Climate Variability Impact Studies in the Rathdrum Prairie region

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July 19, 2010

Climate Variability Impact

Motivation:

Inclusion of climate variability for long-term water management and planning

Need:

- Climate models predict precipitation and temperature changes for the Rathdrum Prairie region.
- It directly impacts hydrologic cycle in terms of how much water reaches the surface, evaporates or transpires, percolates to the aquifer, gets stored as snow or ice, runs off as surface and baseflow.

Scope of the work

- Review of literature to understand changes in regional temperature and precipitation can impact the hydrology and water supply in the Rathdrum Prairie
- Identify atleast three potential climate change scenarios from a suite of climate models and provide the rationale behind the choice of climate data and model

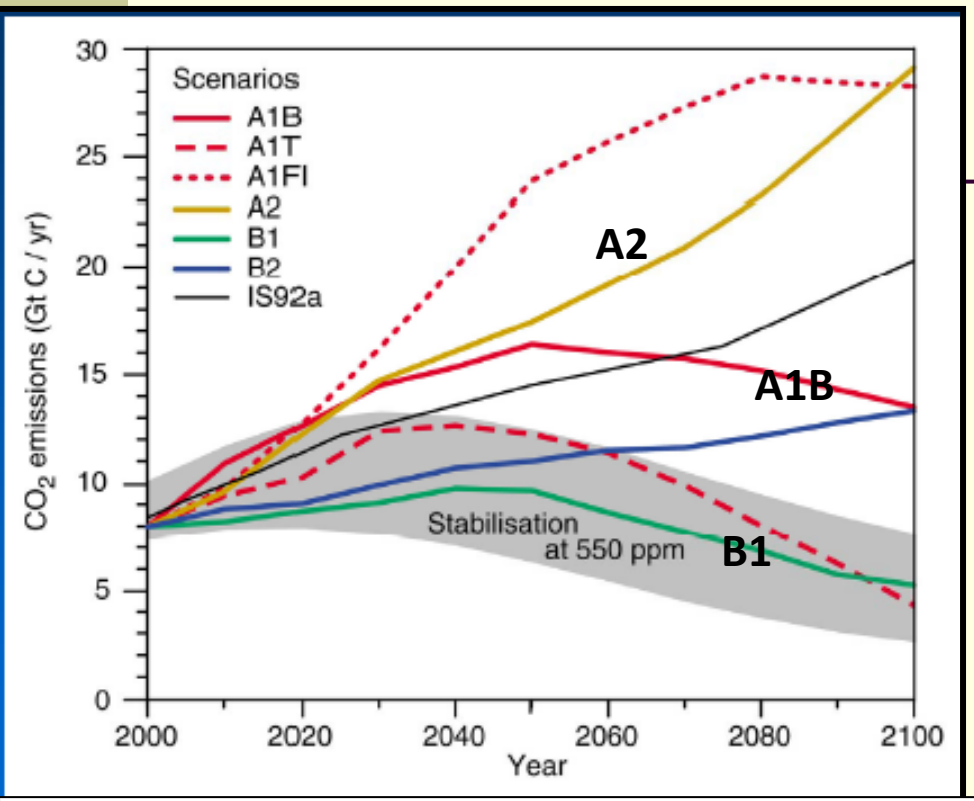
Scope of the work

- Using Soil Water Assessment Tool (SWAT) to describe and quantify the possible impact of climate change on the water supply –for Rathdrum Prairie- amount of rainfall, timing and magnitude of snowmelt, interannual variability assessment in the streamflow and other water balance components including evapotranspiration, soil moisture and recharge.

Intergovernmental Panel on Climate Change (IPCC)

- The leading body for the assessment of climate change
- Established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO)
- Provide the world with a clear scientific view on the current state of climate change and its potential environmental and socio-economic consequences (*www.**ipcc**.ch/*).

IPCC Special Report on Emission Scenarios (SRES)



IPCC, 2007

http://www.ipcc-data.org/guidelines/TGICA_guidance_sdciaa_v2_final.pdf

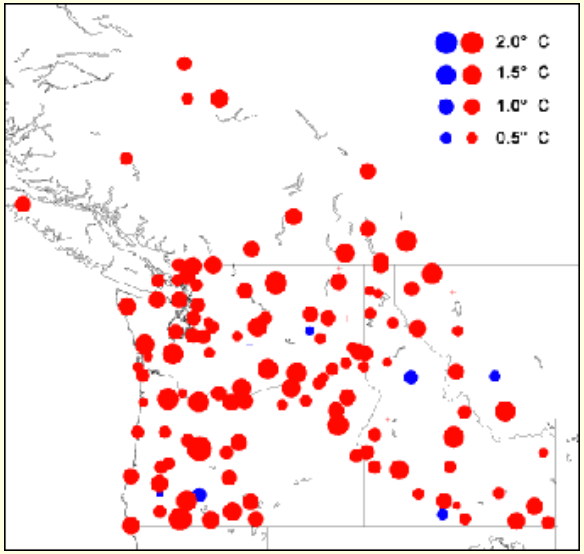
Table 2. The six SRES illustrative scenarios and the stabilisation scenarios (parts per million CO_2) they most resemble (based on Swart *et al.*, 2002).

SRES illustrative scenario	Description of emissions	Surrogate stabilisation scenario
A1FI	High end of SRES range	Does not stabilise
A1B	Intermediate case	750 ppm
A1T	Intermediate/low case	650 ppm
A2	High case	Does not stabilise
B1	Low end of SRES range	550 ppm
B2	Intermediate/low case	650 ppm

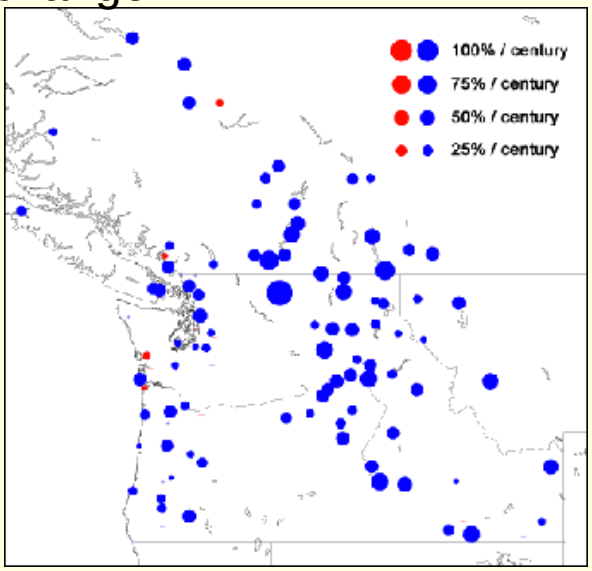
Background: PNW

Source: Climate Impacts Group, UW; http://cses.washington.edu/cig/pnwc/pnwc.shtml

20th century trends in average annual temperature (1920-2000). Increases (decreases) are indicated with red (blue) dots. The size of the dot corresponds to the magnitude of change.



20th century trends in average annual precipitation (1920-2000). Increases (decreases) are indicated with red (blue) dots. The size of the dot corresponds to the magnitude of change.



Warming is expected to continue as a result of climate change, with a likely warming rate of about 0.5°F (0.27°C)/decade. While future changes in precipitation are less certain, overall, precipitation is projected to increase in the PNW.

Literature Summary

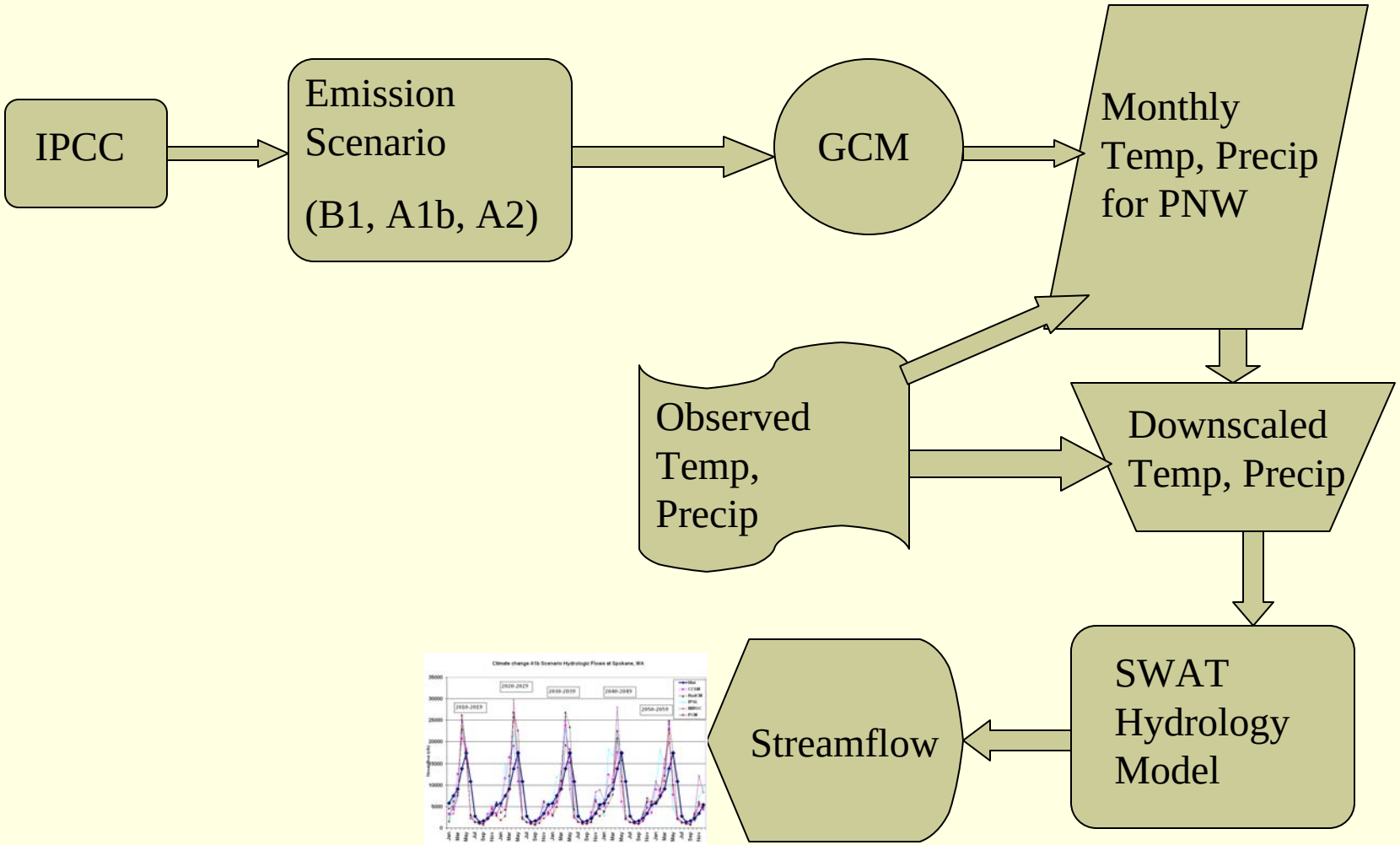
- Most GCMs reproduce key features (Mote and Salathe, 2009)
  - observed PNW climate including the sharp contrast between wet winters and dry summers
  - the 20th century warming of about 0.8°C
  - the mean atmospheric circulation over the North Pacific.
  - Hence, we can expect to have confidence in their projected changes in future climate.
- For the SRES scenarios examined here, all models produce annual mean warming of at least 0.1°C per decade with some prospect of stabilizing climate by 2100 in the B1 scenario.
- For the A1B scenario the warming by the 2080s could be as high as 5.7°C (9.7°F) according to one model.

Choice of Global Climate Models

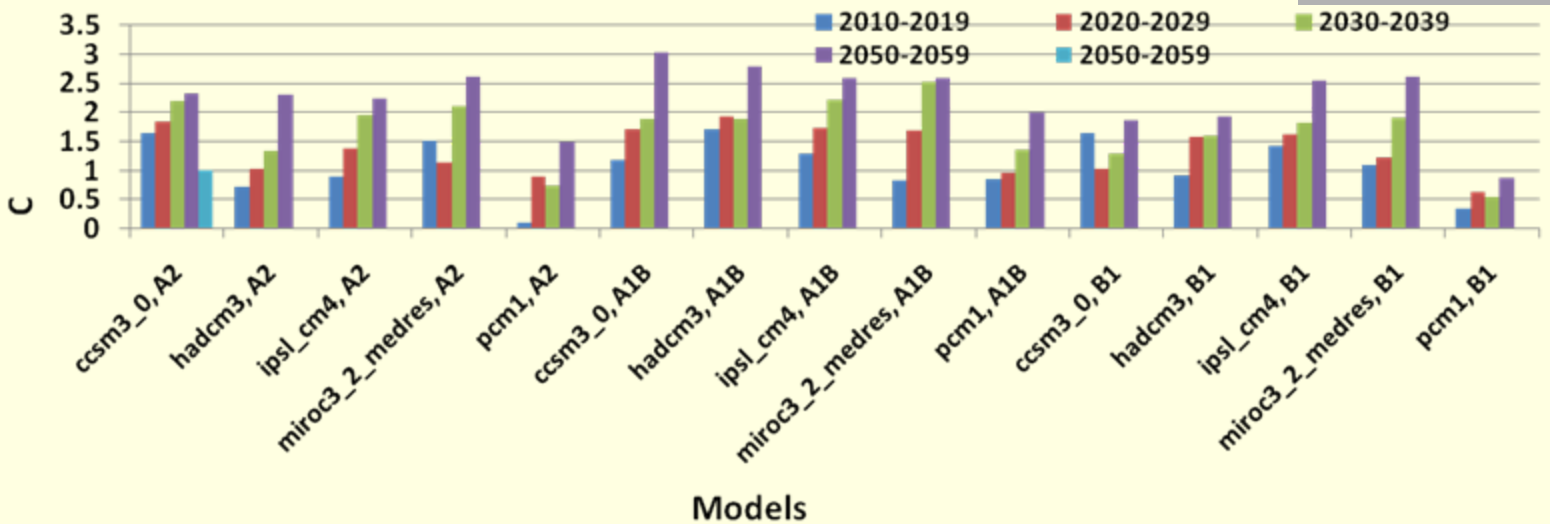
- CCSM3 (National Center for Atmospheric Research, USA)
- HADCM3 (Hadley Centre for Climate Prediction and Research/ Met Office, UK)
- IPSL-CM4 (Institut Pierre Simon Laplace, France)
- MIROC3.2 (medres)(Center for Climate System Research, Univ. of Tokyo, National Institute for Environmental Studies, and Frontier Research Center for Global Change, Japan)
- PCM (National Center for Atmospheric Research, USA)

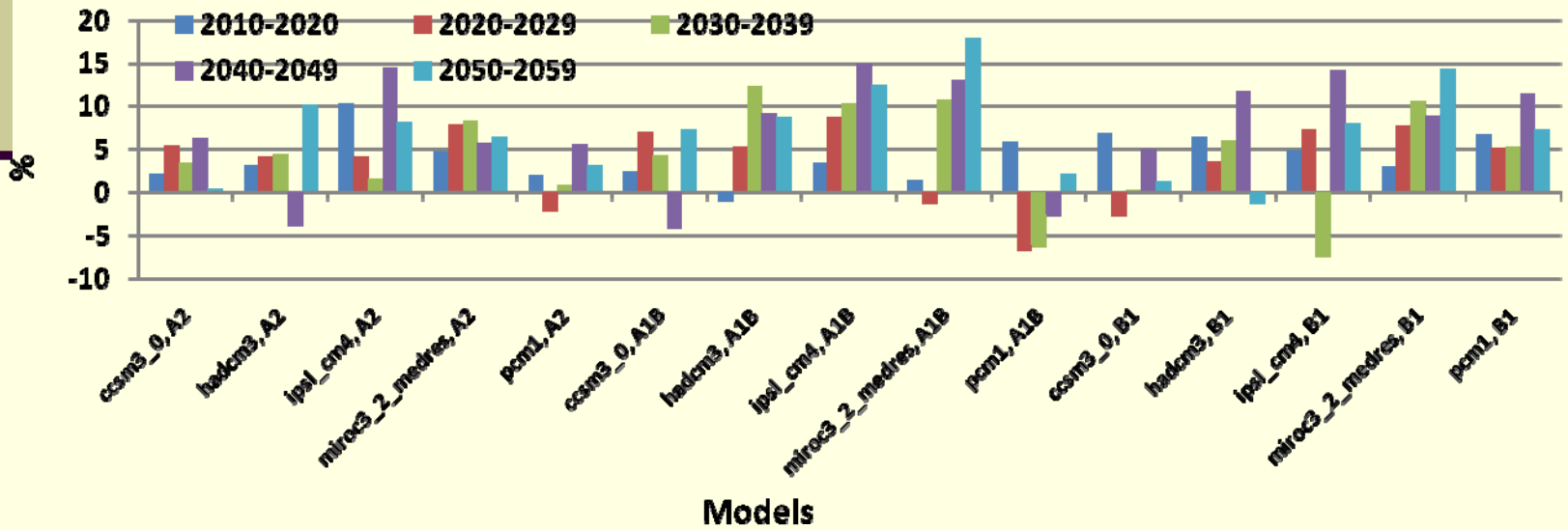
Climate Model Downscaling Approach:

Steps to obtain precipitation and temperature data from global climate models to drive the hydrology model at the local scale



Downscaled GCM Precipitation and Temperature for Spokane Valley-Rathdrum Prairie

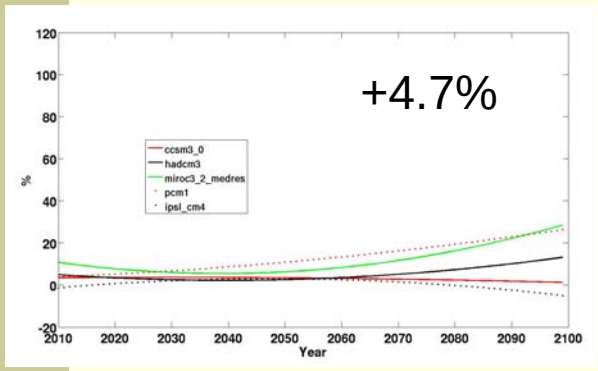


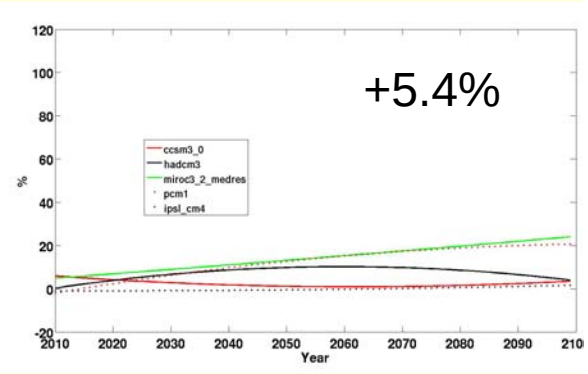


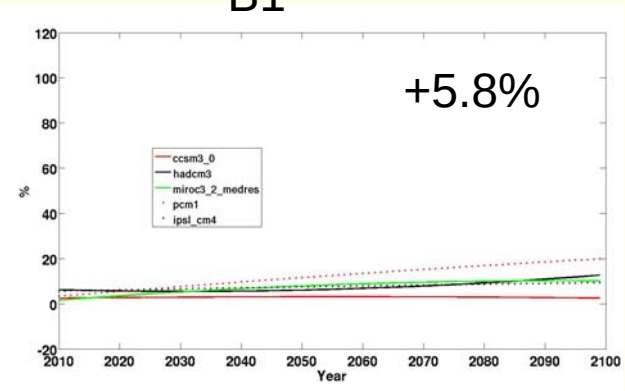
Downscaled GCM Precipitation and Temperature for Spokane Valley-Rathdrum Prairie

A2 A1b B1

P







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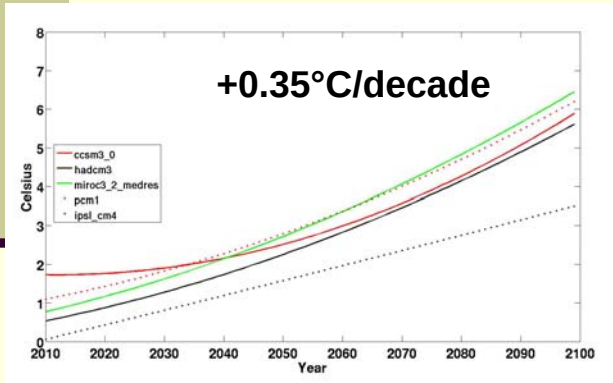
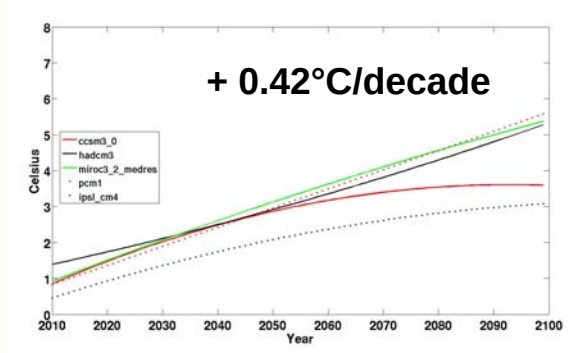
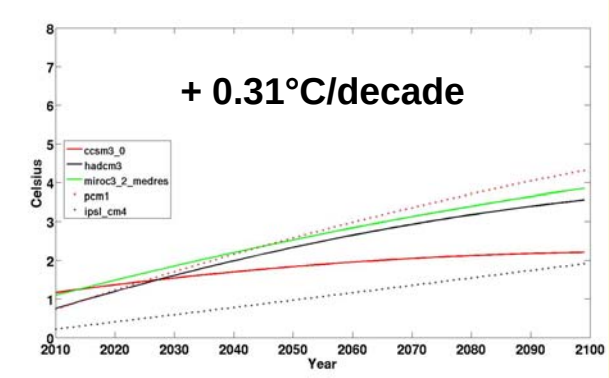
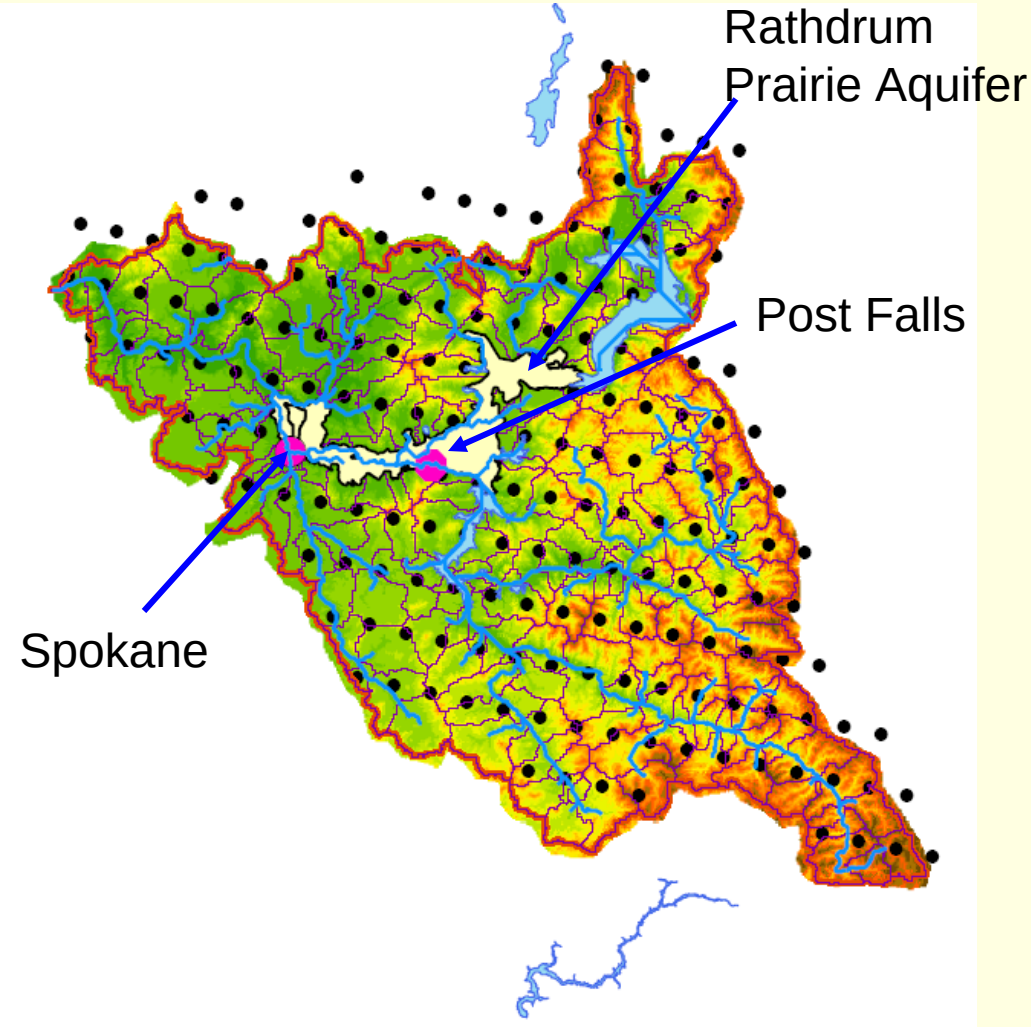






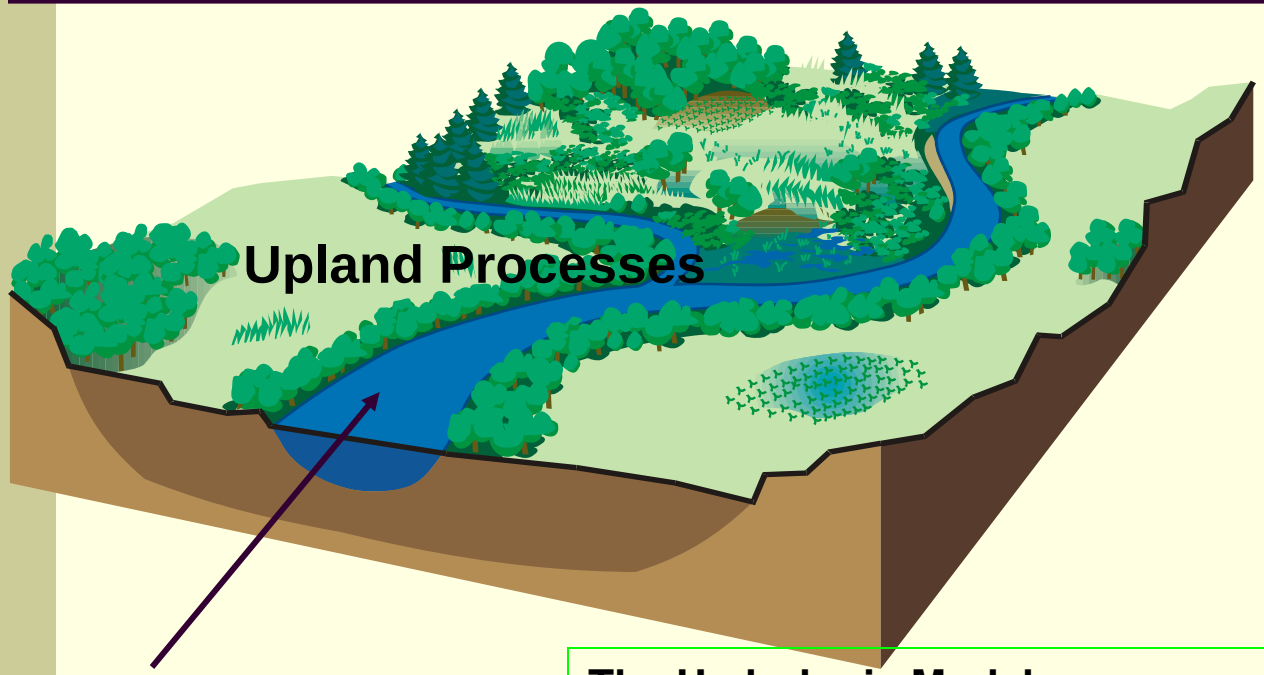
Spokane River Watershed



226 sub-basins

144 Weather points

SWAT Watershed System



Channel/Flood Plain Processes

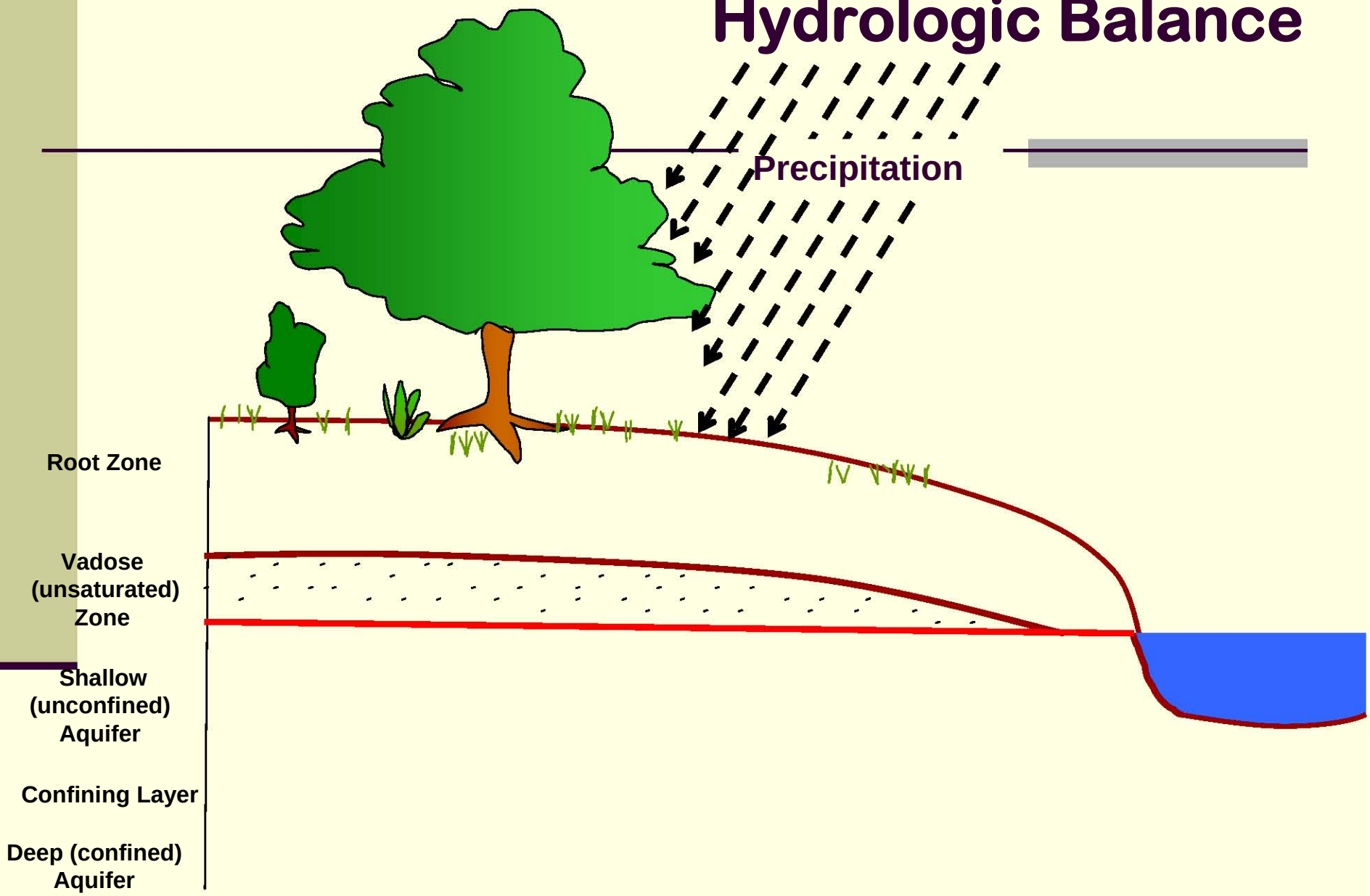
The Hydrologic Model

SWAT is a continuous simulation macroscale hydrologic model that operates on a daily time step and is designed to predict the impacts of land management on the water yield of large ungaged watersheds. The input requirements of the model are data describing a basin's weather, soil properties, topography, vegetation, and land management practices.

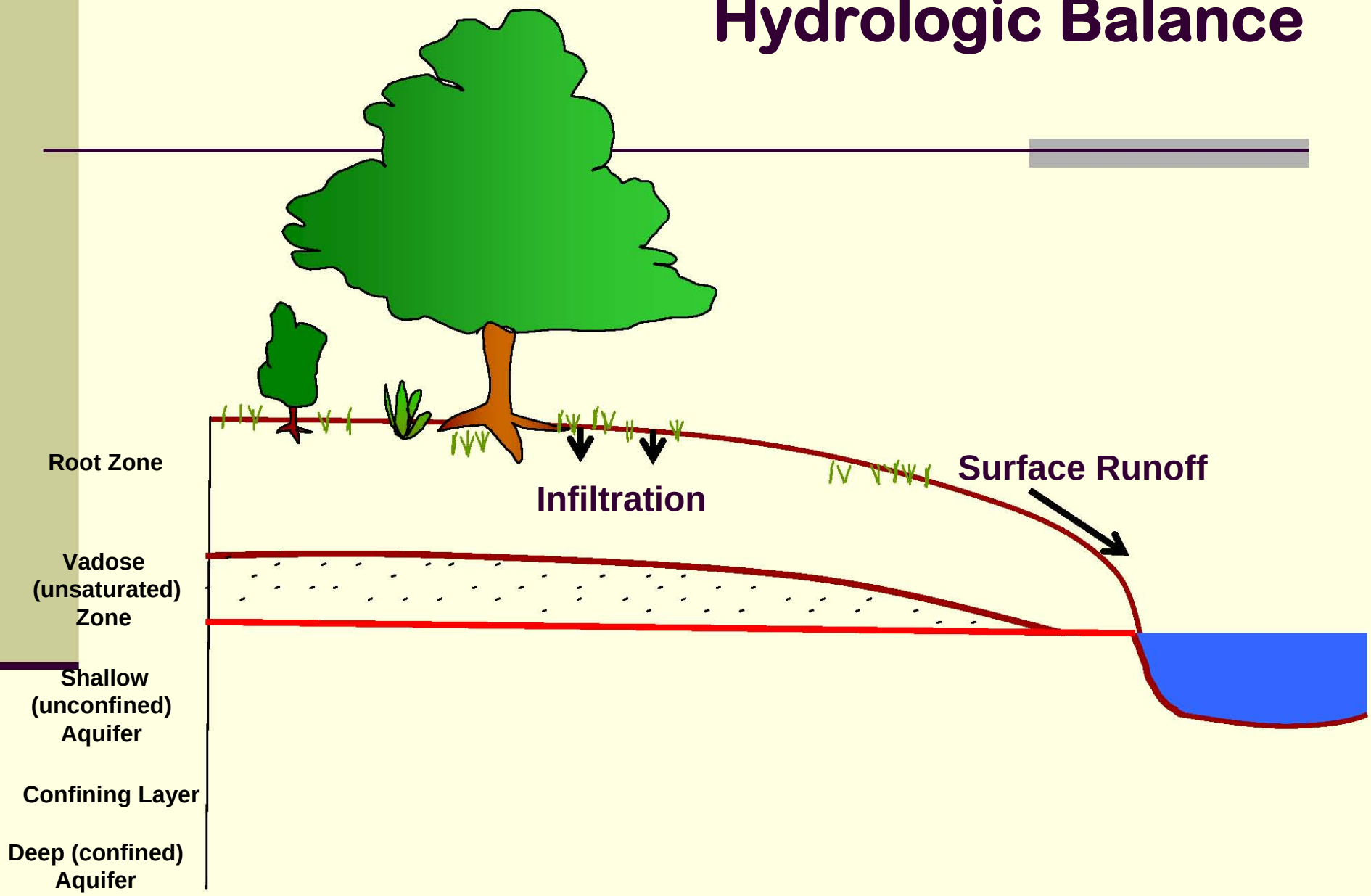
Upland Processes

- Weather
- Hydrology
- Sedimentation
- Plant Growth
- Nutrient Cycling
- Pesticide Dynamics
- Management
- Bacteria

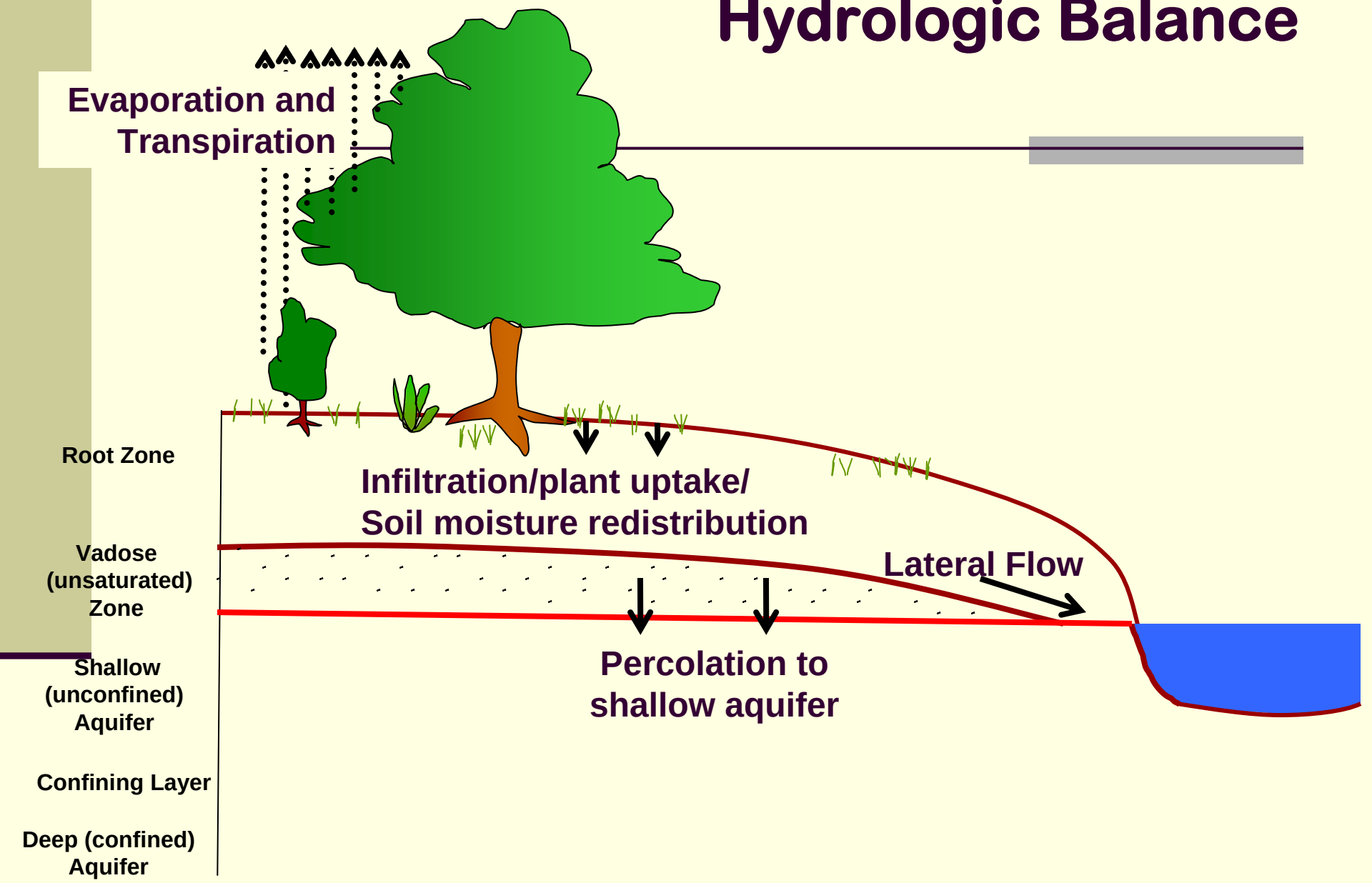
Hydrologic Balance



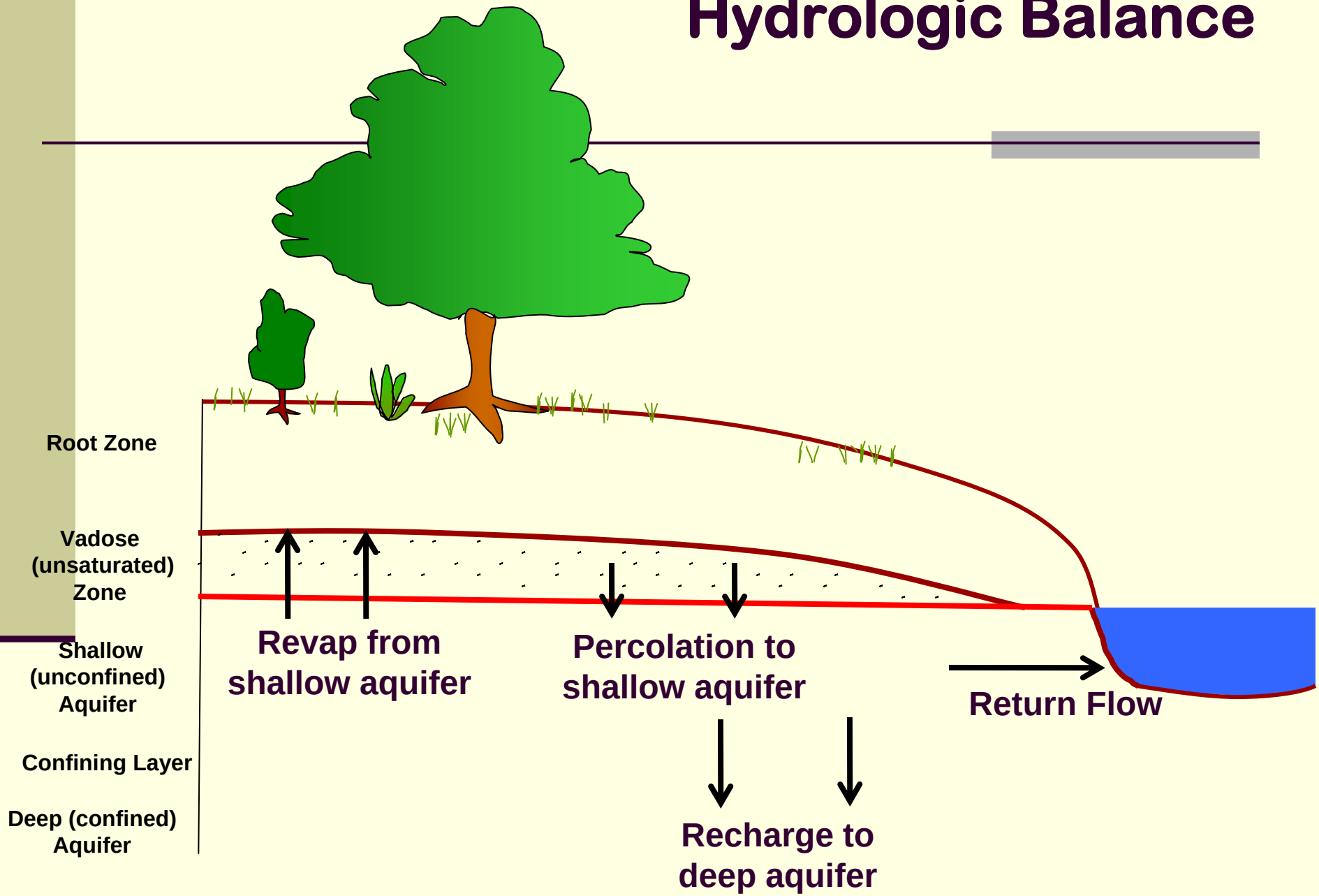
Hydrologic Balance



Hydrologic Balance



Hydrologic Balance



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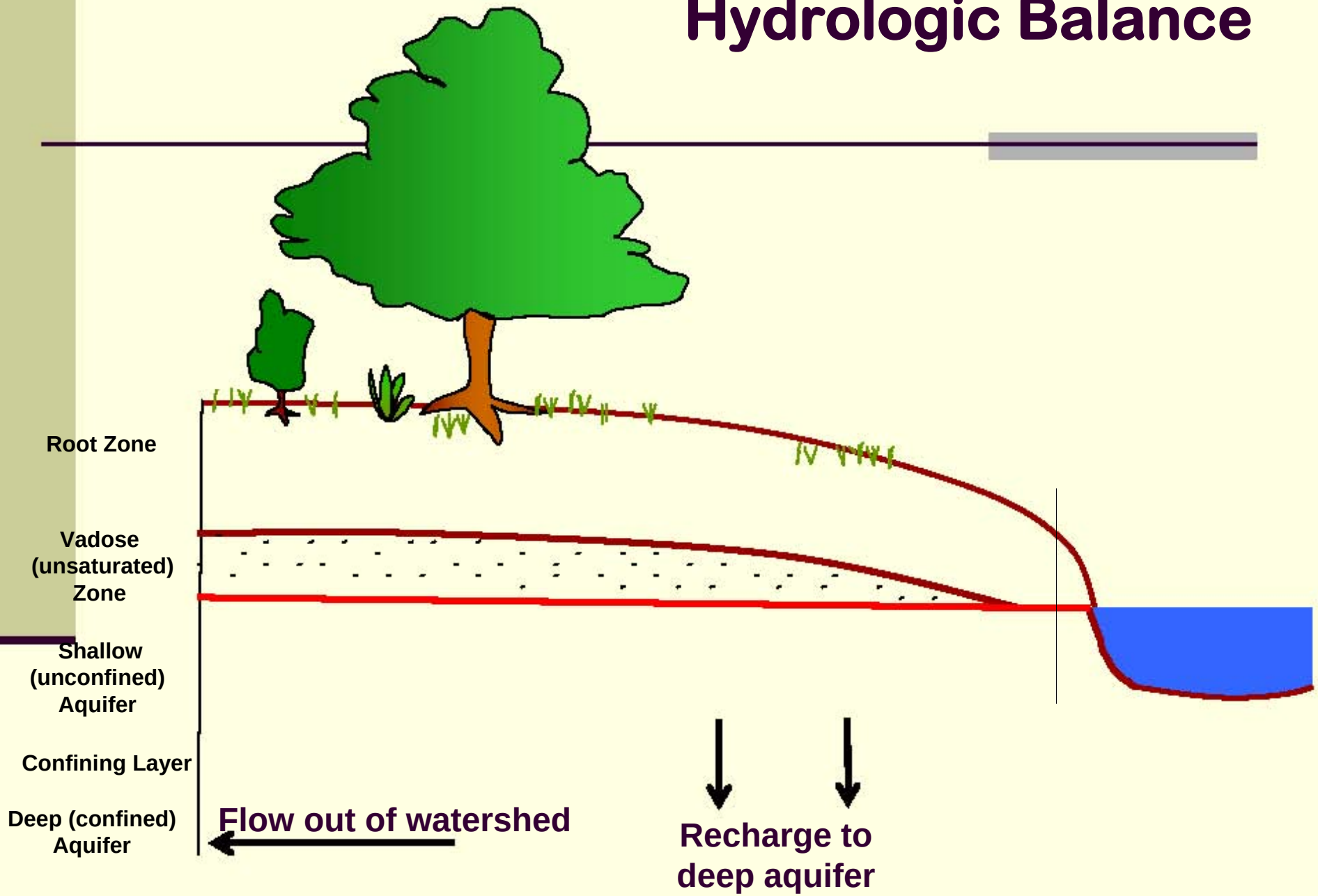
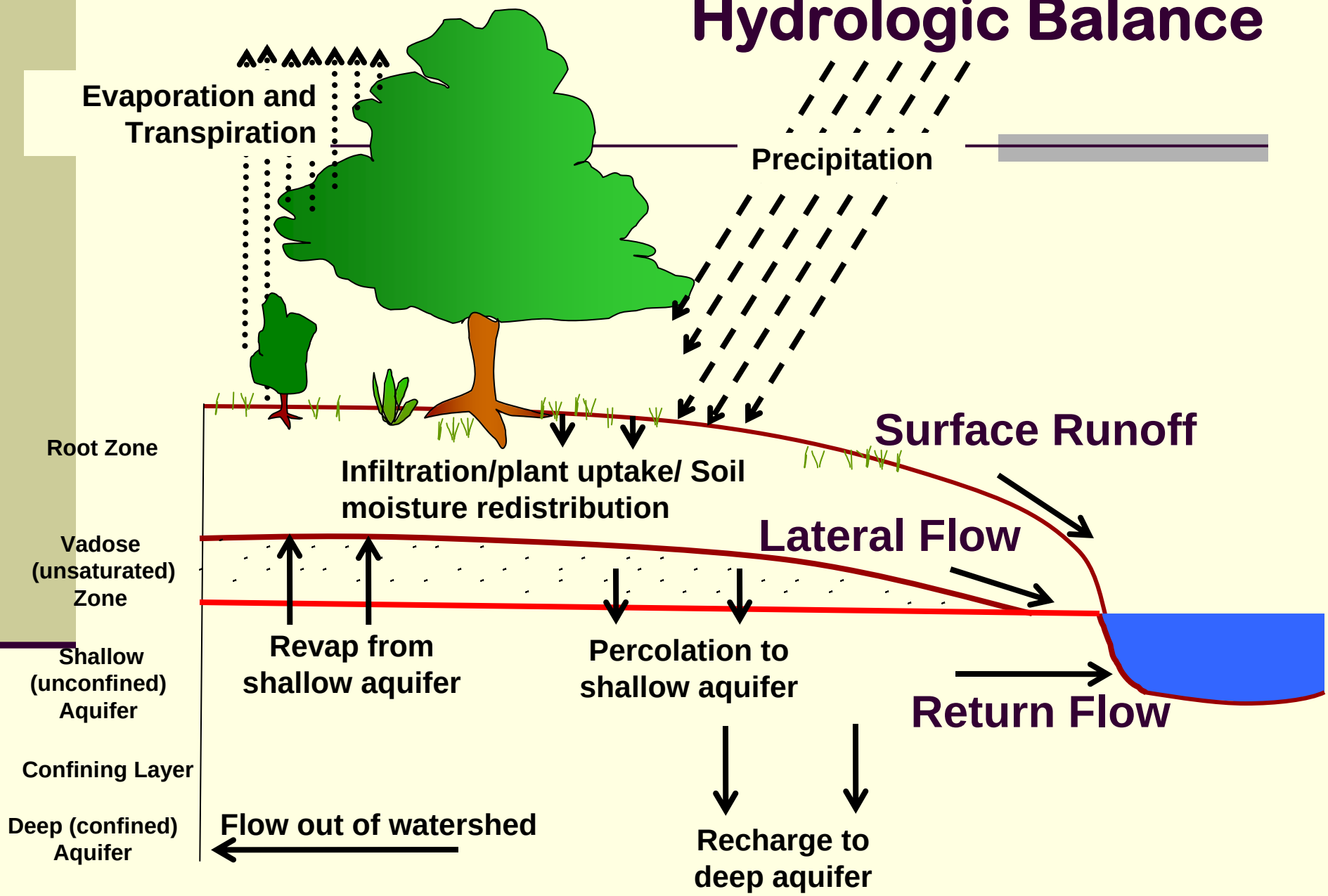
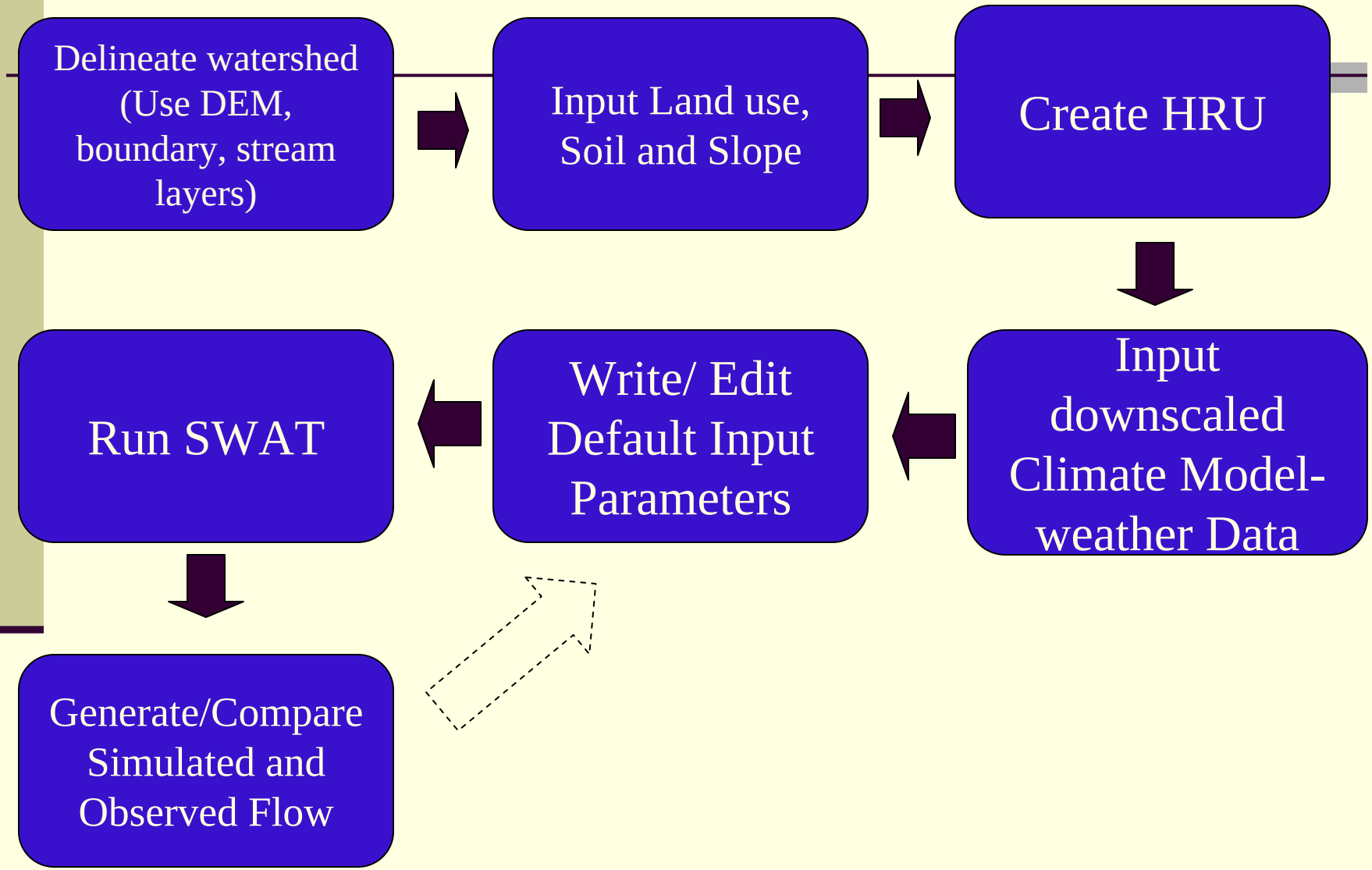


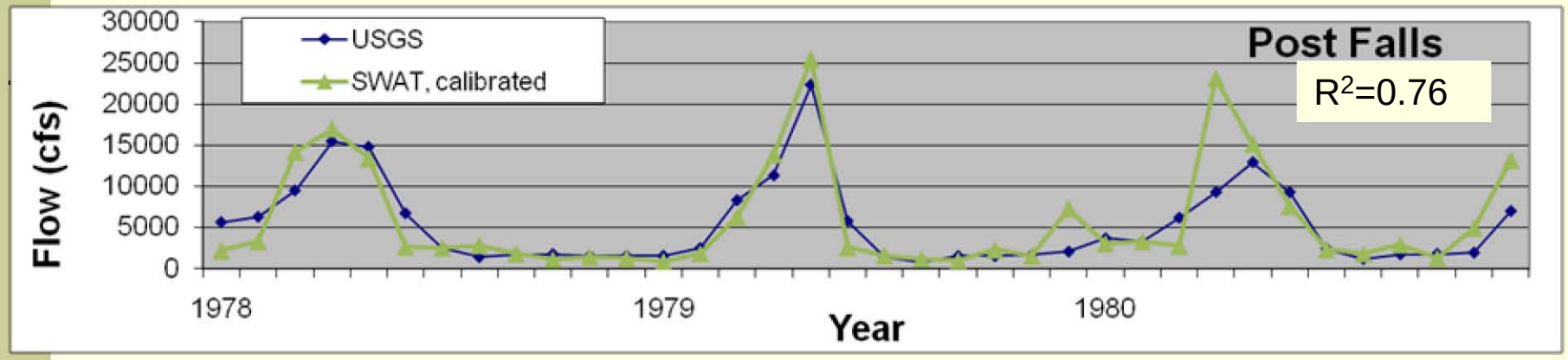
Hydrologic Balance

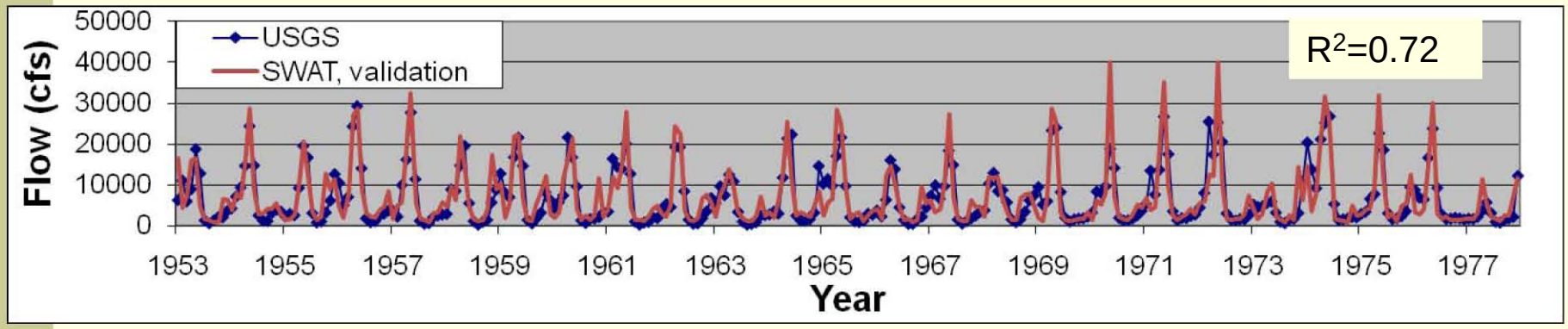


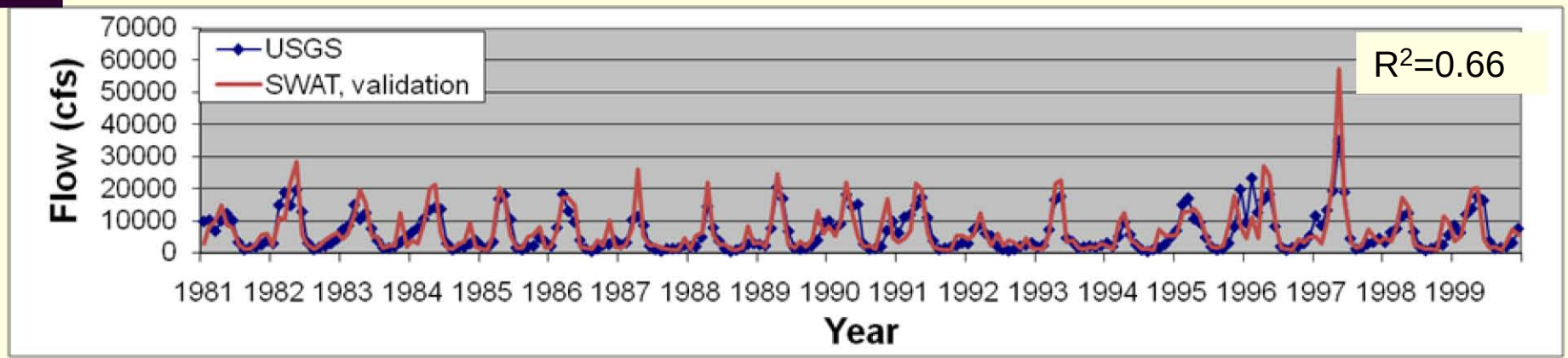
SWAT Model Setup SWAT Setup



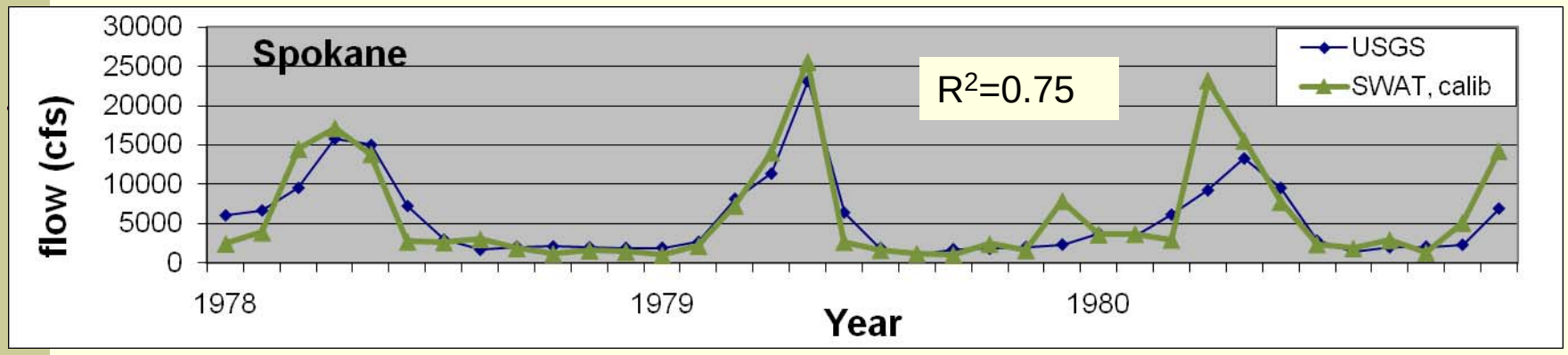
Sequential Uncertainty Fitting (Sufi2) Calibration/Validation Result (Post Falls)

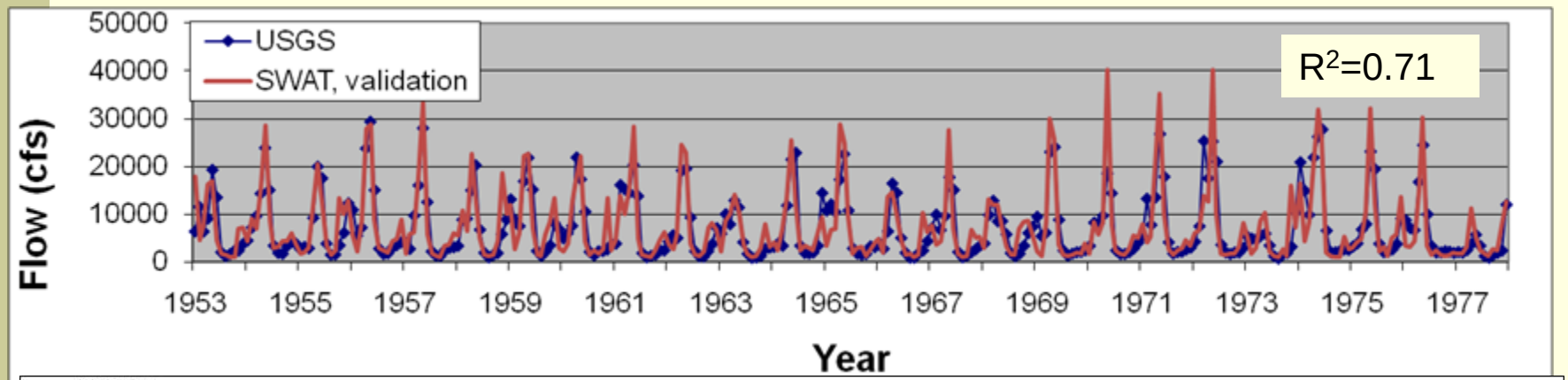


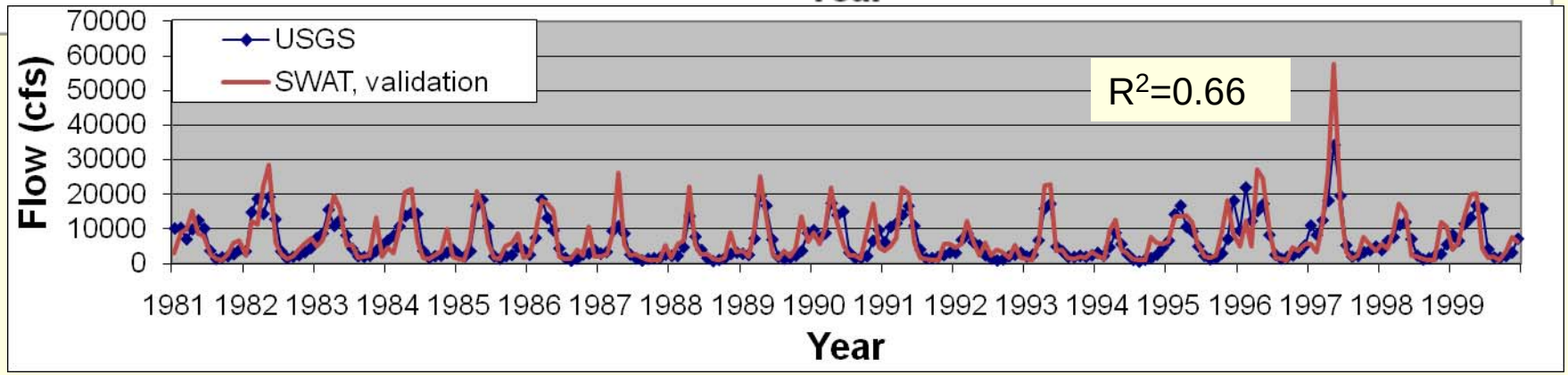




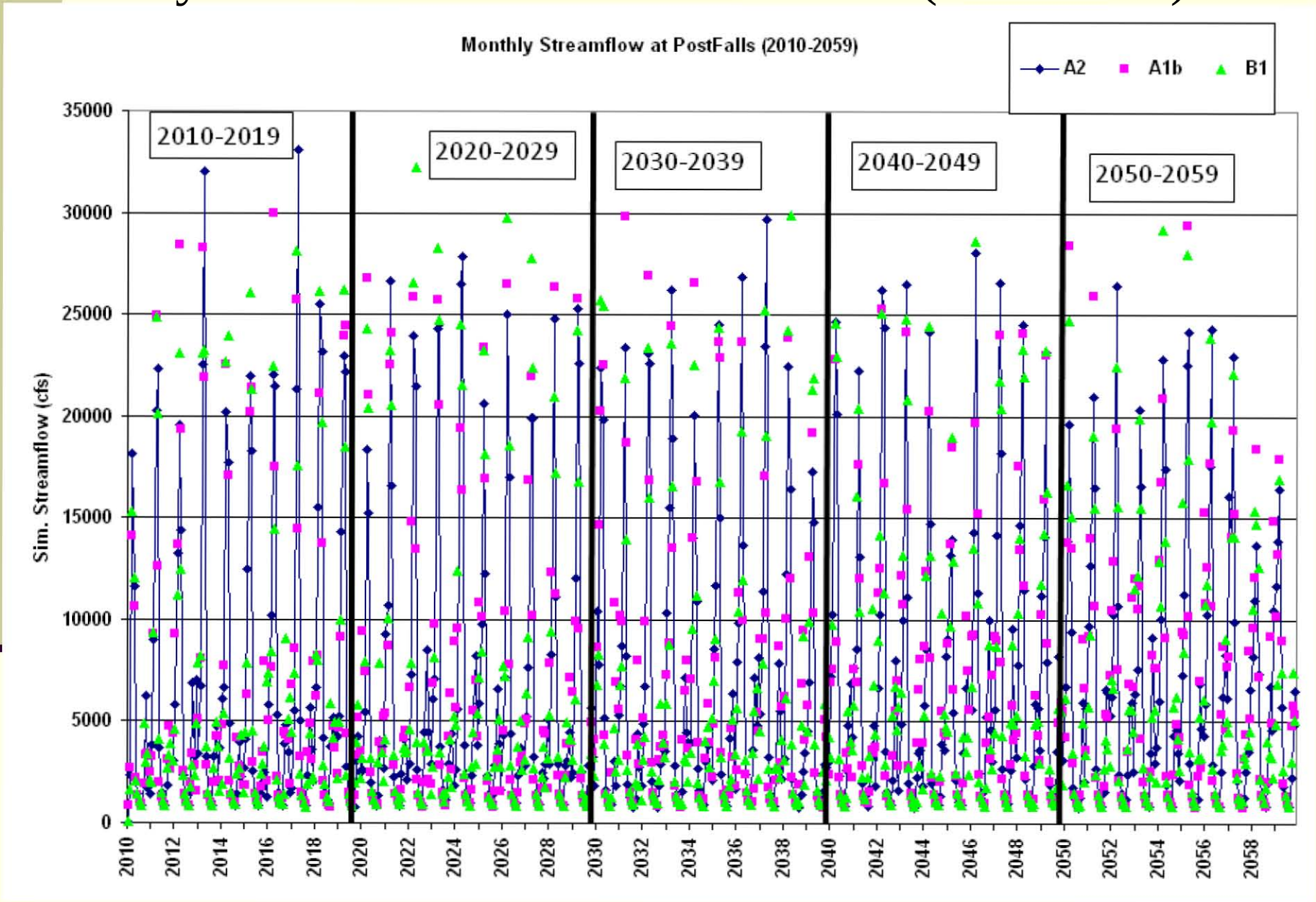
Sequential Uncertainty Fitting (Sufi2) Calibration/Validation Result (Spokane)



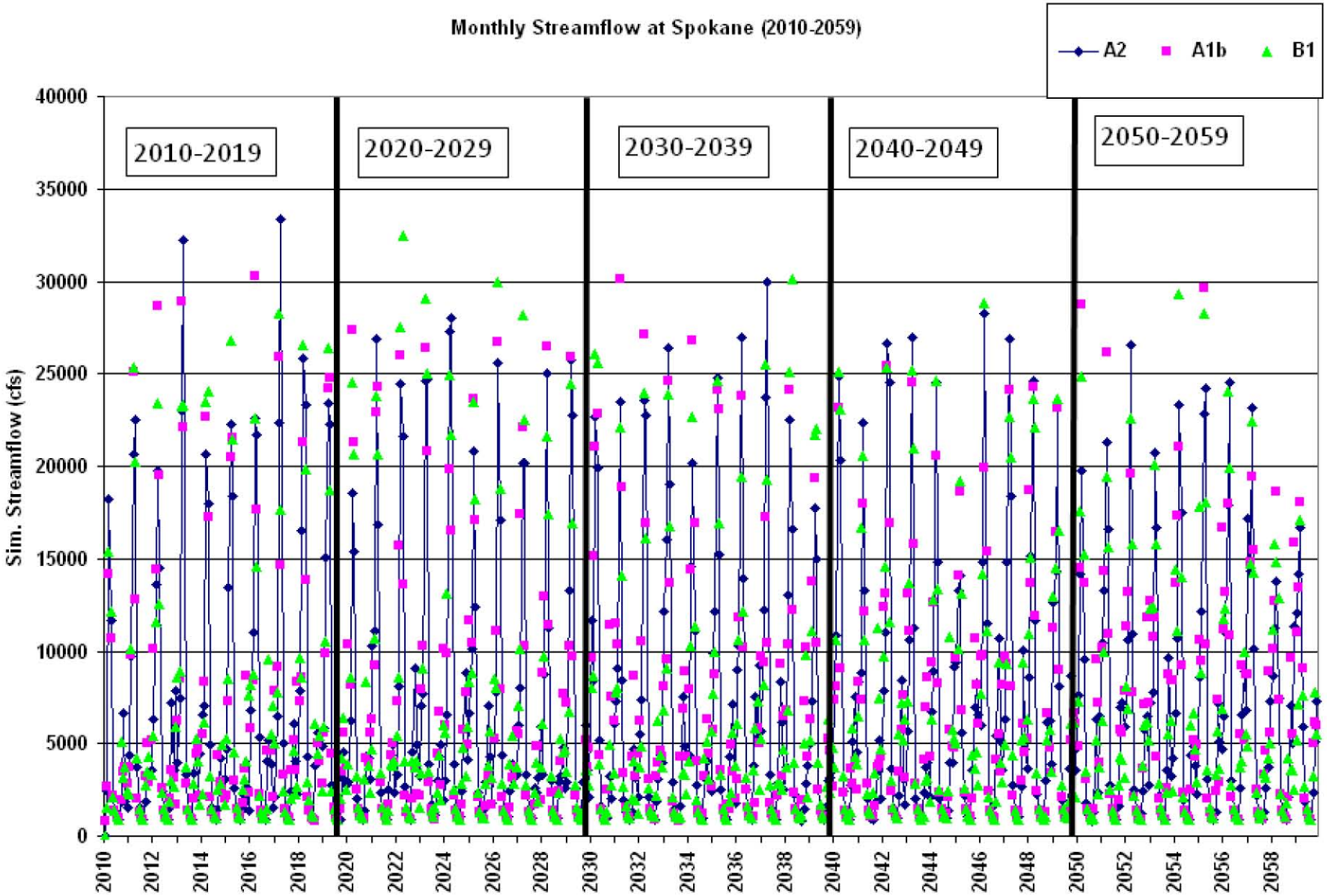




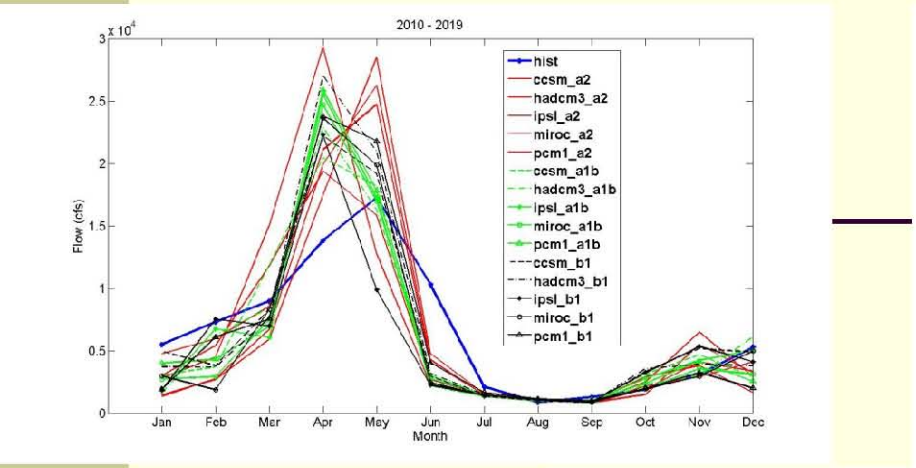
Monthly Natural Streamflow – Post Falls (2010-2059)

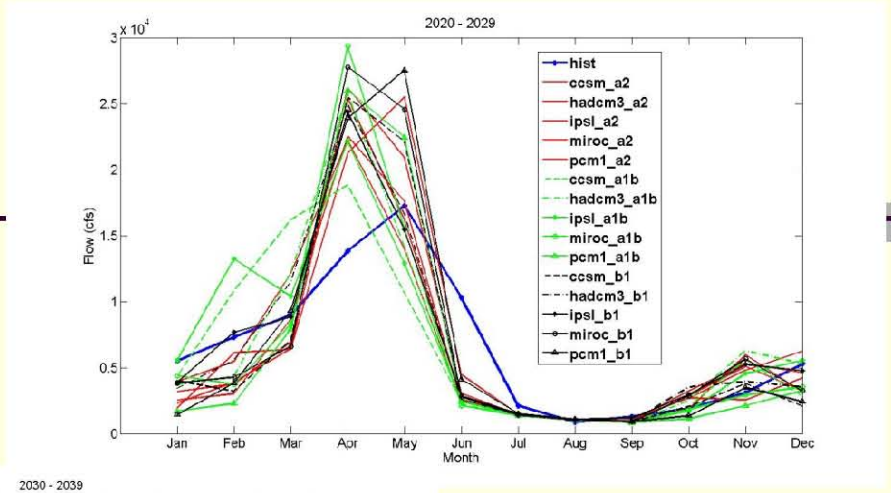


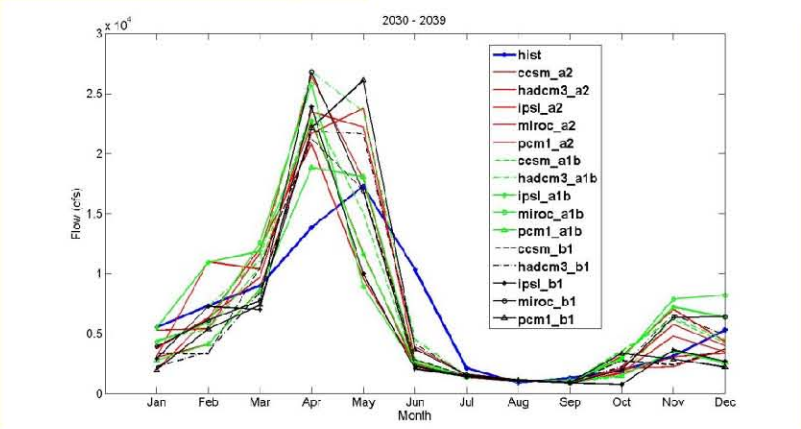
Monthly Natural Streamflow – Spokane (2010-2059)

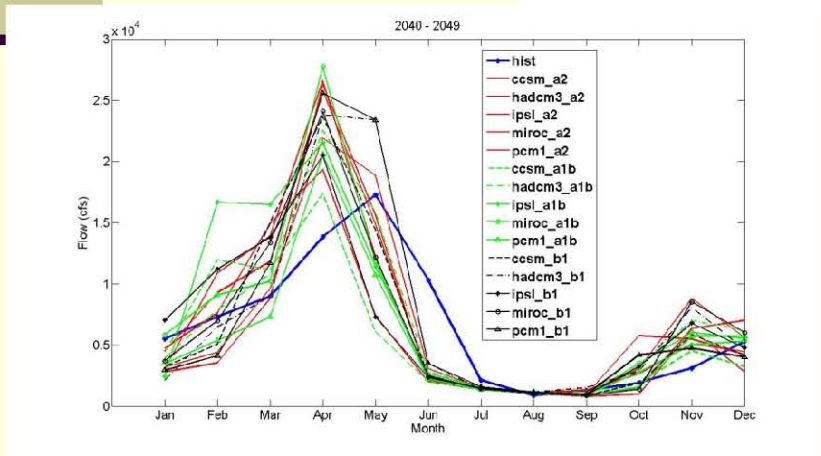


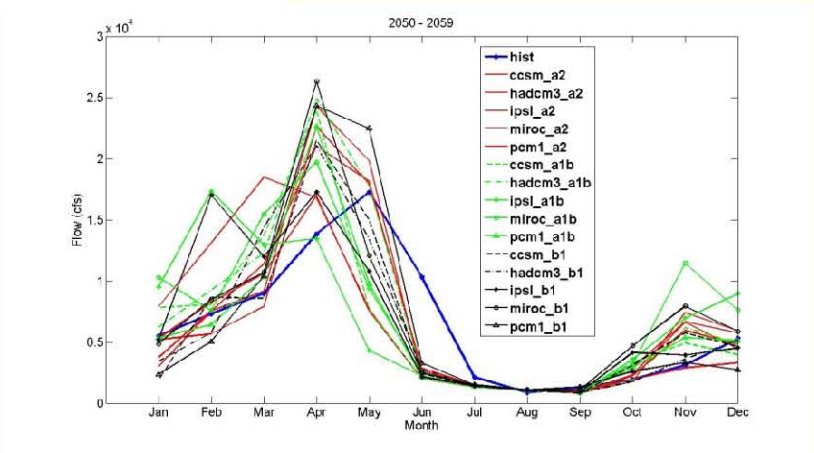
Seasonal streamflow-Post Falls



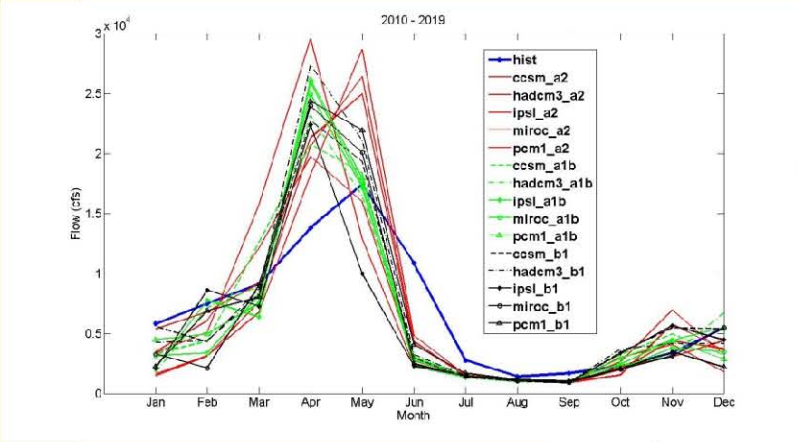


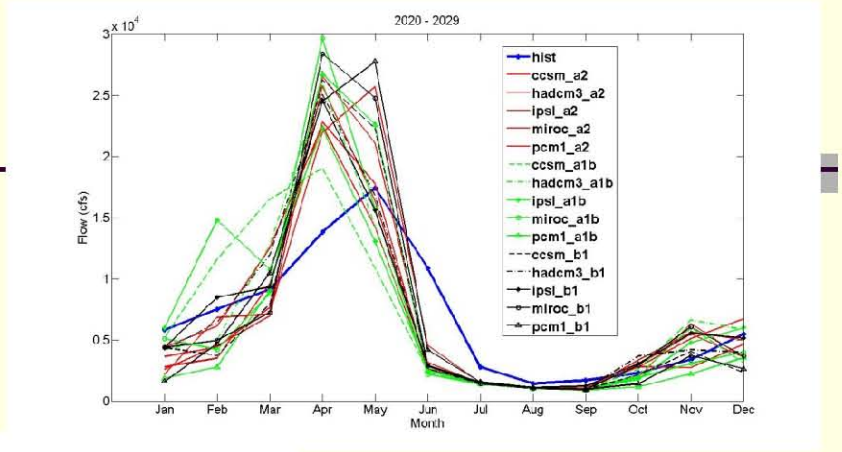


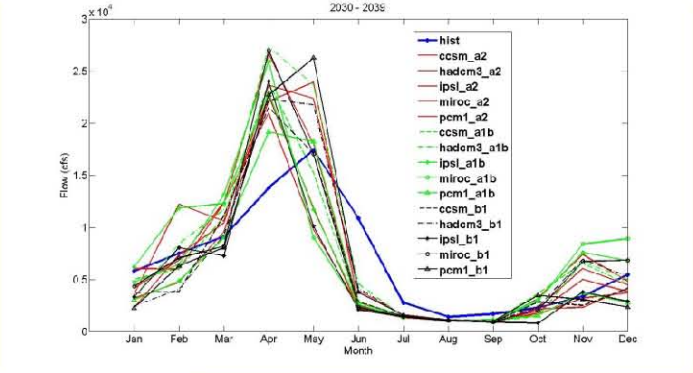


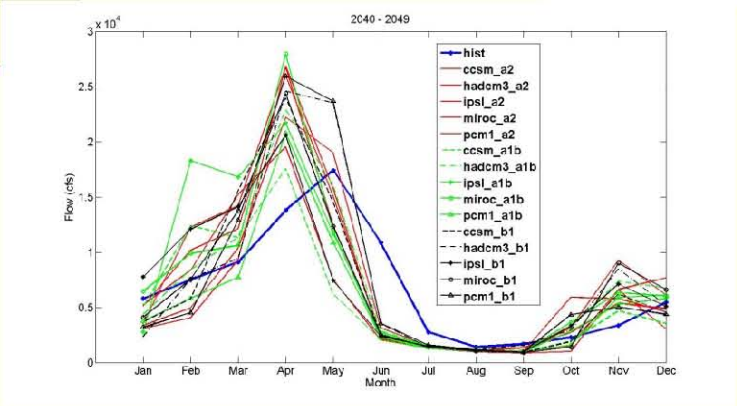


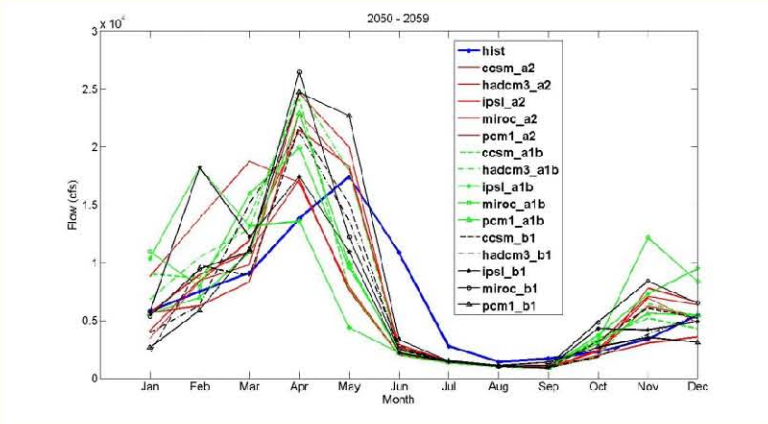
Seasonal streamflow - Spokane



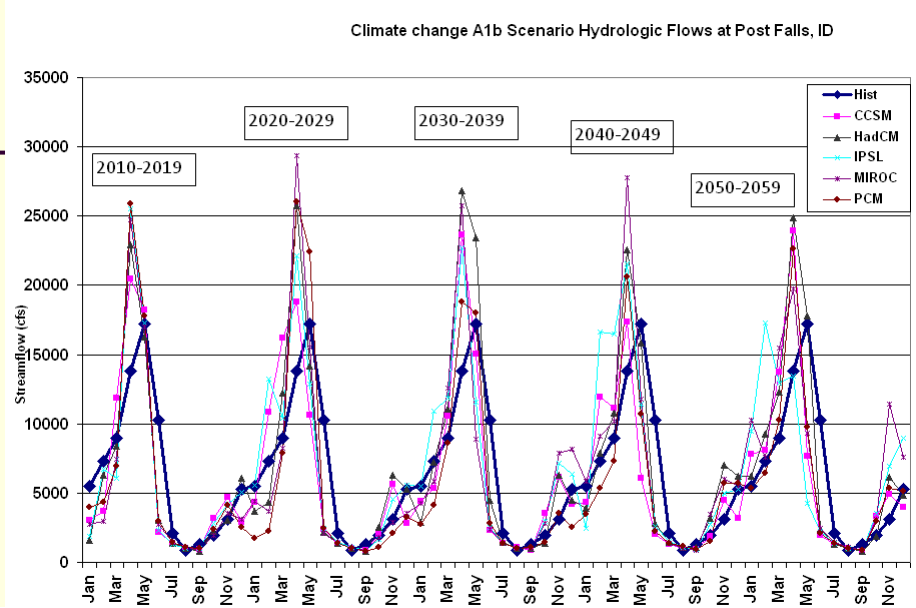


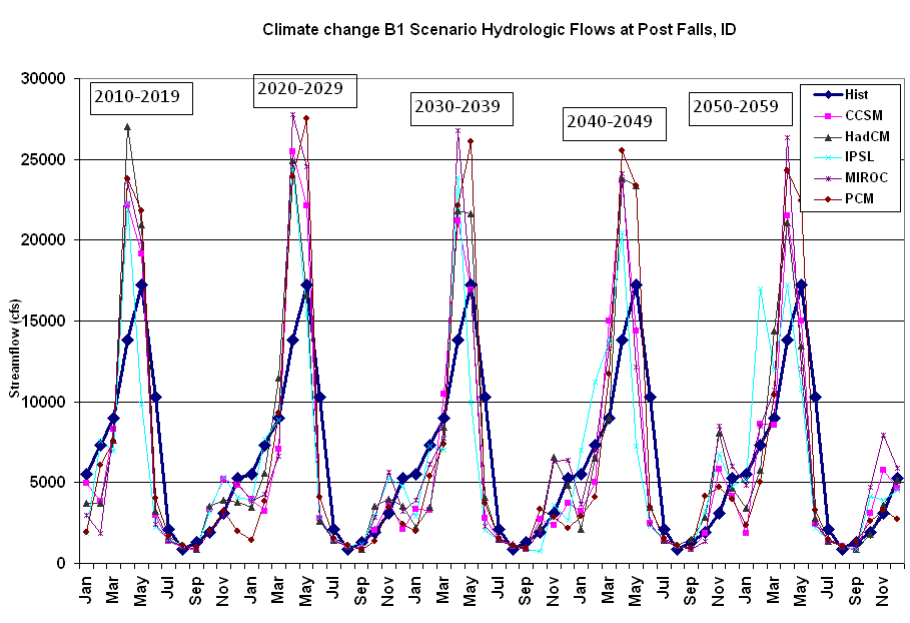


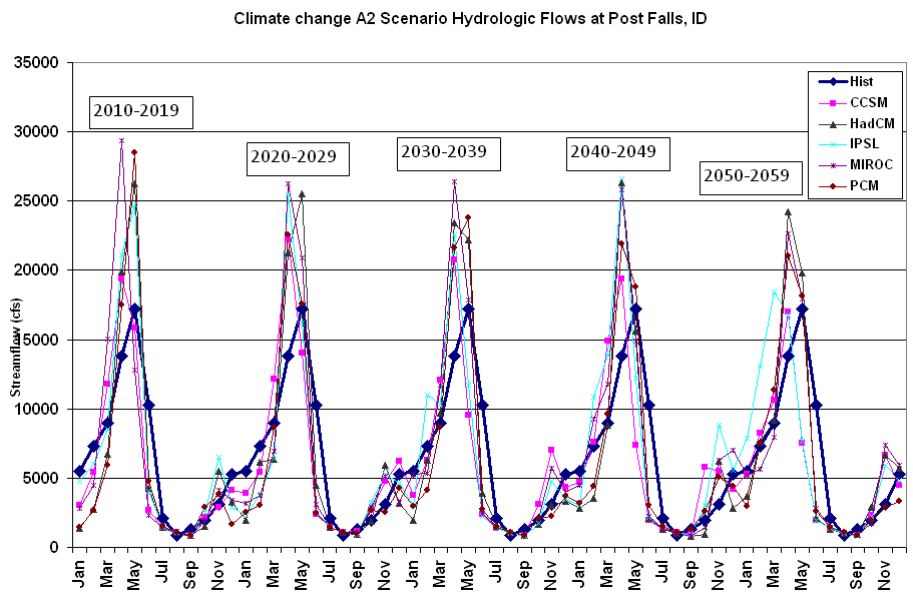




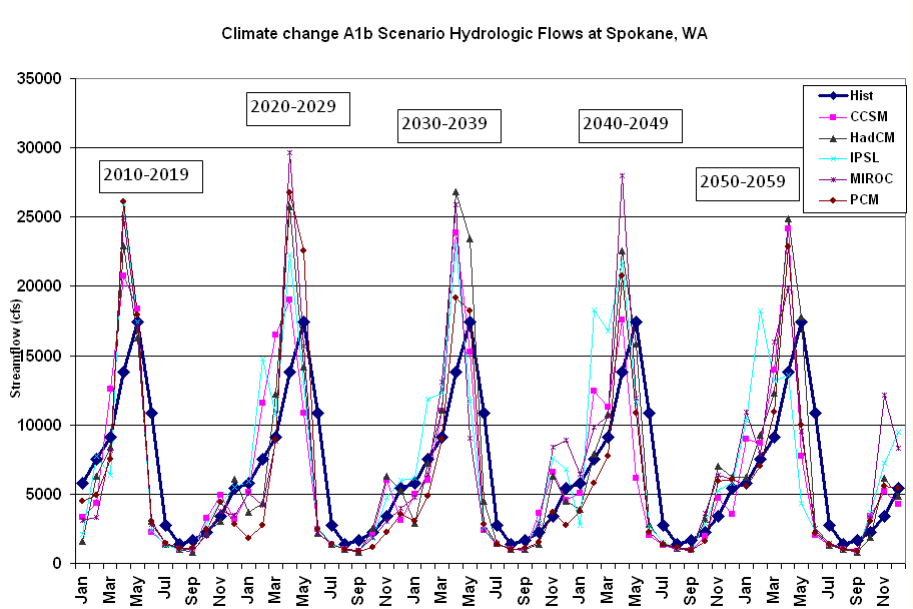
GCM B1, A1b and A2 scenario-based seasonal streamflows at Post Falls, ID

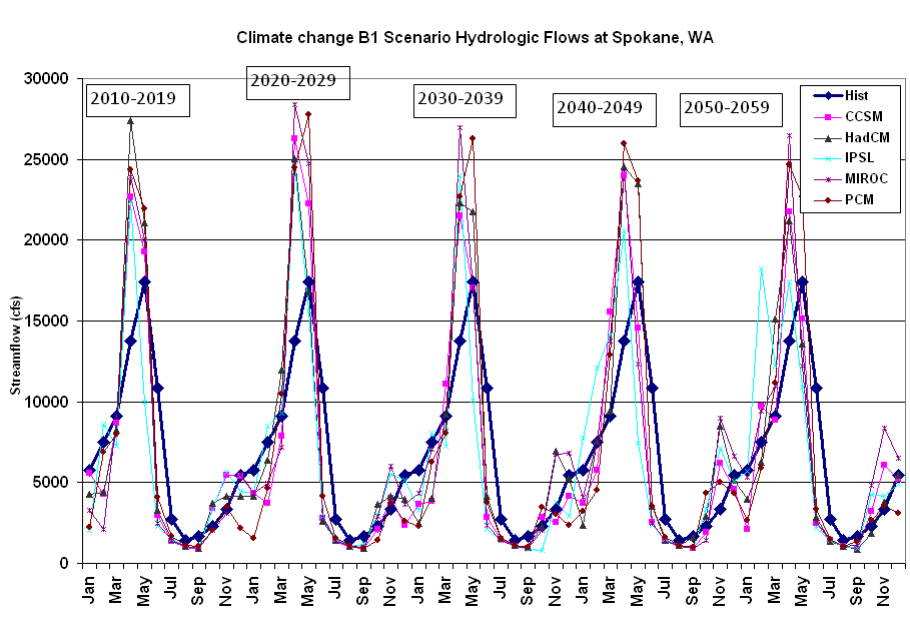


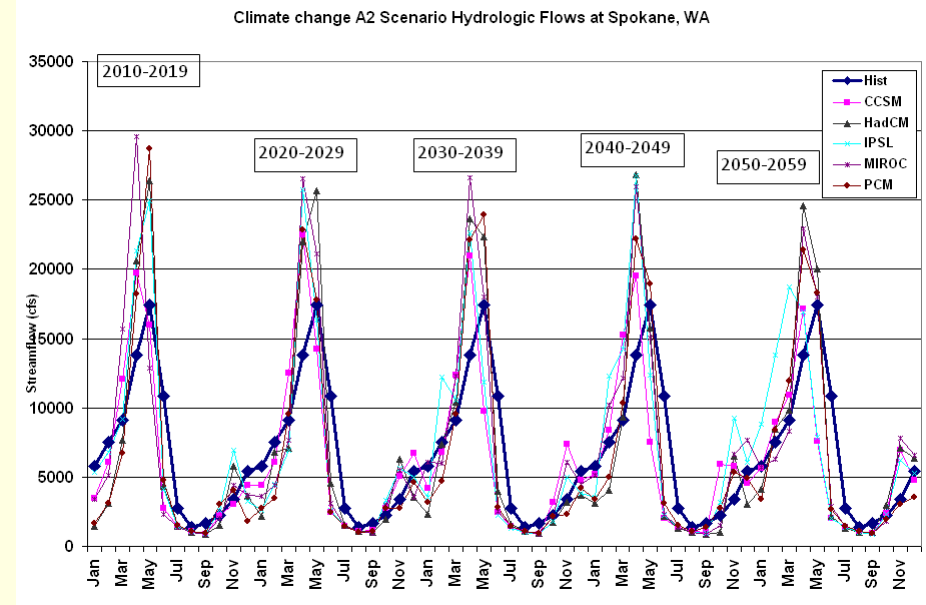




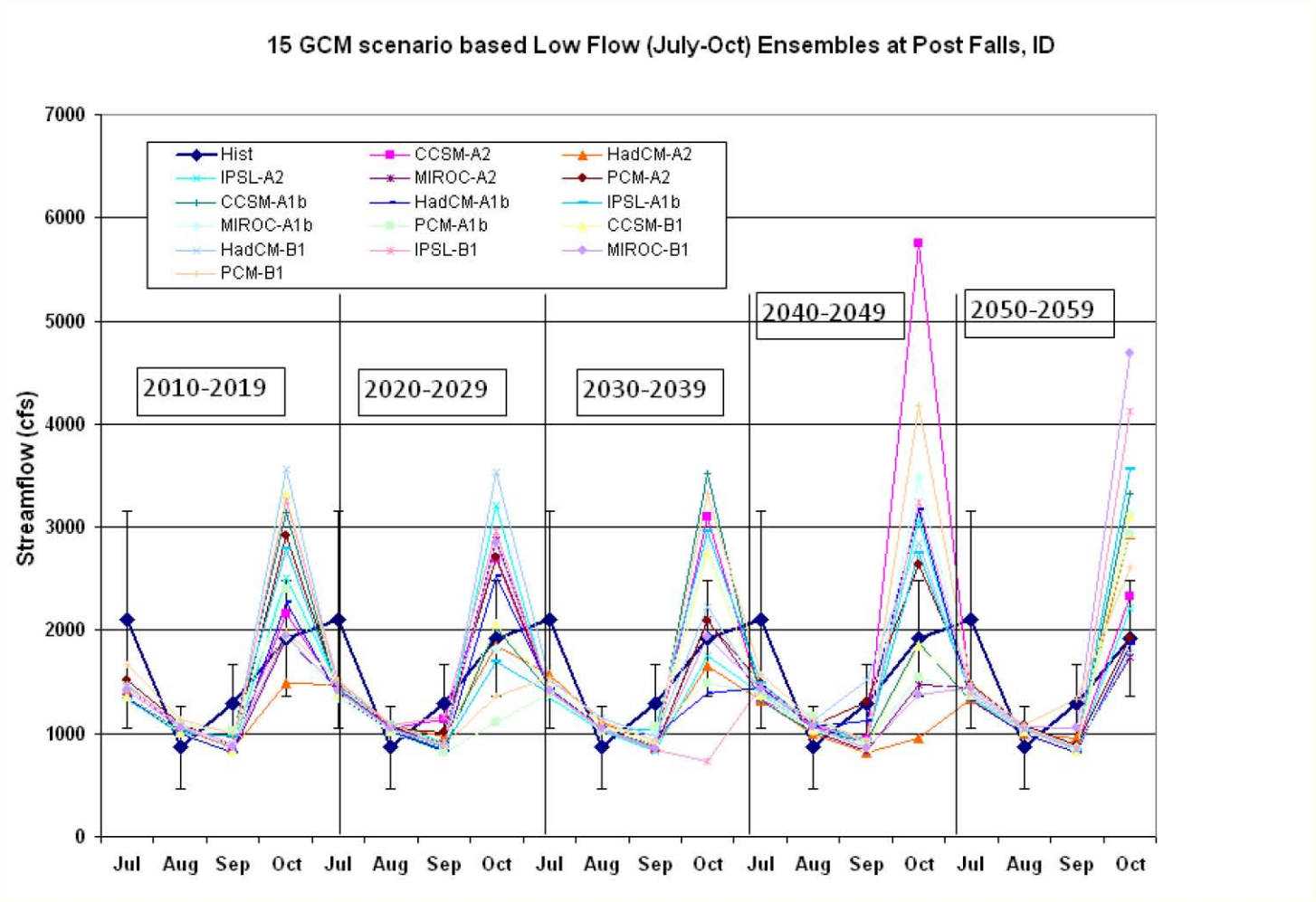
GCM B1, A1b and A2 scenario-based seasonal streamflows at Spokane, WA



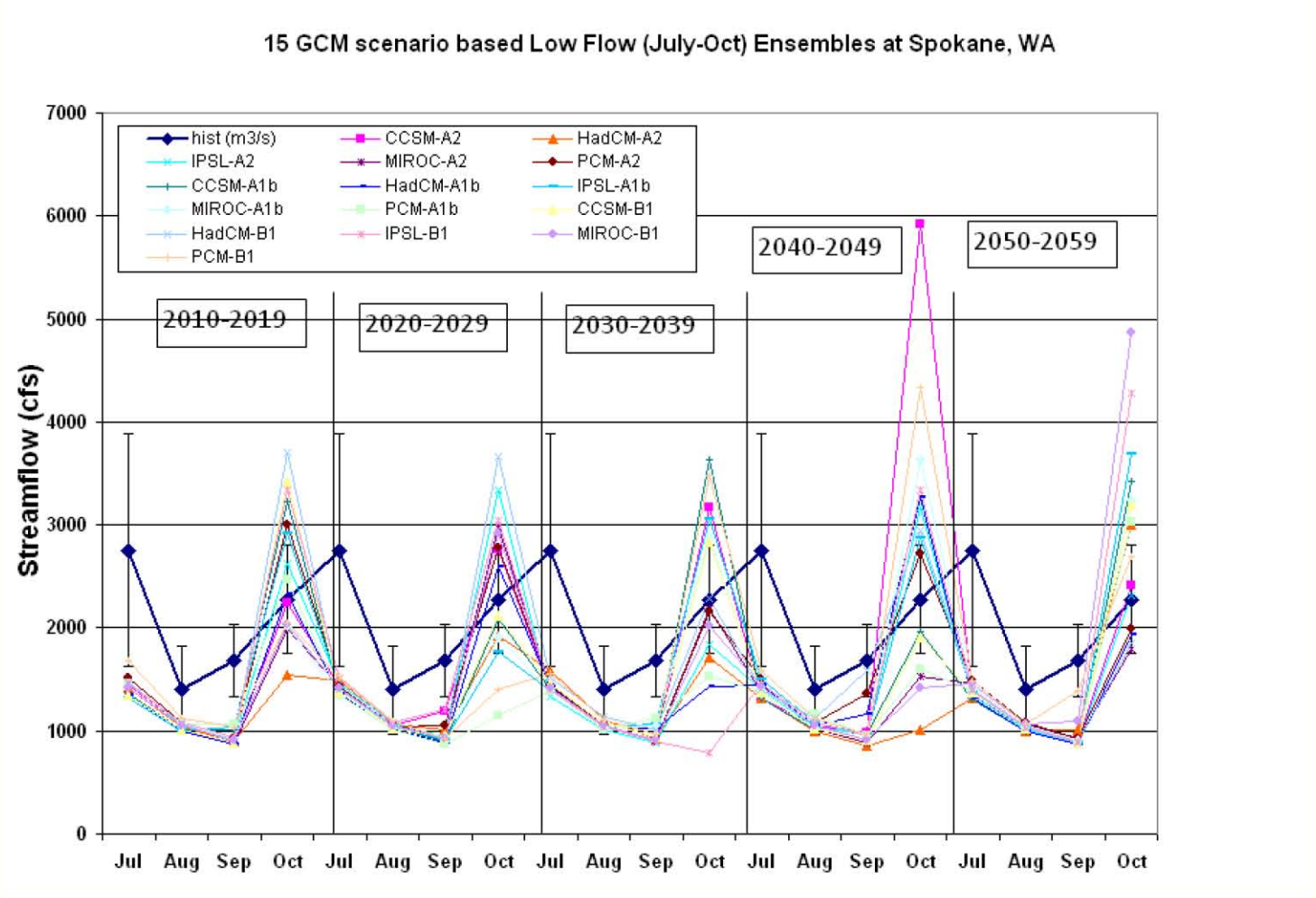




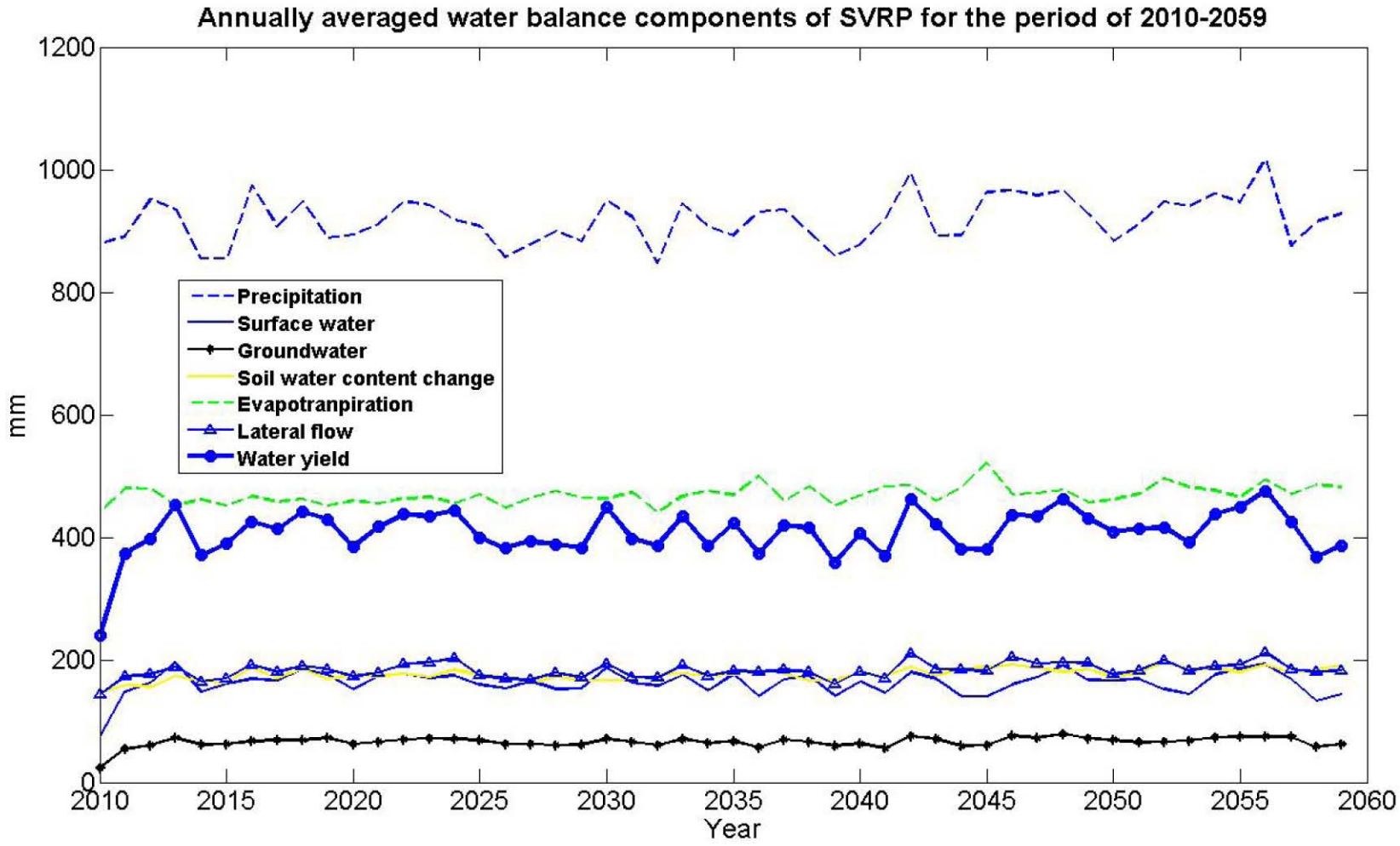
Low flows (July-Oct) GCM ensembles at Post Falls, ID



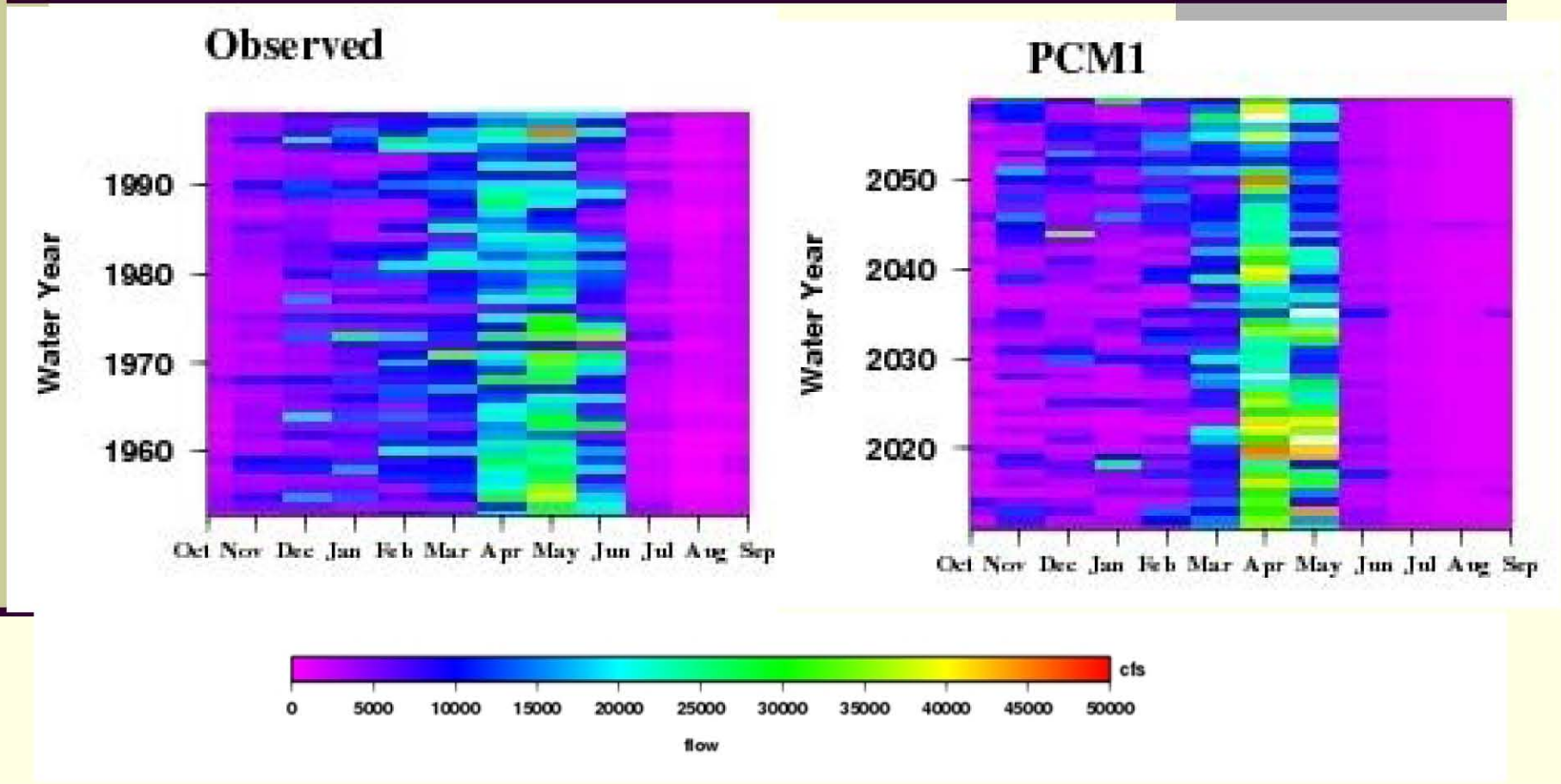
Low flows (July-Oct) GCM ensembles at Spokane, WA



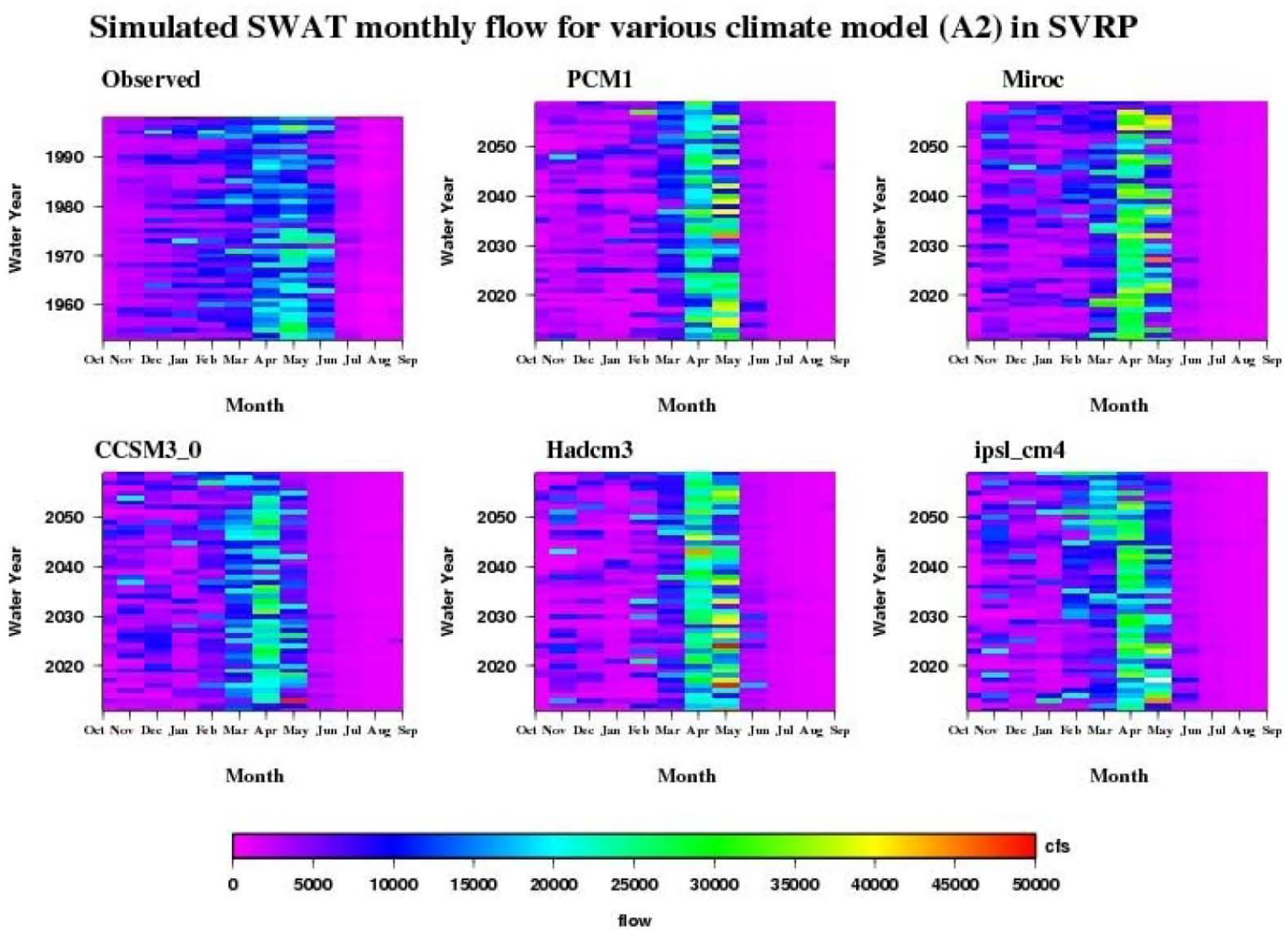
Annual water balance components



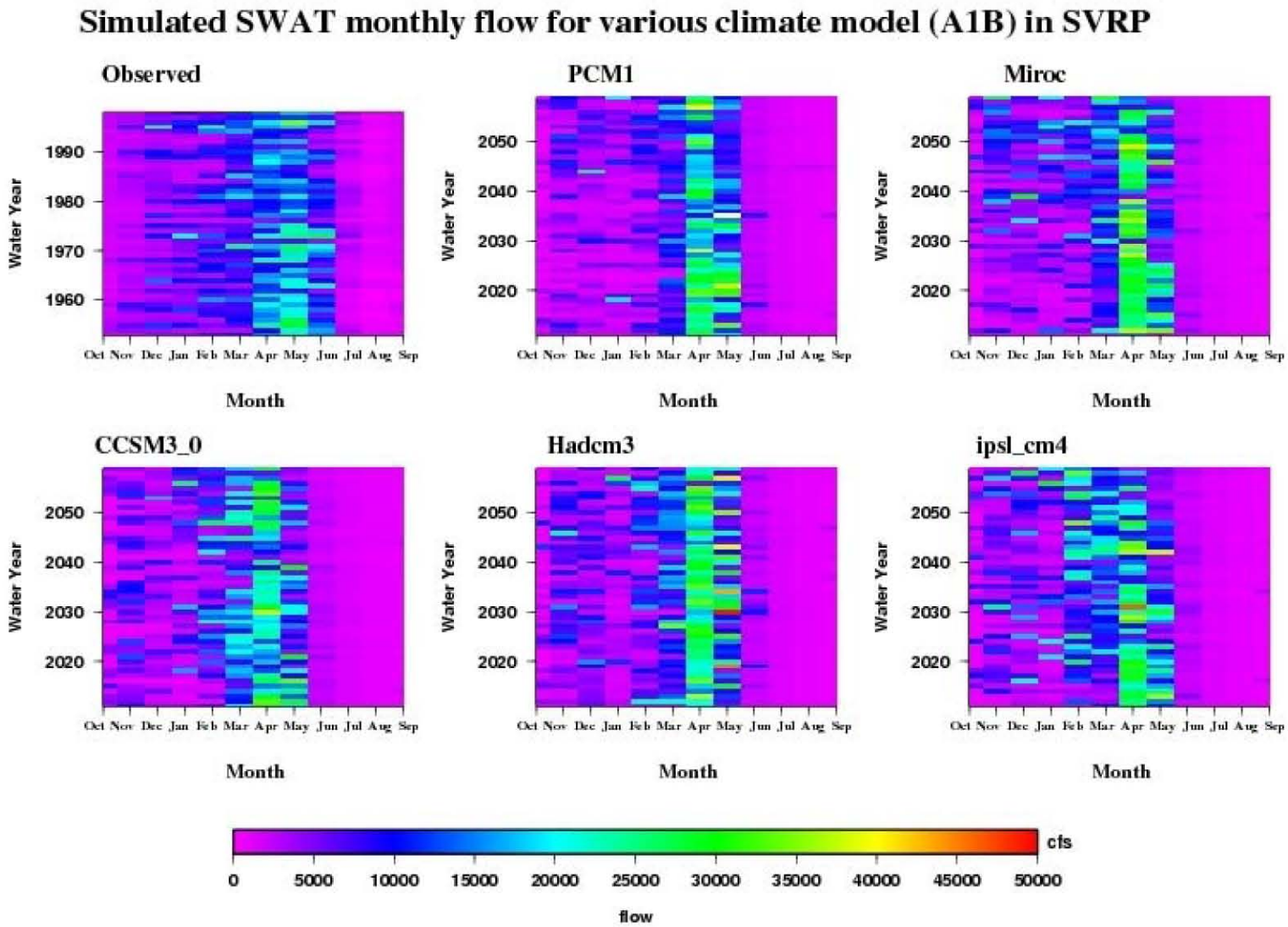
Time Map – Post Falls, A1B



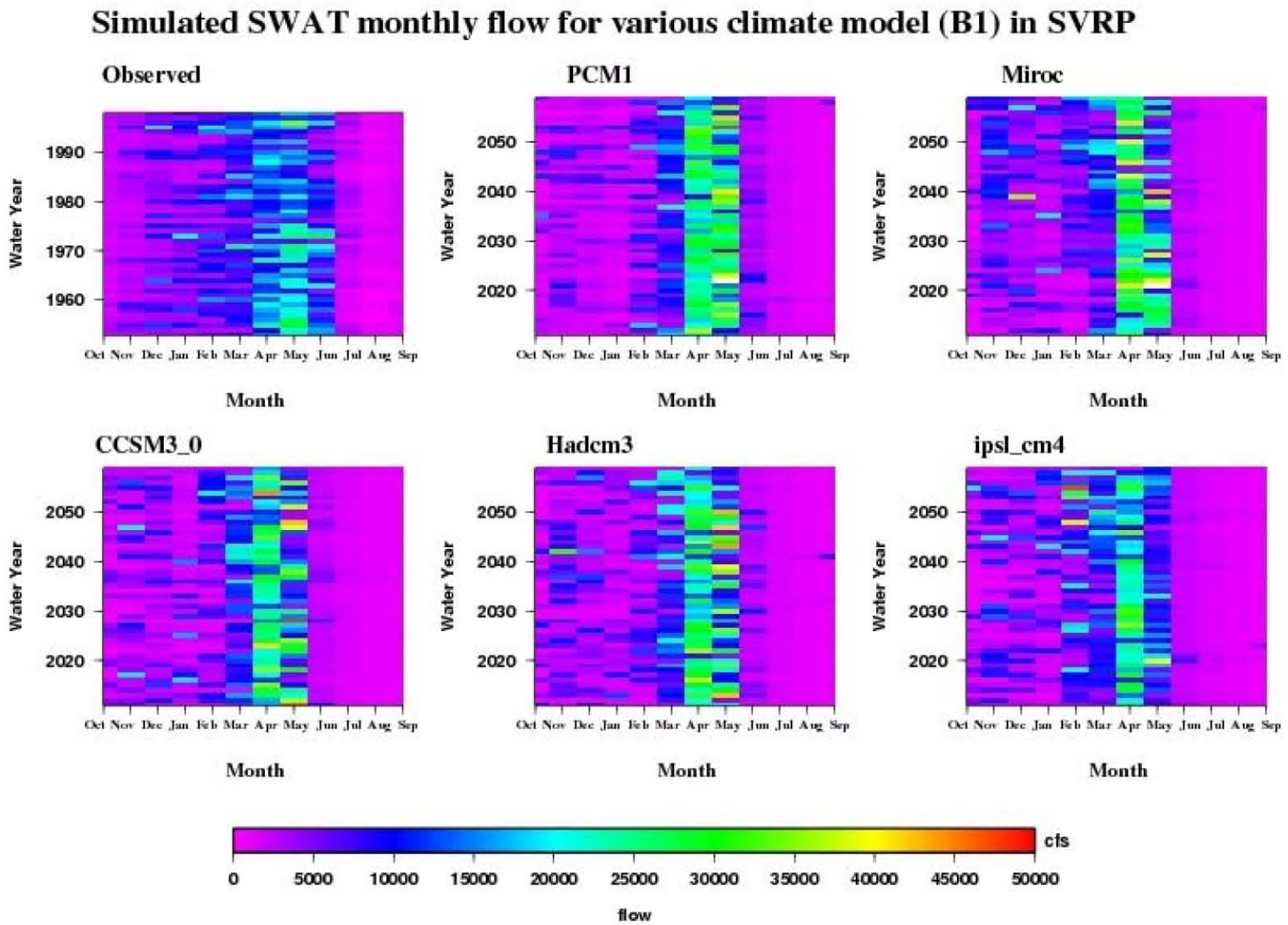
Time Map – Post Falls, A2



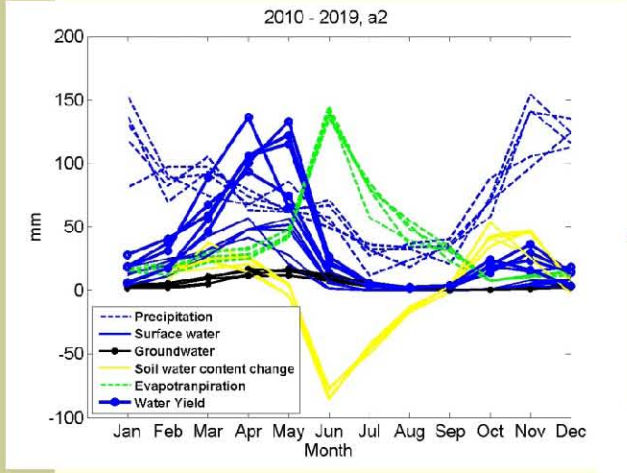
Time Map – Post Falls, A1B

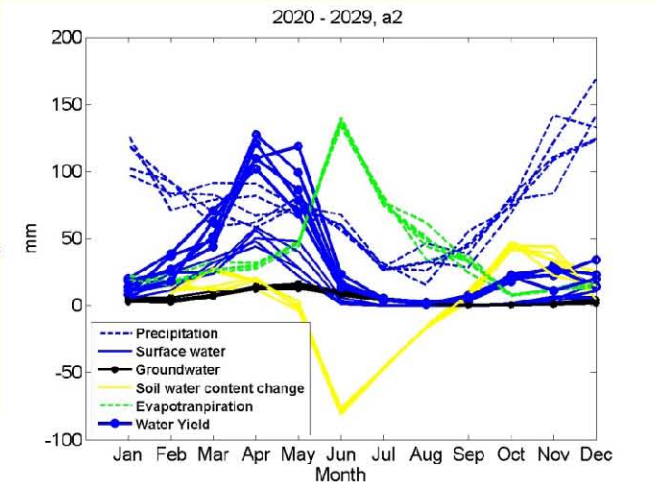


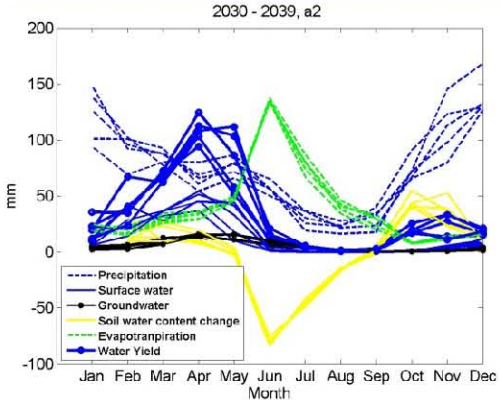
Time Map – Post Falls, B1

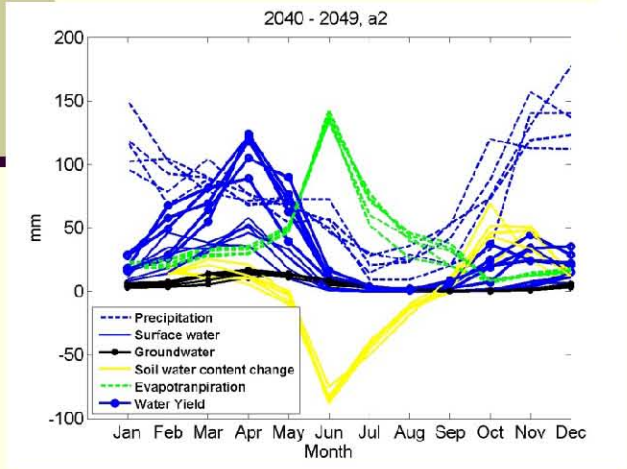


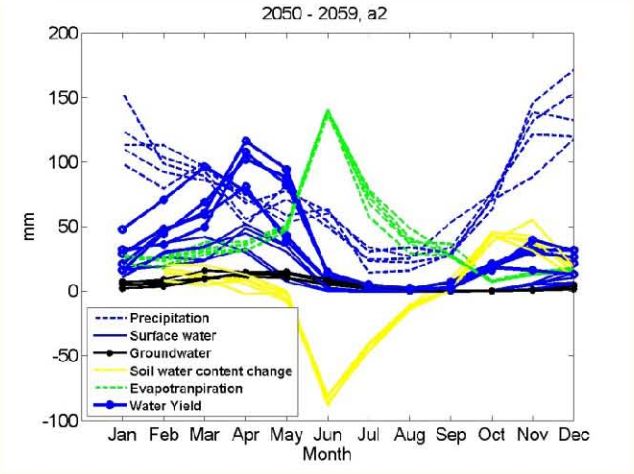
Seasonal analysis on water components, A2











Summary

- Precipitation forecast is less certain. However, temperature increase is found to be consistent. The region is expected to see an increased precipitation (4-5%) and temperature(0.31-0.45 ºC/decade) when averaged over all the GCMs.
- Hydrologic flows appear to have higher variability both annually and seasonally.
- Spring Snowmelt runoff magnitude (high) and timing (earlier) is altered.
- High flows might be higher than historically observed and low flows might be lower than or about the same as observed flows. Comparisons are made between model produced natural flows and USGS-gage data which is regulated.
- Post Falls and Spokane shows similar trends for both high and low flows and uncertainty in our estimates might be due to
  - GCM-produced precipitation and temperature
  - Model parameters and structure (for instance reach gain or loss, residence time of aquifer recharge)
  - measured regulated flow and its year-to-year variability