



# FORECAST INFORMED RESERVOIR OPERATIONS

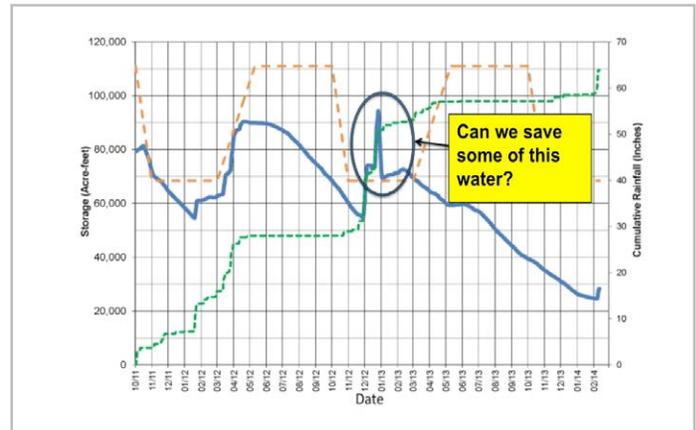
## CHALLENGE

California's water supplies rely on adequate precipitation, which is largely dependent on atmospheric rivers (ARs). The absence of AR storms often leads to drought, whereas strong ARs can cause flooding. Currently, most reservoirs are operated without the benefit of AR forecasts. However, there is now potentially useful skill in forecasting ARs. Predicting the timing and intensity of these critical precipitation events (and the lack thereof) is essential to providing water managers and dam operators with the information they need, with enough lead time, to operate reservoirs to adapt to floods and drought. Applying scientific advances in weather and streamflow prediction can lessen the impacts of weather extremes without the need for expensive infrastructure expansion. This cost-effective management approach, called Forecast Informed Reservoir Operations (FIRO), offers an opportunity to make better use of existing multi-purpose reservoirs across the state and region.

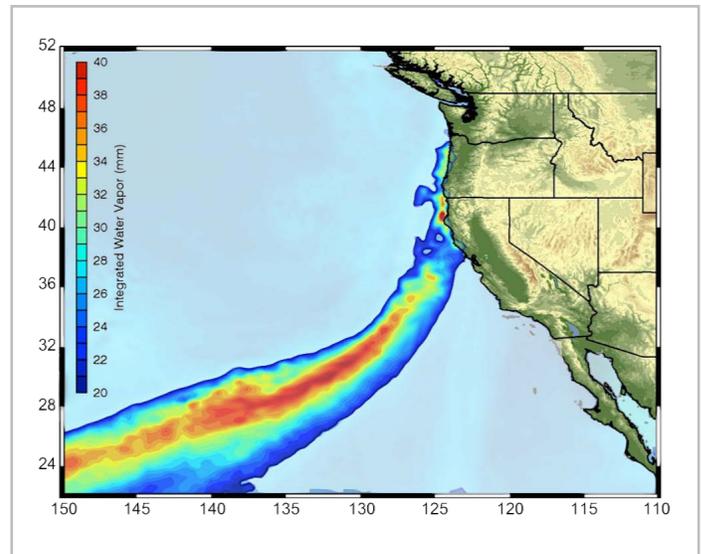
## ACCOMPLISHMENTS

FIRO, first tested at Lake Mendocino, in the Russian River watershed, has shown great promise. A Steering Committee, co-chaired by Marty Ralph (CW3E) and Jay Jasperse (Sonoma Water), is working collaboratively on this project, which has transferability potential to other reservoirs. Results from the Steering Committee's FIRO preliminary viability assessment<sup>1</sup> (2017) showed more than double the potential benefit to water supply as had been the goal, while not increasing flood risk and supporting salmon recovery.

- The final viability assessment is expected to be released in 2020.
- A FIRO project on Prado Dam in southern California is being scoped with a Steering Committee co-chaired by Marty Ralph (CW3E) and Greg Woodside (Orange County Water District) and including representatives of CA DWR, USACE, USFWS, NOAA, and Orange County Public Works.



The blue line shows the actual storage in Lake Mendocino from October 2011 to February 2014. The dashed orange line represents the guide curve, or the allowed storage in Lake Mendocino determined by the U.S. Army Corps of Engineers (USACE) water control manual. The green dashed line is the accumulated rainfall during the period. December 2012 had over 15 inches of rainfall, most of which fell during four AR events. Since the storage level was above the guide curve, this water had to be released; however, over the next 13 months almost no additional rain fell.



The integrated water vapor for a strong AR (Feb 16, 2017) that impacted most of CA and produced 3 inches of precipitation in the coastal ranges. This was one in a series of three ARs that impacted CA in a week.

The FIRO research project is focused on improving forecasts through observations and modeling. Observations are essential for verifying and improving forecast models. Researchers at CW3E are working to understand the dynamics of ARs to better predict landfall location and the amount of precipitation that they will produce. Targeted observations have been collected in the Russian River watershed during the past three winter seasons, filling key gaps in existing observing systems to answer key science questions.

These targeted observations include two sites, one at the coast and one inland, where for the first time simultaneous radiosonde profiles were collected at high temporal resolution during AR conditions. This allows an assessment of AR characteristics, such as the vertical distribution of moisture and winds, orientation, and stability, that influence the resulting spatial patterns of precipitation and streamflow. This work also includes expanding the existing soil moisture, precipitation and streamflow monitoring networks.

**Leveraging Funding:** FIRO leverages funding from various partners to achieve multiple goals. FIRO was initiated via funding from Sonoma Water, followed by significant funding from the US Army Corps of Engineers. CA DWR added support for soil moisture monitoring and exploring FIRO potential at Prado Dam, which was then supplemented by funding from the Orange County Water District.

## NEXT STEPS

Building on the ground-breaking Lake Mendocino FIRO pilot project, CW3E is examining the transferability potential of FIRO tools, approaches and strategies to other reservoirs and the unique meteorological, hydrological, biological and land use considerations that require tailoring for each reservoir. Work has already begun at Prado Dam, and other sites are being considered.

## References

<sup>1</sup> FIRO Steering Committee, 2017, Preliminary viability assessment of Lake Mendocino. Available from: <http://escholarship.org/uc/item/66m803p2>



A CW3E researcher releases a radiosonde during a January 2017 AR at the UC Davis Bodega Marine Lab in the Russian River watershed.



The Lake Mendocino FIRO Steering Committee during a Lake Mendocino tour in January 2018. Left to right: Mike Anderson, CA DWR; Jay Jasperse, Sonoma Water; Nick Malasavage, USACE San Francisco District; Marty Ralph, CW3E; Patrick Rutten, NOAA NMFS; Robin Webb, NOAA OAR; Joseph Forbis, USACE Sacramento District; Cary Talbot, USACE ERDC. Absent: Alan Haynes, NOAA NWS and Levi Brekke, US Bureau of Reclamation.



A CW3E researcher measuring streamflow at a site in the upper Russian River watershed in March 2018.

