Distributed Hydrologic Model Simulations for Forecasting Stream Flows and Reservoir Storage

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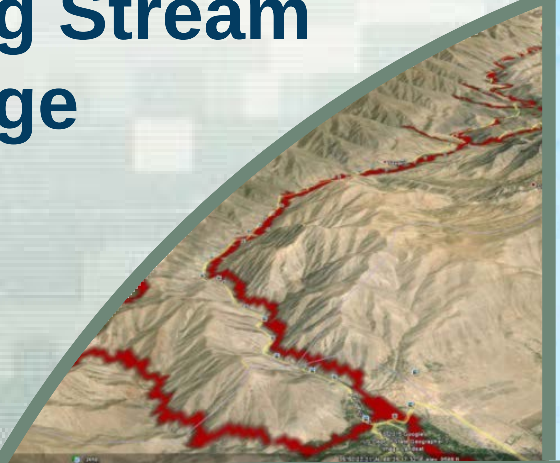
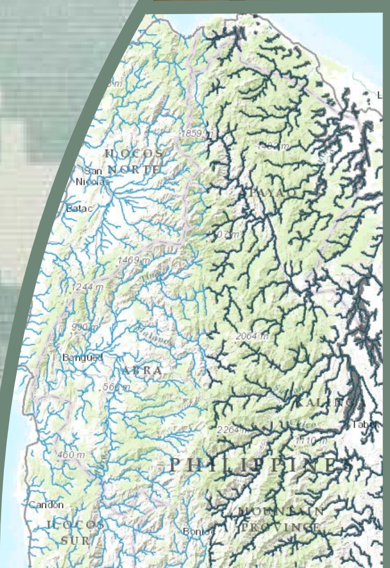
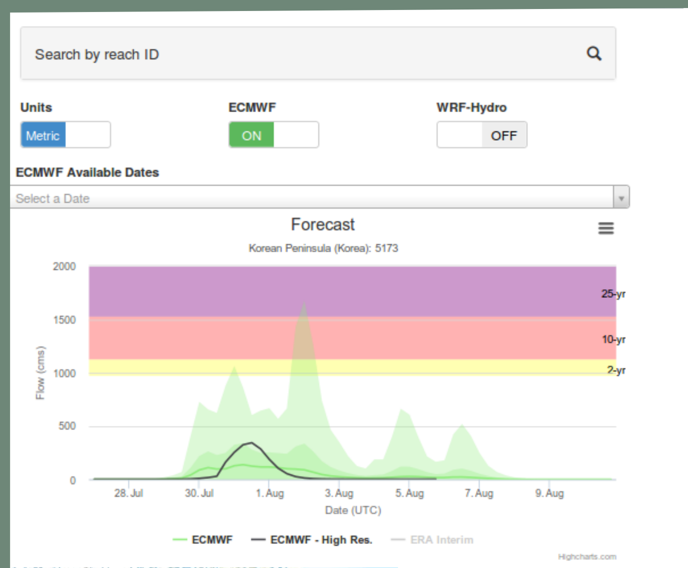


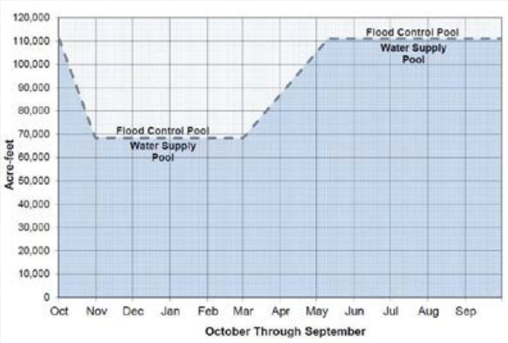




Background

- The US Army Corps of Engineers (USACE) operates reservoirs primarily for flood control, with recreation, water supply, and power generation being authorized uses for many reservoirs.

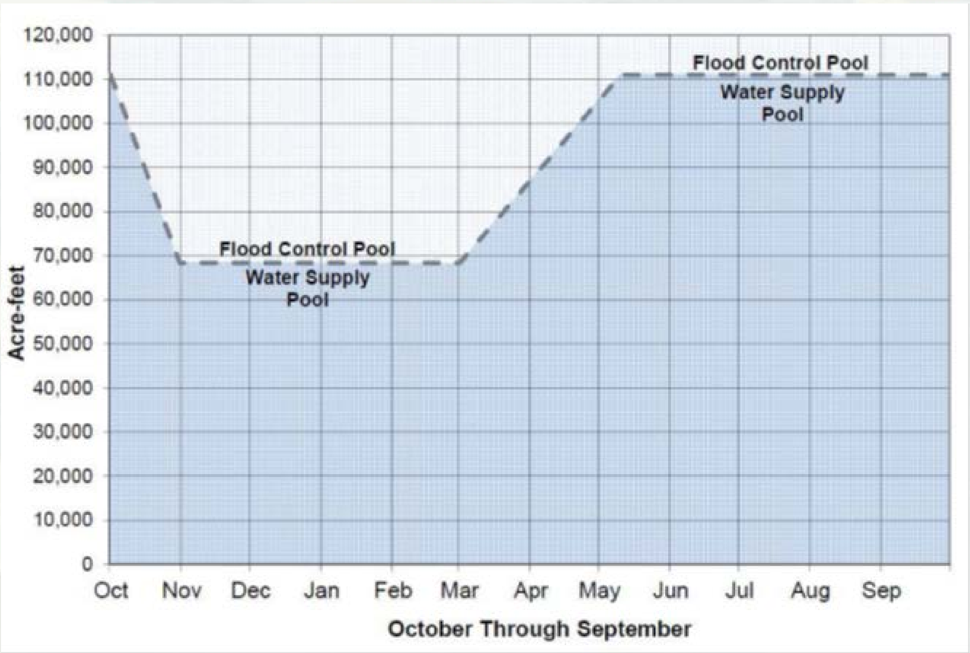
- USACE reservoirs are typically operated according to rule curves, which specify yearly stage variations of the reservoir.



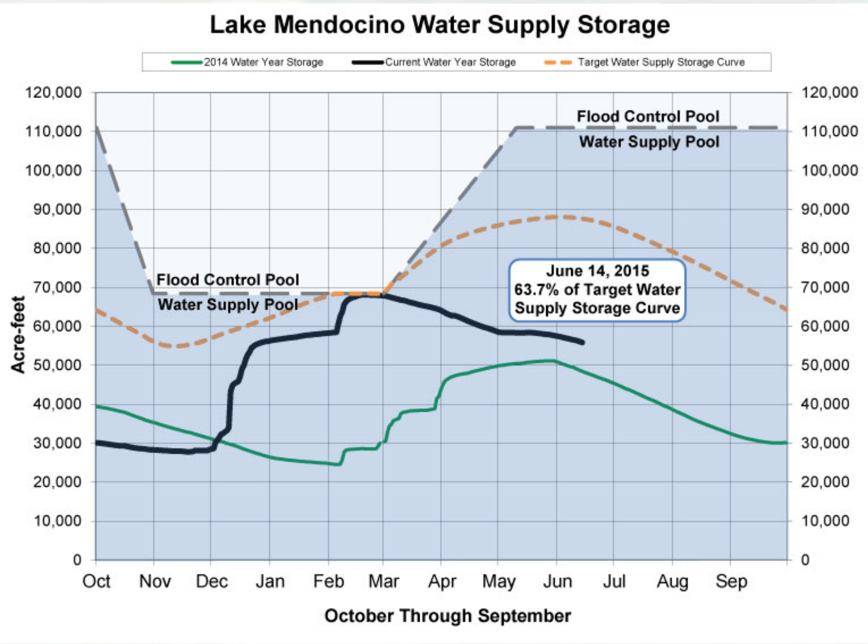
- The operations manual may allow for variations in the rule curve.
- In the Russian River Valley, deviations could possibly increase critical water supplies
- Simulations tools can be used to explore possible variations.

Ultimate Goal

- Utilize coupled weather and hydrologic forecast to allow more flexible operations to enhance secondary benefits without harming flood protection.



Lake Mendocino Rule Curve



Alternate Mendocino Rule Curves Accounting for Forecast Runoff

What Would it Take to Do That?

- Ability to adequately predict the probability of an AR occurring with enough lead time to adjust reservoir operations, 3-7 days for Lake Mendocino.
- Ability to adequately simulate the amount of rainfall in the basin due to an AR.
- Ability to adequately simulate the runoff from the watershed to the reservoir.
- Ability to adequately simulate the reservoir response to the inflow and reservoir operations.

Current Capability

- Inflows are provided by the NWS River Forecast Center (RFC) using an ensemble of numerous rainfall forecasts with the Sacramento model to simulate runoff. USACE can use these forecast directly to make decisions, or filter them through the HEC RESOP model.

Question

- Can research into advanced forecasting tools produce improvements to rainfall, runoff, and reservoir forecast?

Purpose

- Identify important factors and technology gaps in simulating flows and reservoir response in the Russian River Valley utilizing forecasted weather products for the purposes of assessing the effect of variations in reservoir operating rules on water supply and flood control.

What We Are Doing

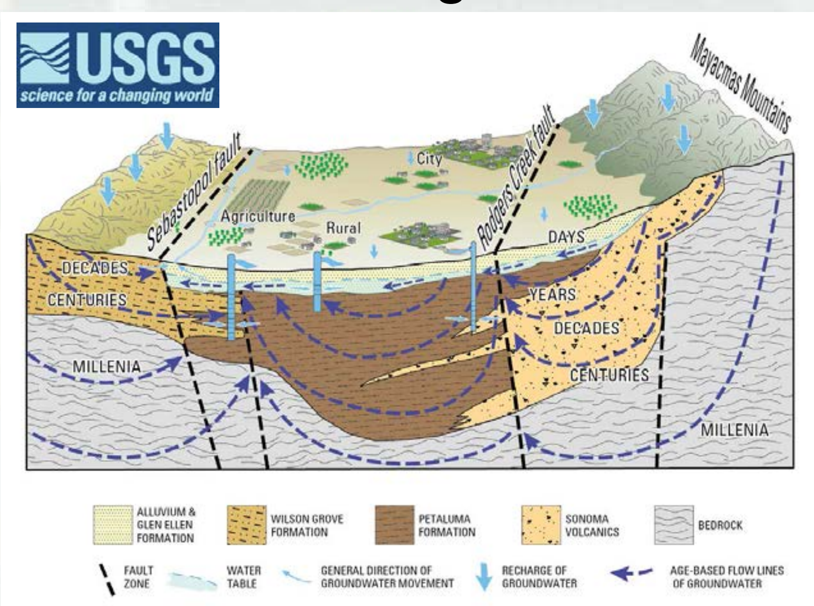
- Developing integrated physics based model of basins in the Russian River, starting with Lake Mendocino.
- Coupling the hydrologic model to West-WRF, and possibly other rainfall forecast products.
- Simulating the runoff and reservoir response observed and forecast precipitation.

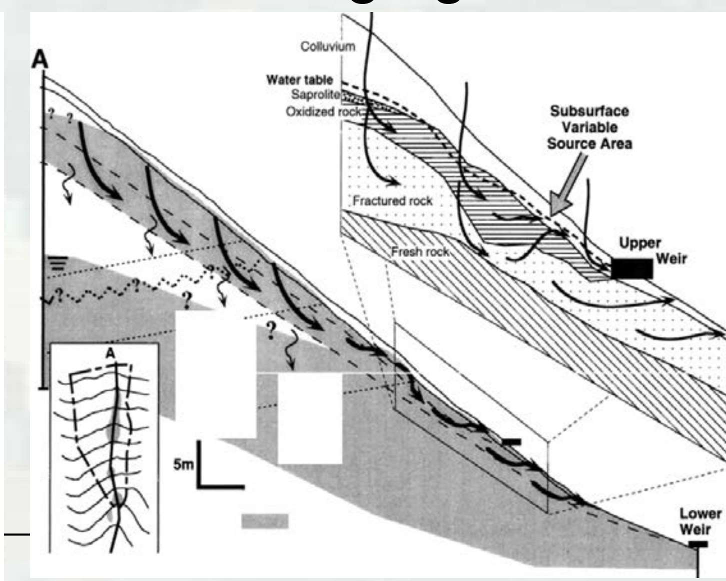
Objectives

- Understand the processes that control runoff in Russian River Valley.
- Assess the ability to simulate flows and reservoir levels in the Russian River Valley with an integrated physics-based watershed model.
  - Advantages/disadvantages to standard methods
  - Effects of scale
- Incorporate forecasted weather products into the watershed model for short term, days to weeks, predictions of flows and reservoir levels.

Technical Challenges of Watershed

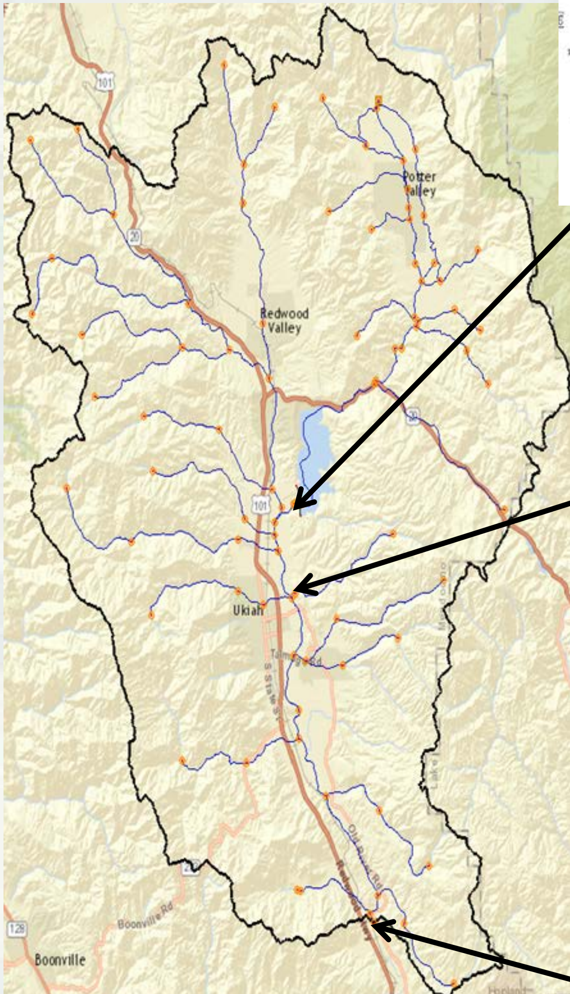
- Groundwater discharge to streams varies greatly within each event, with calculations showing:
  - first 4 hours 10% runoff,
  - 4 to 8 hours 10 to 30% runoff,
  - 8 to 12 hours 30 to 55% runoff,
  - beyond 12 hours of the storm with 55 to 75% runoff
- The flow component on these hillslopes is a combination of overland flow and groundwater flow intermixing as shown in the following figures:



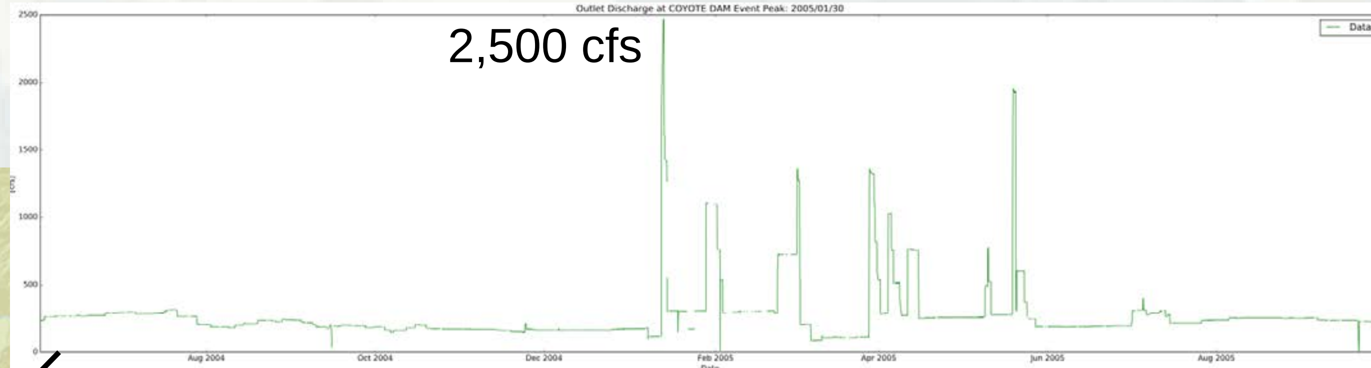


From Anderson (1997)

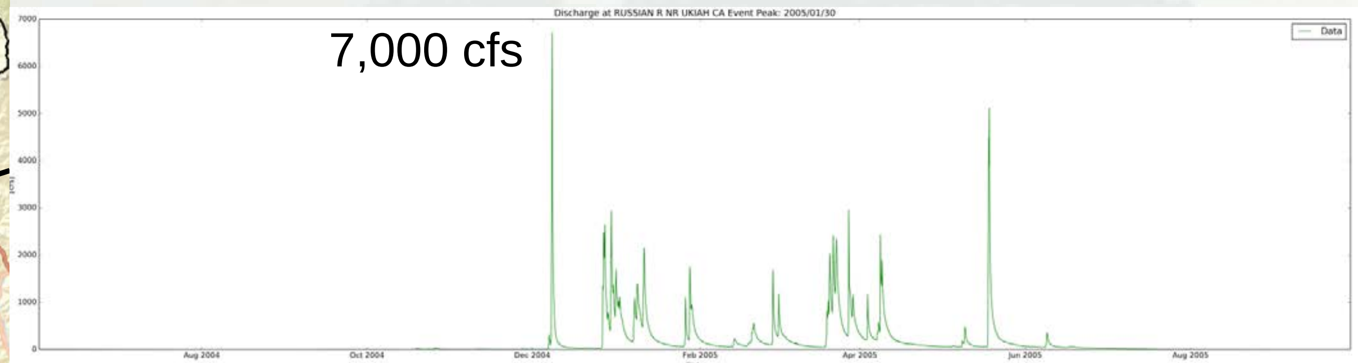
Flow Aug 2004-Aug 2005



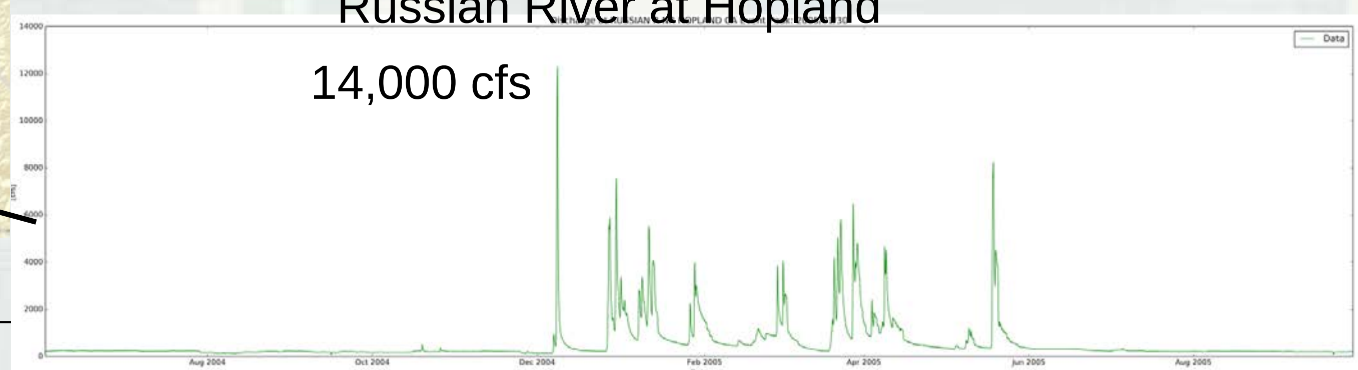
Discharge From Mendocino Dam



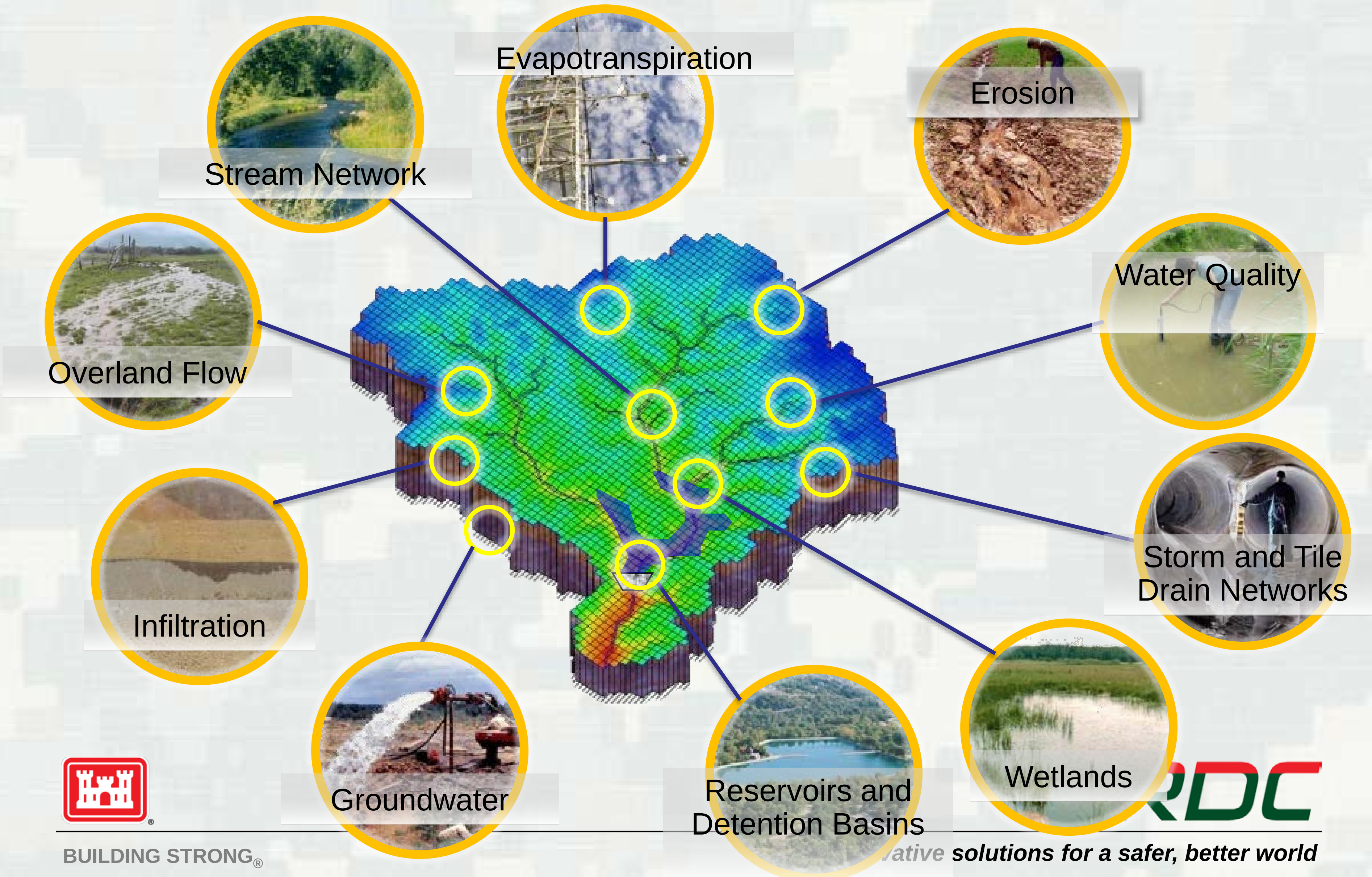
Russian River Near Ukiah (West Fork)



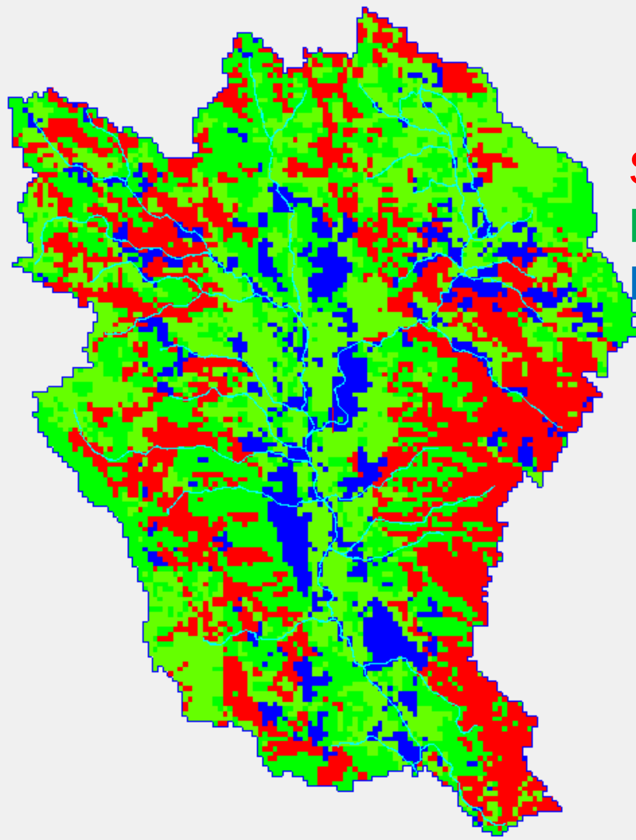
Russian River at Hopland



Watershed Modeling Capabilities

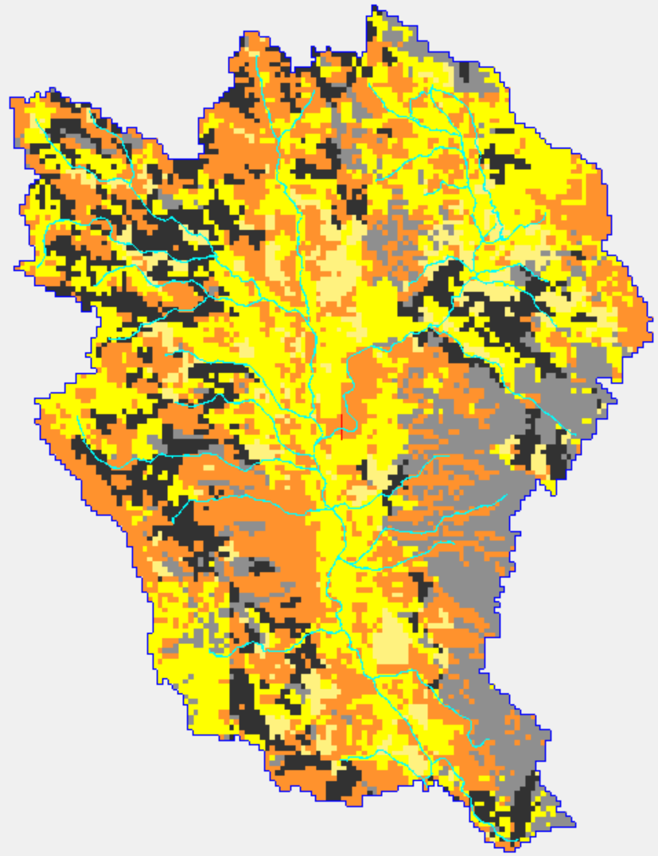


Factors – Soil Depth



Shallow <30 cm
Medium >80 cm
Deep >200 cm

Factors – Soil Texture

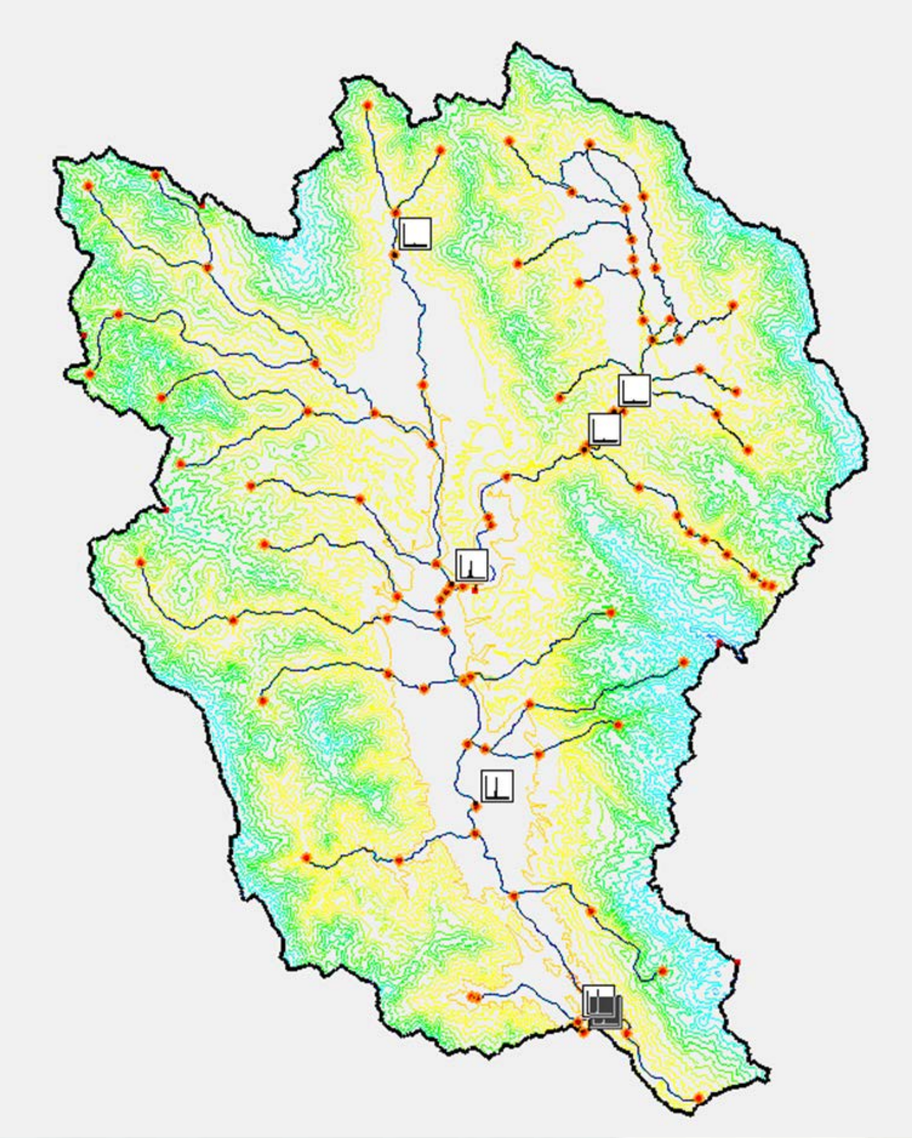


Rock
Unweathered Rock
Clay loam
Sandy clay loam
Loam
Sand

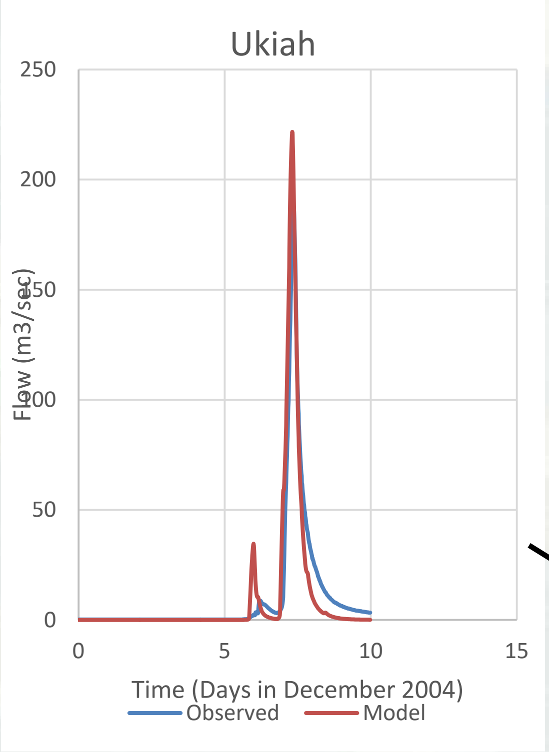
Soil_Type_Reduced
69.0
62.0
52.0
43.0
37.0

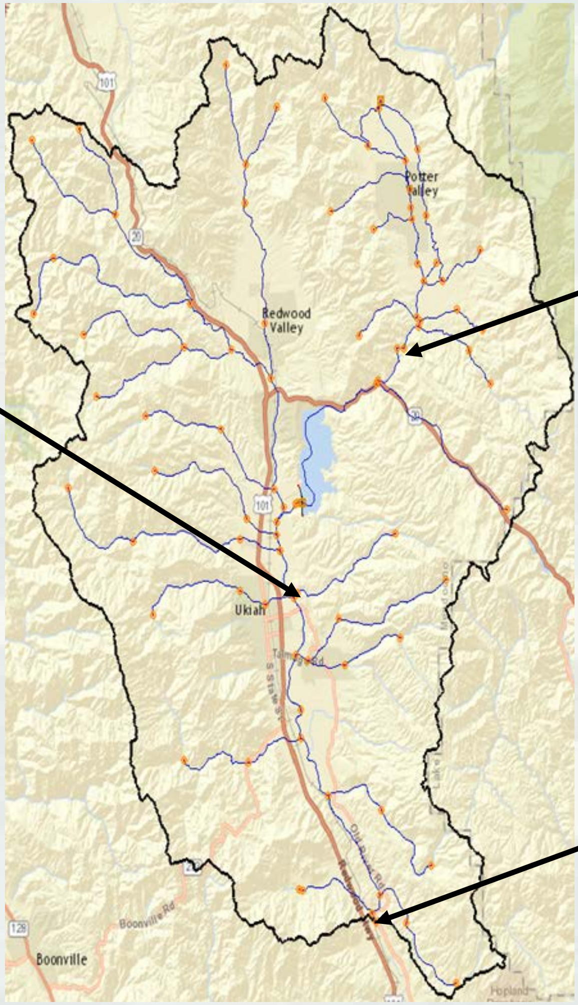
Initial Watershed Conceptualization

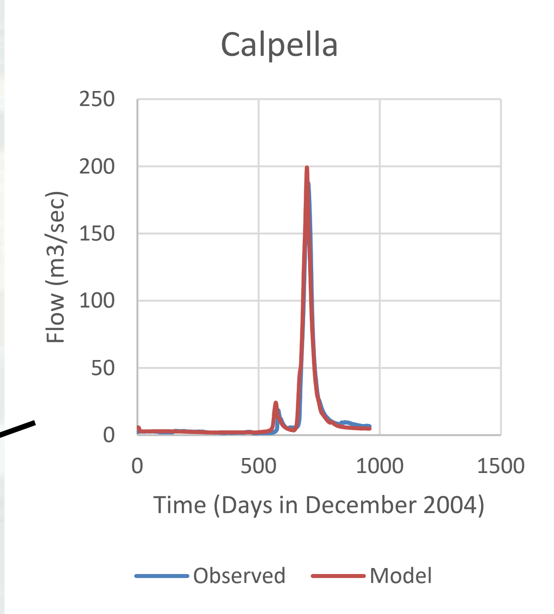
- 2D Overland flow routing with three resolutions to assess effect of grid size.
  - 30m
  - 50m
  - 270m
- 1D Stream network from 10m DEM, HECRAS and field surveys.
- Lake bottom elevations from COE surveys.
- Multi-layer Green and Ampt model to account for strong layering.
- ET – Penman Monteith
- Prescribed stream flows from Eel River diversion and Lake Mendocino discharges.

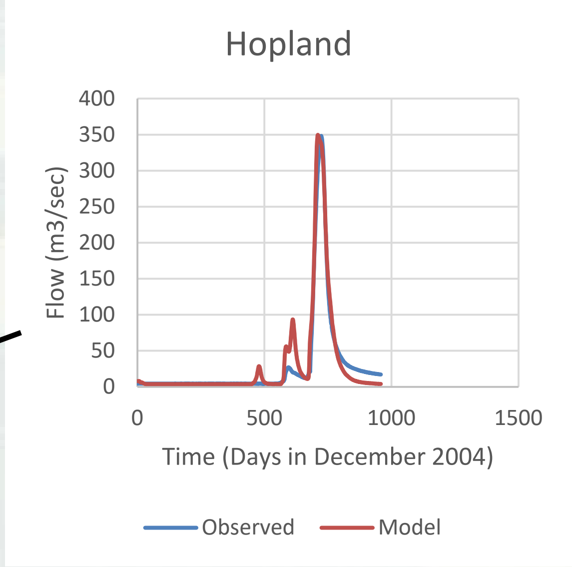


Single Event Calibration – Surface Water Only



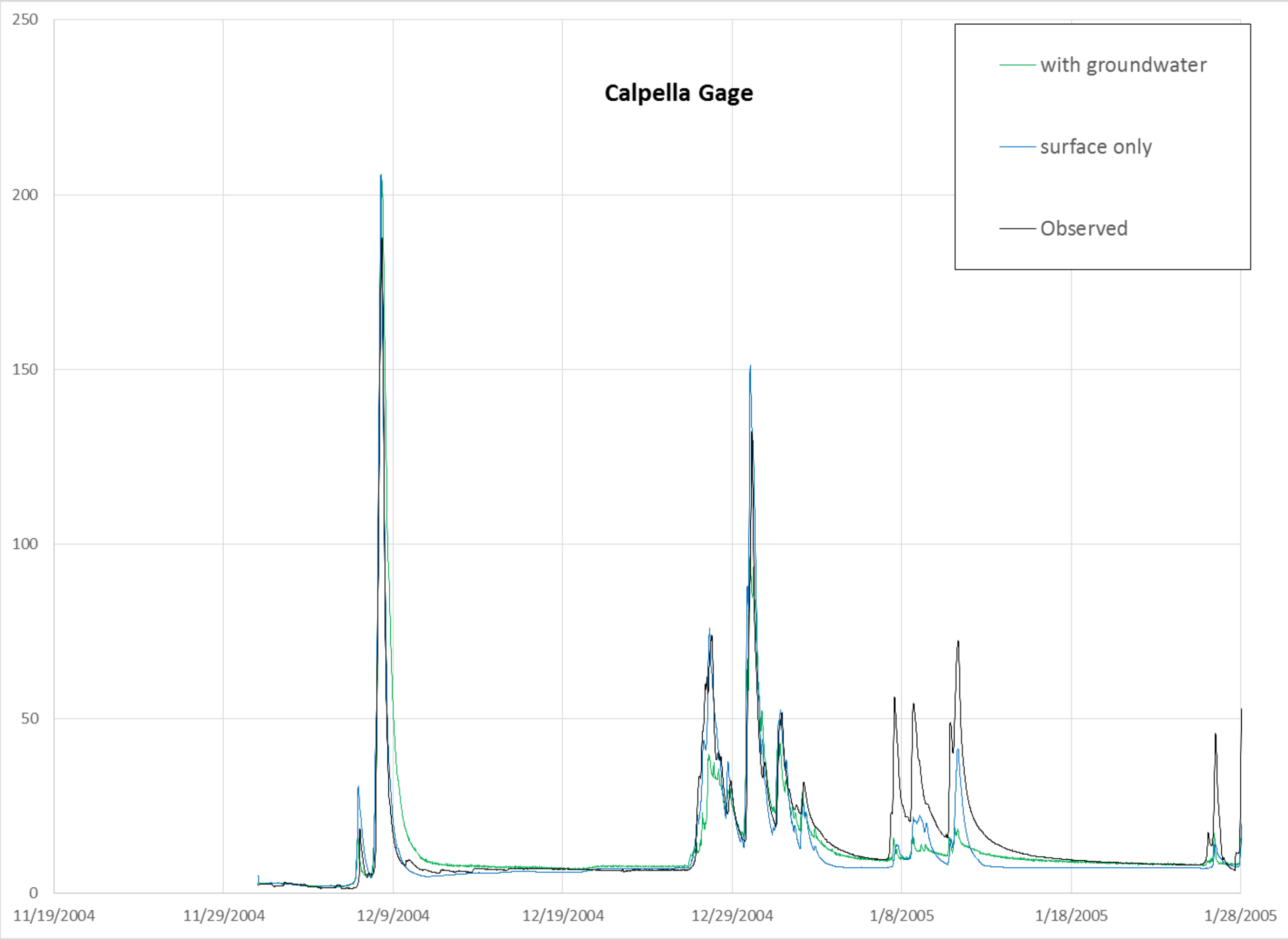






Effect of Groundwater

- Although the model does an excellent good predicting flow in dry conditions.
- Groundwater appears to play a bigger role in wet conditions.



Impressions

- The physics based model was able to accurately simulate runoff for dry conditions.
- The model appeared to be less accurate for wet conditions, possibly due to the lack of groundwater contribution.
- The model is helping the team to understand the system response of the Russian River watershed to ARs.

Continuing Efforts

- Adding groundwater to existing models.
- Building additional model resolutions and domains.
- Recalibrating model with CW3E's Oct 2017 to May 2018 dataset.
- Adding denser stream network.
- Simulating West WRF forecast for last two AR seasons.
- Assessing models' ability to simulate observed soil moisture.
- Adding reservoir operations to the model.