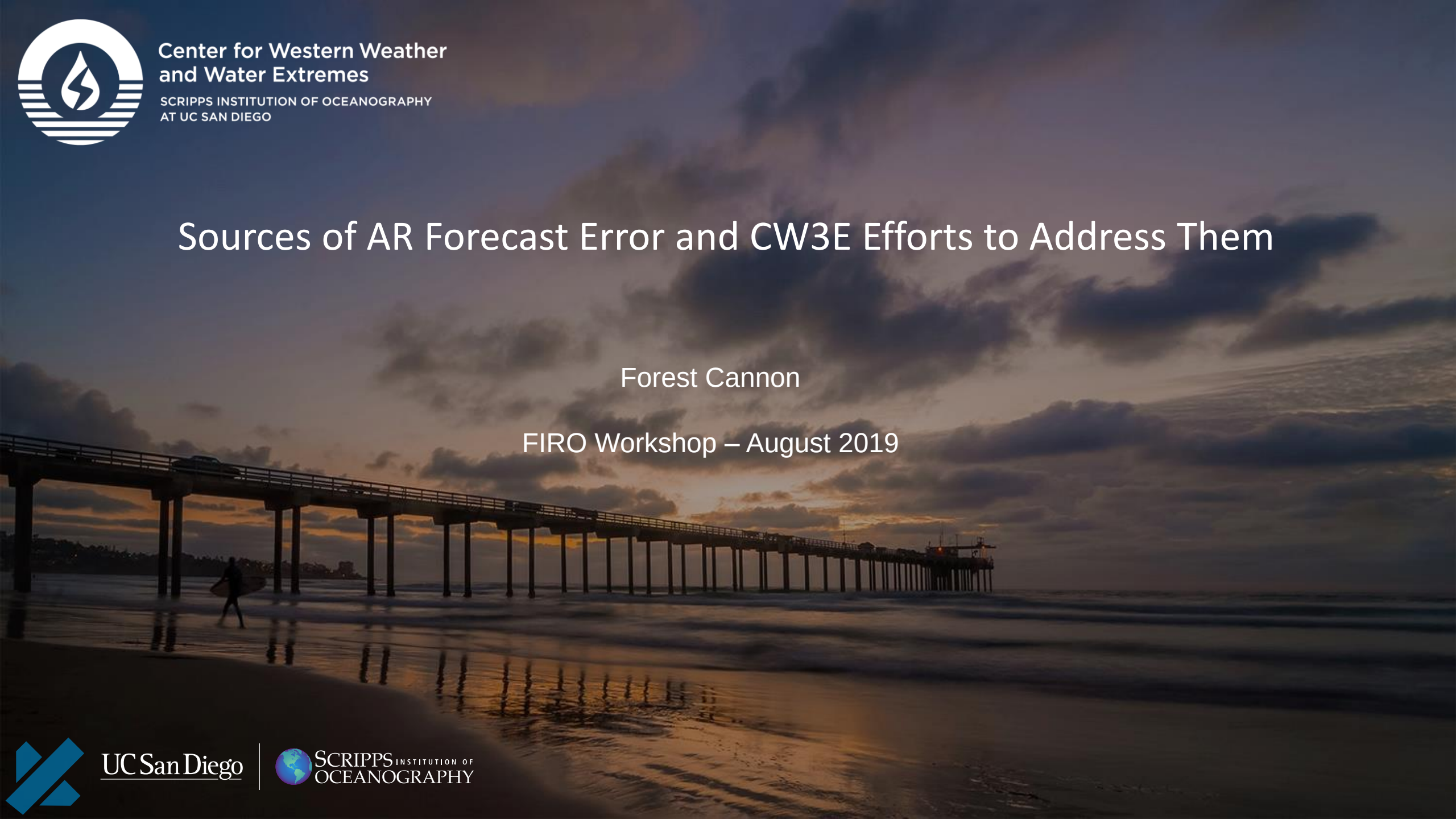
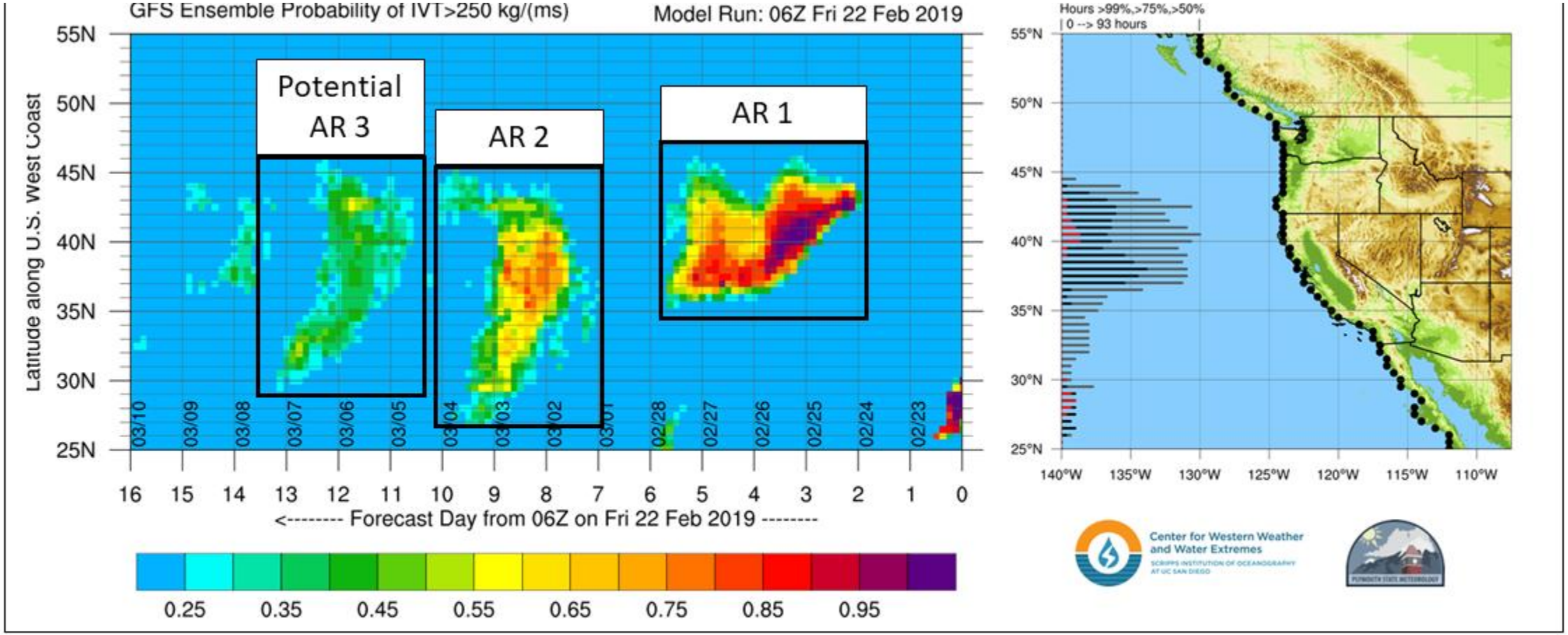


Sources of AR Forecast Error and CW3E Efforts to Address Them

Forest Cannon

FIRO Workshop – August 2019

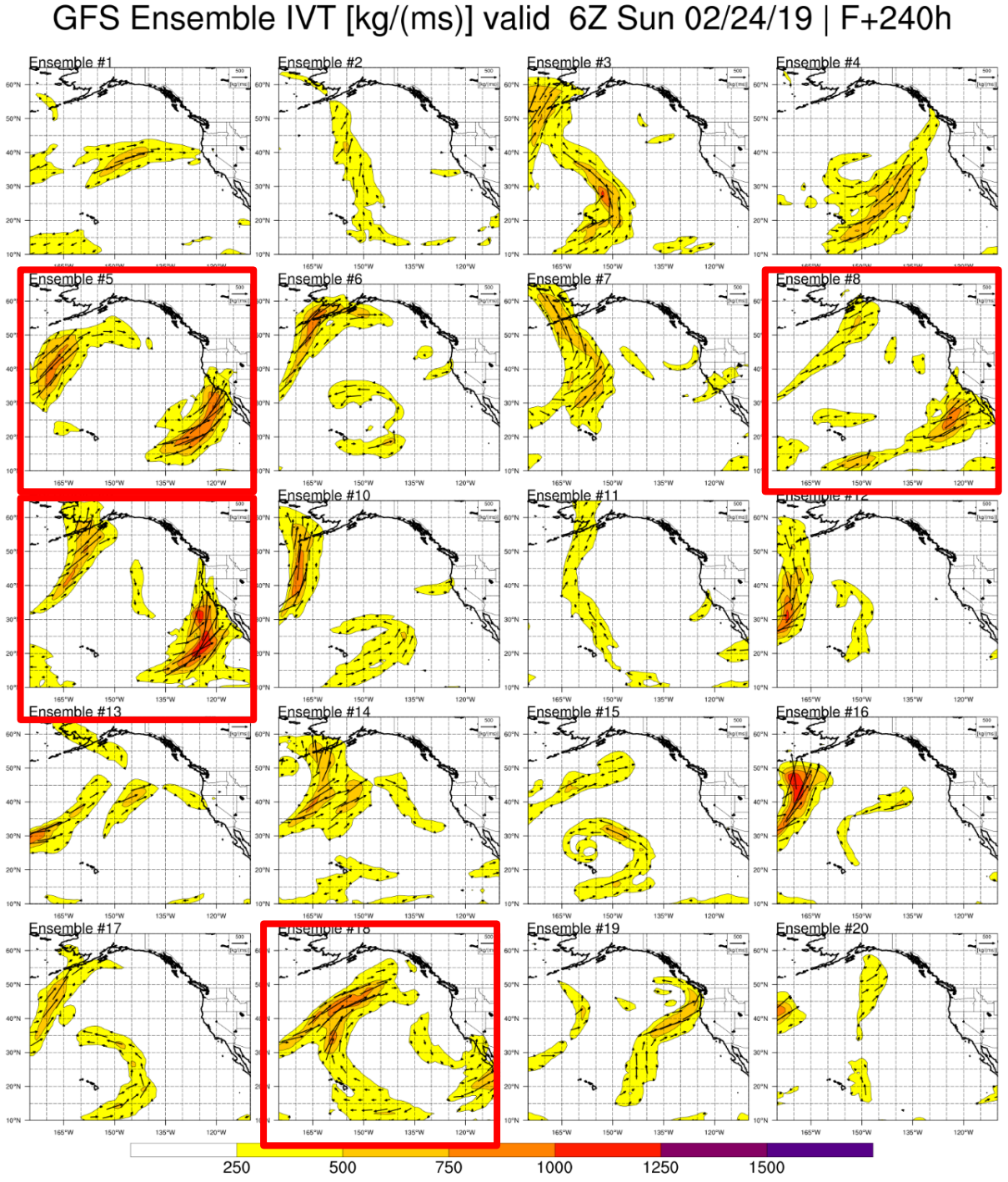
AR Outlook Issued by CW3E on 22 Feb. 2019



- There is high probability (80–100%) of AR conditions (IVT > 250 kg m^{-1} s^{-1}) lasting for an extended period over N. CA and S. OR
- The GEFS suggests AR conditions could last for >24 hours over portions of Northern California
- The ensemble probability of IVT >250 units along the coast is lower in associated with AR 2
- The GEFS is also highlighting the possibility of a third landfalling AR between 5 and 7 March 2019

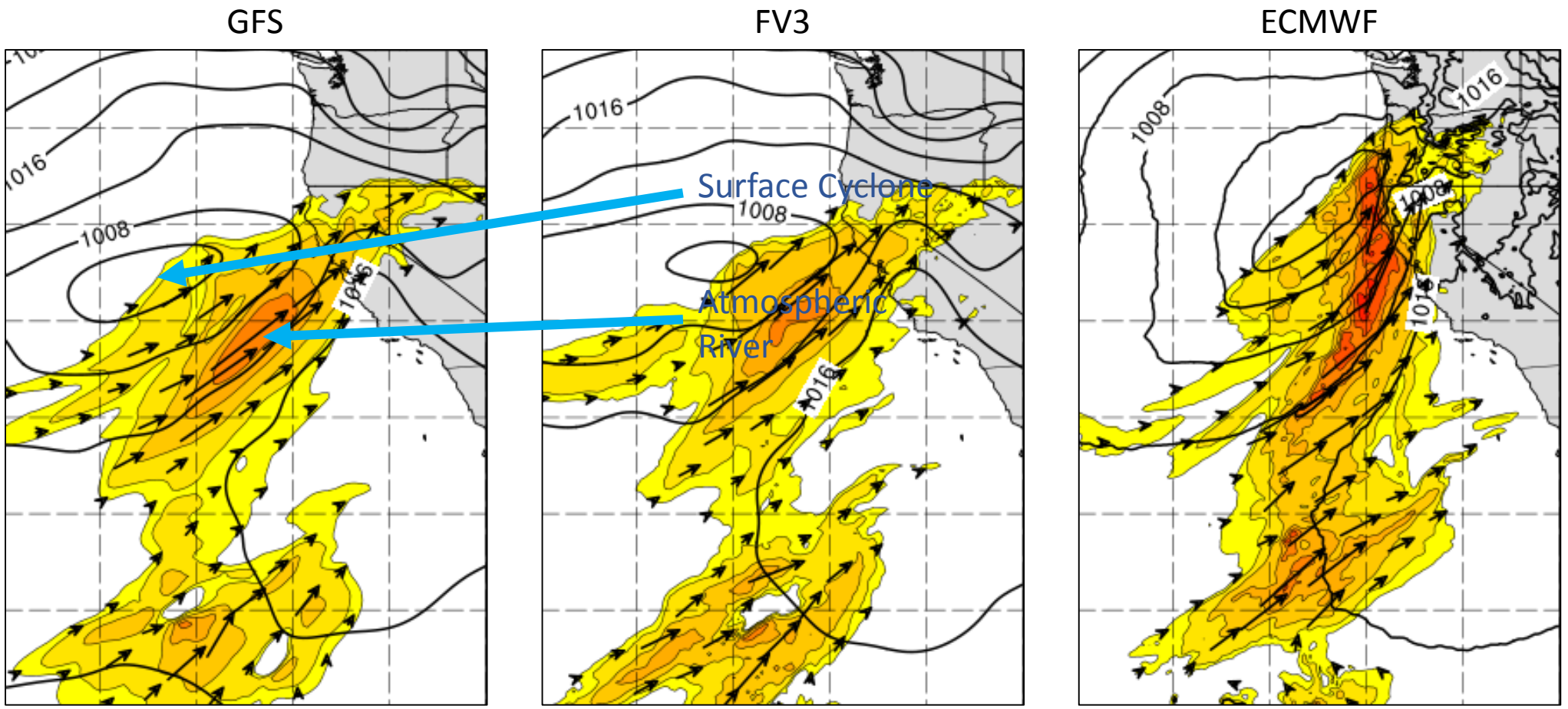
GEFS 240-hr Forecast: Valid 6Z 2/24/2019

A few ensemble members of the GEFS currently suggest the potential for an AR to undercut the persistent Eastern Pacific high pressure and make landfall over Southern California/Baja California, Mexico on 2/24/2019, but uncertainty is extremely high (it is a 240-hr forecast after all)



27 February 2019 AR Forecast Uncertainty

Model Comparison: Initialized 0Z 2/23 (4 day lead) – Valid 00Z 27 February



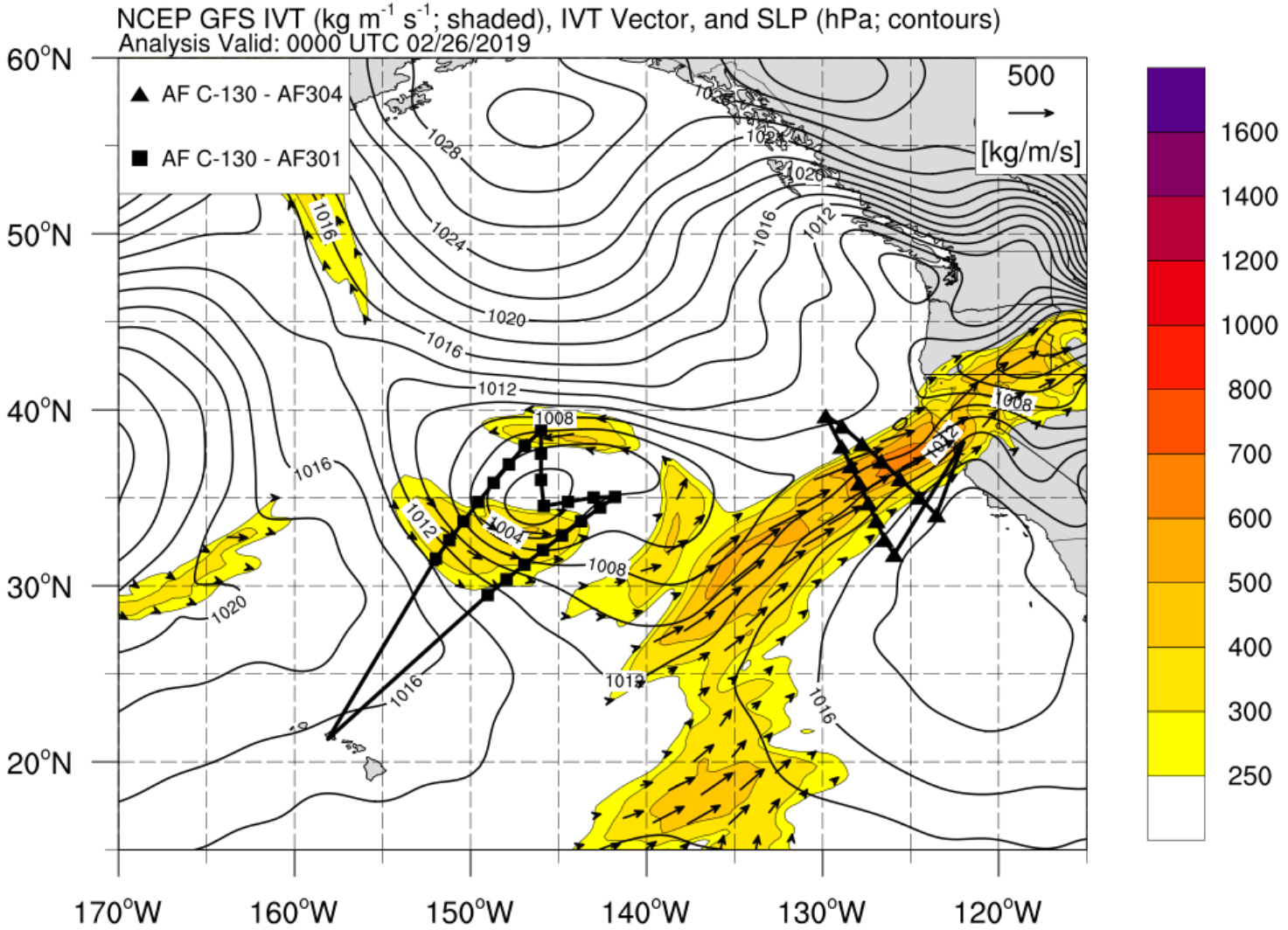
Where does forecast model uncertainty arise?

- Initial Condition Errors

Can be addressed through data assimilation (Over the ocean – relies on satellites…)

Also, ensemble perturbed initial conditions

Potential for AR Recon

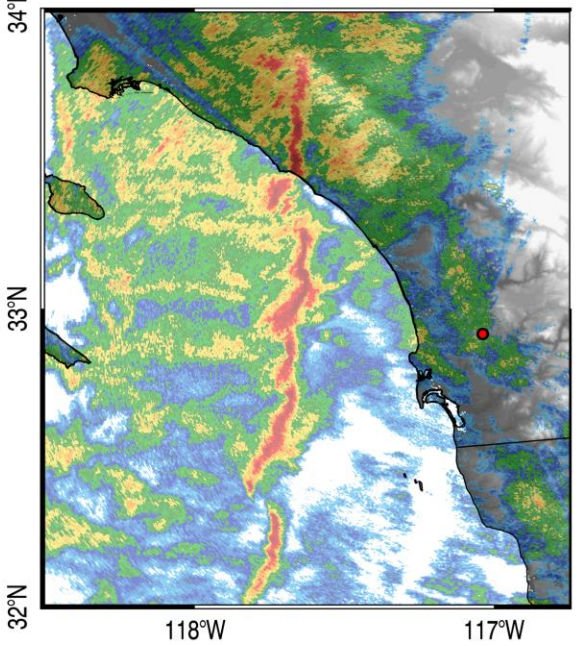


Where does forecast model uncertainty arise?

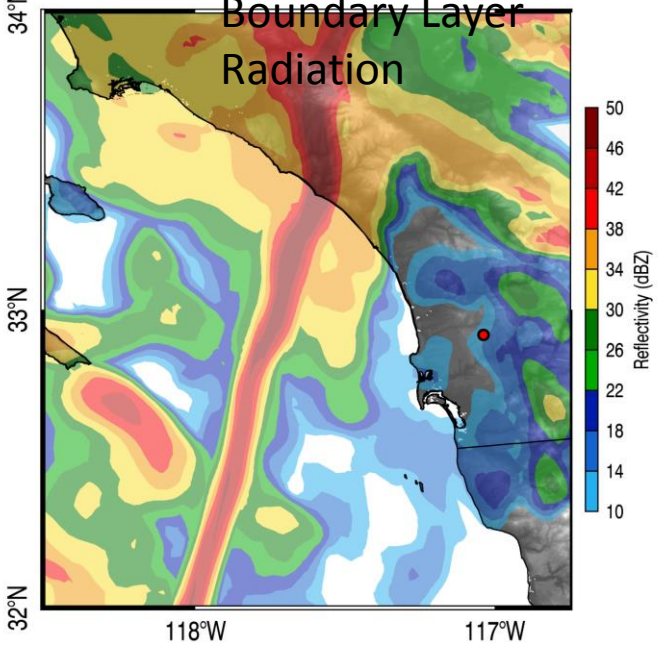
- Parameterized Physics

e.g. –
Convection
Precipitation Microphysics
Boundary Layer
Radiation

NEXRAD Radar

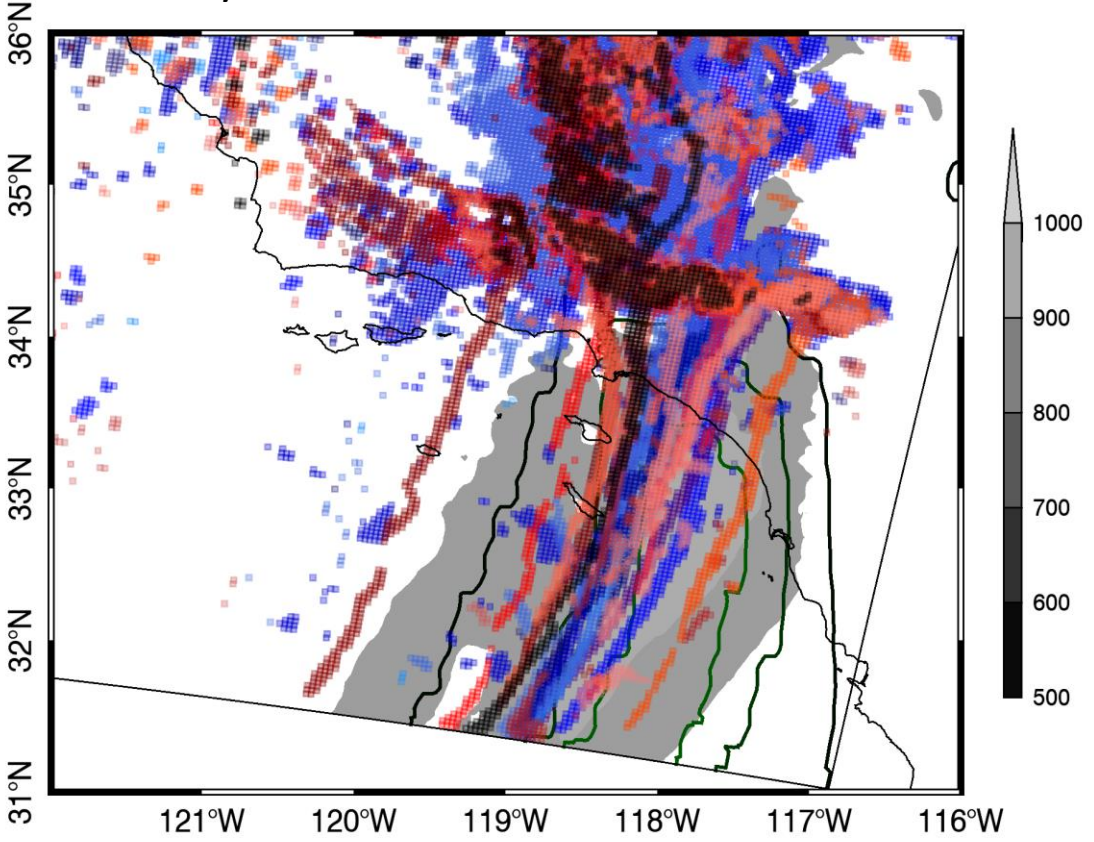


WRF-Simulated Radar



An impactful Narrow Cold-Frontal Rainband (NCFR) off San Diego

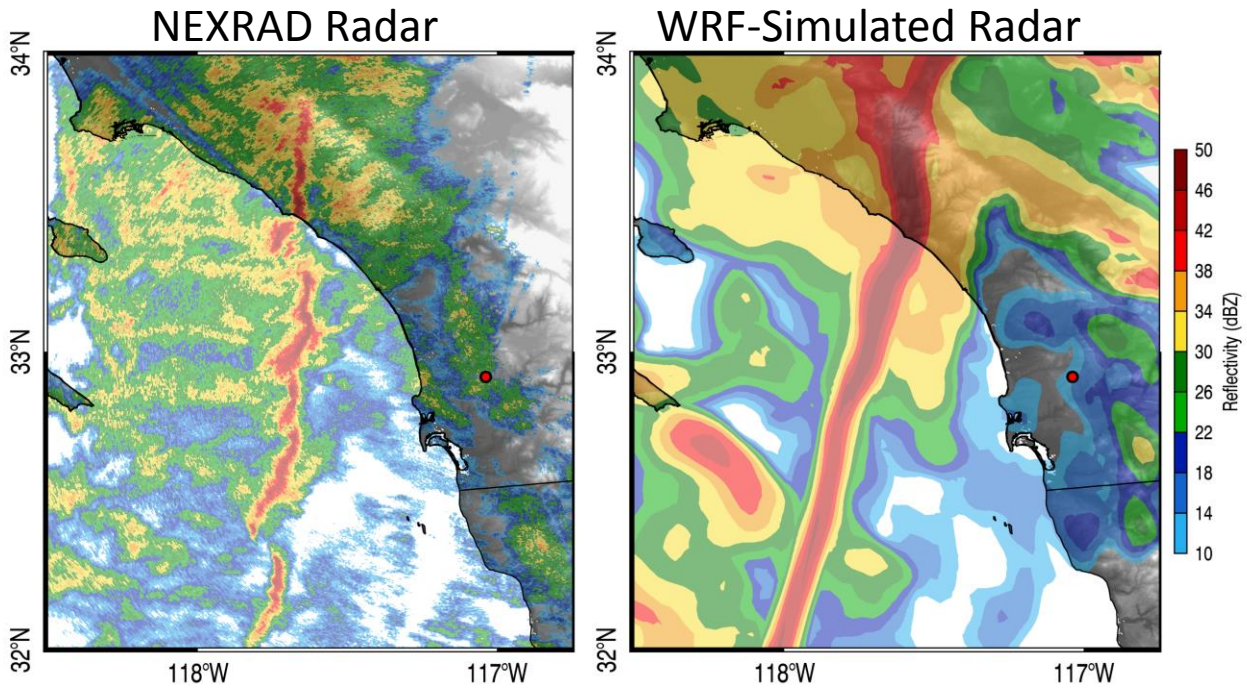
Multi-Physics Ensemble Simulation of an NCFR



Each color represents a different ensemble member

Where does forecast model uncertainty arise?

- Grid-Scale Resolution

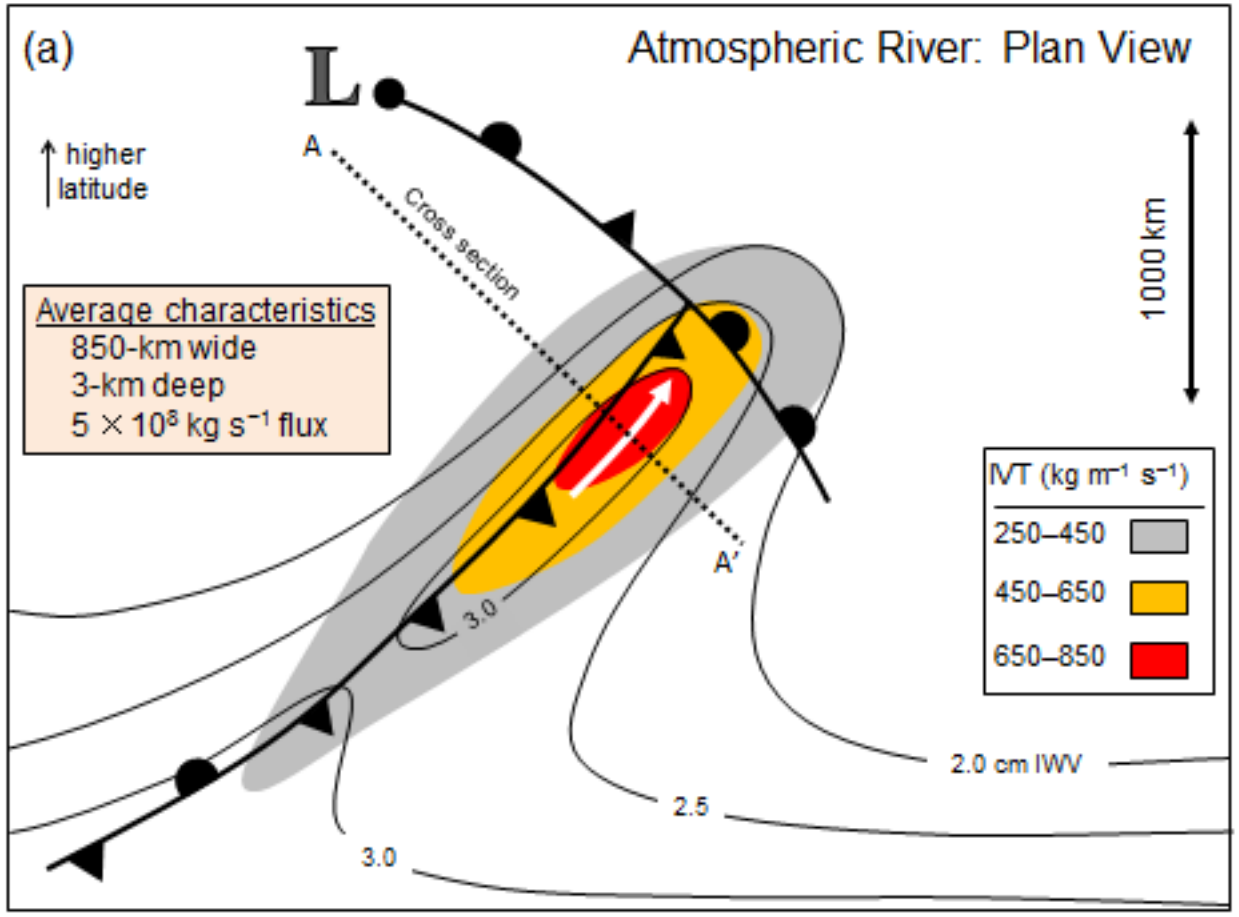


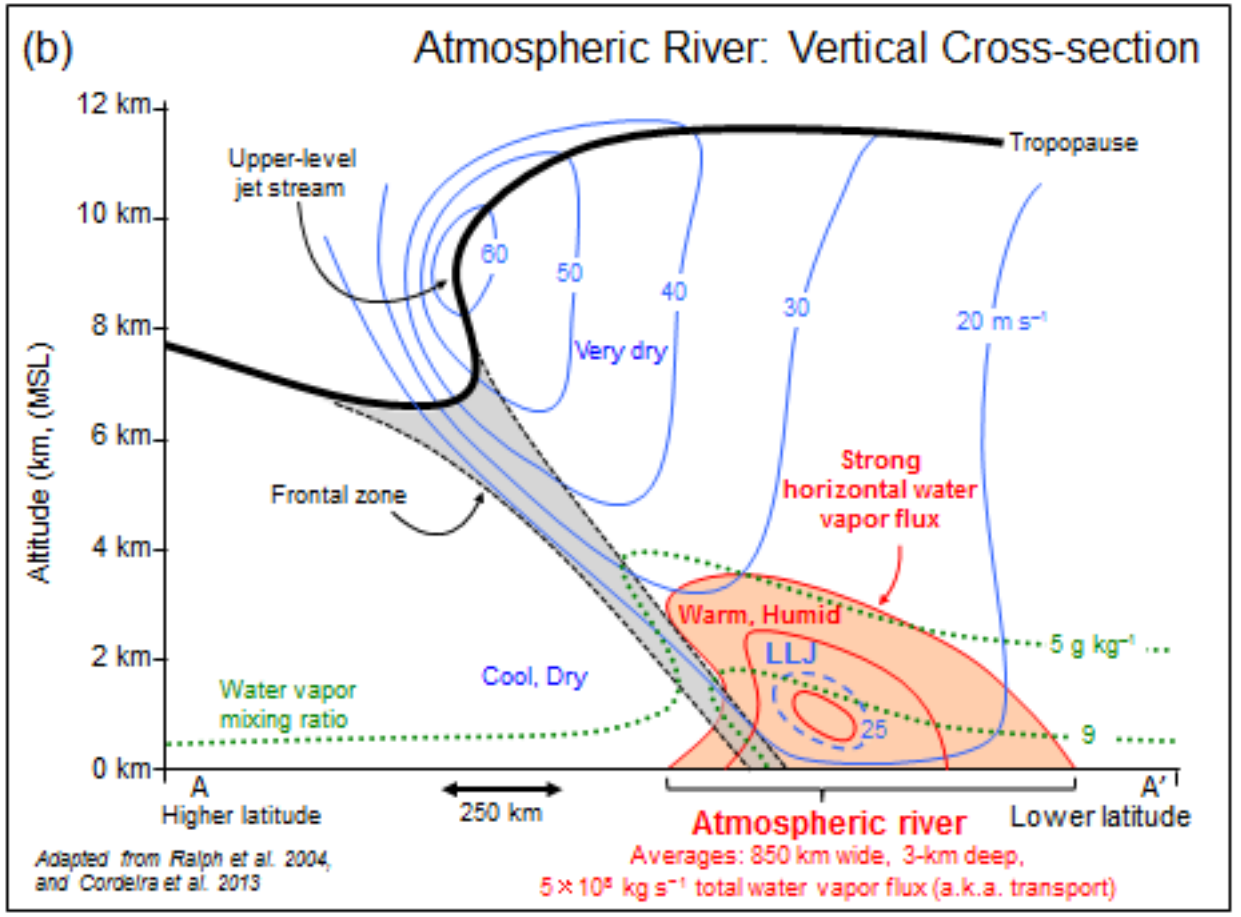
An impactful Narrow Cold-Frontal Rainband (NCFR) off San Diego

The grid scale that physical equations are solved on affects their ability to resolve weather processes.

Grid resolution rapidly increases, but also rapidly introduces new challenges for forecasting.

How do these sources of uncertainty affect the predictability of ARs?





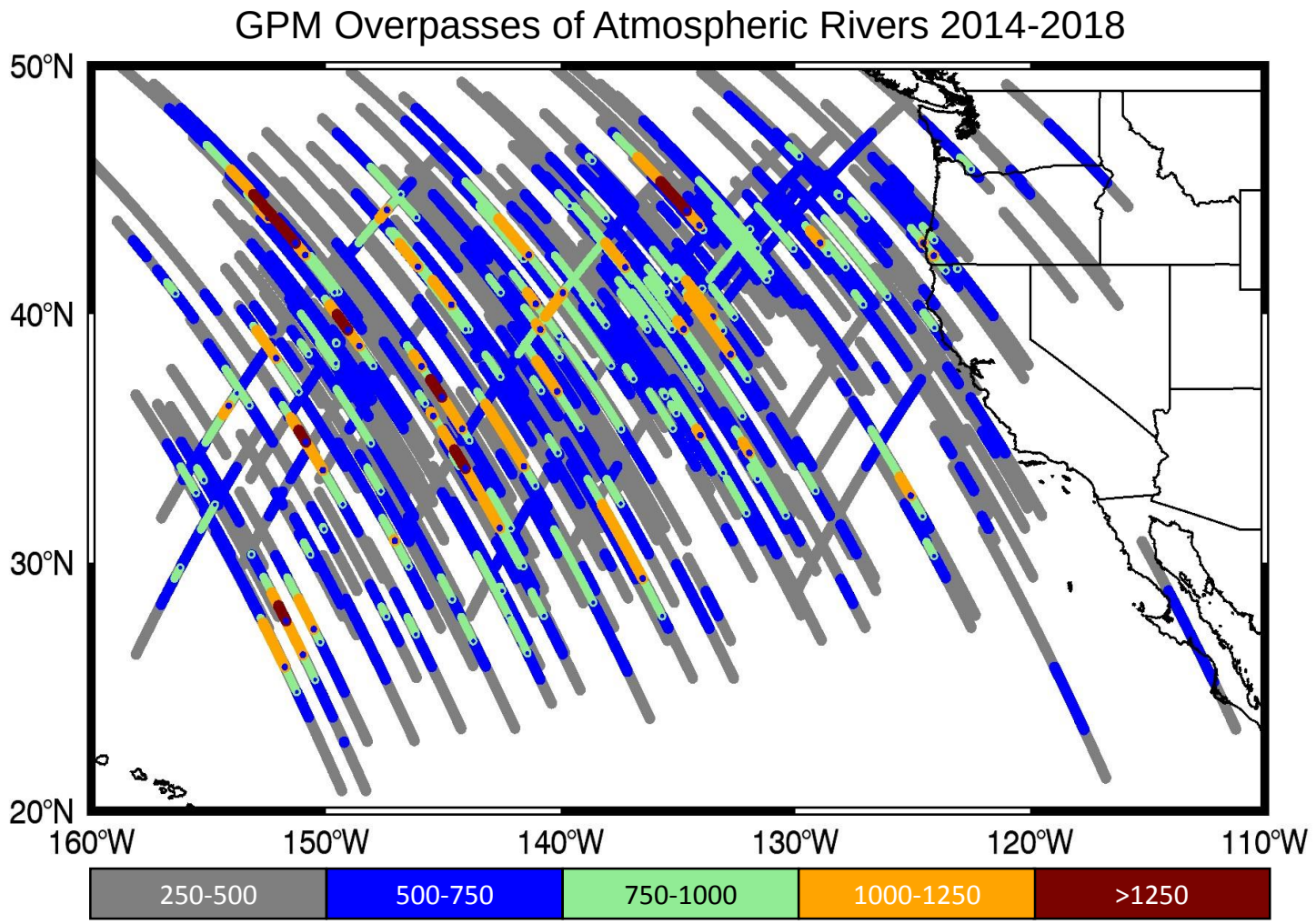
How do ARs evolve, and how are those processes represented by models?

So, how are CW3E studies addressing these challenges?

Satellite Radar Observations of Precipitation in Atmospheric Rivers over the Ocean

Cannon et al.

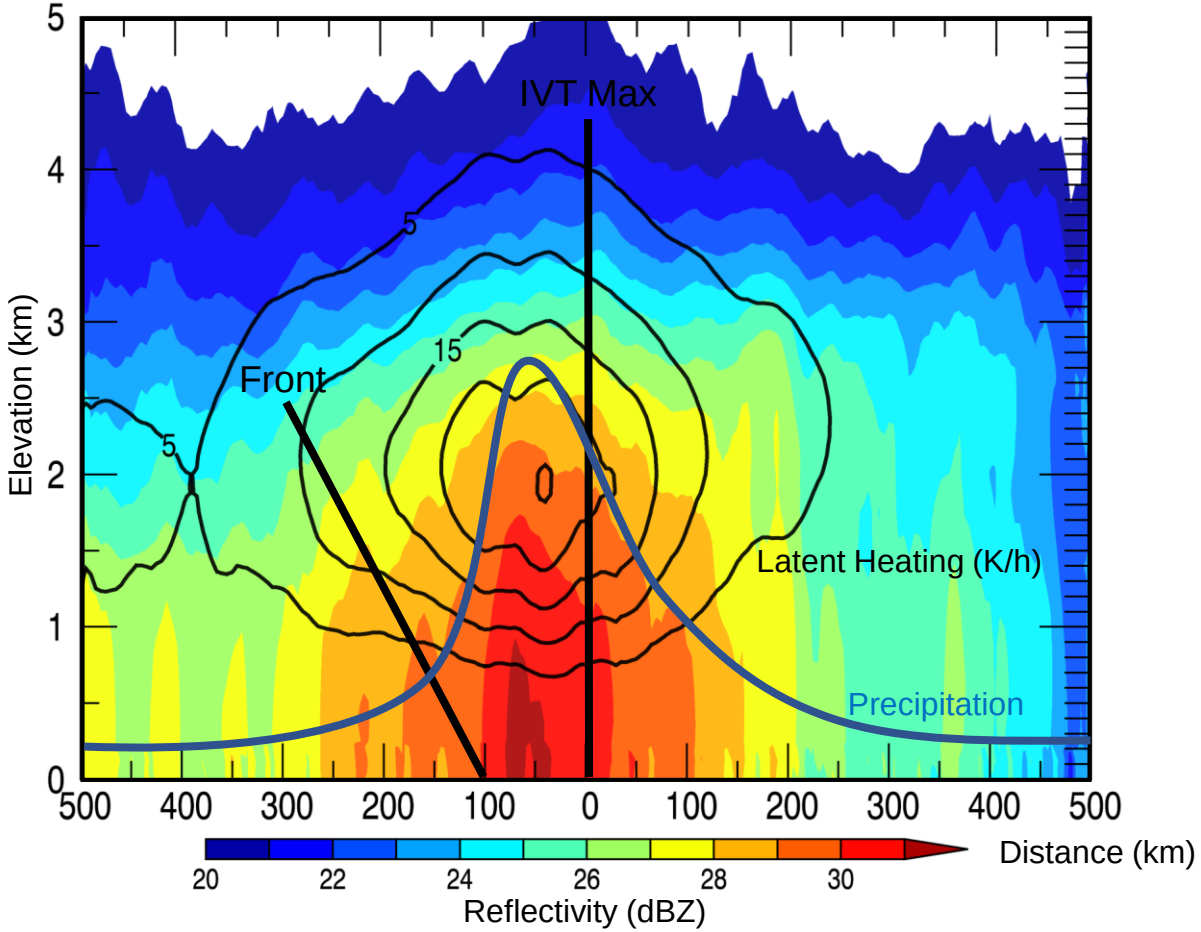
Not an AR!



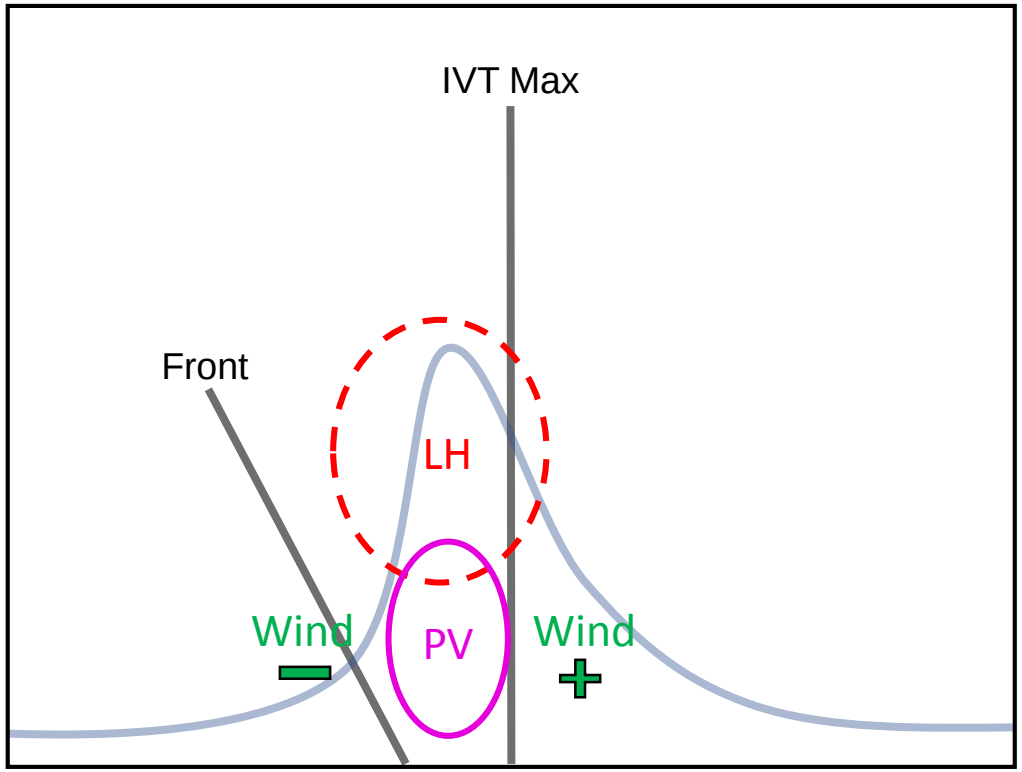
Satellite Radar Observations of Precipitation in Atmospheric Rivers over the Ocean

Cannon et al. 2019 – Mon. Wea. Rev.

Observed Precipitation and Latent Heating from GPM Overpasses of 192 Atmospheric Rivers 2014-2018



Schematic Diagram of the Influence of Precipitation in ARs to their evolution



Precipitation releases LH

LH leads to +PV

+PV leads to stronger LLJ & more moisture convergence

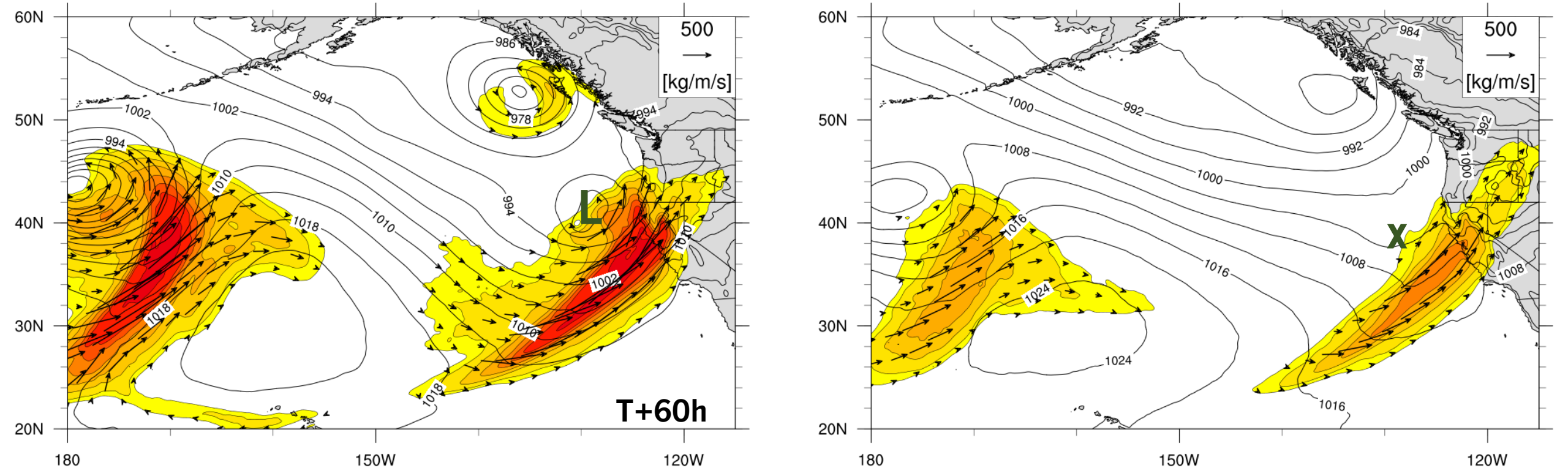
More convergence leads to more intense precipitation

Role of Diabatic Processes in the Formation and Evolution of Mesoscale Frontal Waves in Atmospheric River Events

Allison Michaelis[1], Andy Martin[2], Brian Kawzenuk[1], and F. Martin Ralph[1]

2014 AR - MPAS Control Run

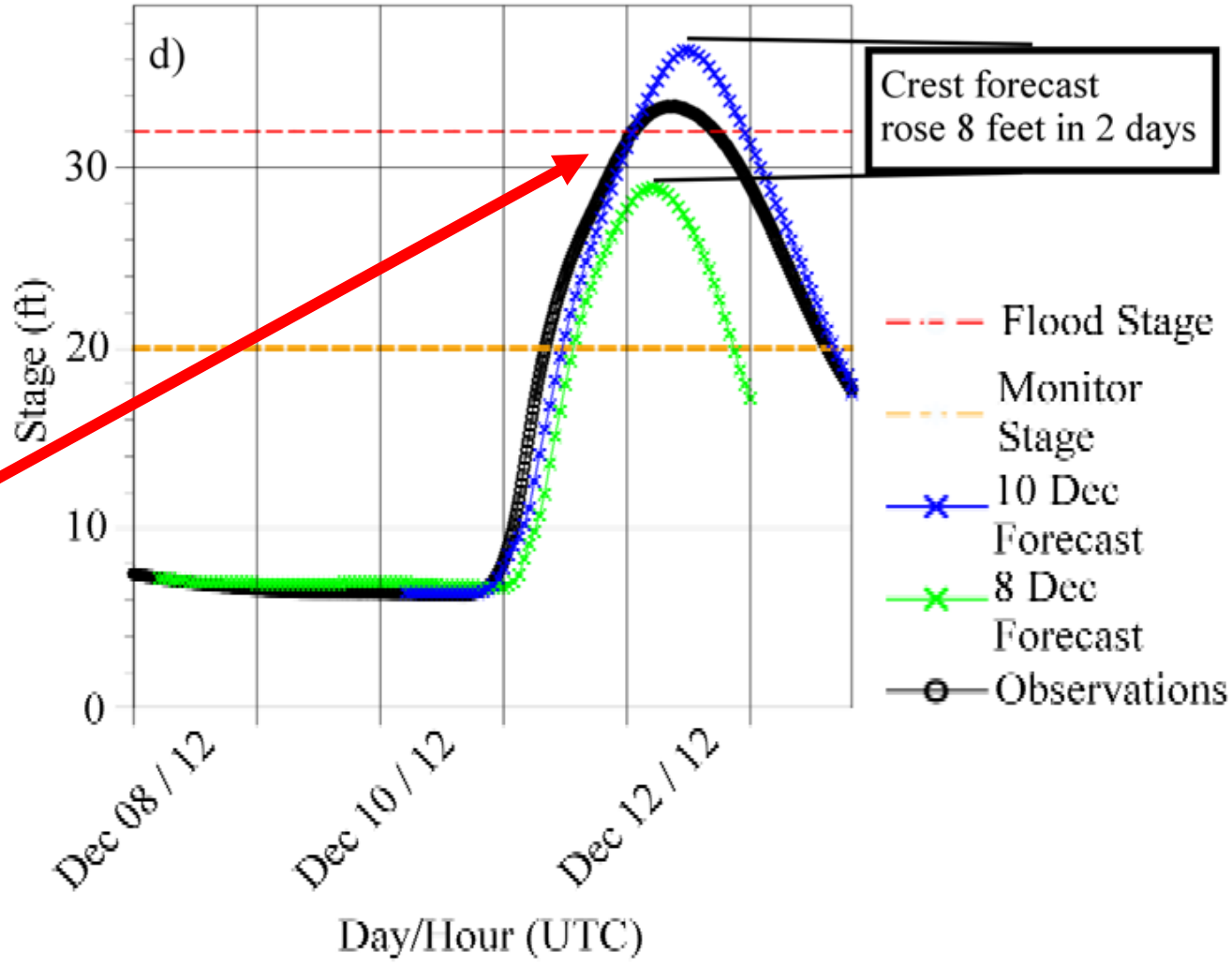
MPAS Dry Run



Rapid Cyclogenesis from a Mesoscale Frontal Wave on an Atmospheric River: Impacts on Forecast Skill and Predictability during Atmospheric River Landfall

Martin, A.C., F.M. Ralph, A. Wilson, L. DeHaan, and B. Kawzenuk,

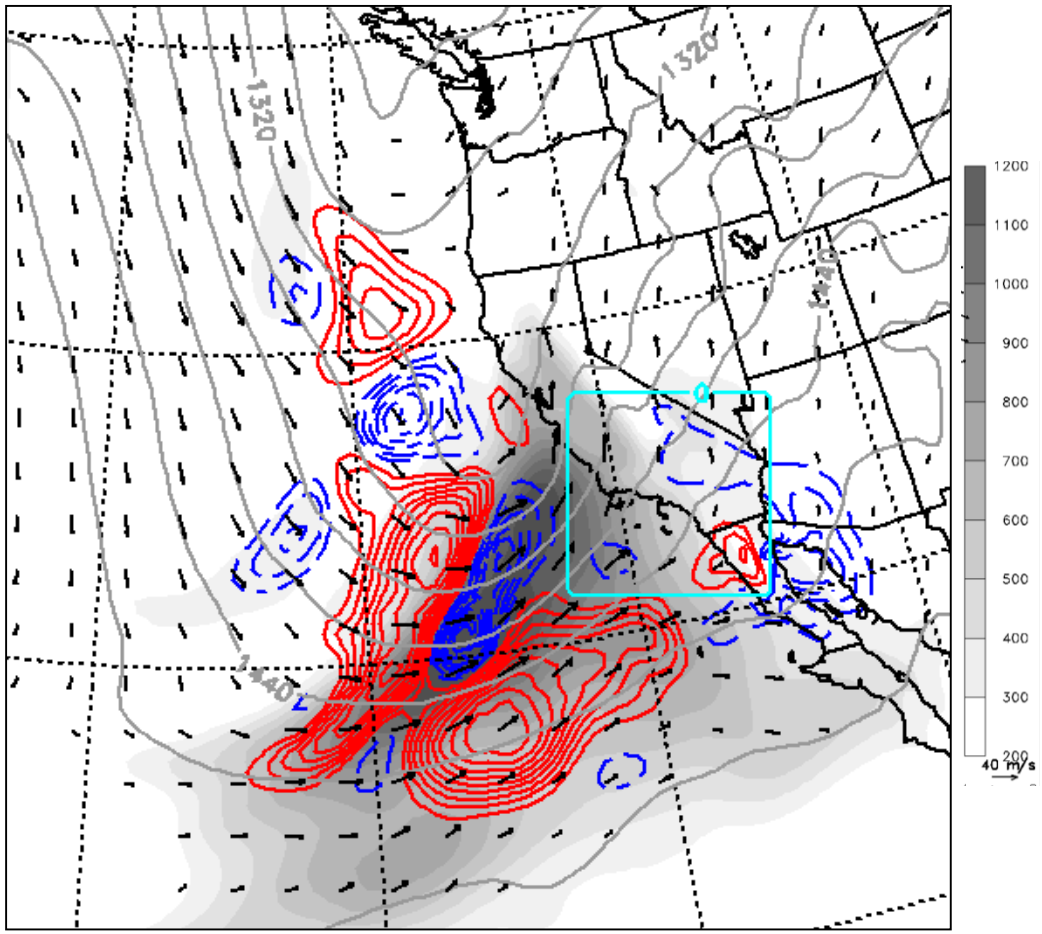
Journal of Hydrometeorology 2019



Hydrologic forecast challenges in Russian River related to challenges in forecasting frontal wave influence on an AR

A Case Study of the Physical Processes Associated with the Atmospheric River Initial Condition Sensitivity from an Adjoint Model

Reuben Demirdjian, Jim Doyle, Carolyn Reynolds, Joel Norris, Allison Michaelis, Marty Ralph



IVT [kg/m/s]

Precip. Sensitivity to Moisture Content

Red/Blue = Negative/Positive Sensitivities

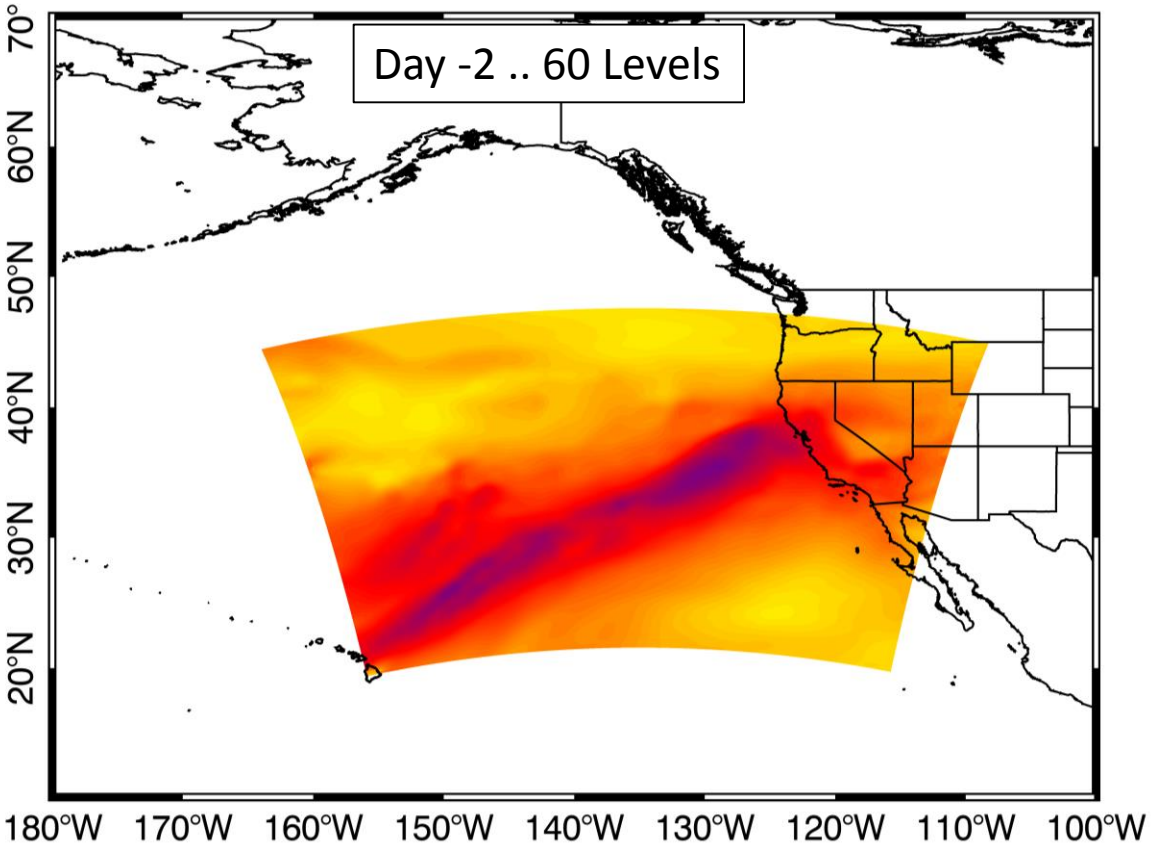
Adjoint Sensitivity of North Pacific Atmospheric River Forecasts

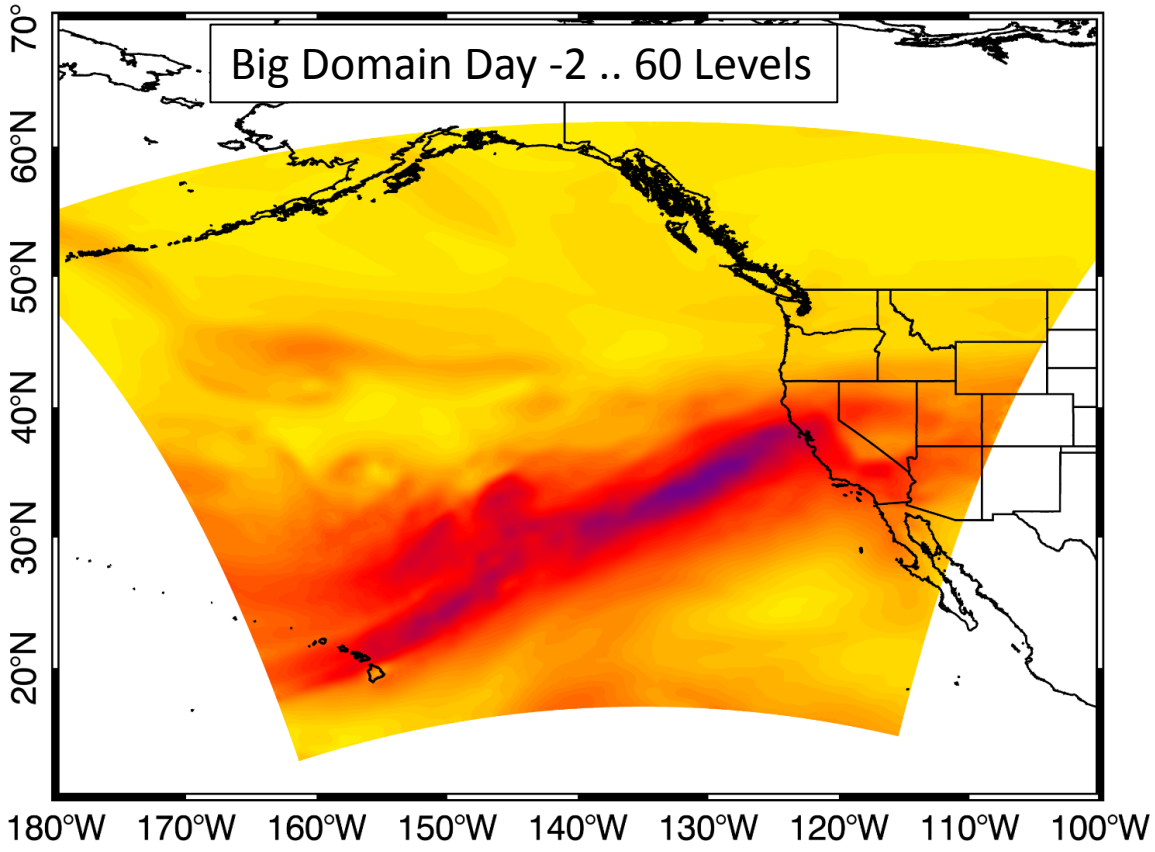
Carolyn A. Reynolds, James D. Doyle, F. Martin Ralph and Reuben Demirdjian

Monthly Weather Review (2019)

West-WRF Development: Domain Extent Change to Simulate Diabatic Processes in AR evolution

AR Event: 7 Feb 2017, 1200 (Max IVT)

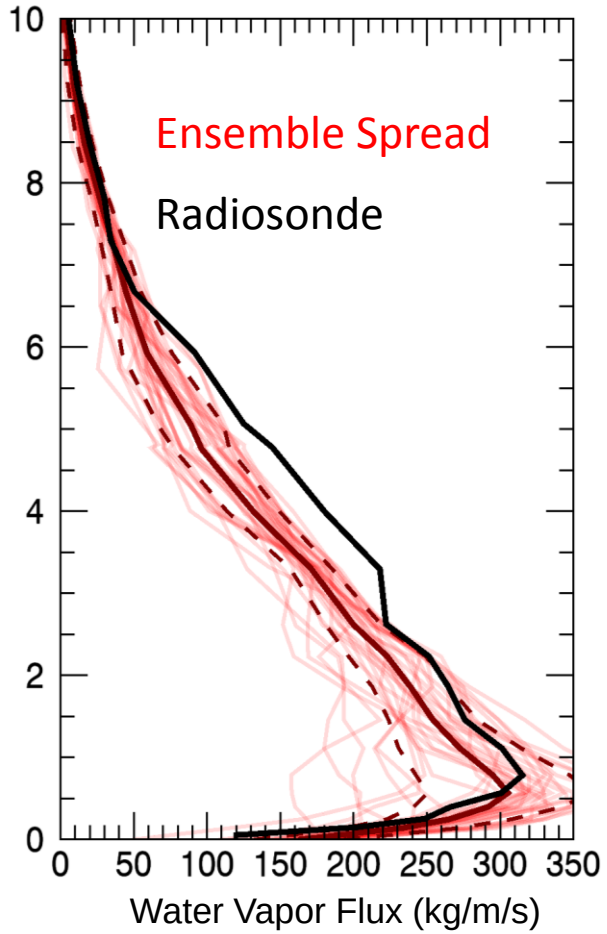




Allowing domain to cover region of AR/ETC Interaction Improves Forecast at 1-3 day Lead Time

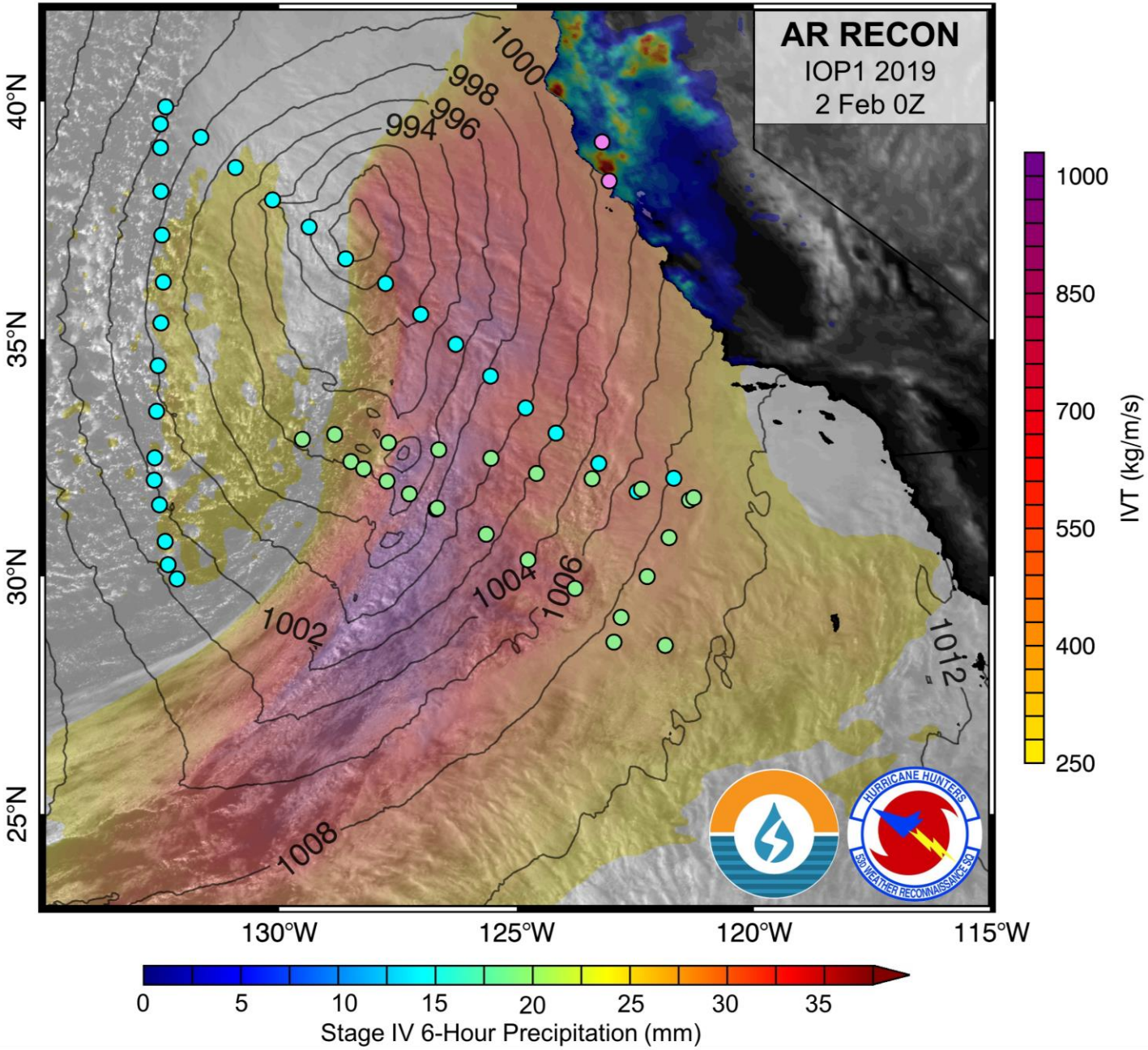
Physical Process Representation

Field Campaigns to Support Model Development



Observation-based evaluation of model representation of physical processes.

Ensemble enables model uncertainty to be evaluated separately.



Predictability of hazard precipitation in an AR Recon case study

Forest Cannon, Nina Oakley, Chad Hecht, Allison Michaelis, Brian Kawzenuk, Reuben Demirdjian, Anna Wilson, and F. Martin Ralph

Poster Today!

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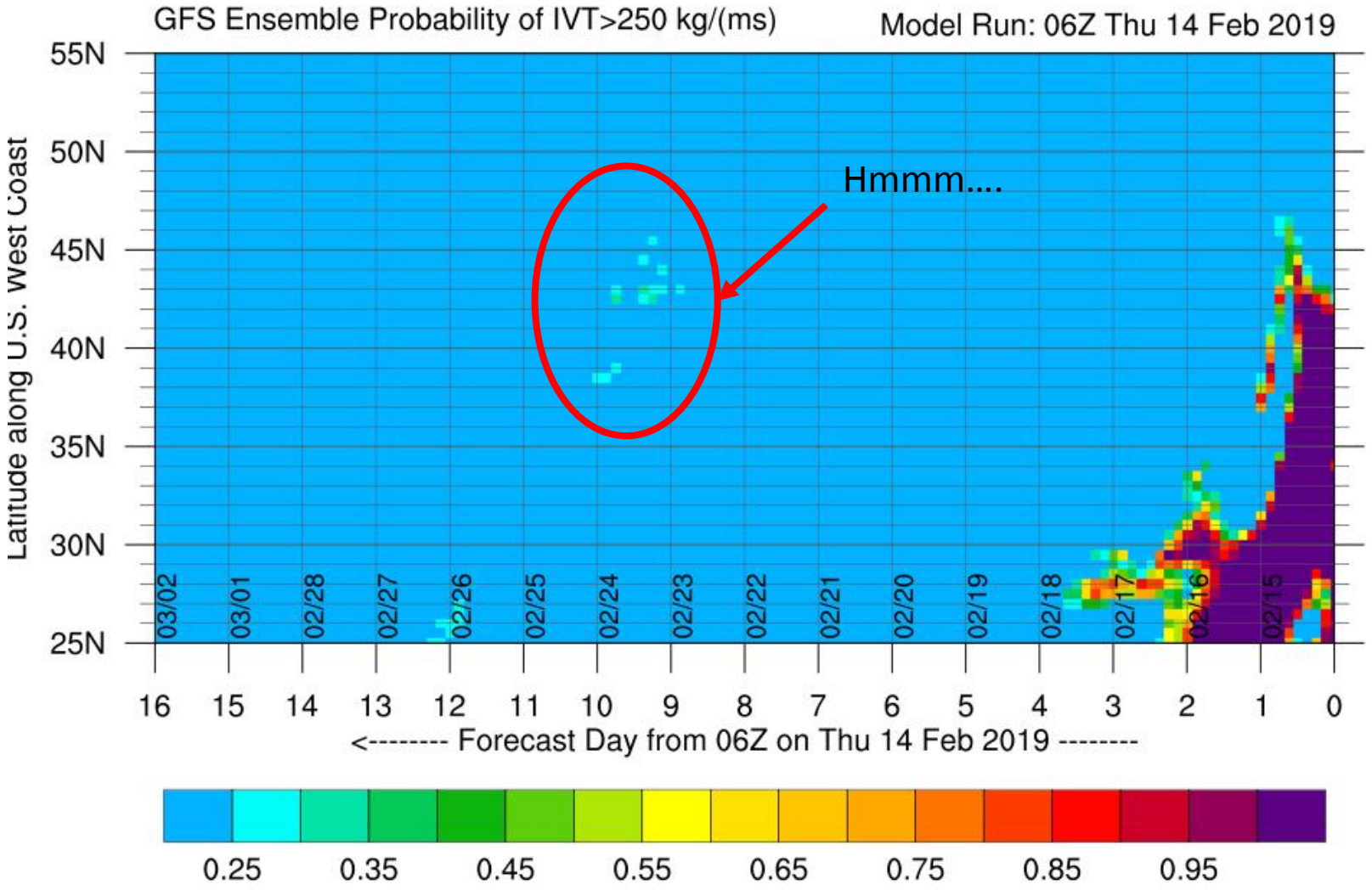
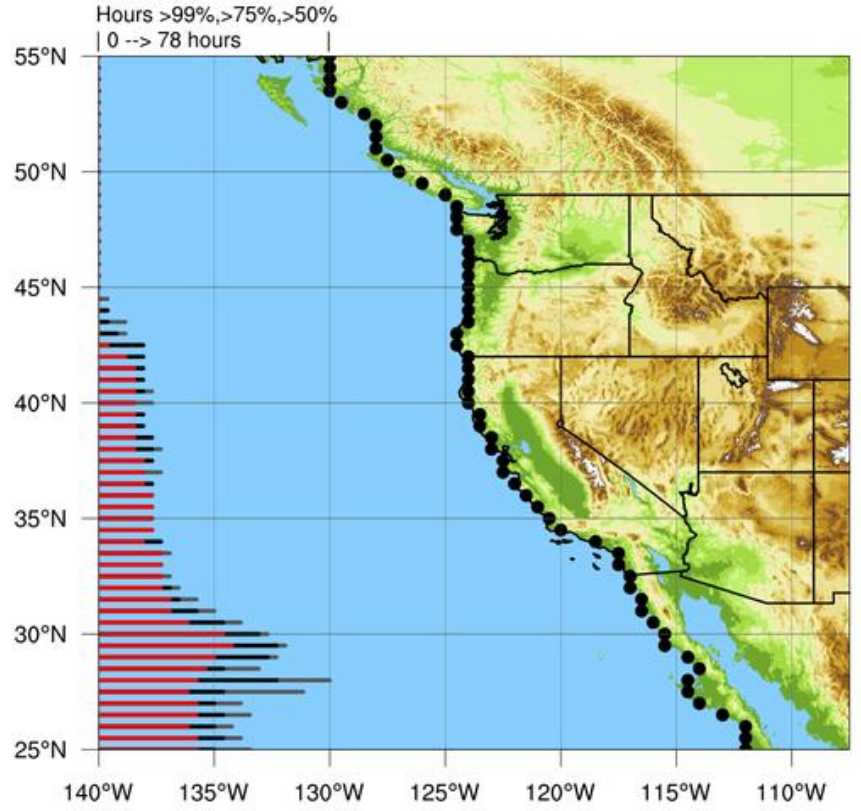
Concluding Remarks

- Precipitation forecast uncertainty tied to AR forecast uncertainty (1-4 day lead)
- AR Forecast uncertainty arises from challenges related to model initial conditions, parameterized physics, and grid-scale resolution
- Diabatic processes are key to AR evolution, but their simulation is affected by all three sources of model error listed above
- Multiple studies utilizing observations (e.g. AR Recon & Radiosondes) to evaluate physical process representation in models
- Multiple studies evaluating forecast impact of diabatic processes
- Ongoing development of CW3E West-WRF and DA studies to address AR forecast challenges

GEFS Long Range Forecast





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PLYMOUTH STATE METEOROLOGY

- GFS Ensemble is currently suggesting little to no probability of IVT >250 over any USWC Coastal location after 06Z 2/17/2019
- Slight signal between days 9 and 10