NOAA's Hydrometeorological Testbed: Lessons from the Russian River During HMT-2004 and Plans for the Future

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BIOGRAPHICAL SKETCH

Dr. Ralph is a research meteorologist who has focused on studies of phenomena that cause variations in daily weather. A key area of expertise is exploring how to best observe the atmosphere, with an emphasis on what data are needed to improve weather forecasts, especially precipitation and wind forecasts on relatively local (mesoscale) spatial and temporal scales. He has worked closely with the operational weather forecasting community to develop new forecasting techniques based on better physical understanding of the weather and on better use of observations to guide predictions.

As the leader of the CALJET and PACJET experiments off the U.S West Coast in 1997/98, 2000/01 and 2001/02, he has brought together scientists, forecasters, and representatives of critical sectors that depend on weather observations and forecasts in their fields (e.g., emergency management, flood control, marine industry, energy, etc.). From these interactions have come several new ideas on what predictions are needed by users of forecasts, what forecasters require in order to provide these, and how research can help create these capabilities. These include methods for improving regional forecasts during especially high risk periods associated with the ENSO cycle.

He has contributed to forecaster training courses for meteorologists and hydrologists, and has been involved in educational programs such as NOVA. He is currently the Chief of a Division of 30 scientists and engineers responsible for exploring and developing new applications for modern technologies in the atmospheric sciences, weather forecasting and climate arenas.

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Dr. F. Martin Ralph

NOAA Environmental Technology Laboratory
Boulder, CO

OUTLINE

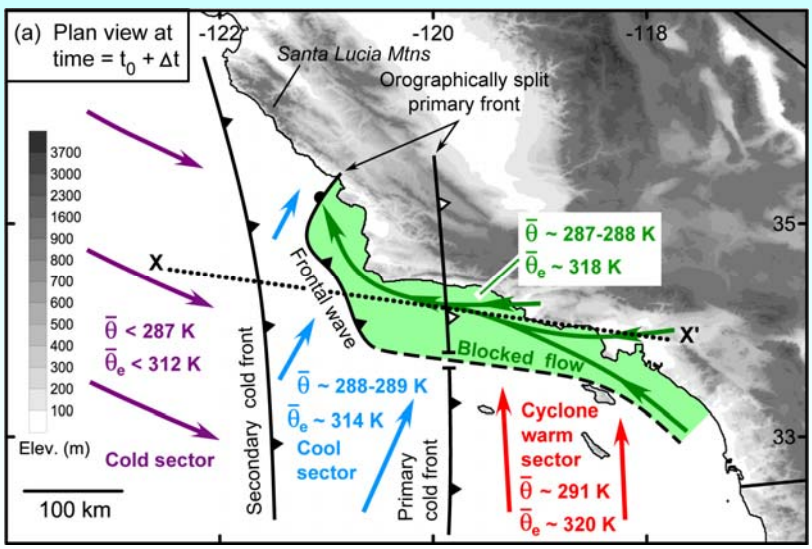
- ***Selected Prior Results (CALJET/PACJET)***
- ***Hydrometeorology Testbed***
  - ***Progress Report on Planning***
  - ***Initial Results from HMT-2004***
- ***Future Directions***
  - ***Transition to American River Basin***

CALJET / PACJET

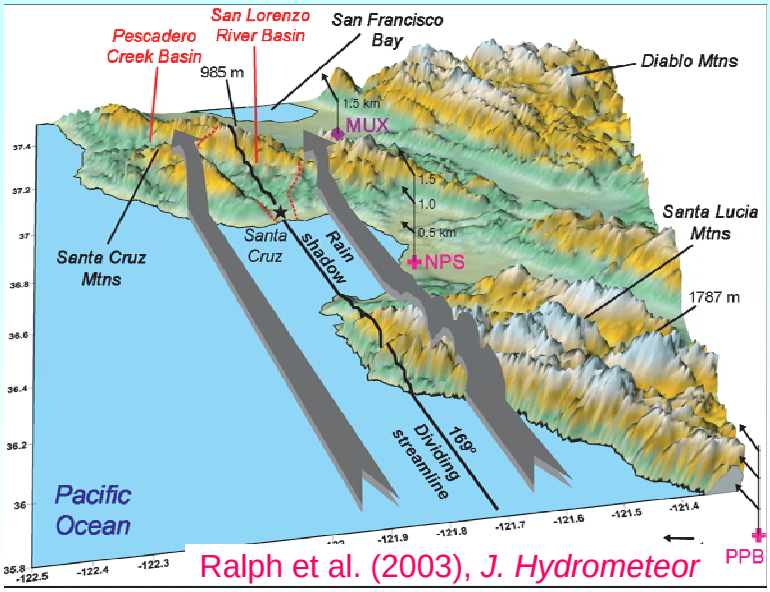
GOAL: Improve 0-24 h prediction of land-falling Pacific winter storms

METHODS
- **Physical Process Studies**
- **Observing System Tests**
- **Forecasting Applications**

TIMELINE
- **1997-1998 CALJET**
- **1999-2002 PACJET**
- **2003-2004 HMT**

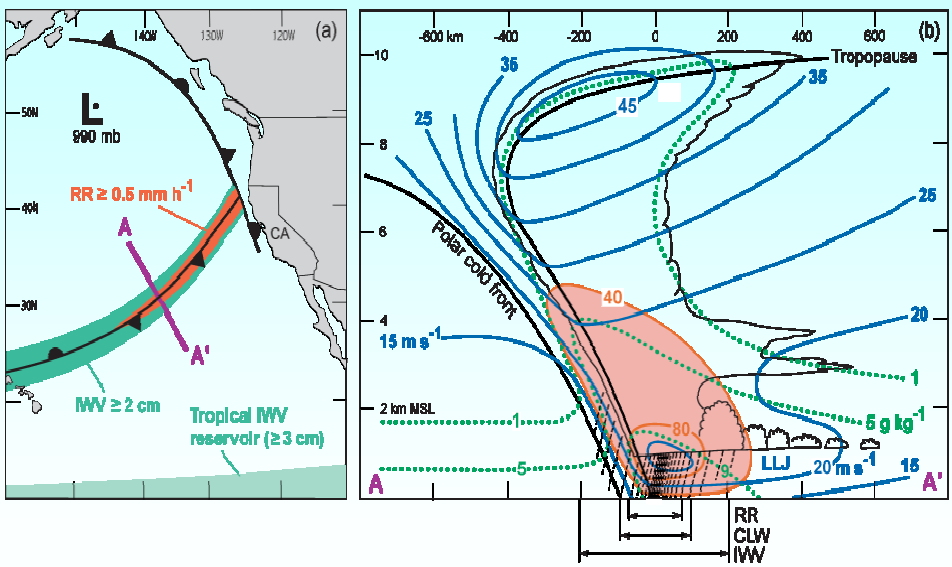


Neiman et al. (2004); *Monthly Weather Review*



Ralph et al. (2003), *J. Hydrometeor*

- Wind direction in the warm sector determined the location of a rain shadow
- The rain shadow resided partially over a populated watershed
- Small wind direction variations can modulate winter flooding in complex terrain

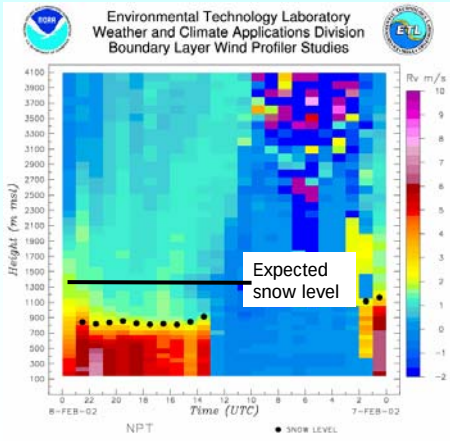


Ralph et al. (2004), *Mon. Wea. Rev.*, in press.

Winter Storm Warning Issued Based on PACJET-2002 Melting-Level Data

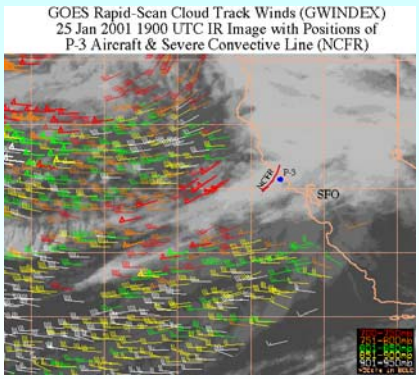
- Newport, OR profiler detected a lower snow level than had been expected (2700 ft vs 4000 ft).
- This caused Portland NWS to change from a Snow Advisory to a Winter Storm Warning.

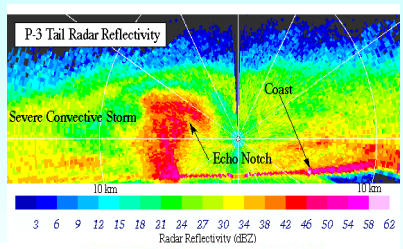
White et al. (2002),
J. Atmos. Ocean. Tech.

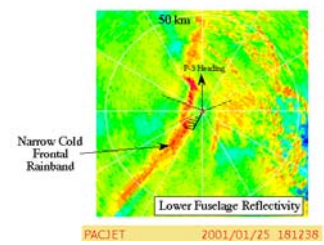


Time (UTC)	2330	2230	2130	2030	1930	1830	1730	1630	1530	1430	1330	1230
Snow Level (m)	none	843	818	836	858	825	811	820	809	847	915	none
Snow Level (ft)	none	2765	2683	2742	2814	2705	2660	2689	2653	2778	3001	none
Sfc Temp (C)	4.00	4.74	5.42	6.02	6.21	6.46	6.52	6.95	7.25	7.30	7.93	8.70

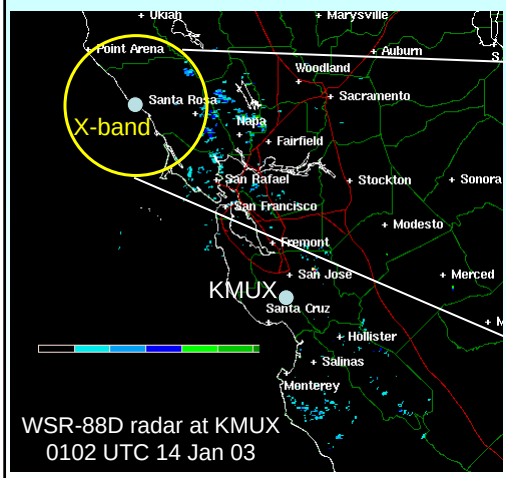
Severe Thunderstorm Watch Issued Based on "NEXRAD in-the-sky" Data

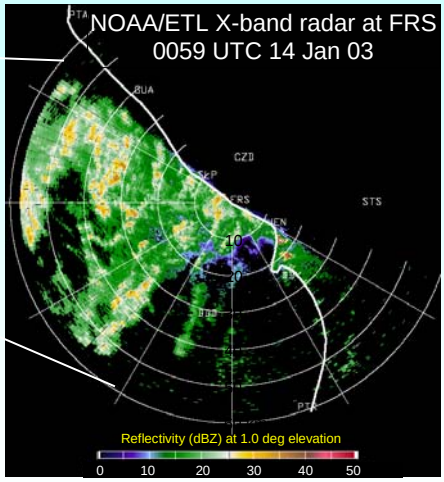






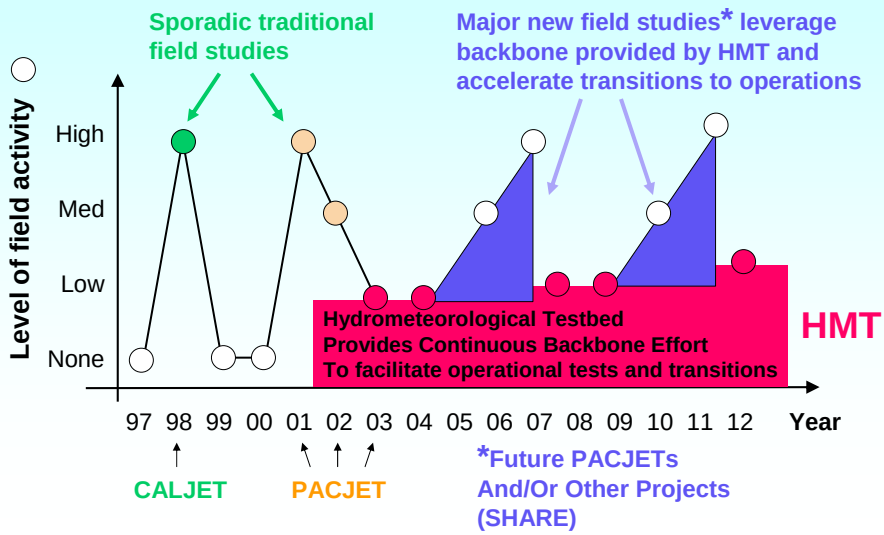
PACJET-03: Coastal Gap-Filling X-band Radar vs. WSR-88D





- **Nearest NEXRAD radar sees no significant echoes approaching flood-prone watershed**
- **NOAA/ETL's Coastal X-band radar fills NEXRAD gap**

CALJET to PACJET to HMT



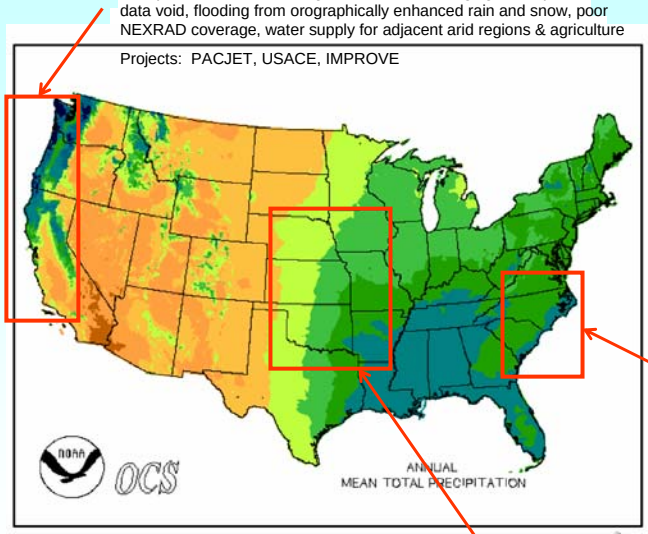
PLANNING ACTIVITIES

- ***Interagency Workshops Refined Testbed Concept***
  - ***Mesoscale Observing Systems Workshop (Dec 2003)***
  - ***Cool-Season QPF Workshop (Feb 2004)***
- ***NOAA Water Resources Information Program***
  - ***HMT concepts have contributed***
  - ***American River identified as a priority area to begin work***
- ***NOAA Coasts, Estuaries, Oceans Program Formed***
  - ***Linkages between hydrology and ecosystem health***

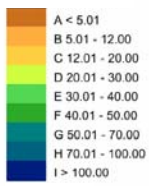
West Coast - Cool Season

Precip Concerns: landfalling winter storms emerging from upstream data void, flooding from orographically enhanced rain and snow, poor NEXRAD coverage, water supply for adjacent arid regions & agriculture

Projects: PACJET, USACE, IMPROVE



Mean annual precipitation (inches)



Carolinas – All Season

Precip Concerns: flooding from hurricane rain and surges, winter storm flooding, agriculture

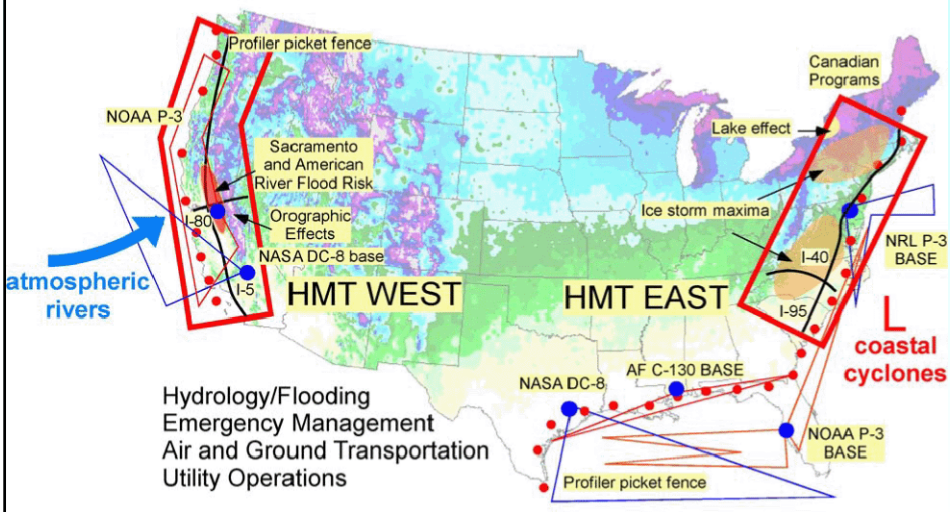
Projects: IFLOW

Regional HydroMet Testbed Candidates

Plains – Warm Season

Precip Concerns: thunderstorms, flash floods, damaging hail, agriculture
Projects: JPOLE, NSF Hydro, GPM + ARM

Overarching Recommendation:
Use a National Hydrometeorological Testbed (HMT) approach to improve cool season QPF



Cool-season QPF multi-agency workshop report, May 2004

Consensus Definition

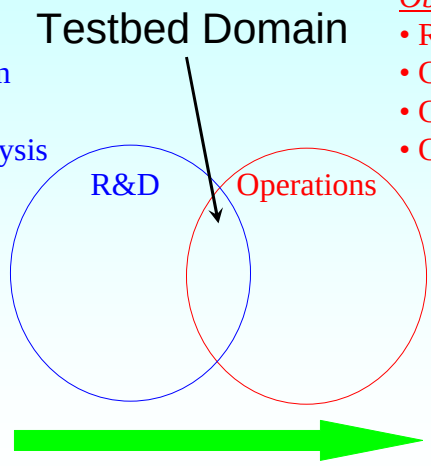
•Entails working relationship in quasi-operational framework among forecasters, researchers, private-sector, and government agencies aimed at solving operational and practical regional _____ problems with a strong connection to end-users.

- Outcomes are improved services, products, and economic/public safety benefits.
- It must accelerate the transition of R&D to better operations, services, and decision making.
- Requires long-term commitment and partnerships.

Workshop on Mesoscale Observing Systems, Boulder, CO, Dec. 2003

Testbed Observing System Perspectives

Obs Sys Priorities
- Exploratory
- Higher Resolution
- Multi-Sensor
- Exploratory Analysis
- New Variables

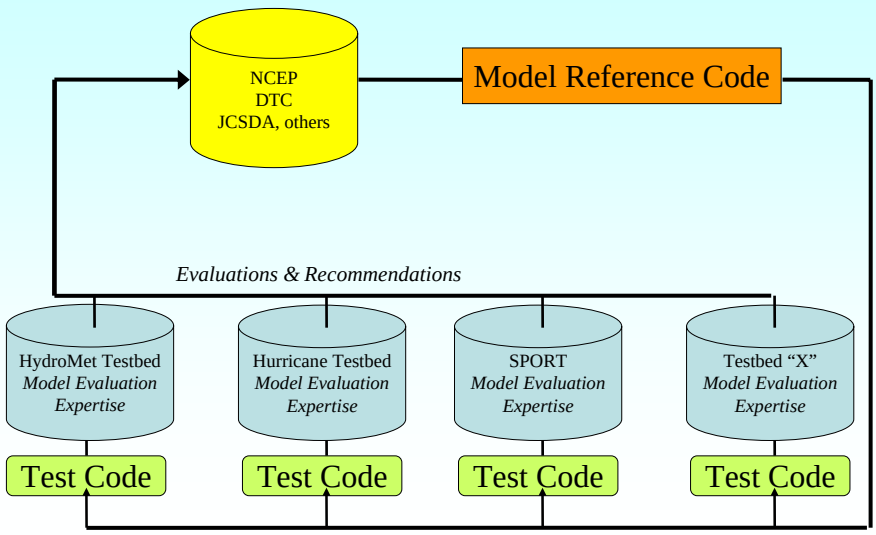


Obs Sys Priorities
- Reliability
- Cost Effectiveness
- COTS (plug n' play)
- Continuity

Basic R&D → Improved User Decisions

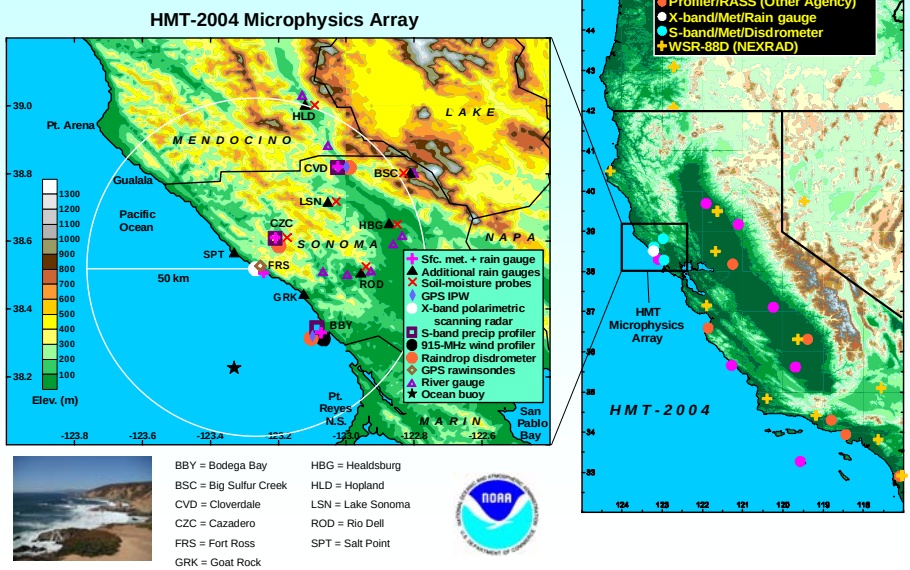
Workshop on Mesoscale Observing Systems, Boulder, CO, Dec. 2003

Strawman Relationship between Testbeds & Modeling/Assimilation Centers



HMT-2004

A Hydrometeorological Testbed (HMT) for the Russian River Watershed



BBY = Bodega Bay
BSC = Big Sulfur Creek
CVD = Cloverdale
CZC = Cazadero
FRS = Fort Ross
GRK = Goat Rock
HBG = Healdsburg
HLD = Hopland
LSN = Lake Sonoma
ROD = Rio Dell
SPT = Salt Point

Fort Ross, CA Instrumentation

PACJET-03 and HMT-04 Goals

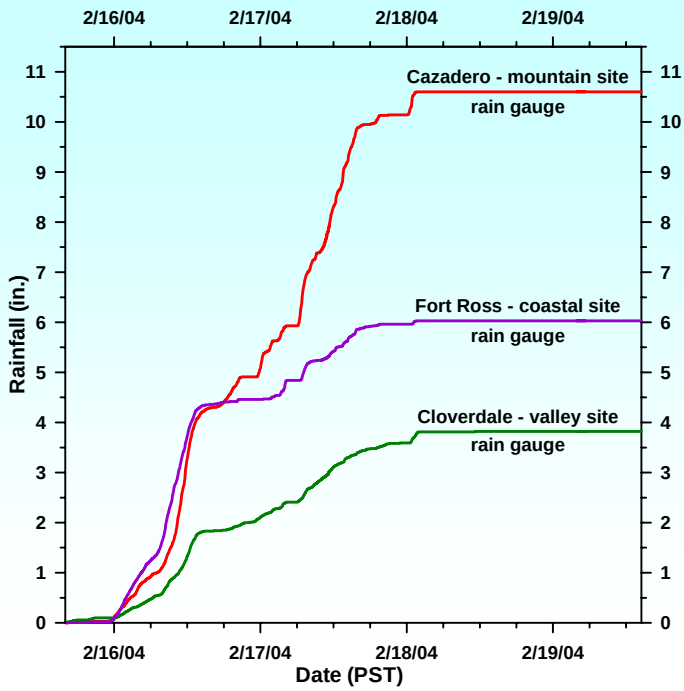
- Demonstrate the concept of a regional Hydrometeorological Testbed as a conduit to infuse new science and technology into operations.
- Continue to develop a climatology of orographic precipitation along the coastal mountains of California north of San Francisco to examine linkages between climate and weather.
- Document storm features that slip beneath coverage of the nearest WSR-88D radars, and send the X-band radar images to NWS forecast offices via the Web.
- Study the microphysical features and orographic precipitation mechanisms in storm clouds over the coastal mountains.
- Continue testing experimental polarimetric radar estimations of rainfall rate and classifications of hydrometeor types.
- Investigate the impact of a modest coastal barrier on upwind versus leeward precipitation and integrated precipitable water.
- Deploy an array of rainfall gauges, and soil moisture probes to provide data for evaluating operational stream flow models

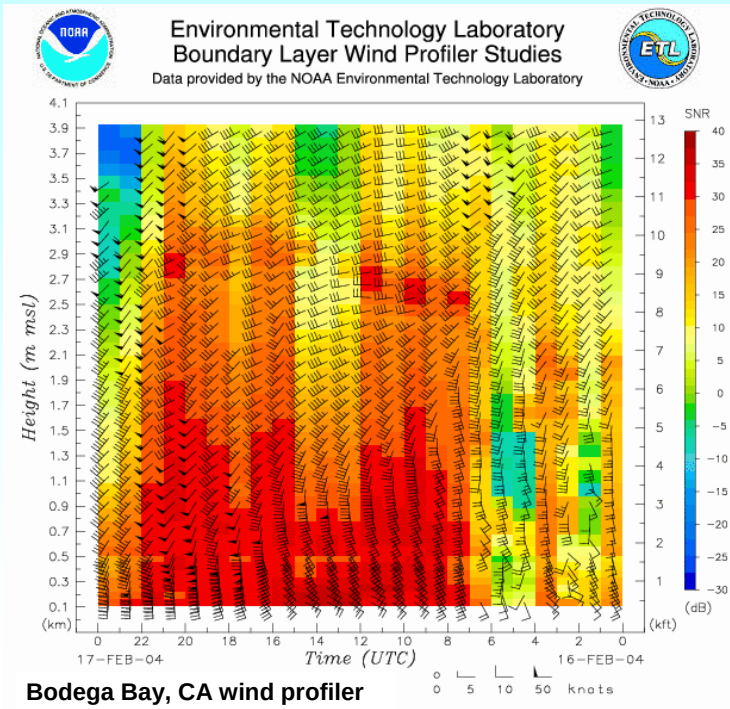
PACJET-03 and HMT-04 Participants

- NOAA Environmental Technology Laboratory
- NOAA National Severe Storms Laboratory
- NOAA National Weather Service-Western Region
- NOAA National Centers for Environmental Prediction
- NOAA California/Nevada River Forecast Center
- NOAA Aeronomy Laboratory
- NOAA Forecast Systems Laboratory
- University of Washington

Highlights of 2004 Field Season

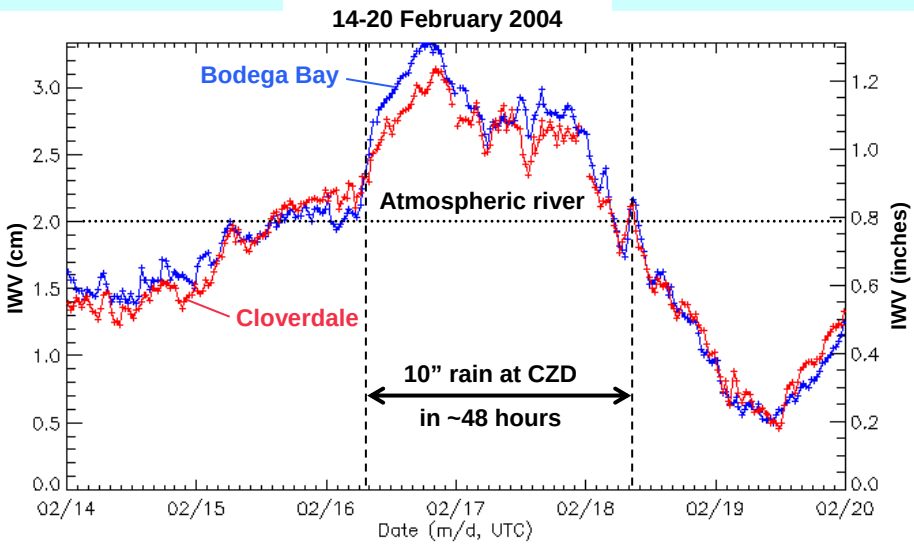
- Data collection from 10 Dec 2003 – 21 Mar 2004
- Total precipitation at CZD: 1161 mm (45.7”)
- Several Storms with Heavy Rainfall
- Flooding Event on 16-18 Feb 2004
- Initial QPE Results from X-Pol Radar

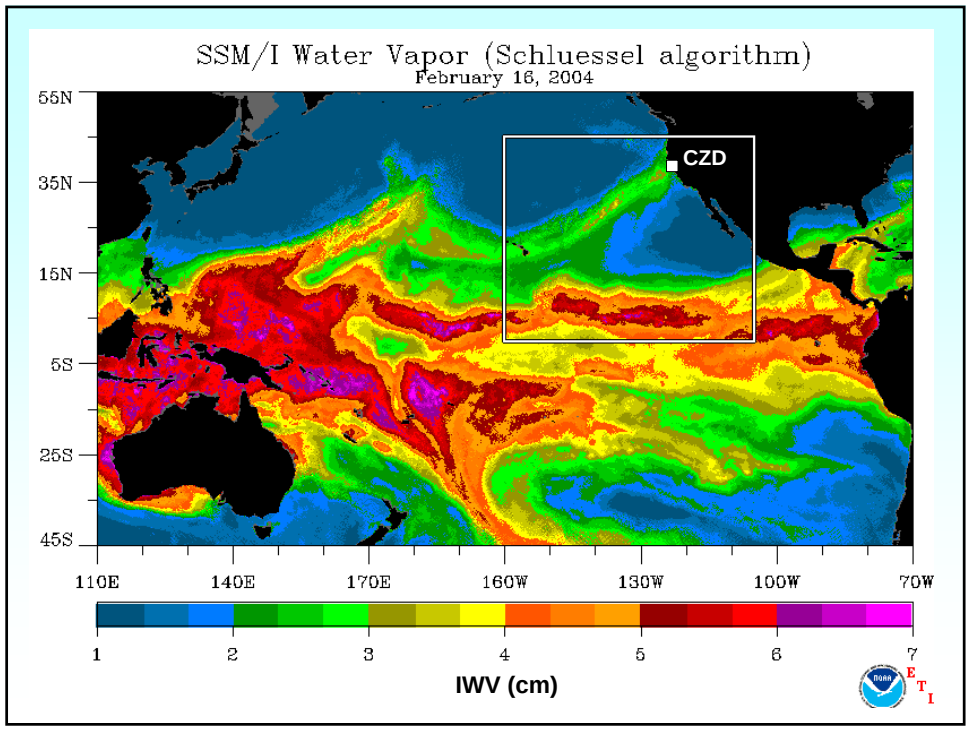




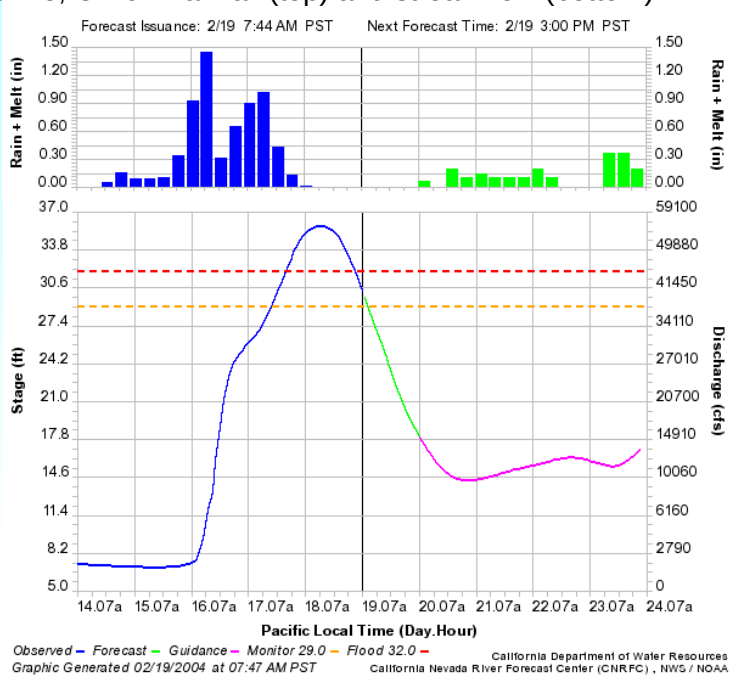
Bodega Bay, CA wind profiler

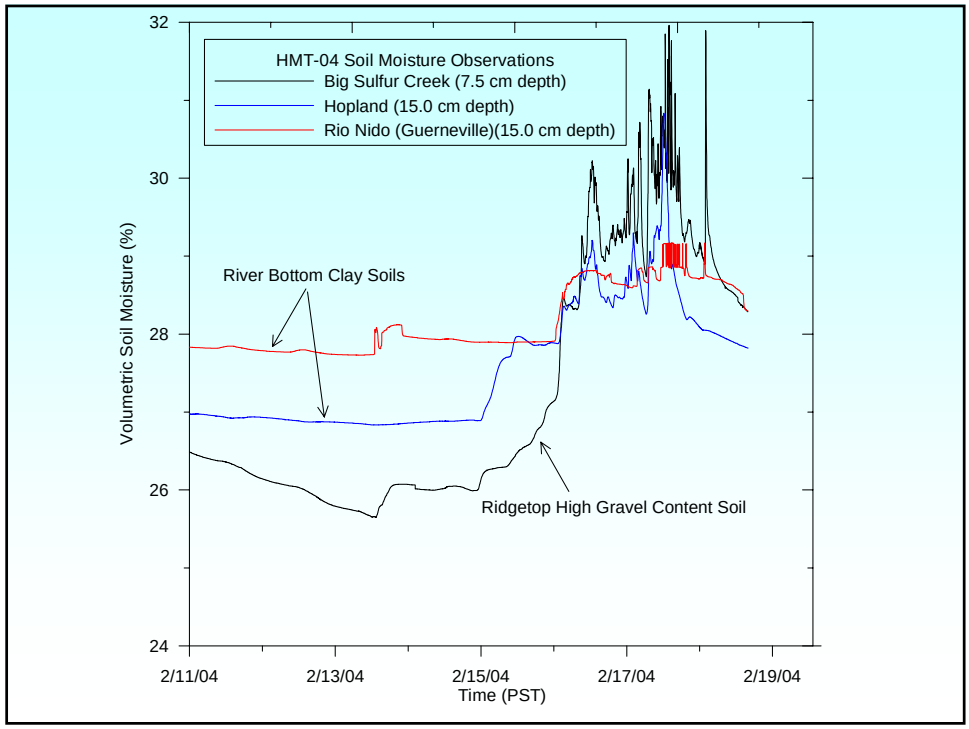
GPS IWV data from near CZD





Guerneville, CA 6-h rainfall (top) and streamflow (bottom): 14-19 Feb 04





SSM/I IWV Composite Satellite Image 25 Feb 2004

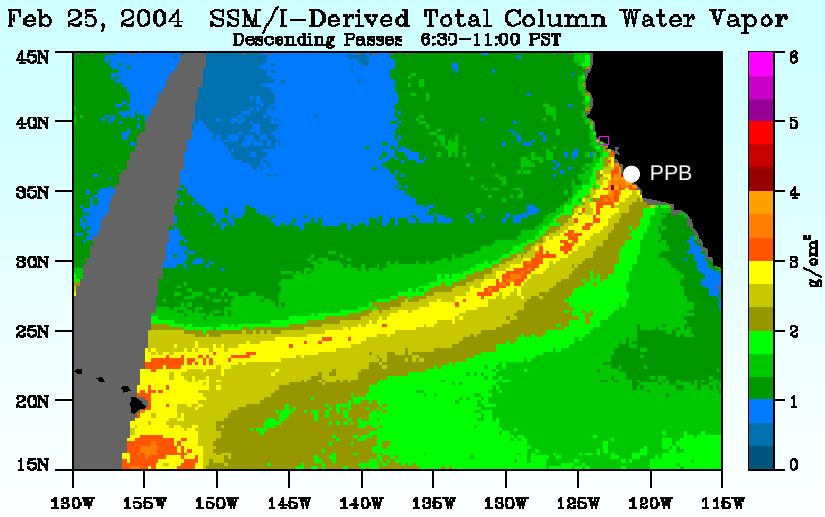
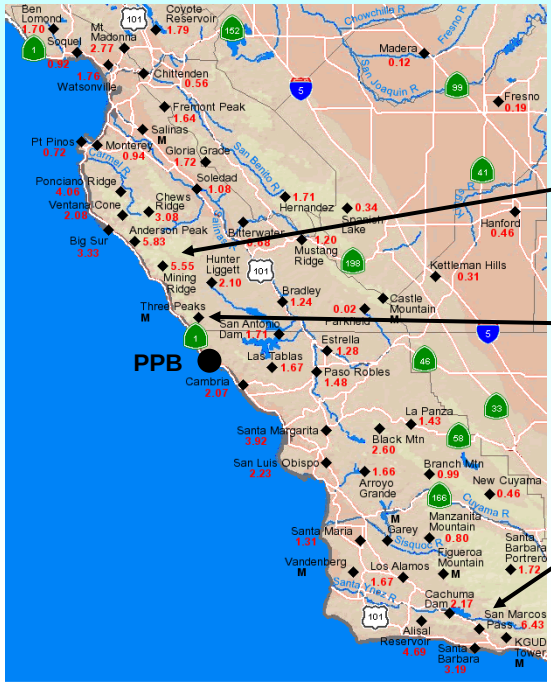


Image Courtesy Gary Wick, NOAA ETL



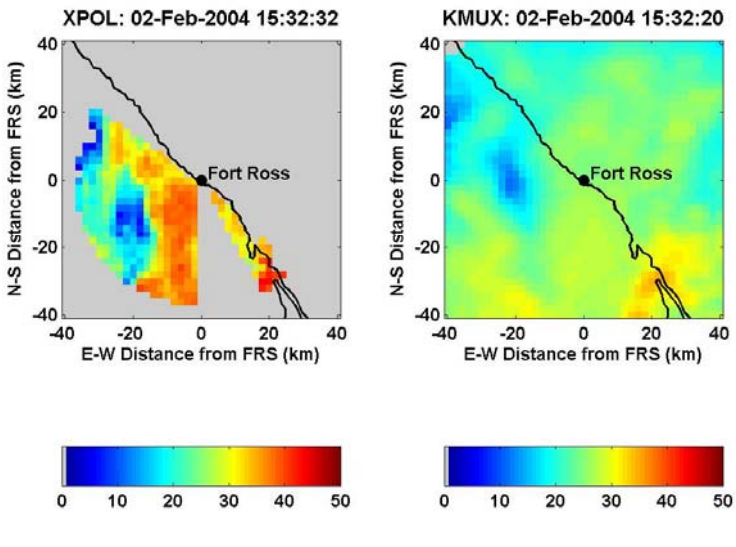
25-26 February 2004

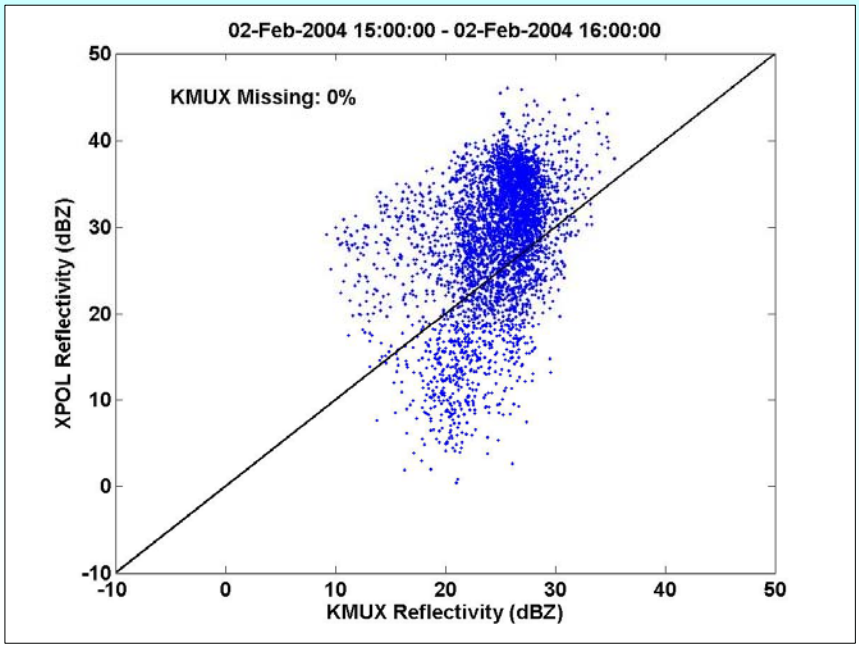
5-6 inches of rain in 24 hrs

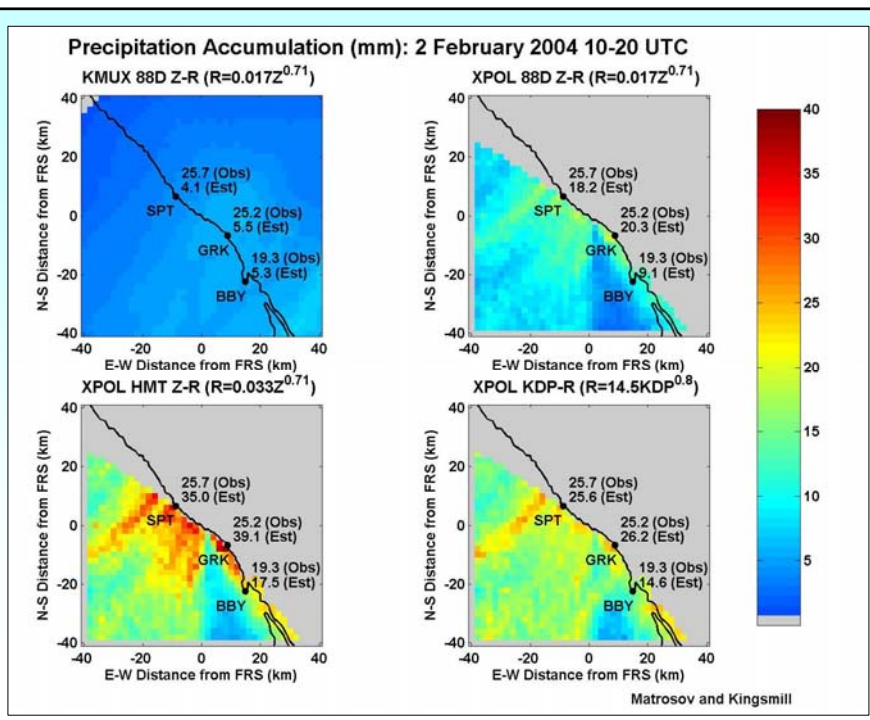
10-11 inches at TPK

6.43 inches

HMT-04: Coastal Gap-Filling X-band Radar vs WSR-88D




02-Feb-2004 15:00:00 - 02-Feb-2004 16:00:00
KMUX Missing: 0%
XPOL Reflectivity (dBZ)
KMUX Reflectivity (dBZ)
50
40
30
20
10
0
-10
-10
0
10
20
30
40
50

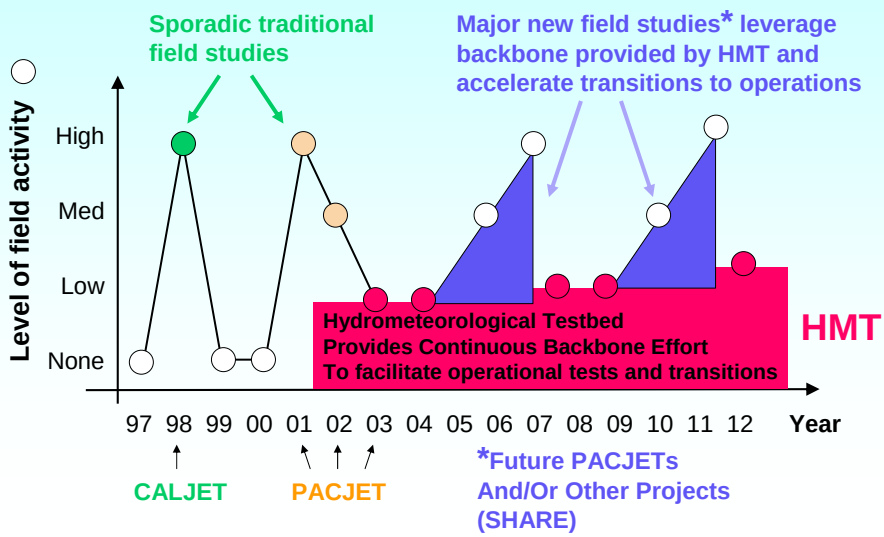

Precipitation Accumulation (mm): 2 February 2004 10-20 UTC
KMUX 88D Z-R (R=0.017Z^0.71)
XPOL 88D Z-R (R=0.017Z^0.71)
XPOL HMT Z-R (R=0.033Z^0.71)
XPOL KDP-R (R=14.5KDP^0.8)
25.7 (Obs)
4.1 (Est)
25.2 (Obs)
5.5 (Est)
19.3 (Obs)
5.3 (Est)
25.7 (Obs)
18.2 (Est)
25.2 (Obs)
20.3 (Est)
19.3 (Obs)
9.1 (Est)
25.7 (Obs)
35.0 (Est)
25.2 (Obs)
39.1 (Est)
19.3 (Obs)
17.5 (Est)
25.7 (Obs)
25.6 (Est)
25.2 (Obs)
26.2 (Est)
19.3 (Obs)
14.6 (Est)
SPT
GRK
BBY
N-S Distance from FRS (km)
E-W Distance from FRS (km)
Matrosov and Kingsmill

Precipitation Accumulation Observations and Estimates (mm)
2 February 2004: 10-20 UTC

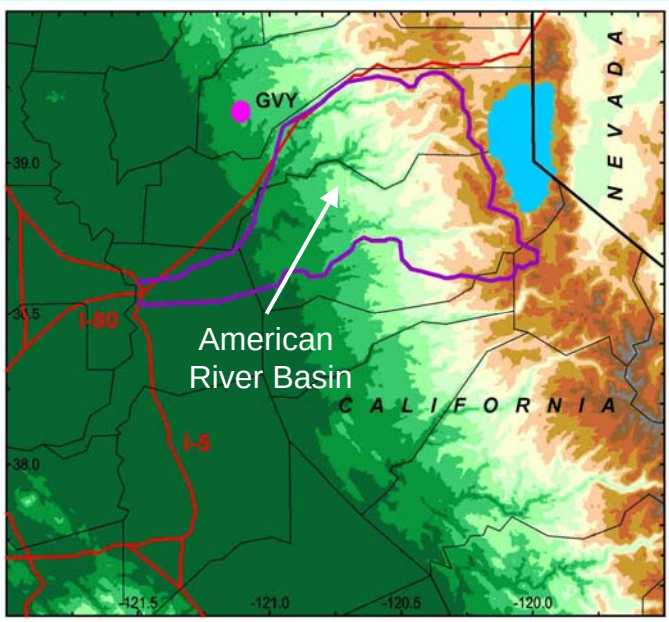
	Rain Gauge	KMUX 88D Z-R ($R=0.017Z^{0.71}$)	XPOL 88D Z-R ($R=0.017Z^{0.71}$)	XPOL HMT Z-R ($R=0.033Z^{0.71}$)	XPOL* KDP-R ($R=14.5KDP^{0.8}$)
SPT (mm)	25.7	4.1 (-21.6)	18.2 (-7.5)	35.0 (+9.3)	25.6 (-0.1)
GRK (mm)	25.2	5.5 (-19.7)	20.3 (-4.9)	39.1 (+13.9)	26.2 (+1.0)
BBY (mm)	19.3	5.3 (-14.0)	9.1 (-10.2)	17.5 (-1.8)	14.6 (-4.7)
Avg. (mm)	23.4	5.0 (-18.4)	15.9 (-7.5)	30.5 (+7.1)	22.1 (-1.3)
Avg. Error (%)		-79	-32	+30	-5

* Based on Matrosov et al. (2002), "X-band Polarimetric Radar Measurements of Rainfall", Journal of Applied Meteorology, 41, 941-952.

CALJET to PACJET to HMT

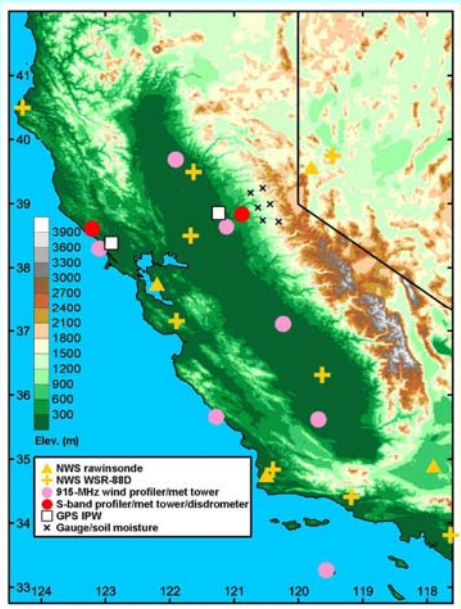


HMT transitions to American River Basin: 2005-2007

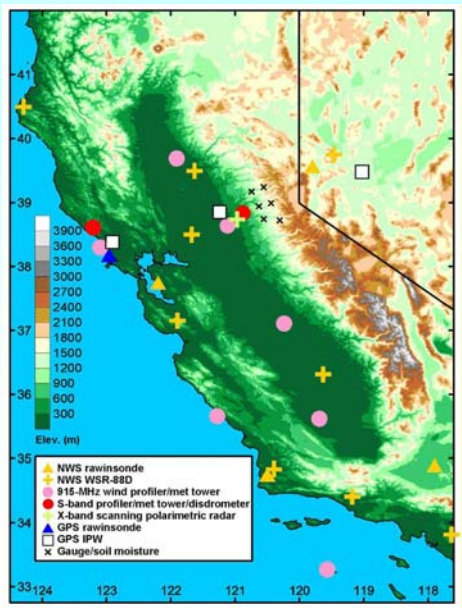


ETL Observing System Contributions

HMT-05



HMT-06



ETL Observing System Contributions

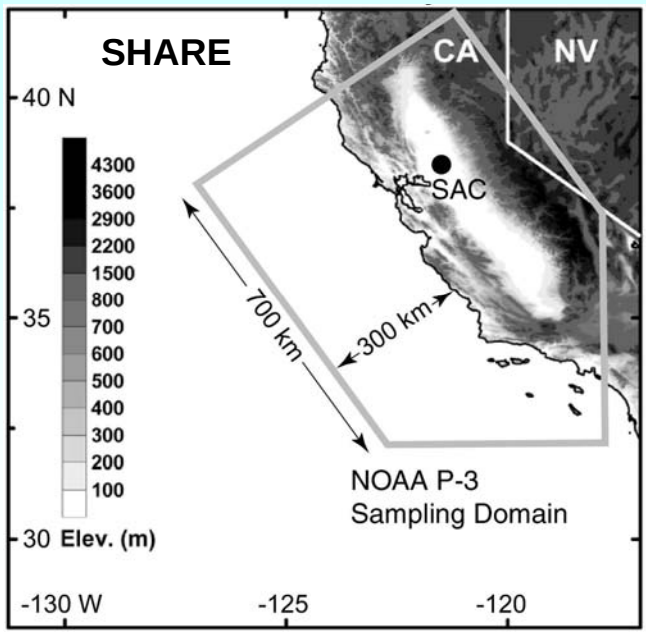
Observing System	Project	Commitment 2005 > 90 %	Commitment 2006 > 90 %	Possible Additions
915 MHz Profiler	HMT, Wx-Clim, CCOS, Prof-Eval	7	7	0
S-band Profiler / JW Disdrometer	HMT, Wx-Clim	2	2	1
GPS IWV	Wx-Clim	2	3	1
Scanning X-band Polarimetric Radar	HMT	0	1	0
Precip. Gauge / Soil Moisture	HMT	6	6	10
GPS Balloon Sounding	HMT	0	1	0
449 MHz Profiler	Wx-Clim	0	0	1
Scanning C-band Doppler Radar	HMT	0	0	1

HMT: Hydro-Meteorological Testbed Wx-Clim: Weather-Climate Connection
CCOS: Central California Ozone Study Prof-Eval: Profiler Evaluation Study

Sierra Hydrometeorology and Atmospheric River Experiment (SHARE)

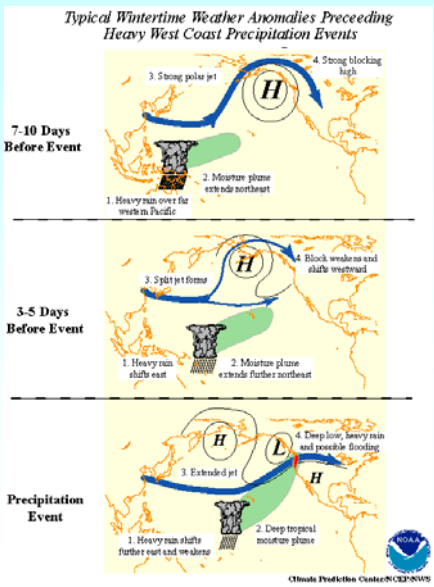
- Overall goal:
  - To track the evolution of atmospheric rivers from 300 km offshore of California, across the coastal mountains into the central valley and across the Sierra Nevada mountains while also examining the hydrometeorological processes and impacts associated with them.
- Atmospheric River:
  - A narrow region of strong horizontal water vapor flux associated with polar cold fronts
- Tentative dates:
  - 20 January to 20 March 2006 or 2007

Additional instruments from NOAA, NSF and other agencies will be added to the HMT suite of instruments

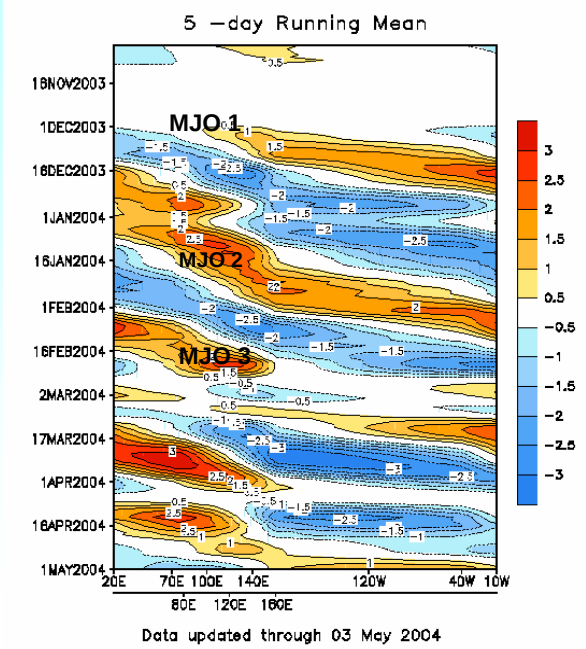


Possible 10-14 Day Heads-up – Climate Weather Connection

CPC MJO Graphic Used in Winter Weather Briefings



http://www.cpc.ncep.noaa.gov/products/precip/CWlink/daily_mjo_index/mjo_index.html



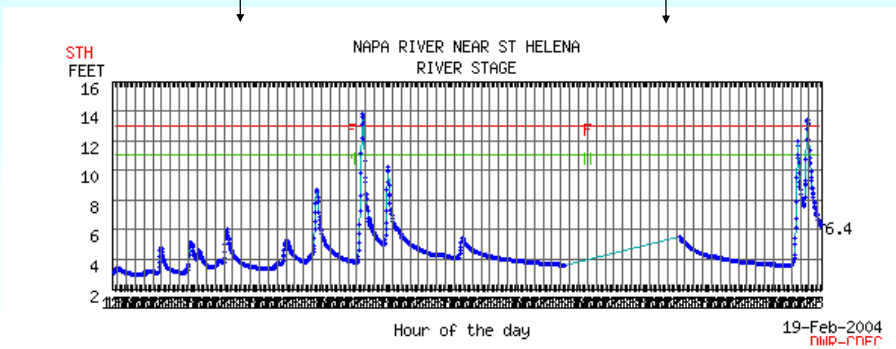
Napa River at St Helena

MJO # 1 Identified

About 12 days flood

MJO # 2 Identified

About 14 days flood



Data from 12/01/2003 00:00 through 02/19/2004 08:11 · Duration: 80days
Max of period: 13.78 · Min of period: 2.97

Comparison between predicted (CNRFC 0-60 h QPF) and observed storm-total rainfall (00 Z 16 Feb – 12 Z 18 Feb 2004