
H. Indirect Cost	$286
I. Total Costs	**$900**

Notes:

1) Year 6 (Year 1 of CSDMS 2.0) estimates include salaries projected out 3 months to the end of the CSDMS fiscal year.
2) * Communication Staff includes Cyber + EKT Scientists
3) ** Admin Staff includes Executive Assistant + System Administrator + Accounting Technician.
4) CU completes a preliminary estimate of expenditures after 60 days of a time marker. CU provides a finalization typically within 90 days of a fiscal year.

Additional Funds Received by CSDMS IF Staff and Associates (see Section 2.4)

Year 6:

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

Appendix 1: Institutional Membership & Member Location Maps — those in marked in blue have joined CSDMS since 1 July 2012. There are now more than 443 affiliated institutions.

U.S. Academic Institutions: Current total of 123 with 7 new members from 31 June 2012 – 30 April 2013

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

99. University of Pittsburgh
100. University of Rhode Island
101. University of South Carolina
102. University of South Florida
103. University of Southern California
104. University of Tennessee - Knoxville
105. University of Texas – Arlington
106. University of Texas – Austin
107. University of Texas – El Paso
108. University of Texas – San Antonio
109. University of Utah
110. University of Virginia
111. University of Washington
112. University of Wyoming
113. Utah State University
114. Vanderbilt University
115. Villanova University, Pennsylvania
116. Virginia Institute of Marine Science (VIMS)
117. Virginia Polytechnic Institute, VA
118. Washington State University
119. West Virginia University
120. Western Carolina University
121. Wichita State University
122. William & Mary College, VA
123. Woods Hole Oceanographic Inst.

U.S. Federal Labs and Agencies: Current total of 22 as of 31 June 2012 – 30 April 2013

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

U.S. Private Companies: Current total of 22 with 3 new members from 31 June 2012 – 30 April 2013

1. Airlink Communications, Hayward CA
2. Aquaveo LLC, Provo, Utah
3. ARCADIS-US, Boulder, Colorado
4. Chevron Energy Technology, Houston, TX
5. ConocoPhillips, Houston, TX
6. Deltares, USA
7. Dewberry, Virginia
8. Everglades Partners Joint Venture (EPJV), Florida
9. ExxonMobil Research & Engineering, Houston TX
10. Geological Society of America Geocorps
11. Idaho Power, Boise
12. PdM Calibrations, LLC, Florida
13. Philip Williams and Associates, Ltd., California
14. Schlumberger Information Solutions, Houston, TX
15. Science Museum of Minnesota, St. Paul, MN
16. Shell USA, Houston, TX
17. Stroud Water Research Center, Avondale, PA
18. URS–Grenier Corporation, Colorado
19. Warren Pinnacle Consulting, Inc., Warren, VT
20. The Von Braun Center for Science & Innovation Inc
21. The Water Institute of the Gulf, Louisiana
22. UAN Company

Foreign Membership: Current total of 275 with 52 of them being new members from 31 June 2012 – 30 April 2013 (**63** countries outside of the U.S.A.: Algeria, Argentina, Armenia, Australia, Austria, Bangladesh, Belgium, Bolivia, Brazil, Bulgaria, Cambodia, Canada, Chile, China, Colombia, Cuba, Denmark, Egypt, El Salvador, France, Germany, Ghana, Greece, Hong Kong, Hungary, India, Indonesia, Iran, Ireland, Israel, Italy, Japan, Kenya, Malaysia, Mexico, Morocco, Myanmar, Nepal, New Zealand, Nigeria, Norway, Pakistan, Peru, Philippines, Poland, Portugal, Romania, Russia, Scotland, Singapore, South Africa, South Korea, Spain, Sweden, Switzerland, Taiwan, Netherlands, Turkey, UK, United Arab Emirates, Uruguay, Venezuela, Việt Nam).

Foreign Academic Institutes:

1. Aberystwyth University, Wales, UK
2. Adam Mickiewicz University (AMU) Poznan, Poland
3. AGH University of Science and Technology, Krakow, Poland
4. AgroCampus Ouest, France
5. Aix-Marseille University, France
6. Anna University, India
7. ANU College, Argentina
8. Aristotle University of Thessaloniki, Greece
9. Bahria University, Islamabad, Pakistan
10. Bangladesh University of Engineering and Technology, Dhaka, Bangladesh
11. Birbal Sahni Institute of Palaeobotany, India
12. Bonn University, Germany
13. Blaise Pascal University, Clermont, France
14. Brandenburg University of Technology (BTU), Cottbus, Germany
15. British Columbia Institute of Technology (BCIT), Canada
16. Cardiff University, UK
17. Carleton University, Canada
18. China University of Geosciences- Beijing, China
19. China University of Petroleum, Beijing, China
20. Christian-Albrechts-Universitat (CAU) zu Kie, Germany
21. CNRS / University of Rennes I, France
22. Cracow University of Technology, Poland
23. Dalian University of Technology, Liaoning, China
24. Darmstadt University of Technology, Germany
25. Delft University of Technology, Netherlands
26. Diponegoro University, Semarang, Indonesia
27. Dongguk University, South Korea
28. Durham University, UK
29. Ecole Nationale Superieure des Mines de Paris, France
30. Ecole Polytechnique, France
31. Eidgenossische Technische Hochschule (ETH) Zurich, Switzerland
32. FCEFN-UNSJ-Catedra Geologia Aplicada II, Argentina
33. Federal Ministry of Environment, Nigeria
34. Federal University of Itajuba, Brazil
35. Federal University of Petroleum Resources, Nigeria
36. Federal University Oye-Ekiti, Nigeria
37. First Institute of Oceanography, SOA, China
38. Free University of Brussels, Belgium
39. Guanzhou University, Guanzhou, China
40. Heriot-Watt University, Edinburgh, UK
41. Hohai University, Nanjing, China
42. Hong Kong University, Hong Kong
43. IANIGLA, Unidad de Geocriologia, Argentina
44. Imperial College of London, UK
45. India Institute of Technology – Bhubaneswar, India
46. India Institute of Technology – Delhi
47. India Institute of Technology – Kanpur
48. India Institute of Technology - Madras
49. India Institute of Technology – Mumbai
50. Indian Institute of Science – Bangalore
51. Institut Univ. Europeen de la Mer (IUEM), France
52. Institute of Engineering (IOE), Nepal
53. Instituto de Geociencias da Universidade Sao Paulo (IGC USP), Brasil
54. Kafrelsheikh University, Kafrelsheikh, Egypt
55. Karlsruhe Institute of Technology (KIT), Germany
56. Katholieke Universiteit Leuven, KUT, Belgium
57.
58. King's College London, UK
59. Kocaeli University, Izmit, Turkey
60. Lanzhou University, China
61. Leibniz-Institute fur Ostseeforschung Warnemunde (IOW)/Baltic Sea Research, Germany
62. Leibniz Universitat Hannover, Germany
63. Loughborough University, UK
64. Lund University, Sweden
65. McGill University, Canada
66. Mohammed V University-Agdal, Rabat, Morocco
67. Mulawarman University, Indonesia
68. Nanjing University of Information Science & Technology (NUIST), China
69. Nanjing University, China
70. National Taiwan University, Taipei, Taiwan
71. National University (NUI) of Maynooth, Kildare, Ireland
72. National University of Sciences & Technology, (NUST), Pakistan
73. Natural Resources, Canada
74. Northwest University of China, China

75. Norwegian University of Life Sciences, Norway
76. Ocean University of China, China
77. Padua University, Italy
78. Peking University, China
79. Pondicherry University, India
80. Pukyong National University, Busan, South Korea
81. Royal Holloway University of London, UK
82. Sejong University, South Korea
83. Seoul National University, South Korea
84. Shihezi University, China
85. Singapore-MIT Alliance for Research and Technology (SMART), Singapore
86. Southern Cross University, United Arab Emirates (UAE)
87. Sriwijaya University, Indonesia
88. SRM University, India
89. Stockholm University, Sweden
90. Tarbiat Modares University, Iran
91. The Maharaja Sayajirao University of Baroda, India
92. Tianjin University, China
93. Tsinghua University, China
94. Universidad Agraria la Molina, Peru
95. Universidad Complutense de Madrid, Spain
96. Universidad de Granada, Spain
97. Universidad de Guadalajara, Mexico
98. Universidad de la Republica, Uruguay
99. Universidad de Oriente, Cuba
100. Universidad de Zaragoza, Spain
101. Universidad Nacional de Catamarca, Argentina
102. Universidad Nacional de Rio Negro, Argentina
103. Universidad Nacional de San Juan, Argentina
104. Universidad Politecnica de Catalunya, Spain
105. Universidade de Lisboa, Lisbon, Portugal
106. Universidade de Madeira, Portugal
107. Universidade do Minho, Braga, Portugal
108. Universidade Federal do Rio Grande do Sul (FRGS), Brazil
109. Universit of Bulgaria (VUZF), Bulgaria
110. Universita "G. d'Annunzio" di Chieti-Pescara, Italy
111. Universitat Potsdam, Germany
112. Universitat Politecnica de Catalunya, Spain
113. Universitas Indonesia, Indonesia
114. Universite Bordeaux 1, France
115. Universite de Rennes (CNRS), France
116. Universite du Quebec a Chicoutimi (UQAC), Canada
117. Universite Joseph Fourier, Grenoble, France
118. Universite Montpellier 2, France
119. Universiteit Gent, Ghent, Belgium
120. Universiteit Stellenosch University, South Africa
121. Universiteit Utrecht, Netherlands
122. Universiteit Vrije (VU), Amsterdam, Netherlands
123. Universiti Teknologi Mara (UiTM), Mayalsia
124. Universiti Malaysia Pahang, Malaysia
125. University College Dublin, Ireland
126. University of Bari, Italy
127. University of Basel, Switzerland
128. University of Bergen, Norway
129. University of Bremen, Germany
130. University of Brest, France
131. University of Bristol, UK
132. University of British Columbia, Canada
133. University of Calgary, Canada
134. University of Cambridge, UK
135. University of Copenhagen, Denmark
136. University of Dhaka, Bangladesh
137. University of Dundee, UK
138. University of Edinburgh, Scotland
139. University of Edinburgh, UK
140. University of Exeter, UK
141. University of Ghana, Ghana
142. University of Guelph, Canada
143. University of Haifa, Israel
144. University of Kashmir, India
145. University of Lethbridge, Canada
146. University of Malaya, Kuala Lumpur, Malaysia
147. University of Milano-Bicocca, Italy
148. University of Natural Resources & Life Sciences, Vienna, Austria
149. University of New South Wales, Australia
150. University of Newcastle upon Tyne, UK
151. University of Newcastle, Australia
152. University of Nigeria, Nsukka, Nigeria
153. University of Palermo, Italy
154. University of Padova, Italy
155. University of Pavia, Italy
156. University of Queensland (UQ), Australia
157. University of Reading, Berkshire, UK
158. University of Rome (INFN) "LaSapienza", Italy
159. University of Science Ho Chi Minh City, Viet Nam
160. University of Southampton, UK
161. University of St. Andrews, UK
162. University of Sydney, Australia
163. University of Tabriz, Iran
164. University of Tehran, Iran

165. University of the Philippines, Manila, Philippines
166. University of the Punjab, Lahore, Pakistan
167. University of Waikato, Hamilton, New Zealand
168. University of Warsaw, Poland
169. University of West Hungary - Savaria Campus, Hungary
170. University of Western Australia, Australia
171. VIT (Vellore Institute of Technology) University, Tamil Nadu, India
172. VUZF University, Bulgaria
173. Wageningen University, Netherlands
174. Water Resources University, Hanoi, Viet Nam
175. Wuhan University, Wuhan, China
176. Xi-an University of Architecture & Technology, China
177. York University, Canada

Foreign Private Companies

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

Foreign Government Agencies

1. Agency for Assessment and Application of Technology, Indonesia
2. Bedford Institute of Oceanography, Canada
3. Bhakra Beas Management Board (BBMB), Chandigarh, India
4. British Geological Survey, UK
5. Bundesanstalt fur Gewasserkunde, Germany
6. Bureau de Recherches Géologiques et Minières (BRGM), Orleans, France
7. Cambodia National Mekong Committee (CNMC), Cambodia
8. Center for Petrographic and Geochemical Research (CRPG-CNRS), Nancy, France
9. CETMEF/LGCE, France
10. Channel Maintenance Research Institute (CMRI), ISESCO, Kalioubia, Egypt
11. Chinese Academy of Sciences – Cold and Arid Regions Environmental and Engineering Research Institute
12. Chinese Academy of Sciences – Institute of Mountain Hazards and Environment, China
13. Chinese Academy of Sciences – Institute of Tibetan Plateau Research (ITPCAS), China
14. Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia

15. Consiglio Nazionale delle Ricerche (CNR), Italy
16. French Agricultural and Environmental Research Institute (CEMAGREF)
17. French Research Institute for Exploration of the Sea (IFREMER), France
18. Geological Survey of Canada, Atlantic
19. Geological Survey of Canada, Pacific
20. Geological Survey of Israel, Jerusalem, Israel
21. Geological Survey of Japan (AIST), Japan
22. Geosciences, Rennes France
23. GFZ, German Research Centre for Geosciences, Potsdam, Germany
24. GNS Science, New Zealand
25. *GNU VNIIGiM*, Moscow, *Russia*
26. Group-T, Myanmar
27. Helmholtz Centre for Environmental Research (UFZ), Germany
28. Indian National Centre for Ocean Information Services (INCOIS), India
29. Institut des Sciences de la Terre, France
30. Institut National Agronomique (INAS), Algeria
31. Institut Teknologi Bandung (ITB), Indonesia
32. Institute of Atmospheric Sciences and Climate (ISAC) of Italian National Research Council (CNR), Italy
33. Institute for Computational Science and Technology (ICST), Viet Nam
34. Institute for the Conservation of Lake Maracaibo (ICLAM), Venezuela
35. Institute of Earth Sciences (ICTJA-CSIC), Spain
36. Instituto Hidrografico, Lisboa, Lisbon, Portugal
37. Instituto Nacional de Hidraulica (INH), Chile
38. Instituto Nazionale di Astrofisica, Italy
39. International Geosphere Biosphere Programme (IGBP), Sweden
40. Iranian National Institute for Oceanography (INIO), Tehran, Iran
41. Italy National Research Council (CNR), Italy
42. Japan Agency for Marine-Earth Science Technology (JAMSTEC), Japan
43. Kenya Meteorological Services, Kenya
44. Korea Ocean Research and Development Institute (KORDI), South Korea
45. Korea Water Resources Corporation, South Korea
46. Lab Domaines Oceanique IUEM/UBO France
47. Laboratoire de Sciences de la Terre, France
48. Marine Sciences For Society, France
49. Ministry of Earth Sciences, India
50. Nanjing Hydraulics Research Institute, China
51. National Institute of Water and Atmospheric Research (NIWA), Auckland, New Zealand
52. National Research Institute of Science and Technology for Environment and Agriculture (CEMAGREF became IRSTEA), France
53. National Institute for Space Research (INPE), Brazil
54. National Institute of Oceanography (NIO), India
55. National Institute of Technology Rourkela, Orissa, India
56. National Institute of Technology Karnataka Surathkal, Mangalore, India
57. National Institute of Water and Atmosphere (NIWA), New Zealand
58. National Marine Environmental Forecasting Center (NMEFC), China
59. National Research Centre for Sorghum (NRCS), India
60. National Research Council (NRC), Italy
61. National Space Research & Development Agency, Nigeria
62. Scientific-Applied Centre on hydrometeorology & ecology, Armstatehydromet, Armenia
63. Senckenberg Institute, Germany
64. Shenzhen Inst. of Advanced Technology, China
65. South China Sea Institute of Technology (SCSIO), Guanzhou, China
66. The European Institute for Marine Studies (IUEM), France
67. The Leibniz Institute for Baltic Sea Research, Germany
68. UNESCO-IHE, Netherlands
69. Water Resources Division, Dept. of Indian Affairs and Northern Development, Canada
70. World Weather Information Service (WMO), Cuba

Independent Researchers (both U.S. and Foreign): **31** members self-identify either as independent researchers or left their affiliation unknown.

Membership Maps Feb 2013

Map
Satellite
Norway
Finland
Baltic Sea
Estonia
Latvia
North Sea
Lithuania
Ireland
Belarus
Poland
Ukraine
Austria
Romania
Serbia
Black Sea
Georgia
Caspian Sea
Spain
Greece
Turkey
Syria
Iraq
Iran
Tunisia
Mediterranean Sea
Morocco
500 km
200 mi
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North Atlantic Ocean
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Tunisia
Mediterranean Sea
Iraq
Iran
Algeria
Libya
Egypt
Saudi Arabia
Western Sahara
Mauritania
Mali
Niger
Chad
Sudan
Yemen
Gulf of Aden
Cuba
Puerto Rico
Nicaragua
Venezuela
Guyana
Suriname
Colombia
Ecuador
Peru
Brazil
Bolivia
Paraguay
Guinea
Gulf of Guinea
South Sudan
Ethiopia
Somalia
Gabon
DR Congo
Tanzania
Angola
Zambia
Mozambique
Namibia
Zimbabwe
Botswana
Madagascar
South Atlantic Ocean
South Africa
2000 km
1000 mi
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Bay of Bengal
Andaman Sea
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China
South Korea
Sea of Japan
East China Sea
South China Sea
Philippines
Vietnam
North Pacific Ocean
Banda Sea
Arafura Sea
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Appendix 2: 2013 CSDMS Annual Meeting Abstracts (Keynotes and Posters)

Numerical modeling of turbulence and sediment transport in lateral recirculation zones along the Colorado River in Grand Canyon

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A number of two- and three-dimensional models are currently available to calculate sediment transport and channel change in rivers. These three-dimensional models rely on time-averaging and parameterization of the turbulence. Available depth-averaged, two-dimensional models also rely on simple boundary stress closures. In relatively simple channels these models have predictive capability, but they often perform poorly when there is large-scale flow separation or when secondary circulation is strong. Sharp meanders, channel constrictions, many engineering structures, vegetation, and certain types of bedforms all cause flow separation, secondary circulation, and free shear layers. Turbulence-resolving flow and sediment transport models may do better at predicting channel change in complex channels, but at a substantially larger computational cost. With parallelization, turbulence-resolving models can now be developed and applied to refractory fluvial morphodynamic problems.

Detached-Eddy Simulation (DES) is a hybrid large eddy simulation (LES) and Reynolds-averaged Navier Stokes (RANS) method. RANS is applied to the near-bed grid cells, where grid resolution is not sufficient to fully resolve wall turbulence. LES is applied further from the bed and banks. A one equation turbulence closure model with a wall-distance dependence, such as that of Spalart and Allmaras (SA), is ideally suited for the DES approach. The rough wall extension of the SA model is utilized herein. Our river DES numerical modeling system was developed in OpenFOAM. The model resolves large-scale turbulence using DES and simultaneously integrates the suspended sediment advection-diffusion equation, wherein advection is provided by the DES velocity field minus particle settling, and diffusion is provided by the sub-grid or RANS eddy viscosity. As such, turbulent suspension throughout most of the flow depth results from resolved turbulent motions. A two-dimensional, depth-averaged flow model, also written in OpenFOAM, determines the local water surface elevation. A separate program was written to automatically construct the block-hexagonal, computational grid between the calculated water surface and a triangulated surface of a digital elevation model of the given river reach. Domain decomposition of the grid is employed to break up the integration between multiple processors, and Open MPI provides communication between the processors. The model has shown very good scalability up to at least 128 processors.

Results of the modeling system will be shown of flow and suspended sediment model in lateral separation eddies in the Colorado River in Grand Canyon. The eddy recirculation zones exist downstream of channel constrictions from tributary debris fans. The modeling system is currently being developed and validated to be used in designing discharges from Glen Canyon Dam for the preservation of sandbar beaches, which are critical habitat for endangered fish.

HydroDesktop and the CUAHSI Hydrologic Information System

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This presentation or poster will discuss the latest developments of the CUAHSI Hydrologic Information System including 1) the new open source server components built using PHP and MySQL specifically to support citizen science; and 2) the desktop application HydroDesktop with its extensions for search and discovery of data on the 100 servers of the CUAHSI data network. The presentation or poster will include a discussion of the potential integration of HIS data sources in CSDMS modeling efforts and potential for integration of the CSDMS modeling architecture with the HydroDesktop client application.

The effects of interannual climate variability on the extraction of climate estimates from glacial moraines

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Robert S. Anderson, *University of Colorado Department of Geological Sciences and INSTAAR Boulder Washington, United States*. robert.s.anderson@colorado.edu

In most mountainous regions reconstructed glacial histories are the primary record of past climate and are typically based on unsorted accumulations of debris (moraines) deposited at the terminus of glaciers. Former glacier geometries—

preserved as moraines and trim lines— are the primary constraint for extracting paleoclimate estimates using either equilibrium-line altitudes or numerical glacier models.

It is an implicit assumption in the glacial geology community that terminal moraines were formed by glaciers responding to the mean value of summer temperature and winter precipitation at the time of formation. In reality glacier termini oscillate around a mean glacial length even in a steady climate, defined by a constant mean and constant standard deviation. These length oscillations are driven by the alignment of more negative (positive) periods of mass balance that arise out of random year-to-year climate variability. Because glaciers that override moraines almost always destroy them, the furthest terminal moraines from the headwall during the time period of interest represent the maximum excursion of the glacier from its mean length. This implies that paleoclimate estimates based upon the furthest terminal moraine are actually maximum estimates of climate change.

We use a linearized glacier model developed by Roe and O'Neal (2009) to determine the mean length of eleven Last Glacial Maximum (LGM) glaciers in the northern Front Range, Colorado. Mean glacier lengths during the LGM were ~15% upvalley from the LGM terminal moraines. In the Colorado Front Range estimating LGM paleoclimate from the furthest terminal moraine rather than the mean length adds an extra ~1°C temperature change or an additional 25% increase in precipitation to estimate of differences from the modern climate. Furthermore, it is possible that 'recessional' moraines were formed by length oscillations driven by interannual variability.

On a Neck, On a Spit

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Recurved barrier spits occur in a wide variety of environments, from active delta complexes to rocky coasts, where spits extend depositionally from a shore that is otherwise eroding. Although controls on spit orientation are often presented in the literature a posteriori (i.e. after the spit has been observed), there surprisingly remains no general model that predicts spit shape and orientation in terms of external variables, such as wave climate, sediment supply, and embayment depth. We study spit shape controls using the Coastline Evolution Model (CEM), a numerical model that evolves the plan-view coast based upon the processes of alongshore sediment transport and barrier overwash maintaining a minimum critical barrier width. Model results demonstrate that the directional distribution of approaching waves serves as a first-order control on spit shape, with waves from multiple directions playing a vital role in spit extension and reshaping. Surprisingly, we find that boundary effects, namely the rate of change of the updrift coast location, play a similarly important role in spit shape. The depth of the platform upon which a spit grows plays another important role, with deeper platforms tending to accommodate more sharply curved spits. Every day, spits act as a type of messenger in disguise, revealing wave forcing, sediment supply, and local geometry.

Landscape evolution models and stream piracies phenomena

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On earth, landscape morphology is mainly controlled by rivers evolutions and their interactions with hillslopes. But hydrographic network may be re-organized by stream capture and modify deeply the relief. This transition may be induced by several mechanisms (diversion, headward erosion, avulsion, or subterranean filling up). It has interested numerous scientists since a long time (Davis 1895, Blache 1943, Lesson-Quinif 2001 & Le Roux-Harmand 1997-2009…). Here we focus on stream piracies by headward erosion, when an actively eroding low level stream (called the captor) encroaches on the drainage of a nearby stream flowing at a higher level (called the diverter) and diverts part of the water of the higher stream. During the last decades, several landscapes evolution models (LEM) have been developed to quantify the topography evolution with diffusion and advection equations. These models play an important role in sharpening our thinking to better understand the interaction between landscape evolution processes. LEM were developed basically to simulate erosion, tectonic and climate at different scales of time and space. But, these models were not designed to describe specific mechanisms as the stream capture. It's one of the aims of this work to evaluate LEM for this purpose. In this paper, we develop a 1D model based on LEM equations to investigate the stream piracy by headward erosion responses to climatic or tectonic changes. This model incorporates the most common equations used in quantitative geomorphology; diffusion in hillslope, advection in river (detachment-limited mode) and an inequality based on slope and drainage area for the limit between these two domains (Montgomery and Dietrich, 1988). First, simulations on analytical cases highlight the stream head progression mechanism, and the results indicate that this progression rate is mainly controlled by the slope at the captor source. Consequently, the aggradation of the diverter or (and) the incision of the captor accelerate the process. Then, a predictive study with an improved version of GOLEM (software developed by Tucker & Slingerland in 1994) on the Meuse basin shows that several piracies may probably occur in the future. A comparison with the 1D model gives similar results. The simplicity and the flexibility of the 1D model allow complex simulations in the Meuse basin taking into account: lithological differences of outcropping layers, Meuse deposition tendency, etc. Once the 2D simulations or topography analysis locate potential captures, 1D simulation may intensively be used, as it presents many advantages; weak execution time, simple limits conditions setting, less time for data preparation, etc. Consequently, a sensitivity analysis to estimate piracies ages is realized with the developed 1D model.

A morphodynamic link between grain size and delta morphology

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Delta morphology is traditionally explained by differences in fluvial energy and wave and tidal energy. However, deltas influenced by similar ratios of river to marine energy can display strikingly different morphologies. Other variables, such as grain size of the sediment load delivered to the delta, influence delta morphology, but these models are largely qualitative leaving many questions unanswered. To better understand how grain size modifies deltaic processes and morphologies we conducted 33 numerical modeling experiments using the morphodynamic physics-based model Delft3D and quantified the effects produced by different grain sizes. In these 33 runs we change the median (0.01 – 1 mm), standard deviation (0.1 – 3 φ), and skewness (-0.7 – 0.7) of the incoming grain-size distribution. The model setup includes a river carrying constant discharge entering a standing body of water devoid of tides, waves, and sea-level change. The results show that delta morphology undergoes a transition as median grain size and standard deviation increase while changing skewness has little effect. At low median grain size and standard deviation, deltas have elongate planform morphologies with sinuous shorelines characterized by shallow topset gradients ranging from 1×10^{-4} to 3×10^{-4}, and 1 - 8 stable active channels. At high median grain size and standard deviation, deltas transition to semi-circular planform morphologies with smooth shorelines characterized by steeper topset gradients ranging from 1×10^{-3} to 2×10^{-3}, and 14 - 16 mobile channels. The change in delta morphology can be morphodynamically linked to changes in grain size. As grain size increases delta morphology transitions from elongate to semi-circular because the average topset gradient increases. For a given set of flow conditions, larger grain sizes require a steeper topset gradient to mobilize and transport. The average topset gradient reaches a dynamic equilibrium through time. This requires that, per unit length of seaward progradation, deltas with steeper gradients have higher vertical sedimentation rates. Higher sedimentation rates, in turn, perch the channel above the surrounding floodplain (so-called 'super-elevation') resulting in unstable channels that frequently avulse and create periods of overbank flow. That overbank flow is more erosive because the steeper gradient causes higher shear stresses on the floodplain, which creates more channels. More channels reduce the average water and sediment discharge at a given channel mouth, which creates time scales for mouth bar formation in coarse-grained deltas that are longer than the avulsion time scale. This effectively suppresses the process of bifurcation around river mouth bars in coarse-grained deltas, which in turn creates semi-circular morphologies with smooth shorelines as channels avulse across the topset. On the other hand, finest-grained (i.e. mud) deltas have low topset gradients and fewer channels. The high water and sediment discharge per channel, coupled with the slow settling velocity of mud, advects the sediment far from channel mouths, which in turn creates mouth bar growth and avulsion time scales that are longer than the delta life. This creates an elongate delta as stable channels prograde basinward. Deltas with intermediate grain sizes have nearly equal avulsion and bifurcation time scales, creating roughly semi-circular shapes but with significant shoreline roughness where mouth bars form.

A volume of fluid method for bank erosion in Delft3D

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Rudy Slingerland, *Penn State University University Park Pennsylvania, United States*. sling@geosc.psu.edu

By using a fixed-mesh approach, morphodynamic models have some difficulty to predict realistic equilibrium hydraulic geometries with vertical banks. In order to properly account for bank erosion without resorting to a complicated moving mesh algorithm, an immersed boundary approach that handles lateral bank retreat through fix computational cells is needed. One of the main goals of the FESD Delta Dynamics Collaboration is developing a tested, high-resolution quantitative numerical model to predict the coupled morphologic and ecologic evolution of deltas from engineering to geologic time scales. This model should be able to describe the creation and destruction of deltas made of numerous channels, mouth bars, and other channel-edge features, therefore requiring an approach that is able to deal with the disruption, destruction, and creation of sub-aerial land. In principle, these sub-aerial land surfaces can be randomly distributed over the computational domain. We propose a new approach in Delft3D based on the volume of fluid algorithm, widely used in the literature for tracking moving interfaces between different fluids. We employ this method for implicitly tracking moving bank interfaces. This approach easily handles complicated geometries and can easily tackle the problem of merging or splitting of dry regions characterized by vertical vegetated banks.

Cross-shore and Vertical Distribution of Turbulence Kinetic Energy in the surf zone generated by plunging breakers.

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Breaking waves, especially plunging breakers, generate intense turbulence and is crucial in dissipating incident wave energy, suspending and transporting sediment in the surf zone. Therefore quantifying breaking-induced turbulence kinetic energy (TKE) is essential in understanding surf zone processes. Surf zone hydrodynamic data collected at the Large-scale Sediment Transport Facility (LSTF) at the U.S. Army Engineer Research and Development center were used here. One LSTF case, with irregular waves (3 s peak period), is examined here. This case resulted in dominantly plunging type of breaker. Waves and currents were measured simultaneously at 10 cross-shore locations and throughout the water column, with a sampling rate of 20 Hz. In order to separate orbital wave motion from turbulent motion, an adaptive moving average filter is developed, involving a 5-point moving average, with additional 3-point moving average at sections with more fluctuations. This adaptive moving average filter is able to maintain more wave energy as compared with the results from 7-point moving average, while resolve more turbulence energy as compared with the result from 5-point moving average.

Biologic-Geomorphic feedbacks that sculpt tidal landscapes

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Tidal systems are biogeomorphic systems of great relevance, providing important ecosystem services and coastline protection against storms. The dynamics of these systems, currently threatened by the acceleration in the rate of global sea level rise (SLR) and the decrease in sediment supply, are governed by complex interactions between hydrological, ecological, and geomorphological processes. How do salt-marsh ecosystems respond to changes in the environmental forcings? What is the role physical and biological processes and of their interactions through eco-geomorphic feedbacks in controlling salt-marsh dynamic response to these changes and the existence of possible equilibrium states? To address these important issues and improve our understanding of the chief eco-geomorphic processes controlling salt-marsh response to current changes, we have developed a suite of eco-morphodynamic models accounting for complex two-way interactions between ecological and geomorphological processes. We find that vegetation crucially affects the equilibrium marsh elevation, marsh resilience to accelerations in SLR rates, and the morphological features of salt marsh channels. As soon as the platform is colonized by vegetation, plants crucially affect the local hydrodynamic circulation, favor channel incision, enhance particle settling by a reduction of turbulence levels within the canopy, promotes trapping sediment, and provides organic material. Model results suggest that highly productive and sediment-rich marshes will approach new equilibrium states in response to changes in the rate of SLR faster than sediment-poor or less productive marshes. Moreover, marshes exposed to large tidal ranges are more stable, and therefore more resilient to changes in the rate of SLR, than their microtidal counterparts. We also find that marshes are more resilient to a decrease rather than to an increase in the rate of SLR, and they are more resilient to a decrease rather than to an increase in sediment availability. Our modeling approaches emphasize that biological and physical interactions are crucial in determining the observed spatial patterns in the biological and in the geomorphic domains. The existence of feedbacks between physical and biological processes affects the evolutionary trajectories of saltmarsh ecosystems, and the reversibility of such trajectories, thus highlighting the importance of accounting for biogeomorphic feedbacks to obtain realistic representations of the system dynamics in response to climatic changes.

Modeling The Isotopic "Age" of Water in Hydroecological Systems

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Theories have been proposed using idealized tracer age modeling for ocean ventilation, atmospheric circulation, soil, stream and groundwater flow. In this research we developing new models for the dynamic age of water in hydroecological systems. Approaches generally assume a steady flow regime and stationarity in the concentration (tracer) distribution function for age, although recent work shows that this is not a necessary assumption. In this paper a dynamic model for flow, concentration, and age for soil water is presented including the effect of macropore behavior on the relative age of recharge and transpired water. Several theoretical and practical issues are presented.

DAKOTA: An Object-Oriented Framework for Simulation-Based Iterative Analysis

Michael S. Eldred, Sandia NL

The DAKOTA project began in 1994 with the primary objective of reusing software interfaces to design optimization tools. Over nearly 20 years of development, it has grown into an open source toolkit supporting a broad range of iterative analyses, typically focused on high-fidelity modeling and simulation on high-performance computers. Today, DAKOTA provides a delivery vehicle for uncertainty quantification research for both the NNSA and the office of science, enabling an emphasis on predictive science for stockpile stewardship, energy, and climate mission areas.

Starting with an overview of the DAKOTA architecture, this presentation will introduce processes for setting up iterative analyses, interfacing with computational simulations, and managing high-fidelity workflows. Algorithmic capabilities in optimization, calibration, sensitivity analysis, and uncertainty quantification (UQ) will be briefly overviewed, with special emphasis given to UQ. Core UQ capabilities include random sampling methods, local and global reliability methods, stochastic expansion methods, and epistemic interval propagation methods. This UQ foundation enables a variety of higher level analyses including design under uncertainty, mixed aleatory-epistemic UQ, and Bayesian inference.

Implications of land-cover changes caused by sea-level rise on hurricane storm surge damage

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Hurricanes are one of the most costly natural disasters impacting US coastal areas. Recent studies point towards an increase in damages caused by hurricanes, resulting from sea-level rise (SLR), possible hurricane intensification due to a warmer climate and increasing coastal populations. The SLR is one of the most significant factors of climate change that will impact coastal areas. Besides geometrical changes in coastal bays (i.e., deeper water depth and larger surface area), SLR is also expected to have substantial impacts on the patterns and process of coastal wetlands, thereby affecting surge generation and propagation inside the bays. We analyzed the impacts of SLR on hurricane storm surges, structural building damage, and population and businesses affected for coastal bays located on the Texas central coast. To evaluate the effects of SLR on surges, we considered its impacts on changes in land cover and bay geometry caused by SLR. The analyses were conducted using the hydrodynamic model ADCIRC and a wind and pressure field model (PBL) representing the physical properties of historical hurricane Bret and hypothetical storms. The effects of land cover change were represented within ADCIRC by the changes in the frictional drag at the sea bottom and changes in momentum transfer from the wind to the water column caused by vegetation losses. Simulations were performed using a high-resolution unstructured numerical mesh to study surge response in communities along the coastal bays of Texas. First, we evaluated the impacts of land cover changes due to SLR on the surge response. Second, we evaluated the impacts of neglecting land cover changes due to SLR on the surge response. Finally, we evaluated the overall effect of SLR on the mean maximum surge and the consequent extent of the flooded areas. Although the overall impacts of SLR on surge (i.e.: water elevation above mean water level) are highly dependent on storm conditions and specific locations within the study area, we showed that the mean maximum surge (spatial average within each bay) increases with SLR. The overall mean maximum surge within the study area increased on average approximately 0.1 m (SLR of 0.5 m) and 0.7 m (SLR of 2.0 m). Simulations neglecting land cover changes due to SLR did significantly underestimate the expected structural damage for buildings. This difference increased with SLR and was affected by the storm meteorological conditions. Stronger and faster storms were associated with higher underestimation. Although considering land cover changes resulted in an overall damage increase, for SLR below 0.5 m, this increase was almost negligible. As a result, the land cover changes arising from SLR are important for damage estimation considering SLR scenarios over at least 0.5 m. For example, when considering a SLR of 0.6 m, based on the Intergovernmental Panel on Climate Change's (2007) high emission scenario, we demonstrated a 10% increase in building structural damage. The assimilation of land cover changes is especially important when calculating expected damages from high SLR scenarios. If a SLR of 2.0 m is assumed, a 35% increase in the expected structural damage to buildings is estimated. In summary, the changes in coastal bay geometry and land cover caused by SLR play an important role in the resulting surge response. The variability of the surge response is also greatly affected by location and the characteristics of the storm.

2D modelisation of non-hydrostatic internal waves on idealised embankment

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An Isopycnic Coordinate Ocean Model is used to represent the propagation of internal tides in the Bay of Biscay and their desintegration into solitons. To model important vertical variability of the thermocline, such as solitons, a non-hydrostatic model is necessary. In this study, we test the possibility of integrated non-hydrostatics terms under weakly nonlinear and nonhydrostatic approximation. Non-hydrostatic terms derived with this assumption, are directly added to the hydrostatic equations. We then address numerical problems : mesh size limitation responsible for numerical dispersion, numerical instabilities. After having investigated these problems analytically and tested the limitation, a stable method is proposed. Results for a 2D idealised configuration of the Bay of Biscay is described : the model is forced by the semi-diurnal tidal wave M2, two layers of different density are considered. The internal waves is desintegrated into solitons after few tidal periods.

Combining Observations and Numerical Model Results to Improve Estimates of Hypoxic Volume Within the Chesapeake Bay

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The overall size of the Chesapeake Bay "dead zone" is quantified by the Bay's hypoxic volume (HV), i.e., the volume of water with dissolved oxygen (DO) less than 2 mg/L. In order to improve estimates of HV, DO was subsampled from the output of three dimensional model hindcasts at times/locations matching the set of 2004-2005 stations monitored by the Chesapeake Bay Program. The resulting station profiles were then input into an interpolation program to produce Bay-wide estimates of HV in a manner consistent with non-synoptic, cruise-based estimates. Interpolations of the same stations sampled synoptically as well as multiple other combinations of station profiles were examined in order to quantify uncertainties associated with interpolating HV from observed profiles. The potential uncertainty in summer HV estimates resulting from profiles being collected over two weeks rather than synoptically, averaged ~5 km^3. This is larger than that due to sampling at discrete stations and interpolating/extrapolating to the entire Bay (2.4 km^3). As a result, sampling fewer, selected stations over a shorter time period is likely to reduce uncertainties associated with interpolating HV from observed profiles. A function was also derived, that, when applied to a subset of 13 stations, significantly improved estimates of HV. Finally, multiple metrics for quantifying Bay wide hypoxia were examined, and cumulative hypoxic volume was determined to be particularly useful, as a result of its insensitivity to temporal errors and climate change. A final product of this analysis is a nearly three-decade time series of improved estimates of HV for Chesapeake Bay.

Landlab: a component-based software modeling environment for computational Earth-surface processes modeling

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The Landlab project creates an environment in which scientists can build a numerical landscape model without having to code all of the individual components. Landscape models compute flows of mass, such as water, sediment, glacial ice, volcanic material, or landslide debris, across a gridded terrain surface. Landscape models have a number of commonalities, such as operating on a grid of points and routing material across the grid. Scientists who want to use a landscape model often build their own unique model from the ground up, re-coding the basic building blocks of their landscape model rather than taking advantage of codes that have already been written. Whereas the end result may be novel software programs, many person-hours are lost rewriting existing code, and the resulting software is often idiosyncratic and not able to interact with programs written by other scientists in the community. This individuality in software programs leads to lost opportunity for exploring an even wider array of scientific questions than those which can be addressed using a single model. The Landlab project seeks to eliminate these redundancies and lost opportunities by creating a user- and developer-friendly numerical landscape modelling environment which provides scientists with the fundamental building blocks needed for modeling landscape processes. The Landlab will include a number of independent, interoperable components such as (1) a gridding engine to handle both regular and unstructured meshes, (2) an interface for space-time rainfall input, (3) a surface hydrology component, (4) an erosion-deposition component,

(5) a vegetation dynamics component and (6) a simulation driver. The components interface with each other using the basic model interface (BMI) and will be fully compatible with the CSDMS Modeling Toolkit. Users can design unique models simply by linking together already-built components into a "new" landscape model within the landlab environment. Alternatively, users can design new landscape models by creating process components that are specialized for individual studies and linking these new components with preexisting Landlab components.

Exploring the mechanisms that control valley spacing in higher order fluvial channels with the CHILD Model

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Previous studies have found that the ratio between valley spacing and mountain range width is relatively constant across the globe, but the processes responsible for its uniformity are not well understood. To determine the reasons for this uniform ratio, we firstly need to explore why valleys are evenly distributed in a mountain range, and what factors can impact valley spacing. Recent research has found that the critical length between hillslope and fluvial processes is an important control on the valley spacing of first order fluvial channels. In this study, we use the CHILD landscape evolution model to explore how the critical length affects valley spacing in higher order fluvial channels, and we use these results to help explain the narrow range of observations in the valley spacing ratio. We find that valley spacing has a linear relationship with critical length in higher order channels and, for a given order channel, the ratio between valley spacing and critical length is relatively constant. This relationship demonstrates that the competition between hillslope and fluvial processes influences the distribution of higher order channels across the landscape. However, we also find that valley spacing is influenced by model initial conditions and variability across the landscape, such as orographic precipitation patterns. Moreover, for a fixed domain in our model, although the critical length may vary, the ratio between the valley spacing of trunk channels and mountain width remains in the range observed in real landscapes. The reason for this is that the order of trunk channels varies with the critical length. Therefore, for a given domain size (or mountain range width), a larger critical length can produce lower order trunk channels but with the same spacing value as higher order trunk channels with a smaller critical length. This may be one of the reasons why the spacing ratio is relatively constant across diverse natural settings.

Linking Sediment Transport Processes and Biogeochemistry with Application to the Louisiana Continental Shelf

Courtney Harris, VIMS

Though it enhances the exchange of porewater and solids with the overlying water, the role that sediment resuspension and redeposition play in biogeochemistry of coastal systems is debated. Numerical models of geochemical processes and diagenesis have traditionally parameterized relatively long timescales, and rarely attempted to include resuspension. Meanwhile, numerical models developed to represent sediment transport have largely ignored geochemistry. Here, we couple the Community Sediment Transport Modeling System (CSTMS) to a biogeochemical model within the Regional Ocean Modeling System (ROMS). The multi-layered sediment bed model accounts for erosion, deposition, and biodiffusion. It has recently been modified to include dissolved porewater constituents, particulate organic matter, and geochemical reactions.

For this talk, we explore the role that resuspension and redeposition play in biogeochemical cycles within the seabed and in benthic boundary layer by running idealized, one-dimensional test cases designed to represent a 20-m deep site on the Louisiana Shelf. Results from this are contrasted to calculations from an implementation similar to a standard diagenesis model. Comparing these, the results indicate that resuspension acts to enhance sediment bed oxygen consumption.

Land Subsidence at Aquaculture Facilities in the Yellow River Delta, China

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While many researchers have mapped and tracked coastal erosion in the Yellow River Delta, determining its cause has proven nearly impossible, because myriad natural and anthropogenic processes are simultaneously affecting the delta. These processes include reduced sediment supply, reduced river discharge, changing tide and current patterns, new seawalls, groundwater withdrawal, substrate compaction, oil extraction, burgeoning urban centers, and rising sea level. Here, we use Interferometric Synthetic Aperture Radar (InSAR) to map surface deformation in the delta between the years 2007 and 2011. We find that rapid, localized subsidence of up to 22 cm/y is occurring along the coast, apparently related to groundwater extraction at aquaculture facilities. This finding has important consequences for the sustainability of the local aquaculture industry. Similar subsidence may also be occurring in deltas like the Mekong, though these signals may be difficult or impossible to measure.

Exploring Models

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When we build models we create worlds that we hope will inform us about the world in which we live. We hope models will help us understand processes, causes and effects; avoid difficulties; benefit human endeavors; and accommodate and nurture the ecology which has its own beauty and importance, and upon which human existence and our economy depend. Here we discuss how models can be used to achieve these goals by considering the importance of transparency (revealed importance) and refutability (tested hypotheses). We consider models with substantial execution times (for our example one model run requires 20 minutes) and transparency and refutability available using computationally frugal methods. Challenges of using these methods include model nonlinearity; non-Gaussian errors and uncertainties in observations, parameters, and predictions; and integrating information from multiple data types and expert judgment. A synthetic test case illustrates the importance of transparency and refutability in model development. The test case represents transport of an environmental tracer (cfc) and contaminant (pce) in a groundwater system with large-scale heterogeneities. Transparency is served by identifying important and unimportant parameters and observations. The frugal methods identified consistently important and unimportant parameters for three sets parameters for which sum of squared weighted residuals (SOSWR; dimensionless; constructed with error-based weighting) varies between 5606 and 92. Observations important to the parameter values are largely consistent, but the order varies for results using different parameter values because of model nonlinearity. For each set of parameters these results required 17 model runs. Refutability is served by estimating parameter values that minimize SOSWR and evaluating resulting model fit and parameter values. The computationally frugal parameter-estimation method reduced SOSWR from 5606 to 92, displayed no evidence of local minima, and required about 100 model runs each of the 10 times it was executed. The similar important parameters and observations for different parameter sets and performance of parameter estimation suggest the utility of the computationally frugal methods even for models as nonlinear as the one considered here. The value of the kinds of insights gained in this work is highlighted by the 10,000s to 1,000,000s of model runs being conducted in many studies to obtain them.

Insights into late Quaternary events on the Beaufort Shelf and Slope from sea level and stratigraphic modeling

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Notice: Kim Picard is 1st author; Phil Hill 2nd author; Andrew Wickert 3rd author This work aims to improve the late Quaternary stratigraphic framework for the outer shelf and slope of the Beaufort Sea and to assist in the assessment of geohazards, particularly those related to slope instability. Slope failures have been identified on the upper slope, but the age and triggers of slope failure are poorly understood. Existing conceptual models of late Quaternary stratigraphy of the Beaufort shelf and slope are quite generalized and based on a poorly constrained relative sea level curve. Sea level and stratigraphic modeling are used to test the relationships between glaciation, sea level and sedimentation. The results of the work suggest that glacio-isostatic effects cause the relative sea level (RSL) curve to vary significantly across the Beaufort Shelf particularly in the cross-shelf direction. Stratigraphic modeling with a variable RSL input successfully reproduces depositional patterns in the Mackenzie Trough including distinctive highstand and lowstand wedges and a retrogradational transgressive systems tract. However on the eastern shelf, more pronounced isostatic depression is required to match the known stratigraphy, suggesting deviation from the assumed ice loads or crustal properties in the model. Two outburst floods documented to have occurred in the region would have had a marked effect on shelf edge and slope sedimentation. Modeling suggests significant progradation of the shelf edge and rapid deposition on the slope and outer shelf at lowstand and in the early stage of transgression.

Combined Effects of Climate Change and Urbanization on Cohesive Streambank Erosion

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Urbanization and global climate change will severely stress our water resources. One potential unforeseen consequence of these stressors, which is neglected in channel evolution models, is accelerated stream channel erosion due to change in stream water temperature, pH and salinity which affect the surface potential and hence stability of soil colloids. Summer thunderstorms in urban watersheds can increase stream temperature >7 °C and the impact of global warming on average stream temperature is already evident in some stream systems. Initial estimates indicate a 2 °C rise in stream temperature could increase erosion by 30%. Urbanization has significant effects on the pH and salinity of stormwater runoff and as a result on the water quality of headwater streams. Channel erosion and the resulting sediment pollution threaten the sustainability of water resources and urban infrastructure. The goal of this research is to assess the impact of changes in stream water temperature, pH and salinity on stream channel erosion rates and to explore changes in the electrical surface potential of clay colloids as a potential soil stability mechanism. This exploratory research utilizes two reference clays with different permanent surface charges: montmorillonite, and vermiculite. Samples will be eroded in a recirculating sediment flume to determine soil critical shear stress and erodibility. Three water temperatures (12 °C, 20 °C, 27 °C), two pH (5 and 7), and two salinity levels (5 and 50 mg/l NaCl) will be analyzed. Three replicates of each treatment will be conducted for each clay. Additionally, the zeta potential of the clays will be determined under each condition. Research has demonstrated that variations in zeta potential affect liquid limit and shear stress of soil colloids. Results of this research could lead to a reassessment of stream channel stability modelling in urban watersheds and a paradigm shift in urban stormwater management.

Simulating Fine-grained Alluvial Fan Sedimentation

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The majority of process studies on alluvial fans have focused on gravely fans. Many fan systems, however, are sourced from basins composed of fine-grained sediments. Deposition on such fans involves deposition from hyperconcentrated- or mud-flows. Many of such fans occur where there is sufficient vegetation to affect and, often, obscure depositional processes.

The modeling effort to be presented is motivated by the occurrence of fine-grained alluvial fans on Mars that feature a network of distributaries floored with coarser sediment and what we interpret to be fine-grained overbank deposits that comprise the bulk of the sediment. We have identified active fine grained fans in the arid Atacama desert deriving sediment from the higher Andes and lowland deposition dominated by muddy sheetflow sediment.

We are constructing a simulation model for deposition on such fans based on the fan-delta model of Sun et al. (2002). The model routes water and sediment through multiple distributaries that can branch, recombine, and avulse. Modeling flow and bedload sediment through the distributaries is relatively straightforward, but overbank deposition and avulsion processes are more problematic to characterize realistically (e.g. avoiding development of "holes" in fans or preventing evolution to a fixed distributary pattern). Our observation of overbank processes on the Atacama fans demonstrates the importance of sedimentation by long shallow sheetflow floods in addition to local levee aggradation. These processes are being implemented into our fan model.

Data Services for Long Tail Science at the Integrated Earth Data Applications (IEDA) Data Facility

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IEDA (Integrated Earth Data Applications, www.iedadata.org) is a data facility funded through a contract with the US National Science Foundation to operate data systems and data services for solid earth geoscience data. There are many similarities between IEDA and its community of data producers and users and CSDMS and its community of model creators and users. IEDA has developed a comprehensive suite of data services that are designed to address the concerns and needs of investigators, especially researchers working in the 'Long Tail of Science' (Heidorn 2008). IEDA provides a data publication service, registering data sources (including models) with DOI to ensure their proper citation

and attribution. IEDA works with publishers on advanced linkages between datasets in the IEDA repository and scientific online articles to facilitate access to the data, enhance their visibility, and augment their use and citation. IEDA also developed a comprehensive investigator support that includes tools, tutorials, and virtual or face-to-face workshops that guide and assist investigators with data management planning, data submission, and data documentation. A relationship between IEDA and CSDMS benefits the scientists from both communities by providing them with a broader range of tools and data services.

Model-Assisted River Discharge Estimates

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Often a rivers discharge is calculated by constructing an empirical relationship between concurrent, direct measurements of river stage and discharge. In many remote parts of the world however technical and logistical challenges make building of such relationships difficult.

We test and present an alternative approach for use in remote Greenlandic Rivers. We used in-situ stage observations, but converted these measurements into estimates of discharge using a fluid mechanically based model (Kean and Smith, 2005; Kean et al., 2009; Kean and Smith, 2010). We first tested this approach against the one river in Greenland with a well-developed empirical stage- discharge relationship. Modeled relationships agreed well with the empirically derived relationship. We then used this same technique to aid in estimating discharge on two additional rivers in Greenland where only stage measurements were available. This technique presents an alternative option when other methods are logistically prohibitive. In the future this approach may also be useful to aid in estimating river discharge from space.

The effect of snow: How to better model ground surface temperatures

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We present a method that reconstructs daily snow thermal conductivities using air and ground temperature measurements. The method recovers the daily snow thermal conductivities over the entire snow season. By using reconstructed snow conductivities we can improve modeling of ground surface temperatures. Simulation of the ground surface temperatures by using changing in time snow thermal conductivities could potentially reduce ground temperature modeling uncertainty. The developed method was applied to four permafrost observation stations in Alaska. Reconstructed snow thermal conductivity time series for the interior stations in Alaska revealed low conductivity values that reach their maximum towards the end of the snow season, while the northern stations showed high conductivity values that reach their maximum towards the middle of the snow season. The differences in snow conductivities between interior and northern stations are most likely due to wind compaction which is more pronounced in the Northern Arctic lowlands of Alaska.

Globally extensive, Subgrid scale, Seafloor Drag (z0) for Input to Models

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By using spatially-varying estimates of seabed bottom drag (z0) the performance of ocean current and tide numerical models may be improved. To an extent, the seabed database dbSEABED is able to supply these values from data on the seabed materials and features. But then adjustments for varying dynamic (wave, flow) conditions are also required. So the data and model must work closely together. We developed methods for calculating inputs of z0 for circulation models in this way. Preliminary outputs from this new globally capable facility are demonstrated for the NW European Shelf region (NWES).

A vision for EarthCube from the perspective of solid Earth geophysics

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A major challenge of geophysics today is addressing the problems of general interest through intense collaboration that bridges disciplinary boundaries. Such collaborations are greatly complicated by the fact that Earth Sciences have steadily diverged and evolved to the point of the Tower of Babel. Scientific jargon makes it difficult to meaningfully explore ideas across disciplines, while lack of cyberinfrastructure for sharing causes poor reproducibility and code reuse. My vision for an EarthCube frontend is that of a maximally simple API that could be run from any platform or in a browser. At it's core, it would support the following functionality:

1. make it really simple for someone to submit their own data, models and software with provenance and descriptive metadata;
2. support data discovery in 4D space, at a range of scales, through semantically-enabled metadata (and the data might - and will - be stored in one of the existing databases);
3. have potential for elaborate visualization capabilities;
4. build up upon a social network of some sort (so that there's a face behind each data component); and, finally,
5. make it easy to create, modify and run workflows remotely through intelligent combination of software and data components.

The last point seems critical for long term useability of EarthCube, and requires upfront thinking and code coupling capabilities. Specifically, the plug-and-play component programming approach used by CSDMS could be adapted by the larger solid Earth geophysics community with great long-term benefits, hopefully resulting in better scientific reproducibility, code reuse and, eventually, streamlined collaboration.

A 3-D cellular depositional model of platform evolution delivered at fine scale

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Satellite and field observations find modern carbonate depositional systems to be self-organized, yet the processes generating such behavior are not fully understood. A 3-D forward model of carbonate reef growth rooted in cellular automata is developed to simulate the evolution of self-organized geometry through time. Carbonate landscapes are generated over spatial extents of several kilometers through time scales of millennia at meter-scale resolution. Classes in the model include carbonate factories (e.g., branching and massive coral communities, algal communities) and sinks (e.g., unconsolidated sand). Environmental factors include relative sea level and light intensity, and ecological controls are based on life history traits for the biological facies. Ecological processes within the model include mortality and colonization rates for biological classes, transition probabilities between facies, and rates of vertical accretion. The algorithm results in a self-organized landscape that emulates those observed in nature, such as rims and reticulate structures. Visualizations can be produced by accessing topographic and facies maps generated at each time step. This project's goals are 1) to investigate which configurations of environmental parameters result in specific spatial motifs, 2) examine the effects of environmental perturbations on reef construction, and 3) understand the importance of biological and physical regimes on the generation of geomorphological features.

Building a Network for Sediment Experimentalists and Modelers

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In the modeler community, hindcasting (a way to test models based on knowledge of past events) is required for all computer models before providing reliable results to users. CSDMS 2.0 "Moving forward" has proposed to incorporate benchmarking data into its modeling framework. Data collection in natural systems has been significantly advanced, but is still behind the resolution in time and space and includes natural variability beyond our understanding, which makes thorough testing of computer models difficult.

In the experimentalist community, research in Earth-surface processes and subsurface stratal development is in a data-rich era with rapid expansion of high-resolution, digitally based data sets that were not available even a few years ago. Millions of dollars has been spent to build and renovate flume laboratories. Advanced technologies and methodologies in experiment allow more number of sophisticated experiments in large scales at fine details. Joint effort between modelers and experimentalists is a natural step toward a great synergy between both communities.

Time for a coherent effort for building a strong global research network for these two communities is now. First, the both communities should initiate an effort to figure out a best practice, metadata for standardized data collection. Sediment experimentalists are an example community in the "long tail", meaning that their data are often collected in one-of-a-kind experimental set-ups and isolated from other experiments. Second, there should be a centralized knowledge base (web-based repository for data and technology) easily accessible to modelers and experimentalists. Experimentalists also have a lot of "dark data," data that are difficult or impossible to access through the Internet. This effort will result in tremendous opportunities for productive collaborations.

The new experimentalist and modeler network will be able to achieve the CSDMS current goal by providing high quality benchmark datasets that are well documented and easily accessible.

Use of satellite remote sensing to study land surface changes during extreme events

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Satellite remote sensing is a powerful tool for terrestrial hydrological studies. In particular studies of droughts and floods - hydrological extremes can be well accomplished using remote sensing. In particular, we will use data from the visible-infrared and microwave sensors on NASA platforms to studies the onset and propagation of droughts as well as spatial extent of flooding. In this talk we will present numerous examples of hydrological extreme events and the use of satellite remote sensing as a tool for mapping the spatial extent and the temporal persistence. The droughts of 1988 and 2012 in the United States Midwest, flooding in 1993 and 1998 are strong examples in United States. There have been numerous such events in Asia in India, Pakistan and China which have affected billions of people who depend on the land and agricultural productivity to a much greater degree than in United States.

Cellular automata modeling of flow-vegetation-sediment interactions in low-gradient environments

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Cellular automata models have gained widespread popularity in fluvial geomorphology as a tool for testing hypotheses about the mechanisms that may be essential for the formation of landscape patterning. For instance, studies of braided rivers using cellular automata modeling suggested that erodible banks are an essential characteristic for formation of the braid-plain morphology. In wetlands with emergent vegetation and complicated flow patterns, distilling the relevant, nonlinear interactions to a relatively simple set of rules that can be used in cellular automata modeling poses challenges, but the advantage of doing so lies in the ability to perform sensitivity analyses or examine system evolution over millennia. Here I show how a hierarchical modeling strategy was used to develop a cellular automata simulation of the evolution of a regular, parallel-drainage patterned landscape in the Everglades. The Ridge and Slough Cellular Automata Landscape model (RASCAL) suggested that this landscape structure is stable only over a small range of water-surface slopes (the driving variable for flow)—a result that both explains the limited distribution of low-gradient parallel-drainage systems worldwide and would likely have not been detected had a non-hierarchical CAM been used. Additional sensitivity analyses with RASCAL show how interactions between flow, vegetation, and sediment transport can lead to a wide variety of other regular and amorphous landscape patterns, depending on the relative strength of physical and biological feedbacks. Comparisons between RASCAL and well-known CAM models of braided stream dynamics raise interesting questions about the level of complexity that need to be incorporated into models of transitional (low- to high-energy) environments such as wet meadows and small/intermittent streams.

Integrated modeling of coupled flow, transport, and biogeochemical processes in the natural subsurface

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Reactive Transport Modeling (RTM) has been developed in the past decades and used extensively to understand the coupling between fluid flow, diffusive and dispersive transport, and biogeochemical processes in the natural subsurface in a wide range of applications relevant to earth and environmental sciences. Reactive transport modeling solves conservation equations of mass, momentum, and energy. Process-based reactive transport modeling allows the regeneration of spatial and temporal propagation of tightly coupled subsurface processes at spatial scales ranging from single pores (microns) to watershed scales (kilometers). RTM can keep track of evolving porous medium properties including porosity, permeability, surface area, and mineralogical composition. In this presentation I will introduce the general framework of RTM together with its advantages and challenges. The use of RTM at different spatial and temporal scales will be illustrated using two examples. A one-dimensional chemical weathering model for soil formation in Marcellus Shale will illustrate its use in Critical Zone (CZ) processes at the time scales of tens of thousands of years. A two dimensional biogeochemical transport model will exemplify its use in understanding engineered bioremediation processes in natural, heterogeneous porous media at the time scale of months to years.

A simple morphodynamic model of coastal barrier response to rising sea level

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Low-lying coastal barriers face an uncertain future over the next century, with many projections suggesting end-of-century rates of sea-level rise as high as 1 cm/yr. The hazards associated with this passive inundation can be reasonably estimated using state-of-the-art tools. However, the coast is not a bathtub - increased sea levels enhance the ability for waves to reorganize the coast, typically resulting in increased shoreline retreat by moving sediment either offshore into deeper waters or onshore by overwashing the existing coast.

Although many models of coastal change have been developed, the majority are either highly calibrated and intended to operate at the temporal scales of engineering projects (< ~5 years), offering little possibility of forecasting never-seen behaviors such as barrier drowning, or long-term geologic models, which typically assume that the coast maintains an 'equilibrium' configuration that moves with sea level. We aim at bridging the gap between these approaches by constructing a simple model that focuses on dynamical coupling of two primary barrier components: the marine domain represented by the active shoreface, which is constantly affected by transport and reworking by waves, and the backbarrier system, where the infrequent process of overwash controls landward mass fluxes. The model demonstrates that coastal barriers can respond to an accelerated sea-level rise in complex, less predictable manners than suggested by existing conceptual and long-term numerical models. Model behaviors under constant sea-level rise reveal two potential modes of barrier failure: 'height drowning', which occurs when overwash fluxes are insufficient to maintain the landward migration rate required to keep in pace with sea-level rise; and 'width drowning', which occurs when the shoreface response is insufficient to maintain the barrier geometry during landward migration. We also identify a mode of discontinuous barrier retreat, where barriers can experience punctuated intervals of rapid rollover and shoreline stability, even with constant rates of sea-level rise. We explore the sensitivity of these modes to external and internal variables, including sea-level rise rate, maximum overwash rate, shoreface response rate, and inland topography.

Landscape Evolution Models as a Public Education Tool

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At the Visual World Investigation Lab of the Nature Research Center, we are developing a module where museum visitors investigate geomorphic and land-use scenarios through a landscape evolution model. Visitors use touchscreen computers to select simplified inputs for the CHILD model. Model visualizations will be produced for each trial in which they run the scenario. For example, visitors can explore the impact of the percentage of impervious surfaces in a section of urbanized Raleigh that will be adjusted by scaling infiltration parameters, and how the headwaters of the Little Tennessee River would differ if the southern Appalachians were still undergoing tectonic uplift. These scenarios provide relatable experiences to visitors, an opportunity to educate them upon the science behind the scenarios, and the purpose and limitations of models. We will first develop the framework of the module to be able to accept scenarios and its inputs, including digital elevation models, such that others can contribute scenarios. This module is early in its conception, thus we will present our initial framework with the intent to elicit feedback from the community.

Underworld: A high-performance, modular long-term tectonics code

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The Underworld code was designed for solving (very) long timescale geological deformations accurately, tracking deformation and evolving interfaces to very high strains. It uses a particle-in-cell based finite element method to track the material history accurately and highly-tuned multigrid solvers for fast implicit solution of the equations of motion. The implementation has been fully parallel since the inception of the project, and a plugin/component architecture ensures that extensions can be built without significant exposure to the underlying technicalities of the parallel implementation. We also paid considerable attention to model reproducibility and archiving — each run defines its entire input state and the repository state automatically.

A typical geological problems for which the code was designed is the deformation of the crust and lithospheric mantle by regional plate motions — these result in the formation of localised structures (e.g. faults), basins, folds and in the generation of surface topography. The role of surface processes — redistributing surface loads and changing boundary conditions, is known to be significant in modifying the response of the lithosphere to the plate-derived forces. The coupling of surface process codes to Underworld is feasible, but raises some interesting challenges (and opportunities !) such as the need to track horizontal deformations and match changes to the topography at different resolutions in each model. We will share some of our insights into this problem.

Modeling the Upper Little Missouri River flash flood 2010 Using a Coupled Distributed Hydrologic and Hydraulic Model

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Flash floods are among the most devastating natural hazards, which cause loss of life and severe economic damages. Modeling flash floods to provide warnings to the public to prevent/mitigate the impacts of this type of disaster is still challenging. A coupled model which consists of the currently used Hydrology Laboratory - Research Distributed Hydrologic Model (HL-RDHM) at NWS and a high resolution hydraulic model (BreZo) has been developed for flash flood modeling purposes. The model employs HL-RDHM as a rainfall-runoff generator in coarse resolution to produce surface runoff which will be zoned into point source hydrographs at the sub-catchment outlets. With point source input, BreZo simulates the spatial distributions of water depth and velocity of the flow in the river/channel and flood plain. The model was utilized to investigate the historical flash flood event in the Upper Little Missouri River watershed, Arkansas. This event occurred on June 11th, 2010 and had killed 20 people and caused severe property damages. The catchment was divided into 55 sub-catchments based on Digital Elevation Model (DEM) at 10m resolution from USGS. From HL-RDHM surface runoff, 55 hydrographs can be derived, which then become 55 point sources as input in BreZo. The system was calibrated by tuning the roughness parameter in BreZo to best match the USGS discharge observation at the catchment outlet. The simulation results show the system performed very well not only for the total discharge at the catchment outlet (Nash-Sutcliffe efficiency = 0.91) but also the spatial distribution of the flash floods.

Morphodynamic modeling of large anabranching rivers

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The morphodynamics of large anabranching sand-bed rivers is investigated using a numerical model of hydrodynamics, sediment transport, bank erosion and floodplain development, operating over periods of several hundred years. Model sensitivity to key parameters is examined, and simulated channel and natural river morphology are compared in terms of the statistical characteristics of channel width, depth and bar shape distributions, and mechanisms of unit bar, compound bar and island evolution. Model results provide insight into controls on the frequency of mobile sand bars and the stability of larger vegated islands.

Growth and abandonment: quantifying first-order controls on wave influenced deltas

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River delta evolution is characterized by cyclical progradation and transgression: the delta cycle. We investigate the growth and decay of the individual or main lobes of deltas with strong wave influence with the aim to quantitatively compare marine to terrestrial controls.

We apply a model of plan-view shoreline evolution to simulate the evolution of a deltaic environment. The fluvial domain is represented by deposition of sediment along the shoreline, developing along a predefined single or multi-channel fluvial network. We investigate the influence of wave climate, fluvial sediment input and network geometry.

For growing deltas, we present a sediment-flux-based approach to quantify the relative influence of fluvial versus marine (wave) controls on morphology. Wave domination requires that the magnitude of the fluvial bedload flux to the nearshore region be less than the alongshore sediment transport capacity of waves removing sediment from the mouth. Fluvial dominance occurs when fluvial sediment input exceeds the wave-sustained alongshore sediment transport for all potential shoreline orientations, both up- and downdrift of the river mouth. For a single delta (or delta lobe), this transition depends not only on the fluvial river sediment flux and wave energy, but also on the directional wave climate.

Channel bifurcation is critical; it splits the sediment discharge from the river, while the potential alongshore sediment flux per channel remains equal. Fluvial dominance persists until sufficient bifurcations have split the fluvial sediment flux among the channels or until the occurrence of a river avulsion. This simplified model allows us to quantify the transition from fluvial to wave dominance and enables comparisons with natural examples near this transition, such as the Tinajones lobe of the Sinu River Delta, Colombia, and the Po Delta, Italy.

During delta abandonment, model results suggest littoral sediment transport can result in four characteristic modes of wave reworking, ranging from diffusional smoothing of the delta (or delta lobe) to the development of downdrift-extending recurved spits. The directional characteristics of the wave climate, along with the pre-abandonment delta shape, determine the mode of reworking. Simple analysis of pre-abandonment delta shape and wave characteristics provides a framework for predicting the mode of delta reworking; model predictions agree with the observed morphology of historically abandoned delta lobes, including the Nile, Ebro, and Rhone. These results provide insight into the potential evolution of active delta environments facing near elimination of fluvial sediment input.

Integration of an 'Eco-hydrologic Component' to a Generic Gridding Engine for 2D Modeling of Earth-Surface Dynamics

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This presentation discusses the implementation of component-based software design in Eco-hydrologic modeling. As a first step, we present development and integration of a radiation component that uses the local topographic variables to compute shortwave and longwave radiation data over a complex terrain for modeling Eco-hydrologic dynamics. This component is integrated to a central element that develops and maintains a grid, which represents the landscape under consideration. This component communicates with various other components such as 'vegetation component' and 'soil moisture component'. This component is adapted from the Channel-Hillslope Integrated Landscape Development (CHILD) Model code and has been enhanced. Preliminary results of this study demonstrate the advantages of adopting component-based software design such as improved flexibility, interchangeability and adaptability.

The Dynamic Watershed and Coastal Ocean: Predicting Biogeochemical Linkages and Variability over Decadal Time Scales

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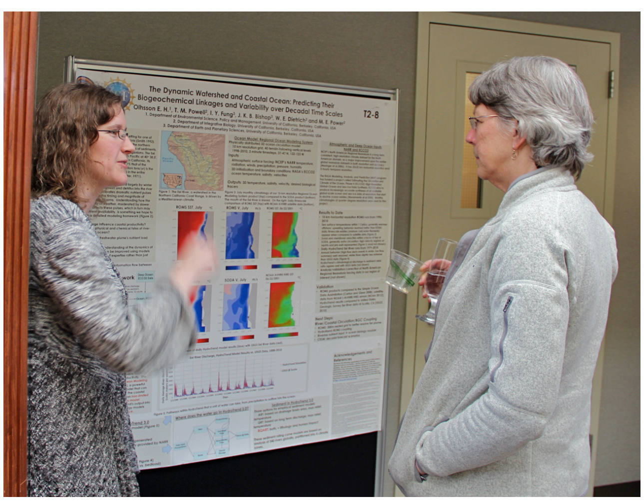
The west coast of North America is the setting for one of the world's largest coastal upwelling regions. Large rivers drain from North America into the northern eastern Pacific Ocean, delivering large loads of sediments, as well as nutrients, organic matter and organisms. The Eel River discharges into the North Pacific just north of Cape Mendocino in Northern California. Its annual discharge (~200 m3/s) is about 1% that of the Mississippi, but its sediment yield (15 million tons/yr) is the highest for its drainage area (9500 km2) in the entire continental US. This strongly seasonal signal, generated largely by winter storm events that flush sediment and detritus into the river and down to the sea, generates dramatic nutrient pulses that may play a role in the timing and magnitude of offshore phytoplankton blooms. Understanding how the interannual variability of weather, moderated by slower trends in climate, affects these pulses, which in turn may alter offshore nutrient availability, is something we hope to explore through a detailed modeling framework. In our coupled modeling framework, the watershed is currently represented by the lumped empirical watershed model HydroTrend for its ability to generate high-frequency water and sediment time series in relatively unstudied basins. The atmosphere is represented by the NCEP North American Regional Reanalysis, a model and data assimilation tool. Eventually, we hope to represent the atmosphere with the Community Earth System Model, a powerful tool for studying climate change projections, which will let us talk about possible future impacts of climate change on coastal productivity. The ocean is represented with the Regional Ocean Modeling System, a powerful and very modular, physically distributed model that can efficiently solve fine-scale resolution grids. The coastal biology will be handled by modification of an iron-limited nutrient-phytoplankton-zooplankton-detritus model.



A Mophodynamic Explanation for the Shoreface Depth of Closure

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This research aims to understand the evolution of the shoreface of sandy, wave-dominated coasts. Using energetics-based formulations for wave-driven sediment transport, we develop a robust methodology for estimating the morphodynamic evolution of a cross-shore beach profile. We compare how shallow water wave assumptions and linear Airy wave theory affect the estimation of morphodynamic shoreface evolution, in contrast to previous work, which has applied shallow water wave assumptions across the entire shoreface. The derived cross-shore sediment flux formula enables the calculation of a steady state (or dynamic equilibrium) profile based on three components of wave influence on sediment transport: two onshore-directed terms (wave asymmetry and wave drift) and an offshore-directed slope terms. Equilibrium profile geometry depends on wave period and grain size. The profile evolution formulation yields a morphodynamic Péclet number that can be analyzed in terms of perturbations around the steady-state profile. The diffusional, offshore-directed slope term dominates long-term profile evolution. A depth-dependent characteristic timescale of diffusion allows the estimation of an effective morphodynamic depth of closure for a given time envelope. Theoretical modeled computations are compared to four field sites along the Eastern US coastline. For each of these four field sites, we use hindcast wave data to determine a representative wave height and period using a weighted frequency-magnitude approach. Using the characteristic wave quantities for each site, we compute the equilibrium profile and the morphodynamic depth of closure, showing reasonable similarities between the computed equilibrium profiles and the actual profiles. In addition, the estimated morphodynamic depth of closure matches well with the location of the visually estimated depth of closure (based upon slope break) for each site. Overall, the methodology espoused in this paper can be used with relative ease for a variety of sites and with varied sediment transport equations.

Modeling of Waves and Storm Surge along the Arctic Coast of Alaska

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Arctic coasts have been impacted by rapid environmental change over the last 30 years. Warming air and water temperatures and the increased duration of the open water season, correlate with increases in the rate of already rapid erosion of ice-rich bluffs along the Beaufort Sea coast. To investigate longer-term changes in near-shore wave dynamics and storm surge set up as a result of sea-ice retreat, we coupled two simple modules.

Following Dean and Dalrymple (1991), we model wind-driven setup as a function of wind speed and direction, azimuth relative to the shore-normal, fetch and bathymetry. The wave module calculates the wave field for fetch-limited waves in shallow water based on the Shore Protection Manual (1984). For a given wind speed, dynamic water depth and fetch, we predict the significant wave height and wave period. Both modules require fetch as a controlling parameter. Sea-ice influenced coasts, are unique in that fetch is spatially variable due to the geometry of the shoreline and temporally variable as the location of the sea ice edge moves through the sea ice free season. We determine the distance to the sea ice edge using daily Nimbus 7-SMMR/SSM/I and DMSP SSMI Passive Microwave Sea Ice Concentration data. The sea ice edge is defined at a threshold sea ice concentration of 15%. We find a good match between the model predictions and our observed records of meteorological conditions and nearshore water level and waves along the Beaufort Coast in the summers of 2009 and 2010.

Over the period 1979-2012, fetch has increased significantly. In our study area near Drew Point, Alaska, the open water season itself lengthened from ~45 days to ~90 days. In the 1980's and early 1990's wave dynamics were fetch-limited during a significant period of the open water season. More recently, the distance from the coast to the sea ice edge shifts extremely rapidly (often 100's of km over 1-2 weeks); fetch therefore only minimally influences wave dynamics as offshore distance exceeds the 140 km threshold over most of the open water season. Wave heights and surge set-up events on average have not changed in magnitude significantly, but storm surge set up events have increased in frequency.

Towards a Model Web for Sustainability on a Changing Planet

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Sustainability of the anthroposphere is a result of a multitude of decisions made concerning social, economic and environmental questions. Decision makers who would like to ensure sustainable development as an emerging characteristic of humanity are challenged by the complexity of a planetary system re-engineered by an increasingly powerful global species. Examples of such problems are sustainable urban growth and the food-water-energy nexus. Tools to reliably assess the consequences of decisions from local to global level are not readily available.

In particular, current capabilities for assessing the various impacts of climate variability and change, as well as other changes are inadequate. The Group on Earth Observation (GEO) recognized this emergency and promoted several initiatives that can help address this shortcoming. One of them is the GEO Model Web initiative. The goal of this initiative is to develop a dynamic modelling consultative infrastructure of intercommunicating models and datasets to serve researchers, managers, policy makers and the general public. It focuses on enhancing interoperability of existing models and making them and their outputs more accessible. The development of the Model Web holds the promise of more decision support tools becoming available. These tools would allow decision makers to ask "What if" questions prior to the implementation of decisions and support adaptive management and responsive design. The Model Web will also benefit researchers by making it easier to run model experiments and model comparisons or ensembles, as well as help highlight areas needing further development. The Model Web would support a synchronization across different spatial and temporal scales and across the languages of different disciplines, thus making the System of System (SoS) more intelligent. The beauty of having a SoS like this is that it amplifies the signal. An immediate application is the emerging geodesign approach to the design of sustainable built environments.

The Model Web is developed in the framework of the Global Earth Observation System of Systems (GEOSS) implemented by GEO. The observing, modelling and other systems that contribute to GEOSS must be interoperable so that the data and information they generate can be used effectively. The Committee on Earth Observation Satellites (CEOS) is promoting interoperability through the Virtual Constellations concept, the Sensor Web approach, and by facilitating model interoperability and access via the Model Web concept.

The Model Web is a concept for a system of interoperable models and data capacities communicating primarily via web services. It would consist of an open-ended, distributed, multidisciplinary network of independent, interoperating models plus related datasets. Models and datasets would be maintained and operated and served by a dynamic network of participants. In keeping with the SoS approach, the Model Web initiative will explore the interoperability arrangements necessary to integrate multi-disciplinary environmental model resources. The approach of loosely coupled models that interact via web services, and are independently developed, managed, and operated has many advantages over tightly coupled, closed, integrated systems, which require strong central control, lack flexibility, and provide limited access to products. Developing a long-term perspective, a logical next step would be the Internet of Models (IOM). Comparable to the already developing Internet of Things (IOT), which is predicted to connect by 2020 more than 50 billion "things" talking to each other without human interaction (or even knowledge), the IOM would have models talking to each other when needed without human interaction. If we compare the IOT to the nerve system of a human body, then the IOM would be the brain of the human being. Key to the development of IOT and IOM are standards that allow "things" and "models" to communicate when needed and to exchange information as needed (similar to the role of standards in the success of the WWW). Frameworks for model interactions are already developing (e.g. Object Modelling System, ModCom, the Invisible Modelling Environment, the Open Modelling Interface: OpenMI, the Spatial Modelling Environment: SME, Tarsier, Interactive Component Modelling System: ICMS, Earth System Modeling Framework: ESMF, SEAMLESS-IF , CSDMS, etc.), but they are not sufficient to achieve the Model Web (or the IOM). A major effort to develop the standards for the IOT is under way, and a similar effort to needed for the IOM standards. The combination of IOT and IOM would greatly enhance science capabilities, early warning, assessments of impacts, etc.

Modeling floodplain dynamics: Can the Ganges-Brahmaputra Delta keep pace with 21st century sea level rise?

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Sediment delivery to low-lying coastal zones must keep pace with, if not exceed, the rate of sea level rise in order to maintain a positive surface elevation. Deltaic lowlands are vulnerable to both sea-level rise and changes in river discharge, but whether the floodplains and coastal areas will ultimately drown depends on a balance of aggradation, eustatic sea level rise and subsidence. The Ganges-Brahmaputra (G-B) Delta is an example of a densely populated coastal system that could be flooded by rapid sea level rise within the next century. Annual monsoonal river flooding and cyclonic storm surges are the principal mechanisms by which sediment is distributed across the G-B floodplain and coastal plain. Stratigraphic reconstructions show that sedimentation in the upper floodplain was more than doubled under the Early Holocene enhanced monsoonal regime, suggesting that the delta may withstand an increase in monsoonal intensity, flooding, and tropical cyclones that are currently predicted in ensemble Community Climate System Model scenarios.

In an effort to improve predictions of climatic forcing on aggradation rates in the G-B floodplain and lower delta, direct sedimentation measurements are paired with a series of model components coupled within the CSDMS Modeling Tool (CMT). A sediment flux model, a floodplain sedimentation model and a tidal-plain sedimentation model will be linked to explore the response of the G-B river system to a future sea-level rise and changes in river discharge. Model algorithms will be validated by sedimentation data collected in 2008 and 2012 from the tidal delta (The Sundarbans National Reserve mangrove forest) and the highly cultivated fluvial-dominated delta plain. Field data will also be compared to model outputs by constraining the spatial patterns of sedimentation across the delta front. In this talk, we present initial sedimentation results and discuss controls on heterogeneous patterns of deposition in the tidal versus fluvial dominated parts of the delta. Early results from individual model components will also be discussed in an attempt to integrate current understanding of the G-B System into a numerical modeling framework.

The Influence of Tectonic Strain on Landscape Evolution

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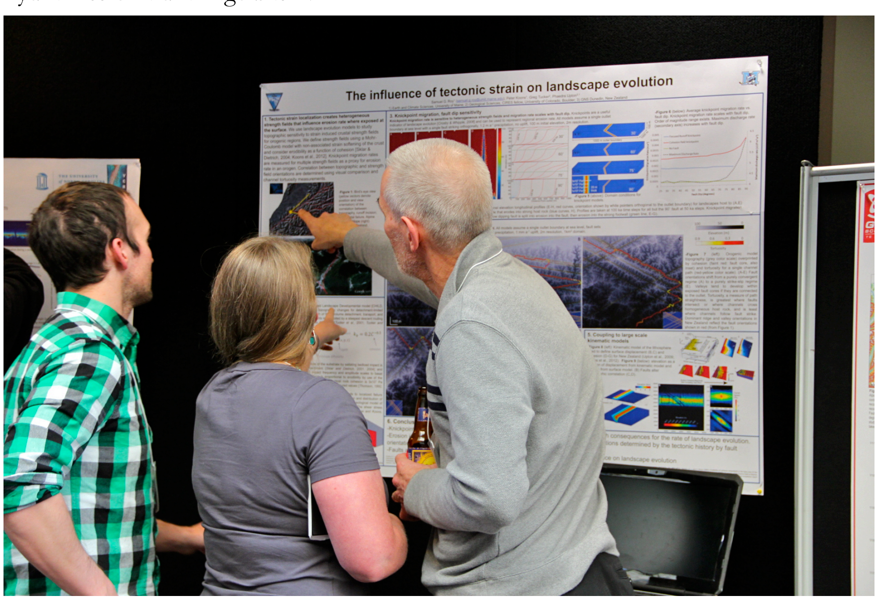
Tectonic strain localization creates spatially anisotropic mechanical strength patterns that are reflected by landscape. Strain in the frictional-brittle crust produces predictable anisotropic cohesion and grain size distribution fabrics that influence spatial strain induced (SI) erodibility patterns where exposed at the surface. We assume that bedload impact is the primary mechanism for bedrock incision and erodibility is an inverse function of cohesion, which can be reduced by more than 2 orders of magnitude at the meter scale due to fragmentation and grain size reduction. The density, position, and orientation of SI anisotropies depends on the magnitude of strain and the tectonic horizontal/vertical shear stress ratio. The influence of tectonic strain on landscape becomes apparent by incorporating 3D strain induced crustal failure in a landscape evolution model. Natural observations and model results suggest naturally occurring SI anisotropy exerts a first order influence on geomorphic metrics for active orogens, including incision rate, 3D stream network geometry, and topographic evolution. Rates of vertical incision and knickpoint migration are orders of magnitude faster along SI anisotropy exposures. Shallowly dipping faults produced in a dip-slip regime are largely protected from vertical incision by unstrained overburden while a steeply dipping fault produced in a strike-slip regime is largely exposed to vertical incision. The strain field controls hydraulic geometry by influencing 1) the spatial distribution of discharge by establishing anisotropic erodibility patterns and 2) slope changes at erodibility transitions and differential uplift in a watershed. The influence of tectonic strain on landscape increases with the horizontal/vertical shear stress ratio because more steeply dipping and interconnected faults are produced. SI anisotropy controls channel network geometry by amplifying long wavelength tortuosity where fault-bound channels connect and muting short wavelength tortuosity along faults. Both effects increase with increasing tectonic horizontal shear strain. Channel width becomes constricted by the width of SI cohesion reduction, causing channel width to become a function of strain rather than reflecting only the hydraulics of a drainage basin.



Turbulence- and particle-resolving numerical modeling of sediment transport

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The motion of sediment in water is caused by fluid pressure gradient forces, primarily drag, on sediment grains. Turbulence-resolving experiments show significant temporal and spatial variability of fluid and sediment motion and particle forces at all stages of sediment transport. The signature of turbulence structures and their modification by sediment is apparent from incipient motion to vigorous suspension. This presentation introduces a numerical model that combines large eddy simulation (LES) of turbulence and the distinct element method (DEM) of granular motion. The LES and DEM models are fully coupled in momentum. Information from the LES is used to specify forces on the DEM particles, and those particle forces are given in an equal and opposite direction in the filtered and discretized Navier-Stokes equations at each grid cell in the finite volume LES. Parameterization of turbulent sediment transport processes is the basis of any well founded model of morphodynamics in fluvial and marine environments. Current parameterizations rely on a mixture of theory and empirical evidence. LES-DEM simulations can be performed in conditions that are difficult to reproduce in the laboratory and that stretch the limits of theory. It is hard to build an apparatus that can produce sediment transport under field-scale cnoidal waves, on sloping beds, with currents of arbitrary direction, and a range grain size distributions. Further, even in simple unidirectional flows only rough empirical relations exist for the critically important suspended sediment rate of entrainment. Validation of the LES-DEM approach is essential before development of transport relations for large-scale morphodynamic models. A series of LES-DEM simulations of unidirectional flow over flat beds of medium sand, ranging from no transport, to bedload, to vigorous suspension are presented. Simulations of flat sand beds under oscillatory waves and unidirectional flow downstream of a backward-facing step are compared to laboratory measurements. Simulations over ripples and through vegetation are also presented. Examples of some of the simulations can be previewed at the links below.

A Generic "Gridding Engine" for 2D Modeling of Earth-Surface Dynamics

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This presentation addresses an important limitation to scientific productivity in fields that rely on computational modeling of landscape processes. Landscape models compute flows of mass, such as water, sediment, glacial ice, volcanic material, or landslide debris, across a gridded terrain surface. Science and engineering applications of these models range from short-term flood forecasting to long-term landform evolution. At present, software development behind these models is highly compartmentalized and idiosyncratic, despite the strong similarity in core algorithms and data structures between otherwise diverse models.

We report progress on a proof-of-concept study in which an existing landscape model code is adapted and enhanced to provide a set of independent, interoperable components (written initially in C++). These include: (1) a gridding engine to handle both regular and unstructured meshes, (2) an interface for space-time rainfall input, (3) a surface hydrology component, (4) an erosion-deposition component, (5) a vegetation component and (6) a simulation driver. The components can communicate with each other in one of two ways: using a simple C++ driver script, or using the Community Surface Dynamics Modeling System (CSDMS) Model Coupling Framework.

A central element is the gridding engine, which provides the ability to rapidly instantiate and configure a 2D simulation grid. Initially, the grid is an unstructured Delaunay/Voronoi mesh. Because the internal representation of geometry and topology is quite generic—consisting of nodes (cells), directed edges, polygon faces, etc.—the software can be enhanced to provide other grid formats, such as a simple raster or a quad-tree representation. The gridding engine also provides basic capabilities for finite-volume numerics, such as calculation of scalar gradients between pairs of neighboring cells, and calculation of flux divergence within cells.

Our hope is that these interoperable and interchangeable components with simple, standardized interfaces, will transform the nature and speed of progress in the landscape sciences by allowing scientist-programmers to focus on the processes of interest rather than on the underlying software infrastructure.

Coupled models place constraints on fluvial input into Lake Ohau, New Zealand

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Lake records provide a long-term record of climate events and transitions, earthquakes in tectonically active regions, landscape response during and following deglaciation and recent human influenced land use changes. In order to unravel the story preserved in lake sediments, it is necessary to understand the dynamics of the lake system and the source of the sediment coming into the lake. Our study focuses on Lake Ohau, New Zealand, which occupies a fault controlled glacial valley and contains a high resolution sedimentary record of the last ~17 ka. It is presently the focus of a multi-disciplinary studied which aims to recover a long core encompassing the whole ~17 ka record in the next several years.

We use two CSDMS codes: HydroTrend, a climate-driven hydrological model, and Sedflux, a basin filling model, to model sediment flux into Lake Ohau. Using measured climate parameters from the last 60 years, we model water and sediment discharge into the lake and the distribution of sediment through the lake basin. Using a simple conceptual model of the lake dynamics, we produce a series of simulations to examine sediment accumulation at different positions across the lake basin. We then compare these modelled accumulation records to short cores from a number of locations within the lake basin.

Modeling channelized and distributed subglacial drainage in 2D

Mauro Werder, Simon Fraser University

This model of the subglacial drainage system simulates the pressurised flow of water at the ice-bed interface of glaciers and ice sheets. It includes both distributed and channelized water flow. Notably the model determines the geometry of the channel network as part of the solution. The resulting channel network is similar to subaerial stream networks with channels carving out hydraulic potential "valleys". However, there are some pronounced differences to subaerial drainage, for example that the time for a network to form (and decay) is on the order of weeks to months; or that, channels originating at point sources can lie on ridges of the hydraulic potential. The model employs a novel finite element approach to solve the parabolic equations for the hydraulic potential simultaneously on the 1D channel network and 2D distributed system.

Wax Lake Delta, Louisiana: Factors Controlling Hydrodynamics and Morphological Changes during Hurricane Rita (2005)

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Close to half a billion people live on deltas, many of which are threatened by flooding. Delta flooding also imperils valuable ecological wetlands. In order to protect deltas, it is critical to understand the mechanisms of flooding and evaluate the roles of different forcing factors.

Delft3D, a widely used 3D hydrodynamic and sediment transport model, has been applied to the Wax Lake Delta in Louisiana in order to explore the impacts of wind, waves, and vegetation during extreme conditions. Using wind and pressure field inputs of Hurricane Rita in 2005, the simulation indicates that the deltaic hydrodynamics and morphologic changes are determined by the interactions of all three factors. Wind shows a large impact on water level and velocity, especially in the shallow water zone, where water level increases by ~2 m and water velocity increases by ~1 m/s. Waves, on the other hand, demonstrate almost no effect on water level and velocity, but significantly increase sediment transport due to increasing bed shear stress. Sediment deposition occurs primarily at the coast, when water floods higher elevated land and velocities start to decrease, leading to a significant drop in bed shear stress. Vegetation, a critical factor that influences deltaic hydrodynamics, is represented in the model by adding 2D roughness to the bed. The vegetated wetland and its surrounding area show a notably different pattern in erosion and deposition compared to the unvegetated simulations. The vegetated islands receive significant deposition, while adjacent channels become much more eroded because water is routed through channels when the surrounding vegetated islands are more difficult to erode.

To take into account the impact plant roots have on the soil (increase in soil strength and therefore an effectively reduction in erosion), a new root routine has been added to Delft3D. This routine mimics this process by increasing the soil critical shear stress required to reduce erosion. The modeled results indicate that more deposition appears on the vegetated root area, while more significant erosion simultaneously occurs at those sides of these islands that are facing the ocean. This illustrates that, while vegetation can protect land from erosion, it can also intensify erosion in the surrounding area. Therefore, the use of natural vegetation as a protection against coastal erosion processes requires more research.

Long-term Seasonal Trends of Nitrogen, Phosphorus, and Suspended Sediment Load from the Non-tidal Susquehanna River Basin to Chesapeake Bay

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Reduction of nitrogen (N), phosphorus (P), and suspended sediment (SS) load has been a principal focus of Chesapeake Bay Watershed management for decades. To evaluate the progress of management actions in the Bay's largest tributary, the Susquehanna River, we analyzed the long-term seasonal trends of flow-normalized N, P, and SS load over the last two to three decades, both above and below the Lower Susquehanna River Reservoir System. Our results indicate that annual and decadal-scale trends of nutrient and sediment load generally followed similar patterns in all four seasons, implying that changes in watershed function and land use had similar impacts on nutrient and sediment load at all times of the year. Above the reservoir system, the combined loads from the Marietta and Conestoga Stations indicate general trends of N, P, and SS reduction in the Susquehanna River Basin, which can most likely be attributed to a suite of management actions on point, agricultural, and stormwater sources. In contrast, upward trends of SS and particulate-associated P and N were generally observed below the Conowingo Reservoir since the mid-1990s. Our analyses suggest that (1) the reservoirs' capacity to trap these materials has been diminishing over the past two to three decades, and especially so for SS and P since the mid-1990s, and that (2) the Conowingo Reservoir has already neared its sediment storage capacity. These changes in reservoir performance will pose significant new kinds of challenges to attainment of total maximum daily load goals for the Susquehanna River Basin, and particularly if also accompanied by increases in storm frequency and intensity due to climate change. Accordingly, the reservoir issue may need to be factored into the proper establishment of regulatory load requirements and the development of watershed implementation plans.

Appendix 3: 2013 CSDMS Annual Meeting Clinics

Introduction to the Weather Research & Forecasting (WRF) System, a High-Resolution Atmospheric Model

Gary Clow, USGS

WRF is a highly parallel state-of-the-art numerical weather prediction model hosted by the National Center for Atmospheric Research (NCAR). This community model was designed from the onset to be fairly flexible, supporting both operational forecasting and atmospheric research needs at scales ranging from meters to thousands of kilometers. Given the model's physics implementation and it's modular design, WRF naturally became the core for a number of more specialized models, including: HWRF (used to forecast the track and intensity of tropical cyclones), WRF-CHEM (simulates the emission, transport, mixing, and chemical transformation of trace gases and aerosols simultaneously with meteorology), Polar WRF (a version of WRF optimized for the polar regions), CWRF and CLWRF (versions of WRF modified to enable regional climate modeling), and planetWRF (a general purpose numerical model for planetary atmospheres used thus far for Mars, Venus, and Titan).

The goal of this clinic is to provide an overview of the WRF model, including: model architecture, physics options, data required to drive the model, standard model output, model applications, and system requirements. Several examples will be presented. A Basic Model Interface (BMI) is currently being developed for WRF to facilitate the coupling of this atmospheric model with other earth system models.

TURBINS using PETSc

Eckart Meiburg & students University of California, SB

This clinic will provide information on how laboratory scale flows and field scale flows can be simulated by direct numerical simulations (DNS) and large-eddy simulations (LES) using parallel, high-performance computing facilities. DNS results, from the software TURBINS, of gravity and turbidity currents propagating over complex sea floor topography will be discussed. The use of the PETSc software package within the DNS simulations will be highlighted. LES results of high Reynolds number gravity and turbidity currents, and reversing buoyancy currents over a flat topography will be discussed. Issues relevant to LES such as grid resolution, grid convergence, subgrid models and wall-layer modeling will also be discussed.

Modeling of Earth Surface Dynamics and Related Problems using OpenFOAM®.

Xiaofeng Liu, UT San Antonio

This clinic aims to introduce the open source computational fluid dynamics (CFD) platform, OpenFOAM®, to the earth surface dynamics research community and to foster collaborations. OpenFOAM® is essentially a computational toolbox which solves general physical models (differential equations) using finite volume method. This short clinic is tailored to be suitable for an audience at various levels (from beginners to experienced code developers). It will provide an overview of OpenFOAM. We will demonstrate its usage in a variety of applications, including hydrodynamics, sedimentation, groundwater flows, buoyant plumes, etc. Participants can also bring the problems in their fields of interest and explore ways to solve them in OpenFOAM®. Knowledge of C++, object-oriented programming, and parallel computing is not required but will be helpful.

Introduction to the Basic Model Interface and CSDMS Standard Names

Scott Peckham, University of Colorado

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

Once a BMI-enabled model has been wrapped by CSDMS staff to become a CSDMS component, it automatically gains many new capabilities. This includes the ability to be coupled to other models even if their (1) programming language, (2) variable names, (3) variable units, (4) time-stepping scheme or (5) computational grid is different. It also gains (1) the ability to write output variables to standardized NetCDF files, (2) a "tabbed-dialog" graphical user interface (GUI), (3) a standardized HTML help page and (4) the ability to run within the CSDMS Modeling Tool (CMT).

This clinic will explain the key concepts of BMI, with step-by-step examples. It will also include an overview of the new CSDMS Standard Names, which provide a standard way to map input and output variable names between component models as part of BMI implementation. Participants are encouraged to read the associated CSDMS wiki pages in advance and bring model code with specific questions.

CMT clinic

Irina Overeem, University of Colorado

This clinic will look at the CSDMS Modeling Tool (CMT). We share the philosophy behind CMT, will demo the functionality of CMT and show what models are incorporated into it. New educational material on several models allows scientists and students to more easily use CSDMS models for classes and simple simulations and we will provide clinic participants with the latest information on these resources. The CMT clinic will be hands-on, we will run a few simple runs and visualize them. Finally, we will spend some time on discussing common problems and strategic solutions.

Toward Transparent, Refutable Hydrologic Models in Kansas or Oz

Mary Hill USGS

Numerical models are critical to integrating knowledge and data for environmental systems and understanding future consequences of management decisions, weather variability, climate change, and so on. To attain the transparency and refutability needed to understand predictions and uncertainty and use models wisely, this clinic presents a strategy that emphasizes fundamental questions about model adequacy, sensitivity analysis, and uncertainty evaluation, and consistent use of carefully designed metrics. Emphasizing fundamental questions reveals practical similarities in methods with widely varying theoretical foundations and computational demands. In a field where models take seconds to months for one forward run, a credible strategy must include frugal methods for those in Kansas who can only afford 10s to 100s of highly parallelizable model runs in addition to demanding methods for those in Oz who can afford to do 10,000s to 1,000,000s of model runs. Advanced computing power notwithstanding, people may be in Kansas because they have chosen complex, high-dimensional models, want quick insight into individual models, and/or need systematic comparison of many alternative models. This class will briefly review the fundamental questions, demonstrate relations between existing theoretical approaches, and address challenges and limitations. Students will be able to examine a model constructed using FUSE and compare results from computationally frugal method evaluations conducted in class and demanding methods for which results are provided.

Modeling and analysis of evolving landscapes in GRASS GIS

Helena Mitasova, North Carolina State Univ.

This clinic will introduce participants to GRASS6.4.3 with special focus on terrain modeling, geomorphometry, watershed analysis and modeling of landscape processes such as surface water flow and erosion/deposition. The hands-on section will explore lidar-based terrain models, multiple surface visualization, analysis of coastal lidar time series and visualization of terrain evolution using space-time cube. Overview of new capabilities in the GRASS7 development version will also be provided.

Dune erosion and overwash with XBeach

Ad Reniers, University of Miami

A short tutorial and hands-on workshop to set up and run XBeach to predict the morphodynamic response of dune protected areas under hurricane conditions. We will cover the set up of the computational grid, boundary conditions, model processes and data analysis. The XBeach model runs on a windows platform. If you have a Mac, you can still run the model provided you have software (like parallels or vmware) that enables you to run windows programs.

A very basic introduction to numerical methods for scientific computing

Hari Rajaram, University of Colorado

I will give a overview of the basic foundations of numerical methods for modeling earth systems described by ordinary and partial differential equations. I will discuss the underlying foundations of finite-difference, finite-volume and finite-element methods using diffusion/conduction equations as an example. I will discuss explicit and implicit methods for time-stepping, and stability analysis of time-integration schemes. All numerical methods for ODEs and PDEs in some form arrive at algebraic approximations, translating them into systems of algebraic equations. I will discuss basic algorithms for solving systems of algebraic equations, and how they are incorporated into various software packages, and also emphasize the importance of sparsity in matrix computations. I will include examples derived from practical problems in reactive transport and glacier dynamics to illustrate how basic concepts apply to real-world problems and make a difference when we want to develop efficient and accurate models.

Python for Matlab users clinic

Thomas Hauser & Monte Lunacek, University of Colorado

This workshop is a hands-on introduction to using Python for computational science. Python is a powerful open source interpreted language that has been adopted widely in many application areas. The goal of this workshop is to teach participants how to use Python as an open source alternative for MATLAB in their computational workflows. While we will demonstrate how to implement MATLAB-based scientific computing workflows in Python, attendees are not required to have MATLAB or Python experience. The goal of this tutorial is to show how an open source alternative to MATLAB can be used productively for computational science research. In the first part of this workshop we will introduce basic Python concepts and iPython with a focus on migrating from MATLAB to Python. We will show how the Python modules Numpy and Scipy, for scientific computing, and Matplotlib, for plotting, can make Python as capable as MATLAB for computational science research. In the second part of the tutorial we will discuss on how to interface Python with compiled languages like C or Fortran to improve performance of numerical codes. Additionally we will show how to use distributed parallel computing on a supercomputer from interactive python notebooks.

Three carbonate sedimentation models for CSDMS

Peter Burgess & Chris Jenkins, Royal Holloway, UK & Univ. of Co.

This workshop will showcase three different models of carbonate sedimentation, produced under the CSDMS umbrella: carboCat for facies, carboCell for guilds, carboPop for communities. Participants will be able to download and run (on own or provided machines) these models in Python and Matlab environments, discuss how to select appropriate parameters for them using the various databases being developed in concert with the models, and contribute to plans for further development of models and databases.

Appendix 4: 2013 CSDMS Annual Meeting Awards

The 2013 CSDMS Lifetime Achievement Award in Earth Surface Dynamics Modeling was presented to **Professor Alan Howard** (UVA) in Boulder Colorado, as part of the 2013 CSDMS Annual Meeting. Presenters included Dan Hobley, Alex Morgan and James Syvitski.

Photo: Professor Howard (left) receives a one of a kind art piece from Professor James Syvitski (right). The art piece reads " Out of this World" depicting an image of the planet mars and a parrot — two phenomena of strong interest to Alan.

Dedication: "Professor Alan Howard epitomizes an awardee of the CSDMS Lifetime Achievement Award. Alan has been contributing insightful and innovative earth-surface dynamics modeling since the early 1970's -- an act of courage since his colleagues were not exactly supportive of that field. Concepts that he began exploring in the 1980's are now fundamental in landscape evolution. The nature of his personality is that he is a "quiet pioneer": not the type to try to make a big splash with a nature paper, but rather with a thoughtful and understated style. His modeling efforts include those river channels and networks, floodplains, speleology, Aeolian dune transport, groundwater transport, badland development, planetary impact craters, Martian landscape, and even continental margin features of interest to the Navy. Over the years he has influenced and trained exceptional students and post-docs. It is with our admiration for his intellectual and personal integrity that we wish to honor him with the CSDMS Lifetime Achievement Award for 2013. **- James Syvitski, CSDMS Executive Director**

The 2013 CSDMS Best Poster Award went to Rebecca L. Caldwell, Dept. of Geological Sciences, Indiana University, relecald@indiana.edu

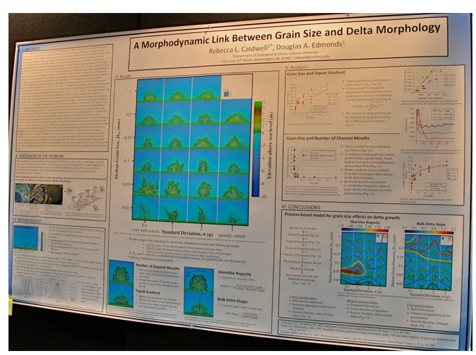

Photo: Rebecca Caldwell (left) receives a Kindle from Professor Wiberg, SC Chair

CSDMS Student Modeler of the Year Award for 2012 goes to **Surendra Adhikara** (CalTech).

At the Annual Meeting CSDMS awarded its annual student modeler award to Dr. Surendra Adhikari for his modeling study of valley glaciers. Adhikari working with Prof Shawn Marshall at the University of Calgary, formulated a new hierarchy of dynamical models that describes distinct physical processes of deformational flow. Together these models provide an intuitive tool for studying the mechanics of glaciers and help to improve sea level rise estimates.

Surendra is a Nepalese national, explaining his fascination with glaciers. Now a postdoctoral scholar at the California Institute of Technology, Surendra is exploring the influence of short-term hydrology (e.g, hydraulic-fractures) on ice sheet dynamics. He is also affiliated with Jet Propulsion Laboratory (JPL) for better understanding how solid Earth's response affects the ice sheet dynamics on decade-to-century time scales.

http://csdms.colorado.edu/wiki/Model_highlight#Student_Modeler_Award_2012

Appendix 5: Jillian Wallis COG/CSDMS interview summaries

Informal Survey of the CSDMS Community

During the recent CSDMS Annual Meeting 19 members were pulled aside and asked some questions about their experiences in the community and any feedback they had on the resources and services provided by CSDMS. The members ranged from students attending their first CSDMS meeting to members who have been a part of the CSDMS community since before it was a formal project. The following is a summary of their experiences and feedback.

Impressions of the CSDMS annual meeting. The members' overall impression of the meeting was that it was going great. Specific aspects of the meeting that they were enjoying included interesting discussions, making new contacts, exposure to the work of their colleagues, and generating new ideas. A couple members mentioned that the smaller size of the meeting made it easier for them to approach people. A number of people liked the many opportunities there were to learn, not only through the clinics and talk, but how decisions are made within the community.

Reasons why members joined CSDMS. The members provided many reasons why they joined the CSDMS community, many of which speak to the strong vision and network of CSDMS. By far the most popular reason was that the member liked the direction CSDMS was taking the community with both the plug-and-play framework and sharing models. Four of the members mentioned being invited by Dr. Syvistki or other member of the CSDMS IF, and three joined because their advisor was involved with CSDMS. A couple of members had joined because they were involved in developing similar resources. Two of the members joined because CSDMS has become the de facto standard, saying, "*if you are not in, you are out.*" Other reasons included the availability of computational resources, model tools and expertise provided by CSDMS IF personnel, and community support as they developed their own model.

How involvement in CSDMS has affected their research. Being a member of the CSDMS community has its advantages. According to members, their involvement has connected them to their colleagues, stimulating new collaborations and proposals, as well as new directions for their research. Being a member provides an awareness of available models, and has helped members to understand how their research fit into the larger research landscape. Being a member of CSDMS has encouraged them to think about model coupling when building their models, and the larger community has provided them with feedback about their models. Roughly a third of the members interviewed were new members, and could not yet speak to how their involvement affected their research.

How involvement in CSDMS has affected their professional reputation. The CSDMS community has provided opportunities for networking and collaboration, research exposure, and building bridges between disciplinary communities that otherwise share tools and techniques. Involvement has also lead to opportunities for recognition, such as best model and paper awards or invited keynotes. Two of the members interviewed had given talks during the Annual Meeting, one had received a best poster award, one had received a best model award, and another had received a career award. Involvement has also provided opportunities to take leadership roles, such as leading a working group or being a member of the steering committee.

Use of CSDMS resources *(models, website, HPCC, or EKT materials)*. A few of the members interviewed had not yet used any of the resources to speak of, and a couple had plans to use models and EKT materials to run courses in the future. A couple of the student members had used resources as part of a course. Of those who had used CSDMS resources for their research, five had used the computing cluster, a couple had used the website to collect background material, a few had downloaded models, a couple had used the CMT, and one mentioned downloading software. One member provided an unexpected use of CSDMS resources, he drew on available models and information from the website to write an NSF proposal.

Use of CSDMS services ***(support, strategic plans, data and model repositories).*** Like the use of CSDMS resources, nearly half of the members interviewed had not yet used CSDMS services, but many had planned to do so in the future. Those who had used CSDMS services specifically mentioned what they had used and either how or to what end. One of the members singled out computing cluster support he had received from CSDMS IF personnel. The two members interviewed who were part of the governing bodies mentioned using the strategic plans as reference for their governing roles. A couple members mentioned browsing the repositories for models and documentation. One member mentioned using data from the data repository, and a couple members had contributed models to the model repository.

Trouble using CSDMS resources and services. The majority of members interviewed had no trouble using CSDMS resources and services, but this small sample included people who had used neither the resources nor services, so the question was not applicable to them. Even those who had used the resources and/or services had no trouble with them. One member even went on to say, "*everything seemed really straightforward, … seemed really clear and organized.*" For those members who mentioned having problems they all seemed to revolve around working remotely or installing locally. There was some frustration on the part of students running processes remotely, because they were not able to watch them as they are happening. A couple members mentioned issues with getting CMT to run. The first mentioned having trouble getting CMT downloaded and installed locally. The second mentioned platform-dependency problems when he moved his work between Windows to MacOS machines. Two of the members mentioned that where the technical processes broke down, personnel from the CSDMS IF stepped in to support them. When one member had trouble getting models to run on their local machines, he had ready and willing help from Dr. Hutton. When another member found some bugs trying to run CMT with a newer version of Java, Dr. Kettner gave them a hand.

What CSDMS could do to better support the community. When asked what CSDMS could do to better support them in the future, the members' answers ranged from concrete requests such as coupling specific models and adding more flops to the computing clusters, to more abstract requests such as providing more opportunities for students to volunteer in the governing bodies. Members asked for the incorporation of more marine models, and the coupling of river and ocean models. A couple members expressed a desire to be able to upload data to the repository. One member would like the CSDMS IF to focus on making it easier to incorporate their model in the framework, and another member wanted CSDMS to provide some funding to cover the time necessary to componentize their model. One member asked that CSDMS provide more depth to model descriptions so that users can make more informed decisions about which models to download. Another member asked for more clinics or online workshop designed to introduce users to a specific model, rather than overviews of the CSDMS framework or general techniques. When members interviewed could not think of ways CSDMS could improve they tended to list their favorite aspects of CSDMS or praise them generally, such as the model usage metrics, data exchange, and maintaining a directory and ranked list of available models. Members mentioned how supportive Dr. Syvitski has been, even writing letters of support for other members. A couple members indicated that Dr. Hutton needs to be cloned so that he could assist on more projects. Overall member thought that the CSDMS IF were doing a good job, and encouraged them to "*keep up the good work.*"