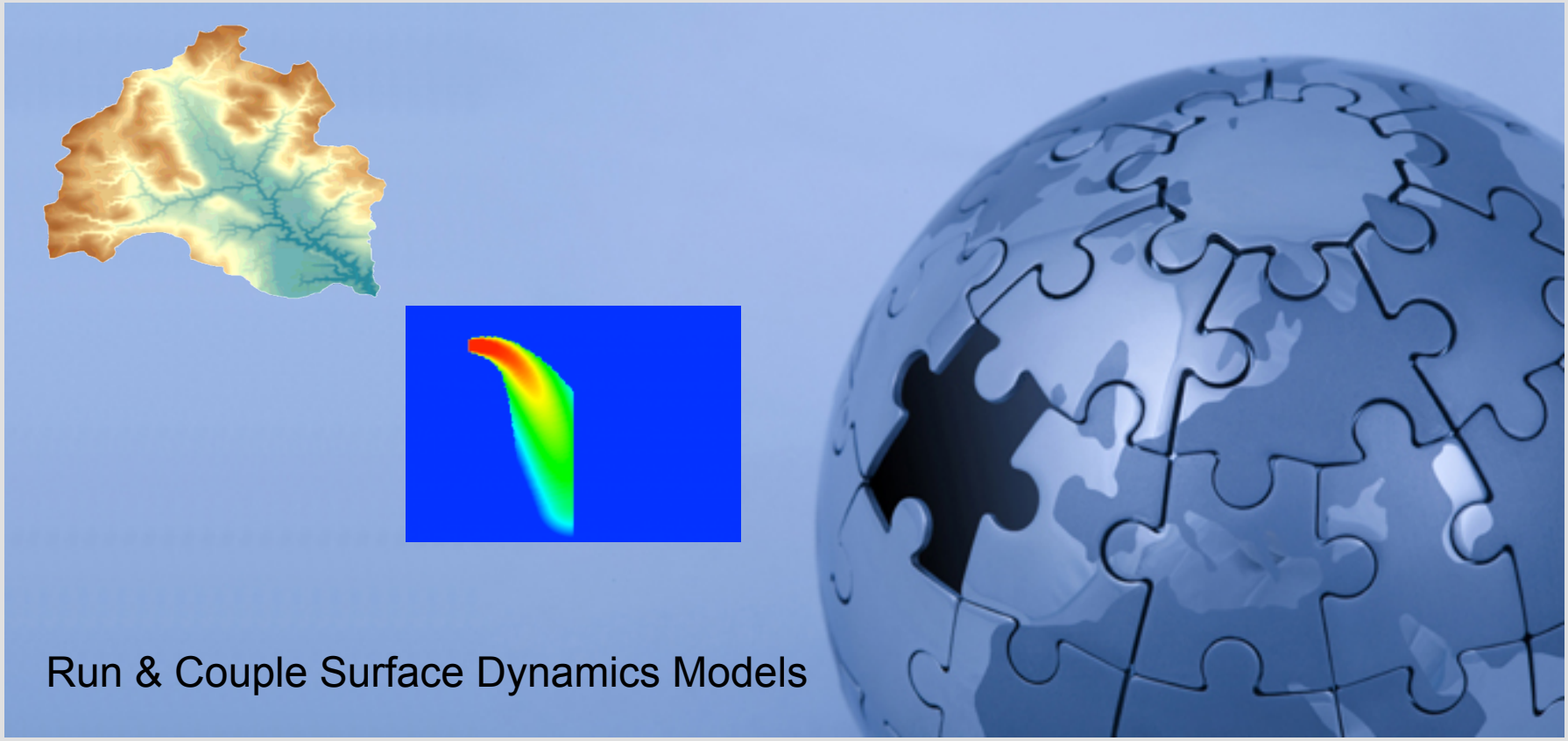
# CSDMS Component Modeling Tool Introduction




By Irina Overeem, March 2013

# Outline

Introduction
- Vision behind CMT
- Update on Existing Components

Basic CMT functionality
- Select Projects
- Workspace
- Set Up and Run Simulations
- Visualization with VisIt

Demo 1
- Run a Stand-alone Model

Demo 2
- Set-Up and Run Coupled Model

15 Minutes – Questions, Sign-up for an Account, troubleshoot VPN or CMT

# Grand Vision behind CMT

Develop a modeling framework of inter-connectable process modules able to predict the transport and deposition of water, sediment and nutrients over the Earth's surfaces, and how surfaces evolve over a broad range of time and space scales.

- Empowering users to model science questions...
- Streamlining process of idea generation to actual simulation….
- Be inclusive, modular, and user-friendly…..

# What Framework Services?

(1) Platform-independent *GUI CMT* (Linux, Mac OS X, Windows)

(2) Language interoperability (C, C++, Java, Python, Fortran) with *Babel;*

*(3)* Component preparation & project management using *Bocca;*

*(4)* Low-level model coupling within a HPC environment using *Ccaffeine;*

*(5)* Single-processor spatial regridding (OpenMI *Regrid)* or multi-processor spatial regridding (ESMF *Regrid)* – all grid types;

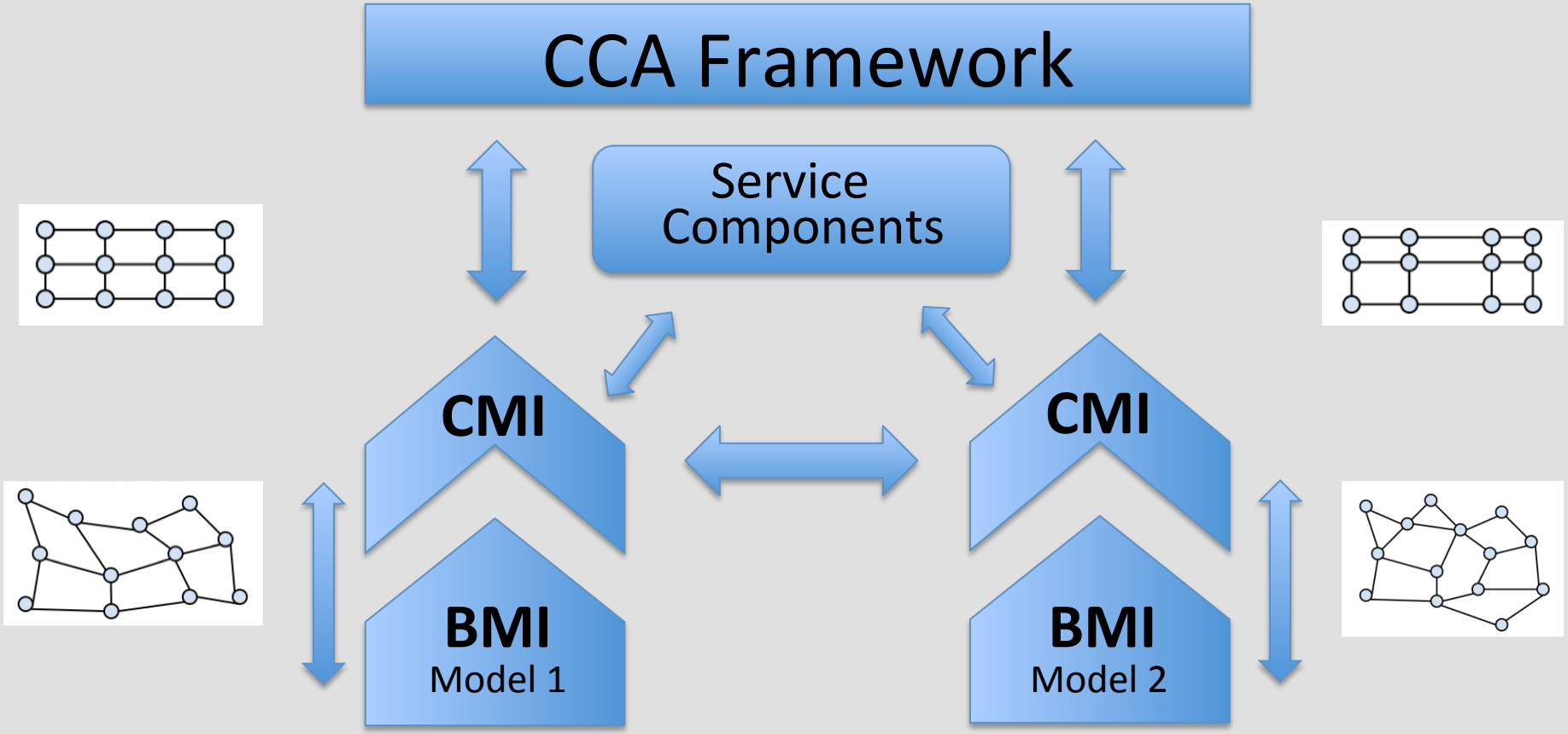
(6) Component interface standards BMI & CMI;

(7) Open-source standards (e.g. CCA, MPI, NetCDF I/O, OpenDAP).

*(8)* Visualization of large datasets in a multiple processor environment (*VisIt)*

*(9)* Platform for help / documentation associated with models to make them transparent

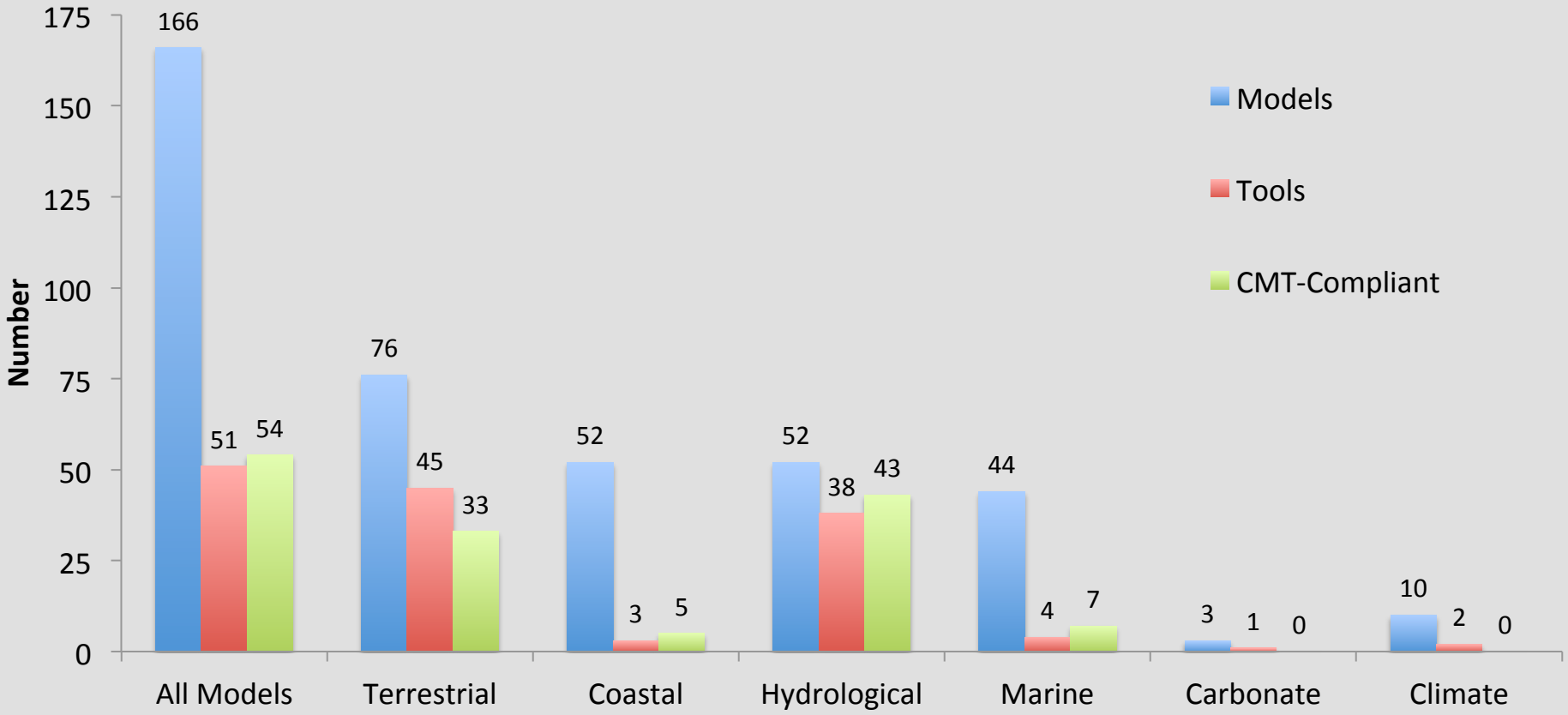
# Protocols for CSDMS-component models




**BMI** CSDMS "Basic Model Interface" is a set of public functions for developers

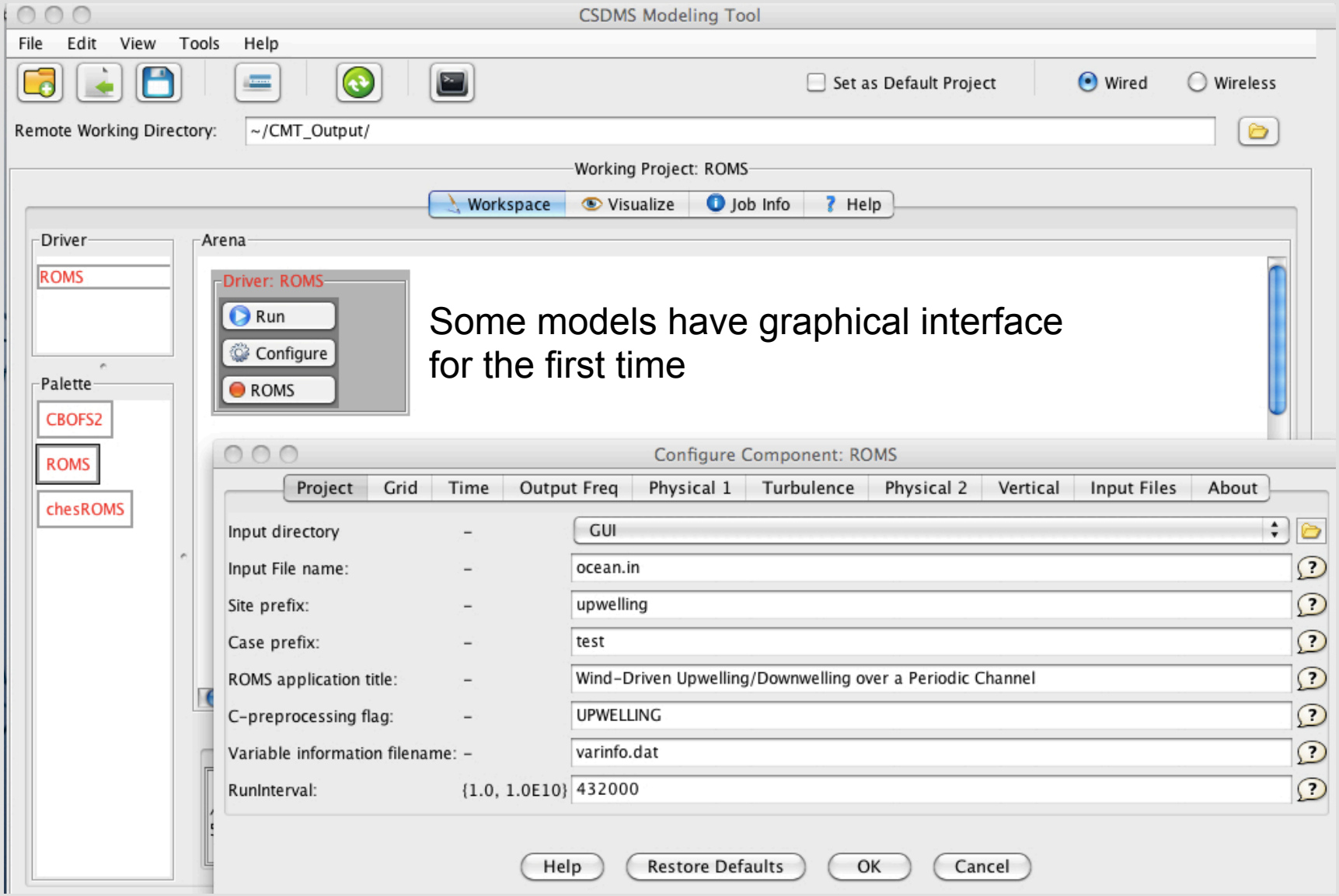
**CMI** CSDMS “Component Model Interface” provides BMI components with CMT services for coupling models written in different: 1) programming languages, 2) computational grids, 3) time-stepping, 4) variable names, 5) units; or 6) to run models on HPCC, or to 6) write output to NetCDF files (and future service functionality….)

# Number of Components

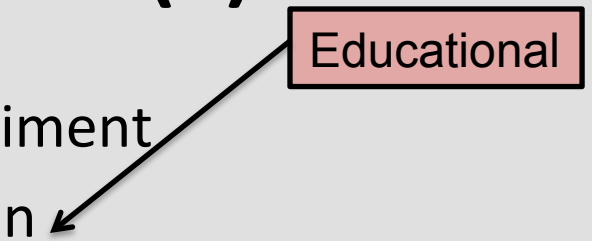



A total of 54 components: first scientific papers are published
Another main use is in graduate classes & clinics (4 courses, 4 clinics 2009-2012)

# Available Projects in CMT (1)



# Available Projects in CMT (2)




- HYDROTREND – river basin runoff and sediment
- PLUME – 2D river plumes into marine basin
- COASTAL EVOLUTION MODEL (CEM) – wave dominated coasts
- WAVES – wave climate generator
- CEM-HYDROTREND-AVULSION-WAVES coupled


- D8 FLOW - determine flowpaths on elevation grids
- TOPOFLOW – hydrological toolbox (precipitation, infiltration, evapotranspiration, runoff, snow, channel dynamics)
- Data – HIS service component


- GC2D – glacier model
- TOPOFLOW – GC2D coupled
- Sediment Transport Models (e-book)

# How to Get and Use CMT?

# CMT runs on Beach

Download the CMT
to your computer

PRE-REQUISITES

- Need to be a member
- Need an account to use HPCC
- Need a secure connection (with VPN)

- Realize you are one of many users
- Realize that 2-way traffic is ongoing

Beach in Colorado
512 nodes 4U

Beach will have a new head-node in Spring 2013;
will ease use, not competing with intensive model & data simulations

# Download CMT

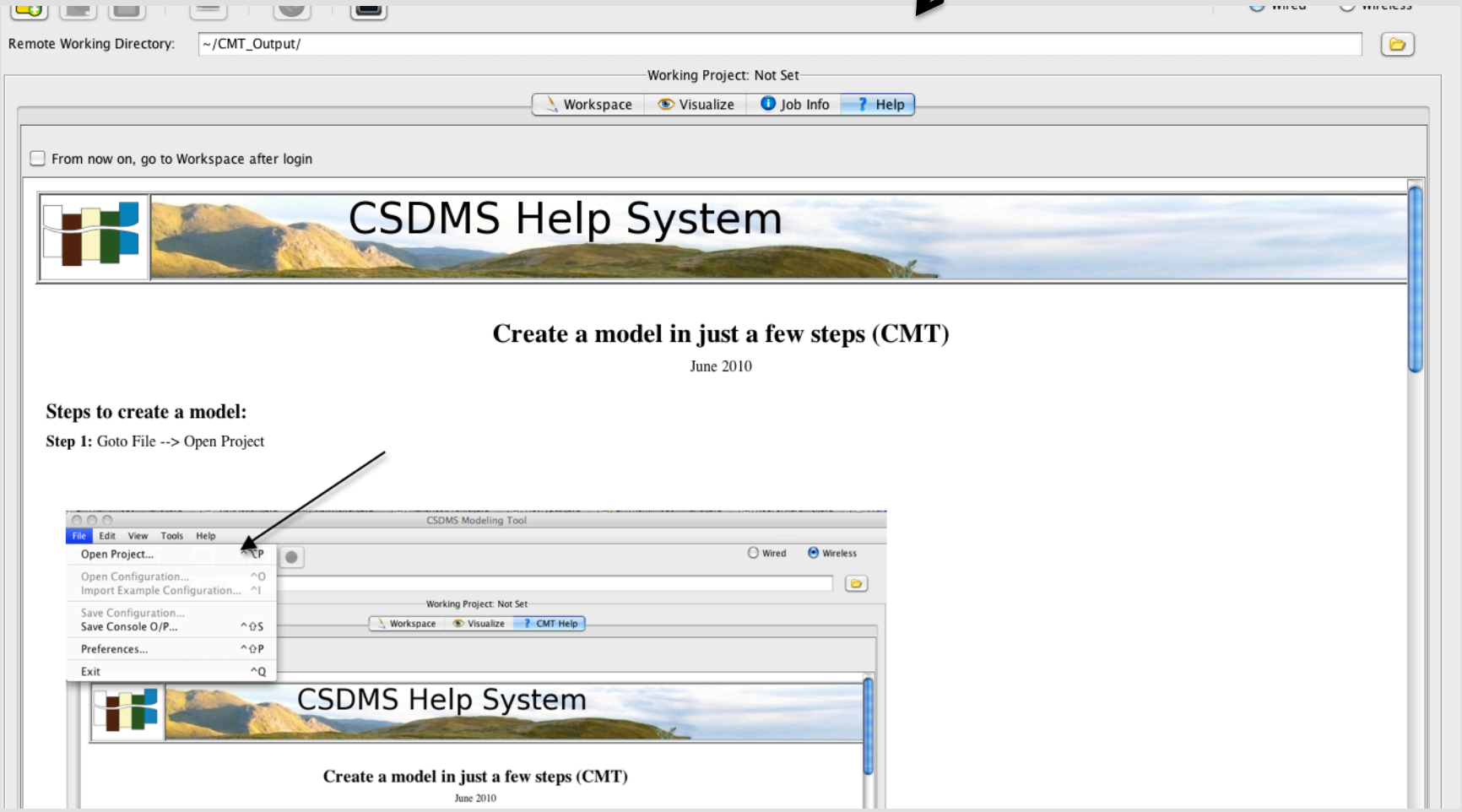
Get Help! information on the CMT


Info Here

Download from CSDMS wiki: http://csdms.colorado.edu

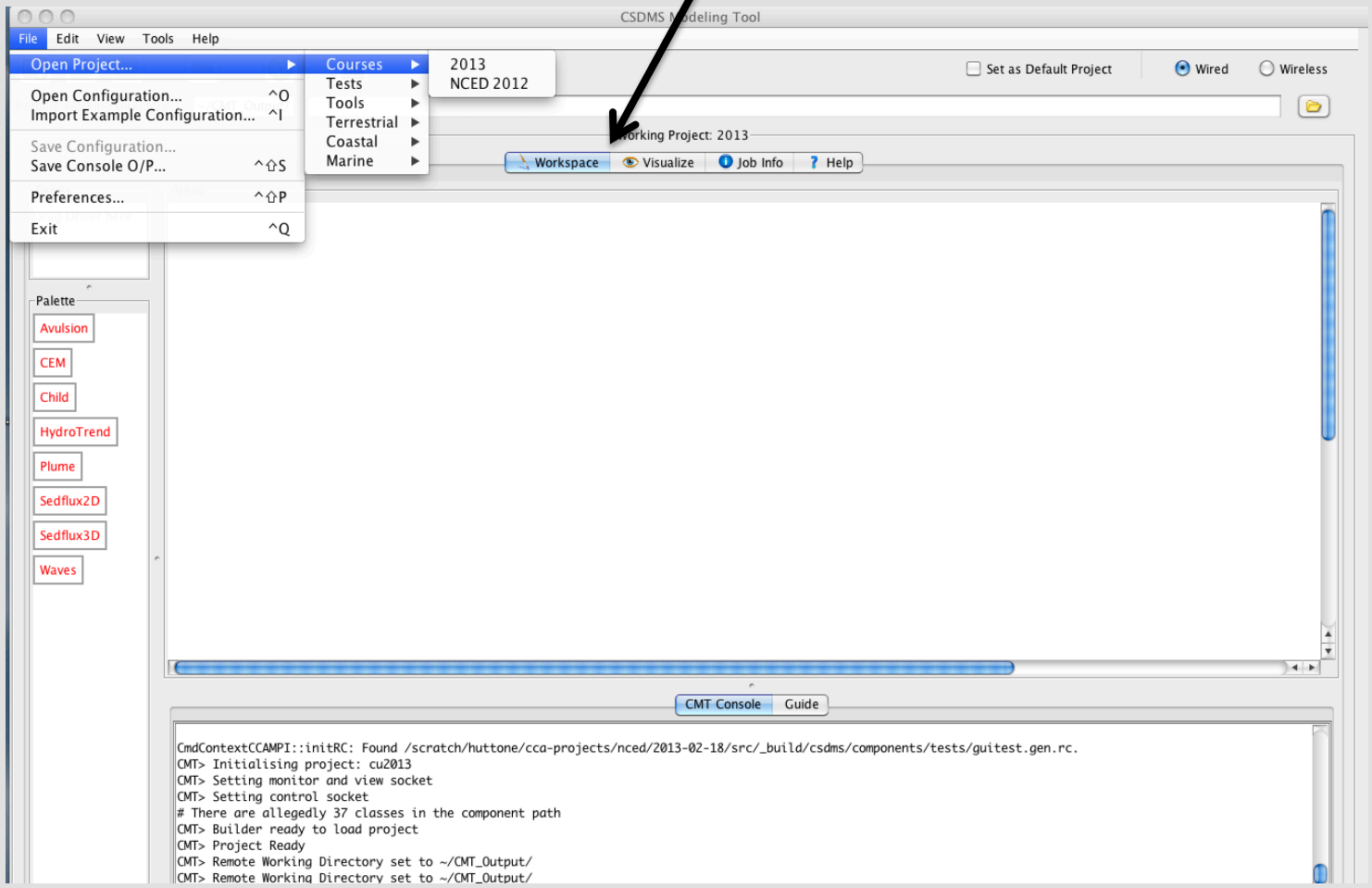
# CMT Default Start-Up Screen

Workspace Visualize Job Info Help

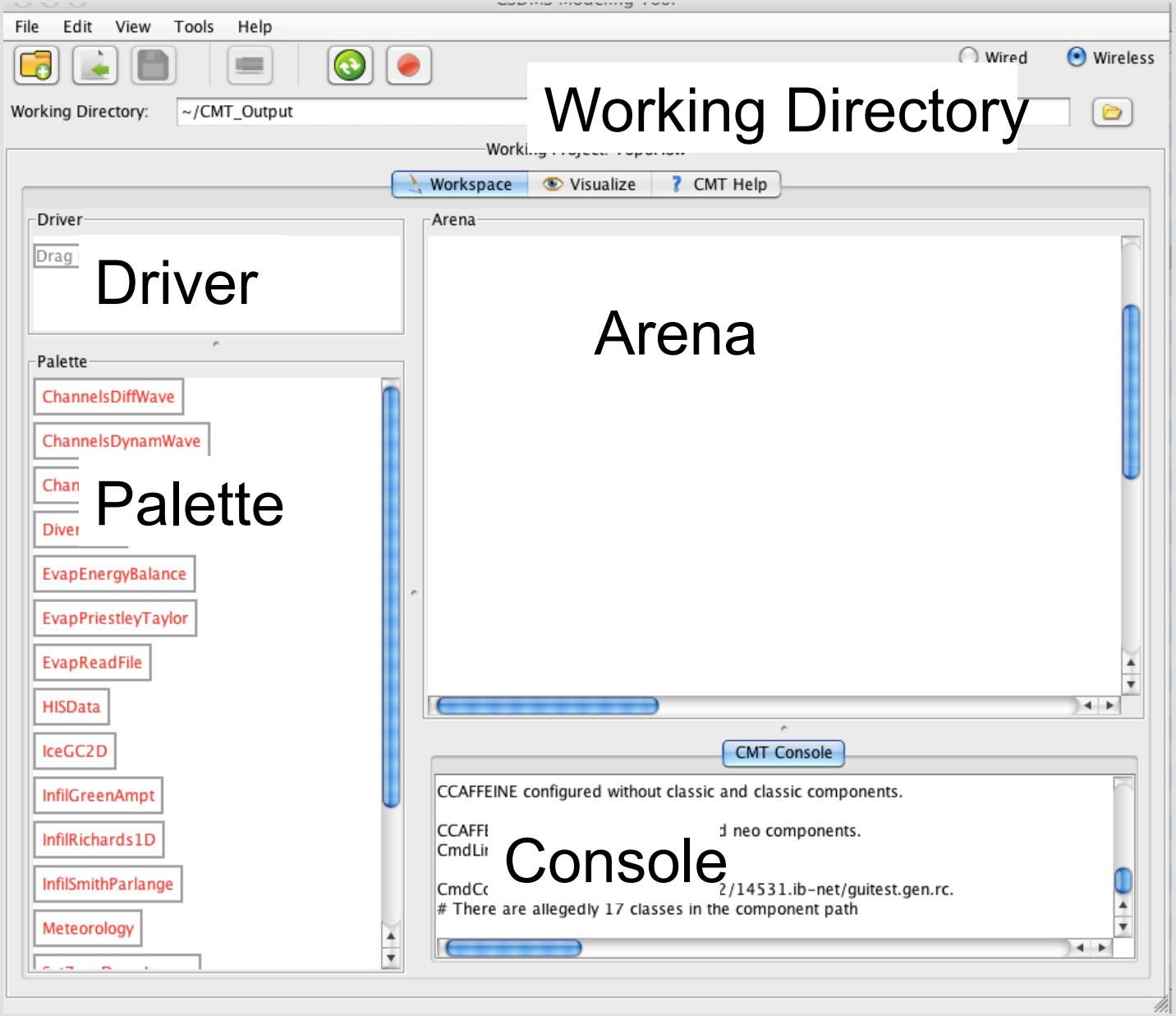


# Open Projects

Workspace

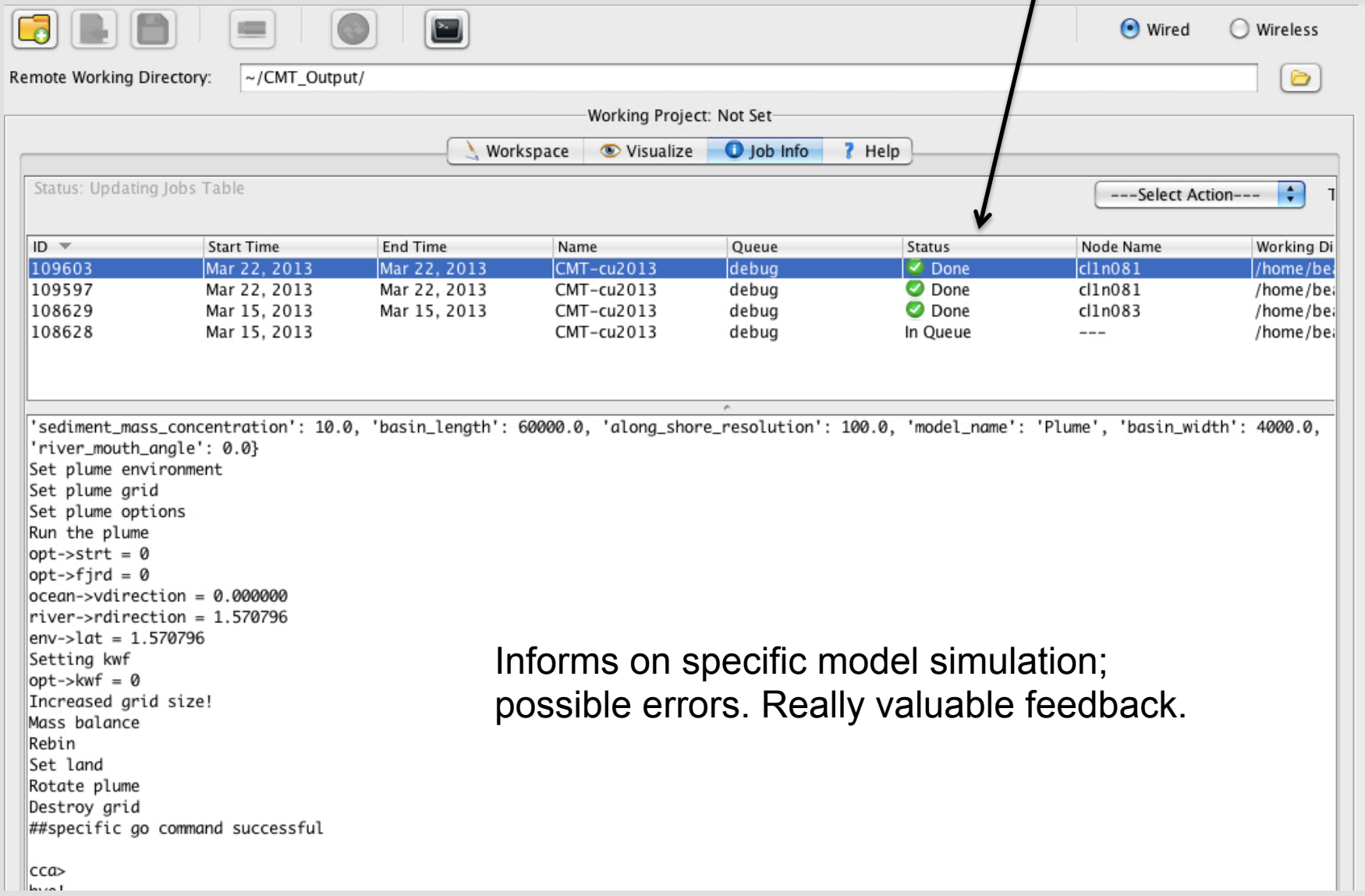


# Workspace Features



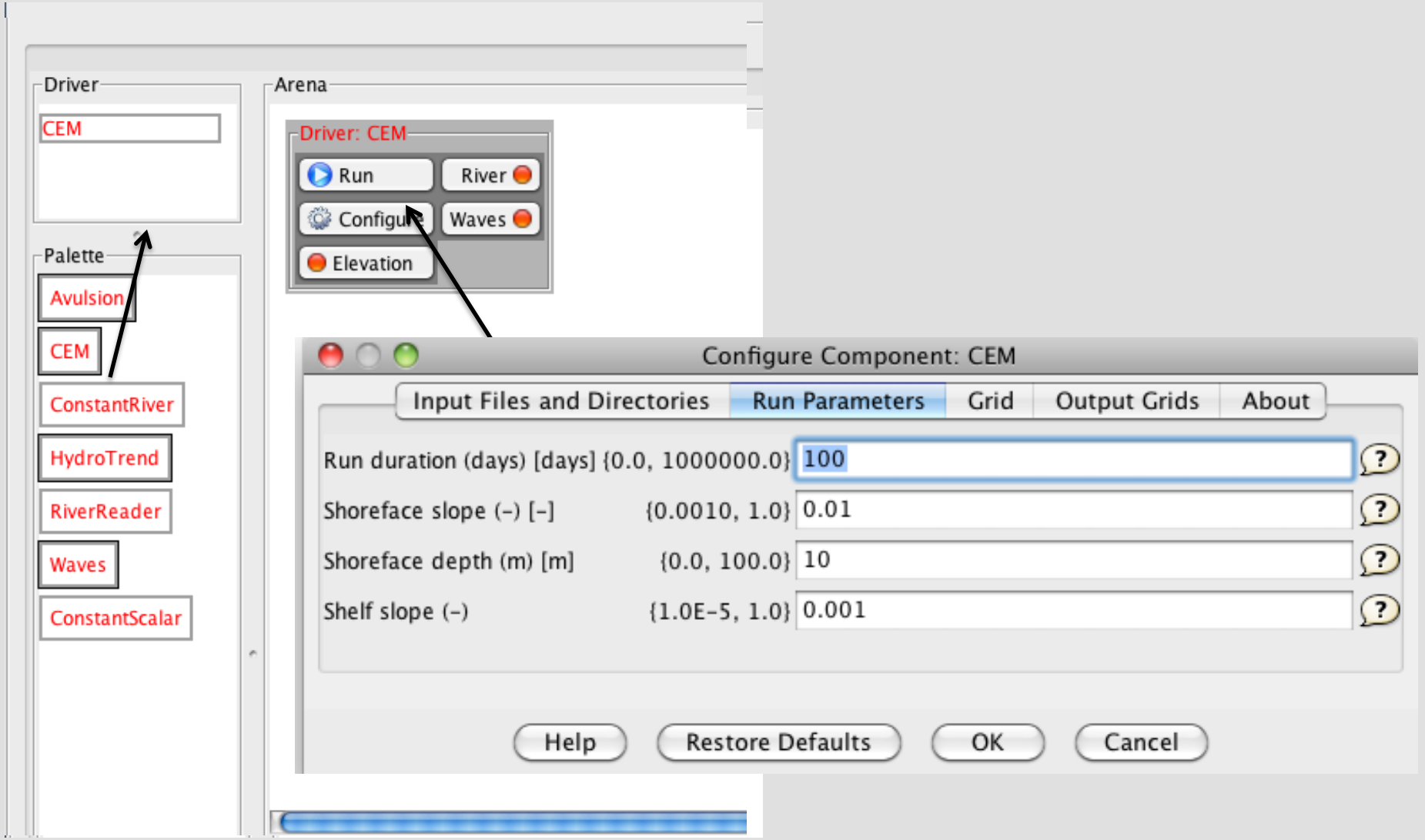
# Job Info

Informs on simulation status on Beach




Informs on specific model simulation; possible errors. Really valuable feedback.

# Setting up a Stand-Alone Model



# Demo 1: Run a Stand-Alone Model

- Activate your VPN for secure connection
- Launch the CMT tool (from the CSDMS website)
- Log in to beach.colorado.edu

Once Set-Up
<2 Minutes

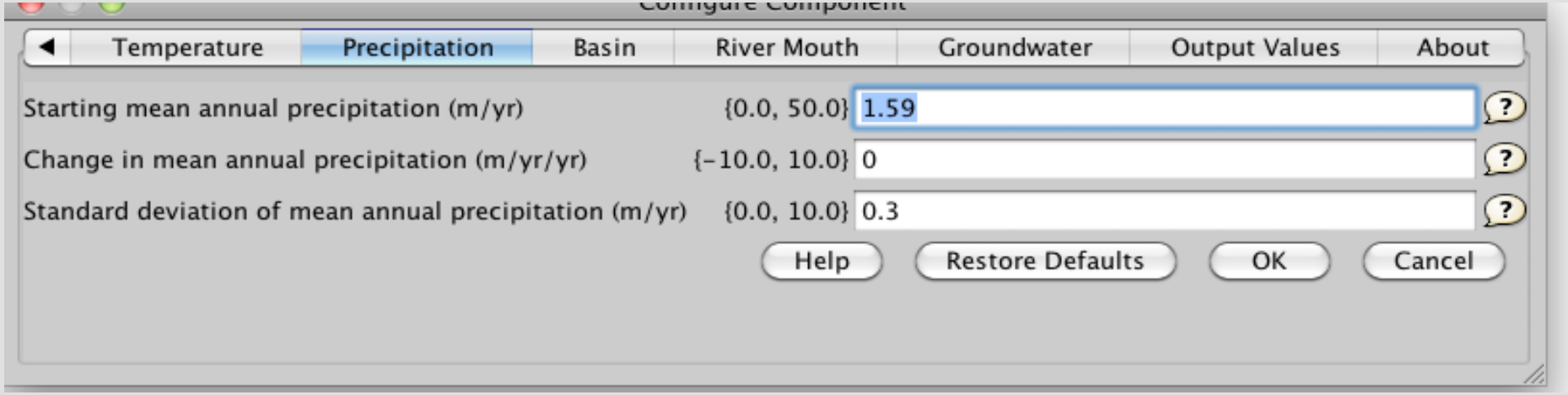
- Open Group: Coastal
- Open Project: Hydrotrend + Avulsion +CEM
- Drag in HydroTrend Component to be the Driver
- Change Settings in the HydroTrend Configure Menu
- Run Simulations, Look at your results in the Console

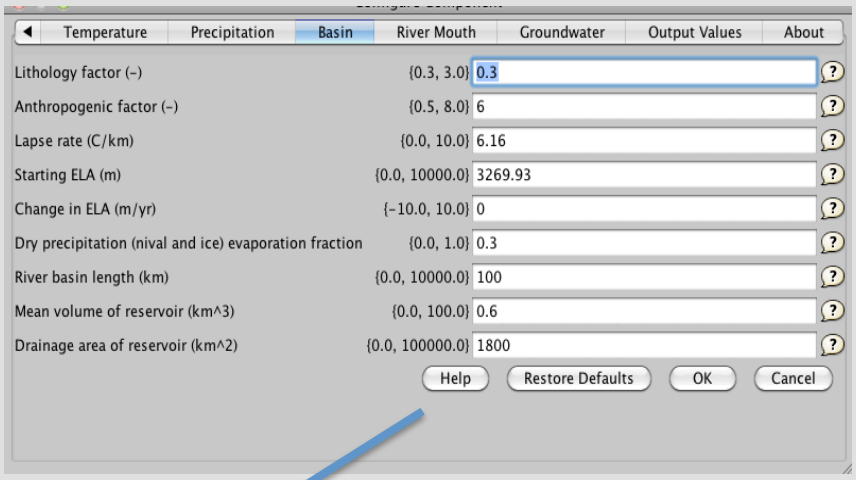
10 Minutes

# Topical Example: River response to climate change?

What is the effect of a 100% increase of precipitation over the next century?

HydroTrend Configure Menu: adapt precipitation






The ‘Help’ button in the Configure Menu links to online information on model parameters.

Model Help is a wiki-based resource, open and editable!

## HydroTrend Help [edit]

### Input files [edit]

There are 2 input files required to run the model: HYDRO.IN and HYDRO0.HYPS. You can use an optional input file (HYDRO.CLIMATE) to specify daily precipitation and temperature events if you do not want to use the climate generator build in to HydroTrend. Each file has it's own format which are discussed below together with an explanation of each of the input parameters.

### HYDRO.IN [edit]

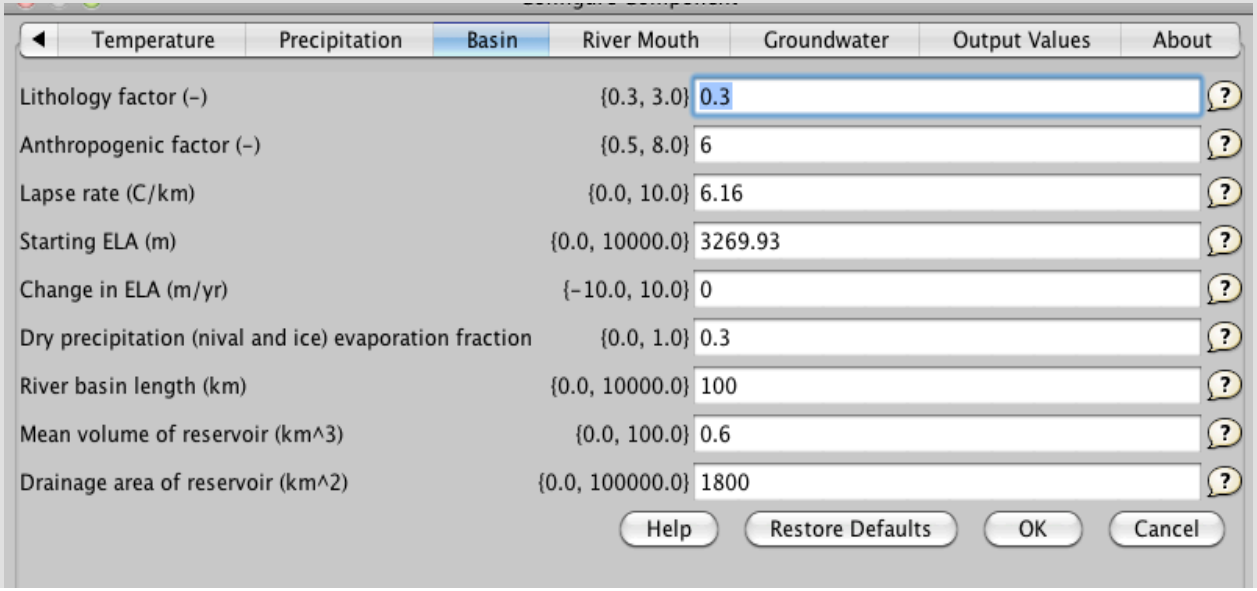
Explanation table for HYDRO.IN input file. Download this example HYDRO.IN file In case you want to set up a HydroTrend run for your specific river drainage basin.

| Line # | Description | Explanation |
|---|---|---|
| 1 | Title | This first line of the input file, is written to a header line in many of the output files and is used to track the model runs. Up to 119 characters are read. You can set a title for each run, not per epoch! |
| 2 | ASCII on/off | This option allows you to turn the option of writing output to ASCII files on or off. If it's turned on 6 ASCII files will be created. All the output is standard written to a binary file which is readable by matlab.<br>Notice: If you are running the model for more than 20.000 years the option will automatically set to OFF. This because the files sizes are getting to big to handle. |
| 3 | Set output directory | Defines location where the output data will be stored. (This option is not available in the web version of HydroTrend). |
| 4 | Nepochs | Defines the number of climate epochs to run. A HydroTrend epoch is a period of time over which linear (or no) climate change accurs. If you are running more than 1 epoch start copying the lines after this input, (so starting from line 5) all down to the bottom and past the block with a blance line between each epoch. |
| 5 | Syear, Nyears, timestep | Syear: Defines the start year for this epoch. The years are used in many of the ouput files.<br>Nyears: Number of model years for this epoch. Note that for following epochs the start year must match the end year of the previous epoch, syear[ep + 1] == syear[ep] + nyears[ep].<br>Timestep: HydroTrend always runs on a daily time step. This variable defines the time step over which the data output are averaged. D = daily, M = monthly, S = Seasonally, Y = yearly. |
| 6 | Number of grain sizes | The number of grain sizes (max = 10) to simulate for the suspended sediment load. |
| 7 | Proportion of sediment | The proportion of sediment in each grain size. The number of values on this line should match the number specified by line 6, and should sum to one. (sum[nr. of grain] == 1). |
| | | Tstart: The beginning annual mean temperature (8C) for this climate epoch. Tstart should be warmer than -20ºC and colder than 30ºC |

# River system response to human impacts?

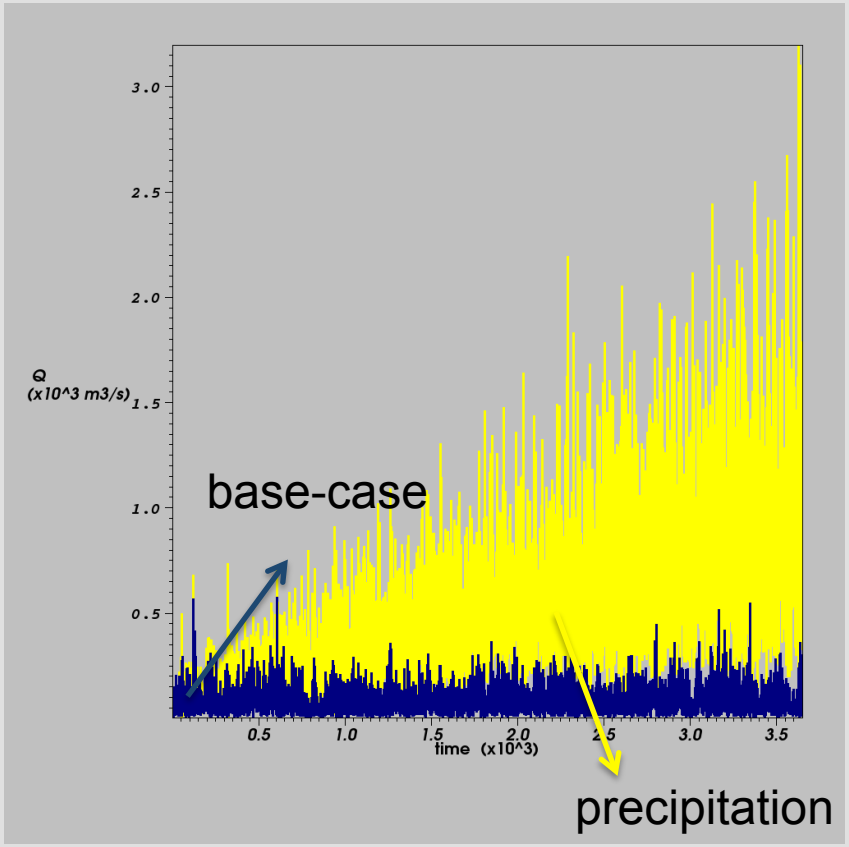
Model a planned drinking water supply reservoir in the basin. The reservoir would have 1800 km$^2$ of contributing drainage area, and be 1 km long and 100m wide, 5m deep.

HydroTrend Configure Menu: adapt reservoir settings

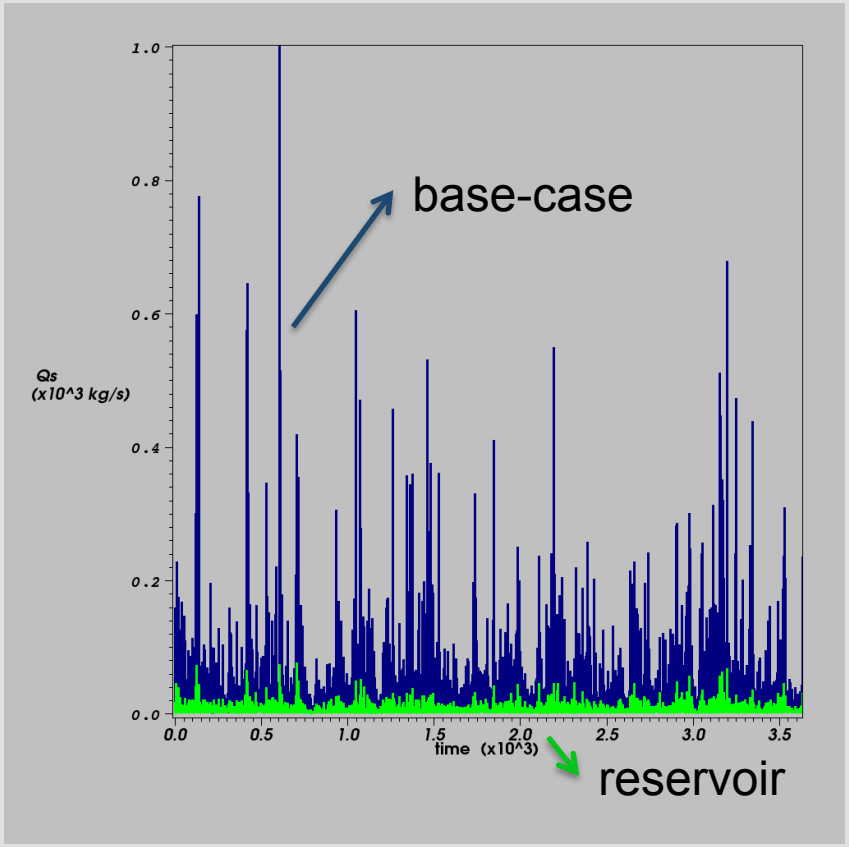


# Output

VisIT: Daily Water Discharge Output



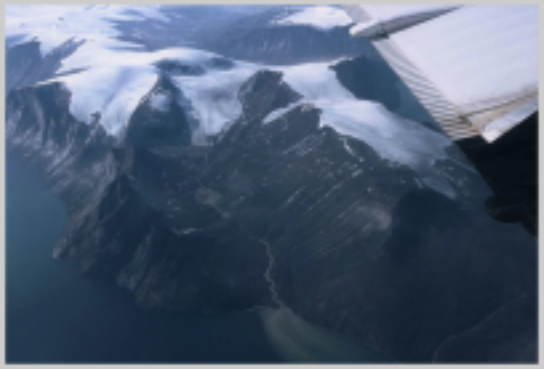

VisIT: Daily Sediment Load Output




Drastic changes in water flux result from increased precipitation regime,
Severe reduction in sediment flux results from damming.

# HydroTrend Example
# Educational Material in CSDMS wiki

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

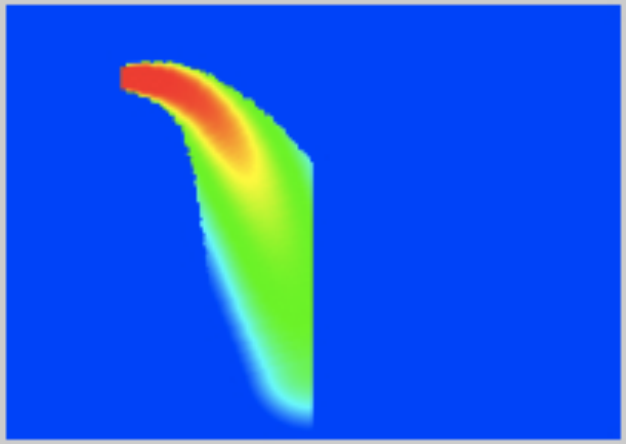


**Sediment Supply to the Global Ocean**

Investigate river sediment supply to the ocean by 1) a spreadsheet lab or 2) an advanced modeling lab using the HydroTrend Model to explore 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 River Sediment Supply Modeling with CMT

# Plume Example
# Educational Material in CSDMS wiki

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

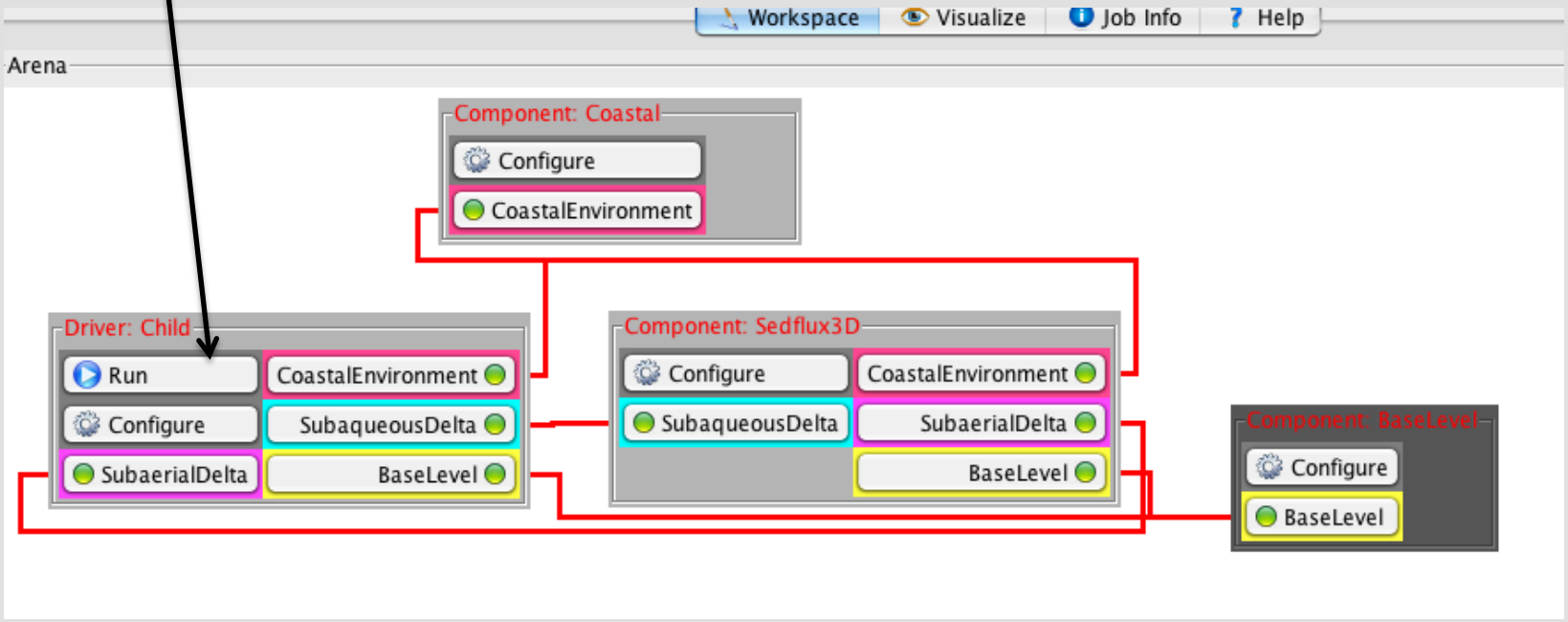


**Modeling River Plumes**

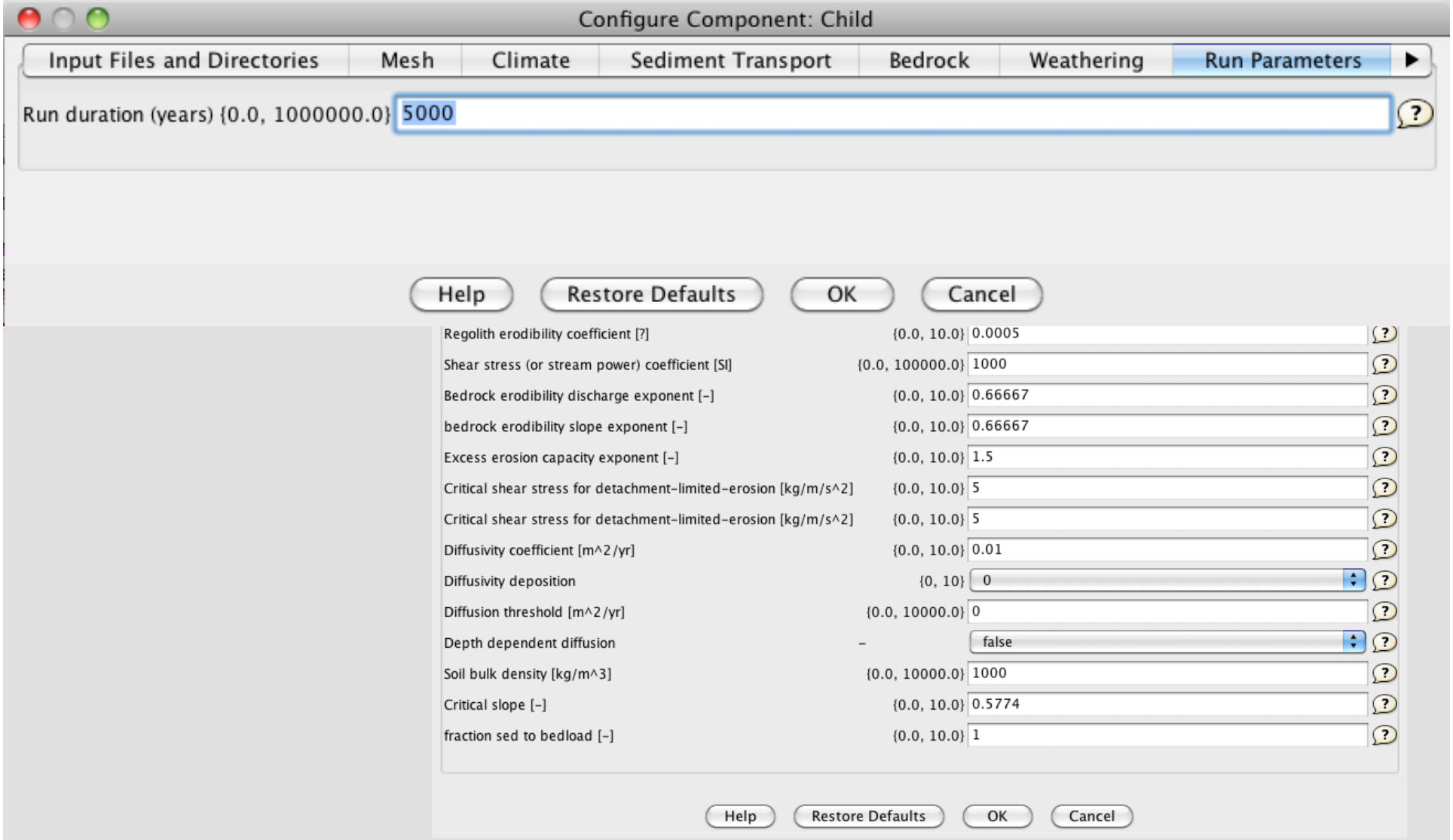
Riverine freshwater and the suspended sediments will form a so-called hypopycnal sediment plume. We will use a component called PLUME to investigate the behavior of these sediment plumes. Plume Modeling with CMT

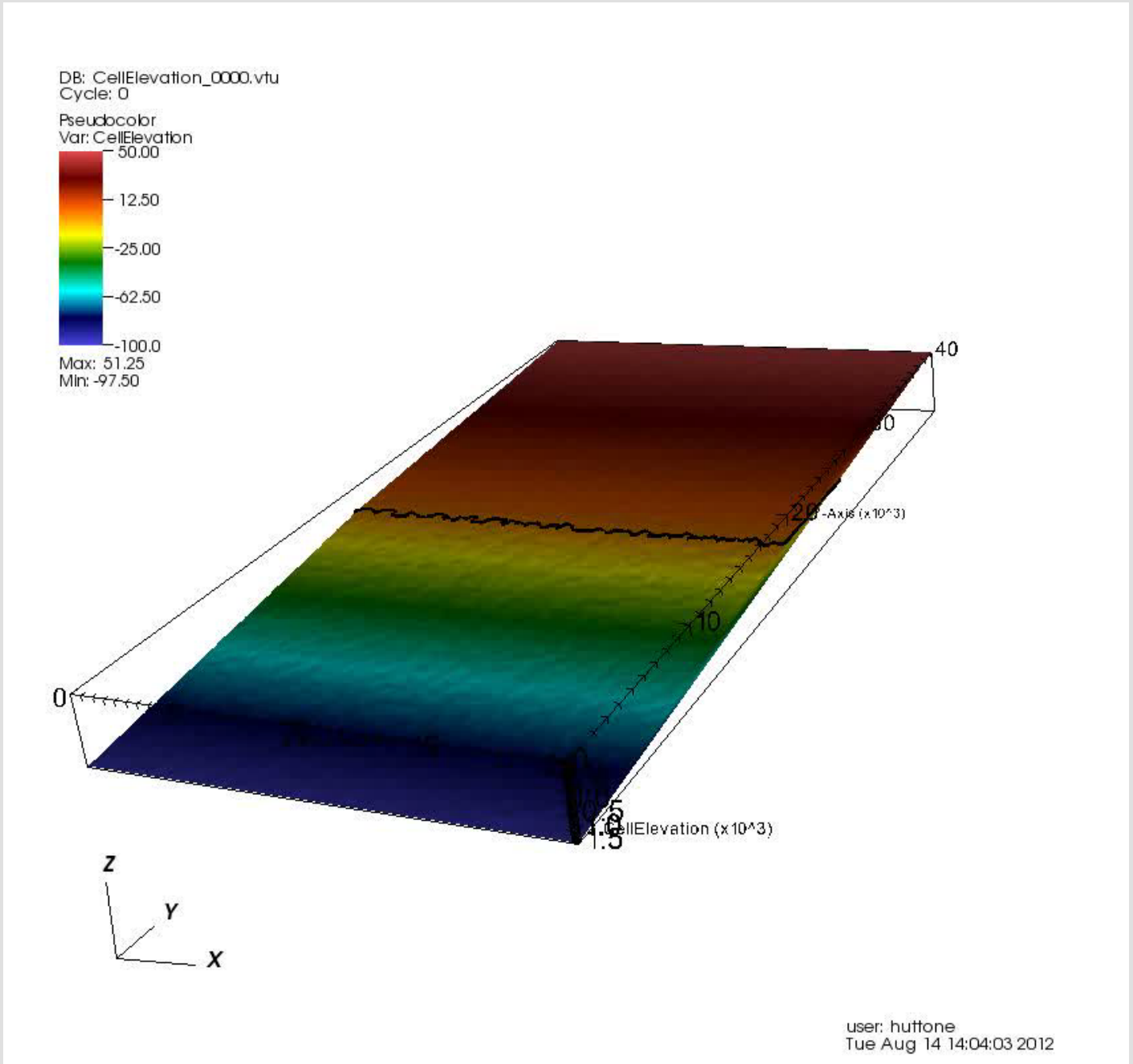
# Demo 2: Setting up a Coupled Simulation

Now Configure

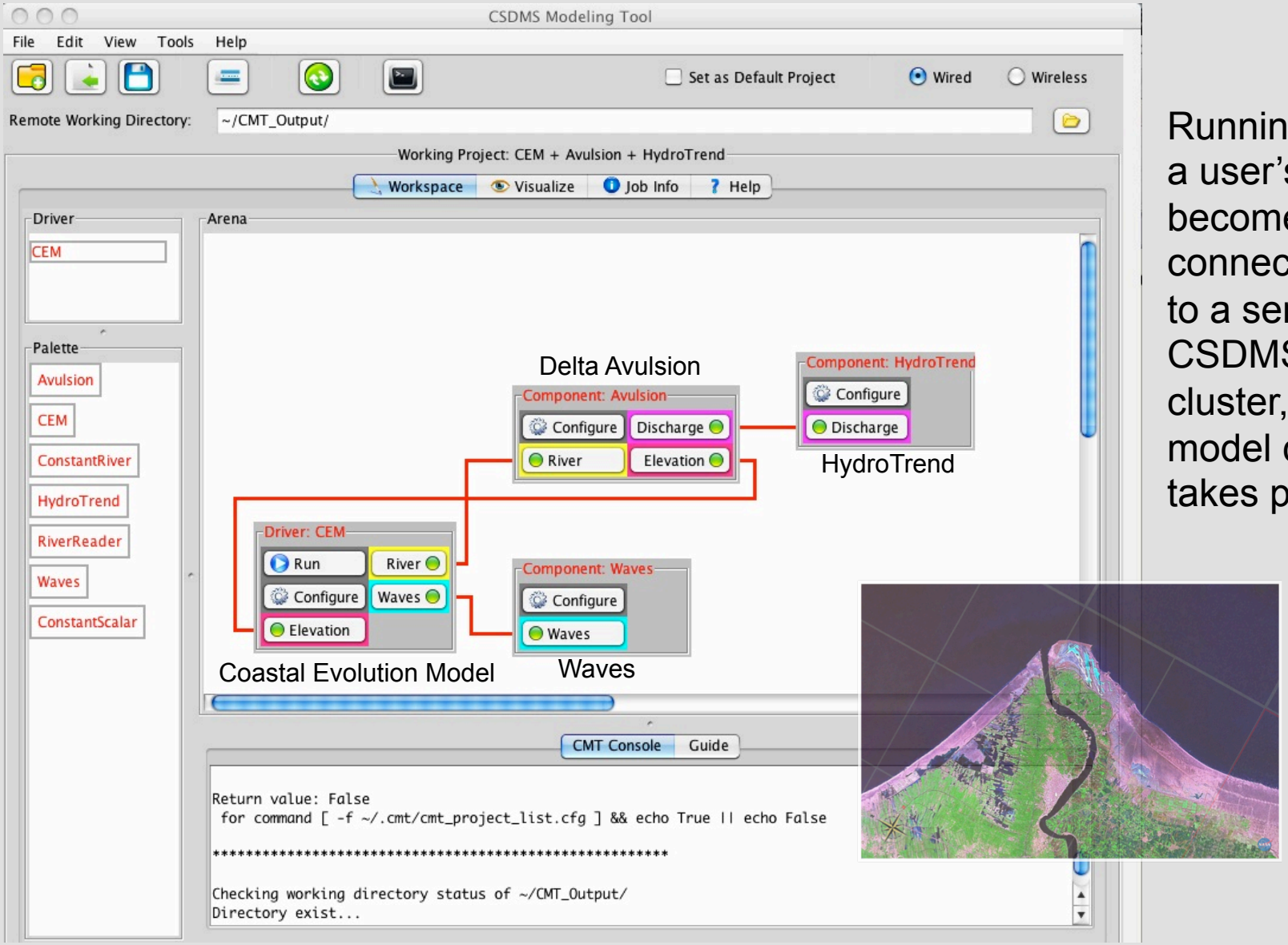


# Demo 2: Configuration




DB: CellElevation_0000.vtu
Cycle: 0
Pseudocolor
Var: CellElevation
50.00
12.50
-25.00
-62.50
-100.0
Max: 51.25
Min: -97.50
40
10
0
Z
Y
X
user: huttone
Tue Aug 14 14:04:03 2012

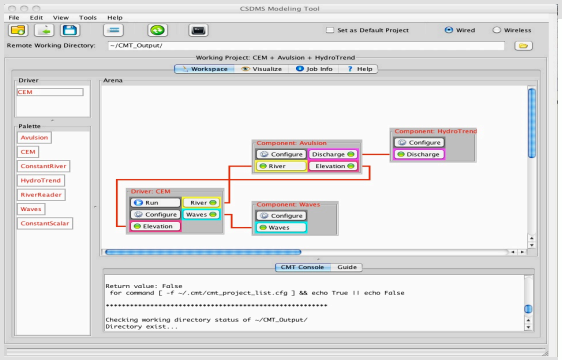
# Model Coupling Example

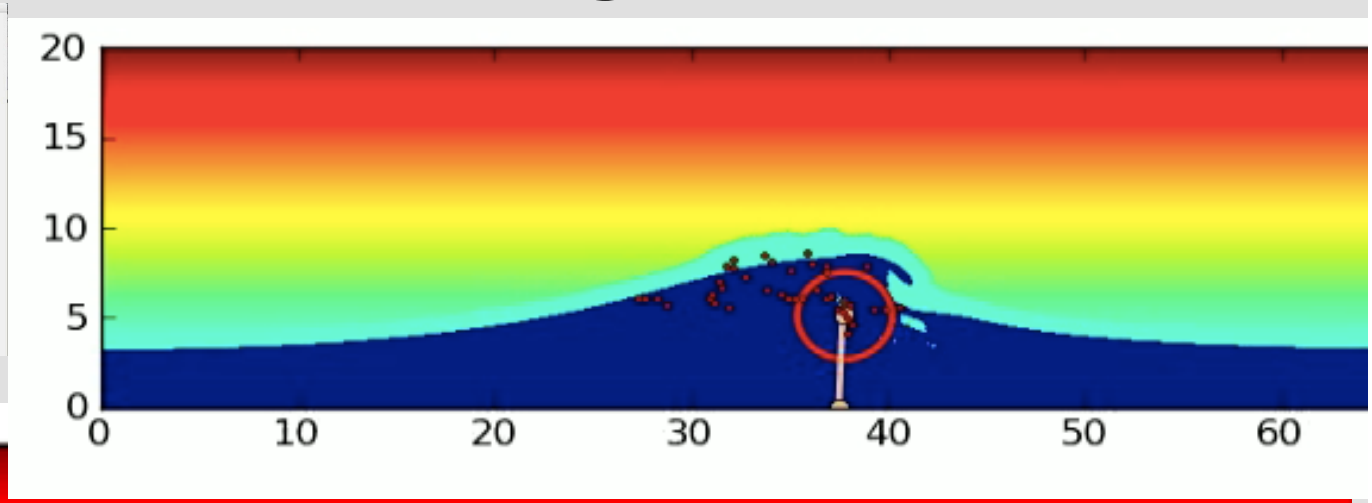


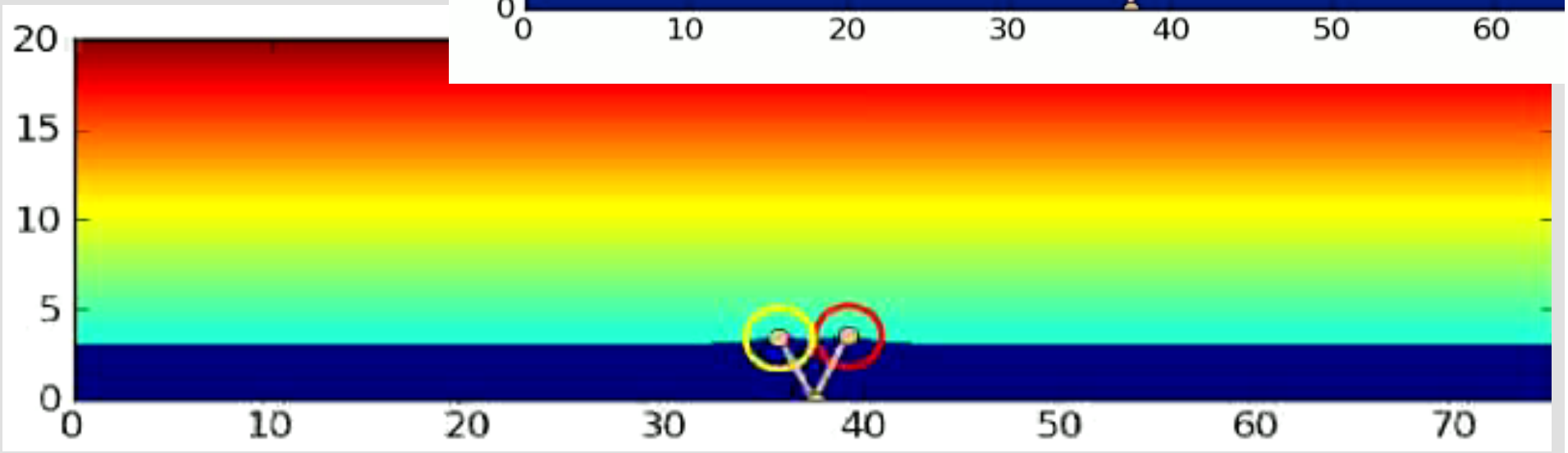

Running CMT allows a user's computer to become a client that connects remotely to a server on the CSDMS HPC cluster, where the model computation takes place

Coupled code has 3 legacy models and 1 new model of > 7 developers linked.

# Model Coupling



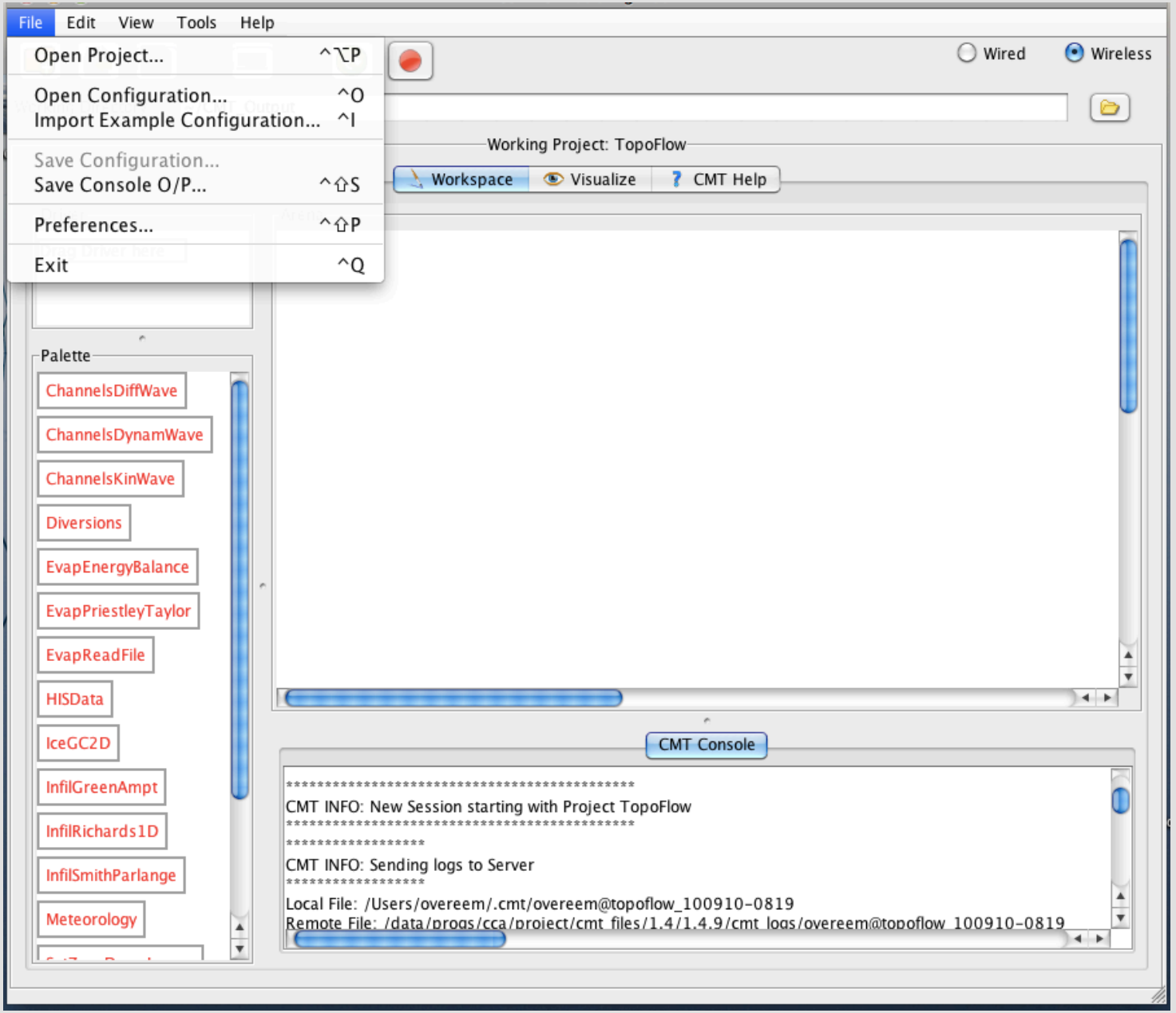



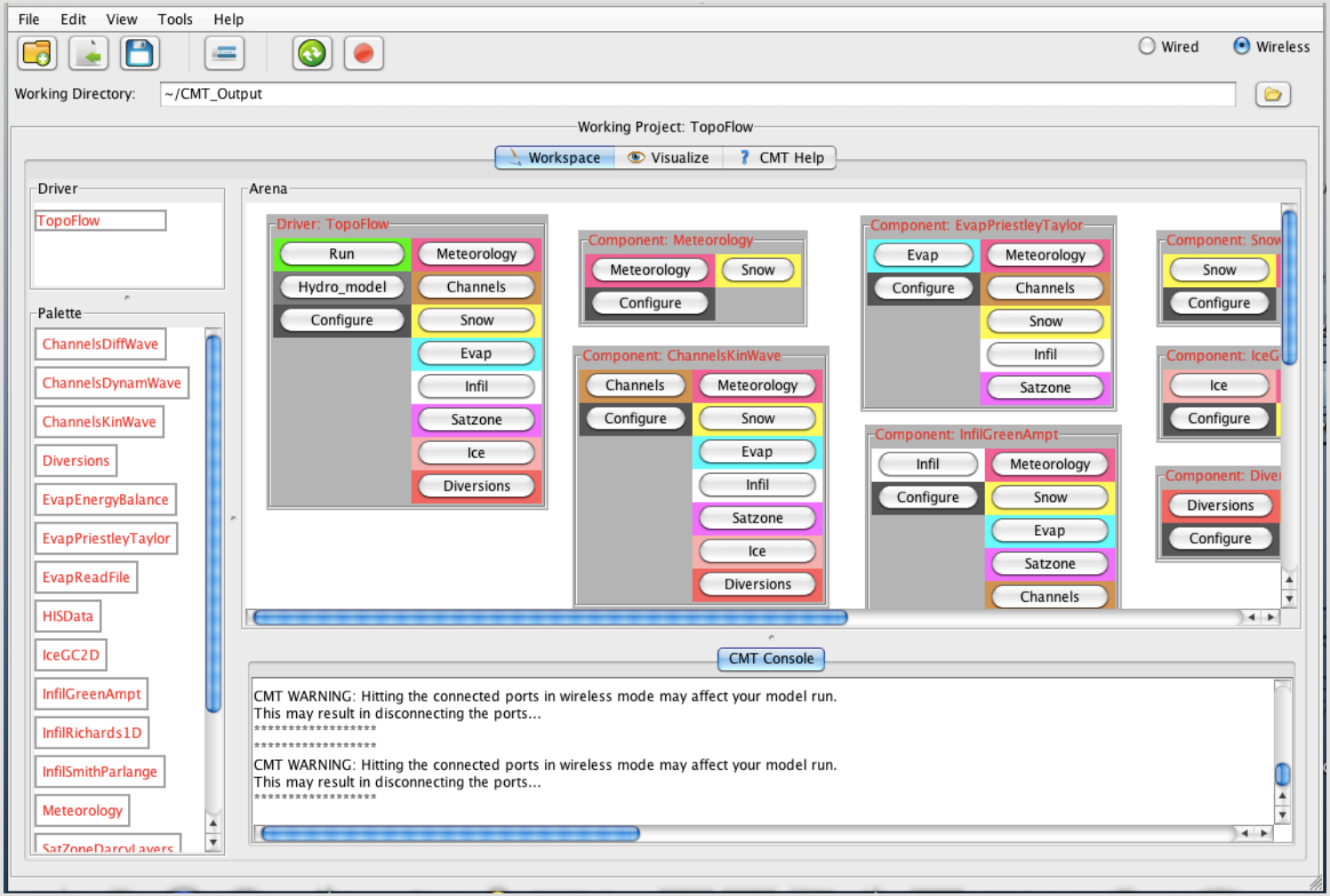

Coupling a coastal evolution model (CEM) with a delta avulsion model (Avulse), a hydrological model (HydroTrend) and a wave generator (WAVE).
These codes were all in C, but originally had different dimensions (1D and 2D).

*(Ashton et al., Computers & Geoscience, 2013)*

# Example Configurations: ‘BLD-Files’



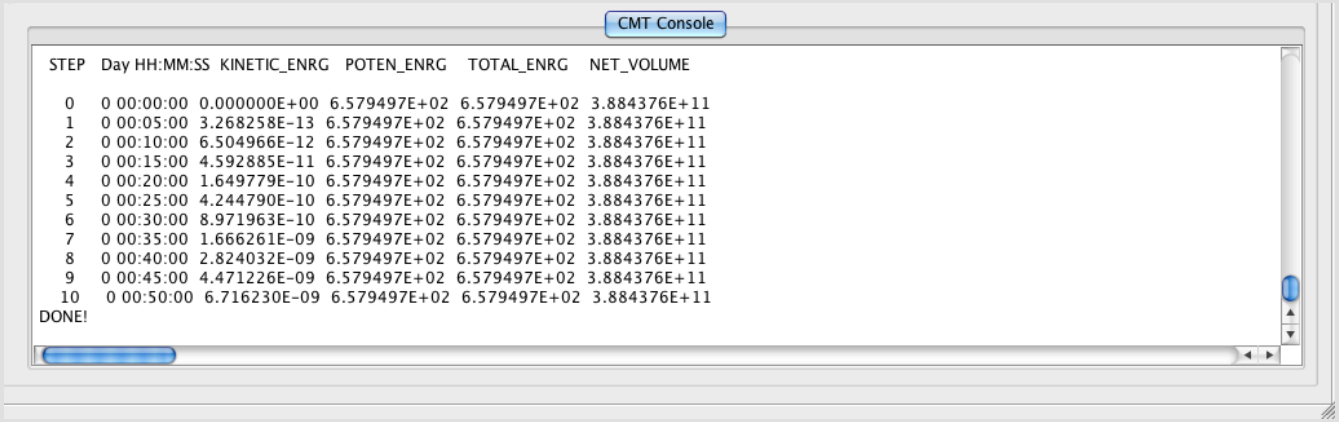
# Example Configurations: ‘BLD-Files’



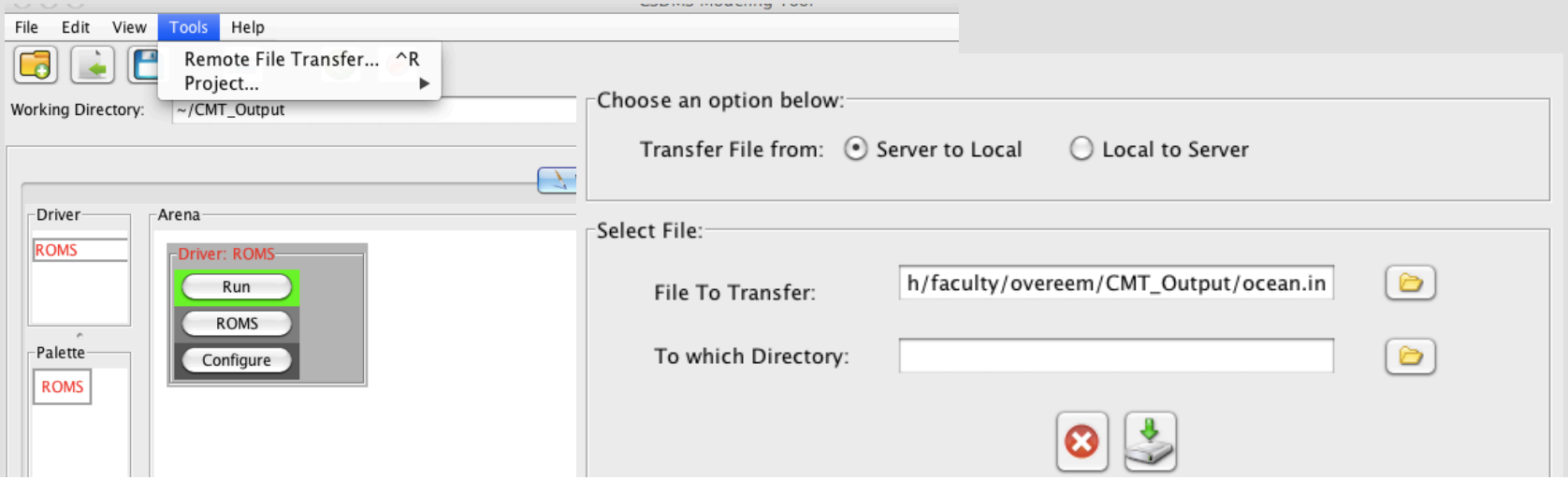

TopoFlow; infiltration modules. This is an example where you can first run more simple algorithms, Green-Ampt Infiltration, and then swap in more complex methods, f.e. Richards Infiltration.

# Getting Simulation Results

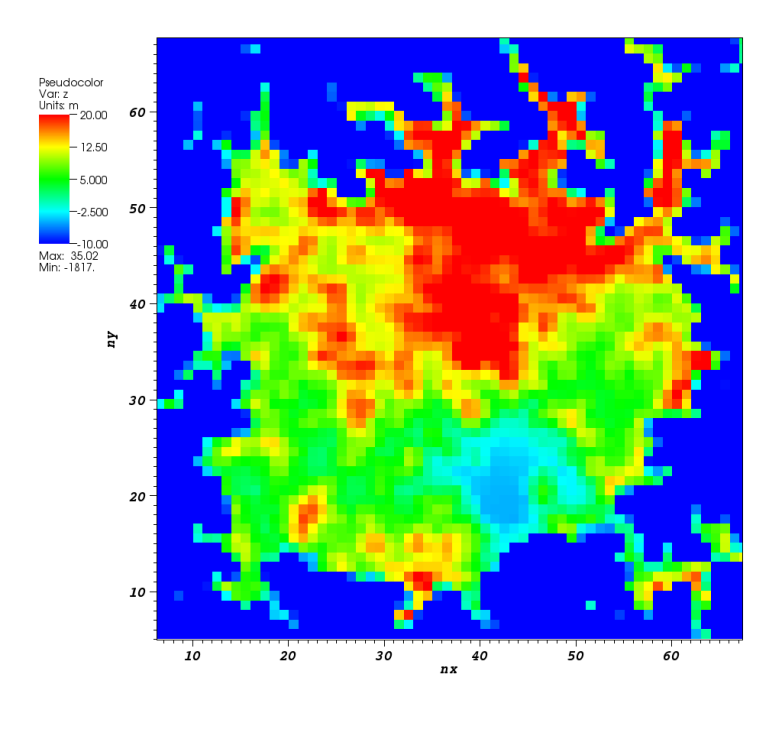
1. Console prints basic model results & statements on simulation

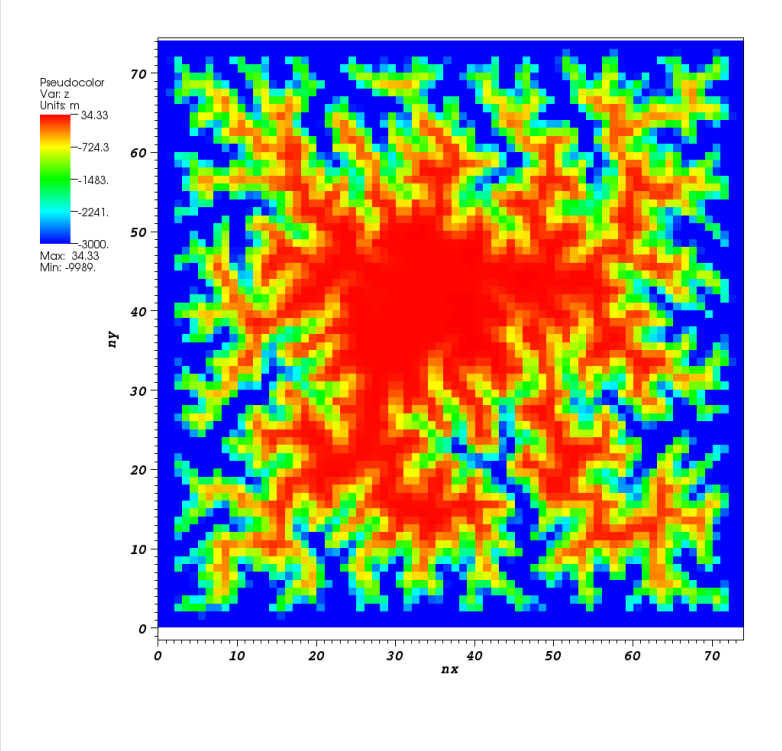



2. Output files have been written onto your Working directory on Beach. Go grab them! Transfer the remote file to your local machine.



# VisIt: Visualizing Grids




Example: Visualization of Landscape Evolution Experiments with ERODE-Global

Time-series, Grid-Stacks (0D,1D, 2D)
You can do this on HPCC and use multiple processors for large datasets

# Questions on CMT?

# Trouble Shooting for Users

- VPN and Firewall issues (involve local IT staff)
- Did jobs run & complete? (consult job info)
- Empty Palette (bug we are working on; restart)

- Directory for file I/O (set unique directories for individual simulations)
- Model Errors (consult job Info)

# Help on CSDMS wiki

1) Register for HPCC account and use Beach
http://csdms.colorado.edu/wiki/HPCC_Access

2) CSDMS Modeling Tool installation and use
http://csdms.colorado.edu/wiki/CMT_download

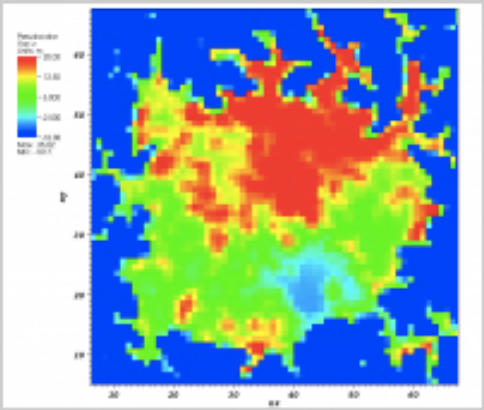
3) VisIt for parallel scientific visualization
http://csdms.colorado.edu/wiki/CMT_visualization
https://wci.llnl.gov/codes/visit/

4) NetCDF output files now standard within CSDMS framework
http://www.unidata.ucar.edu/software/netcdf/

# Get Started with Labs 2013

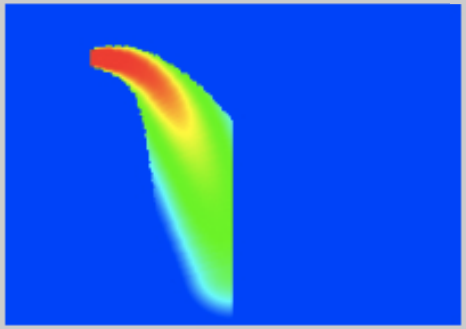

**Get Started with CMT**

This lab teaches you how to use CSDMS Modeling Tool; it is focused most on how to use the CMT software and its visualization environment. Labs_Basic_CMT



**Landscape Evolution Modeling 1**

Learn about landscape evolution modeling, flow routing over a landscape and basic algorithms for numerical modeling of combined hillslope and river sediment transport processes. Landscape Evolution Modeling with ERODE



**Modeling River Plumes**

Riverine freshwater and the suspended sediments will form a so-called hypopycnal sediment plume. We will use a component called PLUME to investigate the behavior of these sediment plumes. Plume Modeling with CMT

# Future CMT-Related Development

1. A web-based Component Modeling Tool (**CMTweb**) that allows users to run CMT directly through a web browser
2. Automate ‘wrapping’ processes to allow legacy code in the repository to become plug-and-play components faster
3. Incorporate benchmark data into the CSDMS modeling framework, for model inter-comparisons
4. Development of an Educational Toolkit