

WMT-Hydrology Clinic

Irina Overeem and Mark Piper
Scott Peckham

CSDMS Annual Meeting, May 2016

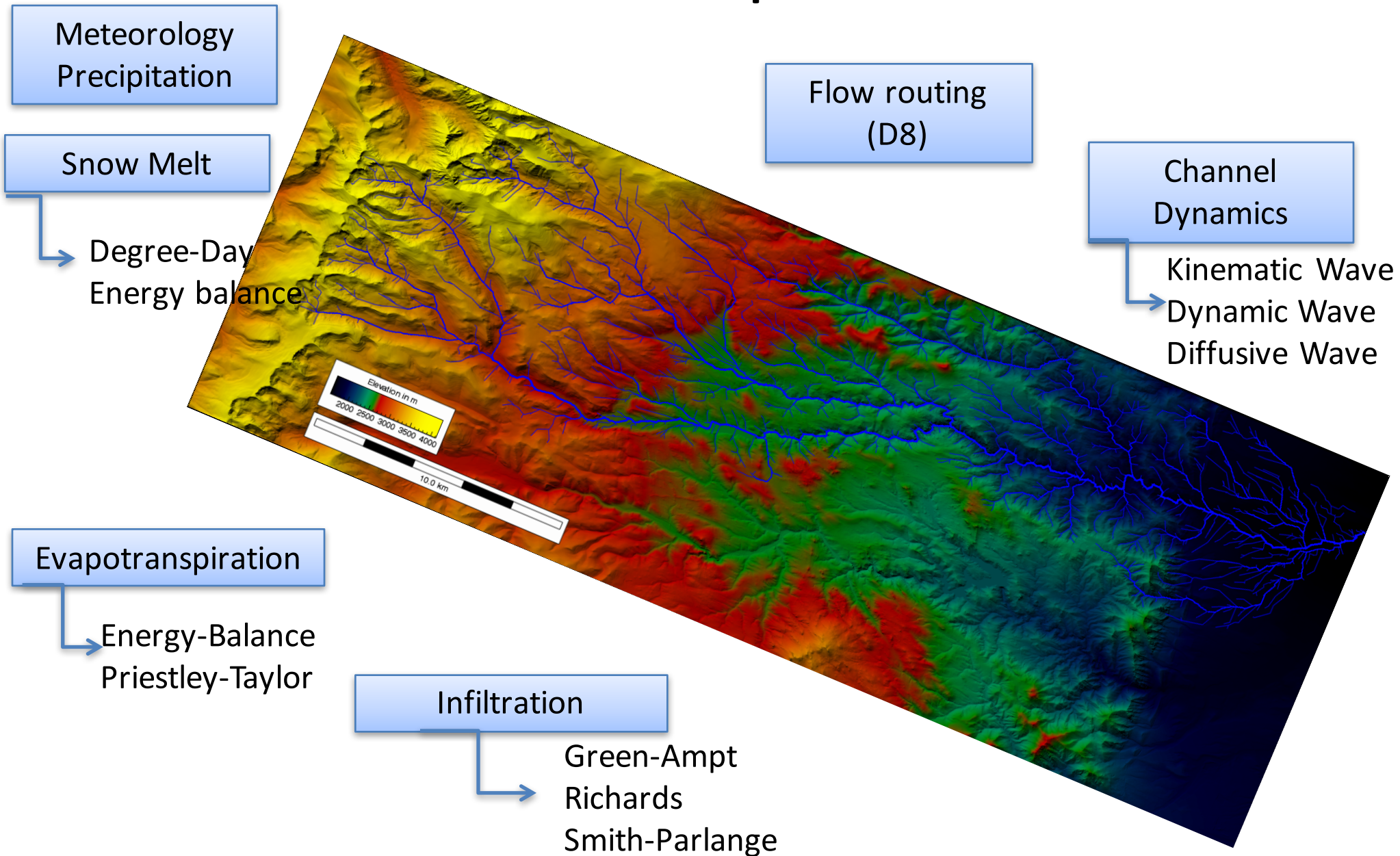
Clinic Outline

- 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



WMT-Hydrology Philosophy

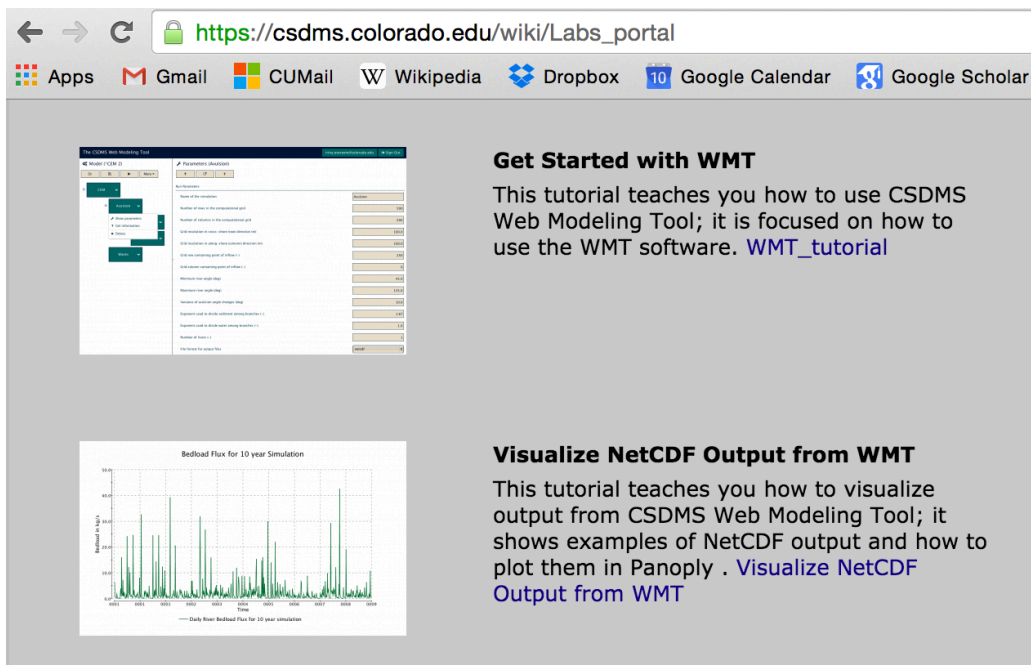
- Tool for Teaching!
- Level: advanced undergraduates
- Goals: familiarize with running numerical models, familiarize with exploring scenarios, with fiddling with input data, get basic insight in model coupling techniques
- Topical goals: quantitative hydrology, mass balance, energy balance, flow routing,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

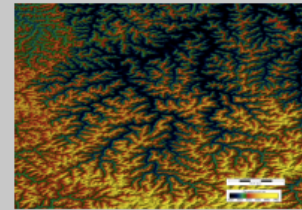


The screenshot shows the CSDMS Labs Portal website. At the top, there are navigation links for Apps, Gmail, CUMail, Wikipedia, Dropbox, Google Calendar, and Google Scholar. Below the navigation bar, there are two main sections:

Get Started with WMT
This tutorial teaches you how to use CSDMS Web Modeling Tool; it is focused on how to use the WMT software. [WMT_tutorial](#)

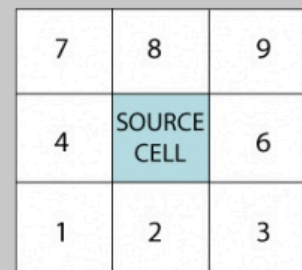
Visualize NetCDF Output from WMT
This tutorial teaches you how to visualize output from CSDMS Web Modeling Tool; it shows examples of NetCDF output and how to plot them in Panoply. [Visualize NetCDF Output from WMT](#)

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



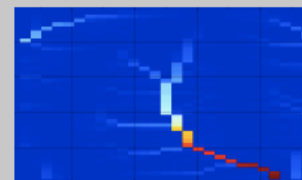
Hydrology and Energy Balance

Introduction to hydrological process modeling. Learn about incoming solar radiation and the effects of watershed latitude, and local slopes and aspects on the energy balance. [Hydrology Modeling with WMT](#)



Hydrology and Flow Routing

Learn about flow routing over a landscape and basic algorithms for numerical modeling of combined hillslope and river sediment transport processes. [WMT Modeling Exercise on flow routing](#)

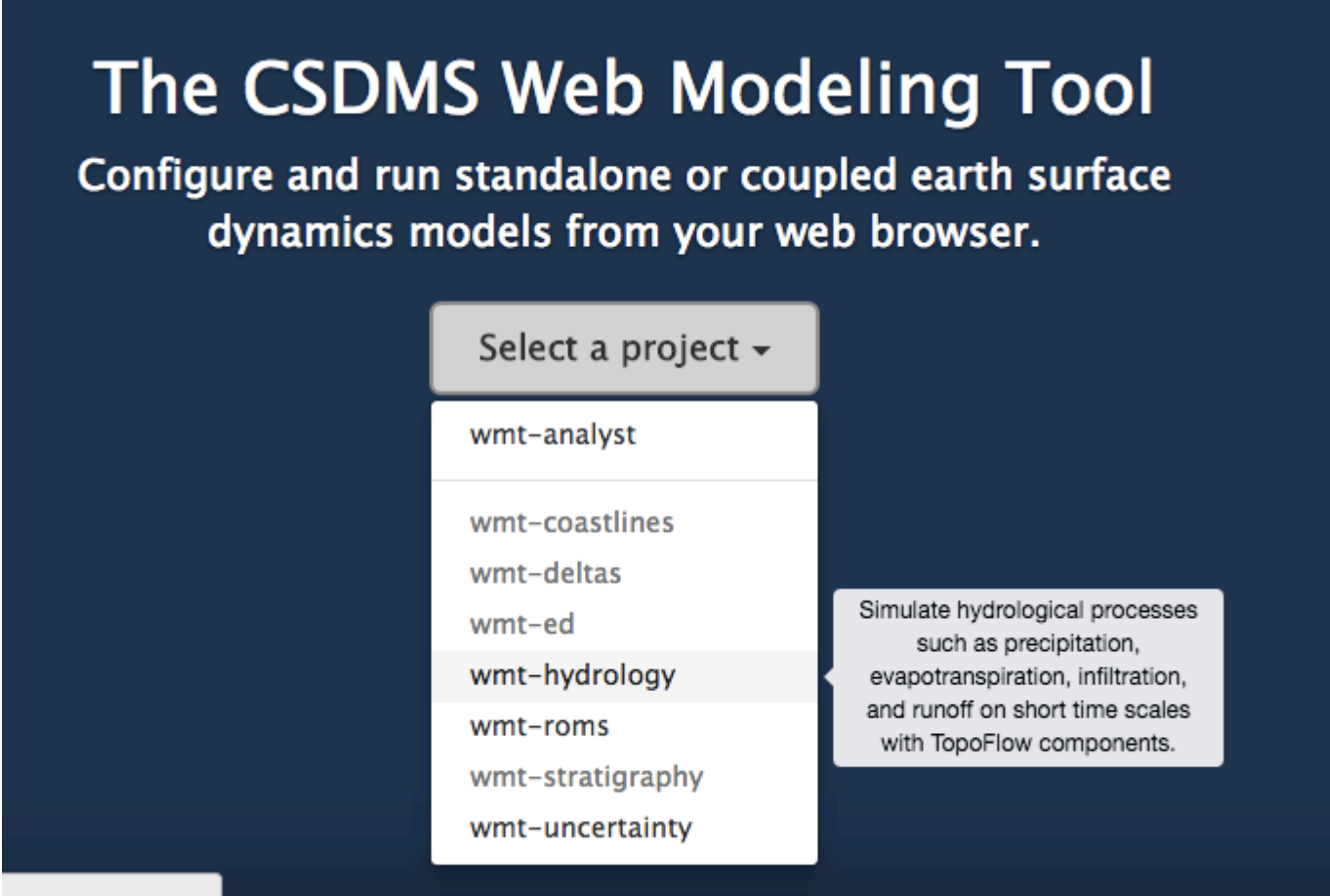


Stream Response to Rain

Introduction to hydrological process modeling. Learn about stream responses to different rainfall events. Explore hydrographs. [Modeling Stream Response to Rainfall](#)

Web Modeling Tool

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



The CSDMS Web Modeling Tool
Configure and run standalone or coupled earth surface dynamics models from your web browser.

Select a project ▾

- wmt-analyst
- wmt-coastlines
- wmt-deltas
- wmt-ed
- wmt-hydrology**
- wmt-roms
- wmt-stratigraphy
- wmt-uncertainty

Simulate hydrological processes such as precipitation, evapotranspiration, infiltration, and runoff on short time scales with TopoFlow components.

Components originate from TOPOFLOW

The CSDMS Web Modeling Tool

⚙️ Model/Tool



- driver* +
- ⚙️ ChannelsDiffusiveWave
 - ⚙️ ChannelsDynamicWave
 - ⚙️ ChannelsKinematicWave
 - ⚙️ D8Global
 - ⚙️ DiversionsFractionMethod
 - ⚙️ ErodeD8Global
 - ⚙️ ErodeD8Local
 - ⚙️ EvapEnergyBalance
 - ⚙️ EvapPriestleyTaylor
 - ⚙️ EvapReadFile
 - ⚙️ InfilGreenAmpt
 - ⚙️ InfilRichards1D
 - ⚙️ InfilSmithParlange

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

The screenshot displays the CSDMS Web Modeling Tool interface. The top header shows 'The CSDMS Web Modeling Tool' and the user email 'irina.overeem@gmail.com'. The main area is divided into two panels: 'Model/Tool (*ChannelsKinematicWave 1)' and 'Parameters (ChannelsKinematicWave)'. The 'Model/Tool' panel includes a toolbar with icons for file operations and a 'More' dropdown. Below the toolbar, a tree view shows the model structure with expandable sections: 'ChannelsKinema...', 'satzzone', 'evap', 'Meteorology', 'snow', and another 'snow' section. A black arrow points from the 'ChannelsKinema...' section to the 'Run' button in the 'Parameters' panel. The 'Parameters' panel has a toolbar with a lightning bolt, a share icon, and a question mark. It is organized into sections: 'Globals' (Simulation run time [s]), 'Grid' (RiverTools info file, RiverTools grid file containing a DEM, RiverTools grid file of D8 flow codes, RiverTools grid file of D8 slopes), and 'Run' (Model time step [s], Interval between port updates [s]).

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

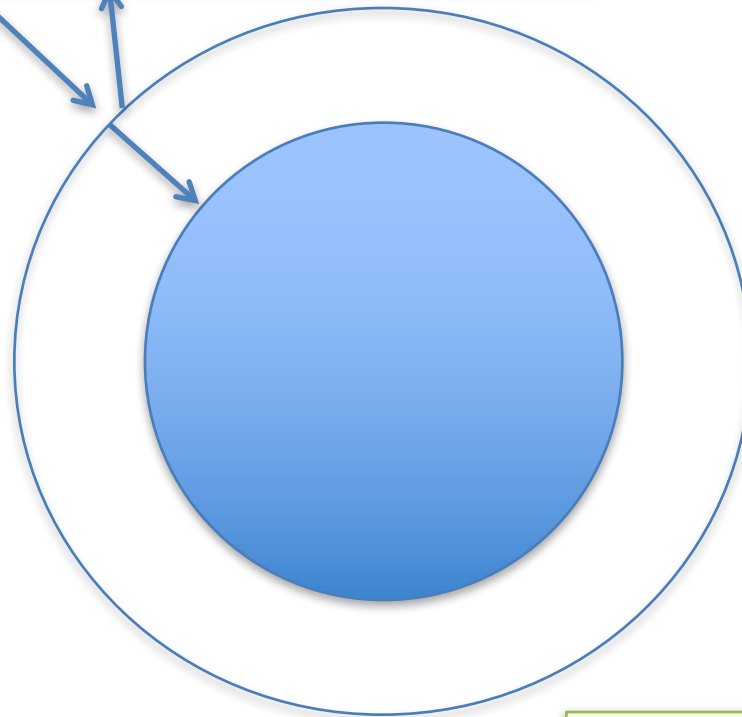
Key concepts

- 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
 $S = 1.74 * 10^{17} \text{ W}$

Planetary albedo ~ 0.3
 $a_p = 0.3$



Stefan-Boltzmann Constant

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

Earth's surface area

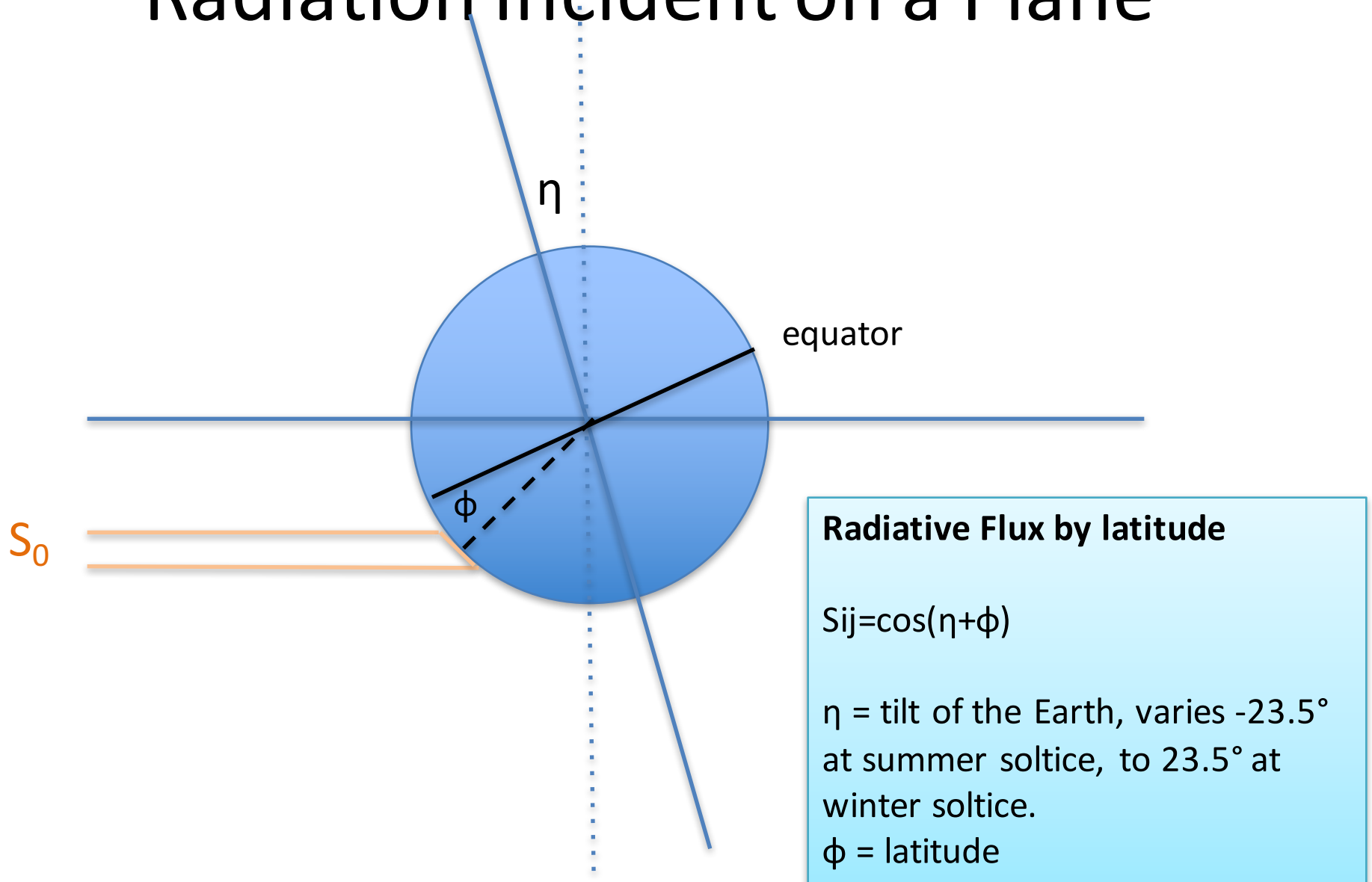
$$5.1 * 10^{14} \text{ m}^2$$

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

**Planetary Temperature
without Atmosphere**

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

Example Watershed Application: Radiation Incident on a Plane



Morphometry of a Watershed

North-facing slopes



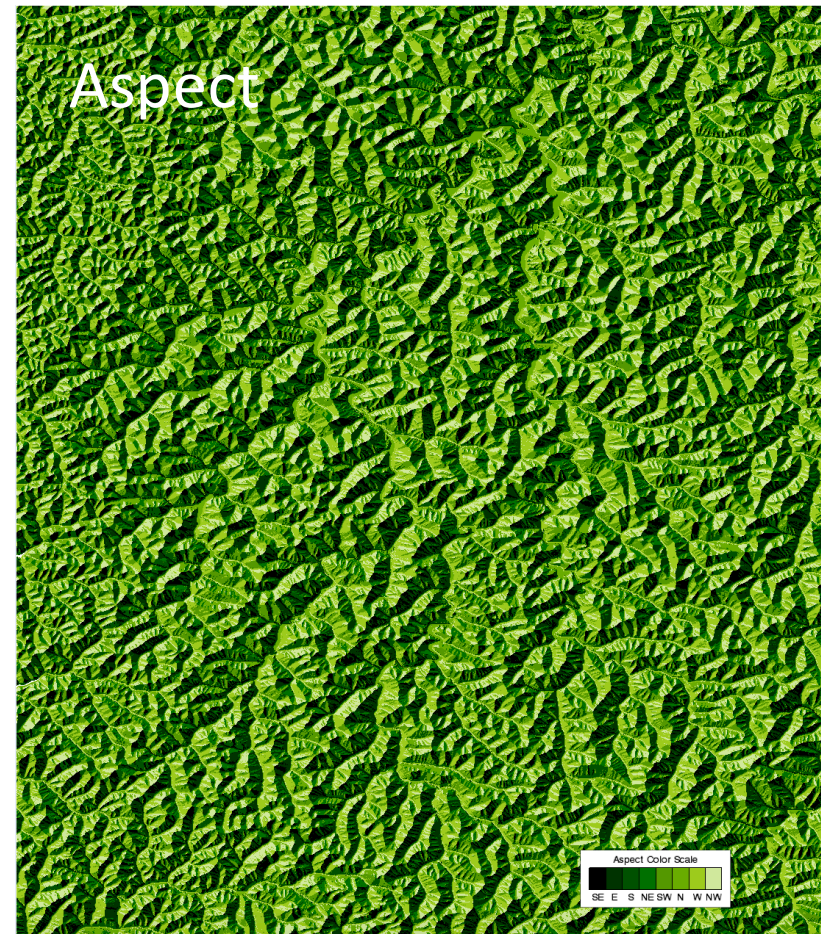
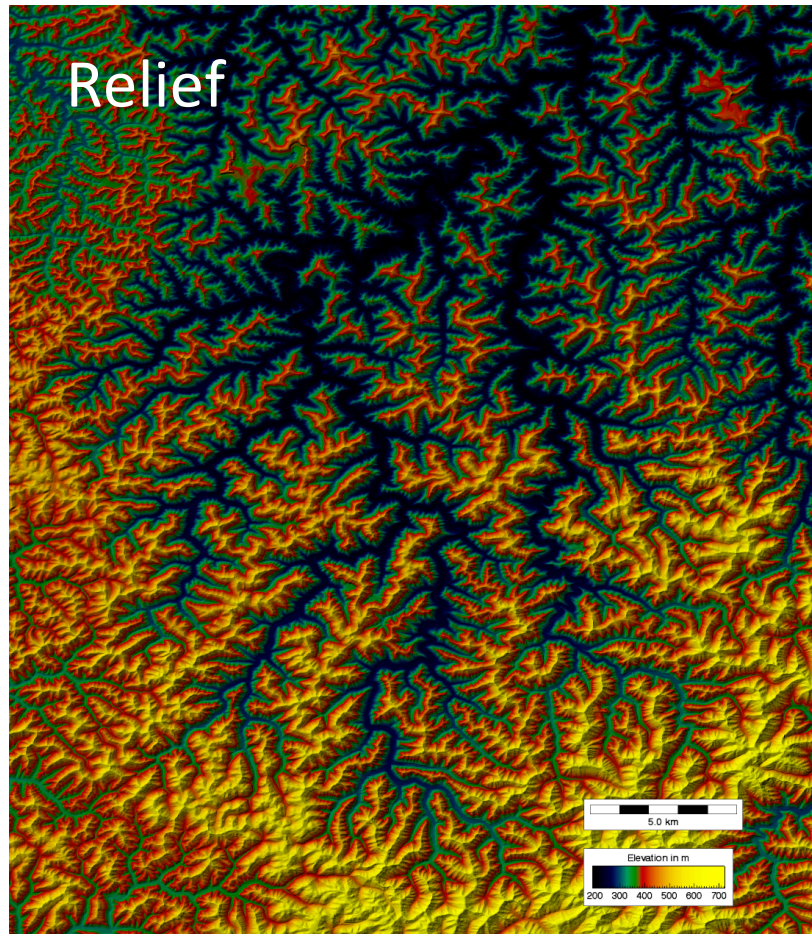
Image Courtesy; Irina Overeem

South-facing slopes

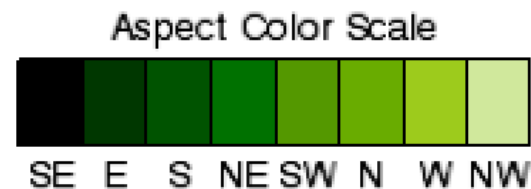
Aspect = direction that a topographical slope faces

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



Beaver Creek is at 37° N

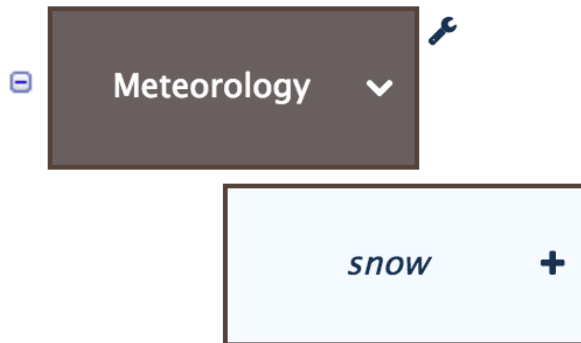


Classified into
45 degree bins

WMT-Hydrology

The CSDMS Web Modeling Tool

⚙️ Model/Tool (*Meteorology_shortwave0)



Energy Balance in Meteorology Component

Select Meteorology Component

Save output for:

'land-surface-net-shortwave-radiation__energy flux

Output file for land_surface_net-longwave-radiation__energy_flux

off

Output file for land_surface_net-shortwave-radiation__energy_flux

land_surface_net-shortwave-

Output file for land_surface_net-total-energy__energy_flux

off

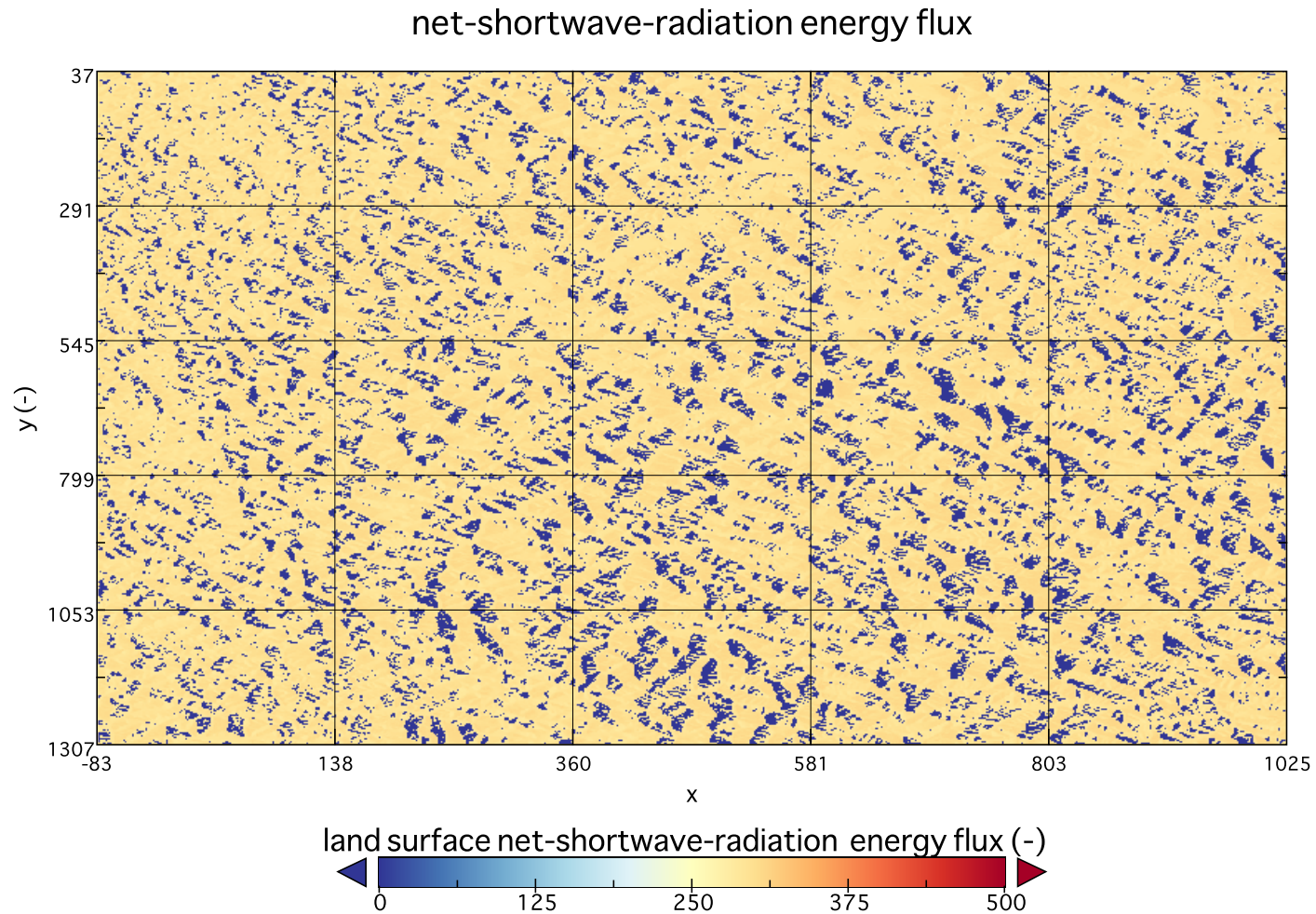
Output file for physics__stefan_boltzmann_constant

off

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

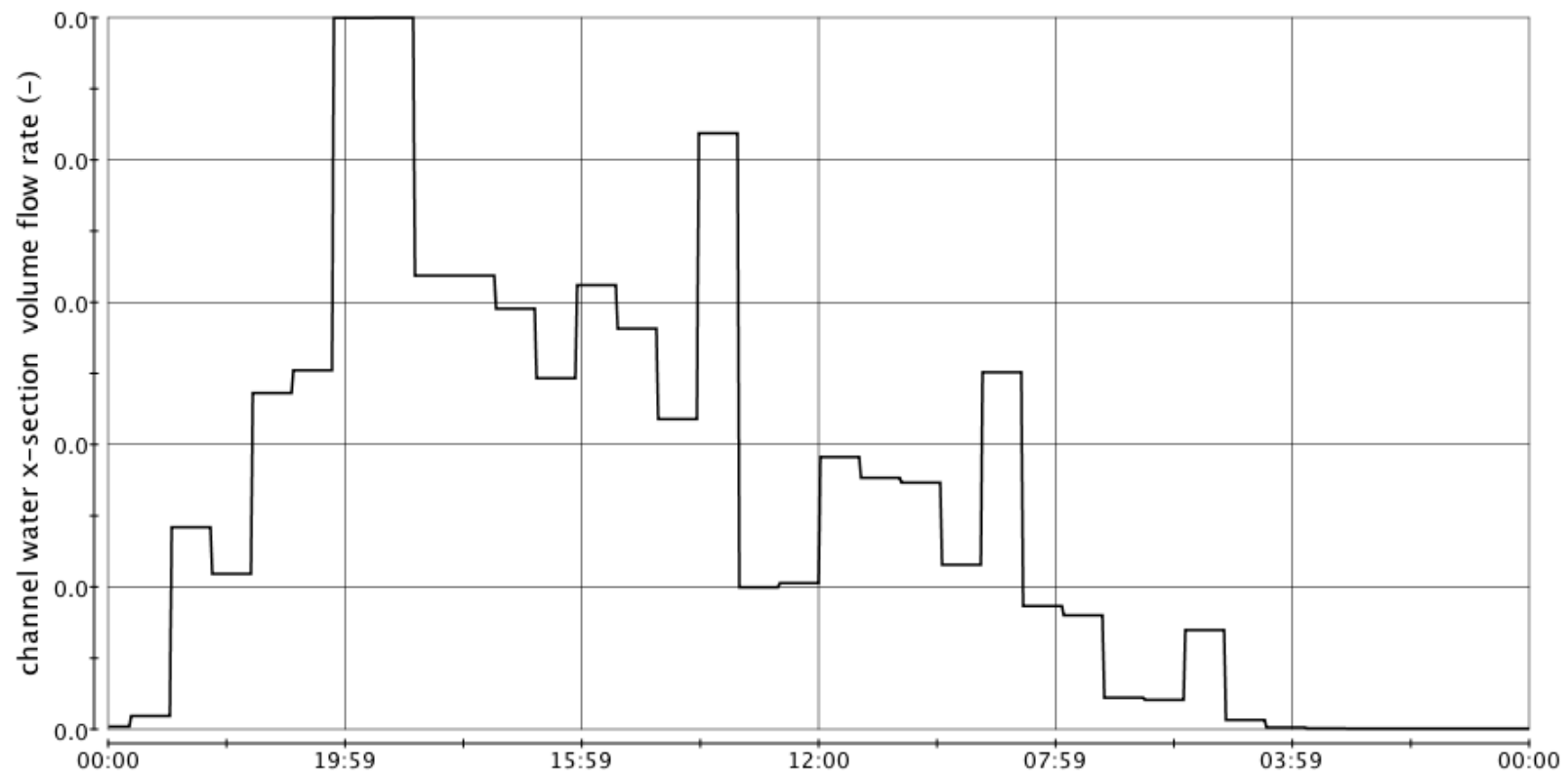
- Coupled models through BMI (time-step)
- Standard names for parameters

Hands-on: Explore Lab 3

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

Simulation Output: Hydrographs

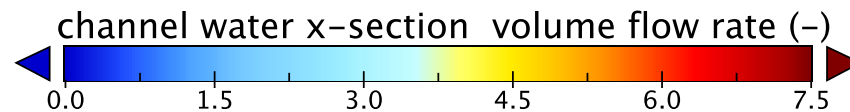
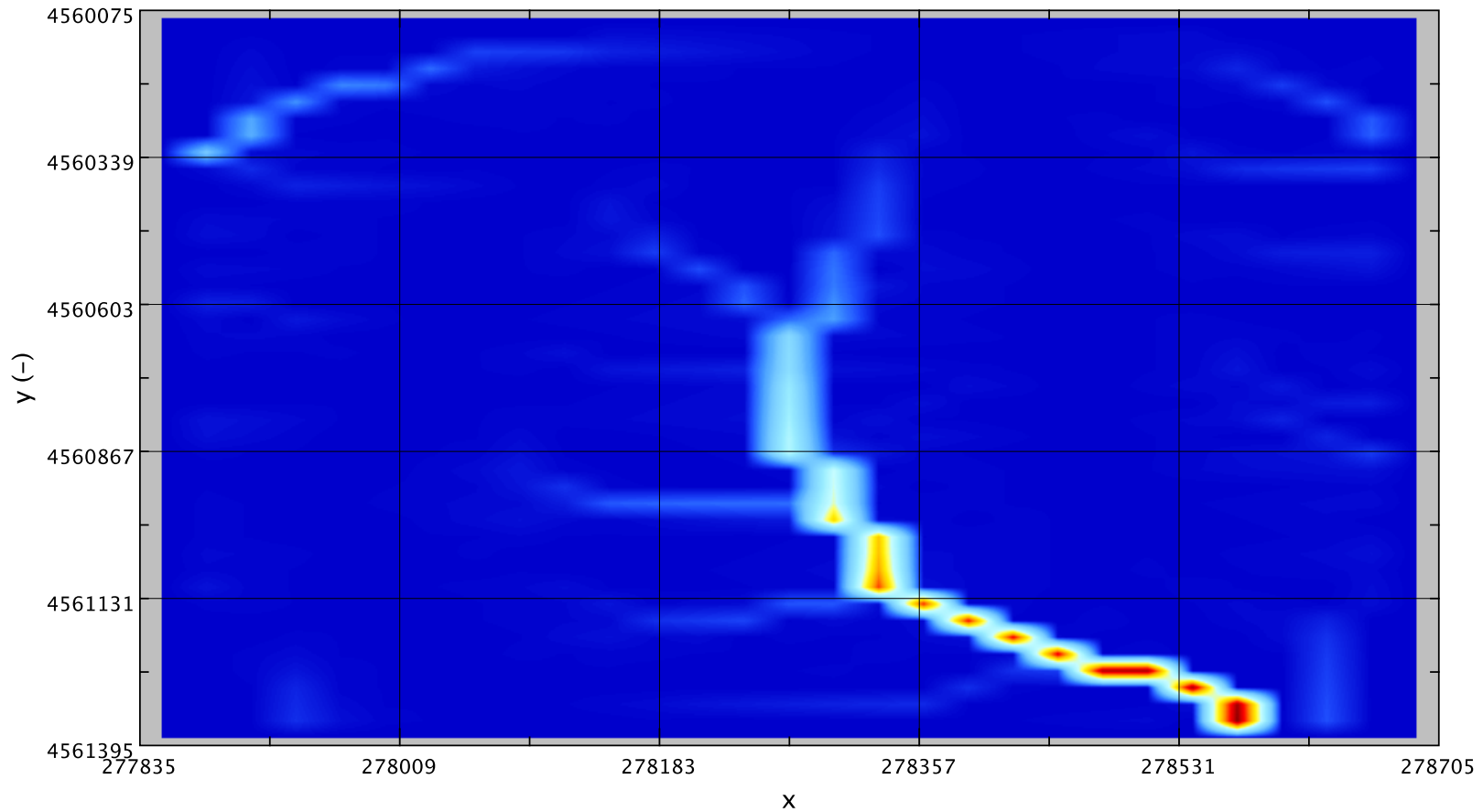
Treynor water discharge at outlet, June 20th 1967



Freeform manipulation, or manipulate after reviewing theory?

Simulation Output: Planview Maps

channel water x-section volume flow rate



Modeling Concepts- Standard Names

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

channel_water_x-section__mean_depth

off

channel_water_x-section__volume_flow_rate

channel_water_x-section_

channel_water_x-section__volume_flux

off

channel_water_x-section__wetted_area

off

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?)