Bringing CSDMS Models into the Classroom

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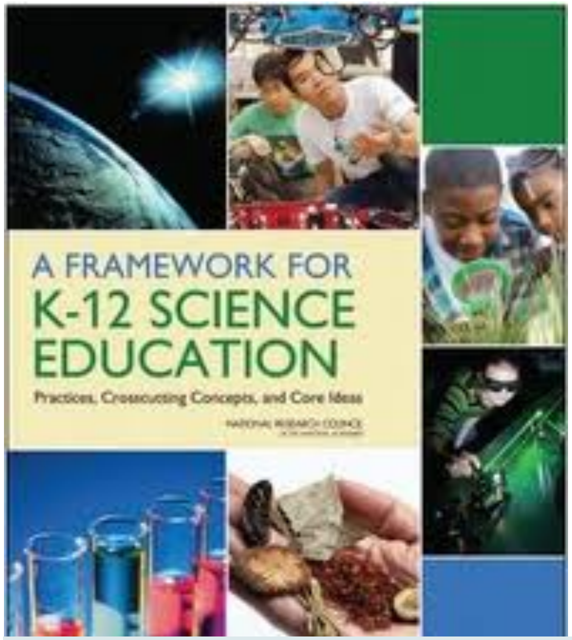
Agenda

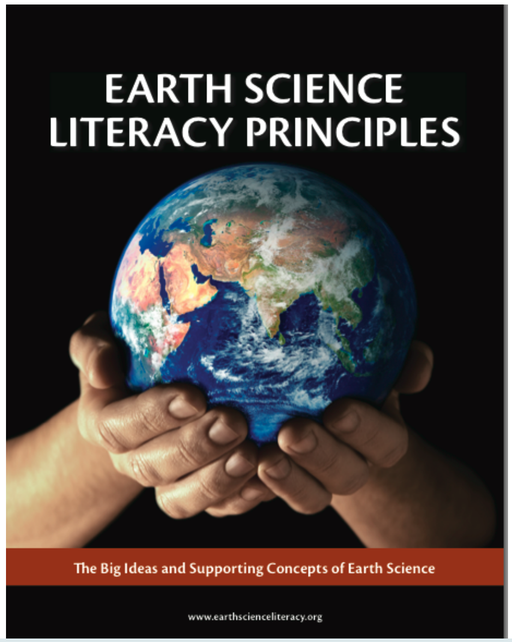
Using models in classroom?	45 minutes
Overview and demo of Web Modeling Tool	
Available Model-Labs in EKT Repository	
Hands-on Lab with ROMS-Lite	45 minutes
Visualization with Panoply	
New developments in Educational Resources	30 minutes
Discussion on community use of these resources	

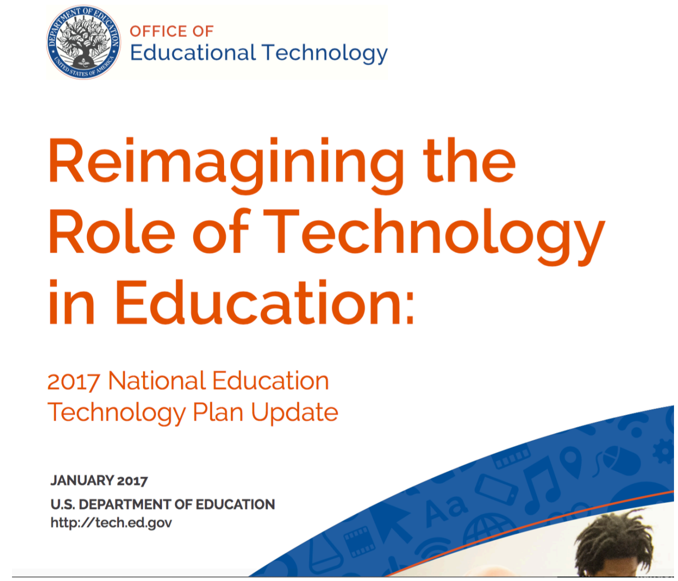
Vision

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

Why teach modeling? To Future Citizens.



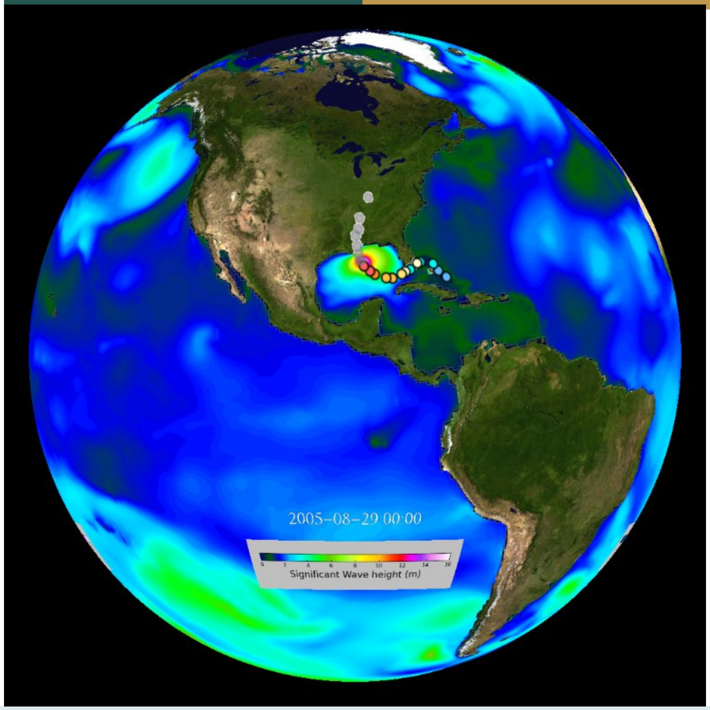




Essential basic elements of the science and engineering curriculum relate to modeling:

1. Asking questions and defining problems
2. Developing and using ‘models’
3. Analyzing and interpreting data
4. Using mathematics, information and computer technology and computational thinking
5. Constructing explanations and designing solutions
6. 2017: emphasis on targeted lesson material, flexibility and online resources.

Teach modeling to Future Earth Scientists



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

Geoscience research nowadays heavily uses models:

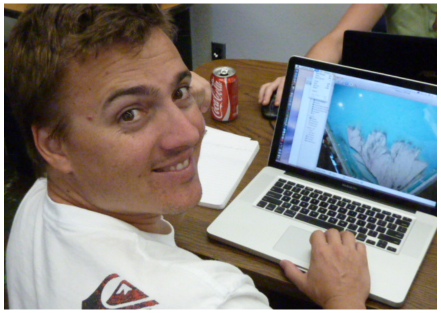
1. Asking questions and defining problems
2. Developing and using codes
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics, information and computer technology and computational thinking
6. Constructing explanations and designing solutions

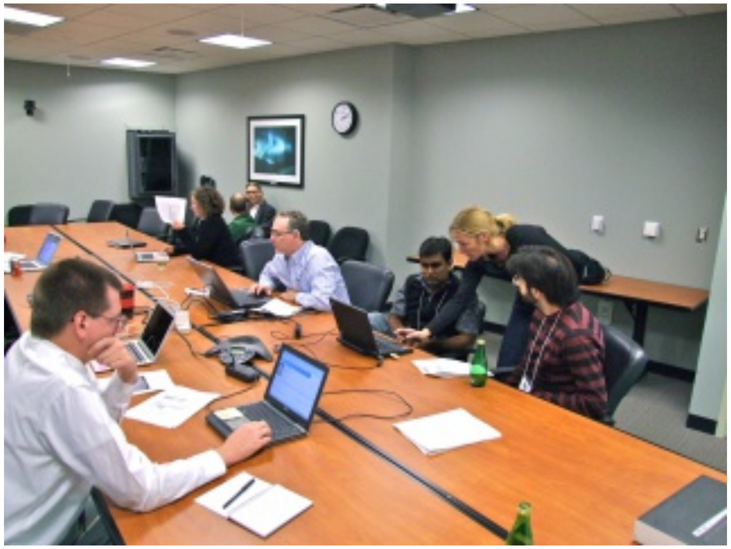
Learning outcomes of modeling labs

- Awareness of models versus instrumental data
- Awareness of simplification, assumptions and uncertainty in models
- Explore possible outcomes of a system under different parameters
- Describe feedbacks in coupled systems

- Computing skills – basic familiarity with HPCC procedures
- Efficacy with NetCDF File format and visualization

Using WMT for teaching



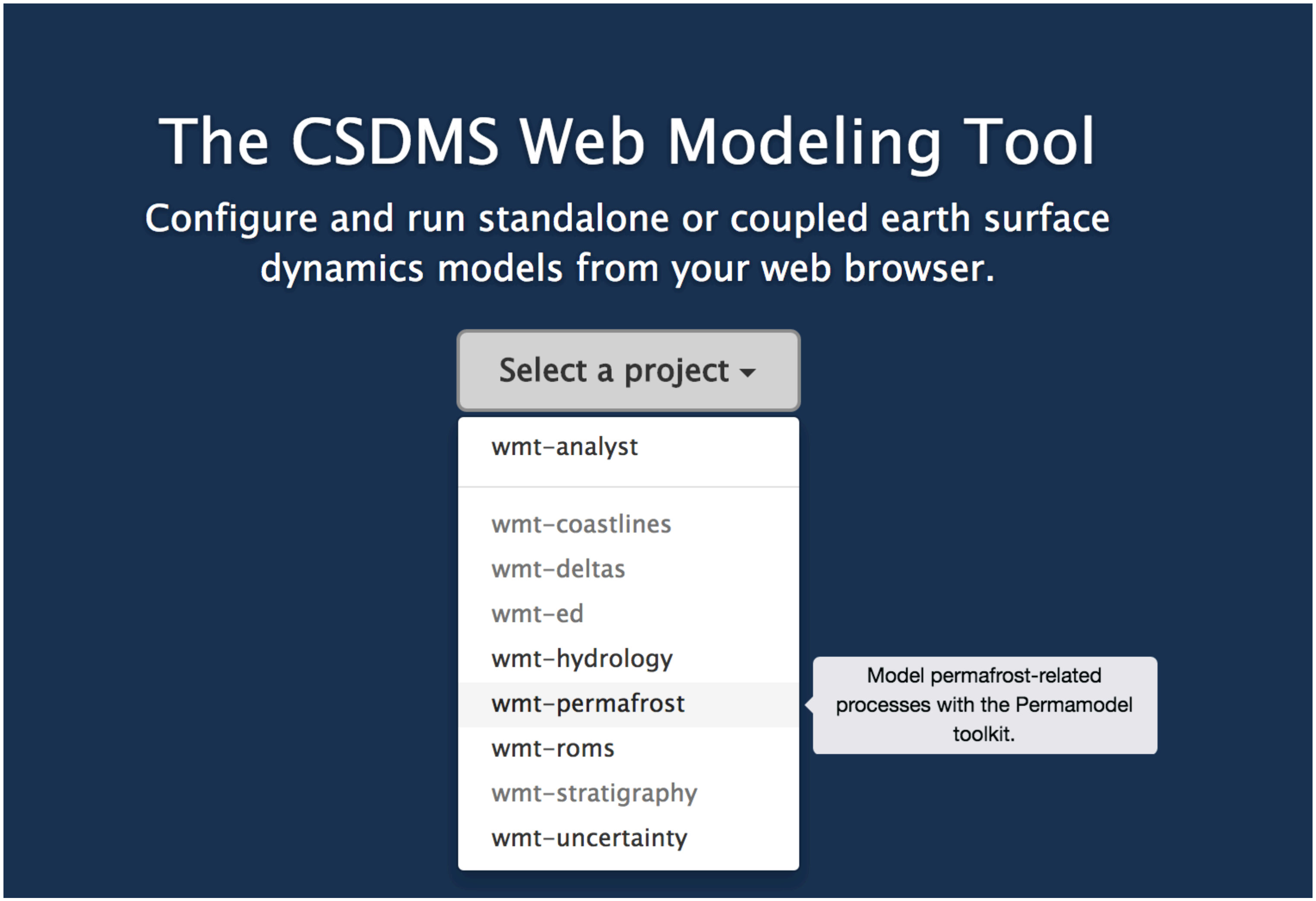


CSDMS members and > 150 graduate students have been exposed to CSDMS Modeling Tool

- CSDMS clinics from 2010 to now.
- CU graduate course on Earth Surface Process modeling
- NCED SIESD 1 or 2-day clinics from 2011-now

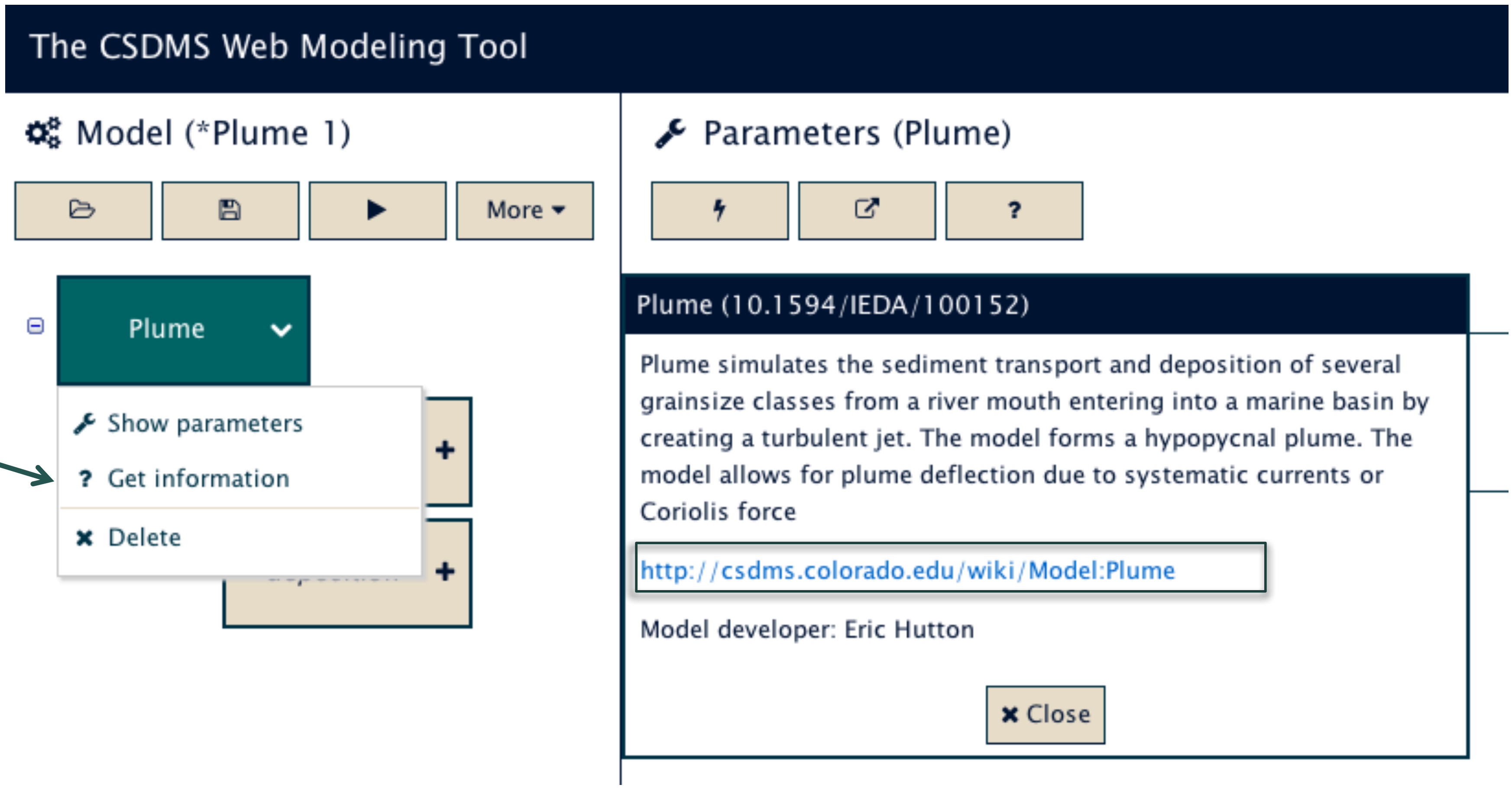
We now use the WMT, the web-based tool

Web Modeling Tool



https://csdms.colorado.edu/wmt/

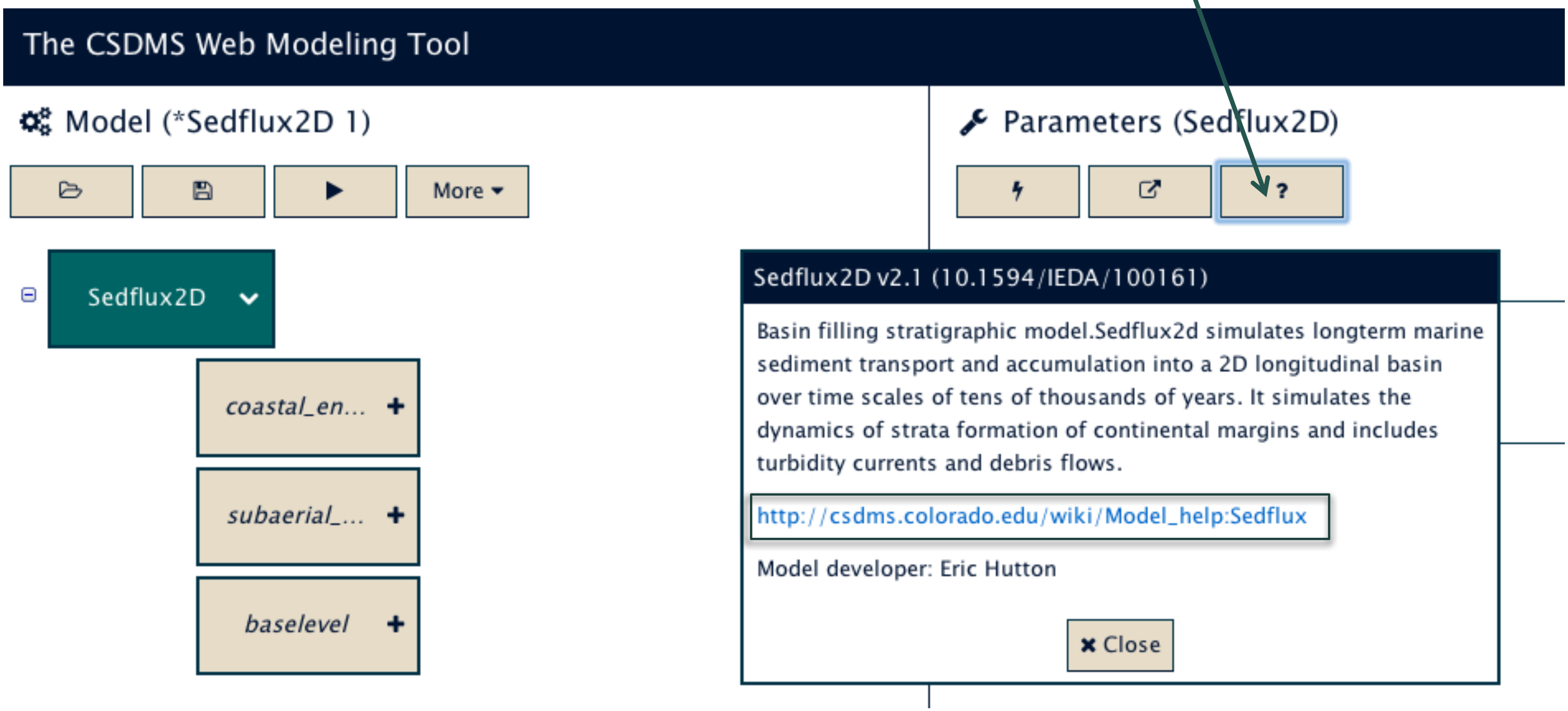
Integration between WMT and wiki



Click here

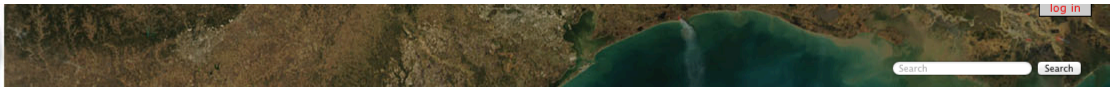
Model Help?

or Click Here



Model Help?

CSDMS
COMMUNITY SURFACE DYNAMICS MODELING SYSTEM



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

Input Files and Directories | Ports | Run Parameters | Processes | Output Grids | Output Gubes | About

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

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

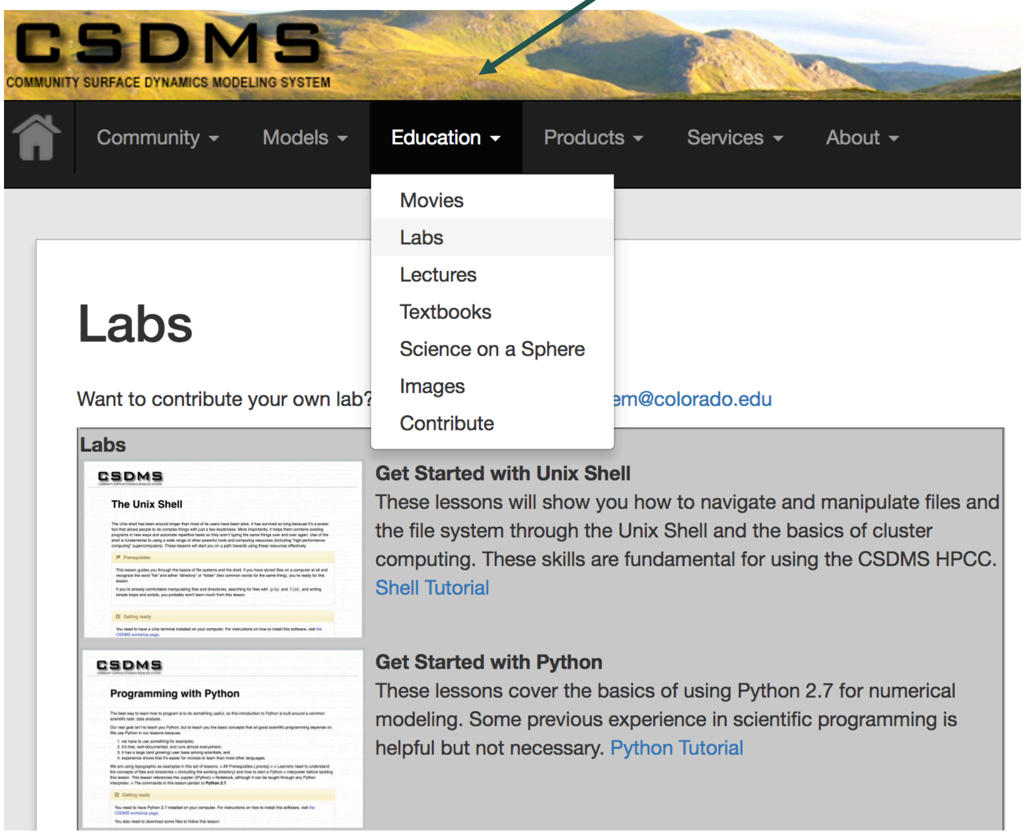
$$t(x,y) = \frac{u_0 + u_c(x) + 7u(x,y)}{9} \quad (10)$$

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

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

Existing Model Labs

Go to Education tab to find the “Labs” section



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

Model Labs

- Labs are intended for advanced undergraduate and graduate classes (2-3 hrs, with homework). Labs include:

1) Tutorial on use of WMT
2) Tutorial on simple visualizations of NetCDF output
3) Presentations on the specific model and processes.
4) Instructions to run simulations. These runs have been tested.
5) Questions to meet topical learning objectives.
6) Key references to learn more on relevant processes and models.

Logistics/classroom management

- Students need accounts on the CSDMS super-computer. This takes time; count on 4-5 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 Panoply, VisIT or ParaView (all open-source visualization tools) or Matlab. Some models have their own ASCII files. We provide a few examples with Panoply.

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 susmpended sediment (day^-1)	16.8

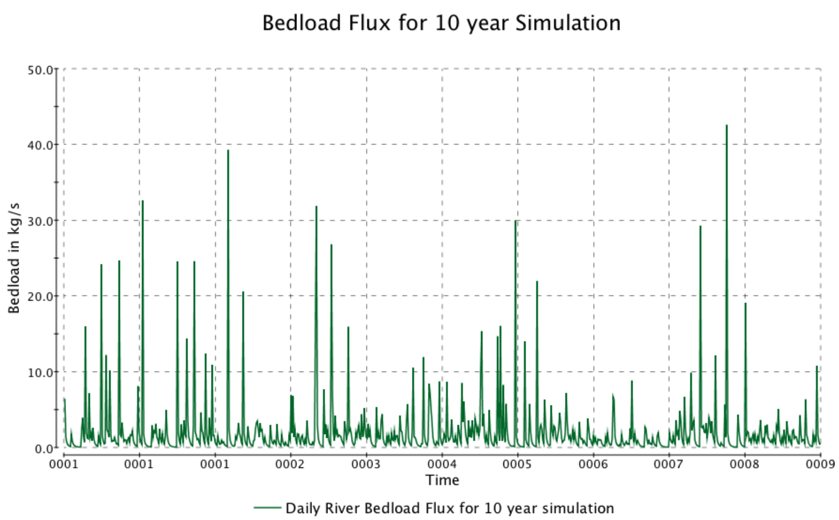
\>> Run 3 simulations of PLUME. Vary the removal rates systematically.
\>> List your parameters for grainsize and removal rate, discharge scenario and basin shape.

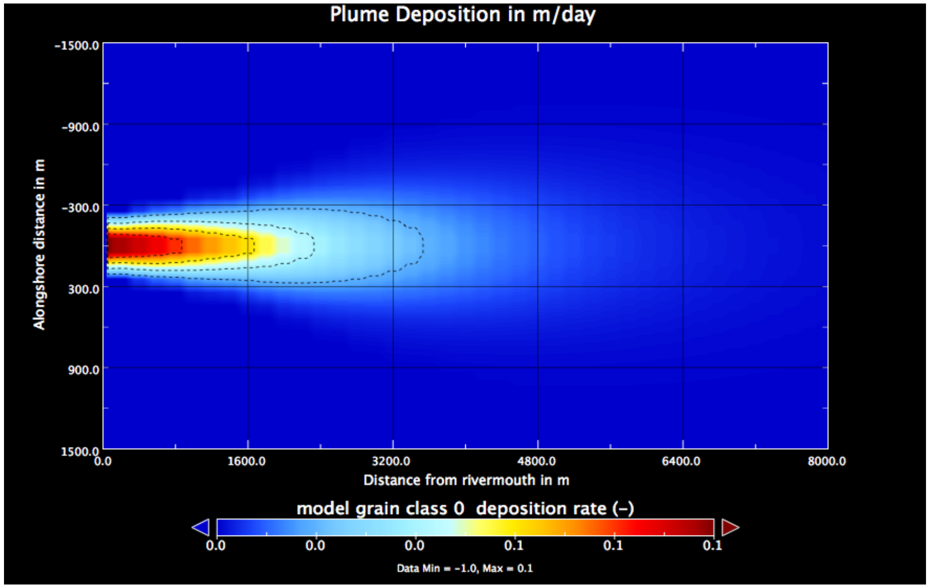
Instructions on Parameter Settings

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?
```

Visualize Output Files





Time Series Data

[For straightforward visualization of netCDF files, Panoply software is handy.](http://www.giss.nasa.gov/tools/panoply/)

http://www.giss.nasa.gov/tools/panoply/

Demonstration of WMT features

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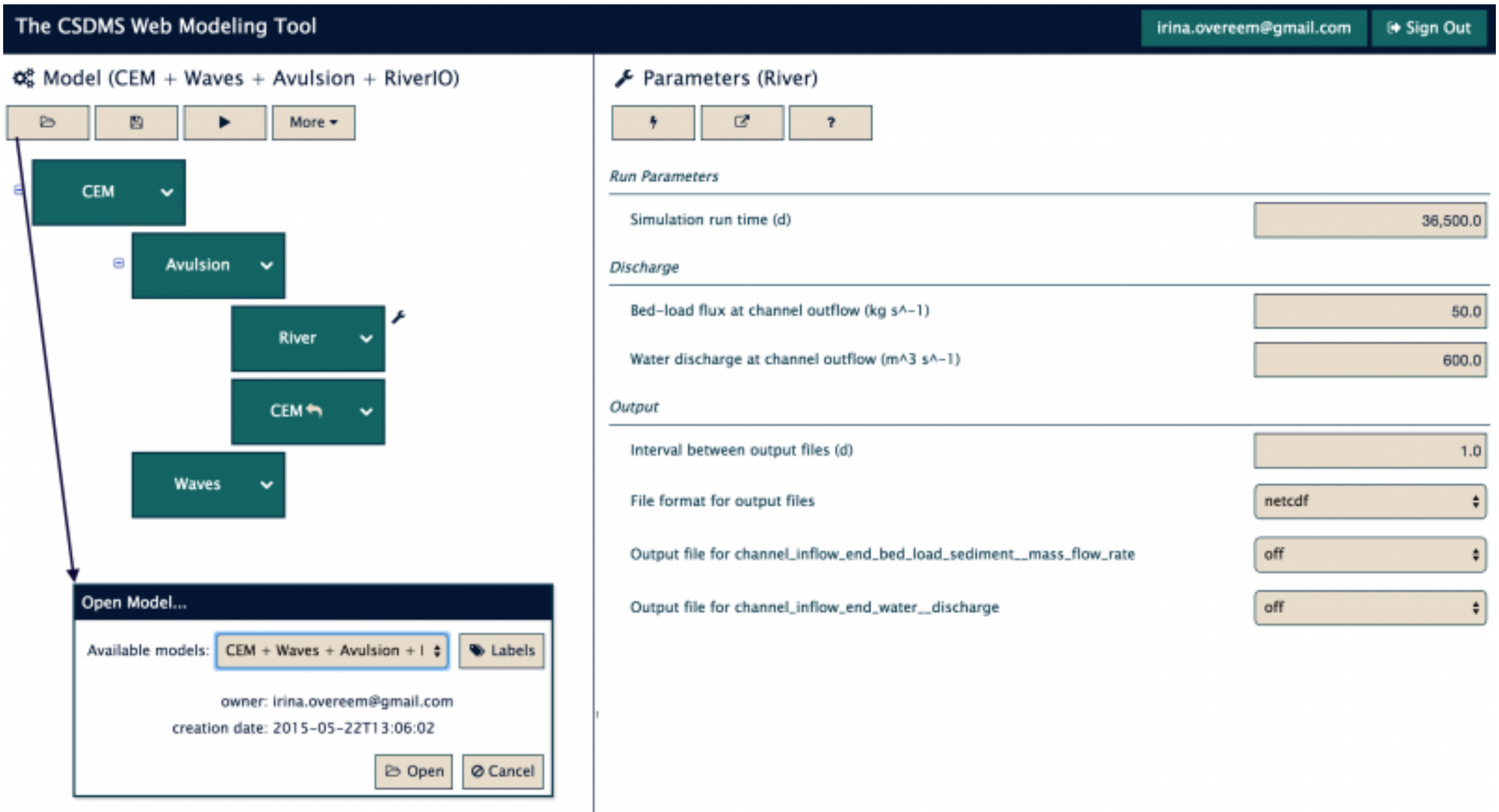
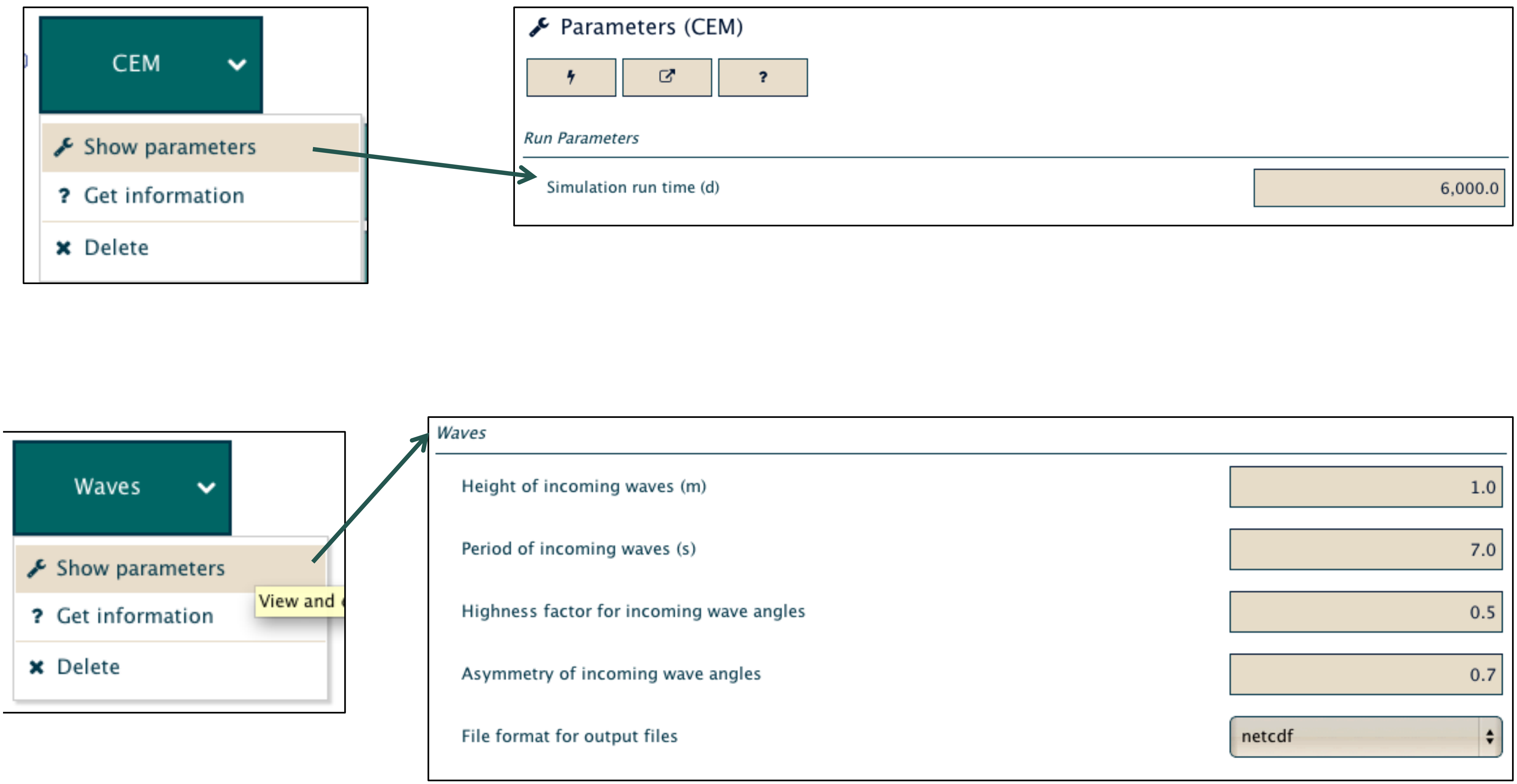
Open Example CEM+Waves+Avulsion



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

Parameter Setup



More information on Model

CEM

[edit]

Metadata

[edit]

Summary | Contact | Technical specs | In/Output | Process | Testing | Other | Component info

This part will be filled out by CSDMS staff

OpenMI compliant	No but planned
CCA component	Yes
IRF interface	Yes
CMT compontent	Yes

DOI model	10.1594/IEDA/100100
For model version	0.1.1
Year version submitted	2011

Can be coupled with:	Avulsion,

Model info

Authors [show]

Source code [show]

DOI [hide]

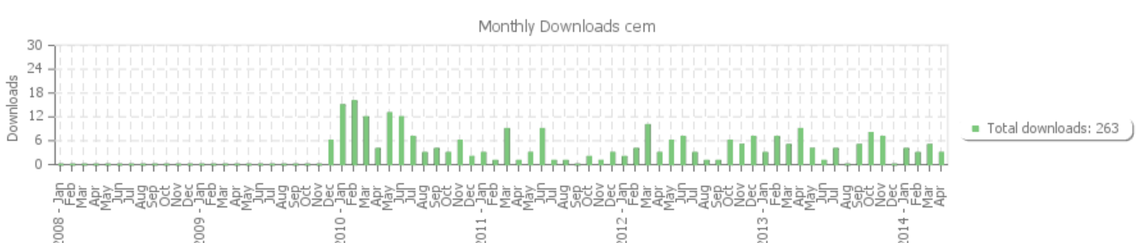
- CEM version: 0.1.1
  Doi: 10.1594/IEDA/100100

QR-code [hide]

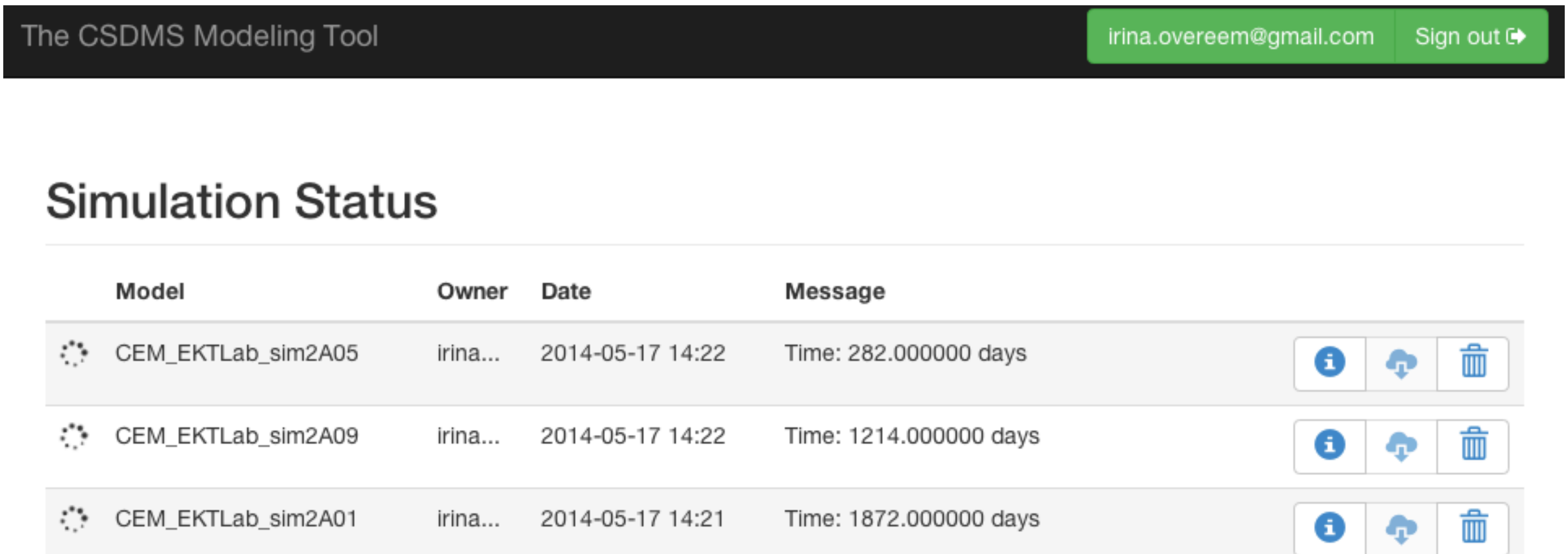
Link to this page

Other models by this author [show]

Download statistics



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

Hands-on Model Lab

Explore a model lab on coastal plume modeling (45 minutes)
ROMS-Lite, configured for teaching.

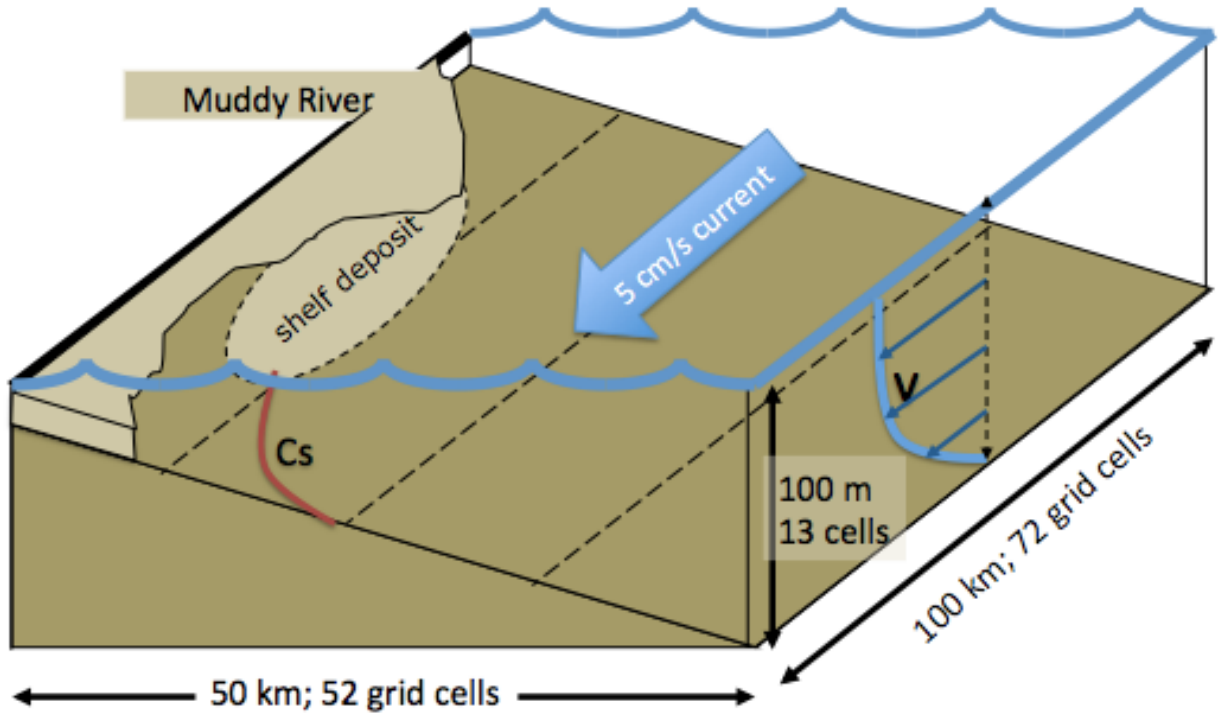
Team up with people who have their Beach account information available: you will need your user name and password.

Directions are on CSDMS wiki:
https://csdms.colorado.edu/wiki/Labs_WMT_ROMSLIte_RiverPlume

What is ROMS-Lite?

A basic configuration of the Regional Ocean Modeling System (ROMS) for inexperienced modelers to learn about ROMS, basic concepts in ocean modeling and look at a river plume affecting the coastal ocean and sediment transport.

ROMS-Lite is based on RiverPlume



We set up a basic numerical experiment with inputs considered representative for a medium-sized river draining freshwater and sediment into the coastal ocean. The river discharge is kept constant at 1500 m^3/sec.

Domain is 72 by 52 gridcells. ROMS has 20 vertical layers in the water column, and stores 10 layers in the ocean bed.

Visualize NetCDF files with Panoply

- Download Panoply software

http://www.giss.nasa.gov/tools/panoply/

This is a crossplatform application. Downloads are available for Windows XP/Vista, Mac OS X, Linux.

Panoply is designed for NetCDF files (and also handles HDF and GRIB).

If model output includes geospatial information, this software is especially powerful.

Hands-on Model Lab

Explore a model lab on coastal plume modeling (45 minutes)
ROMS-Lite, configured for teaching.

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Directions are on CSDMS wiki:
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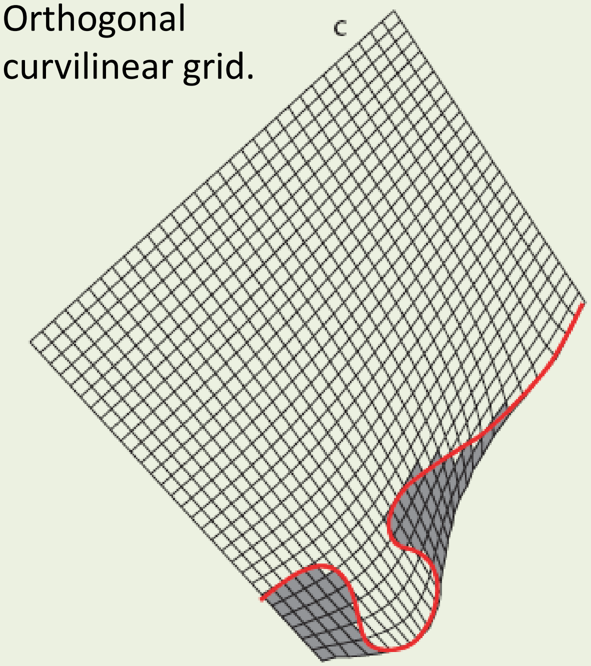
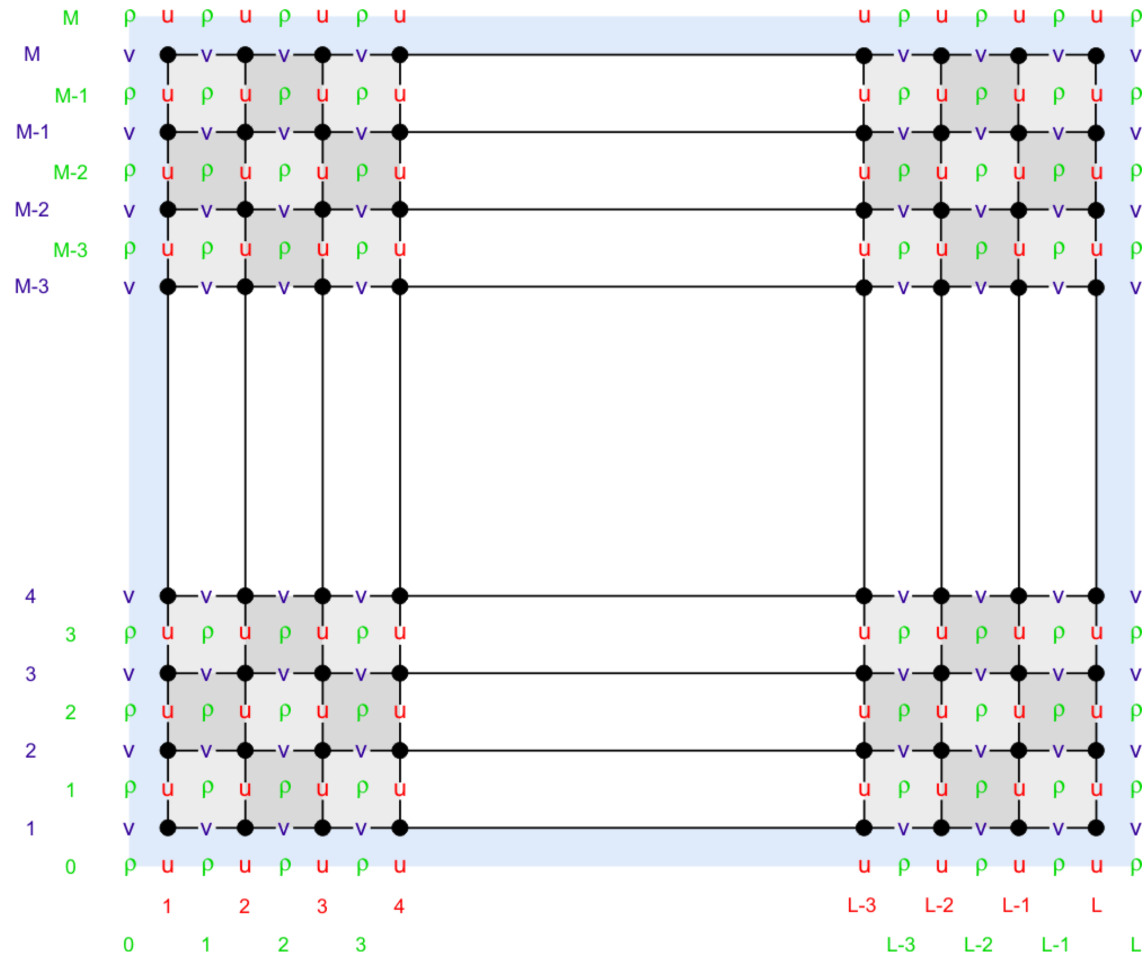
ROMS' Horizontal Grid



Orthogonal curvilinear grid.

Fringer, McWilliams, and Street, 2006.



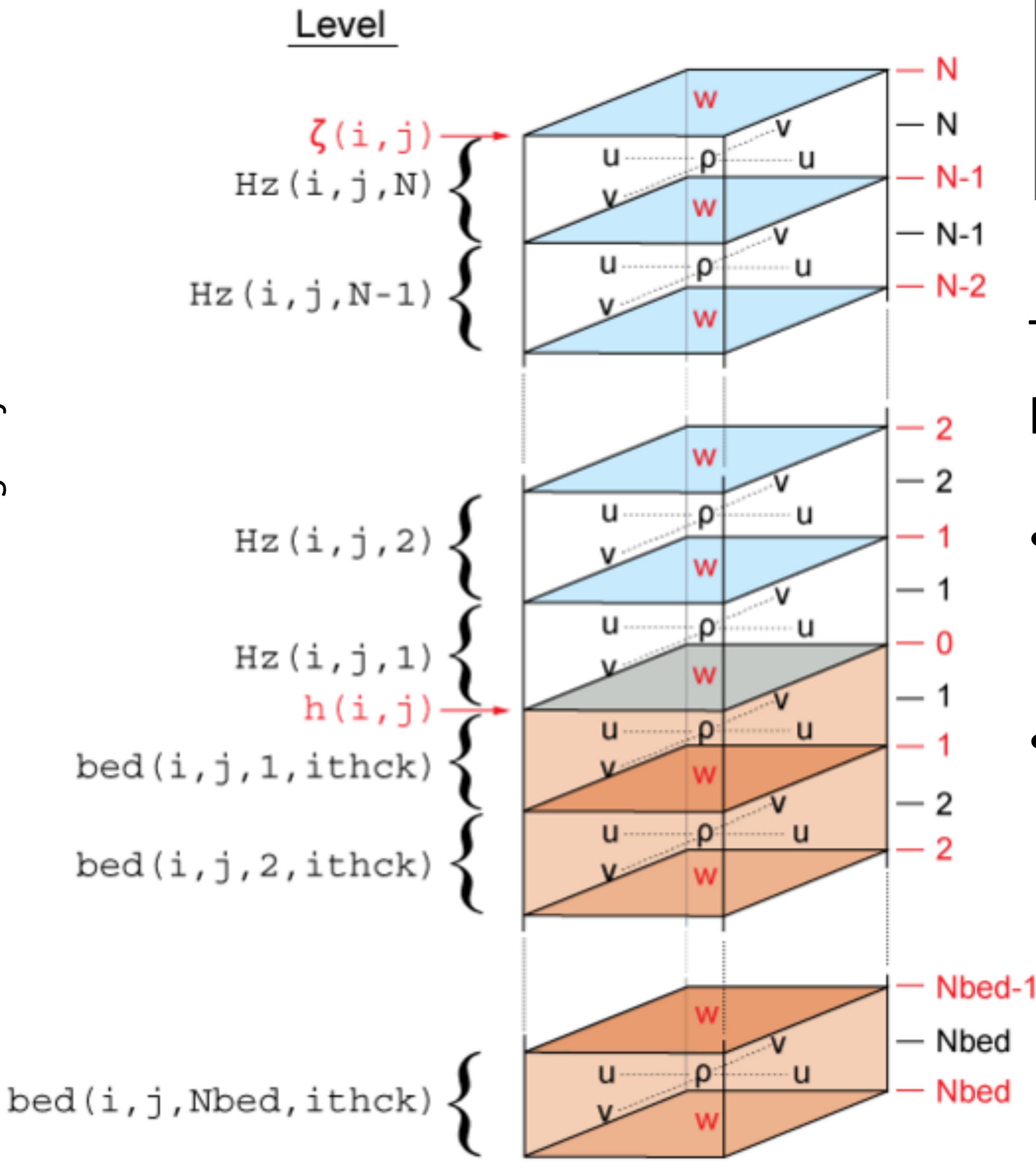
Arakawa-C grids often used in coastal models..

- U, v, w, and ρ are represented at different locations within the model grid.
- The u-, v-, and ρ-grids are different.
- The u-, v-, and ρ-grids are different *sizes*

Figures from ROMS wiki.

ROMS Vertical Grid

Figure from Warner et al. 2008



The vertical grid has two parts:

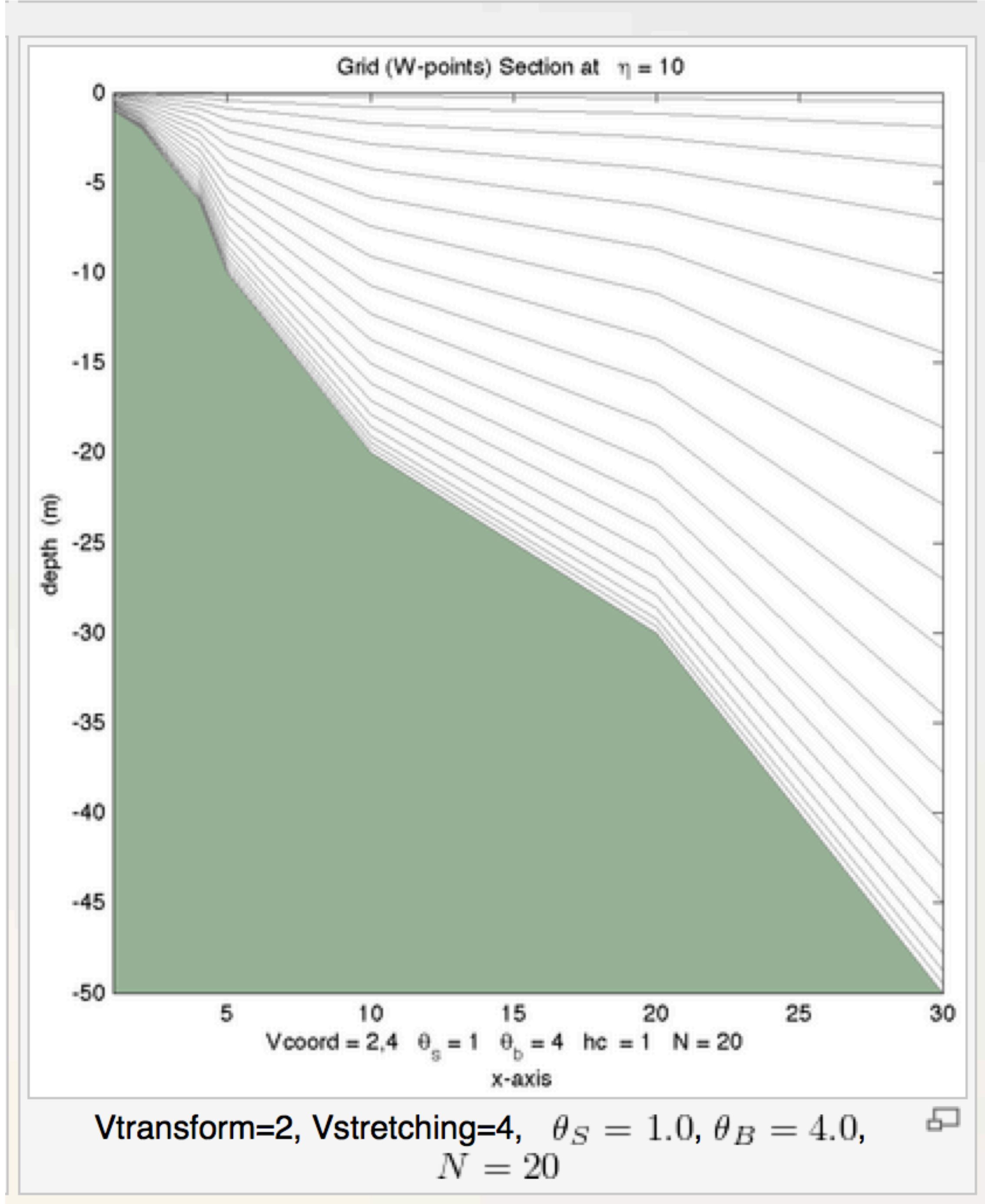
- Water column shown in blue. “N” layers.
- Sediment bed shown in brown. “Nbed” layers.

ROMS' Vertical Grid

- Terrain following.
- Number of vertical grids is constant.
- Stretched.

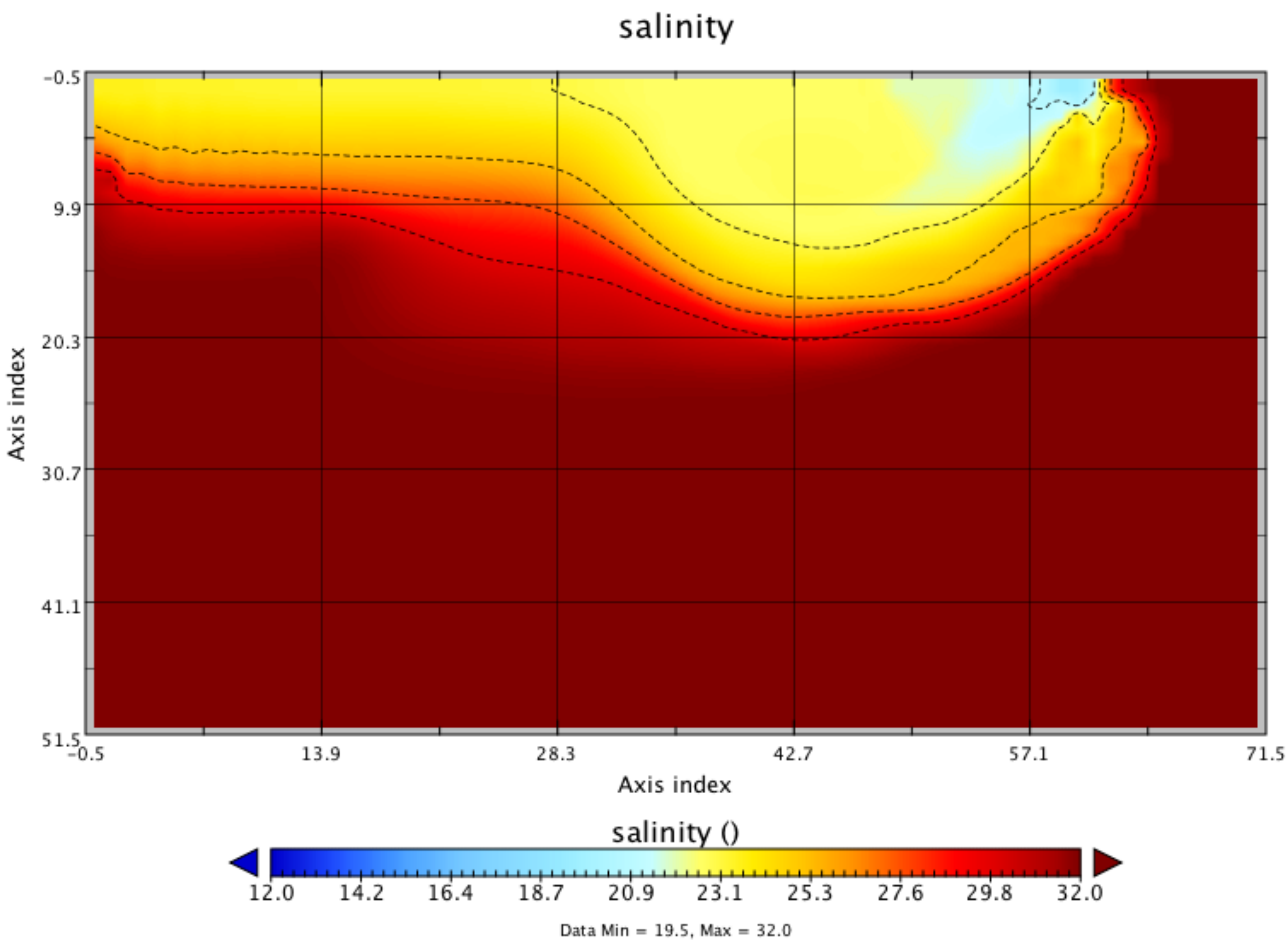
Implications:

- Can maintain thin layers at surface and bed.
- Need post-processing to calculate vertical water depths.

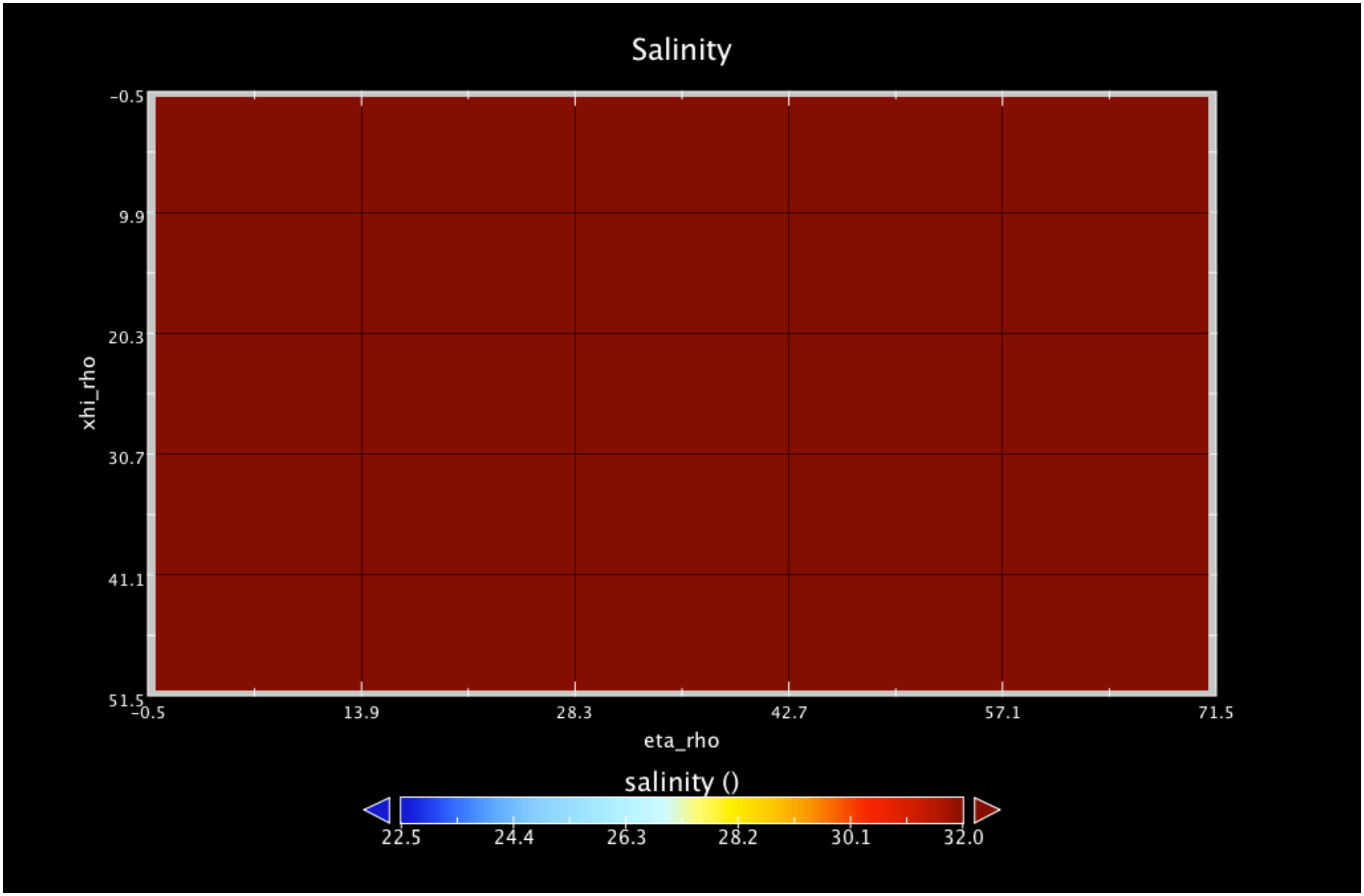


Example figure from ROMS wiki

Hands-on Model Lab (1)



Salinity at the River Mouth
X-section, 96 hours simulation



Model estimates for different river discharges
Salinity and velocity

Figure by Fei Ye, VIMS

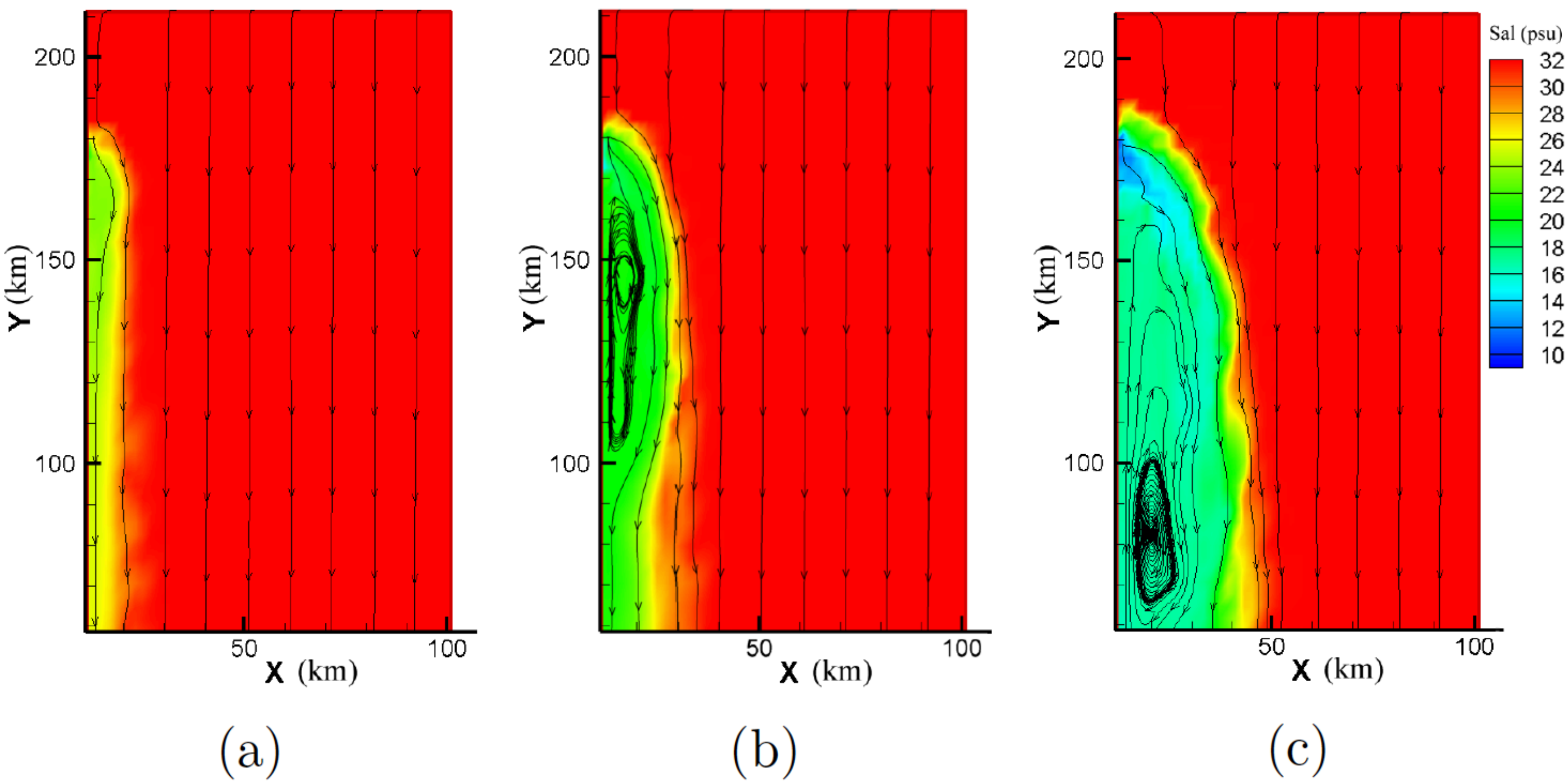
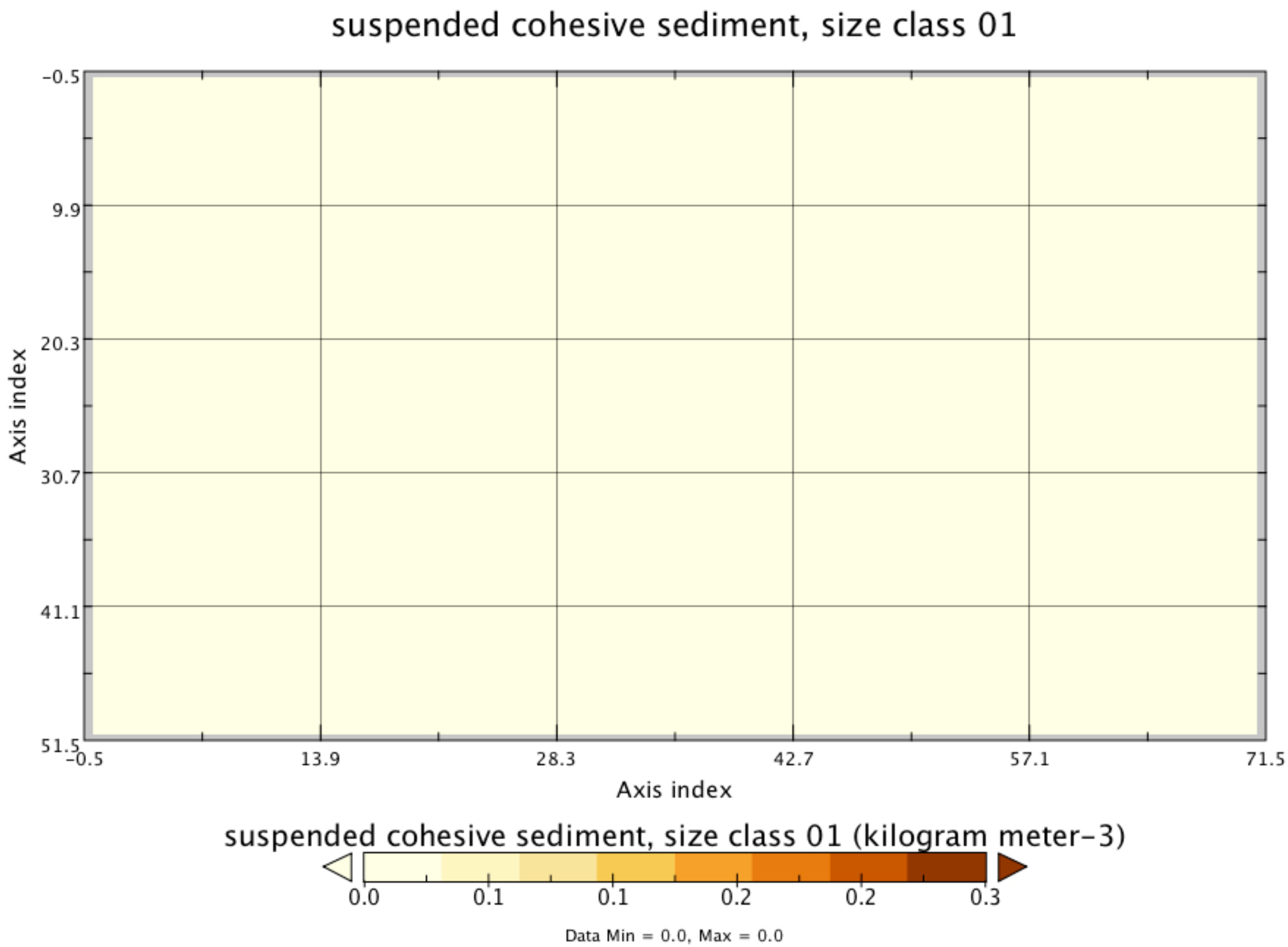
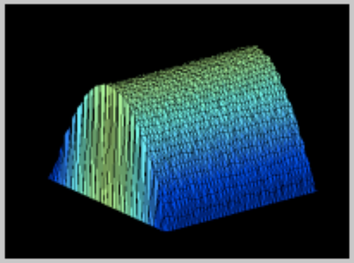


Figure 2: Surface salinity and surface streamlines. River Discharge: (a) 750 m^3/s; (b) 1500 m^3/s; (c) 3500 m^3/s. The domain is truncated at Y=58.5 km to exclude the erroneous flow pattern near the south boundary.

Suspended Sediment Concentration Planview, 96 hours simulation

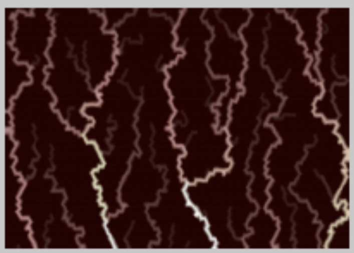


Available Model Labs



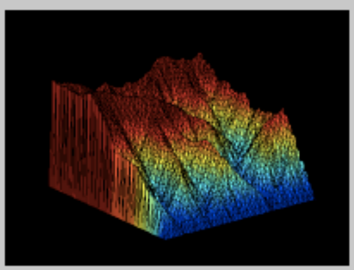
Landscape Evolution Modeling with CHILD, Part 1

Introduction to landscape evolution modeling with CHILD in WMT. Part 1 covers continuity of mass and discretization, and gravitational hillslope transport. Matlab is required to visualize the model output.



Landscape Evolution Modeling with CHILD, Part 2

Introduction to landscape evolution modeling with CHILD in WMT. Part 2 covers rainfall, runoff and drainage networks and hydraulic geometry. Matlab is required to visualize the model output.

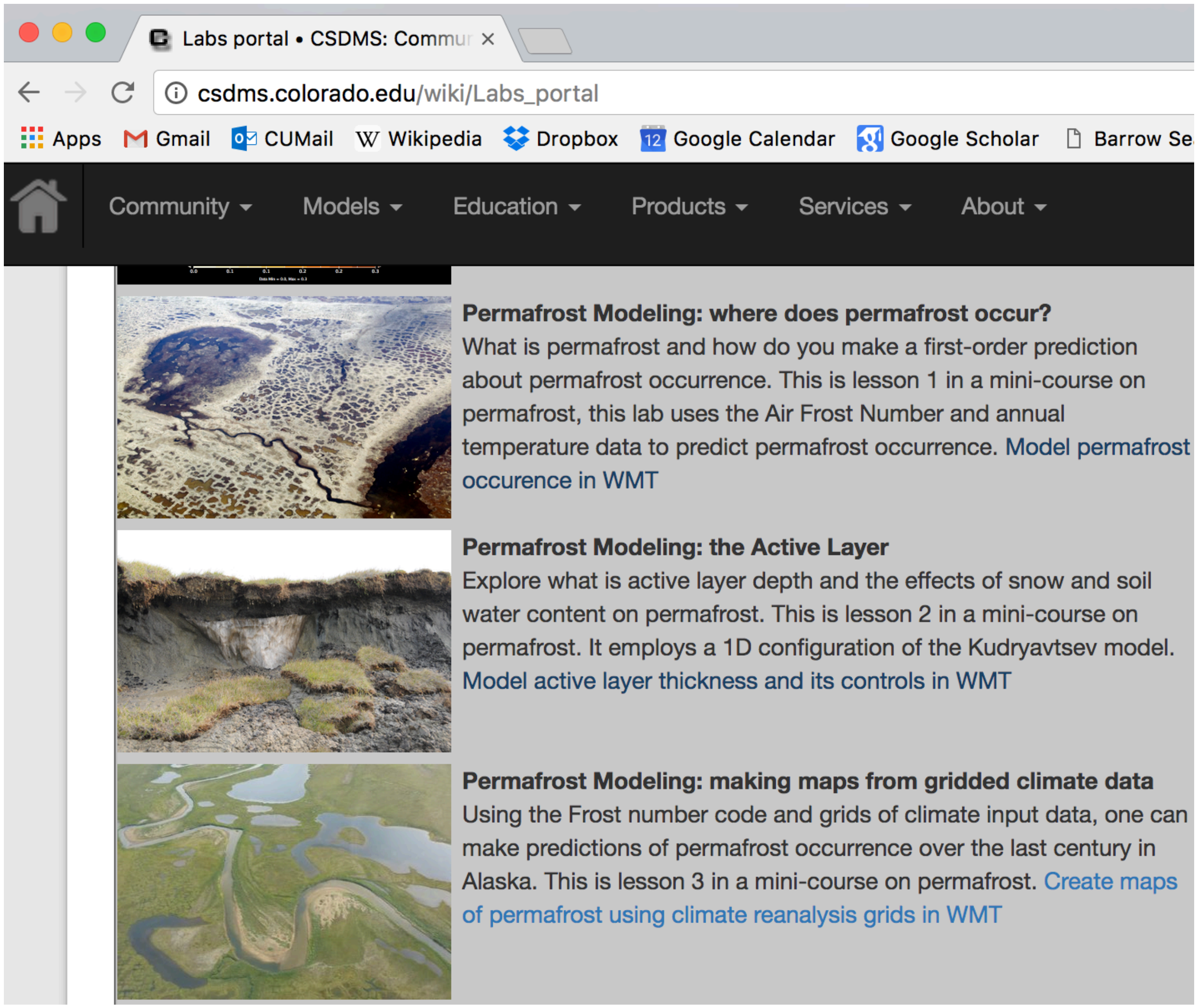


Landscape Evolution Modeling with CHILD, Part 3

More landscape evolution modeling with CHILD in WMT. Part 3 covers erosion and transport by running water, multiple grain sizes, and the Ten Commandments of Landscape Evolution Modeling. Matlab is required to visualize the model output.

- Introduction to WMT and Panoply
- HydroTrend
- HydroTrend and CESM input for future predictions
- River Plumes
- Coastal Evolution – Avulsion - Waves
- Stratigraphic modeling Sedflux2D and 3D
- Landscape Evolution Modeling with CHILD (Hillslopes, Drainage Networks, Erosion and Deposition, series of 3 labs modified from teaching material by Greg Tucker)
- TOPOFLOW hydrological modeling (3 labs)
- ROMS-Lite coastal processes (3 labs designed by Courtney Harris and Julia Moriarity
- Permafrost Labs (3 labs from permafrost modeling project)

Available Model Labs



Questions and Discussion

Community input through EKT WG

- What models are next?
- Which topics are next?
- What about documenting output?

Community volunteering

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

A couple of Future Developments

- WMT and Dakota, develop associated teaching material
- RC-Delta, reduced complexity model of deltaic processes
- Pre- and post lab assessments

- Pathways to programming; IPython Notebooks