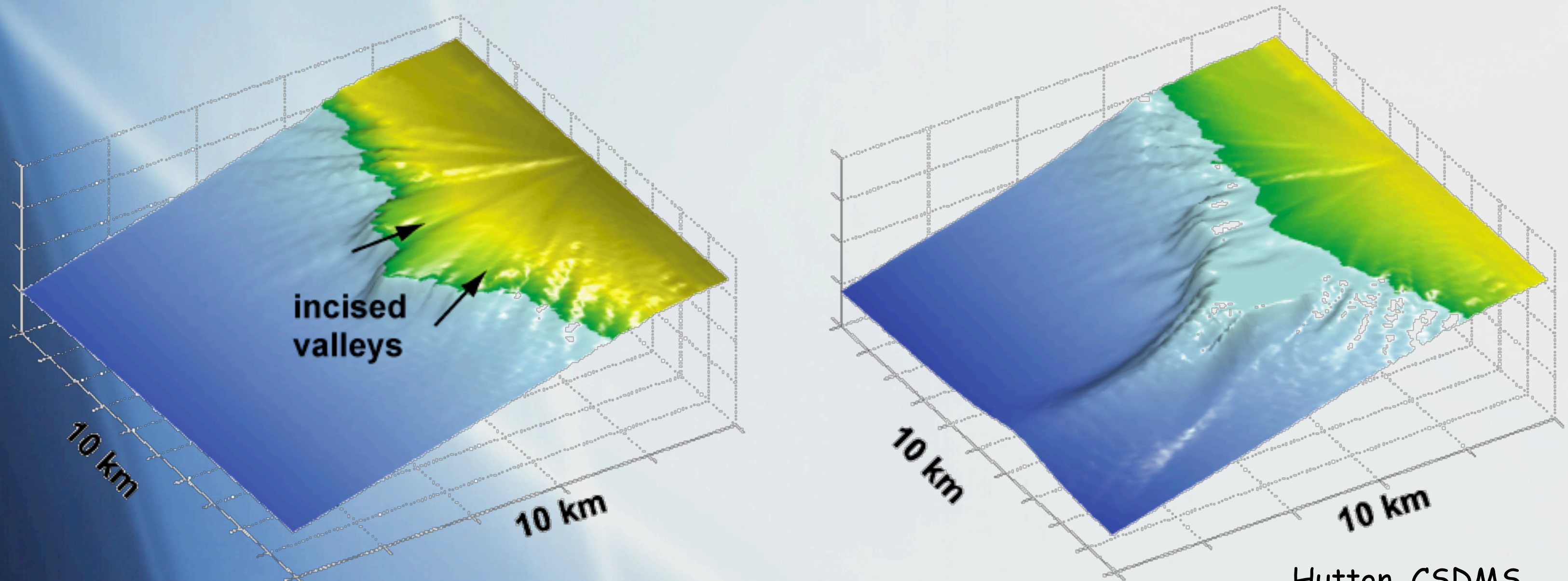
The Community Surface Dynamics Modeling System

James P.M. Syvitski
CSDMS Integration Facility
U.Colorado—Boulder



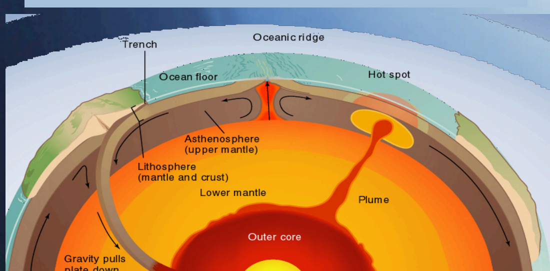
Hutton, CSDMS

Community Surface dynamics
CSDMS
Modeling system

What is CSDMS?

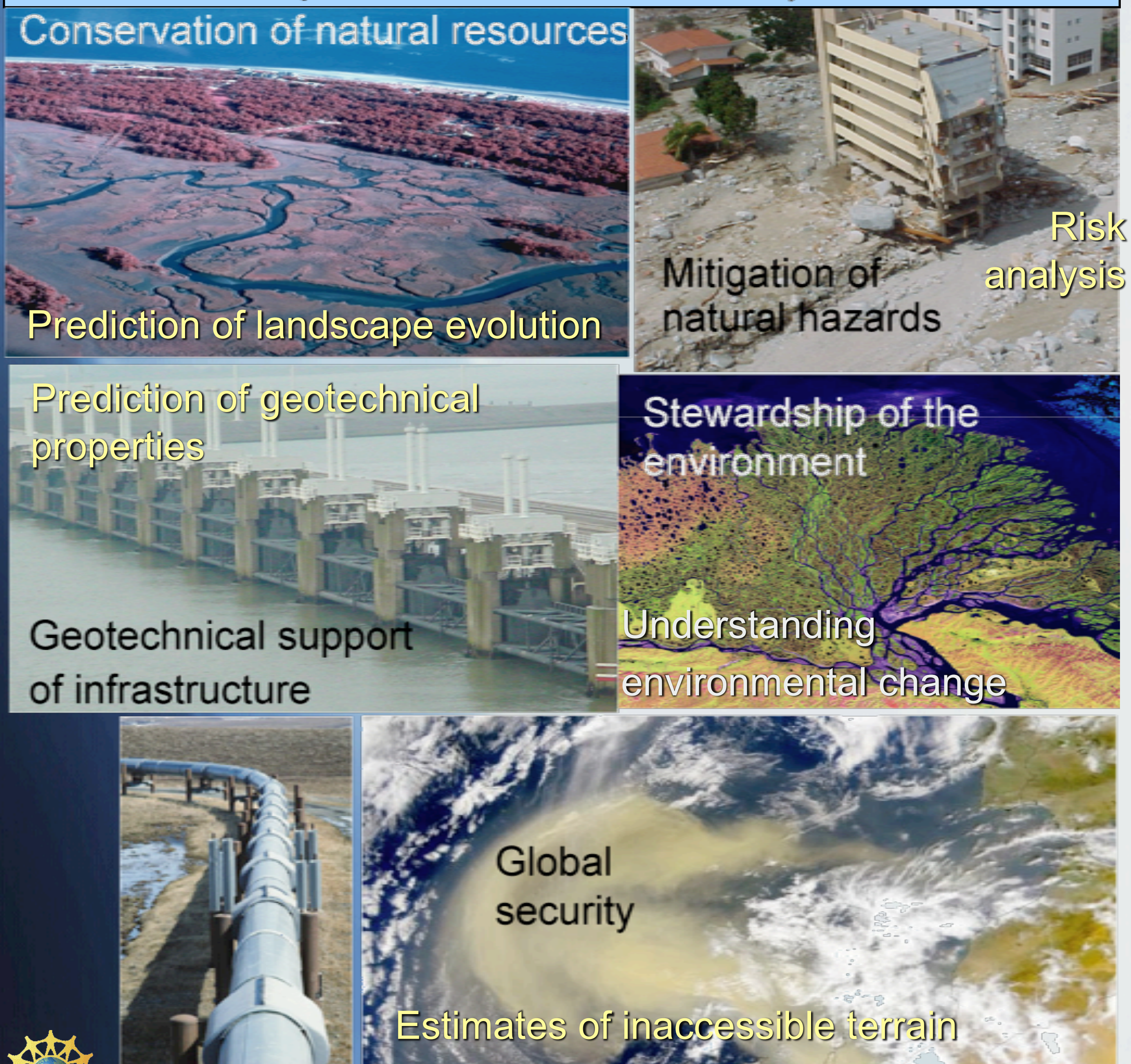
- An integrated community of experts to promote the modeling of earth-surface processes.
- Protocols for the library of community-generated, continuously evolving, open software.
- Cyber-infrastructure to distribute software tools & models in aid of applied and education uses.
- Partnerships with related scientific programs, providing strong linkage between predictions and observations.

Modeling Planet Earth (CIG, CSDMS, CCSM)



CSDMS

NRC National Imperatives will be addressed by the CSDMS Effort



CSDMS Goal:

Develop and disseminate software to predict the erosion, transport, and deposition of sediment & solutes in landscapes and their sedimentary basins.

CSDMS

USGS
science for a changing world

OFFICE OF NAVAL RESEARCH
ONR
USN

GEON PORTAL

neon
NATIONAL ECOLOGICAL OBSERVATORY NETWORK

NATIONAL SCIENCE FOUNDATION

US Army Corps of Engineers ®

NASA

CZO CZEN

NCED
Earth · Water · Life

MARGINS
to understand the complex interplay of processes that govern the evolution of continental margins

RDECOM
TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.
U.S. Army Research, Development and Engineering Command

U.S. Army Research Laboratory

CUAHSI
universities allied for water research

NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
UNITED STATES DEPARTMENT OF COMMERCE

The National Center for Atmospheric Research
NCAR
sponsored by NSF
managed by UCAR to serve the community

GWSP
Global Water System Project

LOICZ

IAHS
AISH

NOPP
National Oceanographic Partnership Program
Promoting Partnerships for the Future of Oceanography

International Council for Science
Scientific Committee on Oceanic Research

GLOBAL IGBP CHANGE
International Geosphere-Biosphere Programme

IASC
International Arctic Science Committee

NSF

CSDMS

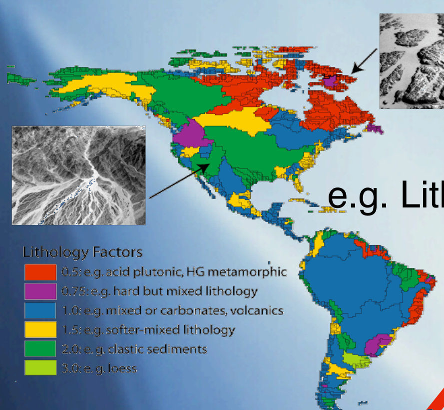
CSDMS is developing industrial consortiums: (Environment & Engineering; and Geological)

The following have provided members to CSDMS working groups.

The CSDMS Data Repository

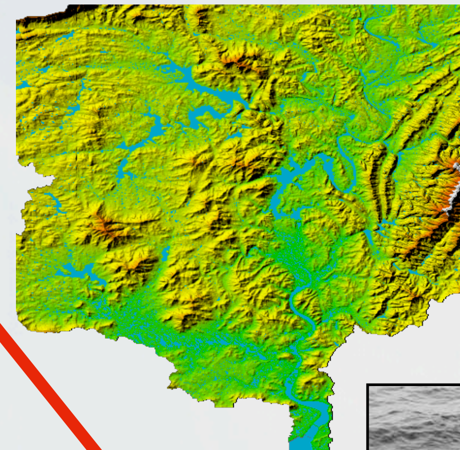
Climatology: T°C, PPT, Wind, Waves

e.g. Runoff



e.g. Lithology

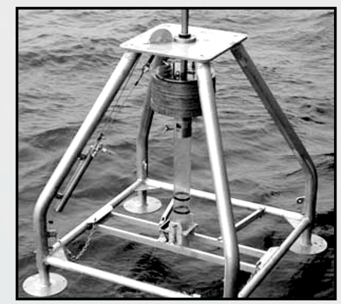
Topography/Bathymetry/Sea Level



Gridded Boundary Conditions

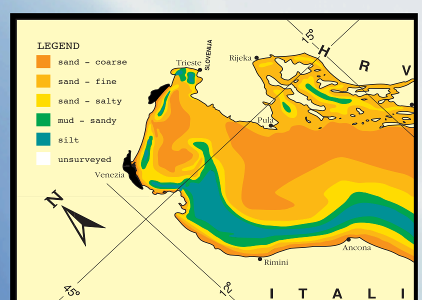
Data Integration in Modeling

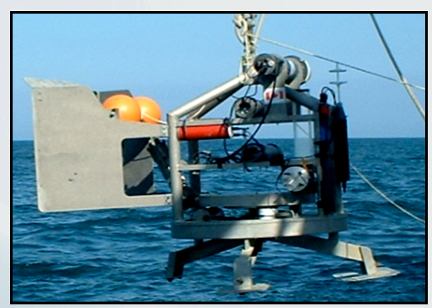
$$Q^x_{s,s} = \int_{z=\delta wbl}^{h} c_s U dz$$



Gridded Initializations

Ice Sheet Cover
Soil Type/Thickness
Grain Size
Lakes/Reservoirs
Human Factors: GNP, Pop.
Vegetation
Lithology





Domain Parameterization

Flocculation
Critical Shear Stress
Bioturbation
Weathering grade
Productivity
Authigenesis

http://csdms.colorado.edu/models/data.html

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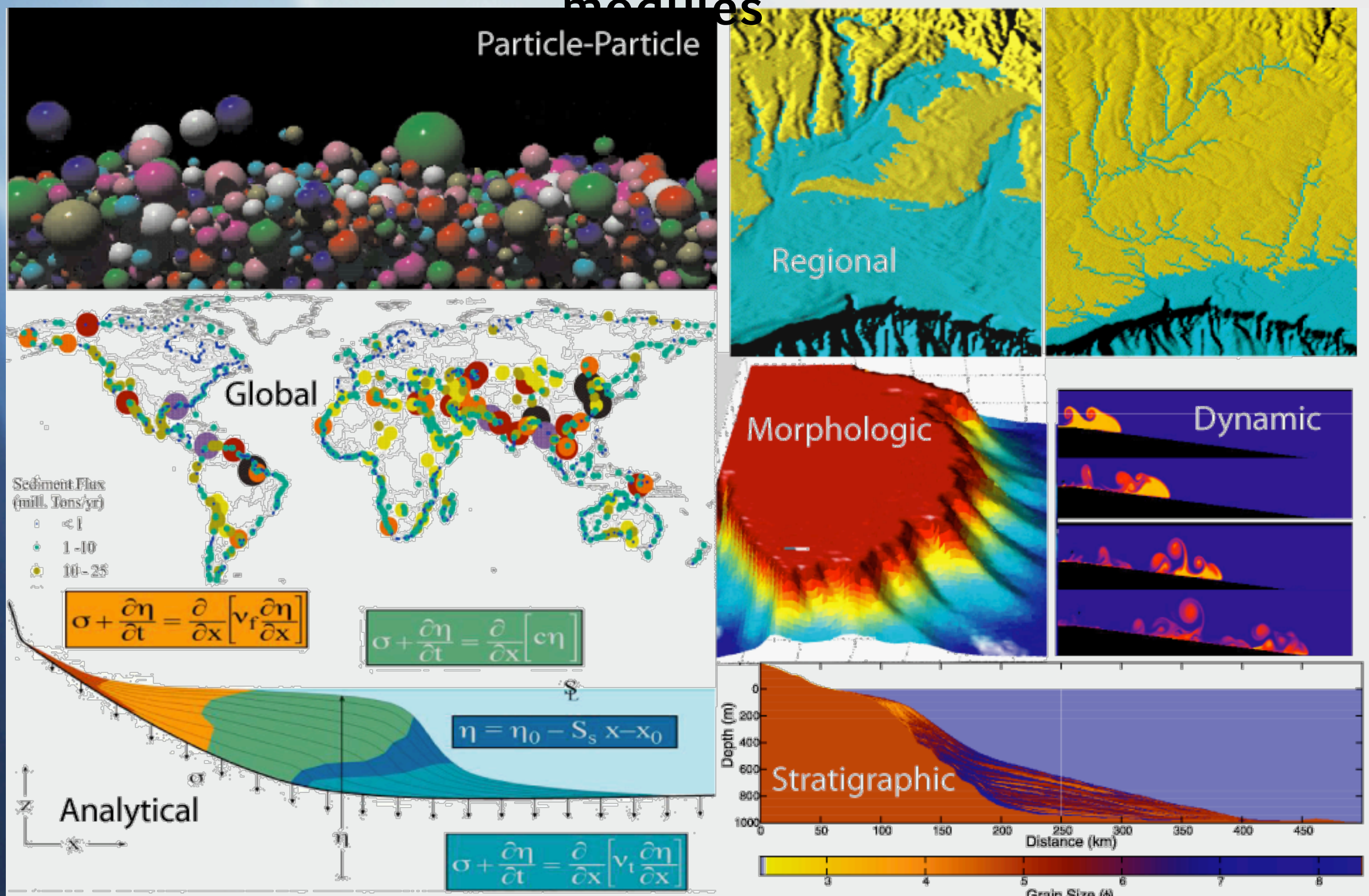
The CSDMS Model/Tools Repository

CSDMS welcomes stand-alone models/languages & tools relevant to surface dynamics, including novel computational strategies, moving boundary methods, distributed source terms, & nested modules



http://csdms.colorado.edu/models/introduction.html

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The CSDMS Model/Tools Repository

CSDMS will point to, or distribute, legacy models/ code

CSDMS

COMMUNITY SURFACE DYNAMICS MODELING SYSTEM

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About | Organization | Meetings | Models | Products | Working groups

Introduction | Models | Tools | Data | Products

Models

- Terrestrial
- Coastal
- Marine

Software name	Company / Organisation	Contact person	Extra info
ADCIRC	USACE / CHL	Rick Luettich	No
Coaster ?	Univ. Colorado, USA	Scott Peckham	No
Delft3D	WL I Delft Haudraulics, Netherlands	Delft3D Team	No
NearCOM	Univ. Delaware / CACR, USA	James T. Kirby	No
Nearshore POM	Univ. Delaware, USA	James T. Kirby	No
POM	Princeton Univ., USA	Tal Ezer	No
SEOMS	Rutgers University, USA	Dr. Hernan G. Arango	No
SedFlux 2.0	Univ. of Colorado, USA	Eric Hutton	No
ROMS / TOMS	USGS Woods Hole, USA	Christopher Sherwood	No
SHORECIRC	Univ. Delaware, USA	James T. Kirby	No

http://csdms.colorado.edu/models/models.html

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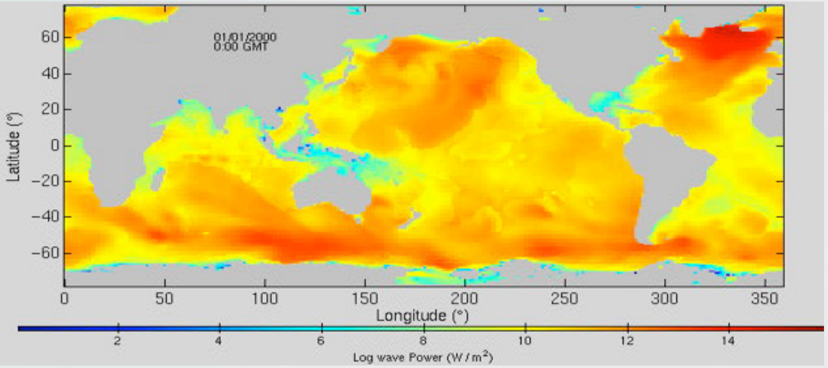
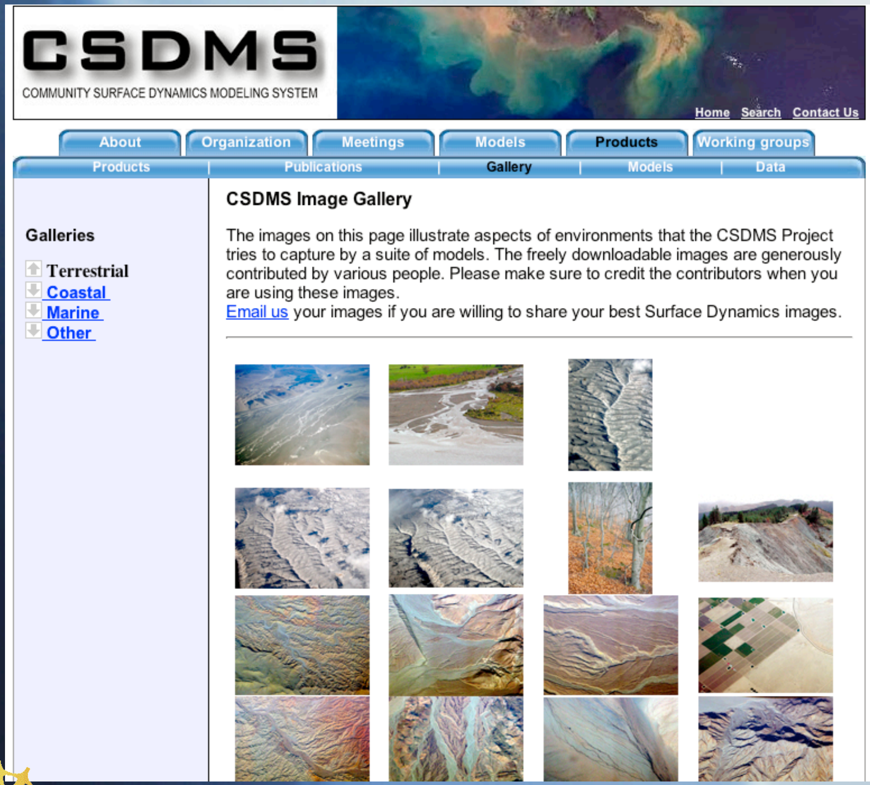
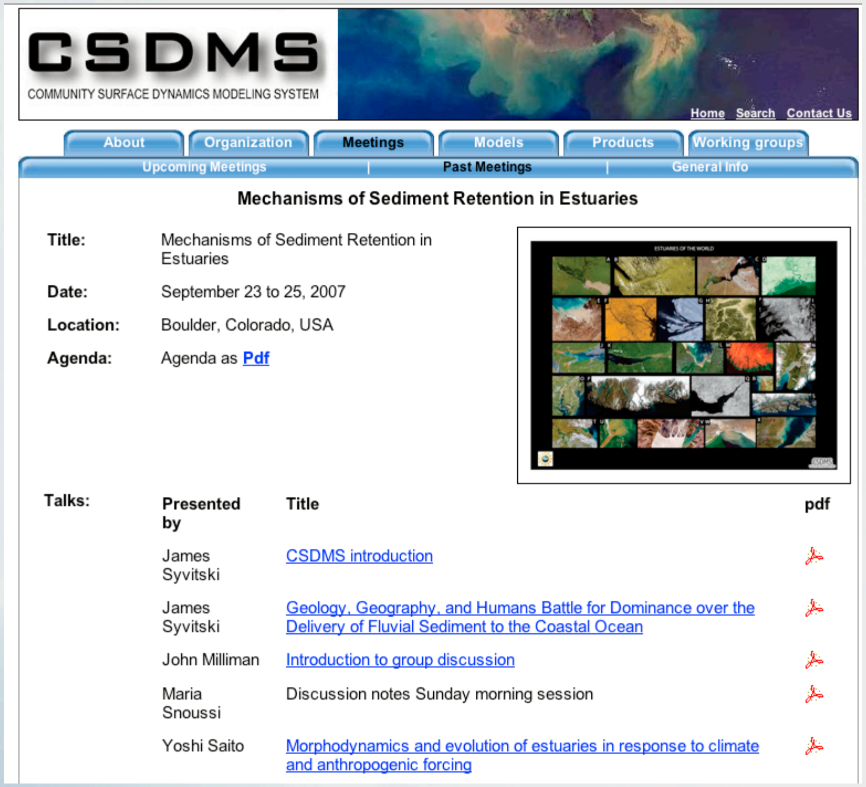
The CSDMS Education Repository

CSDMS will also distribute: 1) model simulations, 2) Educational PPTs, 3) Reports, Publications, 4) Short Course Materials, 5) Images, 6) Workshop presentations.





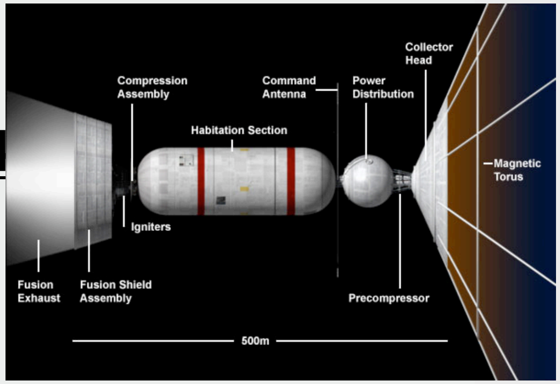


http://csdms.colorado.edu/models/models.html

CSDMS

The CSDMS Compliant Repository

Contributed compliant code able to function within the CSDMS integrated modeling framework



Specs for the CSDMS Framework

Supports multiple operating systems: *Linux, OSX & Windows*

Supports parallel computation *(via MPI standard)*

Language interoperability: *C, Fortran, Java, C++, Python)*

Supports both legacy (non-protocol) code and structured code (procedural and object-oriented)

Interoperable with other coupling frameworks (*e.g. ESMF*)

Supports both structured and unstructured grids

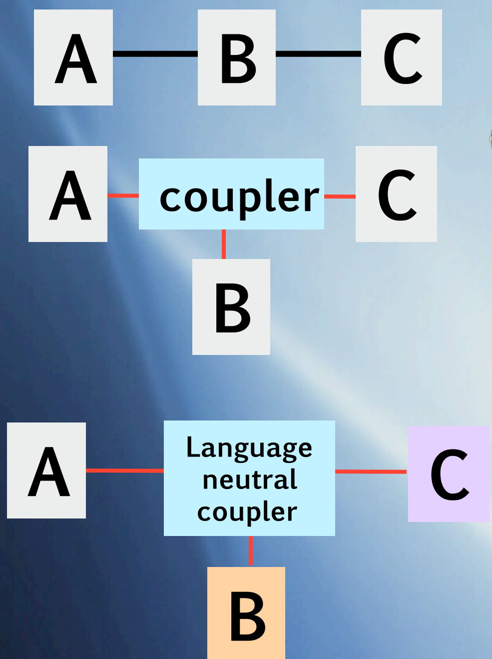
Supports platform-independent GUI *(e.g. via wxPython)*

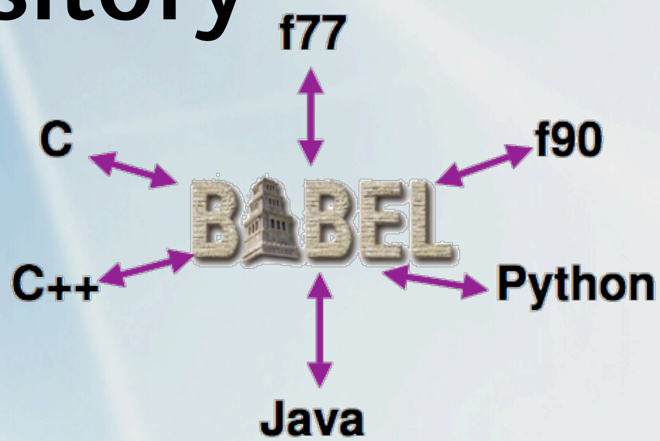
Large offering of open-source tools

Open source software license, industry-friendly, protection for authors, tracks modifications, GPL2 compatible OSI approved.

CSDMS

The CSDMS Compliant Repository





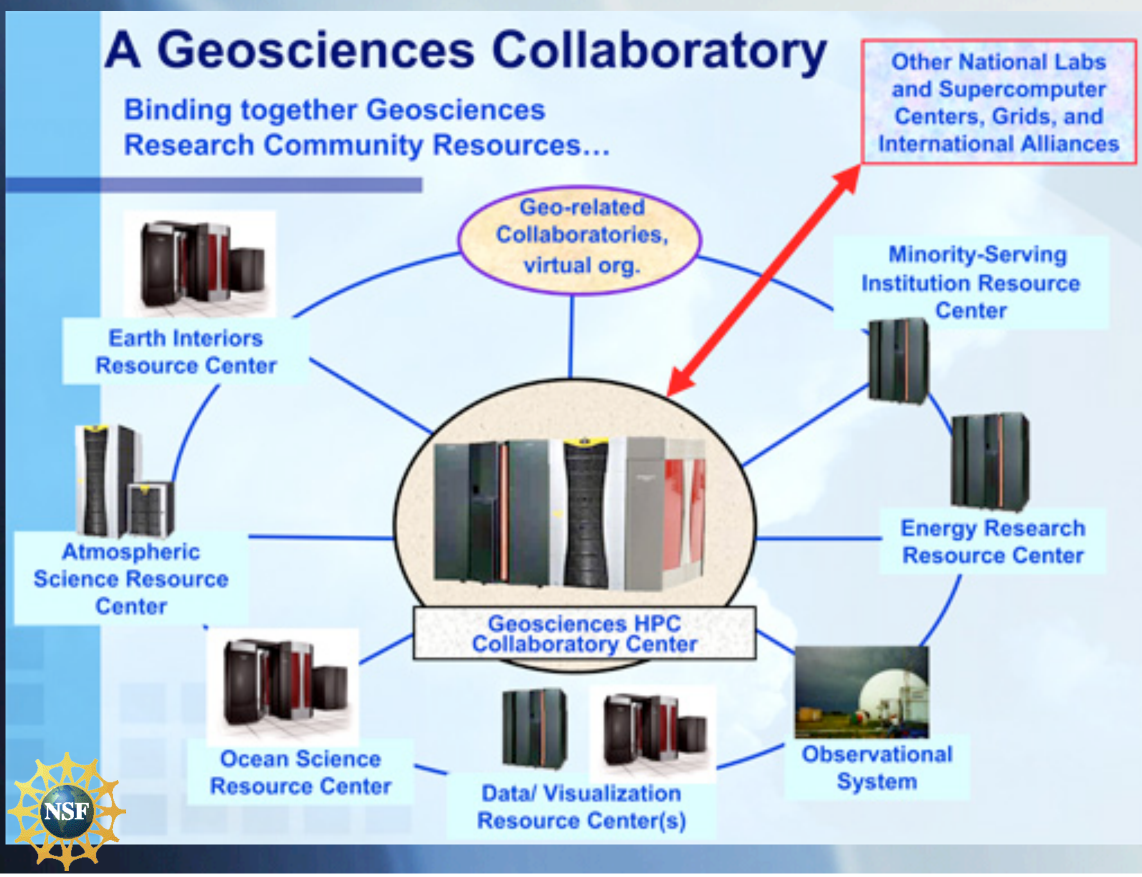
Language interoperability: Components written in different languages can be rapidly linked with little performance cost, allowing for open-source solutions (e.g. libraries), and access to both procedural and object-oriented strategies (legacy and modern code), with graphics & within GUIs.

CSDMS uses the CCA **Architecture** (*set of standards for component technology*), through a **Framework** (*execution rules & services, e.g. Ccaffine*), where **Components** (*modules/models e.g. CHILD or SedFlux)* are linked through **Interfaces** (*communication data protocols*) via **Ports** (*tasks related to the communication between components*).

"CSDMS accepts the NSF directive to aid the surface-dynamics community moving towards modern High Performance Computers."

-- Syvitski, 2006, NCAR

The CSDMS IF will acquire a CSDMS-operated Experimental Supercomputer (ES) offering >256 cores for >4 teraflops of computing power, and configured with two HPC approaches — 1) massive shared memory among fewer processors, and 2) the more typical parallel configuration — running Linux with Fortran, C and C++ compilers.



The CSDMS ES will be linked to the proposed Front Range HPC with 7000 core, >100 teraflops, in turn linked to the US TerraGrid and the proposed Cheyenne NCAR/UCAR Petascale HPC dedicated to the NSF Geoscience Collaboratory.

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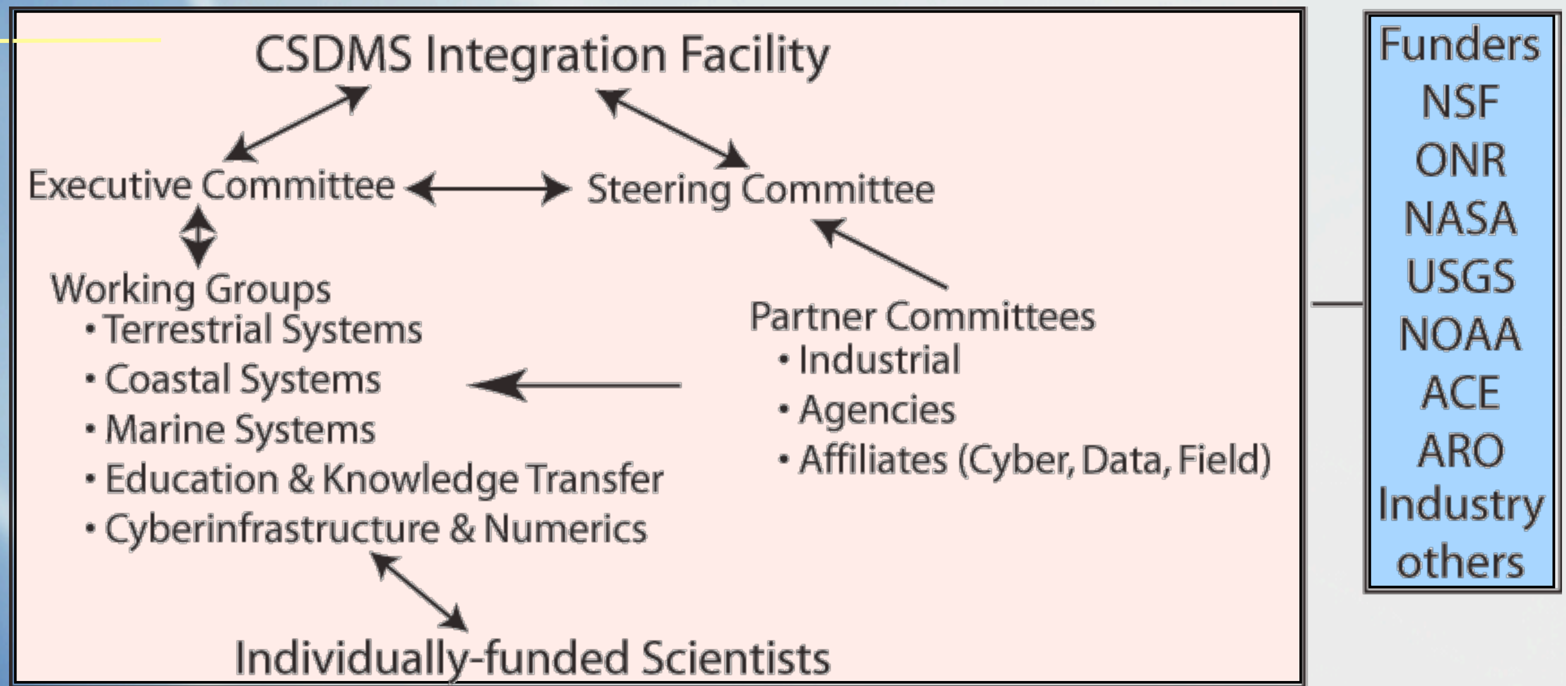
The CSDMS Org Chart



Yr 1: CSDMS NSF-supported staff = **3.5 FTE**
CSDMS non NSF-supported staff (NOPP, NASA, ONR, IC, CU) = 3.5 FTE
= 7 FTE

Yr 2: CSDMS NSF-supported staff = **4.5 FTE**
CSDMS non NSF-supported staff ≈ 4.5 FTE
= 9 FTE

Yr 3: CSDMS NSF-supported staff = **7 FTE**
CSDMS non NSF-supported staff ≈ 5 FTE
= 12 FTE

The CSDMS Team

Terrestrial	Coastal	Marine	Cyber/ Numerics	EKT
Tucker/CIRES	Murray/ Duke	Wiberg/ UVA	Tao Sun/ ExxonMobil	Pratson/ Duke
63 members	53 members	46 members	30 members	12 members
45 institutions	43 institutions	40 institutions	20 institutions	11 institutions
			3 countries	USA

CSDMS ExCom: primary decision-making body. Ensures that the NSF Cooperative Agreement is met. Develops Bylaws & Operational Procedures, and the rolling 5-y Strategic Plan. Approves memberships and the Bylaws.

Consists of the **ExDir as ExCom Chair** + **5 W.G. Chairs** + **S.C. Chair** + **S.S.E.**

CSDMS Steering Committee: primary advisory body. Assesses the competing objectives and needs of CSDMS; progress in terms of science, management, outreach, and education; and advises on revisions to the 5-y strategic plan. Approves the Bylaws.

Chair R. Slingerland (Penn State); T. Drake (ONR), B. Jagers (Delft Hydraulics), R. Sarg (Mines), G. Parker (U. Ill. Urbana Champaign), D. Tetzlaff (Schlumberger-Doll), D. Furbish (Vanderbilt), T. Dunne (UC-Santa Barbara) + Ex officio members J. Syvitski (CSDMS ExDir) & M. Ellis (NSF).

The CSDMS Integration Facility

- **Maintains** the CSDMS Repositories: 1) Data Repository; 2) Model/Tools Repository; 3) Education Repository; 4) Compliant Repository;

- **Oversees** CSDMS Membership, Communication and Governance: 1) Business Meetings (SC, ExCom, Partner); 2) Working Group Meetings; 3) CSDMS Workshops, 4) Short Courses; 5) Web Wiki, 6) Teleconference, 7) Videoconferences, and 8) Email Communication

- **Conducts** Tool/Model Protocol testing & evaluation on varied platforms

- **Evaluates** hardware & software configurations with CSDMS products

- **Develops** the CSDMS cyber-infrastructure (e.g. coupling frameworks; licenses; protocols)

- **Provides** CSDMS software modeling guidance (expertise)

- **Facilitates** Community coordination & public relations

- **Facilitates** Product Penetration

- **Maintains** the CSDMS Vision & Cooperation between disparate communities, & between field and modeling communities.

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CSDMS Environmental Working Groups

Identifies processes in their disciplinary toolkit, gaps in knowledge, and areas for numerical module development.

Keeps current both short & long term goals

Sets modeling priorities for their disciplines.

Ensures quality control for 1) their algorithms and modules including use of benchmark or validation datasets, and 2) adequacy of supporting boundary conditions and boundary initializations.

Coordinates the evaluation of numerical codes according to interoperability, scientific contribution, protocol compliance, and technical documentation.

Addresses CSDMS proof-of-concept challenges.

Provides community continuity to meet long-term CSDMS objectives.

Stimulates proposals and input from the community.

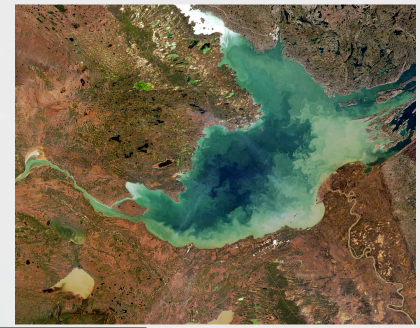
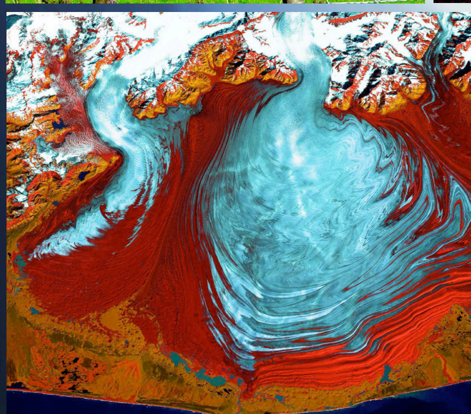
Reports progress annually.

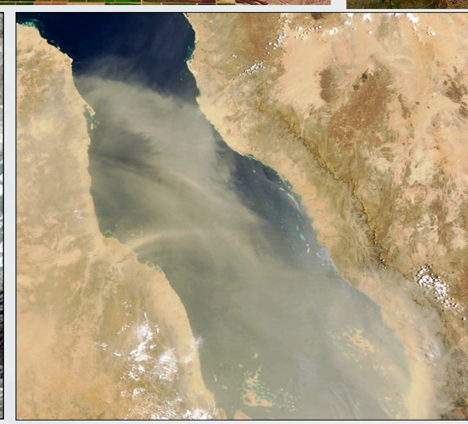
CSDMS Terrestrial Working Group Scope







CSDMS Coastal Working Group Scope

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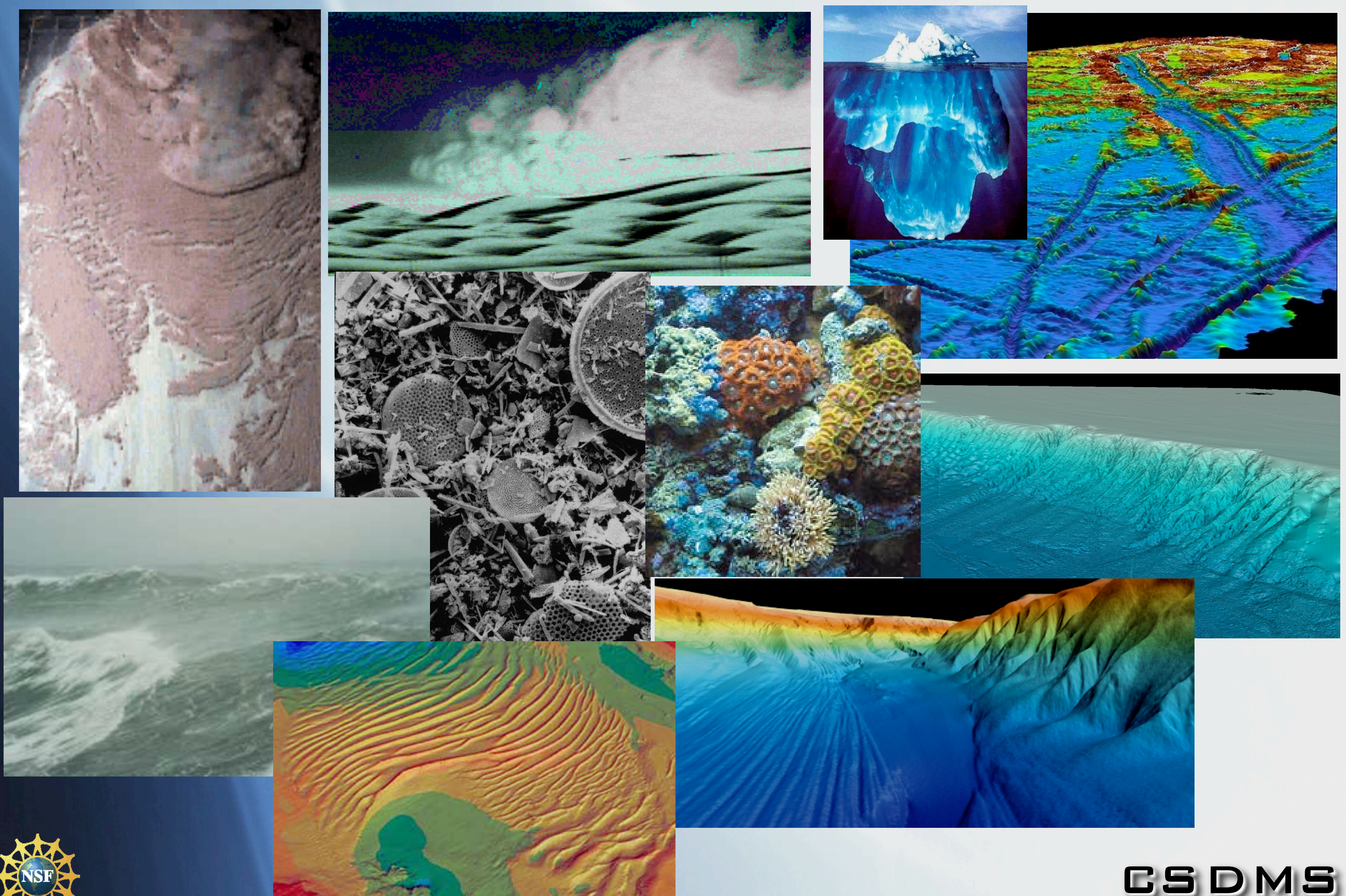
CSDMS Marine Working Group Scope



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CSDMS Cyber & Numerics Working Group

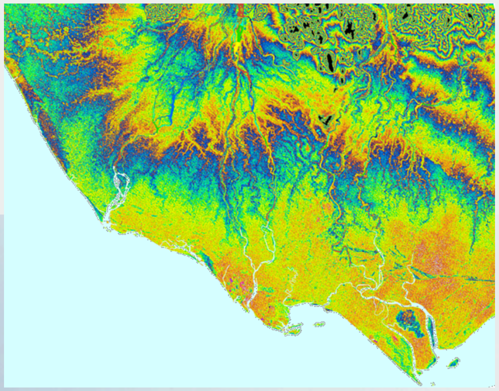
Develop the CSDMS 5-year Cyber-Infrastructure.

- Protocols for linking modules.
- Common data structures and interfaces to link transport processes.
- Incorporation of "legacy code" from the modeling community.
- Toolkits for pre- and post-processing, and model visualization.
- Standards for benchmarking and testing modules.
- Standard computational tools, including I/O error handling, data exchange, grid generators and PDE/flux solvers.
- Infrastructure to facilitate the proof-of-concept challenges
- Graphical user interface (GUI).

Metrics for success:

1) Ability to track the material flux and its characteristics, with conservation of mass and momentum, from the mountains to deep ocean,
2) Ability to link modules with dynamic feedback of state variables/arrays between modules, and
3) Ability to flip modules in and out.

Report progress annually.



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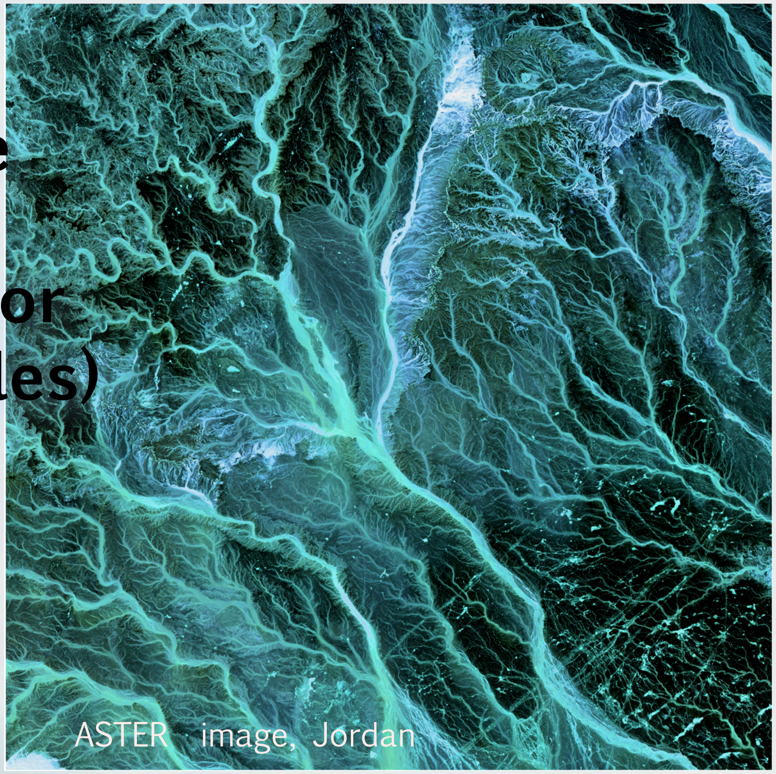
CSDMS Proof of Concept Model Challenges

1. Models that track the transport and fate of water, sediments, carbon & nutrients.

2. Surface dynamic models that include the Human Dimension

3. Models that track surface dynamics across moving boundaries (sea level &/or climate, &/or glacial cycles)



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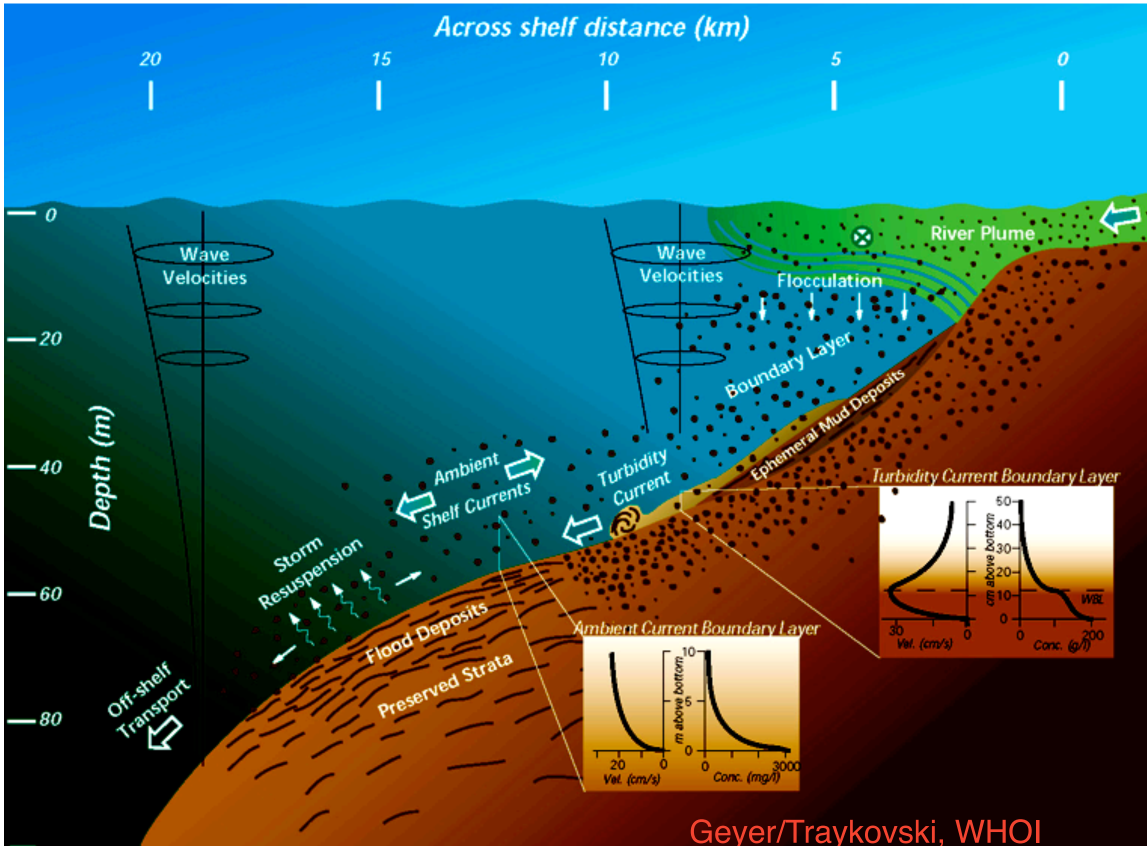
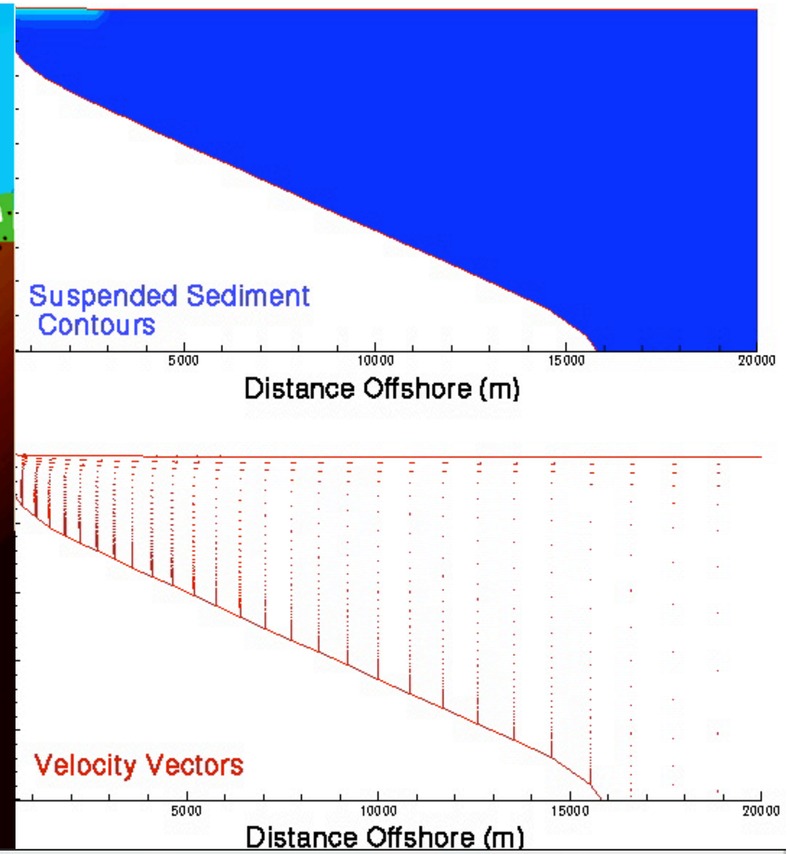




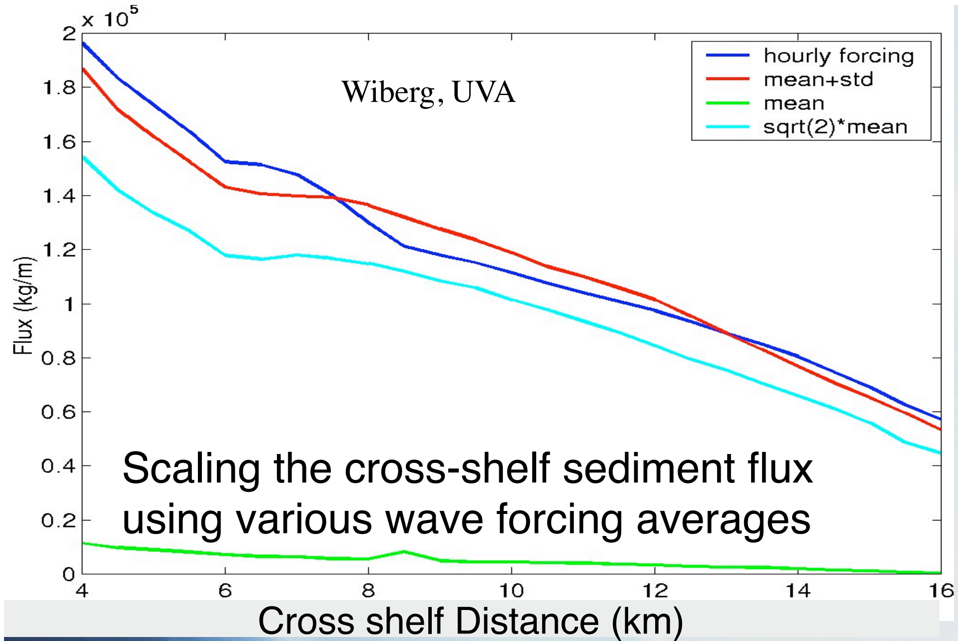
Reed/Niedoroda, URS

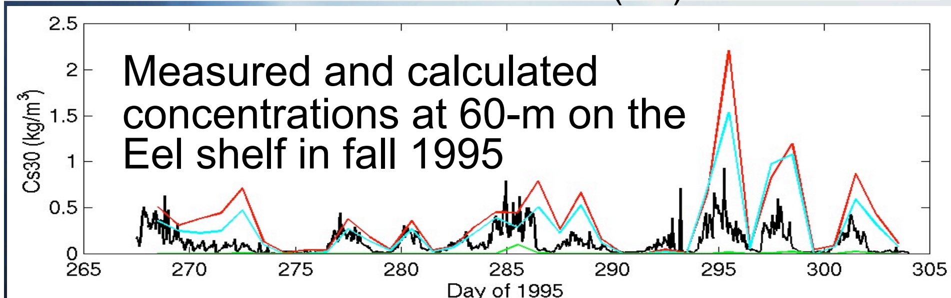
Linking processes with strata

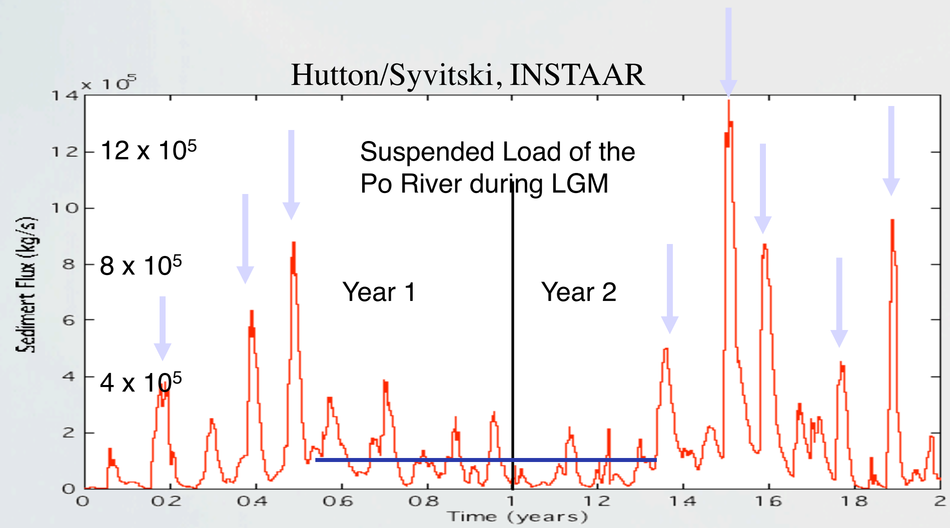
e.g. fluid mud transport on high supply shelves, linked to a coherence of river flood & ocean storm events, leading to 1) inner shelf dirty sands, and 2) outer shelf to upper slope mud deposition

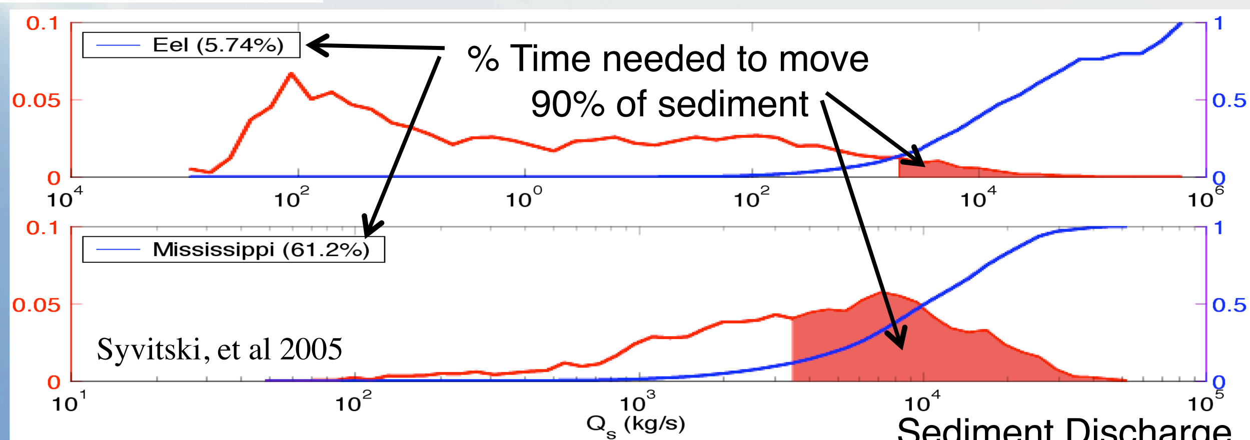
Scaling across time and space

Low Frequency, High Magnitude Events (PDF-CDF approach)









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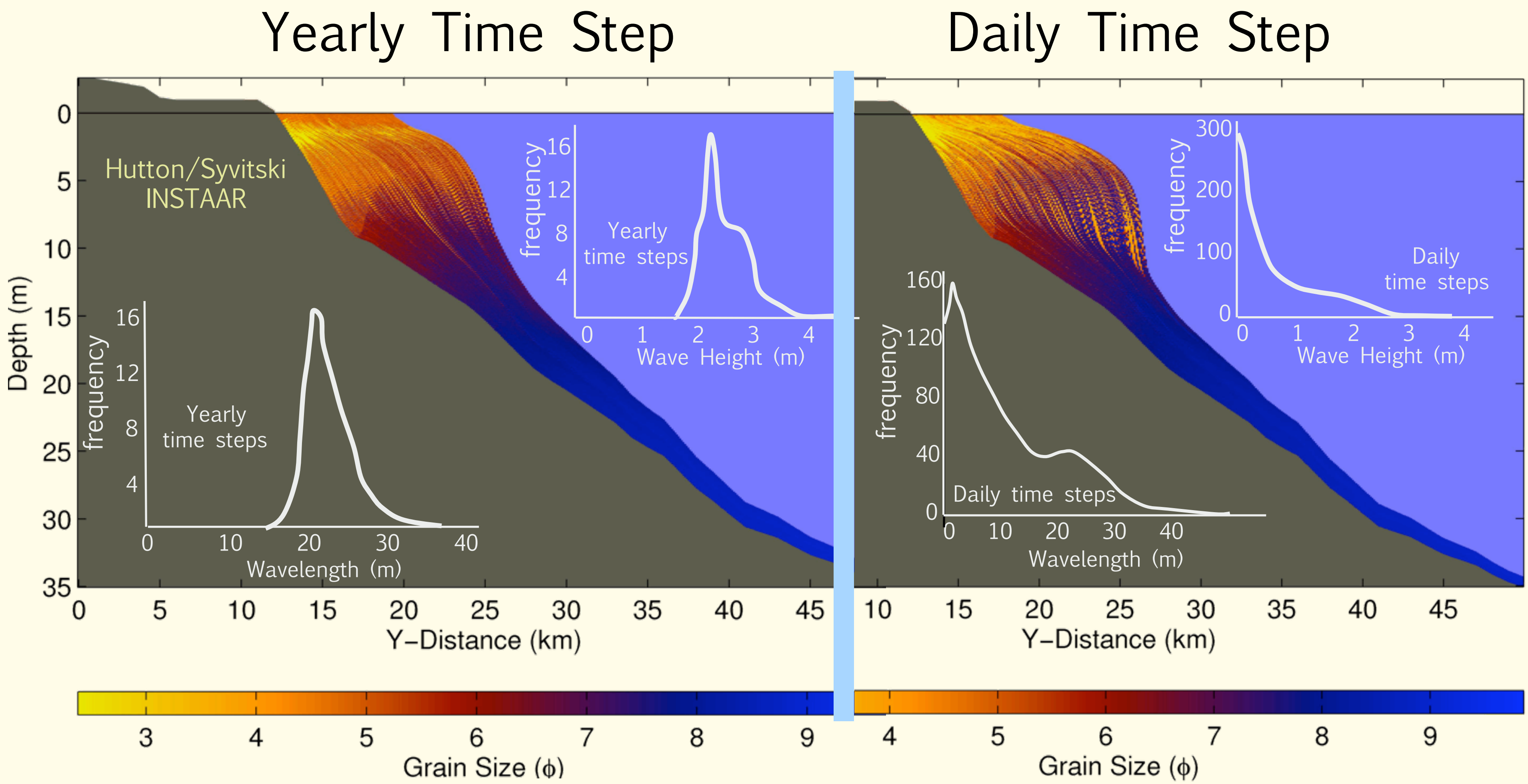
Temporal Resolution



Scaling across time and space

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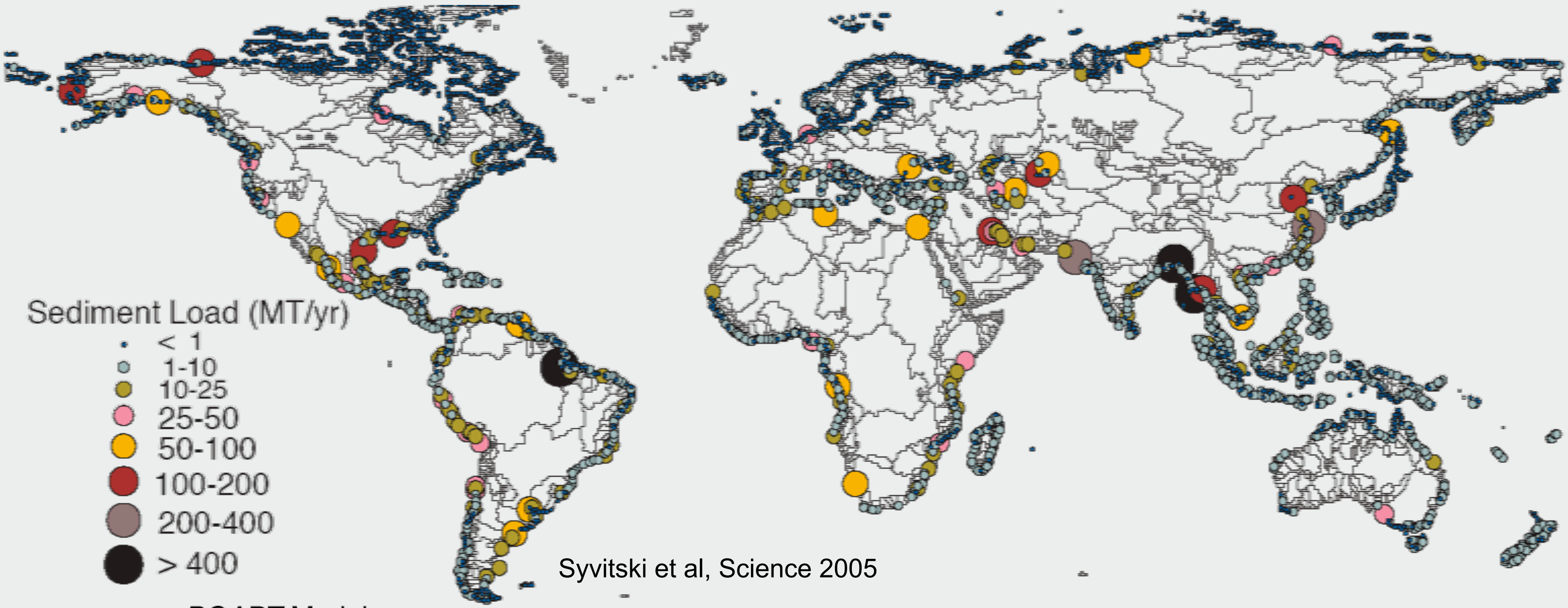
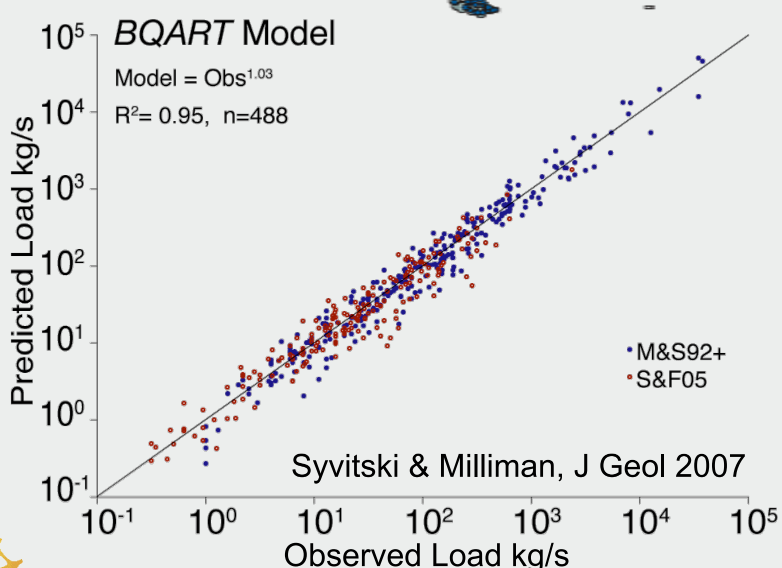


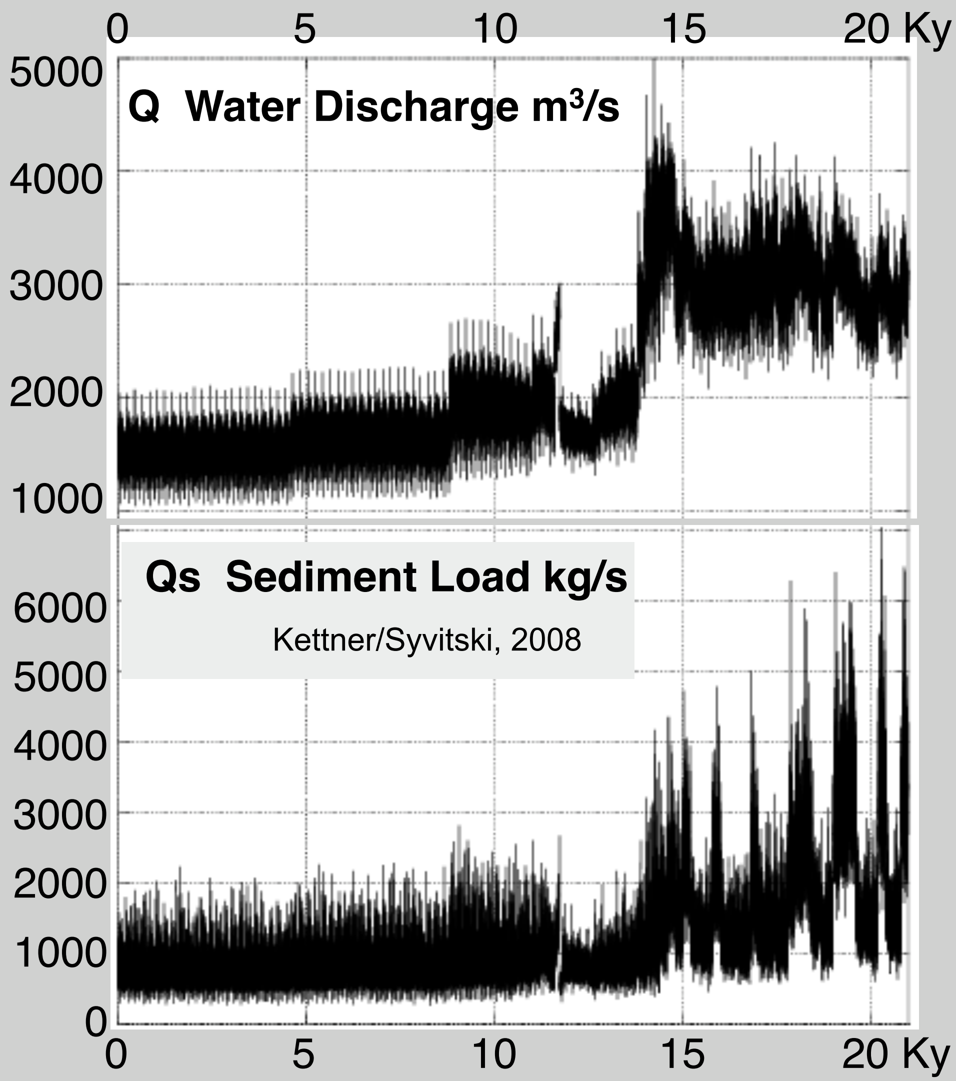
Syvitski et al, Science 2005

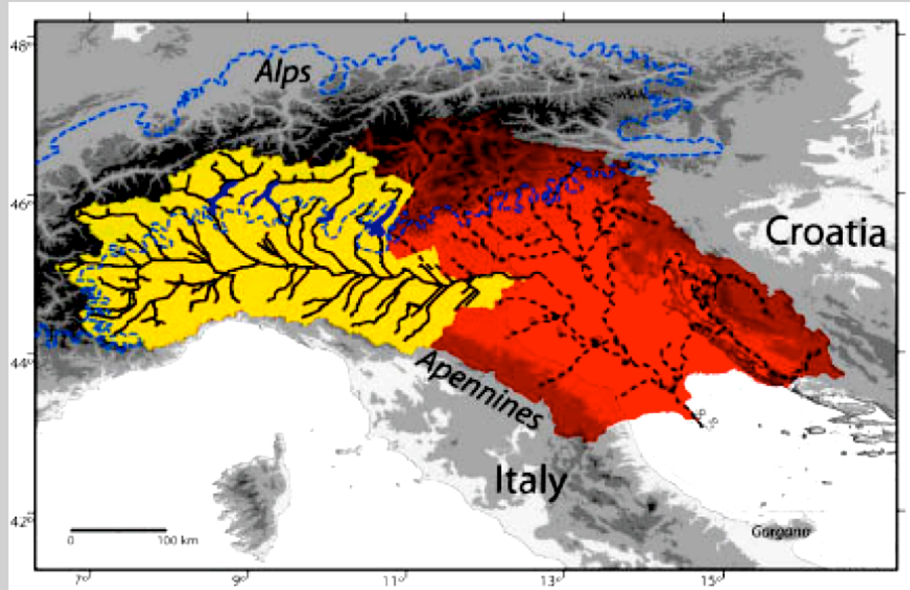


Syvitski & Milliman, J Geol 2007

Quantitative prediction of material fluxes

CSDMS





Daily discharge & sediment load various with rainfall, snowmelt, ice melt, and groundwater discharge. The Pleistocene suspended load of the Po is 1.7 times the Holocene flux.

Quantitative prediction across moving boundaries

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CSDMS Users:

- Tests hypotheses to support data interpretation
- Utilize pre- & post-processing visualization tools
- Tests modules as part of field campaigns

- Runs scenarios
- Relates GIS output to environmental factors & land use
- Quantifies uncertainties in decision making

- Illustrates surface processes using pre-packaged models
- Builds intuition with "what-if"-type model runs
- Develops case studies that integrate field data and model simulations.
- Prepares exploratory exercises for students

Uncertainty, Variability, Error,
Precision, Accuracy, Confidence

CSDMS

Membership has its privileges

- Part of a family of experts — advantages in staying current within a community taking the Earth Sciences to the next level
- Competitive funding opportunities — better integrated proposals
- Better knowledge on available models — for education and application
- Recognized service in an interesting & new field of interdisciplinary science
- Better/faster penetration of one's numerical advances, data and simulation products
- Closer interaction with a wide variety of industrial & NGO partners and federal agencies, with possible spin-off funding opportunities
- Better academic & public recognition for code development
- Increased outreach and knowledge-transfer opportunities

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Is CSDMS a Community Clastic Model? — No. It is a modeling community supporting a modeling architecture (not an uber model). It deals with hydrology, nutrients, sediment (incl. carbonates), ecosystems, glaciers, oceanography, weather, etc --- earth-surface dynamics. CSDMS protocols allow for model components to be mixed in unique ways to answer diverse question — reef dynamics, carbonate reservoirs & aquifers, sedimentation … CSDMS is as interested in stand alone models as compliant comtributions.

What are the funding opportunities? — Competitive --- but 1) supported by a state-of-the-art research agenda developed by an integrated community; 2) supported by a community of modelers & software engineers; 3) access to a sophisticated modeling architecture, data systems, and high performance computing; & 4) CSDMS opportunities with NGO's, agencies, industry partners.

How are coders recognized? — 1) Through the CSDMS web site, 2) with the metadata following the model, 3) with GPL2 software license protection, 4) through community exposure, vetting and recognition & 5) through accelerated citations within CSDMS-supported peer-reviewed publications. The CSDMS Integration Facility will insist on best practices to ensure that proper credit is provided by those who use CSDMS products, along with proper protection of, for example, contributions by graduate students. CSDMS has the advantage of following in the footsteps of CCSM and CIG initiatives.

CSDMS

The Promise of CSDMS

- Better understand the evolution of Earth's surface environments, while understanding the uncertainties in the predictions.
- New tools/models in support of surface-dynamic research.
- Address the complexities of feedbacks and linkages in surface science, employing a wide variety of expertise.
- Useful products for the benefit of broader society.

CSDMS