The Potential for Expanded NWS Hydrologic Support of Emergency Management Training Exercises:

Simulating the ARkStorm Scenario Using the CNRFC Modeling Framework

California Cooperative Snow Surveys Meeting
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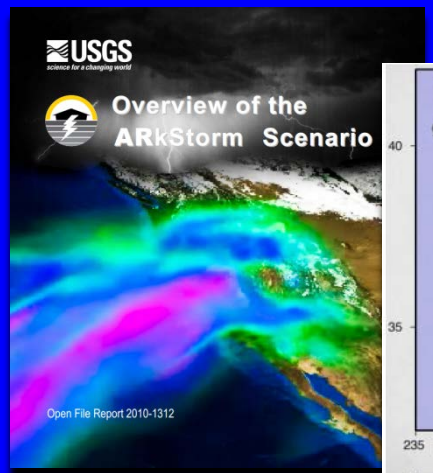
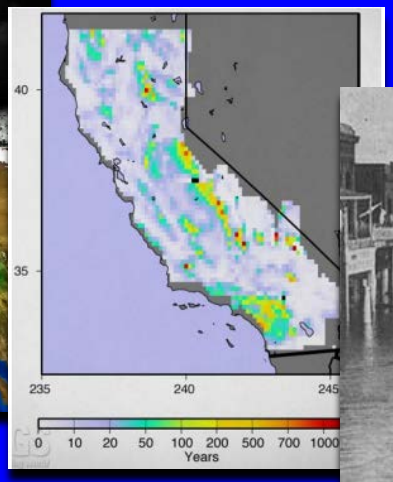
What is the "ARkStorm"?

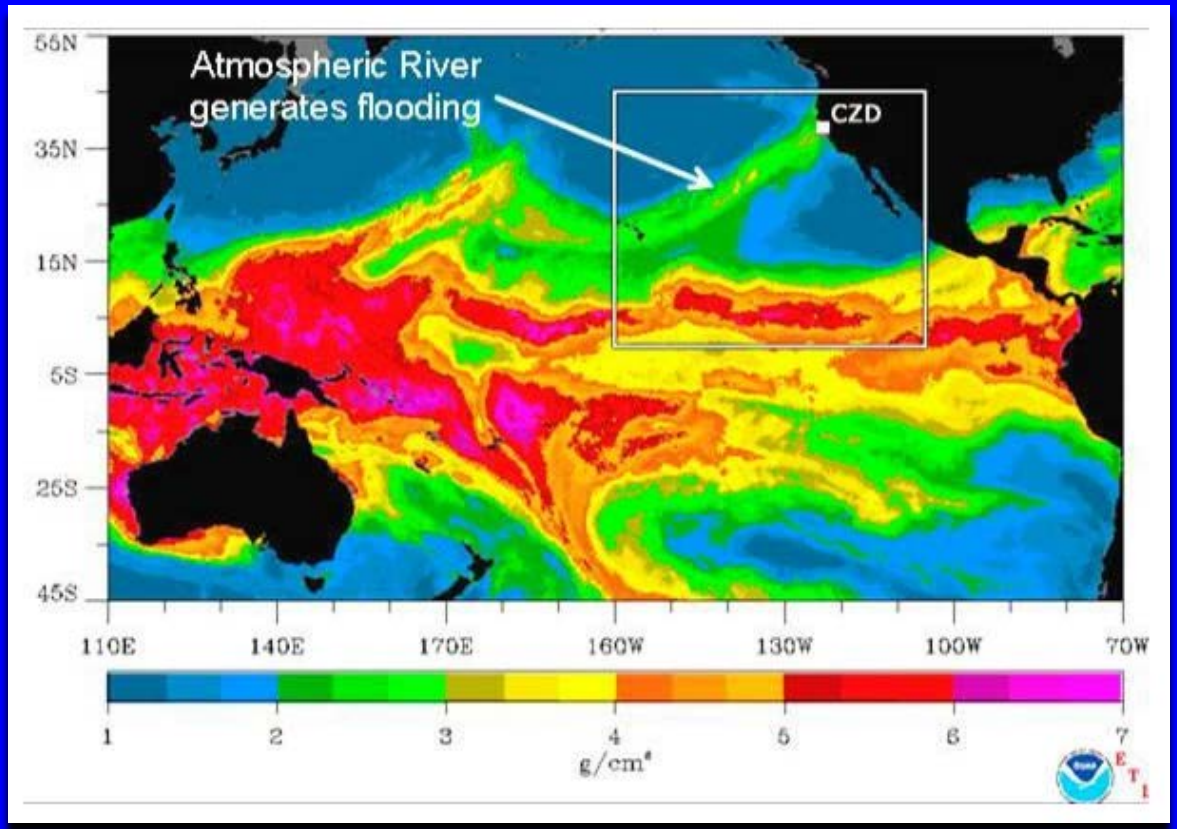
- An emergency planning scenario associated with a hypothetical severe winter storm striking California
- Designed by a collaborative group led by the U.S. Geological Survey, California Geological Survey, and others, under the authority of the U.S. Geological Survey Multi-Hazards Demonstration Project for Southern California





K Street, Sacramento, looking east
1861-1862

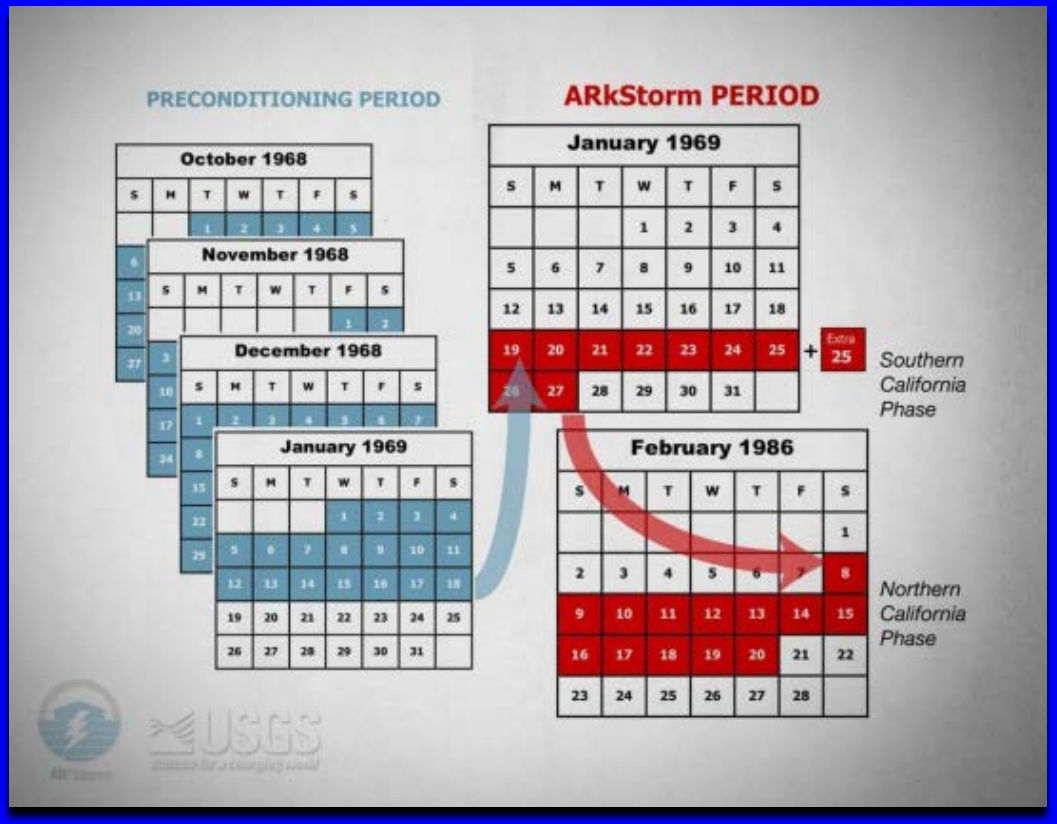
ARkStorm Meteorology



Atmospheric River originating over the central Pacific
On February 16, 2004..

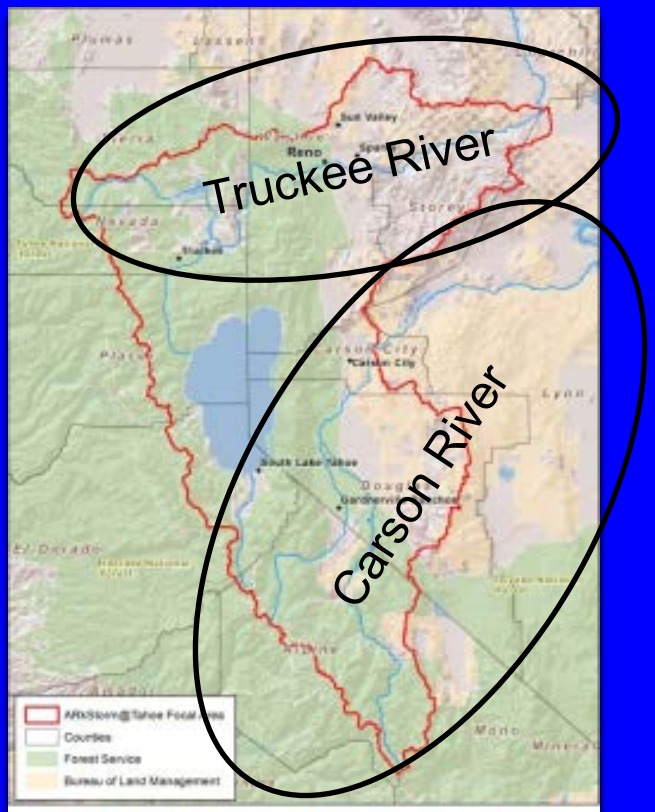
ARkStorm Meteorology

January 19-25 1969
January 25 1969
January 26-27 1969
February 8-20 1986



ARkStorm stitched-storm calendar, with moderately wet early winter “predonditioning” (blue shading), followed by two intense-storm periods (red shading represents actual storms of 1969 and 1986)..

ARkStorm@Tahoe



Lake Tahoe region and communities of interest for ARkStorm@Tahoe winter storm scenario

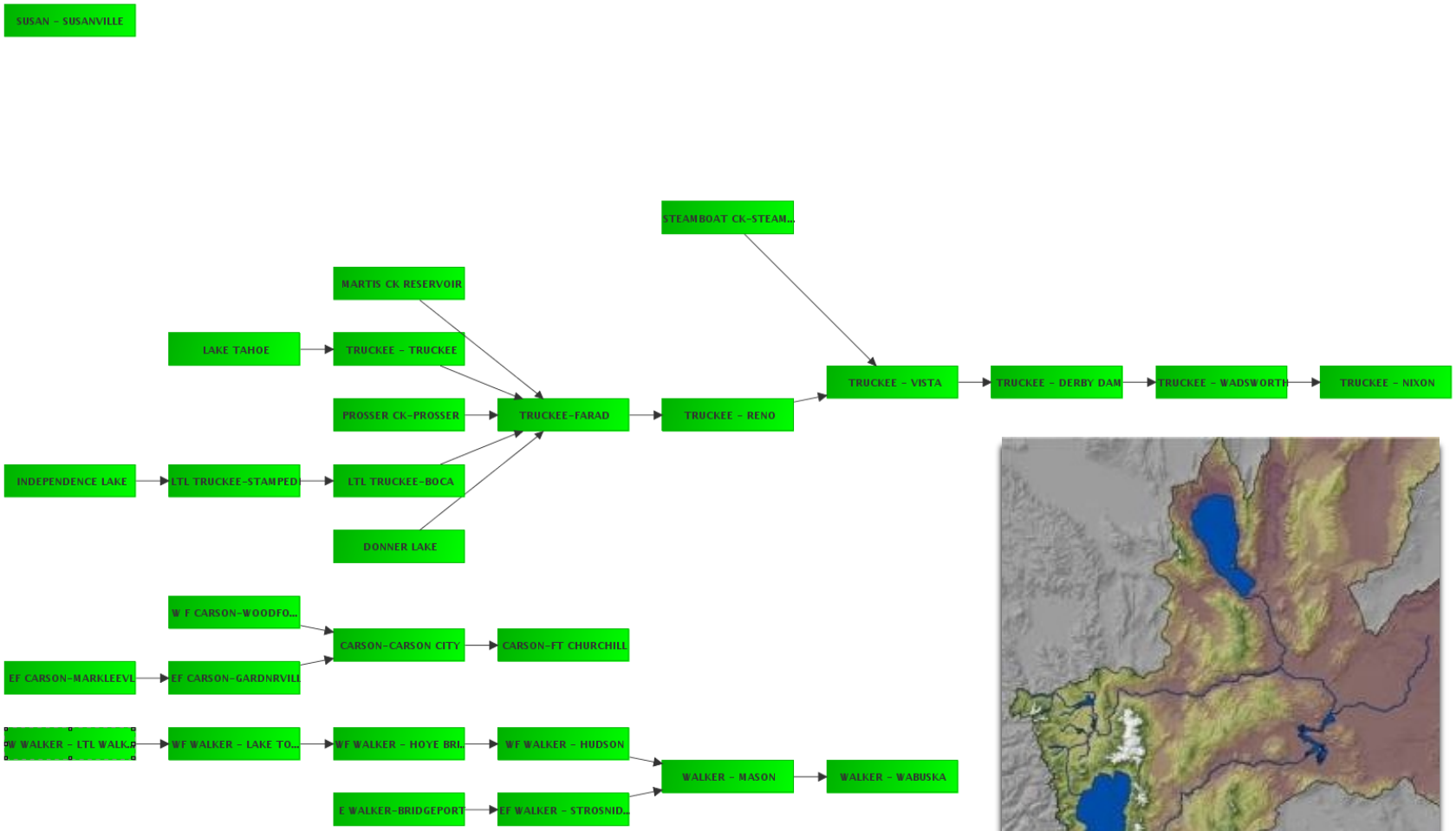
What is ARkStorm@Tahoe?

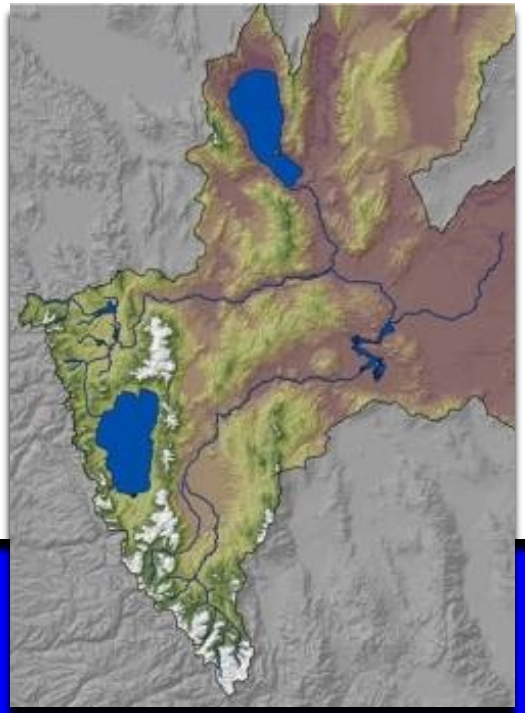
- exercise to explore the likely impacts of an ARkStorm in the Lake Tahoe Region
- first time the scenario was explored in a region that includes mountainous terrain with precipitation in the form of snow and large areas of non-urban land
- first time scenario was used to assess both near- and long-term impacts and impacts to ecological systems

Model Configuration

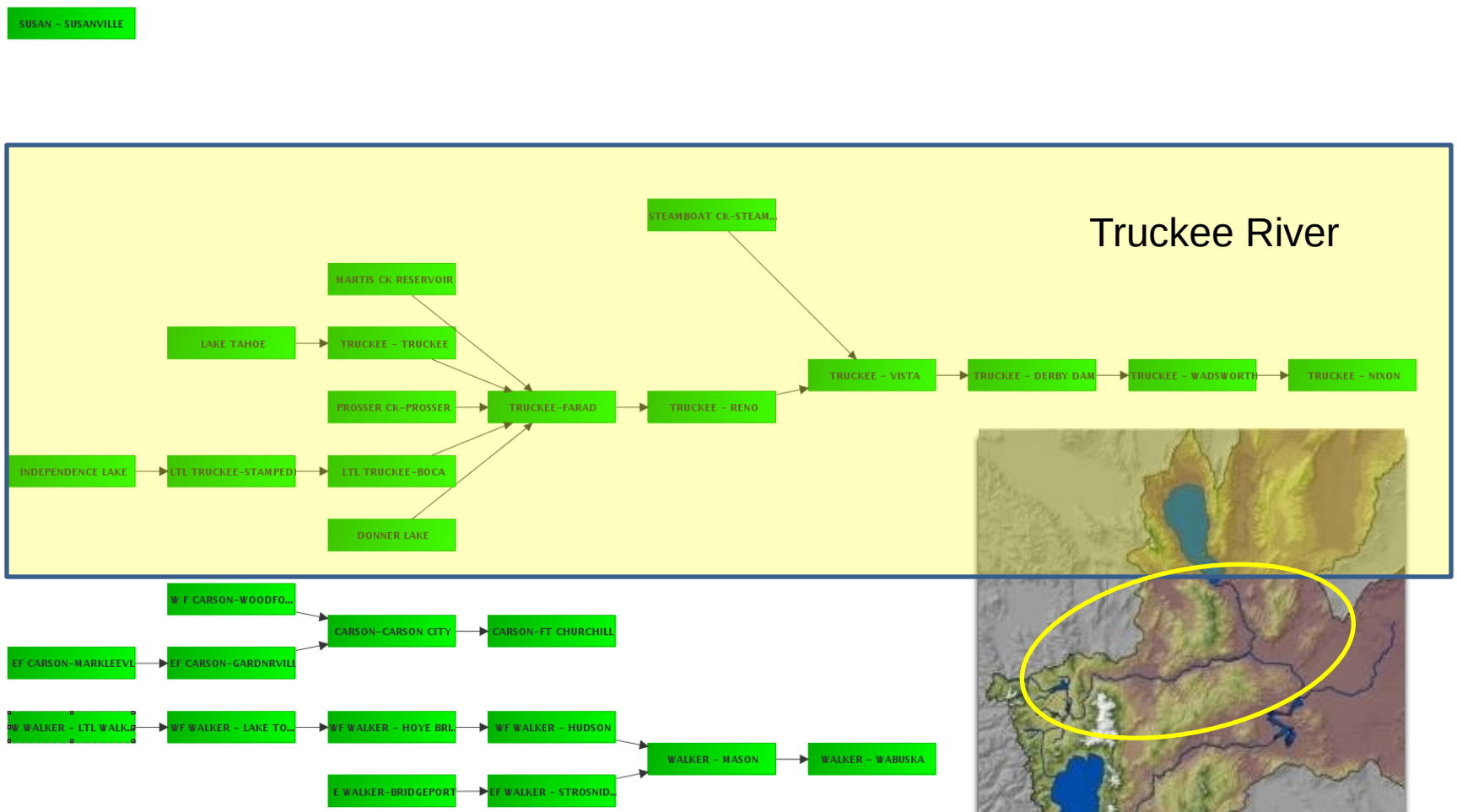
- Used the CNRFC's Community Hydrologic Ensemble Forecast System (CHPS)
  - East Side Sierra Forecast Group
- Simplified operational configuration by removing most reservoirs – assumed that they would be spilling (passing inflow) for majority of event
- Lake Tahoe was included

Model Topology

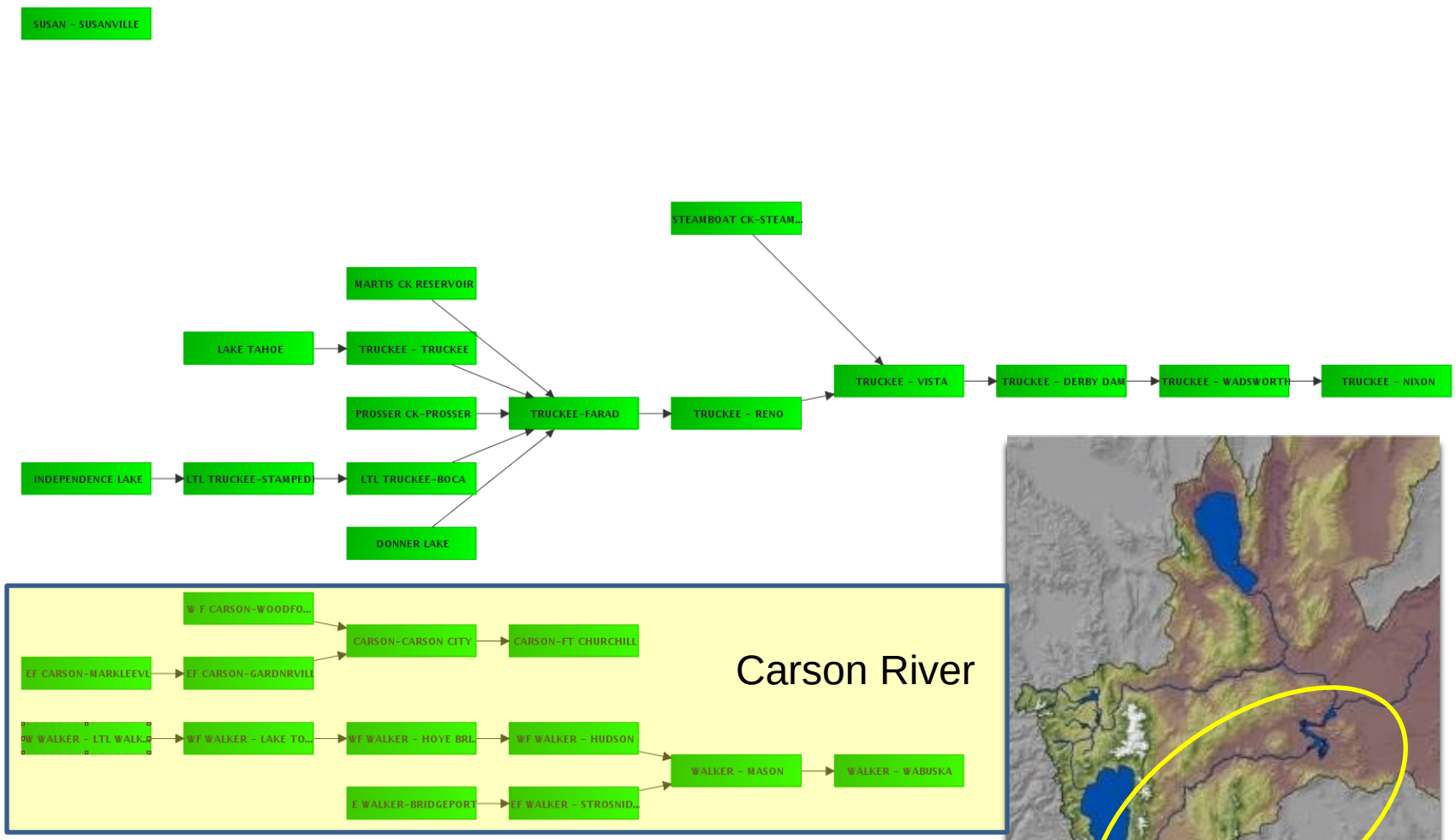


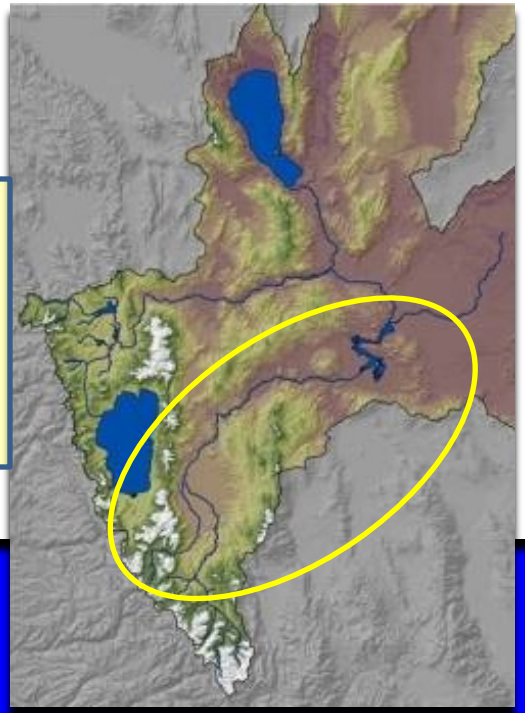


Model Topology



Model Topology





CNRFC Hydrologic Modeling System

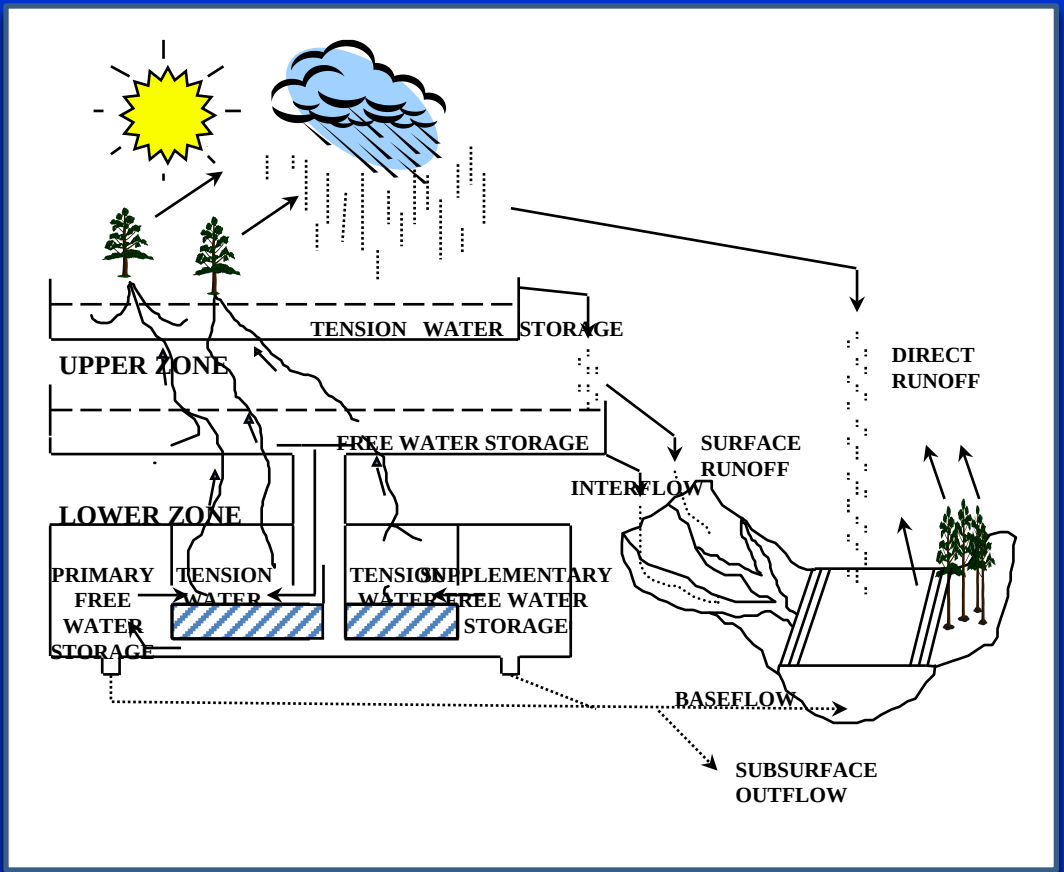
- Rain-Snow Elevation
- Snow-17
- Soil Model (SAC-SMA)
- Unit Hydrograph
- Reservoir Models
- River Routing Models

- Six hour time step
- Lumped (not distributed)
- Mountainous basins

  Subdivided into:

  -Upper / Lower

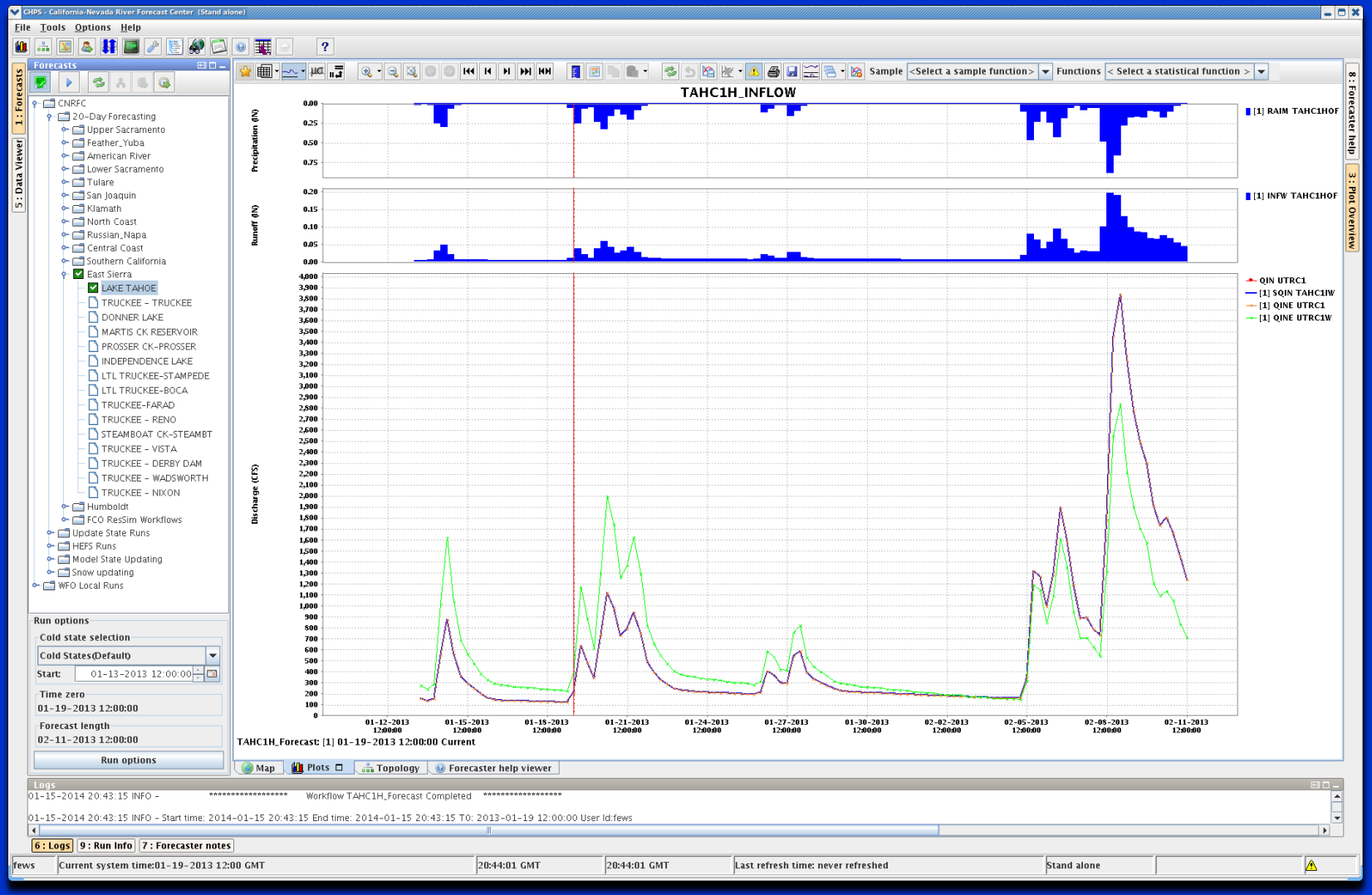
  -Upper / Middle / Lower



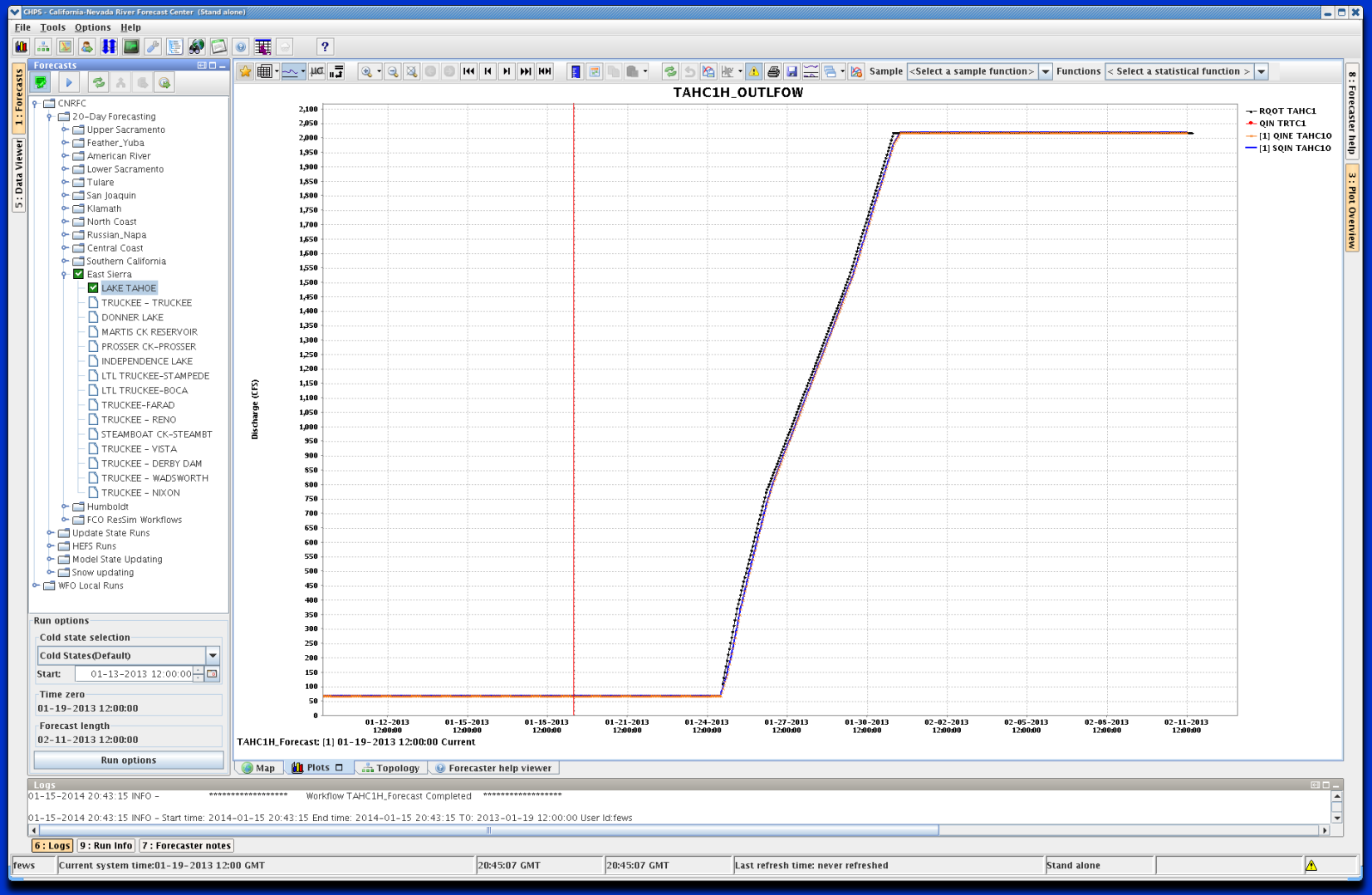
Initial Conditions & Model Run

- Used historic conditions prior to the January 19-25 1969 event
  - Model was initially "spun" for a few years prior to 1969, then run from Oct. 1 1968 to Jan. 20 1969
  - Model states saved for Jan. 18th 1969
  - These states used for event & represent wet antecedent conditions
- Rain/snow elevation modified to increase runoff
  - elevation increased 1000 feet for the 1986 portion of the event (max 8200 ft)
- Plausible Tahoe operations included in simulation
  - Lake Tahoe elevation set to two feet below max allowed (6227.1 ft)
  - Tahoe max legal elevation initially exceeded by 0.8 ft
  - Tahoe outflows ramped up to ~2000 cfs when the lake level approached 1 ft of legal max (to account for assumed operations)
  - Max pool elevation reduced to 6229.3 ft

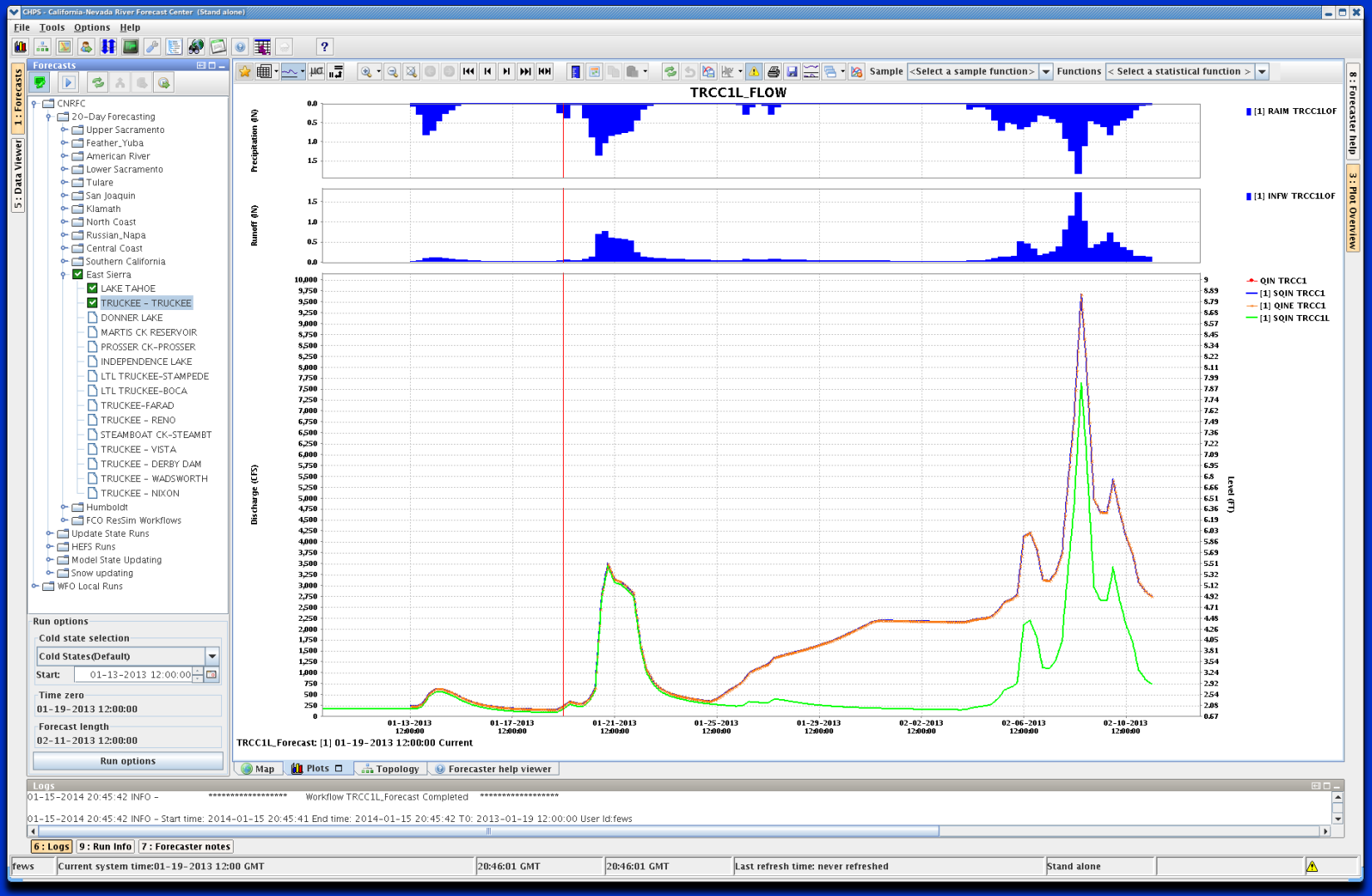
Lake Tahoe Inflow



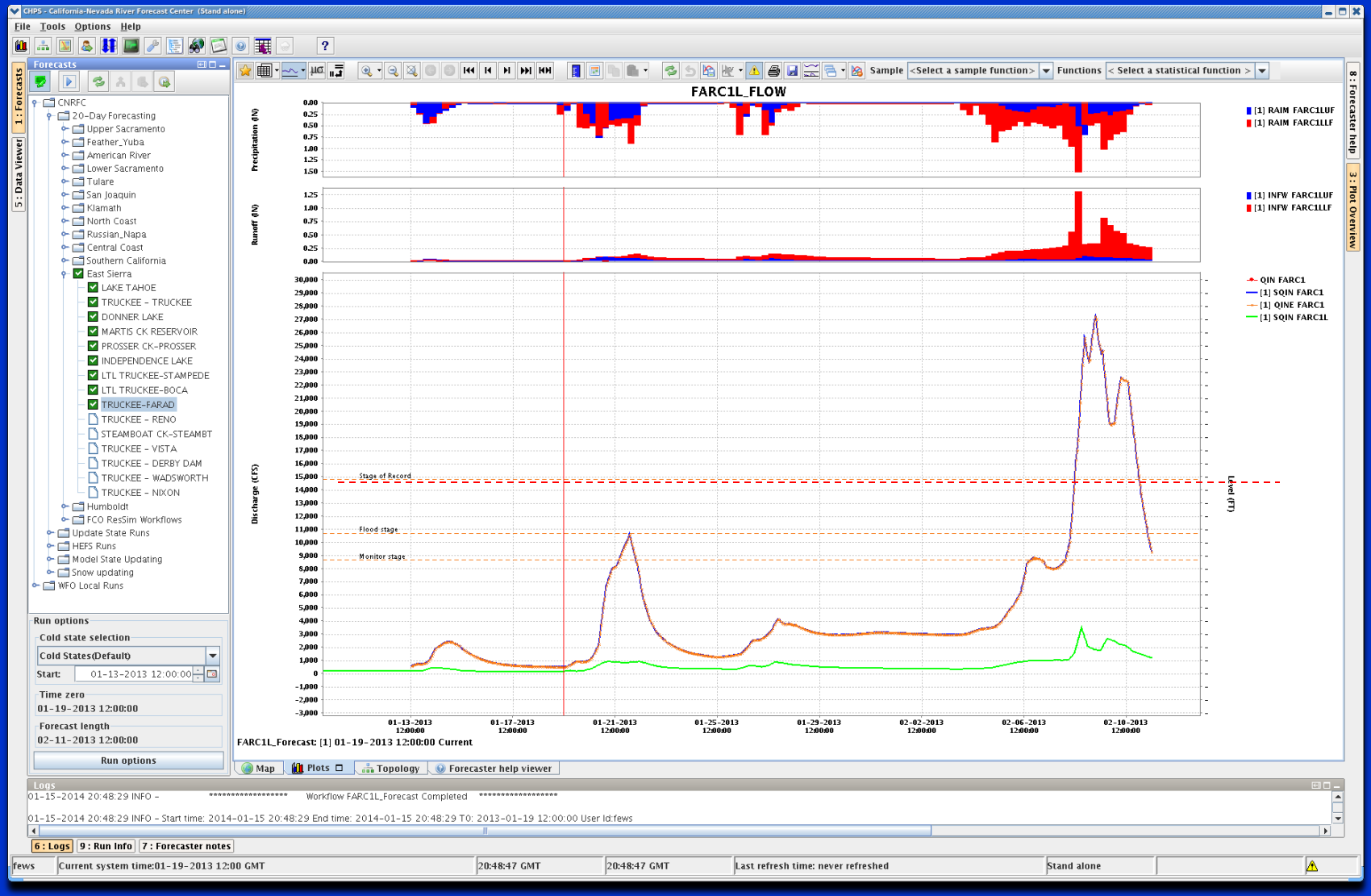
Lake Tahoe Outflow



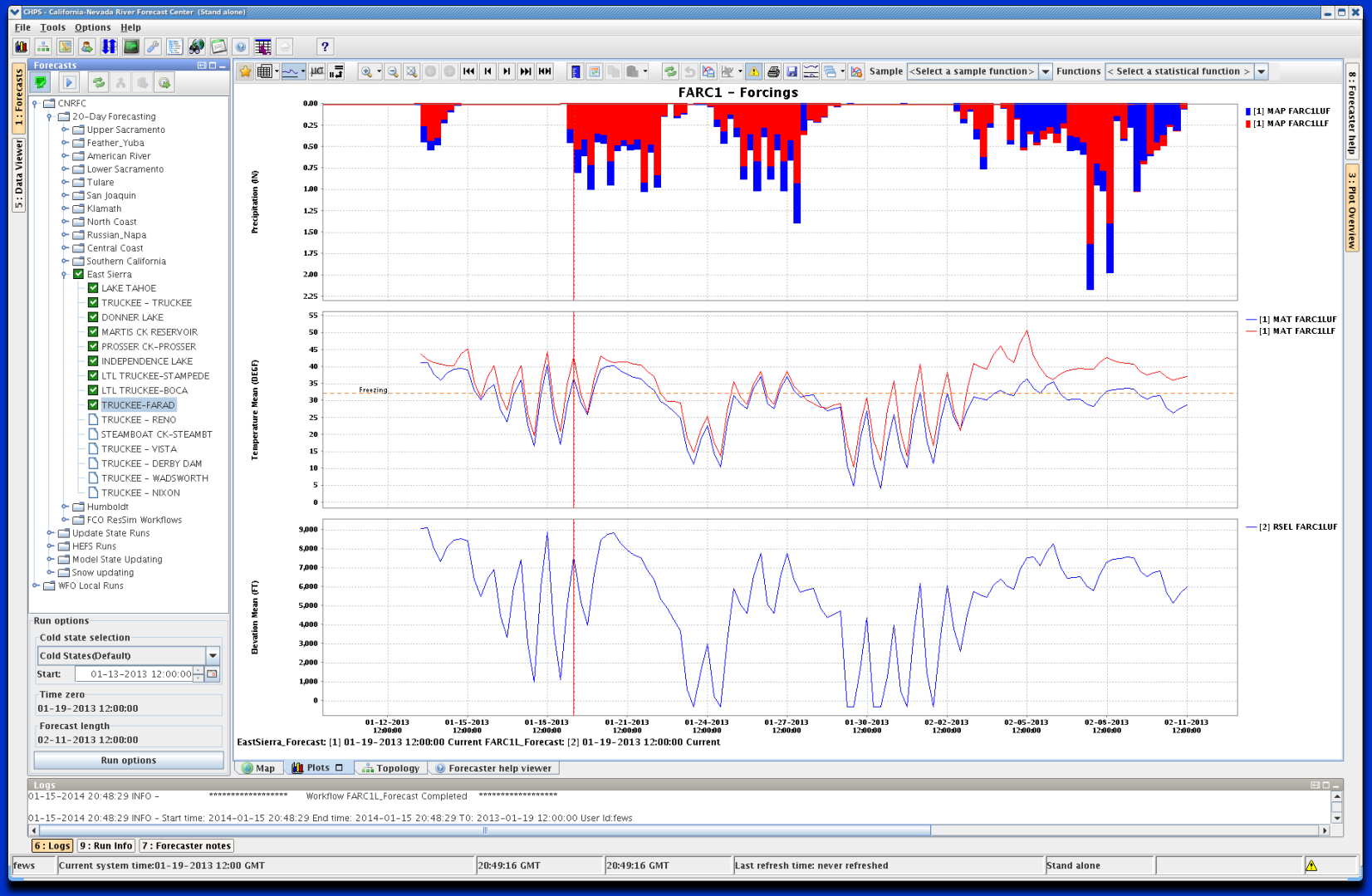
Truckee at Truckee



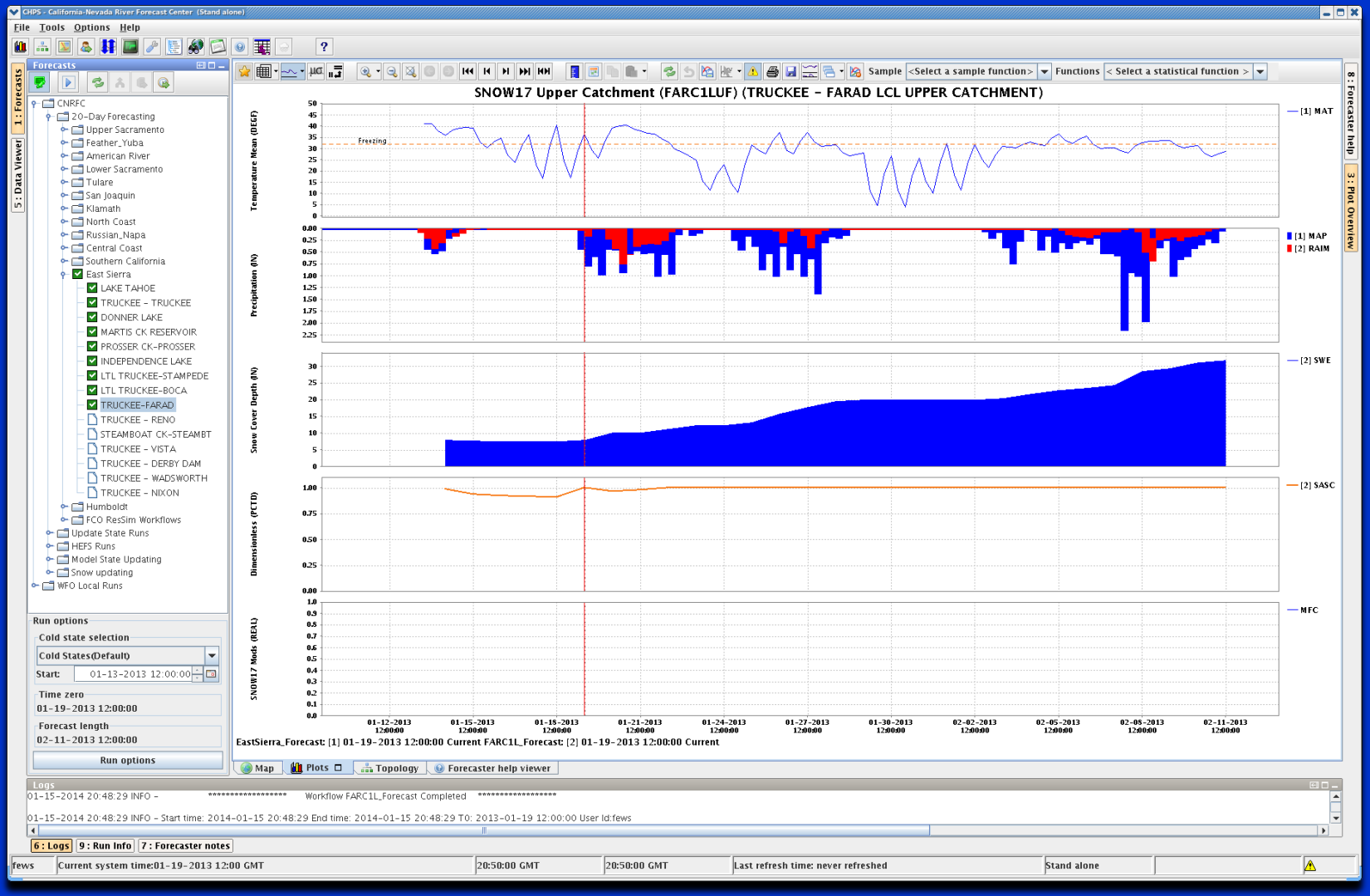
Truckee at Farad



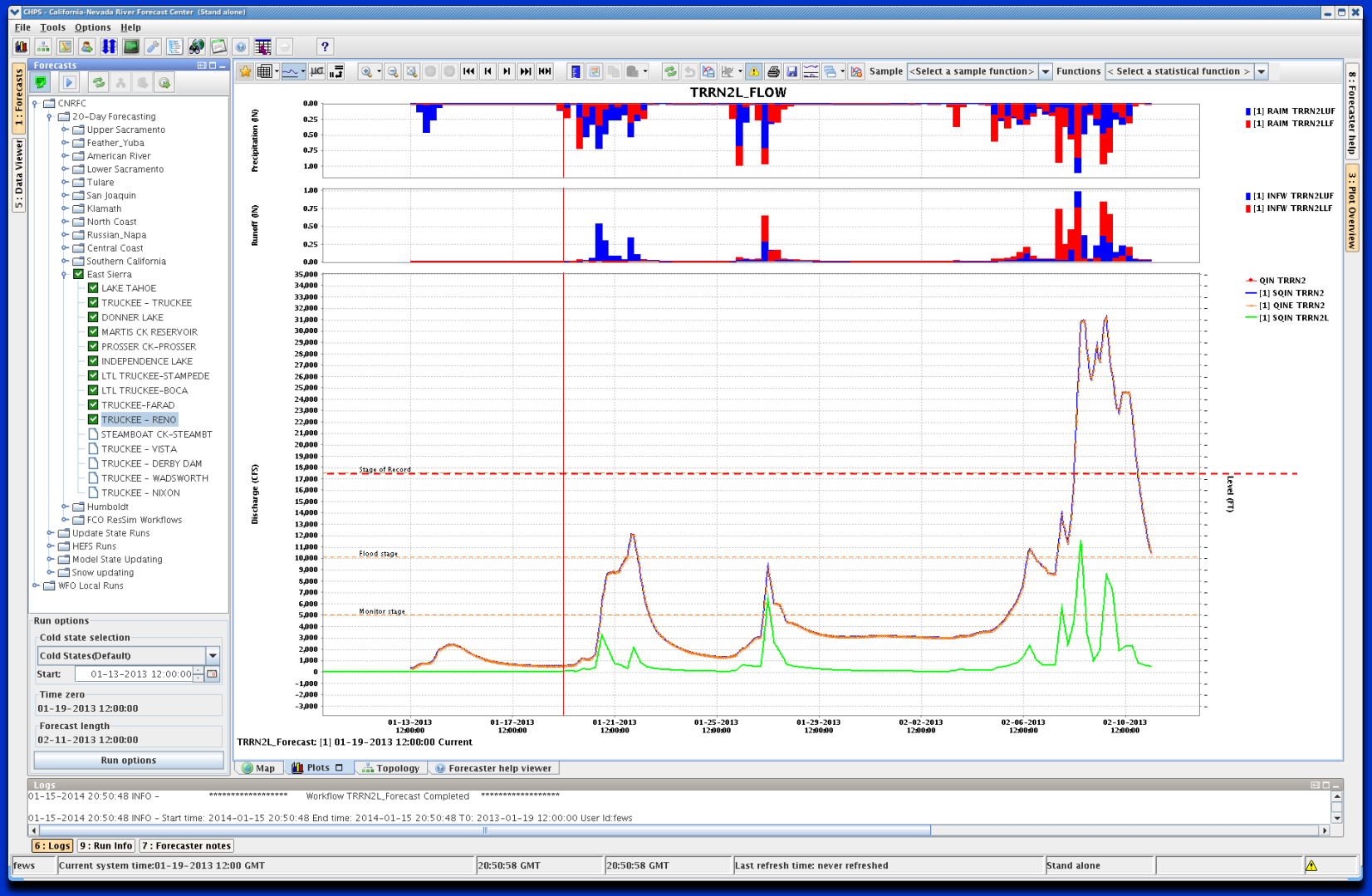
Truckee at Farad - Forcings



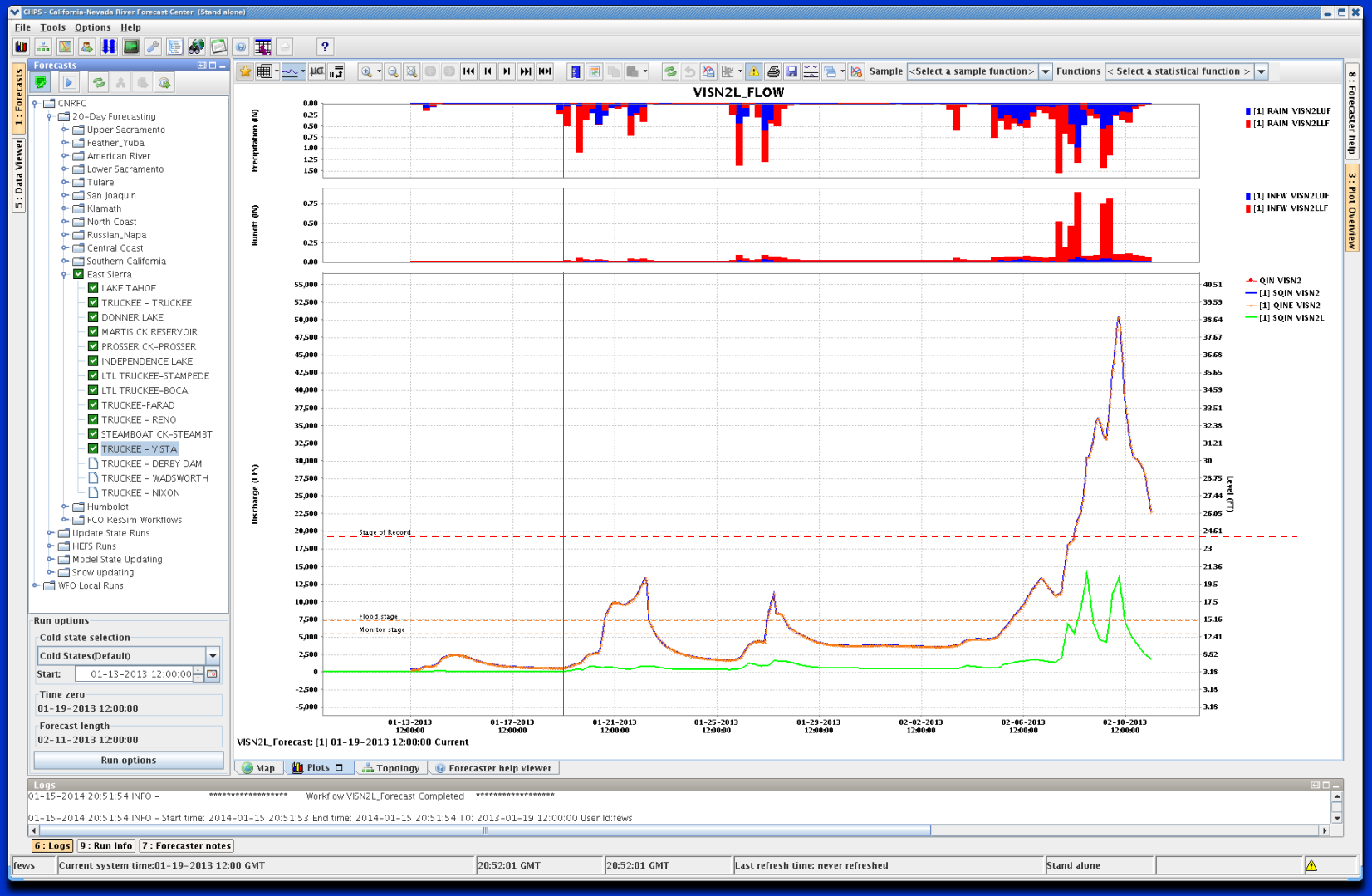
Truckee at Farad – Snow Model



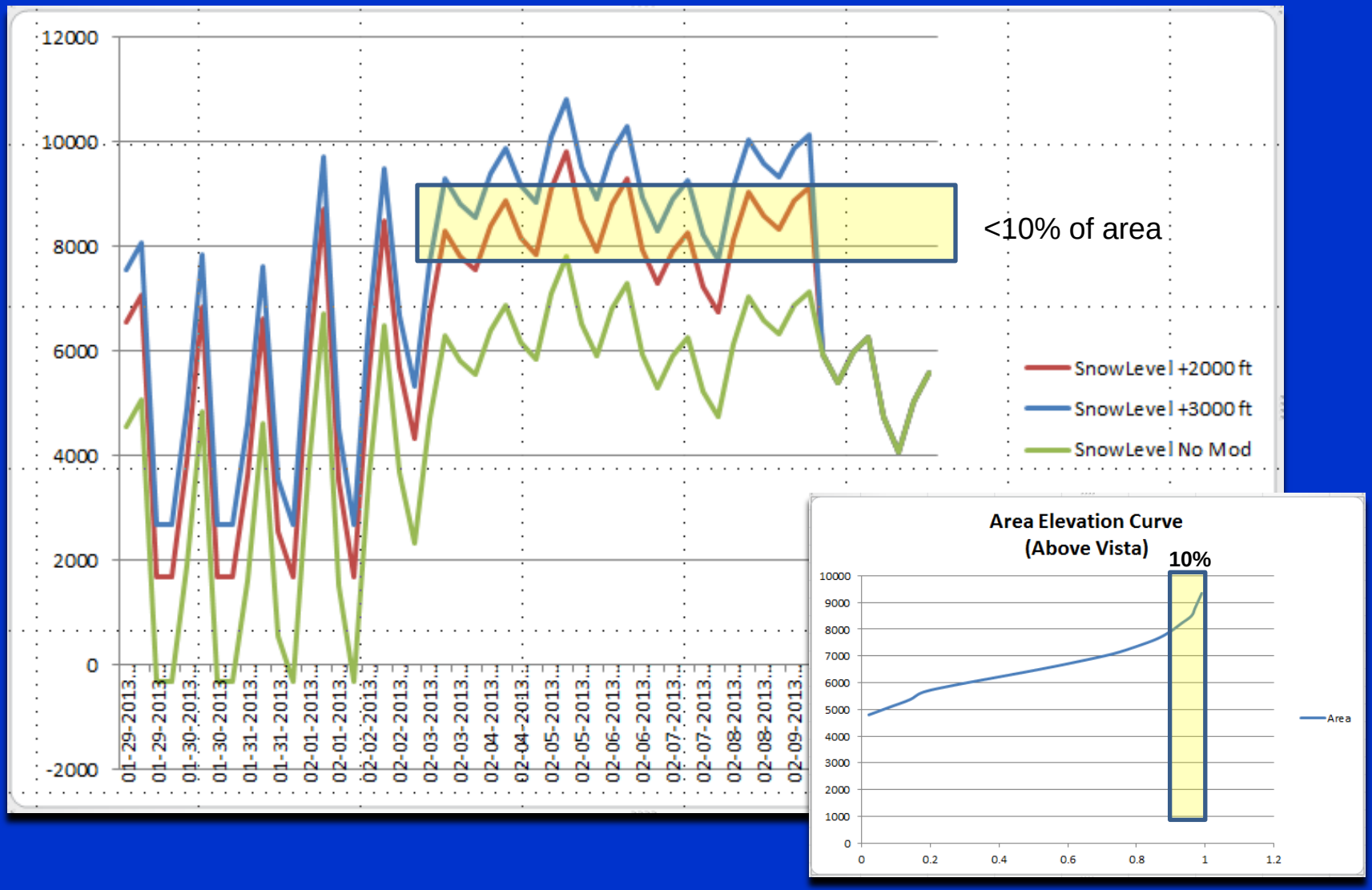
Truckee at Reno



Truckee at Vista



Snow Level Sensitivity
Truckee at Vista



Snow Level Sensitivity
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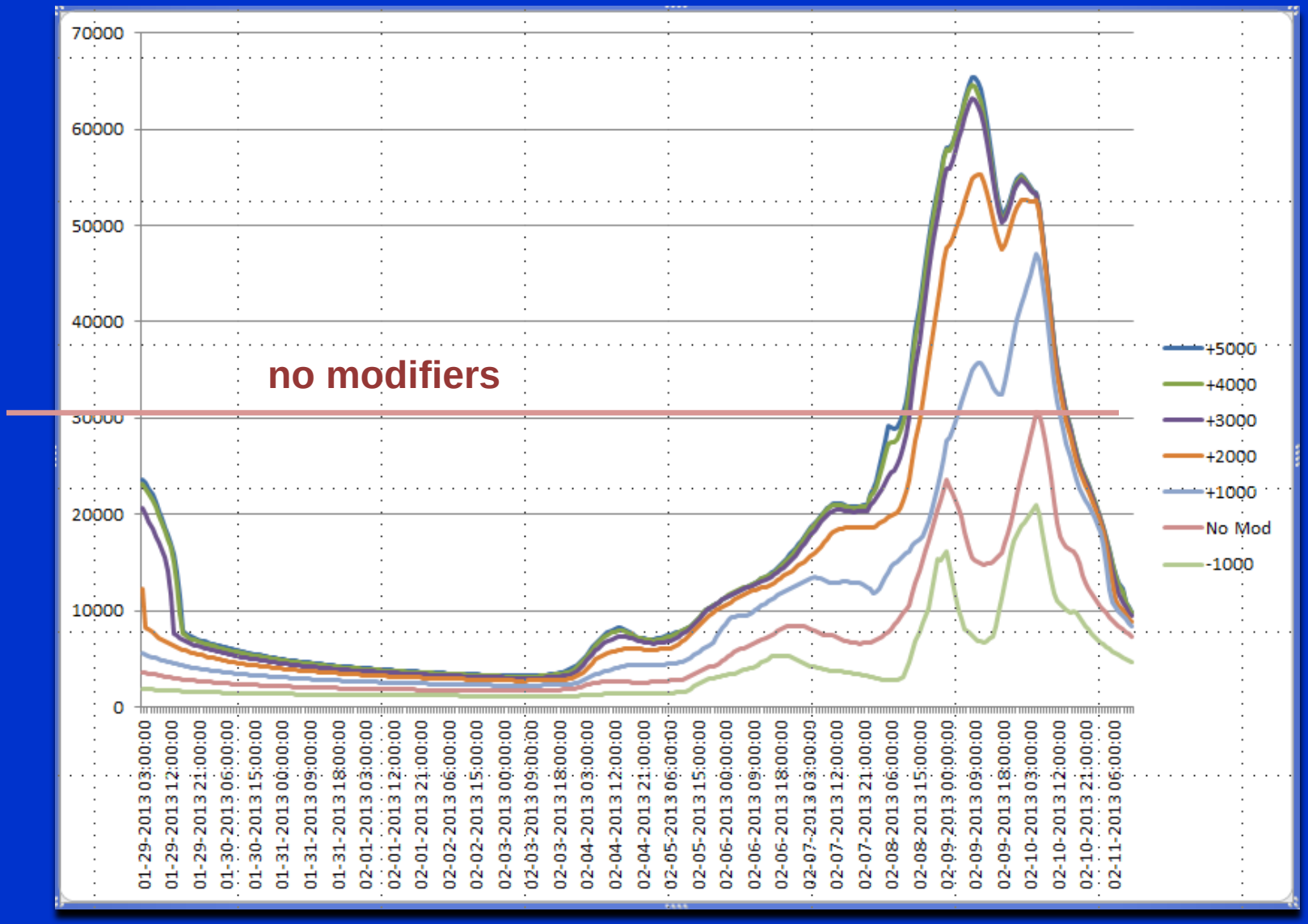

Simulation Results

Location	1/20/2013 Day 2	1/21/2013 Day 3	1/22/2013 Day 4	1/23/2013 Day 5	1/24/2013 Day 6	1/25/2013 Day 7	1/26/2013 Day 8
Truckee @ Farad			touches flood stage				
Truckee@Reno		exceeds flood stage	crests at 12,000 cfs				
Truckee@Vista		exceeds flood stage	crests at 13,300 cfs				
	1/27/2013 Day 9	1/28/2013 Day 10	1/29/2013 Day 11	1/30/2013 Day 12	1/31/2013 Day 13	2/1/2013 Day 14	2/2/2013 Day 15
Truckee @ Farad							
Truckee@Reno							
Truckee@Vista	exceeds flood stage						
	2/3/2013 Day 16	2/4/2013 Day 17	2/5/2013 Day 18	2/6/2013 Day 19	2/7/2013 Day 20	2/8/2013 Day 21	2/9/2013 Day 22
Truckee @ Farad						exceeds flood of record	crests at 25,250 cfs
Truckee@Reno						exceeds flood of record	Crests @ 29,200 cfs
Truckee@Vista				exceeds flood stage		Exceeds flood of record	
	2/10/2013 Day 23	2/11/2013 Day 24					
Truckee @ Farad		falls below flood stage					
Truckee@Reno		falls below flood stage					
Truckee@Vista	crests at 48,300 cfs						

Key	
	= above FS
	=river crests above FS
	=river exceeds flood of record
	=river crests above flood of record

Summary

- Dealing with events in real-time is much more complex than depicted in scenarios
  - Inputs are forecast-based (not observation based!)
  - Actual hydrology and water management can be complex
  - Data availability will be an issue
  - simulations can be highly sensitive to certain factors such as snow level
- CHPS framework allows scenarios like ARkStorm to be run on operational modeling system
- Hydrographs with a realistic look and feel can be generated for use in functional exercises

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Acknowledgments

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The presenters would also like to acknowledge Dr. Michael Dettinger of the U.S. Geological Survey and the Scripps Institution of Oceanography for suggesting our participation in this project and for providing helpful pointers on getting the project started.

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