Center for Western Weather and Water Extremes
SCRIPPS INSTITUTION OF OCEANOGRAPHY AT UC SAN DIEGO

FORECAST INFORMED RESERVOIR OPERATIONS (FIRO):

UPDATE ON OBSERVATIONS: OFFSHORE AND ONSHORE

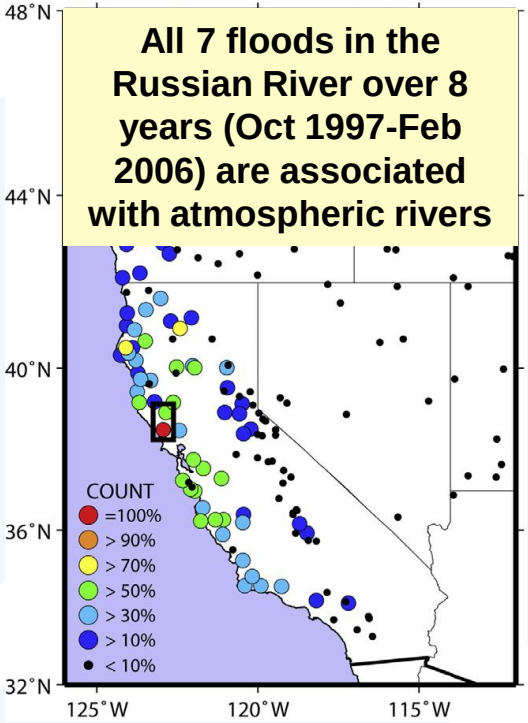
Anna Wilson, F. Martin Ralph, and many others

Center for Western Weather and Water Extremes

UC San Diego | SCRIPPS INSTITUTION OF OCEANOGRAPHY

FIRO Workshop, 7 August 2019, La Jolla, CA

THE ROLE OF ATMOSPHERIC RIVERS IN CA'S EXTREME PRECIPITATION



All 7 floods in the Russian River over 8 years (Oct 1997-Feb 2006) are associated with atmospheric rivers

Fig. 6a, Ralph et al. 2006

AR Summary: 25-27 Feb 2019

For California DWR's AR Program

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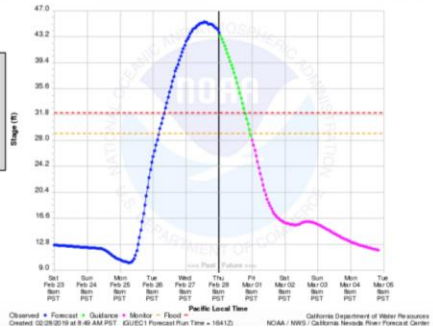
Guerneville along River Road (Sonoma Sherriff via Twitter)

Residents use a raft to cross flooded Highway 116 between Santa Nella and Guerneville (Feb 27). Photo: N. Oakley

Guerneville gauge peaking over 45 feet
For more information please visit cnrfc.noaa.gov



Governor Newsom declared State of Emergency for five northern CA counties due to storm impacts: Amador, Glenn, Lake, Mendocino and Sonoma

https://cw3e.ucsd.edu/cw3e-ar-update-25-27-february-post-event-summary/

THE ROLE OF ATMOSPHERIC RIVERS IN CA'S EXTREME PRECIPITATION

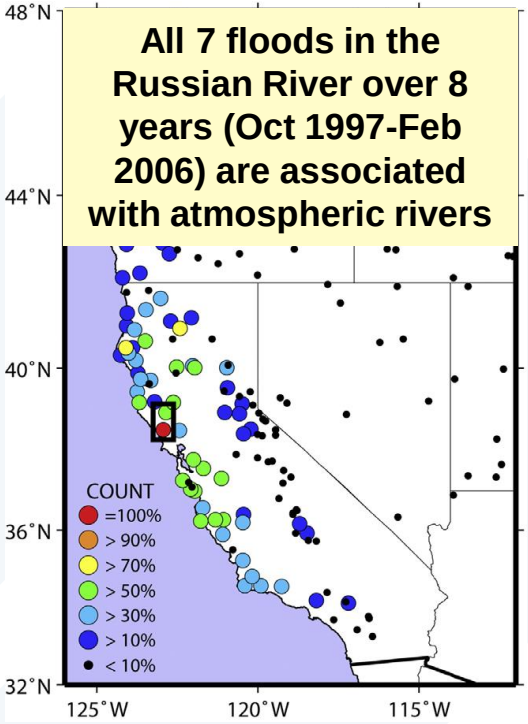


Fig. 6a, Ralph et al. 2006

Water Year 2019: February Atmospheric Rivers

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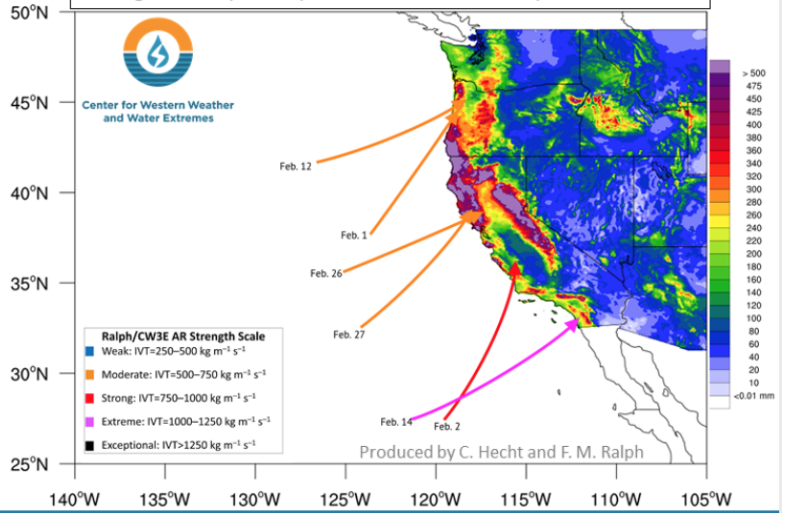
AR Strength	AR Count
Weak	0
Moderate	4
Strong	1
Extreme	1
Exceptional	0

Regions Impacted by Each AR	
State/Region	AR Conditions
Washington	2
Oregon	5
Northern CA	6
Central CA	3
Southern CA	3

Six atmospheric rivers made landfall over the U.S. West Coast during February 2019 (fifth month of WY 2019)



CW3E
Center for Western Weather and Water Extremes

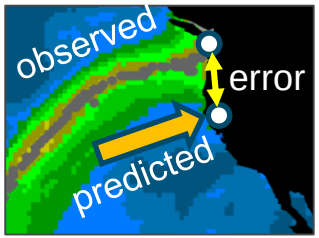
https://cw3e.ucsd.edu/water-year-2019-february-atmospheric-rivers/

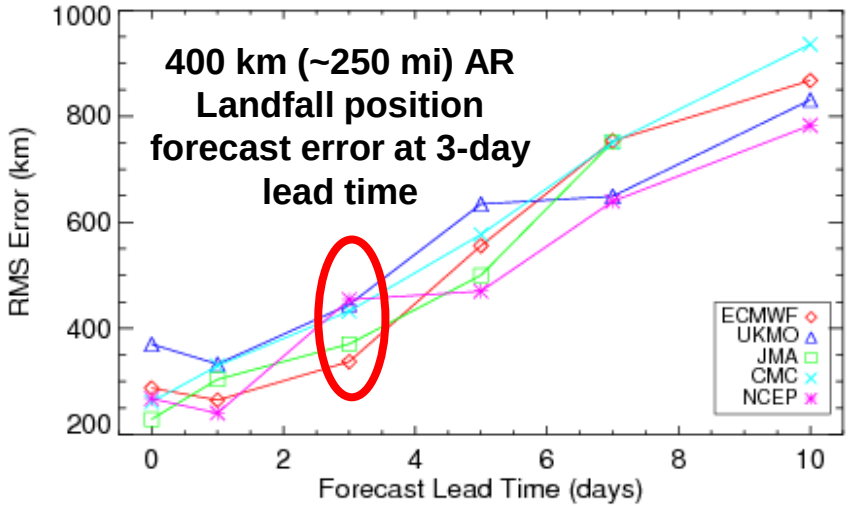
Atmospheric River Reconnaissance

FM Ralph (Scripps/CW3E), V Tallapragada (NWS/NCEP), J Doyle (NRL)

Water managers, transportation sector, agriculture, etc… require improved atmospheric river (AR) predictions

AR Forecast skill assessment establishes a performance baseline





Wick, G.A., P.J. Neiman, F.M. Ralph, and T.M. Hamill, 2013: Evaluation of forecasts of the water vapor signature of atmospheric rivers in operational numerical weather prediction models. *Wea. Forecasting*, **28**, 1337-1352.

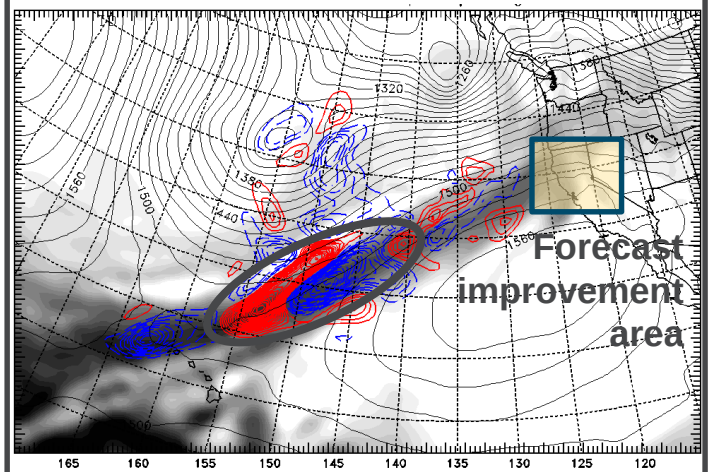
New Adjoint includes moisture – and finds AR is prime target

36-h Sensitivity (Analysis) 00Z 13 February (Final Time 12Z 14 February 2014)

J. Doyle, C. Reynolds, C. Amerault, F.M. Ralph

(International Atmospheric Rivers Conference 2016)

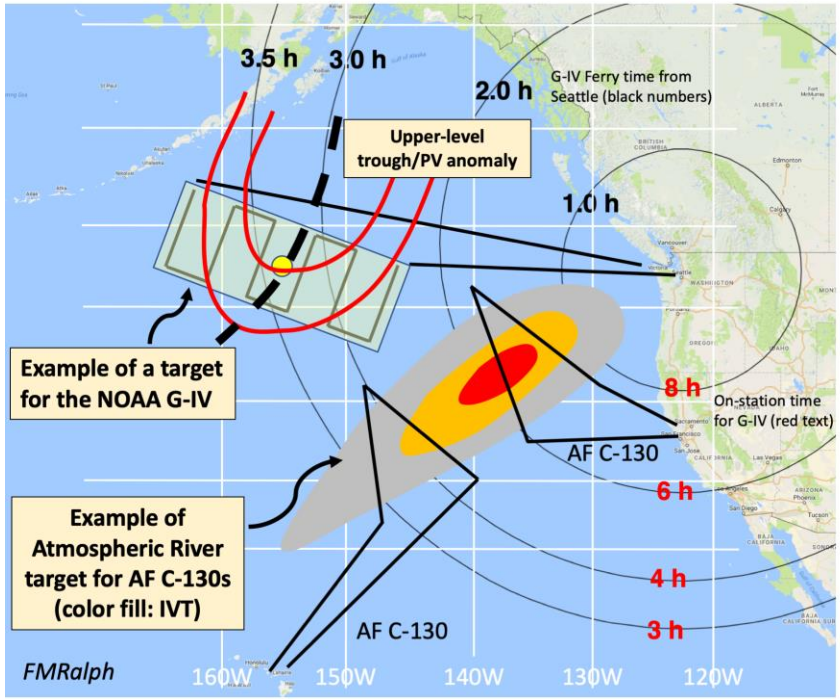
Color contours show the forecast sensitivity to 850 mb water vapor (grey shading) uncertainty at analysis time 00Z 13 Feb 2014 for a 36-h forecast over NorCal valid 12Z 14 Feb

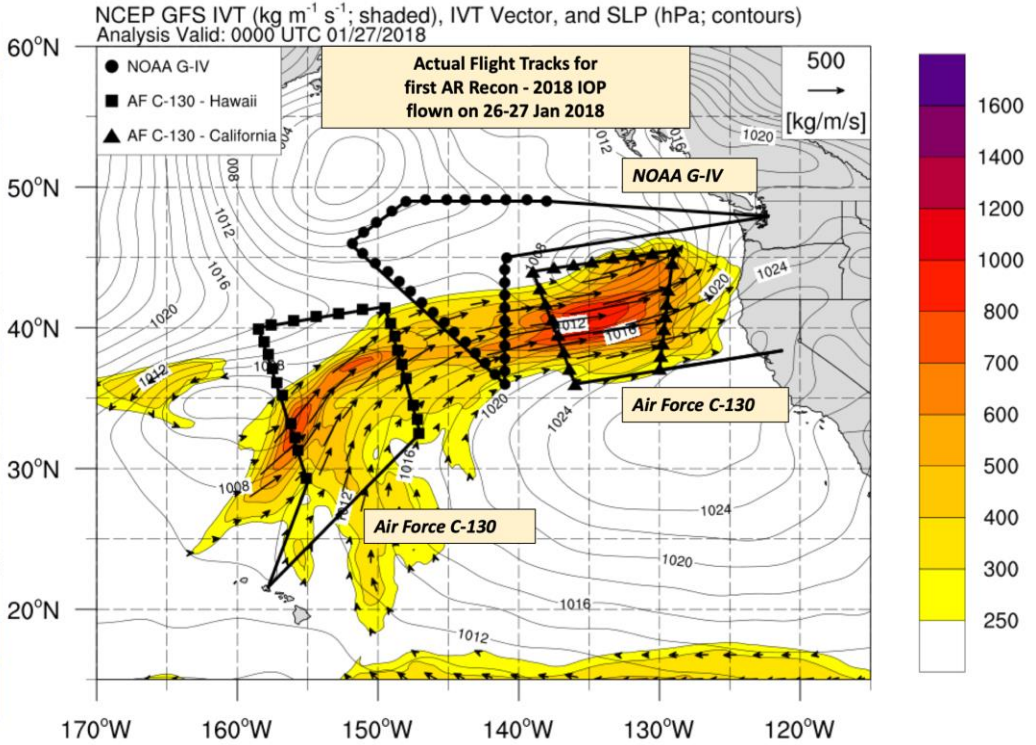


- Moisture sensitivity is strongest along AR axis; located > 2000 km upstream
- **Moisture sensitivity substantially larger than temp. or wind sensitivity.**

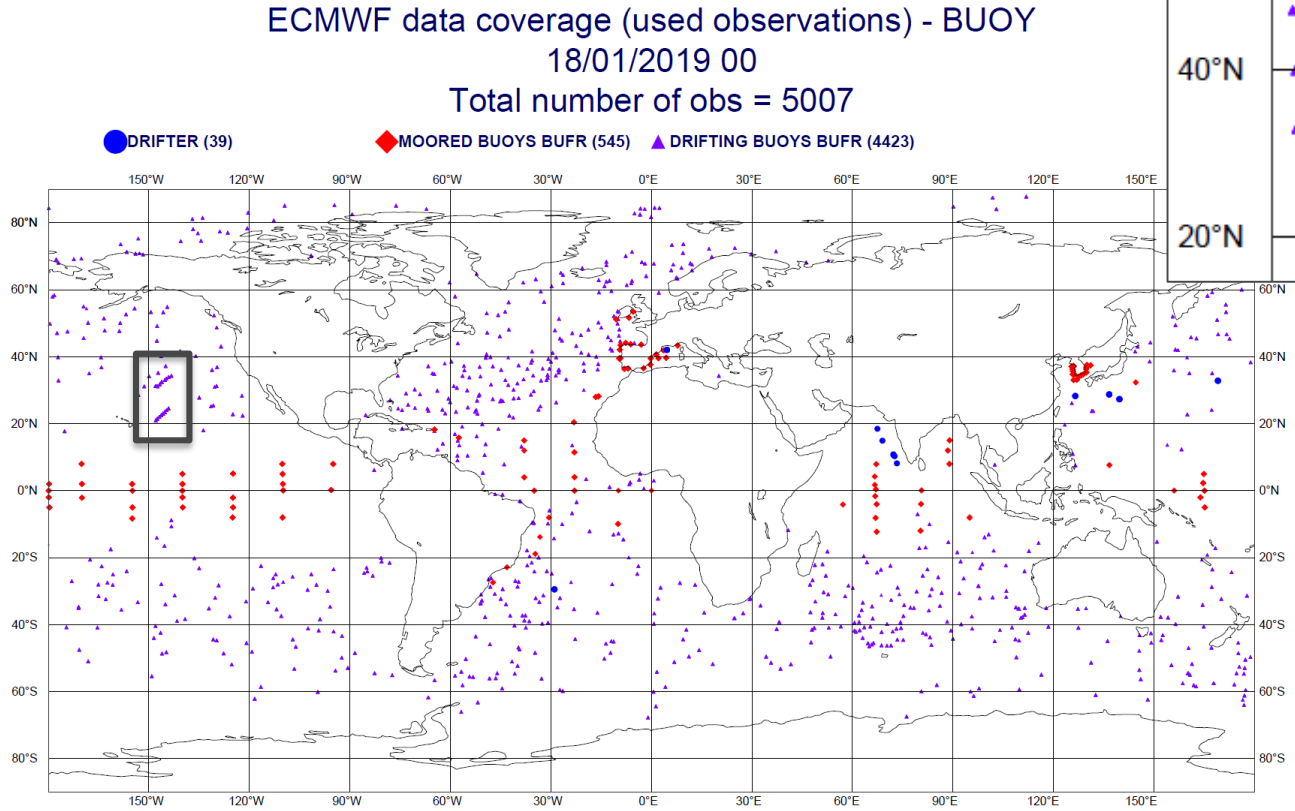
Atmospheric River Reconnaissance

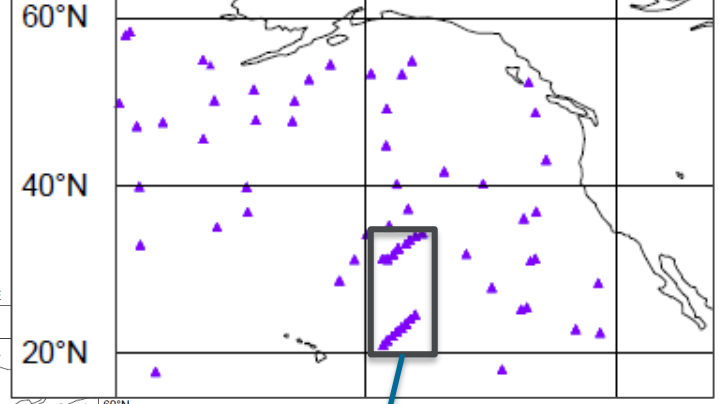
FM Ralph (Scripps/CW3E), Co-PI V Tallapragada (NWS/NCEP)





AR Recon 2019 - Drifting Buoys Assimilated





AR Recon – 2019
Added pressure to 32 drifters in coordination with Global drifter program. Air Force's 53rd Weather Recon Squadron deployed the drops during two training flights.

Sponsored by California's Atmospheric Rivers Research, Mitigation, and Climate Forecasting Program Managed by CA DWR, led by CW3E

PI: F. Martin Ralph, Scripps Partner Luca Centurioni

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AR Recon – 2019: IOP 1 on 1-2 Feb 2019

Key sponsors include US Army Corps of Engineers, and California Dept. of Water Resources

Center time for dropsondes: 0000 UTC 2 Feb 2019
Number of dropsondes planned (dropped):
27 (30), 26 (23) (C-130 CA1, C-130 CA2)

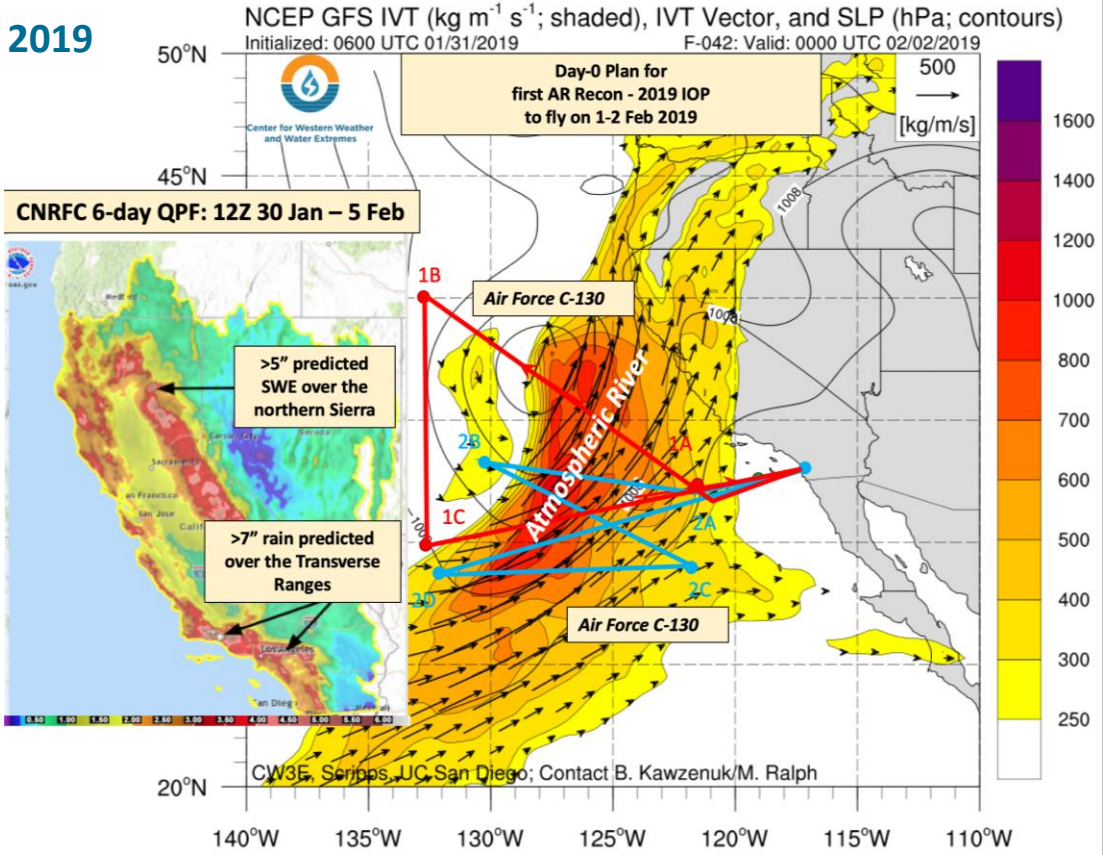
Forecasting/Flight Planning Partners

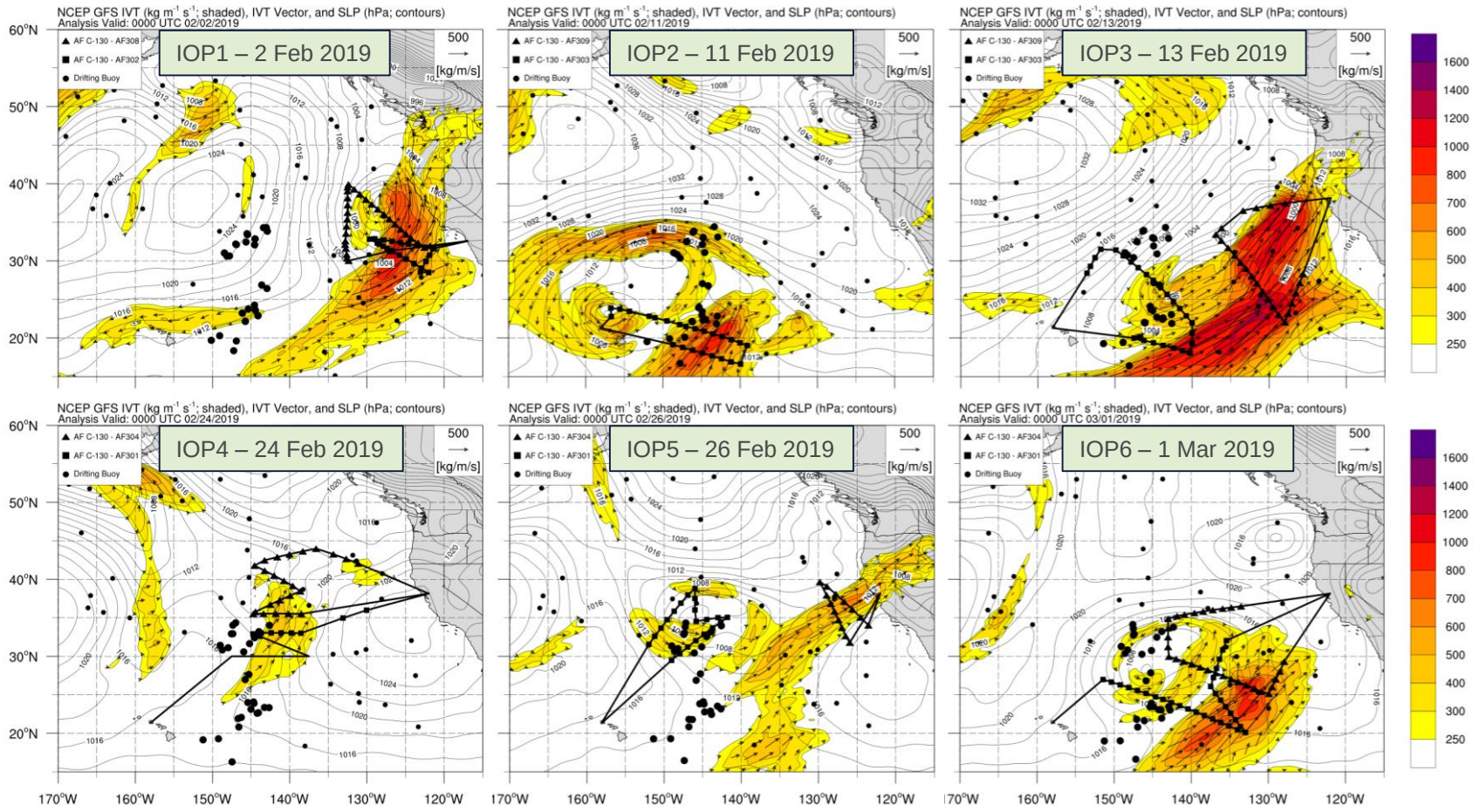
NWS/NCEP US NAVY SUNY Albany
ECMWF NCAR USAF
UC Boulder Plymouth State

Modeling Partners

NWS/NCEP US NAVY
ECMWF NCAR

Air Force C-130 Aircraft – Weather Recon' Squadron





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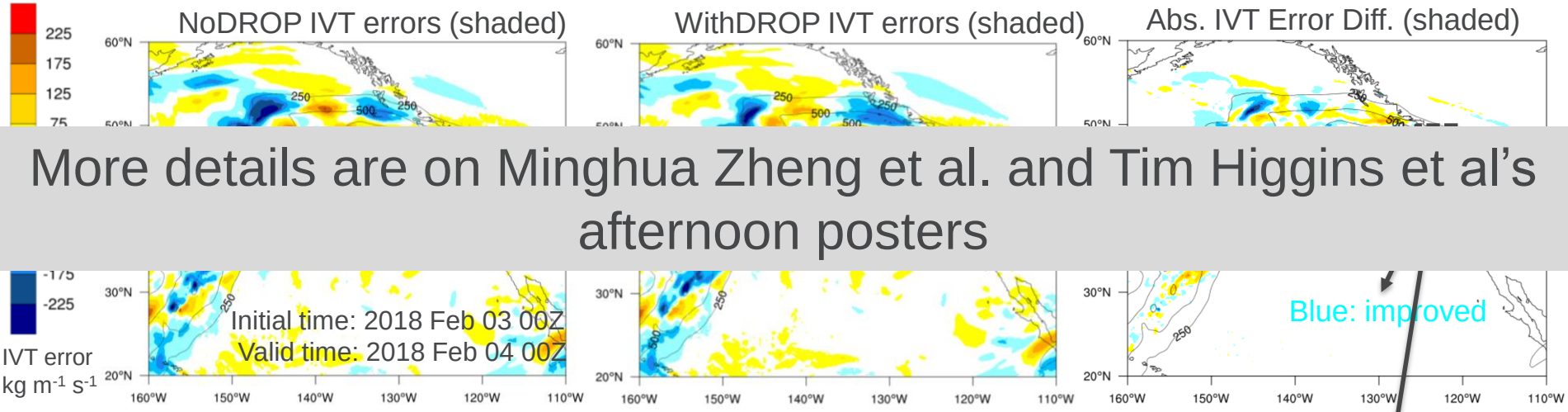
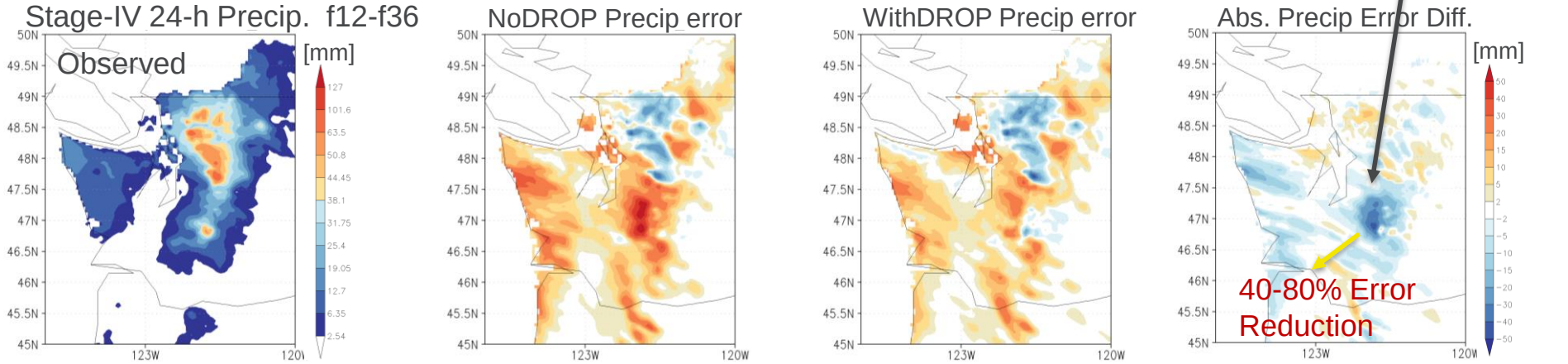
PI: F. Martin Ralph

Impact of AR Recon dropsondes on forecast skills of ARs and precipitation (2018 IOP4)

Contours: ERA5 IVT (truth) from 250 Unit



More details are on Minghua Zheng et al. and Tim Higgins et al's afternoon posters



ONSHORE: FIRO AT LAKE MENDOCINO FIELDWORK OBJECTIVES

- What happens when the AR passes over the coastal ranges and/or is channeled by local valleys?
- How do vertical variations in WV modulate AR transport?
- Support assessment of variance in the bulk upslope flux and precipitation relationship
- Support West-WRF modeling
- Improve understanding of the spatial variability of precipitation, soil moisture, and streamflow to inform hydrological modeling forecasts (e.g. GSSHA)
- Quantify runoff volumes and sources of runoff (e.g. surface vs. groundwater) to aid in understanding hydrologic response to ARs
- Observe the hydrometeorology of the watershed during events that provide inflows to Lake Mendocino; diurnal, seasonal, interannual watershed cycles

INVESTIGATING ATMOSPHERIC PROCESSES

Poster assessing radiosonde data and AR impact on reservoir operations using observations

- Strong interannual variability reflected in characteristics such as duration and strength of ARs illustrates potential to respond to flexible reservoir management
- Variability in AR vertical structure and differences in AR characteristics such as strength and duration are quantified between the coastal and inland sites, and these factors may modulate impacts

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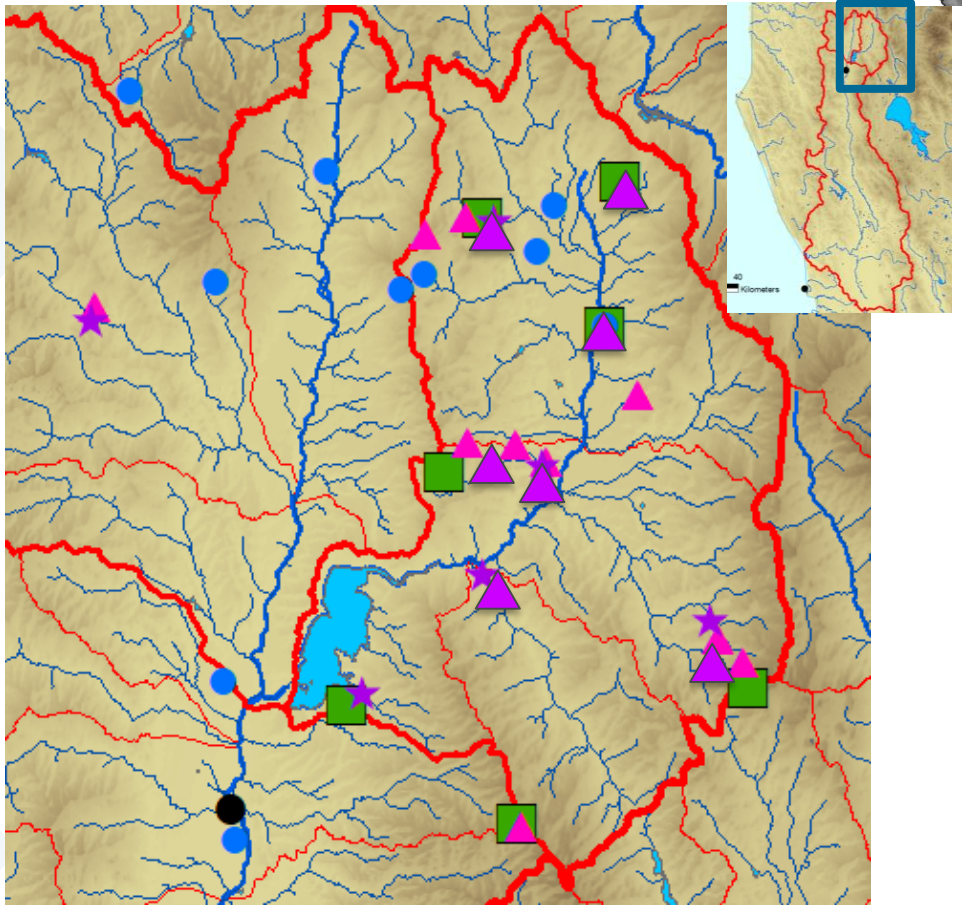
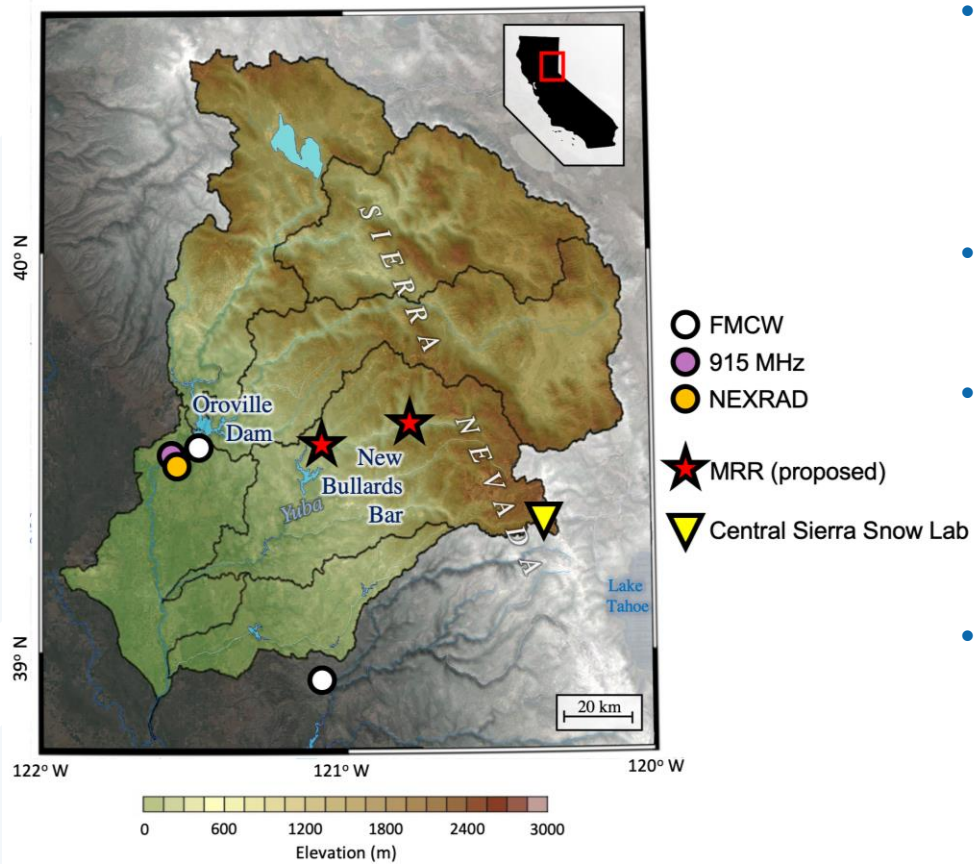
INVESTIGATING HYDROLOGICAL PROCESSES

Several posters describing how we are using soil moisture and stream observations to improve our understanding of the physical processes in the watershed and our ability to produce skillful forecasts.

- Spatial patterns of precipitation and streamflow including discharge, isotopes, anions/cations, conductivity
- Case study of the February 2019 AR events, demonstrating the use/value of the Russian River network in evaluating the watershed rainfall-runoff process during extreme events
- Ongoing calibration of GSSHA to 2017-2018 data, and plans to either verify or recalibrate with 2018-2019 data



WATER YEAR 2020 PLANS



- Instrument Yuba-Feather (6 soil moisture – 2 radar sites)-augmenting existing observations, addressing specific science questions
- Instrument Prado – meetings this week (later today) on needs
- AR Recon –As of June 2019, it is **officially called for** in the NWSOP (Office of Federal Coordinator of Meteorology National Winter Season Operations Plan)
- Continue high density radiosonde sampling – mobile stations enable us to make observations wherever is active

Summary

- Targeted data collection is a key component of FIRO
  - in order to advance our understanding of physical processes and ability to reproduce them in numerical weather prediction models → **better forecasts!**
  - Provide data in near real time for monitoring and situational awareness to forecasters, managers, others; for data assimilation to improve forecast model initial conditions


Air Force C-130 Aircraft – Weather Recon' Squadron


NOAA G-IV