CalWater 2 – Precipitation, Aerosols, and Pacific Atmospheric Rivers Experiment

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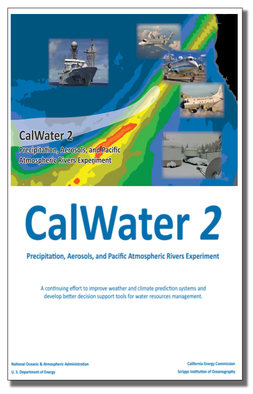
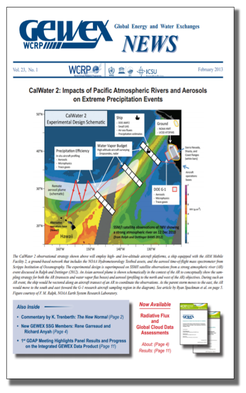
Executive Summary

Emerging research has identified two phenomena that play key roles in the variability of the water supply and the incidence of extreme precipitation along the U.S. West Coast. These phenomena include the role of:

(1) **Atmospheric rivers** (ARs) in delivering much of the precipitation associated with major storms along the U.S. West Coast, and

(2) **Aerosols**—from local sources as well as those transported from remote continents—and their modulating effects on western U.S. precipitation.



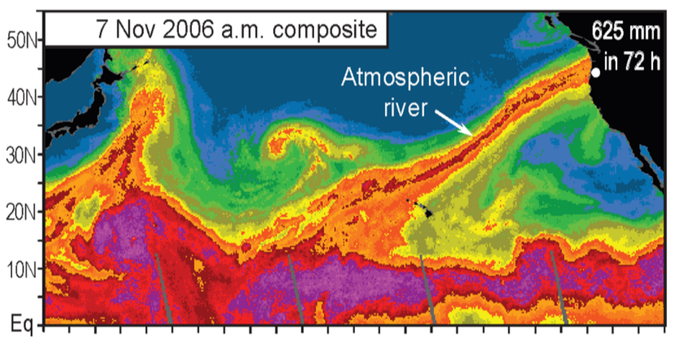


Expected outcomes for CalWater 2 include:

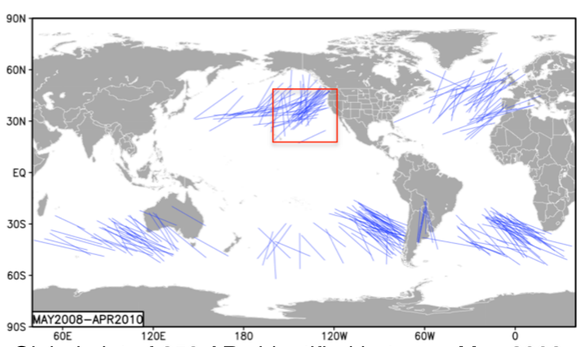
- Improvements in prediction systems for the water cycle at weather and climate timescales,
- Distribution of an unprecedented meteorological, microphysical, and chemical dataset collected in AR environments both onshore and offshore for advancing understanding and prediction of aerosol effects on precipitation, and
- Development of decision support tools for extreme precipitation events, hazard response, and water supply for more effective water resources management.

(1) Atmospheric River Phenomenon

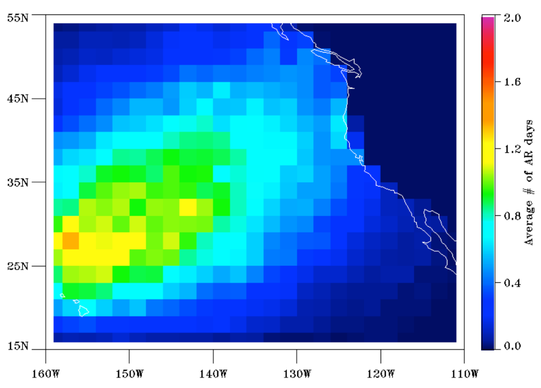
ARs are a dynamic confluence of atmospheric moisture prevalent in the midlatitudes and can lead to extreme precipitation totals when they make landfall. They can both produce hydrological hazards and supply valuable water resources.



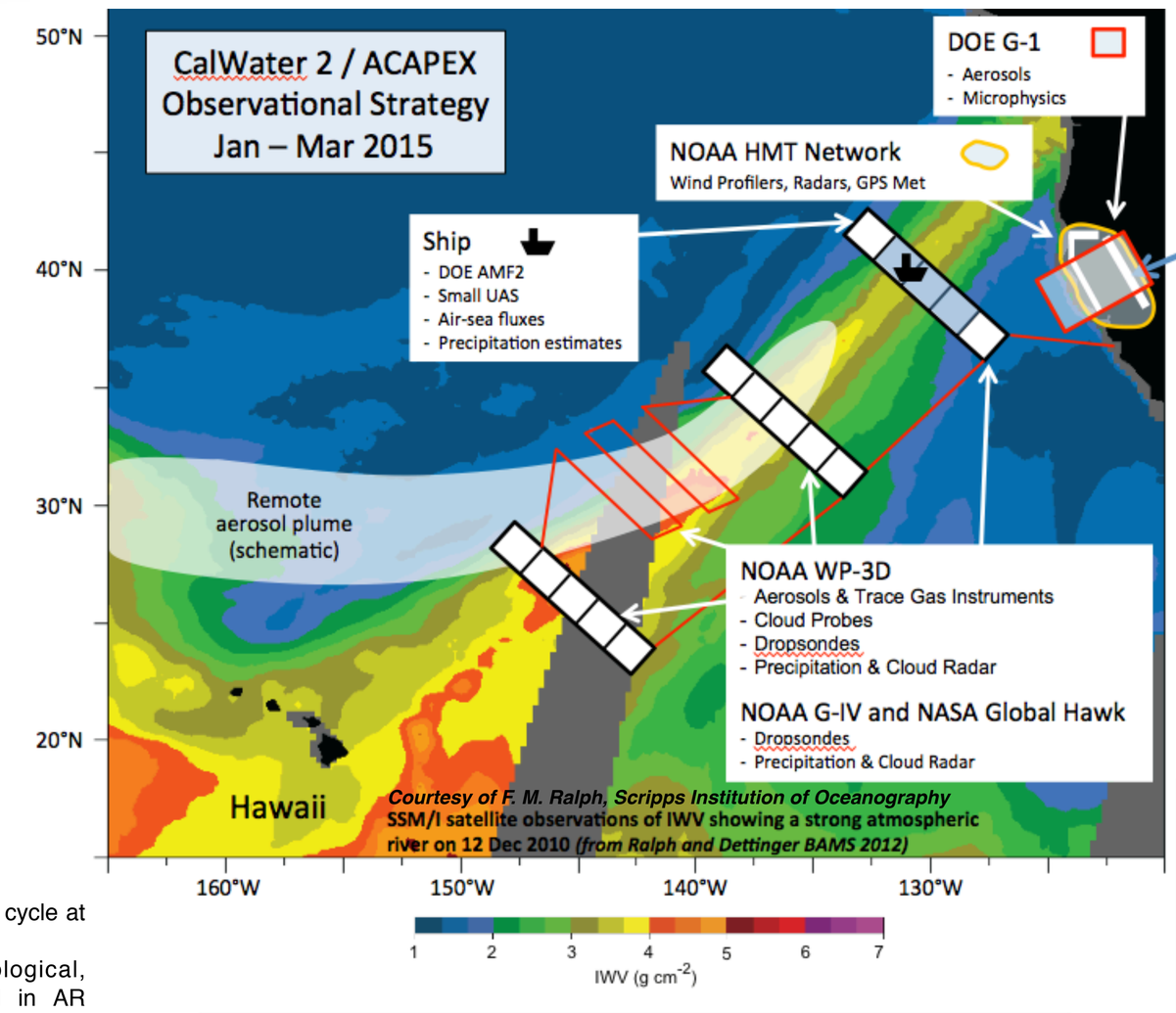
Integrated Water Vapor (IWV) satellite observations over the North Pacific illustrating the November 7, 2006 AR that made landfall in western Washington and northern Oregon.



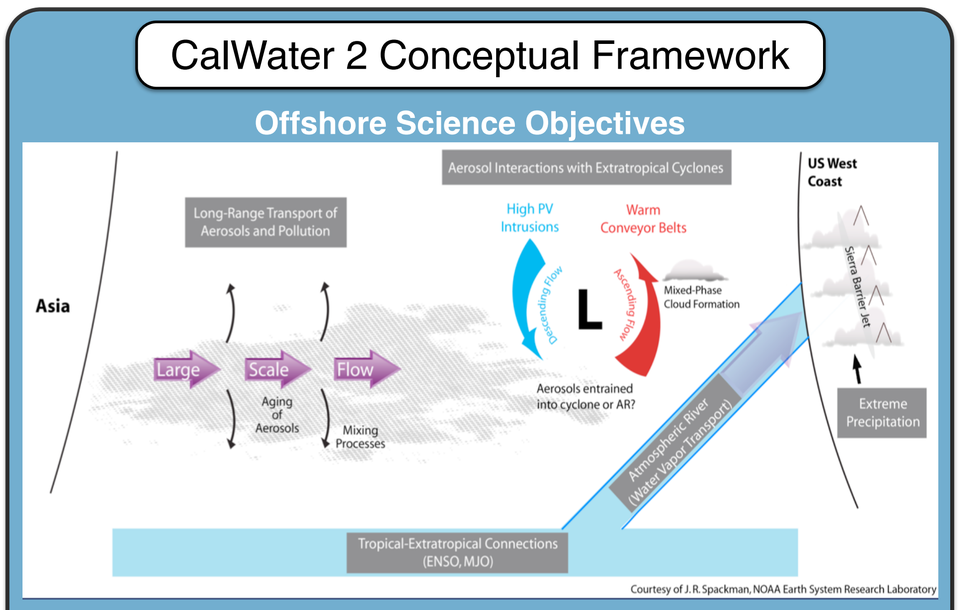
Global plot of 259 ARs identified between May 2008-April 2010. The red box denotes the theater of operations for CalWater 2. Image courtesy of Waliser et. al 2012 *Bull. Amer. Meteor. Soc.*



Average number of AR days per week from 1 November to 31 March for 2003-2012. Courtesy of G.A. Wick, NOAA Earth System Research Laboratory.

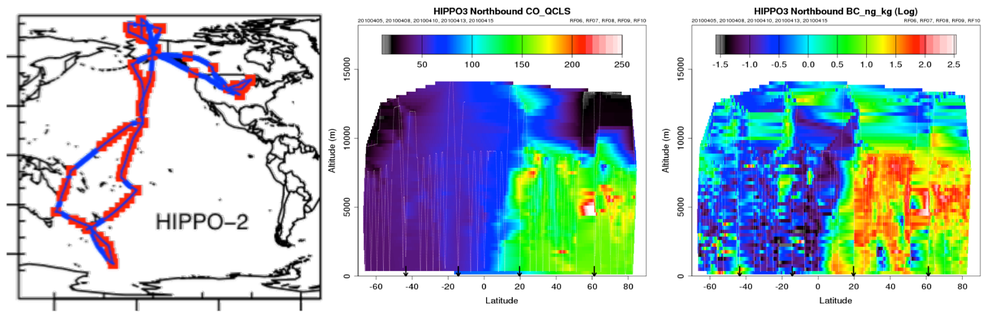


Courtesy of F. M. Ralph, Scripps Institution of Oceanography
SSM/I satellite observations of IWV showing a strong atmospheric river on 12 Dec 2010 *(from Ralph and Dettinger BAMS 2012)*



(2) Cloud-Aerosol-Precipitation Interactions

Atmospheric dynamics couples the water vapor content in the tropics and midlatitudes with aerosols through microphysical processes that, along with orography, influence precipitation. The large-scale flow influences where the aerosols and clouds encounter each other and the thermodynamics determines how the aerosol particles nucleate water vapor to form cloud droplets and ice crystals. Many questions remain regarding the role of aerosols in the development of extratropical cyclones and associated ARs.



Above: HIAPER Pole-to-Pole Observations (HIPPO) of Carbon Cycle and Greenhouse Gases Study depicting CO (middle), Black Carbon (right), and an example flight path of the observations where the red markers indicate vertical profiles.

Implementation Strategy

A set of science investigations have been proposed to fill gaps including a targeted set of aircraft and ship-based measurements and associated evaluation of data over regions offshore of California and in the eastern Pacific for an intensive observing period between January 2015 and March 2015. The DOE Atmospheric Radiation Measurement (ARM) program has committed airborne and ship-borne facilities for this same period in a study called ACAPEX (ARM Cloud Aerosol and Precipitation Experiment), a complementary study to CalWater 2.

Sierra Nevada and Coastal Ranges (white bars)

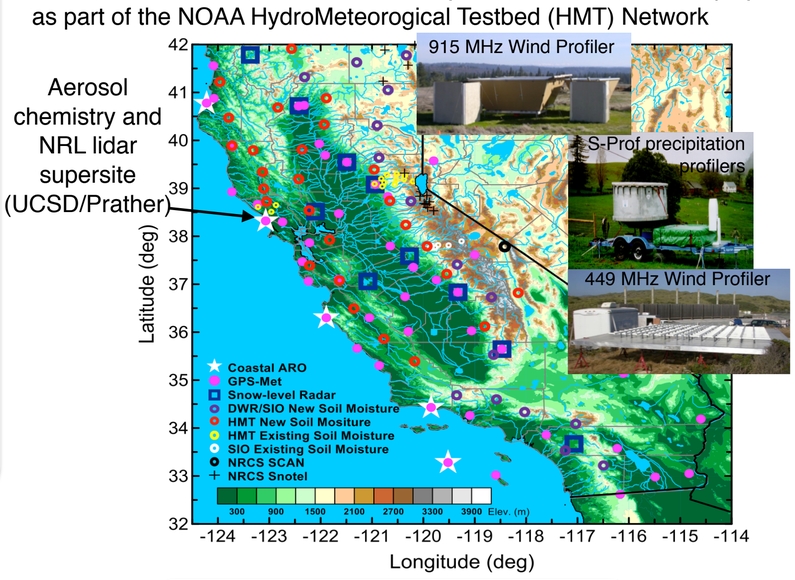
<u>Ship-Based Facilities:</u> Department of Energy Atmospheric Radiation Measurement (ARM) Mobile Facility (DOE AMF2)

<u>Airborne Facilities:</u>

Platform	Theater of Operations	Measurements
DOE G-1 *Altitude < 23 kft* 	On/ Offshore CA	Aerosols (total aerosol number and size distributions, BC mass, dust, scattering/absorption, single particle mass spectrometer) Chemical tracers (CO, ozone) Microphysics (CCN, IN, cloud drop size distribution, water/ice content) Meteorological data (T, P, RH, wind, turbulence)
NOAA WP-3D *Altitude < 22 kft* 	Offshore CA	Dropsondes (P, T, RH, wind) Tail Doppler radar Microphysics (CCN, IN, cloud water/ice, precipitation spectra) Aerosols and chemical tracers
NOAA G-IV *Altitude < 45 kft* 	HI to CA	Dropsondes (P, T, RH, wind) Tail Doppler radar Chemical tracer (ozone)
NASA Global Hawk *Altitude 45-65 kft*	HI to CA	Dropsondes (P, T, RH, wind speed/ direction) HAMSR (T, integrated water vapor)

<u>Ground-Based Assets</u>: CalWater 2 will leverage a set of advanced, land-based observations of the water cycle and ARs that are deployed as part of the NOAA HydroMeteorological Testbed (HMT) Network

Aerosol chemistry and NRL lidar supersite (UCSD/Prather)



CalWater 2 Vision

Observations are also proposed for subsequent winter seasons as part of a 5-year broad interagency vision to address the CalWater 2 science objectives.

Major Platforms	CY 2014	CY 2015	CY 2016	CY 2017	CY 2018
NOAA HMT Network	■	■	■	■	■
DOE ACAPEX AMF2 + G-1		■ ■		■	
NOAA ship Ron Brown		■			
NOAA WP-3D		■		■	
NOAA G-IV	■	■ ■	■	■	
AREX NASA Global Hawk		■	■	■	
AREX NASA DC-8			■	■	

Facility Status: *Committed* ■ *Requested* ■ *To be developed* ■ *Hypothetical* ■