



Teaching with WMT

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Agenda

➤ Why Teaching of Modeling of Earth Surface Processes?

What possibilities does CSDMS WMT offer?

➤ Integrated Help System between WMT and CSDMS wiki

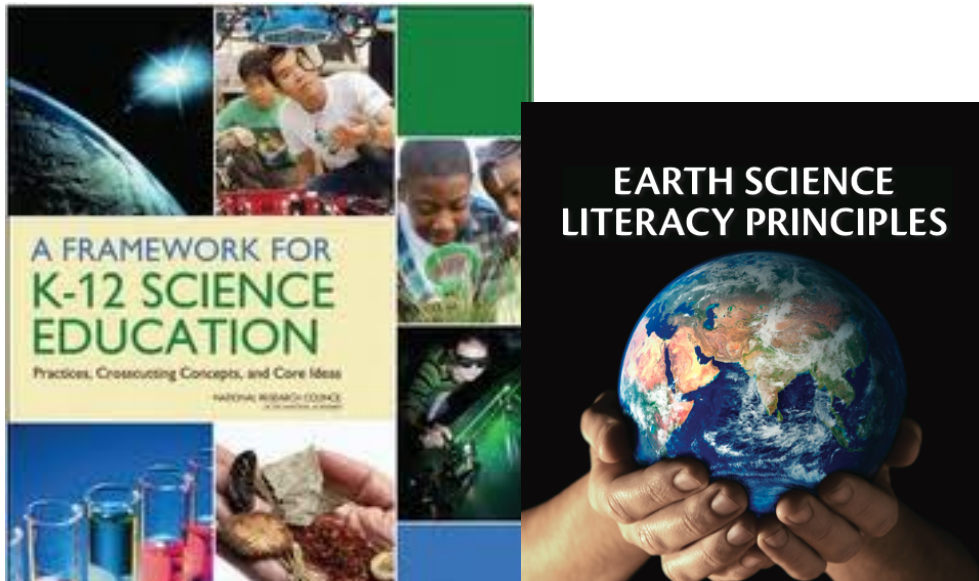
➤ Model-Labs in EKT Repository

➤ Hand-on Modeling Lab with CEM

Vision

- CSDMS motto: “Explore Earth’s Surface with Community Software”
- Develop a modular modeling environment capable of significantly advancing fundamental earth-system science; and
- Develop fully functional and useful repositories for models, supporting data and tools, and other products for education in quantitative modeling.

Why teach modeling?

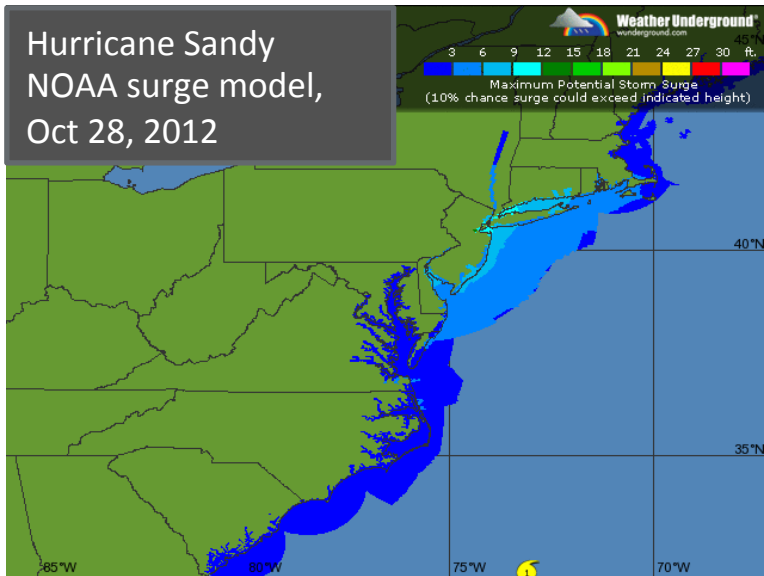


Essential elements of the K-12 science and engineering curriculum relate to modeling:

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics, information and computer technology and computational thinking
6. Constructing explanations and designing solutions

Why teach modeling?

Hurricane Sandy
NOAA surge model,
Oct 28, 2012



Modeling is imperative to forecasting the behavior of a complex and evolving Earth System

Geoscience research nowadays heavily uses models:

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics, information and computer technology and computational thinking
6. Constructing explanations and designing solutions

Learning outcomes of modeling labs

- Awareness of models versus instrumental data
- Awareness of simplification, assumptions and uncertainty in models
- Explore possible outcomes of a system under different parameters
- Create and analyze model output
- Predict attributes of complex system behavior
- Describe feedbacks in coupled systems
- Computing skills – familiarity with HPCC procedures

Using WMT for teaching



CSDMS members and > 100 graduate students have been exposed to CSDMS Modeling Tool

- CSDMS clinics in 2010, 2011, 2012 and 2013
- CU graduate courses on Earth Surface Process modeling
- NCED SIESD 2-day clinics in 2011, 2012, 2013

We are moving this course material to WMT web-based tool

Integration between WMT and wiki

The CSDMS Web Modeling Tool interface is shown, divided into two main panels. The left panel, titled "The CSDMS Web Modeling Tool", contains a "Model (*Plume 1)" section with icons for file operations and a "More" dropdown. A dropdown menu for "Plume" is open, showing options: "Show parameters", "Get information", and "Delete". A green arrow points to the "Get information" option with the text "Click here". The right panel, titled "Parameters (Plume)", contains a "Plume (10.1594/IEDA/100152)" section with a description of the model and a link to the wiki page: <http://csdms.colorado.edu/wiki/Model:Plume>. A "Close" button is located at the bottom right of the right panel.

The CSDMS Web Modeling Tool

Model (*Plume 1)

Parameters (Plume)

Plume (10.1594/IEDA/100152)

Plume simulates the sediment transport and deposition of several grainsize classes from a river mouth entering into a marine basin by creating a turbulent jet. The model forms a hypopycnal plume. The model allows for plume deflection due to systematic currents or Coriolis force

<http://csdms.colorado.edu/wiki/Model:Plume>

Model developer: Eric Hutton

Close

Click here

Model Help?

or Click Here

The CSDMS Web Modeling Tool

Model (*Sedflux2D 1)

Parameters (Sedflux2D)

Sedflux2D v2.1 (10.1594/IEDA/100161)

Basin filling stratigraphic model.Sedflux2d simulates longterm marine sediment transport and accumulation into a 2D longitudinal basin over time scales of tens of thousands of years. It simulates the dynamics of strata formation of continental margins and includes turbidity currents and debris flows.

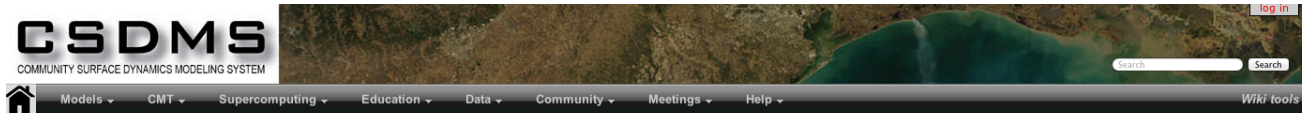
http://csdms.colorado.edu/wiki/Model_help:Sedflux

Model developer: Eric Hutton

Close

The screenshot shows the CSDMS Web Modeling Tool interface. At the top, a dark blue header contains the text 'The CSDMS Web Modeling Tool'. Below this, the main interface is divided into two panels. The left panel, titled 'Model (*Sedflux2D 1)', contains a toolbar with icons for file operations and a 'More' dropdown. Below the toolbar is a tree view showing a folder named 'Sedflux2D' with three sub-items: 'coastal_en...', 'subaerial_...', and 'baselevel'. The right panel, titled 'Parameters (Sedflux2D)', contains a toolbar with icons for refresh, share, and help. A green arrow points from the text 'or Click Here' to the help icon (a question mark) in this toolbar. A help popup window is open, displaying the title 'Sedflux2D v2.1 (10.1594/IEDA/100161)', a description of the model, a URL to the help page, the model developer's name 'Eric Hutton', and a 'Close' button.

Model Help?



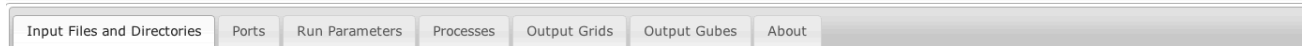
? Sedflux

SEDFLUX is a basin-fill model, written in ANSI-standard C, able to simulate the delivery of sediment and their accumulation over time scales of tens of thousands of years. It simulates the dynamics of strata formation of continental margins fuse information from the atmosphere, ocean and regional geology, and it can provide information for areas and times for which actual measurements are not available, or for when purely statistical estimates are not adequate by themselves.

Model introduction

Sedflux combines individual process-response models into one fully interactive model, delivering a multi-sized sediment load onto and across a continental margin. The model allows for the deposit to compact, to undergo tectonic processes and isostatic subsidence from the sediment load. The new version, Sedflux 2.0 introduces a series of new process models, and is able to operate in one of two models to track the evolution of stratigraphy in either 2D or 3D. Additions to the 2D mode include the addition of models that simulate (1) erosion and deposition of sediment along a riverbed, (2) cross-shore transport due to ocean waves, and (3) turbidity currents and hyperpycnal flows. New processes in the 3D mode include (1) river channel avulsion, (2) two-dimensional diffusion due to ocean storms, and (3) two-dimensional flexure due to sediment loading. The spatial resolution of the architecture is typically 1–25 cm in the vertical and 10–100 m in the horizontal when operating in 2D mode. In 3D mode, the horizontal resolution usually extends to kilometers. In addition to fixed time steps (from days to hundreds of years), Sedflux 2.0 offers event-based time stepping as a way to conduct long-term simulations while still modeling low-frequency but high-energy events.

Model parameters



Parameter	Description	Unit
Input directory	path to input files	-
Site prefix	site prefix for Input/Output files	-
Case prefix	case prefix for Input/Output files	-

Uses ports

This will be something that the CSDMS facility will add

Provides ports

This will be something that the CSDMS facility will add

Main equations

- River dynamics (using HydroTrend model)

1) Water discharge

$$Q_0 = u_0 b_0 h_0$$

3) Plume's centerline

$$\frac{x}{b_0} = 1.53 + 0.90 \left(\frac{u_0}{v_0} \right) \left(\frac{y}{b_0} \right)^{(0.37)} \quad (8)$$

4) Non-conservative concentration along and surrounding the centerline position

$$C(x, y) = C_0 \exp(-\lambda t) \sqrt{\frac{b_0}{\sqrt{\pi} C_1 x}} \exp\left[-\left(\frac{y}{\sqrt{2} C_1 x}\right)^2\right] \quad (9)$$

$$t(x, y) = \frac{u_0 + u_c(x) + 7u(x, y)}{9} \quad (10)$$

$$u_c(x) = u_0 \sqrt{\frac{b_0}{\sqrt{\pi} C_1 x}} \quad (11)$$

$$u(x, y) = u_0 \sqrt{\frac{b_0}{\sqrt{\pi} C_1 x}} \exp\left[-\left(\frac{y}{\sqrt{2} C_1 x}\right)^2\right] \quad (12)$$

Model Labs

The screenshot shows the CSDMS (Community Surface Dynamics Modeling System) website. At the top, the logo 'CSDMS' is displayed with the tagline 'COMMUNITY SURFACE DYNAMICS MODELING SYSTEM'. Below the logo is a navigation bar with a home icon and dropdown menus for 'Models', 'CMT', 'Supercomputing', 'Education', 'Data', and 'Community'. The 'Education' menu is open, showing a list of options: 'Movies', 'Labs', 'Lectures', 'Textbooks', 'Images', 'Contribute', 'What's new', and 'FAQ'. The 'Labs' option is highlighted. Below the navigation bar, the text 'Labs' is followed by a link: 'Want to contribute your own lab? Please contact irina@csdms.colorado.edu'. The main content area is titled 'Labs' and contains three entries:

- Get Started with WMT**: This tutorial teaches you how to use CSDMS Web Modeling Tool; it is focused on how to use the WMT software. [WMT_tutorial](#)
- Sediment Supply to the Global Ocean**: Investigate river sediment supply to the ocean by exploring the effects of climate changes on river fluxes. We also look at the effect of humans on rivers: the building of a reservoir. [Spreadsheet Lab](#) or the [HydroTrend Modeling with WMT](#)
- Modeling River Plumes**: Riverwater and its suspended sediments will form a hypopycnal sediment plume. We will use a component called PLUME to investigate the behavior of these sediment plumes. [Plume Modeling with WMT](#)

Overview of Labs for Teaching:
http://csdms.colorado.edu/wiki/Labs_portal

Example:
http://csdms.colorado.edu/wiki/Labs_WMT_River_Sediment_Supply

Model Labs

- Labs are intended for advanced undergraduate and graduate classes (3-4 hrs, with homework). Labs include:
- 1) Tutorial on use of WMT
 - 2) Presentations on the specific model and processes.
 - 3) Instructions to run simulations. These runs have been tested.
 - 4) Questions to meet topical learning objectives.
 - 5) Key references to learn more on relevant processes and models.

Logistics

- Students need accounts on the CSDMS super-computer. This takes time; count on 5 work days.
- Student need to familiarize with WMT
- Students learn to visualize NetCDF time-series and grids. All CSDMS compliant models output NetCDF files. NetCDF can be visualized in VisIT or ParaView (open-source visualization tools) or Matlab. Some models have their own ASCII files.

Example of a Model Lab

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

Sediment Settling Rates

PLUME is one of the key components of the marine sedimentation model SedFlux; river plumes are just one of the marine processes that control marine sedimentation. Other processes include waves and tides and turbidity currents and biological production. The stand-alone plume component runs for a single flood event, and it runs for a single suspended sediment load class only. You can imagine that in a more comprehensive framework the plume model runs for several grain-size classes and for a sequence of many different discharge events over time. We will look at the effect of changing the suspended grain-size in the river. Empirically, sediment removal rates, λ , [1/T] for fine sediment in the plume model are defined as a function of grain-size, D:

$$\lambda(D) = 0.222D + 1.573$$

This relationship was derived from time-lapse image analysis of underwater particle settling for grains between 2 micron and 42 micron.

Sediment

Saturated bulk density of bottom sediments (kg/m ³)	1,800.0
Removal rate of suspended sediment (day ⁻¹)	16.8

- >> Run 3 simulations of PLUME. Vary the removal rates systematically.
- >> List your parameters for grainsize and removal rate, discharge scenario and basin shape.

← Instructions on Parameter Settings

↙ Questions to guide more in-depth analysis of parameters

Question 4

Compare the empirically derived removal rates with Stokes settling velocities for these grain diameters?
What would be the removal rates if you assume turbulent conditions during settling?
Can you explain the difference?

Hands-on Model Lab

Explore a model lab on coastal evolution modeling (20 min)
CEM Model (Murray, Ashton, Nienhuis), HydroTrend Model
(Kettner), Avulsion Model (Hutton)

Team up with people who have their Beach account information available: you will need your user name and password.

Directions are on CSDMS wiki:

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

Simulation Setup

The CSDMS Web Modeling Tool irina.overeem@gmail.com [Sign Out](#)

⚙️ Model (*CEM + Waves + Avulsion + River)

📁 📄 ▶️ More ▾

CEM ▾

Avulsion ▾

River ▾

CEM ↶ ▾

Waves ▾

⚙️ Parameters (CEM)

⚡ 📄 ?

Run Parameters

Simulation run time (d)	6,000.0
-------------------------	---------

Grid

Number of rows in the computational grid	100
Number of columns in the computational grid	200
Grid resolution in cross and along-shore direction (m)	100.0

Coastal Geometry

Gradient of the shoreface (-)	0.01
Water depth of the shoreface (m)	10.0
Gradient of the shelf (-)	0.001
Sediment flux flag	1

Open Model...

Available models: CEM + Waves + Avulsion + | ▾ 🏷️ Labels

📄 Open 🗑️ Cancel

Option: use the pre-wired example; and start changing parameters from there.

Parameter Setup

CEM ▾

- Show parameters
- Get information
- Delete

Parameters (CEM)

⚡ ↗ ?

Run Parameters

Simulation run time (d)	6,000.0
-------------------------	---------

Waves ▾

- Show parameters
- Get information
- Delete

Waves

Height of incoming waves (m)	1.0
Period of incoming waves (s)	7.0
Highness factor for incoming wave angles	0.5
Asymmetry of incoming wave angles	0.7
File format for output files	netcdf













Simulation Status

The CSDMS Modeling Tool

irina.overeem@gmail.com

Sign out ↗

Simulation Status

Model	Owner	Date	Message	
 CEM_EKTLab_sim2A05	irina...	2014-05-17 14:22	Time: 282.000000 days	  
 CEM_EKTLab_sim2A09	irina...	2014-05-17 14:22	Time: 1214.000000 days	  
 CEM_EKTLab_sim2A01	irina...	2014-05-17 14:21	Time: 1872.000000 days	  

Simulation takes about 5 minutes to complete, it reports progress in the 'Simulation Status' window

<https://csdms.colorado.edu/wmt/api-dev/run/show>

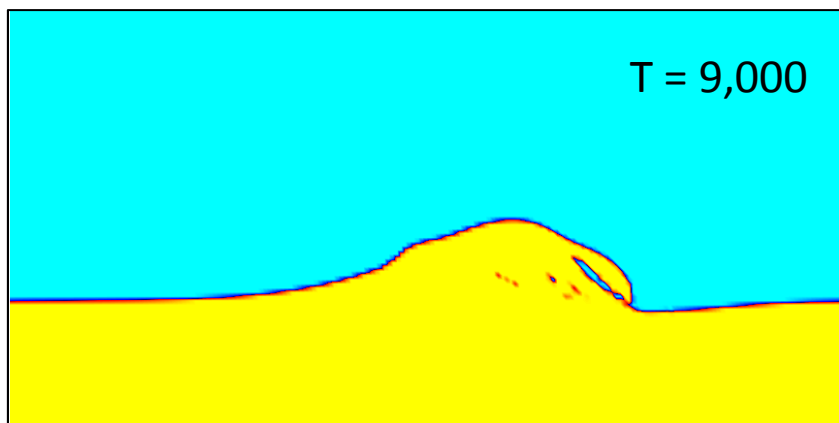
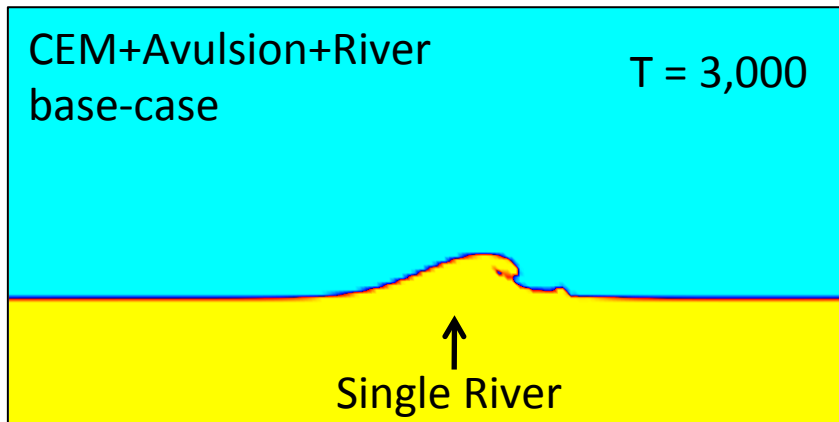
Visualize NetCDF files with VisIT

➤ Download VisIT software

<https://wci.llnl.gov/codes/visit/>

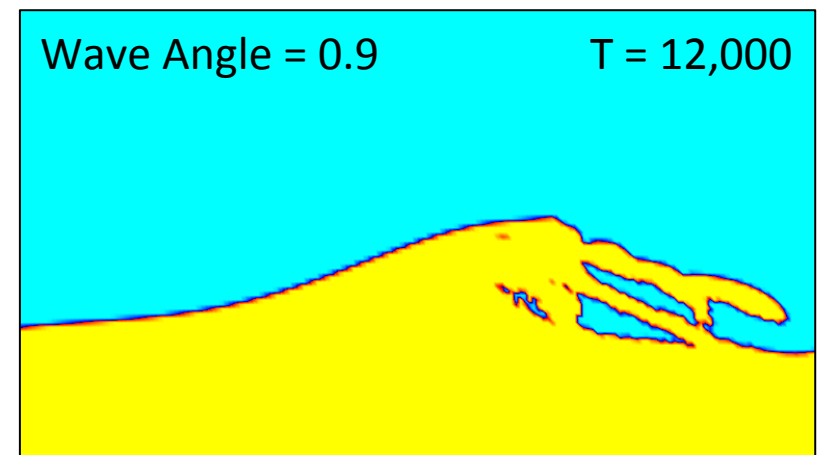
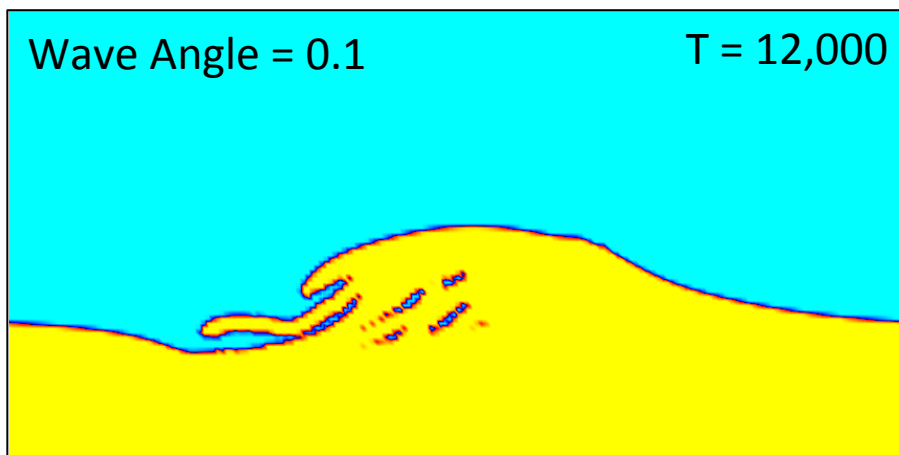
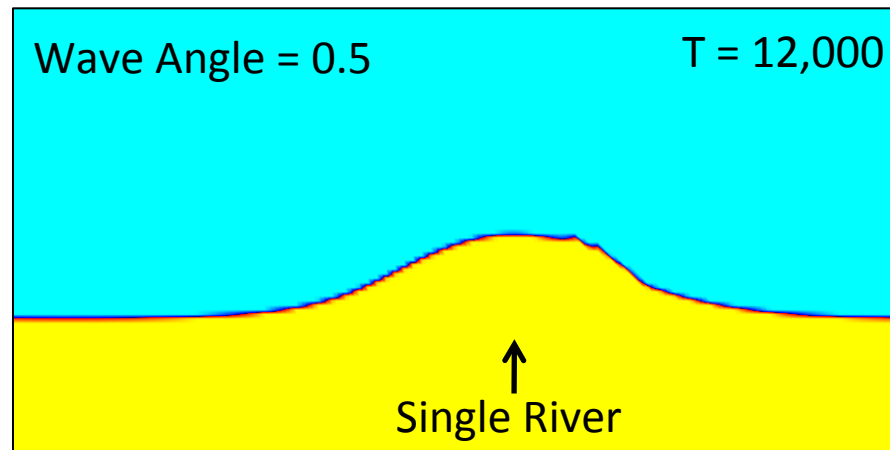
Downloads are available for Windows XP/Vista, Mac OS X,
Linux RedHat and Ubuntu

Hands-on Model Lab (1)



Simulation 1 allows simple exploration of coastal geomorphological evolution over time.
Learning Objective: Create-Describe-Interpret Model information

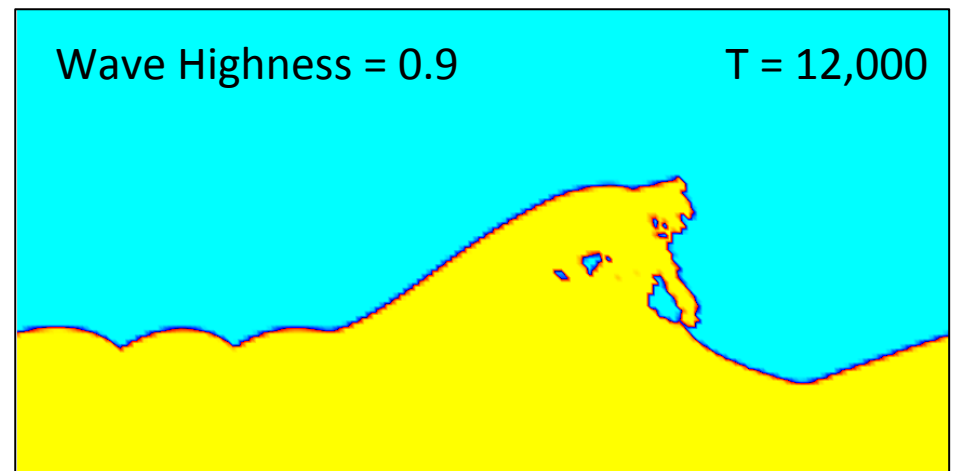
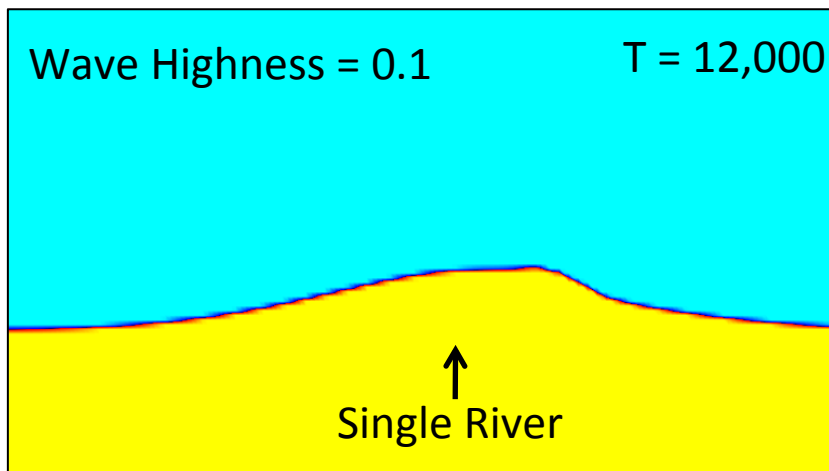
Hands-on Model Lab (2)



Simulation set 2 allows process-response relationships to be explored.

Learning Objective: Describe-Predict certain responses based on specific process parameters

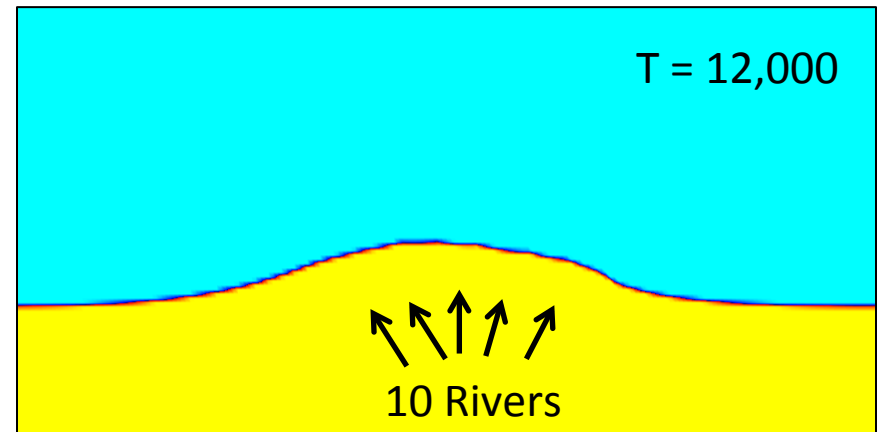
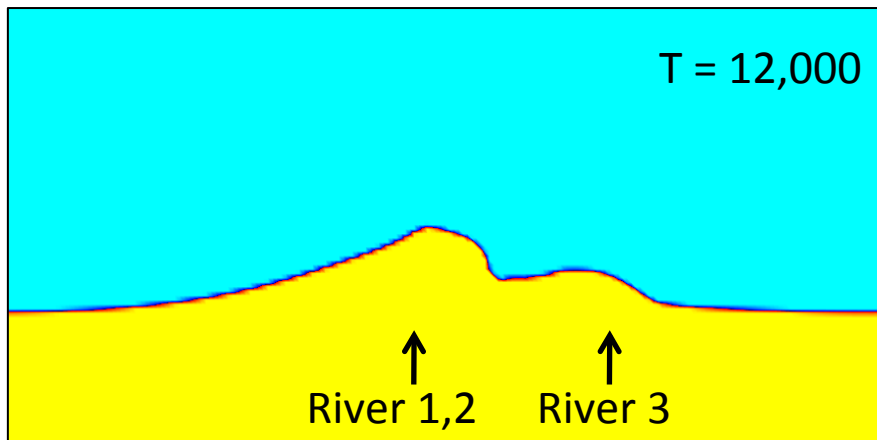
Hands-on Model Lab (2)



Simulation set 2 allows process-response relationships to be explored.

Learning Objective: Describe-Predict certain responses based on specific process parameters

Hands-on Model Lab (3)



Simulation set 3 explores feedbacks between processes. Divide bedload based on channel length. Learning Objective: Describe-Predict feedbacks between specific process parameters

A. Ashton, E. Hutton, A. Kettner, F. Xing, J. Kallumadikal, J. Nienhuis, L. Giosan, Progress in coupling models of coastline and fluvial dynamics, *Computers & Geosciences*, 53, 2013, 21-29, <http://dx.doi.org/10.1016/j.cageo.2012.04.004>.

Available Model Labs

CSDMS
COMMUNITY SURFACE DYNAMICS MODELING SYSTEM

log in

Models ▾ CMT ▾ Supercomputing ▾ **Education ▾** Data ▾ Community ▾

Labs

Want to contribute your own lab? Please contact irina@csdms.org

Labs

- Movies
- Labs**
- Lectures
- Textbooks
- Images
- Contribute
- What's new
- FAQ

Get Started with WMT

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Sediment Supply to the Global Ocean

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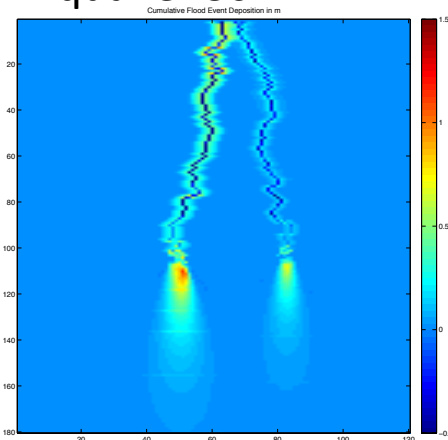
Modeling River Plumes

Riverwater and its suspended sediments will form a hypopycnal sediment plume. We will use a component called PLUME to investigate the behavior of these sediment plumes. [Plume Modeling with WMT](#)

- WMT basics
- HydroTrend
- River Plumes
- Coastal Evolution – Avulsion - Waves
- Sedflux2D Stratigraphy
- *Soon to be updated from CMT lab*
- *TOPOFLOW*
- *CHILD*
- *ERODE*

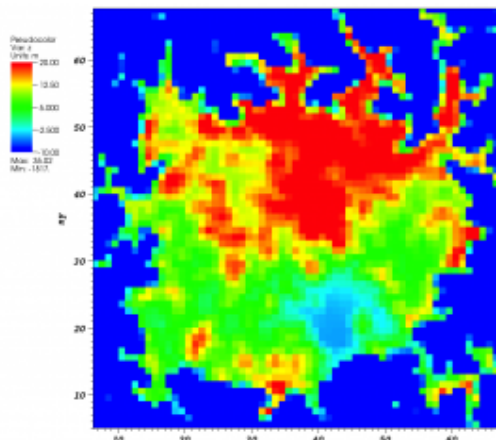
Questions and Discussion

AquaTellUs



- Community input through EKT WG
- What models are next?
 - Which topics are next?
 - What about documenting output?

ERODE



Community volunteering

- We are recruiting TA's and faculty to adopt and evaluate these teaching resources