CSDMS

Community Surface Dynamics Modeling System

Annual Report, Dec. 31, 2010

NSF Cooperative Agreement 0621695

Community Surface Dynamics Modeling System
Annual Report, Dec. 31, 2010

Executive Summary

CSDMS continues to gain momentum, with 140 new members in 2010 (>480 members in total). CSDMS has become the international coordinator of open source surface dynamics models and modeling efforts, both nationally (>120 institutions) and internationally (>100 foreign institutions from 30 countries). The CSDMS Model Repository offers >160 open-source models (>3.4 million lines of code) registering more than 8000 downloads, directly addressing the historical lack of readily available models for research and application. This penetration of computational tools into the earth-science community should provide valuable future dividends. The CSDMS Web Portal with more than 1.5 million visits is becoming a “go to” site for models and CSDMS-related data and educational products including animations and images, modeling labs and lecture materials. Use on a dedicated supercomputer is offered free to the CSDMS community and presently supports more than 100 users.

Year 1 and 2 focused on developing the architecture for model coupling. Year 3 was dedicated to advanced simulations through proof-of-concept projects. Year 4 witnessed continued growth and advances in community products, including 1) completely revised web portal and services, 2) the first official release of the CSDMS model-coupling tool CMT, 3) an 800% increase in the number of models made into components within CMT, 4) an alpha-version of the CSDMS Domain Architecture *SedGrid*, 5) new data handling abilities (NetCDF, WML), 6) the first all-hands conference *Modeling for Environmental Change*, and 7) numerous tested educational modules, clinics, and courses.

In addition to the Annual CSDMS Student Award, a CSDMS Lifetime Achievement Award is being handed out and the first recipient is Professor Gary Parker. Recognizing productive efforts of our community is important. For too long the efforts of those who write and develop numerical models and tools for the productive advance of the geosciences, has been both under-funded and under-recognized.

This report outlines Year-4 progress and provides Year-5 goals and resource requirements needed to advance the CSDMS effort. The Annual Report documents community activity, management structure and plans, publications and presentations, meetings, models, membership, and provides budgetary details on income and expenditures. The report builds upon the Year-4 Semiannual Report and other CSDMS documents.

CSDMS Annual Report, Dec. 31, 2010

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CSDMS Annual Report, Dec 31, 2010

1.0 CSDMS Mission: The Community Surface Dynamics Modeling System (CSDMS) develops, supports, and disseminates integrated software modules that predict the movement of fluids (wind, water, and ice) and the flux (production, erosion, transport, and deposition) of sediment and solutes in landscapes, seascapes and their sedimentary basins. CSDMS involves the Earth surface — the dynamic interface between lithosphere, atmosphere, cryosphere, and hydrosphere.

This Annual Report covers the period from January 1, 2010 to December 31, 2010, and provides anticipated progress through March 31, 2011.

2.0 CSDMS Management and Oversight.

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

- Rudy Slingerland (April, 2007), Chair, CSDMS Steering Committee, Penn State Univ.
- Brad Murray (April, 2007), Chair, Coastal Working Group, Duke Univ.
- Pat Wiberg (April, 2007), Chair, Marine Working Group, Univ. of Virginia
- Greg Tucker (April, 2007), Chair, Terrestrial Working Group, CIRES, U. Colorado – Boulder
- Eckart Meiberg (Jan, 2009), Chair, Cyberinformatics & Numerics WG, U. California-Santa Barbara
- Karen Campbell (Oct, 2008), Chair, Education & Knowledge Transfer WG, NCED, U. Minnesota
- James Syvitski *(ex-officio),* CSDMS Executive Director, INSTAAR, University of Colorado - Boulder
- Scott Peckham *(ex-officio)* Chief Software Architect, CSDMS Integration Facility, U. Colorado – Boulder

The Executive Committee is the primary decision-making body of CSDMS, and ensures that the NSF Cooperative Agreement is met, oversees the Bylaws & Operational Procedures, and sets up the annual science plan. ExCom approves the business reports, management plan, budget, partner memberships, and other issues that arise in the running of CSDMS. ExCom met (virtual or in person) four times in 2010 (01/28/10; 05/19/10; 09/01/10; 10/17/10).

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

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

The CSDMS SC assesses the competing objectives and needs of the CSDMS; assesses progress in terms of science, outreach and education; advises on revisions to the 5-year strategic plan; and approves the Bylaws and its revisions. The CSDMS SC met as part of the first joint meeting with the CSDMS Executive Committee on 10/17/10.

2.3 CSDMS Working and Focus Research Groups

The CSDMS community grew by 140 new members reaching a total of 480 (as 12/27/10). A member may join more than one CSDMS group. Growth has accelerated in 2010 bringing forth new talent and ideas to invigorate CSDMS. Membership in Groups as of 12/27/10 was as follows:

Terrestrial	228	Cyber	92
Coastal	163	EKT	59
Marine	124	Carbonate	45
Hydrology	139	Chesapeake	32

Because CSDMS membership is now large, we no longer include a membership listing within this or future Annual Reports. Instead see csdms.colorado.edu/wiki/All_CSDMS_members. **Appendix 1** continues to provide a listing of participating US academic institutions, foreign institutions, and government agencies.

2.4 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. In 2010, Consortia resources were focused on usability of the CSMDS Modeling Tool (CMT) and in the area of Educational activities (short course in Ainsa, Spain; Kiel, Germany). The CSDMS Executive Director met with the engineering modeling team at Électricité de France (EDF), the world's largest utility company. EDF will support the CSDMS effort by offering an extensive state-of-the-art software library designed for hydrology and morphodynamics as open source code (e.g. Telemac, Tomawac etc). Deltares likewise will also make their Delft 3D code open source to the academic community as of January 2011.

2.5 The CSDMS Integration Facility (IF)

The CSDMS Integration Facility (IF) maintains the CSDMS Repositories, facilitates community communication and coordination, public relations, and product penetration. IF develops the CSDMS cyber-infrastructure (e.g. coupling framework, tools, services and software protocols), and provides software guidance to the CSDMS community. The IF maintains the CSDMS vision and supports cooperation between observational and modeling communities. CSDMS' IF is located at INSTAAR, University of Colorado-Boulder, csdms.colorado.edu/wiki/Contact_us. As of Dec 31, 2010, CSDMS IF staff included csdms.colorado.edu/wiki/Staff

- Executive Director, Prof. James Syvitski (April, 2007) — CSDMS and CU support
- Executive Assistant, Ms. Marlene Lofton (Aug. 2008) — CSDMS support
- Chief Software Engineer, Dr. Scott Peckham (April, 2007) — CSDMS and other NSF/NOAA support
- Software Engineer, Dr. Eric Hutton (April, 2007) — CSDMS & LASP support
- Software Engineer, Dr. Beichuan Yan (April, 2009) — CSDMS support
- Computer Scientist, Jisamma Kallumadikal (Aug, 2009) — Industry, CSDMS & NOAA support
- Cyber Scientist Dr. Albert Kettner (July, 2007) — CSDMS, NASA and other NSF support
- EKT Scientist Dr. Irina Overeem (Sept, 2007) — CSDMS, NOPP, ConocoPhillips and other NSF support
- PDF Dr. Maureen Berlin (Oct, 2009) — Other NSF support
- PDF Dr. Sagy Cohen (Aug, 2010) — NASA support
- Ph.D. GRA Stephanie Higgins (Sept, 2010) — Other NSF support
- Ph.D. GRA Fei Xing (July, 2010) — CSDMS and other NSF support
- Ph.D. GRA Mark Hannon (July, 2007) — ONR & ConocoPhillips support
- Ph.D. GRA Ben Hudson (May, 2010) — Other NSF support
- Accounting Technician Mary Fentress (April, 2007) — CSDMS and other support
- Systems Administrator Chad Stoffel (April, 2007) — CSDMS and other support

CSDMS Associates at the Integration Facility include

• Director G Robert Brakenridge, Dartmouth Flood Observatory (Jan, 2010) — NASA support
• Senior Research Scientist Christopher Jenkins (Jan 2009) — NSF and other support

CSDMS IF Visiting Scientists or Students

• Hernan Arango	Prof Marine Sci	Rutgers University, New Jersey	2010 March
• John Gallant	Prof Geol Sci	CSIRO, Australia	2010 April
• Adam Campbell	Ph.D. Student	U. Washington, Seattle	2010 April
• Elchin Jafarov	Ph.D. Student	U. Alaska, Fairbanks	2010 April
• Vittorio Maselli	Ph.D. Student	University of Bologna, Italy	2010 May – June
• Silke C. Lutzmann	M.Sc. Student	University of Bonn, Germany	2010 March – June
• Juan Restrepo	Prof Geol. Sci	EAFIT University, Columbia	2010 July
• Gary Wilgoose	Prof Geol. Sci	Univ. Newcastle, Australia	2010 Sept

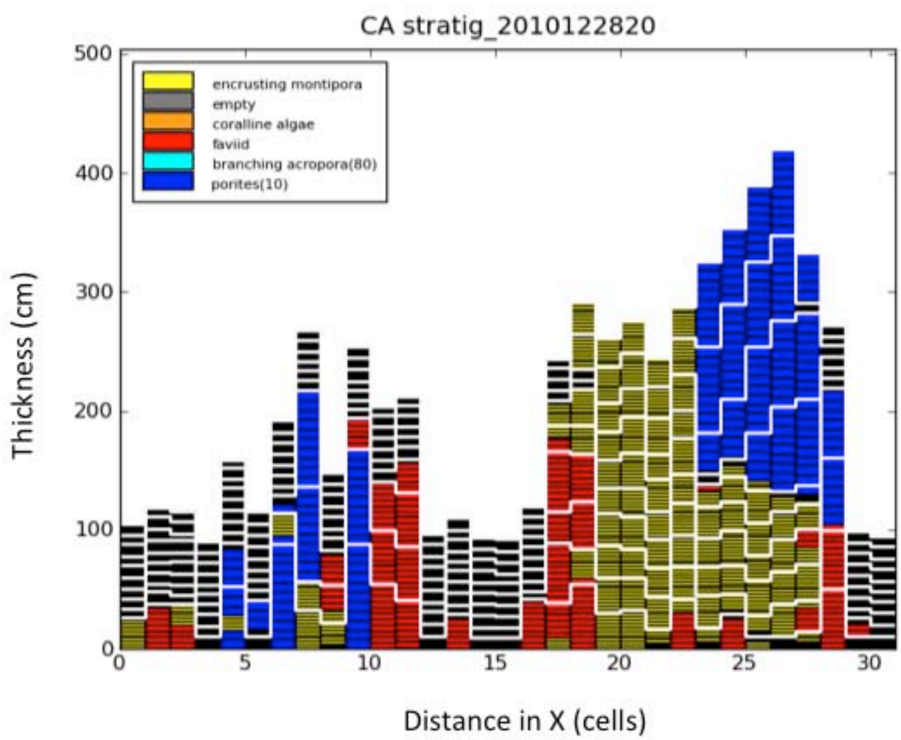


Figure 1. The CSDMS Carbonate Focus Research Group is developing the first open source community carbonate model pyCarboCAT_4_5.py with public release to be in early 2011 (Burgess and Jenkins pers comm., 2010). The figure shows a coral reef thickness accumulation (cm) over 100 years, for a cross-section of the Cellular Model. Isochrons are at 10-year intervals. The relief generated starts from a flat bottom. Testimonial — "Before CSDMS provided the carbonate community with its own Focus Research Group to discuss and advance its own open-source carbonate workbench, the community was dispersed, poorly integrated into the oceanographic community, and highly suspicious of each others models — Rick Sarg (CSM)"

3.0 Just the Facts

3.1 CSDMS Model Repository offers more than 160 models (**Appendix 3**): 72% are available for download through the CSDMS web site (e.g. CHILD, SedFlux), 28% are available after separately registering with other community efforts (e.g. ROMS, NearCOM). Of the 3.4 million lines of code associated with the repository, 57% are written in Fortran and 36% of the CSDMS models are written in C or C++, with Python and MATLAB code comprising most of the remaining models.

Beach Repository statistics as of Dec 2010: csdms.colorado.edu/wiki/Model_SLOC_Page

Language	Projects	Comment	Source	Total
Fortran 77/90/03	45	599649	1353309	1952958
C/C++	39	270681	952747	1223428
Python	5	42645	106482	149127
MATLAB	11	12545	28202	40747
IDL	1	16730	18426	35156
Statistical Analysis Software	1	2390	5796	8186
Java	1	1107	6422	7529
Visual Basic	1	537	5735	6272
Total	**164**	**946284**	**2477119**	**3423403**

Models by Environmental Domain csdms.colorado.edu/wiki/Model_download_protal

106 Terrestrial models,
35 Coastal models,
21 Marine models,
73 Hydrology models,
1 Carbonate models.

Of the 164 CSDMS models, 49 have refactored to be CMT compliant. Model code is downloaded ~2500 times per year. Models can be run on the CSDMS supercomputer without download and are not included in the statistics below. Community models downloaded from other sites (e.g. ROMS, NearCOM) are not counted in the model statistics below. The top downloaded models (as of Nov 25, 2010) csdms.colorado.edu/wiki/Model_download_Page

	Model	No. Times	Topic
1.	**Topotoolbox**	*520*	Matlab functions for topographic analysis
2.	**Child**	*423*	Landscape evolution model
3.	**TopoFlow**	*499*	Spatially-distributed, D8-based hydrologic model
4.	**SedFlux**	*204*	3D coastal-marine transport and stratigraphic model
5.	**2dflowvel**	*151*	Tidal & wind-driven coastal circulation routine
6.	**Adi-2d**	*146*	Advection Diffusion Implicit (ADI) method for solving 2D diffusion
7.	**Midas**	*144*	Coupled flow- heterogeneous sediment routing model
8.	**Bing**	*140*	Submarine debris flows
9.	**HydroTrend**	*129*	Climate driven hydrological transport model
10.	**Gc2d**	*106*	Glacier / ice sheet evolution model
11.	**CEM**	*101*	Coastline evolution model

3.2 CSDMS Data Repository (csdms.colorado.edu/wiki/Data_download) has grown rapidly over the last 12 months. The Dartmouth Flood Observatory has relocated to the CSDMS Integration Facility floodobservatory.colorado.edu/ with its data holdings of particular interest to the CSDMS hydrology community:

1) Global Flood Atlas (digital GIS data showing flooded lands as observed via orbital remote sensing, and with associated recurrence intervals/accidence probabilities for the inundation outlines)

2) River Watch (estimated daily river discharge values from remote sensing for ~2500 sites, distributed along major rivers and tributaries on all continents, July 1, 2002 to present)
3) Global Active Archive of Large Flood Events (catalog of flood events and associated attributes for each, such as geographic centroid coordinates for area affected, duration, calendar start and end dates, fatalities, severity estimates, etc: for 1985-present).

As of Nov 25, 2010, the CSDMS Data Repository offers:

Data Type	Databases		
Climate	3	Oceanography	8
Cryosphere	3	River discharge	7
GIS Tools	12	Sea level	1
Human Dimensions	2	Soils	2
Hydrography	5	Surface Properties	2
Land cover	2	Topography/bathy	16
Network Extraction	8		

3.3 CSDMS Education & Knowledge Transfer (EKT) Repository

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

Climate & Oceanographic Animations	7	Marine Animations	9
Terrestrial Animations	18	Laboratory Movies	13
Coastal Animations	17	Real Event Movies	24

Image Library csdms.colorado.edu/wiki/Images_portal

Terrestrial Images	90
Coastal and Marine Images	49

Modeling Labs csdms.colorado.edu/wiki/Labs_portal

1. Glacio-Hydrological Modeling
2. Modeling River-Delta Interactions
3. Sediment Supply Numerical Experiments
4. Landscape Evolution Numerical Experiments
5. 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. Earth-surface Dynamics Modeling & Model Coupling — JPM Syvitski
3. 1D Sediment Transport — G Parker
4. Morphodynamics of Rivers — G Parker
5. Geological Modeling — I Overeem

Modeling Textbooks csdms.colorado.edu/wiki/Modeling_Textbooks

1. Quantitative Modeling of Earth Surface Processes *By: Pelletier, J.D.*
2. Simulating Clastic Sedimentary Basins: Physical Fundamentals and Computing Procedures *By: R.L. Slingerland, K. Furlong and J. Harbaugh*
3. 1D Sediment Transport Morphodynamics with applications to Rivers and Turbidity Currents *By: G Parker*

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

The CSDMS High Performance Computing Cluster *Beach* has operated well over the last year with CPU loads between 50% and 90% of capacity. *Beach* supports 109 CSDMS members with accounts. Core capacity has recently increased through financial contributions by the U.S.G.S. and the University of Colorado. Users will have met one of the following use criteria:

- Running a CSDMS model(s) to advance science (Fig. 2)
- 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.

Beach is an SGI Altix XE 1300 with 88 Altix XE320 compute nodes (704 cores, 3.0 GHz E5472 Harpertown processors) (≈8 Tflops). 64 nodes have 2 GB of memory per core, 16 nodes have 4 GB of memory per core. *Beach* is controlled through an Altix XE250 head node. Internode communication is accomplished through a non-blocking InfiniBand fabric. Each compute node has 250 GB of local temporary storage. All nodes are able to access 36TB of RAID storage through NFS. *Beach* provides GNU and Intel compilers as well as their MPI counterparts (mvapich2, mpich2, and openmpi). The main power management is an APC UPS with 30 minutes of uptime at 50% load. *Beach* head-nodes are backed-up by a separate SGI installed UPS system. *Beach* is supported by the CU ITS Managed Services (UnixOps) under contract to CSDMS.

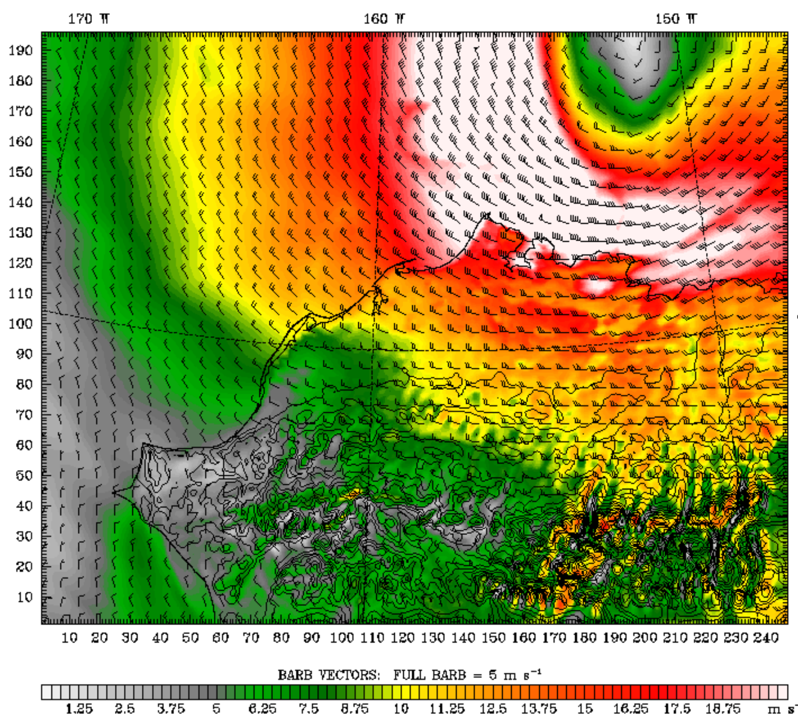


Fig. 2: The Weather Research & Forecasting (WRF) model was created through a partnership with National Oceanic & Atmospheric Administration, National Center for Atmospheric Research and >150 organizations and universities in the US and abroad. Simulation shown is for the WRF wind field for the north slope of Alaska (Aug 10, 2010), at 3.3 km resolution model run on the CSDMS supercomputer Beach. Testimonial — "With a compute time of <1 min per simulation hr, we are cookin' with gas! – Gary Clow"

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

Content Pages	221	Page Edits	19, 683
Total Pages	3,252	Registered Users	533
Upload Files	1,599	View Statistics	1,659,106

4.0 Advances and Progress on Goals

4.1 Goal 1) CSDMS Website 'A Gateway into the CSDMS World'

The CSDMS website has been transformed into an efficient gateway to the main CSDMS Repositories and provided with a faster portal to the CSDMS Modeling Tool CMT.

Fast portal to the CSDMS Modeling Tool (CMT)

a. The front page offers a direct link '**Get started with CMT**' to take visitors to a page that a) explains CMT, b) guides visitors through the three steps required be users, and c) shows how to download and install the CMT. Help pages have been added for each CSDMS components csdms.colorado.edu/wiki/Portal_join_the_community

b. A global '**CMT**' drop box is placed on the site toolbar, where more information about the CMT is provided, including a) how to use the tool, b) visualizations within CMT, c) how to add models to CMT, and d) how to get help csdms.colorado.edu/wiki/CMT_portal.

For people who want to be involved in the CSDMS community

a. A fast '**Contribute'** link is on the front page directs visitors to the various ways to get involved. This guides people on: a) how to submit source code, b) how to make a CMT component, c) how to provide educational material (EKT), d) how to contribute data, e) how to edit the wiki, f) meetings of interest to the CSDMS community, and g) how to provide feedback to CSDMS. csdms.colorado.edu/wiki/Portal_contribute

b. A fast '**CSDMS for me**' link guides visitors to a page where they can: a) become a member, b) find out about CSDMS, c) identifies their capabilities (model user, developer, field researcher, educator, planner, industry), and d) describes the Working or Focus Research Groups. csdms.colorado.edu/wiki/Portal_join_the_community

c. The '**Help**' button on the front page and top menu bar provides further options to: a) search the web, b) read FAQs for each topic, c) read about how to make changes to the website, and d) how to contact the CSDMS integration facility members. csdms.colorado.edu/wiki/Portal_help

Efficient gateways to the three main repositories

a. The three main CSDMS Repositories are: Models, EKT and Data. Each repository has entry through the top website menu bar: '**Models**', '**Education**', and '**Data**', where visitors can contribute, download or read more about the various products. The Repositories are built on database structure that allows for: a) organization based on themes, b) word searching, and c) members to submit a product through a user-friendly form that automatically places the product in the database. Soon a new database structure will allow participants to add a product to smaller datasets (summer 2011).

   Models: csdms.colorado.edu/wiki/Model_download_protal

   Education: csdms.colorado.edu/wiki/Education_portal

   Data: csdms.colorado.edu/wiki/Data_download

b. The Repositories are also directly accessible through a front page "**Download**" quick link that points to additional download material: a) presentations at CSDMS meetings, b) reports and documents such as the CSDMS handbook on modeling tools, c) the CMT tool to run models or couple models on the HPCC. If people wish to contribute material to the repositories, they can follow the quick link on the CSDMS front page "**Contribute**", which will take them to the start page on how to add material to the repositories.

   Download: csdms.colorado.edu/wiki/Portal_download

   Contribute: csdms.colorado.edu/wiki/Portal_contribute

In response to the BP oil spill in the Gulf of Mexico, CSDMS created a Marine Working Group discussion page that served as a clearing house for spill information and was accessed almost 4000 times. csdms.colorado.edu/wiki/Talk:Marine_Discussion.

4.2 Goal 2) Usability of the 'CSDMS Modeling Framework'

The CSDMS Modeling Tool (*CMT*) is a key CSDMS product, allowing earth scientists with modest coding experience to run models in standalone mode or coupled configurations, for surface dynamics research and education on the CSDMS computing cluster. On June 14, 2010, CSDMS announced the first official release of the CSDMS Modeling Tool, version 1.4. Between September and December 2010, the CMT has been evaluated through a CSDMS-sponsored graduate level course taught at the University of Colorado called 'GEOL5700: Surface Process Modeling: applying the CSDMS Modeling Tool'. Students learned to run hydrological and geological models on the CSDMS supercomputer, visualize their simulations with *VisIt*, and gain skill using NetCDF files. Importantly, students coupled models that bridge traditional modeling domains. The course identified user needs that prompted improvements in the *CMT* software, model communication with *Beach*, and enhanced the *CMT* documentation. Improvements led to the release of version 1.5.3. (12/23/2010). *CMT* is platform independent and available for use on Mac, Window, and Linux operating systems (Fig. 3).

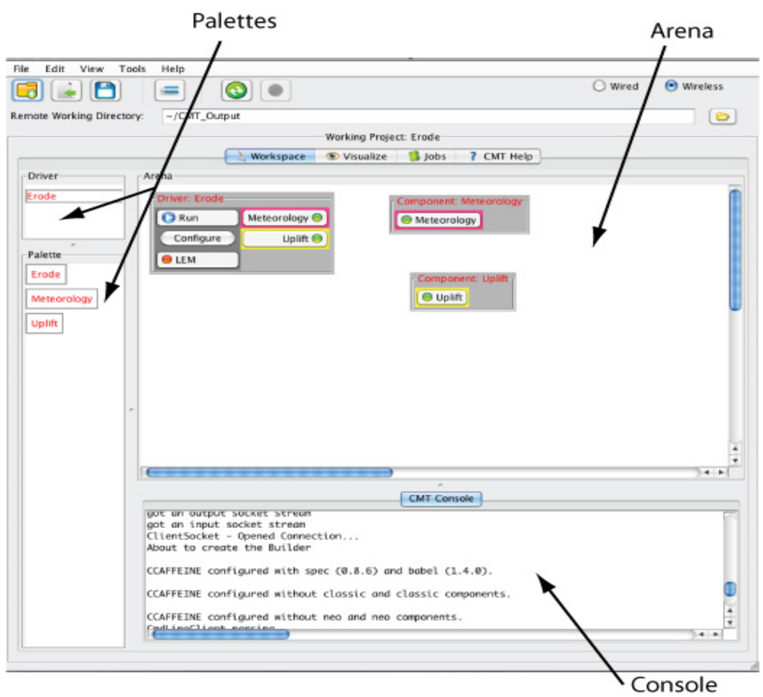


Figure 3. The CMT GUI for model coupling on the CSDMS HPCC Beach. Users can drag and drop components from in this example a Terrestrial Project environment, to activate the working Arena. Color-coded bullets visually enhance model connections, along with input-output linkages: green buttons shows active connections.

Requirements for New Users of CMT:

We have streamlined the CMT 1.6 installation process for new users, including the three requirements before one can run experiments on the CSDMS HPCC:

1. Be a CSDMS member,
2. Get an account on the supercomputer *Beach*,
3. Install VPN software and gain a secure connection to the CU network.

Upon opening *CMT 1.6*, users are prompted to enter their *Beach* login information. A link to the CSDMS website prompts if the user has not already obtained access to *Beach*. The opening screen of CMT 1.6 starts on the "About *CMT*" tab, which offers a general help page: "Getting Started with the CSDMS Modeling Tool". This page provides step-by-step instructions on how to start and login to *CMT*. The general layout of *CMT*, including the Palette, Arena, and Console, is demonstrated (Fig. 3). Each of the commands on the menu bar is described. If the user navigates away from this page, the Getting Started document can be accessed from the Help menu or by clicking the About *CMT* tab. Another "Getting Started" help page is available on how to create a coupled model project. This page outlines the steps to such a model within *CMT* by dragging components from the Palette into the Arena.

VisIt:

VisIt is a free interactive parallel visualization and graphical analysis tool for viewing scientific data on Unix and PC platforms, developed by the Department of Energy's Advanced Simulation and Computation Initiative. The CSDMS wiki now contains detailed instructions on how to install *VisIt* for both Mac and Unix and PC systems. csdms.colorado.edu/wiki/CMT_visualization. *VisIt* uses the computing power of *Beach*. Students have commented that *VisIt* is not straightforward to use. As a consequence we provide tutorials on common visualization tasks. Once users have installed *VisIt* on their local machine, they may follow along with a brief tutorial "Getting Started" under the Help >> *VisIt* menu. This tutorial walks the user through the interface by which they can select model output files stored on beach, and visualize these results using *VisIt*. An additional tutorial under the Help >> *VisIt* menu, "Create Movies" provides detailed instructions on creating movies using *VisIt*. In this case, *VisIt* is launched from *beach* rather than from the user's local machine, in order to produce better quality MPEG movies.

CSDMS Modeling Tool *CMT 1.5.3* made user-friendly for both novice and expert users:

- Communication from the user's computer to *Beach*
  - The *CMT 1.5.3* can be download directly from the CSDMS website as a java application (Mac, Windows, and Linux versions are available).
  - For fast access by experienced users, one can go to the database of model components on the CSDMS wiki and start the *CMT* directly for *CMT* compliant models.
  - Users are automatically informed when a new version is available upon start up.
- Improved Remote Access Functionality to link users to *Beach*
  - Login screen bypasses SSH command line interaction of users.
  - SSH tunneling is automatically funneled via *CMT*.
  - Sftp transfers input and output files from *Beach* to users local machine and vice versa.
- Improved Look and Feel
  - Components are labeled with their model name, to make apparent what connections are active.
  - Clear distinction between a 'Driver', which orchestrates the simulation, and other components.
  - Component connections are color-coded so that coupling can be visualized (Figure 4).
  - Wired and wireless options for creating models; wireless option can automatically connect components in the Arena. Green buttons indicate whether connection is active.
  - Customizable background color and screen font
- Improved Input/Output Operations
  - A Console window prints model run messages that can be saved as log files for debugging.
  - 'Submit Job' is an option, apart from 'running the CMT while watching its progress'. This functionality is useful when doing multiple scenarios, sensitivity experiments or testing, all of which are situations where multiple experiments need to be run at the same time. Using the job manager of the CMT bypasses expert-use of scripts and direct job management on *Beach*. Users can decide whether to receive an email upon completion of their requested job.
- New or multiple experiments
  - Open & Save Configuration of experiments so that re-runs of simulations are efficient.
  - Import Example Configurations by loading tested 'pre-wired' example *.bld files
  - Configure Dialogs, for user to configure the input and output parameters and files for each model component in a Graphical User Interface. Some models have never had a GUI for setting up simulation, for example the Regional Oceanographic Ocean Model ROMS, and so it is a real novelty to provide a click and play environment for these models (Figure 5).
- Usability for Advanced Users to quickly switch environments

- Set a default modeling project
- Option to Remove/Delete components and Clear Arena
- Project Refresh & Reload options
- Preferences page

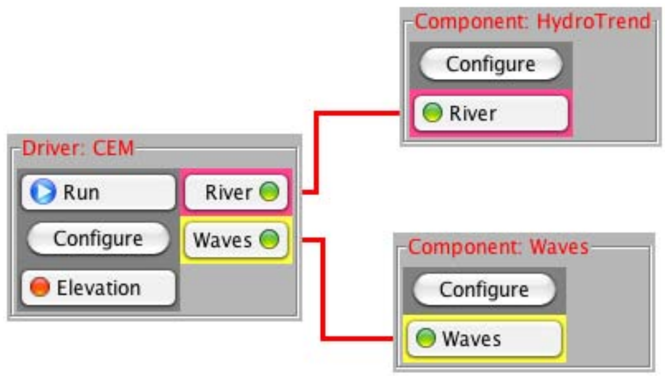


Figure 4. Wiring diagram shows coupling of HydroTrend (simulator of water and sediment discharge), with Waves (wave climatology simulator), driven by the Coastal Evolution Model to simulate a delta evolution (see Fig. 8). Users can drag and drop the components from a Coastal Project environment. Tabbed 'configure' menus for each component allow the specification of simulation parameters. A click on 'run' and the coupled components execute on simulation on the CSDMS HPCC Beach.

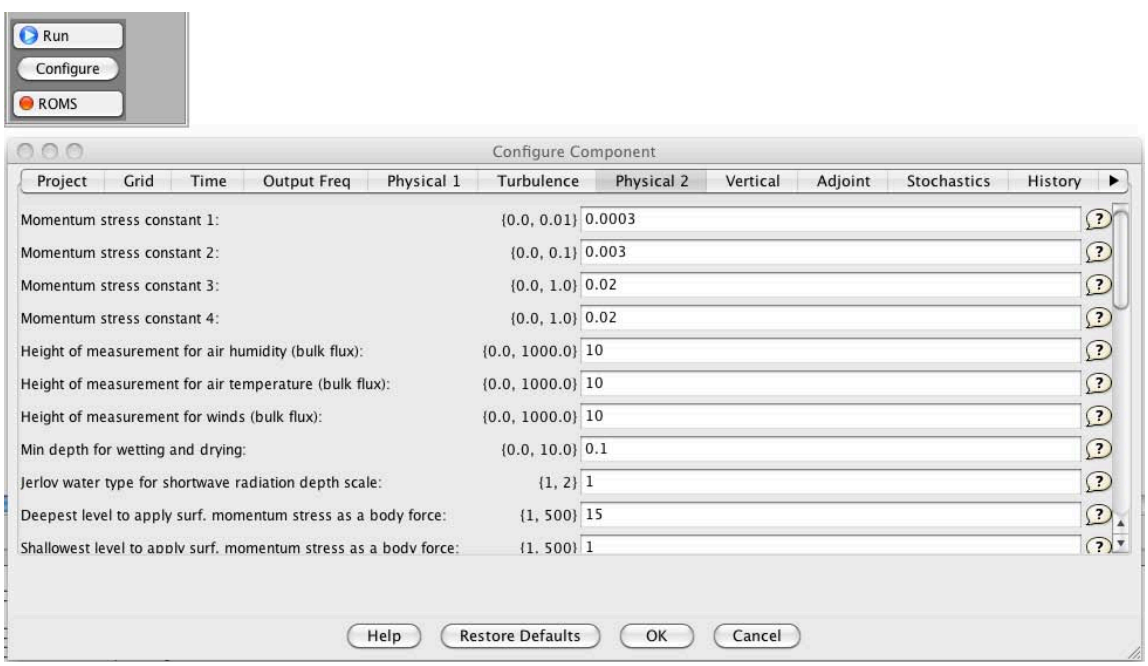


Figure 5. ROMS-the Regional Ocean Modeling System can be run stand-alone in CMT. Users click on the 'configure' tab and set simulation parameters. The 'help' button on the bottom-left leads to advanced documentation on model setup and parameters. Given ROMS vibrant user-base and documentation on its wiki website, the 'help' her leads to the MyROMS community user page.

- Visualization Tool
  - Added access to HPCC visualization tool (VisIt) for output figures and movies
  - Changed input and output files of many components to have NetCDF capability to visualize through VisIt.

- Help within the context of the CMT has been added at Introduction level, at Example Configuration Level and at the Most Advanced Process and Parameter level (further discussed under Goal 7 below).

Moving the CMT beyond 'the black box'

Model users should have access to a model's background information, its process equations and its parameter definitions. Each compliant CSDMS module is given 'HTML Help Pages' on the CSDMS wiki, listing information on the model's processes and parameters. Developers ensure the information posted on our wiki-based site is accurate. Upon opening a CMT project, users may choose to open example configuration files (where model components are already configured in the CMT Arena), or to drag components into the Arena from the model Palette. Each component has a "Configure" button that opens a tabbed dialog box where the user may click on the "Help" button to open a CSDMS wiki help page. The help pages are component-specific and provide detailed information on the processes, governing equations, and parameters for each model component, as well as relevant references. Component-specific help files are currently available for TopoFlow, Erode, HydroTrend, GC2D, CEM, Waves and SedFlux model components. For components that have yet to receive html help files, the "Help" button connects to the model's metadata on the CSDMS wiki or to alternate community portals (e.g. ROMS). All example configuration (.bld) files are tested (execution and output); this does not include extensive testing with different parameter combinations. Note: .bld files were not created for the ODE or PDE components, examples already document within the CCA Forum Tutorial.

Framework testing by non-experts.

The CSDMS component testing team includes the original developer, CSDMS software architects, web master, EKT specialist, and testers with limited modeling experience. For example Aaron Zettler-Mann, a CU summer Undergraduate Research Assistant, ran tests of the *HydroTrend*, *CEM*, *TopoFlow*, and *WaterTank* components and assisted in the development of model tutorials. Silke Lutzmann, an MSc student at Bonn University, Germany, tested the *HydroTrend* component employing reconstructions of the sediment load of the Rhine River over the Holocene. Vittorio Maselli, a PhD student at University of Bologna, Italy is testing the *SedFlux* components with his modeling of sequence stratigraphy in the central Adriatic Sea. Dr. Phaedra Upton, a professor in Geodynamics at the University of Otago, New Zealand, is pioneering source-to-sink modeling by coupling *HydroTrend*, *SedFlux* and *CHILD* for an application related to the Waipaoa River basin. *CMT* components have also been extensively tested in a CSDMS-sponsored graduate course (see Goal 7), which have led to numerous improvements in software communications with the computing cluster, and enhancements of the *CMT* Documentation and Help System.

4.3 Goal 3) Componentizing the CSDMS Model Repository

In Year 3, 6 models were transformed into CSDMS components to operate within a beta version of *CMT*. The models encompassed six authors, four languages, four environmental domains, three types of gridding, and two levels of modularity. The success of this effort led CSDMS engineers to engage on sequentially componentizing the CSDMS holdings. Presently 49 models have been refactored into plug-and-play components, an 800% increase. Prioritizing was based on Working Group feedback. New utilities greatly simplify wrapping contributed models as CSDMS components. Examples are given below.

The *STM* project is the set of Gary Parker's eBook, "1D Sediment Transport Morphodynamics" wrapped as CSDMS plug-and-play components. *STM* is a collection of models that deals with 1-dimensional sediment transport morphodynamics with application to rivers and turbidity currents. The book includes 27 independent models covering various aspects such as threshold of motion and suspension, bulk relations for transport of total bed material load, 1D aggradation and degradation of rivers, morphodynamics of bedrock-alluvial transitions, formulation for slope and bankfull geometry, and plunging of turbidity currents. Each model is now a CSDMS plug-and-play component with enhanced user-friendly graphical interfaces.

ROMS is a free-surface, terrain-following, primitive equations ocean model widely used by the scientific community for a diverse range of applications. It is a modern code supporting serial and parallel computing. In its parallel part, both shared (*OpenMP*) and distributed-memory (*MPI*) paradigms coexist together in a single code. *ROMS*'s serial capability has been wrapped as a CSDMS component and can be run either from CSDMS's *CMT* front-end graphic tool or from a command-line script. *ROMS*'s parallel code has been componentized and able is to run within an alpha version of CMT that can run components within an *MPI* environment.

The Ashton Coastal Evolution Model (*CEM*) component (csdms.colorado.edu/wiki/Model_help:CEM) was refactored as a CMT plug and play component. It now communicates with wave and river components that provide incoming wave characteristics and water and sediment discharge across a delta, respectively. The new *Waves* component (csdms.colorado.edu/wiki/Model_help:Waves) is based on the Ashton wave generator that was incorporated into the original *CEM* model. *Waves* provides time-varying incoming wave angles, wave heights, and lengths. It produces a directional wave climate through two main input parameters: asymmetry of incoming waves angle and proportion of high-angle waves. Although originally intended to couple with the *CEM* component, *Waves* provides wave characteristics that can be used other components that use such input.

Staff componentized the *Avulsion* model part of the *SedFlux* model family. *Avulsion* routes water and sediment to the coast from one or more streams and from a delta "hinge point". The partitioning of distributary discharge is governed by streambed slope. *Avulsion* bridges between components that provide sediment and water discharge (e.g. *HydroTrend*) and components that distribute sediment along a coastline (e.g. *CEM*). The configuration of *CEM* coupled with *Avulsion* is an example of two-way coupling — *CEM* uses output from *Avulsion* (sediment discharge at river mouths) but also provides input to *Avulsion* (delta-plain elevation).

A set of "pre-wired" CSDMS model configurations were developed and tested for use by new users as working examples, for benchmarking and as educational material.

4.4 Goal 4) Advancing Goals of the Working Groups and Focus Research Groups

A CUAHSI HIS "web service component" was completed able to download hydrologic time series data and either share it through a CCA/IRF port with other components or write the data to file. The component has a tabbed-dialog GUI and an HTML help page. Virtually the same code can be adapted for the creation of other web-service components, such as (1) an OpenDAP component (for grids and grid stacks) and (2) downloads of USGS NED (seamless) DEM for a specified bounding box. The HydroModeler tool within the CUAHSI-HIS HydroDesktop includes hydrologic components that have a simplified OpenMI interface. Given this interface, CSDMS will merge these into its existing collection of hydrologic components, in order to better serve the Hydrology FRG.

A set of low-level Python components was developed for the Terrestrial Working Group that can perform fundamental DEM processing tasks like (1) filling depressions in a DEM, (2) extracting drainage networks, (3) computing slope grids and (4) computing contributing area grids. The fluvial landscape evolution model *Erode* that has been fully wrapped as a CSDMS component currently uses this toolkit. We have also tested the new, parallel version of TauDEM on *Beach*, to perform DEM processing tasks while using multiple processors.

SedFlux is being deconstructed into separate process components. Standalone modules at present include *Plume*, *Avulsion*, *Subsidence* and a 2D (vs.) 3D *SedFlux* component. Tabbed dialogs for these components are under development. Abstraction of *SedFlux*'s low-level data structures to create a "*SedGrid*" toolkit (for the Carbonate Focus Group) is near completion. A prototype of a new carbonate component is near completion.

Four of the CSDMS Working or Focus Research Groups (Marine, Coastal, Chesapeake and Carbonate) have identified the *ROMS* ocean model as a high priority for CSDMS staff to refactor into a component. *ROMS* is presently wrapped as a stand-alone component in the *CMT* and for the first time is provided with a tabbed-dialog GUI that simplifies creation of a *ROMS* input file (ocean.in). The model is extended for use within *CMT* with both single and multiple processors. Work is ongoing to have *ROMS* couple with other models within *CMT (e.g.* LTRANS used for larval transport and environmental hazard modeling).

CMT is proving to be a powerful educational tool and is therefore a priority for the EKT working group. Demonstrations of *CMT* at the CSDMS All-Hands Meeting in San Antonio were well received. *CMT* was featured in a graduate-level modeling course (GEOL 5700) taught by CSDMS staff, which led to refinements and new teaching materials.

4.5 Goal 5) Conferences, Meetings, and a CSDMS Special Issue

CSDMS staff participated in the following 2010 related meetings:

01/2010	CSDMS ExCom Teleconference	Boulder CO, USA
02/2010	NSF MARGINS Successor Planning Workshop	San Antonio, TX, USA
03/2010	CSDMS Interagency Meeting	Arlington, VA, USA
03/2010	NERC-NSF Critical Zone Observatories	Arlington, VA, USA
03/2010	Arctic Workshop	Winter Park, CO, USA
04/2010	Joint AAPG and SEPM annual meeting	New Orleans, LA, USA
05/2010	EPSCoR Climate Innovation Workshop	Valles Caldera, NM, USA
05/2010	BP Gulf Oil Spill Teleconference	Boulder, CO, USA
05/2010	CUAHSI HIS Advisory Comm. Telecon	Boulder, CO, USA
05/2010	CSDMS ExCom Teleconference	Boulder, CO, USA
05/2010	American Polar Society meeting	Boulder, CO, USA
05/2010	ONR Coastal Geosciences meeting	Chicago, IL, USA
06/2010	CUAHSI HIS Advisory Comm. Telecon	Boulder, CO, USA
06/2010	Western Pacific Geophysics Conference	Taipei, Taiwan
06/2010	CSDMS-China Cooperation meeting	Qingdao, China
07/2010	NSF CUAHSI Open Meeting	Boulder CO, USA
07/2010	CUAHSI HIS Workshop	Boulder CO, USA
07/2010	Univ. of New Mexico meeting	Reno, NV, USA
08/2010	NSF RAPID oil spill modeling team meeting	Woods Hole, MA, USA
08/2010	NCED Summer Institute	Minneapolis, MN, USA
08/2010	Stratigraphy Tripod S2S ExxonMobil Meeting	Barcelona, Spain
08/2010	CSDMS-EDF Cooperation meeting	Paris, France
09/2010	CSDMS ExCom Teleconference	Boulder CO, USA
09/2010	National CZO Meeting	Boulder, CO, USA
09/2010	NSF RAPID oil spill modeling telecon	Boulder, CO, USA
09/2010	Future Ocean Symposium:	Kiel, Germany
09/2010	Storm Surges Congress	Hamburg, Germany
09/2010	Geol. Soc. Landscapes Into Rock	London, UK
09/2010	18th International Sedimentological Congress	Mendoza, Argentina
10/2010	CSDMS: Modeling for Environmental Change	San Antonio, TX, USA
10/2010	CSDMS ExCom & SteerCom meeting	San Antonio, TX, USA
11/2010	NSF RAPID oil spill modeling telecon	Boulder, CO, USA
11/2010	CUAHSI HIS advisory committee meeting	DC, USA
12/2010	Oceanography of Vietnam Workshop	Hai Phong, Vietnam
12/2010	Intl. Summit on Integrated Environ. Modeling	Reston, VA, USA
12/2010	NSF RAPID oil spill modeling telecon	Boulder, CO, USA
12/2010	AGU fall meeting	San Francisco, CA, USA
12/2010	Gilbert Club	UC Berkeley, CA, USA

Seventy-six CSDMS members participated in the first all hands meeting (San Antonio meeting 10/14/2010 – 10/17/2010) entitled *Modeling for Environmental Change* csdms.colorado.edu/wiki/CSDMS_2010_meeting. The workshop offered 1) scientific insights into the modeling of surface dynamics and environmental change; 2) new advances in cyber-infrastructure; 3) development and use of CSDMS models in education; and for the first time 4) allowed CSDMS Working and Focus Research Groups to meet together and strategize on the direction of CSDMS for the next 5 years. In addition to extensive poster sessions, the meeting featured:

13 keynote lectures

1. Coupling Between Coastline and Fluvial Dynamics: Andrew Ashton (WHOI)
2. The Regional Ocean Modeling System (ROMS): Algorithms and Applications: Hernan Arango (Rutgers U)
3. Terrestrial surface-dynamics modeling: lessons and capabilities: Greg Tucker (CIRES)
4. Weather Research & Forecasting Model (WRF) for Surface Dynamics & Environmental Studies: Gary Clow (USGS)
5. The Regional Ocean Modeling System Within CSDMS for Application to the Chesapeake Bay: Carl Friedrichs (VIMS)
6. State of the Art Carbonate Forward Modeling: Peter Burgess (Royal Holloway)

7. High-Performance Component-Based Scientific Software Development: Boyana Norris (Argonne NL)
8. CSDMS Support for a Community Hydrologic Modeling Platform: Jay Famiglietti (UC Irvine)
9. Taking it to the Streets: The Case for Modeling in the Undergraduate Curriculum: Karen Campbell (NCED)
10. Feature Analysis of Coupling Technology for Climate Models: Spencer Rugaber (Georgia Tech)
11. Gulf Oil Spill: Yonggang Liu (U. South Florida)
12. From sediment routing to fluid flow: turning doodles into digits: Dave McGee (ConocoPhillips)
13. The Morphodynamics E-book: A labor of love that never quite gets finished: Gary Parker (U Illinois – UC)

4 clinics

1. Using the CSDMS Modeling Tool: Irina Overeem (CSDMS IF)
2. New CSDMS Tools and Information for Code Contributors: Scott Peckham (CSDMS IF)
3. Introduction to Parallel Programming with MPI: Pavan Balaji (Argonne NL)
4. Parallel Programming with MPI and Alternate One-sided Programming Models: Pavan Balaji (Argonne NL)

6 multi-session breakout meetings

1. Delta morphodynamics: coupling fluvial, coastal, marine processes and human influences on deltas
2. Couplings between physical, biological and human processes in earth surface and ocean dynamics
3. Landscapes into Rock
4. Strategies for Improving CSDMS Communication and Community
5. CSDMS Education and knowledge transfer strategies
6. CSDMS Cyberinfrastructure: Expanding our Reach

Appendix 2 provides the abstract volume for the San Antonio meeting. **Section 6** provides preliminary 5 year strategic plans for CSDMS.

CSDMS Special Issue of 'Computers and Geosciences' is in the process of completion, generated from papers largely presented by participants of the CSDMS 2010 'Modeling for Environmental Change' Meeting. 27 manuscripts are expected with submission deadline February 15th 2011; scheduled publication by the Fall 2011:

1. *Andrew Ashton*. Progress in Coupling between Coastline and Fluvial Dynamics.
2. *Patrick Belmont.* Extraction of floodplain width for modeling channel-floodplain evolution.
3. *Peter Burgess and C. Jenkins*. A fresh approach to modeling Carbonate Sediments using Cellular Automata, Population Ecology and Knowledge Base.
4. *Karen Campbell.* Talking it to the Streets: The case for modeling in the undergraduate curriculum.
5. *Sagy Cohen, A. Kettner and J. Syvitski.* Modeling global scale sediment flux, a new component in the spatially distributed Framework for Aquatic Modeling of Earth System (FrAMES).
6. *Jennifer G. Duan, S. Zhang, and C. Yu.* Computation of Sediment Sorting in Meandering Channels.
7. *Jose Felix*. Sediment dynamics over Tiger and Trinity Shoals off the Louisiana Coast.
8. *Kaveh Ghayour*. Conditioning of process-based models.
9. *Brendon Hall.* Numerical simulations of Wax Lake Delta.
10. *Brendon Hall and E. Meiburg.* Numerical simulations of eroding and depositing turbidity currents.
11. *Elchin Jafarov, S. Marchenko, and V. Romanovsky*. Numerical Modeling of Permafrost Dynamics in Alaska Using a High Spatial Resolution Dataset.
12. *Rebekka Koppman, J.-M. Hervouet and C. Villaret.* Telemac2D-Sisyphe: morphodynamic modeling of rivers, coastal zones and estuaries.
13. *Michael Li.* Modeling seabed disturbance and sediment mobility on the Canadian Atlantic shelf.
14. *Jorge Lorenzo-Trueba and V. R. Voller*. The utility of geometric models in describing fluvial-deltaic sedimentation.
15. *Dave McGee*. From sediment routing to fluid flow: turning doodles into digits.
16. *Brad Murray, D. McNamara and M. Smith*. Coupling economic and geomorphic models to address joint responses to changing climate forcing: examples from coastal environments.
17. *Mohamad Nasr and Eckart Meiburg*. Turbidity Currents in Meandering Channels.
18. *Boyana Norris, S. Peckham and E. Hutton*. A component-based approach to integrated modeling in the

geosciences.
19. *Scott Peckham and J. Goodall*. Driving plug-and-play models with data from web services - A demonstration of interoperability between CSDMS and CUAHSI-HIS.
20. *Spencer Rugaber, R. Dunlap and L. Mark*. Feature Analysis of Coupling Technology for Climate Models.
21. *Kevin Sellner and C., Friedrichs*. Suites of Chesapeake Models and Importance for Science-Based Management.
22. *Tao Sun*. Process-based modeling of shallow and deepwater depositional systems.
23. *James Syvitski*. (Title to be determined).
24. *Greg Tucker*. ModelGrid: a software component to create and manage 2D grid operations for flux-conservative numerical models.
25. *Phaedra Upton and A. Kettner*. Application of CSDMS codes to Source-to-Sink studies in New Zealand: The Waipaoa and the Waitaki catchments.
26. *Enrica Viparelli, J. Wesley Lauer, P. Belmont and G. Parker*. A numerical model to develop long-term sediment budgets using isotopic sediment fingerprints.
27. *Tzu-hao Yeh, and G. Parker*. An application for evaluation of sediment-induced stratification in open-channel flows.

4.6 Goal 6) Technical Advances in the CSDMS Cyber-Infrastructure

CSDMS staff has worked on a suite of cyber issues to aid in the future direction of the CSDMS modeling environment, including issues related to semantics and ontologies.

- New components were written to save time-indexed model output of four different types to NetCDF files. The types are time series (0D), profile sequence (1D, e.g. soil moisture profile evolving in time), grid sequence/stack (2D), and "cube" sequence (3D). By working with the developer of *VisIt* its basic NetCDF reader can now read and display all 4 types correctly as a time-varying database. One of the 4 new NetCDF I/O tools is now CF compliant (as confirmed with an online compliance checker tool) and the 3 other types will soon be compliant.
- NetCDF files describe data that is overlaid onto a rectilinear grid. Although a majority of models in the CSDMS Repository use rectilinear grids, many do not. Currently, there is no standard for representing unstructured grids with NetCDF, however we are working with Rich Signell and the UGRID community developing a standard. In the meantime, CSDMS has created utilities that write unstructured grids to the VTK unstructured grid format. Both the NetCDF and VTK writers are written in Python but can be used within the CCA framework in any of the supported languages. Virtually all CSDMS model components have been modified to write their output to NetCDF files using these new tools. Components based on unstructured grids now write to VTK format.
- Completed a general tool that allows a tabbed dialog GUI to be generated automatically from a file that provides an XML description of the dialog. This allows developers to easily add or subtract which input items are available to the end user of the model component. This can be done quickly at run-time without needed to rebuild the component or project.
- Completed a general tool that generates model input files based on user selections from the tabbed dialogs within CMT. This same text file also serves as a component's low-level configuration/input file (or files). This tool is written as a Python module and wrapped as a CCA component that can be used by components written in any of the supported languages. All of the CSDMS components now have tabbed-dialogs for input with a uniform look and feel.
- All CSDMS components now have the ability to use separate directories for input and output. They also prompt for a "site prefix" and "case prefix" that they use to generate default filenames for output. The site prefix describes the location or study site and the case prefix describes the model run scenario.
- Wrapped a powerful regridding tool developed within the ESMF project as a CSDMS component. ESMF is a suite of software tools for developing high-performance multi-component Earth science modeling applications. ESMF defines an architecture for composing complex, coupled modeling systems and includes

data structures and utilities for developing individual models. Its infrastructure is able to map or regrid user-defined fields between structured grids and unstructured grids with the support of parallel computing. CSDMS developers extracted the mapping/regridding functionality and wrapped it within a CSDMS component (called ESMF mapper). This enhances CSDMS's potential to integrate and couple models that use different grid types and with increased grid sizes.

- Added a tool to generate a simple, standard report upon completion when components are used in stand-alone mode. The report contains information such as run time and input/output directories, etc.

- Created a new utility that helps streamline creation of CSDMS-compliant components to be used within the *CMT*. The utility, written in Python, creates a new CCA component with the CSDMS interface necessary to link with other components. The component is created with boilerplate code that indicates locations where the developer is to insert implementation code for the particular model. As an alternative, the tool can automate this implementation step by reading a configuration file that summarizes how the developer wishes to implement the model. Although not out of alpha testing this tool serves as a proof-of-concept project for how component creation might be automated.

- Both serial and parallel computing environments have been built on *Beach* to provide a consistent interface to CSDMS users. For example, a user can specify how many computing nodes and how many processors per node he wants for his simulation through CMT tool. The CMT tool generates scripts at two levels (component behavior level and HPCC job scheduling level) and run the model on *Beach*.

4.7 Goal 7) Educational and Knowledge Transfer

2010 EKT goals included the creation and testing of tutorials and a help system for the CSDMS Modeling Tool CMT, and improving the Educational Repository. Clinics and short courses on CMT models and model coupling were developed and provided to the community. Feedback from CSDMS members on their experiences with using the CMT was solicited. The EKT Working Group inventoried Earth Surface Dynamics Modeling courses (highlighted in the 2010 semi-annual report) and solicited CSDMS members with instructional material to share. Common elements of these courses and experiences were identified to inform the development of CSDMS educational modules.

CMT has developed a multilevel help system: there are tutorials for new users and for advanced model developers. CSDMS staff taught a series short course on 'the use of the CMT for running stand-alone and coupled models' (e.g. CSDMS Annual Meeting). This course is prominently featured as a resource in the new web-portal for all new users of the CMT. A 2-credit course for graduate students was taught in the Fall 2010 semester offering laboratory exercises on surface dynamics modeling with the HPCC and CMT. Teaching material is shared through the EKT repository.

The EKT repository has undergone a major overhaul, web-entries are more categorized in a few key portals, and active contributions are facilitated through an automatic database submission form. We think we made it easier for teaching faculty and assistants to mine, share and contribute material.

CMT Help System and Tutorials

The CSDMS Modeling Tool *CMT* will play an important role in making surface dynamics modeling accessible for student users and researchers with modest modeling experience. *CMT* has documentation for ease of use at a number of levels; ranging from general notes on installation, remote access requirements and software use on our wiki, to detailed notes on a certain parameter in a model equation within the menus of the relevant component. This documentation will continue to be refined by users for clarity. Each new user is confronted with a general "Help System' and instruction on 'How to Create a model in a few steps (Fig. 6). These concise learning modules help new students and other science users to get their first hands-on experience with *CMT*.

CMT now offers all relevant coupled components (as of December 2010):

1) Event-driven precipitation influencing landscape evolution (*CHILD or Erode*)

2) Sediment supply to deltas (*HydroTrend*)
3) Valley glacier dynamics affecting basin hydrology (*GC2D* + *TopoFlow*)
4) Model inter-comparisons of 3 infiltration models (*TopoFlow*)
5) Stratigraphic architecture and plume dynamics (*SedFlux 2D* and *3D*)
6) River fluxes into a wave-dominated coastal environment (*HydroTrend* + *CEM*)

Each component has enhanced documentation in the CSDMS EKT Repository and Model Help System, and available manuals incorporated for new users to familiarize themselves with model theory and equations. Each example comes with one or more well-tested 'bld-files' that operate as pre-built coupled components. The CSDMS Help System (Figure 7) provides scientific background of the coupling with example simulation output (Figure 8).

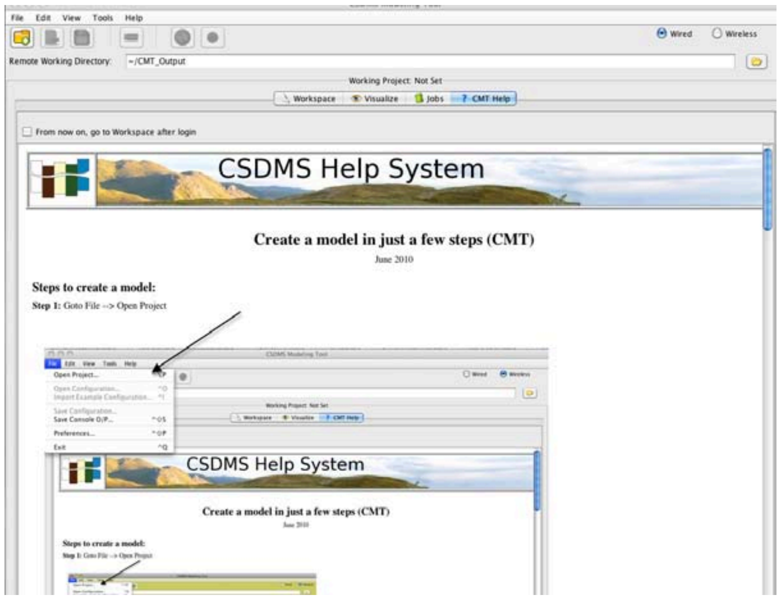


Figure 6. A new user will launch the CMT and then be taken to the first port of call; 'How to create a model'.

Feedback on experiences with CMT

CSDMS members received an announcement of the first official release of *CMT* 1.4 explaining how to report a bug through the CSDMS Track page. Selecting the "Report a bug" option opens a dialog box, in which users may choose whether to create a new ticket for the bug they have discovered, or to view active tickets. Users may contribute tickets without needing to log in to the CSDMS Track page; by providing their email address they will receive replies or updates regarding the bug. A model run on beach using *CMT* generates a log file that records the contents of the .bld file, indicating configuration settings of the model run. These log files are accessible to CSDMS IF staff. Based upon the time of the run and the model name indicated in the log file, log files can be matched to any Track tickets based upon the details that are provided by the user. As more users begin using *CMT* these log files will help with troubleshooting problems with both the model and *CMT*. The CSDMS website portal 'Get Started with CMT' also offers explicit feedback requests. http://csdms.colorado.edu/wiki/CMT_help

Inventory of Earth Surface Dynamics Modeling courses

Based on a recommendation from the EKT Working Group 2009 meeting, a survey of university course catalogs was surveyed to discover how surface process modeling is currently being taught. The Association of American Universities was targeted as a sample of research-intensive universities. Of the 36 private and public universities with a geology or civil engineering department, 16 were CSDMS member institutions. All regions of the United States were represented with concentrations in the Mid-Atlantic, Midwest, and Pacific regions. Undergraduate student populations ranged from <1,000 to >75,000; graduate student populations varied from 1,000 to >14,000. Course catalog and other department information about courses were reviewed: course name, department, level, credit hours, format, required prerequisites, programming languages used, and course objectives. Course titles and keywords that were of interest relevant to CSDMS Working and Focus Research Groups include:

- Modeling of earth surface processes
- GIS/remote sensing
- Quantitative techniques/statistics
- Sedimentary geology modeling
- Hydrology glaciology
- Fluid dynamics
- Groundwater hydrology modeling, hydrogeology
- Global change climate modeling

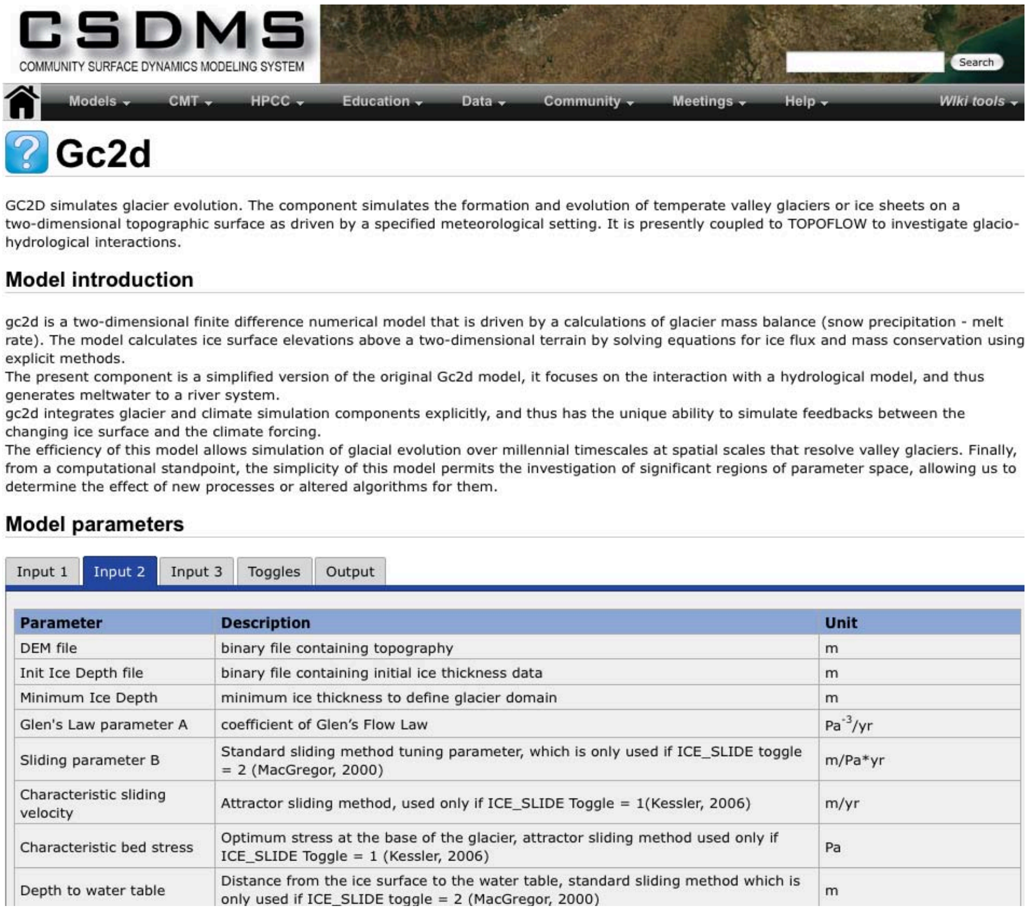


Figure 7. CSDMS website Model Help page of the glacier (GC2D) component. 'Help' buttons within the CMT direct users to documented model theory and concise parameter descriptions. This ensures that users do not perceive model components as a 'Black Box'.

For the 36 universities surveyed, 1043 courses had relevance to CSDMS in terms of subject matter or the use of models. Geosciences and Civil Environmental Engineering Departments had most courses with most related to the Hydrology and Terrestrial groups. Matlab was the most common language mentioned in course descriptions, although CMT-supported languages were also present. Hydrology courses represent the greatest opportunity for immediate or near-term use of CSDMS products; civil/environmental engineering departments may be the most logical host of these courses. The full study is available in the 2010 Semi-Annual Report. A course questionnaire targeting CSDMS members is underway to validate these results. This secondary survey has the goal to identify common elements of these courses and experiences of instructors and students to inform the development of CSDMS educational modules.

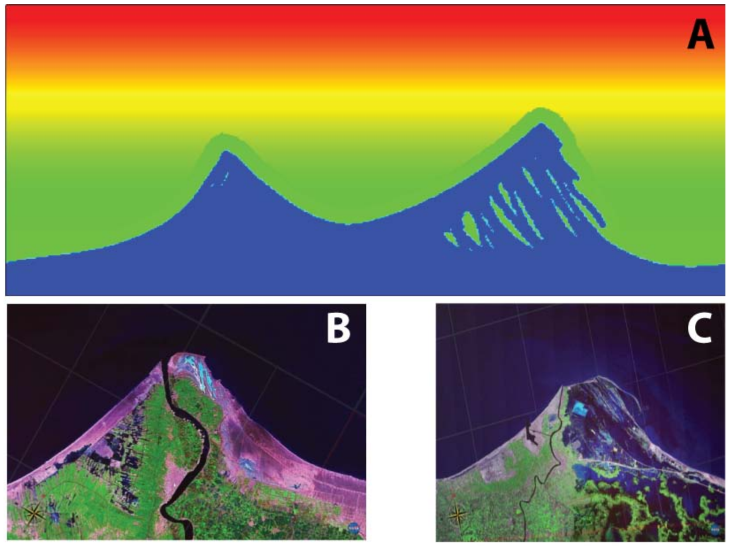


Figure 8. Student generated simulation from a CSDMS-sponsored CU graduate course Surface Process Modeling with CMT. A: Delta simulated with CMT where HydroTrend and CEM were coupled with CMT. The case mimics two different lobes of the Nile Delta (B) Rosetta delta lobe and (C) Damietta delta lobe.

CSDMS Clinic and Courses in 2010:

Model users and developers: Two CSDMS Modeling Tool clinics and two clinics on parallel computing were offered to the 76 participants at the CSDMS Annual Meeting in San Antonio. The first *CMT* clinic targeted new users (Fig. 9) with hands-on exercises: Getting Started, Running a Stand-Alone Model, and Running a Coupled Model. The second *CMT* clinic targeted model developers and contributors with advanced code development and visualization tools for getting models ready for incorporating into the CMT. CSDMS also recognizes the need to improve the high performance computing skills of the Earth Surface Process community, and support HPC-code development. Dr. Pavan Balaji of Argonne National Lab taught two clinics on 'Introduction to Parallel Programming with MPI (Level I)' and 'HPCC Clinic II: Parallel Programming with MPI and Alternate One-sided Programming Models (Level II)'. Feedback from the meeting participants was extremely appreciative about these clinics.

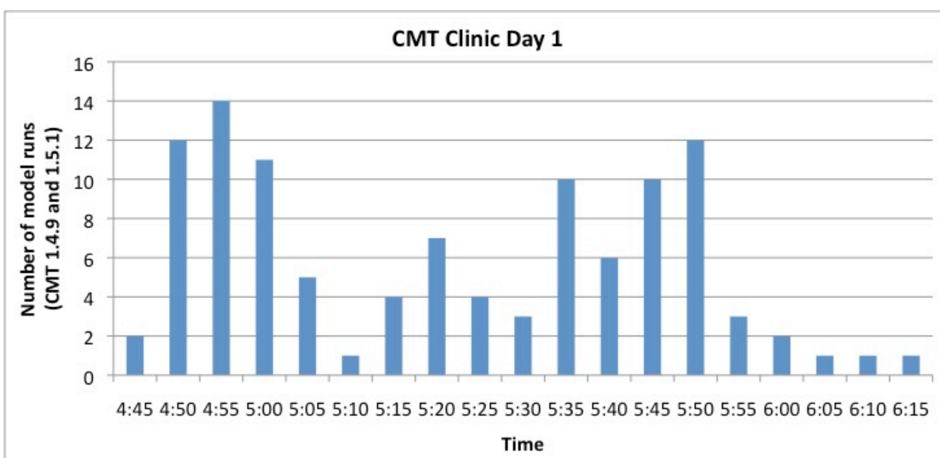


Figure 9. Unique new users running CMT on the CSDMS supercomputer during hands-on portion of the San Antonio clinic.

Students: The two winners of the 2009 CSDMS Student Modeler Award, Adam Campbell and Elchin Jafarov, have visited the CSDMS Integration Facility in April 2010. They were trained on the use of the CSDMS Modeling Tool and explored possibilities for how the CMT could be applied in their own research efforts. They also received instruction on the HPCC system use as well.

The 2 credit CSDMS sponsored CU graduate level course *'Surface Process Modeling: Applying the CSDMS Modeling Tool'* targeted earth sciences and engineering graduate students, with focus on surface process and hydrological models available in the CSMDS Model Repository with application of these tools for own research purposes. The class consisted of 6 4-hour labs with 6 independent modeling projects. Initial focus was on principles of modeling on a supercomputer, and how to visualize model output. Student assignments addressed: long term sediment supply modeling, infiltration modeling, model intercomparison, coupled river-delta modeling, coupled glacial-hydrology modeling, and dynamic time-stepping for numerical stability. Students conducted independent modeling project ranging from landscape evolution to plume sedimentation. All classroom lectures and labs are open-access and available though the CMT examples and EKT lecture and lab repositories: csdms.colorado.edu/wiki/Lectures_portal and csdms.colorado.edu/wiki/Labs_portal. The course has been used as a 'use-case' for the NSF-funded project, "Scaling Up: Introducing Commodity Governance into Community Earth Science Models." The course provided an opportunity for evaluating how current cyber-infrastructure can support educational goals of similar courses.

CSDMS staff also participates in the annual INSTAAR Open House for 170 middle school students with hands-on science measurements and activities. Staff introduced concepts on super-computing. To illustrate parallel processing, versus fast-processing students raced to perform tasks as 'fast processors' or cluster teams' and gained insights on basic supercomputing strategies. They toured the HPCC facility and experienced first hand how heat is generated from calculations performed by the supercomputer.

CSDMS staff presented a guest lecture on integrated modeling and the CMT as part of a graduate-level course called "Interdisciplinary Modeling: Water-Related Issues and Changing Climate" (NRES 730). This course, sponsored by NSF/EPSCoR, was offered at the University of New Mexico in Reno and had an enrollment of 24 graduate students from EPSCoR states.

Figure 10. Visiting CSDMS Ph.D student Vittorio Maselli with CU CSDMS Ph.D. student Benjamin Hudson and recently graduated Aaron Zettler-Mann who are preparing for fieldwork up in Greenland with PI Dr. Irina Overeem.

5.0 Year 5 (2011/12) Integration Facility Goals and Resources

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

The CSDMS website will continue its move towards being an interactive and hands-on wiki site, the gateway for CSDMS members to enter and participate in the CSDMS world. To make the site efficient and easy-to-use we will solicit feedback from representatives of each of the key user-groups, model users, model developers, students, educators, field researchers, industry partners and planners and adapt information trajectories based on responses. The CSDMS website will enthuse, inform and engage end-users. There will be more frequent updates on CSDMS science, with model highlights and new discoveries. The wiki will initiate social networking and multimedia to increase CSDMS' visibility and CSDMS development tracking. The website will be developed to serve as a portal for remote training of CSDMS model users and developers. The gateway will seek member participation through its portal to support the vetting models for the CMT, and for members to prioritize which CSDMS models are to be componentized in CMT. The CSDMS website will further develop new monitoring tools to provide quantitative measures of our community participation; i.e. web visits and repository downloads, HPCC use.

Milestones: Every month a new model or science in the spotlight will be highlighted on the CSDMS front page. CSDMS will actively share news through social networking; Twitter. CSDMS will feature its own YouTube channel, where educational movies, tutorial and model animations will have a larger potential audience. Host a number of video tutorials on topics related to modeling with the CSDMS Modeling Tool (CMT). A system to decide on the transitions of models into fully integrated components will become web-based. GoogleAnalytics, monitors key web use parameters and will be fully integrated into the CSDMS website. Tools for repository downloads, and HPCC use (Ganglia) will be embedded into the website and this information will become open-access. **Resources**: 0.5 FTE Web Specialist.

2011 Communication Strategy:
- Email communication is supported by several list servers through the CSDMS website.
- A CSDMS Newsletter highlights new developments and capabilities with appropriate links to the CSDMS website, and distribution by email.
- The Web site (csdms.colorado.edu/wiki/Main_Page) is the principal means for standard software downloads, sharing of community benchmarks, specifications of standards, and distribution of training manuals. Documents and presentations from CSDMS-sponsored workshops and meetings are posted to the site for the benefit of the entire community. The web wiki allows for working group discussions. The CSDMS calendar of events and documents are continuously updated on the Web site.
- Frequent twitter tweets about newly added items in the repositories, upcoming meetings, and other information that is relevant for our community

Goal 2) Componentizing the CSDMS Model Repository

CSDMS engineers will continue to convert user-contributed code into CSDMS plug-and-play components. CSDMS is in the process of converting several models in its repository to plug-and-play components that can be used within the CMT. **Resources:** 0.5 FTE Software Engineers (also see Goal 3).

Milestones: Recent additions that need further attention:
- ROMS – the premier, open-source ocean model (Arango)
- LTRANS – a Lagrangian transport model, used for ecology and environmental hazards (North)
- MARSSIM – a classic landscape evolution model with support for additional processes such as cratering (Mars) and vegetation effects. (Howard)
- Erode3 – A new version of the Erode model based on a recently-discovered numerical algorithm that involves local time stepping (Peckham)
- PyFlex – A new subsidence/flexure model contributed by a student in our CMT modeling course (Wickert)

Models, which will be converted over the coming year, include:
- AquaTellus – floodplain sedimentation (Overeem)

- Bioenergetics – A lacustrine-thermal-trophic bioenergetics model (Saito)
- ParFlow – a powerful, fully-parallelized groundwater model (Maxwell)
- mARM4D – a spatially-distributed soil production/evolution model (Cohen)
- HydroModeler Suite – hydrologic model components from the CUAHSI-HIS HydroDesktop project
- Grid generator/editor – CSDMS will examine open-source packages that can generate netCDF grids for use by ROMS, including SEAGRID (Denham), GRIDGEN (Sakov) and a tool in CSIRO's ROAM Control System (Rosebrock) and convert it to a CSDMS component www.myroms.org/wiki/index.php/Grid_Generation

Additional lower-level components that we plan to create include:

- OpenDAP Access – Similar to the component we developed to download time-series data via CUAHSI-HIS web services, but for downloading gridded data sets.

Additional models associated with ongoing research projects that could be included given progress:

- SIBERIA – (Wilgoose)
- OMS Suite – a subset of the components from the USDA's Object Modeling System (David)
- Richards1D Implicit Solver – Infiltration process model (Guthman)
- WBM-sed – a global-scale distributed sediment flux model (Fekete)
- Thermal subsurface models – Used for modeling permafrost and frozen soil effects (Clow and Rajaram)

Goal 3) Advancing Selected Goals of the Working Groups and Focus Research Groups

CSDMS supports the each of the 8 Working and Focus Research Groups in various ways as discussed within the other objectives. Here we highlight a few goals and milestones related to specific groups. **Resources: 0.5 FTE Software Engineer.**

Terrestrial Working Group: 1) Document the steps necessary to allow a developer to make a model fully compliant within *CMT* for each of the Babel-supported languages. 2) Add a soil production/evolution model (e.g. mARM4D) to be linked to landscape evolution models (e.g. CHILD, Erode). 3) Examine the complexities of adding hydrologic, agricultural and soil erosion components from USDA's Object Modeling System (OMS) through development of an "interface adapter".

Carbonate Focus Research Group: Componentize the carbonate workbench model when made available to the CSDMS Model Repository.

Hydrologic Focus Research Group: 1) Merge the HydroModeler process components into CSDMS and make the CMT accessible from within the HydroDesktop application. 2) Make ParFlow into a CMT-compatible component. ParFlow is a parallelized, open-source, groundwater model that employs a "profile smoothing" pre-processing tool.

Marine Working Group: 1) Couple the open-source, Lagrangian model LTRANS with ROMS within CMT. 2) Extend LTRANS with a "oil droplet physics" to handle the 3-D transport of aging oil (e.g. in the Gulf of Mexico).

Goal 4) Conferences, Meetings, Planning, and a CSDMS Special Issue

The first all hands meeting last year in San Antonio was a success in the scale of topics covered, quality of presentations and clinics. The Executive Committee will review whether CSDMS reoffer this multiday all-hands style meeting, or return in some form to individual Working and Focus Research Group Meetings. The Executive should decide the function and format of the next year group meetings by 03/31/11, so that travel plans can be coordinated appropriately for the fall or winter of 2011. Clinics were an important feature of the all hands meeting and should be an important determinant in the style and function of the single or multiple meetings. CSDMS will sponsor or participate in important symposia or conferences or activities that represent and contribute to the CSDMS initiatives, e.g.:

AGU Chapman S2S Conference, Jan 23-27, 2011, Oxnard CA
CSDMS Modeling Short Course in Korea April 9-19: KOPRI, KORDI, Kangwon U

Royal Society, London, conference on the Anthropocene May 9-13, 2011;
International Symposium on Geochemistry of the Earth's Surface, June 3-7, 2011, Boulder, CO
DeltaNet: Impacts of Global Change on Deltas, Estuaries and Coastal Lagoons, June 6-9, 2011
Rivers, Coastal, Estuary Morphodynamics, Sept 6-8, 2011, Beijing, China
LOICZ OSC Coastal Systems, Global Change and Sustainability Sept 12-15: Yantai, China,
Geological Society of America, Oct 9-12, Minneapolis, MN
Fall AGU, Dec 2011, San Francisco

The CSDMS Special Issue of 'Computers and Geosciences' will be edited from papers representing the CSDMS 2010 'Modeling for Environmental Change' meeting. 20 to 27 manuscripts are expected with submission by February 15th 2011; scheduled publication is for the Fall 2011. In addition the 5-year renewal will be coordinate and completed by July 2011. **Resources:** 0.5 FTE CSDMS Executive Assistant, 0.5 FTE Executive Director.

Goal 5) Technical Advances in the CSDMS Cyber-Infrastructure

CSDMS staff will work on a suite of cyber issues to aid the future direction of the CSDMS modeling environment. Focus will be on streamlining the component wrapping process for model developers, and opening up component generation to end-users of *CMT*.

Milestones: (1) Develop command line utilities that aid developers in creating CSDMS components from models that expose an IRF interface (these tools may use annotation or configure files as guides). (2) Develop components that enable end users to generate new components. (3) Develop components that compile models as executables to be run directly on beach, and as libraries to be called from other components. (4) Further develop component services, which are available to all CSDMS components, that can equip components with tools for executing common tasks (e.g. ordering and timing of provides-port execution, GUI generation, etc.). (5) Update the CMT client in support of the above goals. **Resources:** 1. 25 FTE Software Engineer

Goal 6) Educational and Knowledge Transfer

The CSDMS Modeling Tool (CMT) is one of the key products of the CSDMS project; it allows earth scientists with modest coding experience to use and couple models for surface dynamics research and education on the CSDMS computing cluster. We will dedicate time and resources to continue to improve the transparency and usability of the CMT. In the coming year we propose to develop a set of web-based video tutorials that show 1) the vision of the CMT, 2) a beginning user how to install the required software, 3) how to create a simple model, and 4) how to create coupled models and lastly 5) how to visualize output. The EKT working group proposed to develop the educational repository such that there are different levels of teaching resources on surface process modeling; simple spreadsheet modeling, web-based relatively simple 'slider' models with limited parameter space, and more advanced modeling with CMT. Over 2010-2011, we aim to develop a proof-of-concept for such an intermediate model package with limited parameter space. This would consist of an interactive, web-based, delta sedimentation model with special focus on teaching quantitative skills. The model would be tested and evaluated for teaching purposes during a 2-day course for teaching assistants and teaching faculty on 'Quantitative Surface Dynamics Modeling' in collaboration with the NCED Summer Institute.

Milestones: 1) Expanded documentation and help system related to the CMT. 2) Key video tutorials on CSDMS wiki. 3) Well-tested teaching package with focus on delta evolution, including a web-based delta sedimentation model aimed at undergraduate students. 4) Feedback from CSDMS members on their experiences with using the CSDMS Modeling Framework. **Resources:** 0.6 EKT Specialist, 0.2 Software Engineer, and 0.2 Web Specialist.

6.0 Five-year Community Goals and Strategic Plans (San Antonio Meeting)

6.1 Delta morphodynamics: Coupling processes and human influences

Short-term goal: Develop a modeling framework that couples multiple components of the delta system:

1. Upland River- controls delivery of sediment and water, influenced by floodplain storage and exchange (could be parameterized by simple boundary conditions).
2. Deltaic portion of the river- morphodynamics feedbacks, couplings between fluvial, wetlands, coastal environments, and floodplains.
3. Coastal ocean basin- subsidence, compaction, relative sea level (local and regional).

The modeling time scale should range from years, to address human intervention, to over millennia to account for self-formed deltaic landscapes and building of continental shelf. The spatial scale should range from 10^1 to 10^3 km^2. Bridging between these temporal and spatial scales could be achieved with a suite of models with a defined hierarchy. The CMT should be used to couple multiple time-scale and hierarchal spatial scale components. Prospective models:

1. Upstream boundary conditions (primarily supply Qs): *HydroTrend*, *CHILD* (long time scale), *HSPF*, *AGNSP*.
2. Deltaic dynamics: *Delft3D*, *1D diffusion of fluvial channels*, *Avulsion* (Mohrig superelevation, *SedFlux*), *EFDC*, cellular delta models.
3. Coastline processes: *CEM*, *Delft3D*, *ROMS*, *ADCIRC*, *SLOSH*, models for subaqueous profiles, models for hyper/hypo flows, Coastal Modeling System *CMS*, *XBEACH*, GEOMBEST.
4. Prodelta: Winterwerp, *Deflt3D*, Swenson, *SedFlux*
5. Wetland evolution & marsh accretion: models of Jim Morris, Matt Kirwan, and Sergio Fagherazzi.
6. Floodplain evolution: Viparelli Model, *AquaTellus*.
7. Relative sea level change: both dynamic and static, *Subside*, *Compaction*, *Ice4D*, Eustasy.

Medium term goals: Validate the model at both large and small spatial scales. Provide verification data to validate the different scenarios simulated by the model. The abundant data on network topology and serial imagery should be used as well as reservoirs, lake and floodplain flooding observations.

Long-term goals: Incorporate human dynamics in the model. This can be done with a user changing boundary conditions (e.g. resolving climate change on discharge) or with a decision making model that dynamically changes boundary conditions based on the growth of the delta. Incorporate mud into the delta simulations.

Scientific objectives/questions for the CSDMS 5-year plan

- What are the fundamental controls on delta size, shape, and elevations?
- What controls the extent of wetland development in deltaic settings?
- How are those controls modified under different scenarios of sea level rise and human manipulations (e.g. as dams are removed and sediment flux is restored to a pre-dam level)?
- How do coastal sediment redistribution properties interact with fluvial properties (e.g. avulsion)?
- What effects do extreme climate events have on delta geomorphology?
- What are the characteristic time scales of delta location adjustment to external forcings?
- How does the transition between deltas and estuaries occur?

6.2 Couplings between physical, biological & human processes

Vegetation and Landscape interaction between landscape processes (e.g. hydrology, sediment fluxes) and vegetation dynamics (through climate and land use changes). A model coupling scheme is needed that integrate vegetation, geomorphology and sediment hydrology and human models at time scales varying from event to geologic.

Coupling of vegetation, geomorphology – sediment - hydrology should predict:

1. Roughness;
2. Cohesion;
3. ET;
4. Runoff;
5. Interception;
6. Storage;
7. Soil production.

Coupling of human and landscape models should simulate:

1. Management styles;
2. Restoration opportunities;
3. Reservoirs.

Develop a generic module to deal with organic baffles by incorporating:

1. Fluid flow;
2. Grain transport and trapping;
3. Baffle life/grow;
4. Organic movement;
5. Human interaction (e.g. forestry practices, costal construction, marine activity, fisheries, costal protection)

The module should predict:

1. Source-sink fluxes;
2. Baffle patch characteristics;
3. Creation-existence-destruction dynamics.
4. Sensitivities to changes.

Shelf/Estuarine environment with complex 3D flows: Couple models of varying complexity: e.g., land use, atmospheric forcing, oceanic forcing, stratigraphic evolution, particle tracking and visualization, to a core 3D shelf-estuarine model (e.g. *ROMS*, *FVCOM*, *SELFE*, *Delft3D*). The clearest feedback of this coupling would be morphological change in regions of complex 3D circulation, feeding back to affect biology, water quality and further hydrodynamic change. Policy driven efforts and failures that improve or degrade water quality (by reducing or changing land-use and sediment properties) could also initiate or affect this morphodynamics feedback loop. Initially ROMS could be linked with multiple exchangeable land-use and river models, atmospheric models, ocean boundary models, tidal forcing models, particle tracking models, etc. Later efforts should explore coupling other 3D hydrodynamic community models such as *FVCOM* and *SELFE*. CSDMS could facilitate the rapid exchange of different grid resolutions, advection choices, and turbulence closures. CSDMS can provide community access to multiple biological and water quality formulations, and sediment transport formulations (e.g. USGS-CSTMS).

6.3 Landscapes into Rock

Design and implement a large-scale (100s of km^2) basin-scale componentized framework nested model (i.e. multiple temporal and spatial scales of process represented within the same model) for stratigraphy within a x, y, z, t coordinate system representing source to sink denudation, transport and deposition, calculated at a 100 year time step. The model should be designed to utilize advances in high performance computing (e.g. new CU HPCC) to minimize run times for multi-million year duration simulations.

Specs for the denudation model (Terrestrial Group):

1. 100 year time step;
2. Output should be a realistic grain size distribution that is a function of x, y, t;
3. Include mud dynamics;
4. Output should be Q_w and Q_{si} where i is a grain size index;
5. Drainage basin should have capacity to calculate sediment storage;
6. Model should be able to input and account for paleo DEM and paleogeology (e.g. drainage basin substrate lithology that varies in x, y and z);
7. Model parameters/processes should include:
    a. Substrate lithology

b. Climate
c. Vegetation
d. Crustal deformation with a lateral component
e. Runoff production

Specs for the transfer zone model: The transfer zone is the fluvial system between the zone of rock uplift and the coast. The model should simulate non-uniform routing of grain sizes including floodplain exchange and allow preservation of transfer zone strata.

Specs for the sink/basin fill model: Model coast-to-basin processes by using compute and drift to solve reduced set of coastal, ocean and wave field equations each 100 year time step and spatial scales of 1-10km cells in outer nest and 100 to 100s m cells in inner nest. The model should be able to build and preserve stratigraphy.

Specs for the downstream/basin fill model: The model should include:

1. Coast to shelf-slope partitioning;
2. Wave field;
3. Tides at 3 scales;
4. Wave-supported density-driven mud transport;
5. Wind driven circulation;
6. Delta and estuarine processes;
7. Turbidity currents;
8. Debris flows;
9. Channelized flow in deep-water;
10. Shelf bioturbation;
11. Burial compaction and pore pressure.

6.4 5-Year Strategy for Improving Communication & Community

Community input and involvement are essential to the success of CSDMS. Improving the CSDMS community interaction varies between different audiences.

Goals:

1. Improve accessibility to potential users;
2. Better communicate potential of CSDMS tools and services;
3. Convince model developers to run models with CMT;
4. Move scientific community toward coupled models.

Strategies:

1. Improve documentations for submitting models in to CSDMS repository;
2. Improve CMT documentation and ease of use (e.g. CMT-lite)
3. Discussion board on CSDMS website to improve community interaction and to allow users to help each other.
4. Encourage acknowledgment of CSDMS in publications, presentations, members' websites and article reviews;
5. Increase visibility of success stories;
6. Theme articles in key journals (e.g. EOS, Sedimentary Records, GSA Today, AAPG);
7. Promote prestige of contributing to CSDMS (traveling CSDMS lecturer, new awards for conference modeling papers);
8. Mentor students to write CSDMS-ready code and submit it (changing culture from bottom up);
9. Promote the use of coupled models by using and highlighting them on the webpage and in publications (e.g. EOS);
10. Demonstrate utility of coupled models via timely use (e.g. use coupled CEM and ROMS to look at remobilization of oiled sediments in GOM);
11. Improving communication between developer and user (and amongst model users) with a web discussion board (developer is notified when his/her code is discussed);
12. Redesign website to address all of the above.

6.5 CSDMS Cyber-infrastructure: Expanding our Reach

More directly connect CSDMS to data centers. Calibration and validation procedures of CSDMS models and modules can benefit from embedded connection to external data centers. In addition creating a CSDMS data center (e.g. OpenDAP server) will allow sharing our outputs with the broader community (e.g. NOAA's 'Live Access Server' http://ferret.pmel.noaa.gov/LAS). Identify an experienced group or person on this topic and invite them to one of our future meeting.

Facilitate easier component building by the community. Improve the ratio between models and components in the CSDMS repository by encouraging modelers to componentize their own models. Component building could be made easier by:

a. Building 'Hello World' examples (currently in preparation by CSDMS staff);
b. A well-documented library of skeleton functions;
c. More interactive training material (e.g. PowerPoint with voiceover, screencast, net meeting (WebEx));
d. A 'toy sandbox' interface which will allow developers to easily and quickly test changes to their model while building a component.
e. Add a shell component to CMT that will allow building components directly on the HPCC. This will improve transportability and control when developing a CMT component;
f. A cloning feature to easily develop a model similar to one that already exists;
g. Learn from SMF experience;

The underlining frame of mind should be: minimal time commitment. How can we design our website so a busy person can get an idea of how to componentize their model within an hour or so and then (using the above resources) have a simple working product within a day or so?

Improve education on using CSDMS HPCC: Need to better communicate what are the available tools and capabilities that CSDMS can provide to both existing members and the outer community. One of the most urging issues in this context is parallelization. We should provide template libraries with parallel communication.

More flexible approach for componentizing models with existing GUI: Some models come with existing GUI, sometime with better functionality then the CMT GUI (e.g. delft3D). We should consider a more flexible and general GUI description (e.g. using a language-agnostic method such as guiML).

6.6 Education and Knowledge Transfer Strategies

"Scientific practice involves the construction, validation and application of scientific models, so science instruction should be designed to engage students in making and using models." From: Modeling Methodology for Physics Teachers (1998). CSDMS should use Earth-Ocean-Climate literacy principles for prioritizing models or teaching modules to be incorporated into CSDMS Educational Repository.

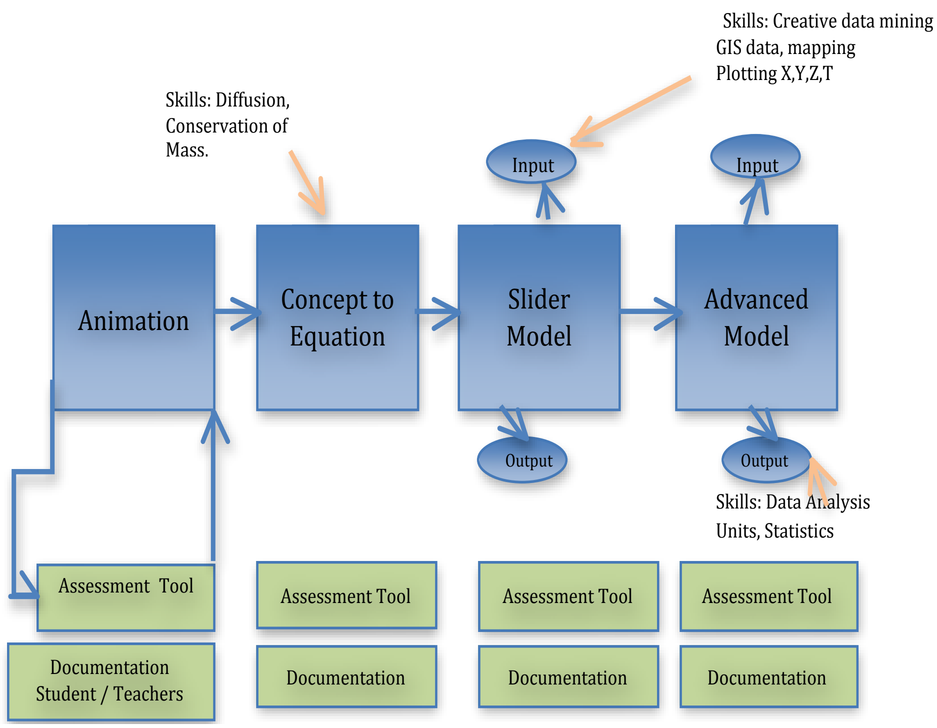
Key Product: A 'Quantitative Surface Dynamics Educational Toolbox'. The toolbox would address a range of earth surface processes; for example glacial evolution, soil weathering, landslides, gully erosion, sediment supply to the coast, river floodplain deposition, coastal erosion, subsidence, delta deposition, wave-driven long-shore transport, muddy prodelta deposition, turbidity currents. These examples will be chosen so that they have a societal relevance, for example glacial melt can be tied in to the hydrological cycle and drinking water resources, or coastal erosion can be tied to loss of property value of coastal communities, turbidity current can wipe out subsea pipelines etcetera. The Toolbox will be designed to have different entry levels:

1) Simple animations function as visualization in lectures.
2) Slider Models; models are simplified, but students can play with them. These models should address common misconceptions (e.g. PhET model of glaciers).
3) 'Concept to Model' exercises function to encourage students to formulate a concept model and translate this model into an equation or a set of equations. These exercises address the notion that students need to be empowered to formulate quantitative models from scratch.

4) Advanced models; students can runs more complex scenarios, can swap in and out different equations for a certain process, student handle input and output data.

Every step along the toolbox chain there will be linked material; documentation and proposed classroom laboratories or exercises. At every step along the toolbox chain there also will be evaluation mechanisms, so that learning objectives can be assessed in a structured way. The Educational and Knowledge Transfer Working Group will recruit and identify a number of members who will be early adopters of the toolbox and will help evaluate the products from the earliest stages.

Strategies for Reaching our Audiences



I. Online Open-Source Toolbox: The toolbox will be made fully and freely available through the Educational Repository of CSDMS csdms.colorado.edu/wiki/Education_portal. There is a recognized need to more broadly advertize this online resource. Existing other online resources (e.g. SERC, DLESE) should be made aware of the CSDMS resources and more intimate links between these initiatives are desirable. The Educational Working group can advertise CSDMS educational resources at the annual GSA meeting, which is more traditionally attended by faculty of the 4-year (undergraduate) colleges.

II Initiatives Focused on Undergraduates and Undergraduate Teachers: We note that the CSDMS community at present has a 'bias' to research scientists and faculty teaching in research universities, and less so in the liberal arts colleges, let alone in community colleges. Many undergraduate courses are taught in these schools. We propose to teach a course explicitly addressing teaching faculty and teaching assistants. Such a course could efficiently be organized by using existing initiatives as a springboard — NCED (summer school?), SERC or Cutting Edge. In addition, CSDMS could teach a short course in association with major meetings — AGU, AAPG or GSA.

CSDMS Public Outreach: 1) Use the NCED 'rain-table' but with a computer model designed to allow experiments with runoff over a DEM. 2) Use Smooth Particle Flow Visualizations in combination with Google Earth to learn about floods and waves. 3) Earth Surface process models for displays in National Parks. 4) Provide NOAA's 'Science on a Sphere' displays with CSDMS related model animations (34 locations worldwide, including many of the major science museums in the US) sos.noaa.gov. A smaller, more economical way of projecting simulations on a sphere is the Magic Planet: it allows development of animations by the CSDMS community). www.globalimagination.com/

III CSDMS Outreach to Industry (E=Education, KT = Knowledge Transfer): CSDMS needs to continue reaching out to industry and governmental partners. We propose to teach a course explicitly addressing industrial partners. Such a course can be organized in association with a major meeting — AGU or AAPG.

Strategies for Accomplishing EKT objectives

EKT Working Group can to be more involved; contributors, early adopters need to be identified, smaller sub-teams can submit EKT proposals to GEO-ED, NOAA literacy, and ONR. CSDMS can offer to their community that they will be the focal pint of the 'Broader Impacts' of CSDMS related research proposals. CSDMS EKT specialists could assist writing the Broader Impacts, and support the dissemination of the science through the CSDMS repositories. In addition, CSDMS software engineers can assist in making new codes available for education. This would require dedicated funds towards Broader Impacts in the individual proposals.

7.0 Integration Facility 2010 Publications & Abstracts

Journal Papers and Newsletters:

Kettner, A.J., Restrepo, J.D., Syvitski, J.P.M., 2010, A spatial simulation of fluvial sediment fluxes within an Andean drainage basin, the Magdalena River, Colombia. J Geology 118: 363-379.

McCarney-Castle K., Voulgaris, G., and Kettner, A.J., 2010, Analysis of Fluvial Suspended Sediment Load Contribution through Anthropocene History to the South Atlantic Bight Coastal Zone, U.S.A J Geology 118: 399-416.

McGrath, D., Steffen, K., Overeem, I., Mernild, S., Hasholt, B., van den Broeke, M., 2010. Sediment plumes as a proxy for local ice sheet runoff in Kangerlussuaq Fjord, West Greenland. Journal of Glaciology (09J116).

Overeem, I., Syvitski, J.P.M., 2010, Experimental exploration of the stratigraphy of fjords fed by glacio-fluvial systems, In: Howe, J. A., Austin, W. E. N., Forwick, M. & Paetzel, M. (eds) Fjord Systems and Archives, Geological Society, London, Special Publications 2010; v. 344; p. 125-142

Overeem, I., Syvitski, J.P.M., 2010, Shifting Discharge Peaks in Arctic Rivers, 1977-2007, Geografiska Annaler 92: 285-296.

Perillo, G, Syvitski, JPM, 2010, Mechanisms of sediment retention in estuaries. Inprint Newsletter of the IGBP/IHDP Land Ocean Interaction in the Coastal Zone 2010/1: 3-5.

Perillo, G.M.E., Syvitski, J.P.M. 2010. Mechanisms of sediment retention in estuaries. Estuarine, Coastal and Shelf Science (2009), doi: 10.1016/j.ecss.2009.10.026

Syvitski, J.P.M. 2010, Projecting Arctic Coastal Change. In: D.L. Forbes (Ed.) State of the Arctic Coast 2010, Scientific Review and Outlook. IASC/IPA/LOICZ, Potsdam. pg 89-92

Voinov, C. DeLuca, R. Hood, S. Peckham, C. Sherwood, J.P.M. Syvitski, 2010, A community approach to Earth systems modeling. EOS Transactions of the AGU, 91(13): 117-124.

Papers submitted of in-press:

Maselli, V., Hutton, E.W., Kettner, A.J., Syvitski, J.P.M., and Trincardi, F. *submitted*. Evidence of high-frequency sea level and sediment supply fluctuations during Termination I: an integrated sequence-stratigraphy and modeling approach from the Adriatic Sea. *Marine Geology*.

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8.0 CSDMS Priorities and Management of Its Resources

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

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

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

With the new staff, Year 4 witnessed rapid growth and advances in community products, including 1) completely revised web portal and services, 2) the first official release of the CSDMS model-coupling tool, 3) an 800% increase in the number of models made into components within the CMT tool, including ROMS, 4) an alpha-version of the CSDMS Domain Architecture *SedGrid*, 5) new data handling abilities (NetCDF, WML), 6) the first all-hands conference *Modeling for Environmental Change*, and 7) numerous pedagogically-tested educational modules, clinics, and courses. Resources were also directed to the ever-growing (almost 500) membership, located in more than 230 institutions and 30 countries. CSDMS has extended its reach into societies (IAMG, AGU's EPSP, LOICZ), industry (e.g. EDF), and U.S. Agencies (e.g. Bureau of Ocean Energy Management, Regulation & Enforcement). We have expanded the CSDMS Integration Facility to accommodate the NASA Dartmouth Flood Observatory and support their data products within the CSDMS Data Repository. We support >100 CSDMS members with model runs on the CSDMS-dedicated supercomputer. These activities have been accommodated with little change in NSF resource allocation between year 3 and year 4, and near identical resource allocation for year 5.

In Year 5, CSDMS Integration Facility Staff will continue to juggle the competing demands of an actively engaged and ever-growing CSDMS Community. CSDMS staff will continue their community interactions at both national and international venues. Expenditures related to the Integration Facility staff, travel expenses related to CSDMS governance, operations and workshop participation costs are provided below in Section 9.0. Priorities for Year 5 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.

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

	Actual Year 1	Actual Year 2	Actual Year 3	Proposed Year 4	Estimated Year 4*	Proposed Year 5
A. Salaries and Wages						
Executive Director:	$48	$52	$52	$53	$52	**$55**
Software Engineers:	$97	$113	$211	$213	$225	**$215**
Communication Staff**	$17	$73	$90	$89	$89	**$93**
Admin Staff***	$48	$63	$81	$84	$84	**$86**
Total Salaries	**$210**	**$300**	**$434**	**$439**	**$450**	**$449**
B. Fringe	**$49**	**$81**	**$121**	**$126**	**$138**	**$143**
D. Travel						
Center Staff:	$23	$28	$29	$24	$30	**$26**
Steering Committee	$2	$7	$8	$7	-	**$5**
Executive Com.	$5	$12	$6	$5	-	**$5**
Total Travel	**$30**	**$47**	**$42**	**$36**	**$30**	**$36**
E. Workshop Participation	**$37**	**$76**	**$68**	**$60**	**$60#**	**$60**
F. Other Direct Costs						
Materials & Suppl	$1	$6	$4	$3	$3	**$3**
Publication Costs	$6	$6	$6	$2	$3	**$4**
Computer Services:	$6	$13	$14	$22	$18	**$21**
Non Capital Equipment	$0	$0	$7	$4	$2	**$2**
Communications	$2	$3	$3	$3	$6	**$5**
Total	**$15**	**$29**	**$34**	**$33**	**$34**	**$35**
G. Total Direct Costs	**$341**	**$533**	**$700**	**$693**	**$712**	**$724**
H. Indirect Cost	$140	$233	$326	$310	$311	**$325**
I. Total Costs	**$489**	**$766**	**$1,026**	**$1,003**	**$1,023**	**$1,049**

Notes:
1) * Year 4 estimates include salaries projected out 3 months to the end of the CSDMS fiscal year.
2) The University of Colorado underwrites the executive director's AY salary. The result is fund transfers to salaries for the software engineers
3) ** Communication Staff includes Cyber Scientist + EKT Scientist.
4) *** Admin Staff includes Executive Assistant + System Administrator + Accounting Technician.
5) 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.
6) # $29K rolled forward from previous year was added to this $60K to cover the higher costs of the All Hands Conference in San Antonio

9.1 Additional Funds Received by CSDMS IF Staff and Associates (compare with Section 2.5)

Year 1:

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

Year 2:

Office of Naval Research: Hydrologic and morphodynamic modeling of Deltas: $110K
NASA: Modeling framework to detect and analyze changes in land-to-coastal fluxes: $70K
ConocoPhillips: Cold-climate sedimentary environments: Sedimentary architecture, GIFT $100K

NSF: Modeling river basin dynamics: Parallel computing and advanced numerical methods $220K
NOPP: Toward a predictive model of Arctic coastal retreat in a warming climate $32K
University of Colorado: Salary and Capital support for the CSDMS Integration Facility: $220K

Year 3:

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

Year 4:

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

Appendix 1: Institutional Membership — those in marked in blue have joined CSDMS in 2010. There are now more than 230 affiliated institutions.

U.S. Academic Institutions

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

U.S. Federal Labs and Agencies

1. The National Science Foundation (NSF)
2. U.S. Office of Naval Research (ONR),
3. U.S. Army Corps of Engineers (ACE)
4. U.S. Army Research Office (ARO)
5. U.S. Geological Survey (USGS)
6. National Aeronautics & Space Administration (NASA)

7. National Oceanic & Atmospheric Administration (NOAA)
8. National Oceanographic Partnership Program (NOPP)
9. Idaho National Laboratory (IDL)
10. National Park Service (NPS)
11. National Forest Service (NFS)
12. U.S. Dept of Agriculture (USDA)
13. Argonne National Laboratory (ANL)
14. National Weather Service (NWRFC)
15. Naval Research Laboratory (NRL)
16. National Center for Atmospheric Research (NCAR)
17. U.S. Nuclear Regulatory Commission (NRC)
18. Bureau of Ocean Energy Management, Regulation & Enforcement (BOERM)
19. U.S. Department of the Interior – Bureau of Reclamation

Foreign Membership 46 new members in 2010 (29 countries outside of the U.S.A.).

1. FCEFN-UNSJ-Catedra Geologia Aplicada II, Argentina
2. IANIGLA, Unidad de Geocriologia, Argentina
3. Geoscience, Australia
4. Australian Commonwealth Scientific and Research Organization (CSIRO), Australia
5. University of Sydney Inst of Marine Science, Australia
6. The University of Newcastle, Australia
7. The University of Queensland (UQ), Australia
8. Digital Mapping, Bangladesh
9. Free University of Brussels, Belgium
10. Universiteit Gent, Ghent, Belgium
11. Federal University of Itajuba, Brazil
12. Petrobras, Brazil
13. UFRGS, Brazil
14. Bedford Institute of Oceanography, Canada
15. Geological Survey of Canada, Atlantic
16. Geological Survey of Canada, Pacific
17. University of British Columbia, Canada
18. University of Calgary, Canada
19. Environnement Illimite Inc., Canada
20. McGill University, Canada
21. University of Calgary, Canada
22. University of Guelph, Canada
23. China University of Geosciences- Beijing, China
24. Nanjing University, China
25. National Marine Environmental Forecasting Center (NMEFC), China
26. Ocean University of China, China
27. Peking University, China
28. Shenzhen Inst. of Advanced Technology, China
29. Tianjin University, China
30. Tsinghua University, China
31. University of Copenhagen, Denmark
32. AgroCampus Ouest, France
33. CNRS / University of Rennes I, France
34. IFREMER, France
35. Institut Francais du Petrole (IFP), France
36. Universite Bordeaux 1, France
37. Aix-Marseille University, France
38. Cambridge Carbonates, Ltd., France
39. CETMEF/LGCE, France
40. Ecole Nationale Superieure des Mines de Paris, France
41. Ecole Polytechnique, France
42. Institut de Physique de Globe de Paris, France
43. IUEM: Institut Univ. Europeen de la Mer, France
44. Lab Domaines Oceanique IUEM/UBO France
45. Laboratoire de Sciences de la Terre, France
46. Marine Sciences For Society, France
47. Universite Bordeaux 1, France
48. Universite de Rennes (CNRS), France
49. Universite Montpellier 2, France
50. University of Brest, France
51. Bonn University, Germany
52. Darmstadt University of Technology, Germany
53. Christian-Albrechts-Universitat zu Kie, Germany
54. Karlsruhe Institute of Technology (KIT), Germany
55. The Leibniz Institute for Baltic Sea Research, Germany
56. Senckenberg Institute, Germany
57. Aristotle University of Thessaloniki, Greece
58. University of West Hungary - Savaria Campus, Hungary
59. SRM University, India
60. The Maharaja Sayajirao University of Baroda, India
61. Mulawarman University, Indonesia
62. University College Dublin, Ireland
63. Consiglio Nazionale delle Ricerche (CNR), Italy
64. University of Padova, Italy
65. Padua University, Italy
66. University of Bari, Italy
67. University of Padova, Italy
68. University of Pavia, Italy
69. University of Rome "LaSapienza", Italy
70. Geological Survey of Japan
71. Japan Agency for Marine-Earth Science Technology (JAMSTEC), Japan
72. Group-T, Myanmar
73. Delft University of Technology, Netherlands
74. Deltares, Netherlands
75. UNESCO-IHE, Netherlands
76. Utrecht University, Netherlands
77. Vrije Universiteit, Netherlands
78. VU University, Amsterdam, Netherlands
79. Wageningen University, Netherlands
80. WL Delft Hydraulics Lab, Netherlands
81. ASR Ltd., New Zealand
82. GNS Science, New Zealand
83. National Institute of Water and Atmosphere (NIWA), New Zealand
84. Federal Ministry of Environment, Nigeria
85. University of Bergen, Norway
86. Geological Survey of Canada (Atlantic), Nova Scotia

87. Adam Mickiewicz University in Poznan (AMU), Poland
88. University of Edinburgh, Scotland
89. Korea Water Resources Corporation, South Korea
90. Seoul National University, South Korea
91. Institute of Earth Sciences (ICTJA-CSIC), Spain
92. Universidad Complutense de Madrid, Spain
93. Universidad de Granada, Spain
94. University of Basel, Switzerland
95. Aberystwyth University, UK
96. BG Energy Holdings Ltd., UK
97. BG Group, UK
98. British Geological Survey, UK
99. Haycock, UK
100. Imperial College of London, UK
101. King's College London, UK
102. Loughborough University, UK
103. Royal Holloway University of London, UK
104. University of Bristol, UK
105. University of Cambridge, UK
106. University of Edinburgh, UK
107. University of Exeter, UK
108. University of Newcastle upon Tyne, UK
109. University of Southampton, UK

U.S. Private Companies

1. Chevron Energy Technology, Houston, TX
2. ConocoPhillips, Houston, TX
3. Dewberry, Virginia,
4. Everglades Partners Joint Venture (EPJV), Florida,
5. ExxonMobil Research and Engineering, Houston, TX
6. Philip Williams and Associates, California
7. Schlumberger Information Solutions, Houston, TX
8. Science Museum of Minnesota, St. Paul, MN
9. Shell USA, Houston, TX
10. URS–Grenier Corporation, Colorado
11. Warren Pinnacle Consulting, Inc., Warren, VT
12. Idaho Power, Boise

Appendix 2 CSDMS 2010 Meeting Abstracts

EVOLUTION OF GNARLY ROCKY HILLSLOPES

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Hillslopes in rugged alpine landscapes tend to be very rocky, with shallow soils and occasional outcrops. These important landforms present a modeling challenge in that they reflect the influences both of changing boundary conditions in the bounding streams, and of non-uniformity of the susceptibility of the bedrock to weathering and transport. Inspired by the landscape of the Boulder Creek Critical Zone Observatory, we present preliminary models of hillslopes in which we attempt to address these complexities. As a tool for interpretation of the landscape, we include model algorithms for the evolution of the 10Be concentrations both in the emerging bedrock and in the mobile regolith. In 1D models we attempt to mimic the blocky nature of the crystalline basement by specifying the block size and rules for the probability of release of the block that include effects of block size and the geometry of the niche in which it sits. We see that local hillslope divides migrate to ward sites of coarsely jointed rocks. In 2D models, variability of susceptibility to weathering is reflected in bedrock outcrop patterns on steep hillslopes. Regolith is steered around these outcrops, generating sinuous regolith pathways off the landscape. While periods of rapid entrenchment of the bounding stream can result in bedrock outcrops near the stream, periods of aggradation can result in a ponding of regolith on the footslopes that can deepen considerably above the mean. In the future, we will also explore 1) the roles of water routing in these landscapes, with attendant impacts on the weathering rates in the subsurface, and 2) the roles of all-important tree-cover in the landscape, which displays both asymmetry with respect to slope aspect, and temporal variation on timescales that are short relative to the timescales of change of hillslope shape.

THE REGIONAL OCEAN MODELING SYSTEM (ROMS): ALGORITHMS AND APPLICATIONS

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ROMS is an open-source, mature numerical framework used by both the scientific and operational communities to study ocean dynamics over a wide range of spatial (coastal to basin) and temporal (days to seasons, inter-annual) scales. It includes a sediment-transport model and several biogeochemical models with increasing ecological complexity. ROMS is unique in that is the only community framework including the adjoint-based analysis and prediction tools that are available in Numerical Weather Prediction (NWP), like 4-dimensional variational data assimilation (4D-Var), ensemble prediction, observations sensitivity and impact, adaptive sampling, and circulation stability and sensitivity analysis. An overview of ROMS framework capabilities to simulate and predict the coastal environment will be presented. Fine resolutions coastal applications are possible via multi-grid nesting and multi-model coupling.

COUPLING BETWEEN COASTLINE AND FLUVIAL DYNAMICS

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Eric Hutton, Community Surface Dynamics Modeling System, INSTAAR, University of Colorado,
Albert Kettner, Community Surface Dynamics Modeling System, INSTAAR, University of Colorado,
Doug Jerolmack, University of Pennsylvania
Liviu Giosan, Woods Hole Oceanographic Institution

The morphology and depositional history of wave-influenced deltas reflects the interplay between the terrestrial and coastal domains. Applications of the Coastal Evolution Model (CEM) to deltaic environments using a simple, fixed location and constant rate riverine sediment source yield a range of interesting delta behaviors observed in nature, demonstrating that wave approach angle can have a first-order impact on delta shape, affecting both progradation rates and leading to the development of depositional asymmetry. To better integrate fluvial processes, we will discuss two related projects that couple fluvial and coastal models. The first project involves the one-way coupling of HydroTrend with CEM to capture how changes in sediment input rates, potentially due to natural variability, climate change, and anthropogenic impacts, affect delta evolution. These simulations are being used to understand how anthropogenic impacts and climate change may have have affected the evolution of the Ebro River, Spain. The coupling between these models, however, is one-way, and does not represent the important phenomenon of river avulsion. We will present preliminary results from the two-way coupling of SedFlux with CEM using, investigating how sediment redistribution by waves influences the river avulsion. An important element of this two-way coupling is implementation of dynamic fluvial avulsion within the SedFlux model. The coupled models can be used to investigate how sediment redistribution by waves affects the timescales and location of river avulsion. These preliminary model experiments demonstrate how two-way model coupling using the CSDMS architecture can be used to investigate the dynamics of systems at the intersection of different process realms.

EXPLORING THE CONTROLS ON PERMAFROST COASTAL BLUFF RETREAT RATE, NORTH SLOPE, ALASKA

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Cameron Wobus; Gary D. Clow, U.S.G.S.

The arctic is a region where modern surface warming has had significant effects on geomorphological processes. Along the Beaufort Sea coastline bounding Alaska’s North Slope, the mean annual coastal erosion rate has doubled from ~7 m/yr for 1955-1979 to ~14 m/yr for 2002-2007 (Mars and Houseknecht, 2007). Locally the erosion rate can reach 30 m/yr, with short-term rates that are far greater than this. A robust understanding of the processes that control the rate of coastal erosion is required to predict response to a rapidly changing climate, with implications for sediment and carbon fluxes, oilfield infrastructure, and animal habitat. We model the evolution of the permafrost bluffs on the North Slope, constrained by time lapse imagery, and by measurements of both the oceanic and atmospheric setting. During the sea ice-free season, relatively warm waters melt a notch into the ice-rich silt that comprises the bluffs. The bluffs ultimately fail by toppling of polygonal blocks bounded by mechanically weak ice-wedges. The toppled blocks then temporarily armor the coast against further attack. The annual retreat rate is controlled by the length of the sea ice-free season, water and air temperatures, and the wave history. Our model is forced by air temperature, water temperature, water level, and wave period, and is validated using field and remote sensing observations over a variety of timescales. The model is then used to explore the expected changes in coastal retreat rates for various climate change scenarios that include increases in the duration of sea-ice free conditions, warming ocean temperatures, and changes in storm frequencies.

MODELING FLOODPLAINS AS A DYNAMIC SOURCE/SINK TERM IN WATERSHED SEDIMENT BUDGETS

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Sediment pathways through drainage networks are poorly understood. Especially difficult to constrain are the rates and mechanisms of sediment exchange between the channel and floodplain over short and long timescales. Lack of predictive models for channel-floodplain interaction limits our ability to constrain sediment budgets with sufficient precision to meet water resource management needs. Specifically, channel-floodplain exchange is critical to understanding how sediment source contributions from the watershed relate to sediment flux measured at a given location, as well as the lag times that might be expected between changes in upland management (e.g. implementation of BMPs) and improvements in water quality. The National Center for Earth-surface Dynamics (NCED) and Barr Engineering Co. (Barr) have collaborated to develop an easily applied code and graphical user interface within ESRI ArcMap software for extraction of morphological information about floodplains, as well as prediction of floodplain inundation and sediment deposition. The tool combines flow duration data with high-resolution topography and field measured cross-sections to extract floodplain inundation and valley-bottom hypsometry. We have applied this tool in the context of developing a sediment budget for the Le Sueur River watershed, southern Minnesota. Specifically we use the tool to predict the duration of floodplain inundation under several hydrologic conditions that are relevant to understanding floodplain storage as a temporary sink term in the watershed sediment budget. Thus, the results from this tool will prove valuable for development and implementation of watershed management plans. The code for the tool is open source and could be used to provide input data for NCED’s sediment routing model as well as other CSDMS models focused on sediment dynamics at the channel network scale.

VARIATIONS IN SEDIMENT-TRANSPORT BETWEEN DIFFERENT DISPERSAL BASIN GEOMETRIES: A CASE STUDY OF POVERTY BAY, NEW ZEALAND

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Courtney K. Harris

Poverty Bay is a significant part of the Waipaoa River sedimentary dispersal system. It has acted as a sediment sink over the past 7,000 years, and processes within the bay significantly modify the fluvial sedimentary signal en route to the continental shelf. Through numerical modeling experiments, we investigated the role that basin geometry and river mouth configuration play in sediment retention within and export from Poverty Bay. The SWAN model coupled to the ROMS estimated wave characteristics, current velocities, and sediment-transport within Poverty Bay. Three different bay geometry and river mouth orientations were investigated: (1) the modern bay, (2) the modern bay circa 2 kya when the river mouth discharged at the bay’s northern end, and (3) about 7 kya when the shoreline was 12 km landward of its present position. Simulations of a winter season and a 40 year recurrence interval storm were conducted using modern and pre-anthropogenic sediment loads to determine the wave energy and sediment-transport dynamics. Dispersal patterns were sensitive to river mouth and shoreline location. The wave sheltering generated by basin geometry was the most dominant control on sediment dispersal. Wave height on an along-bay transect of the 7 kya bay was inversely correlated with shoreline progradation rate along the same transect. Higher wave energy and proximity between the river mouth and continental shelf in the modern and 2 kya bays, compared to the 7 kya bay, lead to an increased export of sediment and coarser sediment supplied to the shelf. Relative to the modern bay, the 7 kya bay was less effective at segregating sediment by size and retained more sediment, potentially fueling the increased rate of shoreline progradation compared to that occurring more recently.

STRATEGIES FOR DEVELOPMENT AND EVOLUTION OF A COMMUNITY MODELING SYSTEM: A MUTISCALE, MULTISTATE FRAMEWORK

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The water cycle is often presented in terms of a simple concept, understandable in principal but with huge uncertainty in spatial and temporal detail. Our ability to accurately predict the distribution, availability, variability and quality of water is limited by the complex interaction of different hydrologic processes, and disparity of environmental data that defines the relationship among these processes. Hydrologic models have evolved from empirical to lumped to distributed in terms of parameter and process representation. The Penn State modeling system is a physics-based integrative strategy that attempts to deal with the data-model complexity. PIHM (Penn State Integrated Hydrologic Model) represents our approach for the synthesis of multi-state, multi-scale distributed hydrologic models using the integral representation of the underlying physical process equations and state variables. PIHM is open source that allows it to evolve in terms of process representation and adapting to any particular modeling needs on source code level. The object oriented data structure provides flexibility to incorporate new processes. Physics based distributed hydrologic model require extensive process of data acquisition, manipulation, and assignment. Steps involved in setting up a model require (1) acquiring different geo-hydrologic data such as climate, terrain, soil coverage, geology, land use and land cover (2) parameter assignment to the model kernel using the data described earlier (3) model simulation and analysis of model simulated results. PIHMservices provides a web based interactive user interface to obtain national dataset (a) USGS DEM (b) SSURGO Soil (c) NLCD 2001 Land cover and (d) NLDASÑ2 climate forcing parameters for any area in the continental United States. Often, geo-hydrologic data are available in GIS format. PIHMgis has been developed as a └tightly ┌ coupled GIS interface to PIHM based on a shared data model. PIHMgis facilitates a procedural framework for efficient domain decomposition; seamless data transfer from the geo-database and data assignment. It also allows models simulation and visualization of model-simulated results. The research also discusses various applications of PIHM in different hydrologic settings to investigate process coupling and dynamics of hydrologic processes to evaluate the ability to predict various hydrologic states and fluxes.

STATE OF THE ART CARBONATE FORWARD MODELLING: HISTORY, PROGRESS AND RECENT DEVELOPMENTS

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Carbonate systems have been a subject of morphodynamic forward model development since the late 1980s. During that time carbonate morphodynamic models have focused on carbonate platform geometry, spatial distribution of carbonate sediment production, carbonate platform interior stacking patterns, and early diagenetic alteration of carbonate strata. These models they have generated much new insight into how carbonate depositional and diagenetic processes work, and evolved from simple 1D models to more complex pseudo-3D representations of multiple interacting carbonate processes. Perhaps most importantly however, these models have helped establish that carbonate strata are the product of complex interactions between biological, chemical and physical processes, and that these interactions maybe responsible for much of the heterogeneity observed in carbonate strata. Based on these findings, and given the limits of existing carbonate models, there is a growing requirement for a next-generation forward modeling system to represent and study in more detail the process interactions leading to heterogenous carbonate strata. Defining and meeting this requirement is a key aim of the carbonate focused research group which is currently working to address this gap in numerical modeling capability and provide prototype forward modeling tools and related databases to better understand heterogeneity in carbonate strata.

DOUBLE-DIFFUSIVE AND GRAVITATIONAL INSTABILITIES IN PARTICLE-LADEN RIVER OUTFLOWS

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When a sediment-laden river flows into the salty ocean, various instabilities may arise. In an initially static environment, these instabilities can be due to either double-diffusive or gravitational effects. As a function of the governing Peclet numbers and the particle settling velocity, we investigate via linear stability analysis under which conditions each instability mode dominates, and when the modes coexist. We find that the settling velocity has a non-monotonic effect on the temporal instability growth rates. While small settling velocities can serve to increase the growth rate of the instability, larger settling velocities are found to reduce the growth rate.

TAKING IT TO THE STREETS: THE CASE FOR MODELING IN THE UNDERGRADUATE CURRICULUM

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The United States faces a crisis in education: a dire shortage of students sufficiently prepared in the STEM (Science, Technology, Engineering and Mathematics) disciplines to competitively enter the workforce. At the same time, there is increasing demand for well-trained Earth scientists in a variety of careers related to the environment and natural resources. Many efforts, including the recently released Earth Science and Climate Literacy Principles, seek to promote better Earth Science education, as well as to strengthen the Earth science literacy of the entire US population. Yet even those undergraduate students who choose to major in Geology or related Earth science disciplines rarely acquire sufficient quantitative skills to be truly competitive graduate students or professionals. Experience with modeling, during their undergraduate careers can greatly increase the quantitative literacy of Earth science majors and help them appreciate the real world applicability of mathematics and computational methods in their future careers in the Earth sciences.

NUMERICAL MODELLING OF HYDRODYNAMICS AND EROSIONAL POWER IN THE FLY RIVER DELTA, PAPUA NEW GUINEA

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A two-dimensional numerical model is used to study tidal hydrodynamics and distribution of bed shear stresses in the Fly River Delta, Papua New Guinea. The model describes the propagation of the tidal wave within the delta and along the lower Fly river. Model results indicate that tidal discharge at the mouths of the distributary channels is between 10 and 30 times larger than the river discharge, and that the upstream part of the delta is flood dominated, whereas near the mouth the delta is ebb dominated. Numerical simulations allow us to investigate the sensitivity of fluxes and bottom stresses with respect to variations of sea level and area of delta islands. The results suggest that a decrease in the total area of the delta occupied by islands increases the tidal prism and, therefore, bed shear stresses. Similarly, an increase in sea level reduces the dissipation of the tidal signal and speeds up the propagation of the tidal wave within the delta, thus yielding higher discharges and increased bed shear stresses.

MODELING GLOBAL SCALE SEDIMENT FLUX, A NEW COMPONENT IN THE SPATIALLY DISTRIBUTED FRAMEWORK FOR AQUATIC MODELING OF EARTH SYSTEM (FRAMES)

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The Framework for Aquatic Modeling of Earth System (FrAMES) is a spatially and temporally explicit multi-scale (local through global) hydrological/biogeochemical modeling scheme. It is an ongoing interdisciplinary project allowing predictions of changing material flux from major continental rivers in response to changing environmental conditions. Here we present an initial evaluation of a new component within this framework, a spatially explicit sediment flux model. We expend the BQART sediment flux model from point (river outlet) to distributed (pixel) scale by integrating it into the WBMplus continental hydrology model. BQART is an analytical model describing the empirical relationship between basin geomorphic (area and relief), climatic (temperature and precipitation), geologic (lithology and ice cover) and human (reservoir and soil erosion) characteristics and short and long-term sediment flux. WBMplus is a spatially explicit model describing varying components of global hydrological cycle. We integrate BQART into WBMplus for two main reasons: (1) WBMplus include most of the spatially and temporally explicit input data needed for distributed BQART and (2) WBMplus has already been implemented and used as part of the FrAMES platform. We validate the new model by comparing its distributed sediment flux predictions to measured fluxes at both river mouths and tributaries.

NUMERICAL SIMULATION OF MEANDERING EVOLUTION

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wo-dimensional depth-averaged hydrodynamic model is developed to simulate the evolution of meandering channels resulting from the complex interaction between downstream and secondary flows, bed load and suspended sediment transport, and bank erosion. The depth-averaged model calculates both bed load and suspended load assuming equilibrium sediment transport and simulates bank erosion with a combination of two interactive processes: basal erosion and bank failure. The mass conservation equation is solved to account for both vertical bed elevation changes as well as lateral migration changes when sediment is removed through basal erosion and bank failure. The numerical model uses deformable elements and a movable grid to simulate the gradual evolution of a near-straight deformable channel into a highly sinuous meandering channel. The model correctly replicates the different phases of the evolution of free meandering channels in experimental laboratory settings including: (1) downstream and upstream migration; (2) lateral extension; and (3) rotation of meander bends.

MORPHODYNAMIC MODELS OF DELTAS

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Predictions of delta response to various external forcings are needed now, yet our modeling capabilities are quite inadequate, and particularly so in the United States. Predicting a delta╒s response to relative sea level rise or a change in water or sediment discharge requires a model complex enough to compute morphodynamic adjustment of a multi-channel network. This includes changes in channel width, depth and friction factors, overbank flows, avulsions, mouth bar formation and destruction, and possibly even sediment critical shear stress evolution due to vegetation changes. This is a grand challenge for CSDMS. As an illustration of these challenges, we will present examples of deltas computed by Delft3D-Flow, a morphodynamic model from Deltares.

CLIMATE CHANGE IMPACT: WHAT DO WE NEED TO MODEL AND HOW DO WE BEST DO IT?

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The impact of climate change is typically and iconically characterized as an increase in temperature or precipitation. These global and necessarily coarse resolution outputs from general circulation models are then used to generate "climate change scenarios" which are used to assess the response of impacted systems (often qualitatively). This is a flawed single approach for several reasons: 1. downscaling is difficult, 2. temporal information is generally lacking, 3. results are limited to emissions scenarios that are themselves outdated and possibly flawed, and perhaps most significantly, 4. the response of environments to climate change is likely to be non-linear, such that probability distributions of climate change will not map simply onto the probability of impacts. A useful and responsible assessment of climate change impacts requires the development of a fully coupled, high-resolution, in spatial and temporal scales, environmental sensitivity model (i.e. an LEM at short time scales that incorporates as many processes as are necessary). Some progress has been made in parts of our broad community and in parts of the environment, but there is a need for a concerted and integrated effort if we are to go beyond the iconic image of climate change impact.

THE UNIVERSITY OF OKLAHOMA'S COUPLED ROUTING AND EXCESS STORAGE (CREST) HYDROLOGIC MODEL

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The University of Oklahoma (OU) Remote Sensing Hydrology Group (RSHG) is developing the Coupled Routing and Excess Storage (CREST) hydrologic model for global and local flood prediction. An overview of the principles and motivation behind the development of CREST will be given. Followed by results from historical reruns of CREST which show improvement over the first generation global flood model. Operational usage of CREST which is currently running in real time globally with a 1/8th degree grid resolution forced with TRMM Multisatellite Precipitation Analysis (TMPA) will be highlighted. Additionally, CREST has been used for targeted flood prediction on the Nzoia river basin in Kenya. MODIS and ASTER flood inundation maps have been used for the calibration of CREST over the Nzoia basin in an experiment to show that orbital sensors providing the spatial extent of flooding can provide valuable information to hydrologic modelers. Initial case study results on the applicability of CREST to CONUS flash flood prediction will also be shown for three flash flood events which caused death and destruction in the United States during 2010.

COMPUTER SIMULATIONS OF SELF-ORGANIZED MEGARIPPLES IN THE NEARSHORE

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Megaripples are bedforms with heights of 20-50 cm and lengths of 1-10 m that are common in the surf zone of natural beaches. They affect sediment transport, flow energy dissipation, and larger-scale hydro-and morpho-dynamics. They are thought to be dynamically similar to bedforms in deserts, rivers, and deeper marine environments. Here, a self-organization model (similar to models for subaerial bedforms) is used to simulate the formation and development of megaripples in the surf zone. Sediment flux is determined from combined wave and current flows using stream power (Bailard 1981) and bed shear stress (Ribberink 1998) formulations as well as a third formulation for transport based on simple rules which represent sheet flow. Interestingly, the transport formulation has little effect on model results. Random bed irregularities, either imposed or resulting from small variations in transport representing turbulence, are seeds for bedform development. Feedback between the bed and the flow in the form of a shadow zone downstream of a bedform and increasing flow acceleration with elevation over the crests of bedforms alter the transport such that organized bedforms emerge. Modeled bedform morphology (including cross-sectional shape and plan view) and dynamics (including growth and migration) are similar to natural megaripples. The model can be used to extend the field observations of Clarke and Werner (2004) which suggest that, if conditions remain the same, megaripples will continue to grow. Contrary to many bedform models (e.g., Hulscher et al. 1996, Nielsen 1981, Clifton 1976, Wiberg and Harris 1994), this model supports the idea that bedform spacing grows continually. At this time the model is being extended in an effort to predict co-existing bedforms of multiple scales in the combined flows (including steady, tidal, wave, and wave driven currents) of river mouths and tidal inlets.

USING THE CHILD MODEL TO CONSTRAIN THE TIMING OF UPLIFT AND NATURE OF FLUVIAL PROCESSES IN THE DADU RIVER, CHINA

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We use the CHILD model to explore two intertwined questions in the Dadu River, China: 1.) What river incision model most closely recreates the observed channel profile and erosion patterns? and 2.) What is the uplift history of the area? The Dadu River is incising into low relief, relict topography and becomes more deeply incised downstream, implying a downstream increase in erosion rates. Further, detrital cosmogenic concentrations from Dadu tributaries indicate a similar pattern of erosion rates. Interpretation of thermochronological data suggests that uplift rates increased dramatically between 9 and 13 million years ago, resulting in 4 km of uplift. We use the CHILD model along with channel profile data and erosion and uplift constraints to gain further insight into the evolution of this region. We explore numerous modeling scenarios, including both spatial and temporal patterns in uplift and various fluvial incision models. Our results suggest that the Dadu is experiencing a transient wave of erosion, rather than a spatial pattern of uplift. In order to sustain the transient signal over 9 ╩ 13 million years, uplift rates likely started low and increased in time. Although the current Dadu channel has many large landslide deposits, we find that sediment-flux erosion models do not create transient profiles similar to that of the Dadu. Only the stream power incision model can

recreate the large knickpoint that is currently present in the Dadu. Further, the incision model must have a slope exponent value that is less than one to match the patterns and values of Dadu channel gradients. Lastly, we find that a mixed transport-limited/detachment-limited model fits the observed channel profile and erosion patterns slightly better than the detachment-limited model alone, but it is difficult to decisively discern between the two process models.

NUMERICAL MODELING OF WAX LAKE DELTA

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Wax Lake Delta (WLD) is a small fluvial-dominated delta in the western part of the Mississippi Delta Complex. Since it began forming in the 1940s, WLD has been well studied (Fisk (1952), Roberts et al. (1980), van Heerden (1983)), resulting in detailed knowledge of its bathymetry, seasonal flow rates, and sediment composition. Abundant vibracore data, coupled with a suite of orthorectified aerial photographs, provide detailed knowledge of the morphologic evolution and the development of internal stratigraphic architecture for WLD (see Wellner et al. (2005)). As a result, numerical simulations of the evolution of this delta can be reasonably well-constrained in terms of initial and boundary conditions. The ExxonMobil process-based forward model was applied to the WLD scenario. This model couples a shallow water flow solver and equations of sediment transport to a 3D basin model. Using topography from 1942 and multiple flow scenarios, the simulations produced sedimentary bodies with similar morphologic expression to those found in WLD. Synthetic cores show qualitative agreement with vibracores taken in representative locations. These simulations also provide a direct link between fluid flow and the formation of sedimentary bodies, yielding insight into the physical mechanisms underlying the evolution of delta morphology.

INTEGRATING OROGRAPHIC PRECIPITATION INTO THE CHANNEL-HILLSLOPE INTEGRATED LANDSCAPE DEVELOPMENT MODEL (CHILD)

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Although some studies suggest that orographic precipitation should affect river discharge, erosion patterns and channel profiles in mountainous regions, most modeling studies still assume uniform precipitation as the driver of channel evolution. We have relaxed this assumption by integrating a linear orographic precipitation module into the Channel-Hillslope Integrated Landscape Development Model (CHILD). Wind direction is an important parameter controlling the movement of air masses across the landscape in the precipitation model. We incorporate a linear interpolation method across the triangular irregular network (TIN) in CHILD in order to track the movement of moisture and calculate precipitation rates. We present a series of simulations that contrast landscape development with and without orographic precipitation. Wind direction and the nondimensional delay time in the orographic precipitation model are the two main parameters impacting the rainfall and erosion patterns. Furthermore, there are a number of feedbacks between precipitation and topography. High topography can lead to higher precipitation rates, but higher precipitation rates lead to higher erosion rates and changes in the relief and concavity of channels. In a steady-state mountain range, channels are more developed and concave on the windward side than on the lee side, and the main drainage divide is displaced from the center of the domain to the lee side. Finally, we explore how vegetation growth may buffer the effects of orographic precipitation by reducing runoff and erosion rates in areas with high precipitation rates.

COUPLING SEDIMENT DYNAMICS AND BIOGEOCHEMICAL MODELS WITHIN ROMS WITH APPLICATION TO THE LOUISIANA TEXAS SHELF

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Kehui Xu, Coastal Carolina University; Katja Fennel, Dalhousie University; Chris Sherwood, U.S. Geological Survey

The Regional Ocean Modeling System (ROMS) contains modules for both sediment transport and biogeochemistry. To date, however, these components have operated independently. Within the biogeochemistry model of Fennel (2006), for example, processes occurring within sediment have been represented using a simplifying assumption whereby material instantly demineralizes once it settles to the seabed. This therefore neglects the role played by burial and diagenesis in biogeochemical cycles. The incorporation of organic matter within the sediment matrix implies that, besides undergoing degradation there, it could be subject to burial, consolidation, resuspension, and redistribution through processes that are treated within the sediment transport model. To address this gap within the biogeochemical model, we are coupling the sediment transport routine to the biogeochemical model within ROMS. Examples from a one-dimensional test case will demonstrate recent progress within this project. Ongoing efforts are adding biodiffusion of both particles and dissolved matter to the sediment bed model. Our eventual goal, once model development has progressed within the one-dimensional framework, is to apply the coupled biogeochemical sediment model within a physical oceanographic model of the northern Gulf of Mexico. Within this poster we will present recent one-dimensional (vertical) test cases that include erosion, deposition, and seabed diffusion of particulate and dissolved tracers. Additionally, we will highlight three dimensional model estimates for the dispersal of Mississippi and Atchafalya sediment in the northern Gulf of Mexico under both fair-weather and storm conditions for the year 1993.

REGIONAL-SCALE MODELING OF PERMAFROST DISTRIBUTION IN ALASKA USING THE GIPL-MPI TRANSIENT MODEL

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According to SWIPA (Snow, Water, Ice and Permafrost in the Arctic: An Arctic Council Project) the arctic cryosphere is undergoing dramatic changes. Major factors contributing to this change are sea ice retreat, the melting of the Greenland Ice Sheet and glaciers, permafrost thawing and less snow. This project addressed permafrost thawing for the State of Alaska. Our goal was to produce a high spatial resolution map of permafrost distribution and dynamics in Alaska for the past, present and future. To achieve this we implemented the GIPL-MPI transient model for the entire Alaska permafrost domain. As a climate forcing we used SNAP (Scenarios Network Planning for Alaska) dataset, which consist of the composite of five IPCC models that performed the best for Alaska. The outputs from these five models have been scaled down to 2 kilometers resolution using the PRISM model (http://www.prism.oregonstate.edu/), which takes into account elevation, slope and aspect. All derived values represent a single month within a given year for the five model composite, for three different emission scenarios. The poster shows modeling results based on boreholes drilled in Alaska. We calibrated GIPL-MPI transient model with past ground thermal development data. Results from downscaled GCM scenarios were used to address possible future ground temperature changes.

BIOGEOMORPHOLOGICAL MODELING

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We are working on improving the modelling capabilities concerning the interaction of flow (optionally waves), vegetation, and morphodynamics for riverine and estuarine applications. This introduces all kinds of interesting questions from small-scale flow-vegetation interaction (including turbulence) to long-term impact on the evolution of the morphology and stratigraphy of rivers and deltas.

STRATEGIC CHOICES IN CARBONATE MODELING

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Numerical models of carbonate sedimentation (NMCS) describe the creation of carbonate essentially from the ambient seawater, on pathways mediated by opportunistic, competing creatures. The carbonate is then subject to dissolution and erosion/transport processes. NCSM tend to be either: (i) rules based, using environmental conditions, or (ii) population ecology based. Looking at (ii) -the second generation NCSM -the general approach is mostly agreed: sets of ordinary differential equations for logistic growth reflect reproduction, competition and mortality under resource limitations. Then growth and calcification rate functions are superimposed. Geologic factors act by varying the resource limitations. But under this there is substantial lack of agreement on ways to proceed. What is the population unit (functional group, dominant species, community)? What are the sharpest resource limitations (light, temperature, stability, sediment)? What type of the competition is in play (preyÑpredator, for space or nutrients)? How do we treat the various types and timings of reproduction (gamete, vegetative, brooded)? Should a model be verified for stasis first before applying a geological history (such as sea-level change)? Computer code, even high-performance code, is unable to deal with biological levels of complexity. Therefore the question becomes: What is the most effective set of (the above) processes and limitations to model? For example, should the model be general enough to be able to simulate metazoan, algal and bacterial production? What is the most valuable target output for validations against field? How best to encode external events, especially a-periodic extreme events? It is clear that -unlike for clastic models -a Knowledge Base (KB) will have to support the modeling. That KB will hold information and datasets which drive and parameterize biologic characterizations such as reproduction, growth and mortality, and environmental zonations and perturbations. Making that KB will require a great amount of expertise in ecology, focused sharply on the needs of the numerical equations, and encoded in an efficient, machine-accessible way. Using a prototype model and knowledge base, we explore these strategic questions facing the development of numerical models for carbonate sedimentation.

OIL SPILL RISK ANALYSIS MODEL

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The oil spill risk analysis (OSRA) model, originally developed by Smith et al. (1982), simulates oil-spill transport using realistic data fields of winds and ocean currents. The model plays an essential role in analyzing oil spill risks in the U.S. continental shelf for the U.S. federal government. The model was recently completely updated and improved to meet the new challenges in the oil spill risk analyses. Many things have been changed since the 1980s, including 1) the needs of OSRA customers have changed and increased; 2) the computer hardware and software have been improved and became much more powerful; 3) mathematical methods and computational schemes have made great progress; and 4) our understanding in the oil spill processes and physical oceanography are also greatly improved. The objectives of this study include: 1) Efficiency: the updated OSRA should be more efficient in terms of computational time. Parallel programming methods are needed for this purpose. 2) Consistency: the updated OSRA should be able to produce results that are consistent with our previous analyses. 3) More user-friendly by incorporating

GIS tools. 4) Options for including new mechanisms. The OSRA model is driven by analyzed sea surface winds and model-generated ocean surface currents. Instead of focusing on individual oil spill events, the OSRA examines oil spill risks over long periods of time (from 5 years to decades) and large spatial scales (up to thousands of kilometers). Also a statistical model, the OSRA model calculates thousands of hypothetical oil spill trajectories over extended areas of U. S. continental shelf and tabulates the frequencies with which the simulated oil spills contact the geographic boundaries of designated environmental resources. An oil spill on the ocean surface moves around by the complex surface ocean currents exerting a shear force on the spilled oil from below. In addition, the prevailing wind exerts an additional shear force on the spill from above, and the combination of the two forces causes the transportation of the oil spill away from its initial spill location. The newly improved OSRA model is tested on a Microsoft Windows-based workstation with 8 CPUs. The combination of code parallization, code optimization, and I/O optimization has greatly improved the computational efficiency. The new model is now more than 50 times faster than the old one. Applying the model to the Gulf of Mexico using 16 years of winds and ocean currents, we find that the newly improved OSRA model can provide important information on the behavior of oil spills more accurately and efficiently. Ultimately, this information will be used in the pertinent environmental impact studies and in the development of oil-spill response plans.

SEDIMENT DYNAMICS OVER TIGER AND TRINITY SHOALS OFF THE LOUISIANA COAST

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Two oceanographic surveys were conducted at the Tiger-Trinity shoal complex in December 2008 and March-April 2009. Oceanographic Tripods were deployed along a transect for monitoring both wave and currents fields on the shoal and adjacent environment. During the 2008 deployment, which lasted for two weeks and with a single tripod deployed over Tiger shoal, three cold fronts crossed the study area and significantly influenced the hydrodynamics of the region. The maximum wind speed observed was 14.2 m/s while the maximum wave height recorded was less than 1 m. This substantial wave attenuation observed for Tiger Shoal can be attributed to the nature of the bottom sediments. The highly viscous bottom sediments dissipate incoming waves, a phenomenon confirmed by previous studies conducted along this coast. Except for a few instances,, the wave-induced shear stress at the bottom was strong enough to re-suspend sediment, during the entire deployment period. The data from the 2009 deployments are being analyzed and will also be discussed in the presentation. A suit of hydrodynamic models was also implemented, as a preliminary study, to estimate the effect of waves and currents on the shoal dynamics. MIKE 21/3 wave and Hydrodynamic models were implemented for the Tiger and Trinity shoal system. A substantial reduction in wave height was observed seaward off Trinity Shoal. This can be attributed to rapid decrease in slope off Trinity Shoal. Also, our preliminary hydrodynamic model data demonstrated that strong currents existed over the shoal region, which are critical in the redistribution of sediment, although the precise patterns and magnitude are still to be quantified, especially during the winter storm period.

SUFFICIENT CONDITIONS FOR DEVELOPMENT OF VALLEY NETWORKS DOMINATED BY DEBRIS FLOWS

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Simulations of landscape evolution are used to determine the suite of geomorphic transport laws necessary to reproduce key features of observed landscapes where large parts of the channel network appear dominated by debris flow scour. Processes tested include the following: chemical weathering, which reduces rock density at a point; physical weathering, which increases with decreasing rock density and decreases with increasing soil depth at a point; shallow landsliding, which is dependent on topography and root strength for a cluster of points; and debris flow scour, which may affect bedrock and may therefore increase with decreasing rock density. These processes are newly incorporated within the Channel-Hillslope Integrated Landscape Development model (CHILD). Simulations will test whether all of these processes or a limited set are sufficient to produce observations from the Oregon Coast Range: topography, as represented by LiDAR-derived digital elevation models (DEMs); rock hardness, assumed proportional to density; and soil thickness, where the latter two are found in the literature. The latest results from this study will be presented.

A CELLULAR DELTA-BUILDING MODEL WITH PARAMETERIZED CHANNEL PROCESSES

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In my current research, a rule-based cellular model is being developed to resolve delta growth at large scale, without ignoring the small scale details. Mouth bar process, bifurcation and avulsion are parameterized and occur naturally as the delta grows. Current result shows that with proper setup the model is capable of producing mouth bar and elongated channels. The rule-based water and sediment routing need more physical insights. This model is still at early stage and will continue throughout my PhD. In the past research, a new approach is developed using the analogy with dendritic crystal. To simulate sediment transport with channelization, two sets of rules are introduced as ╥building╙ rules and ╥aging╙ rules. An unstructured mesh of Delaunay triangulation is used. Each node is assigned several quantities, which include land elevation, sediment amount, etc. These quantities change during the simulation according to the rules. Building rules describe the diffusional process of sediment transport, which are essentially equivalent to a numerical solution of the PDE system describing diffusion of sediment in fluvial delta, or similarly, heat diffusion in dendritic crystal growth, and they develop channels automatically by selecting nodes with the quantity of sediment amount above threshold. Aging rules are applied to the cellular structure of channel networks to regulate channel growth and to mimic the natural process that some channels are filled with sediment after being abandoned. The results are compared to real deltas with fractal geometry analyses in terms of fractal dimension and bifurcation statistics. The agreement is satisfying.

VARIATIONS OF RUNOFF, SOIL MOISTURE, AND NUTRIENTS EXPORT IN NORTH AMERICA DRIVEN BY CLIMATE AND LAND USE CHANGE DURING 1895-2008

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Climate and land use have been suggested as two major factors that control variations of water yield, soil moisture, and water qualities in the world. Landscapes of the North America (NA) have been intensively disturbed or managed by human activities and have been involved in rapid economic development and urbanization in the last century. However, few integrated regional studies had been conducted to characterize how climate variations and climate change, land-use conversions, and land management have affected regional hydrological cycles and water qualities in temporal and spatially domain and further attribute these changes to different driving forces. The magnitude of carbon and nitrogen export from land to aquatic ecosystems and coastal region is far from certain, which has been identified as a major gap in our understanding of the global carbon budget and the predictions of the seasonal hypoxia in coastal estuaries. To quantify the fluxes of water and nutrients export (including DOC, POC, DIN, DON, and PON) from land to aquatic ecosystems and underlying mechanisms, we have developed a integrated Dynamic Land Ecosystem Model that couples hydrologic process, soil biogeochemical processes, vegetation dynamics, and river routine system. In this study we will focus on Mississippi River Basin and Chesapeake Bay and Mid-Atlantic region and answer the following two questions:1) What is the magnitude of river discharge and organic carbon and total nitrogen exported from terrestrial ecosystems to during 1895 to 2008? And 2) What are the relative contributions of each driving force on the variations of water fluxes and nutrient exports to Northern Gulf of Mexico, Chesapeake Bay and Mid-Atlantic region? Driving forces we considered in this study include climate variations (precipitation, temperature, solar radiation, and relative humidity), changes in land-use/land-cover conversions, and land practices (fertilization and irrigation).

A MODEL OF SEDIMENTARY DELTA GROWTH THAT ACCOUNTS FOR BIOLOGICAL PROCESSES

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Feedbacks between biological and physical processes play an essential role in determining the response of coastal dynamics to environmental changes, but to date predictive models do not take them into account. The combination of biomass production by plants and microbial decomposition in wetland environments leads to accumulation of SOC in the form of peat. Organic deposits (peat) represent a significant fraction of the sediment column in the Holocene Mississippi Delta System and several other coastal systems throughout the world. The objective of our research is to construct exploratory models that explicitly account for peat accumulation and degradation via plant growth, burial, and microbial processes influenced by salinity. We propose a set of ╚lumped╔ models aimed at averaging the critical small scale biological processes as source and sink terms that are inserted into larger scale delta growth model. Even in a highly simplified framework, the model suggests that carbon dynamics in the sediment column can significantly influence delta evolution. In a model with pivot subsidence but without a SOC component the shoreline monotonically reaches a steady position where the mineral flux balances the subsidence rate. When we include our proposed simple SOC source term the interactions between subsidence and delta carbon content result in a shoreline that initially advances and retreats before monotonically approaching a steady position. We hypothesize that the initial advance-retreat cycle could represent an important time scale for the role of biological processes in delta building.

MODELING HOLOCENE DISCHARGE AND SEDIMENT FLUXES FOR THE RHINE RIVER

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Long-term sediment fluxes in fluvial systems are governed by a number of external forcing factors like climate change, human impacts, sea level change and tectonic activity. Understanding fluvial response to changing external drivers is of importance to understand past, present and future changes of sediment fluxes. The climate-driven hydrological model HYDROTREND v.3.0 allows simulations of long-term water discharge and sediment loads at the river outlet of large catchments. In this study the model is applied to the Rhine River, Germany over the Holocene time period (10,000 BP ╨ present). During this period human activity worldwide increased profoundly. The Rhine system, a 158,000 km2, has a particularly long story of intense human-riverine interactions, resulting in largely man-induced sediment fluxes from the Mid-Holocene onwards. Of advantage from a methodic point of view is the wealth of geoscientific case studies in the Rhine catchment enabling a comprehensive long-term study due to available quantitative data from various fields of Earth Surface and Social Sciences (instrumental, historical, archaeological and

palaeoecological). The model results are validated against sediment load and discharge observations of the present day Rhine River. Once validated, the model will be applied over the Holocene to analyze the change in water and sediment discharge and to determine the impact of each of the forcing factors.

FROM SEDIMENT ROUTING TO FLUID FLOW: TURNING DOODLES INTO DIGITS

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Successful hydrocarbon exploration and production depends on the ability to be predictive. Prediction must transcend qualitative description by utilizing quantitative tools, workflows, and approaches that allow us to maximize and apply all available data. This presentation illustrates how process-based modeling tools predict sediment routing systems, the resulting three-dimensional sedimentary architecture, and facies distribution. A process-based, quantitative approach is used for predicting sedimentary environments by integrating data and knowledge pertaining to modern depositional systems, subsurface, outcrops, laboratory experiments, and numerical modeling tools. A more quantitative and rigorous data collection and analytical approach is required to facilitate the building of data-constrained predictive models based on first principles. Appropriate sensitivity and uncertainty analysis that captures the complexity of the predicted systems is crucial. A set of case studies demonstrate workflows that integrate diffusion-based forward stratigraphic prediction with petroleum systems prediction. Two of the case studies, one at basin scale and one at prospect scale, are from a deep-water system with a mobile substrate, and a third case study is from a basin with very high rates of subsidence and sedimentation. These case studies show the influence of accommodation, basin geometry and topography, sediment supply on the sediment routing, and impact of a high resolution, three-dimensional sedimentary model on petroleum systems prediction.

INTERNAL BORES: AN IMPROVED MODEL VIA A DETAILED ANALYSIS OF THE ENERGY BUDGET

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Internal bores, or hydraulic jumps, arise in many atmospheric and oceanographic phenomena. The classic single-layer hydraulic jump model accurately predicts a bore's behavior when the density difference between the expanding and contracting layer is large (i.e. water and air), but fails in the Boussinesq limit. A two-layer model, where mass is conserved separately in each layer and momentum is conserved globally, does a much better job but requires for closure an assumption about the loss of energy across a bore. Through the use of 2D direct numerical simulations, we show that there is a transfer of energy from the contracting to the expanding layer due to viscous stresses at the interface. Based on the simulation results, we propose a two-layer model that provides an accurate bore velocity as function of all geometrical parameters, as well as the Reynolds and Schmidt numbers. We also extend our analysis to non-Boussinesq internal bores to bridge the gap between the single and two-layer models.

UNSTABLE MISCIBLE DISPLACEMENTS IN HELE-SHAW CELLS: THREE-DIMENSIONAL NAVIER-STOKES SIMULATIONS

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We simulate unstable miscible displacements in Hele-Shaw cells based on the three-dimensional, variable viscosity Navier-Stokes equations coupled to a convection-diffusion equation for the concentration field. The simulations exhibit the formation of individual, quasisteady fingers whose properties are characterized as a function of the viscosity ratio and the Peclet number. We observe both traditional tip splitting events, as well as a novel inner splitting mechanism that has not yet been reported in the literature. This tip splitting is associated with fluid transport perpendicular to the plane of the Hele-Shaw cell, and hence cannot be reproduced by gap-averaged approaches. It has the effect of splitting the trailing sections of the finger longitudinally, while the finger tip can largely remain intact. This work is supported by NSF, CAPES and a Fulbright fellowship.

COMPLEXITIES IN BARRIER ISLAND RESPONSE TO SEA LEVEL RISE: INSIGHTS FROM NUMERICAL MODEL EXPERIMENTS, NORTH CAROLINA OUTER BANKS

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Using a morphological-behavior model to conduct sensitivity experiments, we investigate the sea level rise response of a complex coastal environment to changes in a variety of factors. Experiments reveal that substrate composition, followed in rank order by substrate slope, sea level rise rate, and sediment supply rate, are the most important factors in determining barrier island response to sea level rise. We find that geomorphic threshold crossing, defined as a change in state (e.g., from landward migrating to drowning) that is irreversible over decadal to millennial time scales, is most likely to occur in muddy coastal systems where the combination of substrate composition, depth-dependent limitations on shoreface response rates, and substrate erodibility may prevent sand from being liberated rapidly enough, or in sufficient quantity, to maintain a subaerial barrier. Analyses indicate that factors affecting sediment availability such as low substrate sand proportions and high sediment loss rates cause a barrier to migrate landward along a trajectory having a lower slope than average barrier island slope, thereby defining an ╥effective╙ barrier island slope. Other factors being equal, such barriers will tend to be smaller and associated with a more deeply incised shoreface, thereby requiring less migration per sea level rise increment to liberate sufficient sand to maintain subaerial exposure than larger, less incised barriers. As a result, the evolution of larger/less incised barriers is more likely to be limited by shoreface erosion rates or substrate erodibility making them more prone to disintegration related to increasing sea level rise rates than smaller/more incised barriers. Thus, the small/deeply incised North Carolina barriers are likely to persist in the near term (although their long-term fate is less certain because of the low substrate slopes that will soon be encountered). In aggregate, results point to the importance of system history (e.g., previous slopes, sediment budgets, etc.) in determining migration trajectories and therefore how a barrier island will respond to sea level rise. Although simple analytical calculations may predict barrier response in simplified coastal environments (e.g., constant slope, constant sea level rise rate, etc.), our model experiments demonstrate that morphological-behavior modeling is necessary to provide critical insights regarding changes that may occur in environments having complex geometries, especially when multiple parameters change simultaneously.

WITH SEA-LEVEL RISE AND CHANGING STORMS, HUMANS REACT TO SHORELINE EROSION BUT SHORELINES REACT BACK (COUPLED ECONOMIC/LANDSCAPE EVOLUTION MODELING)

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When faced with persistent coastal erosion, communities often react by stabilizing the shoreline, commonly through repeated └beach replenishment. ╒ Recent numerical modeling work has shown that even a single community holding the shoreline position fixed by importing sand to keep pace with erosion can significantly affect shoreline change for surprisingly large alongshore distances. Patterns of large-scale coastline change are affected by localized human manipulations even as the humans are affected by coastline change. These two-way couplings between coastal processes and human dynamics also mean that shoreline stabilization efforts at one town affect, positively or negatively, the erosion rates, and therefore real estate values, of other towns along the coastline. Such impacts can occur even when towns are not adjacent to one another. Changing storm behaviors (e.g. intensities) change the distribution of wave influences from different directions, and such changes to wave climates tend to reshape a coastline. The associated acceleration in long-term shoreline change rates intensifies the feedbacks between humans and coastline evolution. We developed an empirically based economic model in which beach replenishment decisions are based on erosion rates, property values, and the costs for replenishment sand. Coupling this work to the large-scale coastline change model allows us to explore how coastal communities affect each other╒s fates and the shape of the coastline under different sea-level rise, climate change, and sand-cost scenarios.

TURBIDITY CURRENTS IN MEANDERING CHANNELS

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We consider continuous, particle-laden gravity currents flowing along sinusoidal submarine channels bounded by levees, with special emphasis on the sediment transport. We investigate these flows via highly resolved three-dimensional direct Navier-Stokes simulations, based on an immersed boundary representation of the channel topography. Results are reported from a parametric study that focuses on shear stress profiles along the channel bed, secondary flow structures in channel cross-sections, lateral overflow over the levees, and sediment deposition, as functions of the channel geometry, the flow parameters, and the particle settling velocity.

COMPONENT-BASED SCIENTIFIC SOFTWARE DEVELOPMENT: USABILITY CHALLENGES AND TOOLS

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Component-based software development enables the creation and maintenance of integrated applications containing contributions from multiple developers and encapsulating a range of capabilities, such as different models, numerical solution methods, data analysis, and visualization. The Common Component Architecture (CCA) defines a component model which has been successfully used within CSDMS to define uniform interfaces for CSDMS models that streamline model integration. Component development entails significant developer overheads, some of which have been addressed through the creation of tools that automate parts of the development process. We will discuss the challenges of developing and maintaining component software in the scientific computing domain. We will overview existing usability support provided through open-source tools developed by members of the CCA Forum and used in CSDMS.

THE MORPHODYNAMICS E-BOOK: A LABOR OF LOVE THAT NEVER QUITE GETS FINISHED

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The e-book project began in 2002 when I was in residence as the Crosby Lecturer in the Department of Earth and Planetary Sciences at the Massachusetts Institute of Technology. Although my position did not require me to teach a full course, I decided to teach one anyway. The topic of the course was river morphodynamics. I covered sediment conservation laws, basic hydraulics and sediment transport relations, and applied these to riverbed aggradation, downstream fining, alluvial fans and delta, and knickpoint migration. I used a combination of PowerPoint lectures, Excel spreadsheets, Word documents and videos to illustrate the material. The coding was done in Visual Basic for Applications (VBA), which is built into Excel. The MIT students found this rather primitive compared to, e.g. Matlab, and MIT in general was not particularly supportive of Microsoft products. I nevertheless chose VBA because just about everyone has Excel, whereas they may or not have Matlab, Fortran, C++ or other programming languages/compilers loaded on their computer. I treated the students on the first day of class to plastic wine glasses and two bottles of wine, a good Alsatian Rhine wine and Manischewitz wine. I then told them that C++ was the Alsatian, but in this class they had to drink Manischewitz. A number of students in the class went on to become researchers in their own right. (This likely has little to do with the course, but it does speak for the quality of the students.) After MIT, I proceeded to the Tokyo Institute of Technology where I taught a 6-week intensive course on river morphodynamics. This experience allowed me not only to develop the course further, but also to prepare a Japanese language version. The MIT and TIT lectures/code/videos/text laid the basis for a full e-book. I wrote this in my spare time, using courses at the University of Minnesota as a way to extend the material. The book is online at http://vtchl.uiuc.edu/people/parkerg/. I haven ̧t updated the website since 2006, but I do have new material developed at the University of Illinois that, someday, I will post. The book on the website is only 2/3 done, but it has given me great pleasure, not only to prepare the material, but also to see others use it. It has also served as a springboard for my own research, and that of my students (who have written or contributed to several of the chapters).

SIMULATING THE THREE DIMENSIONAL DISPERSAL OF AGING OIL WITH A LAGRANGIAN APPROACH

E. W North, Z. Schlag, E. Eric Adams, R. He, K. H. Hyun, C. R. Sherwood, R. P. Signell, S. D. Peckham

The objective of our program is to investigate the far field subsurface and surface dispersal of different size classes of oil released from the Deepwater Horizon well. We use the Lagrangian transport model LTRANS, an open source model, to simulate the trajectories of oil droplets as they age over time. This Lagrangian approach incorporates the effects of differences in initial droplet characteristics, as well as time-varying droplet behavior. Circulation predictions were provided by SABGOM, a ROMS model of the Gulf of Mexico and southeastern shelf, while initial droplet elevations were provided by multi-phase plume modeling. We ran the SABGOM/LTRANS model system for the time period of the Deepwater Horizon oil spill, produced maps and animations of model output, and are in the process of comparing results with available observations. Preliminary findings indicate that oil droplet diameters greater than 100 microns rise quickly to the surface. Droplets with diameters less than 100 microns have markedly different dispersal trajectories than larger droplets, and those 10 micron in diameter have similar trajectories as passive particles. Model predictions, sensitivity, and skill assessment will be presented and discussed. LTRANS v2, including new oil algorithms, will be released as open source code and adapted to run with CF-compliant model output, making it functional with multiple coastal models and allowing simulations and forecasts to be made throughout the US coastal waters. This project is supported by an NSF RAPID grant and one of the goals of the project is to make LTRANS available as a plug-and-play component within the Community Surface Dynamics Modeling System (CSDMS). It is currently driven by ocean model input from ROMS but will be adapted so it can also use ocean model output from other models.

DRIVING PLUG-AND-PLAY MODELS WITH DATA FROM WEB SERVICES -A DEMONSTRATION OF INTEROPERABILITY BETWEEN CSDMS AND CUAHSI-HIS

S. D. Peckham and Jonathan L. Goodall

The CUAHSI Hydrologic Information System (HIS) is an internet-based system to support the sharing of hydrologic data. It is comprised of hydrologic databases and servers connected through web services as well as software for data publication, discovery and access. (See http://his.cuahsi.org.) The CUAHSI HIS system consists of 3 main parts that interact with one another. HIS Server is a repository of hydrologic time series data published as WaterOneFlow web services. HIS Central is a metadata catalog of data accessible through WaterOneFlow web services. Hydro Desktop is an application to access and work with hydrologic data discovered on HIS Central and acquired from HIS Servers. CUAHSI HIS currently supports a large collection of hydrologic data sets in the form of at-aÑpoint observations that vary over time (time series) but may be extended in the future to support gridded data sets that vary over time (grid stacks). The Community Surface Dynamics Modeling System (CSDMS) is a modeling framework in which different approaches to modeling different physical processes appear as interchangeable, reusable, plug-and-play components. (See http://csdms.colorado.edu.) Open-source models that are contributed to the CSDMS project form a quite heterogeneous group as they are (1) written in different languages, (2) have different interfaces, (3) have different computational grids and (4) use different input/output file formats. In order to make these model components interoperable, they must therefore be wrapped to have a common interface, i.e. they must be made to respond to a well-defined set of calling commands. The CUAHSI-HIS project must deal with a similar problem in terms of providing a common mechanism for accessing a heterogeneous group of databases that are available online. Two of the underlying tools used to achieve this are a relational database called the Observations Data Model (ODM) and an XML schema called WaterML. WaterOneFlow is a set of web services based on WaterML (similar to a model interface) that is installed on participating servers that distribute hydrologic data. In order to demonstrate interoperability between CSDMS and CUAHSI-HIS (both funded by NSF), a prototype CSDMS component has been developed that (1) collects information (e.g. geographic bounding box, start time and end time) for a data set "query" using a tabbed dialog, (2) connects to the HIS Central web service and (3) reports on what data is available at HIS Central. These steps can be repeated in "Query mode" until a suitable data set is found, and then the component can be toggled to "Download mode" to download and save the requested data in output files or in the component's state. The new HISData component looks and operates exactly like other CSDMS model components and includes a tabbed dialog for entering input and an HTML help page that provides information as well as links to several online resources for CUAHSI HIS.

REEF GROWTH IN OPTIMAL AND MARGINAL HABITATS: PAST, PRESENT AND FUTURE

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Reef growth is the net result of interactions between processes of biological and geological accretion and physical and biological processes of destruction. These processes vary qualitatively and quantitatively among habitats on the same reef, and also vary among different reefs. Empirical data from Pleistocene to modern reefs in Papua New Guinea, Australia, Hawaii and Midway Atoll indicate the nature, magnitudes and constraints of these habitat-specific processes. Data will include preliminary results from cores taken during the 2010 IODP Expedition 325 (Great Barrier Reef Environmental Change).

BIOLOGICAL DYNAMICS AND CARBONATE PRODUCTION -LINKING SMALL-SCALE, SHORTÑAMPLITUDE TO LARGE-SCALE, LONG-AMPLITUDE PROCESSES

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Carbonate systems are built from organismic skeletons and as such are reflections of life processes. The translation of the ones into the other, as is necessary for the development of growth models for carbonate systems, can present some challenges. In particular in benthic, space-limited systems such as organismic reefs, growth dynamics can be strongly influenced by local small-scale phenomena and the amplitude of life-phenomena is much shorter than that of sedimentary cycles. Thus a single sedimentary sequence can be the sum of many generations of sediment-producers and can encompass many small-scale, short-period environmental influences. To realistically model large-scale and long-amplitude patterns (i.e. the sedimentary sequence) a good understanding of the linkages across these scales is necessary. To achieve increased precision of prediction, carbonate production estimates can be anchored on dynamics of populations rather than on averaged bulk-production rates for a given system and can be integrated with environment-specific taphonomic and diagenetic information. Examples from different modern environments will show how environmental change can influence carbonate production.

FEATURE ANALYSIS OF COUPLING TECHNOLOGY FOR CLIMATE MODELS

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The notion of "coupling" is essential for implementing climate models made up of two or more interacting computer simulations. The software components that link together and mediate interactions between these models are called couplers. Couplers are well-known abstractions in the geophysical and other scientific communities, although their implementations differ vastly. With respect to Earth System Models, no standard reference architecture has emerged. Instead, couplers are designed to address particular modeling situations. The design space of couplers is constrained by properties of the existing models, such as their software architecture, dependencies on third party libraries, numerical properties, and scientific properties, as well as properties of the target computational environment. We are interested in providing support for climate scientists who may wish to couple individual, pre-existing models. Our aim is to determine the extent to which this process can be automated. In particular, we are looking into whether and how couplers can be automatically generated for numerical ESMs. As a first stage in this process, we have performed a feature analysis of coupling technologies. Feature analysis is an attempt to understand a set of related technologies by organizing their features along orthogonal dimensions. In this talk we will introduce feature analysis and feature diagrams, give examples of our analysis and describe some interesting issues that have arisen during our investigation.

OBSERVATIONS AND MODELING OF MUDDY SEAFLOOR RESPONSE TO ENERGETIC SURFACE WAVES ON THE LOUISIANA SHELF

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Mead A. Allison, Jackson School of Geosciences, University of Texas, Austin

Surface waves and near-bed flows were measured for 6-weeks in Spring 2008 at a cross-shore transect between 7.4-and 4-m isobaths on the muddy Atchafalaya Shelf, Louisiana (e.g., Safak et al., accepted for J. Geophys. Res.). The evolution of the sea bed during an energetic wave event (up to 1.4-m significant height, with peak period of 10-s) is studied based on the observations at 4-m depth. The backscatter intensity of the acoustic signal of a current profiler is used to estimate the near-bed vertical structure of suspended sediment concentration (Thorne and Hanes, Cont. Shelf. Res. 2002). A one-dimensional bottom boundary layer model for combined wave-current flow on cohesive beds (Hsu et al., J. Geophys. Res. 2009) is calibrated to fit the estimated concentration profiles. Simulations are used to investigate the relation between flow conditions (waves, turbulence, bottom stress, etc.) and bed state (e.g., amount of sediment in suspension, conditions at which resuspension, liquefaction, and fluid mud formation occur). The results suggest that the state of bed sediment evolves from consolidated before storm, through liquefaction (when long-period swells reached 1-m significant height) and finally to soft bed resulting from settling of suspended sediment. (This study is supported by Office of Naval Research.)

PARBREZO: A PARALLEL, UNSTRUCTURED GRID, GODUNOV-TYPE, SHALLOW-WATER CODE FOR HIGH-RESOLUTION FLOOD INUNDATION MODELING AT THE REGIONAL SCALE

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Jochen E. Schubert, Russel L. Detwiler

Topographic data are increasingly available at high resolutions (< 10 m) over large spatial extents to support detailed flood inundation modeling and loss estimation analyses required for flood risk management. This paper describes ParBreZo, the parallel implementation of a two-dimensional, Godunov-type, shallow-water code, to address the computational demand of high-resolution flood modeling at the regional scale (10^2-10^4 km^2). A systematic approach to unstructured grid partitioning (domain decomposition) is presented, and the Single Process Multiple Data (SPMD) paradigm of distributed memory parallelism is implemented so the code can be executed on computer clusters with distributed memory, shared memory, or some combination of the two (now common with multi-core architectures). In a fully-wetted, load-balanced test problem, the code scales very well with a parallel efficiency of close to 100% on up to 512 processes (maximum tested). A weighted grid partitioning is used to partially address the load balancing challenge posed by partially wetted domains germane to flooding applications, where the flood extent varies over time, while the partitioning remains static. An urban dam-break flood test problem shows that weighted partitions achieve a parallel efficiency exceeding 70% using up to 48 processes. This corresponds to a 97% reduction in execution time so results are obtained in a matter of minutes, which is attractive for routine engineering analyses. A hurricane storm surge test problem shows that a 10 m resolution, 12 hr inundation forecast for a 40 km length of coastline can be completed in under 2 hours using 512 processors. Hence, if coupled to a hurricane forecast system capable of resolving storm surge, inundation forecasts could be made at 10 m resolution with at least a 10 hr lead time.

LINKING DELTAIC AND MARINE SEDIMENTARY PROCESSES: A PRELIMINARY BATHYMETRIC AND SUB-BOTTOM SURVEY OF LAKE CHELAN, WASHINGTON

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Geologists have long recognized the importance of both river deltas and deep-ocean sedimentary fans as major sinks for large quantities of land-derived sediment. Indeed, studies too numerous to count have addressed these depositional systems individually. Relatively few studies, however, have directed their attention at the linkage between the two, despite the fact that the former is almost always intimately related to the latter. This linkage, however, is key to our ability to model and understand both deltaic and deep-marine sedimentation, as these dynamics provide an important boundary condition for terrestrial and marine models. This project is a preliminary study of the relationship between deltaic and deep-water sedimentation in Lake Chelan, WA, where the external forces acting on the system are relatively well-constrained, and the river is directly linked to deeper water. Detailed bathymetric and sub-bottom data were collected in order to characterize the transport and fate of fluvial sediments. These preliminary data are intended as a base-line from which a long-term monitoring study can be started, and are intended as the sort of information that would be useful as constraints on morphodynamic models.

MORPHODYNAMIC MODELS OF DELTAS

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Predictions of delta response to various external forcings are needed now, yet our modeling capabilities are quite inadequate, and particularly so in the United States. Predicting a delta ╒s response to relative sea level rise or a change in water or sediment discharge requires a model complex enough to compute morphodynamic adjustment of a multi-channel network. This includes changes in channel width, depth and friction factors, overbank flows, avulsions, mouth bar formation and destruction, and possibly even sediment critical shear stress evolution due to vegetation changes. This is a grand challenge for CSDMS. As an illustration of these challenges, we will present examples of deltas computed by Delft3D-Flow, a morphodynamic model from Deltares.

BRIDGING THE GAP BETWEEN SEDIMENTARY PROCESS MODELING AND STOCHASTIC OBJECT MODELING

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Recent developments in stochastic modeling using geometric objects (or "Boolean" modeling) include attention to the interaction between generations of inserted objects. Object location, shape, size and orientation are controlled not just by a proiri fields defined for the entire model, but also by the presence of previously inserted objects and their geometry. Thus for example, crevasse splays may be attached to previously generated stochastic channel preferenctially at points of high channel curvature, and pointing outward from the channel. Or post glacial streams may avoid topographics highs such as drumlins left by a retreating glacier. If this concept is taken far enough, it is unavoidable to incorporate true sedimentary process modeling principles into it, occasionally even showing the effect of self organization arising from simple rules. However, this type of hybrid model can be kept simpler than a true sedimentary process model, and due to its stochastic nature, is easier to condition to hard and soft data.

We present preliminary results of several variations of this approach applied to glacial and fluvial environments, and show its potential for other sedimentary environments as well.

TERRESTRIAL SURFACE DYNAMICS MODELING: LESSONS AND CAPABILITIES

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Like other sciences, the study of Earth-surface dynamics involves an ongoing dance between theory and observations. Increasingly, our theoretical framework is supported by computer models that encapsulate current understanding and working hypotheses about the process that move mass across the Earth ╒s surface. This computational infrastructure must constantly adapt change in step with emerging data and ideas. One of the key missions of CSDMS to ensure that the computational technology we use to help understand the natural world is nimble and adaptable, so that it serves to stimulate our imagination rather than impeding our progress. The CSDMS Terrestrial Working Group is currently applying flexible and coupled modeling strategies to a wide range of science problems; some examples include coupled modeling of onshore erosion and offshore sedimentation, interaction between topography and precipitation, impact of tectonic deformation on landscapes, badland landscape development, coupled hydrologic-geomorphic modeling, and many others. To illustrate the value of flexible modeling software, I discuss the example of a landscape evolution model that has grown and evolved considerably since its beginnings 15 years ago. The Channel-Hillslope Integrated Landscape Development (CHILD) model was originally developed at MIT, as a successor to the earlier SIBERIA and GOLEM models, to study the formation of drainage basins in response to climate change. The software was designed using a modular structure, which has facilitated the addition of new capabilities over time. The model has grown substantially over the years in response to newly emerging science questions. Examples of co-evolving science questions and model capabilities include grain-size dynamics, vegetation, thrust tectonics, gully development, and alluvial stratigraphy and geoarchaeology, among others. Overall, one of the most important lessons to emerge from the CHILD experience is that early investment in scientific software design provides a platform for sustained growth, adaptation, and exploration as the frontier of knowledge advances.

APPLICATION OF CSDMS CODES TO SOURCE-TO-SINK STUDIES IN NEW ZEALAND: THE WAIPAOA AND THE WAITAKI CATCHMENTS

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The Waipaoa River catchment on New Zealand ╒s north-eastern coast has a mean annual suspended yield of 6780 t km-2 yr-1. The compact, mountainous and short reach of the Waipaoa River watershed produces among the highest sediment yields per unit area globally. Here, deforested and steep hillslopes composed of extremely weak mudstone argillite lithologies are exposed to a vigorous maritime climate. Sediment from the Waipaoa River is trapped in active tectonic basins on the shelf and slope. We have extended previous HydroTrend simulations of the Waipaoa River water and sediment discharge back to LGM. These predict that, given the increased catchment, similar vegetation cover and landscape susceptibility to erosion, the suspended sediment flux of the LGM Waipaoa catchment was 10-15% higher than during the late Holocene. However, when considered relative to unit area, the LGM suspended sediment yield was perhaps 60% lower than during the late Holocene, reflecting the higher Holocene precipitation. In the Waitaki River catchment, South Island, we are utilizing ~80 years of discharge readings, climate readings and some short cores from Lake Ohau to calibrate a HydroTrend model of the large glacial valleys and lakes that make up the upper Waitaki catchment. We will then use paleoclimate proxies to extend the models back to LGM. Our preliminary models suggest that the Lake Ohau record is dominated by events, large northwesterly storms, rather than seasonal variation.

A NUMERICAL MODEL TO ROUTE SEDIMENT AND COSMOGENIC NUCLIDES AT BASIN-WIDE SCALE. APPLICATION TO THE MAPLE RIVER, MINNESOTA.

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J. Wesley Lauer, Patrick Belmont, Gary Parker

A one-dimensional numerical model that routes sediment and cosmogenic nuclides has been developed in the context of an NCED (National Center for Earth-surface Dynamics) multidisciplinary effort in the Le Sueur River Basin, southern Minnesota. The motivation of the work can be summarized with a relatively short and apparently simple question: Where is this sediment coming from? Sediment loads in the Minnesota River basin have considerably increased in the last two centuries concurrent with the development of intensive agriculture on the uplands. Consequently, sedimentation problems have occurred in the tributaries to the Minnesota River, in the Minnesota River main stem, and farther downstream. For example, measurements in Lake Pepin, a naturally dammed lake on the Mississippi River downstream from the confluence with the Minnesota River, show a five / ten-fold increase in sedimentation rates. Field and numerical work has been conducted in the Le Sueur River basin, which is characterized by one of the highest sediment yields in the Minnesota River basin. Quantification of the differences in sediment loads contributed from an hypothetical, pre-agriculture condition compared to the present, and the prediction of the effectiveness of different restoration strategies to reduce sediment loading requires two steps, 1) a detailed sediment budget, i.e. determine location and magnitude of sources and sinks and route the sediment through the system, and 2) a quantification of the sediment transport pathways, explicitly modeling channel floodplain exchange, constrained by the concentration of cosmogenic nuclides in the floodplain. In the current configuration, the model requires input of water and sediment from externally modeled sources (i.e. bluffs, ravines, tributaries, uplands) in each computational node, it can thus be thought as a potential routing component of a more complex model, where the input of sediment and water is modeled by independent modules. Preliminary results for the Maple River are presented and discussed.

'INTEGRONSTERS' AND THE SPECIAL ROLE OF DATA

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In many cases model integration treats models as software components only, ignoring the fluid relationship between models and reality, the evolving nature of models and their constant modification and re-calibration. As a result, with integrated models we find increased complexity, where changes that used to impact only relatively contained models of subsystems, now propagate throughout the whole integrated system. This makes it harder to keep the overall complexity under control and, in a way, defeats the purpose of modularity, when efficiency is supposed to be gained from independent development of modules. Treating models only as software in solving the integration challenge may give birth to 'integronsters' -constructs that are perfectly valid as software products but ugly and useless as models. We argue that one possible remedy is to learn to use data as modules and integrate them into the models. Then the data that are available for module calibration can serve as an intermediate linkage tool, sitting between modules and providing a module-independent baseline dynamics, which is then incremented when scenarios are to be run. In this case it is not the model output that is directed into the next model input, but model output is presented as a variation around the baseline trajectory, and it is this variation that is then fed into the next module down the chain. The Chesapeake Bay Program suite of models is used to illustrate these problems and the possible solutions.

AN APPLICATION FOR STUDYING SEDIMENT-INDUCED STRATIFICATION IN OPEN-CHANNEL FLOWS

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Flow containing sediment suspension subjects itself to a density gradient in the vertical direction, known as density stratification, due to the tendency for suspended sediment to settle. Velocity and concentration profiles under the effect of density stratification may differ significantly from the conventional logarithmic and Rousean distributions. It is hence important to include this effect into flow computations in order to correctly predict flow characteristics such as roughness coefficient, near-bed sediment concentration, and flow and sediment discharge. While numerous studies have investigated the effect of sediment-induced density stratification in open-channel flows, no simple tool has been developed to study and visualize the level of stratification for a given set of dimensional or dimensionless parameters. Here we introduce an application -Strat1D, for such a purpose. The application contains a user-friendly interface which allows users to compare the velocity and concentration profiles under stratification effects to the conventional distributions under a prescribed set of dimensional or dimensionless parameters. Two algebraic models (Smith-McLean, Gelfenbaum-Smith) and two differential models (k-e, Mellor-Yamada) are among the choices of turbulent closures. It has been found that the Mellor-Yamada model predicts a similar damping effect on the eddy viscosity to the Smith-McLean model, while k-e model consistently predicts a weaker influence of density stratification on both profiles. The application can also be used to study the effect of sediment mixtures on flow stratification by specifying the grain size distribution. In the presence of sediment mixtures, fine material such as mud tends to reduce the density gradient and consequently the stratification effect. With an increasing proportion of fine material in the suspension, the velocity and concentration profiles tend to approach those prevailing under neutral conditions, i.e. logarithmic and Rousean distributions, respectively.

Appendix 3. CSDMS Model Repository

Program, Description, Developer

(1) 2DFLOWVEL, Tidal & wind-driven coastal circulation routine, Slingerland, Rudy
(2) ADCIRC, Coastal Circulation and Storm Surge Model, Luettich, Rick
(3) ADI-2D, Advection Diffusion Implicit (ADI) method for solving 2D diffusion equation, Pelletier, Jon
(4) Acronym1, E-book: program for computing bedload transport in gravel rivers., Parker, Gary
(5) Acronym1D, E-book: program for computing bedload transport in gravel rivers over time., Parker, Gary
(6) Acronym1R, E-book: program for computing bedload transport in gravel rivers with a Manning-Strickler relation for flow resistance., Parker, Gary
(7) AgDegBW, E-book: Calculator for aggradation and degradation of a river reach using a backwater formulation., Parker, Gary
(8) AgDegNormGravMixPW, E-book: calculator for aggradation and degradation of sediment mixtures in gravel-bed streams, Parker, Gary
(9) AgDegNormGravMixSubPW, E-book: calculator for evolution of upward-concave bed profiles in rivers carrying sediment mixtures in subsiding basins., Parker, Gary
(10) AgDegNormal, E-book: illustration of calculation of aggradation and degradation of a river reach using the normal flow approximation., Parker, Gary
(11) AgDegNormalFault, E-book: Illustration of calculation of aggradation and degradation of a river reach using the normal flow approximation; with an extension for calculation of the response to a sudden fault along the reach., Parker, Gary
(12) AgDegNormalGravMixHyd, E-book: A module that calculates the evolution of a gravel bed river under an imposed cycled hydrograph., Parker, Gary
(13) AgDegNormalSub, E-book: Program to calculate the evolution of upward-concave bed profiles in rivers carrying uniform sediment in subsiding basins., Parker, Gary
(14) Anuga, ANUGA is a hydrodynamic modelling tool that allows users to model realistic flow problems in complex 2D geometries., Habili, Nariman
(15) AquaTellUs, Fluvial-dominated delta sedimentation model, Overeem, Irina
(16) Area-Slope Equation Calculator, Pixel scale Area-Slope equation calculator, Cohen, Sagy
(17) Avulsion, Stream avulsion model, Hutton, Eric
(18) BEDLOAD, Bedload transport model, Slingerland, Rudy
(19) BackwaterCalculator, E-book: program for backwater calculations in open channel flow, Parker, Gary
(20) BackwaterWrightParker, E-book: calculator for backwater curves in sand-bed streams, including the effects of both skin friction and form drag due to skin friction, Parker, Gary
(21) Bedrock Erosion Model, Knickpoint propagation in the 2D sediment-flux-driven bedrock erosion model, Pelletier, Jon
(22) BedrockAlluvialTransition, E-book: calculator for aggradation and degradation with a migrating bedrock-alluvial transition at the upstream end., Parker, Gary
(23) Bing, Submarine debris flows, Hutton, Eric
(24) Bio, Biogenic mixing of marine sediments, Hutton, Eric
(25) CAM-CARMA, A GCM for Titan that incorporates aerosols, Larson, Eric
(26) CEM, Coastline evolution model, Murray, A. Brad
(27) CHILD, Landscape Evolution Model, Tucker, Greg
(28) CMFT, Coupled salt Marsh - tidal Flat Transect model, Mariotti, Giulio
(29) CREST, The Coupled Routing and Excess STorage (CREST) model is a distributed hydrologic model developed to simulate the spatial and temporal variation of atmospheric, land surface, and subsurface water fluxes and storages by cell-to-cell simulation., Wang, Jiahu
(30) Caesar, Cellular landscape evolution model, Coulthard, Tom
(31) Channel-Oscillation, Simulates Oscillations in arid alluvial channels, Pelletier, Jon
(32) Compact, Sediment compaction, Hutton, Eric
(33) Coupled1D, Coupled 1D bedrock-alluvial channel evolution, Pelletier, Jon
(34) CrevasseFlow, The module calculates crevasse splay morphology and water discharge outflow of a crevasse splay., Chen, Yunzhen
(35) Cyclopath, A 2D/3D model of carbonate cyclicity, Burgess, Peter
(36) DELTA, Simulates circulation and sedimentation in a 2D turbulent plane jet and resulting delta growth, Slingerland, Rudy
(37) DHSVM, DHSVM is a distributed hydrologic model that explicitly represents the effects of topography and vegetation on water fluxes through the landscape., DHSVM, Administrator
(38) DR3M, Distributed Routing Rainfall-Runoff Model--version II, U.S., Geological Survey
(39) DeltaBW, E-book: Calculator for evolution of long profile of a river ending in a 1D migrating delta, using a backwater formulation., Parker, Gary
(40) DeltaNorm, E-book: Calculator for evolution of long profile of a river ending in a 1D migrating delta, using the normal flow approximation., Parker, Gary
(41) DepDistTotLoadCalc, E-book: Illustration of calculation of depth-discharge relation, bed load transport, suspended load transport and total bed material load for a large, low-slope sand-bed river., Parker, Gary
(42) Diffusion, Diffusion of marine sediments due to waves, bioturbation, Hutton, Eric
(43) DredgeSlotBW, E-book: calculator for aggradation and degradation of sediment mixtures in gravel-bed streams subject to cyclic hydrographs., Parker, Gary
(44) ENTRAIN, Simulates critical shear stress of median grain sizes, Slingerland, Rudy
(45) ENTRAINH, Simulates critical shields theta for median grain sizes, Slingerland, Rudy
(46) Eolian Dune Model, Werner's model for eolian dune formation and evolution, Pelletier, Jon
(47) Erode, Fluvial landscape evolution model, Peckham, Scott
(48) FLDTA, Simulates flow characteristics based on gradually varied flow equation, Slingerland, Rudy
(49) FTCS1D-NonLinear, Forward Time Centered Space (FTCS) method for 1D nonlinear diffusion equation, Pelletier, Jon
(50) FTCS2D, Forward Time Centered Space (FTCS) method for 2D diffusion equation, Pelletier, Jon
(51) FTCS2D-TerraceDiffusion, Forward Time Centered Space (FTCS) method for 2D Terrace diffusion, Pelletier, Jon
(52) FUNWAVE, Fully Nonlinear Boussinesq Wave Model, Kirby, Jim

(53) FVCOM, The Unstructured Grid Finite Volume Coastal Ocean Model, Chen, Changsheng
(54) FallVelocity, E-book: Particle fall velocity calculator, Parker, Gary
(55) FillinPitsFlatsDEM, Filling in pits and flats in a DEM, Pelletier, Jon
(56) Flex1D, Fourier filtering in 1D while solving the flexure equation, Pelletier, Jon
(57) Flex2D, Fourier filtering in 2D while solving the flexure equation, Pelletier, Jon
(58) Flex2D-ADI, Solving the flexure equation applying Advection Diffusion Implicit (ADI) method, Pelletier, Jon
(59) Flexure, Direct 2D finite difference solution of lithospheric plate flexure, Wickert, Andy
(60) Fourier-Bessel-integration, Numerical integration of Fourier-Bessel terms, Pelletier, Jon
(61) FractionalNoises1D, 1D fractional-noise generation with Fourier-filtering method, Pelletier, Jon
(62) FractionalNoises2D, 2D Gaussian fractional-noise generation with Fourier-filtering method, Pelletier, Jon
(63) GEOtop, Distributed hydrological model, water and energy budgets, Rigon, Riccardo
(64) GNE, Set of biogeochemical sub-models that predicts river export, Seitzinger, Sybil
(65) GOLEM, Landscape evolution model, Tucker, Greg
(66) GSDCalculator, E-book: Calculator for statistical characteristics of grain size distributions., Parker, Gary
(67) Gc2d, Glacier / ice sheet evolution model, Kessler, Mark
(68) GravelSandTransition, E-book: Calculator for evolution of long profile of river with a migrating gravel-sand transition and subject to subsidence or base level rise., Parker, Gary
(69) HSPF, a comprehensive package for simulation of watershed hydrology and water quality for both conventional and toxic organic pollutants, Bicknell, Bob
(70) HydroTrend, Climate driven hydrological transport model, Kettner, Albert
(71) Hyper, 2D Turbidity Current model, Imran, Jasim
(72) Ice-sheet-Glacier-reconstruction, Sandpile method for ice-sheet and glacier reconstruction, Pelletier, Jon
(73) Iceages, Stochastic-resonance subroutine of Pleistocene ice ages, Pelletier, Jon
(74) Inflow, Steady-state hyperpycnal flow model, Hutton, Eric
(75) LITHFLEX1, Lithospheric flexure solution, Furlong, Kevin
(76) LITHFLEX2, Lithospheric flexure solution for a broken plate, Furlong, Kevin
(77) LOADEST, Software for estimating constituent loads in streams and rivers, Runkel, Rob
(78) LOGDIST, Logrithmic velocity distribution solution, Slingerland, Rudy
(79) LONGPRO, Dynamic evolution of longitudinal profiles, Slingerland, Rudy
(80) LavaFlow2D, 2D radially symmetric lava flow model, Pelletier, Jon
(81) MARSSIM, Landform evolution model, Howard, Alan
(82) MFDrouting, Multiple Flow Direction (MFD) flow routing method, Pelletier, Jon
(83) MFDrouting-Successive, Successive flow routing with Multiple Flow Direction (MFD) method, Pelletier, Jon
(84) MIDAS, Coupled flow- heterogeneous sediment routing model, Slingerland, Rudy
(85) MITgcm, The MITgcm (MIT General Circulation Model) is a numerical model designed for study of the atmosphere, ocean, and climate., Lovenduski, Nicole
(86) MODFLOW, MODFLOW is a three-dimensional finite-difference ground-water model, Barlow, Paul
(87) NearCoM, Nearshore Community Model, Kirby, James
(88) OTEQ, One-Dimensional Transport with Equilibrium Chemistry (OTEQ): A Reactive Transport Model for Streams and Rivers, Runkel, Rob
(89) OTIS, One-Dimensional Transport with Inflow and Storage (OTIS): A Solute Transport Model for Streams and Rivers, Runkel, Rob
(90) PIHM, PIHM is a multiprocess, multi-scale hydrologic model., Duffy, Christopher
(91) PIHMgis, Tightly coupled GIS interface for the Penn State Integrated Hydrologic Model, Duffy, Christopher
(92) ParFlow, Parallel, high-performance, integrated watershed model, Maxwell, Reed
(93) Pllcart3d, 3D numerical simulation of confined miscible flows, Oliveira, Rafael
(94) Plume, Hypopycnal sediment plume, Hutton, Eric
(95) Point-Tidal-flat, Point Model for Tidal Flat Evolution model, Fagherazzi, Sergio
(96) Princeton Ocean Model (POM), POM: Sigma coordinate coastal & basin circulation model, Ezer, Tal
(97) PsHIC, Pixel-scale Hypsometric Integral Calculator, Cohen, Sagy
(98) QUAL2K, A Modeling Framework for Simulating River and Stream Water Quality, Chapra, Steve
(99) REF-DIF, Phase-resolving parabolic refraction-diffraction model for ocean surface wave propagation., Kirby, James
(100) RHESSys, Regional Hydro-Ecologic Simulation System, Tague, christina
(101) ROMS, Regional Ocean Modeling System, Arango, Hernan G.
(102) RecircFeed, E-book: calculator for approach to equilibrium in recirculating and feed flumes, Parker, Gary
(103) RiverWFRisingBaseLevelNormal, E-book: Calculator for disequilibrium aggradation of a sand-bed river in response to rising base level., Parker, Gary
(104) RouseVanoniEquilibrium, E-book: Program for calculating the Rouse-Vanoni profile of suspended sediment., Parker, Gary
(105) SETTLE, Partical settling velocity solution, Slingerland, Rudy
(106) SIBERIA, SIBERIA simulates the evolution of landscapes under the action of runoff and erosion over long times scales., Willgoose, Garry
(107) SPARROW, The SPARROW Surface Water-Quality Model, Alexander, Richard
(108) SPHYSICS, Smoothed Particle Hydrodynamics code, Dalrymple, Robert
(109) STORM, Windfield simulator for a cyclone, Slingerland, Rudy
(110) STVENANT, 1D gradually varied flow routine, Slingerland, Rudy
(111) STWAVE, Steady-State Spectral Wave Model, Smith, Jane
(112) SUSP, Suspended load transport subroutine, Slingerland, Rudy
(113) SVELA, Shear velocity solution associated with grain roughness, Slingerland, Rudy
(114) SWAN, SWAN is a third-generation wave model, SWAN, Team
(115) SWAT, SWAT is a river basin scale model developed to quantify the impact of land management practices in large, complex watersheds., Arnold, Jeff
(116) SWMM, Storm Water Management Model, Rossman, Lewis
(117) Sakura, 3 Equation hyperpycnal flow model, Kubo, Yusuke
(118) SedBerg, An iceberg drift and melt model, developed to simulate sedimentation in high-latitude glaciated fjords., Mugford, Ruth
(119) SedPlume, SedPlume simulates glacial meltwater plume dynamics and sedimentation., Mugford, Ruth

(120) Sedflux, Basin filling stratigraphic model, Hutton, Eric
(121) Sedtrans05, Sediment transport model for continental shelf and estuaries, Neumeier, Urs
(122) Spirals1D, 1D model of spiral troughs on Mars, Pelletier, Jon
(123) SteadyStateAg, E-book: calculator for approach to equilibrium in recirculating and feed flumes, Parker, Gary
(124) StreamPower, Modeling the development of topographic steady state in the stream-power model, Pelletier, Jon
(125) Subside, Flexure model, Hutton, Eric
(126) SubsidingFan, E-book: calculator for evolution of profiles of fans in subsiding basins, Parker, Gary
(127) SuspSedDensityStrat, E-book: Module for calculating the effect of density stratification on the vertical profiles of velocity and suspended sediment., Parker, Gary
(128) Symphonie, 3D primitive equation ocean model, Marsaleix, Patrick
(129) TAo, tAo is a software designed to model the interplay between lithosphere flexure and surface transport (erosion/sedimentation), particularly during the formation of orogens and foreland sedimentary basins (see details)., Garcia Castellanos, Daniel
(130) TISC, TISC integrates quantitative models of lithospheric flexure, fault deformation, and surface mass transport (erosion/transport/sedimentation) along drainage networks., Garcia Castellanos, Daniel
(131) TOPOG, TOPOG is a terrain analysis-based hydrologic modelling package, Silberstein, Richard
(132) TURB, Gausian distribution calculator of instantaneous shear stresses on the fluvial bed, Slingerland, Rudy
(133) TauDEM, A suite of Digital Elevation Model (DEM) tools for the extraction and analysis of hydrologic information from topography as represented by a DEM. TauDEM 5 is a new version implemented to take advantage of parallel processing, Tarboton, David
(134) TopoFlow, Spatially-distributed, D8-based hydrologic model, Peckham, Scott
(135) TopoFlow-Channels-Diffusive Wave, Diffusive Wave process component for flow routing in a D8-based, spatial hydrologic model, Peckham, Scott
(136) TopoFlow-Channels-Dynamic Wave, Dynamic Wave process component for flow routing in a D8-based, spatial hydrologic model, Peckham, Scott
(137) TopoFlow-Channels-Kinematic Wave, Kinematic Wave process component for flow routing in a D8-based, spatial hydrologic model., Peckham, Scott
(138) TopoFlow-Diversions, Diversions component for a D8-based, spatial hydrologic model., Peckham, Scott
(139) TopoFlow-Evaporation-Energy Balance, Evaporation process component (Energy Balance method) for a D8-based, spatial hydrologic model, Peckham, Scott
(140) TopoFlow-Evaporation-Priestley Taylor, Evaporation process component (Priestley-Taylor method) for a D8-based, spatial hydrologic model, Peckham, Scott
(141) TopoFlow-Evaporation-Read File, Evaporation process component (read from file method) for a spatially-distributed hydrologic model., Peckham, Scott
(142) TopoFlow-Infiltration-Green-Ampt, Infiltration process component (Green-Ampt method) for a D8-based, spatial hydrologic model, Peckham, Scott
(143) TopoFlow-Infiltration-Richards 1D, Infiltration process component (Richards 1D method) for a D8-based, spatial hydrologic model, Peckham, Scott
(144) TopoFlow-Infiltration-Smith-Parlange, Infiltration process component (Smith-Parlange method) for a D8-based, spatial hydrologic model, Peckham, Scott
(145) TopoFlow-Meteorology, Meteorology process component for a D8-based, spatial hydrologic model, Peckham, Scott
(146) TopoFlow-Saturated Zone-Darcy Law, Saturated Zone process component (Darcy's law, multiple soil layers) for a D8-based, spatial hydrologic model, Peckham, Scott
(147) TopoFlow-Snowmelt-Degree-Day, Snowmelt process component (Degree-Day method) for a D8-based, spatial hydrologic model, Peckham, Scott
(148) TopoFlow-Snowmelt-Energy Balance, Snowmelt process component (Energy Balance method) for a D8-based, spatial hydrologic model, Peckham, Scott
(149) TopoToolbox, A set of Matlab functions for topographic analysis, Schwanghart, Wolfgang
(150) VIC, VIC (Variable Infiltration Capacity) is a macroscale hydrologic model that solves full water and energy balances, originally developed by Xu Liang at the University of Washington., Lettenmaier, Dennis
(151) WACCM Dust-Sulfur, Whole atmosphere module of sulfate aerosols., Neely, Ryan
(152) WACCM-CARMA, atmospheric/aerosol microphysical model, English, Jason
(153) WACCM-EE, GCM for deep paleoclimate studies, Wolf, Eric
(154) WAVEREF, Wave refraction routine, Slingerland, Rudy
(155) WAVEWATCH III ^TM, Spectral wind wave model, Tolman, Hendrik
(156) WBM-WTM, Water Balance/Transport Model, Fekete, Balazs
(157) WILSIM, Landscape evolution model, Luo, Wei
(158) WINDSEA, Deep water significant wave height and period simulator during a hurricane routine, Slingerland, Rudy
(159) WPHydResAMBL, E-book: Implementation of the Wright-Parker (2004) formulation for hydraulic resistance combined with the Ashida-Michiue (1972) bedload formulation., Parker, Gary
(160) WRF, Weather Research and Forecasting Model, Skamarock, Bill
(161) WSGFAM, Wave and current supported sediment gravity flow model, Friedrichs, Carl
(162) XBeach, Wave propagation sediment transport model, Roelvink, Dano
(163) YANGs, Fluvial sediment transport model, Slingerland, Rudy
(164) Zscape, A simple parallel code to demonstrate diffusion, Connor, Chuck

Appendix 4. CSDMS — A Modeling System to Aid Sedimentary Research

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What is CSDMS? CSDMS is the Community Surface Dynamics Modeling System, a community effort to create models that predict the transport of fluids, sediment and solutes through landscapes, seascapes and sedimentary basins. As a modeling environment, CSDMS offers open-source, ever-improving software modules, developed and shared by those concerned with earth-surface dynamics. The CSDMS Model Repository offers a growing library of community-generated models to streamline the process of idea generation and hypothesis testing through both stand-alone and linked models. The CSDMS modeling environment enables the rapid creation and application of models tailored to specific settings, scientific problems, and time scales. CSDMS activities are funded through a cooperative agreement with the National Science Foundation with additional support provided from other U.S. agencies and industry.

What need does CSDMS serve? Prediction, as opposed to cataloging, is a major step in the evolution of a science. Quantitative modeling provides a framework in which researchers express their predictive ideas in a precise, consistent format. But researchers often reinvent the wheel as they attempt to enter the modeling world. A community-based modeling environment, built of tools created by and provided for a broad spectrum of users with diverse skills and interests offers the flexibility required by those who will benefit from its products. A community approach allows efficient development of models that are more powerful than could be developed by any single group. Redundancy is reduced, models are better vetted, and the capability for innovations expanded. Importantly, energy can be focused towards earth-surface dynamic domains that are poorly represented, or controversial.

What is in the CSDMS Model Repository? There are more than 160 models affiliated with the Repository: 72% are available for download through the CSDMS web site (e.g. CHILD, SedFlux), 28% are available after separately registering with other community efforts (e.g. ROMS, NearCOM). Of the 4 million lines of code already in the repository, 53% of the CSDMS models are written in C or C++; 30% are written in Fortran, with Python and MATLAB code comprising most of the remaining models.

Terrestrial models cover the following domains: landscape evolution (e.g. CHILD, SIBERIA, Caesar, Erode, GOLEM, MARSSIM, WILSIM), fluvial morphodynamics (e.g. LOGPRO, BEDLOAD, MIDAS, TISC, SUSP, YANGs), eolian transport (e.g. Eolian Dune Model), cryospheric (e.g. GC2D, ISGR, Ice ages), and geodynamics (e.g. TAo, TISC, LavaFlow2D). Hydrology models cover all length scales of drainage from reaches (e.g. STVENANT, SWMM, FLDTA), to basins (e.g. DR3M, TopoFlow, GEOtop, HydroTrend, PIHM, ParFlow, MFDrouting, MODFLOW), to continental (e.g. ANUGA, CREST, DHSVM, PIHM), to global (WBM-WTM, VIC). Some include biogeochemistry and water quality (e.g. QUAL2K, OTEQ, OTIS, SPARROW, GNE, HSPF, LOADEST, RHESSys, SWAT).

Coastal models include flow dynamics (e.g. 2DFLOWVEL, ADCIRC, NearCoM), wave dynamics (e.g. REF-DIF, STORM, STWAVES, SWAN, WAVEREF, WINDSEA, FUNWAVE, ROMS), and coastal evolution (e.g. CEM, Delta, XBeach, CrevasseFlow, Avulsion, AquaTellUs).

Marine models cover physical oceanography (e.g. FVCOM, ROMS, POM, Symphonie, WAVEWATCH-III), sediment transport (e.g. Diffusion, Plume, SedPlume, SedBerg, Sedtrans5, WSGFAM, SedFlux, Sakura, Hyper, Bing, Bio), geodynamics (e.g. Subside, SedFlux), and stratigraphy (e.g. cyclopath, SedFlux).

Climate or weather models include WRF, WACCM+, and MITgcm.

Useful modeling tools are also made available (e.g. ADI2D, LOGDIST, TopoToolbox, TauDEM, Zscape, TURB, TOPOG, Parker Ebook, SVELA, SETTLE, PsHIC, FTCS, Compact).

This alphabet soup of models and tools has the underpinnings of thousands of peer-reviewed papers associated with them. Metadata describing each model, along with key references are available through the CSDMS web site. CSDMS-hosted models are expected to double in the next few years. But not all earth-surface domains and physics are covered.

What surface dynamic models are missing? We are missing lake models, reservoir models, 2D debris flow and 3D sediment failure models, and we have few eolian transport models. In the ocean domain we are missing full-ocean geostrophic and thermohaline circulation models. We look forward to receiving ocean circulation models that can interact with hyperpycnal current, turbidity current and contour current models. We are missing advanced tidal flat models. Unfortunately some of these models are written, but their source code is not freely available.

Why Open Source? Code transparency is important because source code provides the scientific hypotheses embodied in a numerical model, and reveal their implementation. Within the world of software, details are important. A solution to a set of equations can take numerous forms, and each solution has its pyramid of assumptions and limitations. Code transparency allows for full peer review and replication of results — the foundation of modern science. Code transparency also allows for reuse, often in new and clever ways, and reduces redundancy. It some cases, missing domains simply reflects that model development often lags behind observational or theoretical developments.

Why Community modeling? Large codes by their nature involve multiple environmental domains and thus a diversity of experts — the birthplace for community modeling. Community modeling involves the collective efforts of individuals that code, debug, test, document, run, and apply models often within modeling frameworks. Community modeling relies on code transparency to address the practical need of developers to examine and modify the code. Without access to source code, a model could not be converted into a 'plug and play' component (see below). Community modeling effectively allows for code vetting so as to determine whether: 1) the model behaves as advertised; 2) the code meets community specifications and protocols; and 3) the model provides for an acceptable depiction of nature.

What is the role of field or laboratory scientists within CSDMS? Models are the encyclopedia of what we know, and importantly, what we cannot yet quantify. The CSDMS community includes application specialists, and those who conduct field and laboratory experiments, where individual modules and integrated models can be tested under a range of conditions. The CSDMS Data Repository has initially focused on well-described and well-vetted gridded data useful for model initializations: topography, bathymetry, climate, hydrography, discharge, cryosphere, soils, land cover, substrates, human dimensions, sea level, and oceanography.

The CSDMS Data Repository will begin to host laboratory data for the purposes of benchmarking model performance. Flume experiments have known boundary conditions and input. Even with scaling issues between laboratory experiments and field observations, models can still be rigorously tested. Laboratory experiments can be set up to test the entire range of models from those set up to describe landscape evolution to single event processes where computational fluid dynamic models can be tested (e.g. Direct Numerical Simulation models).

A valuable contribution that field campaigns can offer CSDMS would be to organize and grid their field data in a manner that allows for more direct comparison to a model's simulations. This also requires the provision of all input environmental values/files that a model would require. A full error analysis related to field observational grids would allow for a determination of both the spatial and temporal capabilities of a model. Most published papers within the Journal of Sedimentary Research or Marine Geology do not contain adequate error analysis. Three-dimensional deposit shapes, sequences of chronostratigraphic 2-D surfaces, dynamic observations of flow properties, and spatial properties within a sediment volume, are all examples highly valued by modelers. Different or future models could be tested later against these field data and also against the earlier model simulations. Benchmark testing is a prime task for the CSDMS community. CSDMS will post field or experimental data useful for model comparisons, as a recognized venue satisfying data requirements of the U.S. National Science Foundation.

How does CSDMS increase the ease of learning new models? CSDMS addresses this issue with four approaches. Firstly, CSDMS models are being converted into components that can be run as standalone models within the CSDMS Modeling Tool (CMT) GUI. Users will thus find a similar feel about running each model, even though models may have been written by different authors and with different user interfaces. Submitted models without a GUI will automatically gain one when they become a CSDMS component. Secondly, each CSDMS component includes a help system that offers information on a model's main algorithms, and input/output files. Tools associated with CMT will also offer post-processing visualization services. Thirdly, components receive an initial pedagogical evaluation. There is often a "built" example with a loaded input file and an output file from which model runs can be compared. Faculty and students provide feedback on these built model systems. Fourthly, CSDMS component protocols adopt community standards for handling data (e.g. NetCDF, WML). Standards reduce the wide range of available data formats and their inherent complexity. Further, CSDMS organizes instructional courses and workshops to familiarize its community with contributed models and modeling tools. The CSDMS Education Repository posts videos, PowerPoint presentations or PDF files of lectures related to CSDMS components.

What is a modeling framework? When a model grows large and complex, as might be needed for example, to handle multiple environmental domains, it often transitions into a modeling framework that provides for an environment where components can be linked together to form a more complex application. Frameworks deal with modeling complexity: data transfer, grid meshing, up- or down-scaling, time stepping, computational precision, multi-processor support, cross language interoperability, and visualization. Frameworks save time, reduce costs, provide quality control, re-purpose model components, ensure consistency and traceability of model results, and offer scalability to solve complex modeling problems.

Table 1: Examples of framework architectures in the environmental domain: CSDMS — Community Surface Dynamics Modeling System; CCSM/CESM — Community Climate System Model / Community Earth System Model; ESMF — Earth System Modeling Framework; MMS/OMS — Modular Modeling System / Object Modeling System; OpenMI — Open Modeling Interface.

Framework - Architecture	**Start Year**	**Principal Domain**	**Principal languages**	**Models**	**Model coupling**	**Platforms**	**HPC oriented**
CSDMS	2007/08	Ice, Terrestrial, Hydro, Coastal, Marine, +	C, C++, F77, F90, F95, F2003, Python (java)	>150 small to large codes	Interface components	OSX, Linux, (CMT can run on Windows)	yes
CCSM/CESM	1980's	Global climate	Fortran	4 large codes	Couplers	Linux	yes
ESMF	2002	Global climate	Fortran (C, C++)	15+ large codes	Couplers	OSX, Windows, Linux,	yes
MMS/OMS	1990's	hydrologic, agricultural and soil erosion	Fortran (C, C++)	>100 small to medium codes	Annotated Components	Windows, Linux	no
OpenMI SDK	1990's	Hydrology	C# (java)	25 medium codes	Interface components	Windows	no

What is a plug-and-play component? Components are functional units that once implemented in a particular framework are reusable by other units/models within the same (or other) framework with little migration effort. Component-based modeling offers the advantages of "plug and play" technology based on interface standards that allow different models to communicate. In essence, plug-and-play means that a user is able to swap components in and out without needing to recompile. Thus, a user builds a model from components, not a developer. CSDMS components differ from ordinary subroutine software, for example, in that they can communicate with other components written in different programming languages.

Component-based modeling recognizes the utility of subdividing a model's code into three separate functions: Initialize, Run (one or a few steps) and Finalize, otherwise known as an IRF interface. Such an interface provides fine-grained access of a model's capabilities to a calling program so that it can be used in a larger application. The calling program "steers" a set of components and is referred to as a driver. Components also require information on data exchange with other components, i.e. 'getter' and 'setter' functions, so that connected components can query generated data as well as alter data and settings from the other model.

How has CSDMS adapted to plug-and-play technology? CSDMS has adopted, integrated and advanced powerful open-source tools to build its modeling framework. These services are largely invisible to users of the CSDMS Modeling Tool (*CMT*), a GUI based in part on the CCA *Ccaffeine* service for interactive model coupling. *CMT* employs: (1) language interoperability (C, C++, Java, Python, Fortran) using *Babel*; (2) component preparation and project management using *Bocca*; (3) low level model coupling within a HPC environment using *Ccaffeine*; (4) single-processor spatial regridding (*OpenMI Regrid*) or multi-processor spatial regridding (*ESMF Regrid*); (5) component interface standards advanced by *OpenMI*; (6) self-describing scientific data format (*NetCDF*) and the water markup language (*WMF*); (7) visualization of large data sets within a multiple processor environment (e.g. *VisIt)*; (8) message passing within the HPC environment using *MPI* and *OpenMP,* along with *PETSc* a Portable, Extensible Toolkit for Scientific Computation.

What happens when a model enters the CSDMS Model Repository? After a model is received at the CSDMS Integration Facility, CSDMS software engineers determine if the code compiles on the CSDMS-dedicated supercomputer *Beach*. The model is exercised with whatever input files are provided and model results are compared with the provided output files. If the results are identical then the model is made available for the community for download. If a CSDMS working group prioritizes the model for componentization, the model is queued for becoming a component: 1) if necessary, the model is refactored with an IRF interface, and 2) getters and setters are added.

CSDMS components are then made operational with *CMT*. This includes ensuring that output can be visualized (e.g. VisIt) and conforms to CSDMS protocols (e.g. NetCDF or WML). Each component is given input configuration details and provided with help pages. The model is then made available to the community within CMT for standalone runs on *Beach*. If a working group desires that the model be coupled with other CSDMS components, integration staff will then ensure that the time-stepping and regridding and other data services and exchanges work properly. There must be a realistic match between one component and another. Often the style of getters and setters depends on the nature of other components in the suite. This integrated suite of models is then made available within CMT for download, and eventual community testing and vetting.

What if my model is not written in a CMT-supported open-source language? CMT relies on the *CCA-Babel* language interoperability compiler. At present *Babel* supports most of the models contributed to the CSDMS Repository models (C, C++, Fortran, Python and Java). CSDMS has extended an IDL-to-Python converter for our community. This *converter* has successfully converted a refactored hydrological model TopoFlow. Code written in MATLAB code is converted to Python (e.g. *GC2D*). Visual Basic code is also converted to 'c' (e.g. *Parker's E-book* code).

I don't have access to a supercomputer; will CSDMS models or CMT work on my computer? CSDMS makes all contributed models available for free download. There is no guarantee however that the model will work on your computer. With more than 150 models and 30+ combinations of platforms and compilers, that is a task beyond our budget. Metadata provided with each model should allow you to determine compatibility issues and what platforms the model has been successfully run on. CSDMS does provide members with free access to its supercomputer *Beach*, where the model can be run. The University of Colorado together with the U.S. Geological Survey has purchased a CSDMS-dedicated High Performance Computing Cluster (HPCC). NSF covers computer system oversight costs, and remote data storage costs. There are more than 100 CSDMS members who run models on *Beach*. CMT allows *Beach* account holders to build (couple) and execute CSDMS models on *Beach* from their personal computers following cloud-computing principals. The CMT tool can be downloaded for later versions of Windows, OS X, and Linux.

CSDMS staff are examining more convenient ways for members to run models without being subject to CU security protocols for such an open yet dedicated computing cluster. One future way might allow a CSDMS account holder to build 'coupled executables' on *Beach* and then freely make these executables available for use on other computers. This would allow students to manipulate input files and examine model simulations without a *Beach* account. The source code for model components remains available for examination. CSDMS staff have also discussed with CCA staff, the development of DVDs for multiplatform operation of models, a distant goal.

Most high performance codes (e.g. ROMS, WRF) have versions that can be run, albeit more slowly, on single processor computers. High performance codes are often poor performers on single processor machines, and are demanding with countless libraries to enable. Our experience has shown that some HPC models can take a couple of months to work out all the library compatibility issues and become fully operational on a new platform.

What are the CSDMS Working Groups (WGs), and how are they different from CSDMS Focus Research Groups (FRGs)? There are five WGs: Terrestrial, Coastal, Marine, Education & Knowledge Transfer (EKT), and Cyberinformatics & Numerics (C&N), and CSDMS members align themselves with one or more groups. The Terrestrial WG with more than 225 members concerns itself with weathering, hillslopes, rivers, glaciers and ice sheets, deserts, lakes, hydrology, geodynamics and human dynamics. The Coastal WG (>160 members) studies Earth's coastlines, deltas, estuaries, bays, lagoons, and the impact of humans. The Marine WG (>125 members) focuses on continental shelves, slopes, carbonates, and the deep marine. The EKT WG (60 members) equips researchers with model and visualization tools, planners with decision-making tools, educators with pre-packaged models, course material and tools to help illustrate surface processes and build intuition. The C&N WG (>90 members) focuses on high performance computing, visualization, and software protocols. Chairs of these working groups form the CSDMS governing body along with Steering Committee and Integration Facility representation.

CSDMS FRGs differ from WGs in that they serve a unique subset of our surface dynamics community, usually represent an already functioning community co-sponsored by another organization. Chairs of FRGs report directly to the CSDMS Executive Director, and to the Chair or Director of the co-sponsoring organization. The 135-member Hydrology FRG is co-sponsored by CUAHSI and deals with models of the hydrological system. The 45-member Carbonate FRG is developing a numerical carbonate workbench. The Chesapeake FRG is the first 'geographically-focused' effort co-sponsored by the Chesapeake Community Modeling Program, with their unique collection of models and field data set.

What are CSDMS member responsibilities? The Chairs of WGs and FRGs need members who are willing to roll up their sleeves and volunteer time to this community effort. If the burden falls on too few shoulders progress is halted. Participation is through annual meetings, workshops, electronic forums, or through individual hero efforts related to adding, modifying or vetting CSDMS models, data and educational material. After reading this article we encourage interested participants to take the plunge, offer energy, insight and talent to this important community effort.

What are some Sedimentary Geology modeling challenges? We can do no better than offer up the review on this topic by Chris Paola (2000) in the Millennium Issue of Sedimentology. Here are a few additional topics that could be considered over the next decade.

1) Very few of the CSDMS models take advantage of today's high performance computers like *Beach* (teraflops) and there is no model able to scale up to petascale ($+10^{15}$ Flops) or exascale ($+10^{18}$ Flops) platforms of the near future. Authors of models typically give up both spatial and temporal resolution and domain size (area covered, time simulated) in order to work on single processor systems. Most code authors are not trained in MPI and OpenMP, the coding interfaces used to take advantage of multiple processors. NSF has recognized this lack of progress; CSDMS is addressing this shortcoming.

2) We are only beginning to recognize the magnitude of human alteration of our landscape during the 20th century --- the Anthropocene epoch. Yet many of the measurements that we base our theories on contain the overprint of human interference. We need algorithms that can strip off human influences on the landscape (e.g. hardened river banks, hillslope terracing), or add them (e.g. accelerated wetland peat oxidation, mangrove removal).
3) We are much further along in post-diction compared to prediction, yet given our rapidly changing climate and landscape, there is an urgent need to develop surface dynamics models that offer prediction capabilities. Here the resolution issue is particularly relevant, along with access to high performance code.
4) In deformed terrains, it is often difficult to interpret the rock record so as to recover the original depositional slopes of the rock units. Without the depositional slope it is difficult to apply numerical models to constrain the transport dynamics that led to a deposit. This is a problem of too many degrees of freedom. Continental margin deposits are particularly problematic where individual beds might be deposited over a wide range of slopes (e.g. $<1°$ to $15°$). If crustal deformation is both spatially and temporally variable, then reconstruction of depositional slopes becomes nearly impossible. Monte Carlo set-up runs employing coupled geodynamic and sediment transport models might result in a series of believable matches to the deposit geometries. These results would then help develop statistical models for reservoir characterization.
5) CSDMS is helping to make environmental-domain coupling of models easier. Is enough research on hand to capture transition dynamics: terrestrial to coastal, coastal to marine processes, or perhaps reef dynamics with marine processes? If models do not include the appropriate transitional dynamics, there will remain a mismatch with observations.
6) Adding complexity to a model is a two-edged sword. Atmospheric models have always been better at getting temperature correct compared to precipitation, with early models needing better characterization of cloud physics. However, weather models often are so complex that predictions beyond a few weeks are near impossible. Climate models with simpler representations of atmospheric dynamics are more capable of predictions-of-state across decades. Thus earth scientists need to identify where complexity is needed and learn to scale this complexity over geologic time. Scaling of complexity will always remain the center of earth science.
7) The skin of the earth surface has become known as the critical zone. This zone represents the intersection between the hydrosphere, cryosphere, atmosphere, biosphere and the geosphere. Such complexity is not included in any single model. Model coupling offers a way forward in capturing the physics and chemistry of this complex zone, as long as components are developed to capture this complexity.

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Appendix 5. Dedication Gary Parker Recipient to the 2010 CSDMS Lifetime Achievement Award

By David Furbish

The very first time I met Gary I was standing at a urinal. Gary was at the next one over. Gary introduced himself by saying "Hello, Dr. Furbish this reminds me of the time a fundamentalist preacher and a rabbi walked into a bar." So Gary told me this off-the-wall joke, and the joke itself was pretty funny. But I remember that what made the joke really funny was how Gary actually made it relevant to two guys p***ing together. I figure that, even in humor, most of the time there is something substantive in what Gary says. You just have to listen for it.

Being a southerner, I've appreciated knowing that Gary is at least a southerner at heart, having spent much of his growing-up time in New Orleans. But Gary's parents either ignored southern tradition, or they just plain forgot to give Gary a middle name. So I'm going to fix this, right now, officially. And I've taken the liberty of redrafting Gary's birth certificate. I've thought about this a lot. Bubba Parker doesn't seem quite right. Gary Bob is better. But my favorite is Gary Wayne Parker. So it's official. Gary Wayne.

Photo: CSDMS Executive Director James Syvitski (L) is thrilled to hand Professor Gary Parker (R) the first CSDMS Lifetime Achievement award at the 2010 San Antonio CSDMS Annual Meeting.

Here are some things I know. At the risk of stating the obvious, Gary has fundamentally contributed to steering the course of scientific thinking. The breadth of his impact is impressive. To wit: It is a smart move to examine the work of Gary and his colleagues if one is interested in any of the following:

* Bedform dynamics, and river morphodynamics in general
* River meandering
* Downstream fining and floodplain deposition
* Density stratification effects of suspended sediment
* Turbidity currents and submarine debris flows
* Cyclic step formation
* Morphodynamics of fans and deltas
* Bedrock incision
* Sediment transport and sorting, and tracer motions in rivers

In choosing adjectives to describe Gary's work, three immediately come to mind: clever, insightful, creative. Many examples are possible. Here is one.

Whereas we're mostly aimed at numerical stuff at this meeting, at heart Gary is an analytical guy. Gary once gave a talk at the Geophysical Fluid Dynamics Institute at Florida State when I was there. His talk involved the topic of entrainment during turbidity flows. Gary set up the problem with conventional momentum stuff, but then to close the problem, Gary appealed to kinetic energy in a way that delightfully caught us all by surprise. (The audience included folks like Ruby Krishnamurti, Lou Howard and David Loper.) I distinctly recall coming away from Gary's talk thinking, How Clever, the same feeling one has after reading classic papers by individuals such as Sir Geoffrey Taylor.

Two more quick comments regarding the impact of Gary's work:

Choose any of the topics I mentioned previously, look at articles not authored or co-authored by Gary, and then look for Gary's name in the acknowledgments. With significant probability, you will find it.

Impact also extends indirectly beyond the topics I mentioned. For example, it turns out that when a relatively dense magma is intruded into a magma chamber containing less-dense host magma, a viscous version of hydroplaning occurs. Moreover, many physical petrologists have become intrigued with features in solidified chambers that are strongly reminiscent of sedimentary bedforms as well as auto-acephalation. I must tell you that, gosh, it has been great fun to point these folks to the work of Gary and his colleagues on hydroplaning, auto-acephalation, and block glide and bedform development in viscous flows.

Talented students admire Gary as a teacher. SunTao, for example, once took great lengths to describe to me how he had observed that Gary frequently was exhausted after his class lectures because of the effort that Gary poured into them. And it was clearly a source of pride for SunTao to tell the story — that he had experienced these lectures and appreciated Gary's effort. Perhaps you know that Gary was honored with a University of Minnesota Institute of Technology Outstanding Teacher award. Particularly in a time of public cynicism suggesting that faculty care only for research and not teaching, or in view of jaded advice from colleagues, that to excel as a teacher is a kiss-of-death in the promotion-tenure process, to be recognized for excellence as a teacher as well as a researcher is one of highest compliments possible.

Even in research, Gary is a teacher. His e-book is meant to teach.

OK, so here is the politically incorrect part. But I'll be nice, and keep it brief.

> In the sciences there exists a prestigious academy
> Fortunately, tis only one form of flattery
> Far more sublime
> Indeed satisfying the test of time
> Is the enormous impact of Gary's intellectual comradery

I like probabilistic stuff, and it is certainly reasonable to think of Gary as an extreme event. For example, if we assume that Gary is a 100-year flood, then there is a 26% chance that one would experience a flood like Gary during a 30-year career. I'm glad we got lucky.