NASA Science Mission Directorate
Earth Science Division
Applied Sciences Program

Analysis of Agricultural Water Supply-Demand Imbalance During the California Drought

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NASA Water Resources Team Meeting

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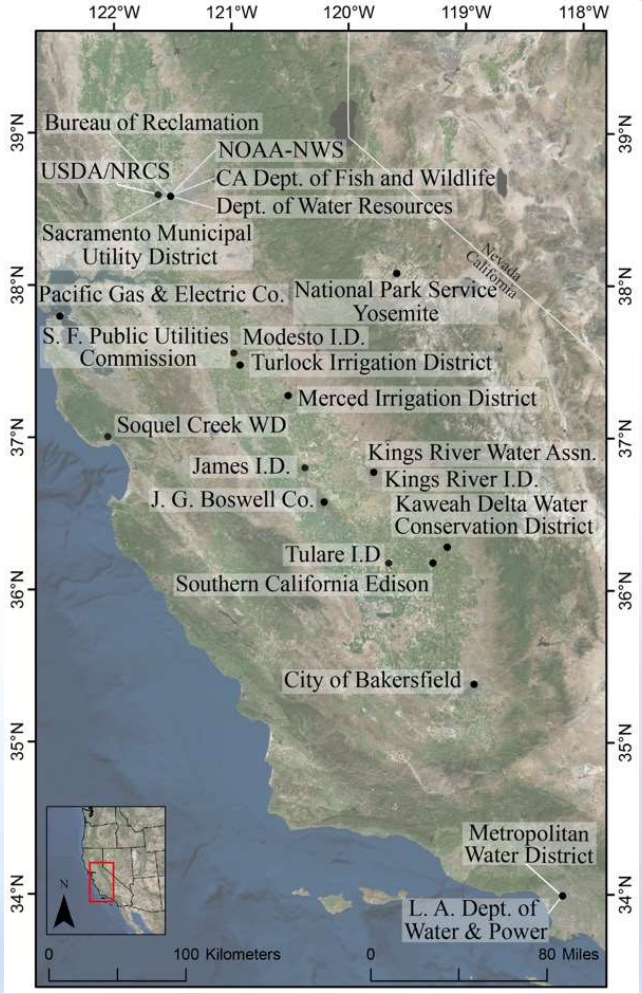
Current partners and user community

- Partner: California Dept of Water Resources
- Center for Water, Earth Science & Technology
- JPL
- User community: Federal, state and local entities across California; e.g. irrigation districts and municipalities.

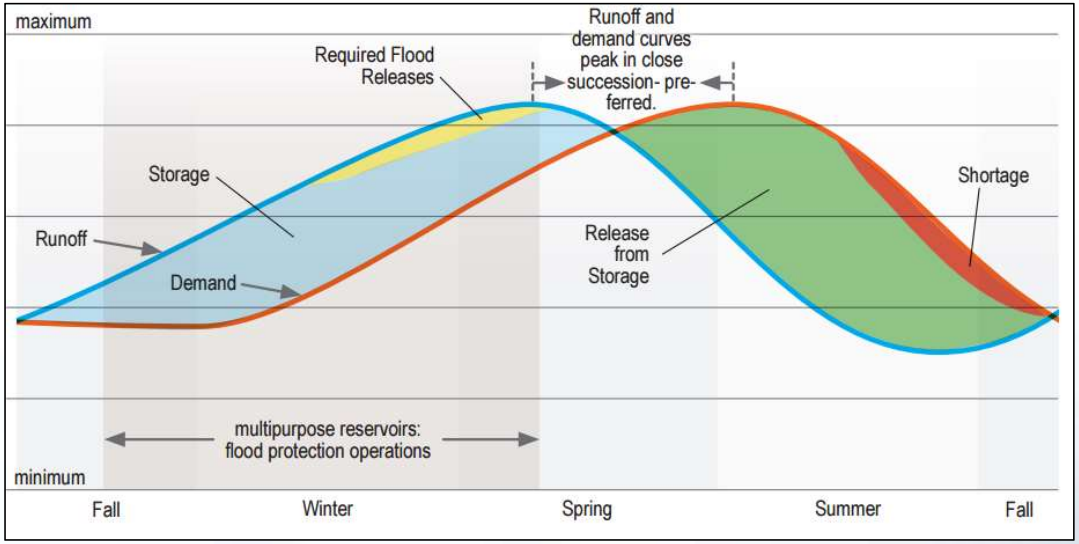
University of Colorado Boulder



Analysis of Agricultural Water Supply-Demand Imbalance During the California Drought

- Evaluate agricultural water supply-demand imbalances.
- How can remotely sensed snow information improve water supply forecasts?
- Assess utility of satellite-based snowpack information with regard to meeting user needs.

Water supply and demand



Source: CA DWR

"A snow pillow is 8' x 5', and I've got 1,500 square miles of watershed..." (Anonymous User)

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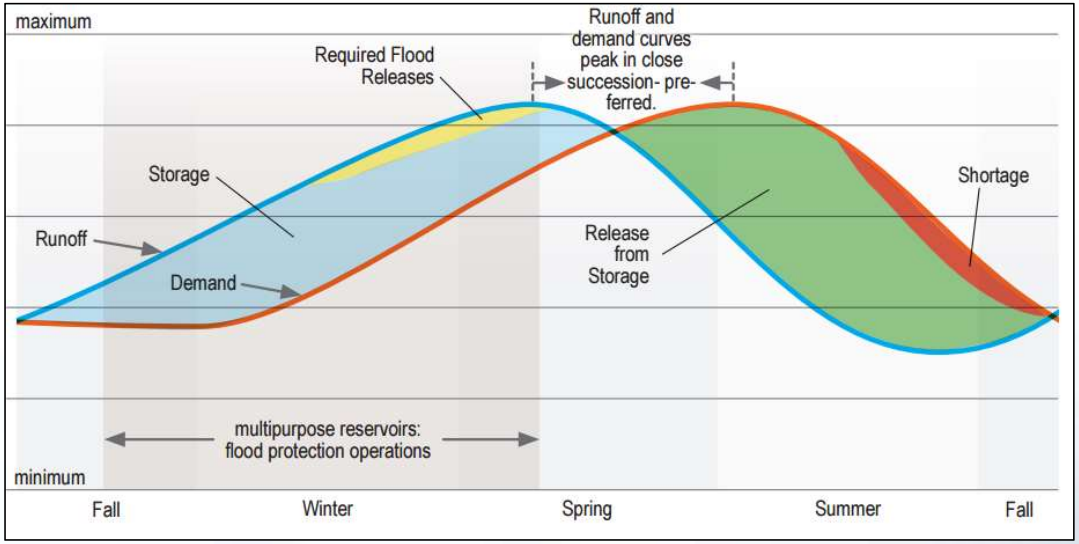
Water supply and demand

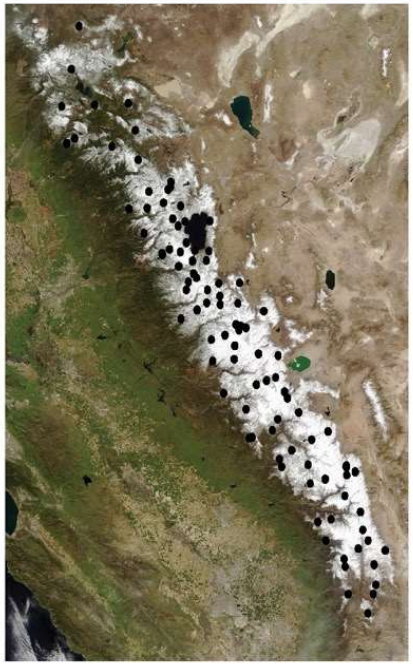


Source: CA DWR

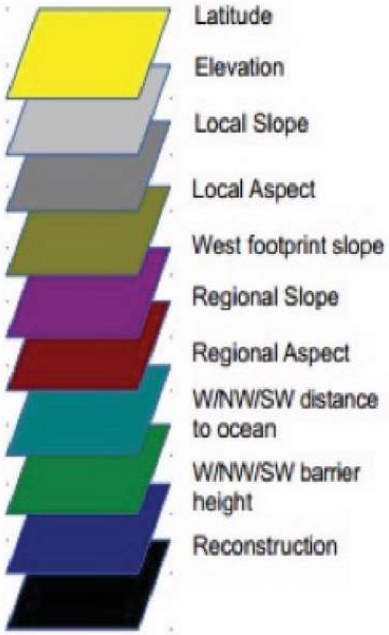
"If you can eliminate or reduce one of the major two uncertainties in runoff forecasting—how much snow is actually up there—that's huge" (Anonymous User)

Regression SWE Modeling Inputs

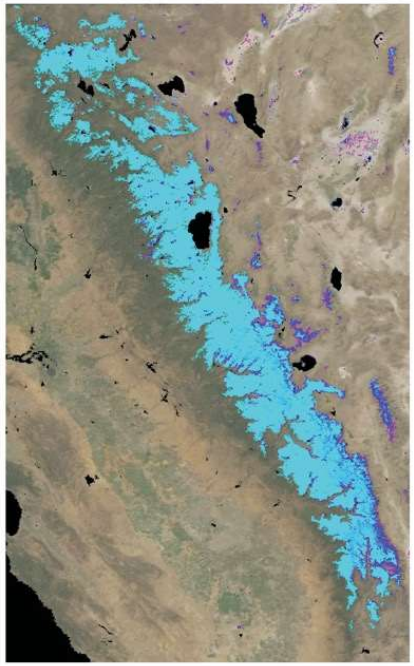
Snow Pillows



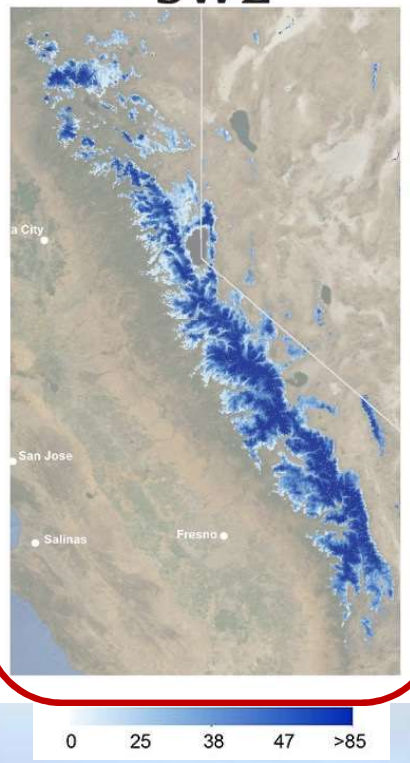
Independent Variables



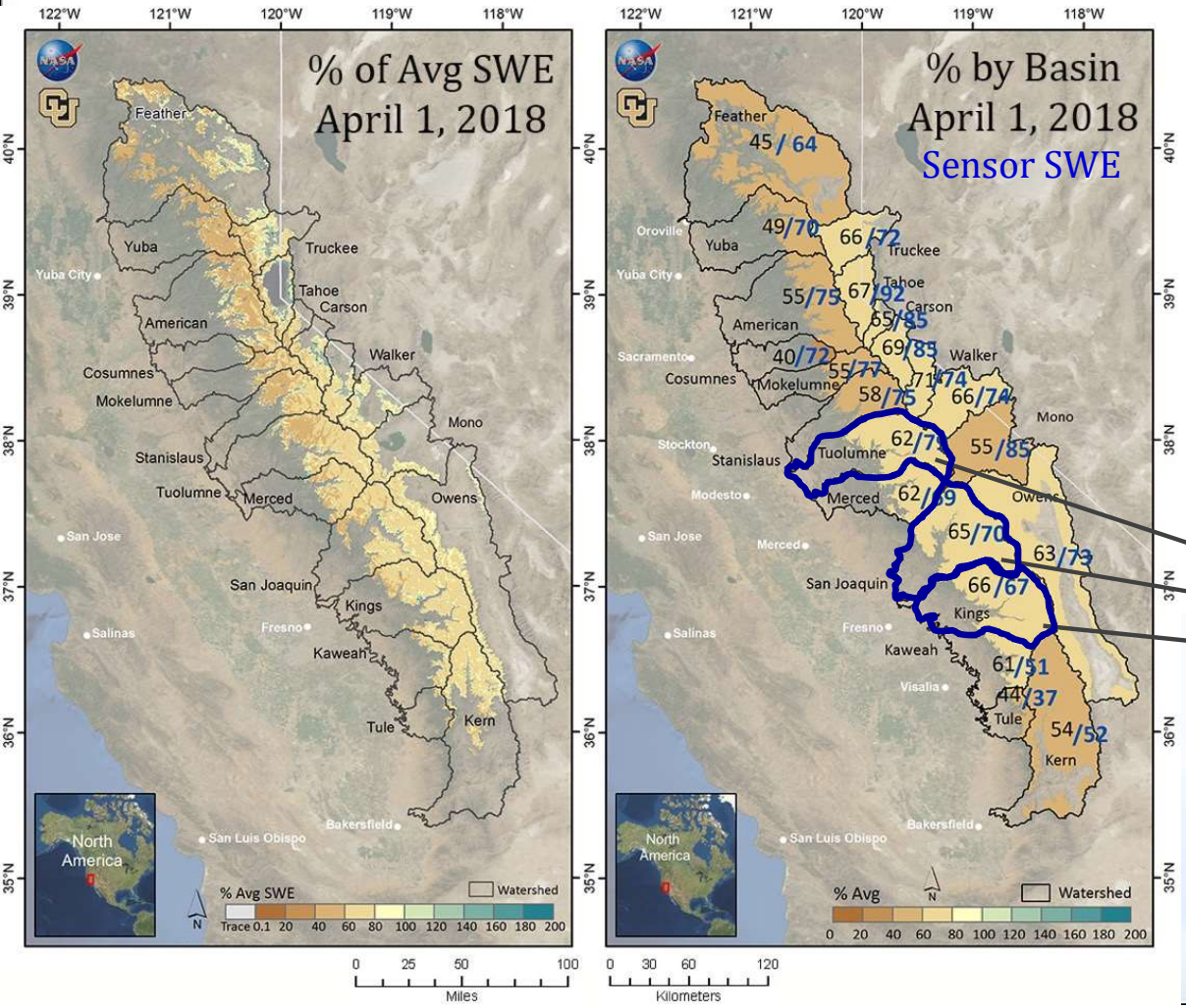
MODSCAG Snow-covered Area

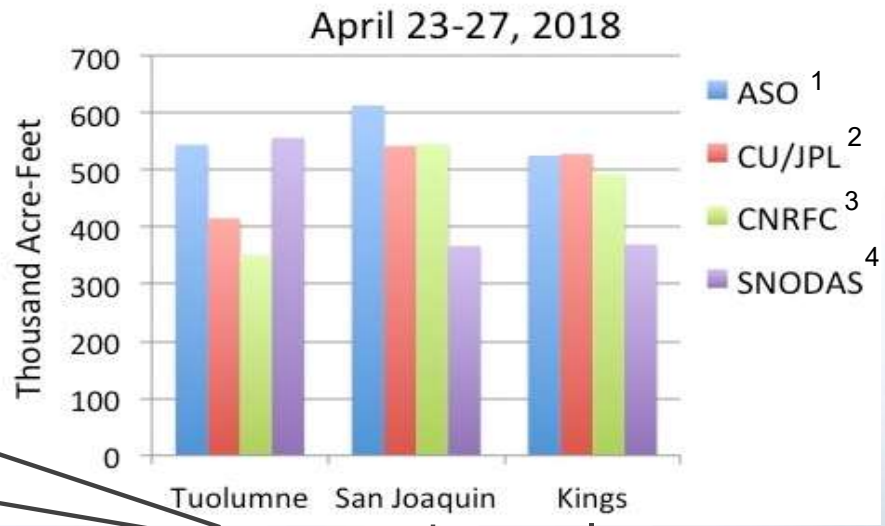


Regression SWE



Can remotely sensed snow information improve water supply forecasts?





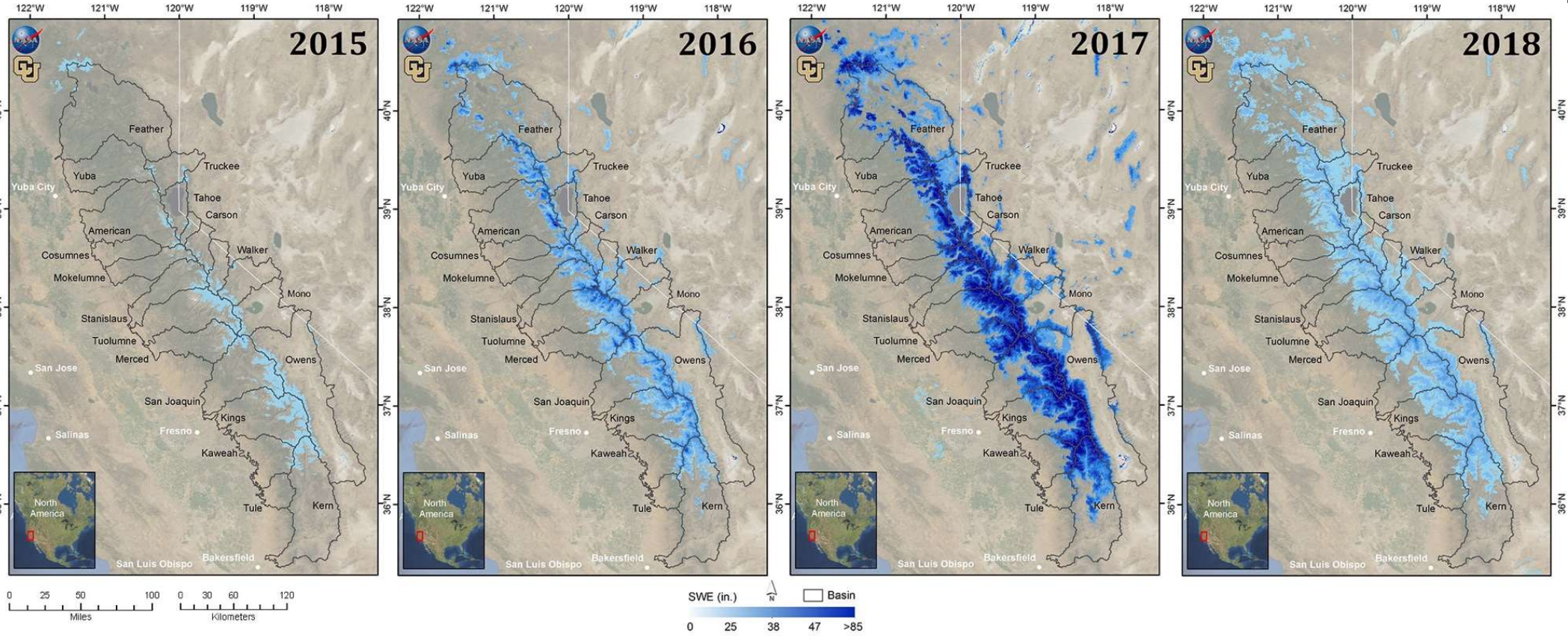
[1] Airborne Snow Observatory

[2] CU/JPL Regression SWE Product

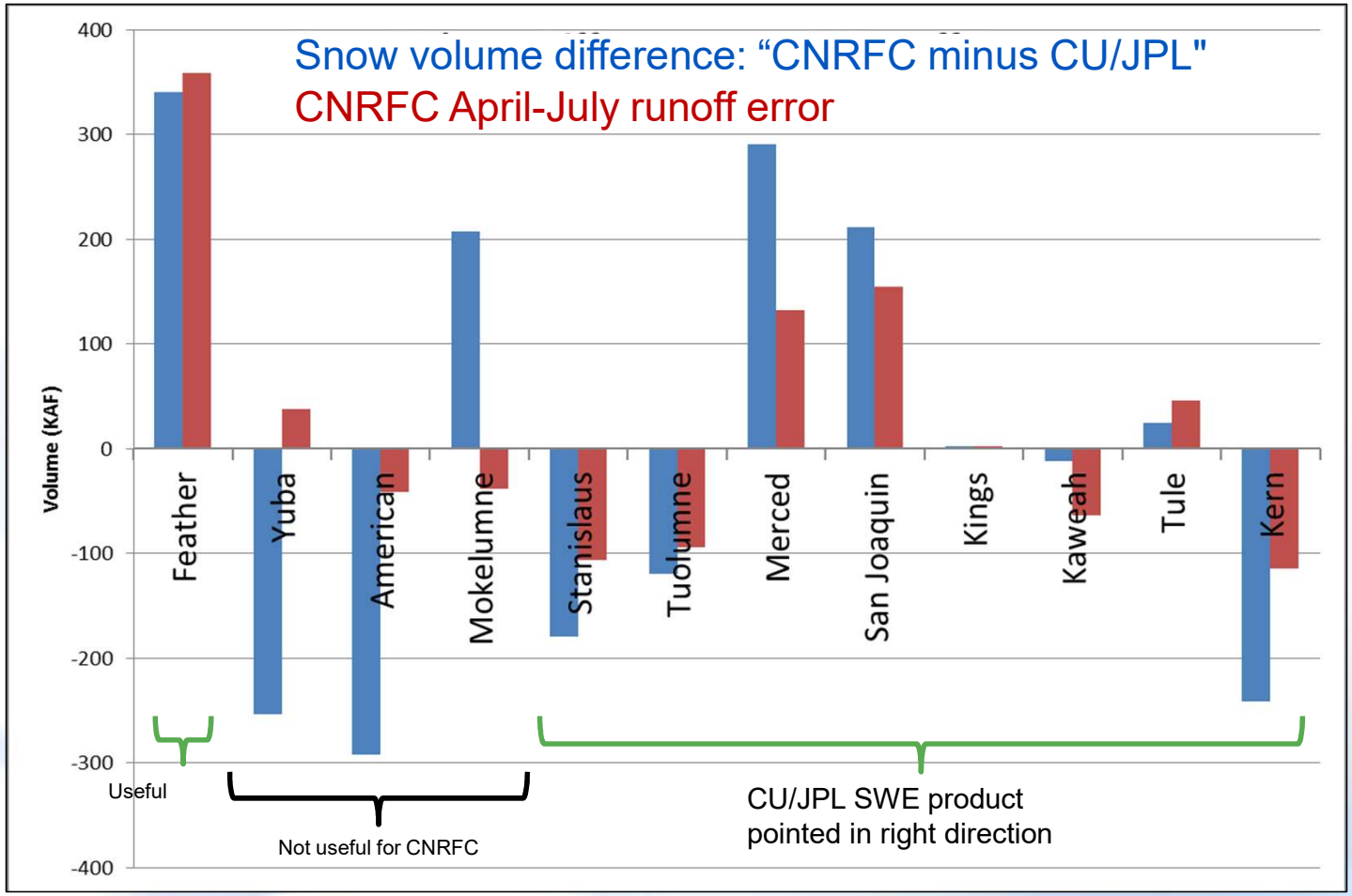
[3] California Nevada River Forecast Center

[4] NOAA NOHRSC National SWE Product

Recent inter-annual variability of April 1st SWE

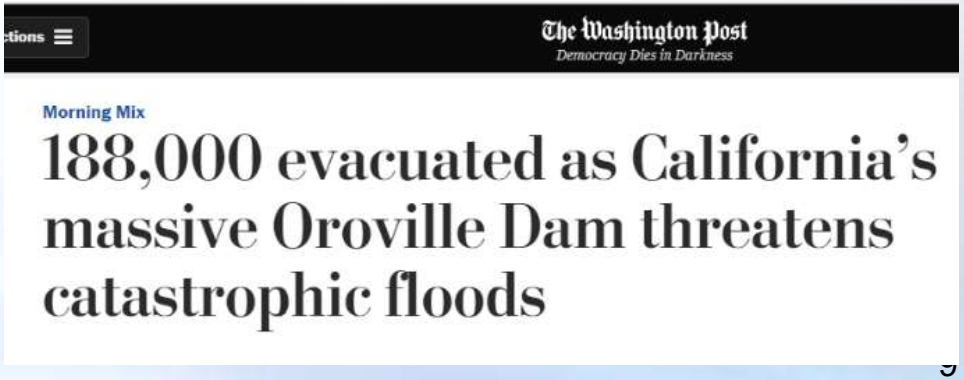


In Nine out of 12 basins, the CU/JPL SWE product would have reduced runoff error for the California Nevada River Forecast Center (CNRFC)



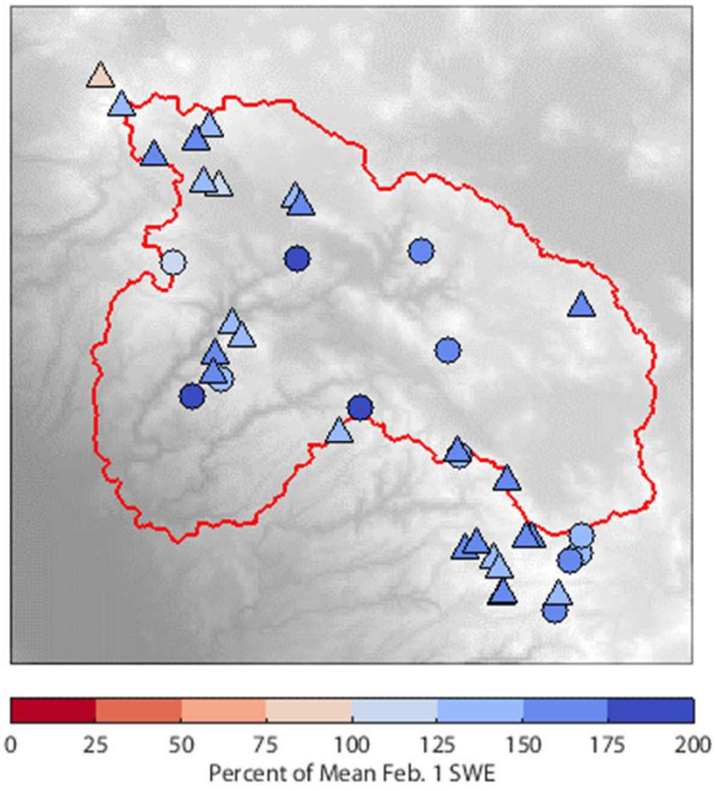
February 2017 Oroville Dam crisis

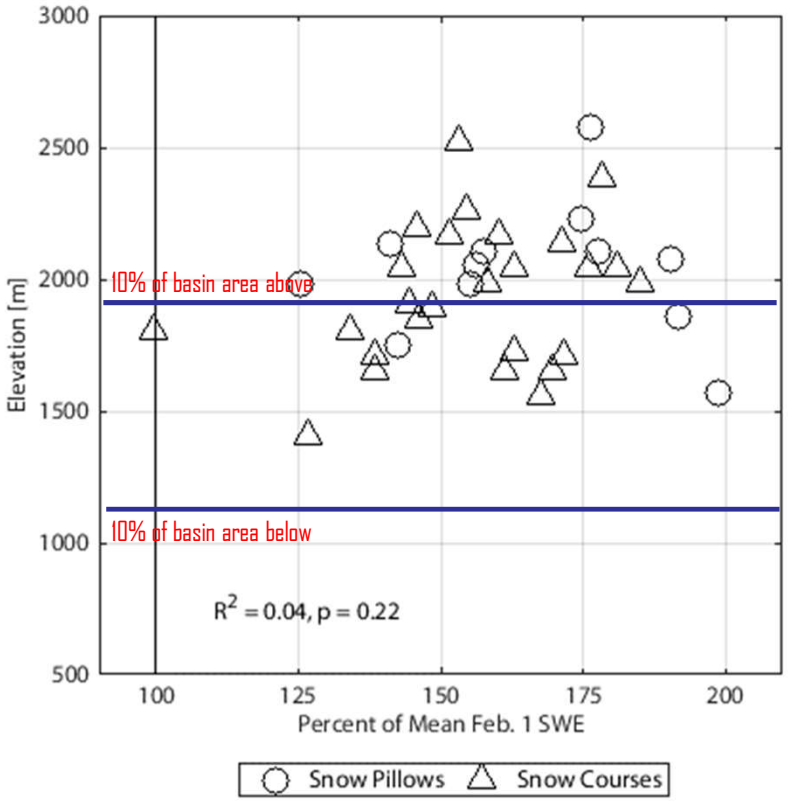
- Extreme inflows to Lake Oroville observed February 7-11, peaking at 192,000 cfs late on February 9
- Highest observed rate since January 1997 flood of record
- 1.3 MAF 5-day inflow total
- What drove such a remarkable streamflow event?



Henn, Musselman, Ralph, Lestak, and Molotch (*in prep*)

Antecedent Snowpack

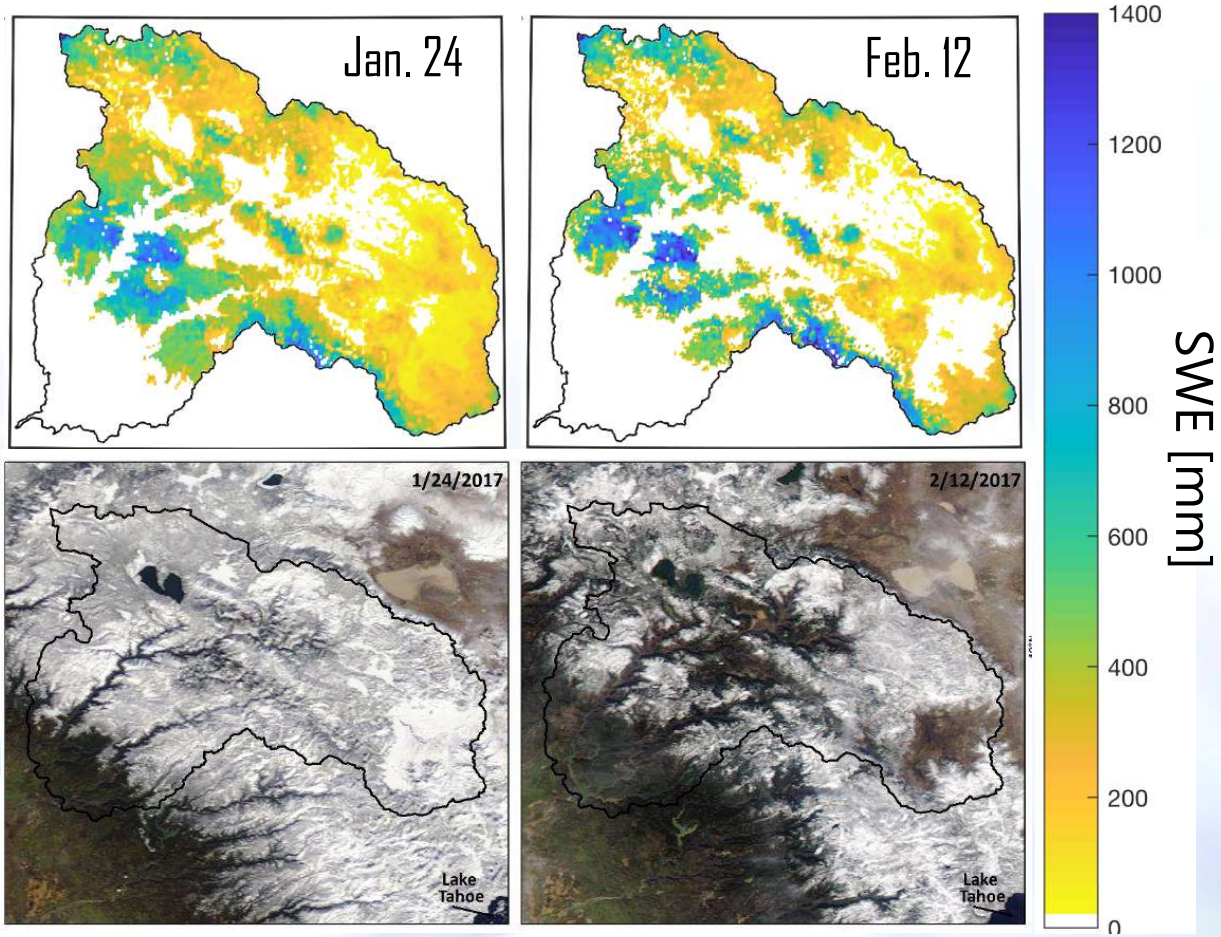




- Antecedent snowpack far above February 1 long-term average (160% of normal) after very active AR sequence in January
- SWE above average at all elevations with pillows/courses

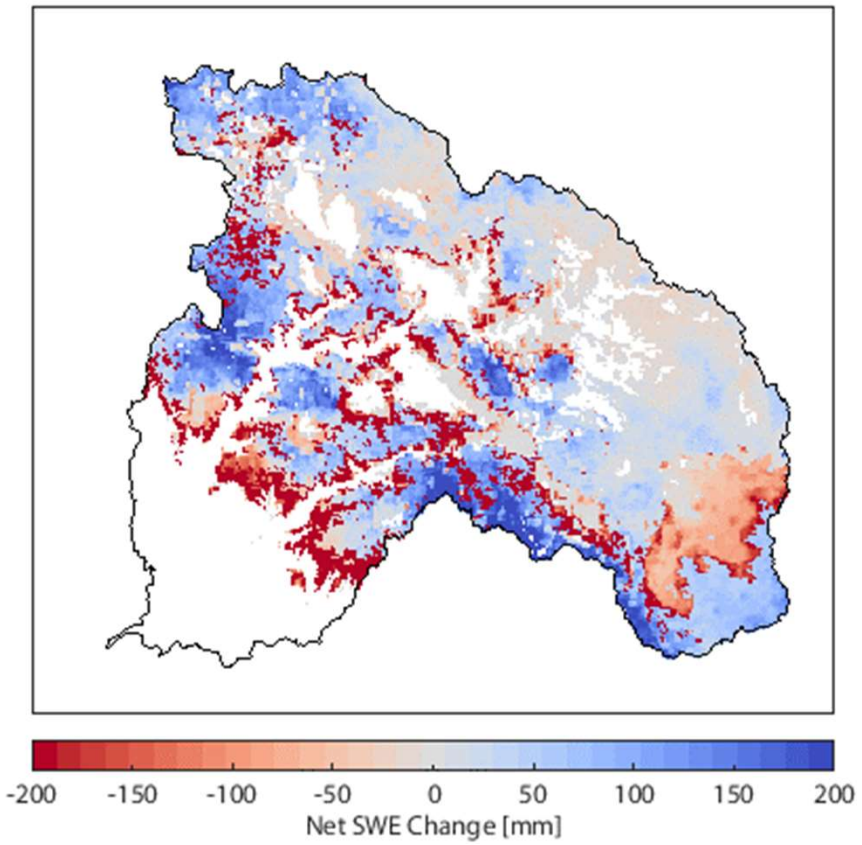
Henn, Musselman, Ralph, Lestak, and Molotch (*in prep*)

SWE maps before and after the flood event show significant snowmelt



- CU / JPL gridded SWE estimates before & after the flood event
- SWE maps available for MODIS clear-sky images on January 24 and February 12, 2017

Basin-wide snowpack losses contributed 11% to the flood wave: CU/JPL SWE Product



- 26 mm SWE loss averaged over Feather River Basin between Jan. 24 and Feb. 12
- 230 mm measured precipitation over basin
- total water available for streamflow generation was 11% higher due to snowmelt

Henn, Musselman, Ralph, Lestak, and Molotch (*in prep*)

CONCLUSIONS

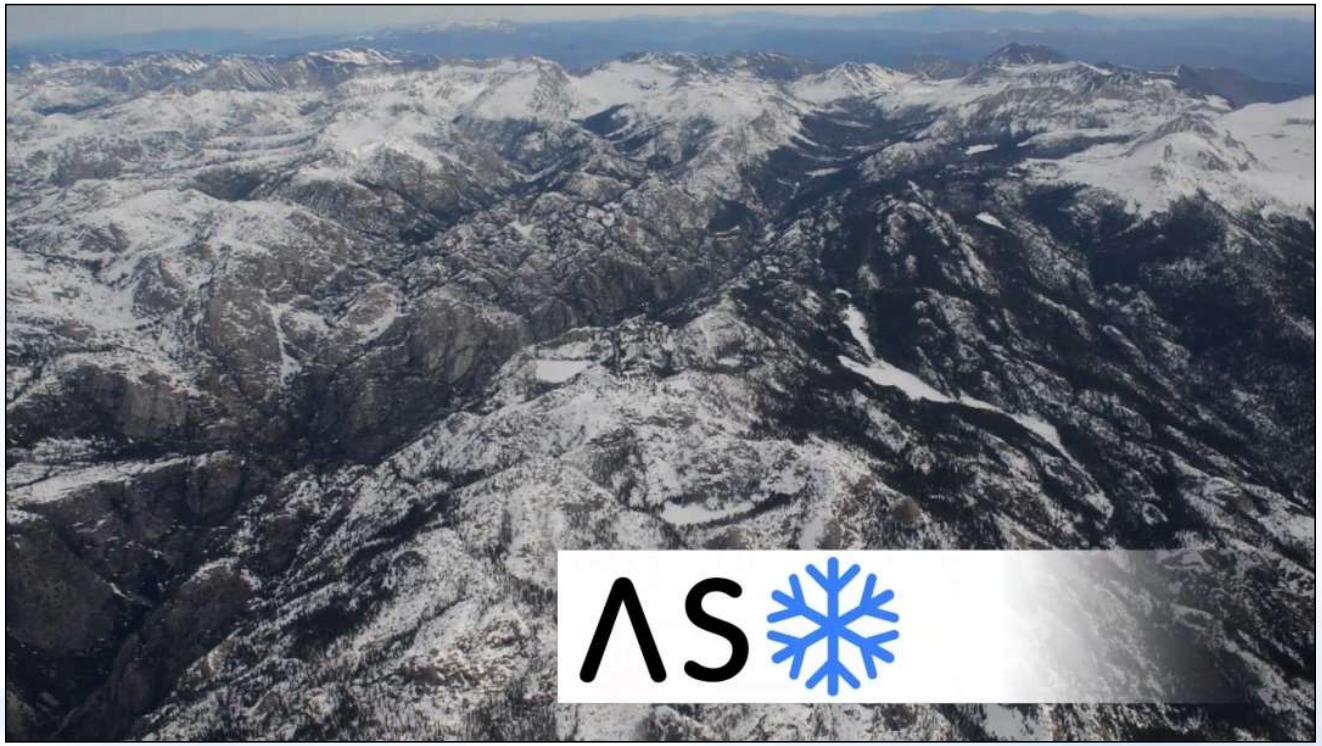
Spatial SWE products offer potential to improve:

- Water supply forecasting: in 9 of 12 watersheds NOAA NWS CNRFC forecasts would have improved with the spatial SWE information
- Flood risk assessment: real time SWE mapping illustrates that 11% of the Oroville-event flood wave was associated with snowmelt / rain-on-snow
- Drought impact assessment: SWE products show a snow-water deficit of 54 Million Acre Feet going into the 2018 water year

And some optimism….

"Every drought, we changed our water management—our water management became more sophisticated… And this most recent drought was no different" (Anonymous User).

How do available SWE products compare to ASO SWE?



How do available SWE products compare to ASO SWE?

1) ASO SWE (Painter et al., 2016)

   a) LiDAR – snow depth; iSnobal – snow density
   b) weekly in snow ablation season, 50m, limited basins, high accuracy,

2) Guan's SWE Reconstruction model (Guan et al., 2013)

   a) land surface model / snow depletion curve / MODSCAG + blended with observed SWE
   b) daily from 3/1 to 8/31 (2000-2014), 500m, entire Sierra, relatively high accuracy

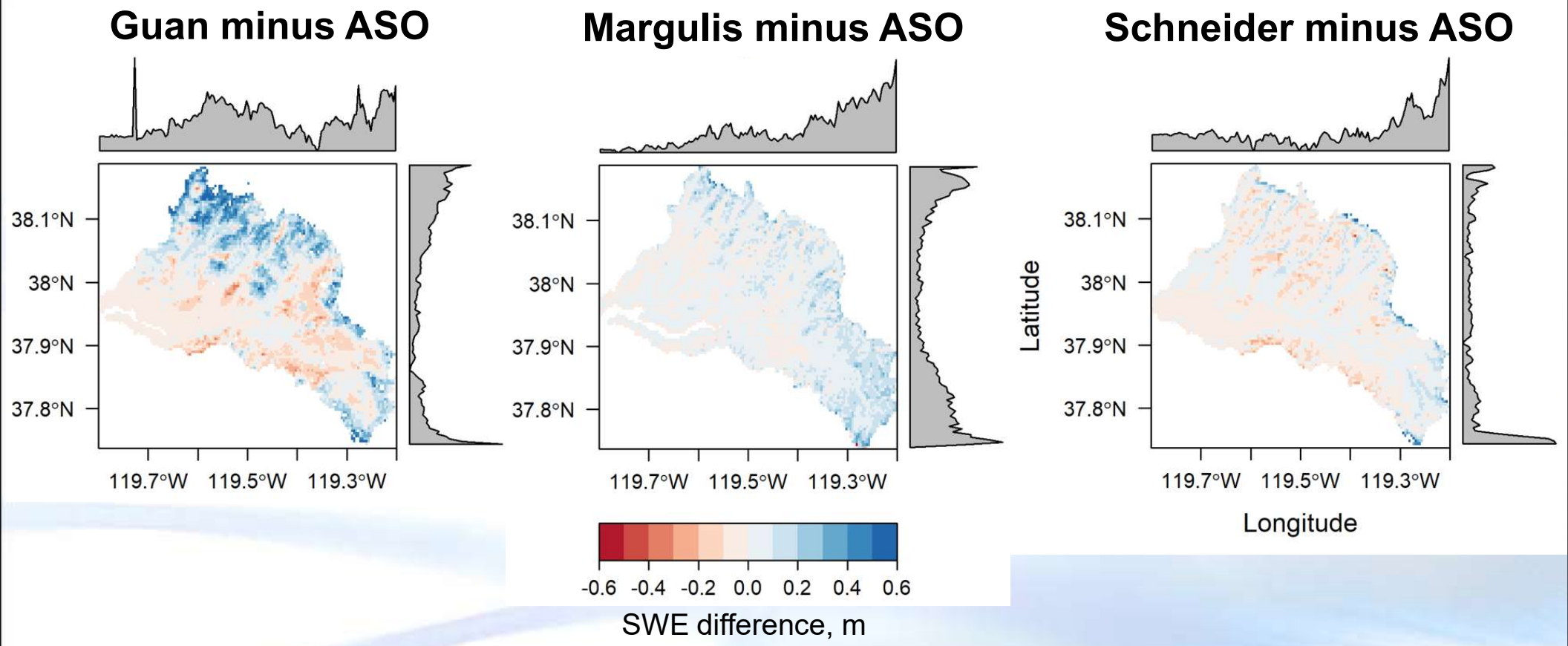
3) Margulis's SWE reconstruction model (Margulis et al., 2016)

   a) A Particle batch smoother – land surface model / snow depletion curve / Landsat fsca
   b) daily (1985-2016), ~90m, entire Sierra, relatively high accuracy

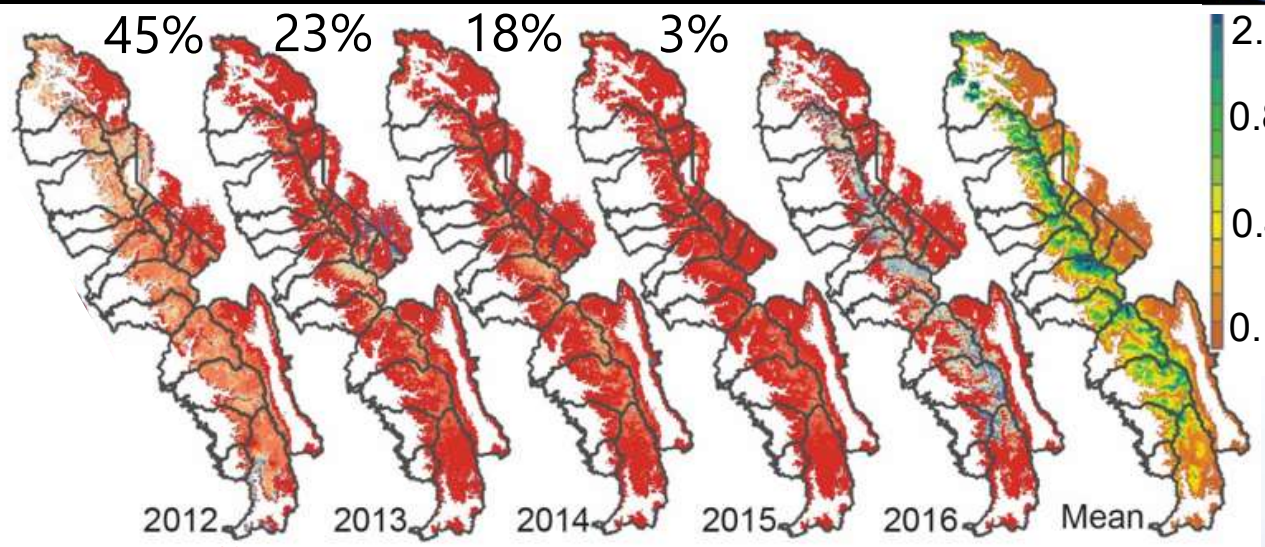
4) Schneider's near real-time regression model (Schneider & Molotch, 2016)

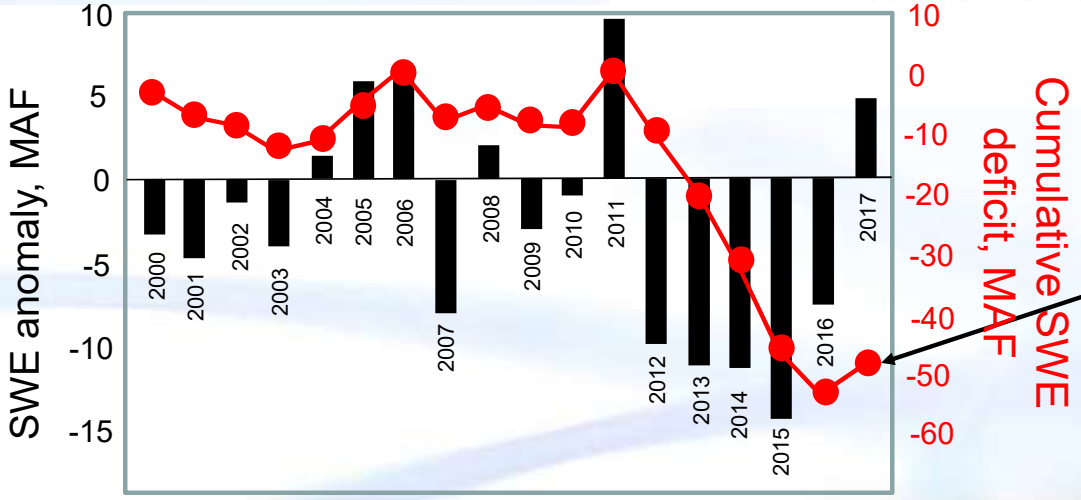
   a) Snow observations + generalized linear model + cross validation
   b) cloud-free day, 500m, entire Sierra, highly depend on snow observations

How do available SWE products compare to ASO SWE on average?



Recent snow-water deficits in the Sierra Nevada resolved with the CU/JPL regression SWE product





Deficit going into 2018 water year: 54 Million Acre Feet

Note: 2018 was also a very low snow year.