Modeling River Sediment Supply

HydroTrend Lab description, September 24th, 2010

Note for Users. This lab relies on the CSDMS Tool. The use of the CSDMS Tool is free for members, but it requires an account on the CSDMS HPCC system. You can sign up here:

http://csdms.colorado.edu/wiki/Help:HPCC_account_request

You will also need a secure way of accessing the system (f.e. VPN software) and to download the CMT tool as well as Visit. More information: http://csdms.colorado.edu/wiki/Help:Ccaffeine_GUI

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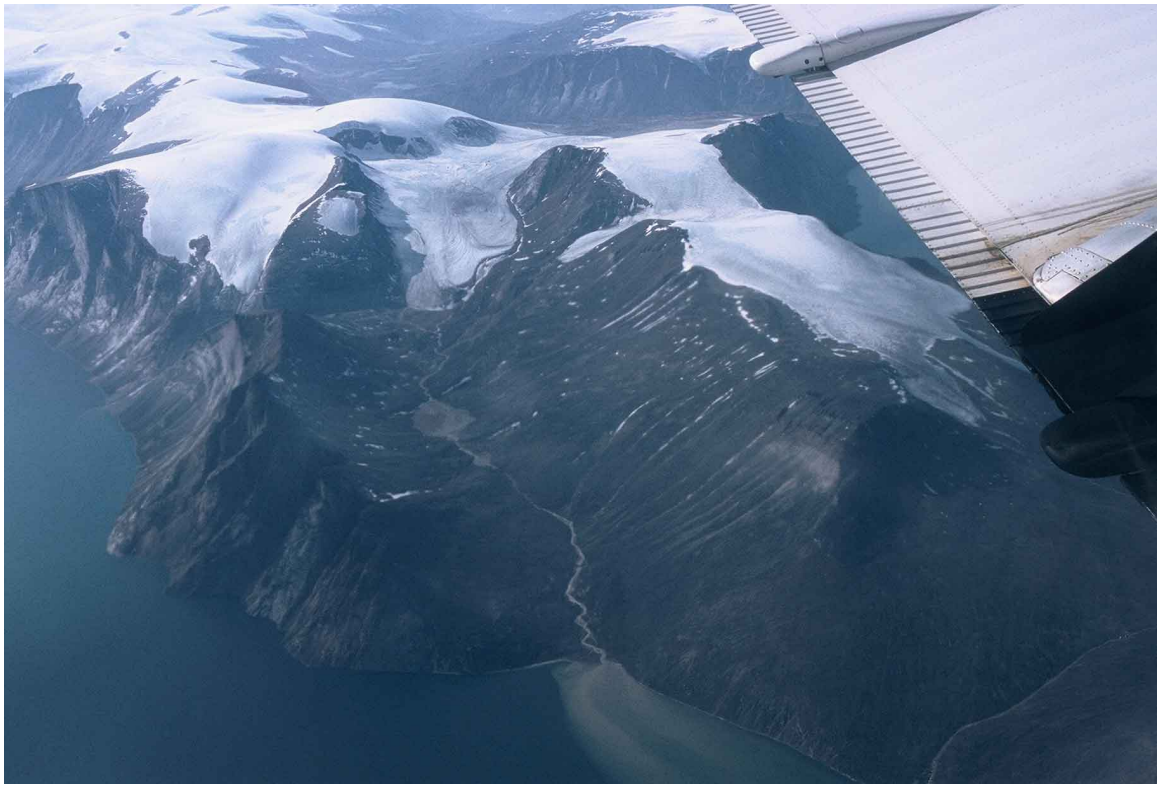


Small river basin on Baffin Island, Arctic Canada supplying sediment to fjord.

Introduction

We are using a small theoretical river basin of ~1990 km^2, with 1200m of relief and a river length of ~100 km. The basin geometry parameters we will not be able to

change in this laboratory. All parameters that are shown by default in the CSDMS Modeling Tool for the HydroTrend Model SetUp are based on a present-day, temperate climate.

Exercise 1: Explore the base-case river simulation

1.1 Run a "base-case" simulation for 100 years at daily time-step.
1.2 Calculate mean water discharge Q, mean suspended load Qs, mean sediment concentration Cs, and mean bedload Qb for the river. Note all values are reported as daily averages. Q= m^3/s, Cs=kg/m^3, Qs =Qb = kg/s.
1.3 Identify the 100-year flood event for this simulation. Plot this year of Q-data.
1.4 Did hyperpycnal flow conditions occur? How can you tell? How often did this happen in the 100 year simulation?
1.5 Calculate the mean annual sediment load for this river system.
1.6 To compare the mean annual load to other river systems you will need to calculate its sediment yield. Sediment Yield is defined as sediment load normalized for the river drainage area; so it can be reported in $T/km^2/yr$. Can you comment whether this is a high load system or a low load system? *(Helpful reference for this comparison: Syvitski and Saito, 2007. Morphodynamics of Deltas under the Influence of Humans, Global and Planetary Change 57, 261-282).*

Exercise 2: How does a river system respond to climate change; a few simple scenarios for the coming century.

2.1) Explore the effect of a warming climate. What happens to discharge, suspended load and bedload if the mean annual temperature in this specific river basin increases by 4 °C?

2.2) Explore the effect of a 100% increase of precipitation in the next century.

How much increase of discharge do you see after 100 years? How is the average suspended load affected? How does the bedload change? What happens to the peak event, look at the highest event of the last 10 years of the simulation?

2.3) In addition, climate model predictions indicate that perhaps precipitation intensity and variability could increase. How would you model this; discuss all your input settings for precipitation?

Run your simulation and compare discharge and sediment load characteristics to the original basecase. What are potential implications of changes in the peak events? Do you see an increase in hyperpycnal flow conditions?

Exercise 3: How do humans affect river sediment loads?

3.1) Describe in your own words the meaning of the human-induced erosion factor, (Eh) (Syvitski & Milliman, 2007). This factor is parametrized as the "Antropogenic" factor in HydroTrend

3.2) Run 3 simulations systematically increasing the antropogenic factor (0.3-8.0 is the range).

3.3) Model a scenario of a drinking water supply reservoir to be planned in the coastal area of the basin. The reservoir would have 1800 km^2 of contributing drainage area and be 3 km long and 200m wide.

Set up a simulation with these parameters. How would such a reservoir affect the sediment load at the coast (i.e. downstream of the reservoir)?

Exercise 4: Sediment Load Model Couplings

4.1 What process models can be coupled to a sediment load model like HydroTrend? Think of an example of climatic processes, or drainage basin processes (i.e. upstream) as well as marine processes (i.e. downstream).

4.2 Please go browse in the CSDMS Model repository whether you can find an example of a model that *could potentially* be coupled. Describe why this coupling would be useful. What research question or applied problem could be addressed?

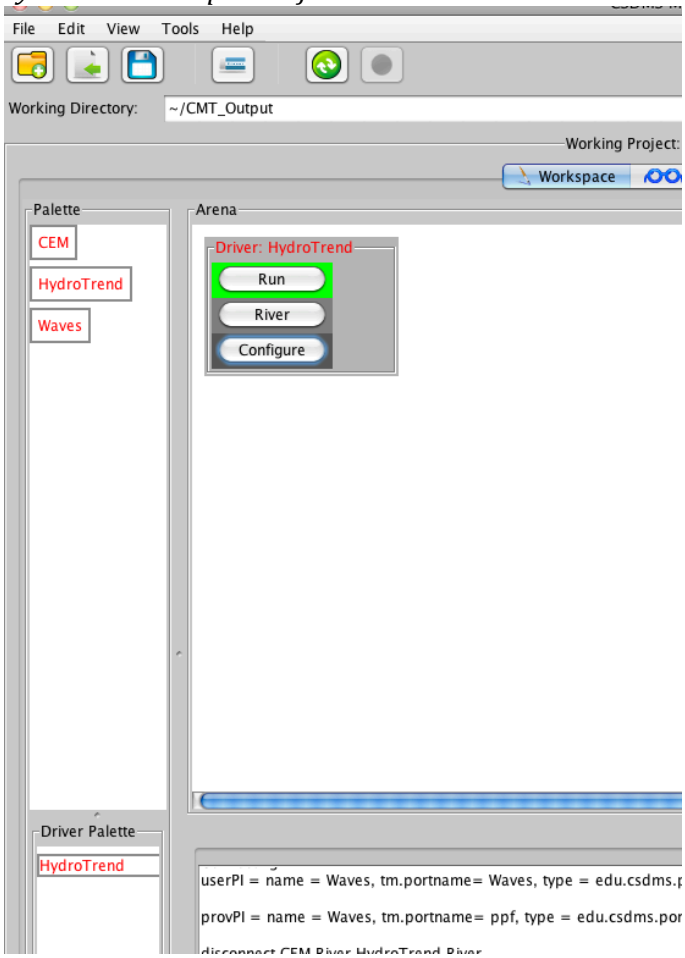
(the CSDMS Model repository is browsable here:
http://csdms.colorado.edu/wiki/Models

Appendix 1: Notes on running HydroTrend simulations with the CMT Tool

>> Download the CMT Tool

>> Open Project: go to Group Terrestrial, Select HydroTrend + CEM project.

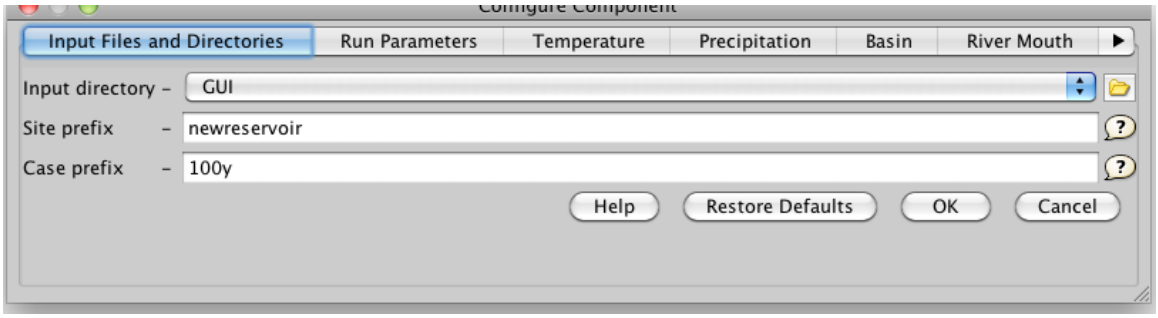
>> We will be running HydroTrend in stand-alone mode. This means that you only drag the HydroTrend Component from the Palette into the Driver Palette.



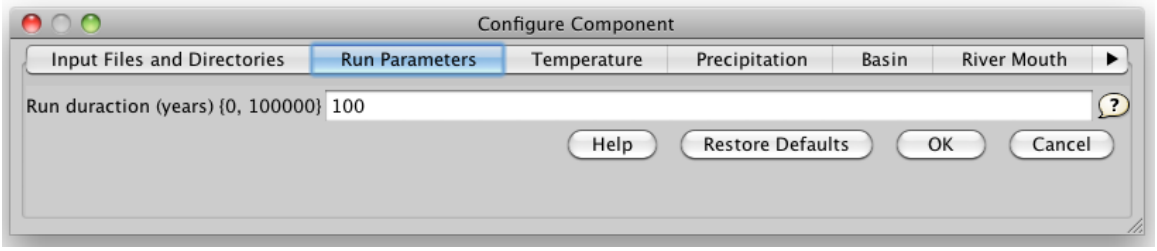
>> HydroTrend will now be active in the CMT Arena. The HydroTrend Configure Menu is used to set the parameters for the simulations. You can set the parameters by going through the different tabs under the configure menu and subsequently run it by hitting the green run button.

>> To run the base case scenario

>>Make sure you have the first tab of the 'Configure Menu" set to GUI. This means that the input to the model is being received from the GUI. Here you can specify your simulation name (the combination of the site and case prefixes).

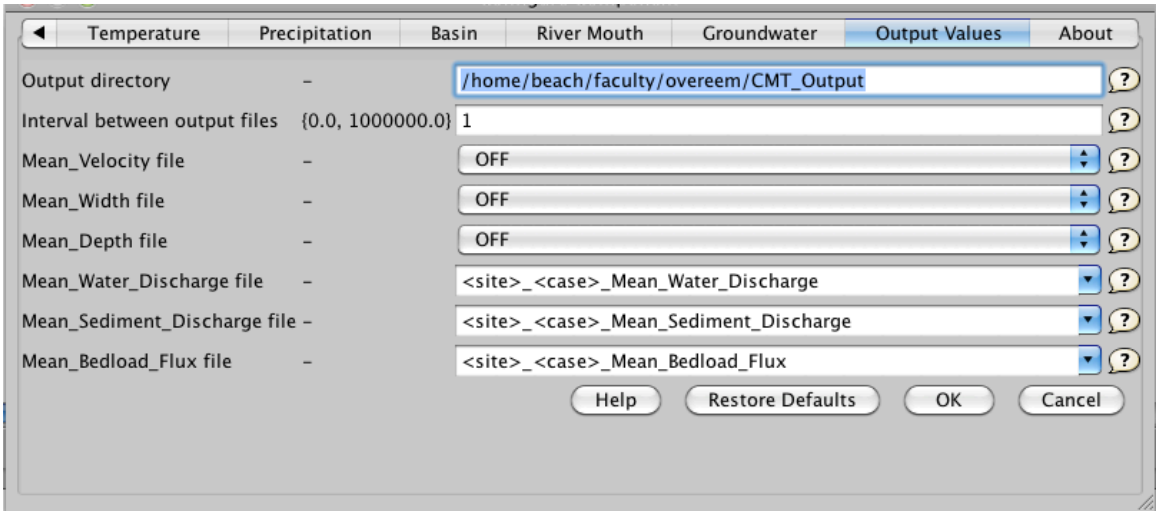


>> Set the run to 100 years duration in the second tab.



>> For the base case scenario we wil leave all process parameters as default values.

>> But we do need to specify what output files will be generated, and at what time interval (dt_output=1 day)

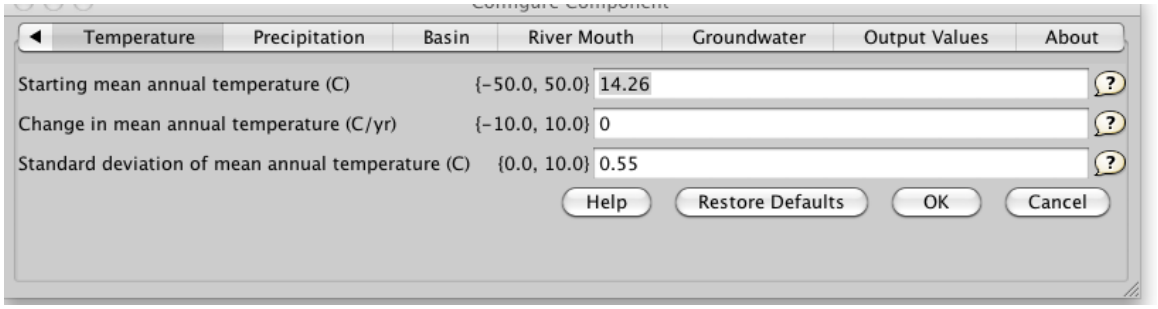


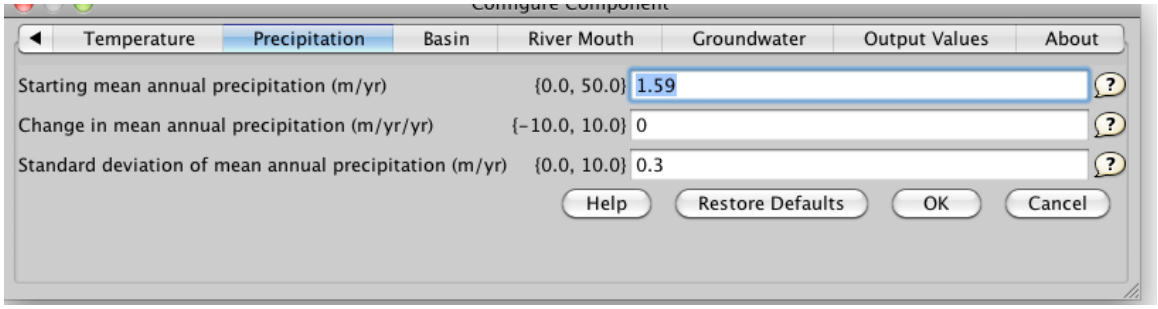
>> Note that the configure menu has a help button (lowerleft), it redirects to the HydroTrend Model entry in the CSDMS Model Repository. There are literature references and model parameter descriptions posted there.

http://csdms.colorado.edu/wiki/Model:HydroTrend

>> To run the climate change scenarios

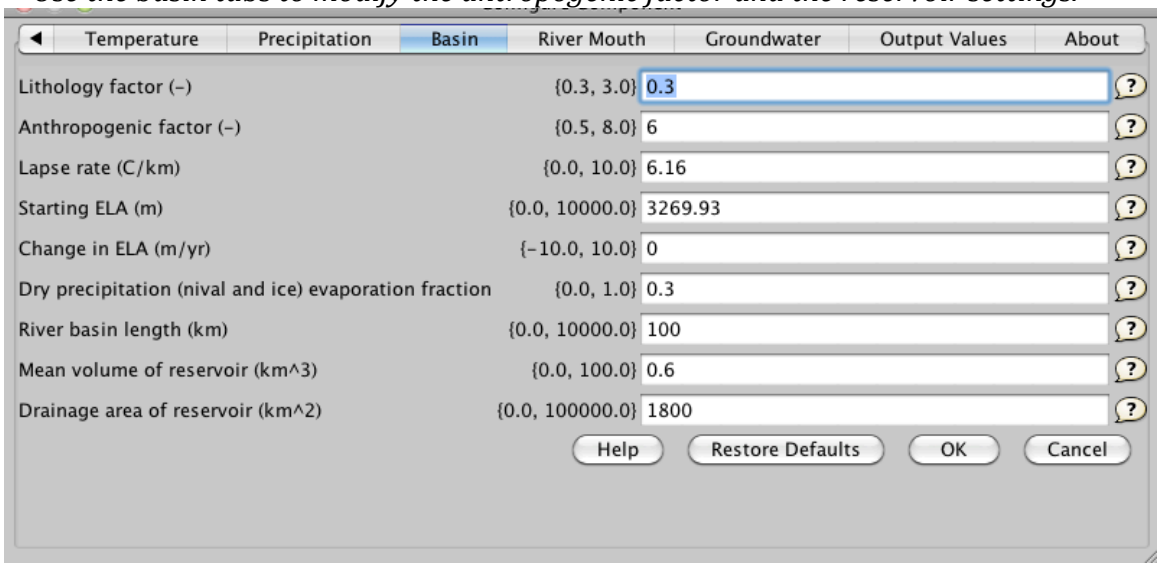
>>Use the temperature and precipitation tabs to modify the mean annual T, the mean annual P, and its variability through the standard deviation



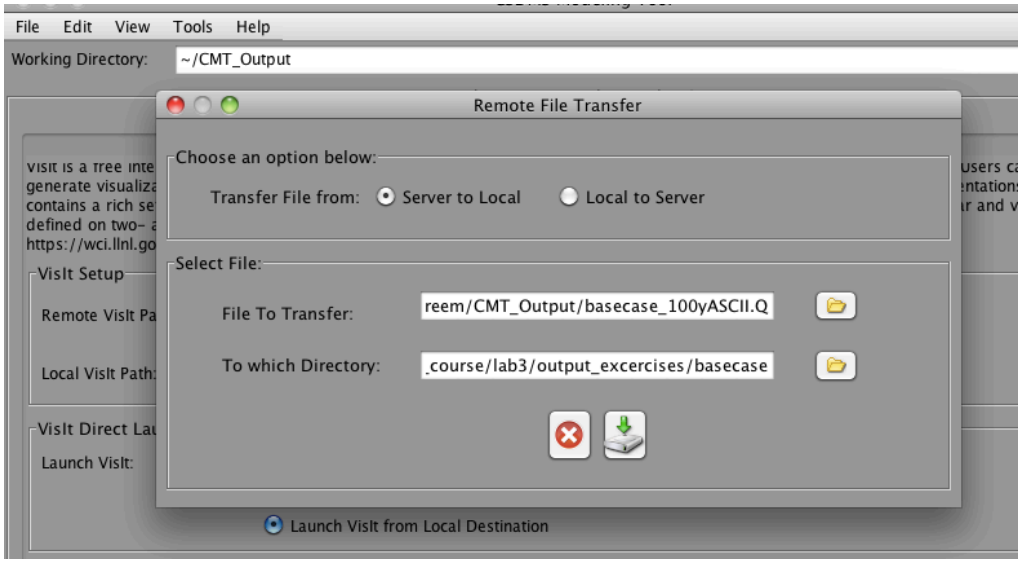


>> To run the human impact scenarios

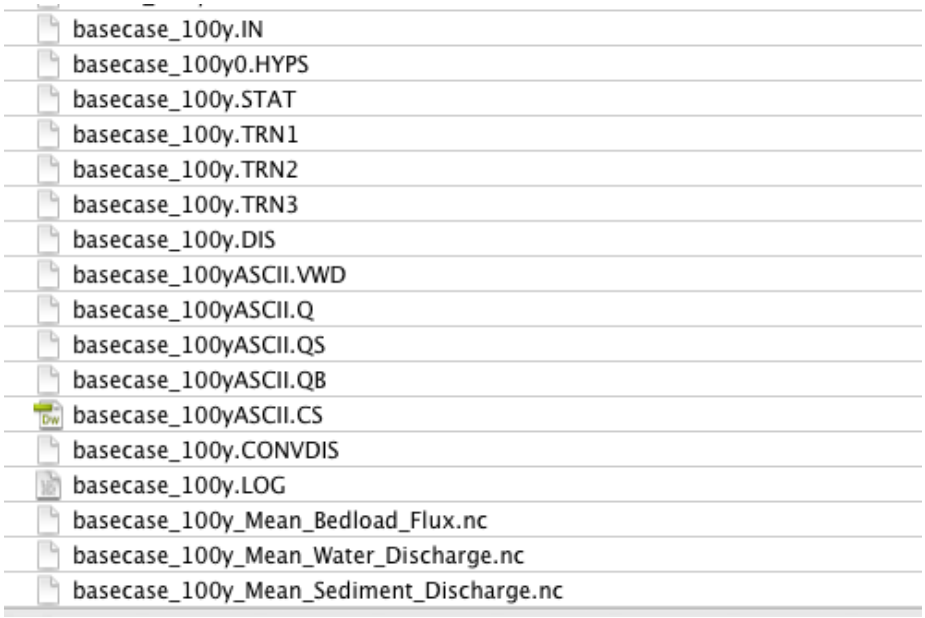
>>Use the basin tabs to modify the antropogenic factor and the reservoir settings.



>> Output files are generated in your specified output directory on beach. You can grab the files and use your own favorite data analysis software. An easy way of doing this is to go to Tools→Remote File Transfer. This opens a menu to bring files from the remote server beach to your local machine.



>> Output files with extension Q = water discharge, Qs = sediment load, Qb = bedload, Cs = concentration, VWD = velocity, width and depth at the specified timestep.



>> For visualization with VisIt it will be easiest to use the NetCDF files. These have extension*.nc.