RUNNING A STAND-ALONE MODEL
Climate-hydrological modeling of sediment supply

Run & Couple Surface Dynamics Models

Outline

OBJECTIVE

- Learn How to Run a Model in the CMT

EDUCATIONAL EXAMPLE HYDROTREND

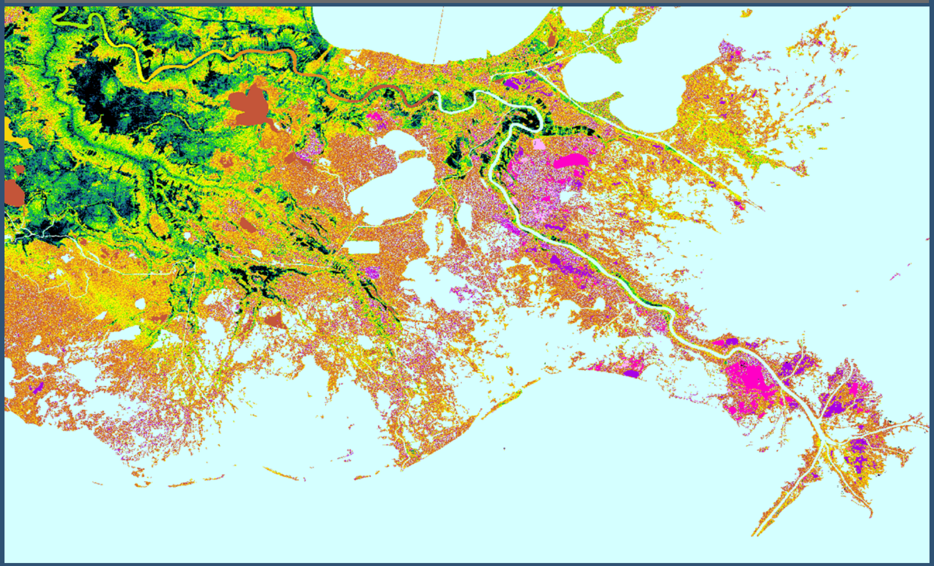
- Why is sediment supply important? Delta formation
- Quantifying Sediment Supply Processes
- Simple Scenario and User Changes to Input Parameters

HANDS-ON

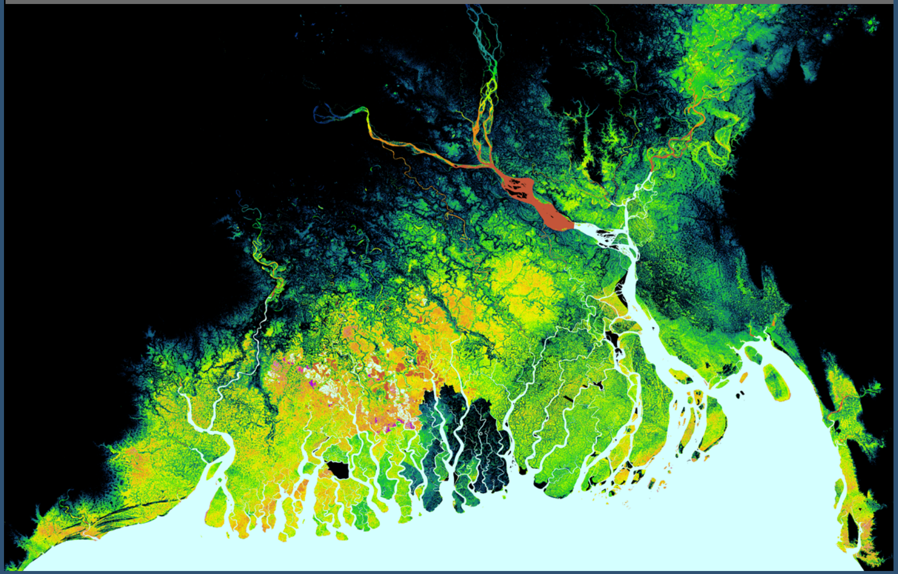
- Run a climate change scenario and human impacts scenario for 21st century

Why Model Sediment Supply?

Mississippi Delta, USA



Ganges-Brahmaputra Delta, India & BD



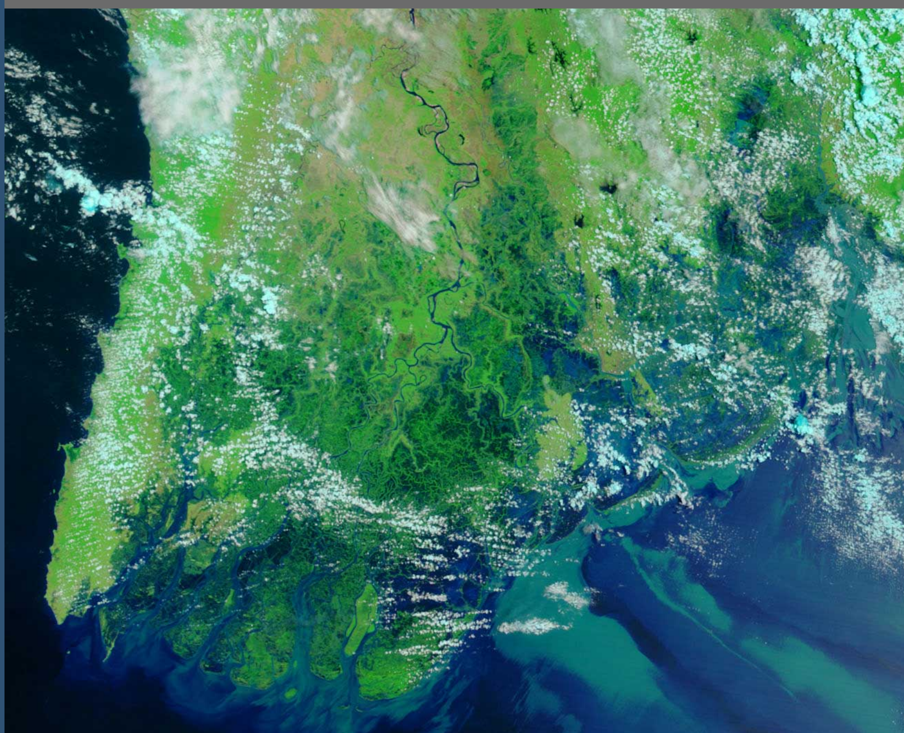
Worldwide 500 million people live in low-lying deltas
Thirty-three major deltas combined have >100,000 km^2 at elevation < 2m a.s.l. (Syvitski et al., 2009).

Sediment affects River Deltas Elevation (ΔRSL) by Aggradation (A)

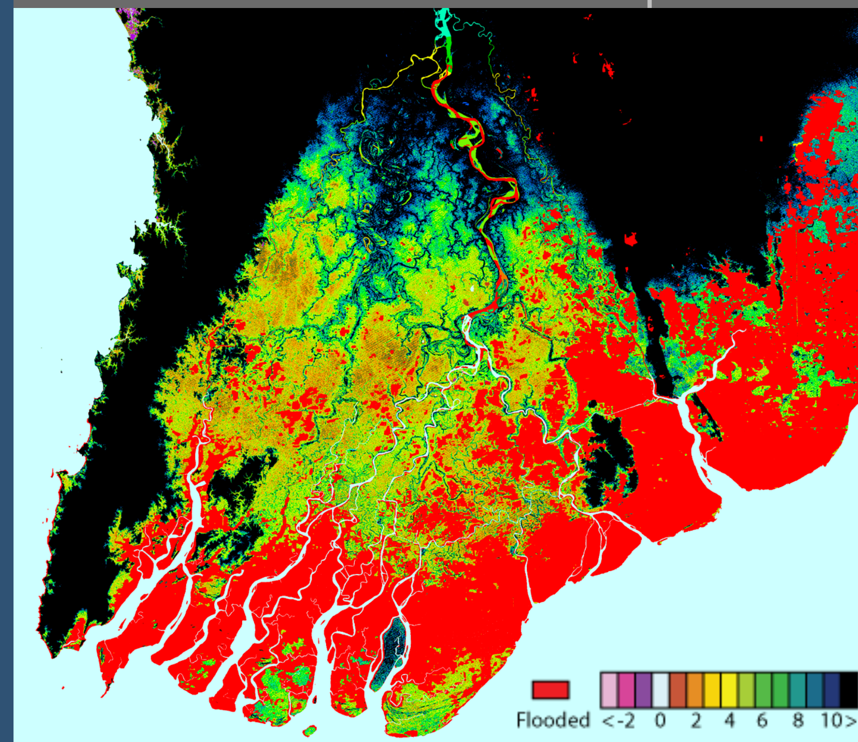
$$\Delta_{RSL} = A - \Delta E - C_n - C_A \pm M$$

Aggradation due to Floods in Deltas

Cyclone Nargis, Irrawaddy Delta
MODIS Terra, May 5th, 2008.



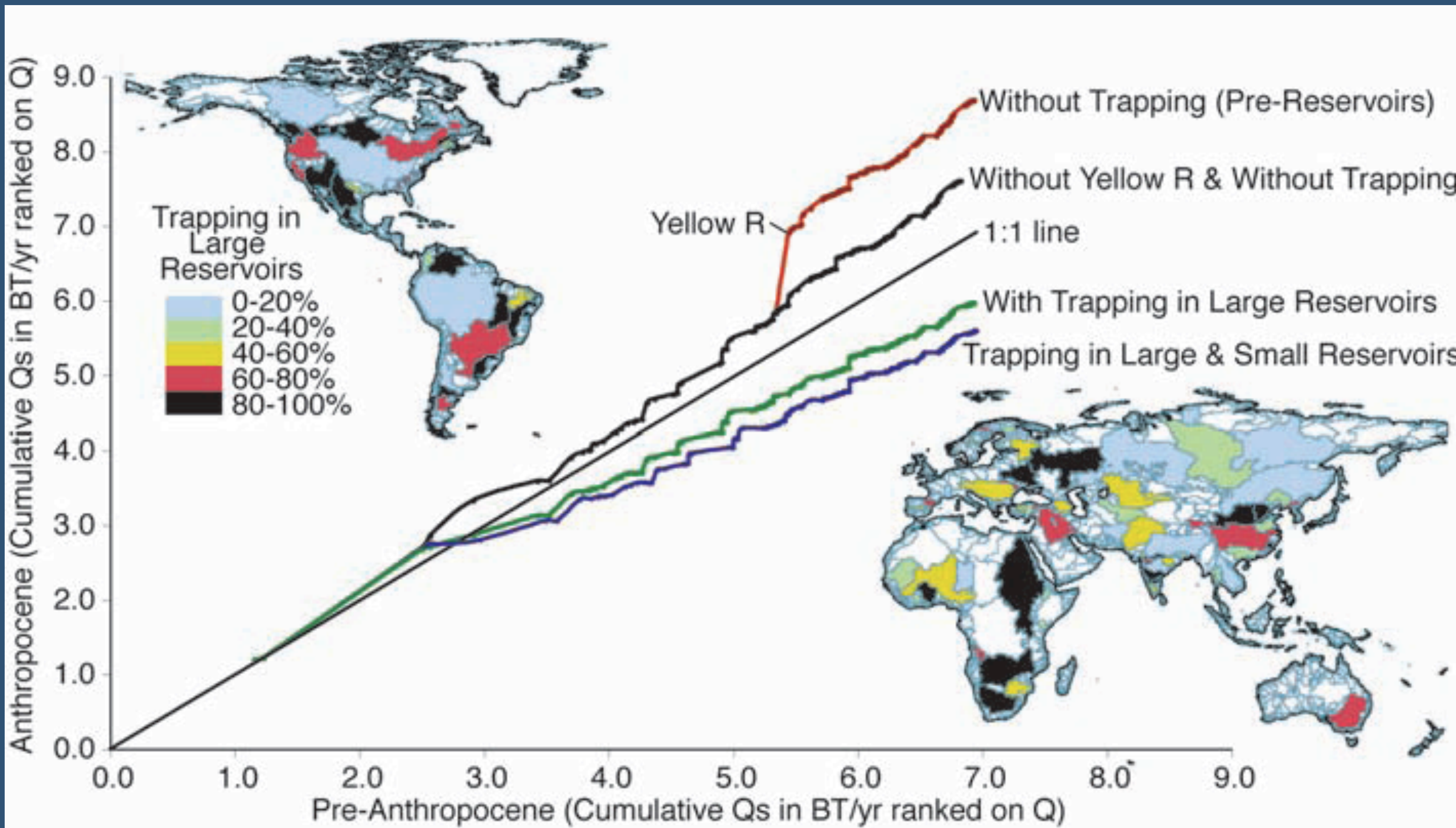
SRTM 90m topographic data overlay with MODIS flood extend map in red.



Floods are widespread, 85% of 33 studied deltas experienced flooding (2001-2008). Total of ~260,000 km^2 was submerged by floods.

Question: are changes in precipitation regimes changing floods into 21st century?

Reduced Aggradation due to Damming



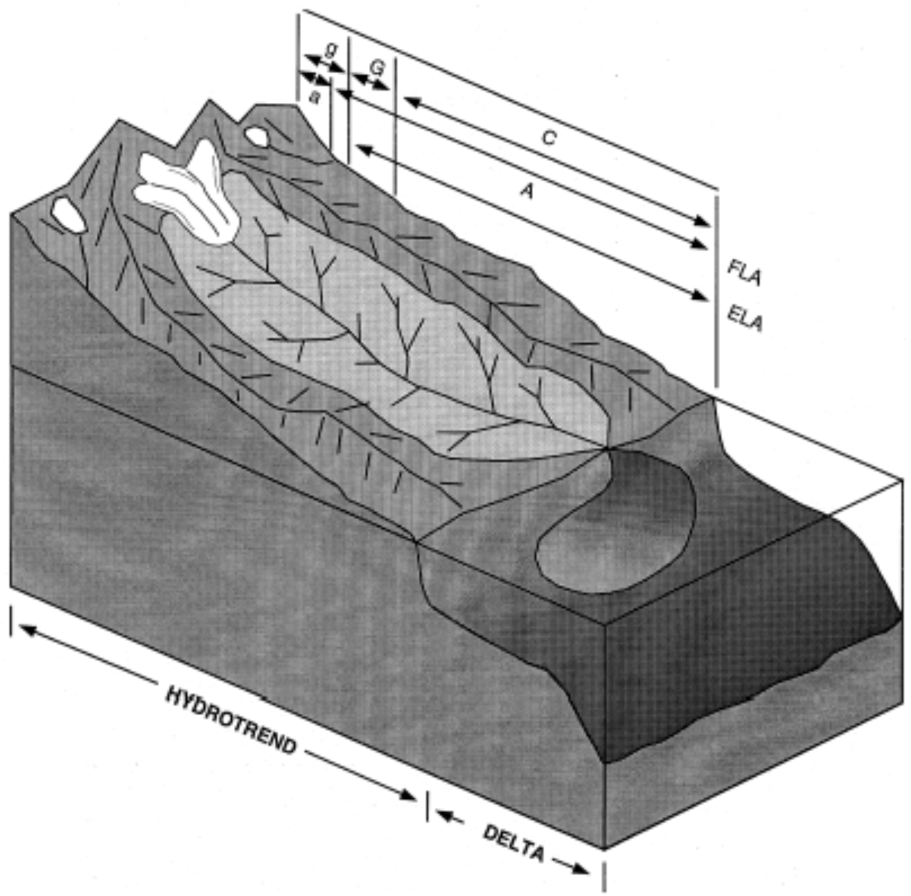
1.4 ± 0.3 billion tons per year LESS sediment reaches the coast worldwide.

Question: how is a new planned dam influencing the sediment flux at the coast?

Ok. It’s important. But how do we quantify sediment supply for an arbitrary river?

Numerical Model HydroTrend

$$Q = Qrain + Qsnow + Qglacier$$



Critical Dynamic Boundaries: Rain-Snow-Ice

-Daily temperature combined with hypsometry and lapse-rate determine the freezing line altitude (FLA) and thus the parts of the basin that get rained on or snowed on.

- Glacier equilibrium line altitude (ELA) combined with the hypsometric curve determines the area of the basin covered with glaciers, and thus area contributing to ice accumulation and ice melt.

Suspended sediment flux

$$Qs = \omega B Q^{0.31} A^{0.5} R T$$

For T-annual >= 2deg C

Qs	sediment load MT/yr
ω	0.0006
Q	discharge in km^3/yr
A	drainage area in km^2
R	relief in km
T	mean annual basin-wide temperature in deg C

The regression for this model is based on analysis of a global database of last century discharge and sediment load observed at river mouths of 100’s of rivers (Syvitski & Milliman, Journal of Geology, 2007).

Trapping sediment in lakes or reservoirs in HydroTrend

The model simulates Trapping Efficiency, TE, based on the modified Brune equation (Vörösmarty et al., 1997), for reservoirs volumes, V, larger than 0.5 km^3

$$TE = 1 - \frac{0.05}{\sqrt{\Delta t}}$$

Wherein $\Delta\tau$ is the approximated residence time and *Qj* is the discharge at mouth of each subbasin *j* ($m^3\ s^{-1}$) draining to a specific lake:

$$\Delta t = \frac{\sum_{j}^{n} V_j}{Q_j}$$

HydroTrend Hands-On Notes

- Activate your VPN for secure connection
- Make sure you have Java 1.6
- Launch the CMT tool (from the CSDMS website)
- Log in to beach.colorado.edu

5 Minutes

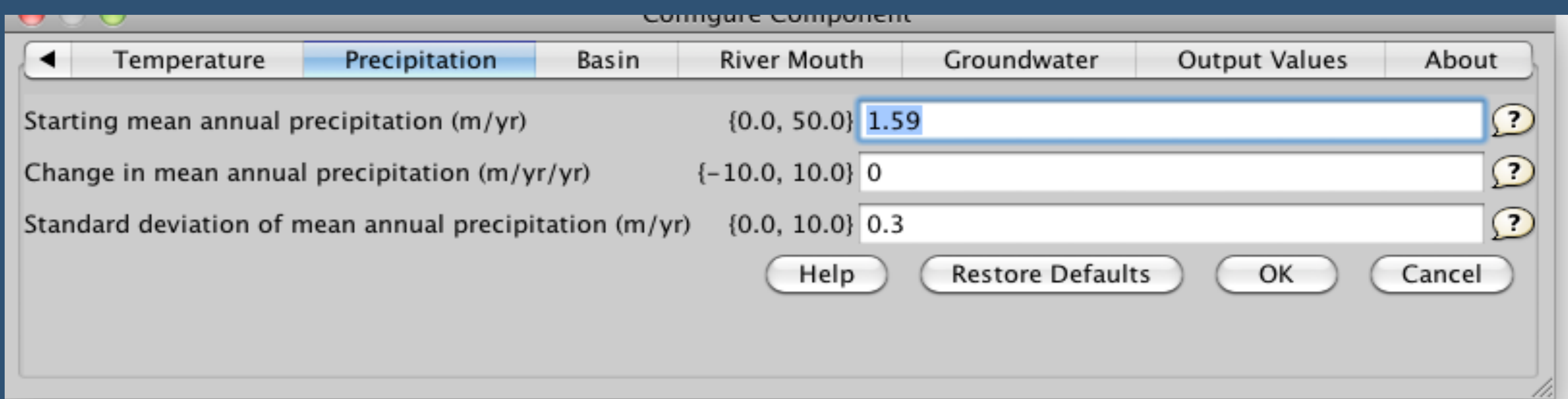
- Open Group: Coastal
- Open Project: Hydrotrend + Avulsion +CEM
- Drag in HydroTrend Component to be the Driver
- Change Settings in the HydroTrend Configure Menu
- Run Simulations, Look at your results in the Console

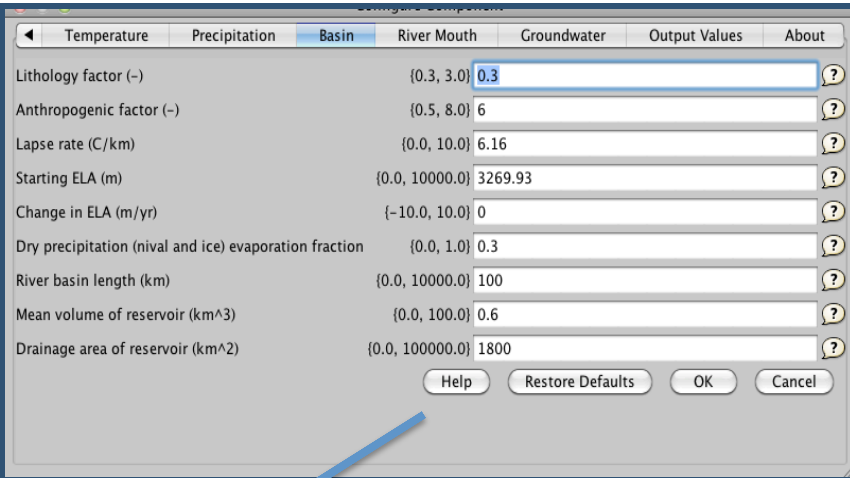
10 Minutes

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.

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]

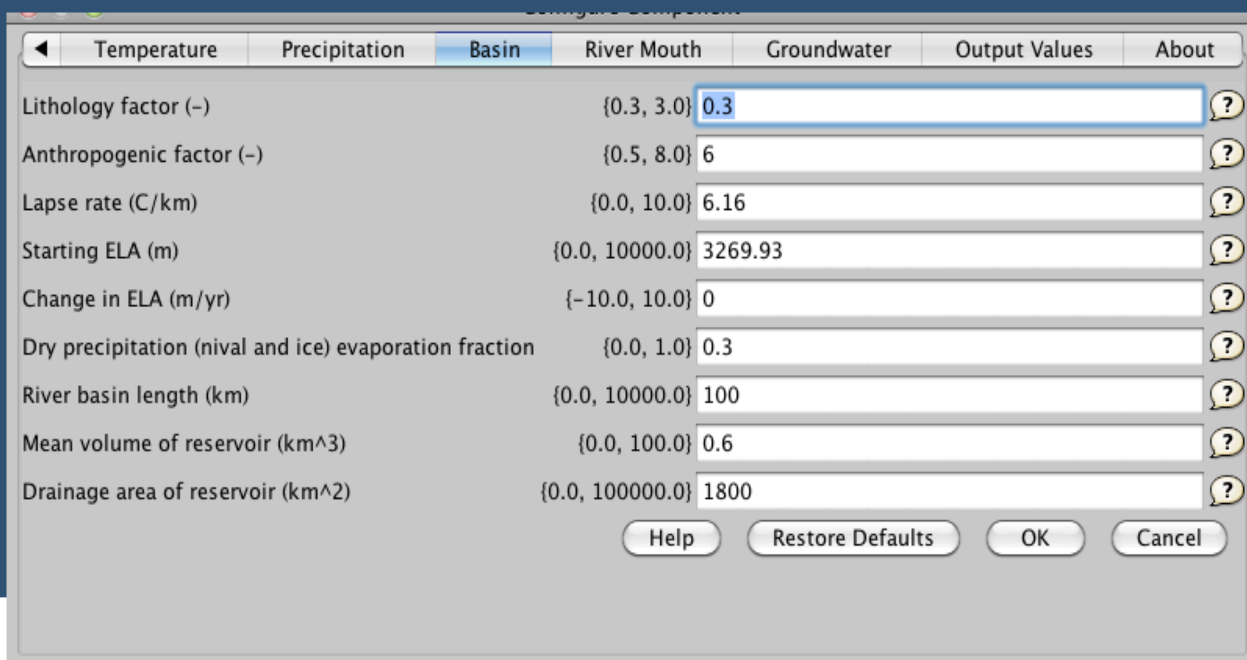
Explanation table for HYDRO.IN input file. Download this example HYDRO.IN file In case you want to set up a HydroTrend run for your specific river drainage basin.

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 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. 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 (ºC) for this climate epoch. Tstart should be warmer than -20ºC and colder than 30ºC.

River system response to human impacts?

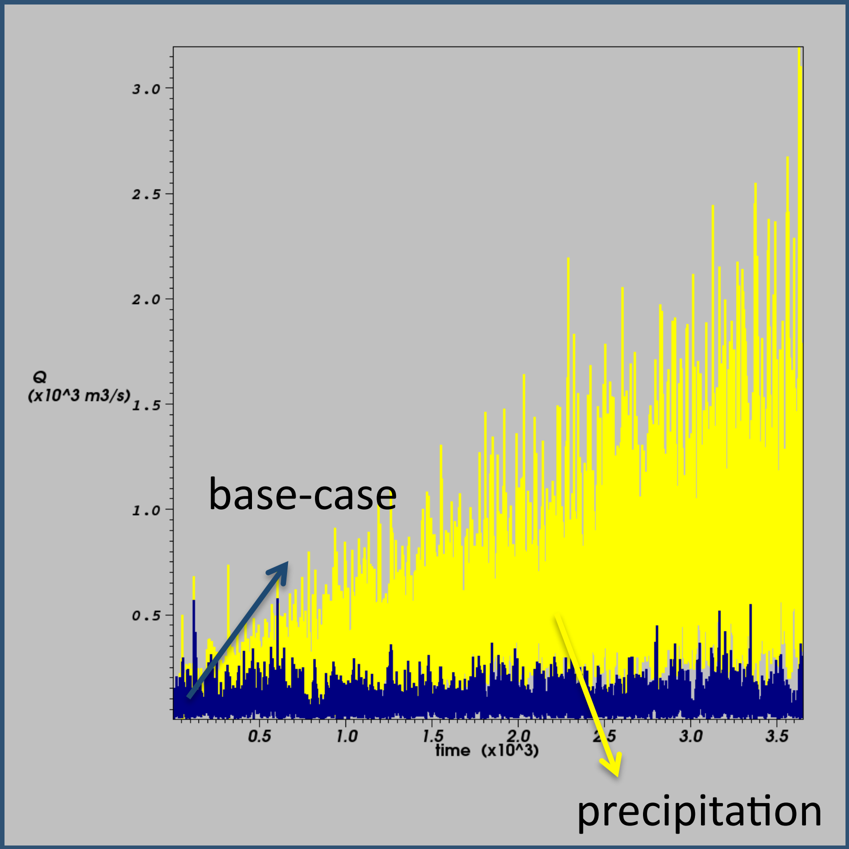
Model a planned drinking water supply reservoir in the basin. The reservoir would have 1800 km^2 of contributing drainage area, and be 1 km long and 100m wide, 5m deep.

HydroTrend Configure Menu: adapt reservoir settings

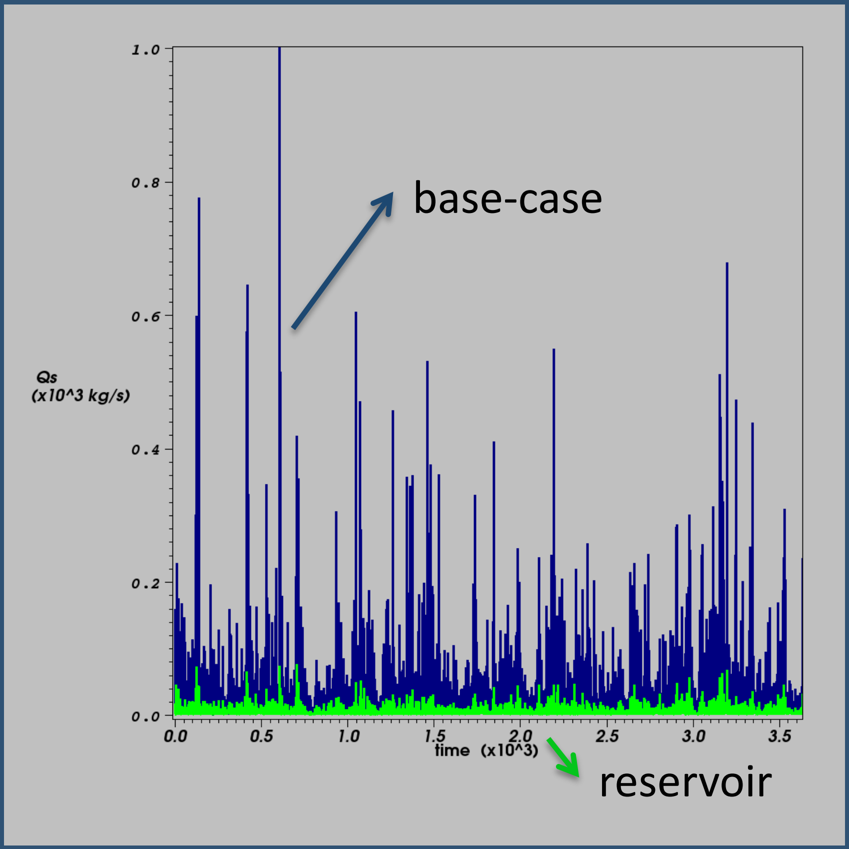


Output

Daily Water Discharge Output



Daily Sediment Load Output

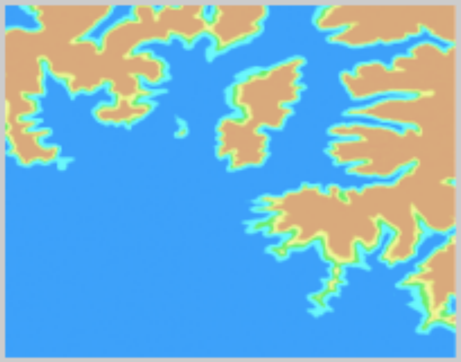


Drastic changes in water flux result from increased precipitation regime,
Drastic reduction in sediment flux results from damming.

Educational Material in CSDMS wiki

Lectures

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



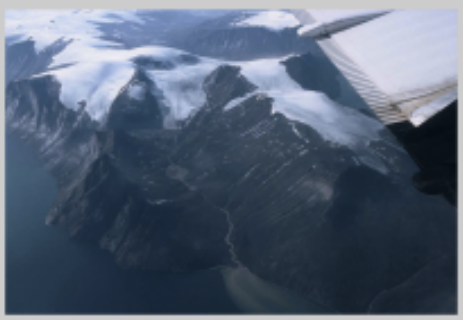
Surface Dynamics Modeling with CMT tool

Irina Overeem & Scott Peckham

These presentations are part of the course on "Surface Dynamics Modeling with the CMT Tool". This course is currently taught and will be completed by December 2010.

Labs

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



Sediment Supply Numerical Experiments

Irina Overeem

This lab uses the CSDMS Modeling Tool to do a number of simple sediment supply simulations. Students will use the HydroTrend Model to explore the effects of next century temperature and precipitation changes on river fluxes. In addition, we run simulations to look at the effect of humans on rivers: the building of a reservoir. PDF

References

Syvitski, J.P.M., Kettner, A.J., Hannon, M. T., Hutton, E.W.H., Overeem, I., Brakenridge, G.R., John Day, J., Vörösmarty, C., Saito, Y., Giosan, L., Nicholls, R.J., 2009. Sinking Deltas due to Human Activities. *Nature Geoscience,* 2, 681 - 686.

Kettner, A.J., and Syvitski, J.P.M., 2008. HydroTrend version 3.0: a Climate-Driven Hydrological Transport Model that Simulates Discharge and Sediment Load leaving a River System. *Computers & Geosciences*, **34**(10), 1170-1183.