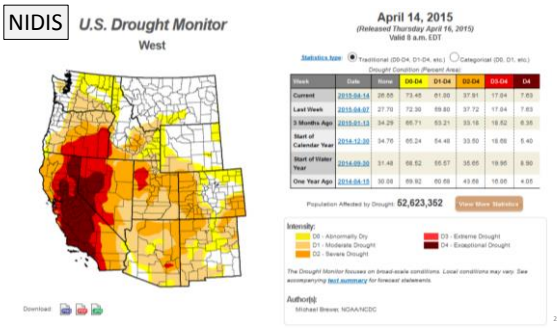
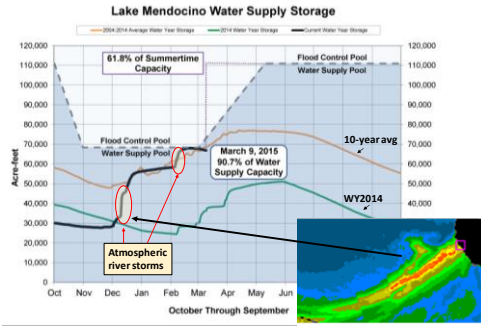
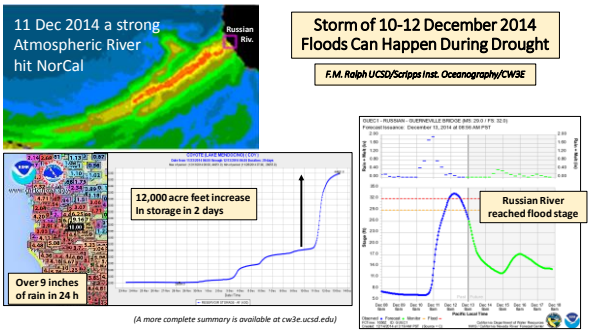
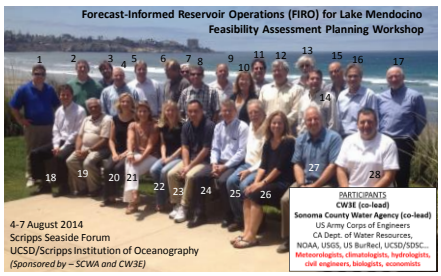
2015 AMS Washington Forum - Panel on Water Resources and Users

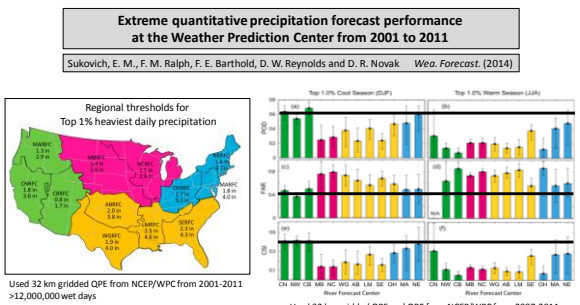
F. Martin Ralph, Director, Center for Western Weather and Water Extremes (CW3E)
At UC San Diego/Scripps Institution of Oceanography



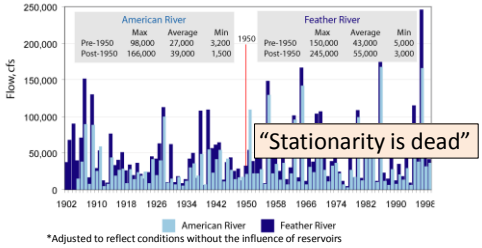








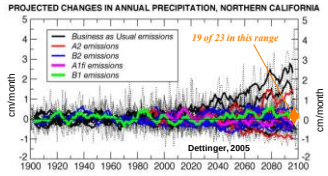
20th Century Annual Peak 3-day Flows*



*Adjusted to reflect conditions without the influence of reservoirs

Courtesy of Mike Anderson CA-DWR

A Key Challenge: Changing Climate

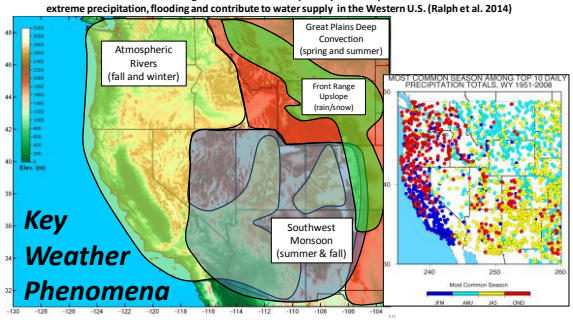


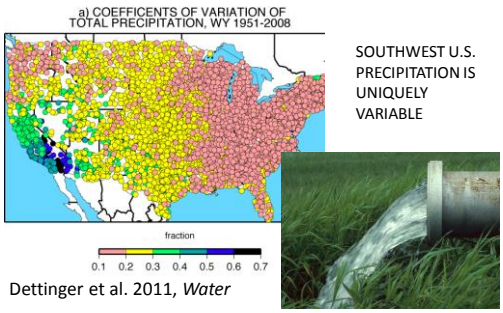
Annual precipitation projections vary mostly due to how extreme precipitation events are handled (in CA this means ARs).

Pierce et al 2013 (J. Clim.): Model disagreements in the projected change in occurrence of the heaviest precipitation days (>60 mm day^{-1}) account for the majority of disagreement in the projected change in annual precipitation, and occur preferentially over the Sierra Nevada and Northern California.

DOE G-1 aircraft: measuring cloud, rain and snow particles, as well as aerosols such as dust and smoke from sources near and far
NOAA G-IV aircraft: measuring atmospheric river strength and structure offshore using dropsondes and precipitation radar
NOAA P-3 aircraft: measuring ocean and atmosphere with radars for precipitation, cloud & ocean waves, and air & ocean sondes
NOAA Ron Brown Ship: measuring aerosols, clouds, atmospheric rivers, ocean surface and subsurface conditions
DOE AMF2: many sensors mounted on the NOAA ship; measuring aerosols, precipitation, clouds & winds aloft and at the surface
CA Dept. of Water Resources extreme precipitation network: measuring atmospheric rivers, snow level and soil across California
NSF - sponsored aerosol and rain measurements at the coast
NASA ER-2 aircraft: measuring aerosols, clouds and water vapor with radar, lidar and radiometer

Schematic illustration of regional variations in the primary weather phenomena that lead to extreme precipitation, flooding and contribute to water supply in the Western U.S. (Ralph et al. 2014)





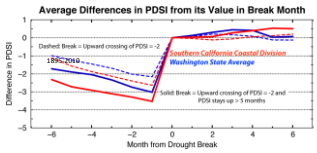
Dettinger et al. 2011, *Water*

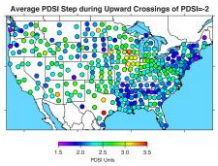
SOUTHWEST U.S. PRECIPITATION IS UNIQUELY VARIABLE

Droughts, on average, end with a bang (and begin with a whimper) all over the U.S.

- **Atmospheric rivers provide the bang** in a large fraction of the west coast drought breaks, especially in winters

Dettinger, Michael D., 2013: Atmospheric Rivers as Drought Busters on the U.S. West Coast. *J. Hydrometeor*, **14**, 1721–1732.

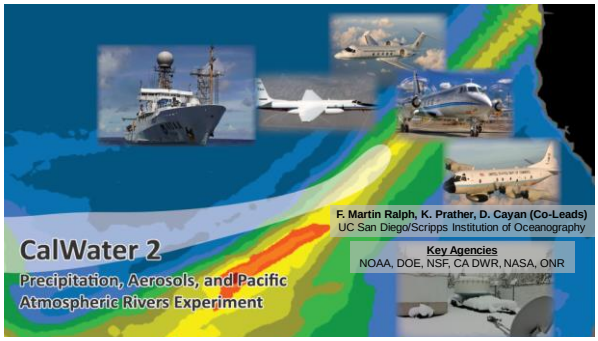


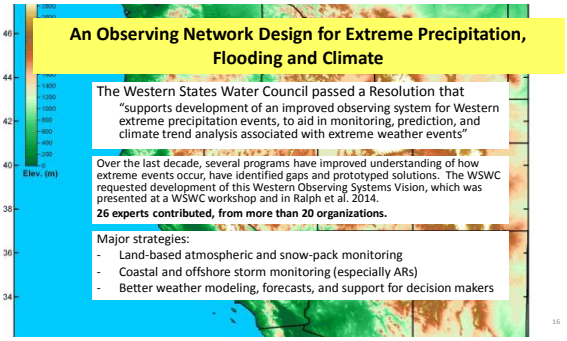


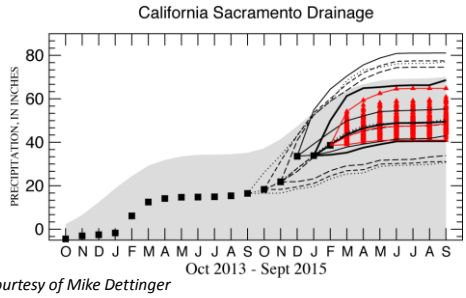
Key Science Gaps

Major goal: Measure influx of moisture to California from landfalling atmospheric rivers and study the influence of transported (cross Pacific) or local (Central Valley) aerosols on precipitation from the coast to Sierra.

- **Evolution and structure of ARs**, including quantifying terms in the water vapor transport budget (air-sea flux, rainout, frontal convergence, entrainment from tropics)
- **Prediction of aerosol burdens and properties** during intercontinental transport from remote source regions to the U.S. West Coast, including dust, biological and ice nuclei
- **Effects of climate variability and change on these phenomena**





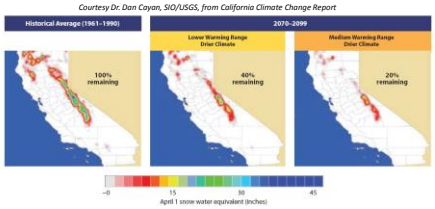


Courtesy of Mike Dettinger

Decreasing California Snowpack

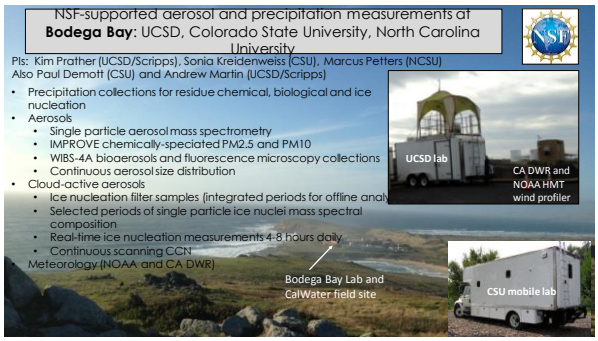
Snow pack acts as a natural reservoir for summer and fall water supply. Its capacity is projected to decrease significantly in a warmer climate.

Courtesy Dr. Dan Cayan, SIO/USGS, from California Climate Change Report



Under an ensemble of climate scenarios, there is marked reduction in spring snow pack:

- by 2100 the chance of achieving historical median SWE falls to about 10%.
- by 2100 the chance of SWE at or below 10 percentile historical rises to about 40%.



The CW3E website has up-to-date information on atmospheric rivers.

CW3E.UCSD.EDU