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

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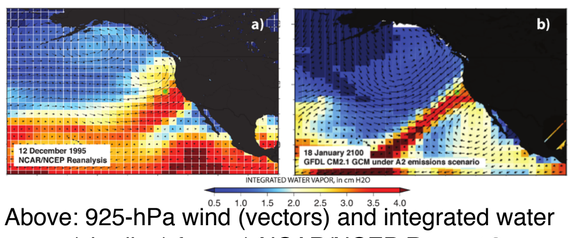
Executive Summary

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.



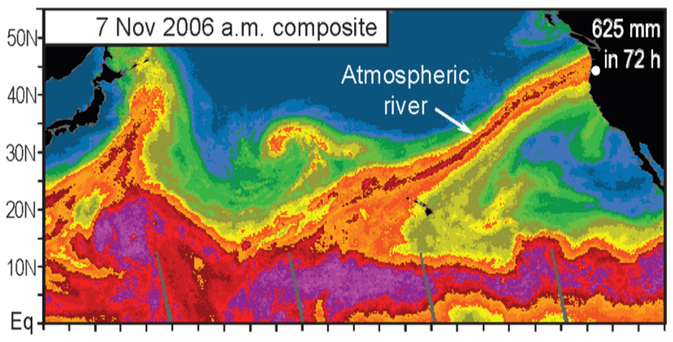
Above: 925-hPa wind (vectors) and integrated water vapor (shading) from a) NCAR/NCEP R1 on 12 December, 1995 and from b) GFDL CM2.1 under A2 emissions scenario on 01/18/2100 (modified from Dettinger et al., 2011).

Expected outcomes for CalWater 2 include:

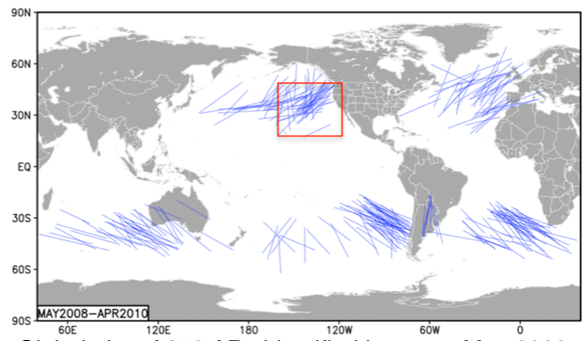
- Distribution of an unprecedented meteorological, microphysical, and chemical dataset collected in AR environments both onshore and offshore for advancing understanding and prediction of aerosol effects on precipitation, and
- Development of decision support tools for extreme precipitation events, hazard response, and water supply for more effective water resources management.
- *Validation of AR and Aerosol-Cloud interaction in Model Prediction Systems, including physical mechanisms .*

Atmospheric River Phenomenon

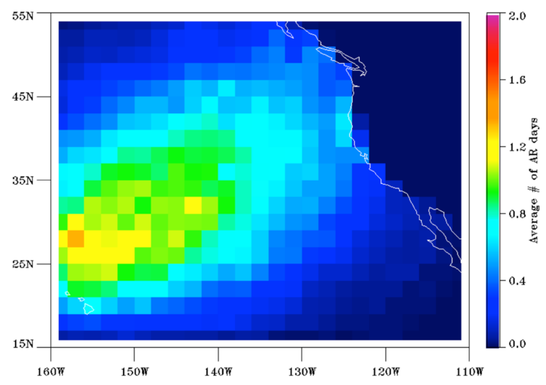
ARs are a dynamic confluence of atmospheric moisture prevalent in the midlatitudes and can lead to extreme precipitation totals when they make landfall. They can both produce hydrological hazards and supply valuable water resources.



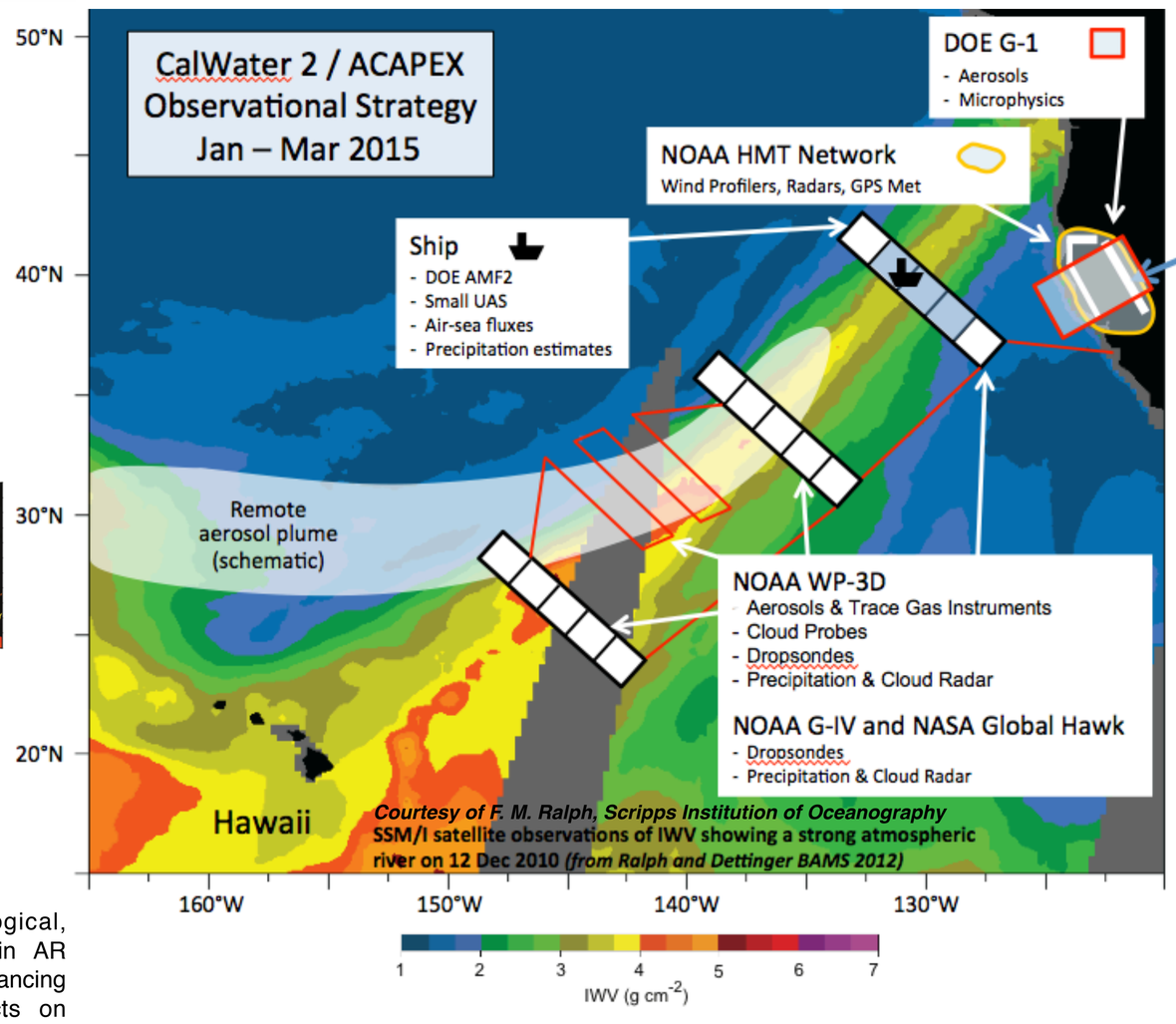
Integrated Water Vapor (IWV) satellite observations over the North Pacific illustrating the November 7, 2006 AR that made landfall in western Washington and northern Oregon.



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.*



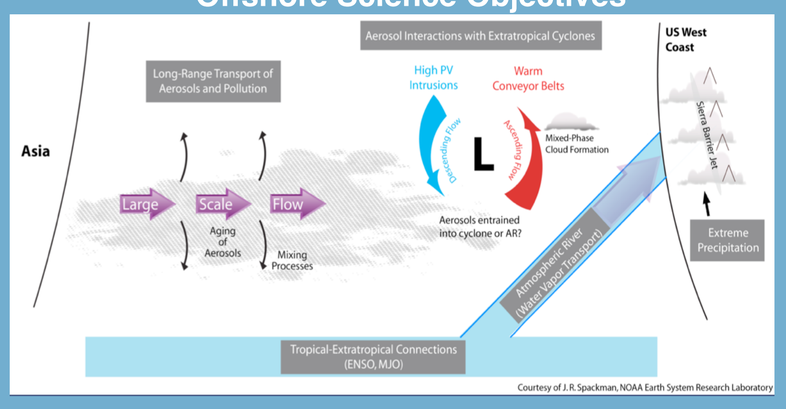
Average number of AR days per week from 1 November to 31 March for 2003-2012. Courtesy of G.A. Wick, NOAA Earth System Research Laboratory.



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)***

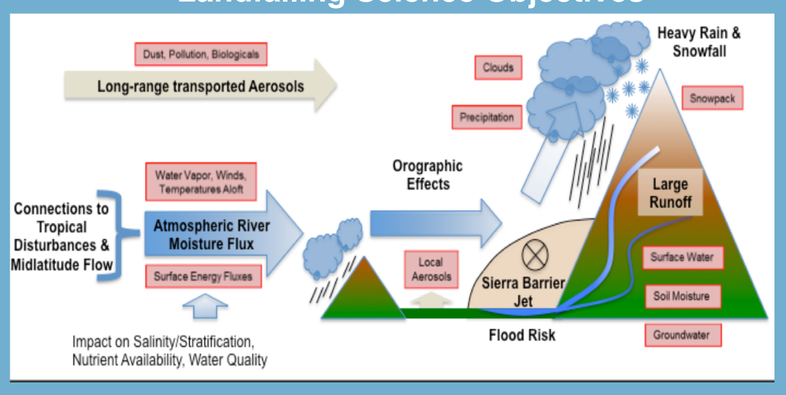
CalWater 2 Conceptual Framework

Offshore Science Objectives



Courtesy of J.R. Spackman, NOAA Earth System Research Laboratory

Landfalling Science Objectives



Courtesy of D.E. Waliser, NASA Jet Propulsion Laboratory

Measurement Facilities

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

Sierra Nevada and Coastal Ranges (white bars)

DOE ARM mobile atmospheric facility

Radar and Lidar

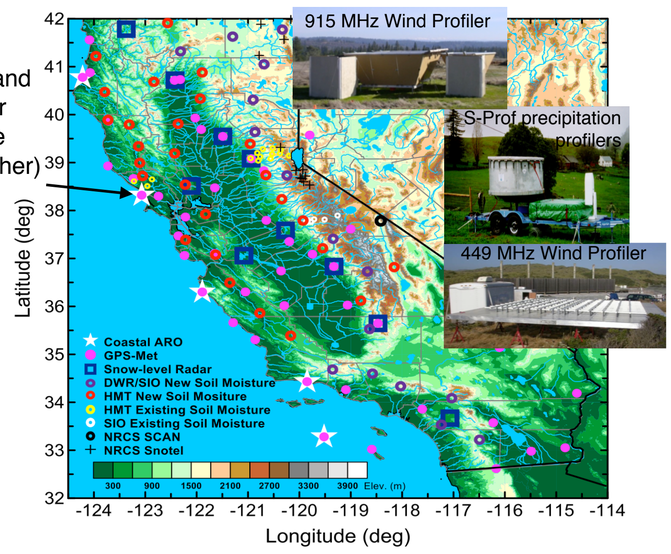
Aerosol Observing System

Airborne Facilities:

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)

Ground-Based Assets: 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)

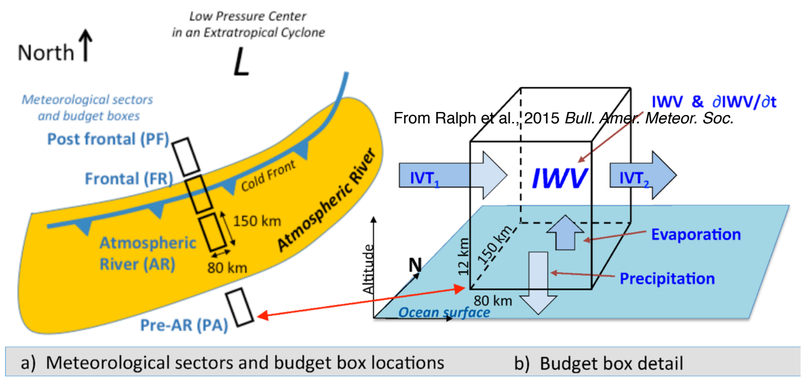


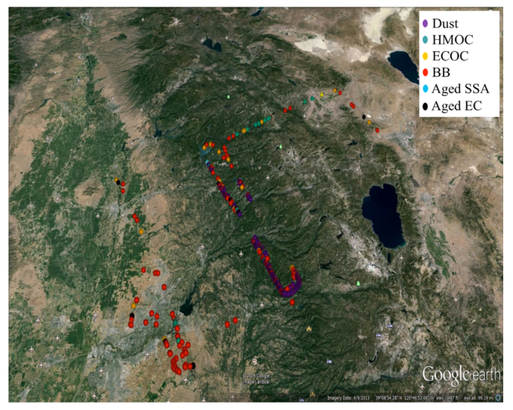
Observations are also proposed for subsequent winter seasons as part of a 5-year broad interagency vision to address the CalWater 2 science objectives.

Validation of Physical Processes in GCM and CTM

Observations from CalWater and ACAPEX present a unique opportunity for physical process validation in both traditional weather/climate model and chemical transport model / cloud microphysics simulations. Observations on-board the NOAA WP-3 and Gulfstream-4 aircraft were designed to work in concert with sea surface measurements on board the NOAA R/V Brown to estimate the atmospheric water vapor budget during AR storms. Single particle chemical mixing state and aerosol size and number from the DOE Gulfstream-1 aircraft can be used to validate CTM predictions of long-range aerosol transport, local aerosol emission, vertical distribution, and cloud activation.

Right: Schematic depicting observational strategy for analyzing the atmospheric water vapor budget in Pre-AR, AR, Cold Frontal, and Post Frontal Conditions.





Left: Major aerosol types sampled in-cloud by the DOE G-1 over the CA Central Valley and Sierra Nevada during a Winter Storm on 03/01/2015. Aerosol types were classified according to significant Mass Spectra chosen by Neural Network

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