WMT-Hydrology Clinic

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Scott Peckham

CSDMS Annual Meeting, May 2016

Clinic Outline

- Intro on WMT Hydrology and TOPOFLOW
- Recent Advances in WMT (*Mark Piper*)
- WMT Hydrology for Teaching (*Irina Overeem*)
- Hands-on Example of Lab
- Discussion on further developments

What is WMT-Hydrology?

A set of 18 hydrological processes components presented in the CSDMS Web Modeling Tool that allow inexperienced users to look at basic hydrological processes such as precipitation, evapotranspiration, infiltration, flow routing, channel runoff dynamics a.o..

Spatially-Distributed Hydrological Model Components

Meteorology
Precipitation

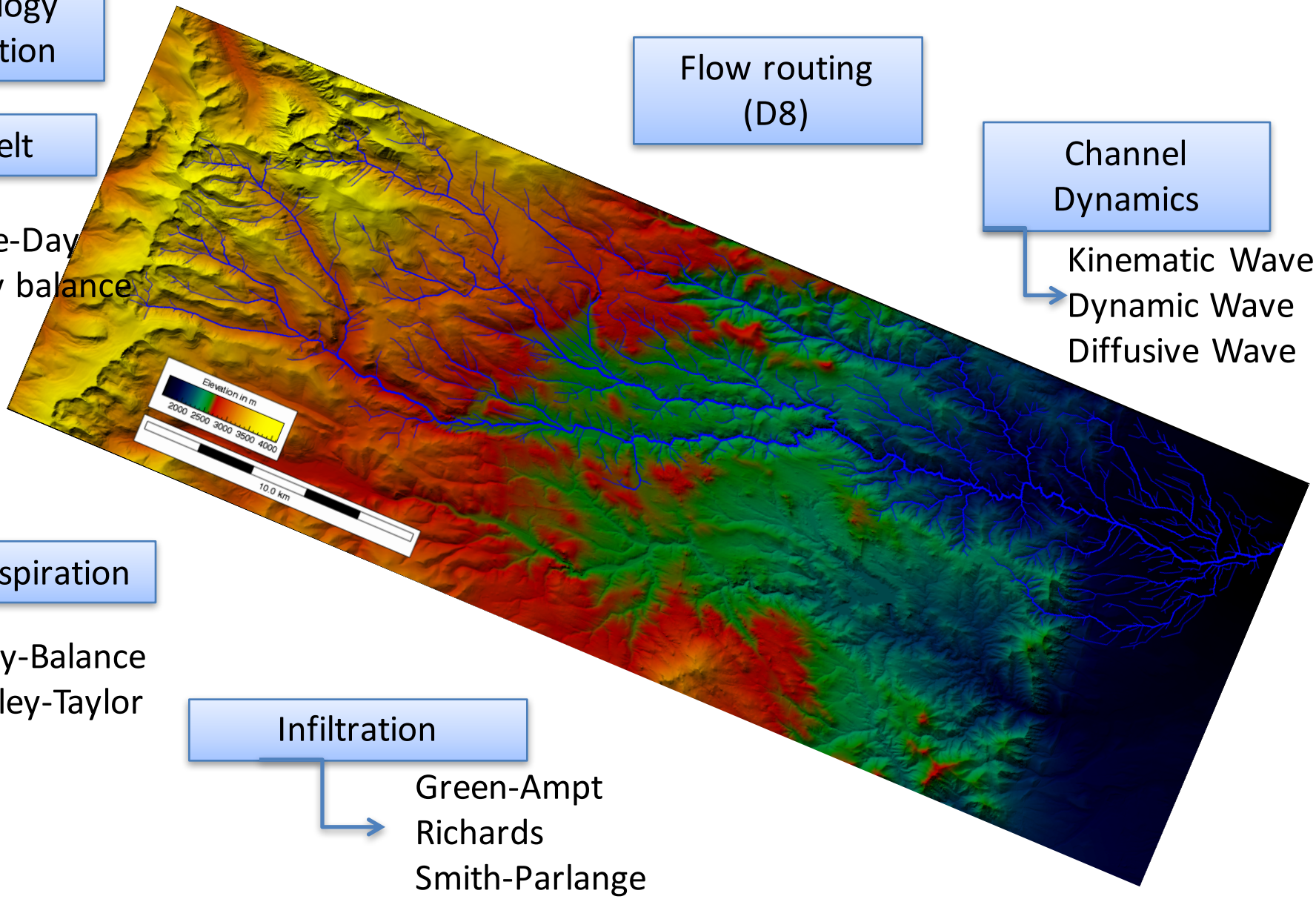
Snow Melt

- Degree-Day
- Energy balance

Flow routing
(D8)

Channel
Dynamics

- Kinematic Wave
- Dynamic Wave
- Diffusive Wave



Evapotranspiration

- Energy-Balance
- Priestley-Taylor

Infiltration

- Green-Ampt
- Richards
- Smith-Parlange

WMT-Hydrology Philosophy

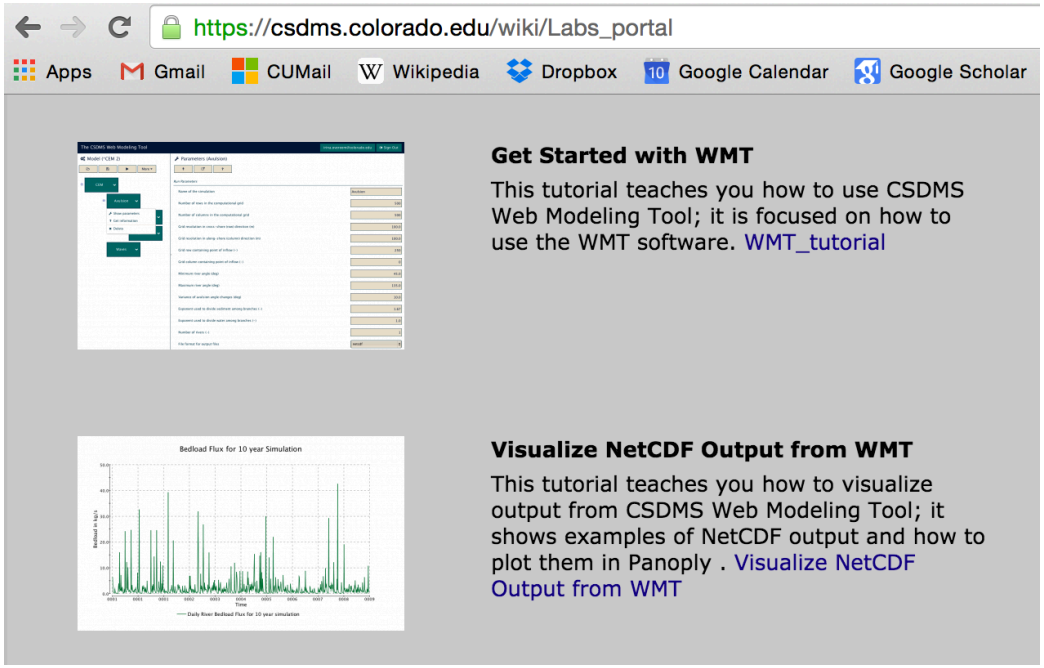
- Tool for Teaching!
- Level: advanced undergraduates
- Goals: familiarize with running numerical models, familiarize with exploring scenarios, with fiddling with input data, get basic insight in model coupling techniques
- Topical goals: quantitative hydrology, mass balance, energy balance, flow routing, channel dynamics etc….

TopoFlow is big and complex.

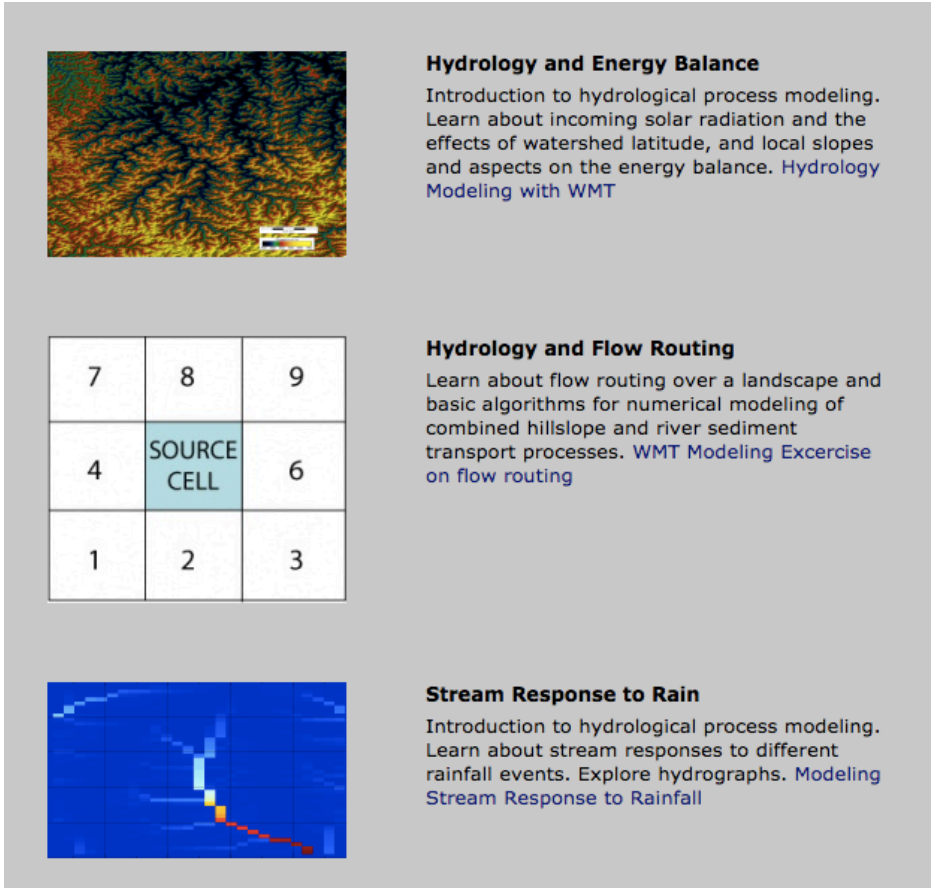
We trimmed it a bit to fit into WMT

Using WMT Hydrology

- As of May 2016, 3 hydrology labs are available
- https://csdms.colorado.edu/wiki/Labs_portal

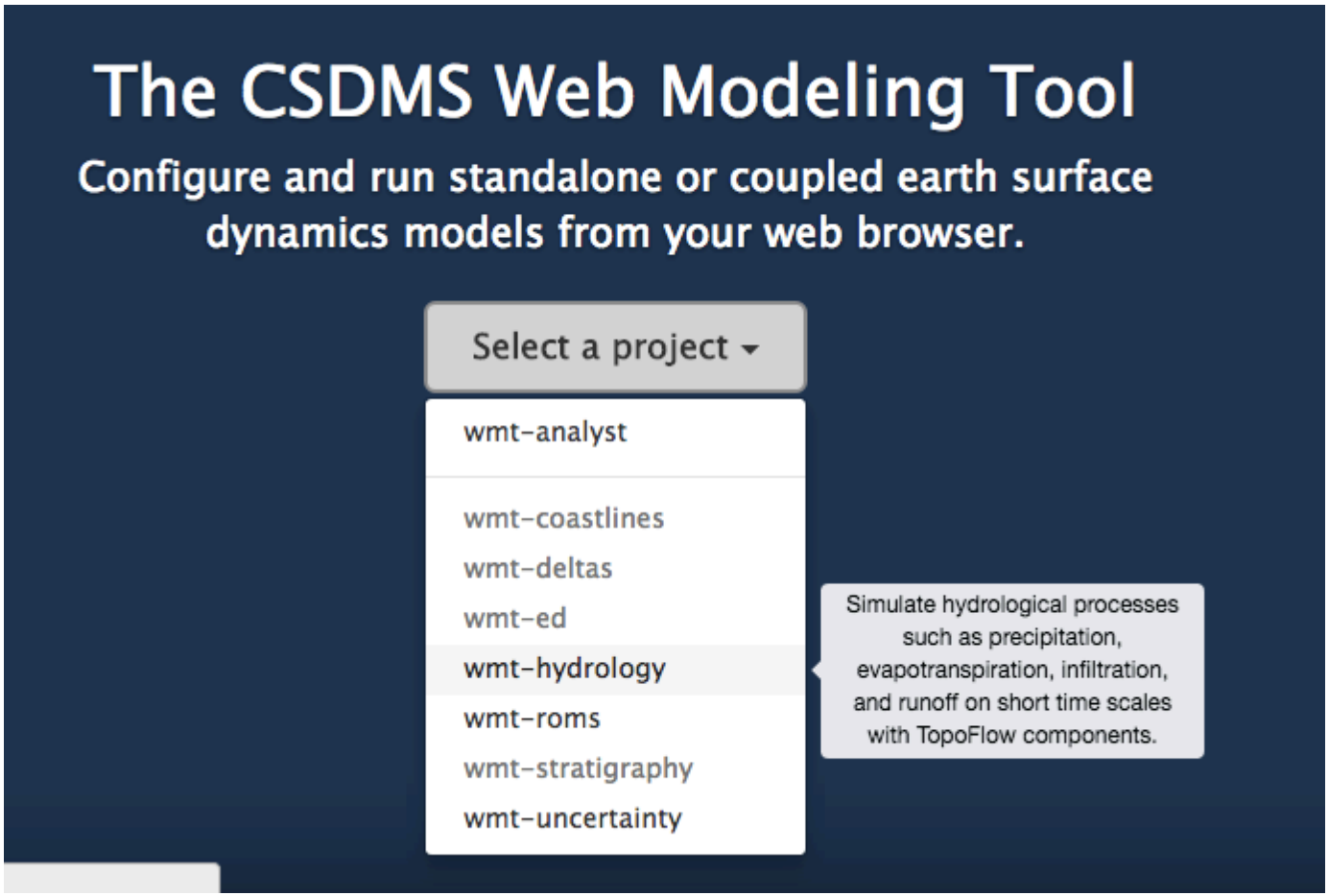


To get students started with WMT & Panoply (2 Labs)

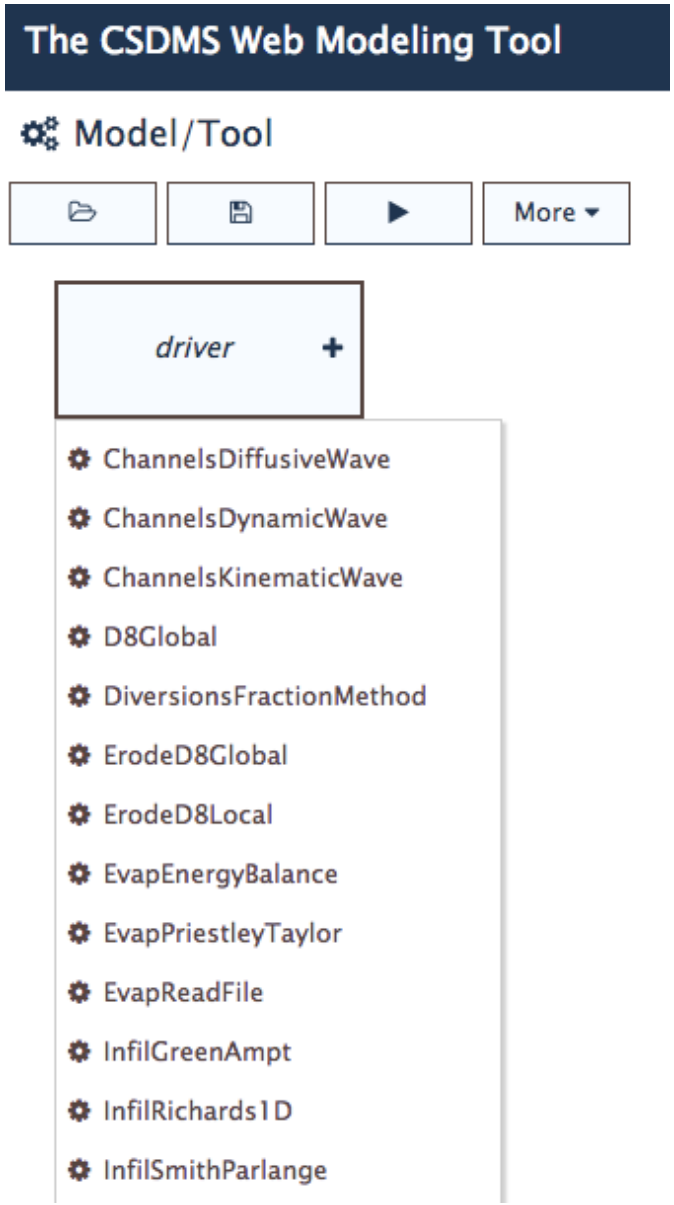


Web Modeling Tool

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



Components originate from TOPOFLOW

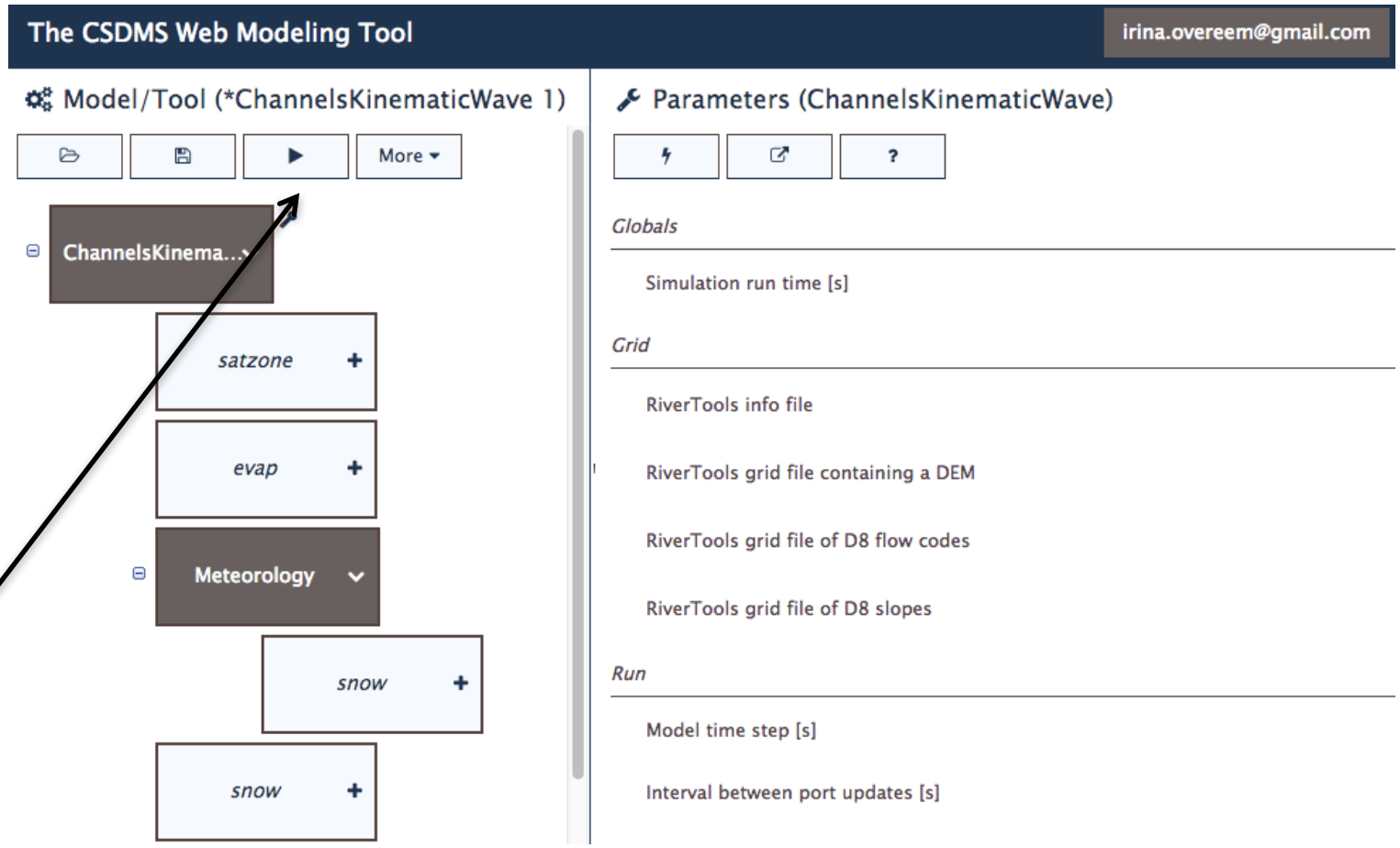


List of components with Basic Model Interface, most of these originate from TOPOFLOW (Peckham 2008). These set of components can now all be run as independent models; and are presented with tested default configuration.

Several components can be coupled programmatically through their BMI.

User can manipulate set of parameters in WMT GUI and run simulations

Run and Download Data



CLICK RUN and SUBMIT TO CSDMS HPCC

Panoply for Data Visualization

- Open source package Panoply for NetCDF files

Plots times-series, X-sections, gridded datasets.

Download it here:

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

To get started CSDMS has a basic lab on using Panoply.

Lab 1 Hydrology Modeling: Energy Balance

Lab based on Meteorology component

Learning objectives

- relation between temperature incoming solar radiation
- importance of watershed slope, aspect

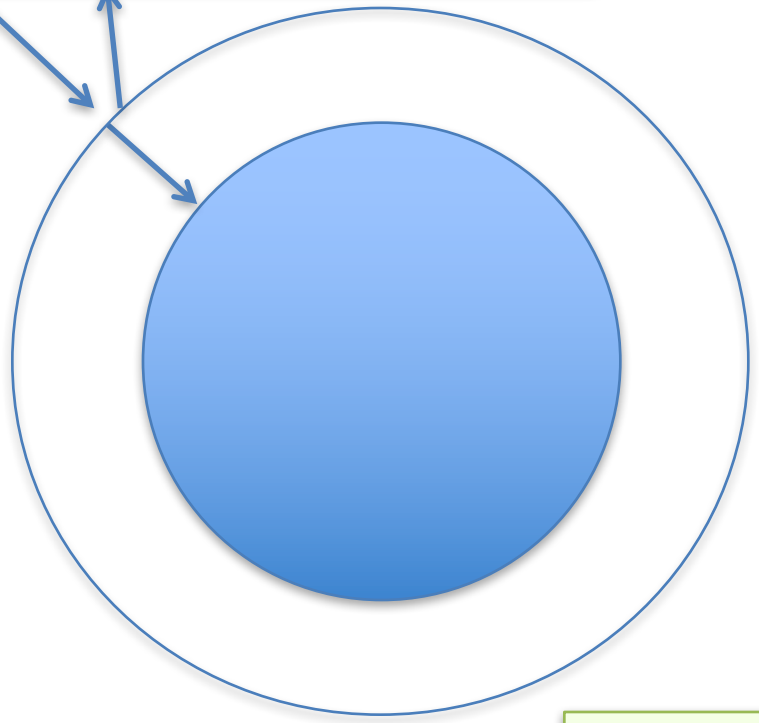
Key concepts

- Stefan-Boltzmann Law
- Geometric relationship between Earth's tilt, day of year and local slope, aspect

Example Concept: Planetary Energy Balance

S= Solar energy Input
S= 1.74 * 10^{17} W

Planetary albedo ~0.3
$a_p = 0.3$



Stefan-Boltzmann Constant

$\sigma = 5.67 * 10^{-8}$ W m^{-2} K^{-4}

Earth's surface area

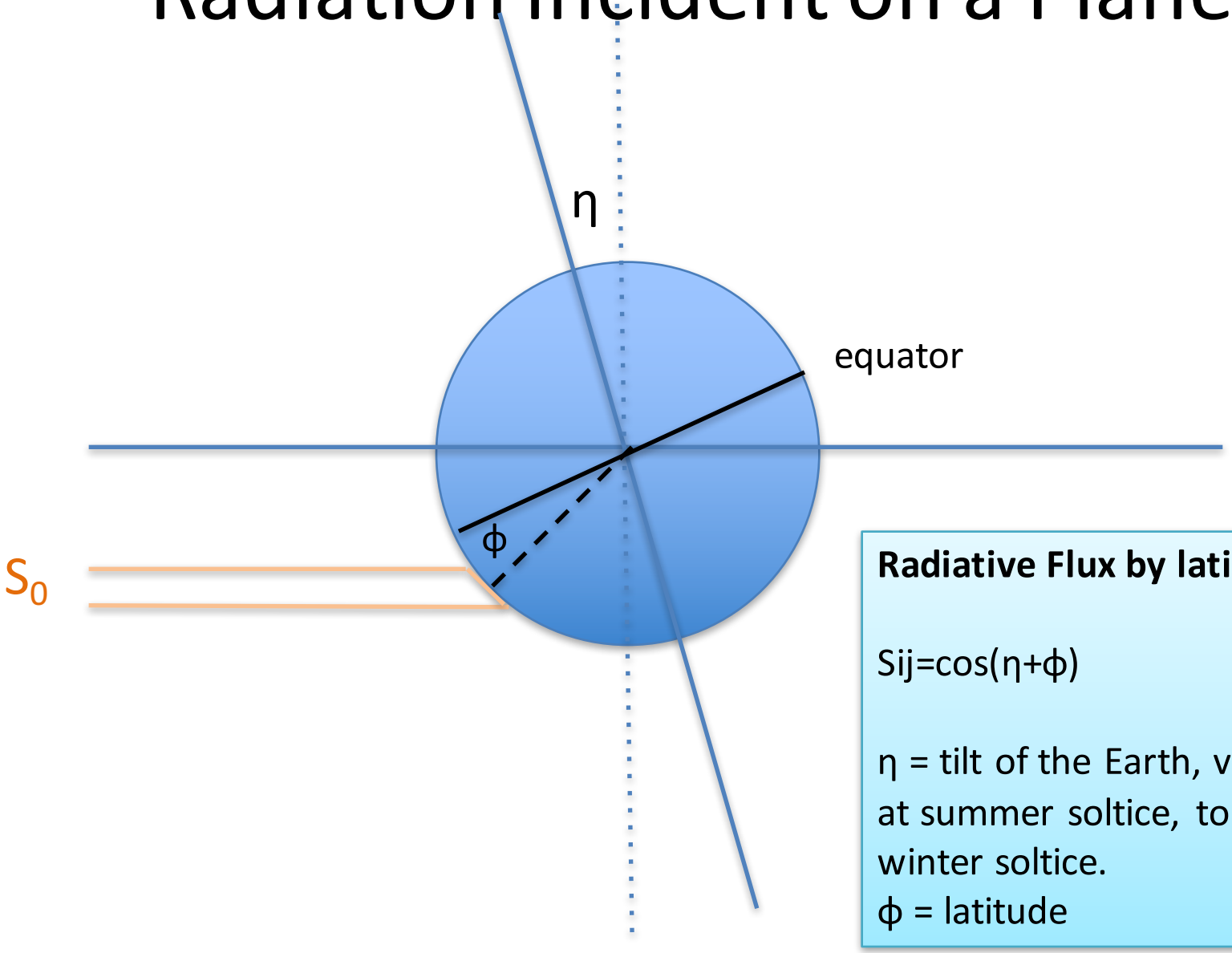
5.1 * 10^{14} m^2

$$T_p = \left[\frac{S(1-a_p)}{\sigma A}\right]^{1/4}$$

Planetary Temperature without Atmosphere

254 K (or -19C or -2F)

Example Watershed Application: Radiation Incident on a Plane



Radiative Flux by latitude

$S_{ij}=\cos(\eta+\phi)$

η = tilt of the Earth, varies -23.5° at summer soltice, to 23.5° at winter soltice.

ϕ = latitude

Morphometry of a Watershed

North-facing slopes

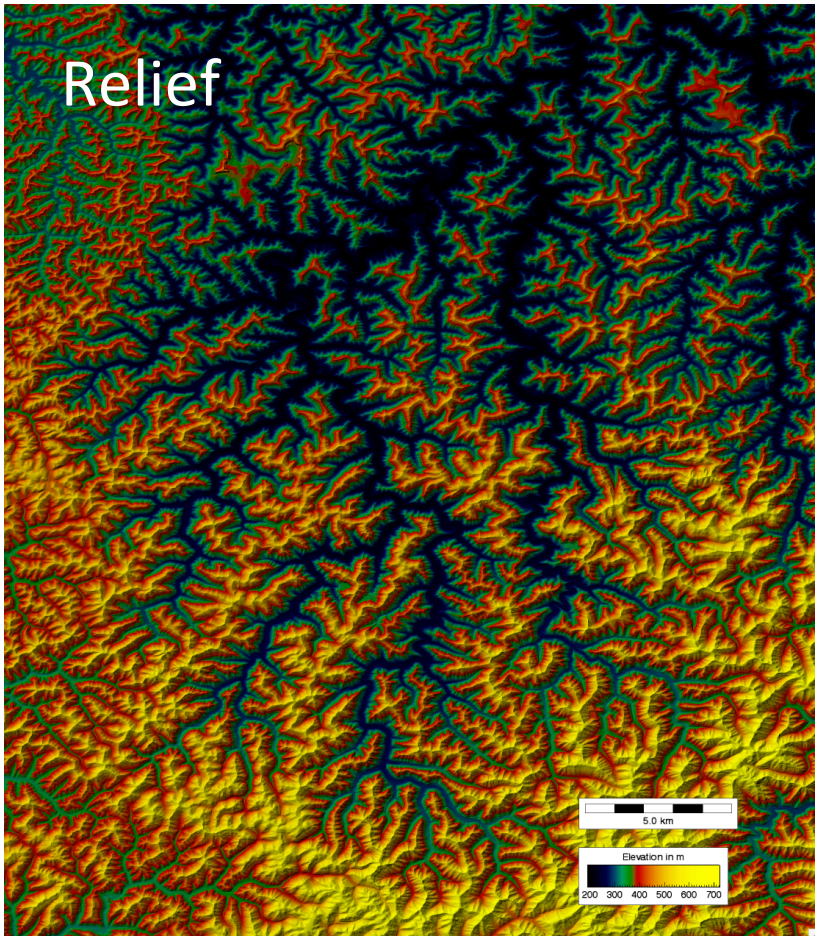
Image Courtesy; Irina Overeem

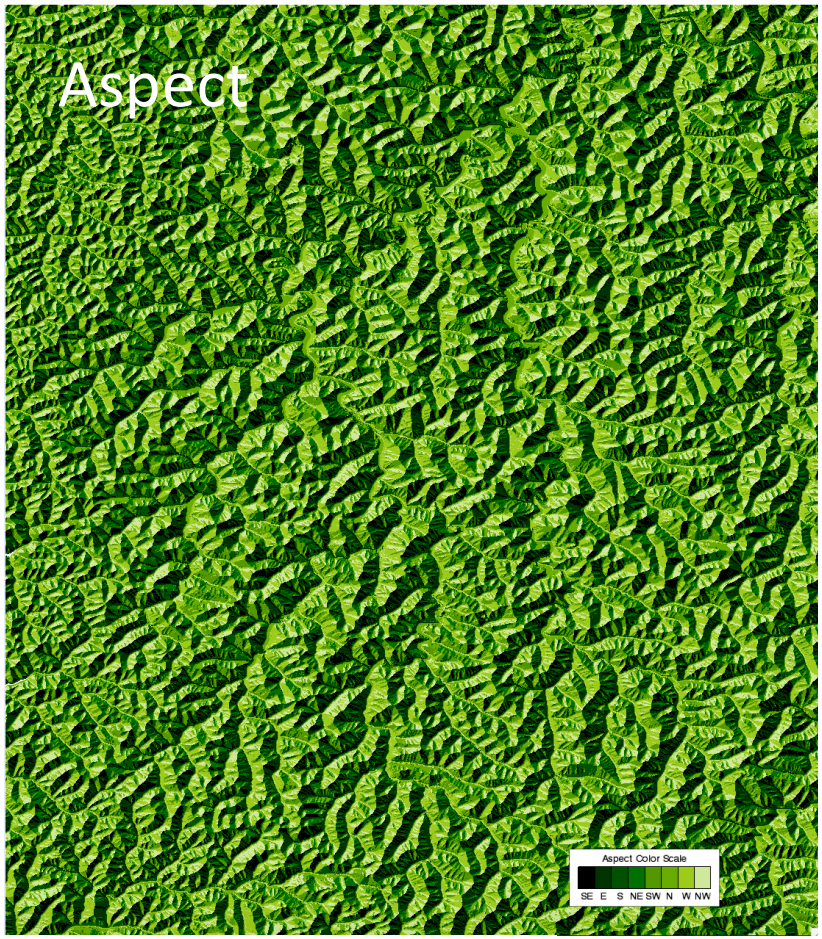
South-facing slopes

Aspect = direction that a topographical slope faces

Example in Rocky Mountain region, near Salida, Colorado.
North-facing slopes hold moisture and promote woody vegetation, whereas south-facing slopes are more dry and only grasses and small shrubs can sustain.

Beaver Creek Watershed, KY





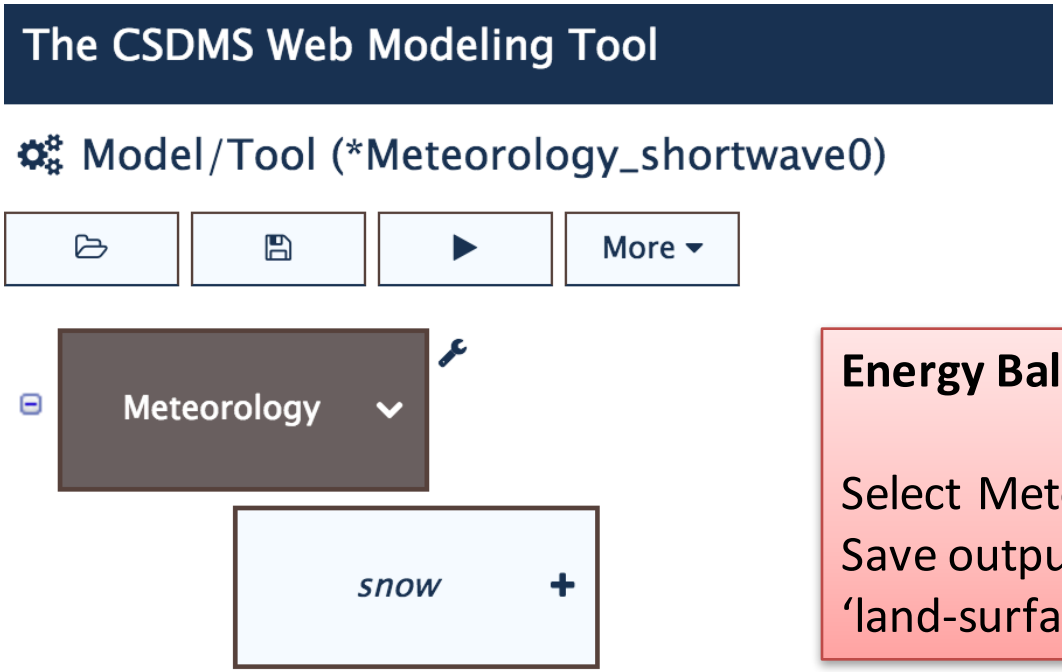
Aspect Color Scale

SE E S NE SW N W NW

Beaver Creek is at 37° N

Classified into 45 degree bins

WMT-Hydrology



Energy Balance in Meteorology Component

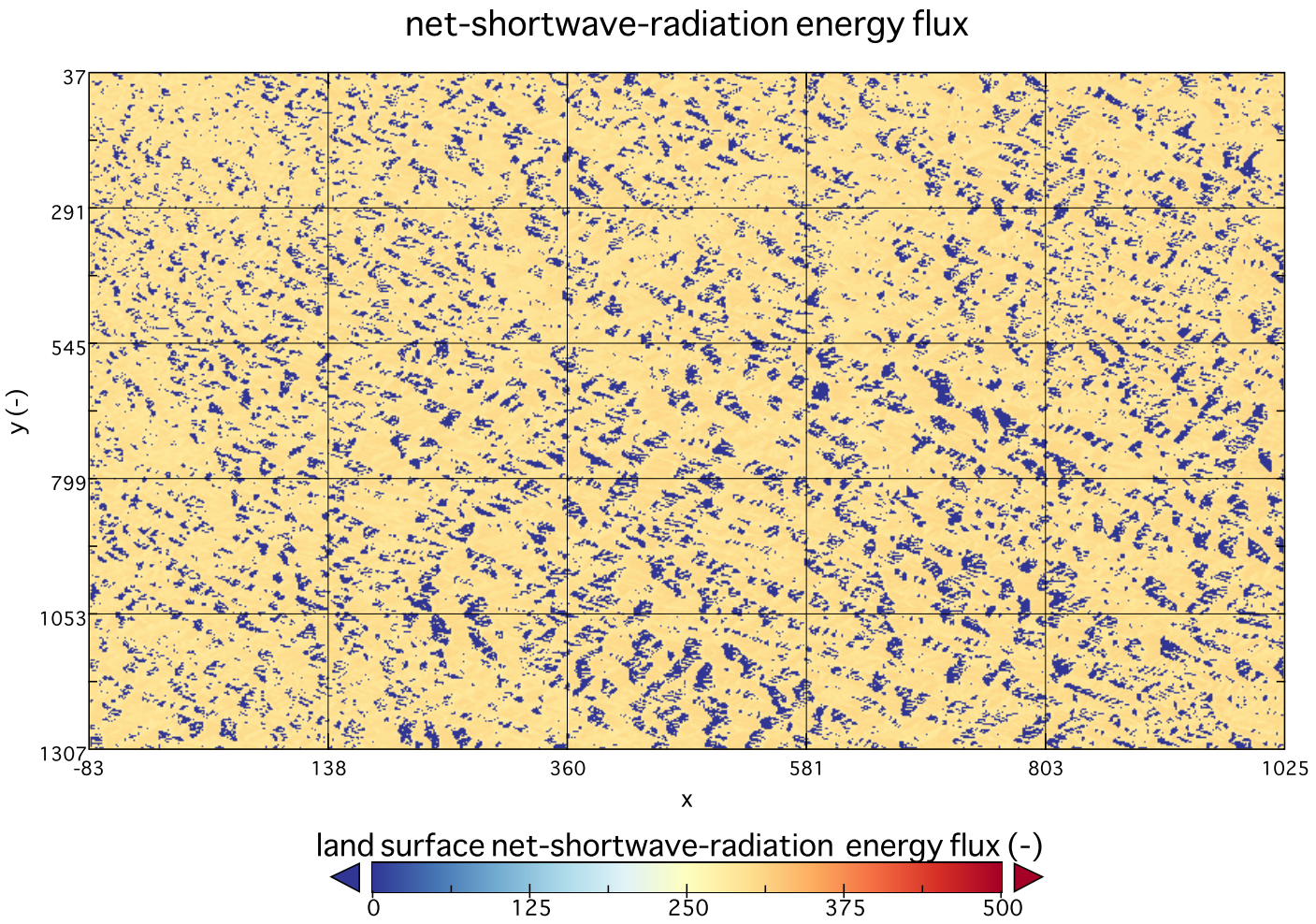
Select Meteorology Component
Save output for:
'land-surface-net-shortwave-radiation__energy flux

Setup in Meteorology

- Use the example "Meteo_Shortwave_BeaverCreek"

- Set up a run for a 6-hr simulation time (e.g. sunrise – noon) at an arbitrary date in the year.

WMT Energy Balance example



Possible Simulations/Exercises

- Change the date settings to include the summer equinox, summer solstice
- Can you discuss how short-wave radiation would change the Beaver Creek catchment would be at 70° N?
- Show the implications of solar radiation differences with aspect.

Example Lab 3

Learning objectives

- concepts of watershed and runoff
- relation between rain and runoff in absence of evaporation and infiltration

Key concepts

- Conservation of Mass

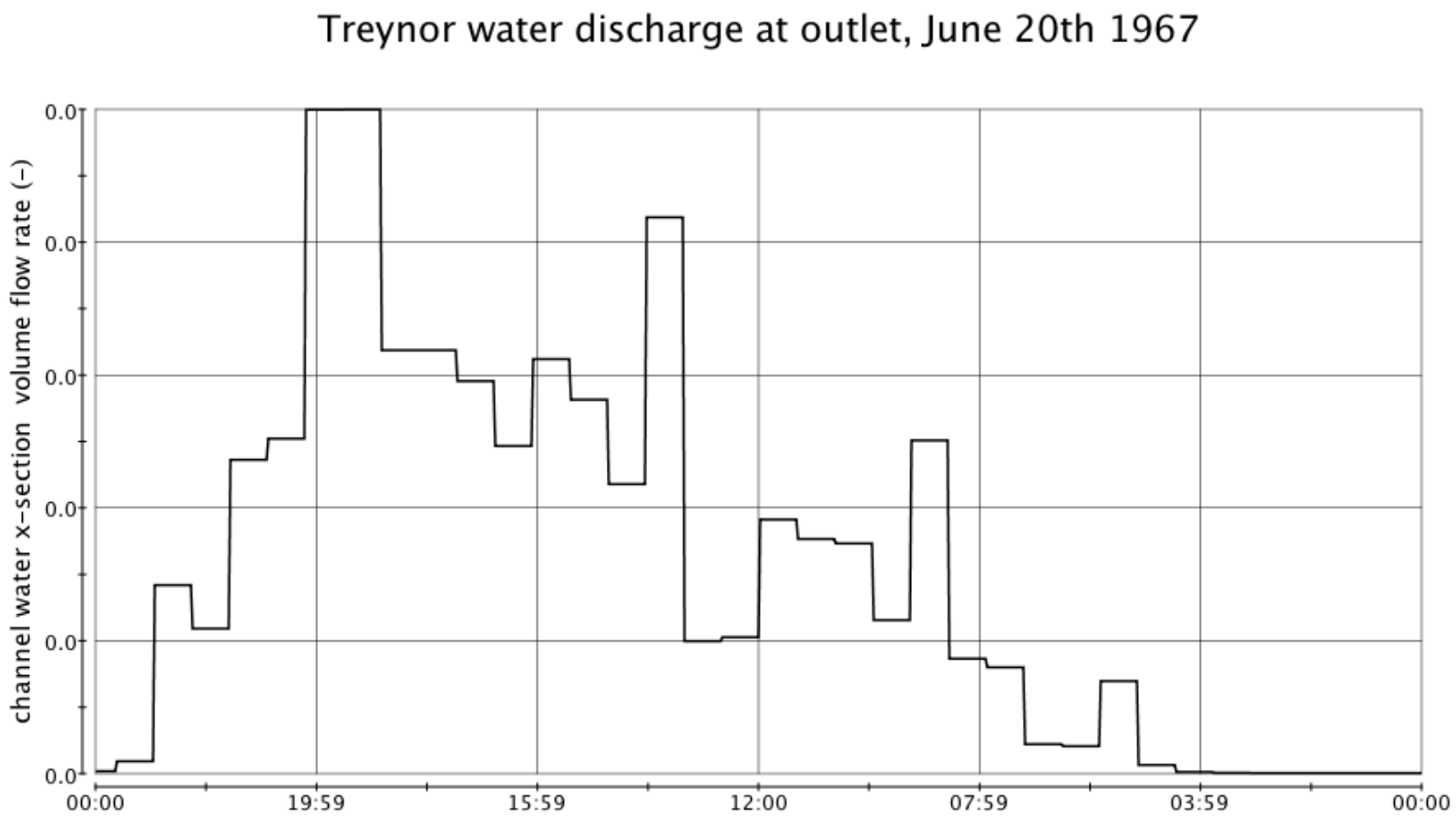
Modeling Concepts

- Coupled models through BMI (time-step)
- Standard names for parameters

Hands-on: Explore Lab 3

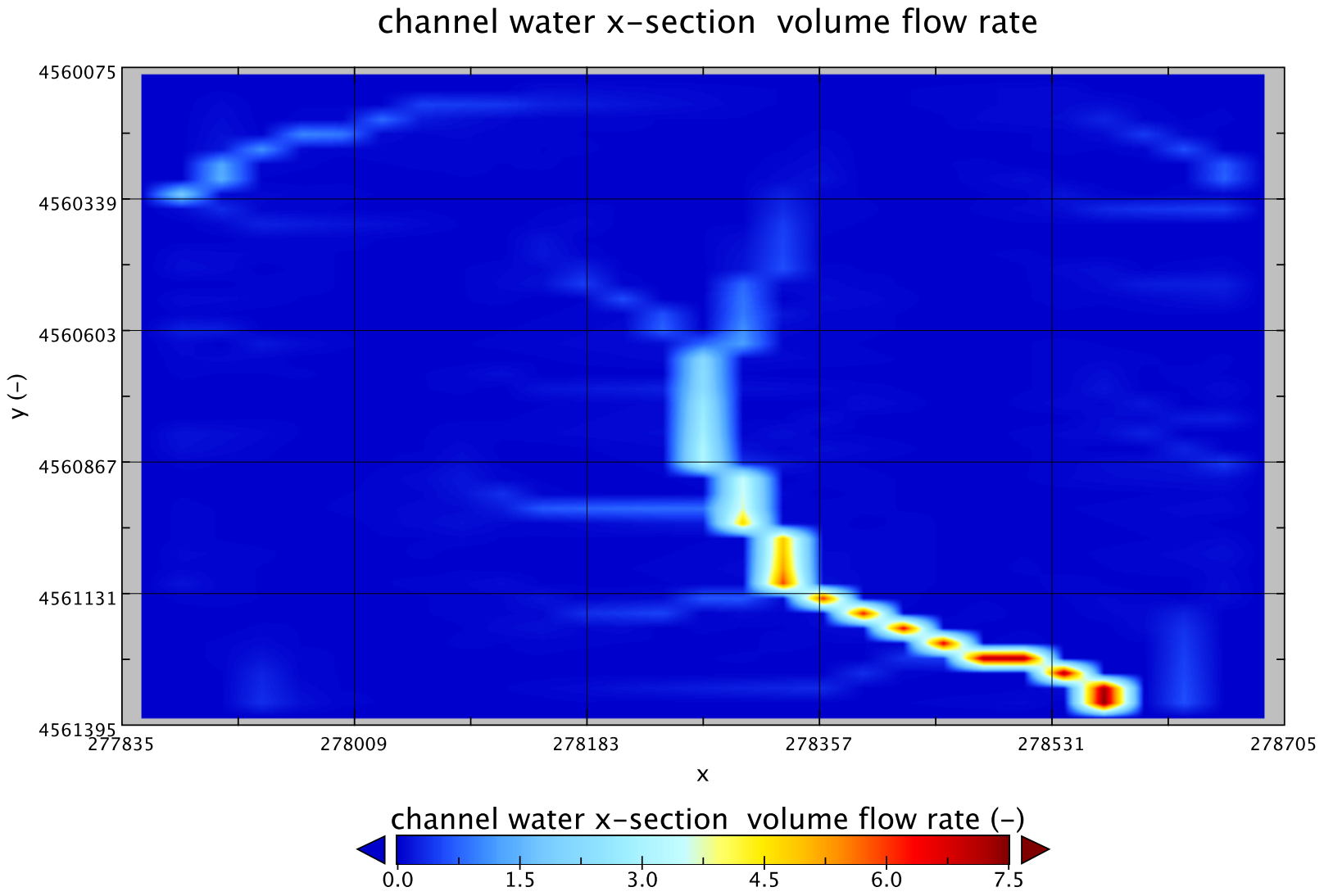
https://csdms.colorado.edu/wiki/Labs_WMT_Hydrology_StreamResponsetoRain

Simulation Output: Hydrographs



Freeform manipulation, or manipulate after reviewing theory?

Simulation Output: Planview Maps



Modeling Concepts- Standard Names

- https://csdms.colorado.edu/wiki/CSDMS_Standard_Names

Create awareness for code development: maintained the 'long parameter names'. These are standard names through which the model BMI passes parameter information

Discussion on Future Development of WMT-Hydrology

EKT

- Two more labs are in the works: snow melt and infiltration processes
- Promote use by teaching faculty and TA's? Who wants to test one or more labs in the classroom?

Software/CSDMS framework side

- Expand capability to use other DEM data formats

What else would you wish for? What contributions can you make?

(More theory? Better learning assessments? Make it easier to publish new labs? Package this as stand-alone application?)