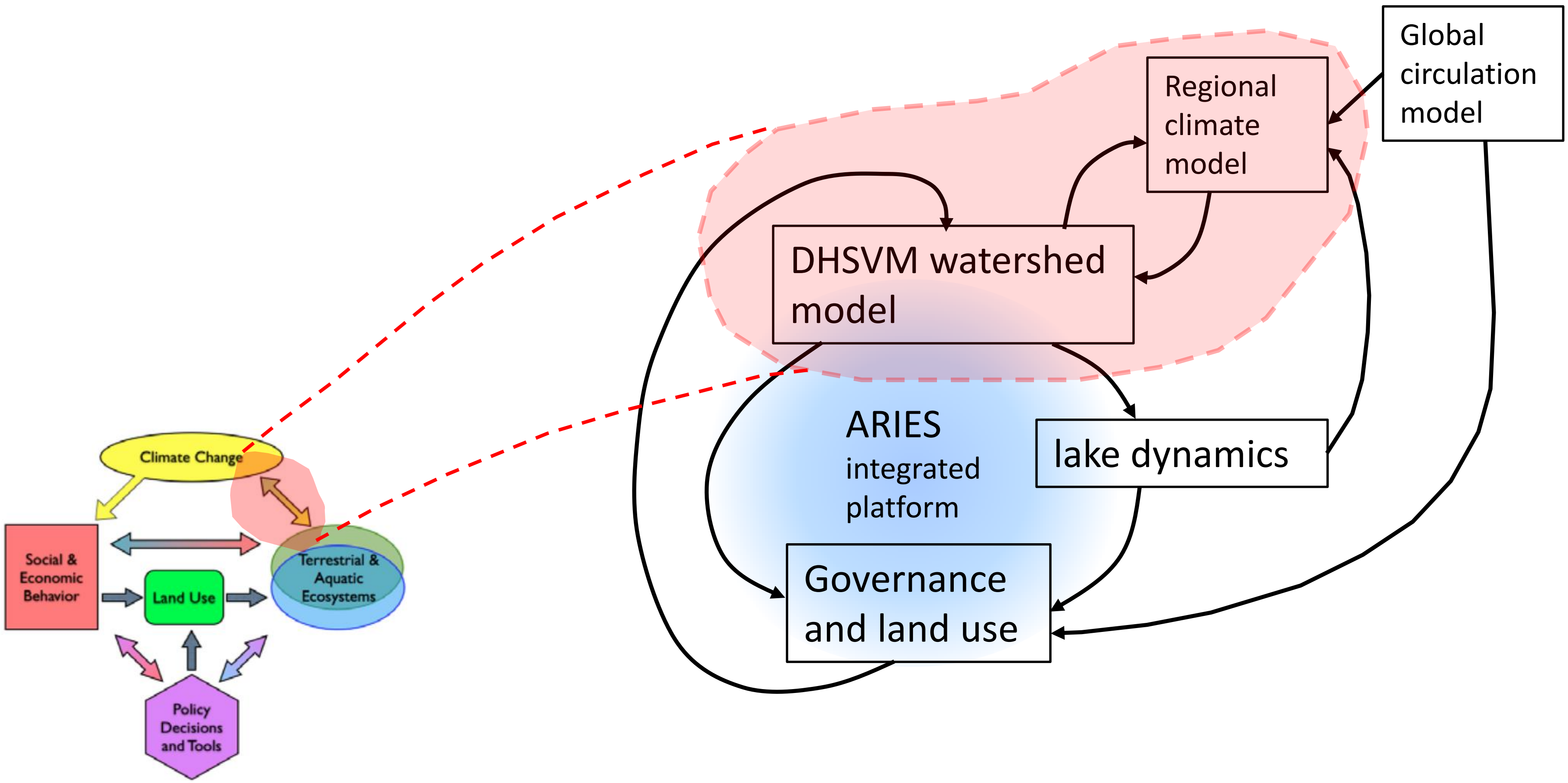
Q2 Watershed modeling group
Annual meeting update

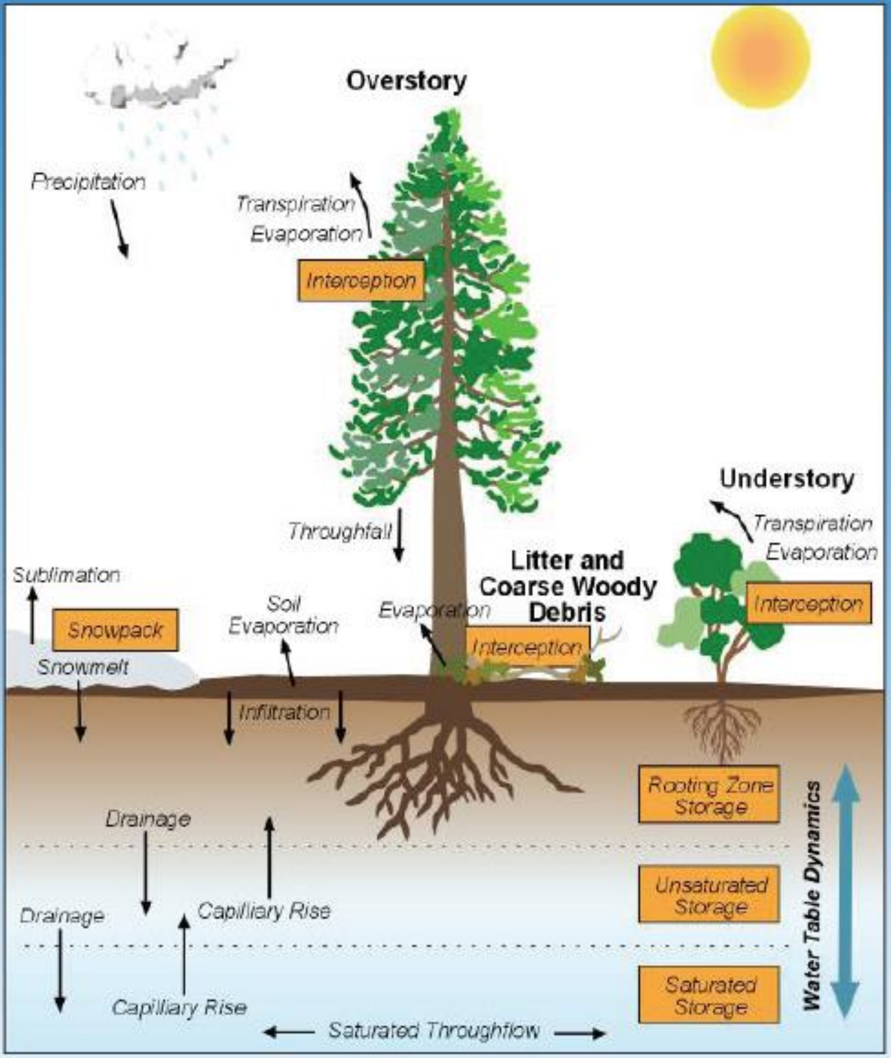
August 5, 2014
Arne Bomblies

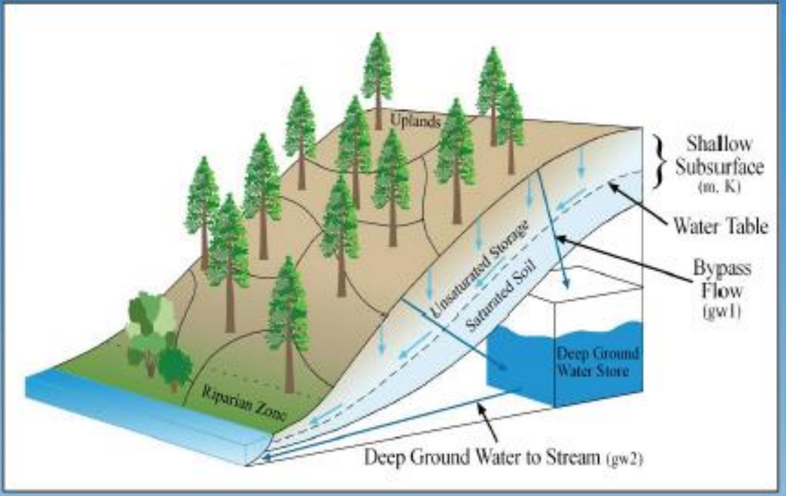
Question 2: Watershed component

"Which alternative stable states can emerge in the watershed and lake resulting from non-linear dynamics of climate drivers, lake basin processes, social behavior, and policy decisions?"



Vertical and Lateral drainage in RHESSys



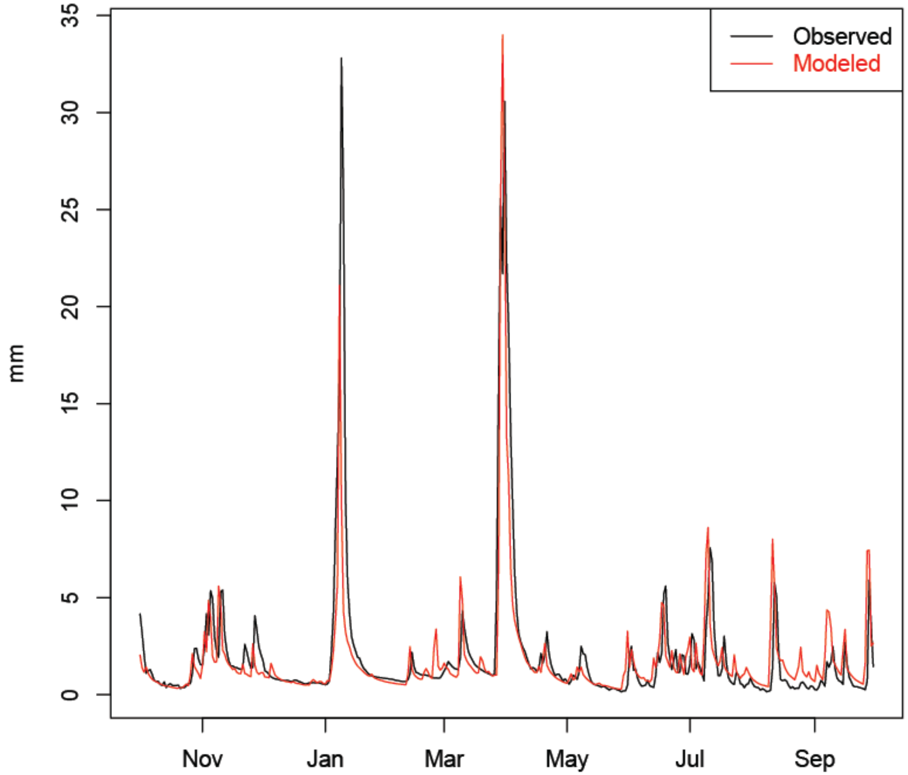


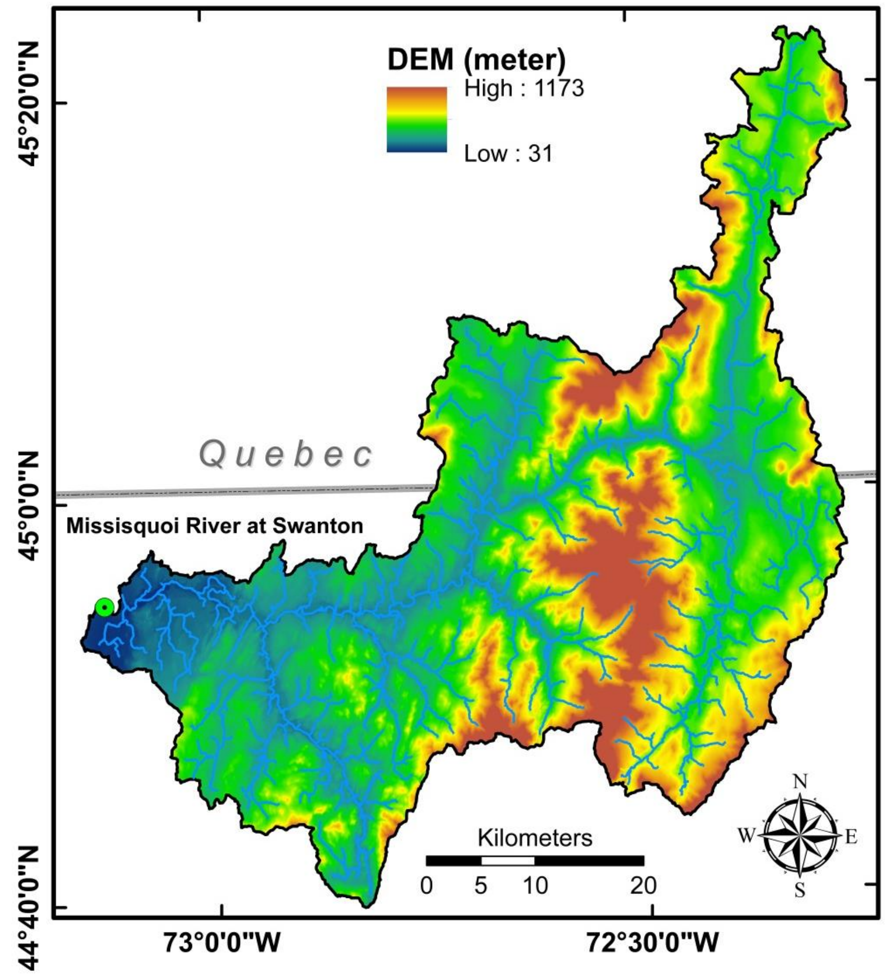
http://fiesta.bren.ucsb.edu/~rhessys/index.html

Excerpt from a speech by *Christina Tague*

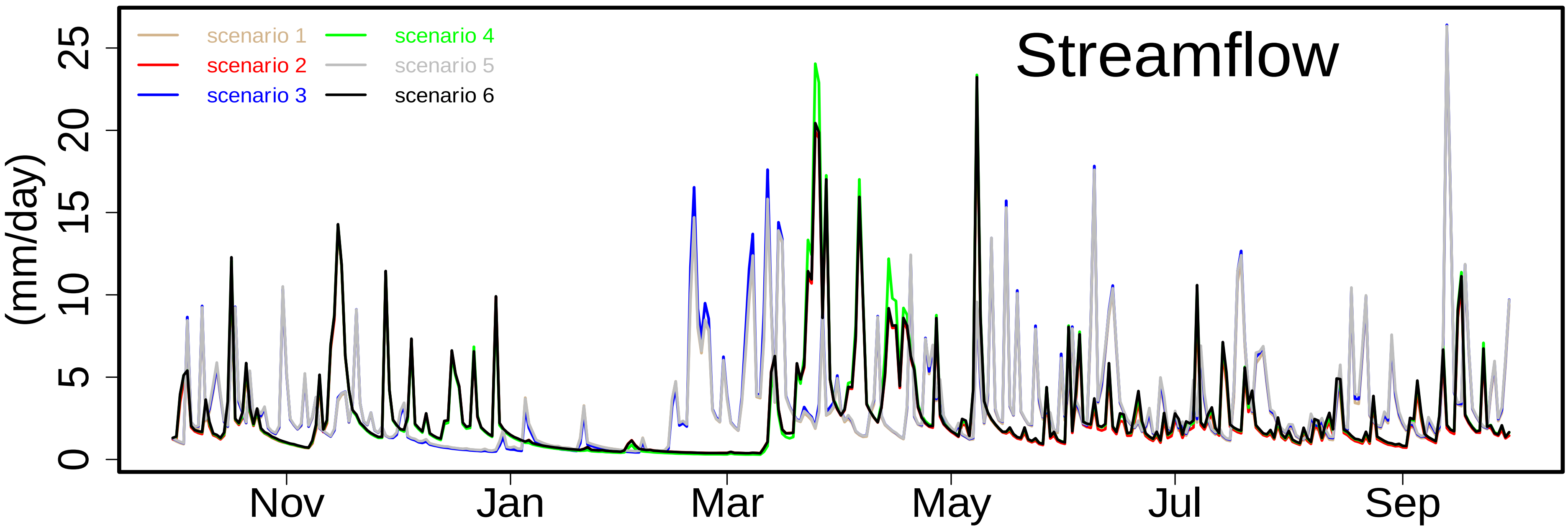
Missisquoi Model

1997-1998 Water Year Observed and Simulated Runoff





Streamflow hydrograph
Missisquoi River at Swanton



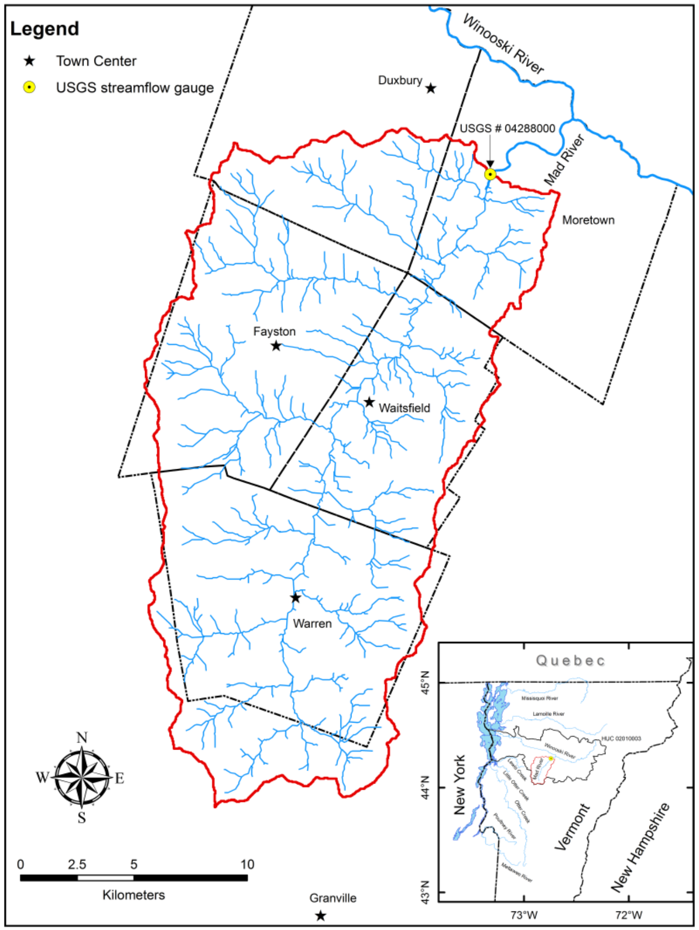
- cali_gr_sh_fo_ag_IP & BNU_ESM rcp85 = scenario 1
- cali_gr_sh_fo_ag_IP & CESM1_BGC rcp85 = scenario 2
- pro-crop-LAP & BNU_ESM rcp85 = scenario 3
- pro-crop-LAPP & CESM1_BGC rcp85 = scenario 4
- pro-forest-IP & BNU_ESM rcp85 = scenario 5
- pro-forest-IP & CESM1_BGC rcp85 = scenario 6

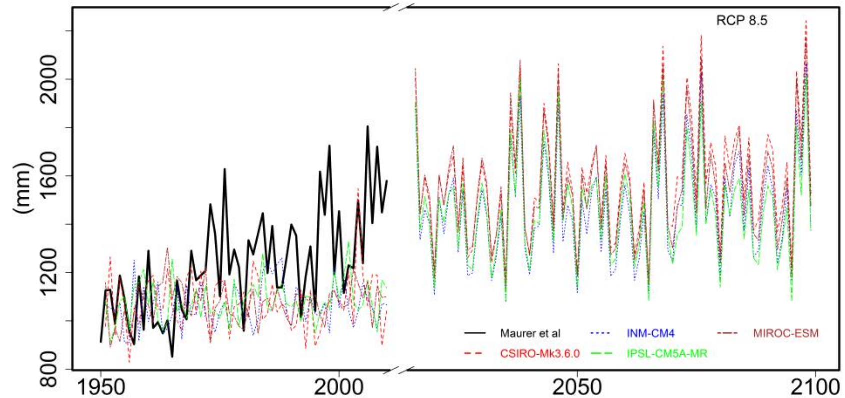
Original and Scenarios Comparison

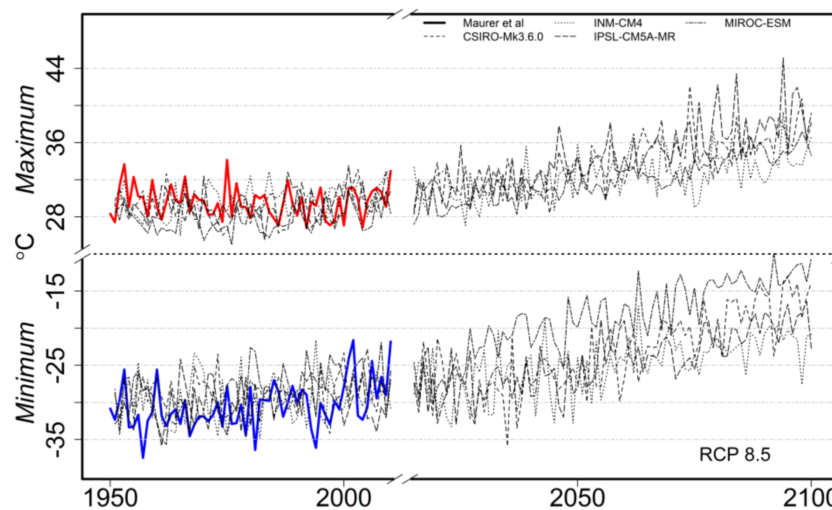
		cali-gr-sh-fo-ag	pro-crop-LAP	pro-forest-IP
Type	Origin (%)	IP 2041 (%)	LAP 2041 (%)	IP 2041 (%)
Shrub	1.22	0.58	0.5	0.56
Grass	0.57	0.45	0.22	1.15
No Vegetation	26.26	27.63	55.8	15.92
Mixed Forest	24.97	24.57	13.67	24.61
Coniferous Forest	8.4	7.88	3.8	7.91
Deciduous Forest	38.58	38.89	26	49.84

Watershed drainage area is 2,200 km^2

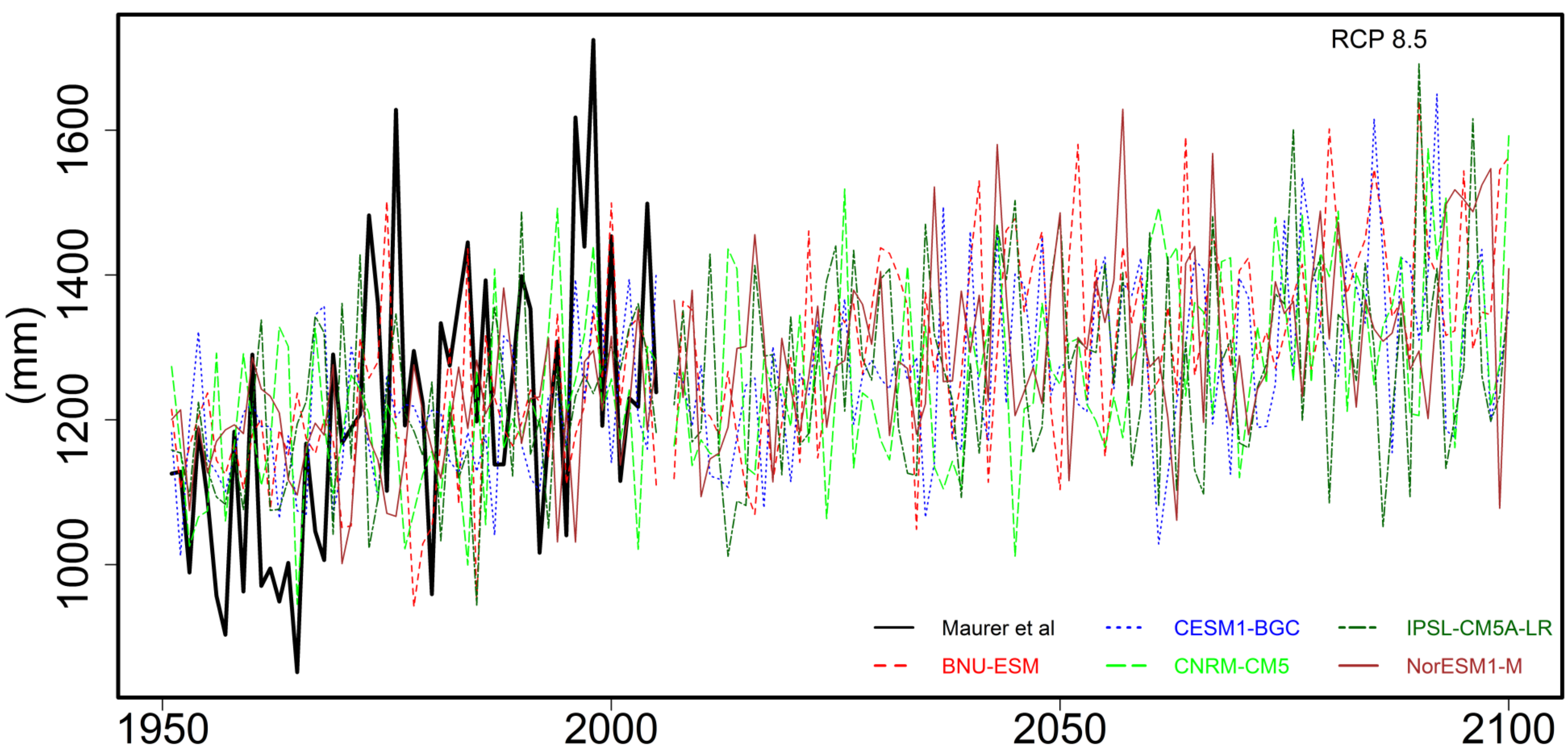
MRV & Climate Input

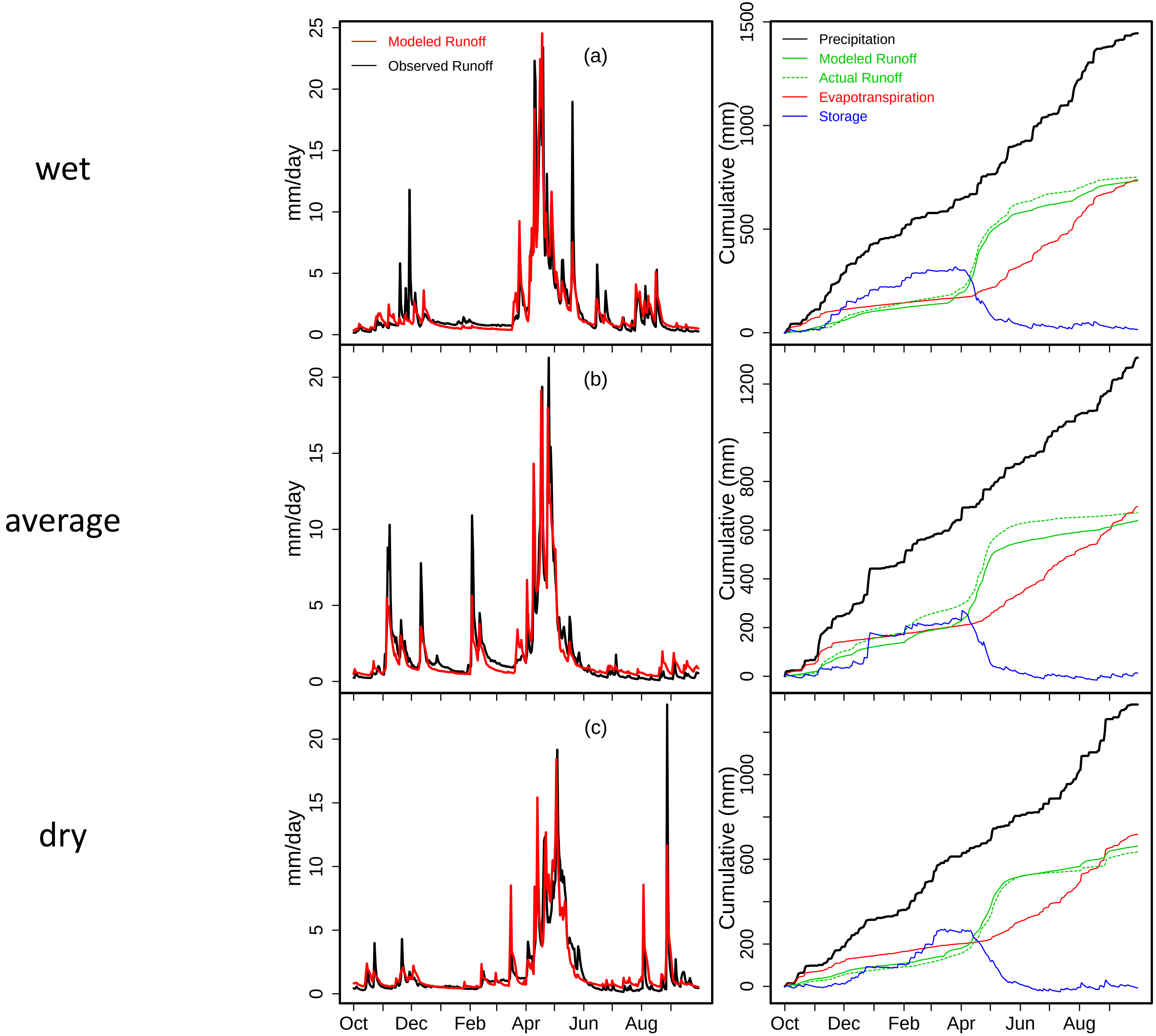




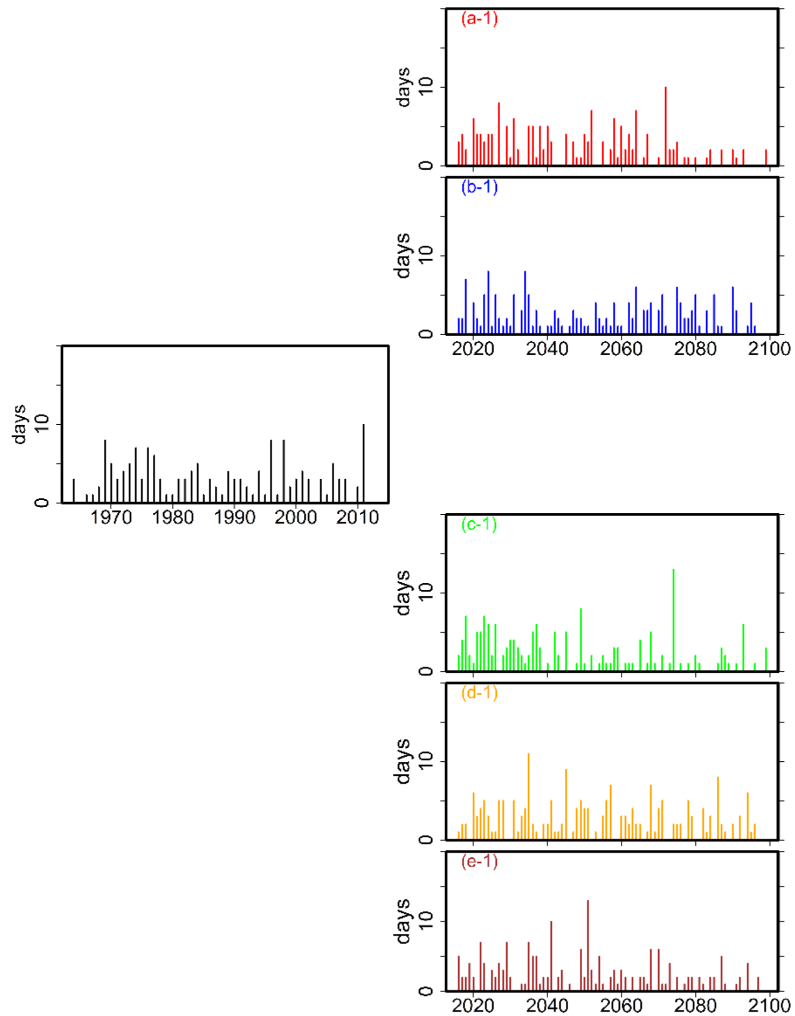


Annual precipitation data over the Mad River Valley showing observed (black line) And five of the “best fit” GCM outputs.

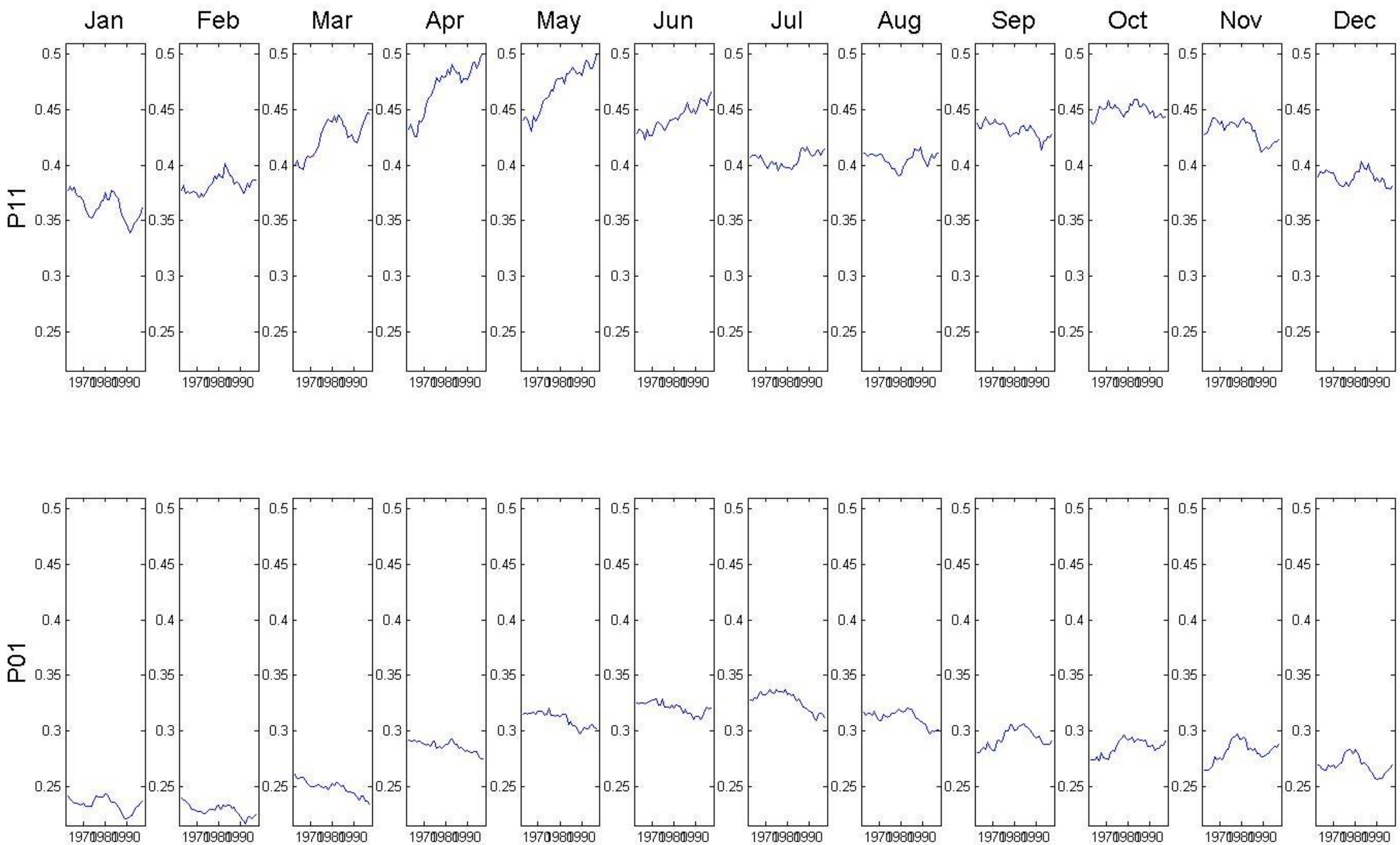


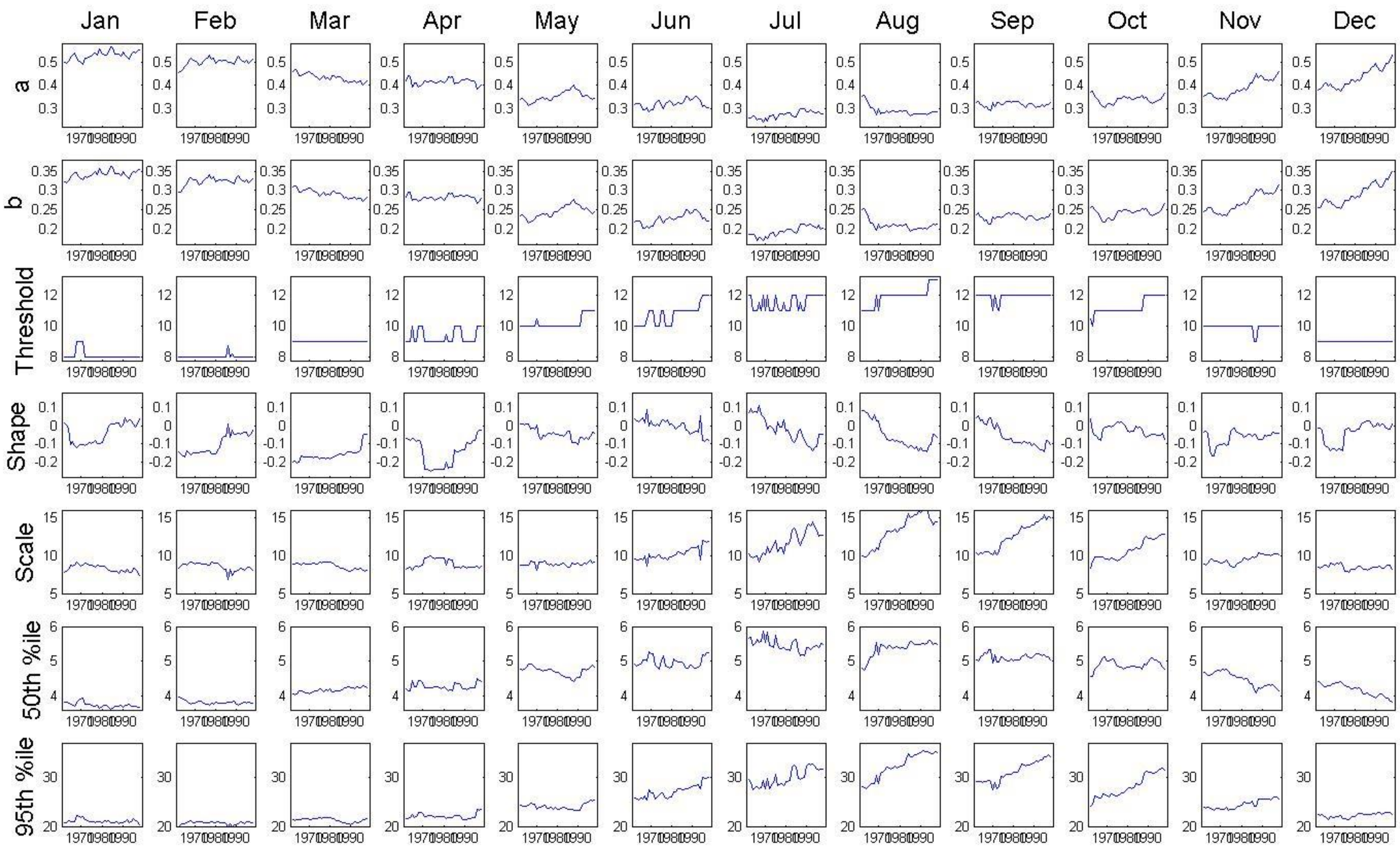

wet
average
dry
Modeled Runoff
Observed Runoff
(a)
(b)
(c)
mm/day
Precipitation
Modeled Runoff
Actual Runoff
Evapotranspiration
Storage
Cumulative (mm)
Oct
Dec
Feb
Apr
Jun
Aug

Model results: The number of days of flood exceedance (2175 cfs) per year. (from CMIP 5 ensembles)



Seasonality of Markov chain parameters: persistence in spring?




Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
a
b
Threshold
Shape
Scale
50th %ile
95th %ile
1970
1980
1990

Distributed Hydrology Soil Vegetation Model

Developed in early 1990s (Wigmosta et al., 1994)

Updated by Lettenmaier and others at Pacific Northwest National Laboratory

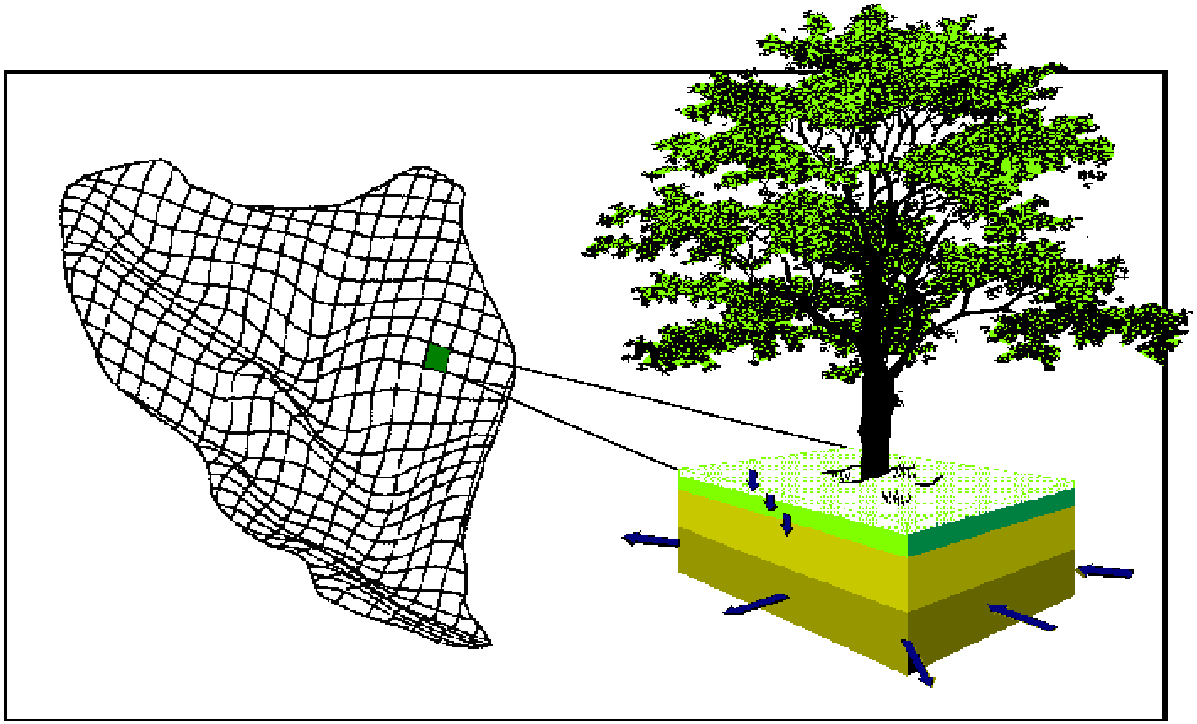
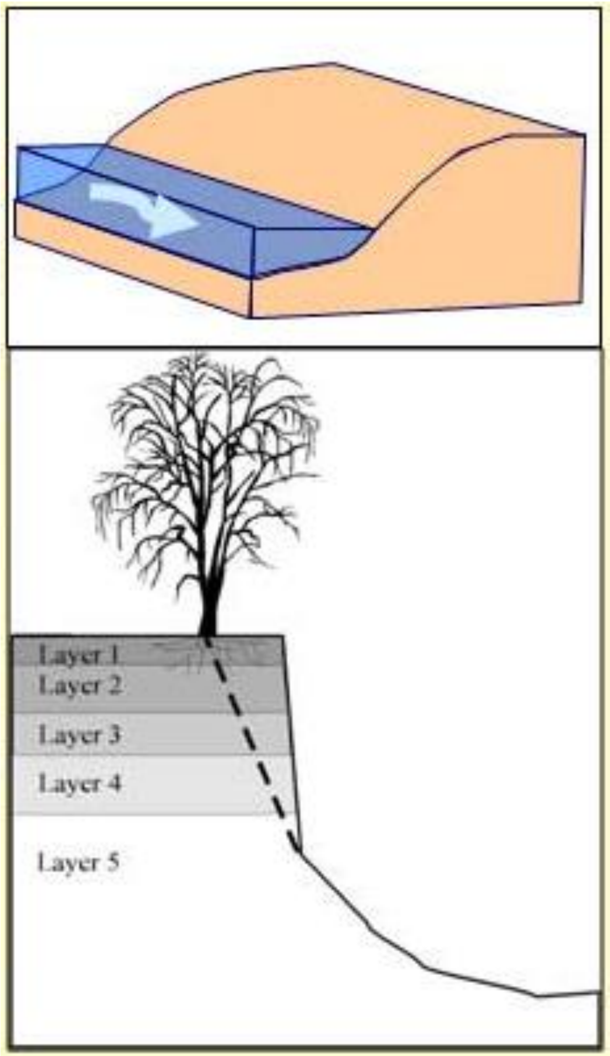


Fig. 2.1. Model representation of a watershed. DEM data are used to model topographic controls on absorbed solar radiation, precipitation, air temperature, and downslope water movement. Grid cells are allowed to exchange water with their adjacent neighbors, resulting in a three-dimensional redistribution of surface and subsurface water across the landscape (adapted from Wigmosta et al., 1994).

Bank Stability and Toe Erosion Model



Source: http://ars.usda.gov/Research/docs.htm?docid=5045

Developed in the 1990s at USDA-ARS National Sedimentation Laboratory (Simon et al., 1999)

Based on Limit Equilibrium analysis

BSTEM: Hydraulic processes

Source: Simon et al., 2000

Critical shear stress:

- Based on hydraulic stress required to mobilize sediment particles
- Combines physical relationships and empirical methods

Excess shear stress is that available to cause erosion:

$$\tau_e = \tau_o - \tau_c$$

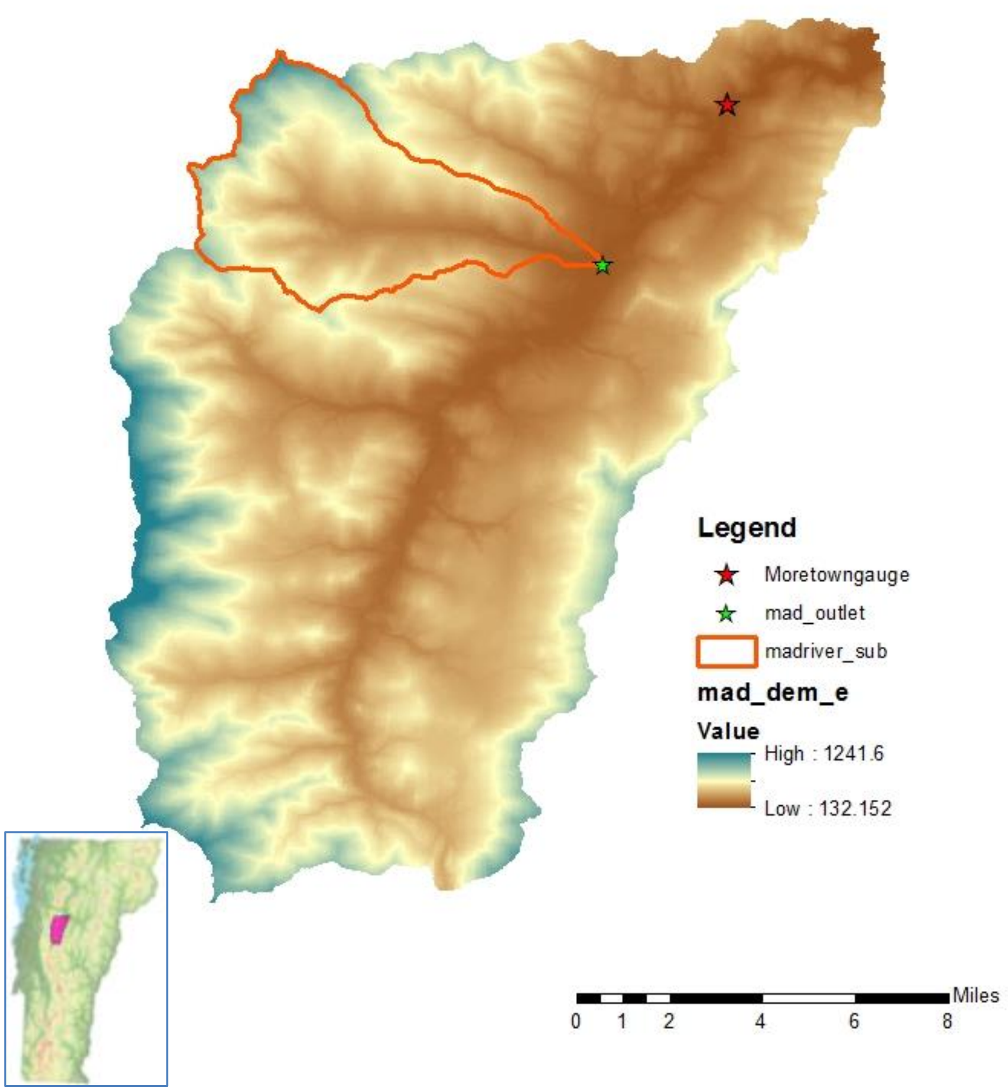
Model Application to Shepherd Brook

Mad River Watershed
(144 mi^2)

Shepherd Brook sub-basin
(17.2 mi^2)

Sub-watershed dimensions

- 30 X 30 m resolution
- 10 X 10 m for sediment routing
- Cols, rows = 364, 318

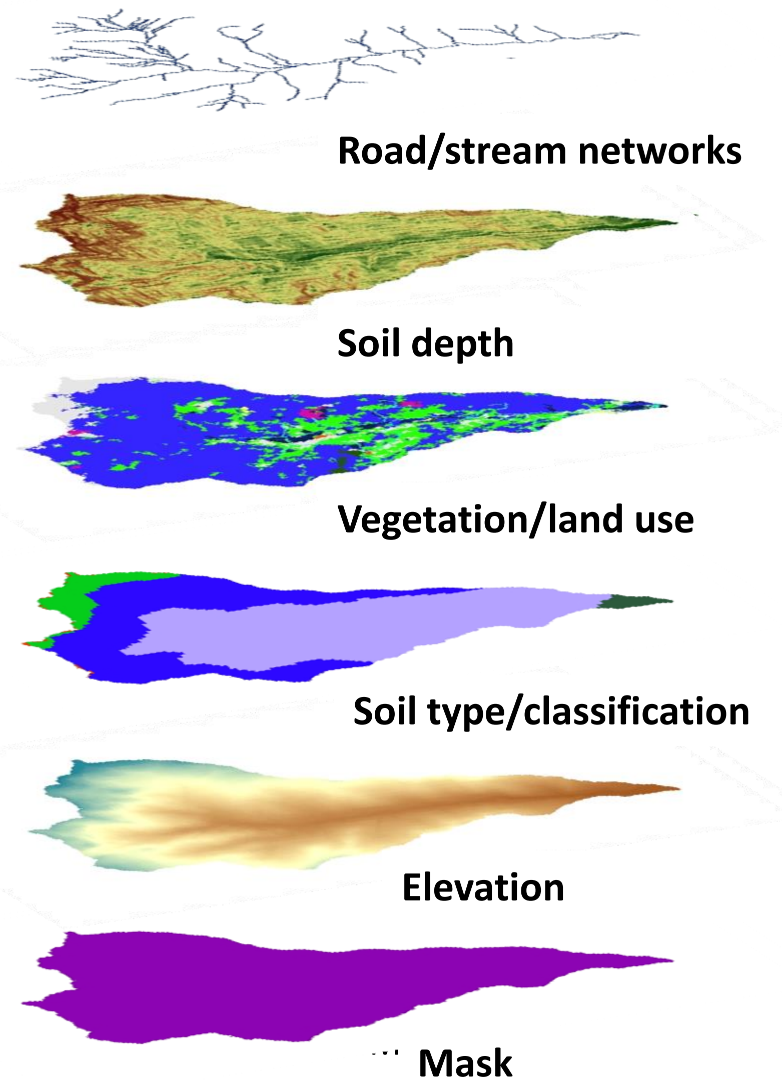


Model Application to Shepherd Brook

Field-derived Inputs

- Meteorological data :
  temperature, RH, precipitation, shortwave/long-wave radiation, wind speed
- Stream data:
  channel gradient, friction angle, initial bank geometry, roughness of channel bed
- Soil/vegetation parameters:
  cohesion, saturated unit weight/bulk density, hydraulic conductivity, porosity, grain size distribution, roughness coefficient, rooting depths/soil layers, LAI

GIS-derived Inputs (for sub-basin)



Model Application: Data for parameterization

- **Soil test pits:**
  - information about soil layering
  - composition of soils
  - grain size distribution

- **Infiltration measurements:**
  - range for saturated hydraulic conductivity

- **Jet testing/bore hole shear testing:**
  - cohesion of bank materials
  - erodibility

- **Piezometers and stage sensors:**
  - water table elevation with respect to stream flow height

Lareau Farms soil test pit, summer 2013.

Source: http://www.ars.usda.gov. Jet testing and bore hole shear testing for bank parameters.

Model Application: Data for calibration/validation

- Discharge from Moretown USGS gauge
- Turbidity measurements
- Snow pack depths
- LIDAR bank scans
- Isotope data
- Other modeling efforts