TopoFlow

A New Distributed Hydrologic Model Based on ARHYTHM and RiverTools

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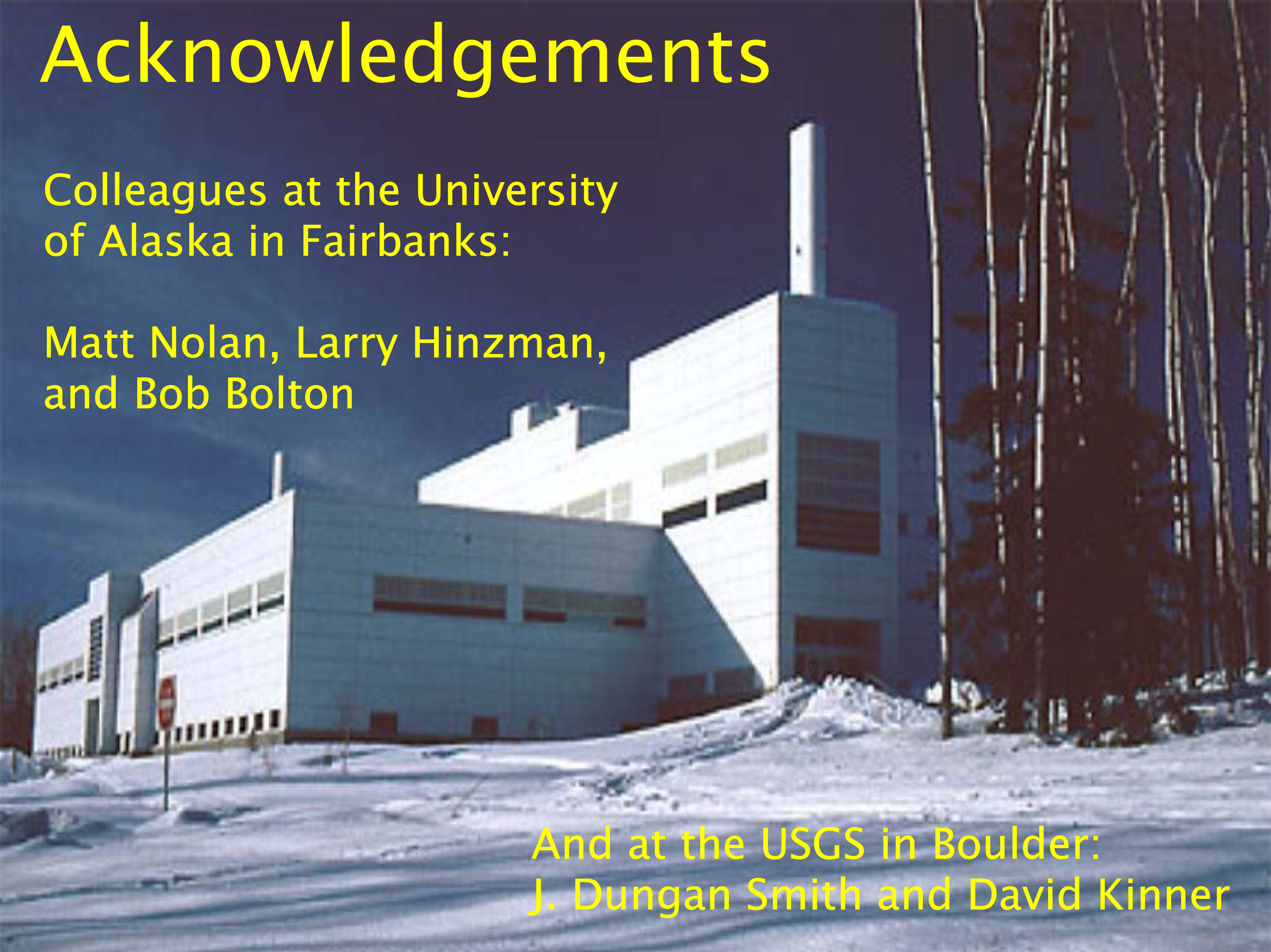
Acknowledgements



Colleagues at the University of Alaska in Fairbanks:

Matt Nolan, Larry Hinzman, and Bob Bolton

And at the USGS in Boulder:
J. Dungan Smith and David Kinner

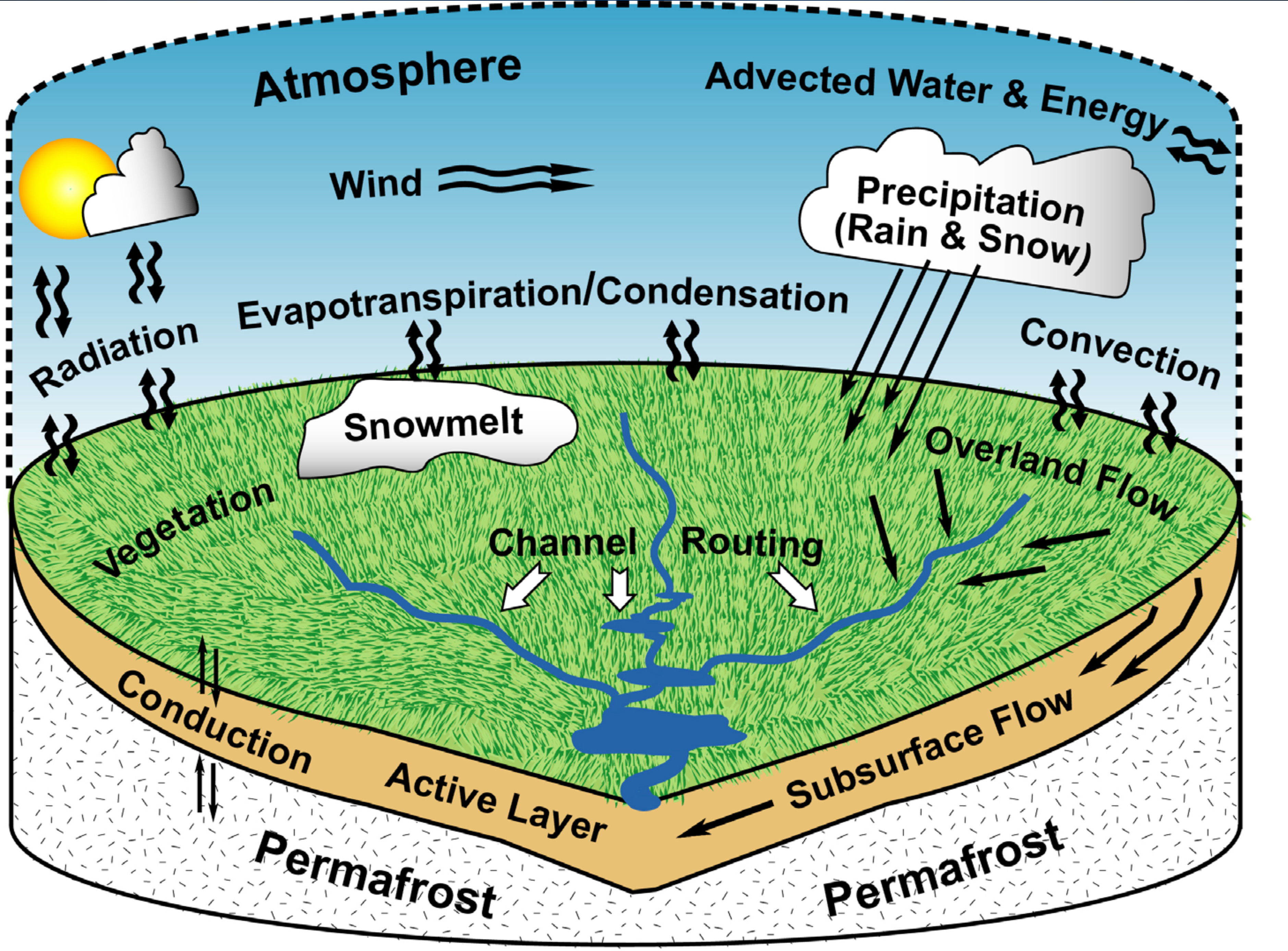
What is RiverTools?

RiverTools is a commercially-sold application for digital terrain and river network analysis. It is a full-featured Windows-style program with raster and vector GIS capabilities, ability to import many DEM formats, advanced visualization and analysis tools, and a wide variety of additional tools for working with DEMs and flow grids. (www.researchsystems.com)

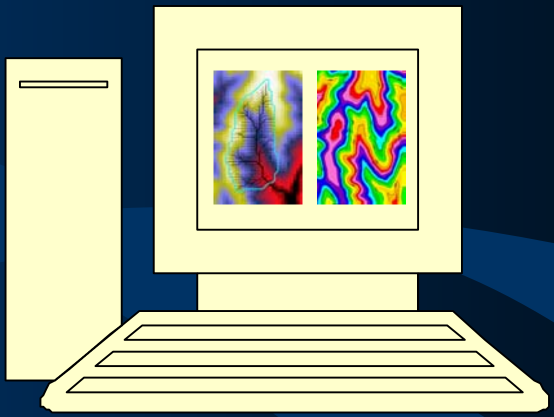
What is ARHYTHM?

ARHYTHM is a spatially-distributed hydrological model that incorporates thermal processes for use in the Arctic. It is physically based and is written in Fortran.

See Zhang, Z., Kane, D.L., Hinzman, L.D. (2000) Development and application of a spatially-distributed Arctic hydrological model and thermal process model (ARHYTHM), *Hydrol. Proc.*, **14**, 1017-1044.


Atmosphere
Advected Water & Energy
Wind
Precipitation
(Rain & Snow)
Evapotranspiration/Condensation
Radiation
Convection
Snowmelt
Overland Flow
Vegetation
Channel
Routing
Conduction
Active Layer
Subsurface Flow
Permafrost
Permafrost

Design Criteria for TopoFlow



- ✓ User-friendly interface
- ✓ User-extendible
- ✓ Open-source code
- ✓ Structured, consistent, clean
- ✓ Different timesteps for processes
- ✓ Multiple output options:
  Grid sequences, hydrographs for multiple outlets, etc.
- ✓ Flexible input options:
  Any input variable can be a scalar or grid.
  Note: IDL's dynamic data typing is perfect for this.

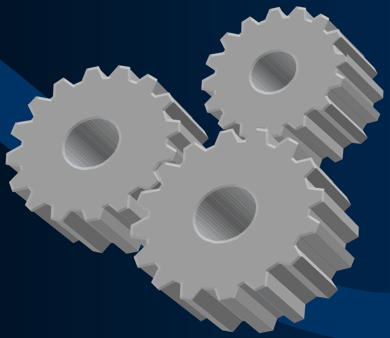
Overall Design Paradigm

Physical Process: (e.g. Snowmelt, ET, Overland Flow, Channel Flow)

Method: (None/Simple/Complex, e.g. None, Degree-Day, Energy Balance)

Formulas: (These define the method. Need enough to solve for all the output variables. Implemented as functions.)

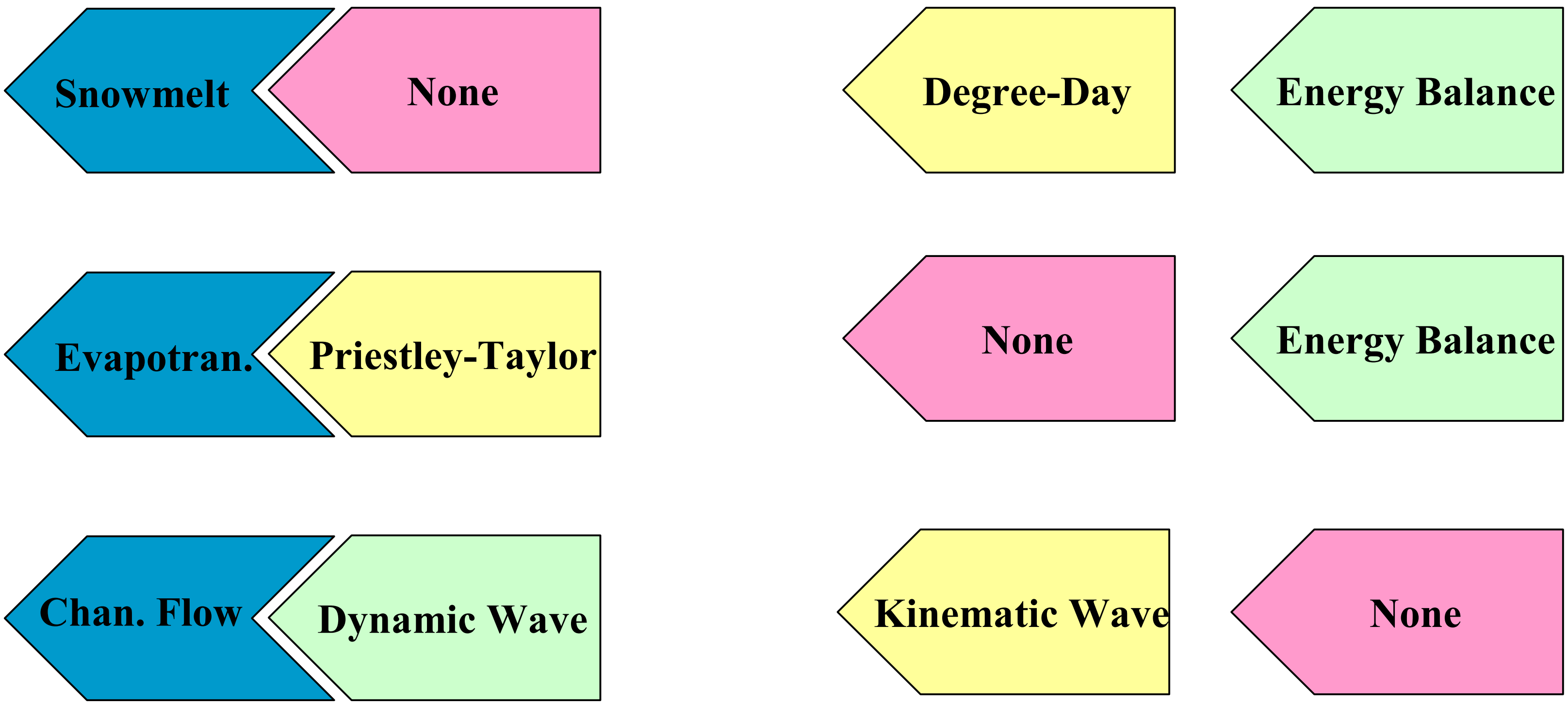
Variables: (Input/Output, Scalar/Grid, Deterministic/Random)



Other Issues:

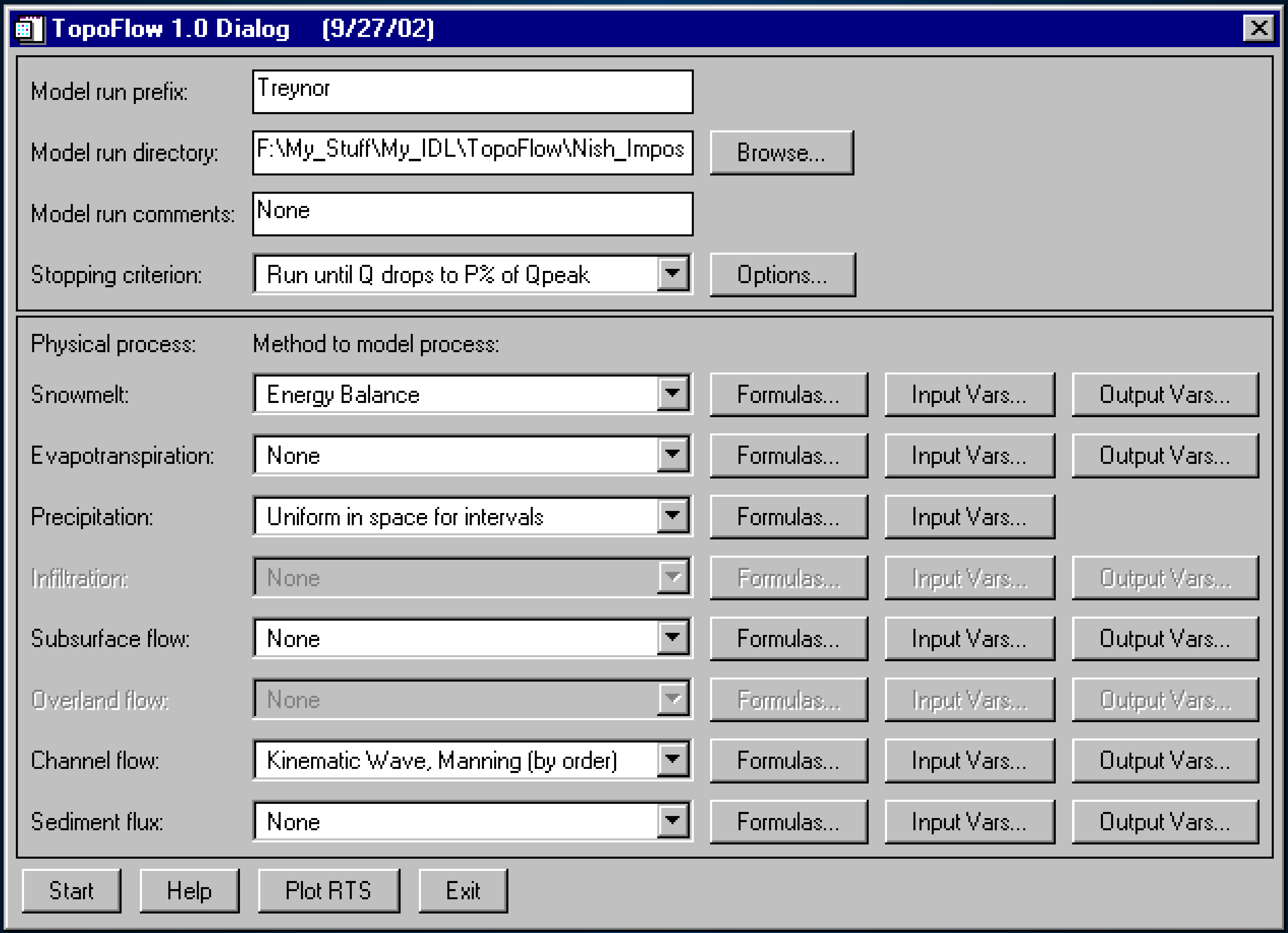
Timesteps
Stopping Criteria
Output Methods

Multiple Methods per Process



Each method has a similar set of dialogs to specify or collect input and output variables. Any process can be turned off.

TopoFlow Main Dialog



Snowmelt: Energy Balance Dialog

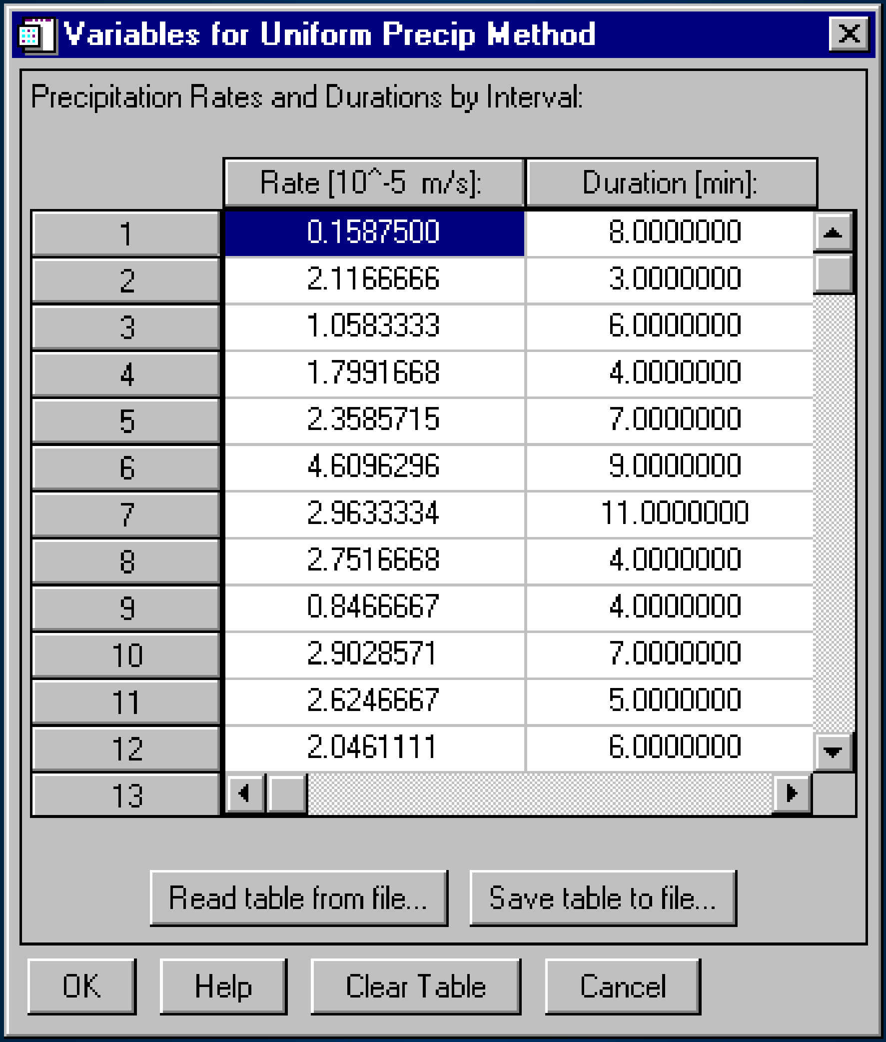
Variables for Snowmelt: Energy Balance Method

Variable:	Type:	Scalar or Grid Filename:	Units:
Qnet:	Scalar	1.0	[W/m^2]
T_air:	Scalar	0.000000	[deg_C]
T_surf:	Scalar	0.000000	[deg_C]
e_air:	Scalar	0.000000	[mbar]
e_surf:	Scalar	0.000000	[mbar]
p0:	Scalar	0.000000	[mbar]
uz:	Scalar	1.00000	[m/s]
z:	Scalar	1.00000	[m]
z0_air:	Scalar	0.0200000	[m]
h_snow:	Scalar	1.00000	[m]
rho_snow:	Scalar	300.00000	[kg/m^3]
Cp_snow:	Scalar	9999	[J/kg/deg_C]
rho_air:	Scalar	1.26140	[kg/m^3]
Cp_air:	Scalar	1005.70	[J/kg/deg_C]

Timestep: 1.0000000 [hours / timestep]

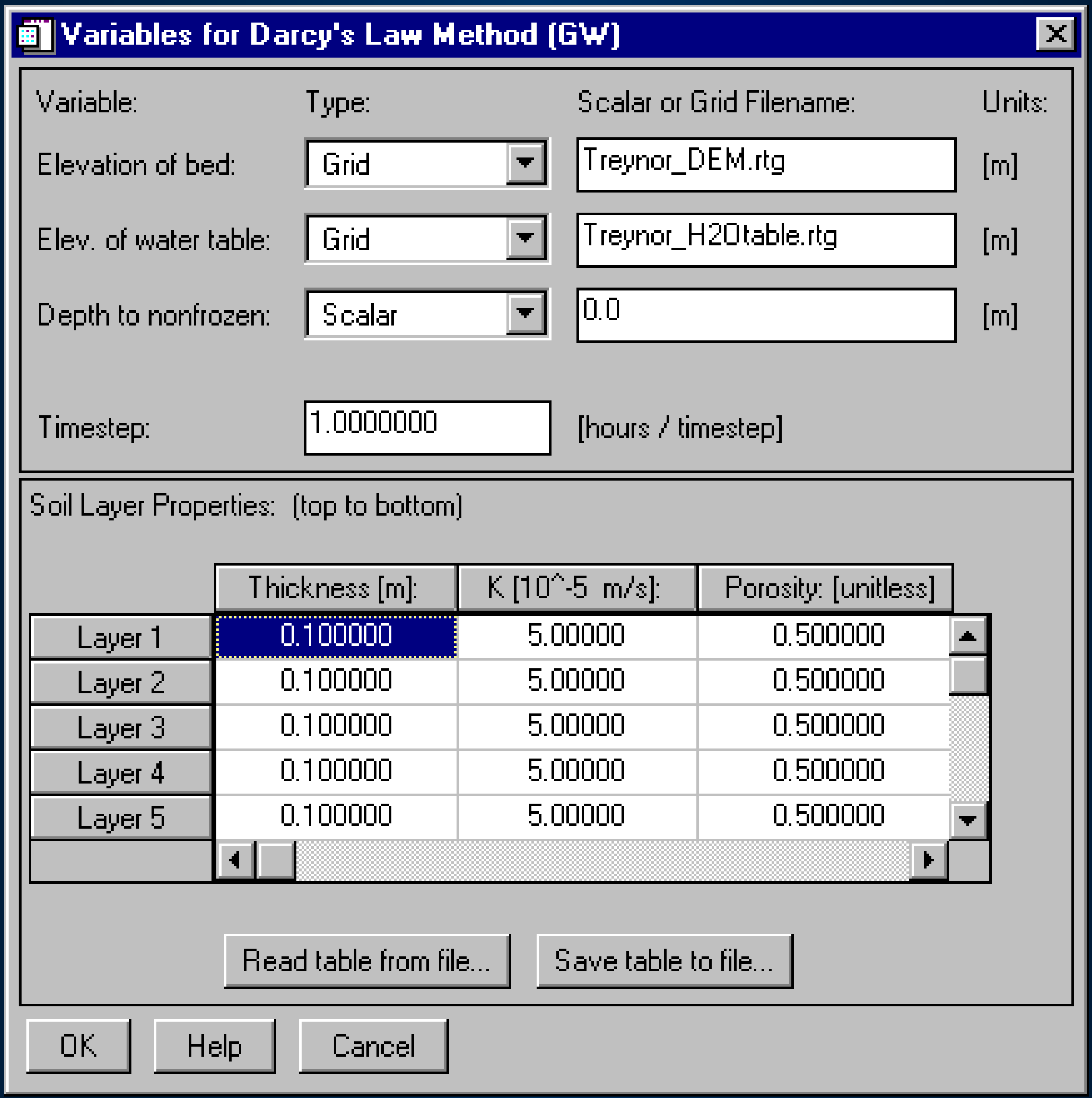
OK Help Cancel

Uniform Precipitation Dialog

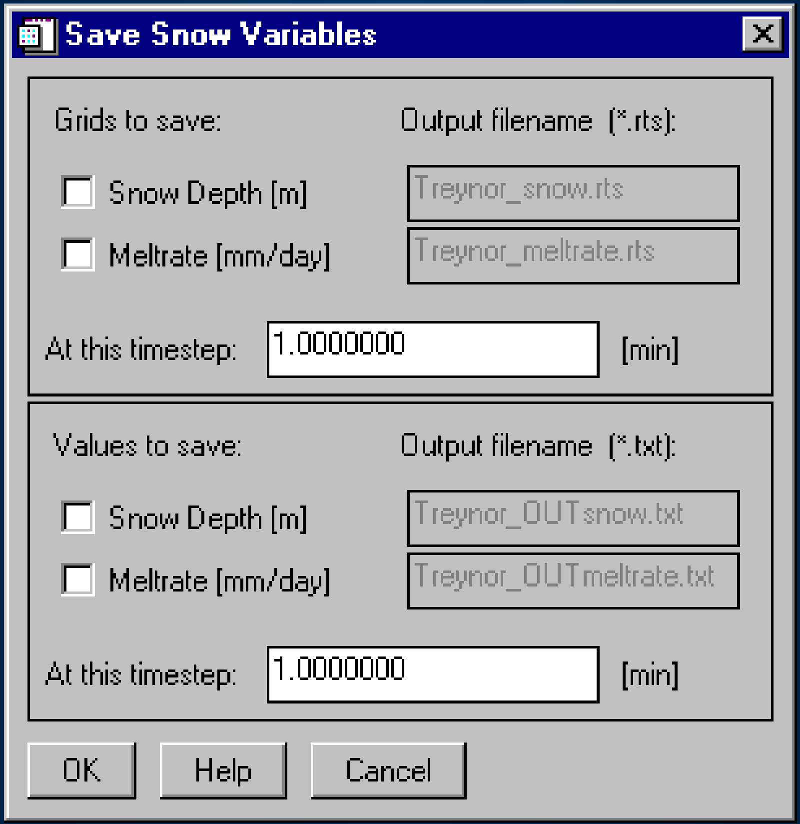


	Rate [10^-5 m/s]:	Duration [min]:
1	0.1587500	8.0000000
2	2.1166666	3.0000000
3	1.0583333	6.0000000
4	1.7991668	4.0000000
5	2.3585715	7.0000000
6	4.6096296	9.0000000
7	2.9633334	11.0000000
8	2.7516668	4.0000000
9	0.8466667	4.0000000
10	2.9028571	7.0000000
11	2.6246667	5.0000000
12	2.0461111	6.0000000
13		

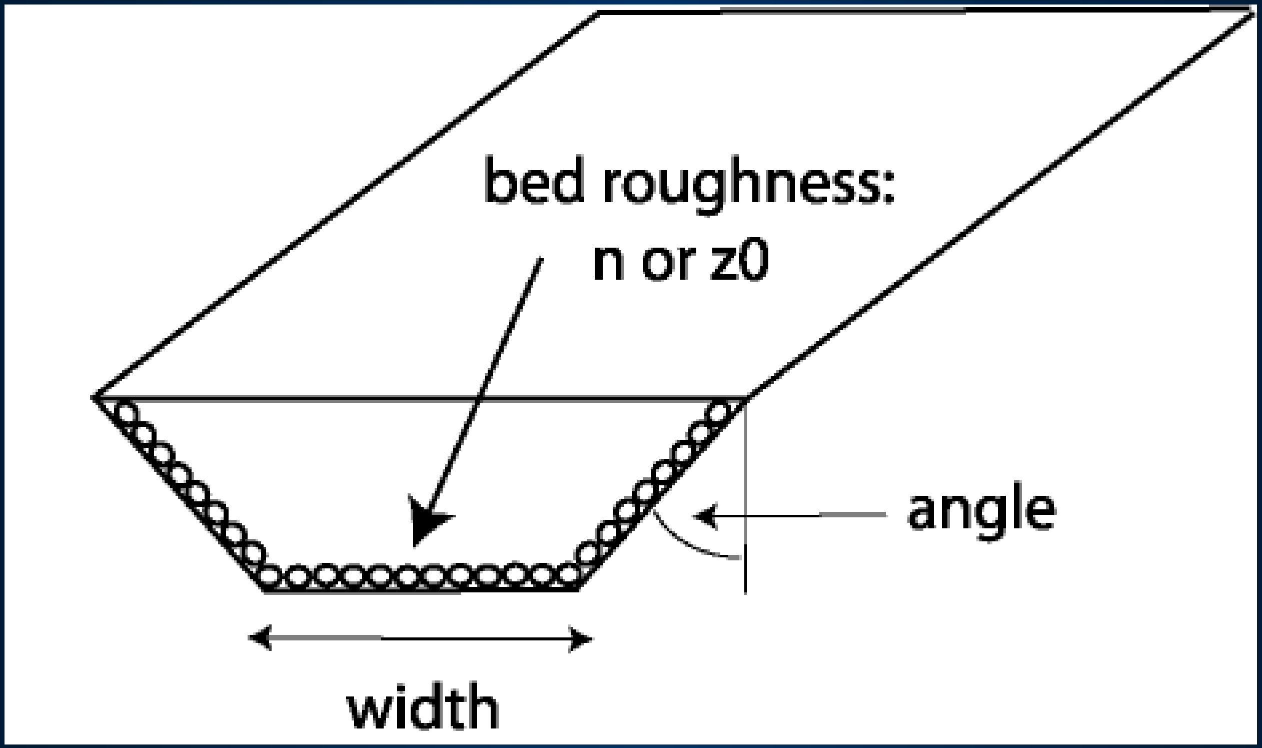
Subsurface Flow Dialog



Output Methods



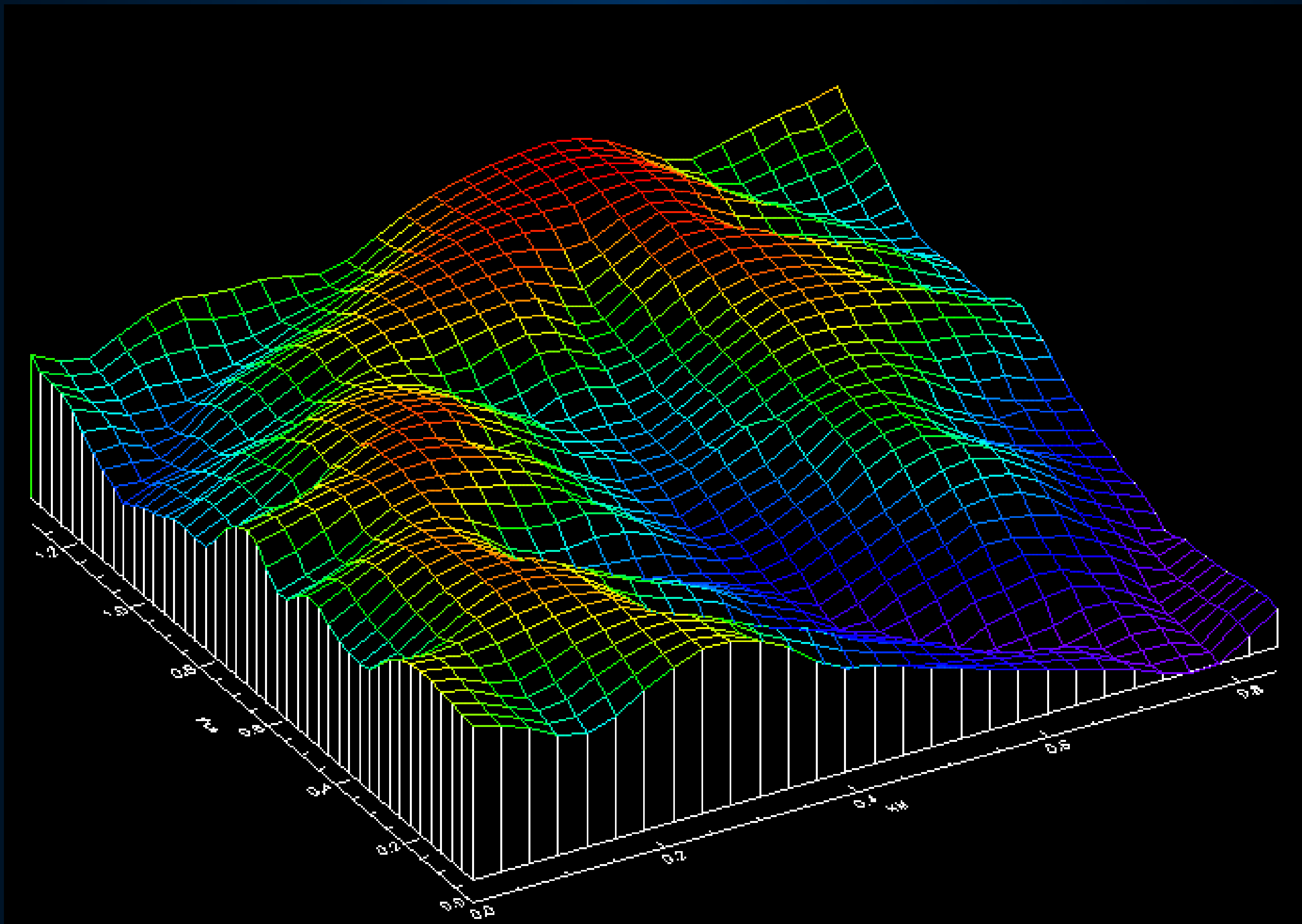
Trapezoidal Channel Cross-Sections
(attributes can depend on HS Order)



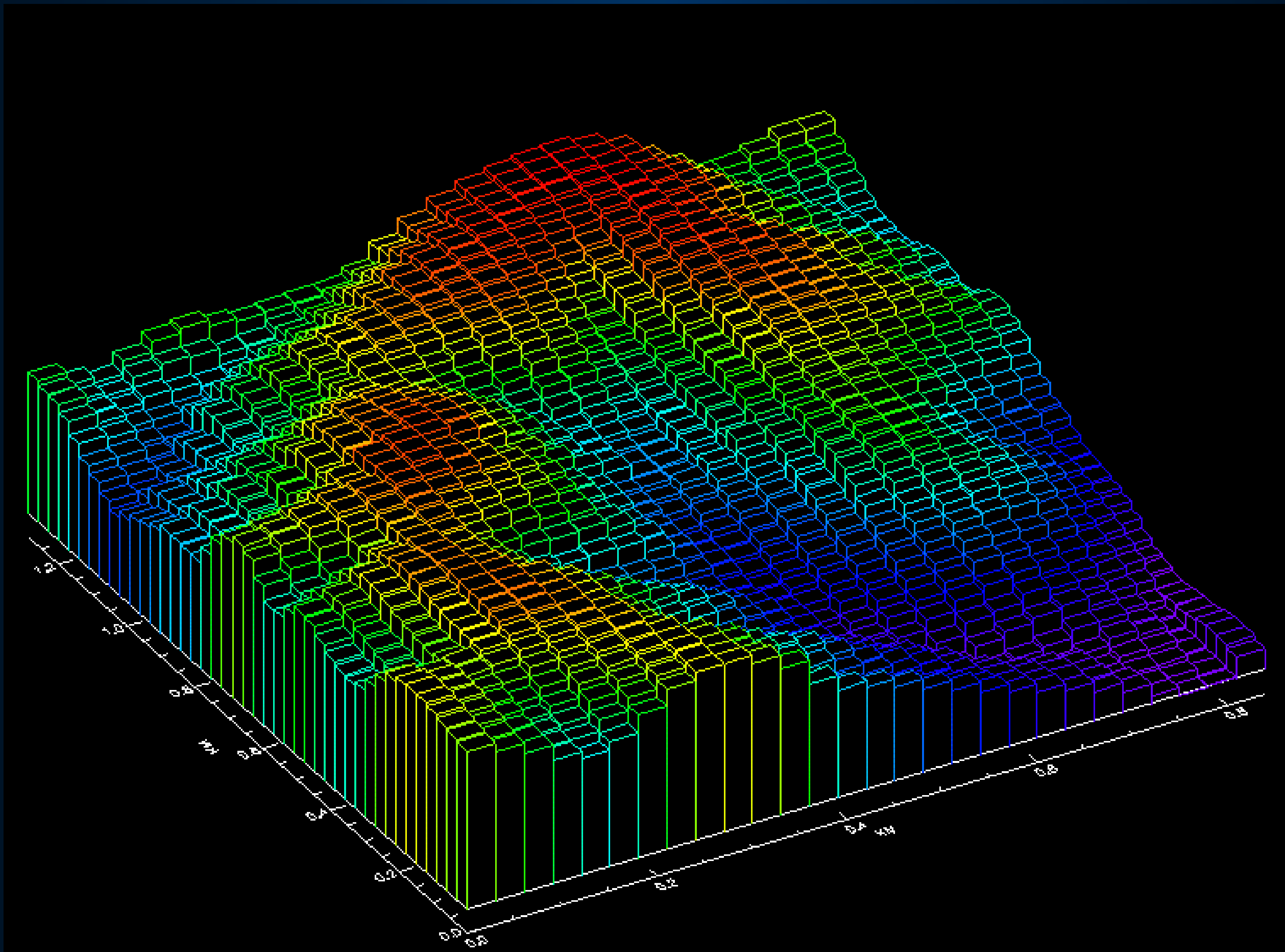
Flow Resistance Options:
- Manning's Formula (n)
- Law of the Wall (z0)

Special Cases:
- Rectangular: width = 0
- Triangular: angle = 0

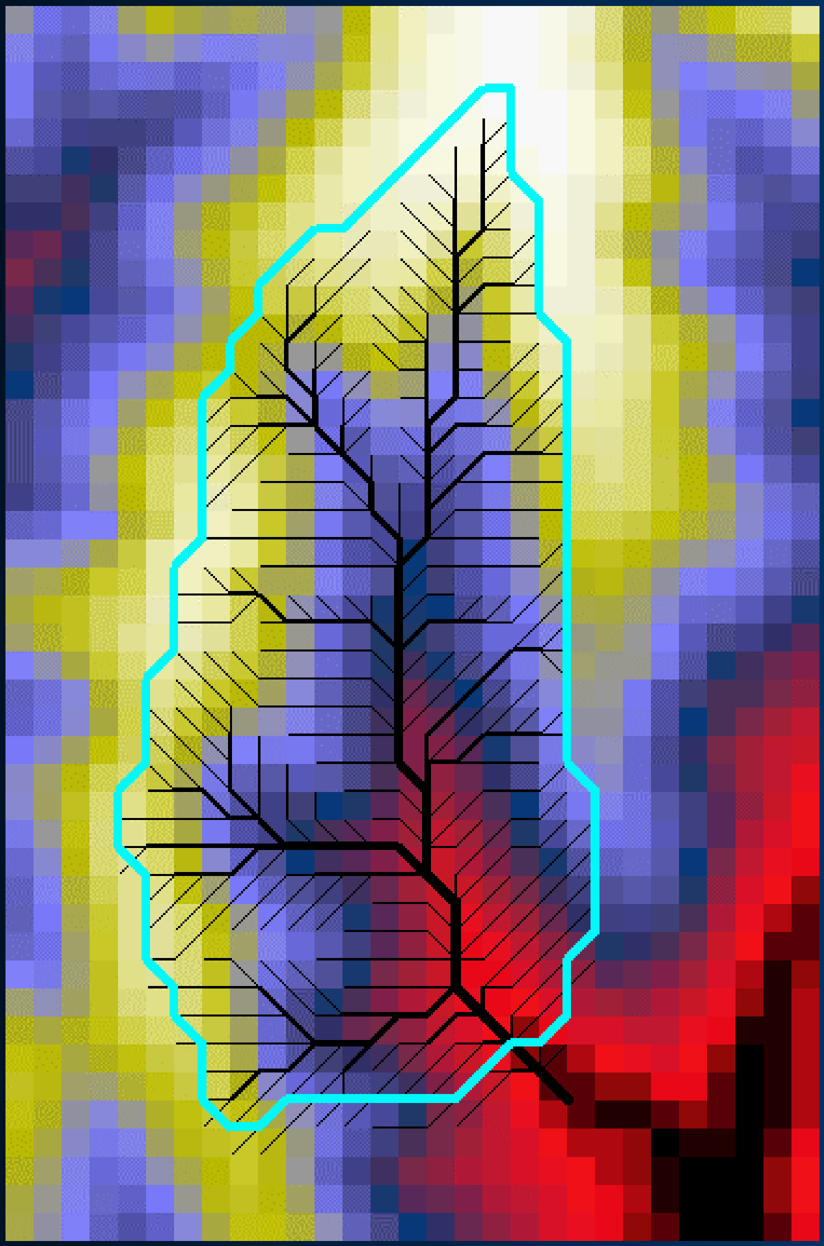
Treynor Watershed Surface Plot

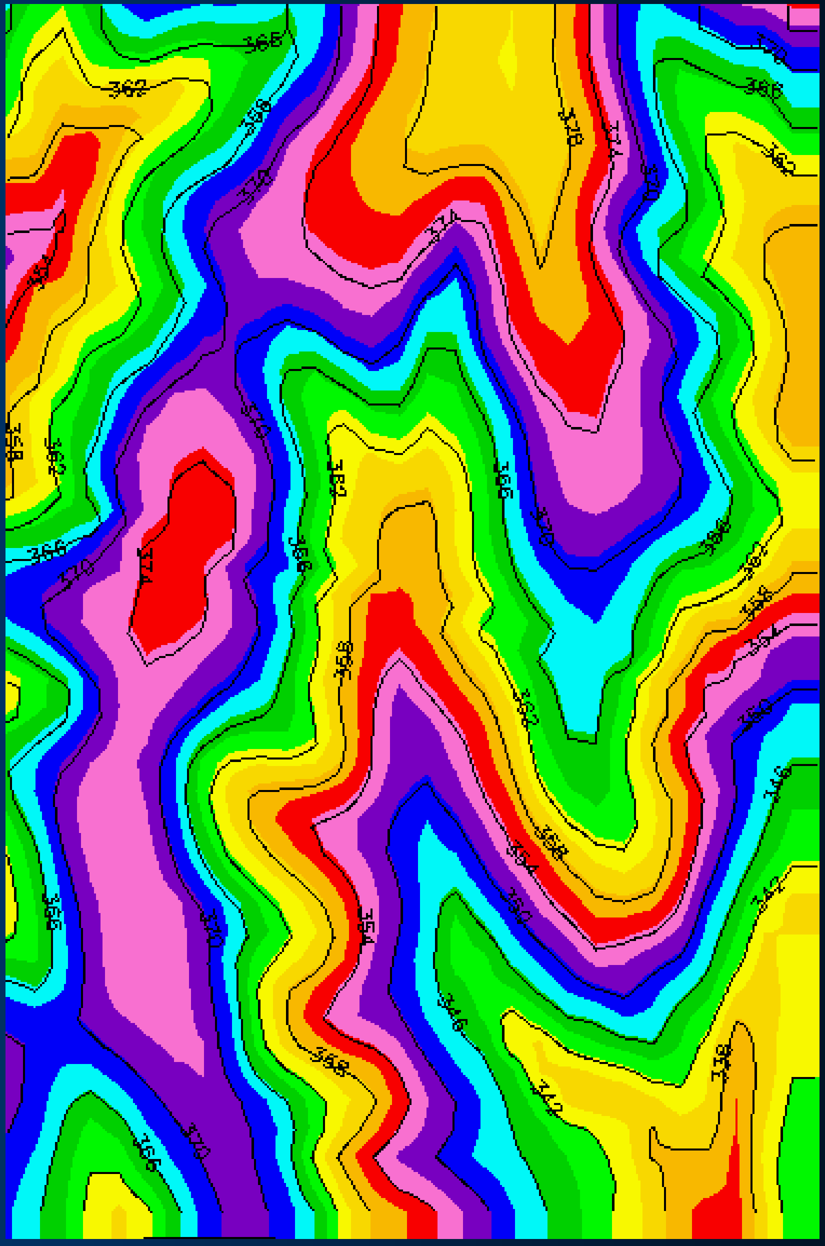


Treynor Watershed Surface Plot

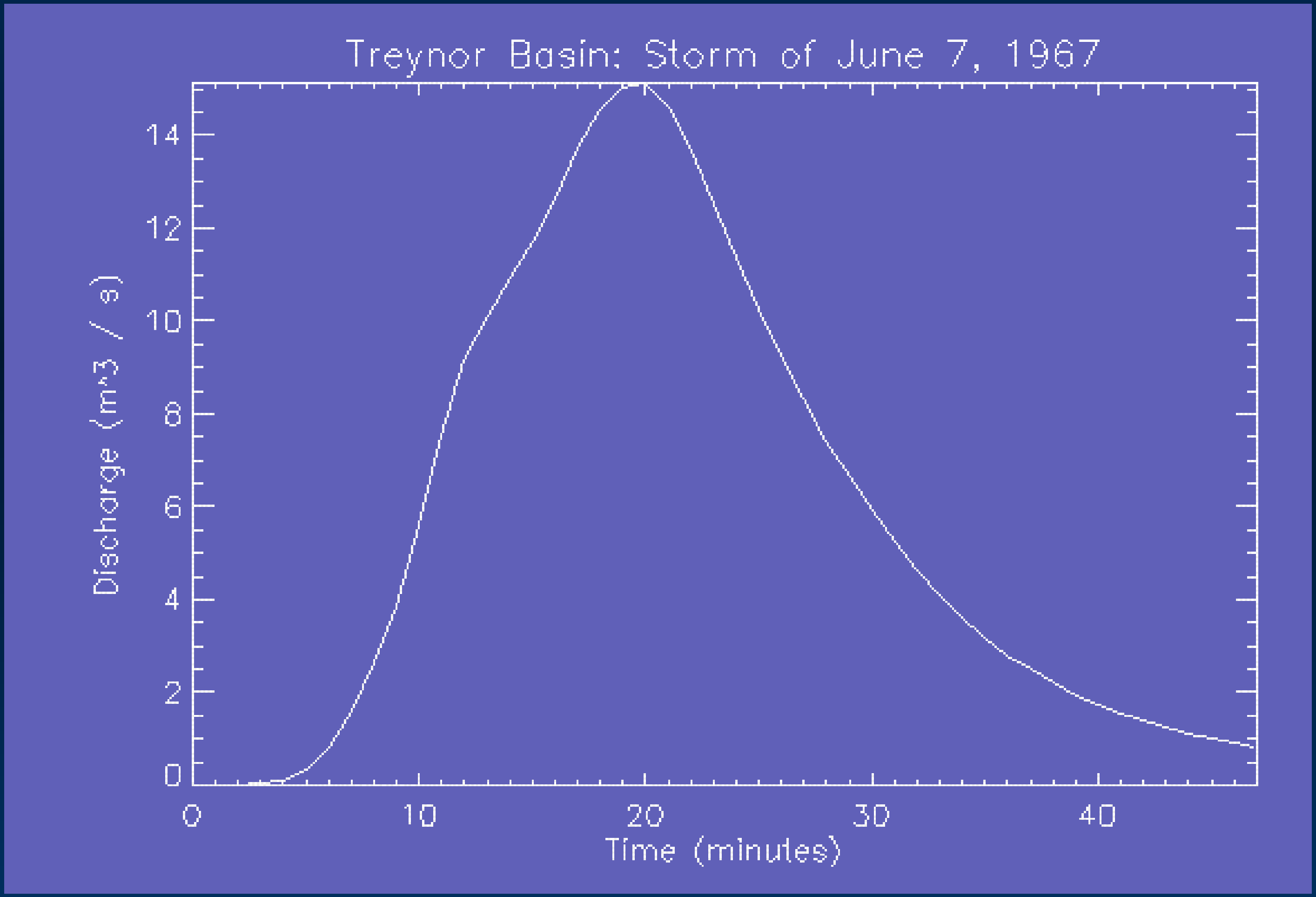


Treynor Watershed, Iowa (0.43 sq km)

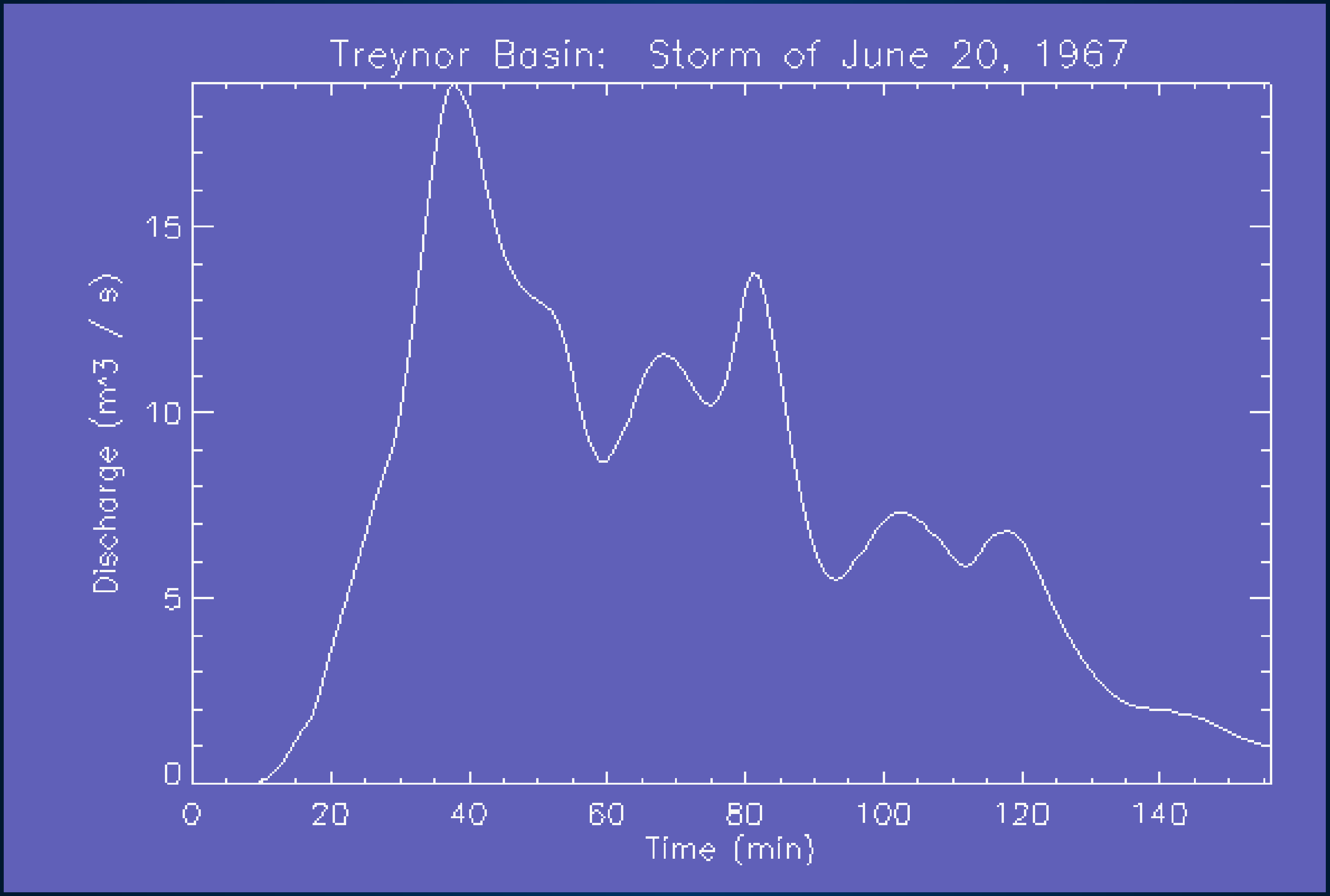




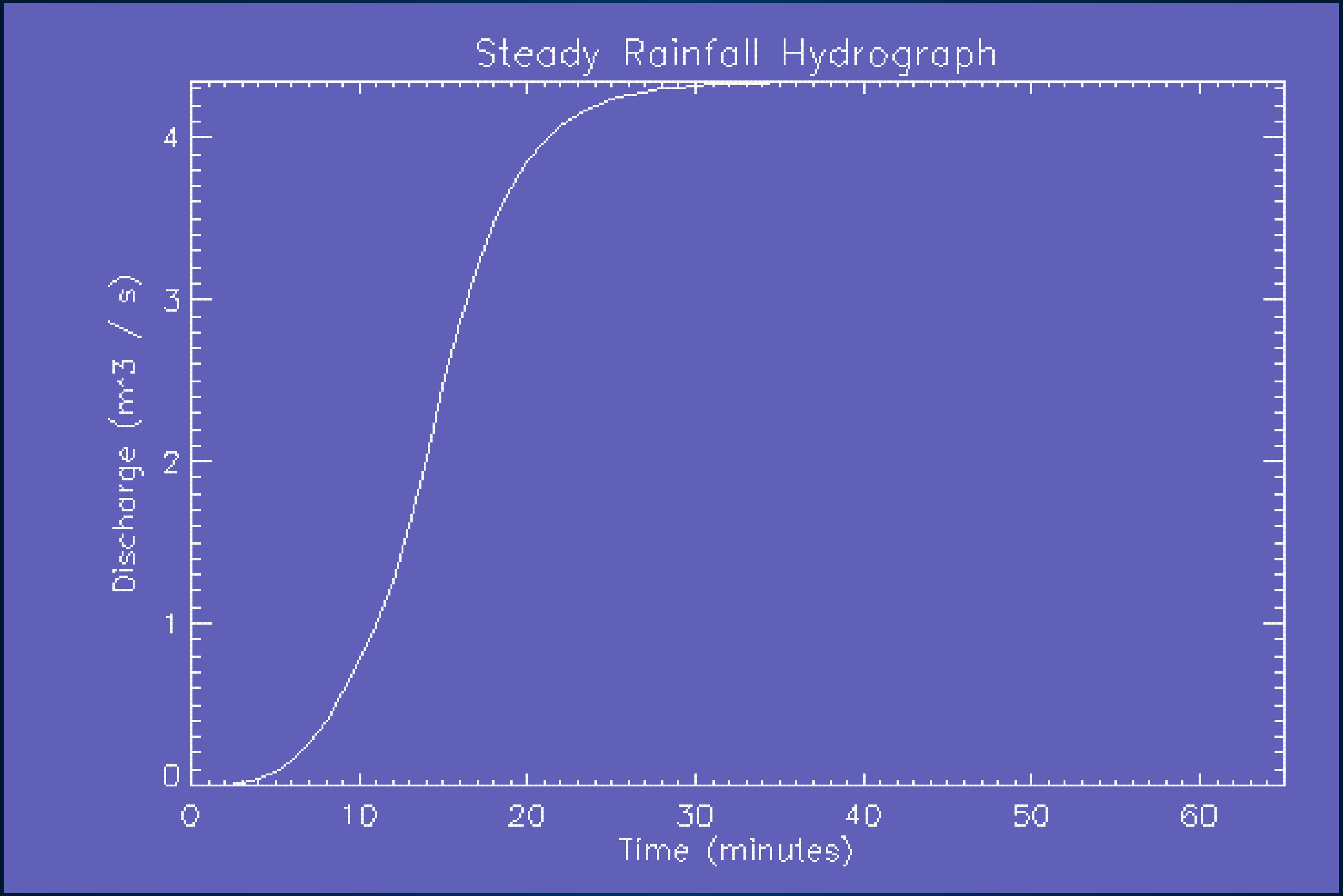
Simulated Hydrograph for Treynor Basin and 6/7/67 Storm



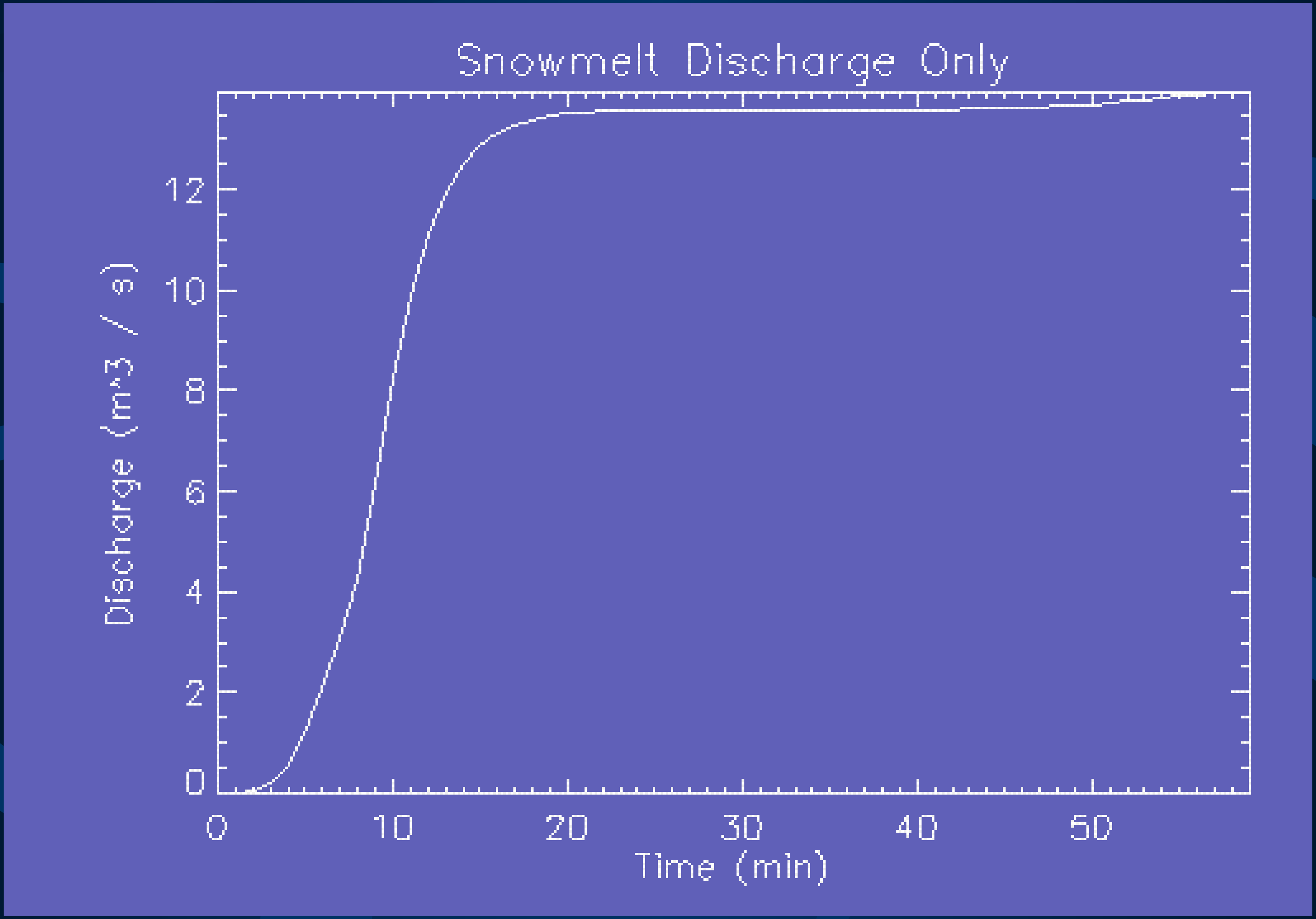
Simulated Hydrograph for Treynor Basin and 6/20/67 Storm



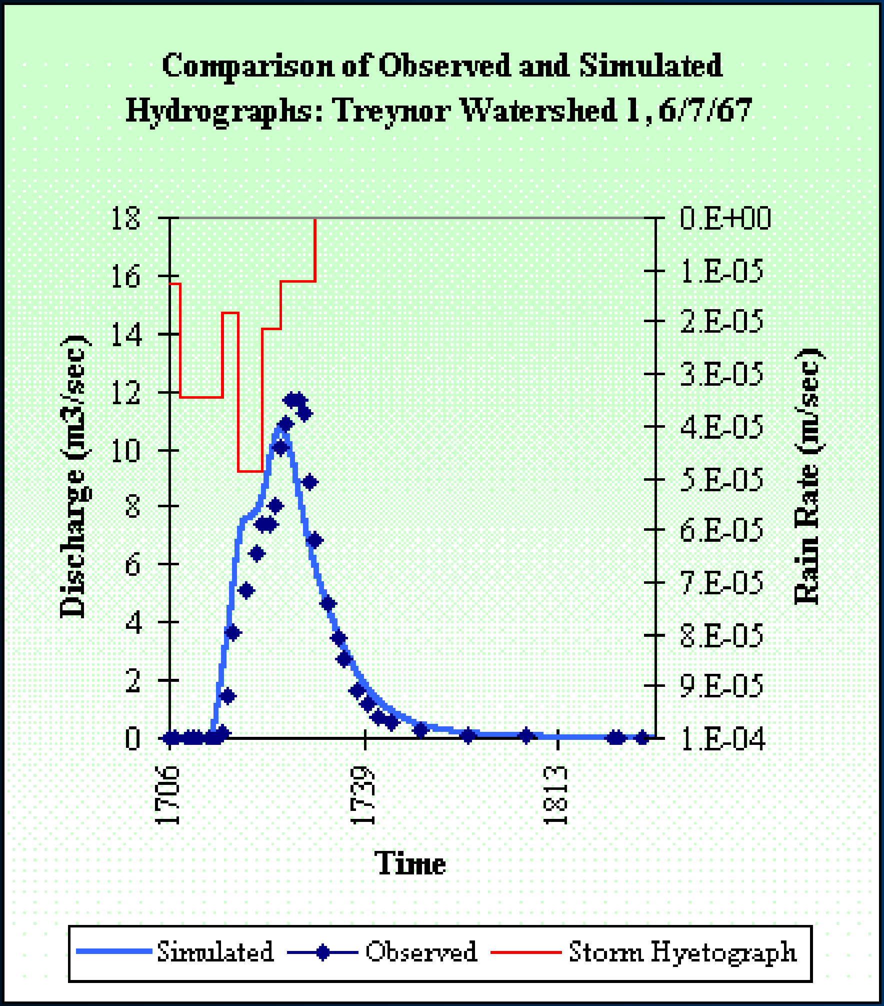
Simulated Hydrograph for Treynor Basin from Steady Rain

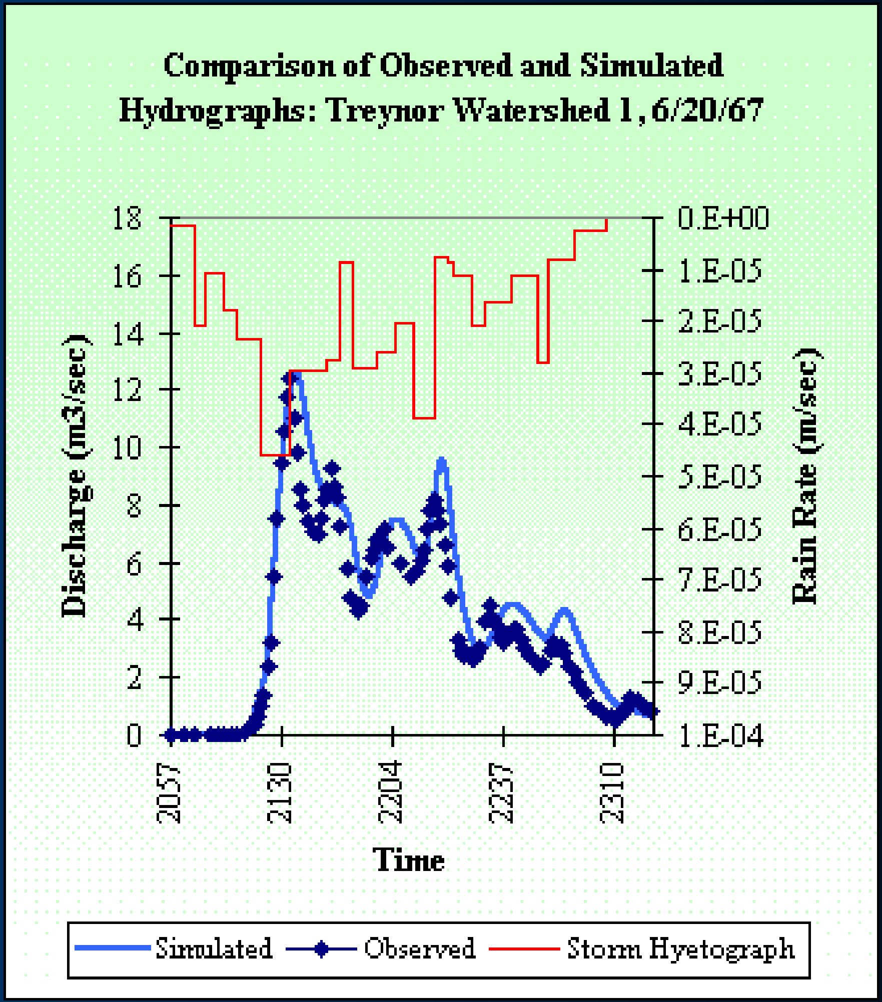


Simulated Hydrograph for Treynor Basin from Snowmelt

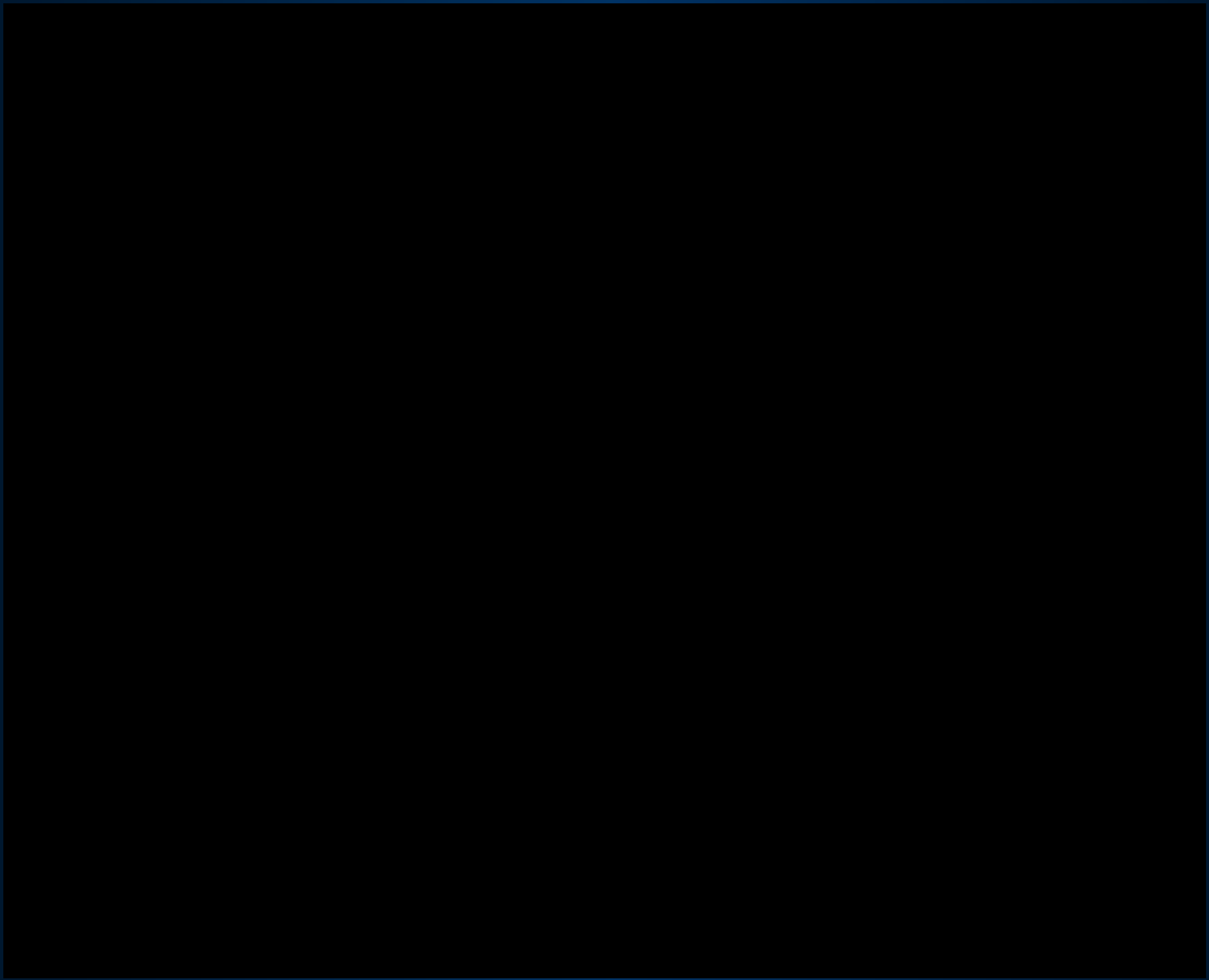


Treynor Hydrographs vs. Data





Distributed Discharge Animations



Extending TopoFlow: Steps for Adding a New Method

Suppose a user with basic programming skills wants to add a new method for modeling a given physical process.

1. Add string to the droplist of methods in code for main dialog.
2. Add name of routine to call when that method is selected.
3. Add any new input variables the method needs to the structure which contains all the input variables for given method.
4. Edit the "method caller" routine to add the new method.
5. Starting with code for an existing method's GUI (viewed as a template), edit it to collect input variables that are needed by the new method.
6. Write a set of functions corresponding to the formulas that define the new method. Model these after examples.

Summary

- ***TopoFlow*** is a new, user-friendly and user-extendible toolkit for spatially distributed hydrologic modeling.

- Although similar in spirit to models like CASC2D and MMS, it offers several advantages, such as the ability for any input variable to be provided as a scalar to be distributed uniformly or as a spatial grid. Similar support for grid sequences is planned.

- It's intuitive, open-source, structured design provides an environment for both research and education.

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