Streamflow Sensitivity to High-Resolution Precipitation Patterns

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FIRO Science Task Group Meeting

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Center for Western Weather and Water Extremes
SCRIPPS INSTITUTION OF OCEANOGRAPHY AT UC SAN DIEGO

Outline

- Need for accurate streamflow simulations for reservoir operations
- Distributed hydrologic modeling forcing data challenges
- Linkage between atmospheric and hydrologic models
- High-resolution modeling framework: West-WRF ensemble forcing data for GSSHA
- Spatially robust hydro-meteorological verification data
- Lake Mendocino hydrometeorology testbed

Acknowledgements

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  - Chris Delaney
  - Jay Jasperse
- PVID:
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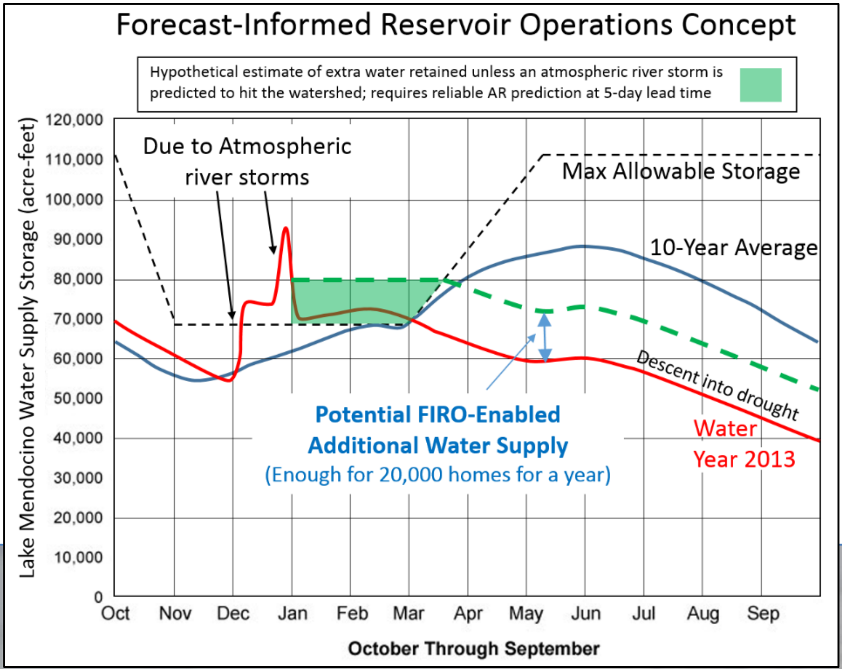
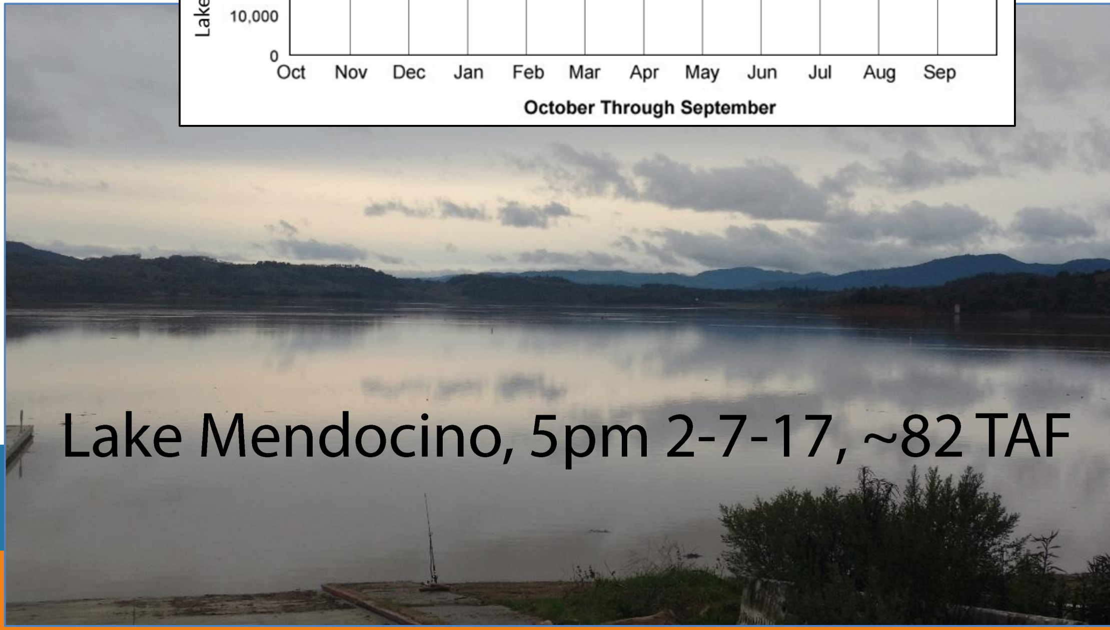
Streamflow Forecasting and FIRO

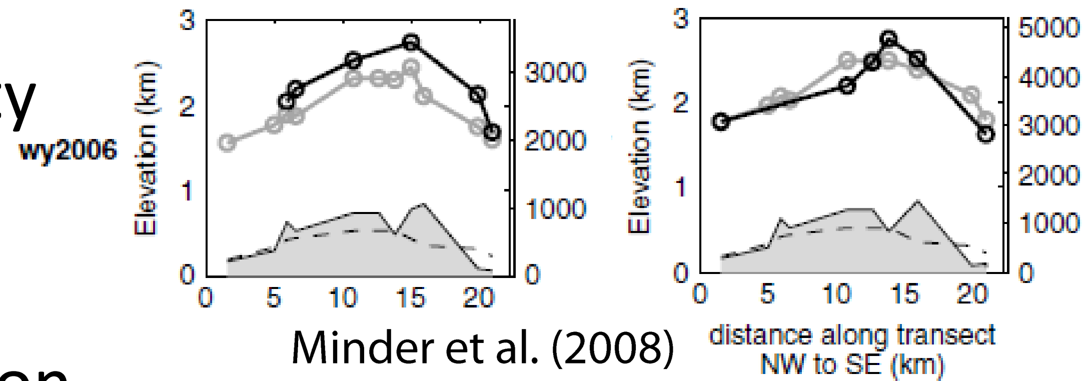
- Skillfull streamflow forecasts needed for FIRO viability
- Streamflow uncertainty = **QPF uncertainty** + **hydrologic uncertainty**
- Need to understand distributed hydrologic processes and sensitivities to precipitation



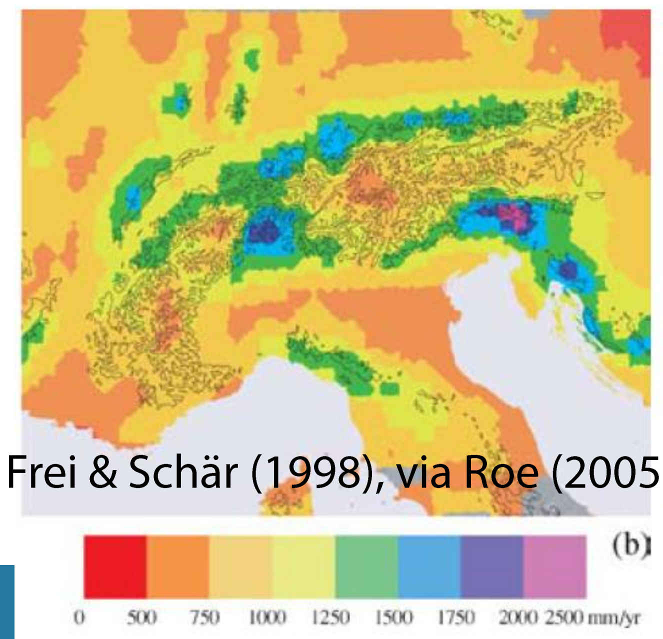


Forcing data in distributed hydrology models

- High spatial variability of precipitation over topography
- AR-driven precipitation particularly sensitive to topography due to moist-neutral LLJ (e.g., Ralph et al. 2005)
- Upslope flow shown to explain precipitation rates (Ralph et al. 2013)



Minder et al. (2008)

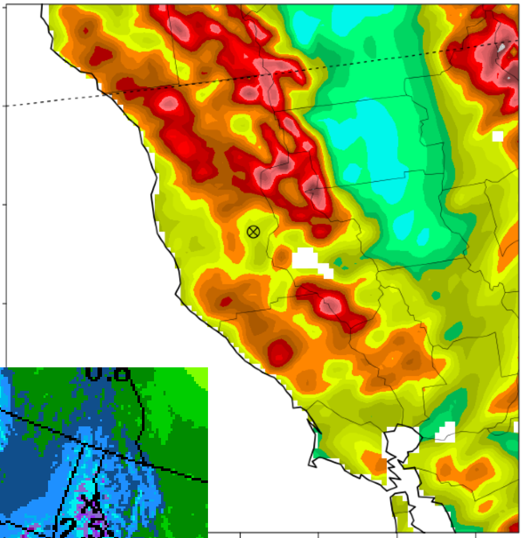


Frei & Schär (1998), via Roe (2005)

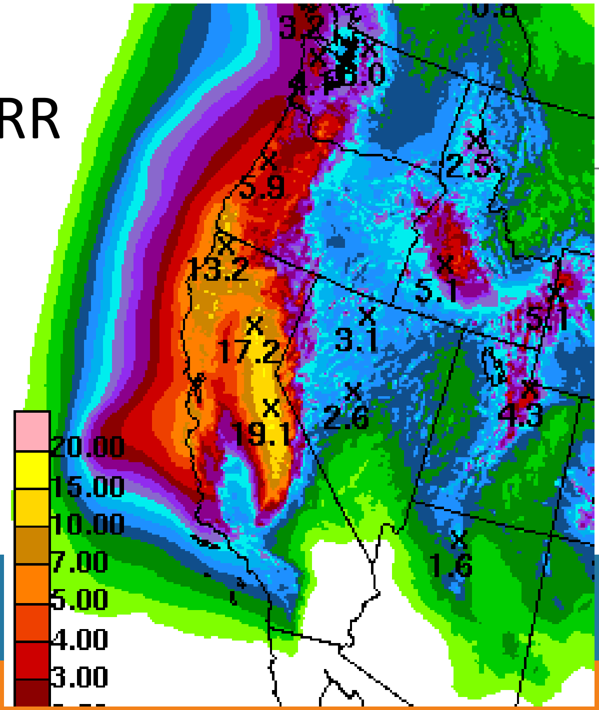
Forcing data in distributed hydrology models

- What is the appropriate scale to represent AR-driven precipitation over the 270 km^2 Lake Mendocino watershed?
  - 25 km GFS
  - 3 km West-WRF/3 km HRRR
  - 800 m PRISM statistical downscaling
  - Something else?

24 hr QPF from West-WRF, 72 hour lead time

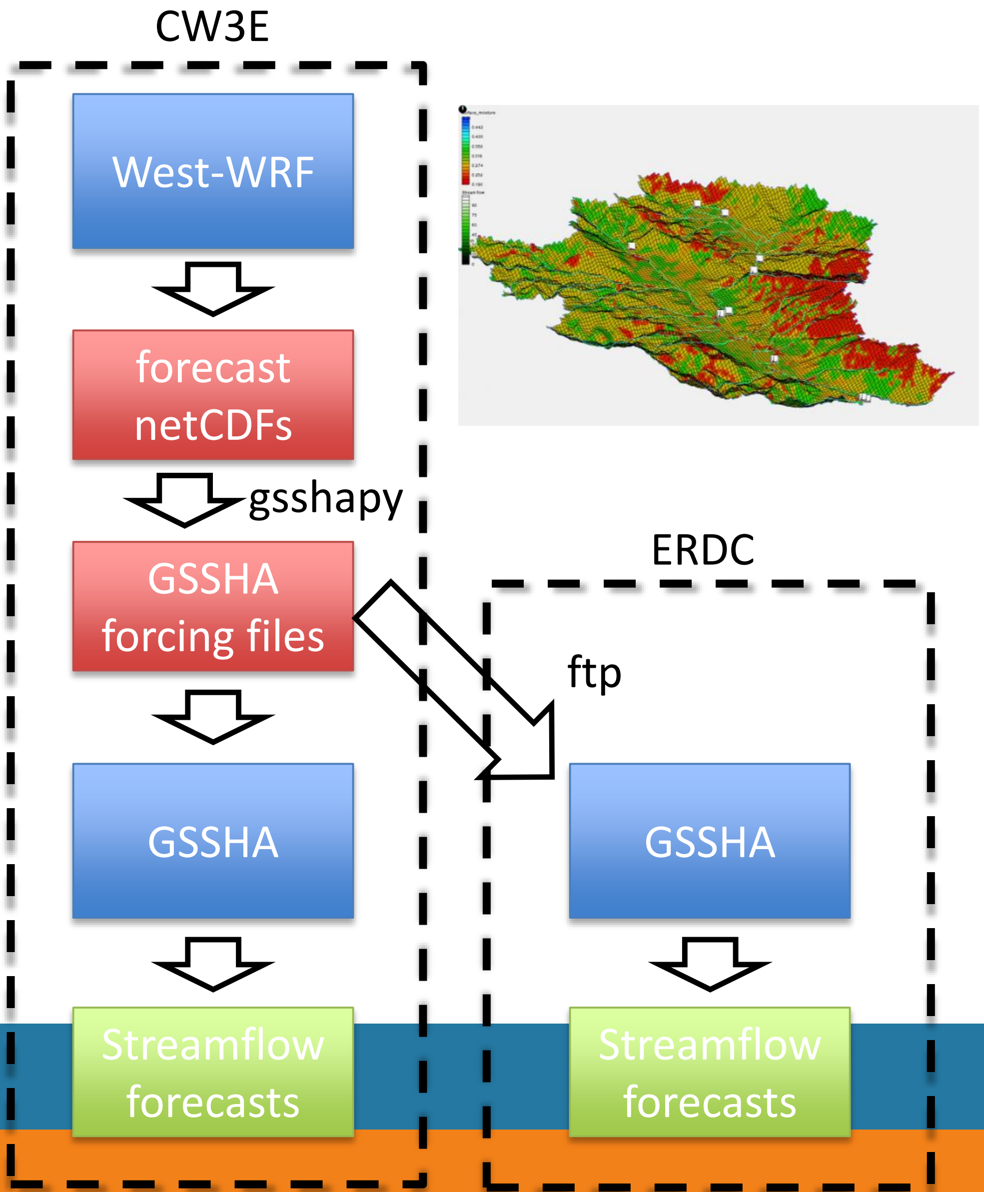


R. Weihs, A. Martin



West-WRF/GSSHA Linkage

- Goal of automating coupled West-WRF/GSSHA streamflow forecasts
- Utilization of gsshapy scripts and ftp to allow automated streamflow forecasts
- Methods in development



West-WRF Ensemble Forecast Example

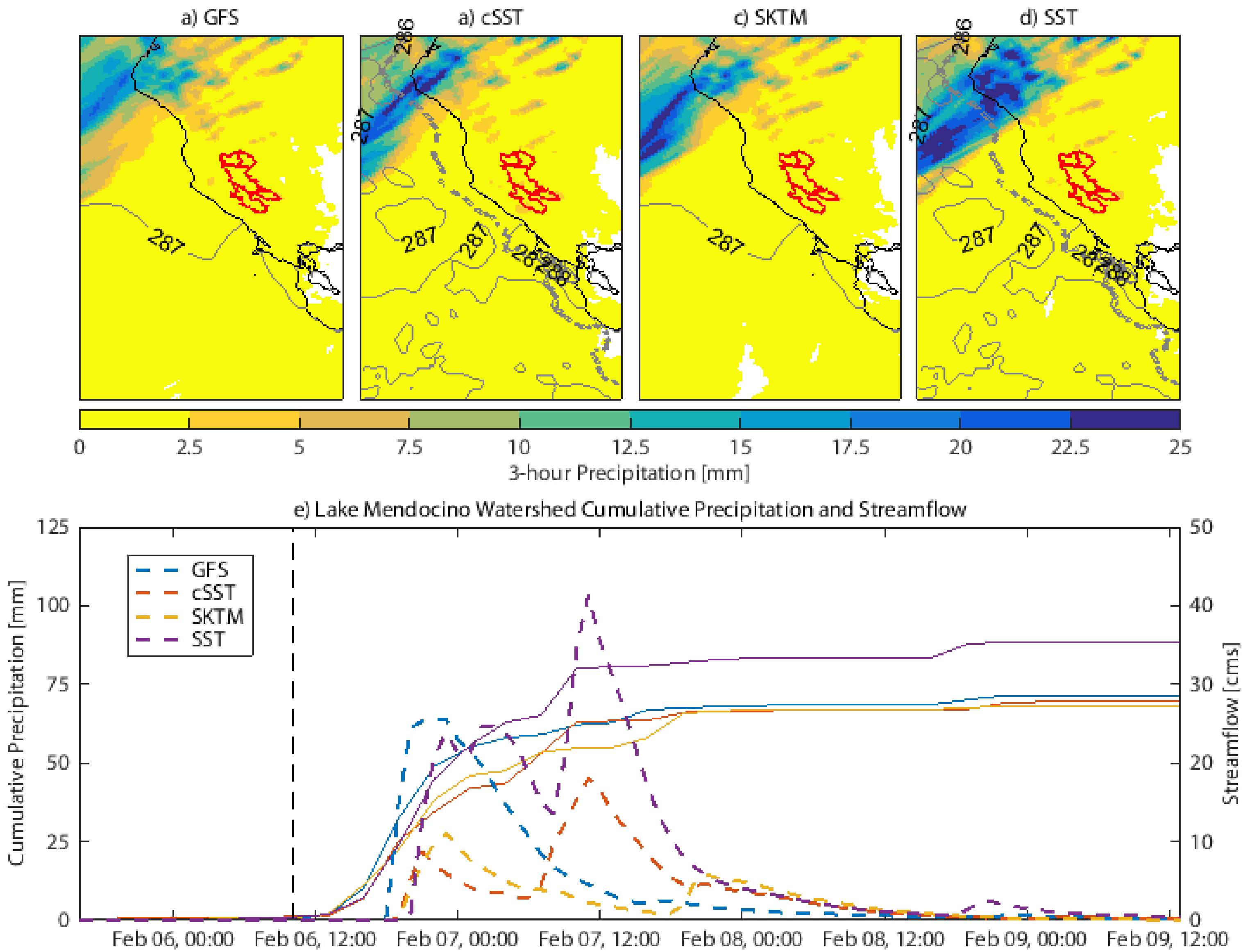
- Multiple 10-day reforecasts of February 6-9, 2015 streamflow event
- GFS boundary and initial conditions for each simulation
- Sea surface temperature boundary conditions varied
- All other West-WRF aspects identical

West-WRF Ensemble Forecast Example

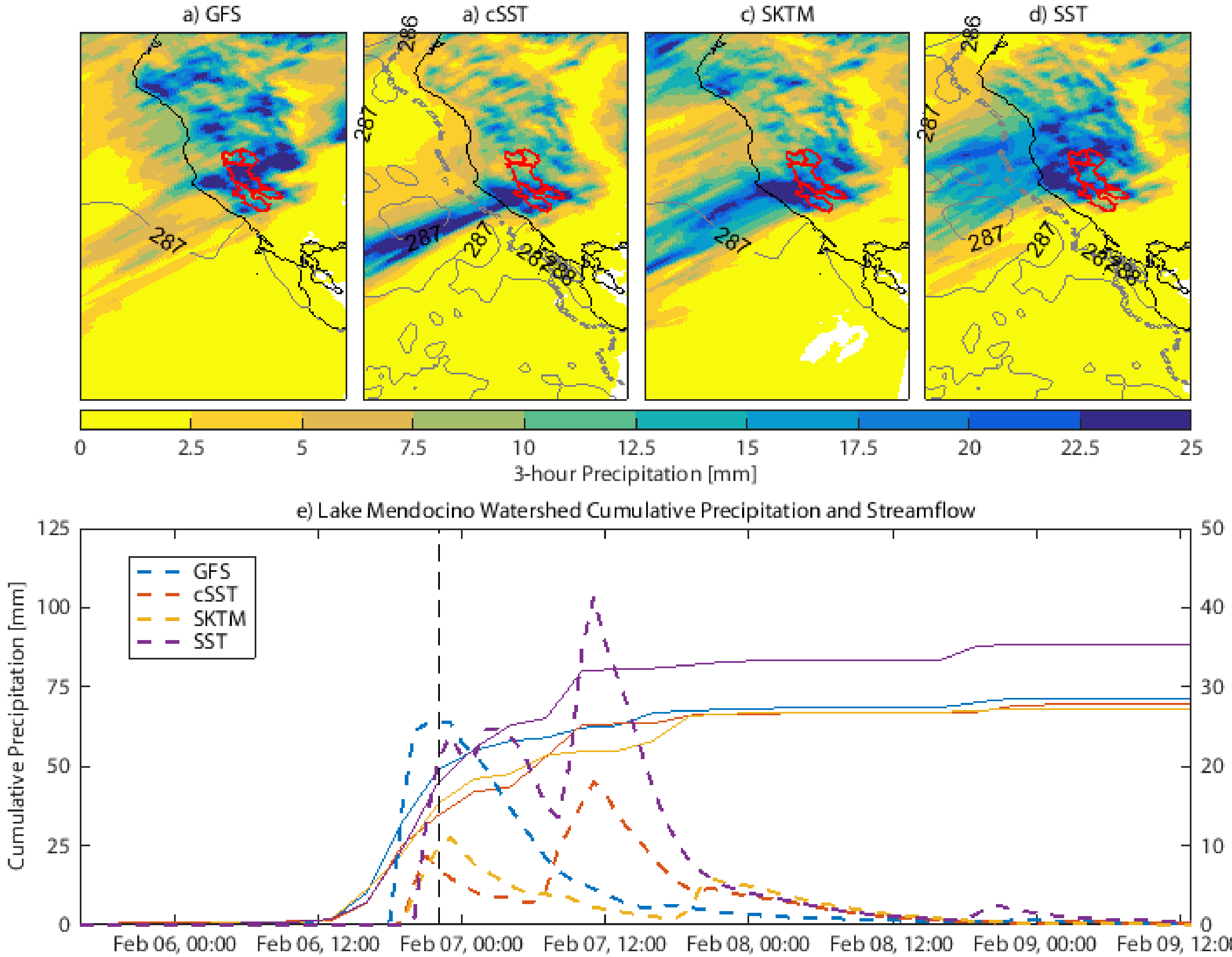
- SST product ensemble:
  - GFS: Only using GFS deterministic forecast data
    - SST is held constant throughout simulation, using Real-Time Global Analysis (RTG) (NCEP/MMAB)
  - SKTM: GFS forecast + SST variability within GFS
    - RTG relaxed to climatology
  - cSST: GFS forecast + constant Hi-Res SST
    - Global 1 km SST (G1SST) satellite and in situ blended product (NASA/JPL) held constant throughout simulation
  - SST: GFS forecast + Hi-Res SST
    - G1SST varies daily (natural weekly/seasonal variability on daily time scales)
- West-WRF precipitation drives 270 m GSSHA model (ERDC-CHL) of Lake Mendocino watershed, as a conceptual example

Slide courtesy Rachel Weihs and Xin Zhang

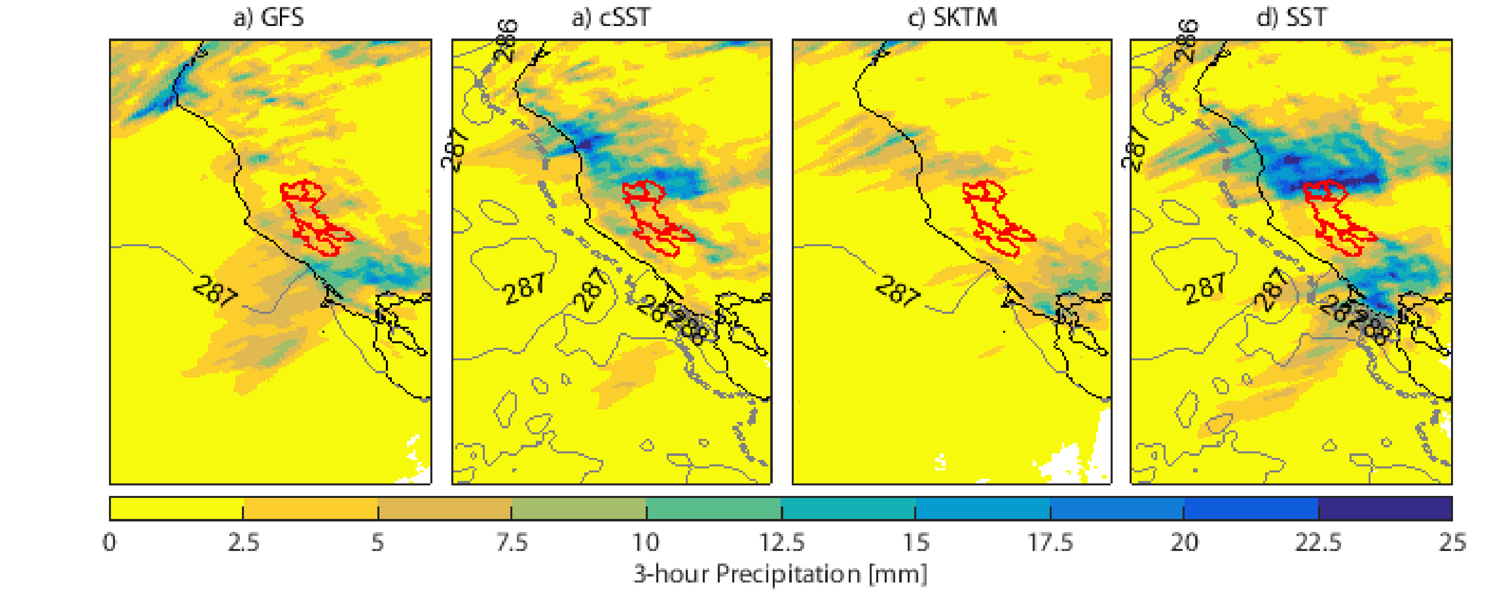
West-WRF Ensemble Forecast Example

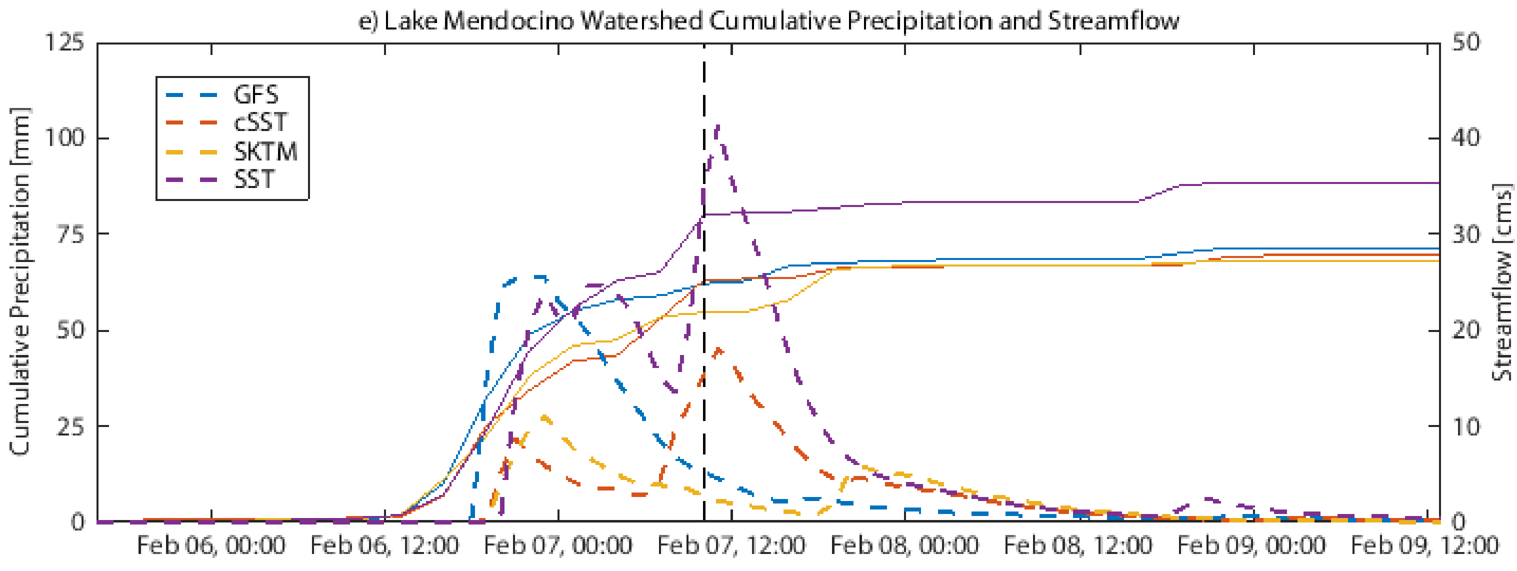


West-WRF Ensemble Forecast Example

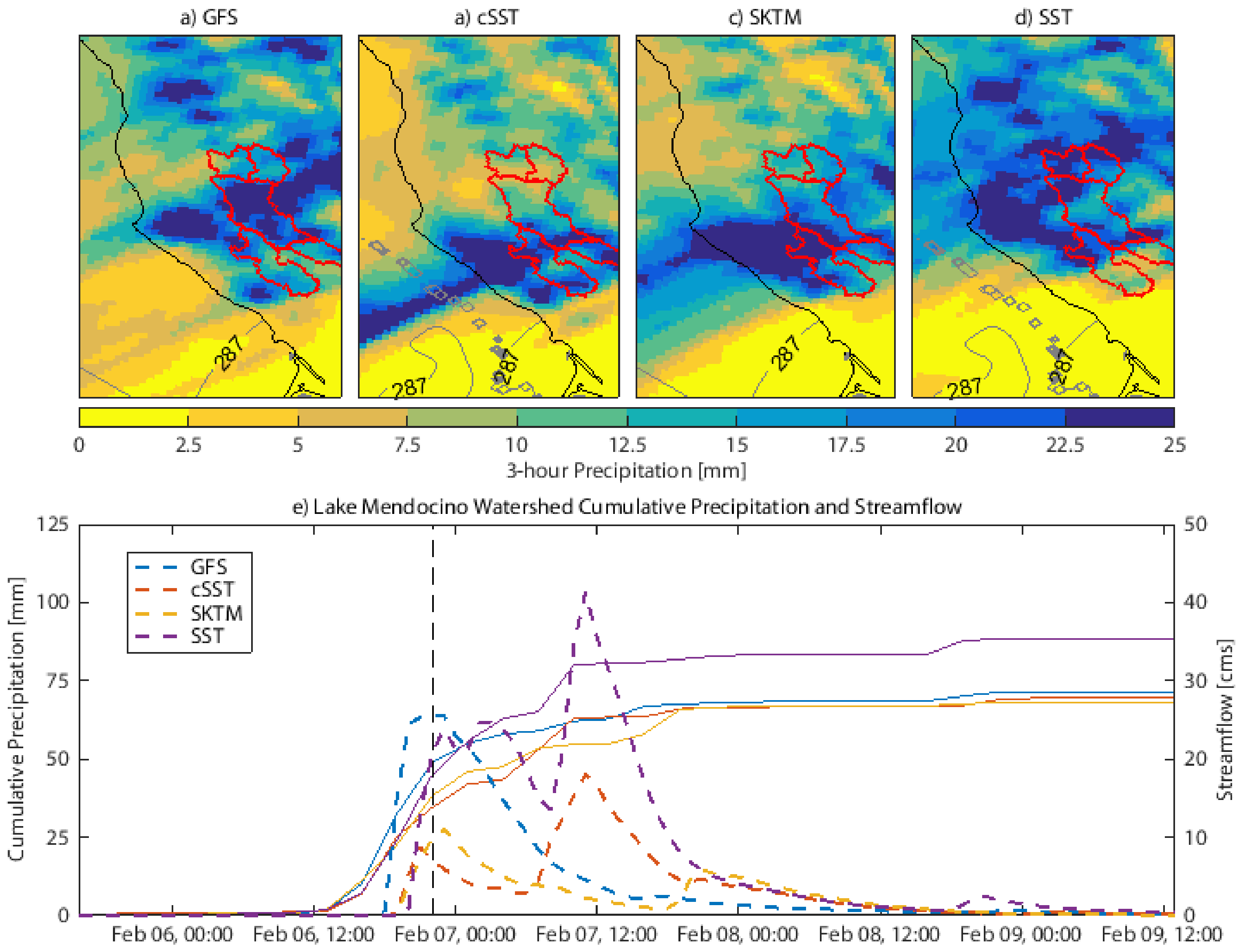


West-WRF Ensemble Forecast Example





West-WRF Ensemble Forecast Example



West-WRF Ensemble Forecast Example

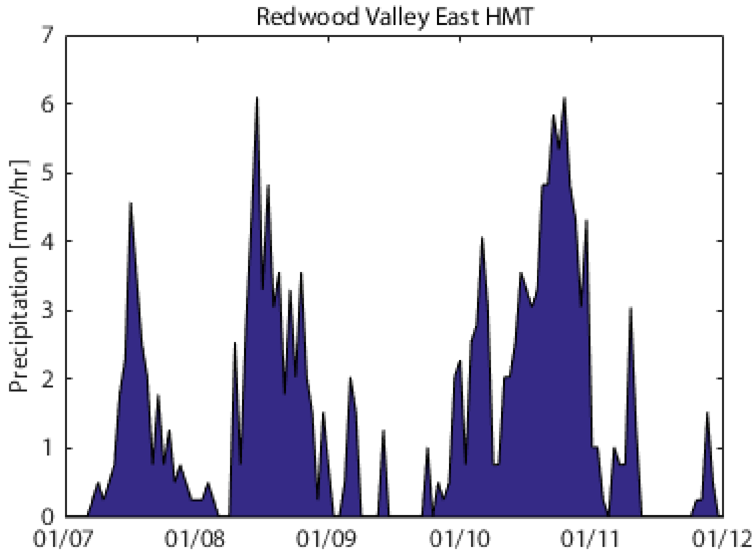
- Forecasts produce similar larger-scale synoptic pattern but differing precipitation patterns at watershed scale
- Streamflow sensitive to precipitation pattern:
  - Intensity
  - Intra-watershed variability

Hydrometeorological Verification Data

- How to assess intra-watershed patterns of precipitation, soil moisture and streamflow variability?
- Expansion of observational network will allow for better observations of ARs and inform development of GSSHA modeling
  - Distributed streamflow response
  - Soil moisture across variable topographic characteristics
  - Spatial distributions of precipitation

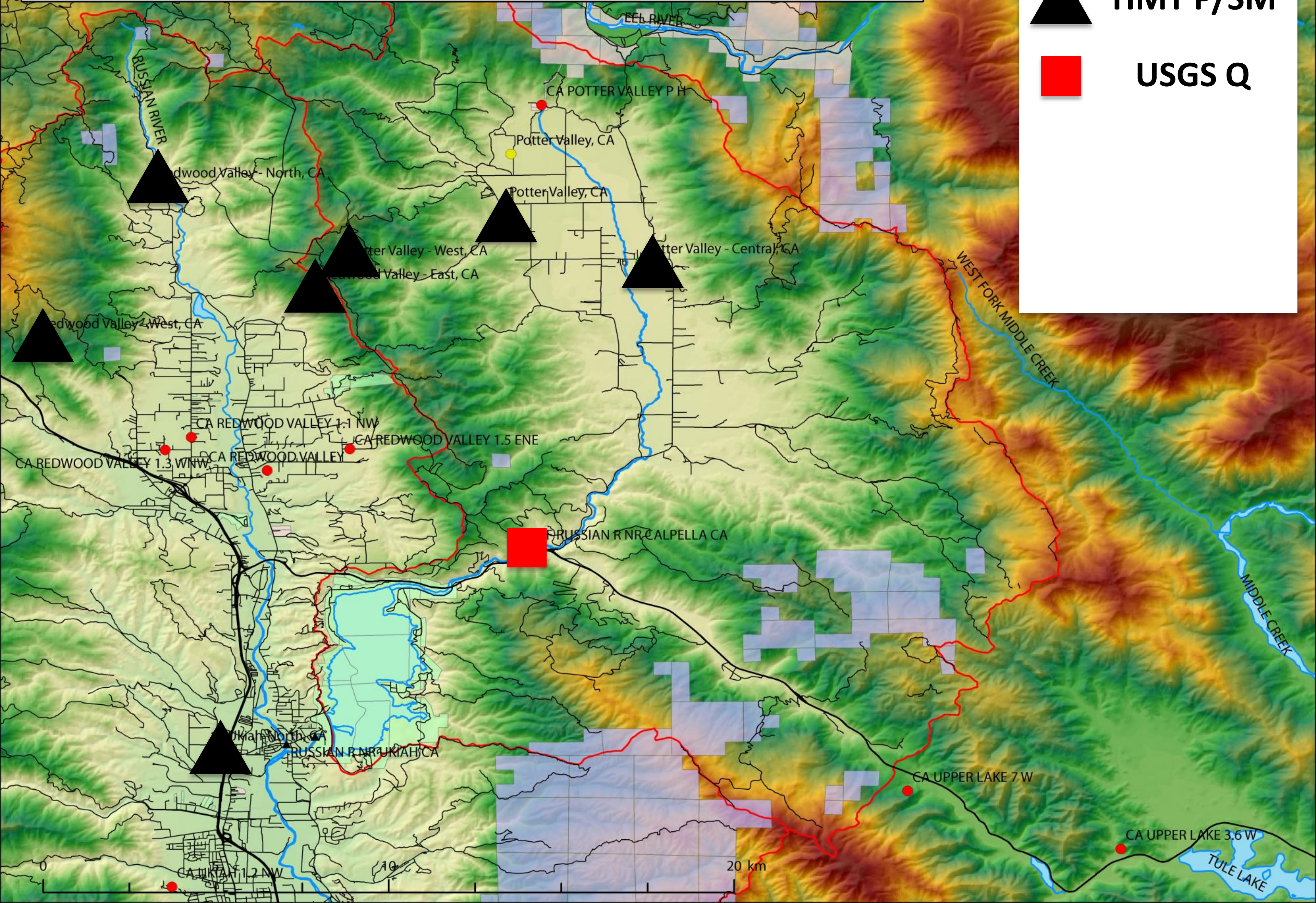
Hydrometeorological Verification Data

- NOAA HMT network:
  - 3 existing stations within Lake Mendocino watershed providing 2-minute precipitation and soil moisture observations since 2015
- USGS Calpella gauge
- Lake Mendocino estimated inflows

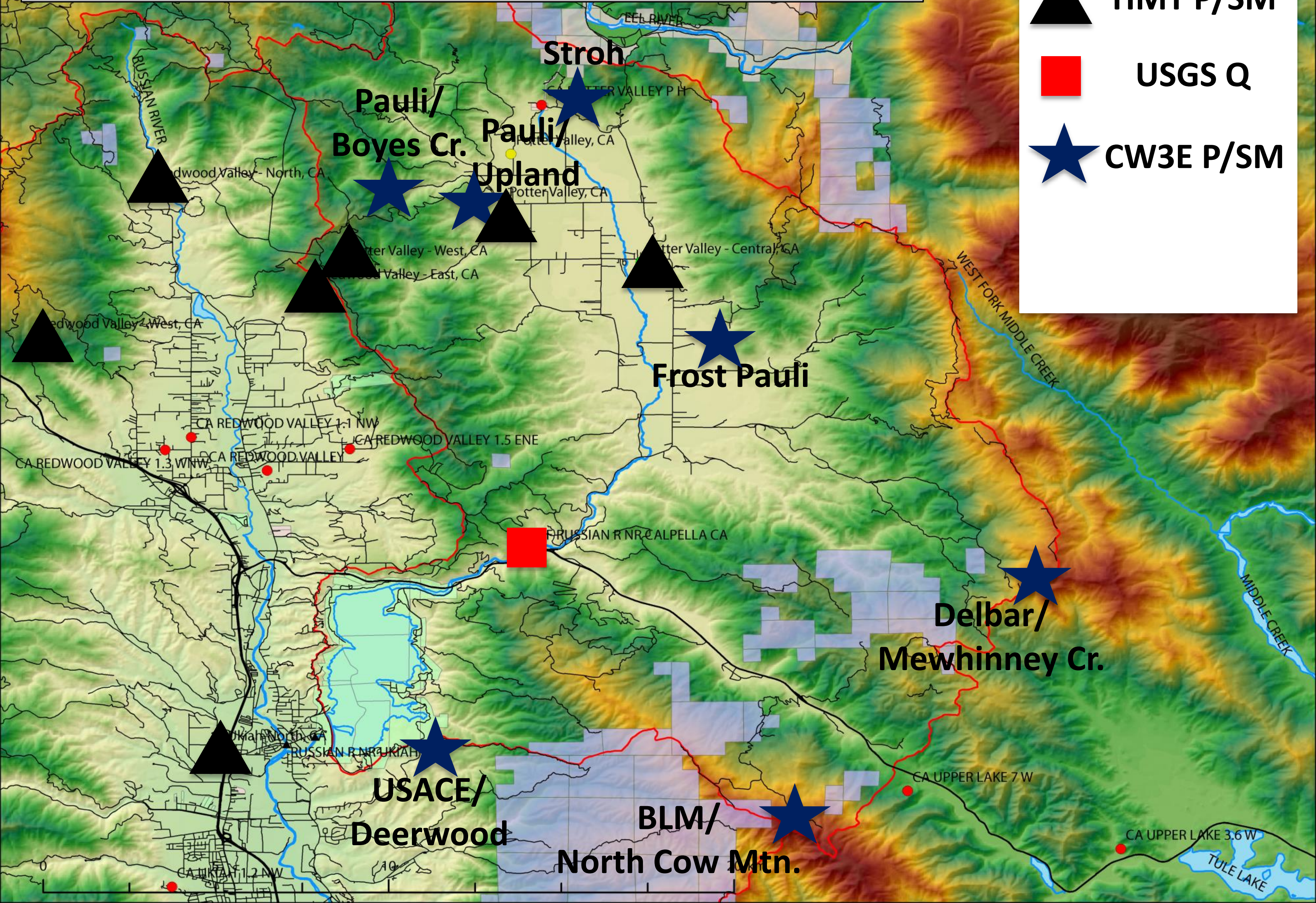


High temporal resolution precipitation observations from NOAA HMT stations

Lake Mendocino Hydrometeorology Testbed



Lake Mendocino Hydrometeorology Testbed



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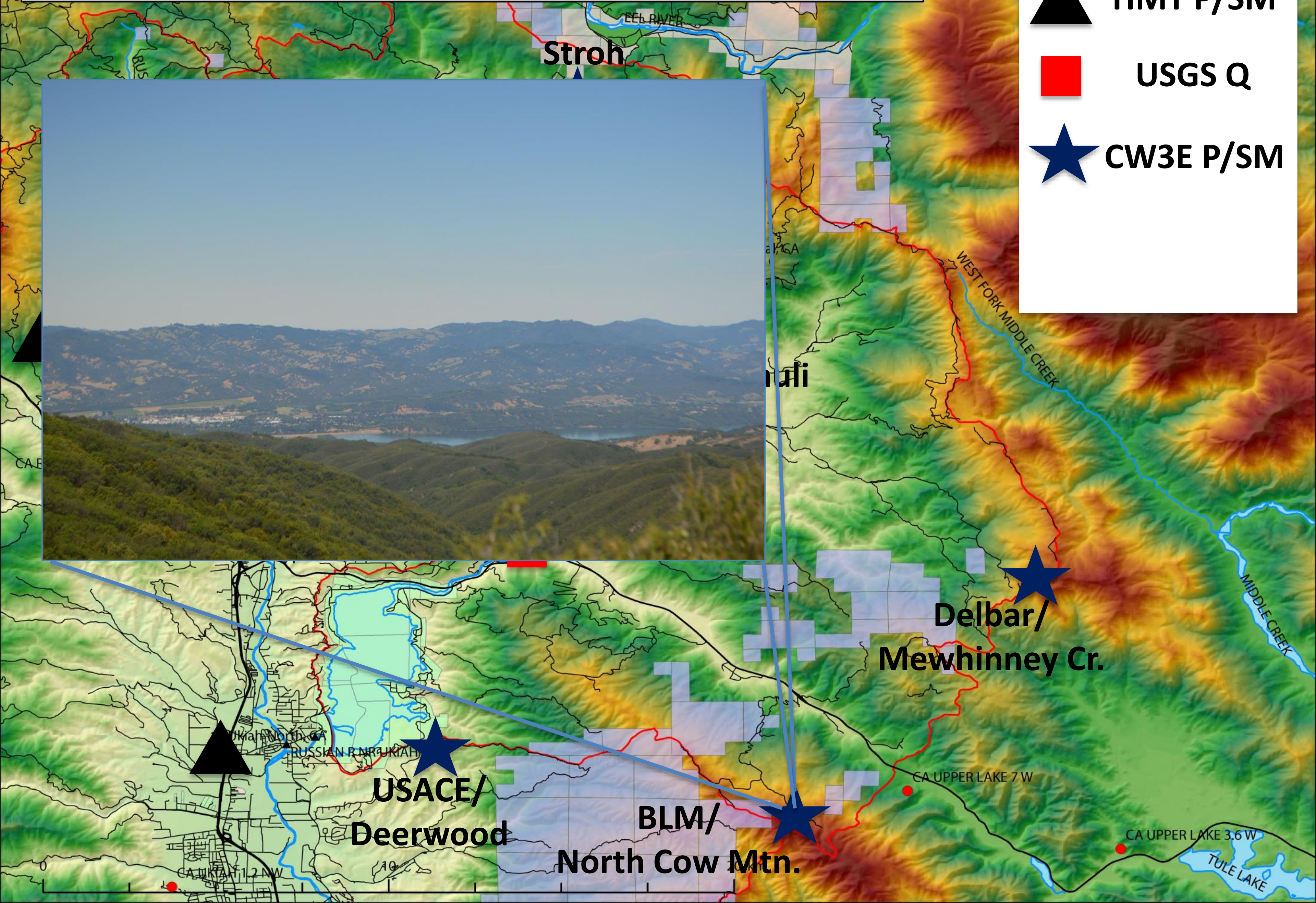

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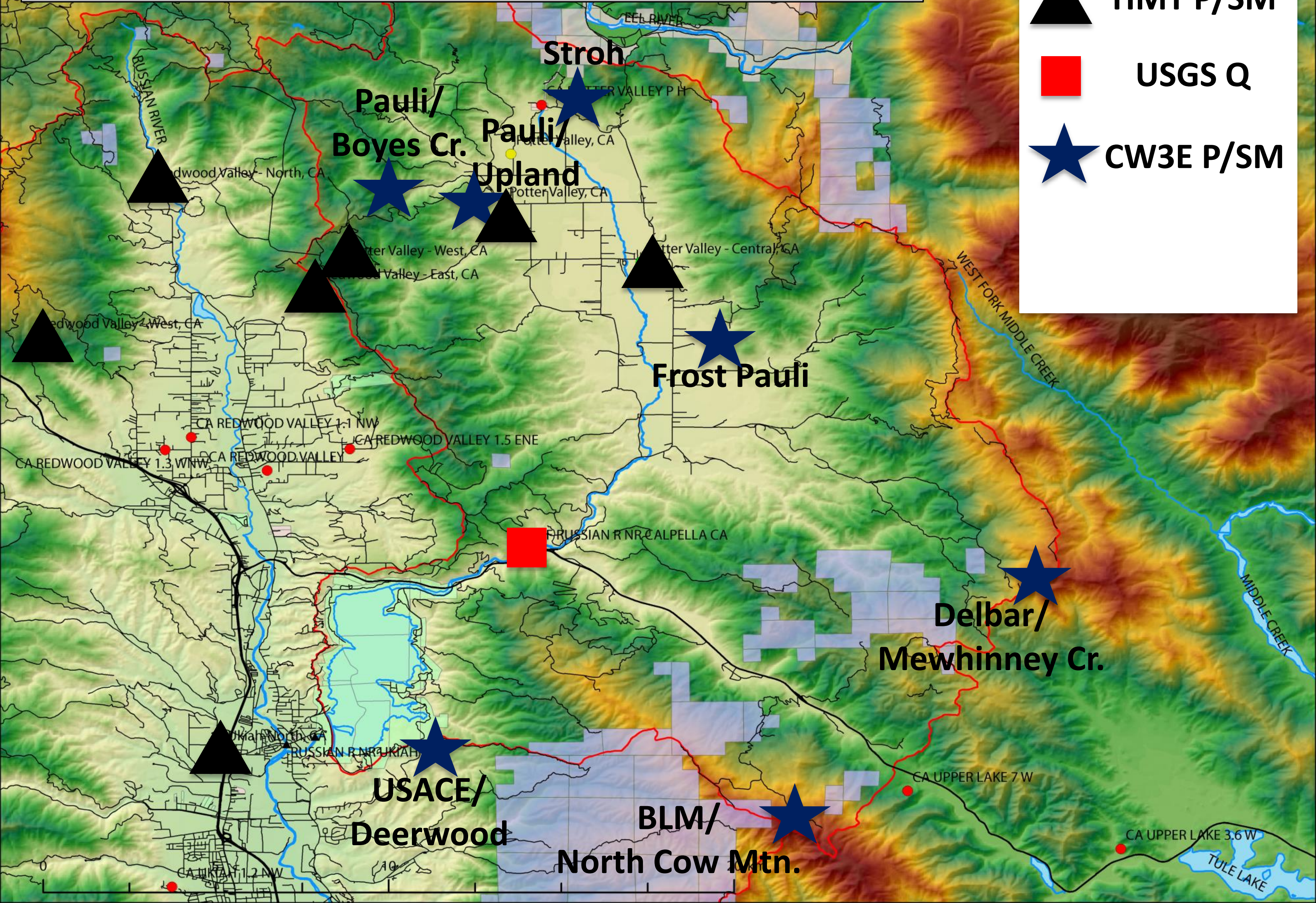

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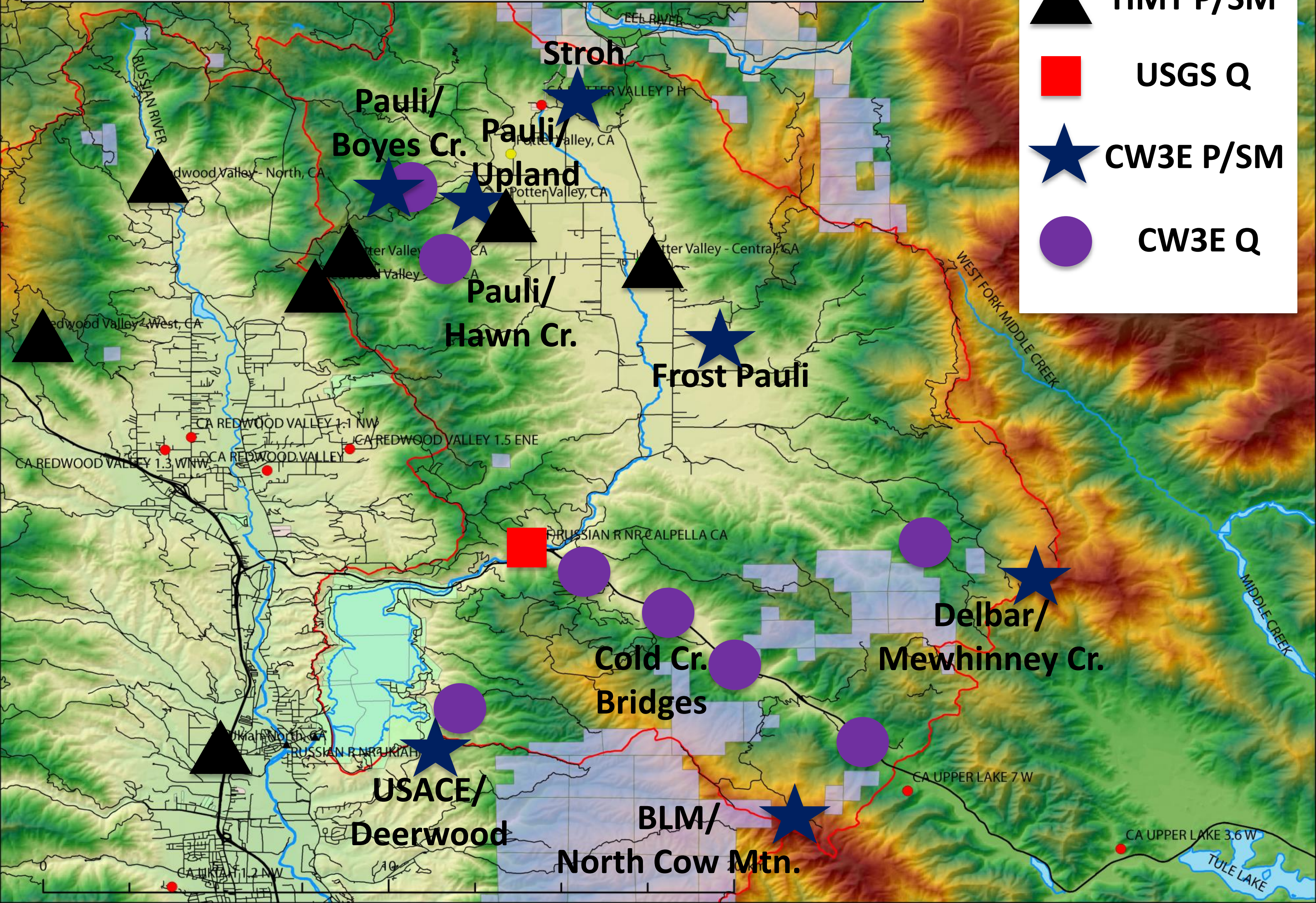

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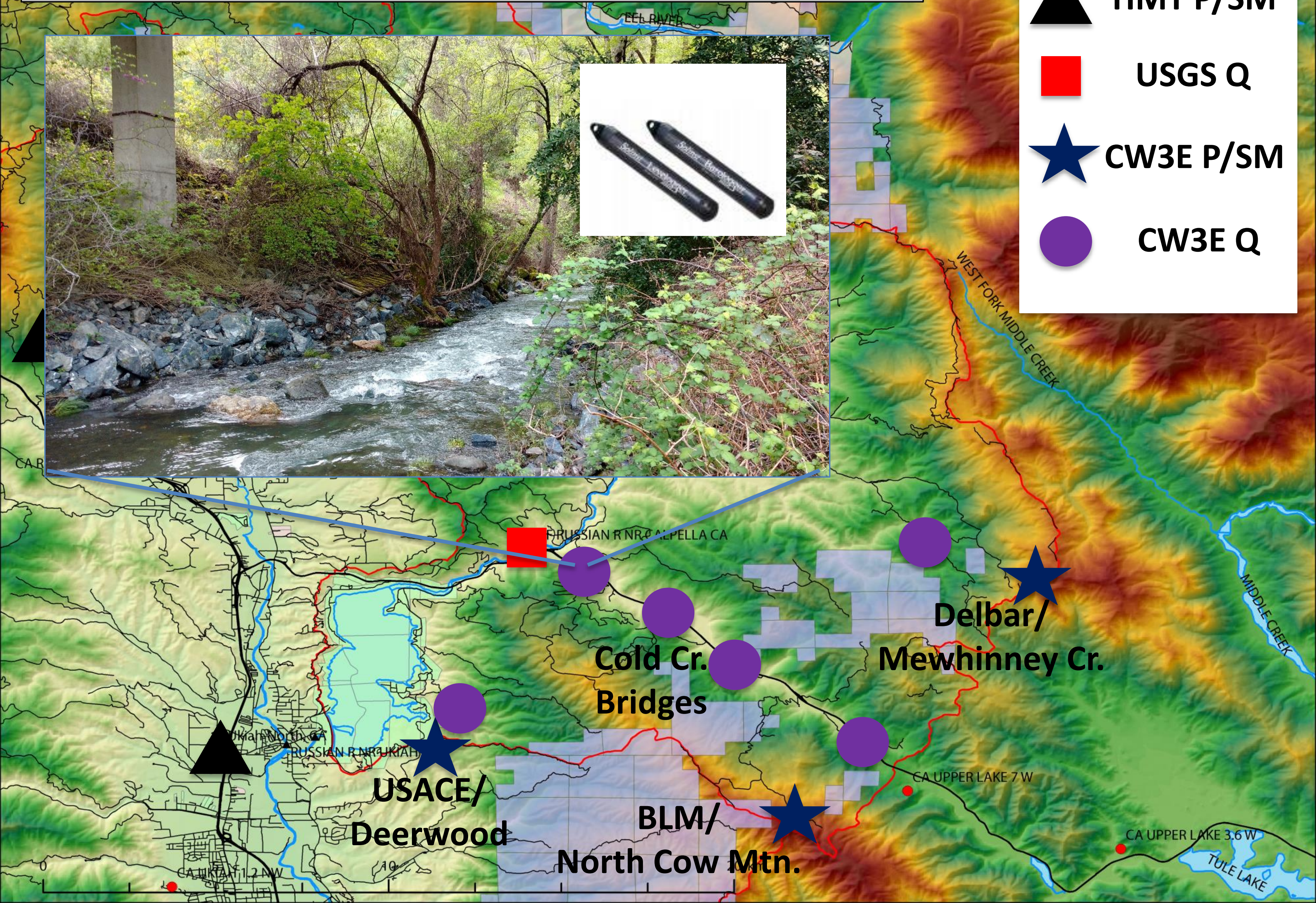

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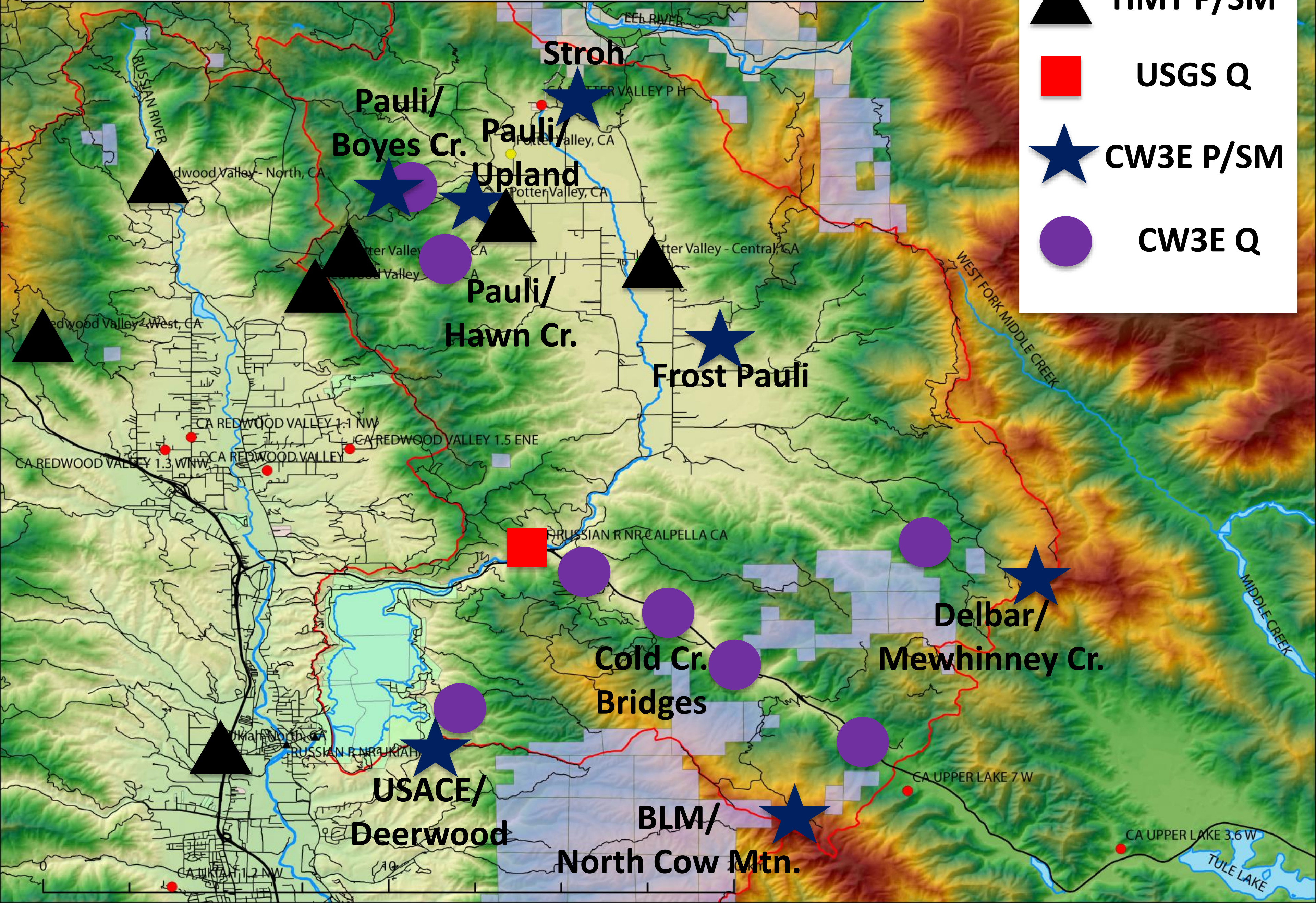

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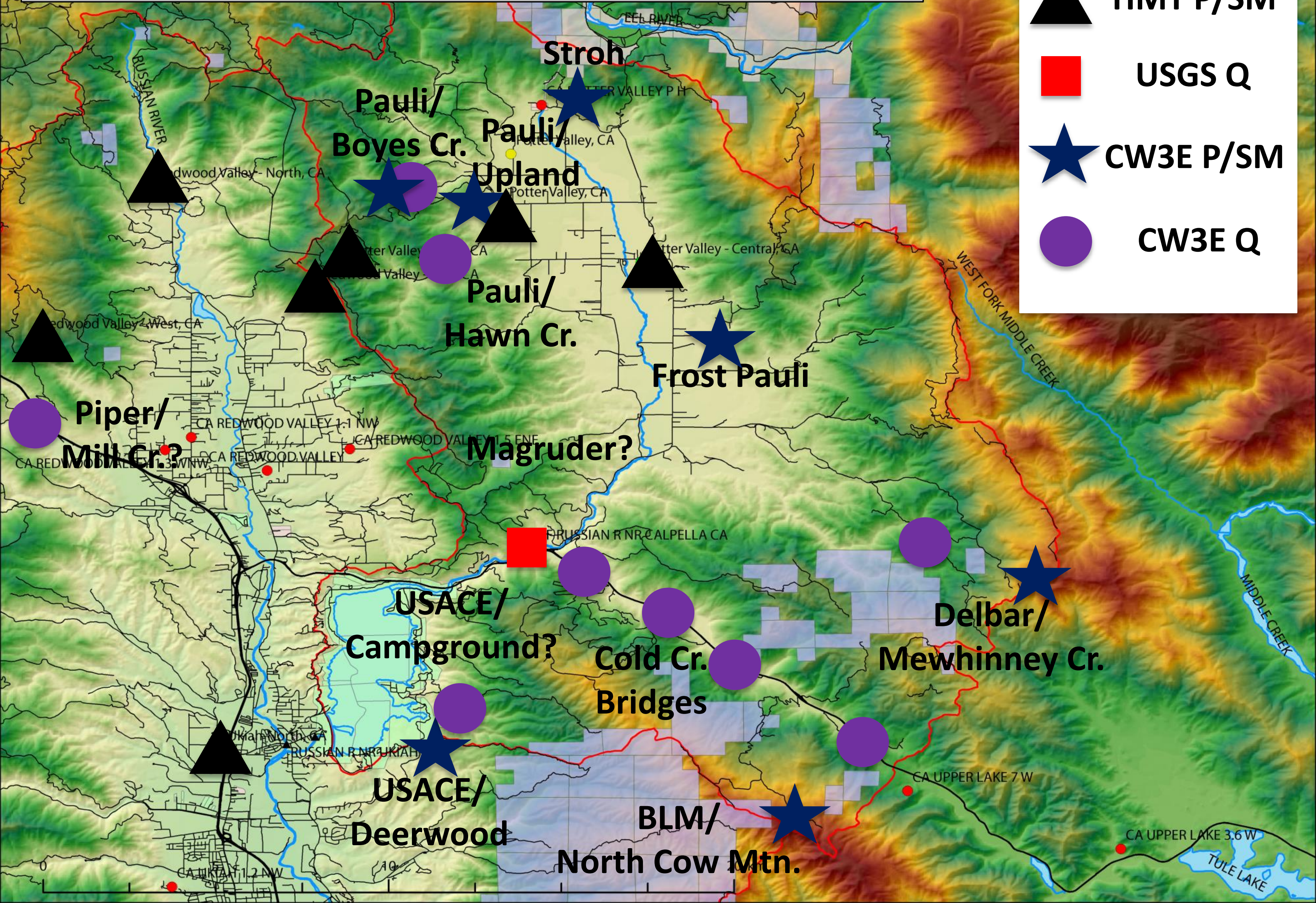

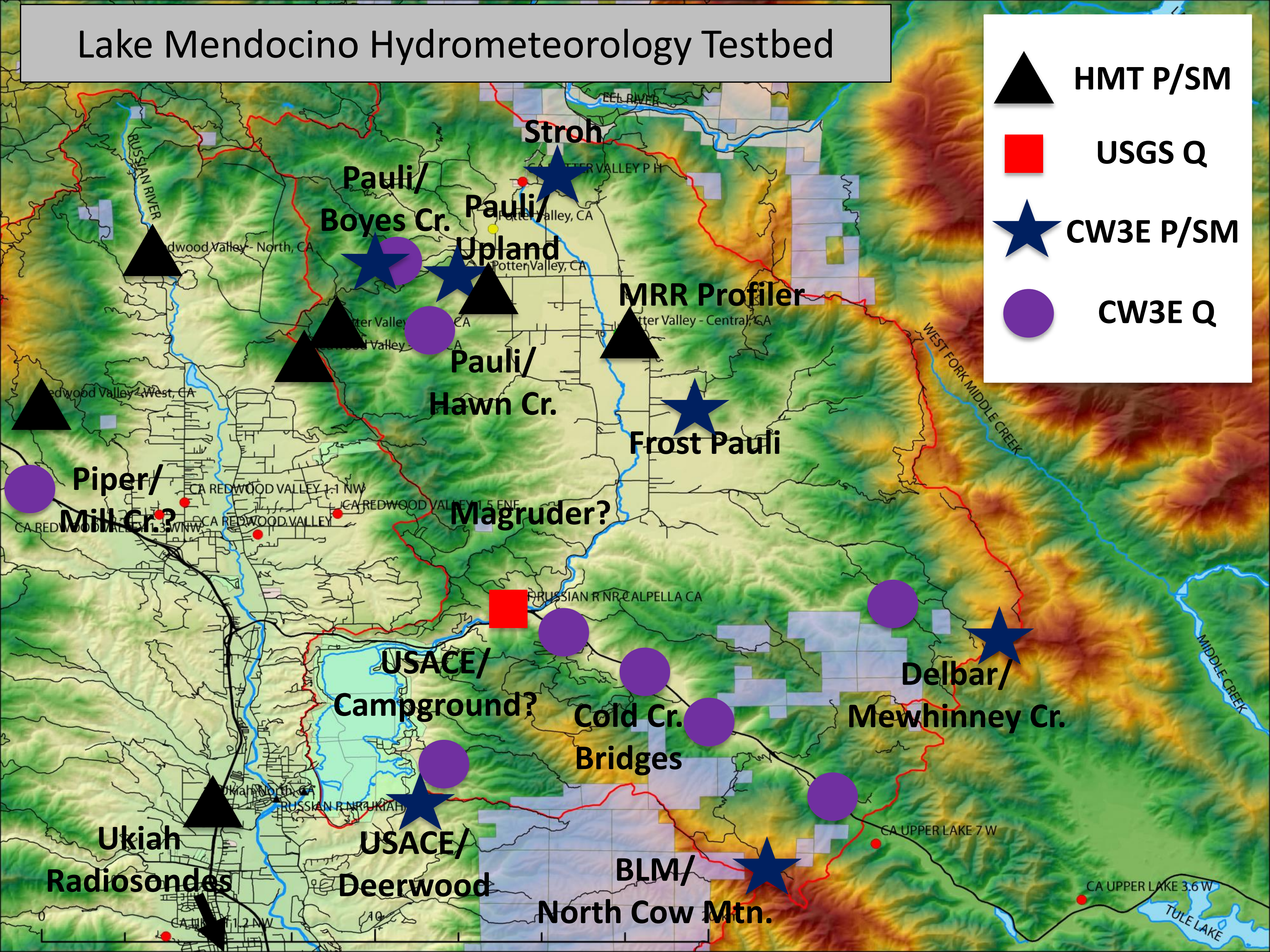
Lake Mendocino Hydrometeorology Testbed
HMT P/SM
USGS Q
CW3E P/SM
CW3E Q
Stroh
Pauli/
Boyes Cr.
Pauli/
Upland
MRR Profiler
Pauli/
Hawn Cr.
Frost Pauli
Piper/
Mill Cr.?
Magruder?
USACE/
Campground?
Cold Cr.
Bridges
Delbar/
Mewhinney Cr.
Ukiah
Radiosondes
USACE/
Deerwood
BLM/
North Cow Mtn.
EEL RIVER
RUSSIAN RIVER
WEST FORK MIDDLE CREEK
MIDDLE CREEK
RUSSIAN R NR CALPELLA CA
CA UPPER LAKE 7 W
CA UPPER LAKE 3.6 W
TULE LAKE
CA REDWOOD VALLEY 1.1 NW

Goals

- Installation of instruments in summer 2017
- 2017-2018 AR season intensive observation
- Assessment of high-resolution precipitation patterns within watershed and sensitivity of streamflow to precipitation and soil moisture