2026 AR Recon workshop and 2nd Observational campaigns workshop for be
weather forecasts

Evaluation of 2026 AR Recon Observations for t
Analysis and Forecasting of Atmospheric Rivers
Downstream Winter Storms Using MPAS-JEDI

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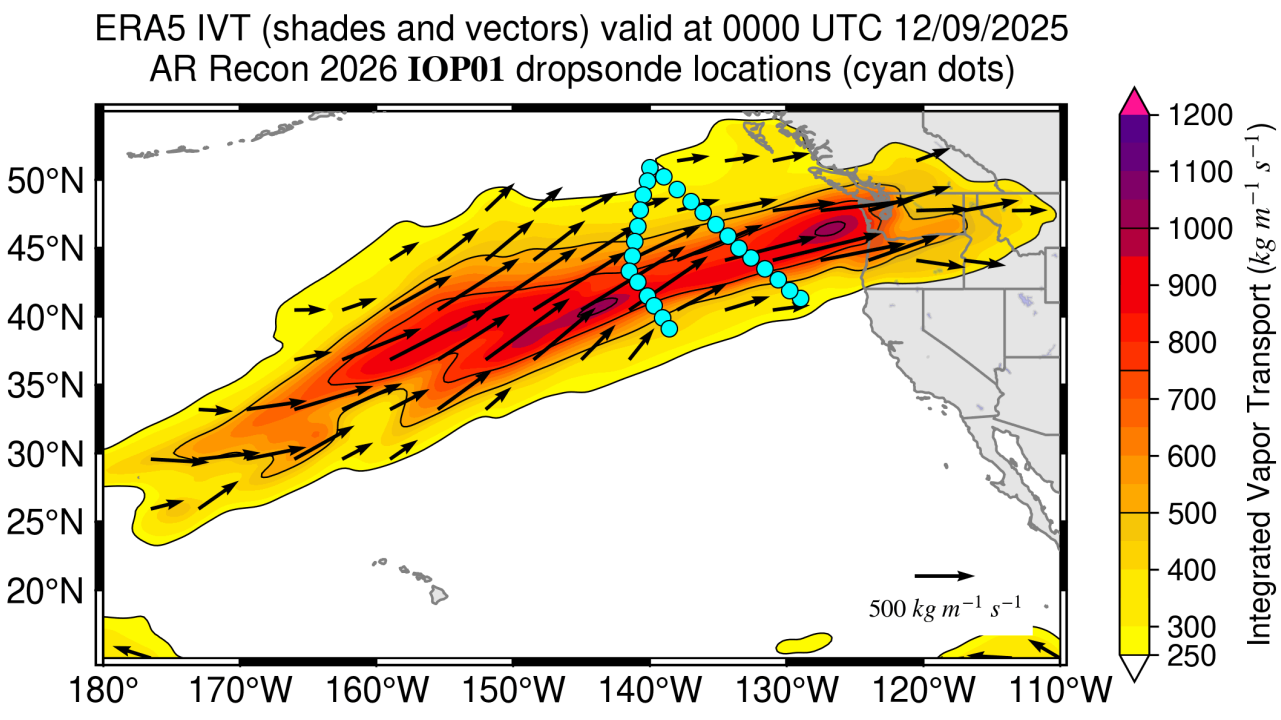
AR Recon: Improving Forecasts of Landfalling Atmospheric Rivers on the US West



2016, 2018–2026

254.5 IOPs, 367 flights

9,050 drops

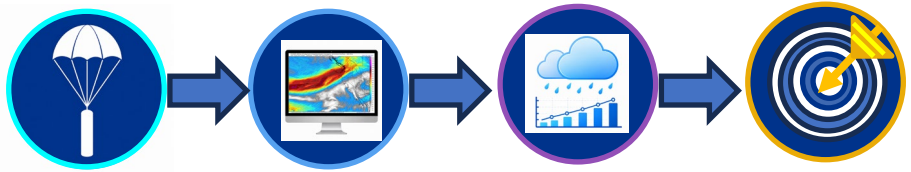
Essential atm. structures

Initial condition sensitivity

Ralph et al. 2020, BAMS
Zheng et al., 2025, BAMS

Research Questions

1. How do AR Recon dropsondes modify AR initial conditions?
2. How do they affect AR and downstream winter storm forecasts?
3. Why do forecasts improve or degrade?

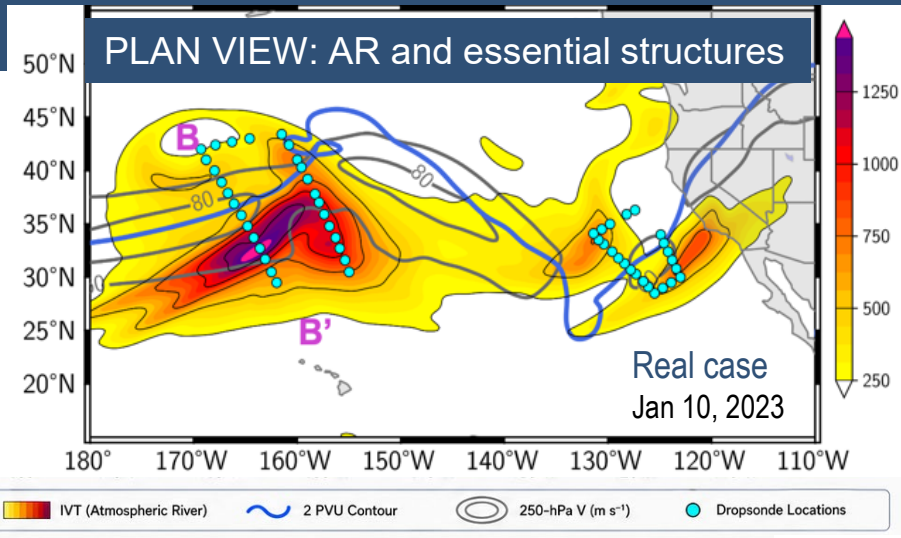


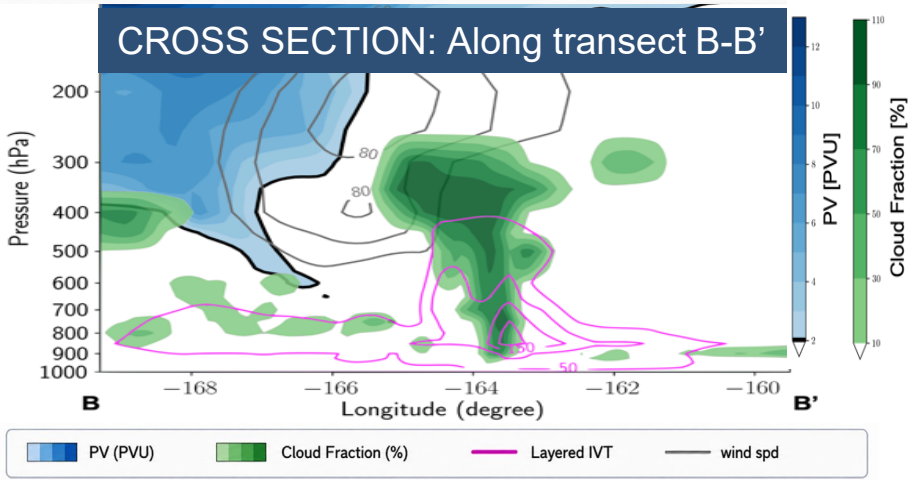
Dropsondes — AR Recon samples ARs & essential atm. structures

Analysis / initial conditions — Modify initial state & create analysis increments

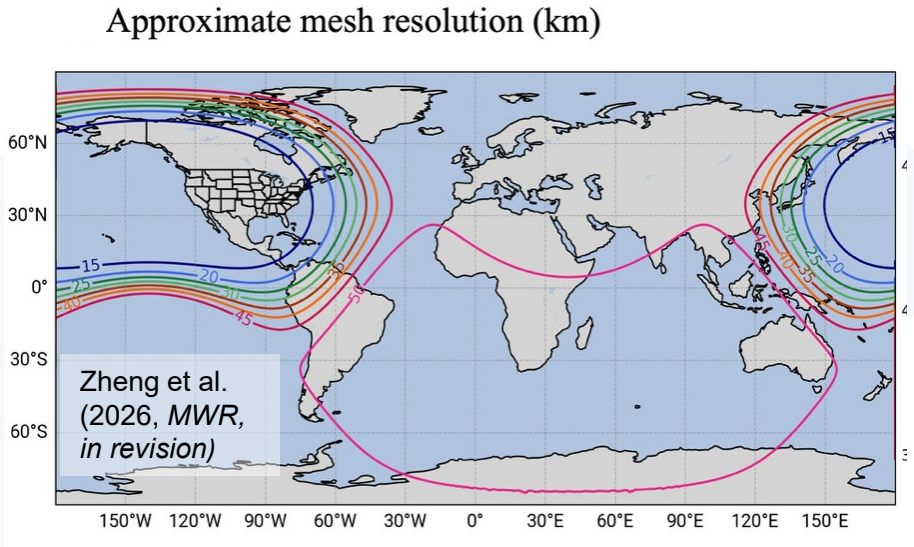
AR Forecasts & QPF — Impacts on AR evolution & heavy precip. forecasts

Understand — Why improvement or degradation occurs





Model and experiment setup



NCAR Model for Prediction Across Scales (MPAS)
Joint Effort for Data Assimilation Integration (JEDI) DA framework

3DEnVar, 60–15-km variable mesh,
55 levels, 30 km model top
Assimilate: conventional data, satellite derived wind and radiance, GPS Radio Occultation
Initial time: 42 IOPs + IOP00 (Dec 4, 2025)

Differences represent impacts from AR Recon data

Figure source: *Ice Age Character Scrat*

2026 North Pacific IOP water vapor transport composite

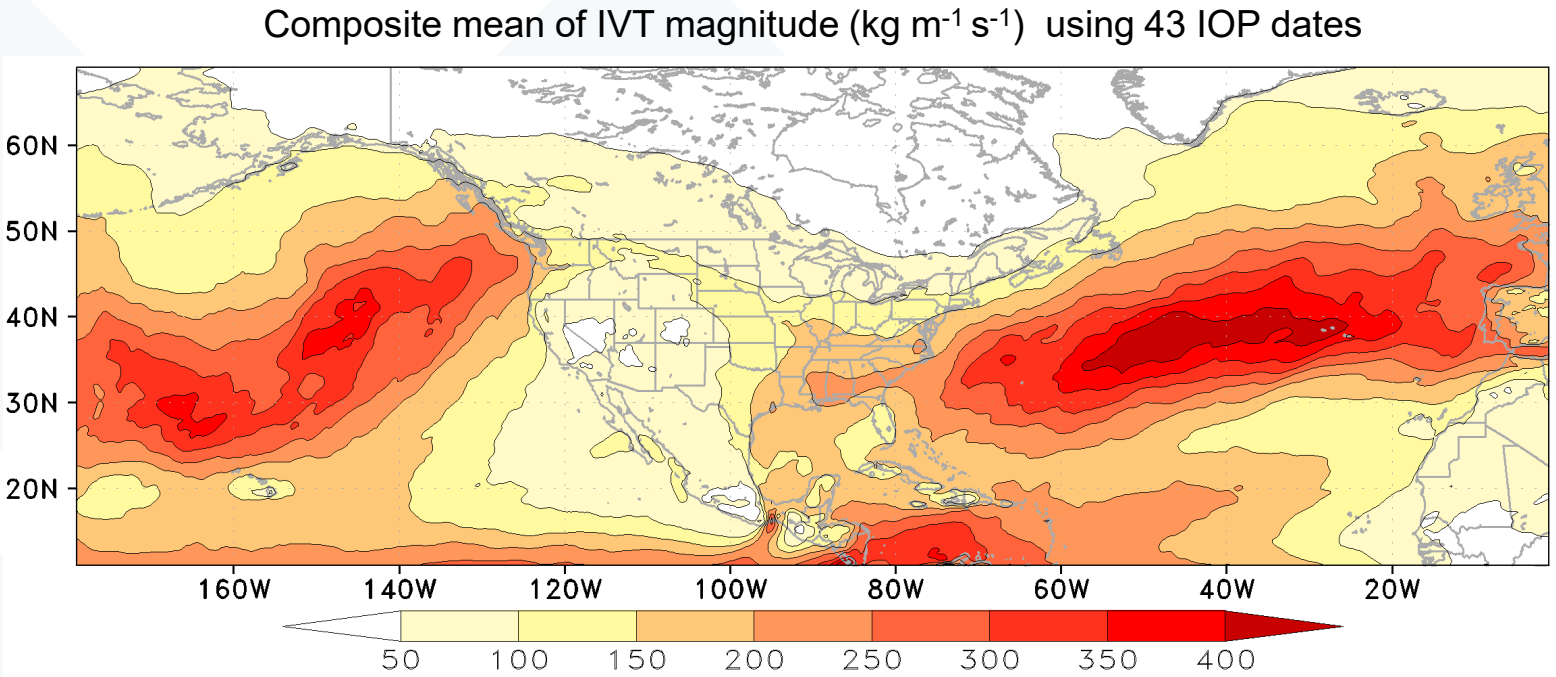


Figure credit: Zhenhai Zhang (UCSD/SIO/CW3E)

2026 North Pacific IOP water vapor transport anomalies

Composite mean anomaly (kg m^{-1} s^{-1}) w.r.t. ERA5 DJFM climatology

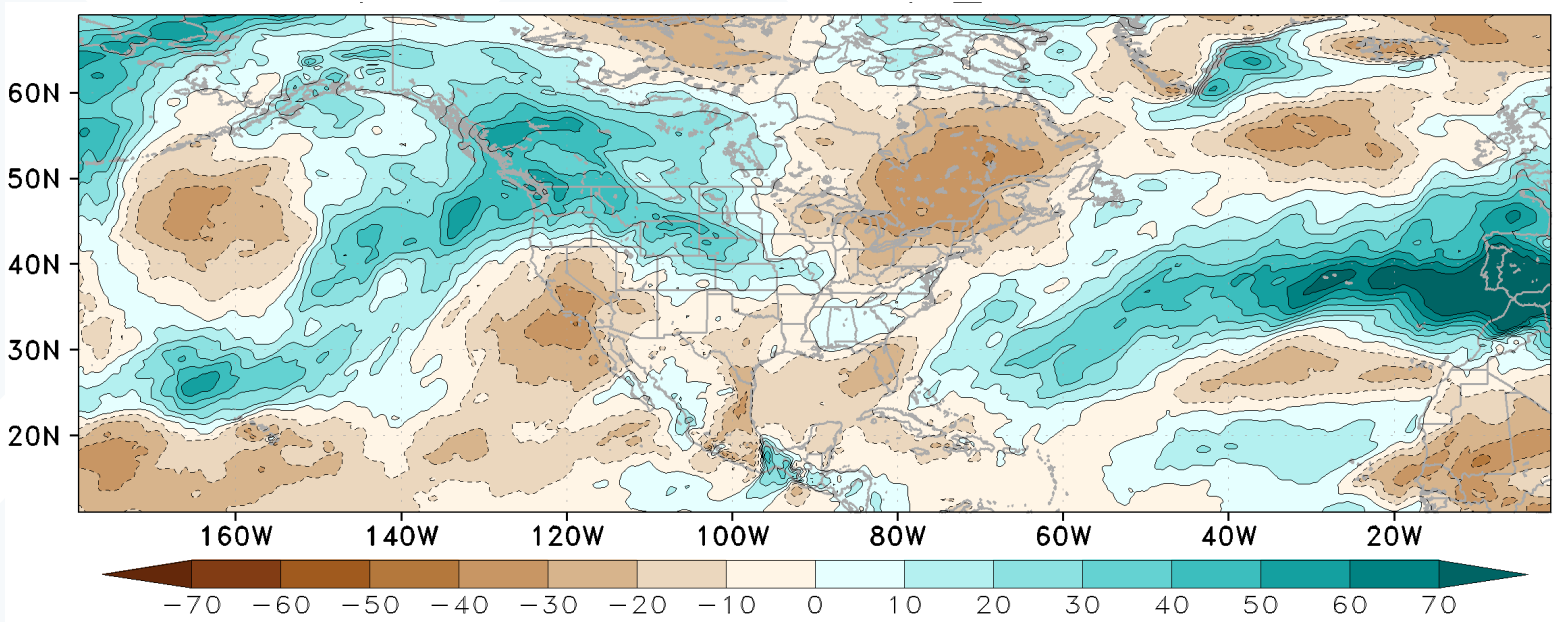
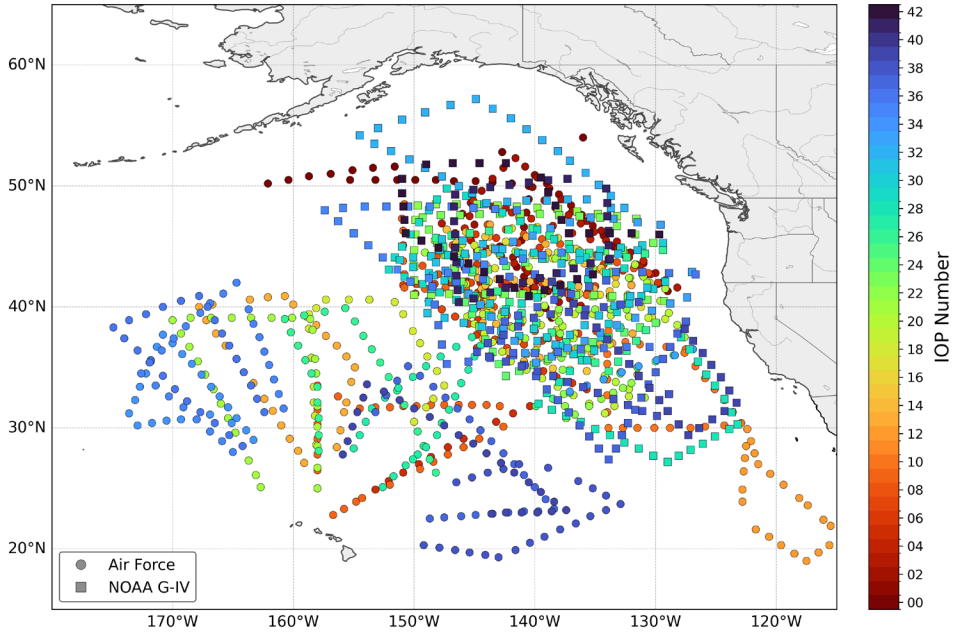
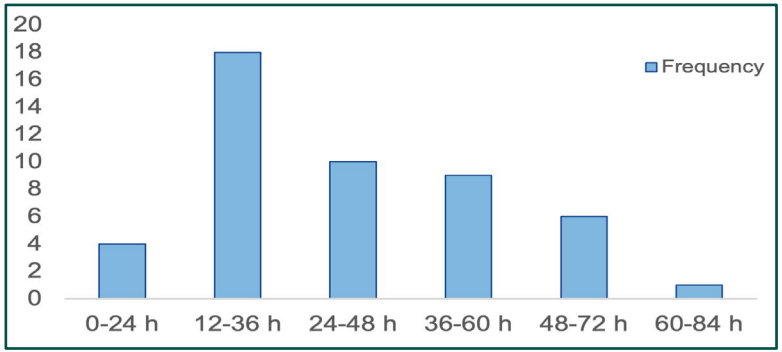


Figure credit: Zhenhai Zhang (UCSD/SIO/CW3E)

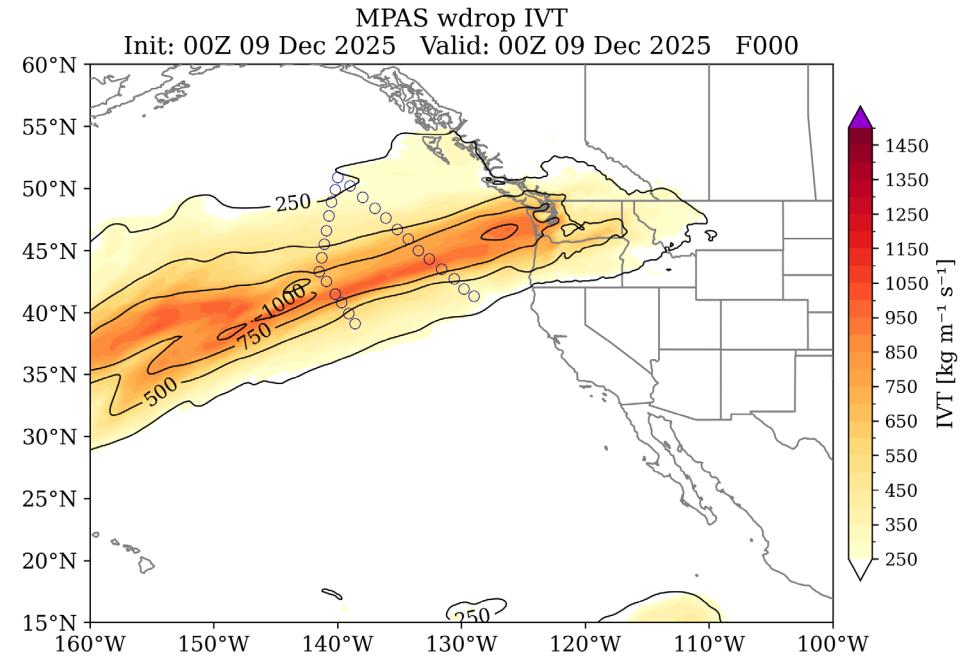
Summary of dropsonde distribution and sensitivity QPF metrics

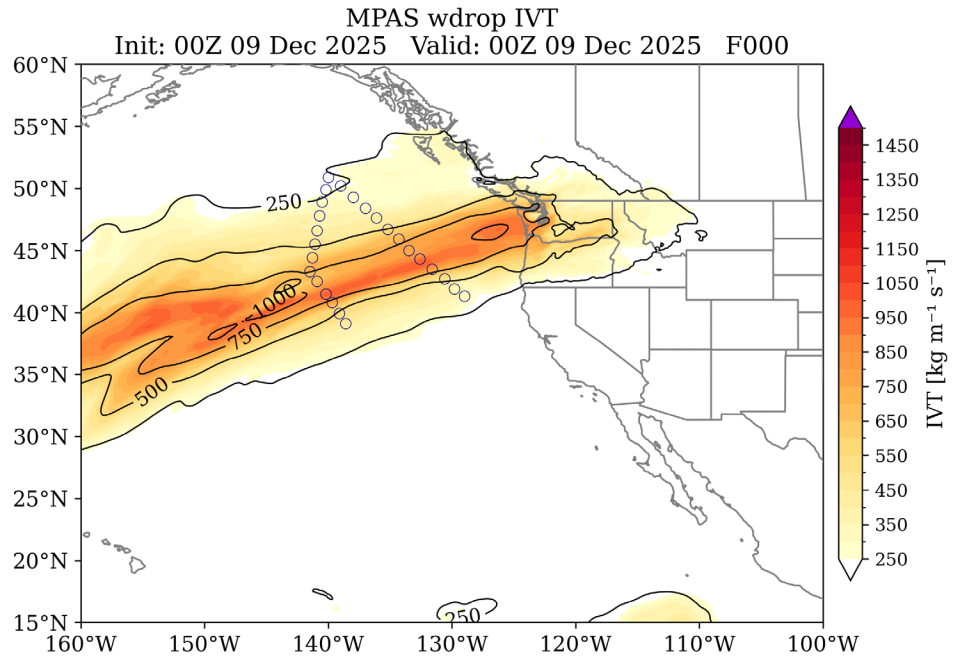




Heatmap figure credit:
Jia Wang (UCSD/SIO/CW3E)

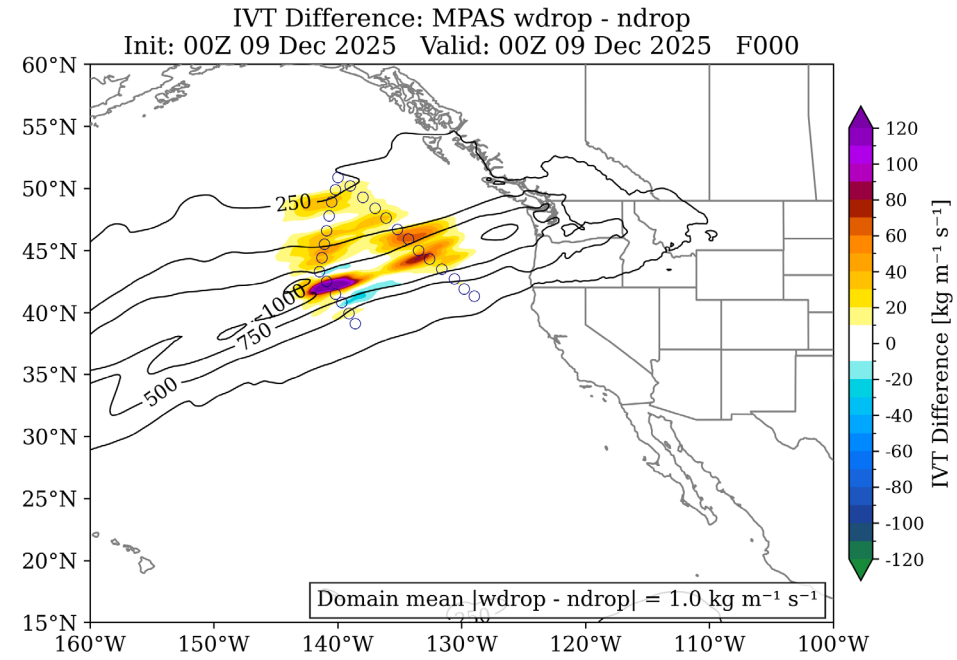
AR Recon IOP01: December 9a PNW AR

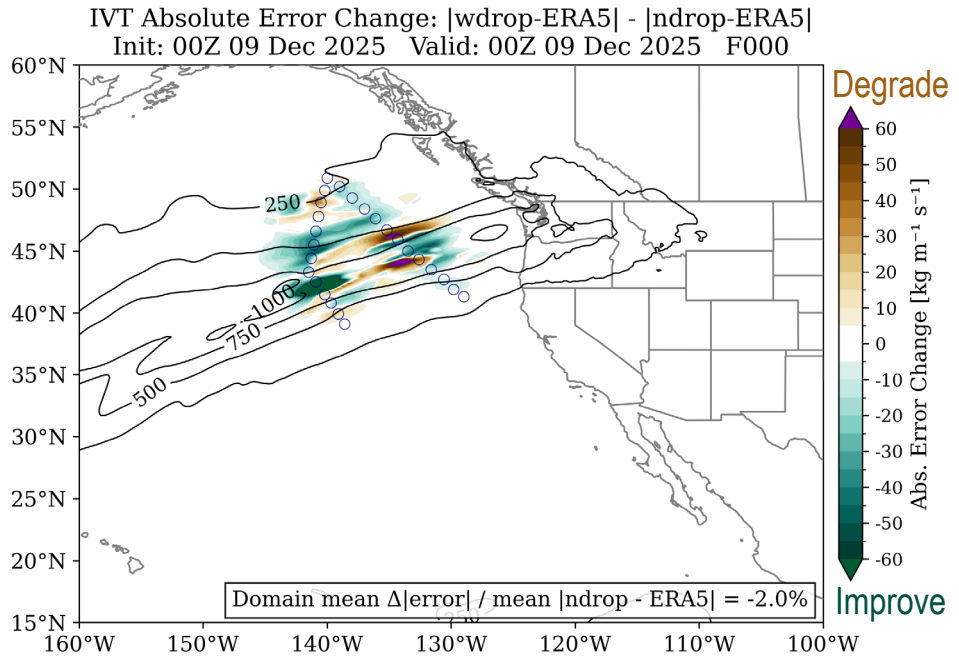




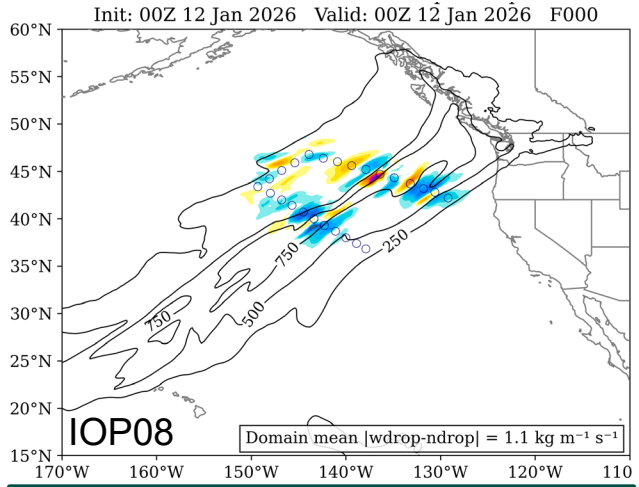
M. Zheng, et al., 2026,
in-prep for JHM

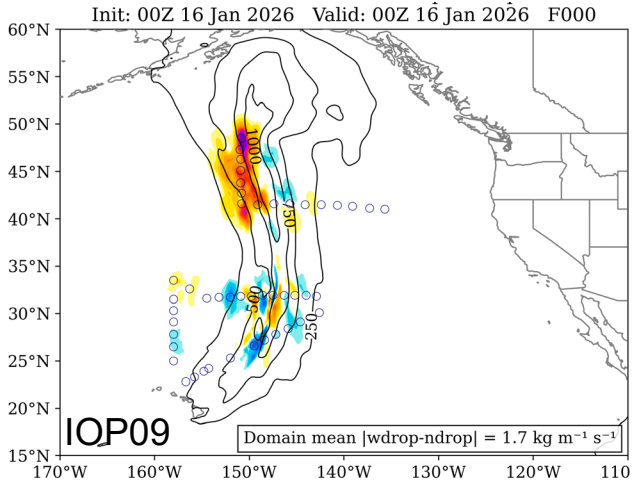
Impacts on IVT at initial time

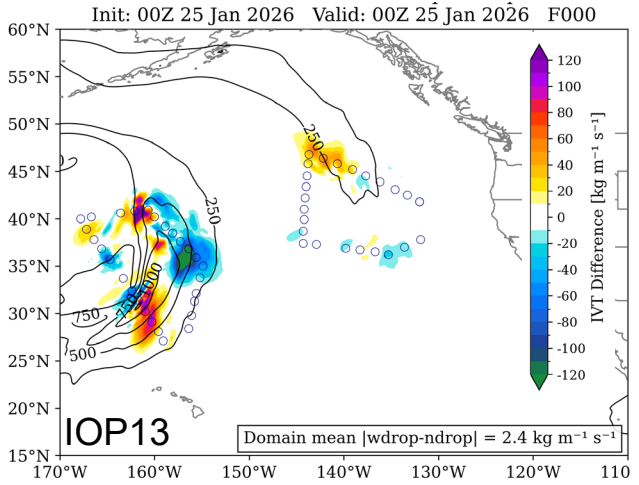


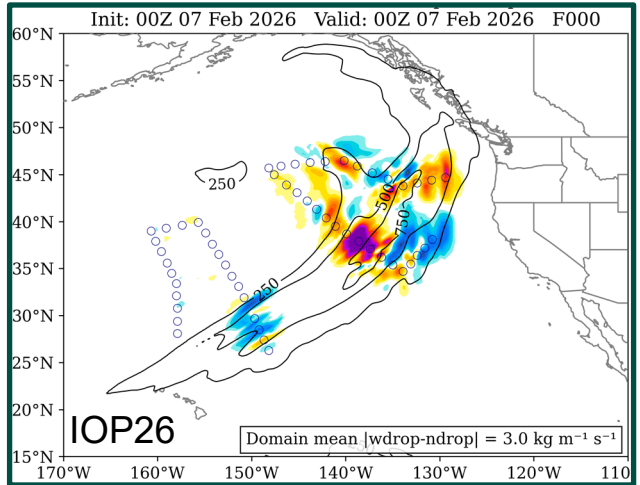


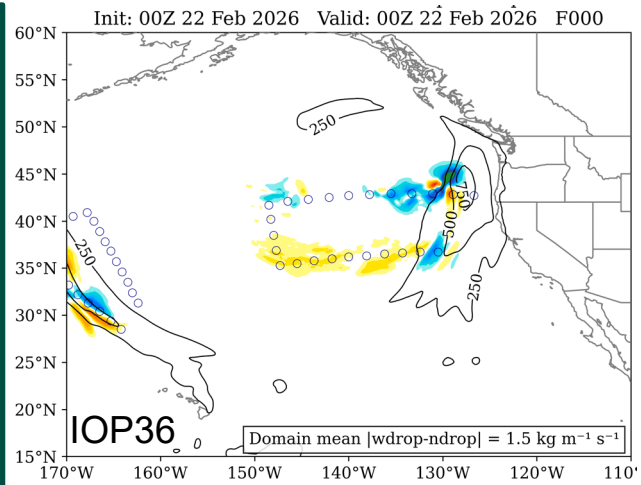
More IOPs–Dropsonde impacts on IVT magnitude at IT

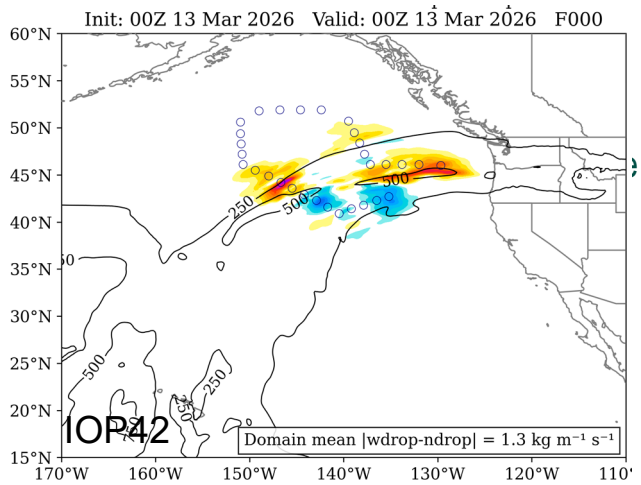




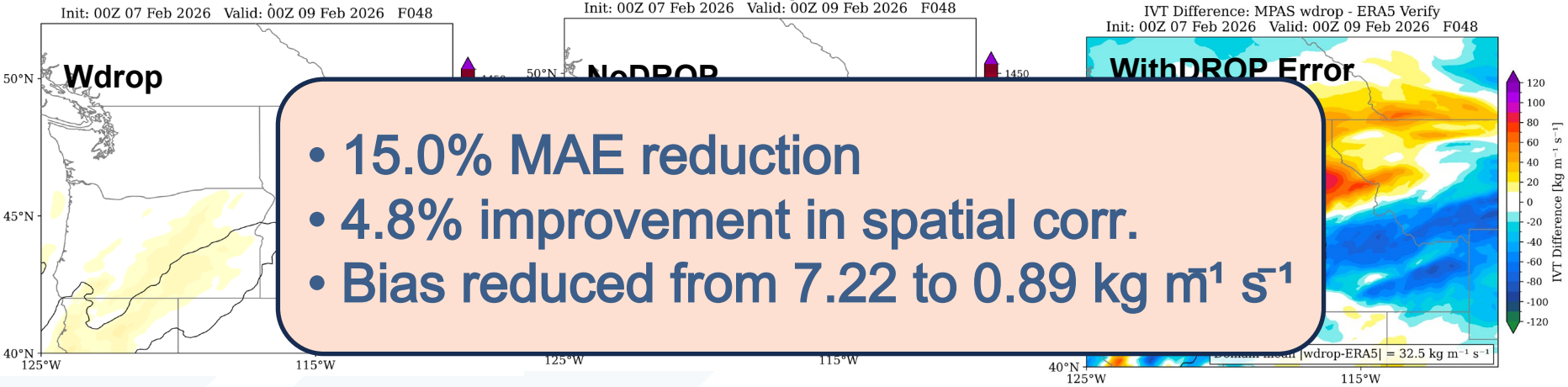




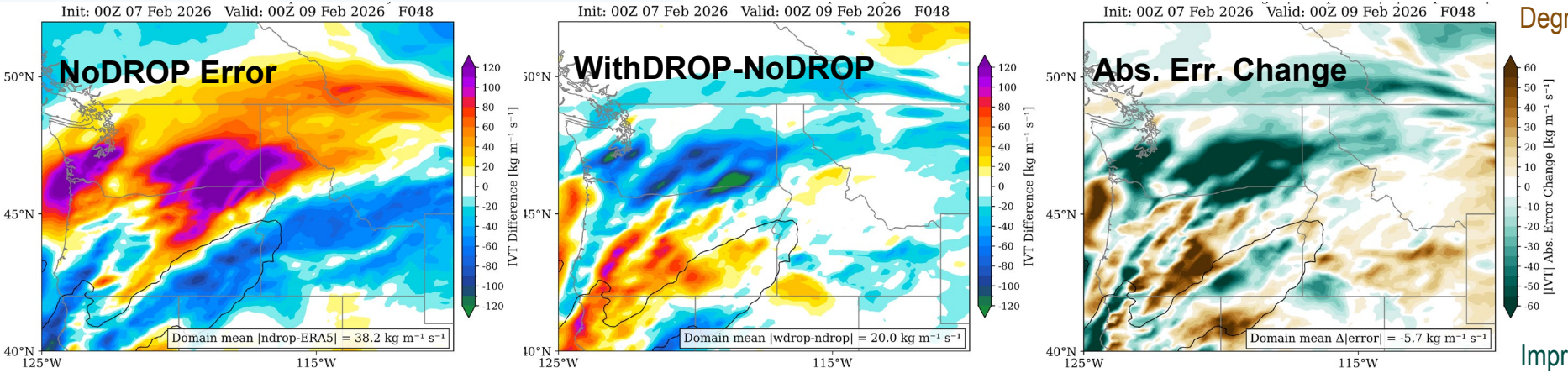




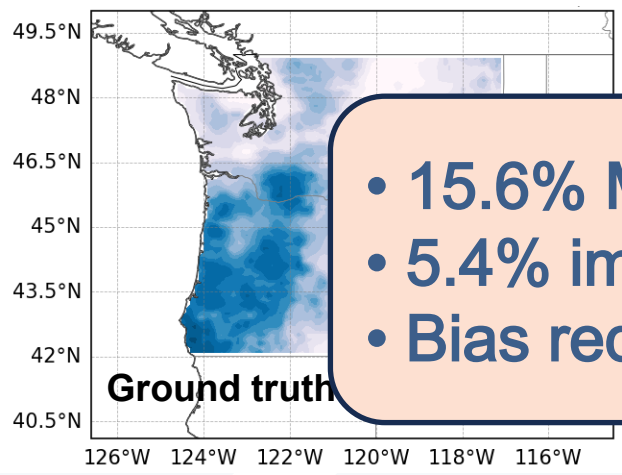
IOP26: Impacts on IVT forecasts, initial time 00Z 7 Feb 26, f048

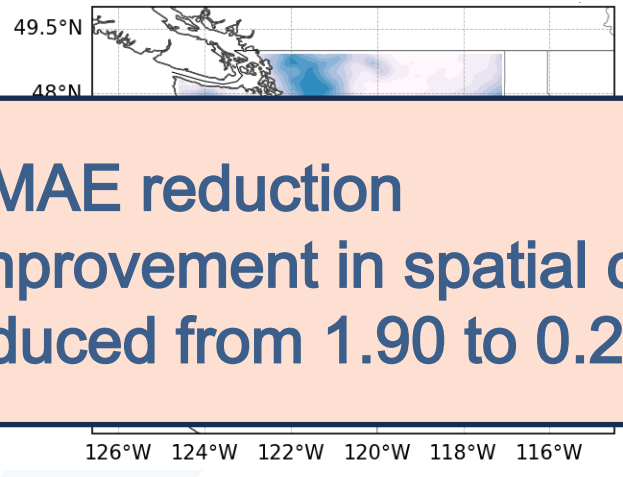


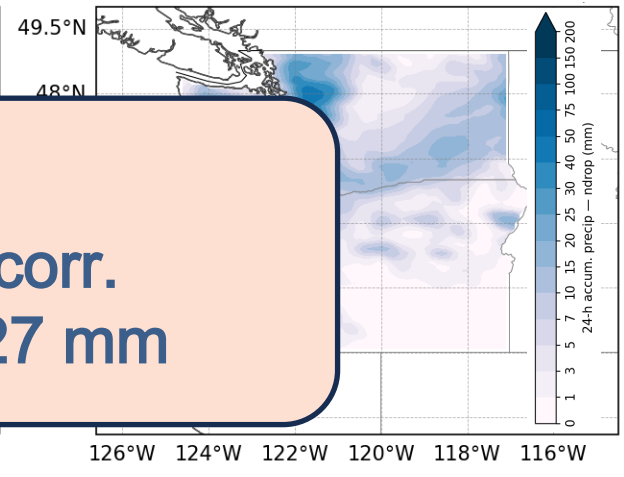
- 15.0% MAE reduction
- 4.8% improvement in spatial corr.
- Bias reduced from 7.22 to 0.89 kg m^{-1} s^{-1}



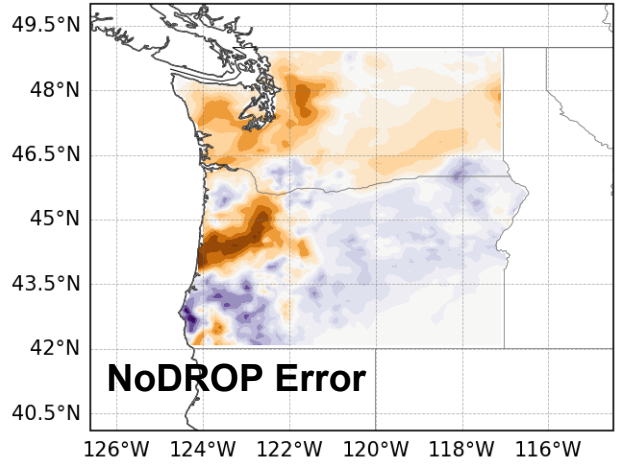
Impacts on QPF–initial time 00Z 7 Feb 26, targeted: f024-048

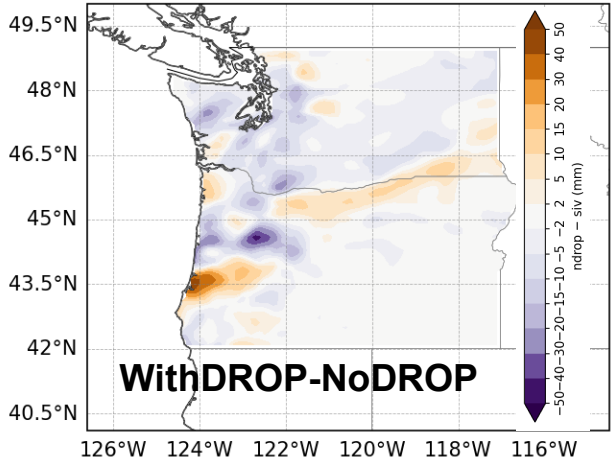


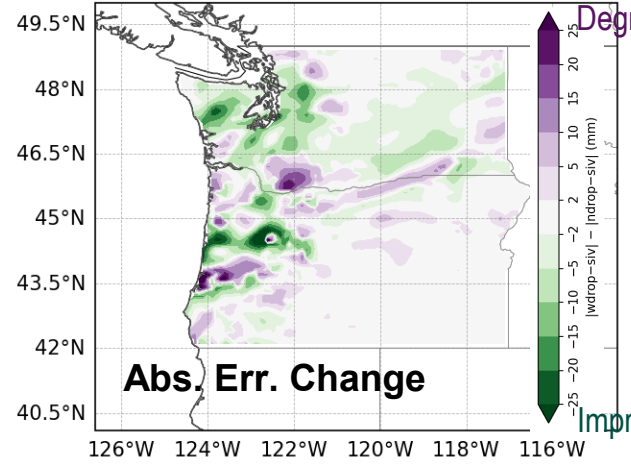




- 15.6% MAE reduction
- 5.4% improvement in spatial corr.
- Bias reduced from 1.90 to 0.27 mm





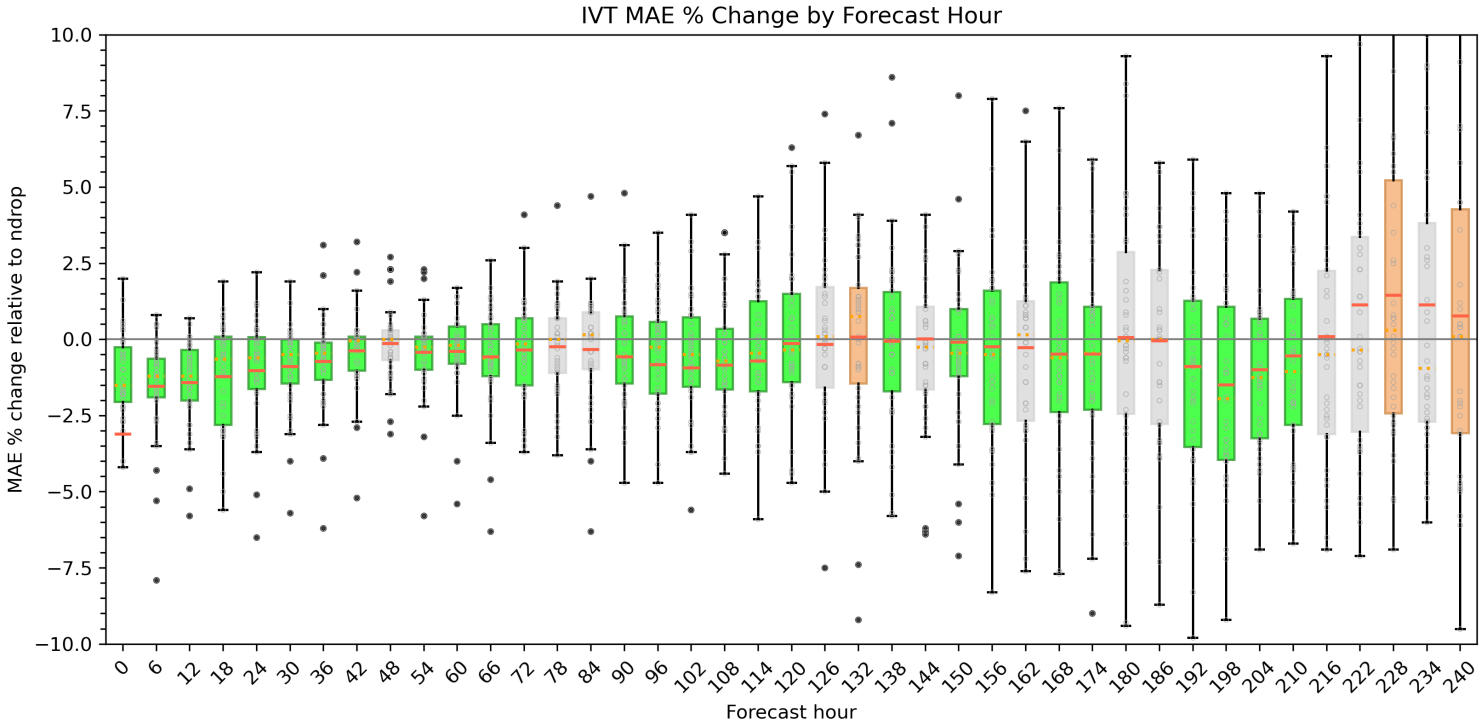


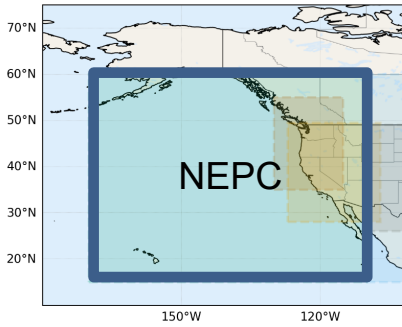
Degrade

Improve

Summary on IVT forecasts– % skill change using MAE

Verification region: NEPC Northeast Pacific

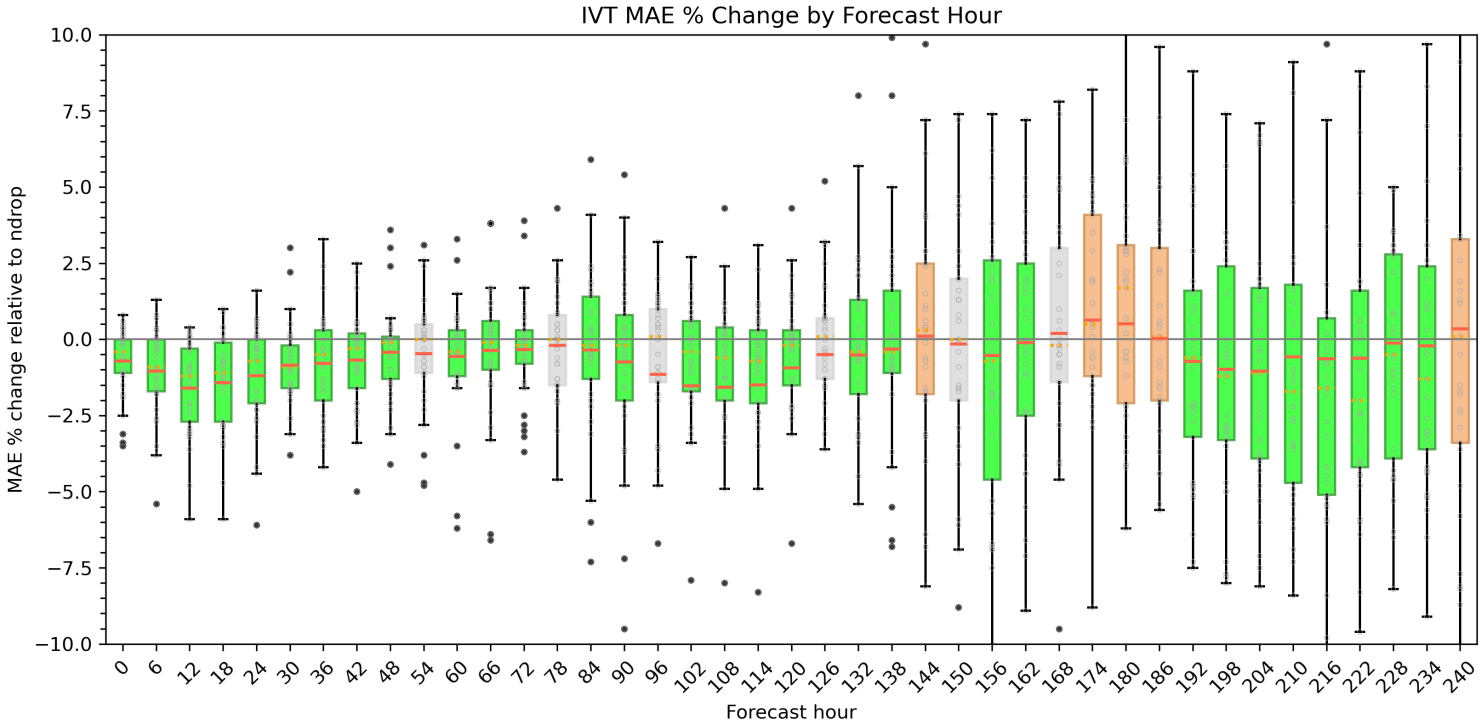


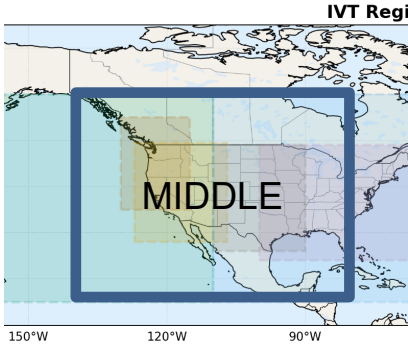


Preliminary
Not published

Summary on IVT forecasts– % skill change using MAE

Verification region: MIDDLE

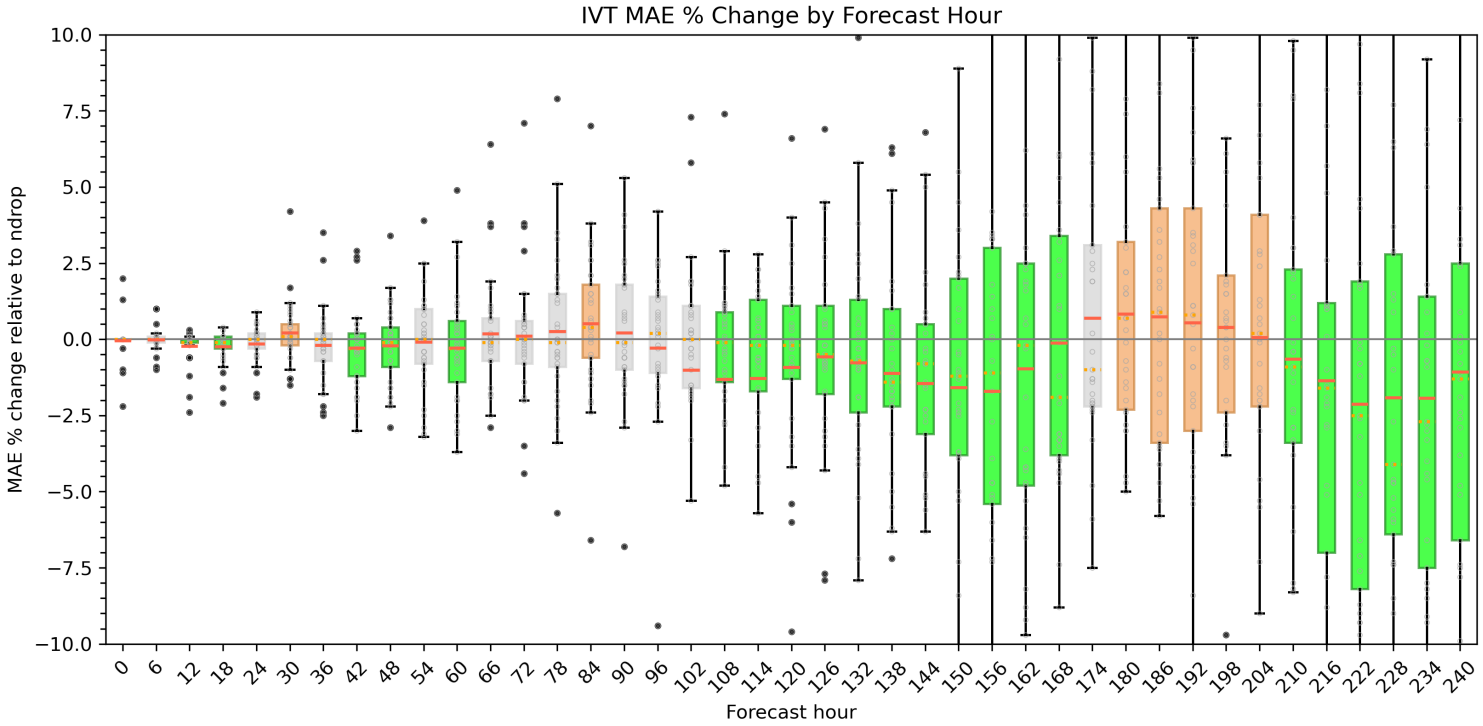


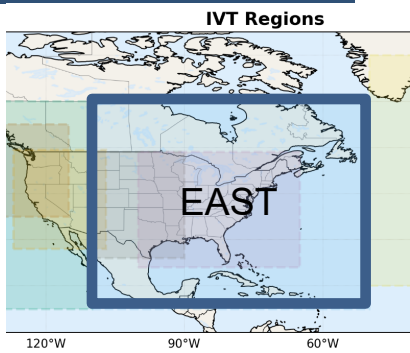


Preliminary
Not published

Summary on IVT forecasts– % skill change using MAE

Verification region: EAST

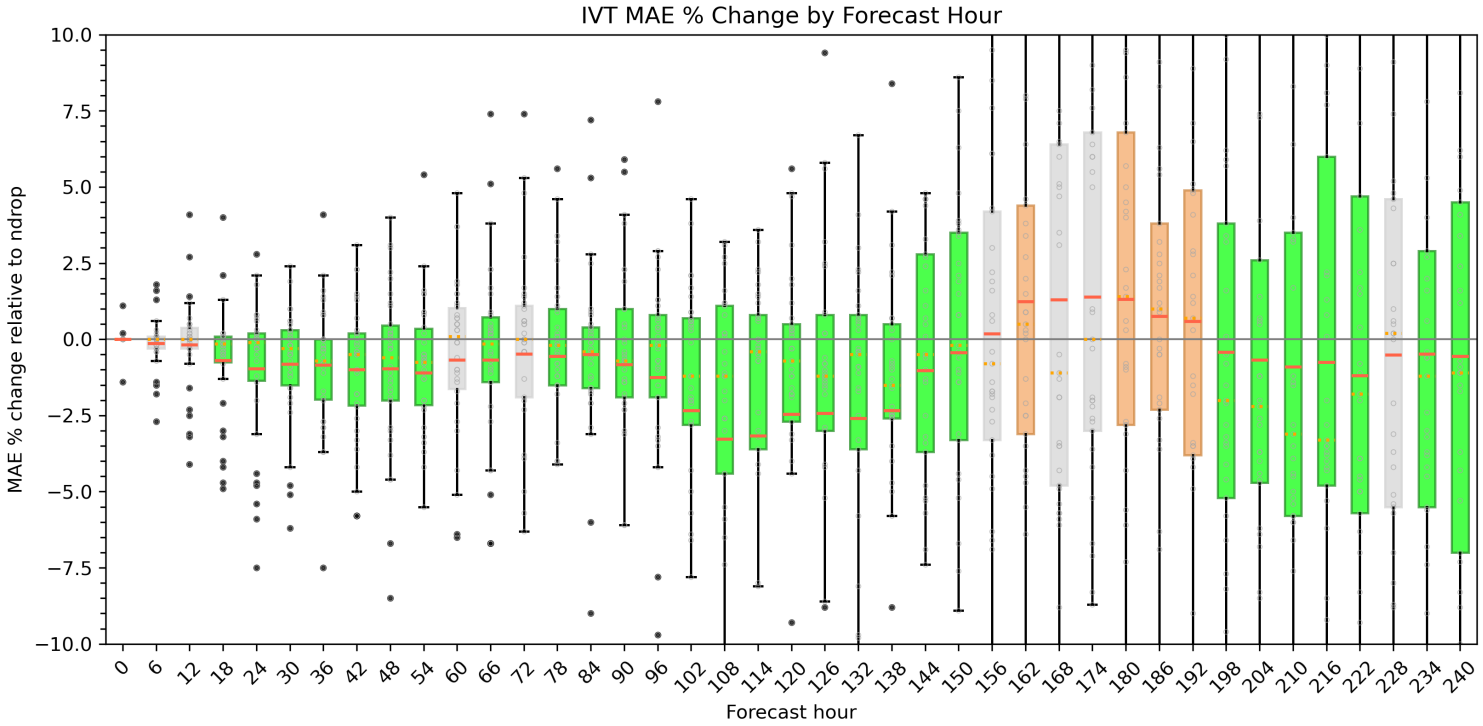


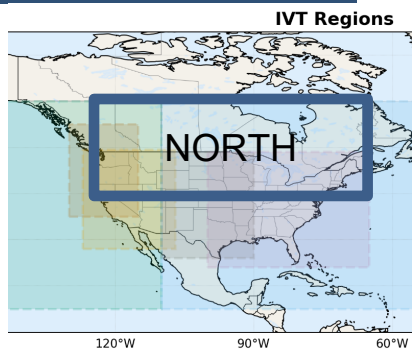


Preliminary
Not published

Summary on IVT forecasts– % skill change using MAE

Verification region: NORTH





Preliminary
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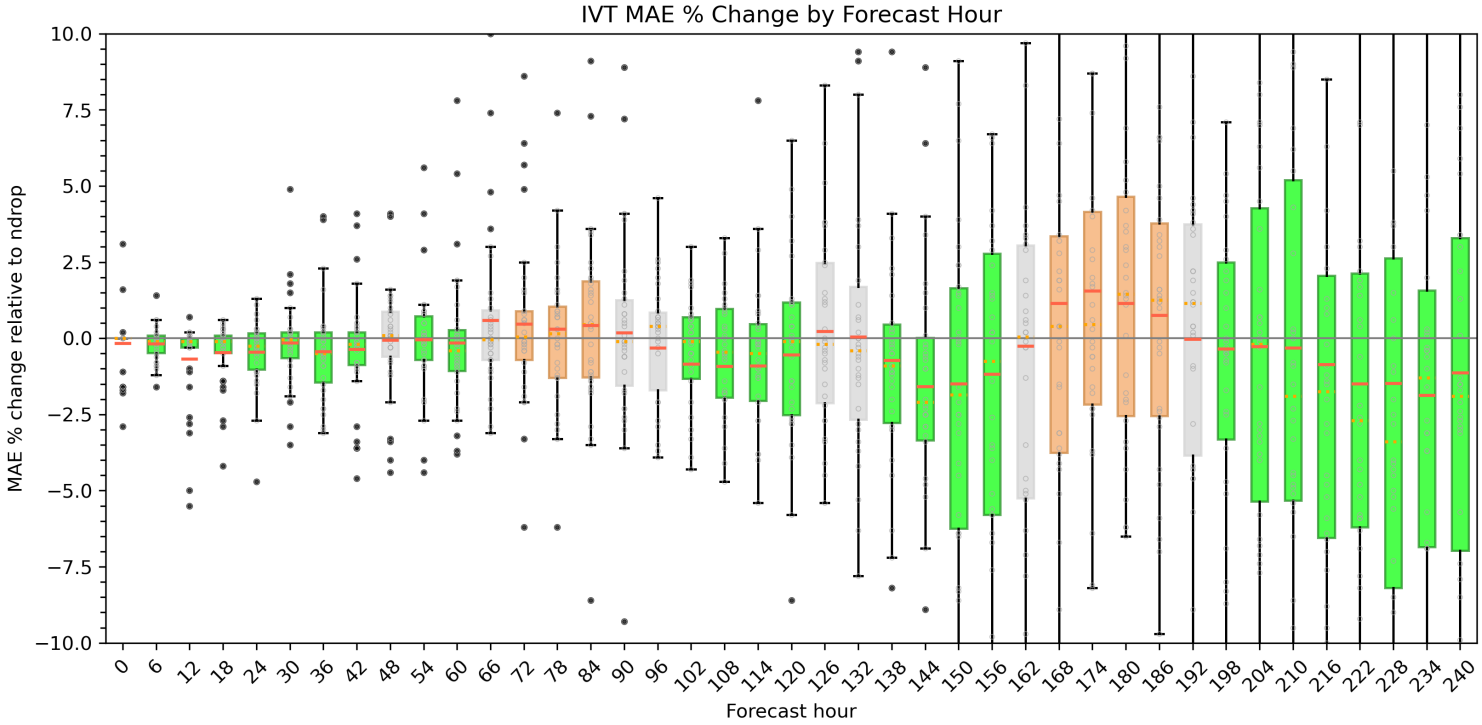
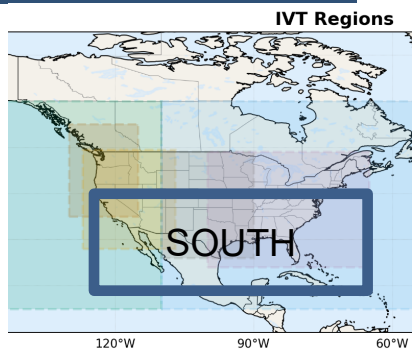
Summary on IVT forecasts–% skill change using MAE

Verification region: SOUTH

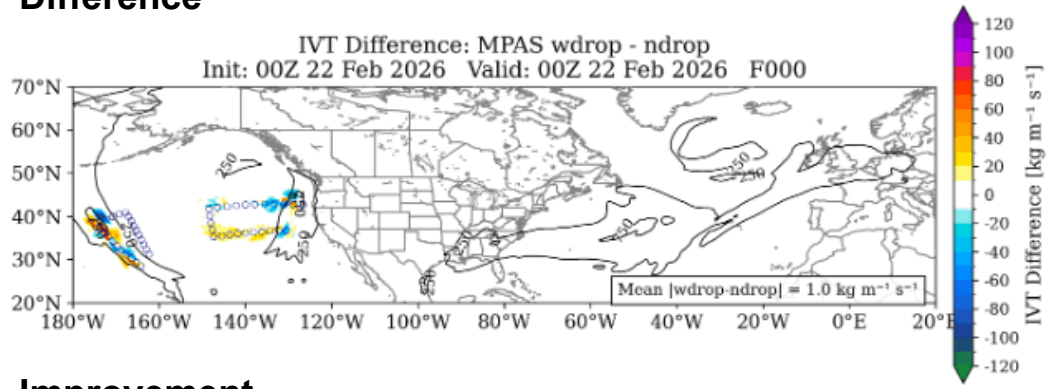




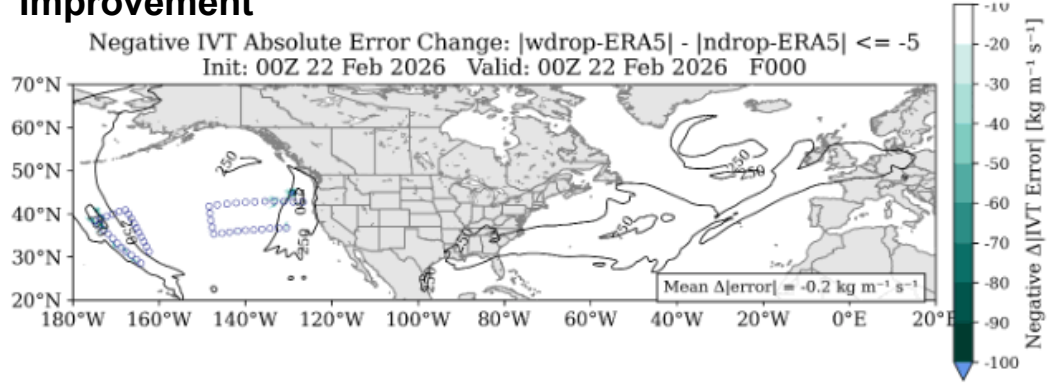
Preliminary
Not published

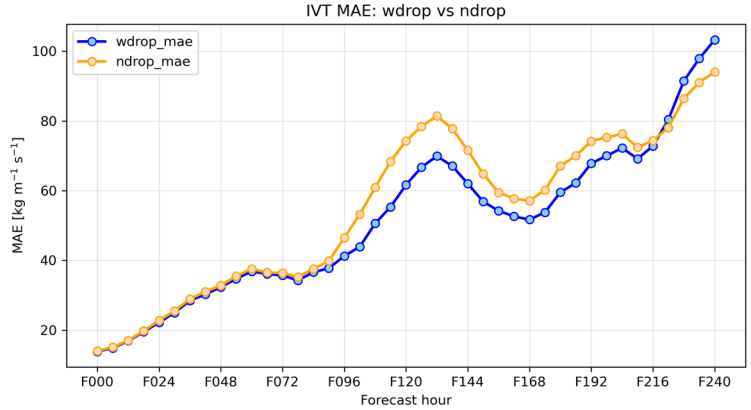
Are the downstream impacts physical? Case 2: IOP36–Feb 22

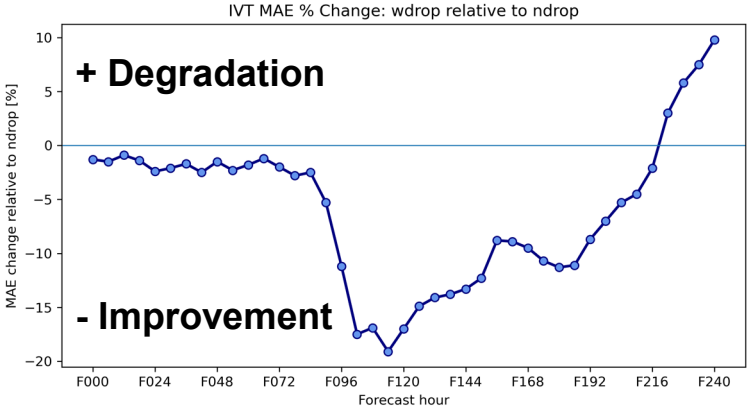
Difference



Improvement



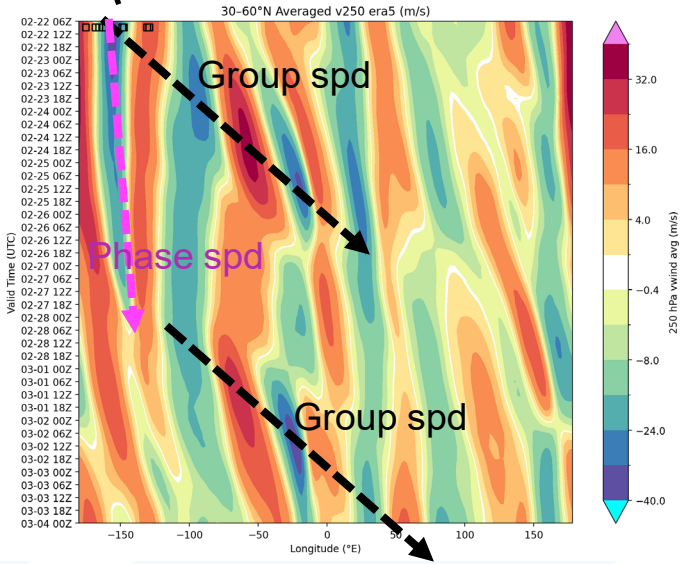




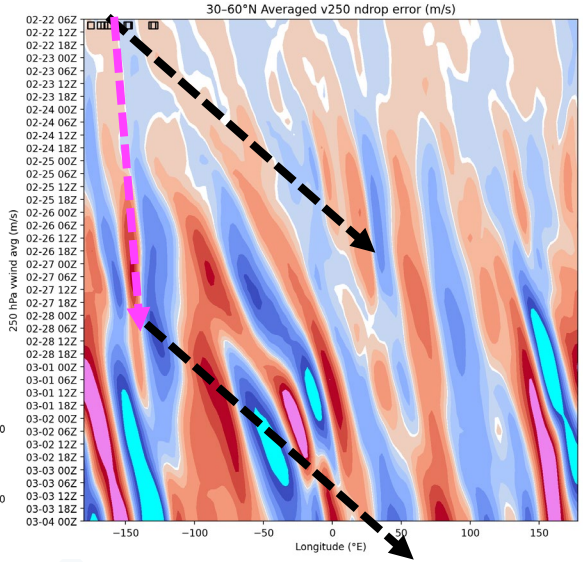
Case 2: Hovmöller diagram F000–F240

OBS Lon

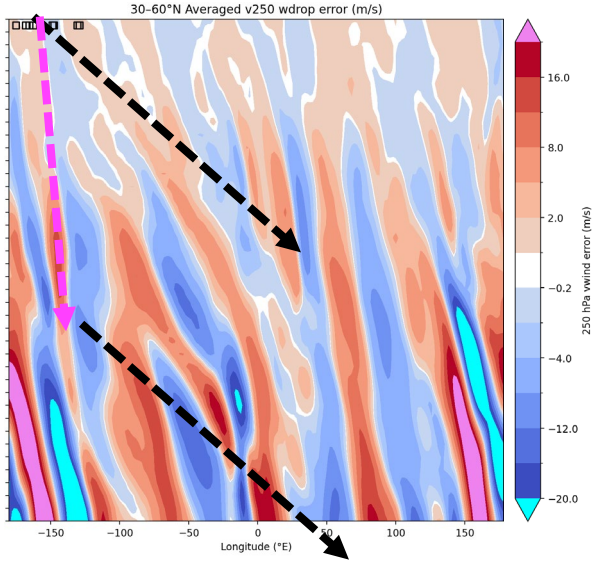
ERA-5



NoDROP Error



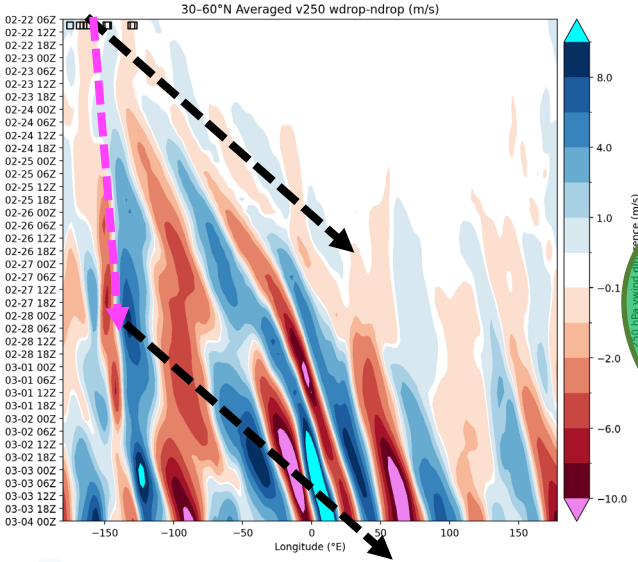
WithDROP Error



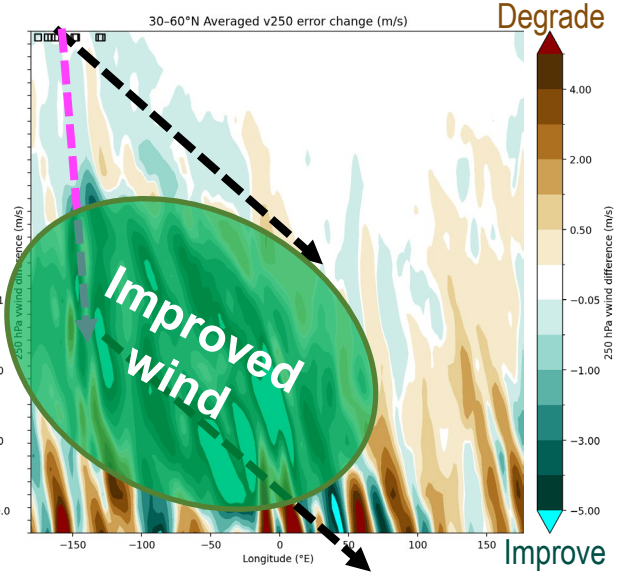
Case 2: Hovmöller diagram F000–F240

Correcting small initial errors can reduce both phase-speed and group-speed errors, with the latter potentially amplifying downstream development errors.

WithDROP-NoDROP



MAE Change



Preliminary
Not published

Ongoing and future work

1. AR Recon 2026 all-IOP exp. summary (drops, drifters, *WindBorne*)
2. MPAS-JEDI sensitivity experiments (optimal use of dropsonde data)
3. Ensemble observational impacts (promising preliminary results!)

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

THANK YOU

Questions can be directed to: Minghua Zheng (email: mzheng@ucsd.edu)

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Funding: *the USACE FIRO grant, the CDWR AR Program, the ONR AR Recon and MEASURE grants, the NASA GOES grant, and the NOAA CIMEAS AR RECON grant.*

HPC: *Thanks to the MMM/Scripps collaboration NMMM0053 (Project lead: Chris A. Davis; Project Administrator: Robyn Elizabeth Tye; MMM director: Gretchen Mullendore) and NSF NCAR's Derecho for supporting the model simulations and analyses;*

Extras

Open question: when perturbations reach coastal regions

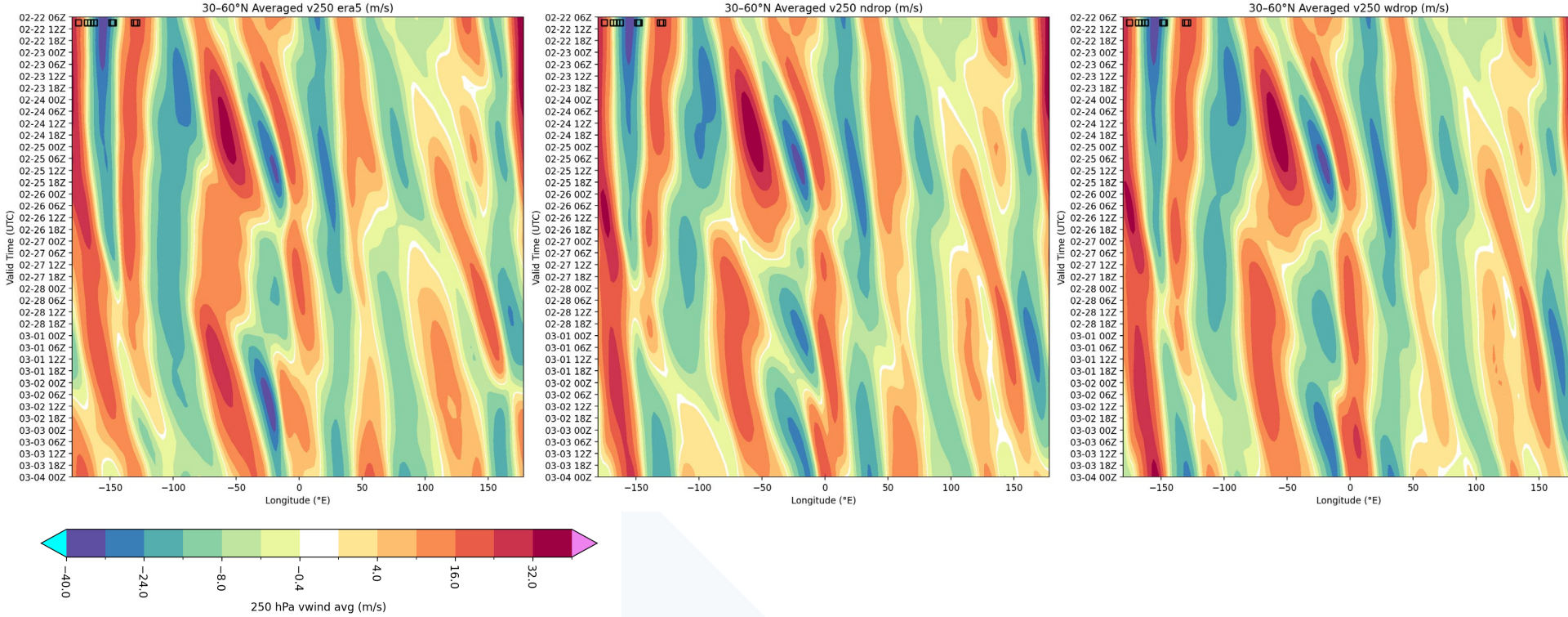
Real challenge: discontinuity

Ocean – Land contrast

Mean sea level – High terrains (e.g., >2 km over Olympics Mts)

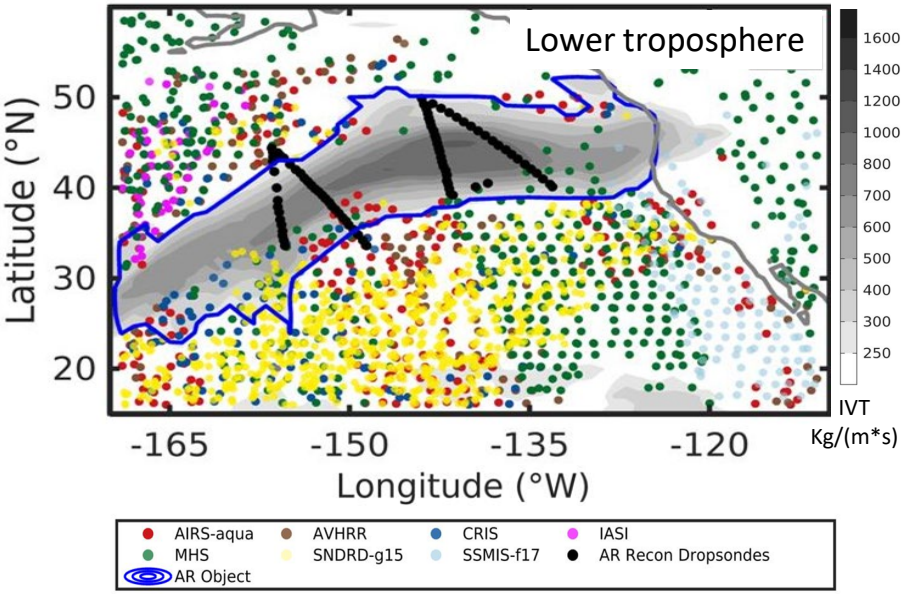
Will the ”correct perturbations” still be correct over land? Over mountains?

Case 2: Hovmöller diagram F000–F240

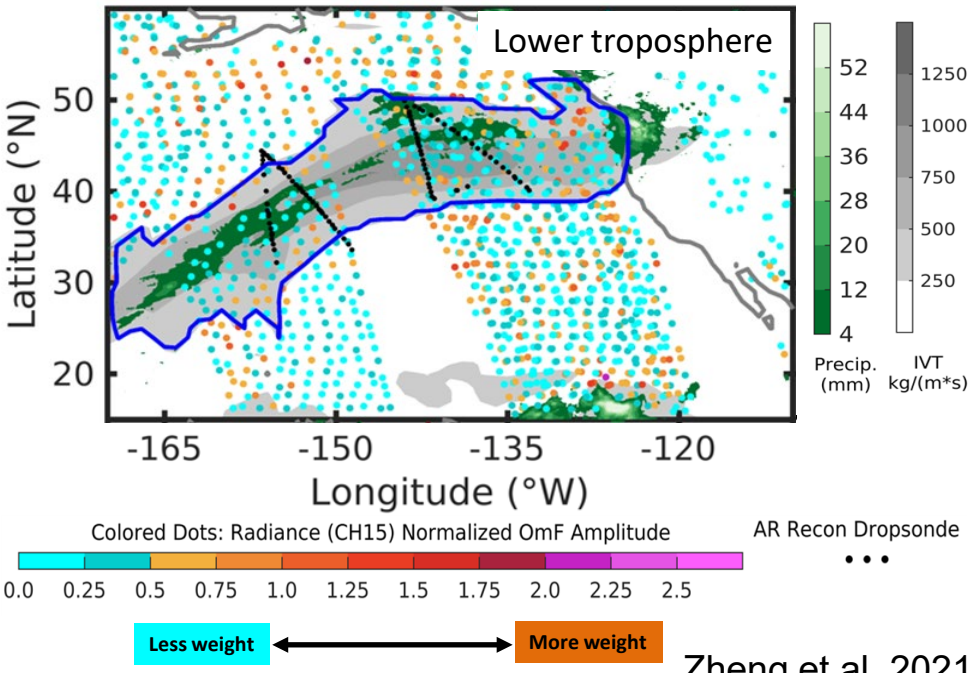


Highlighted finding 1: Data gaps within & near ARs

Clear-sky radiance



All-sky radiance (AMSUA Ch15)



Zheng et al. 2021 BAMS

Impact on initial conditions: WithDROP – NoDROP (changes due to drops)

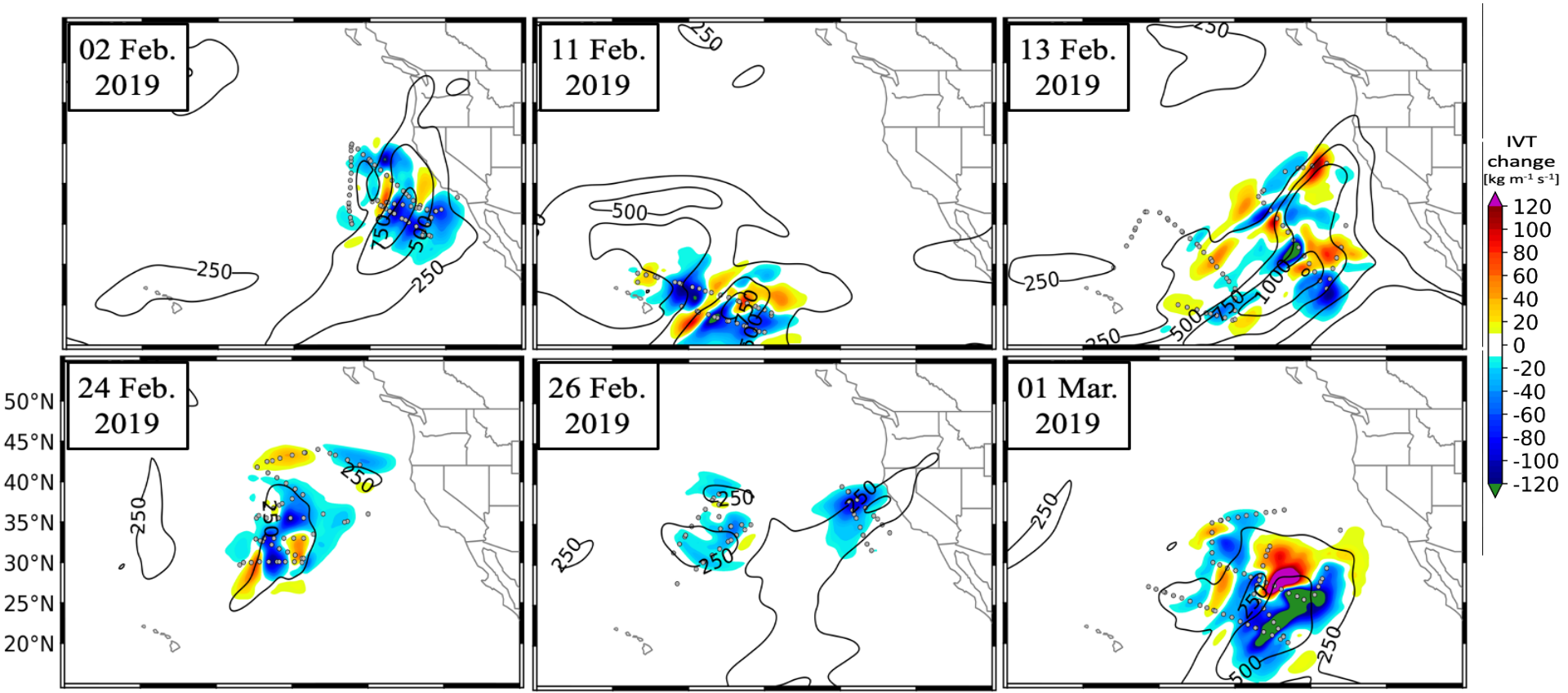
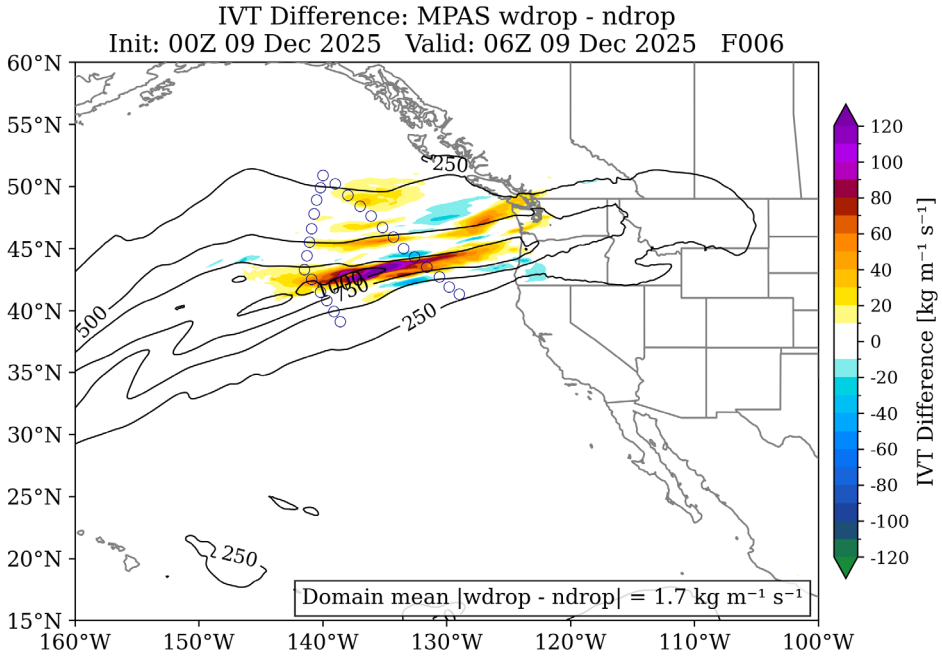
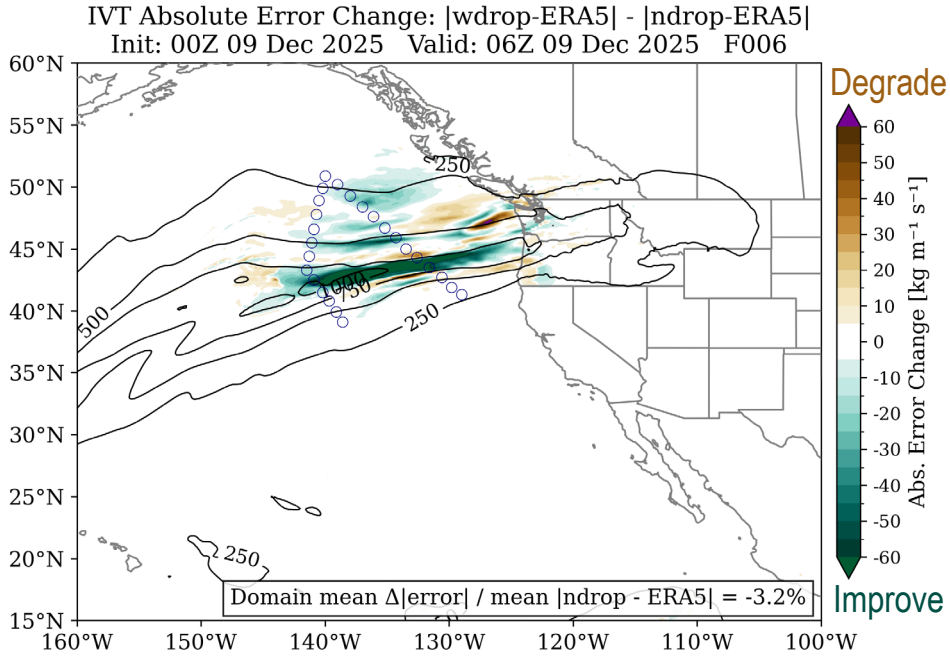


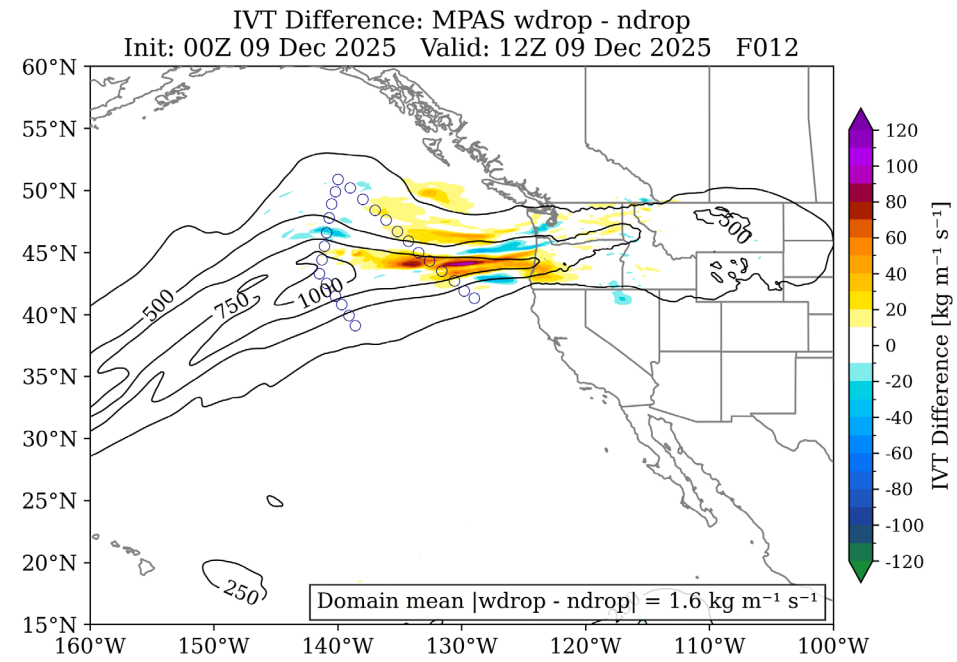
Figure source: *Zheng et al. 2021 JGRA*

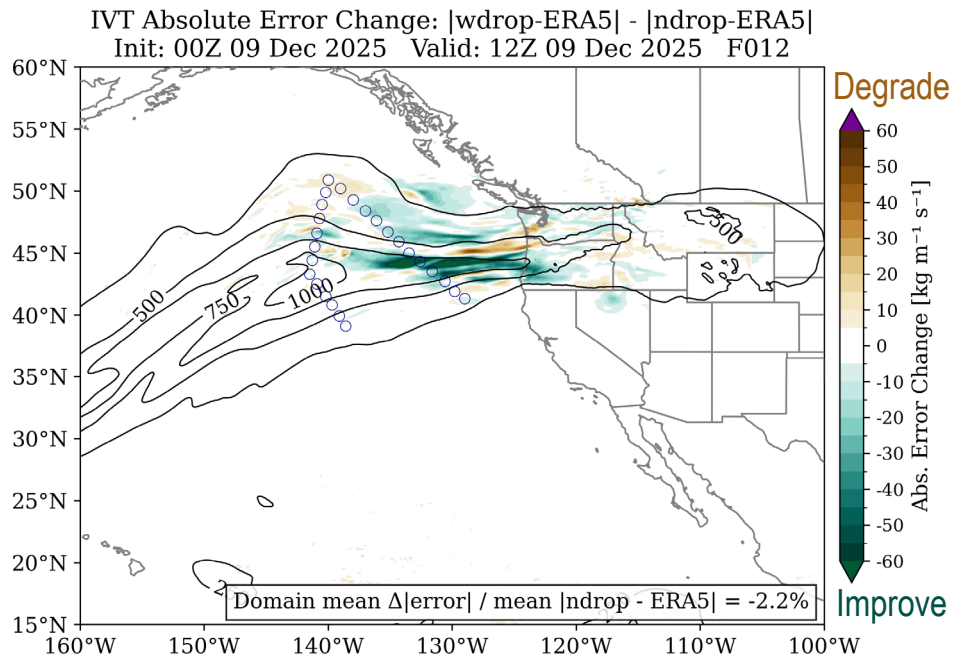
Impacts at forecast time F006



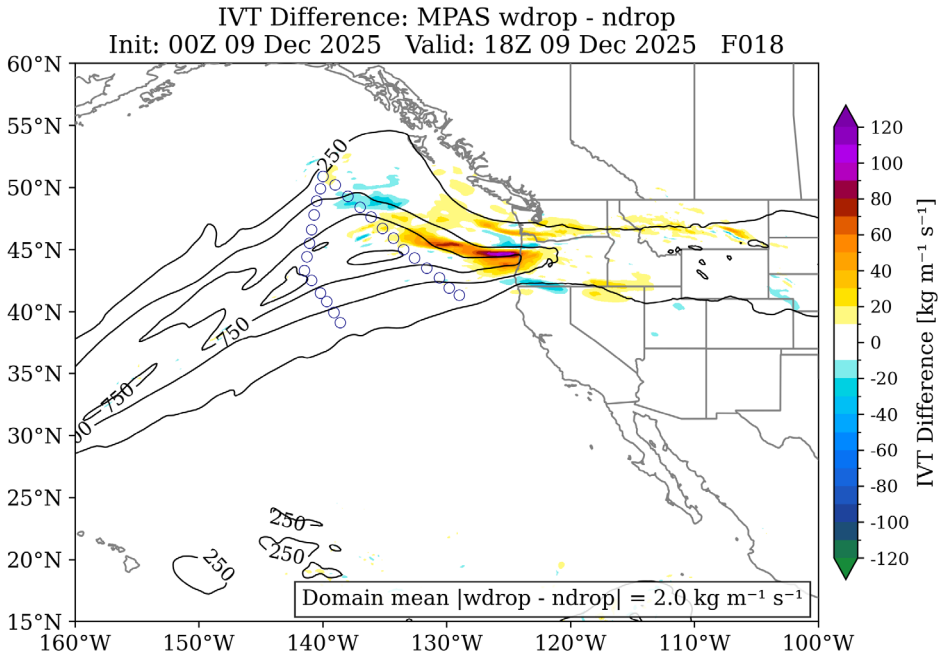


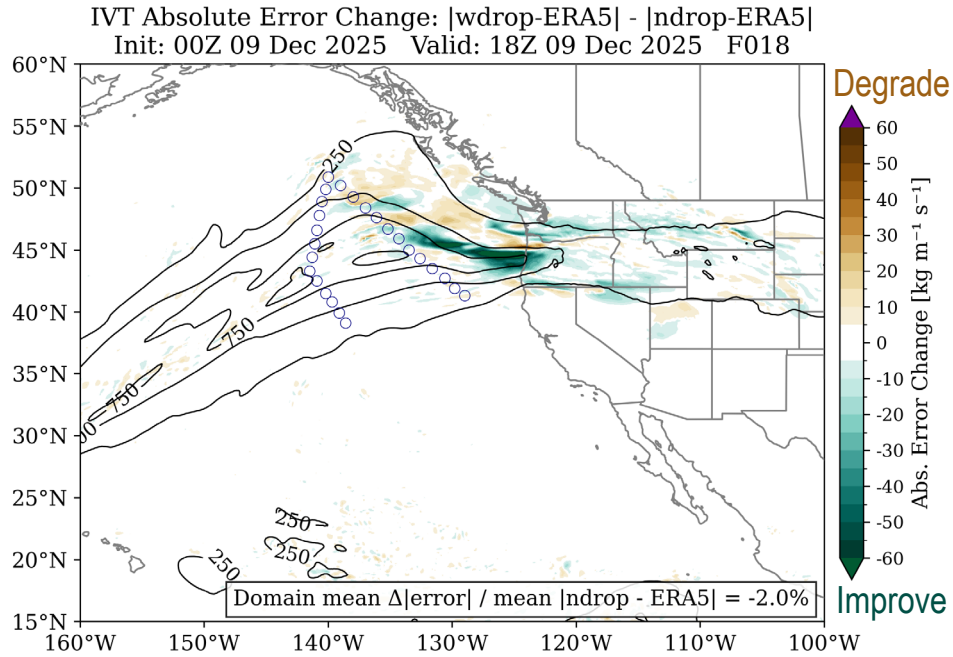
Impacts at forecast time F012



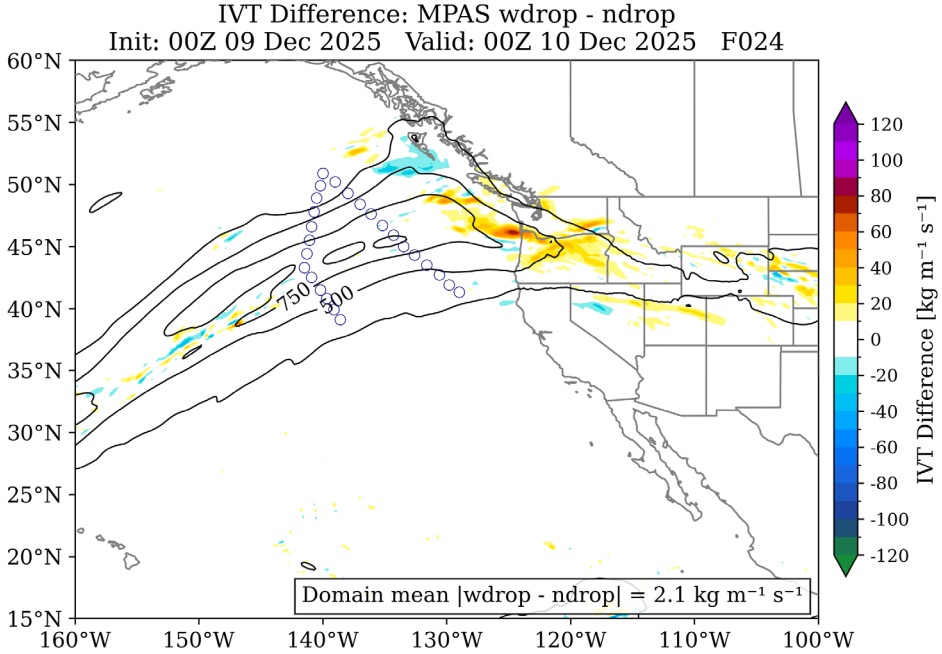


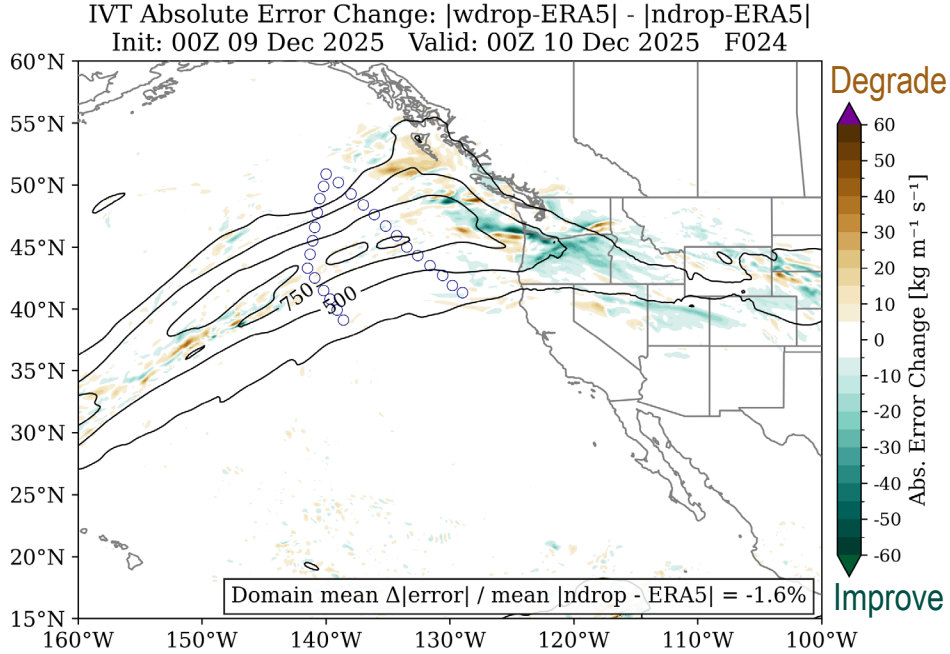
Impacts at forecast time F018



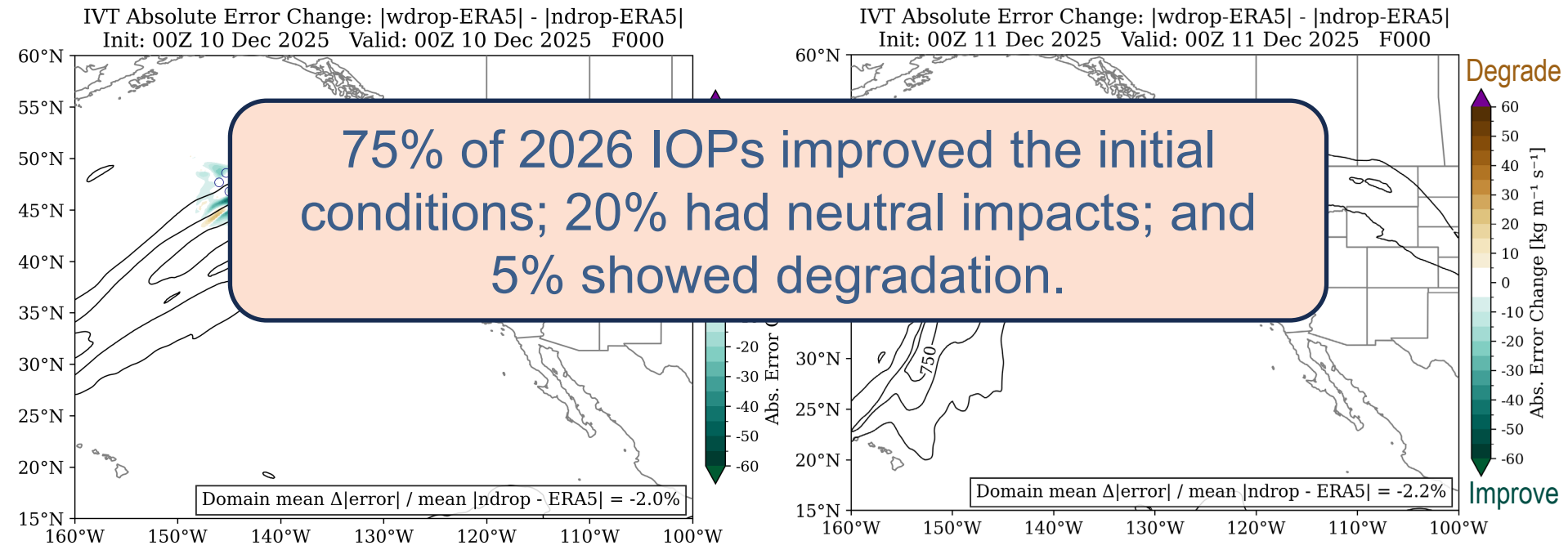


Impacts at forecast time F024





IOP 02 and IOP 03



75% of 2026 IOPs improved the initial conditions; 20% had neutral impacts; and 5% showed degradation.

Why degradation occurs at initial time?

In short: data assimilation system is suboptimal.

Reasons:

1. MPAS JEDI background error covariance model (BUMP) needs to be improved.
2. Ensemble has flaws.
3. Pure 3D EnVar treats all obs at the center analysis time.