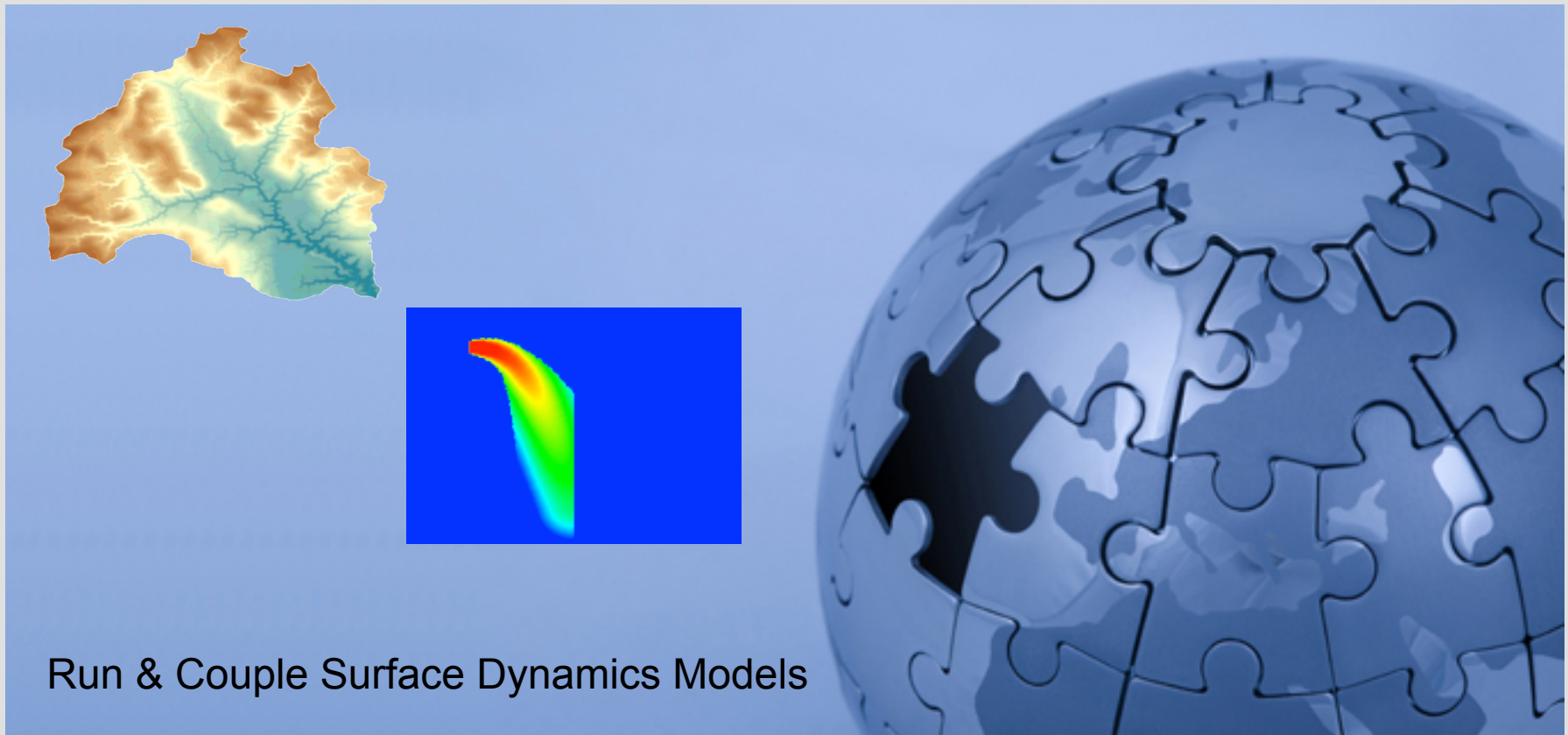


# CSDMS Component Modeling Tool Introduction



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

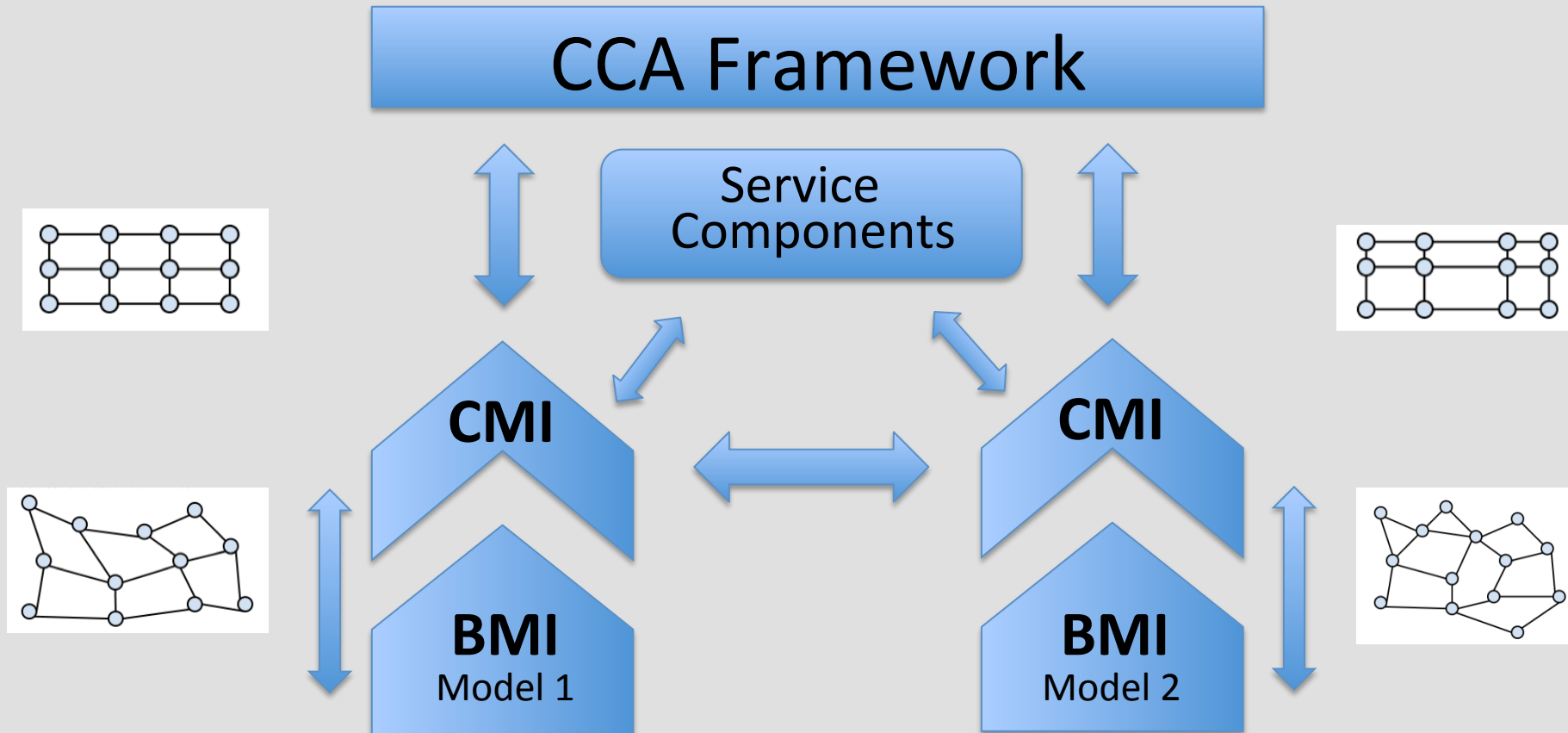
Develop a modeling framework of inter-connectable process modules able to predict the transport and deposition of water, sediment and nutrients over the Earth's surfaces, and how surfaces evolve over a broad range of time and space scales.

- 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

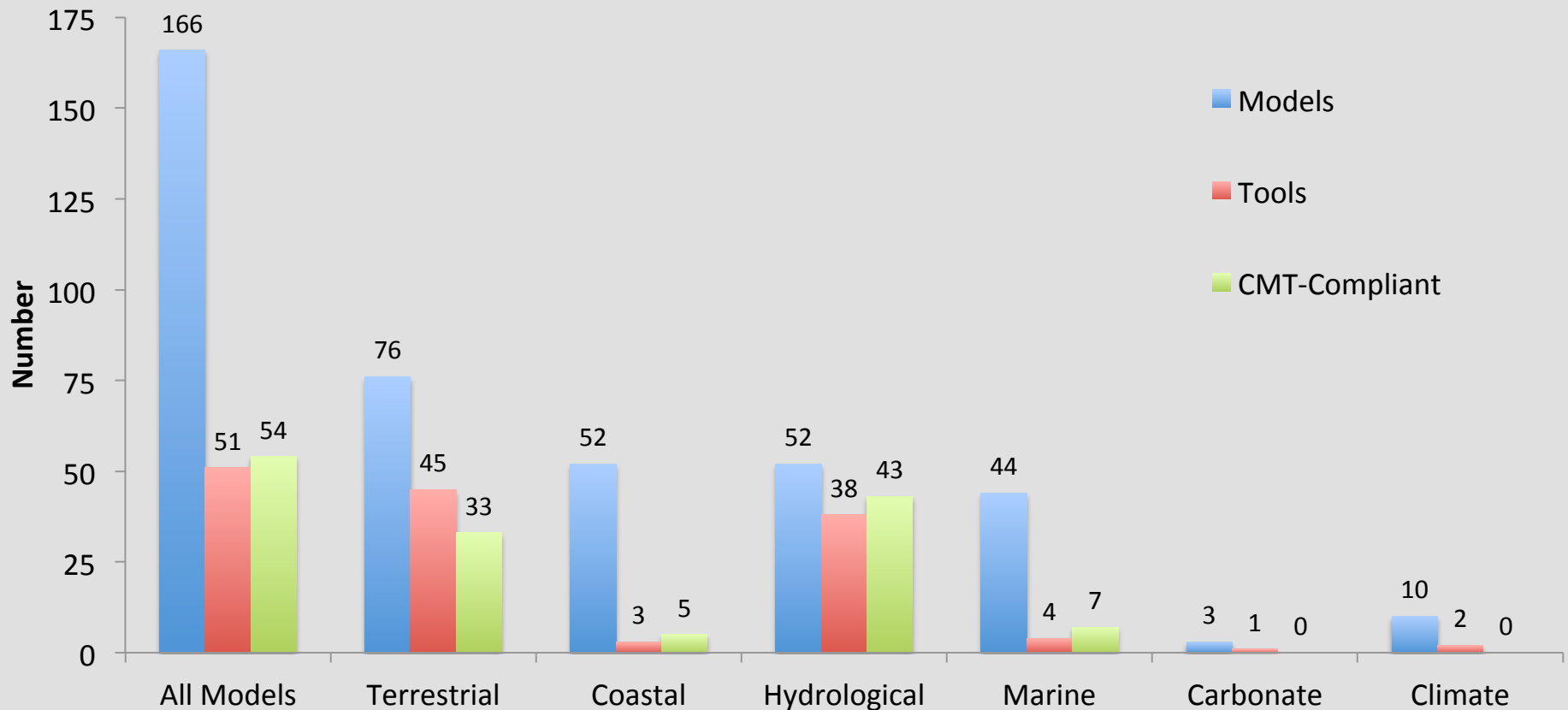
# Protocols for CSDMS-component models



**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)

The screenshot displays the CSDMS Modeling Tool interface. At the top, the title bar reads "CSDMS Modeling Tool". Below it is a menu bar with "File", "Edit", "View", "Tools", and "Help". A toolbar contains icons for file operations and a "Set as Default Project" checkbox. The "Remote Working Directory" is set to "~/CMT\_Output/". The "Working Project" is "ROMS".

The main workspace is divided into several panels:

- Driver:** A list containing "ROMS".
- Palette:** A list containing "CBOFS2", "ROMS", and "chesROMS".
- Arena:** A central area with a "Driver: ROMS" header and buttons for "Run", "Configure", and "ROMS".

Overlaid on the Arena is a text box: "Some models have graphical interface for the first time".

A "Configure Component: ROMS" dialog box is open, showing configuration options for the ROMS project:

Field	Value
Input directory	GUI
Input File name:	ocean.in
Site prefix:	upwelling
Case prefix:	test
ROMS application title:	Wind-Driven Upwelling/Downwelling over a Periodic Channel
C-preprocessing flag:	UPWELLING
Variable information filename:	varinfo.dat
RunInterval:	{1.0, 1.0E10} 432000

Buttons at the bottom of the dialog include "Help", "Restore Defaults", "OK", and "Cancel".

# Available Projects in CMT (2)

Educational

- 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

Tool

- 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)

Data Ingestion



# **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

The screenshot shows the CSDMS website interface. At the top left is the CSDMS logo with the text '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', 'Community', 'Meetings', and 'Help'. An arrow points from the text 'Get Help! information on the CMT' to the 'Help' dropdown menu. Below the navigation bar is a banner with the text 'Explore Earth's surface with community software' and a 'Tweet' button showing 14 tweets. The main content area features a large image of a globe made of puzzle pieces. Below this image is a section titled 'CSDMS Modeling Tool (CMT)' with a sub-header 'CSDMS Modeling Tool (CMT)' and a paragraph: 'CSDMS has developed a user friendly GUI (CMT) to couple and run modules on the CSDMS supercomputer. Find out more on how to download and use the CMT tool.' To the right of the main content is a sidebar with several links, each with a right-pointing arrow: 'CSDMS for you', 'Get started with CMT', 'Contribute', 'Download', 'Announcements', and 'Help'. An arrow points from the text 'Info Here' to the 'Get started with CMT' link.

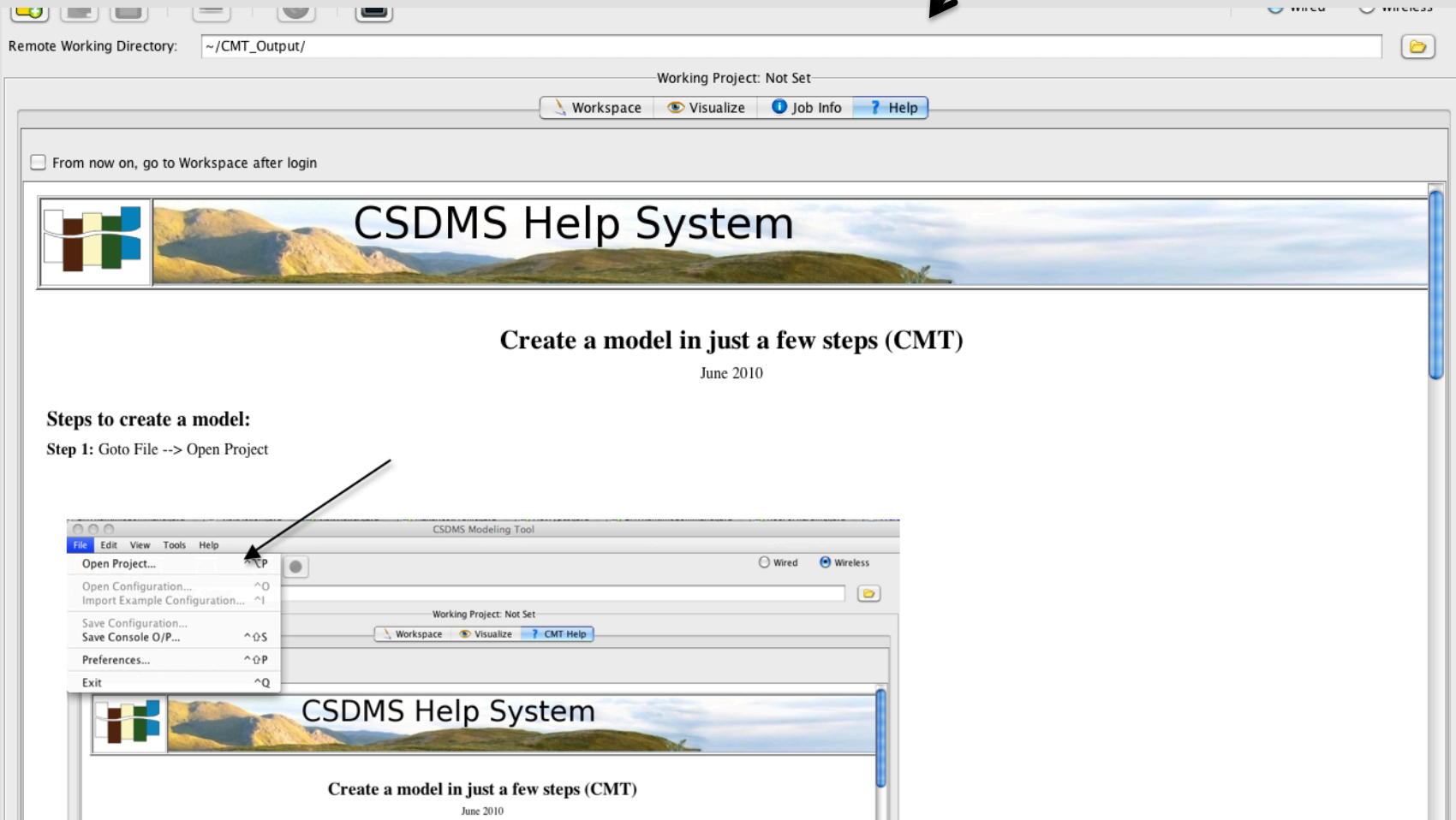
Get Help!  
information  
on the CMT

Info  
Here

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

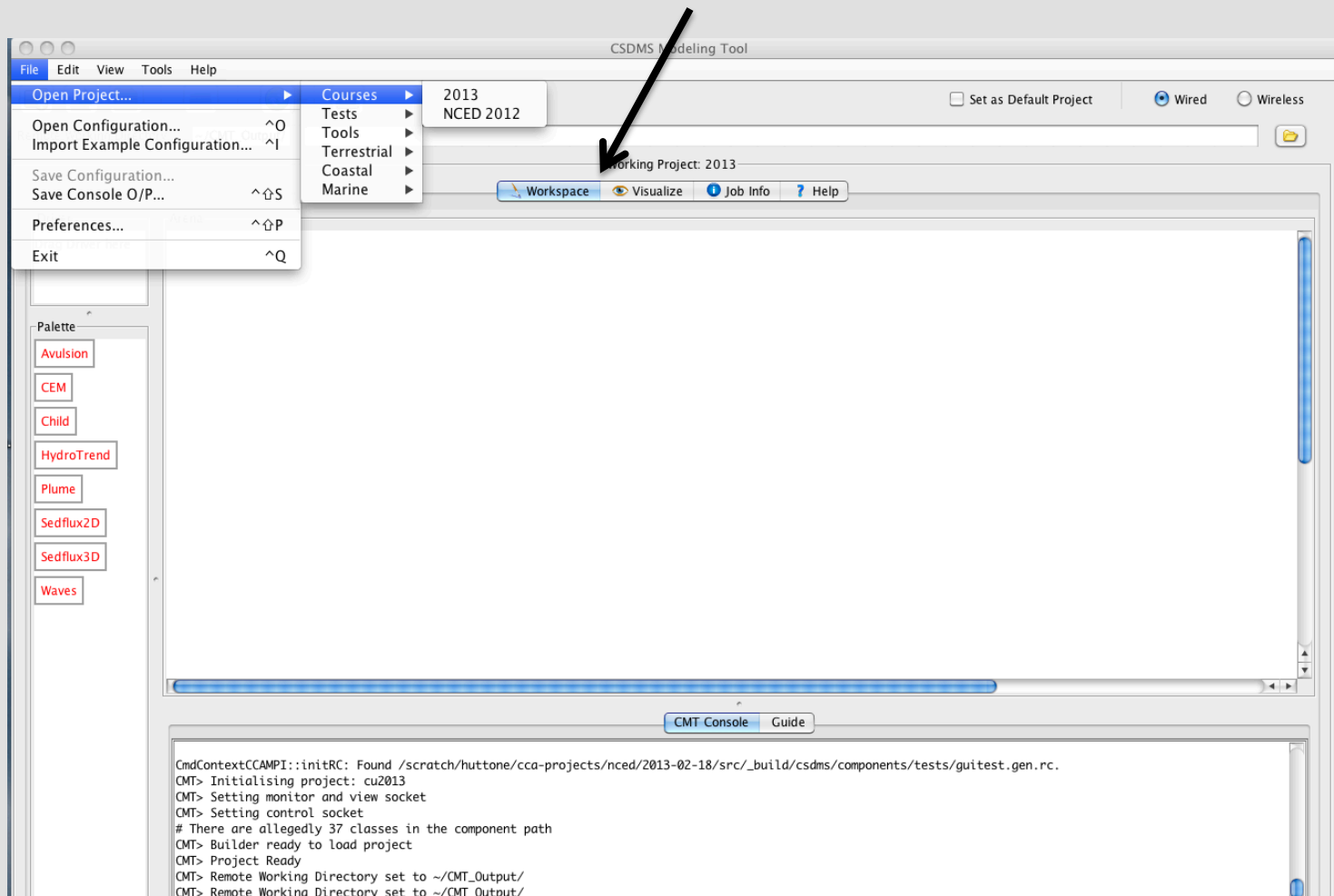
# CMT Default Start-Up Screen

Workspace Visualize Job Info Help

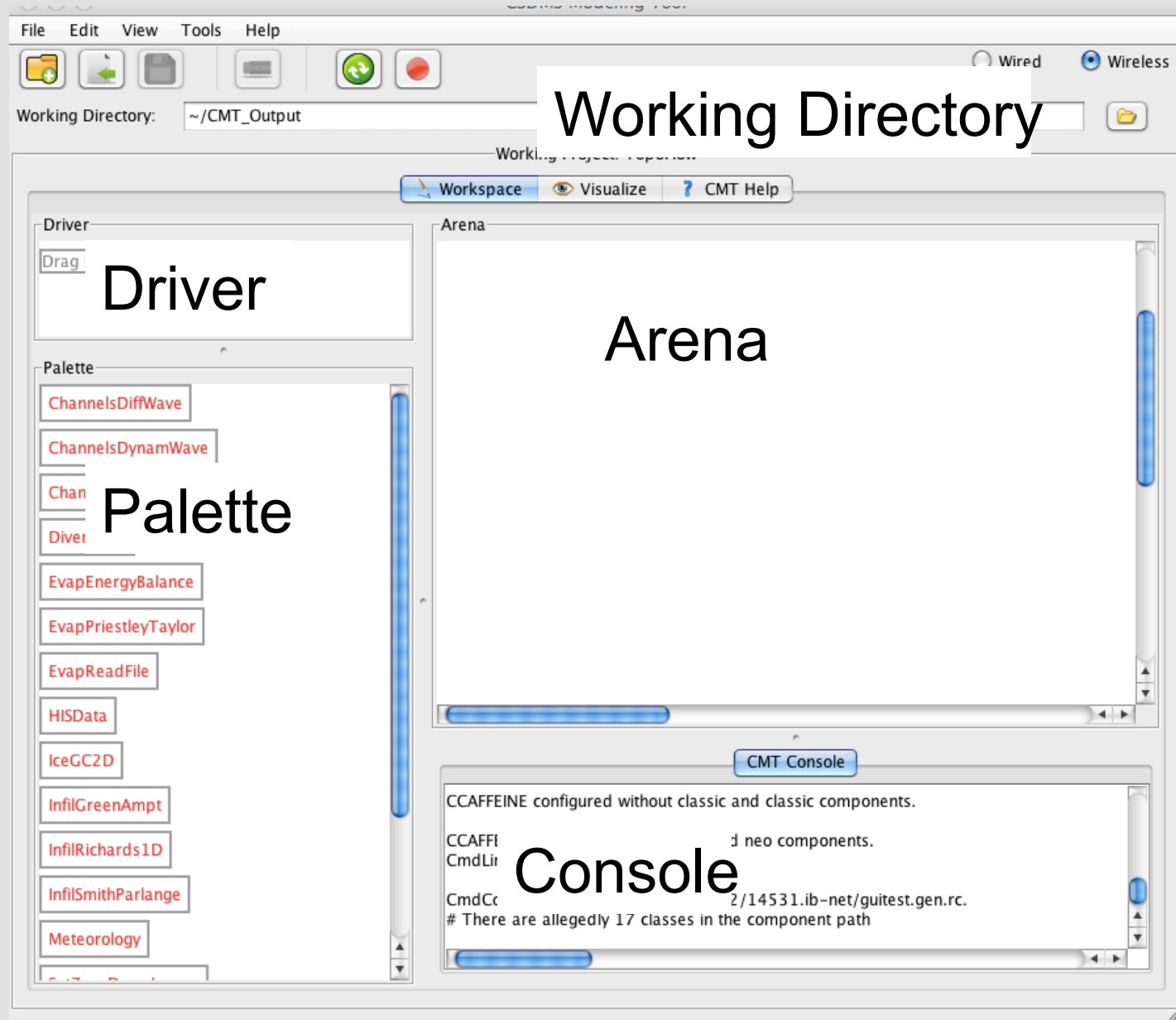


# Open Projects

## Workspace



# Workspace Features



# Job Info

Informs on simulation status on Beach

The screenshot shows a software interface with a top toolbar containing icons for file operations and network settings (Wired/Wireless). Below the toolbar, the 'Remote Working Directory' is set to ~/CMT\_Output/. The main window has a 'Working Project: Not Set' label and a menu bar with 'Workspace', 'Visualize', 'Job Info', and 'Help'. The 'Job Info' tab is active, displaying a table of jobs and a log window below it.

Status: Updating Jobs Table

ID	Start Time	End Time	Name	Queue	Status	Node Name	Working Di
109603	Mar 22, 2013	Mar 22, 2013	CMT-cu2013	debug	Done	cl1n081	/home/be
109597	Mar 22, 2013	Mar 22, 2013	CMT-cu2013	debug	Done	cl1n081	/home/be
108629	Mar 15, 2013	Mar 15, 2013	CMT-cu2013	debug	Done	cl1n083	/home/be
108628	Mar 15, 2013		CMT-cu2013	debug	In Queue	---	/home/be

```
'sediment_mass_concentration': 10.0, 'basin_length': 60000.0, 'along_shore_resolution': 100.0, 'model_name': 'Plume', 'basin_width': 4000.0, 'river_mouth_angle': 0.0}
Set plume environment
Set plume grid
Set plume options
Run the plume
opt->strt = 0
opt->fjrd = 0
ocean->vdirection = 0.000000
river->rdirection = 1.570796
env->lat = 1.570796
Setting kwf
opt->kwf = 0
Increased grid size!
Mass balance
Rebin
Set land
Rotate plume
Destroy grid
##specific go command successful
cca>
```

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

# Setting up a Stand-Alone Model

The image shows a software interface for setting up a stand-alone model. It consists of three main parts:

- Driver Palette:** A vertical list of components on the left side. The 'CEM' component is highlighted in red. Other components include Avulsion, ConstantRiver, HydroTrend, RiverReader, Waves, and ConstantScalar.
- Arena Window:** A window titled 'Arena' showing the selected 'Driver: CEM'. It contains several buttons: 'Run' (with a play icon), 'Configure' (with a gear icon), 'Elevation' (with a red circle icon), 'River' (with a red circle icon), and 'Waves' (with a red circle icon). An arrow points from the 'Configure' button in the Arena window to the 'Configure Component: CEM' dialog box.
- Configure Component: CEM Dialog:** A dialog box with a title bar and a tabbed interface. The 'Run Parameters' tab is active. It contains the following settings:

Parameter	Range	Value	Help
Run duration (days) [days]	{0.0, 1000000.0}	100	?
Shoreface slope (-) [-]	{0.0010, 1.0}	0.01	?
Shoreface depth (m) [m]	{0.0, 100.0}	10	?
Shelf slope (-)	{1.0E-5, 1.0}	0.001	?

At the bottom of the dialog are buttons for 'Help', 'Restore Defaults', 'OK', and 'Cancel'.



# 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
  - 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
- 
- Once Set-Up  
<2 Minutes
- 10 Minutes

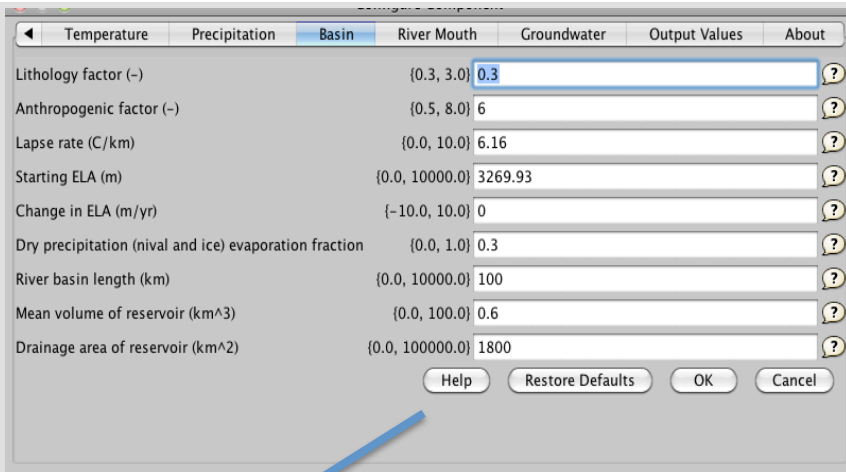
# Topical Example: River response to climate change?

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

HydroTrend Configure Menu: adapt precipitation

The image shows a screenshot of the 'Configure Component' dialog box in the HydroTrend software. The 'Precipitation' tab is selected. The dialog contains three input fields for precipitation parameters, each with a range and a help icon. The 'Starting mean annual precipitation (m/yr)' field is set to 1.59, with a range of {0.0, 50.0}. The 'Change in mean annual precipitation (m/yr/yr)' field is set to 0, with a range of {-10.0, 10.0}. The 'Standard deviation of mean annual precipitation (m/yr)' field is set to 0.3, with a range of {0.0, 10.0}. At the bottom of the dialog are four buttons: 'Help', 'Restore Defaults', 'OK', and 'Cancel'.

Parameter	Range	Value
Starting mean annual precipitation (m/yr)	{0.0, 50.0}	1.59
Change in mean annual precipitation (m/yr/yr)	{-10.0, 10.0}	0
Standard deviation of mean annual precipitation (m/yr)	{0.0, 10.0}	0.3



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 [\[edit\]](#)

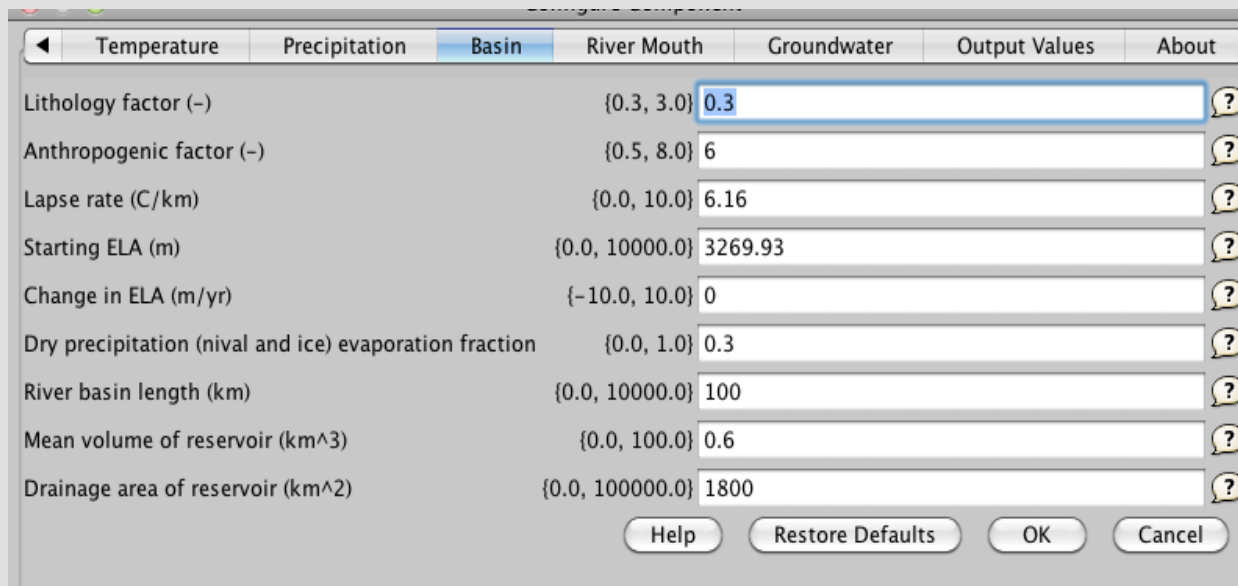
Explanation table for HYDRO.IN input file. Download this example [HYDRO.IN](#) file In case you want to set up a HydroTrend run for your specific river drainage basin.

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. 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 occurs. 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. 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, $syear[ep + 1] == syear[ep] + nyears[ep]$ . 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 (°C) for this climate epoch. Tstart should be warmer than -20°C and colder than 30°C

# River system response to human impacts?

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

HydroTrend Configure Menu: adapt reservoir settings

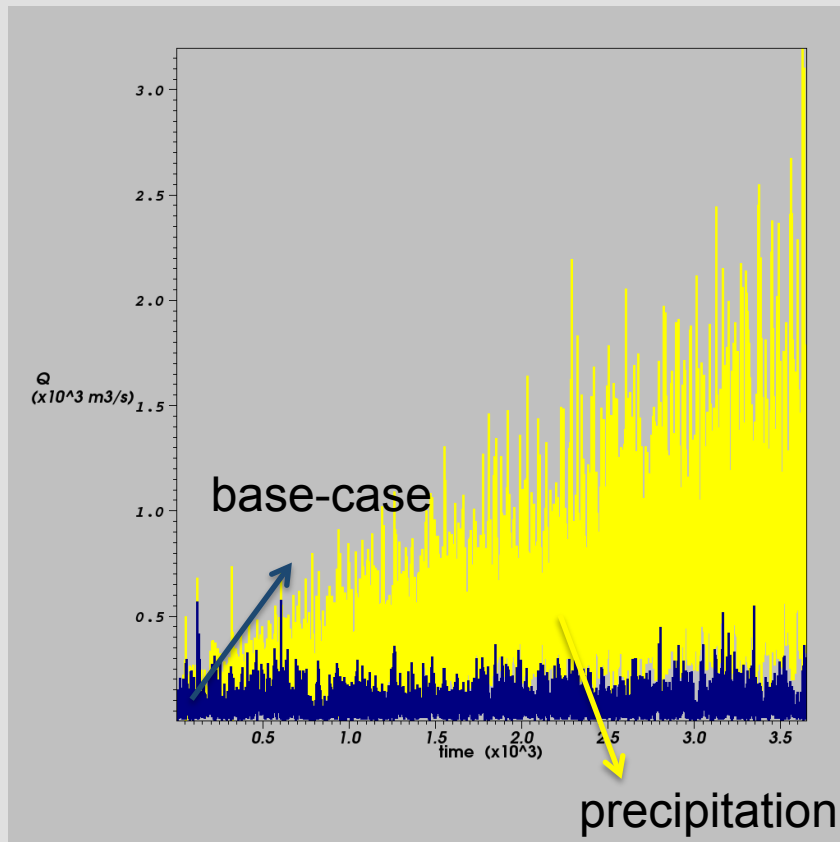


Parameter	Range	Value	Help
Lithology factor (-)	{0.3, 3.0}	0.3	?
Anthropogenic factor (-)	{0.5, 8.0}	6	?
Lapse rate (C/km)	{0.0, 10.0}	6.16	?
Starting ELA (m)	{0.0, 10000.0}	3269.93	?
Change in ELA (m/yr)	{-10.0, 10.0}	0	?
Dry precipitation (nival and ice) evaporation fraction	{0.0, 1.0}	0.3	?
River basin length (km)	{0.0, 10000.0}	100	?
Mean volume of reservoir (km <sup>3</sup> )	{0.0, 100.0}	0.6	?
Drainage area of reservoir (km <sup>2</sup> )	{0.0, 100000.0}	1800	?

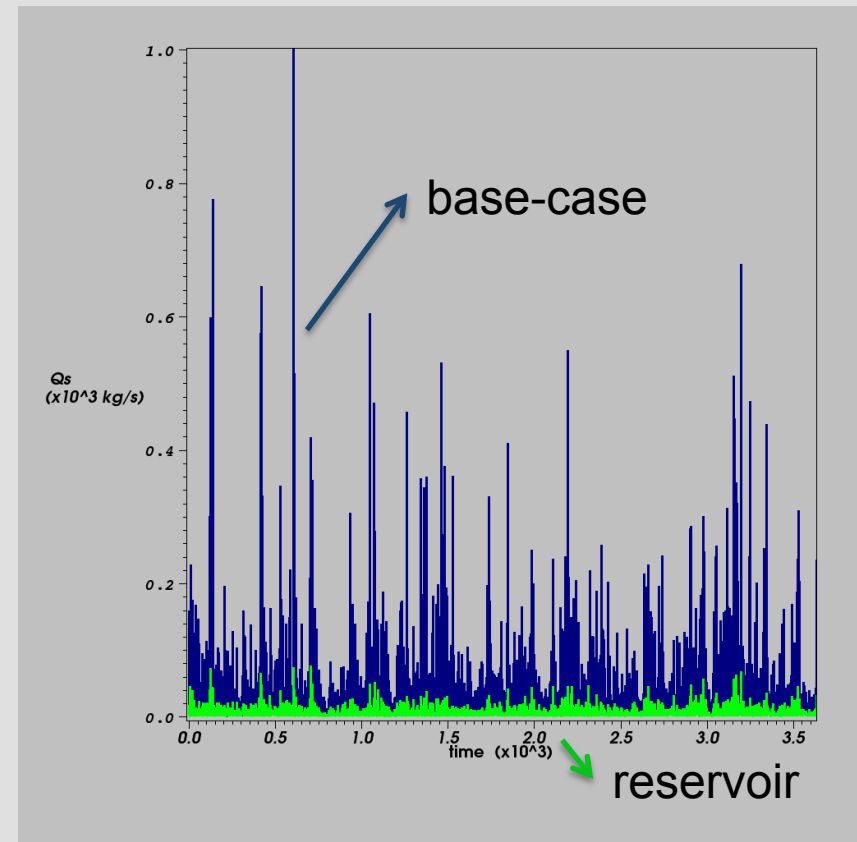
Buttons: Help, Restore Defaults, OK, Cancel

# 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](http://csdms.colorado.edu/wiki/Labs_portal)



### **Sediment Supply to the Global Ocean**

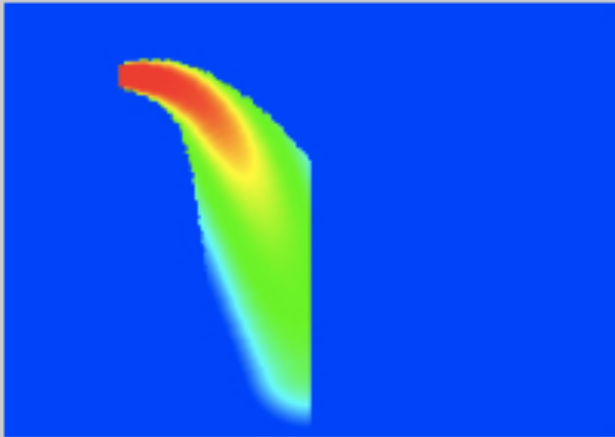
Investigate river sediment supply to the ocean by 1) a spreadsheet lab or 2) an advanced modeling lab using the HydroTrend Model to explore effects of climate changes on river fluxes. We also look at the effect of humans on rivers: the building of a reservoir.

[Spreadsheet Lab](#) or the [River Sediment Supply Modeling with CMT](#)

# Plume Example

## Educational Material in CSDMS wiki

[http://csdms.colorado.edu/wiki/Labs\\_portal](http://csdms.colorado.edu/wiki/Labs_portal)

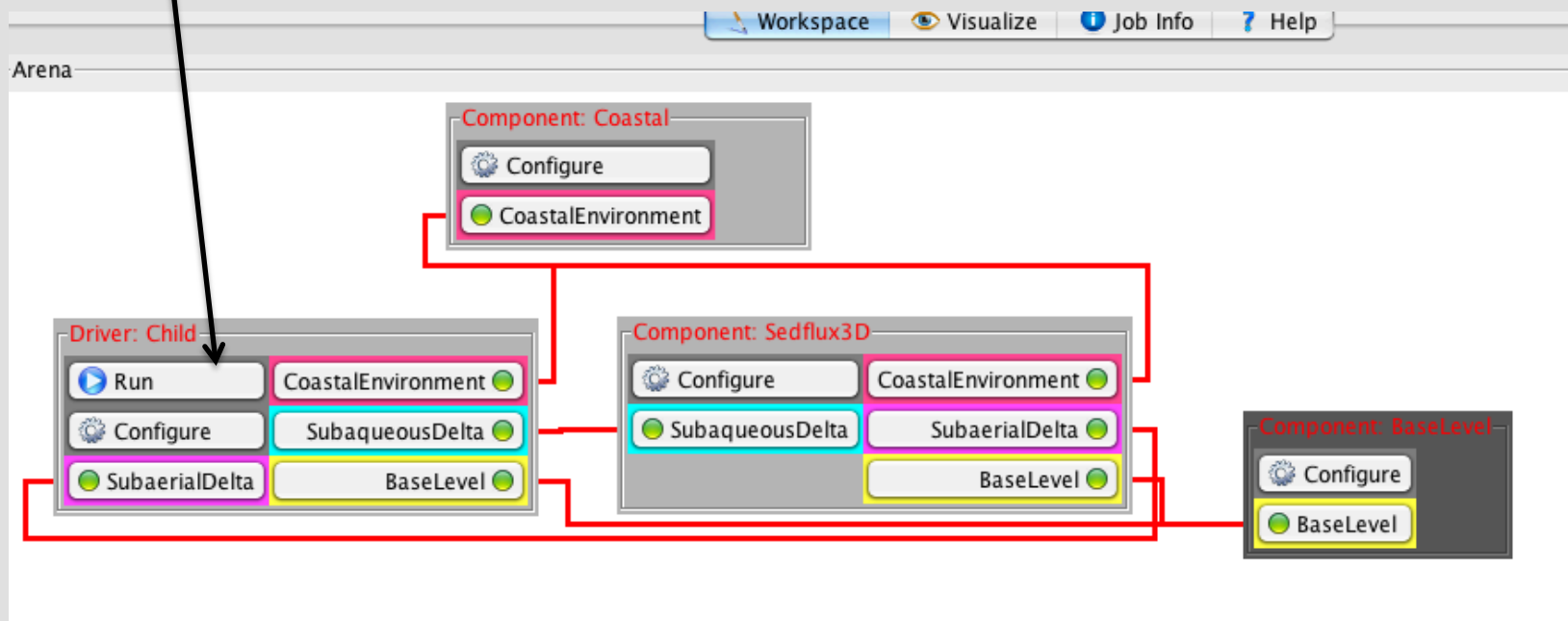


### **Modeling River Plumes**

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

Configure Component: Child

Input Files and Directories | Mesh | Climate | Sediment Transport | Bedrock | Weathering | **Run Parameters**

Run duration (years) {0.0, 1000000.0}  ?

Help Restore Defaults OK Cancel

Regolith erodibility coefficient [?]	{0.0, 10.0}	<input type="text" value="0.0005"/>	?
Shear stress (or stream power) coefficient [SI]	{0.0, 100000.0}	<input type="text" value="1000"/>	?
Bedrock erodibility discharge exponent [-]	{0.0, 10.0}	<input type="text" value="0.66667"/>	?
bedrock erodibility slope exponent [-]	{0.0, 10.0}	<input type="text" value="0.66667"/>	?
Excess erosion capacity exponent [-]	{0.0, 10.0}	<input type="text" value="1.5"/>	?
Critical shear stress for detachment-limited-erosion [kg/m/s^2]	{0.0, 10.0}	<input type="text" value="5"/>	?
Critical shear stress for detachment-limited-erosion [kg/m/s^2]	{0.0, 10.0}	<input type="text" value="5"/>	?
Diffusivity coefficient [m^2/yr]	{0.0, 10.0}	<input type="text" value="0.01"/>	?
Diffusivity deposition	{0, 10}	<input type="text" value="0"/>	?
Diffusion threshold [m^2/yr]	{0.0, 10000.0}	<input type="text" value="0"/>	?
Depth dependent diffusion	-	<input type="text" value="false"/>	?
Soil bulk density [kg/m^3]	{0.0, 10000.0}	<input type="text" value="1000"/>	?
Critical slope [-]	{0.0, 10.0}	<input type="text" value="0.5774"/>	?
fraction sed to bedload [-]	{0.0, 10.0}	<input type="text" value="1"/>	?

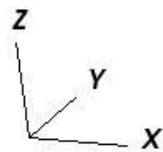
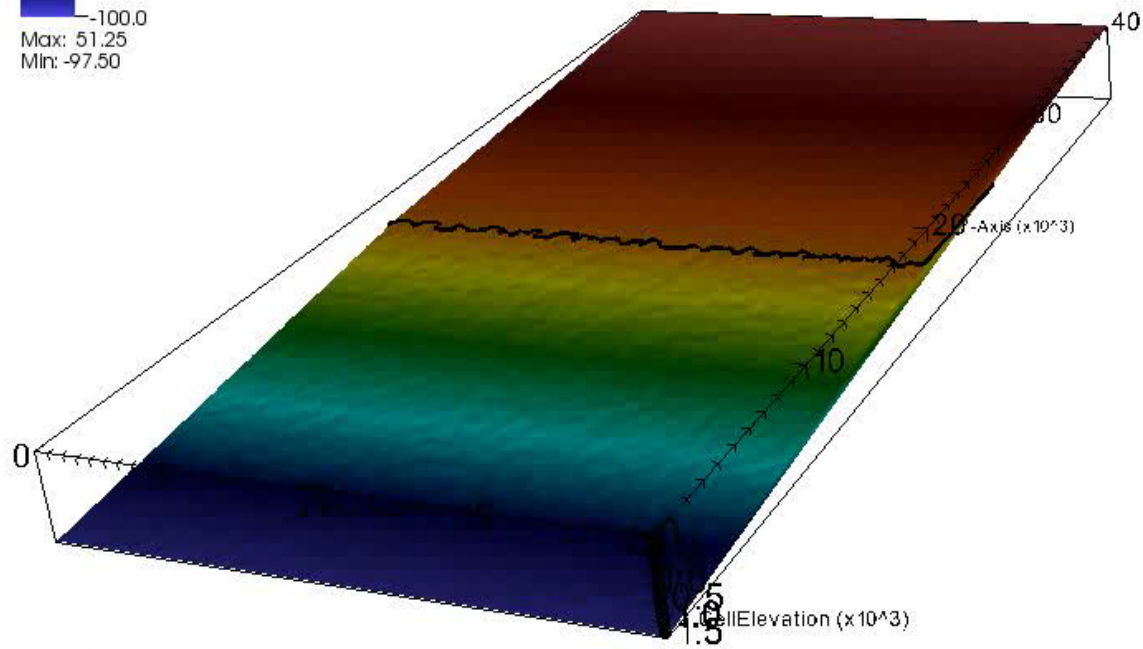
Help Restore Defaults OK Cancel

DB: CellElevation\_0000.vtu  
Cycle: 0

Pseudocolor  
Var: CellElevation



Max: 51.25  
Min: -97.50



# Model Coupling Example

The screenshot shows the CSDMS Modeling Tool interface. At the top, there is a menu bar (File, Edit, View, Tools, Help) and a toolbar with icons for file operations and execution. The main workspace displays a diagram of a coupled model system. The diagram includes a 'Driver: CEM' box with 'Run', 'Configure', and 'Elevation' buttons, and a 'Component: Waves' box with a 'Configure' button and a 'Waves' indicator. These are connected to a 'Delta Avulsion' box, which contains 'Component: Avulsion' (with 'Configure', 'Discharge', 'River', and 'Elevation' buttons) and 'Component: HydroTrend' (with 'Configure' and 'Discharge' buttons). A 'CMT Console' window at the bottom shows the following text:

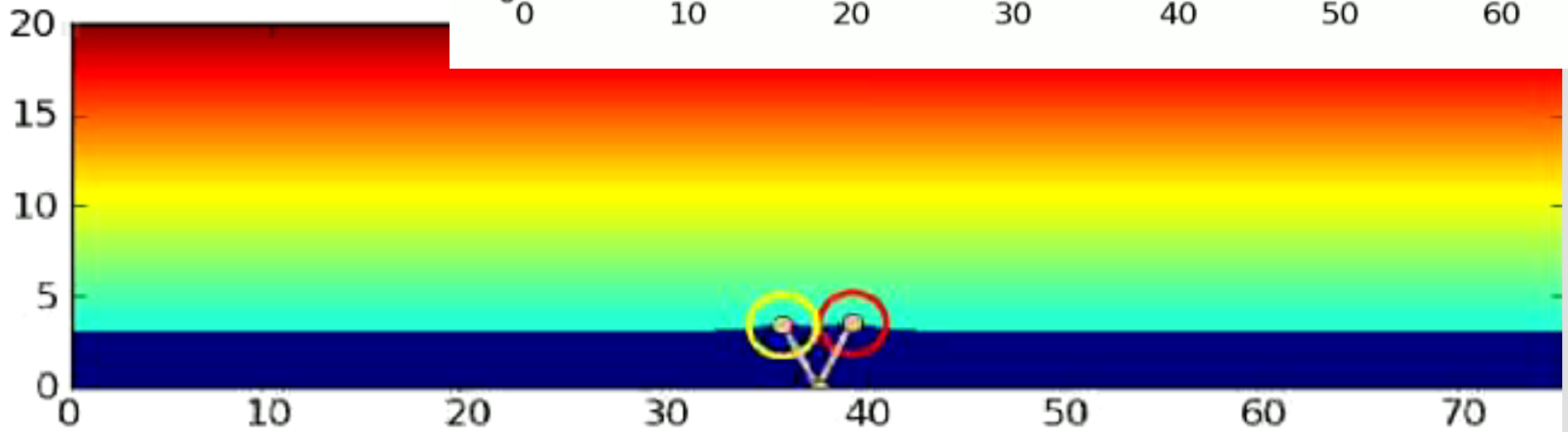
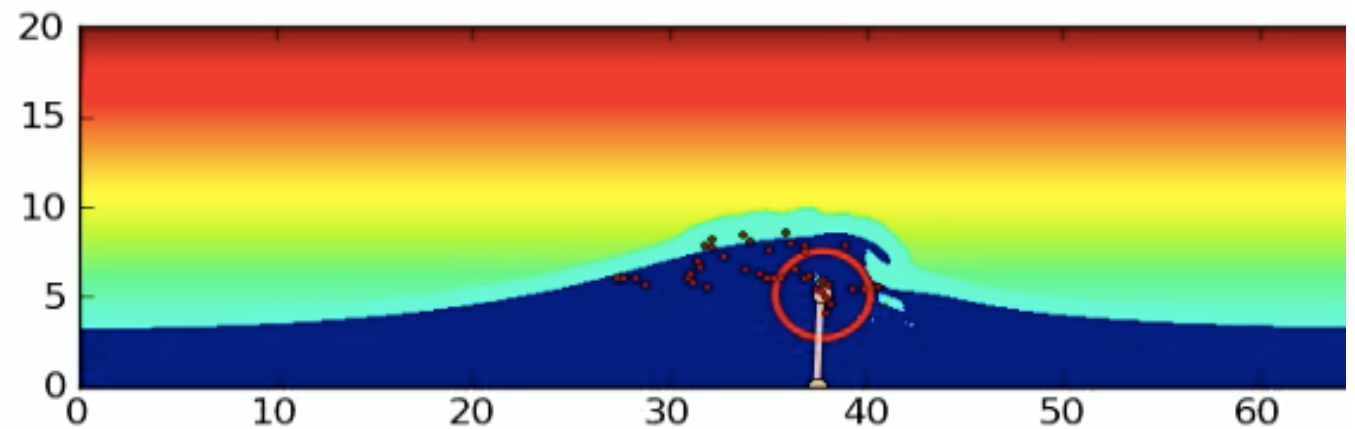
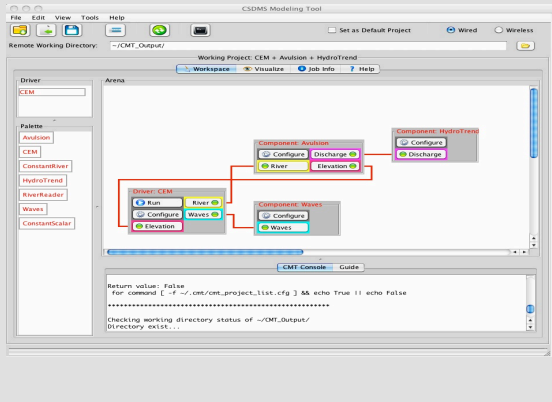
```
Return value: False
for command [ -f ~/.cmt/cmt_project_list.cfg ] && echo True || echo False
*****
Checking working directory status of ~/CMT_Output/
Directory exist...
```

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.

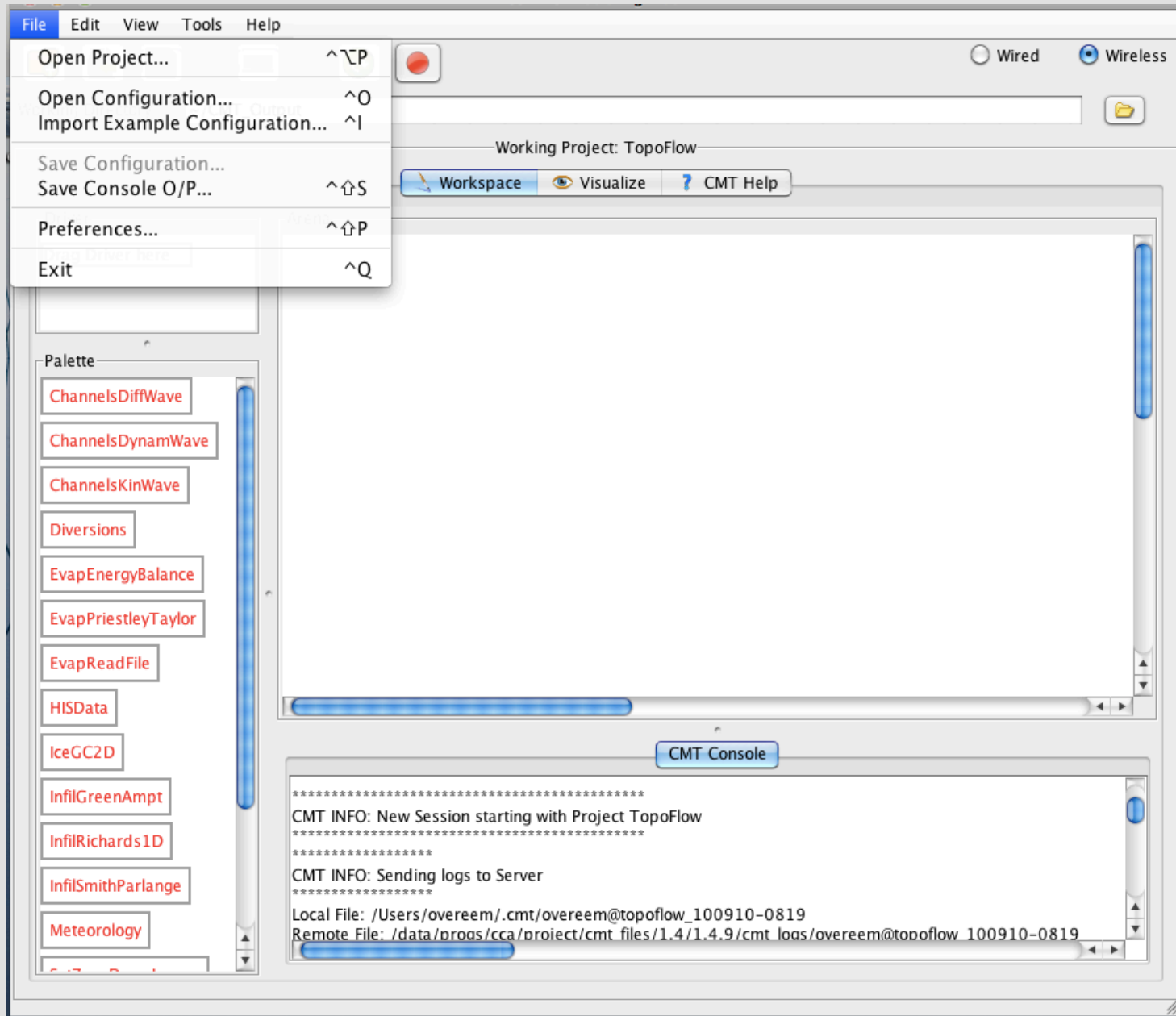
# Model Coupling



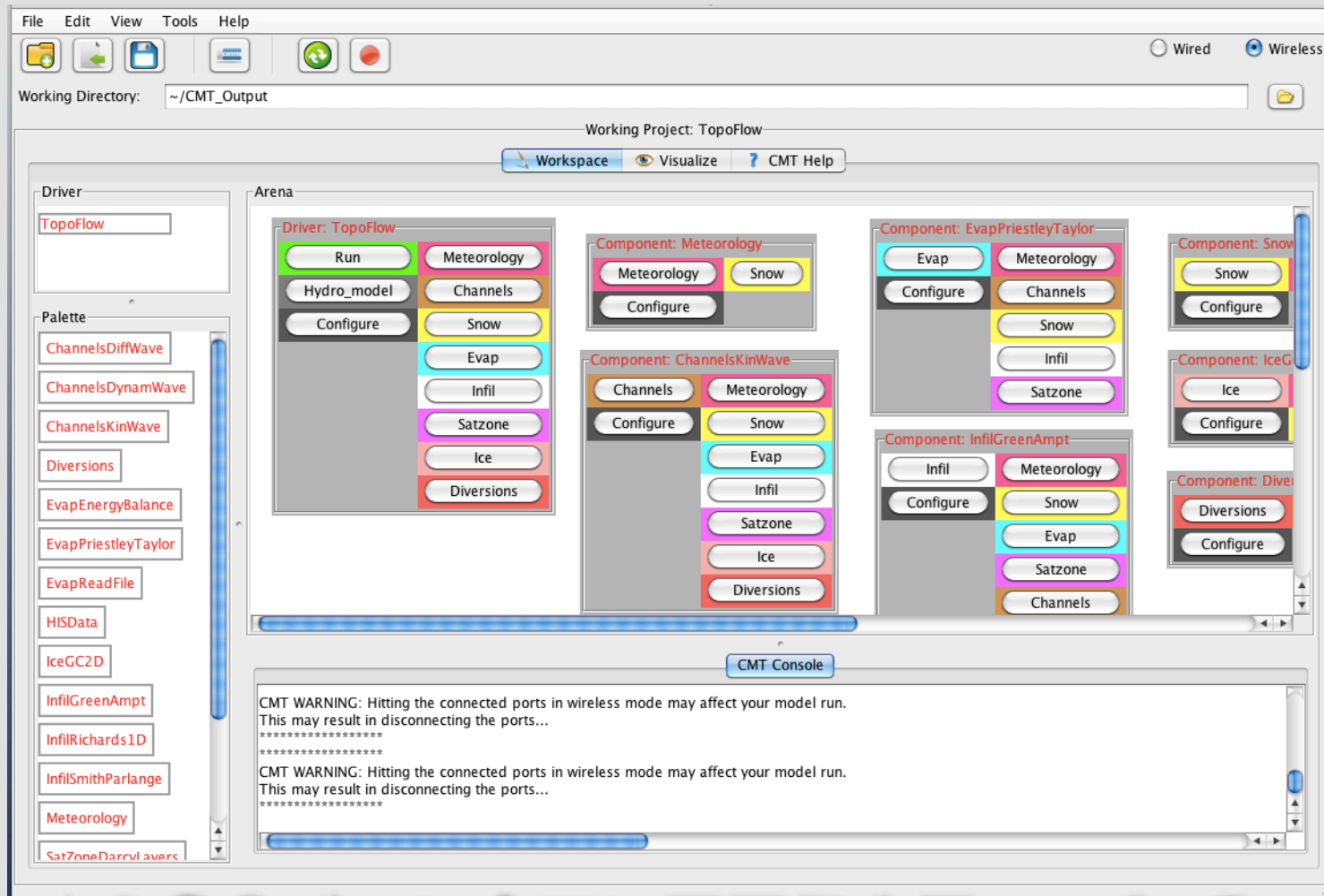
Coupling a coastal evolution model (CEM) with a delta avulsion model (Avulse), a hydrological model (HydroTrend) and a wave generator (WAVE). These codes were all in C, but originally had different dimensions (1D and 2D).

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

# Example Configurations: 'BLD-Files'



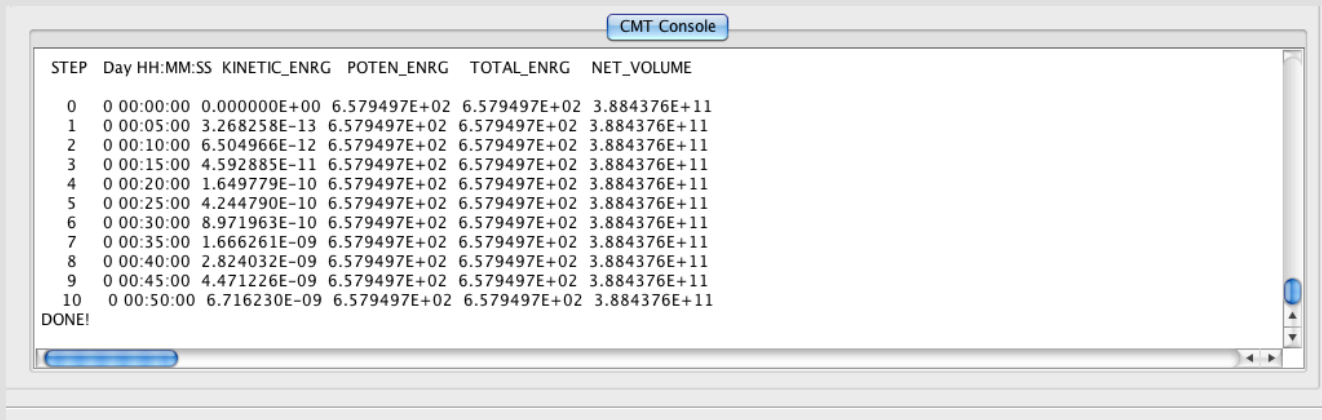
# Example Configurations: 'BLD-Files'



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

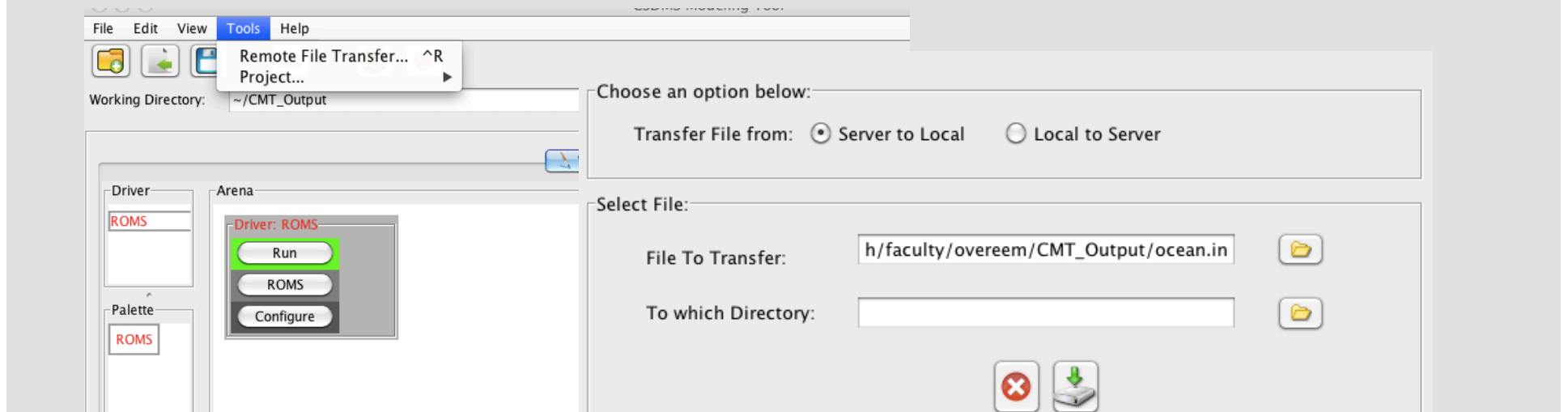


CMT Console

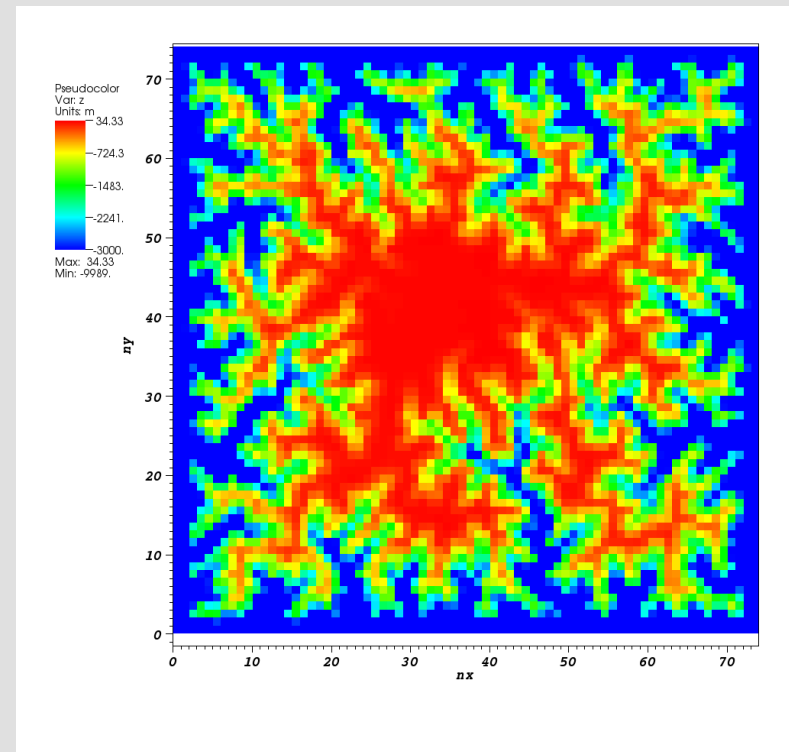
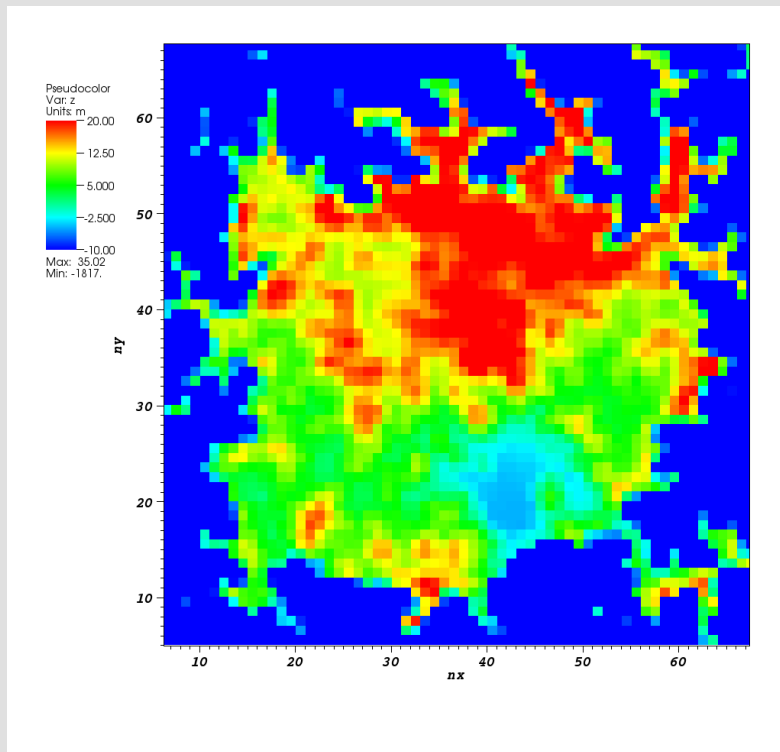
STEP	Day HH:MM:SS	KINETIC_ENRG	POTEN_ENRG	TOTAL_ENRG	NET_VOLUME
0	0 00:00:00	0.000000E+00	6.579497E+02	6.579497E+02	3.884376E+11
1	0 00:05:00	3.268258E-13	6.579497E+02	6.579497E+02	3.884376E+11
2	0 00:10:00	6.504966E-12	6.579497E+02	6.579497E+02	3.884376E+11
3	0 00:15:00	4.592885E-11	6.579497E+02	6.579497E+02	3.884376E+11
4	0 00:20:00	1.649779E-10	6.579497E+02	6.579497E+02	3.884376E+11
5	0 00:25:00	4.244790E-10	6.579497E+02	6.579497E+02	3.884376E+11
6	0 00:30:00	8.971963E-10	6.579497E+02	6.579497E+02	3.884376E+11
7	0 00:35:00	1.666261E-09	6.579497E+02	6.579497E+02	3.884376E+11
8	0 00:40:00	2.824032E-09	6.579497E+02	6.579497E+02	3.884376E+11
9	0 00:45:00	4.471226E-09	6.579497E+02	6.579497E+02	3.884376E+11
10	0 00:50:00	6.716230E-09	6.579497E+02	6.579497E+02	3.884376E+11

DONE!

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 HPC 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](http://csdms.colorado.edu/wiki/HPCC_Access)

2) CSDMS Modeling Tool installation and use

[http://csdms.colorado.edu/wiki/CMT\\_download](http://csdms.colorado.edu/wiki/CMT_download)

3) Visit for parallel scientific visualization

[http://csdms.colorado.edu/wiki/CMT\\_visualization](http://csdms.colorado.edu/wiki/CMT_visualization)

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

4) NetCDF output files now standard within CSDMS framework

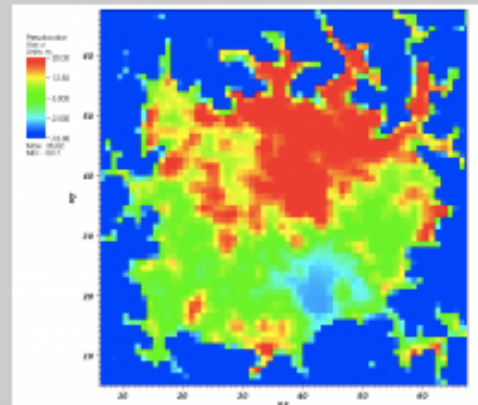
<http://www.unidata.ucar.edu/software/netcdf/>

# Get Started with Labs 2013



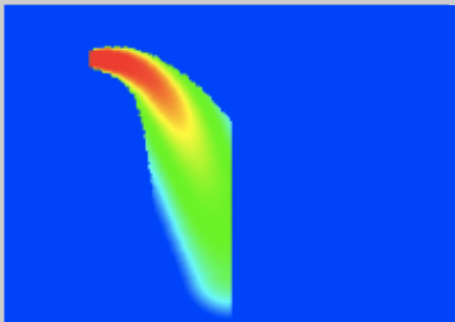
## Get Started with CMT

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