HMT Annual Science Meeting
Hydrologic and Surface Processes

8 November 2012

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OUTLINE

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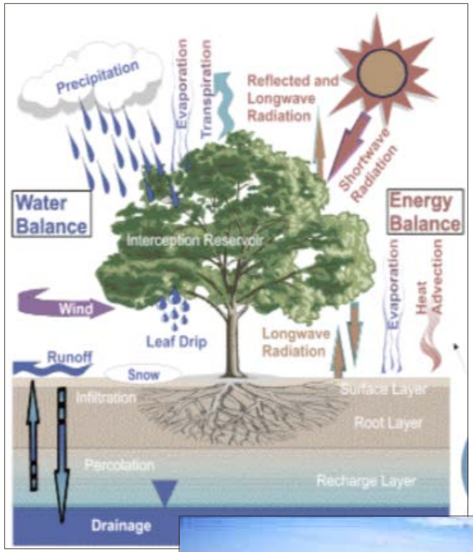
  - Soil moisture
  - Adaptive PRISM
  - Water management apps
- FY 12 Accomplishments
- FY 13 Plans
- Discussion

HASP Participants & Collaborators

- ESRL/PSD - Water Cycle Branch
  - Lynn Johnson
  - Chengmin Hsu
  - Rob Cifelli
  - Ben Moore
  - Dave Reynolds
  - Allen White
  - Robert Zamora
- ESRL GSD
  - Forecast Applications Branch
    - Ensemble QPFs
  - Information Systems Branch
    - System integration
- Univ. Washington
  - Jessica Lundquist
  - Nic Wayland
- Univ. Colorado
  - R. Balaji
- NWS
  - CNRFC
    - Rob Hartman
    - Art Henkel
    - Alan Haines
  - OCWWS – Ed Clark
  - IWRSS – Tim Schneider
  - OHD - Mike Smith, Brian Cosgrove, Victor Koren, Zhengtao Cui
  - NWRFC – Andy Wood
- California
  - Dept Water Resources
  - Sonoma County Water Agency
  - San Francisco PUC

HASP Topics

- Distributed hydrologic modeling
  - Russian-Napa, N Fk American, Babocomari
  - Setup, sensitivity, calibration, verification
  - Influence of scale
- QPE
  - Hydro model validation of QPE products
  - Snow melt
- Soil moisture
  - Monitoring – sensors, network
  - Validation of distributed model
  - Remote sensing
- QPF
  - HMT ensembles
  - Reforecasts
- Water Management
  - "Managed" flows
  - Operational science



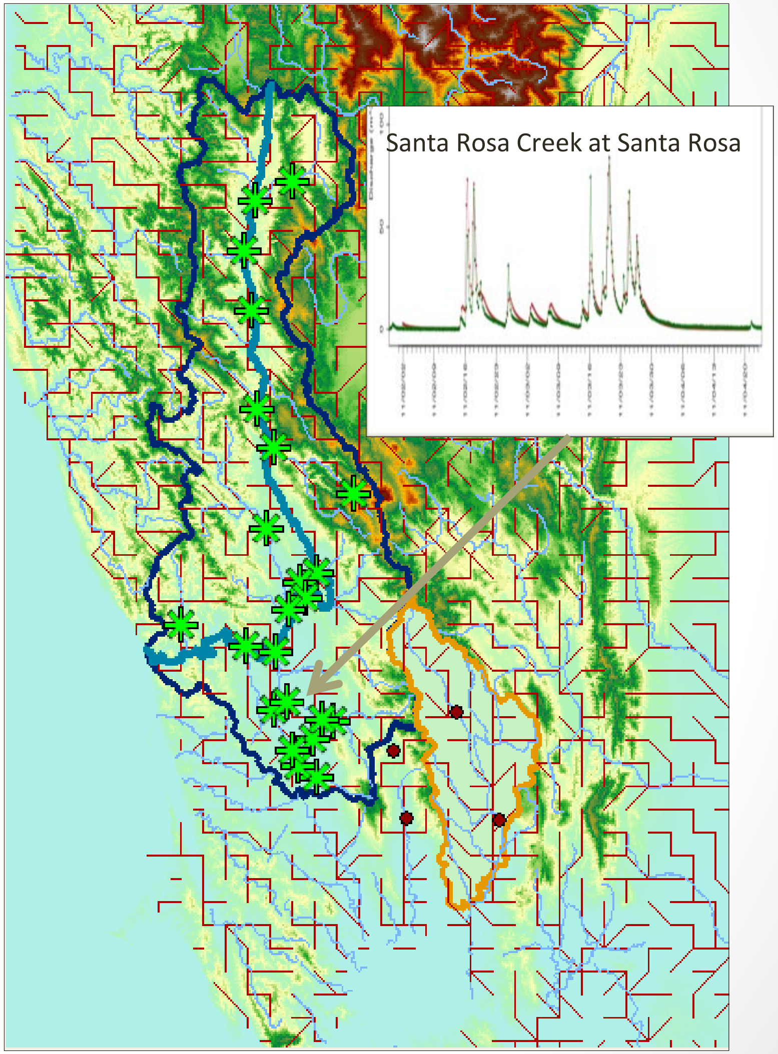
HASP Objectives

- Can distributed hydrologic models be used with current observational networks to provide accurate river simulations and forecasts?
- What is the performance of the distributed model given various inputs derived from as many sources as possible?
- What measurements and observational network density are most critical for accurate hydrological modeling?
- What level of hydrologic model complexity is appropriate for hydrologic forecasts operations?
- What is the level of uncertainty of hydrologic forecasts?
- How can a distributed modeling approach be applied for operations?

Ref: OHD Science Plan 2009

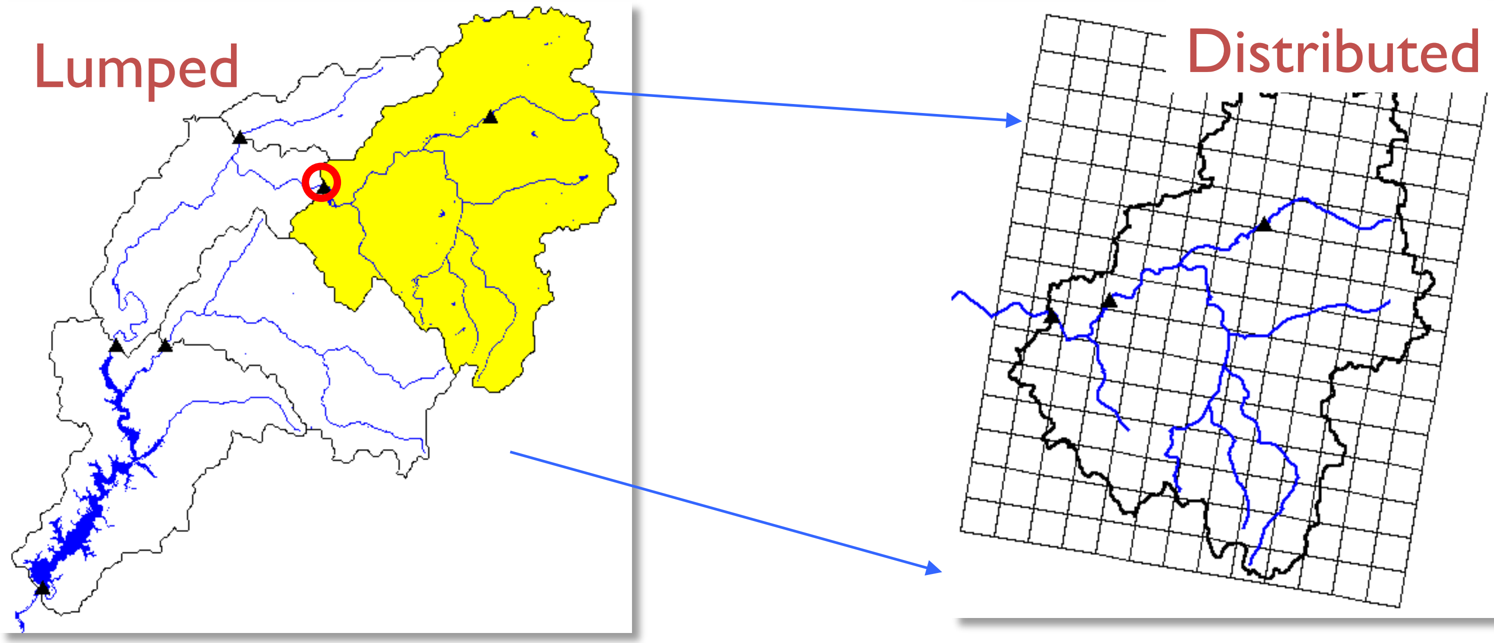
Russian-Napa Basins 2-D Model

- Purpose:
  - Account for spatial distribution of rain, topography, soils, land use and runoff
  - Tool to assess QPE/QPF products
- Research Distributed Hydrologic Model (RDHM)
  - 2-D using HRAP grid (~4.1 km side)
  - Gridded precipitation and surface temperature
  - Sacramento Soil Moisture Accounting Model (SAC-SMA) in each grid cell
  - Connectivity derived from DEM
  - Runoff (overland and channel) routed by kinematic wave equations
  - Soils parameters based on SSURGO
  - Channel routing based on USGS field measurements
  - Soil moisture linked to observations



Lumped vs Distributed Models

Distributed models are well-suited for flash flood prediction and monitoring, offering high-resolution streamflow at outlet and interior points with ability to route flow.



1. Rainfall and soil properties averaged over basin
2. Single rainfall/runoff model computation for entire basin or sub-basin
3. Prediction/verification only at outlet point

1. Rainfall, soil properties vary by grid cell
2. Rainfall/runoff model applied separately to each grid cell
3. Prediction/verification at any grid cell

Ed Clark

OHD Research Distributed Hydrologic Model (HL-RDHM)

Precipitation
Temperature
Potential Evaporation

Snow17 Snow Model

rain + melt

Sacramento Soil Moisture Model

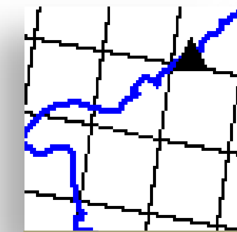
surface/impervious/direct runoff

Hillslope Routing
(brings within-cell flow into channel)

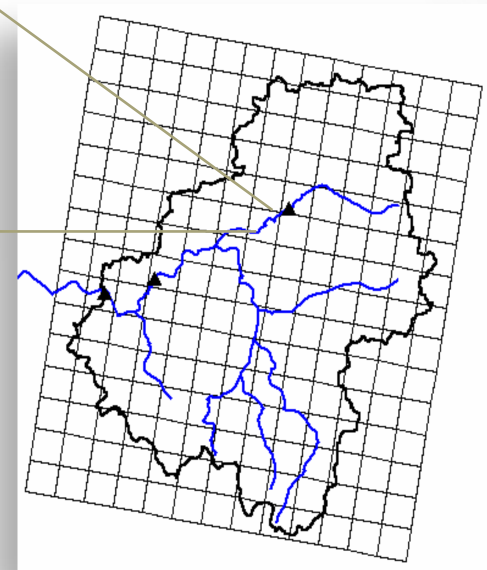
baseflow
interflow

Cell-to-Cell Channel Routing

Flows and State Variables



Modeling element

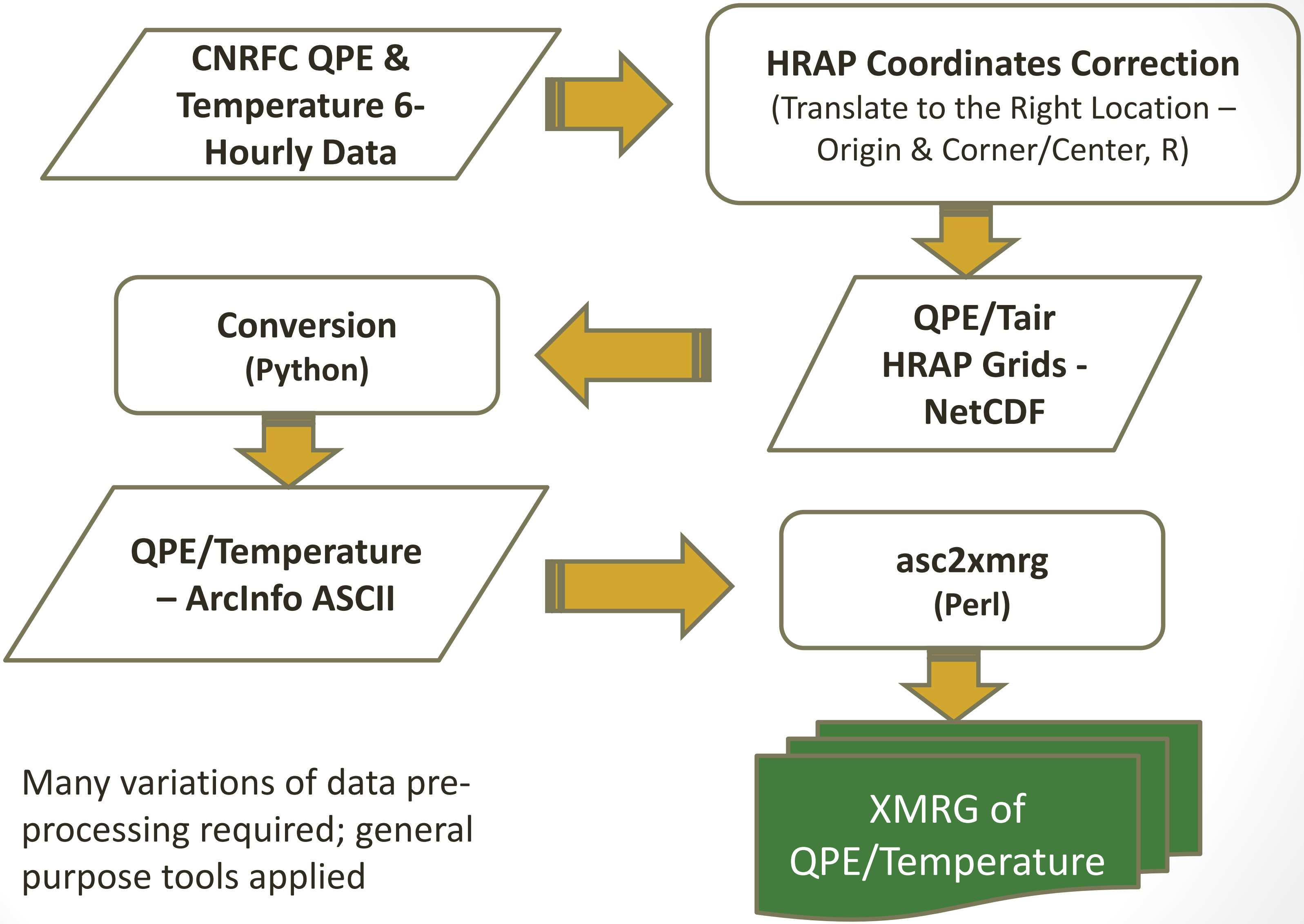


Local Discharge
Routed Discharge

DHM-TF
Flash Flood
Post Processor

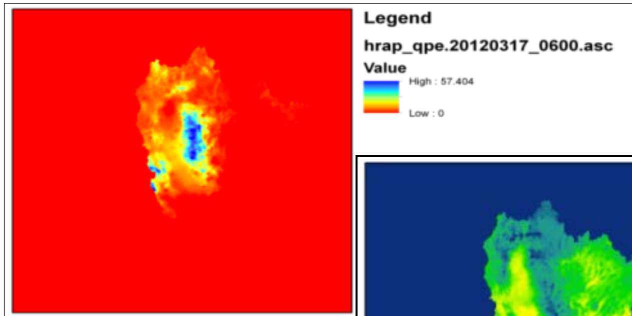
Ed Clark

Forcing Data Preparation

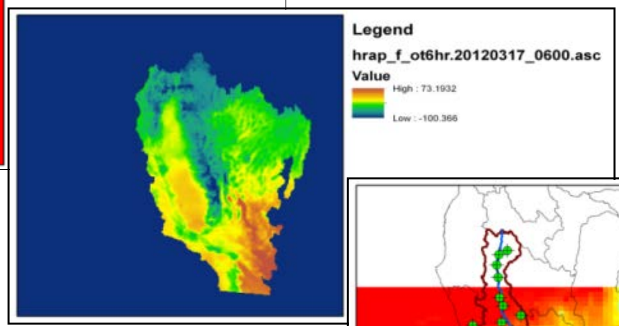


Many variations of data pre-processing required; general purpose tools applied

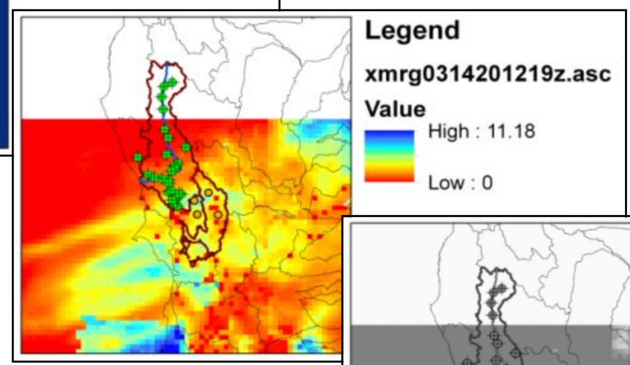
Various Forcings Data



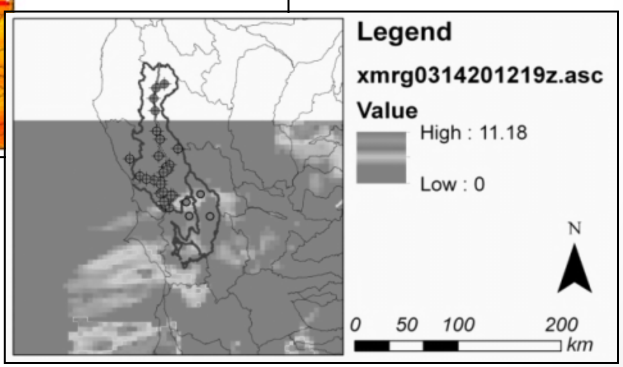
CNRFC
Stage III QPE



CNRFC
Temperature

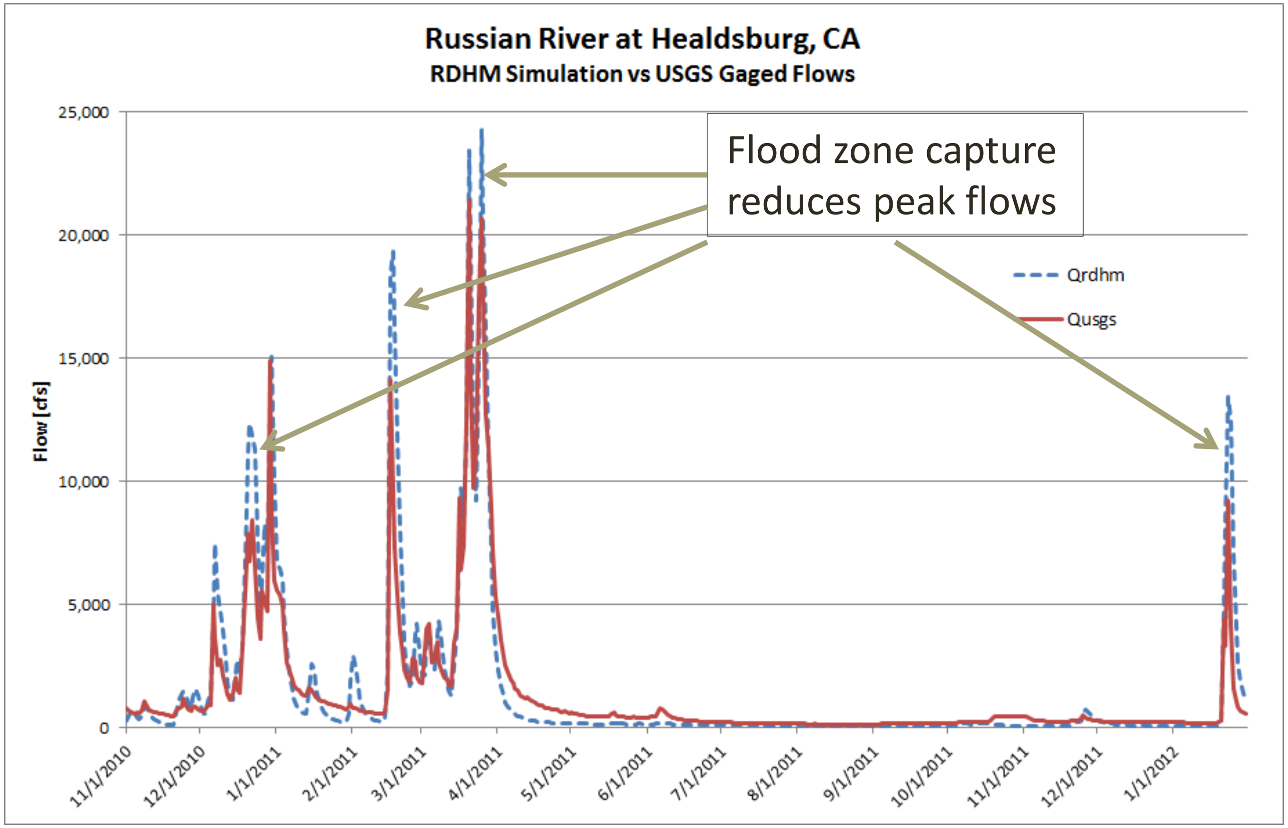


MTR MPE



NMQ

Initial Simulation Results



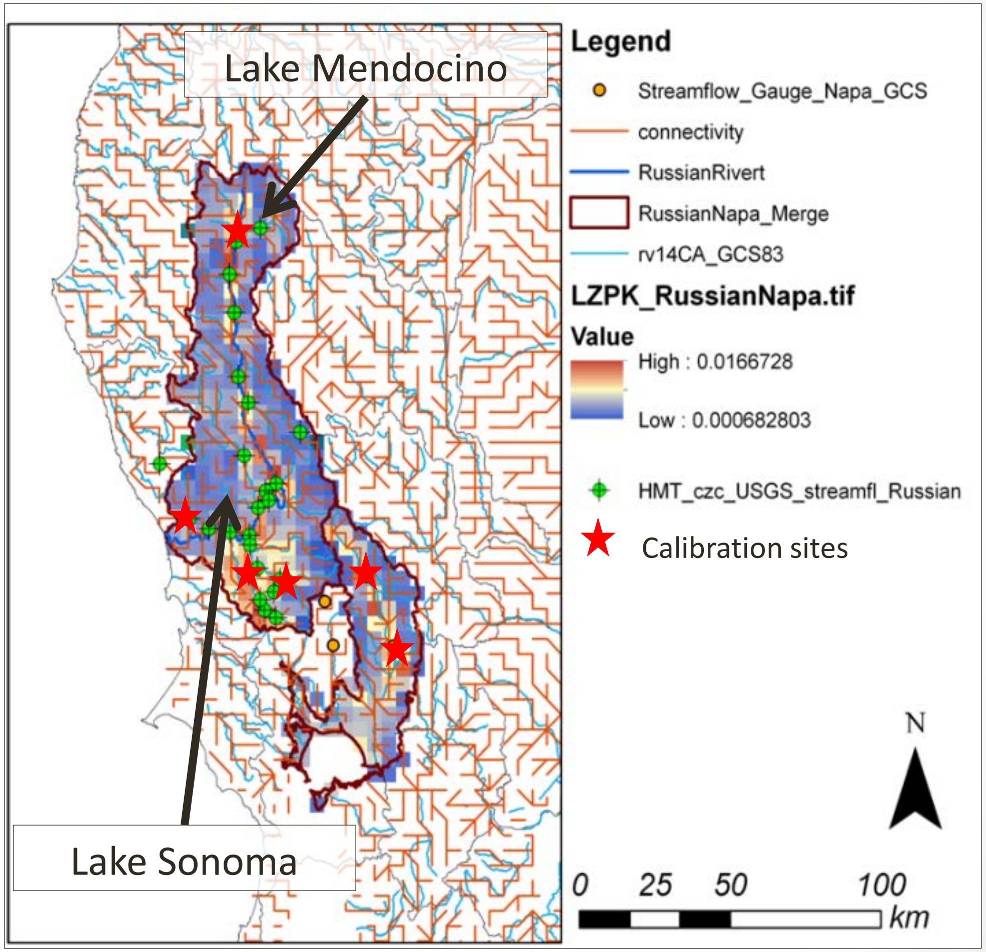
- Main stem RR (partially) controlled by Lake Mendocino
- Flood zone capture by USACE reduces peak flows
- Must include reservoir releases
- Releases obtained from SCWA
- RDHM calibration directed to unregulated tributaries

Most Sensitive RDHM/SAC Parameters

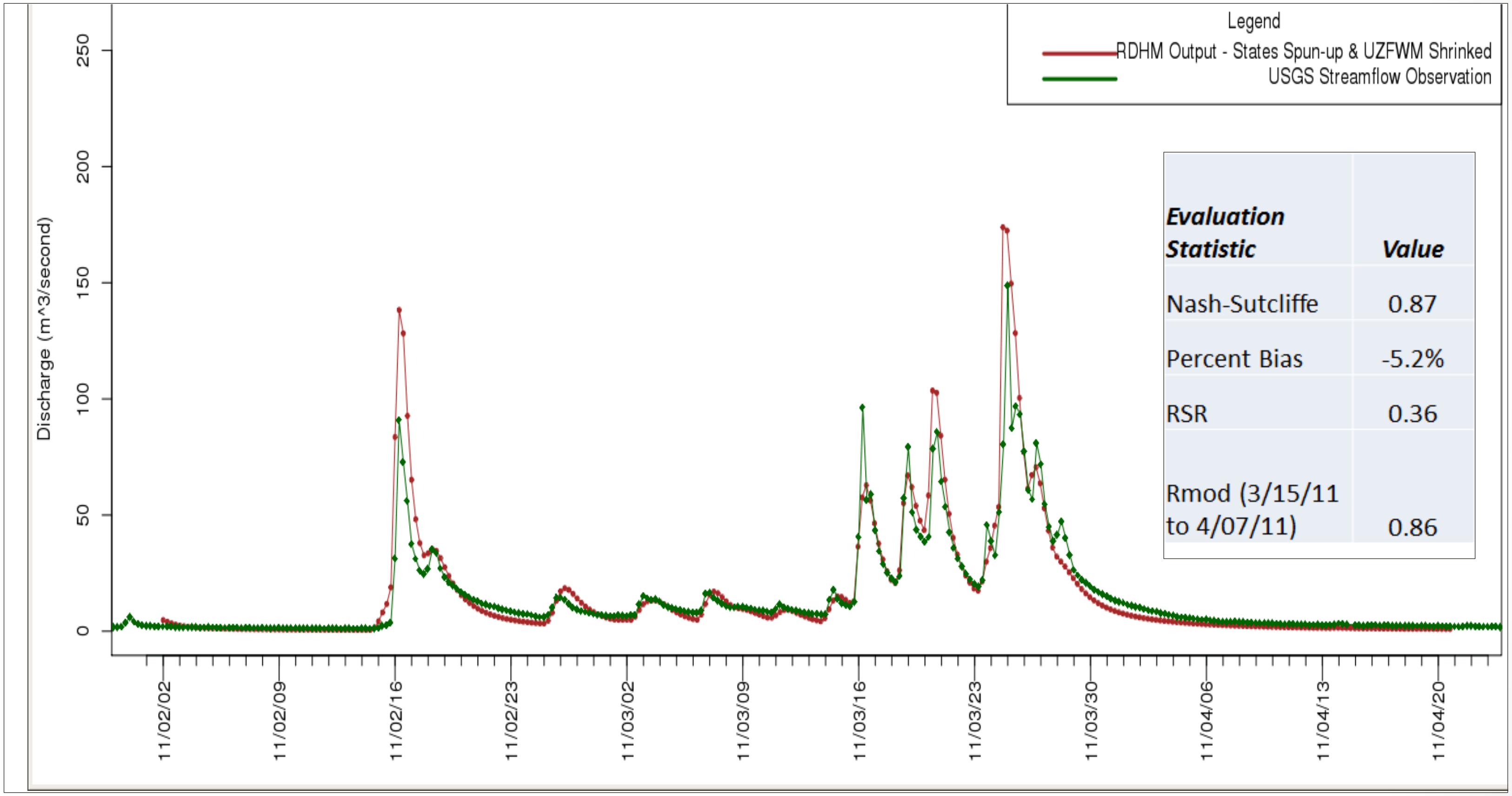
Parameter	Units	Description	Allowable range
UZTWM	mm	Upper zone tension water maximum storage	10 - 300
UZFWM	mm	Upper zone free water maximum storage	10–75
UZK	day^{-1}	Upper zone free water withdrawal rate	0.2–0.5
PCTIM	%/100	% permanent impervious area	0.0–0.05
ADIMP	%/100	% area contributing as impervious when saturated	0.0–0.2
RIVA	%/100	Percent area affected by riparian vegetation	0.0–0.2
ZPERC	none	Maximum percolation rate under dry conditions	20–300
REXP	none	Percolation equation exponent	1.4–3.5
PFREE	%/100	% of perc. going directly to lower zone free water	0–0.5
LZTWM	mm	Lower zone tension water maximum storage	75–300
LZFSM	mm	Lower zone free water supp. maximum storage	15–300
LZFPM	mm	Lower zone free water primary maximum storage	40–600
LZSK	day^{-1}	Lower zone supplementary withdrawal rate	0.03–0.2
LZPK	day^{-1}	Lower zone primary withdrawal rate	0.001–0.015

Calibration Sites on Unregulated Tributaries

- Managed flow Issues on main stem Russian River
- 1) Austin Creek nr Cazadero
- 2) Santa Rosa Creek at Santa Rosa
- 3) Russian River near Ukiah
- 4) Laguna de Santa Rosa near Sebastopol
- 5) Napa River near Napa
- 6) Napa River near St. Helena

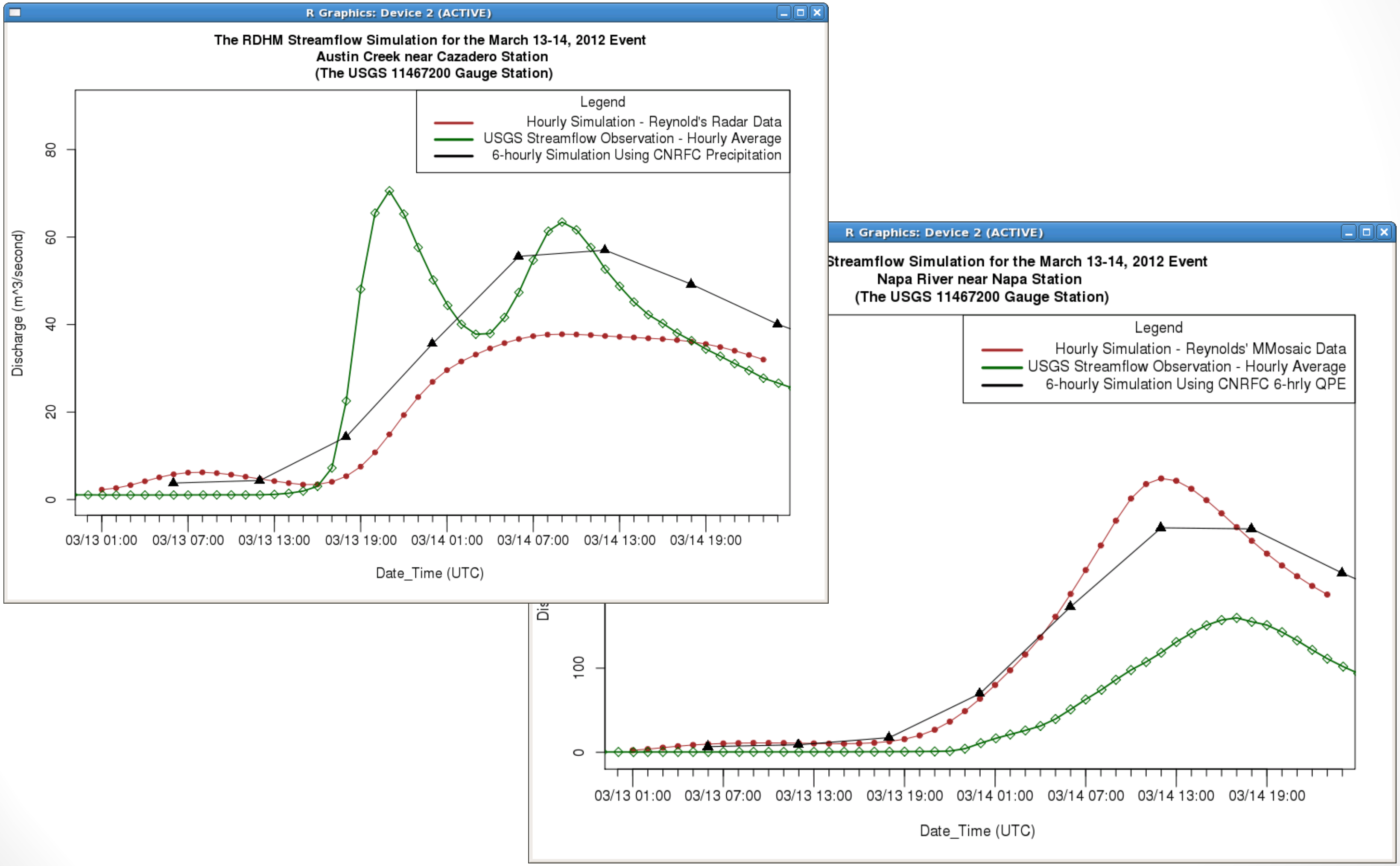


Russian River nr Ukiah

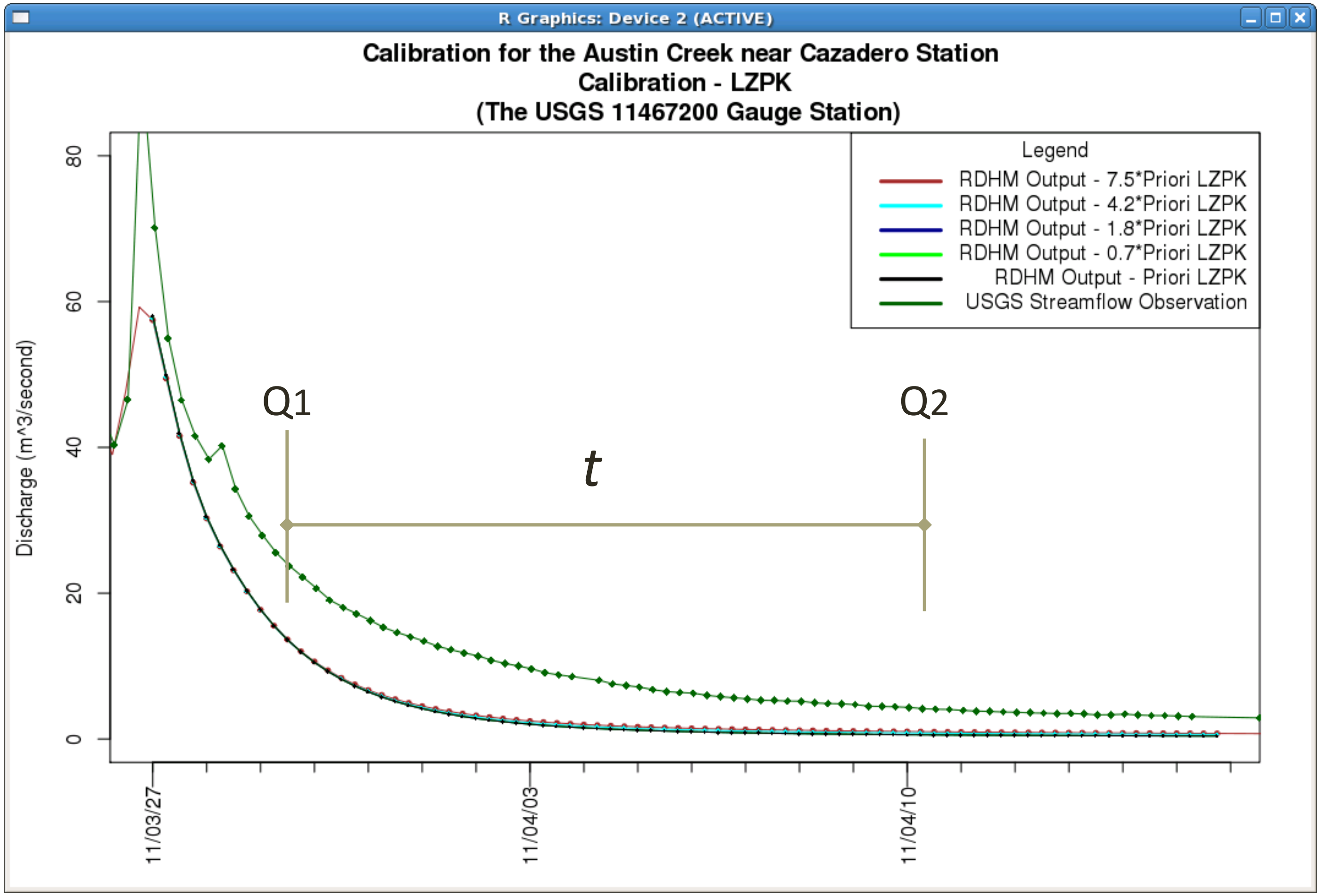


Evaluation Statistic	***Value***
Nash-Sutcliffe	0.87
Percent Bias	-5.2%
RSR	0.36
Rmod (3/15/11 to 4/07/11)	0.86

Evaluation of the MPE products for the March Event of 2012



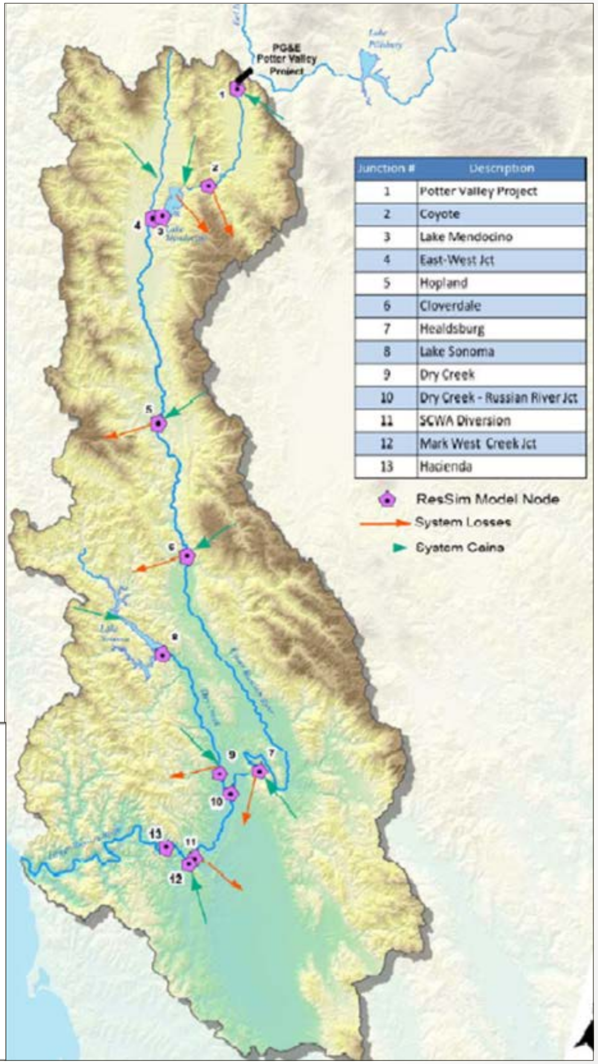
LZPK Calibration

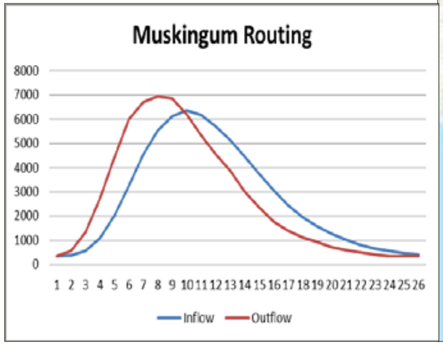


- LZPK: Lower Zone Primary Withdrawal Rate
- Primary Recession Rate, Kp = $(\frac{Q2}{Q_1})^{\frac{1}{t}}$
- LZPK = 1 - Kp

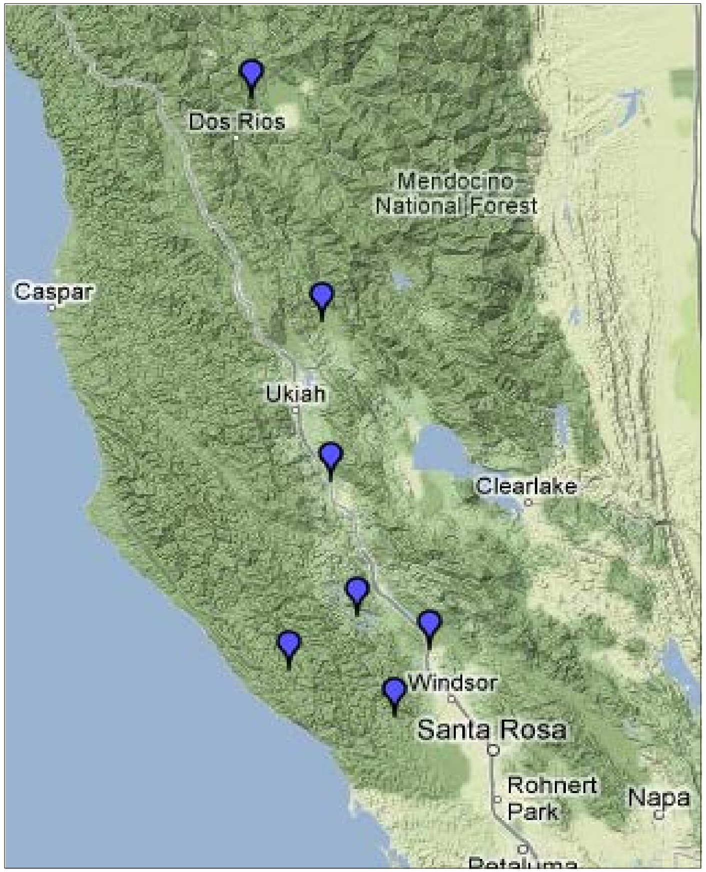
Potential Integration with ResSim

- "Natural" flows as input to ResSim
- "Managed" flows output from ResSim
- ResSim supports main stem flow routing
- Supportive to:
  - Retrospective analysis and design studies
  - Real-time operations
  - Purposes
    - Water supply
    - Flood operations
    - Fishery flows
    - Recreation

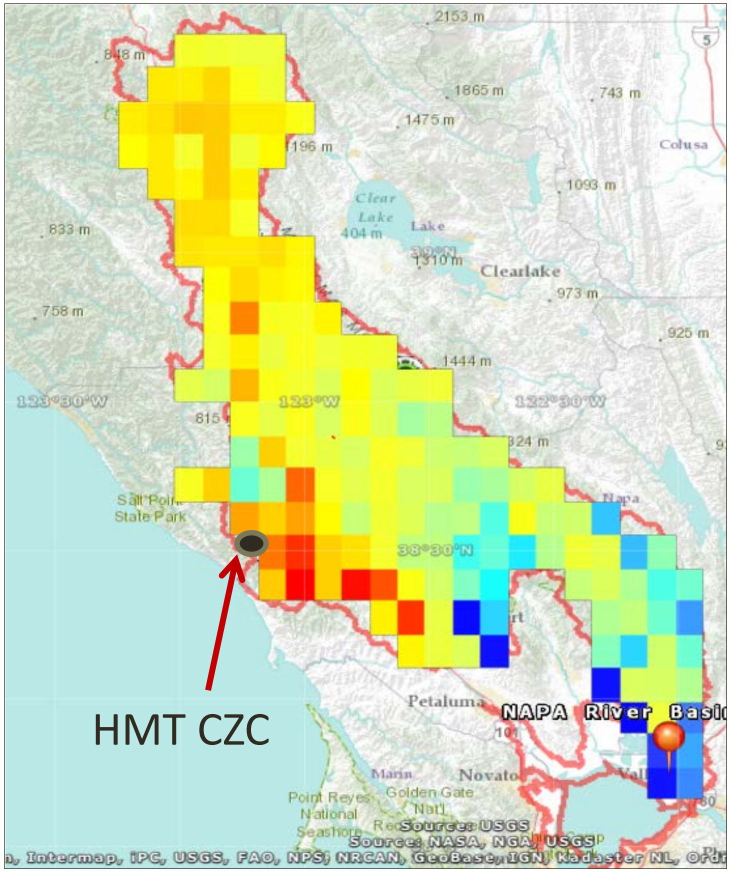




Soil Moisture Validation



Soil moisture monitoring stations



RDHM soil moisture simulation at 10 cm depth

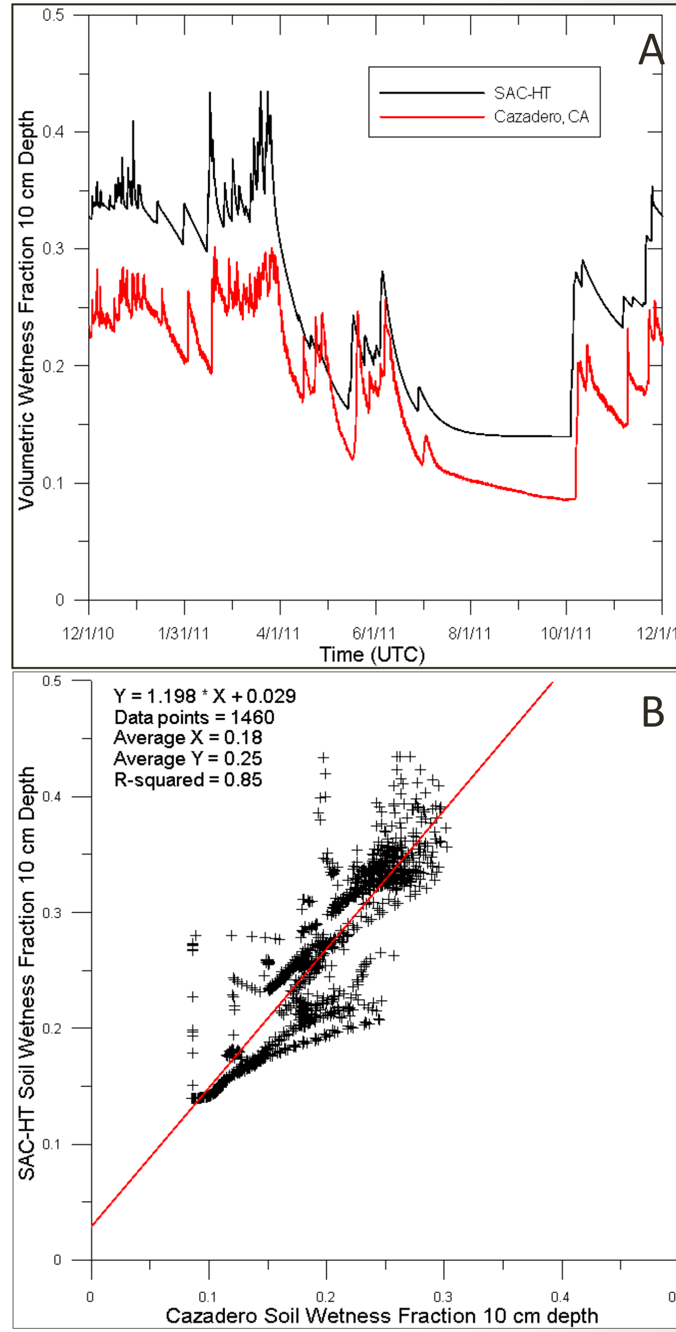
Russian River Soil Moisture Observing Sites

- Cazadero →
- ❖ Rio Nido
- ❖ Lake Sonoma
- ❖ Healdsburg
- ❖ Potter Valley
- ❖ Hopland
- ❖ Wilits

- ❖ Soil moisture and temperature (5, 10, 15, 20, 50, 100 cm)
- ❖ Standard meteorological surface observations
- Ground heat flux (2 cm)
- Eddy correlation momentum fluxes (9 m)
- Eddy correlation sensible heat flux (9 m)
- Eddy correlation latent heat flux (9 m)
- Normal incidence surface solar irradiance
- Diffuse surface solar irradiance
- Down-welling infrared irradiance
- Upwelling infrared irradiance
- Upwelling solar irradiance

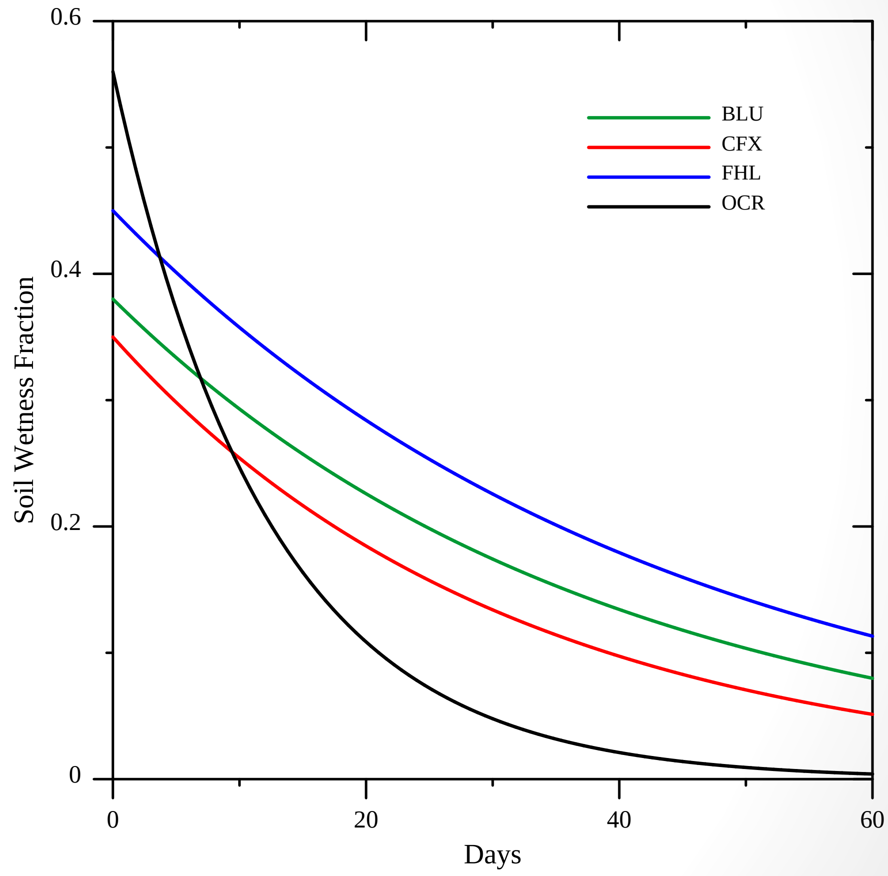
Soil Moisture Validation

- Comparison between monitored and simulated soil moisture
- A. Time series
  - Observations suggest HL-RDHM has a “wet bias” in upper zone
  - May be the correspondence between SAC “tanks” and actual soil layers
  - RDHM captures infiltration and dry-down events
- B. Regression shows good correspondence
- RDHM HT-ET could resolve differences



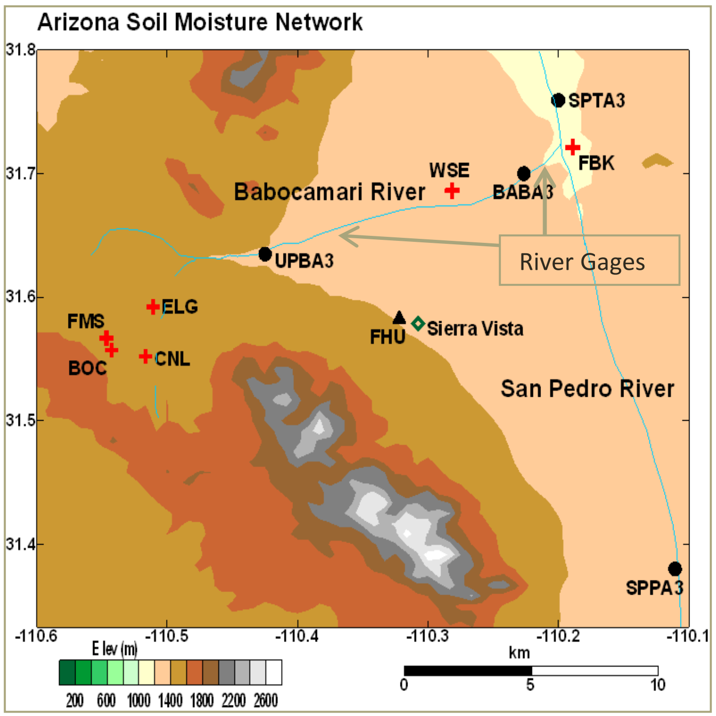
Influence of Soil Texture on Soil Water Storage - North Fork American River Basin

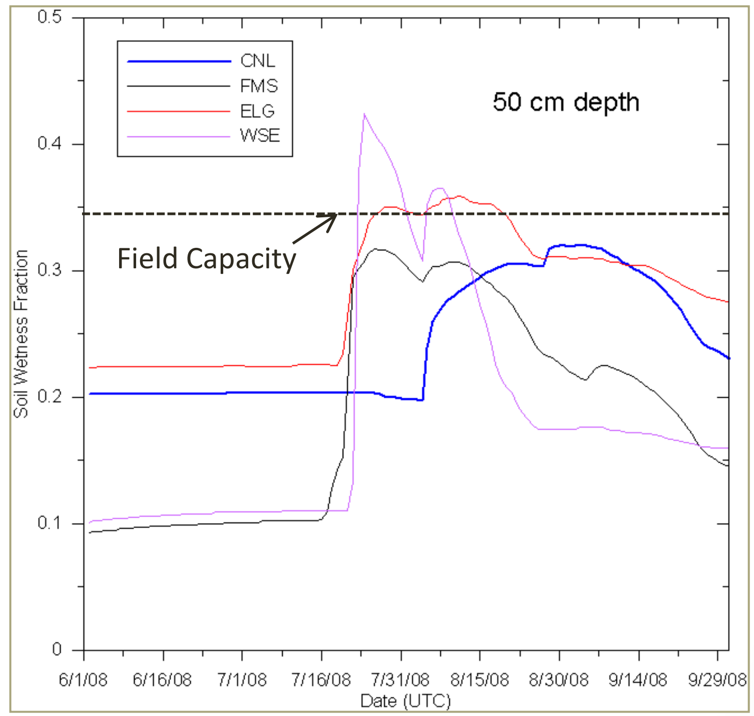
- HMT soil moisture observations used to quantify the way the basin stores and releases water during the spring runoff season
- Upper basin alluvial soils drain quickly - Onion Creek (OCR)
- Lower basin higher clay content soils retain water longer - Foresthill (FHL), Colfax (CFX)
- Soil texture transition zone lies at Blue Canyon (BLU)
- Maximum precipitation and soil water storage occur at BLU
- Suggests that flood potential may increase if more winter precipitation falls as rain in the upper basin



Soil Moisture – Babocomari Basin, AZ

22 July 2008 rainfall brought the soil column to wetness values exceeding field capacity; setting the stage for the flood observed 23 July in the lower basin*

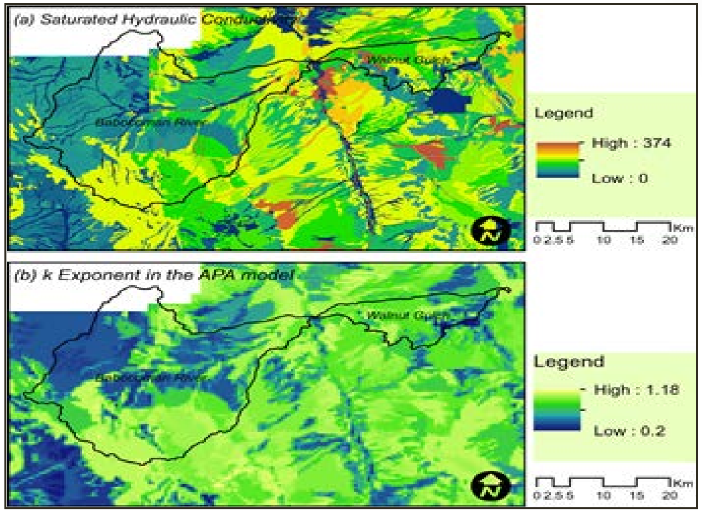


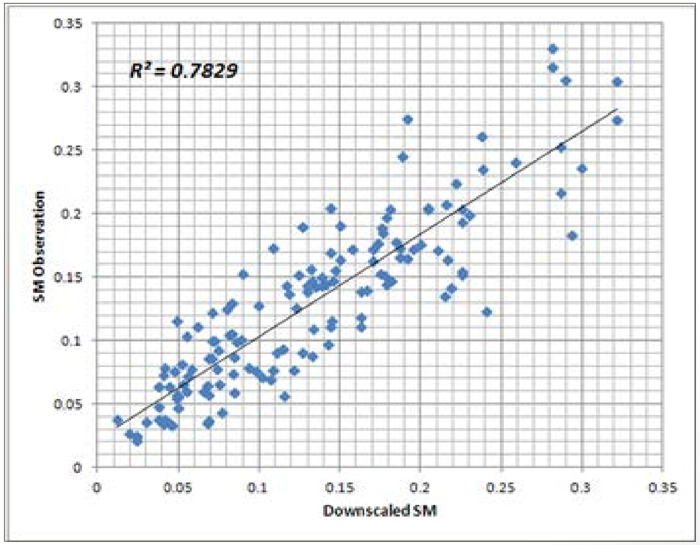


*Zamora, R. et al. 2009: The NOAA Hydrometeorology Testbed Soil Moisture Observing Networks: Design, Instrumentation, and Preliminary Results. J. Hydromet. October.

Downscaling AMSR-E Soil Moisture Retrievals Babocomari Basin, AZ

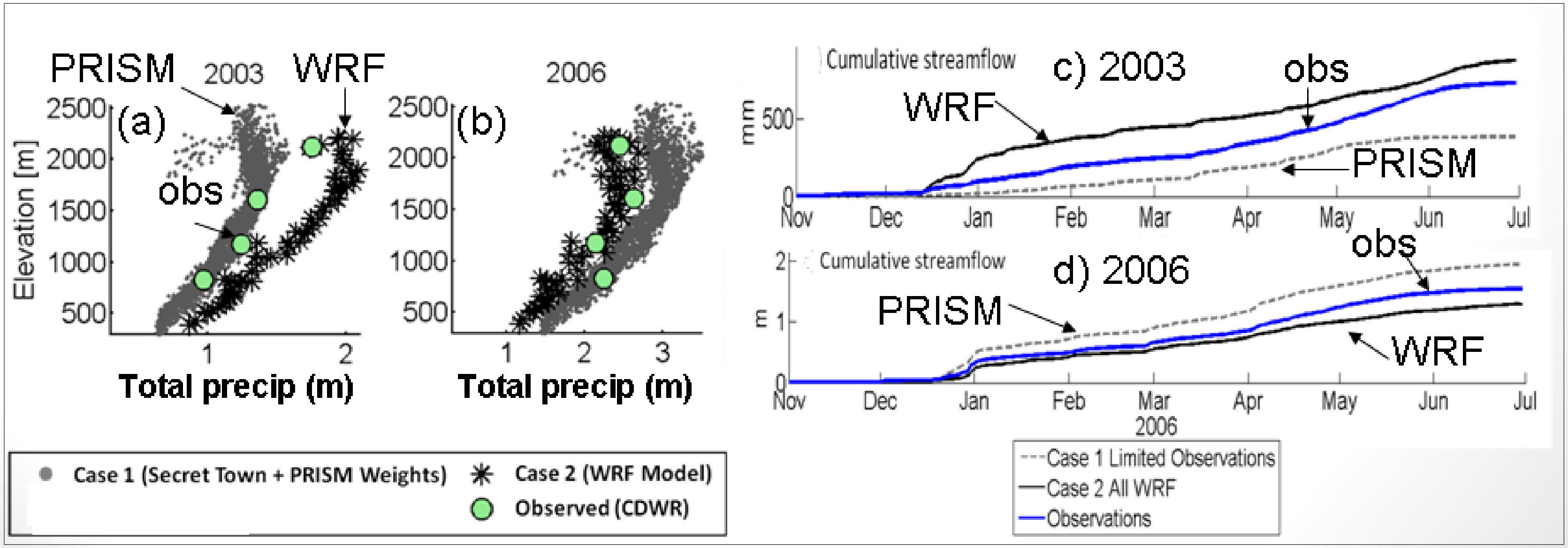
- Developed a Jarvis-type parameterization of the vegetation resistance, soil properties, and relative infiltration rate to calculate Antecedent Precipitation Accumulation (APA) retained in soil.
- Developed a GIS-based downscaling model using the 25-km AMSR-E soil moisture and APA as inputs; to generate 500-m resolution soil moisture.
- Hsu, et al 2012



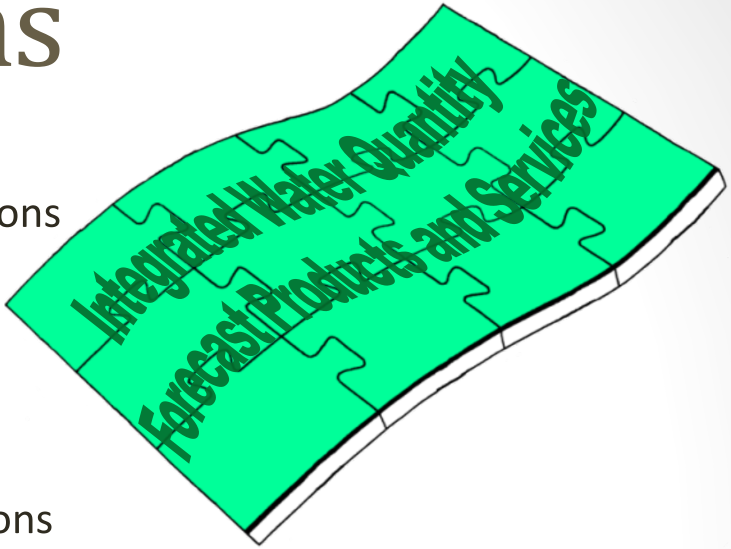


Intercomparison of Meteorological Forcing Data from Empirical and Mesoscale Model Sources - N.F. American River Basin, CA

- Although PRISM estimates appear to overall better match the majority of gauge observations in 2003 (a), cumulative observed streamflow (c) more closely matched streamflow modeled with WRF precipitation input.
- Multi-year simulations (c,d) showed that neither WRF nor PRISM has a systematic bias that could be corrected for but rather, had biases varying by storm that accumulated to over- or under-prediction of cumulative streamflow in different years. (from Wayand et al., 2012 submitted)



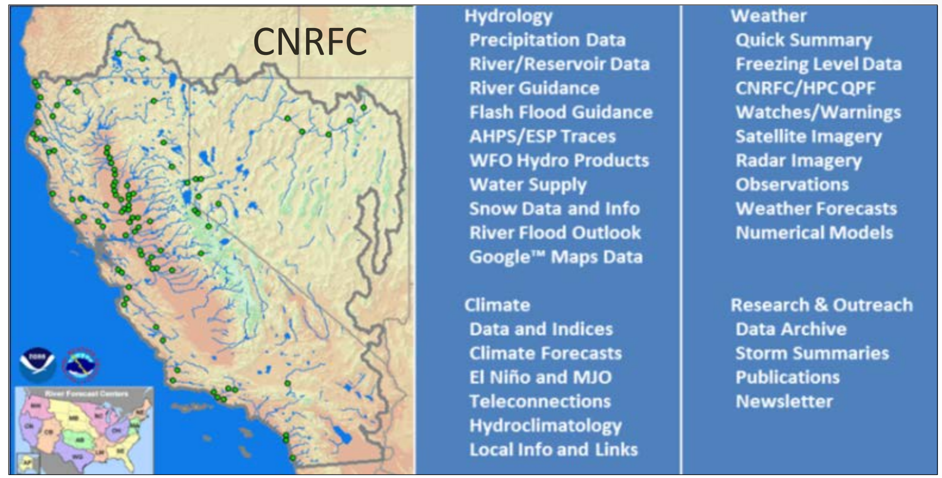
IWRSS Connections

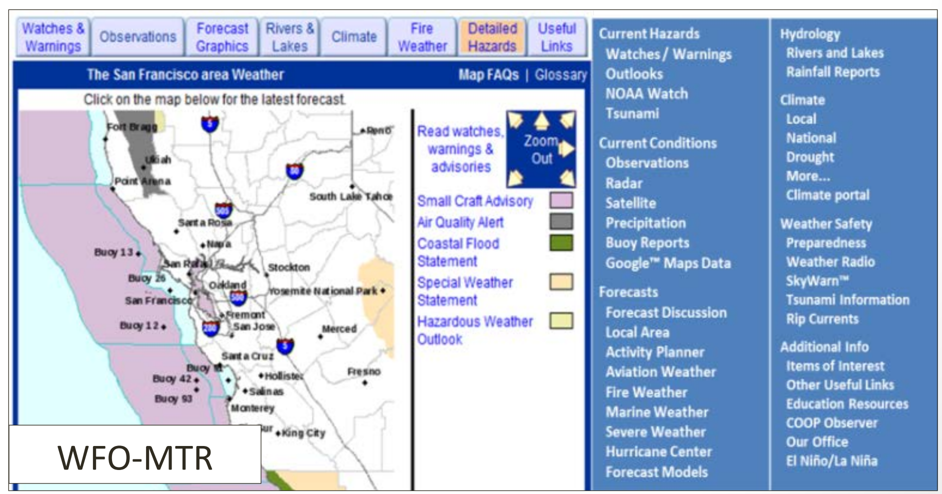


- Human Dimensions
  - Stakeholder interactions and communications
  - Needs assessments
  - Benefits of services
  - Outreach aids and web site content
- Information Services
  - Acquisition and management of observations
  - Data exchanges, eGIS and geo-Intelligence, integrated information delivery
  - System interoperability
- Operational Science
  - Summit-to-sea modeling and prediction framework
  - Historical context and trend information
  - Advance water flow and management capabilities
  - Improve the use of observations
  - Quantify uncertainties and validate analyses and forecasts
  - Relate stakeholder needs to the design and function of operational tools

Partners and Customers for Advanced Precipitation Products

- NOAA Forecast Offices
  - NWS California-Nevada River Forecast Center
  - NWS Weather Forecast Offices (SF Bay Monterey, Sacramento, Ukiah)
- State and local agencies
  - DWR EFREP
  - SCWA
  - SFPUC





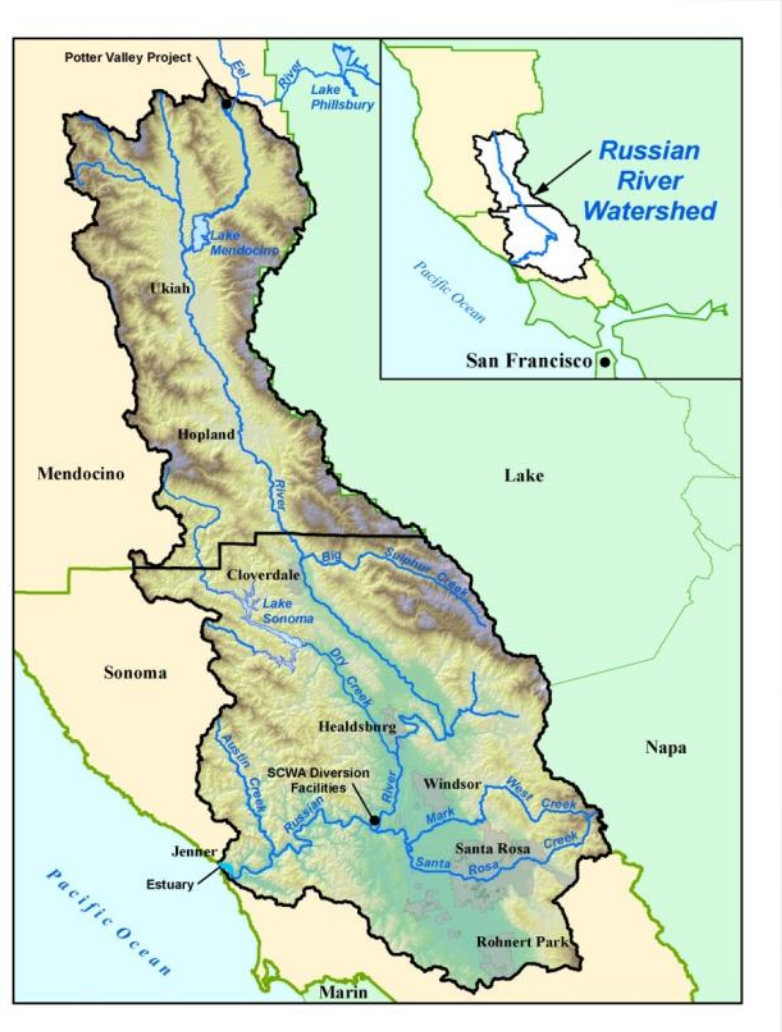
Water Management Actions

Time Frame / Purpose	Nowcast (0 min – 6 hrs)	Near Real-time (6 hr – 1 day)	Short-term (1 day – 1 week)	Near-term (1 wk – 3 mon)	Mid-term (6 mon – 2 yrs)	Long-term (5 years+)
Flood Mitigation	Flood status assessment	FF warning; Response deploy; System opt.	Flood warning; Response deploy; Reservoir FBO	Flood warning; Response deploy; Reservoir FBO	Over-year storage allocation	Flood frequency; Capacity devel; Climate adapt.
Water Supply	Status assessment; Intake operations	Intake and outlet operations	Reservoir FBO; Emergency conservation	Delivery sched.; Reservoir FBO; Conservation	Over-year drought mit.; Conservation	Capacity devel; Demand mana; Climate adapt.
Hydro-Power	Release operations	Reservoir FBO	Reservoir FBO; Demand sched.	Reservoir FBO; Demand sched.	Over-year drought mit.	Capacity devel.; Climate adapt.
Ecosystem Enhancement	Status assessment	Threat assess; River & Reservoir FBO	Threat assess; River & Reservoir FBO	Threat assess; River & Reservoir FBO	Threat assess; Capacity devel; Drought mit.	Ecosystem & Capacity devel; Climate adapt.
Water Quality	Status assess; Real-time control	WW capture & treatment	Threat assess; Sys. optimize	Threat assess; Capacity devel; Sys. optimize	Threat assess; Capacity devel; Sys. optimize	Capacity devel; Climate adapt.
Recreation	Weather status; Warning	Event scheduling	Reservoir FBO	Reservoir FBO	Capacity development	Capacity development

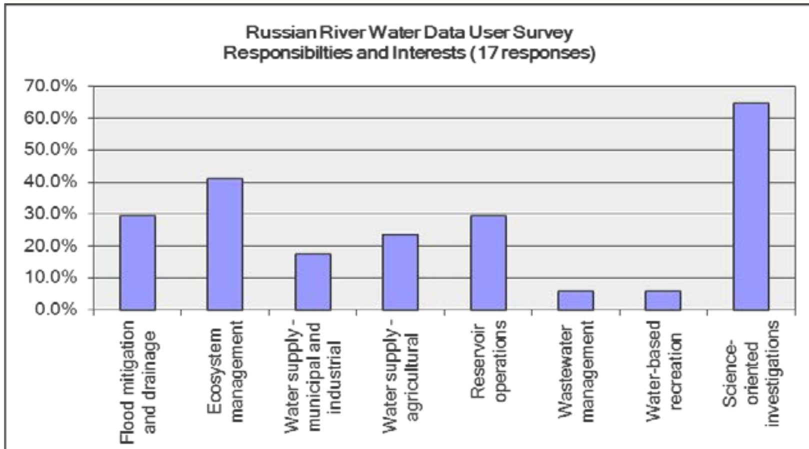
HMT Impacts

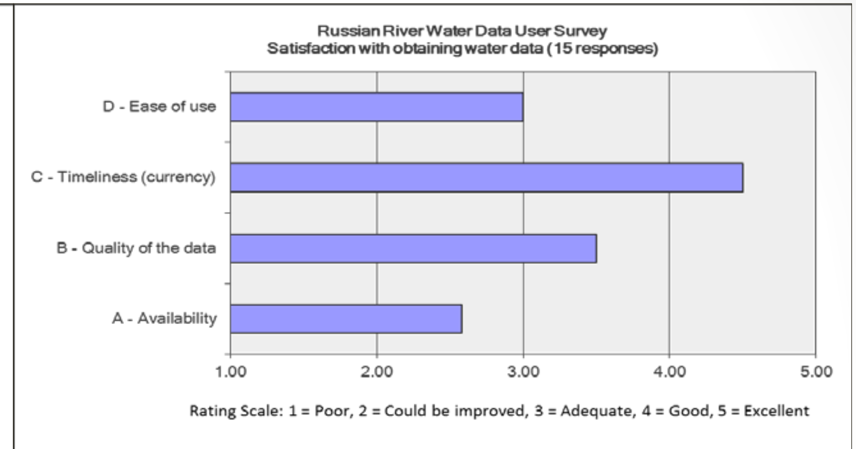
Sonoma County Water Agency

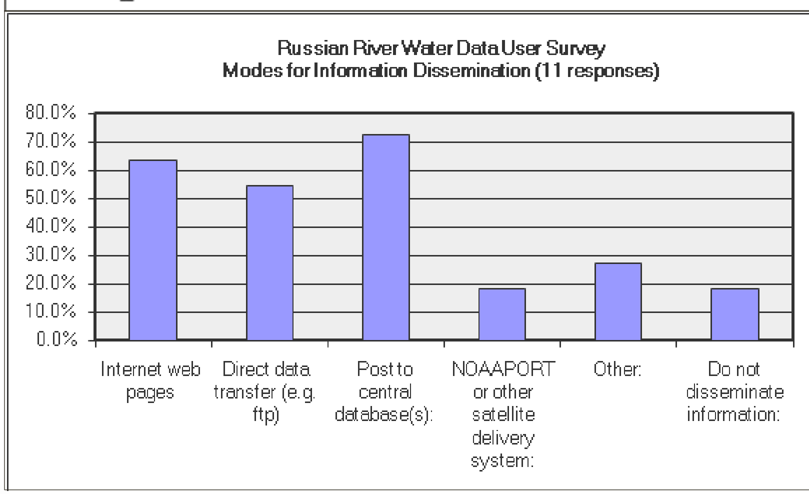
- State Special District (1949) for water supply, flood control, sanitation
- 600,000 North Bay residents
- 1,500 mi^2 Russian River watershed
  - Also, Petaluma River (drains to SF Bay)
- Lake Mendocino (1959), Lake Sonoma (1983)
- Army Corps Flood Control (winter/spring)
- SCWA Water Supply (summer)
- ESA listed Coho, Chinook, Steelhead
- $8 Billion Wine Industry (63,000 ac)
- IWRSS "Case Study" basin

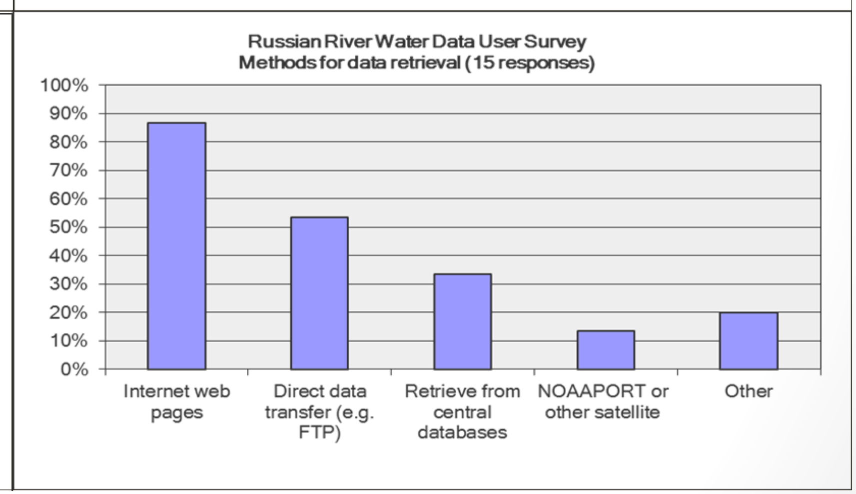


Russian River Water Data User Survey

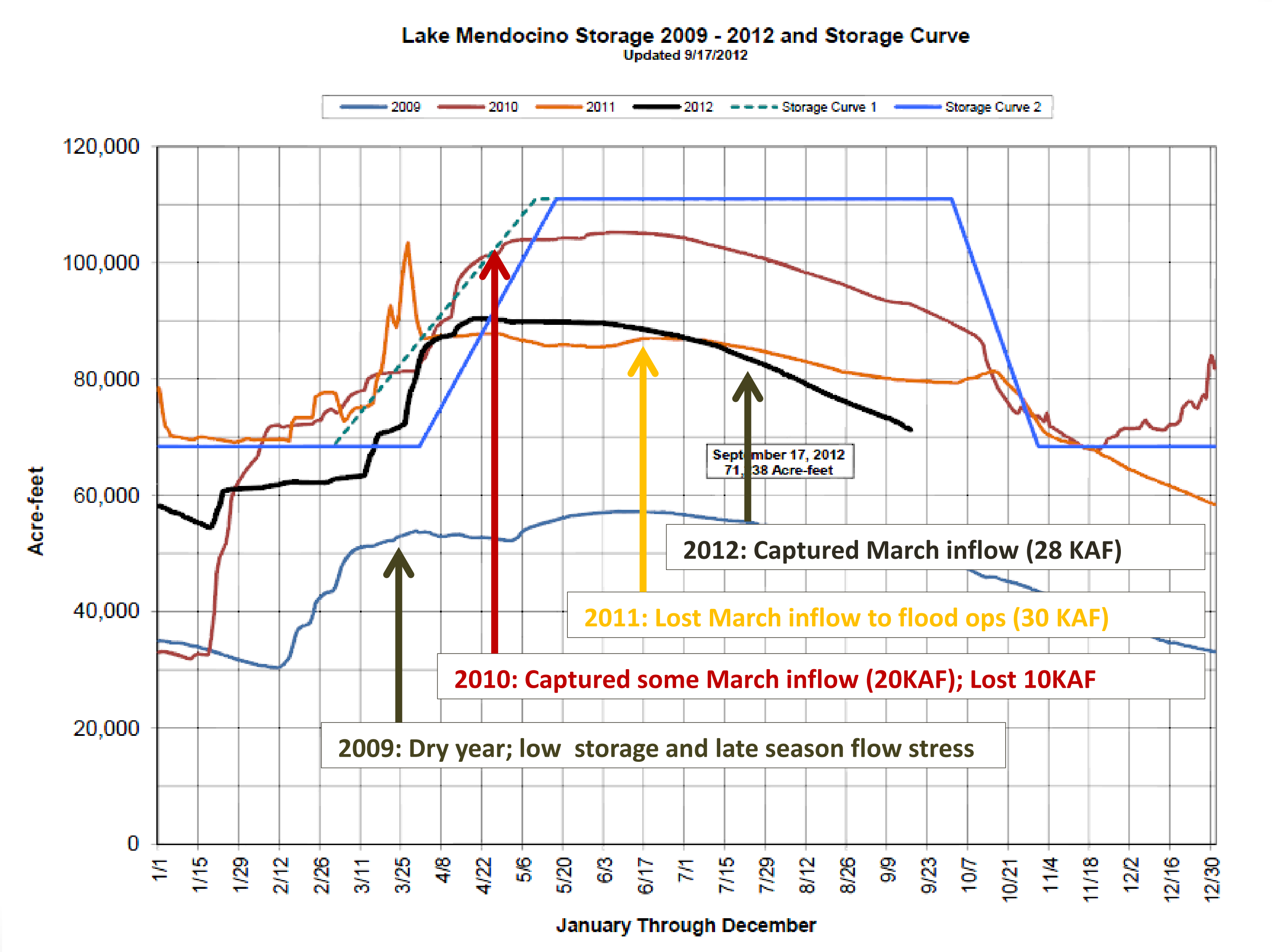






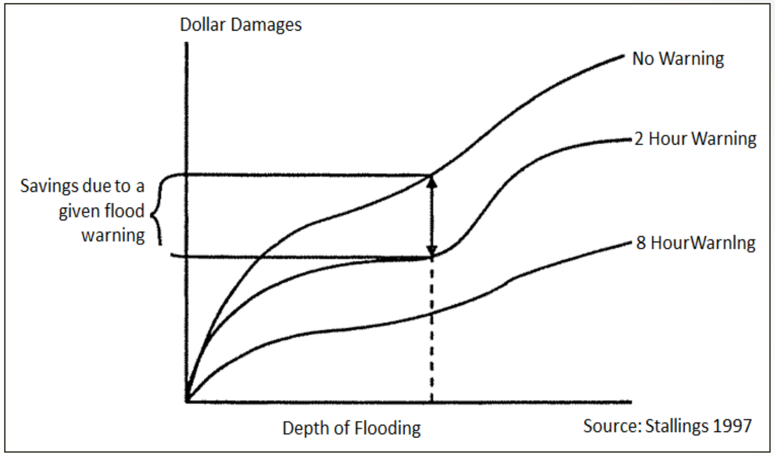


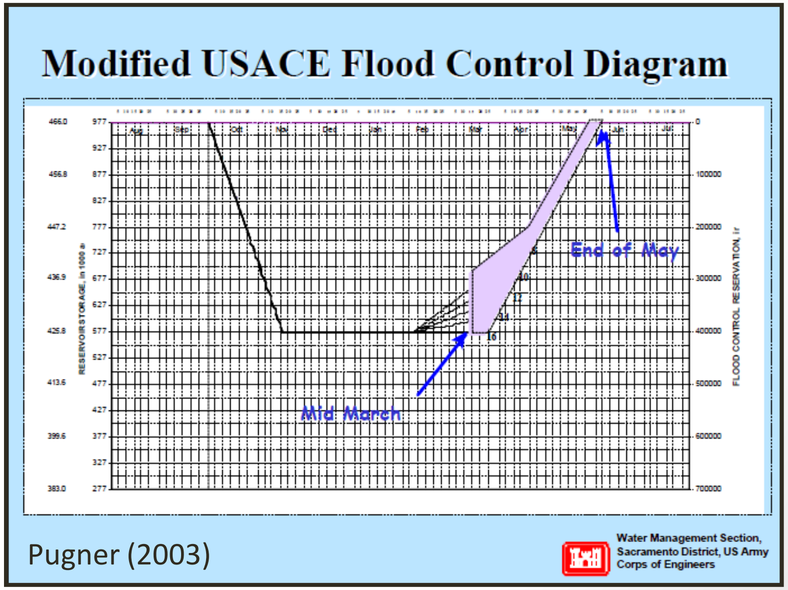
Potential Forecast-Based Operations



SCWA Forecast Benefits

- Flood Mitigation
  - Lead time for moving residential contents (Day/Carsell)
  - 12-hr lead time, 5% reduced damages, $100K content value, 3000 residences, 80% efficiency
  - Value $12M for 2005 event
- Water Supply
  - Reservoir operations in March 2012 secured an extra volume of 30 KAF carried into the summer season
  - Potential FBO value for municipal water supply at $900/AF is $27M/yr
- Fishery Flows
  - Reservoir releases to sustain fisheries enabled by FBO captured water in March
  - Potential FBO value of 30 KAF at $25/AF is $750,000/yr

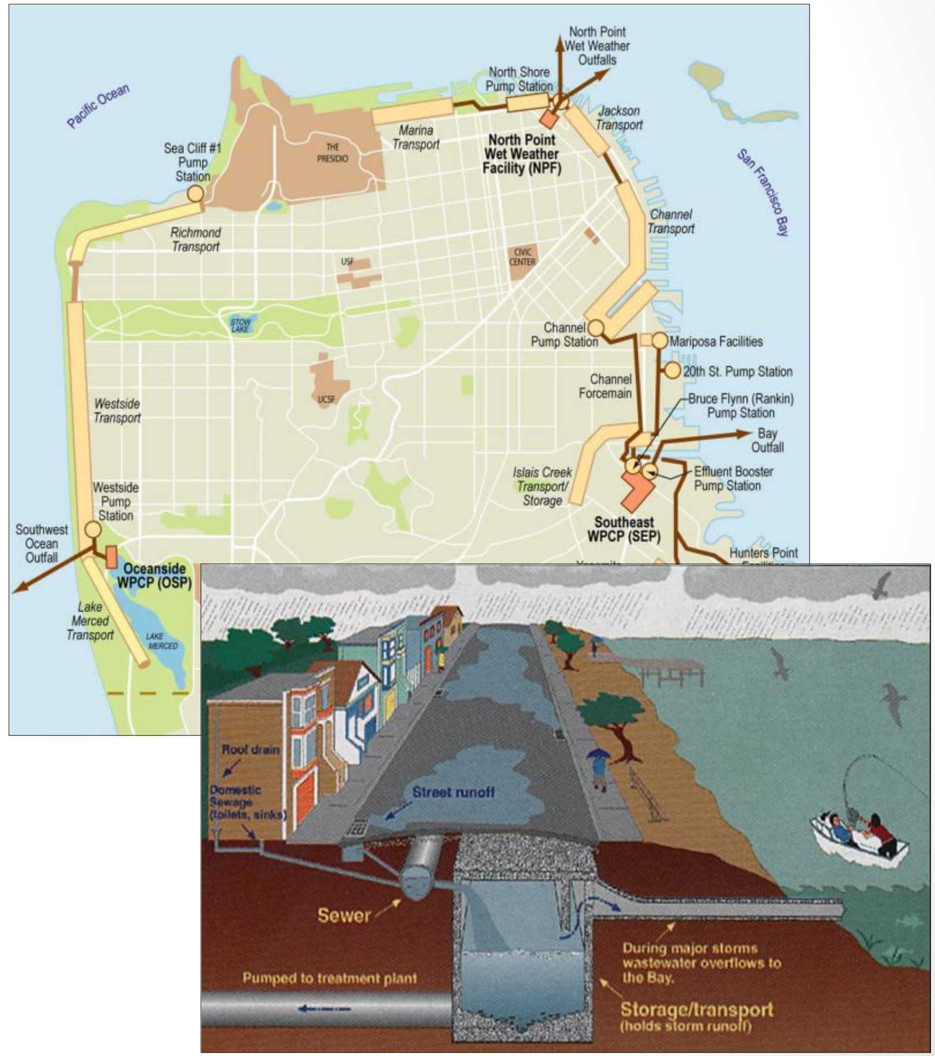




San Francisco Wastewater

- Clean Water Act:
- Reduce combined sewer overflows based on beneficial uses:
  - "bathing beaches"
  - Recreation
  - Shellfish
- 1978-1996: Built "Transport-Storage" system
- Enlarged treatment system
- Seeking optimal real-time operations

Transport and storage (T/S) control system



FY12: Tentative Conclusions

- RDHM
  - Peak flow simulations accurate with small adjustments to soils parameters; main uncertainty is precipitation
  - Code and data sets difficult to work with
  - Spatial detail for small basins good
  - OHD default base parameter values good
    - Connectivity
    - SSURGO soil parameters
  - CNRFC precipitation fields accurate
- Water Management
  - Integration with "managed" flows awkward
  - Need for water data integration
  - Forecast benefits are large

FY12: HASP Accomplishments

- Distributed Modeling
  - Russian River
    - Implemented HL-RDHM
    - Coordinated with CNRFC to obtain precipitation and temperature data
    - Established correspondence to OHD using N. Fk. American River model
    - Developed Russian-Napa Rivers RDHM model
    - Data format transformations
    - Sensitivity analysis
    - Applied RDHM for selected events and periods
      - Calibration period: 1 Nov 2011 to 30 Jan 2012
      - Verification period: 1 Feb 2012 to 30 April 2012
      - QPE Case Study: March 13-14, 2012 event (20%)
  - N. Fk. American River - Intercomparison of meteorological forcing data
- Soil Moisture
  - Monitoring – sensors deployment and network operation
  - Validation of distributed model
  - Remote sensing AMSR downscaling
- Water Management
  - Data User Survey
  - Forecast benefits

FY13: HASP Planned Activities

- Distributed Hydrologic Modeling
  - Complete model calibration
  - Assess spatial resolution (4km HRAP and 1km HRAP)
  - Implement SAC HT-ET
  - Support assessments of QPE products
  - Examine hydrologic uncertainty
  - Extreme Value Analysis (CSTAR proposal with Balaji at CU)
- Soil Moisture and Energy Flux
  - Extend RDHM soil moisture simulation validation to remaining HMT stations in the Russian River basin
  - Evaluate sensitivity of soil moisture simulation to changes in RDHM calibration
  - Compare SAC HT-ET simulated potential evaporation with Cazadero obs.
  - Add 20 cm probes to Hopland & Healdsburg stations
- Water Management Apps
  - Address integration with ResSim
  - Investigate real-time operations requirements

Strategic Directions

- Model Advancement
  - Parameter identification
  - Model refinement and assessment
  - Data assimilation
  - Verification
- Vertical Integration
  - Multi-sensor networks
  - Data assimilation
  - Models integration
  - Forecast operations adoption
- Operational Science
  - Water management applications
  - Benefits characterization
  - Institutional usability

FY 12: HASP Publications

Papers:

- Zamora, R. J., E. Clark, E. Rogers, M. B. Ek, and T. A. Lahmers, 2012: An examination of soil moisture conditions in the Babocomari River Basin: The flood event of 23 July 2008. Journal of Hydrometeorology, Submitted 26 September 2012
- Zamora, R. J., C. W. King, A. B. White, A. Thorstensen, and L. Avery, 2012: The influence of soil texture on soil water storage in the North Fork American River basin. For submission to Journal of Hydrometeorology, Draft completed 27 September.
- Hsu, C., R.J. Zamora, L.E. Johnson, T. Schneider, and R. Cifelli, 2012: Downscaling advanced microwave scanning radiometer (AMSR-E) soil moisture retrievals using a multiple time-scale exponential model. J. Hydrometeor. (Submitted)
- Wayland, NE, AF Hamlet, M Hughes, S. Feld, JD Lundquist 2012: Intercomparison of Meteorological Forcing Data from Empirical and Mesoscale Model Sources in the N.F. American River Basin in northern California. Journal Hydrometeorology (accepted).

Conference Presentations, Posters, Reports

- Hsu, C., L. Johnson, R. Cifelli, and R. Zamora. 2012: Distributed Hydrologic Modeling Using High Resolution Precipitation Products. 7th Biennial Bay-Delta Science Conference, Sacramento, CA (Poster). October.
- Hsu, C., R. Zamora, R. Cifelli, T. Schneider, L. Johnson, 2011: High Resolution Spatial Modeling of Daily Precipitation in California. CIRES 2011 Rendezvous, Boulder, CO, USA, pp. 76-76 April
- Hsu, C., R. Zamora, R. Cifelli, T. Schneider, L. Johnson, 2011: Toward the Estimation of High-Resolution Daily Precipitation in Complex Regions – The Study of Intertwined Physiographic, Vegetative, and Climatologic Factors for PRISM Enhancement. American Geophysical Union, San Francisco, CA, USA (Poster)
- Johnson, LE, G. Braswell, C. Delaney, D. Reynolds. 2012: Water Management Applications of Advanced Precipitation Products7th Biennial Bay-Delta Science Conference, Sacramento, CA. October.
- Johnson, L.E. 2011: Russian River Water Data User Survey. Report prepared for the Russian River IWRSS Pilot Project. September. 20 pp.
- Zamora, R. J., C. King, A. White, A. Thorstensen 2012: The Influence of Soil Texture on Soil Water Storage in the North Fork American River Basin. 7th Biennial Bay-Delta Science Conference, Sacramento, CA. October.