Water Cycle Physical Process: Emerging Science on Precipitation Processes

Allen White, Meteorologist

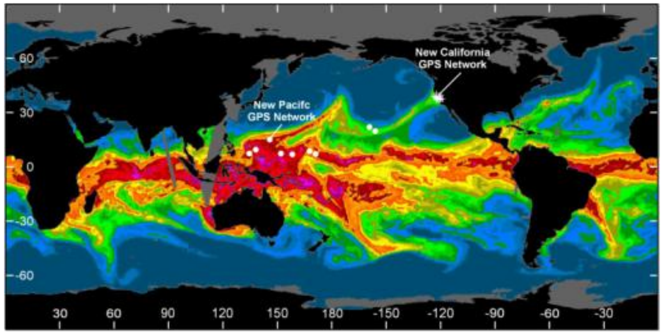
NOAA Earth System Research Laboratory

Boulder, CO

Precipitation Growth Microphysics:

Accretion, Aggregation, Riming, and Coalescence

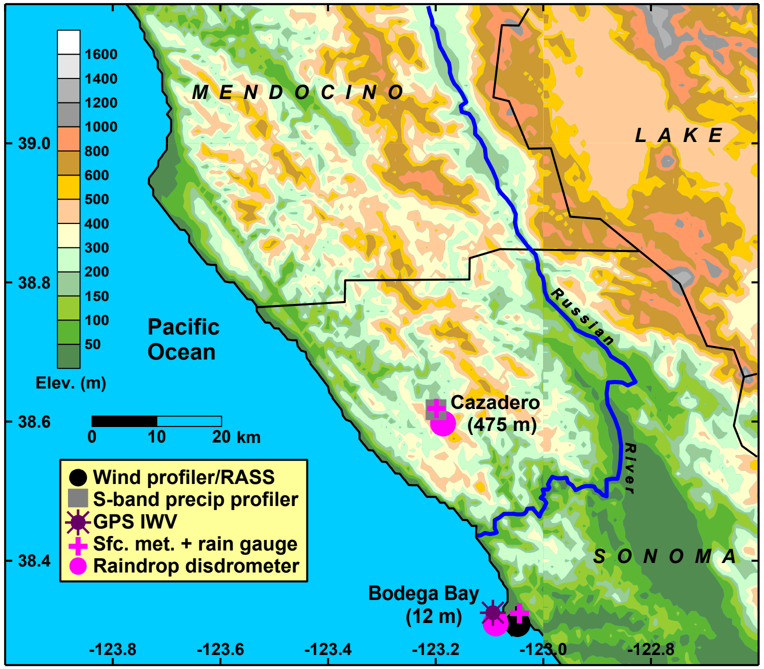
- Not new science but still challenging; how can we better observe/model these processes?
  - Aircraft obs, multi-bin microphysics in models
- How do these processes contribute to varying precipitation intensities (spatially and temporally)?
  - Atmospheric rivers, river and flash flooding
- How do these intensities vary in convective, stratiform, and orographic regimes?
  - Severe Wx, MCCs, tropical storms, mid-lat. cyclones

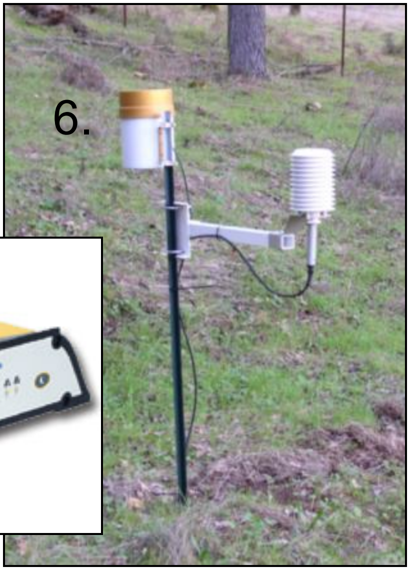


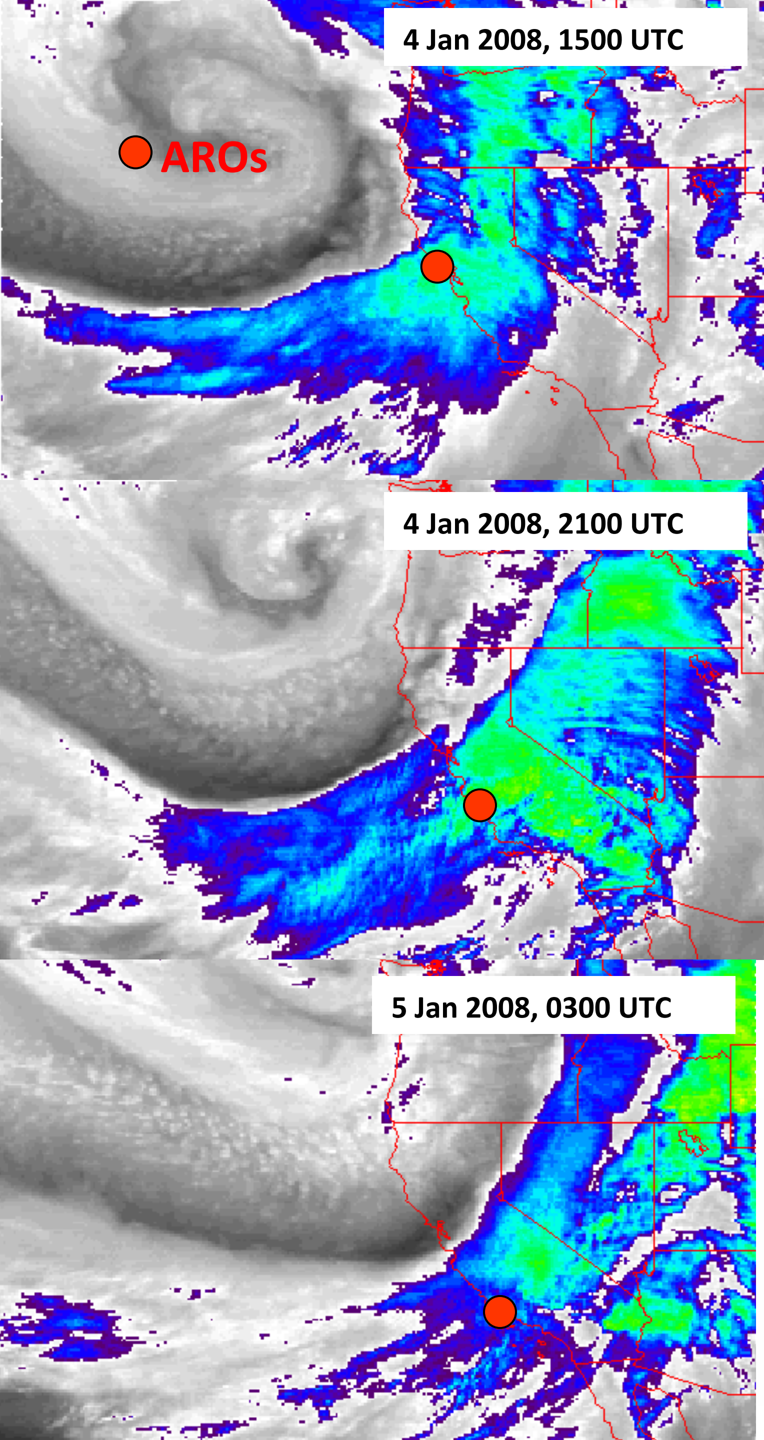
Atmospheric River Observatory (ARO): Russian River Prototype

Objectives: monitor key atmospheric river and precipitation characteristics

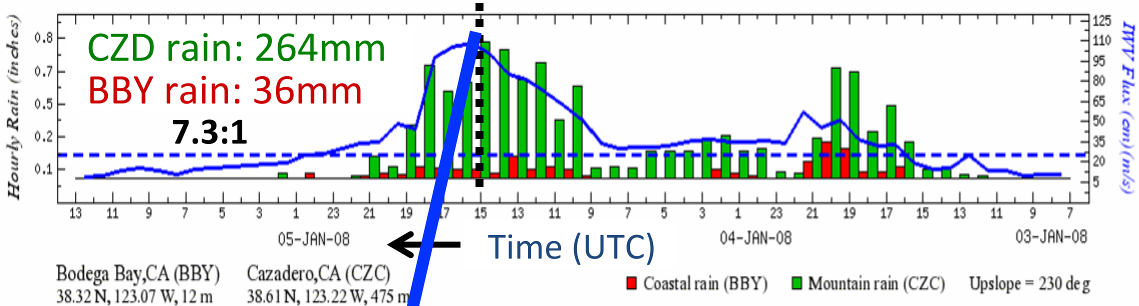
Observing systems:
1. Wind profiler/RASS
2. S-band radar
3. Disdrometer
4. Surface met/soil science
5. GPS integ. water vapor
6. Raingage





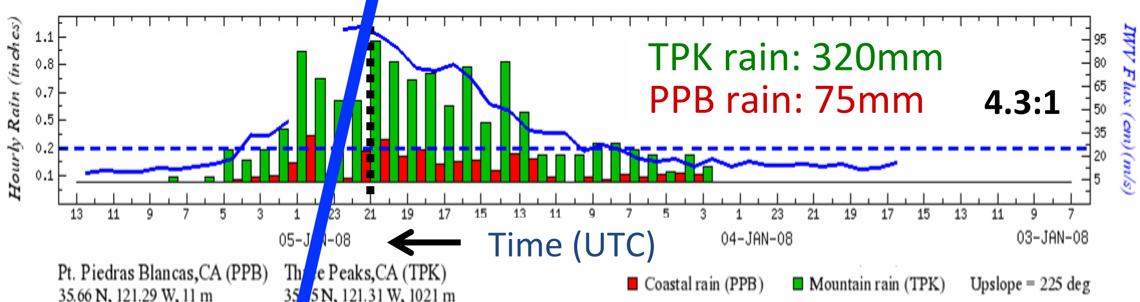


Time of max. IWV flux at BBY: 1500 UTC 4-Jan-08



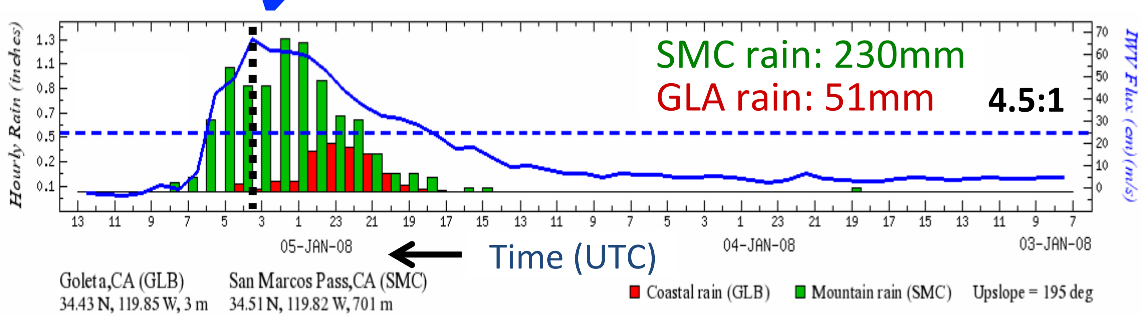
Max. IWV flux in AR highly correlated with max. mountain rainfall at each site

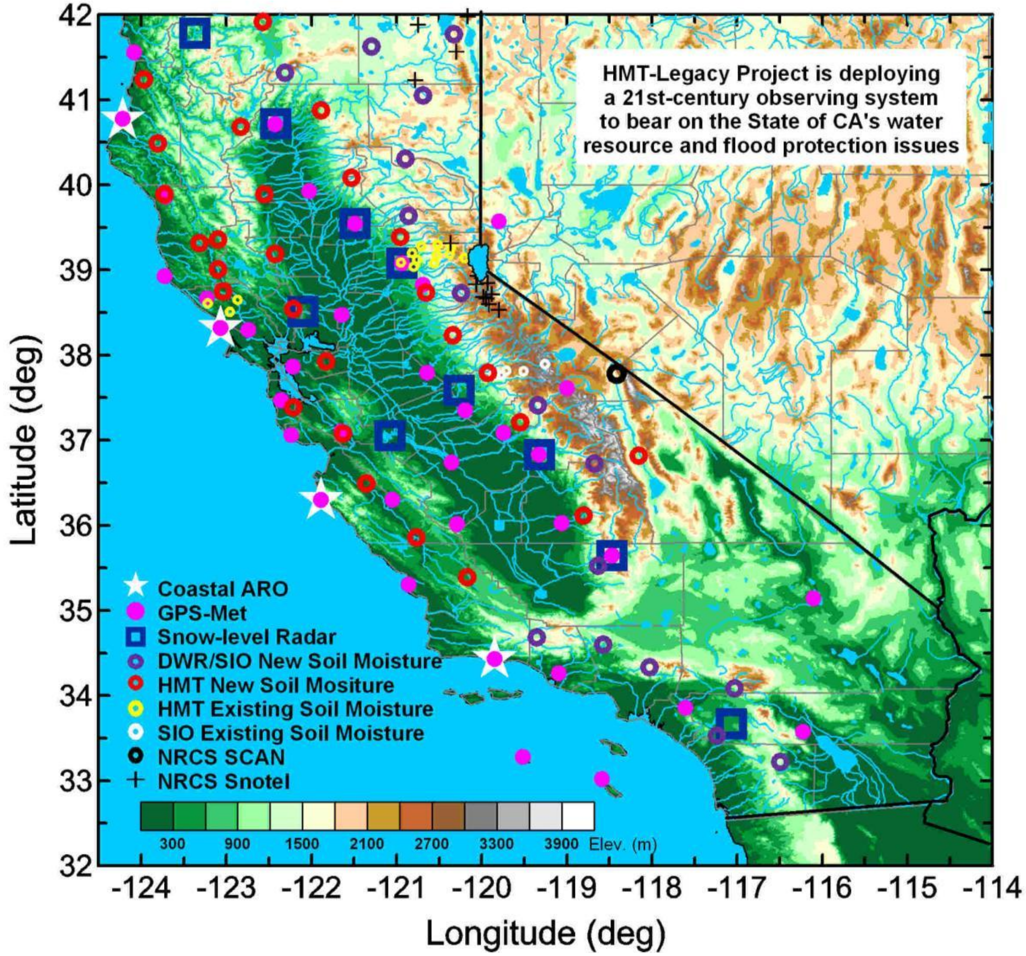
Time of max. IWV flux at PPB: 2100 UTC 4-Jan-08



AR Propagation: ~12 m s^{-1}.
½-day lead time for SoCal

Time of max. IWV flux at GLA: 0300 UTC 5-Jan-08





Soil moisture and
Surface meteorology

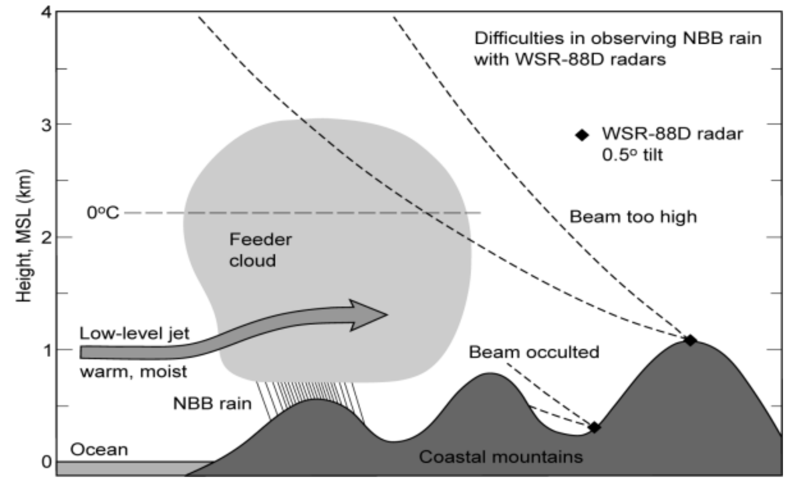
GPS integrated water vapor

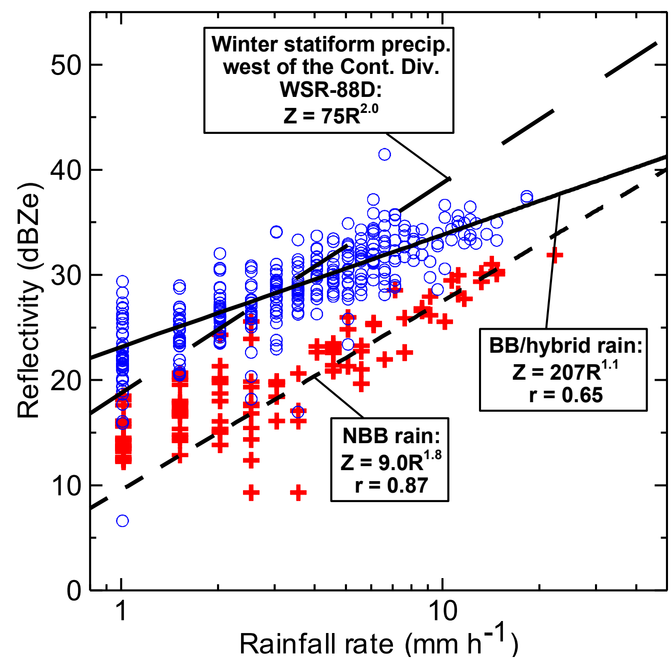
Snow level radar

Coastal ARO: ¼-scale 449-MHz
wind profiler/RASS

Warm Rain Processes

- Current radar network misses much of the action, so how do we best estimate warm rain QPE/QPF?
  - Increase low-altitude radar coverage, implement new algorithms
- How do synoptic and mesoscale dynamics/ thermodynamics contribute to warm rain?
  - Cloud-top temp., therm. stability, vertical motion
- How can the precipitation efficiency in orographic precipitation (including warm rain) be explained better?
  - Is it all coalescence driven? Is a moisture-rich environment required?





White et al., 2003, *J. Hydromet.*

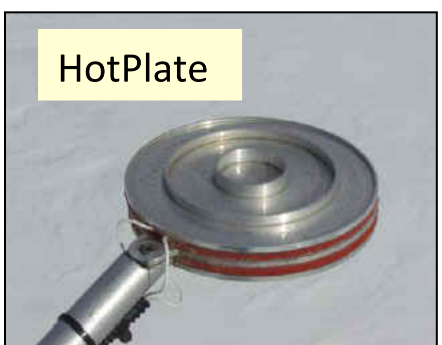
Measuring Snow vs. Rain

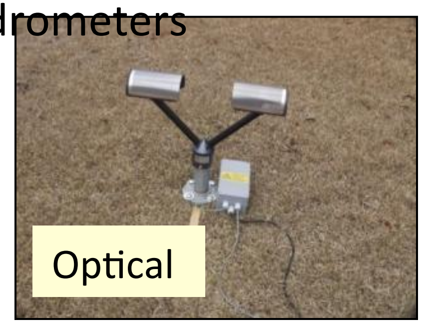
- NOAA's Hydrometeorology Testbed (HMT; hmt.noaa.gov) has tested a variety of different gages in the Sierra Nevada to determine the best candidate for mixed precipitation environments

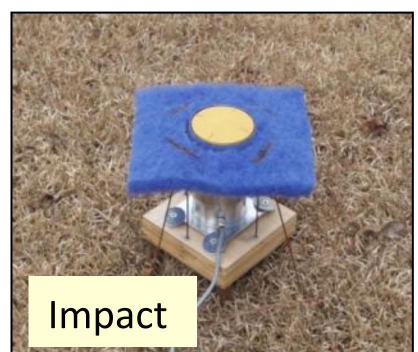
Surface Meteorology & Snow Depth

Precipitation Gauges

Precipitation Disdrometers

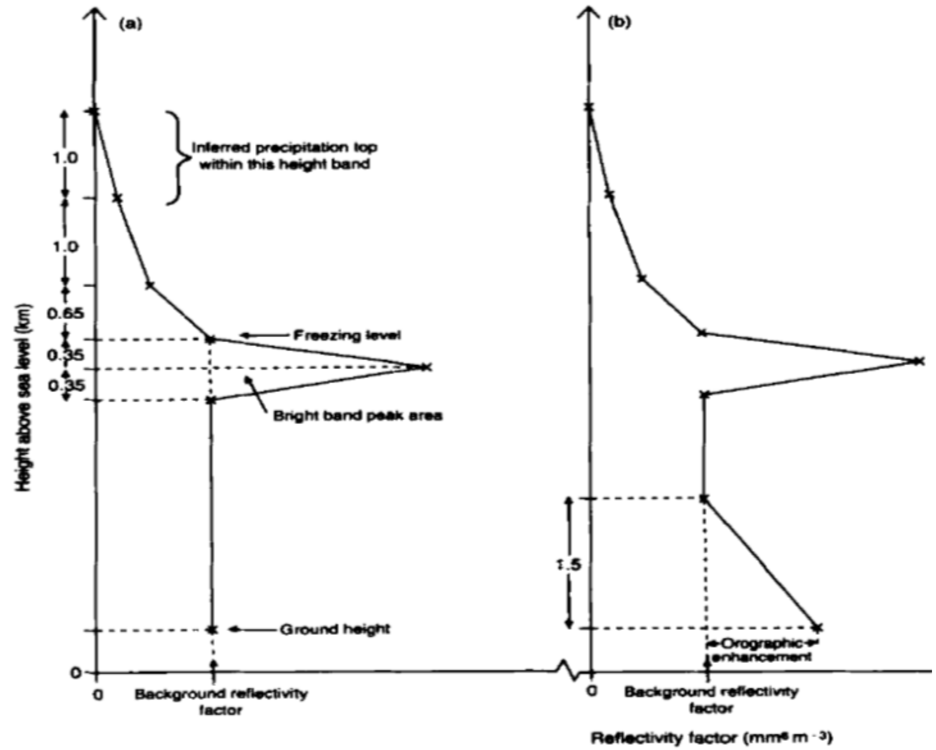






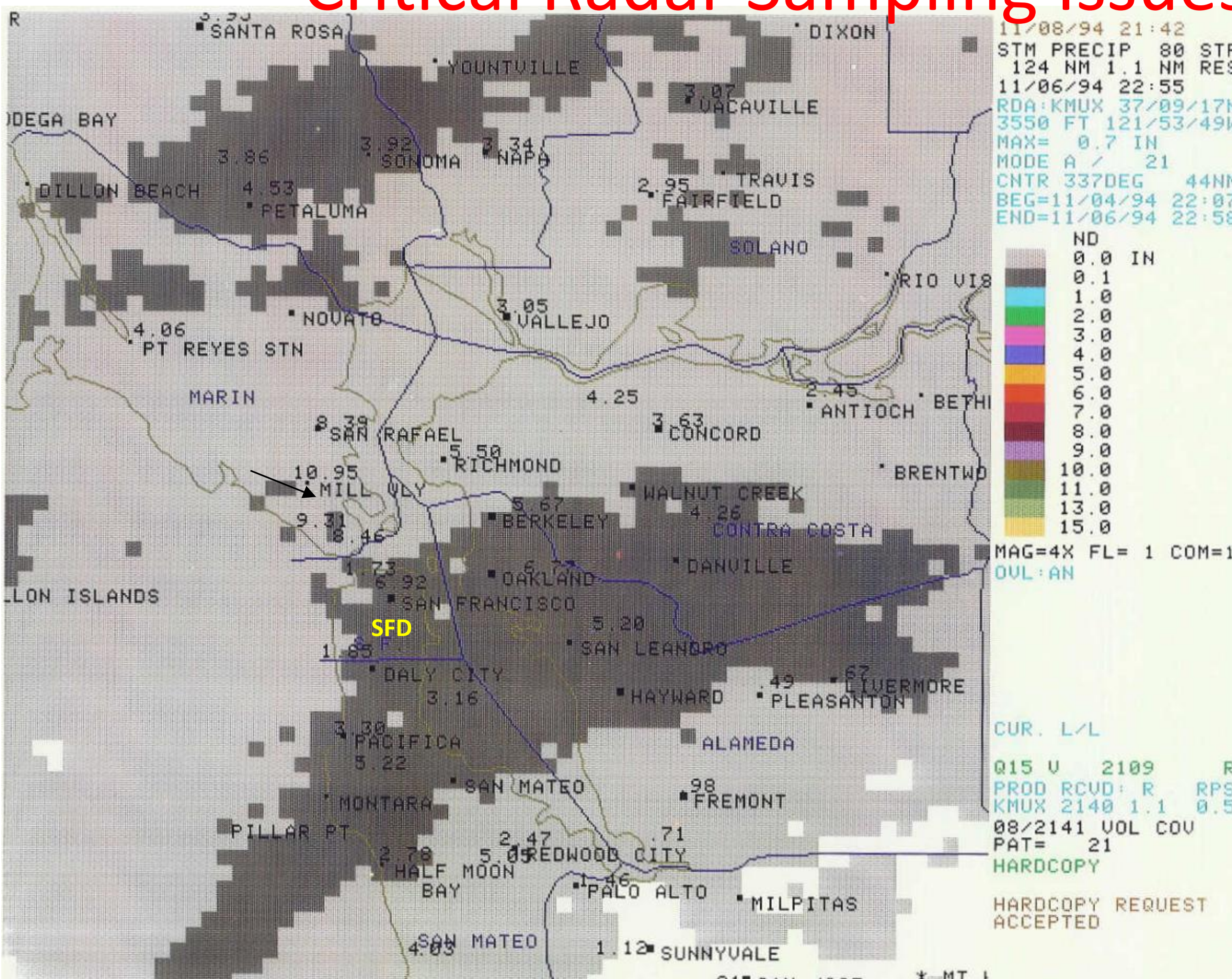
Evaluating the Current State of QPE/ QPF in NOAA

- How can we best address problems with current operational QPE and QPF
  - Radar coverage gaps
  - Microphysics (in both cloud and precipitation modes)
  - Scanning radar bright-band contamination (i.e., VPR)
  - Melting level altitude (snow vs. rain is also a hydro concern)
  - Virga (when is it finally going to reach the surface!)
  - Impact of anthropogenic and biogenic aerosols on precipitation formation and distribution

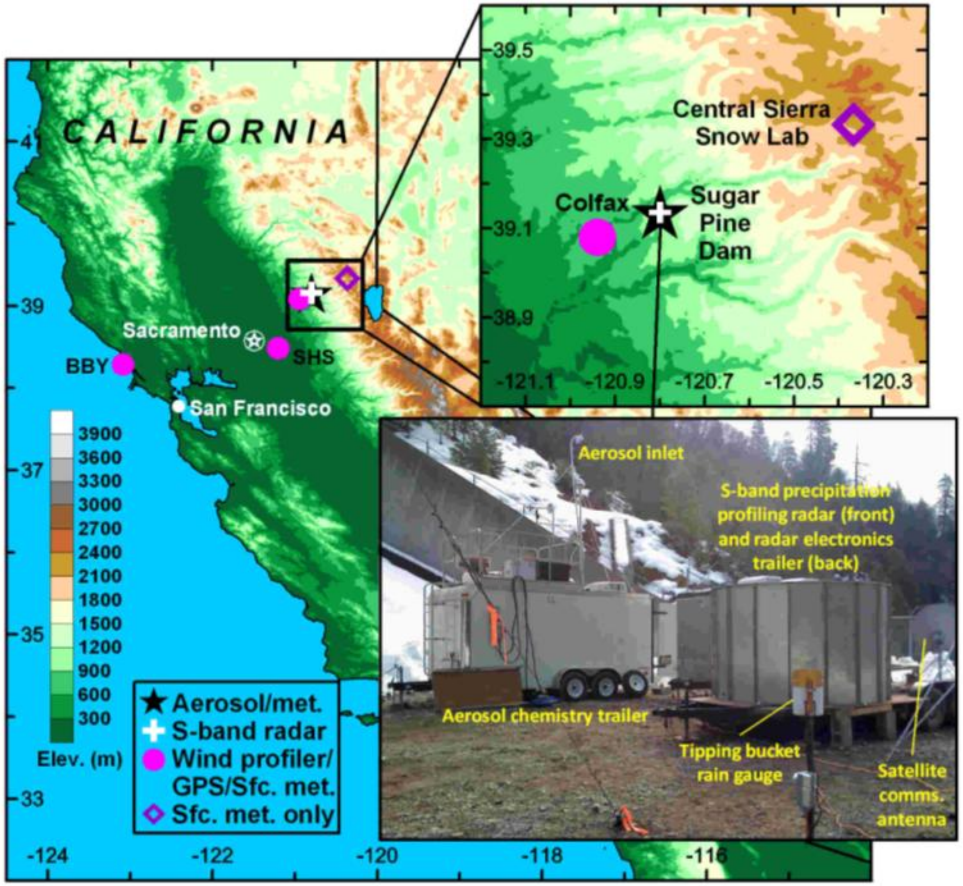


Kitchen et al., 1994, *QJRMS*

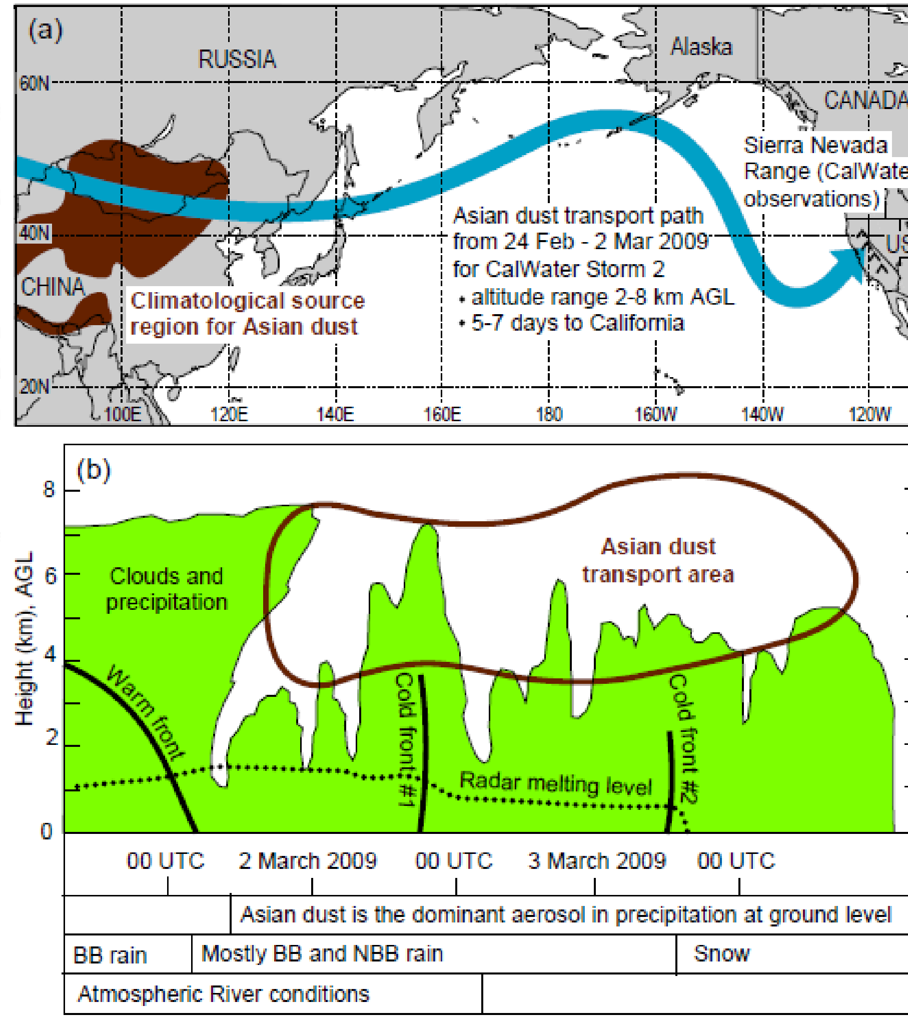
Critical Radar Sampling Issues



Observed 48-hr rainfall compared to NEXRAD estimated rainfall (shading) for Nov. 6, 1994.
Note: NEXRAD estimated < .1 in SFD with 6.92 inches observed. Heaviest 24-hr rainfall ever!



NOAA, UC San Diego, and partner agency scientists are collaborating on CalWater, a project aimed partly at determining the impacts of aerosols on precipitation in the Sierra Nevada.



Ault et al., 2011, *JGR*

By combining an atmospheric river observatory with ground-based chemistry measurements, including aerosol composition via ATOFMS, CalWater scientists are beginning to determine how long range transport of Asian dust and other aerosols may be impacting precipitation in the Sierra Nevada.

Evaluating the Current State of QPE/QPF in NOAA

- Should NOAA design and implement a comprehensive study to catalog and evaluate current and emerging methods of producing QPE/QPF products?

QPE:

- radar (current network)
- radar (dual pol., gap-filling)
- satellite (GPM, GOES-R)
- multi-sensor (MPE, NMQ)
- gauge only / PRISM
- snowfall estimation

QPF:

- precipitation microphysics packages
- data assimilation
- model resolution
- reanalysis tools
- PQPF
- nowcasting, week 1, week 2 forecasts