

Validation of ECMWF forecasts of the midlatitude waveguide nearby divergence using AR Recon dropwindsondes

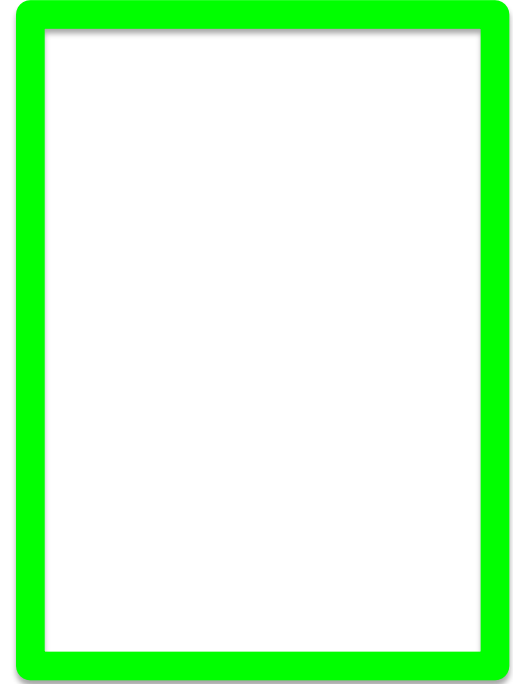
Ryan D. Torn, University at Albany, SUNY

David Lavers, ECMWF



2nd Observational Campaigns Workshop for Better Weather Forecasts

Support from FIRO, US Army Corps of Engineers FIRO and ONR SAFARI Program



Credit: Jason Cordeira, CW3E

The combination of ARs and warm conveyor belts are often associated with substantial upper-trop. divergence near midlatitude PV waveguide



Credit: Jason Cordeira, CW3E

Previous research has suggested that divergent wind advection can yield large midlatitude forecast errors and uncertainty (e.g., Rodwell et al. 2013, Grams et al. 2018, Baumgart and Riemer 2019, Pickl et al. 2023)



Credit: Jason Cordeira, CW3E

AR Recon routinely samples essential atmospheric structures associated with ARs, including divergent outflow. Provides an opportunity to evaluate whether models accurately simulate process

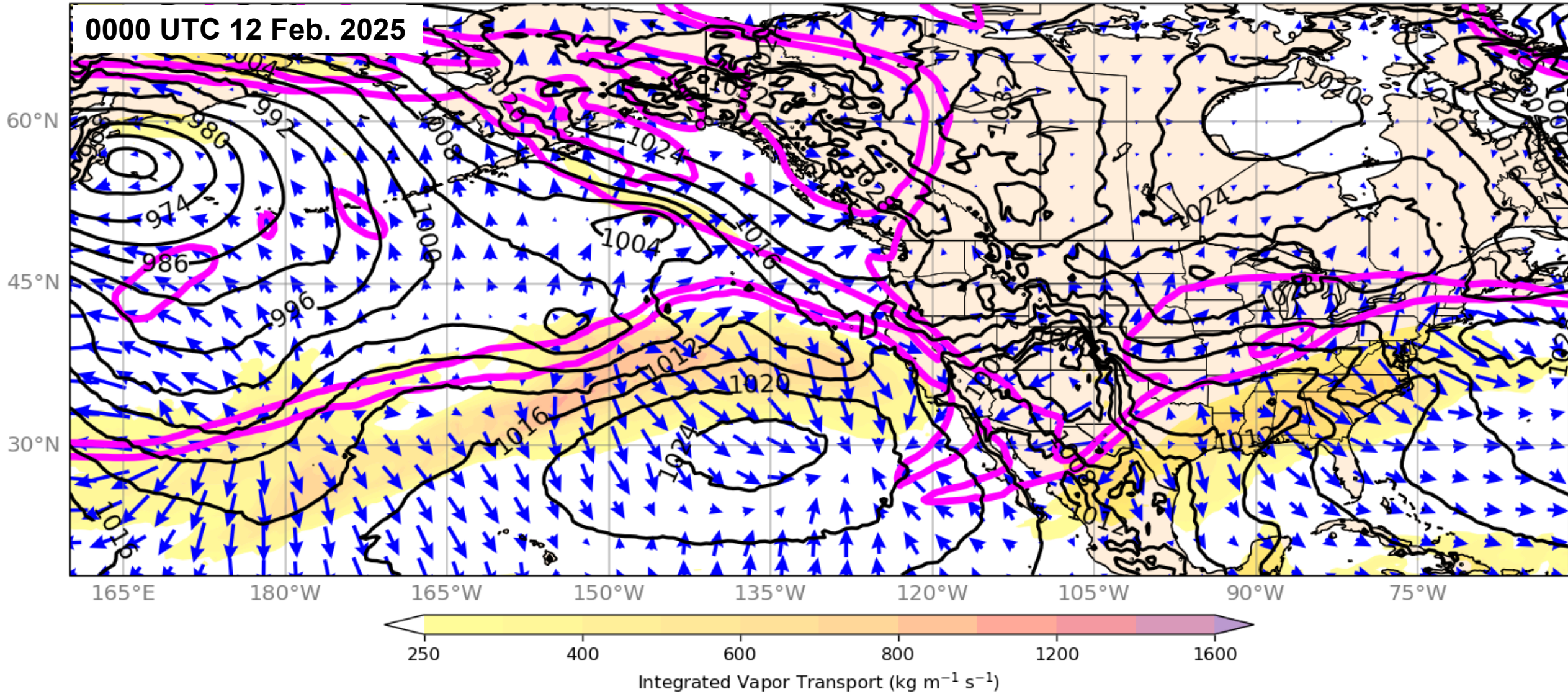
Credit: Jason Cordeira, CW3E

Goal: Validate divergence forecasts from ECMWF IFS model against dropsondes collected during AR Recon that enclose regions of large latent heat release associated with ARs (4 events over last 3 years)

Datasets

- AR Recon WY 2025 IOP 22 (14 February 2025) using dropsondes deployed from G-IV aircraft
 - 30 drops over ~5 h
- ECMWF forecasts valid during the IOP
 - Analysis, background from DA diagnostics
 - Forecast fields obtained from ECMWF archive
- Interpolate model to 2D dropsonde position and time (0.1° horizontal, model levels → 20 hPa resolution)

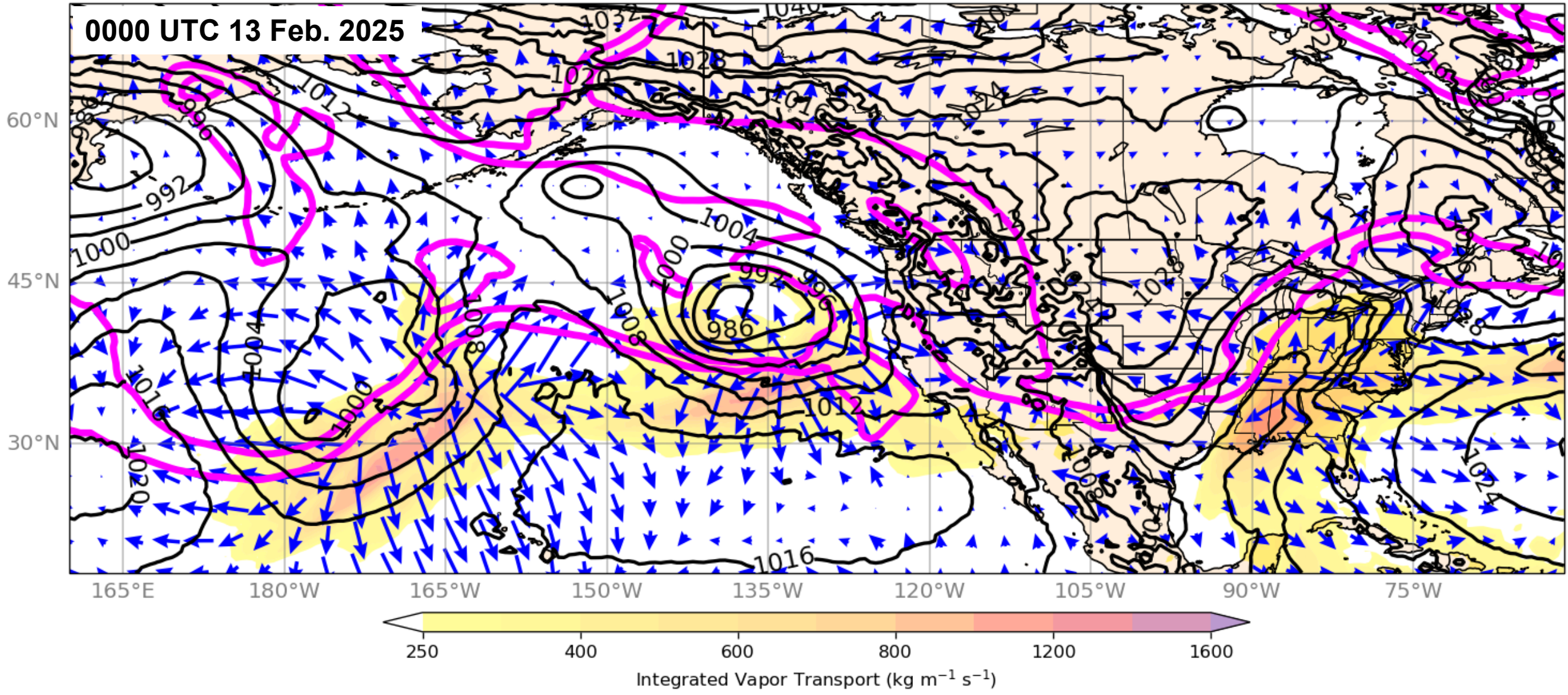
MSLP, IVT, 200-300 hPa Divergent Wind and PV, valid: 2025-02-12_00.00.00 (Hour: 000)



black contours: sea-level pressure
vectors: 200-300 hPa divergent wind

shading: integrated vapor transport (IVT)
magenta contours: 200-300 hPa PV

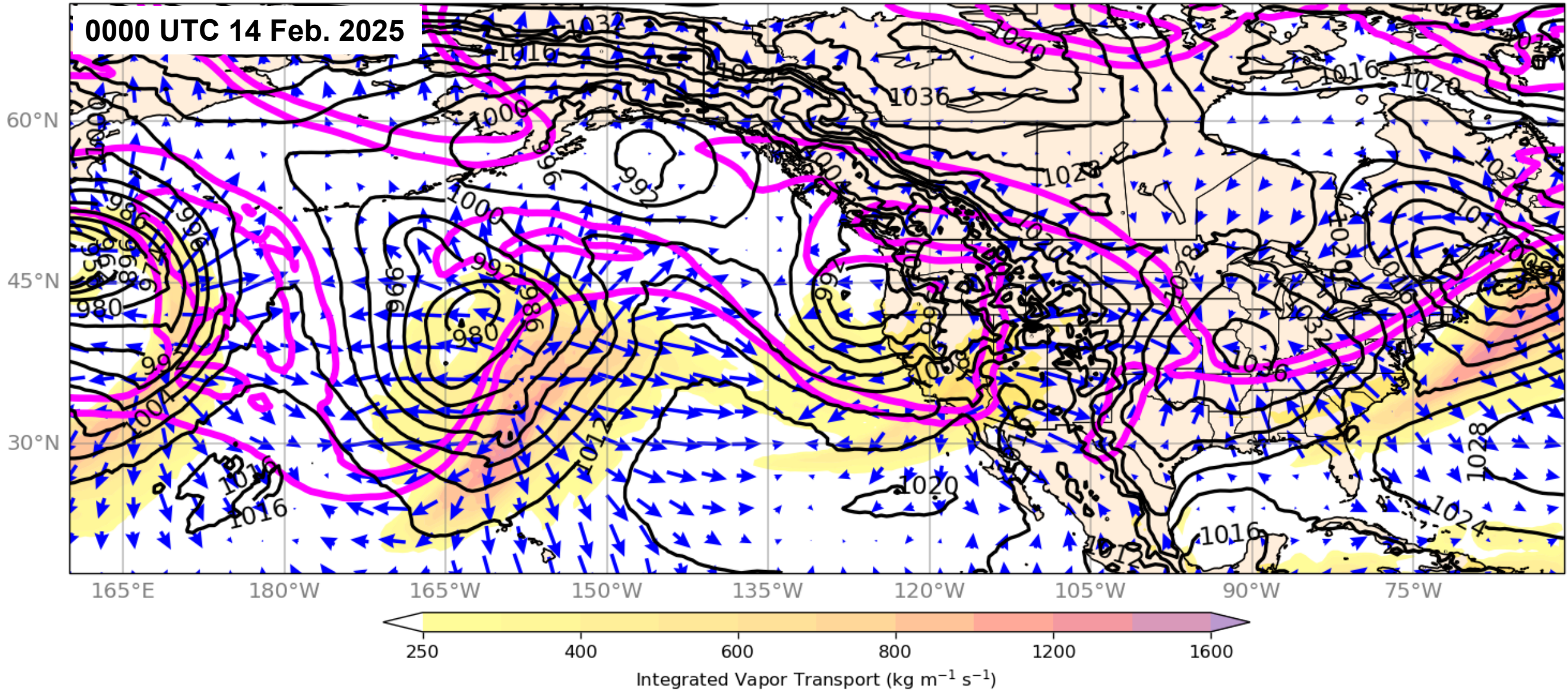
MSLP, IVT, 200-300 hPa Divergent Wind and PV, valid: 2025-02-13_00.00.00 (Hour: 000)



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vectors: 200-300 hPa divergent wind

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magenta contours: 200-300 hPa PV

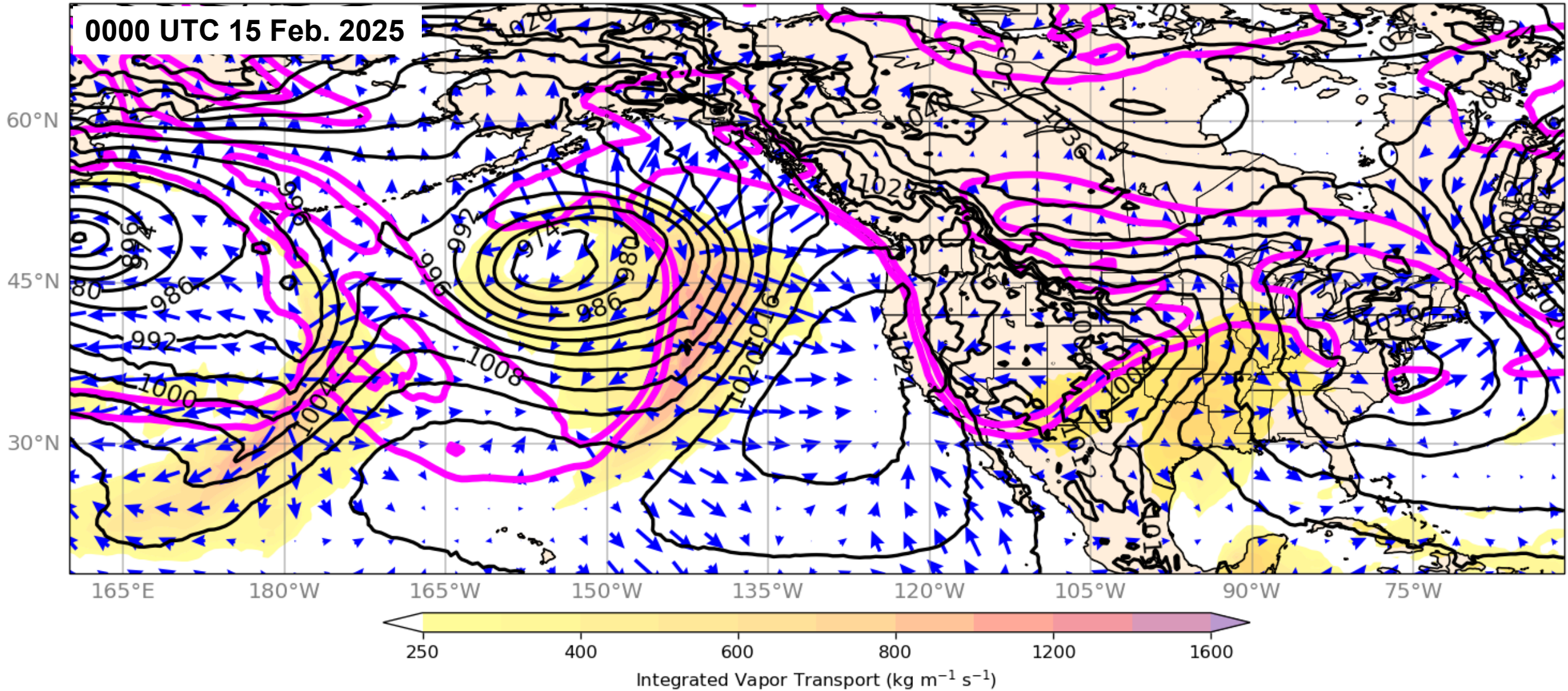
MSLP, IVT, 200-300 hPa Divergent Wind and PV, valid: 2025-02-14_00.00.00 (Hour: 000)



black contours: sea-level pressure
vectors: 200-300 hPa divergent wind

shading: integrated vapor transport (IVT)
magenta contours: 200-300 hPa PV

MSLP, IVT, 200-300 hPa Divergent Wind and PV, valid: 2025-02-15_00.00.00 (Hour: 000)

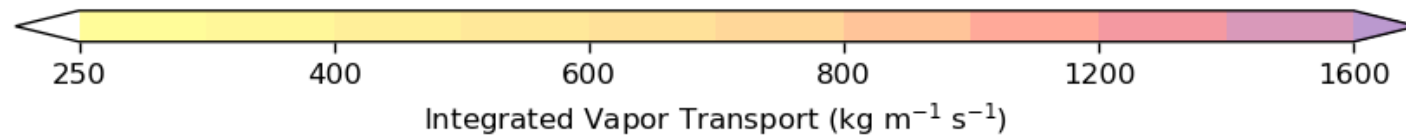
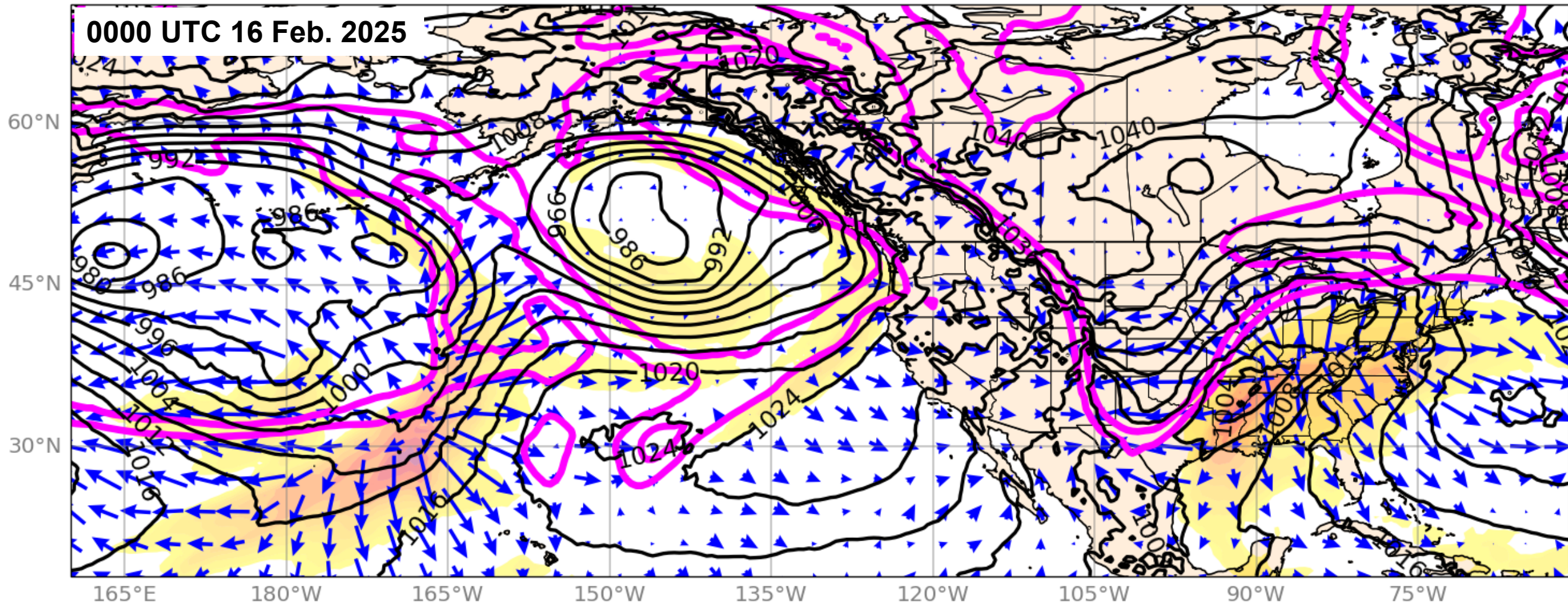


black contours: sea-level pressure
vectors: 200-300 hPa divergent wind

shading: integrated vapor transport (IVT)
magenta contours: 200-300 hPa PV

MSLP, IVT, 200-300 hPa Divergent Wind and PV, valid: 2025-02-16_00.00.00 (Hour: 000)

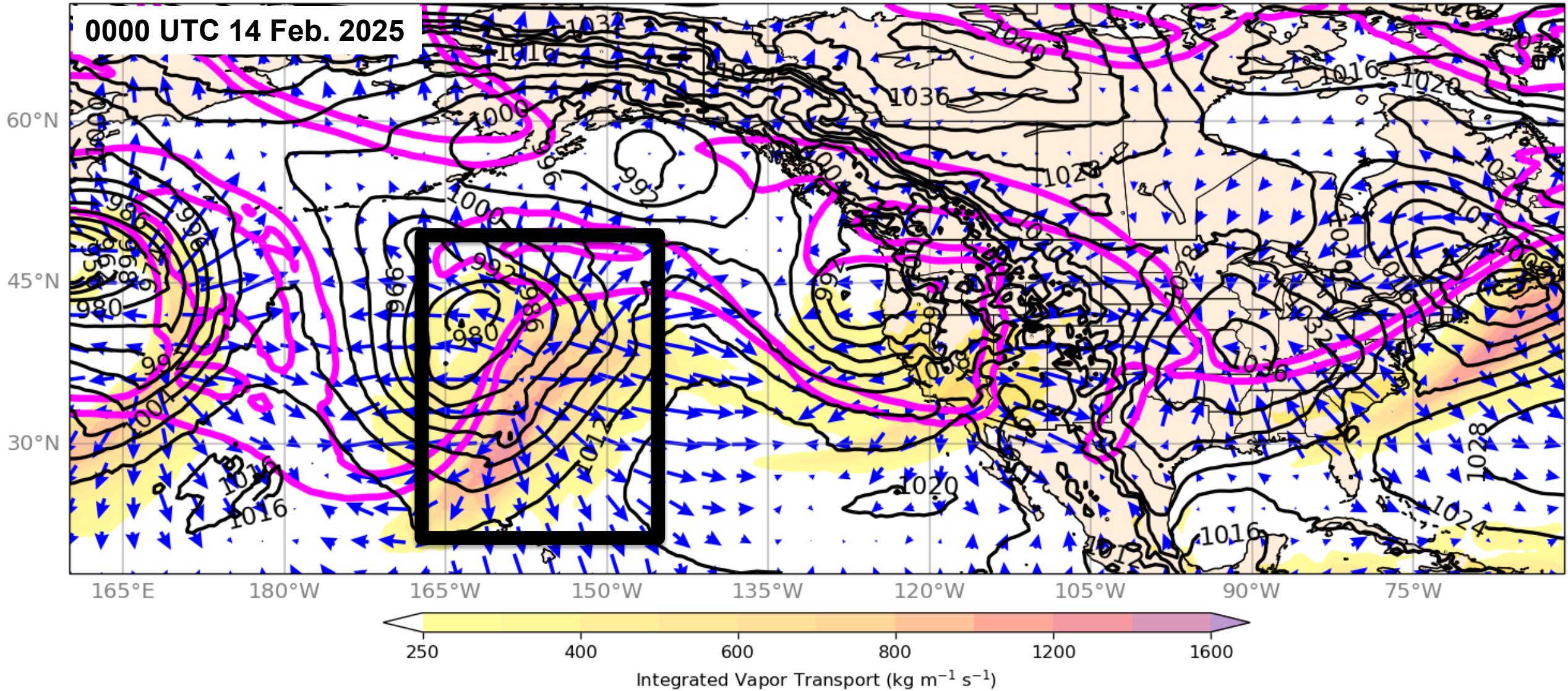
0000 UTC 16 Feb. 2025



black contours: sea-level pressure
vectors: 200-300 hPa divergent wind

shading: integrated vapor transport (IVT)
magenta contours: 200-300 hPa PV

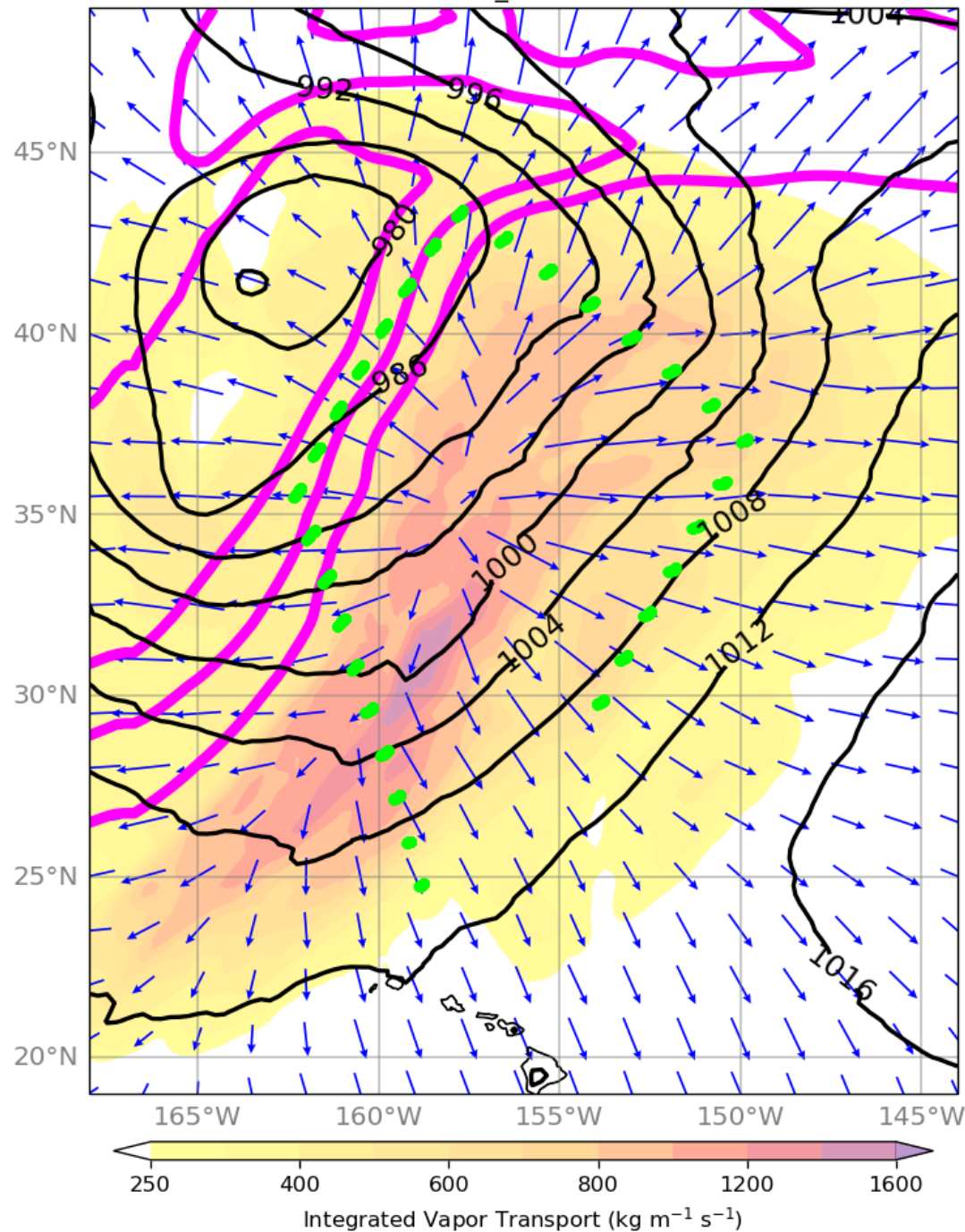
MSLP, IVT, 200-300 hPa Divergent Wind and PV, valid: 2025-02-14_00.00.00 (Hour: 000)



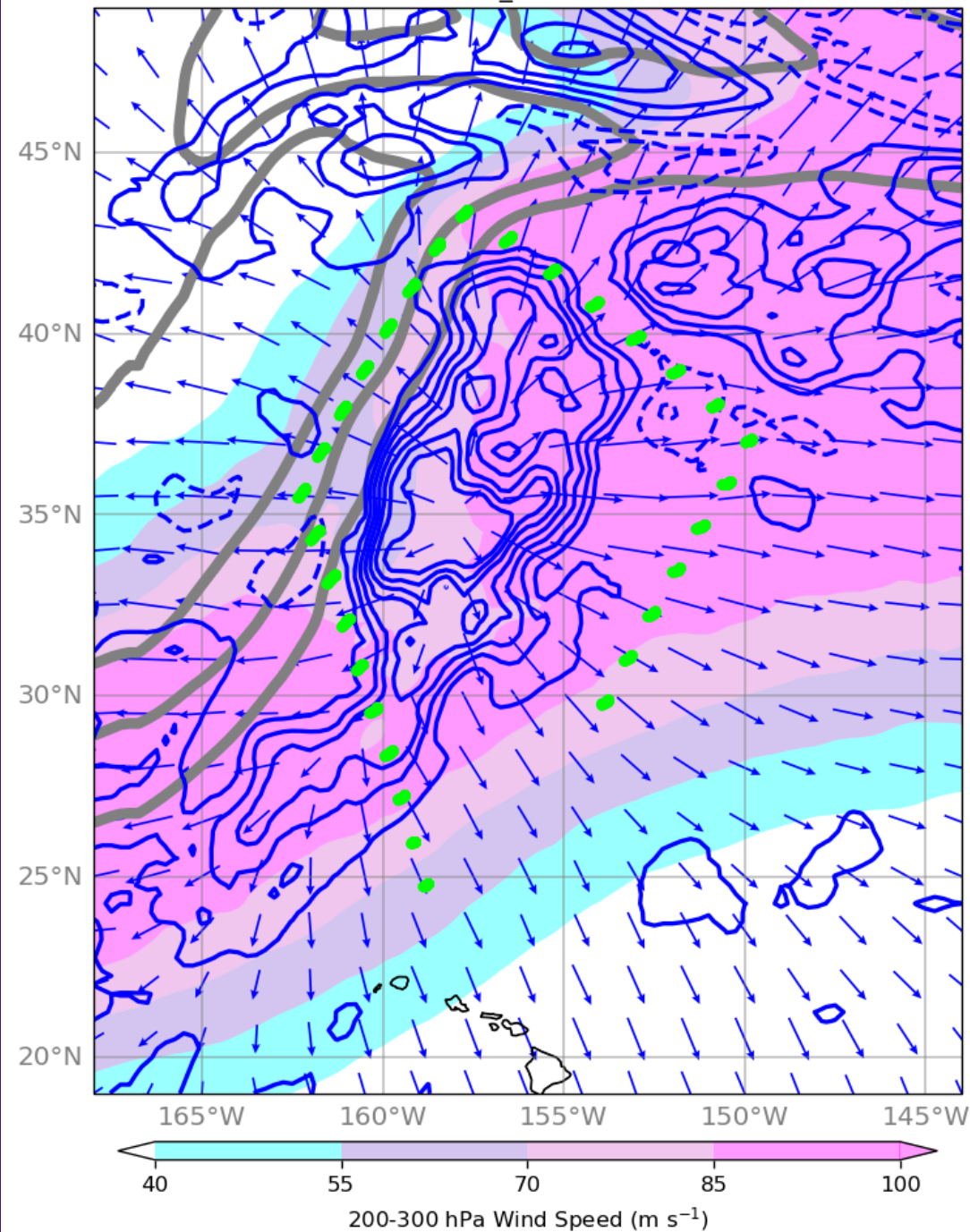
black contours: sea-level pressure
vectors: 200-300 hPa divergent wind

shading: integrated vapor transport (IVT)
magenta contours: 200-300 hPa PV

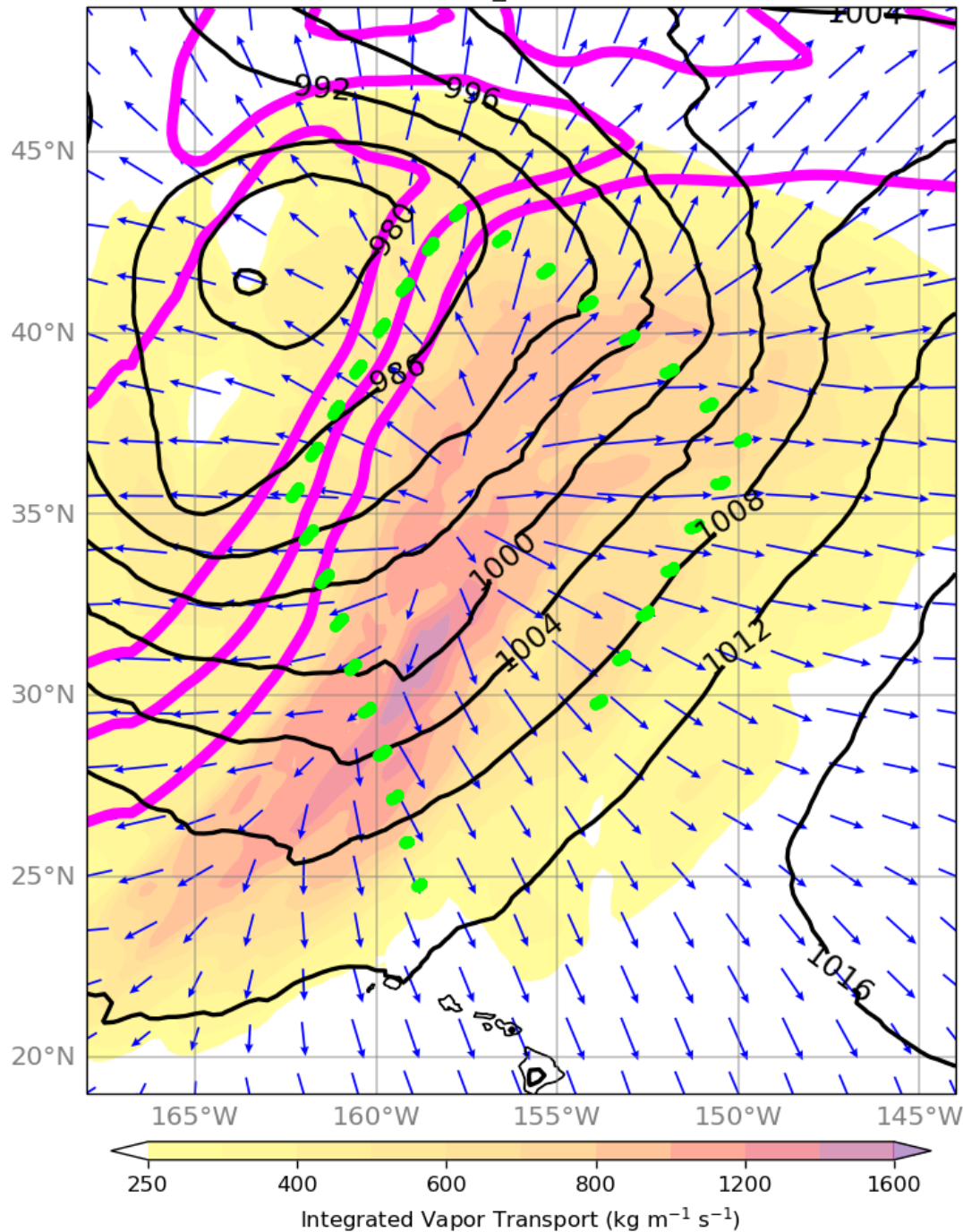
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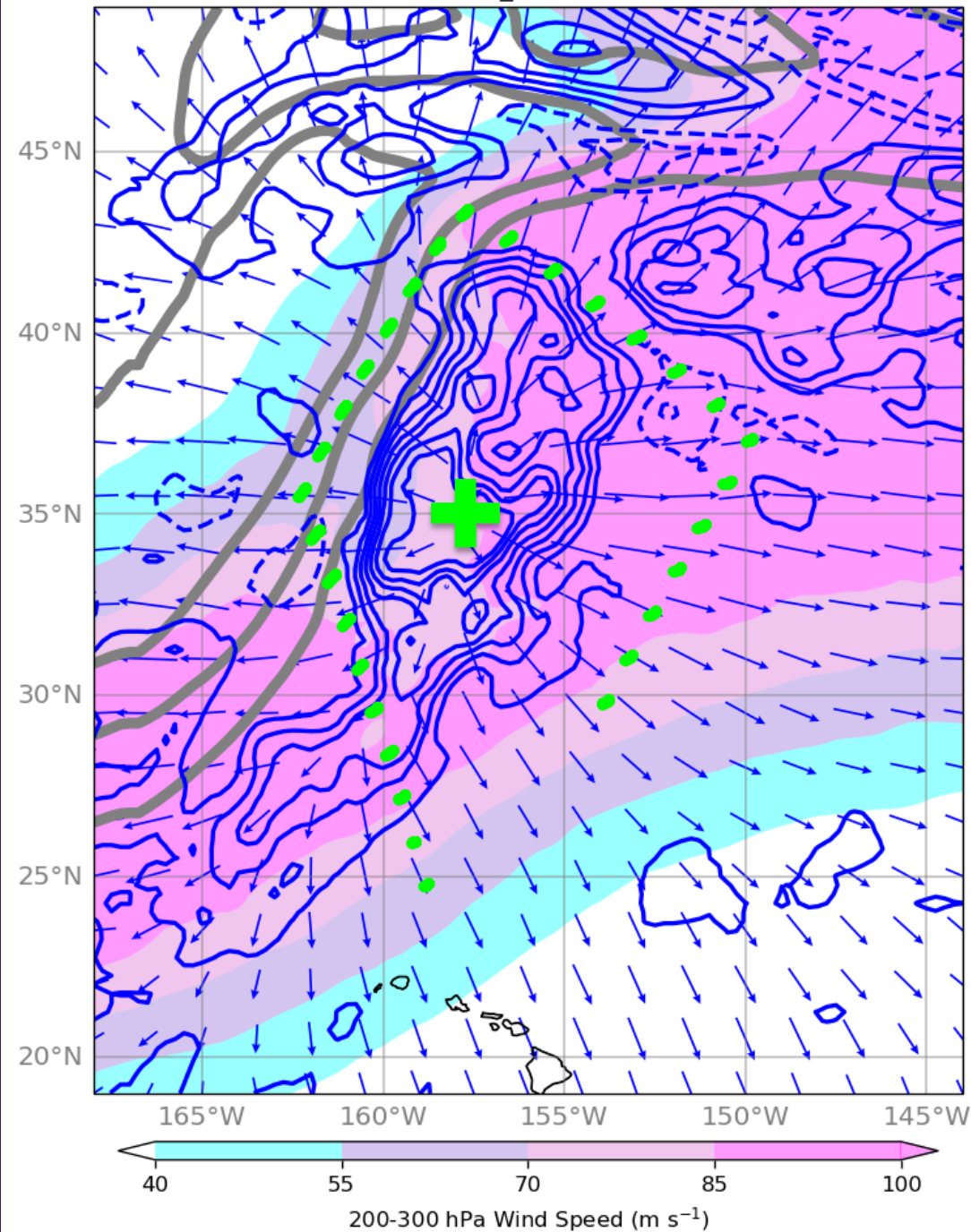
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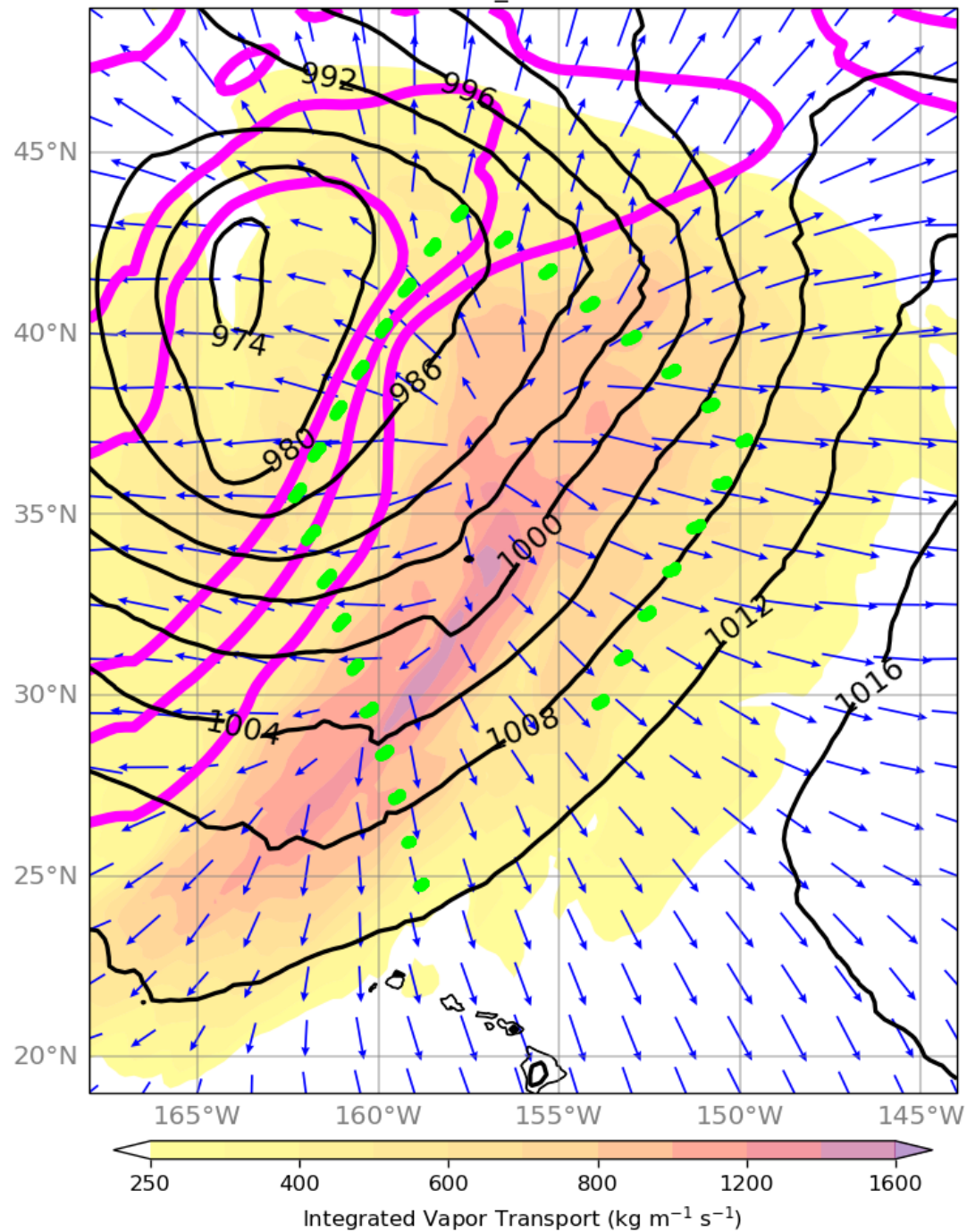
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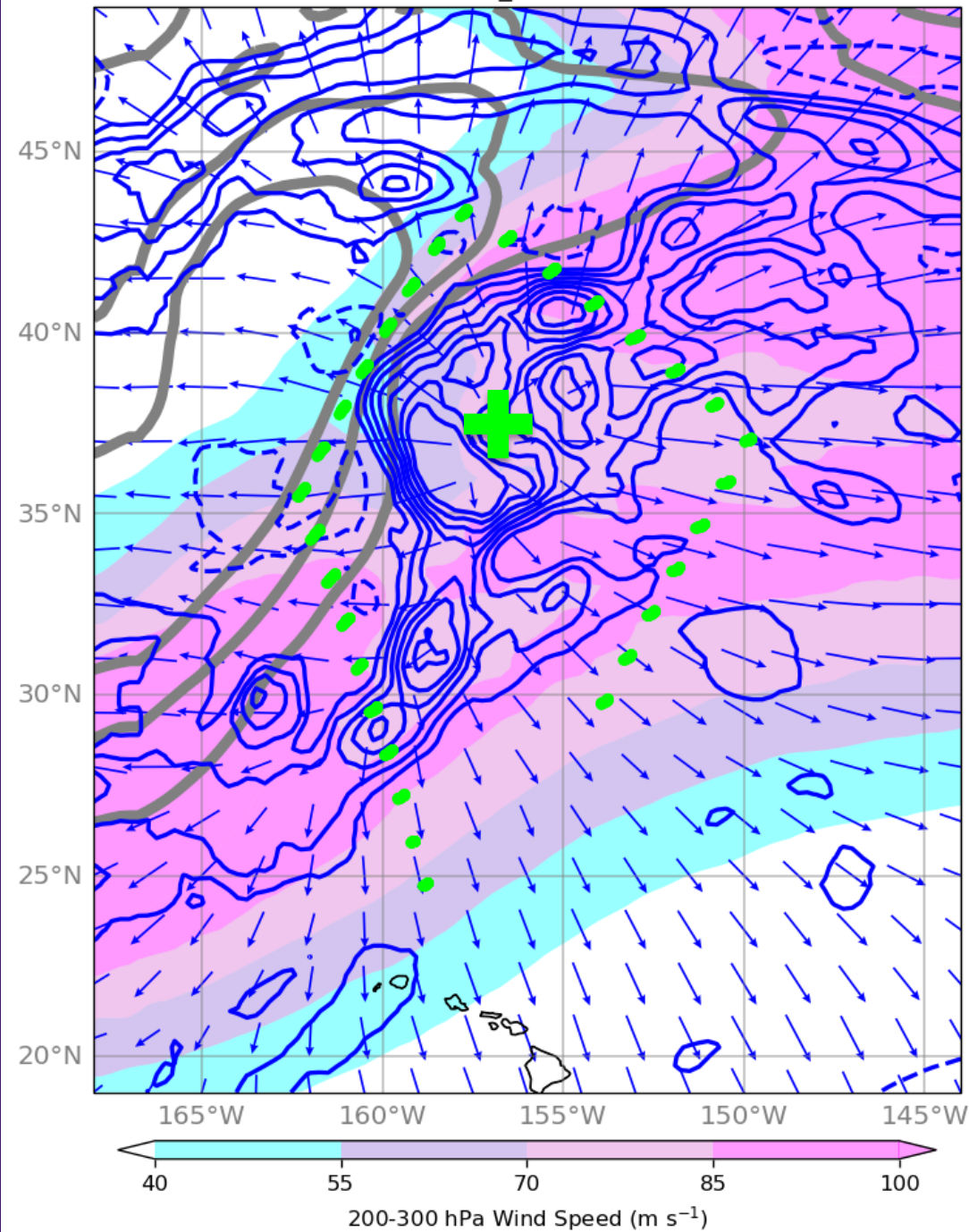
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Valid: 2025-02-14_00.00.00 (Hour: 048)

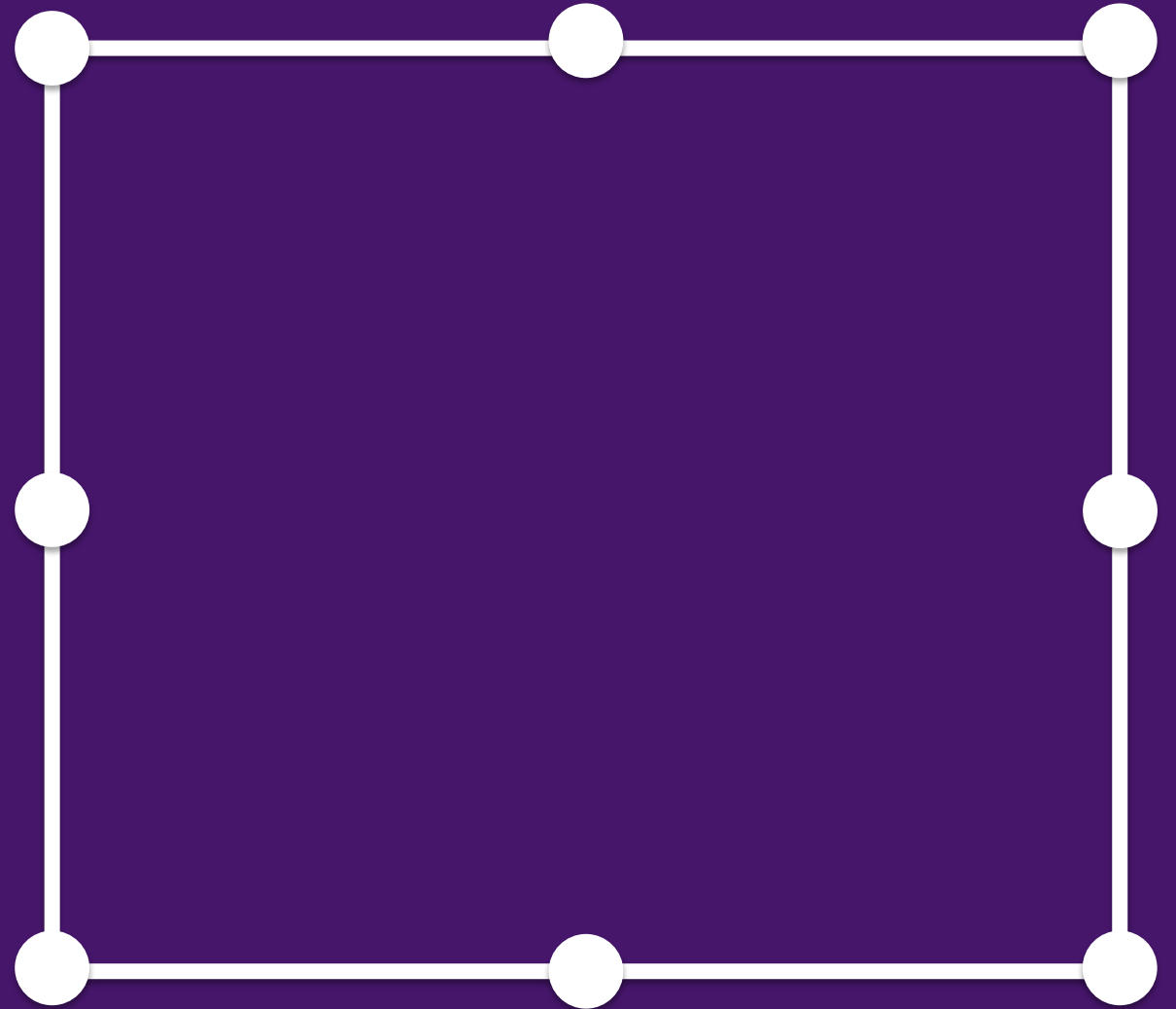


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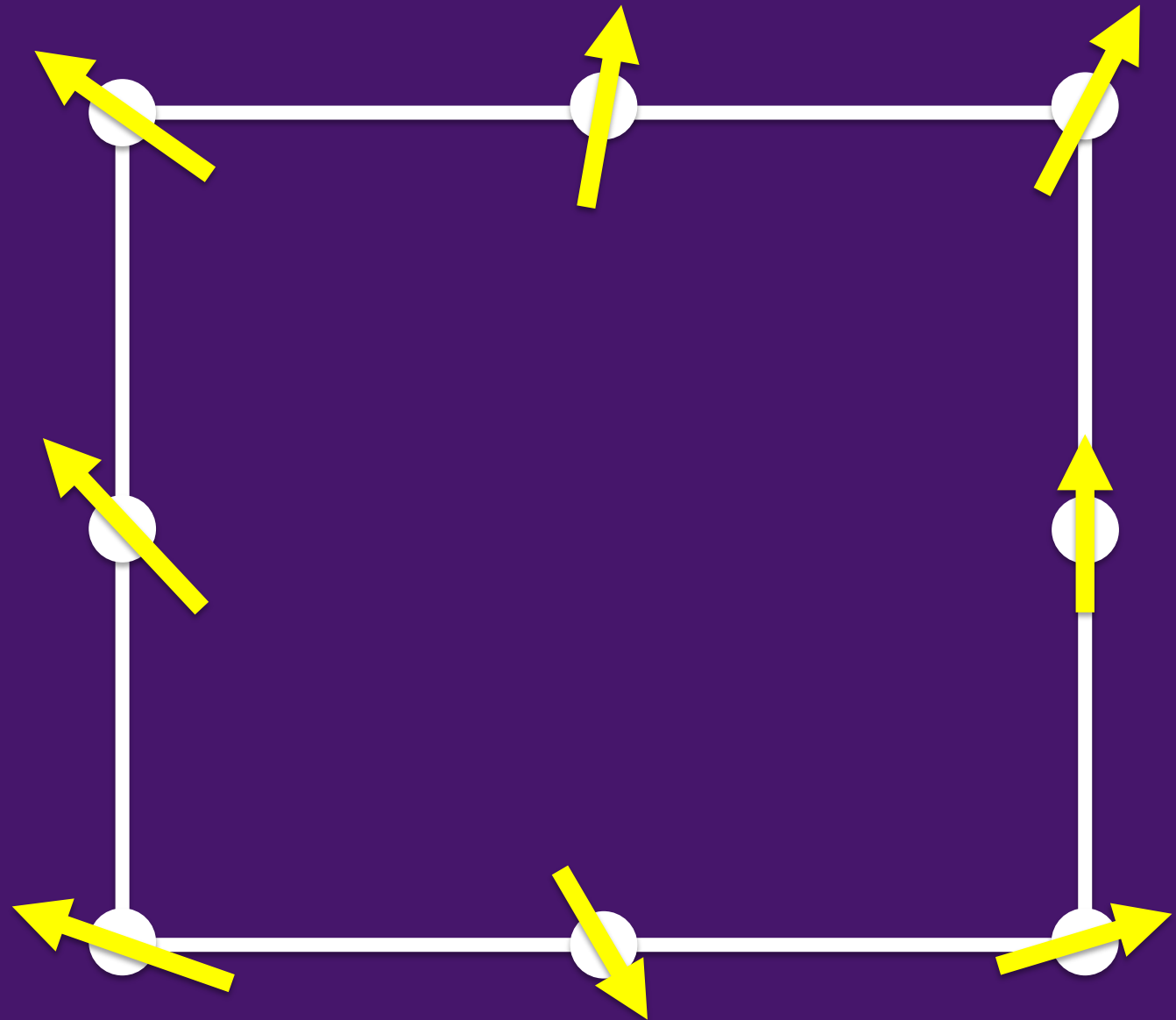
Divergence Calculations

- Consider series of dropsondes that create a closed circuit



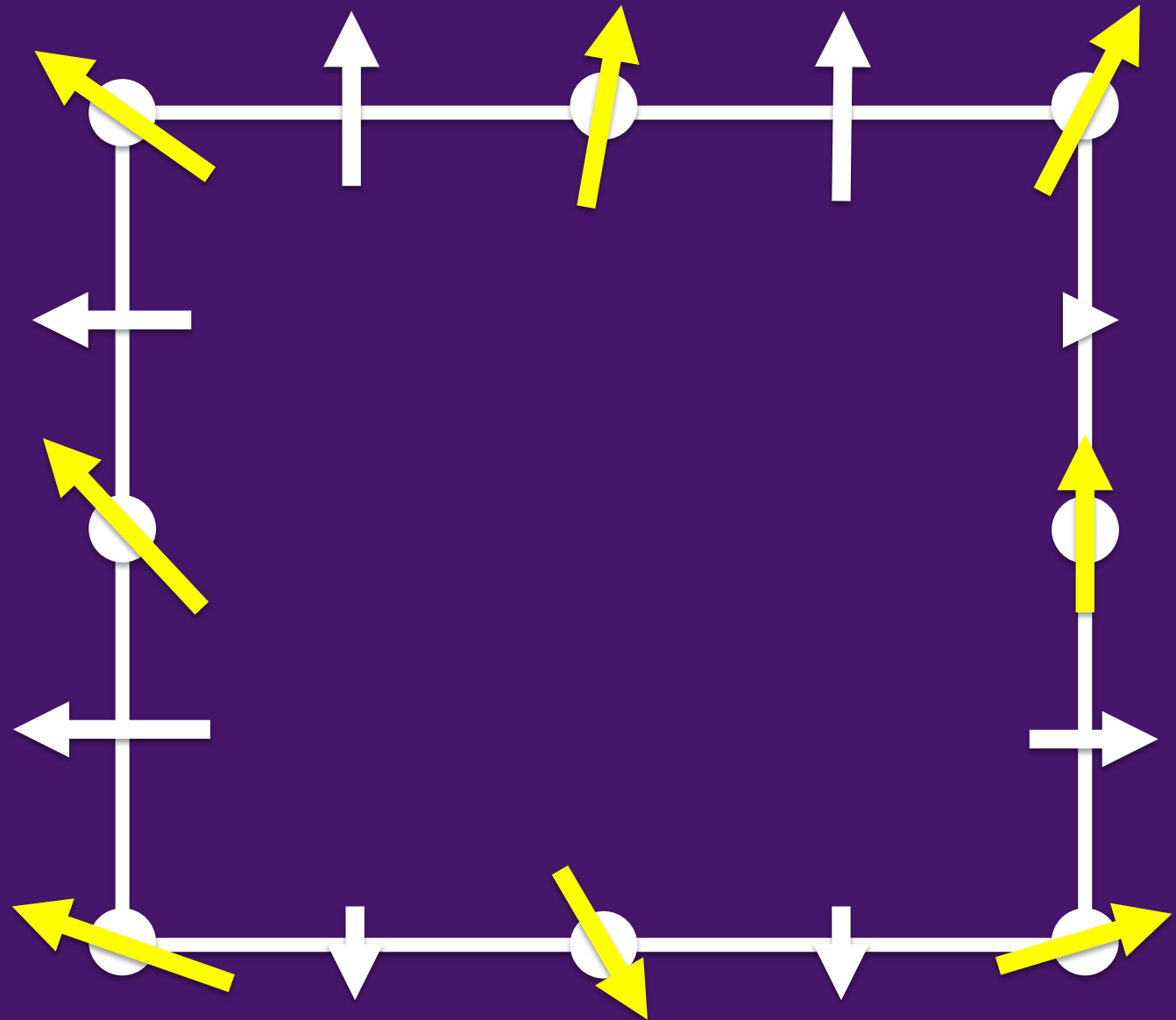
Divergence Calculations

- Consider series of dropsondes that create a closed circuit
- Compute winds for each drop point at a given pressure level



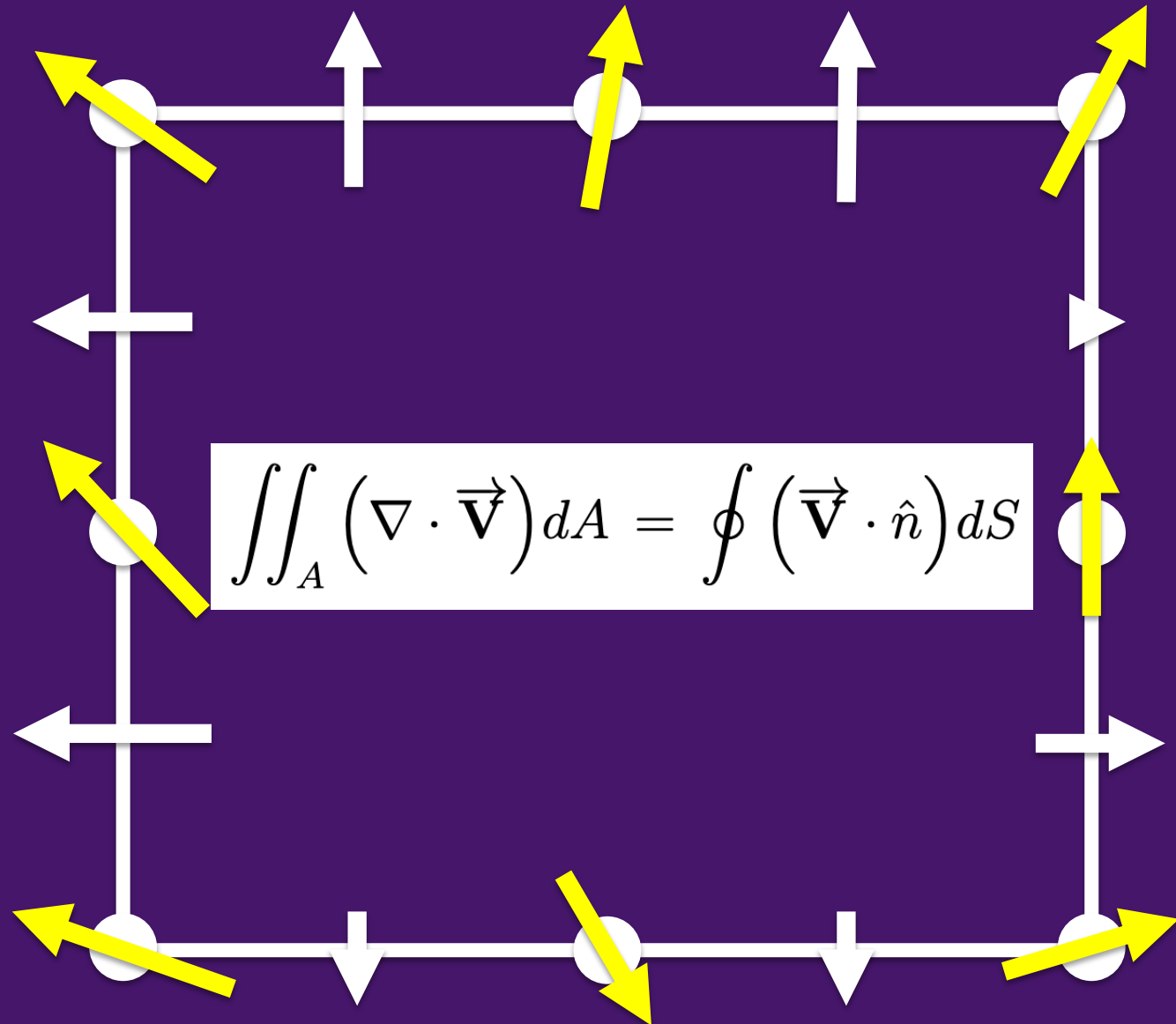
Divergence Calculations

- Consider series of dropsondes that create a closed circuit
- Compute winds for each drop point at a given pressure level
- Calculate the wind normal to the aircraft track



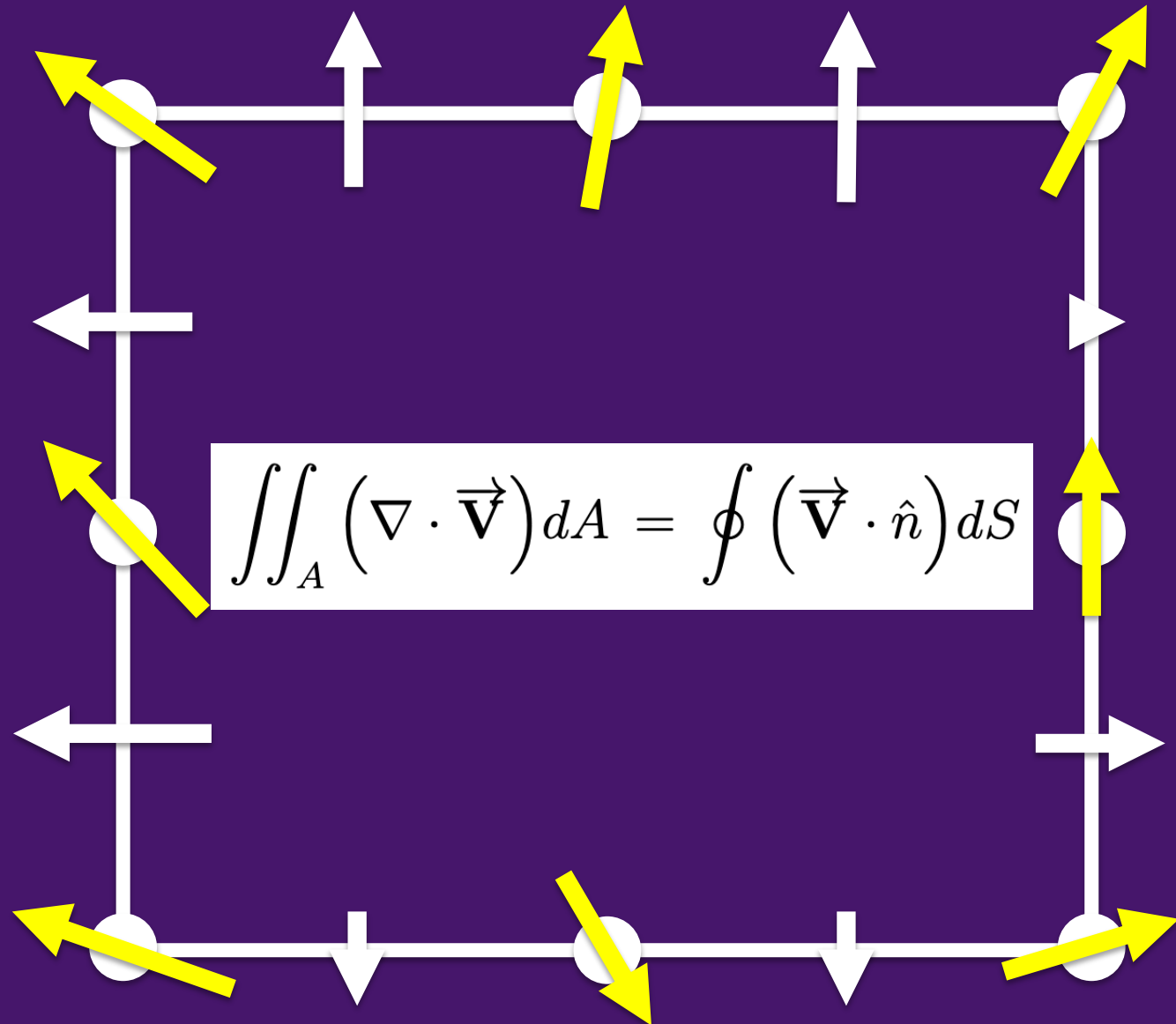
Divergence Calculations

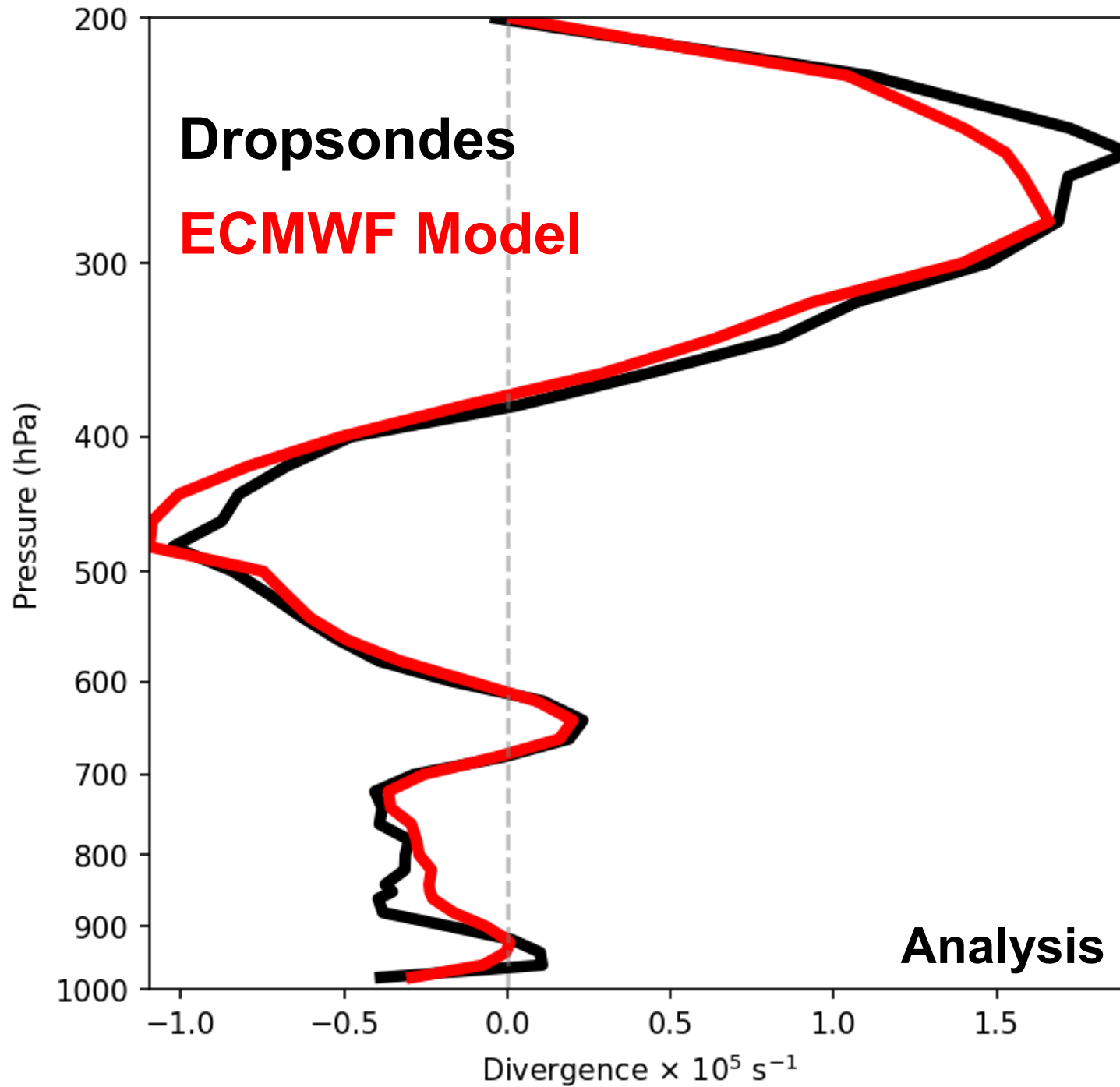
- Consider series of dropsondes that create a closed circuit
- Compute winds for each drop point at a given pressure level
- Calculate the wind normal to the aircraft track
- Compute the divergence using the divergence theorem (need normal wind and drop distance)

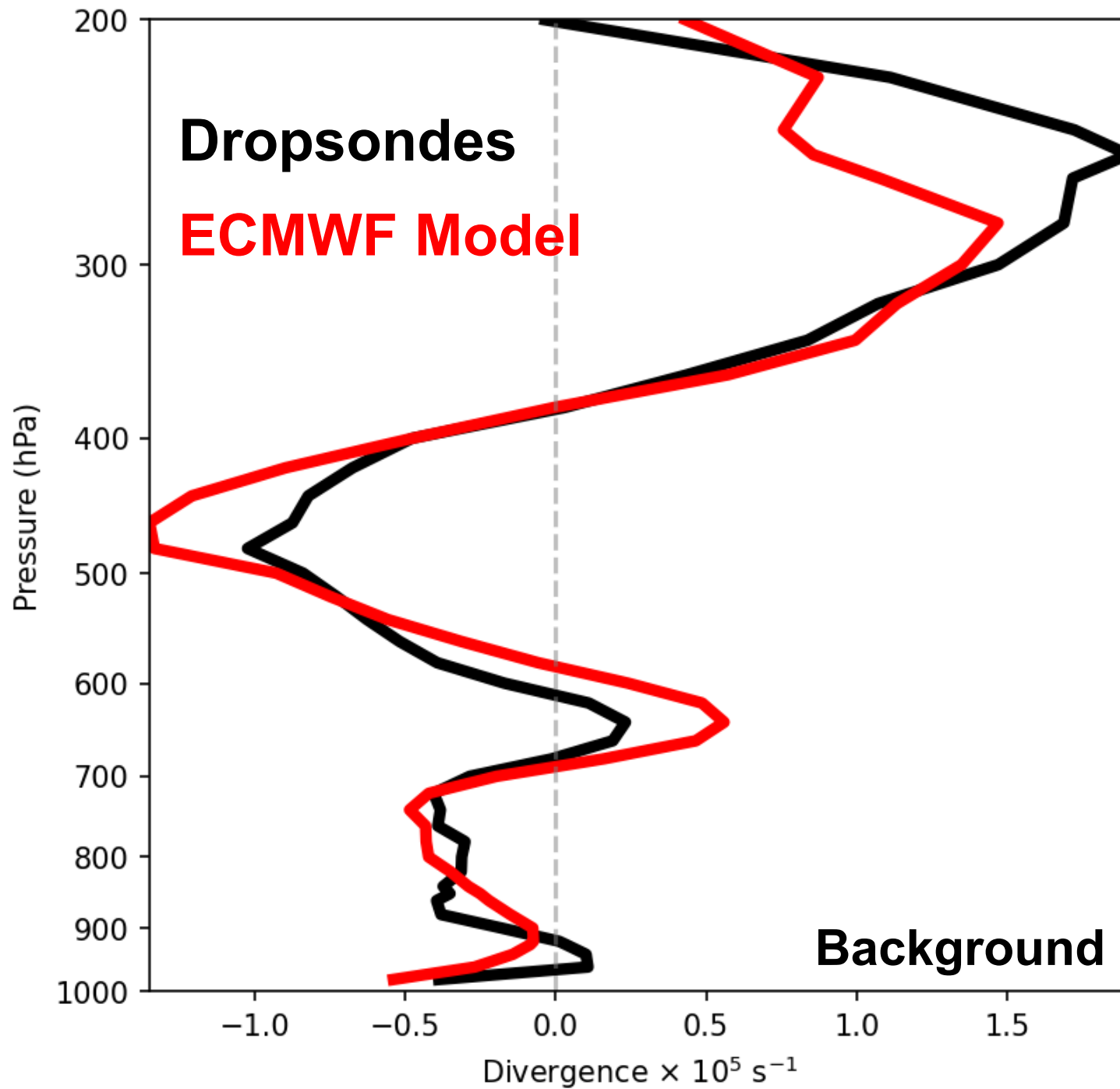


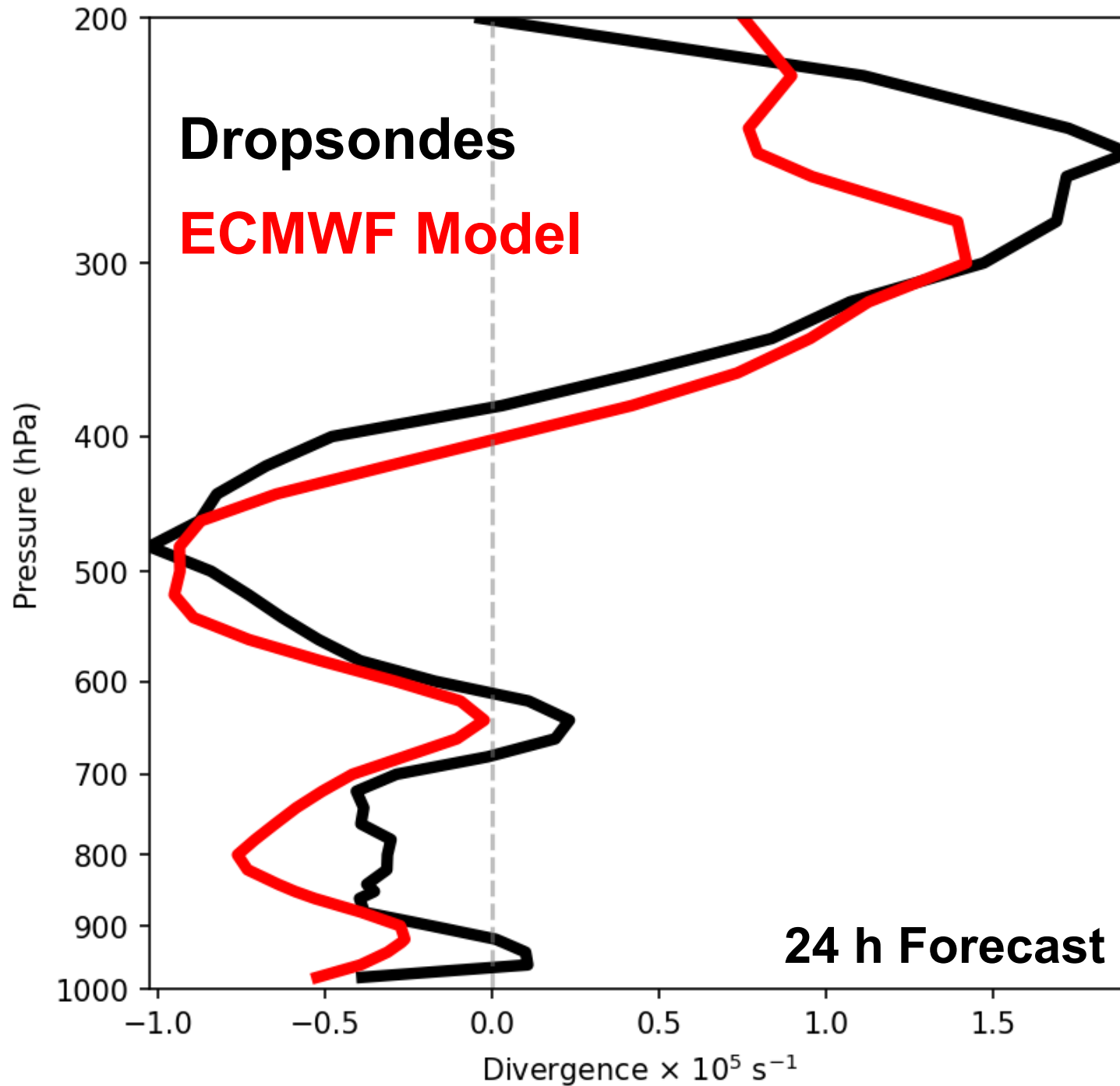
Divergence Calculations

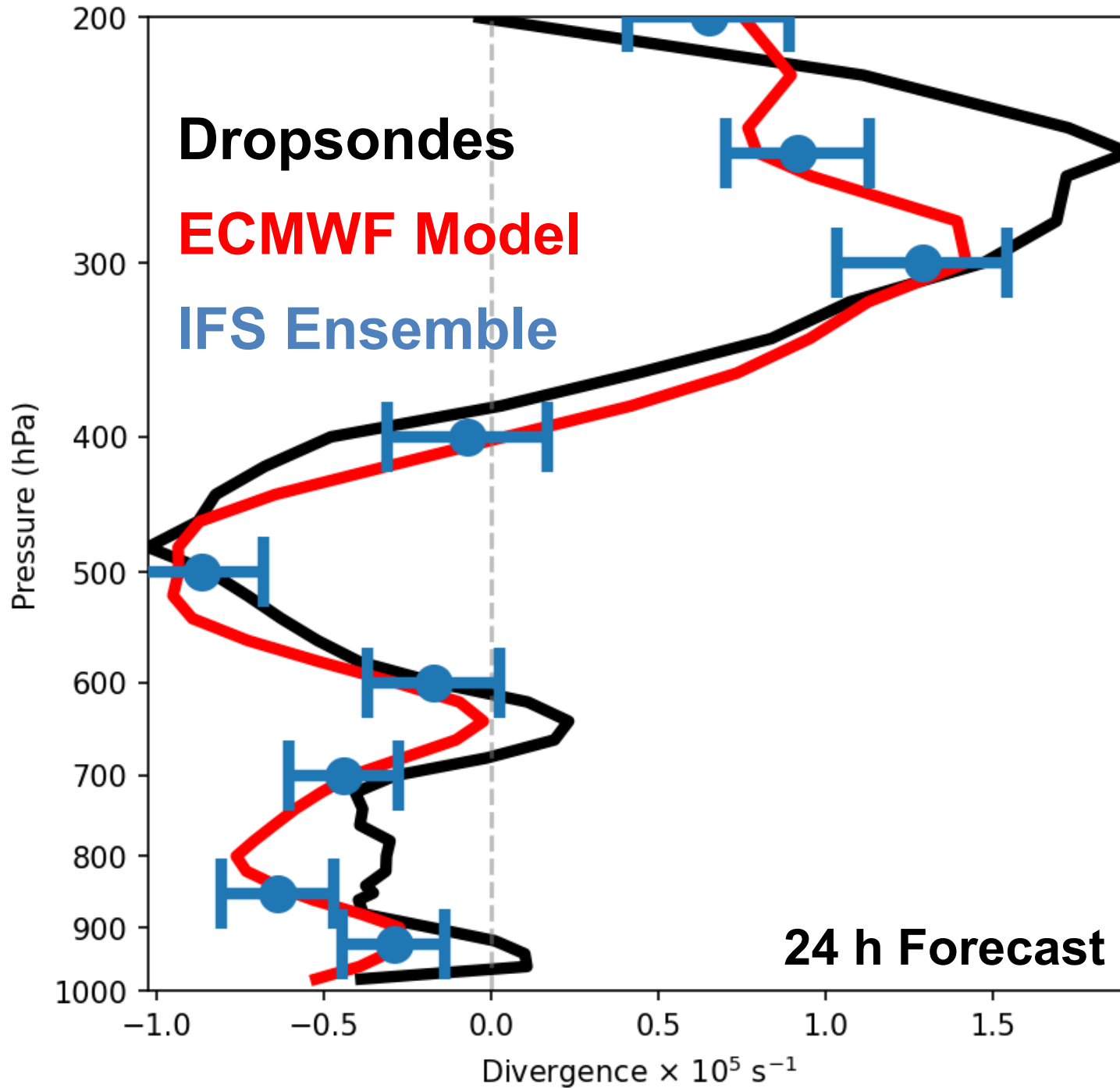
- Consider series of dropsondes that create a closed circuit
- Compute winds for each drop point at a given pressure level
- Calculate the wind normal to the aircraft track
- Compute the divergence using the divergence theorem (need normal wind and drop distance)
- Repeat for each vertical level

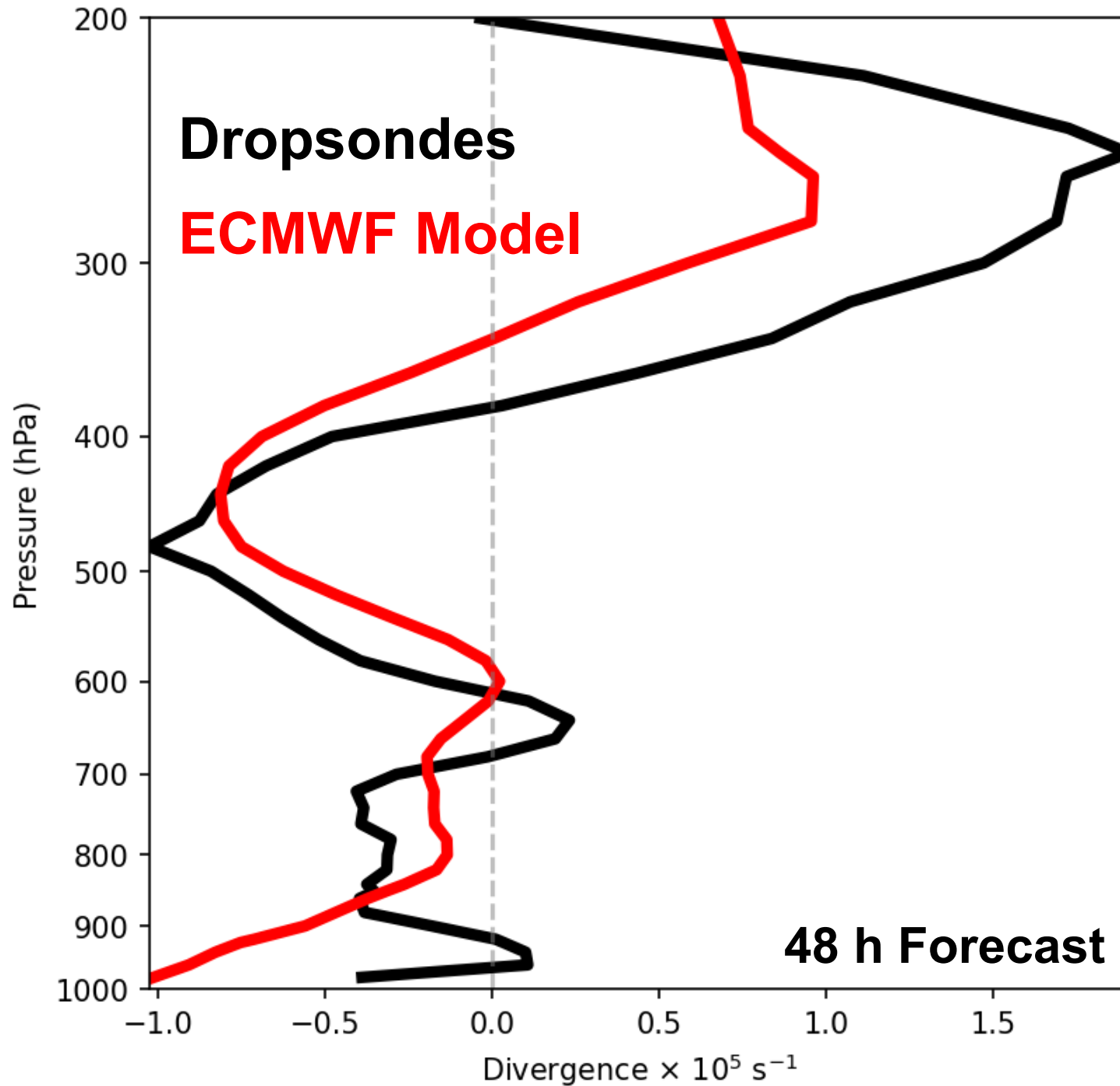


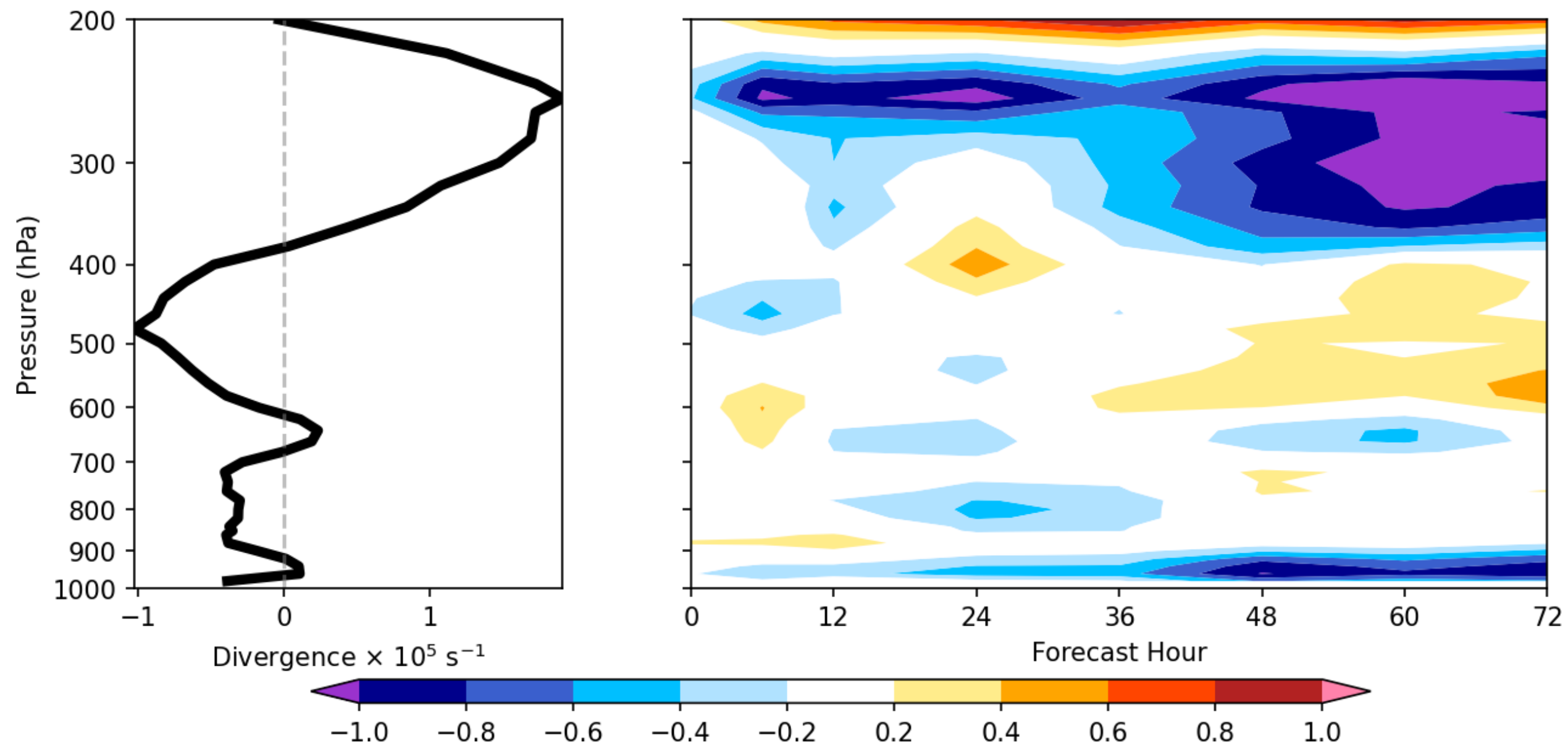




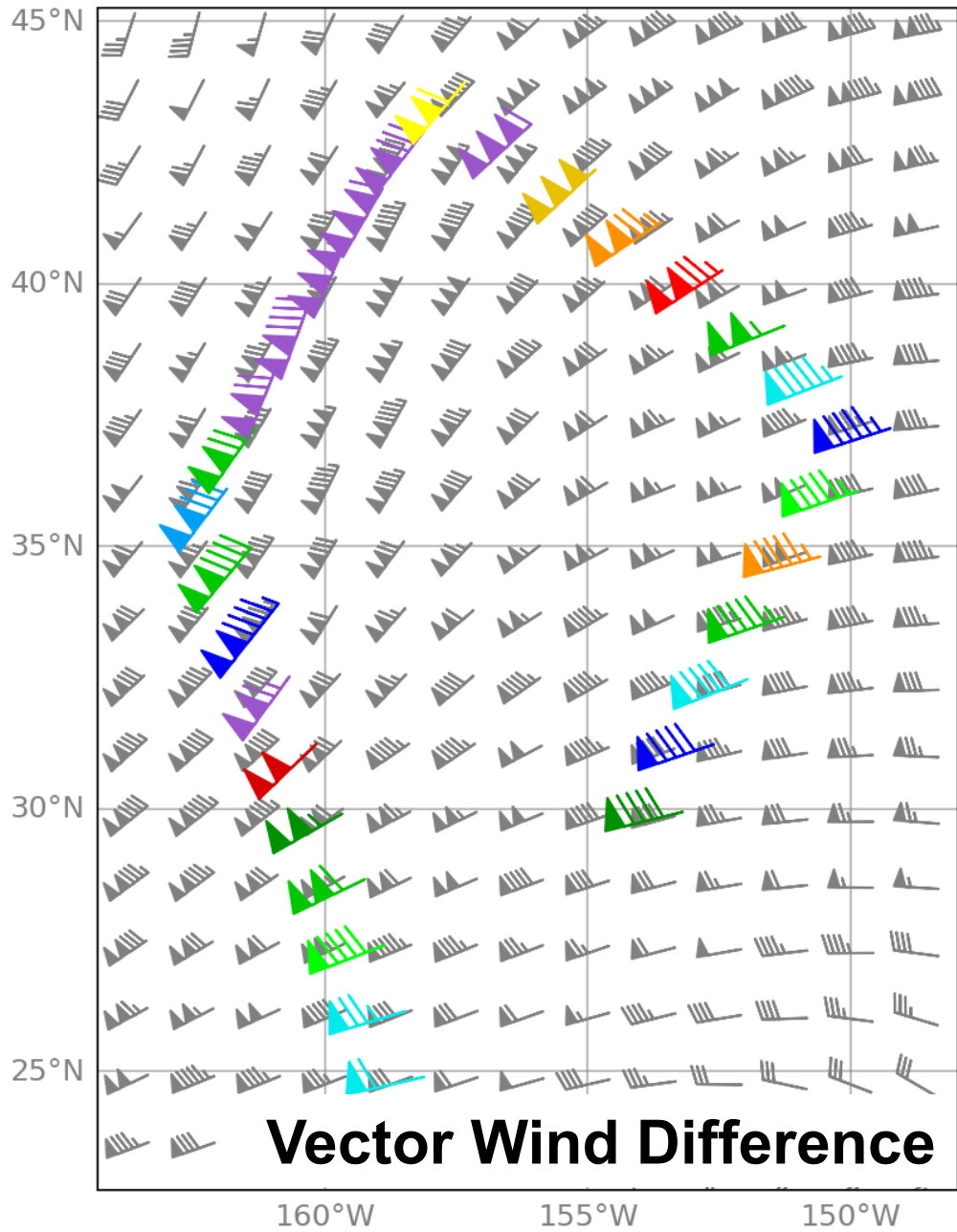








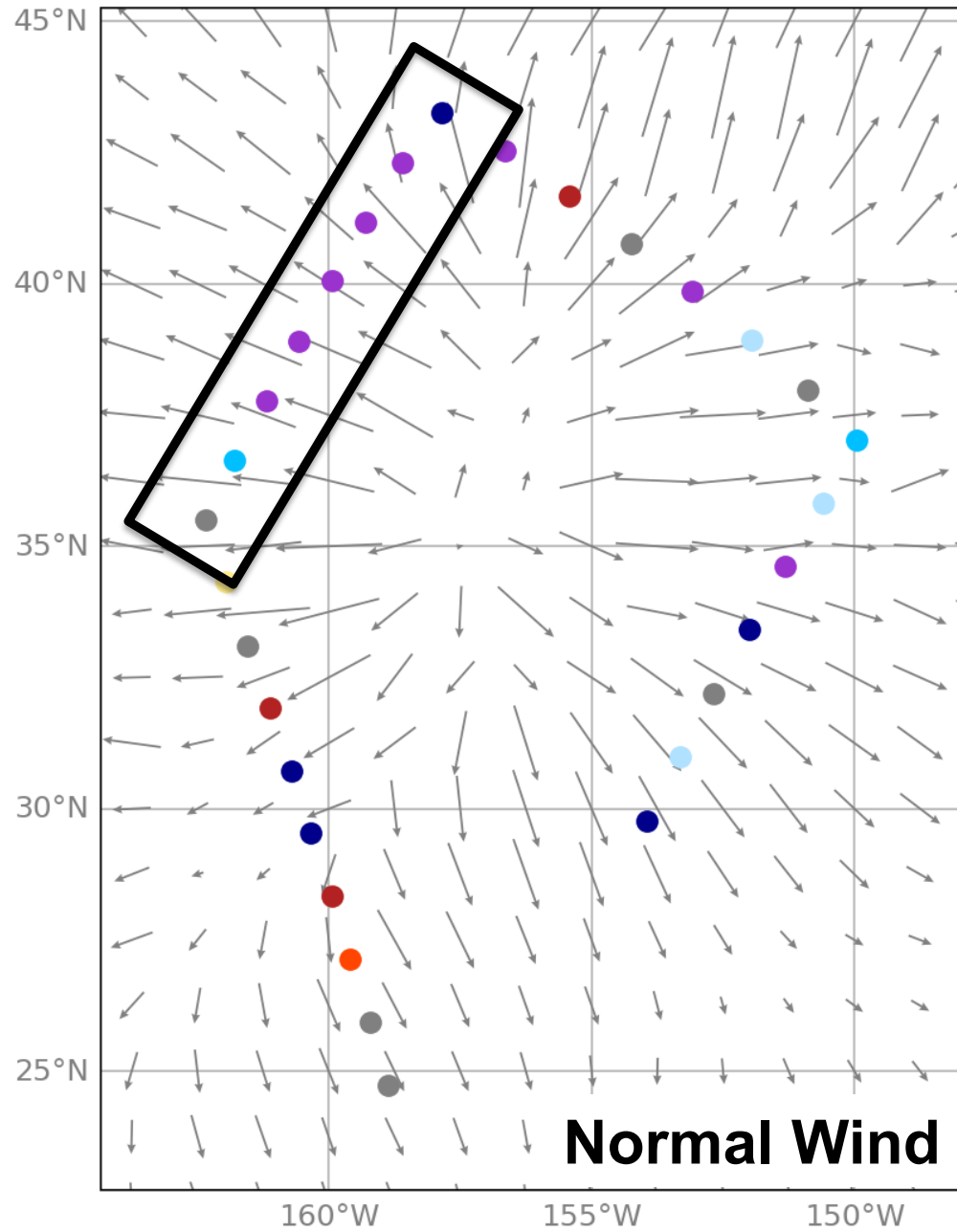
24 h forecast 250 hPa wind (observations)



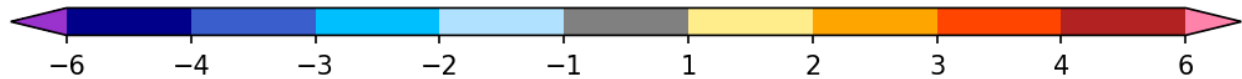
Vector Wind Difference



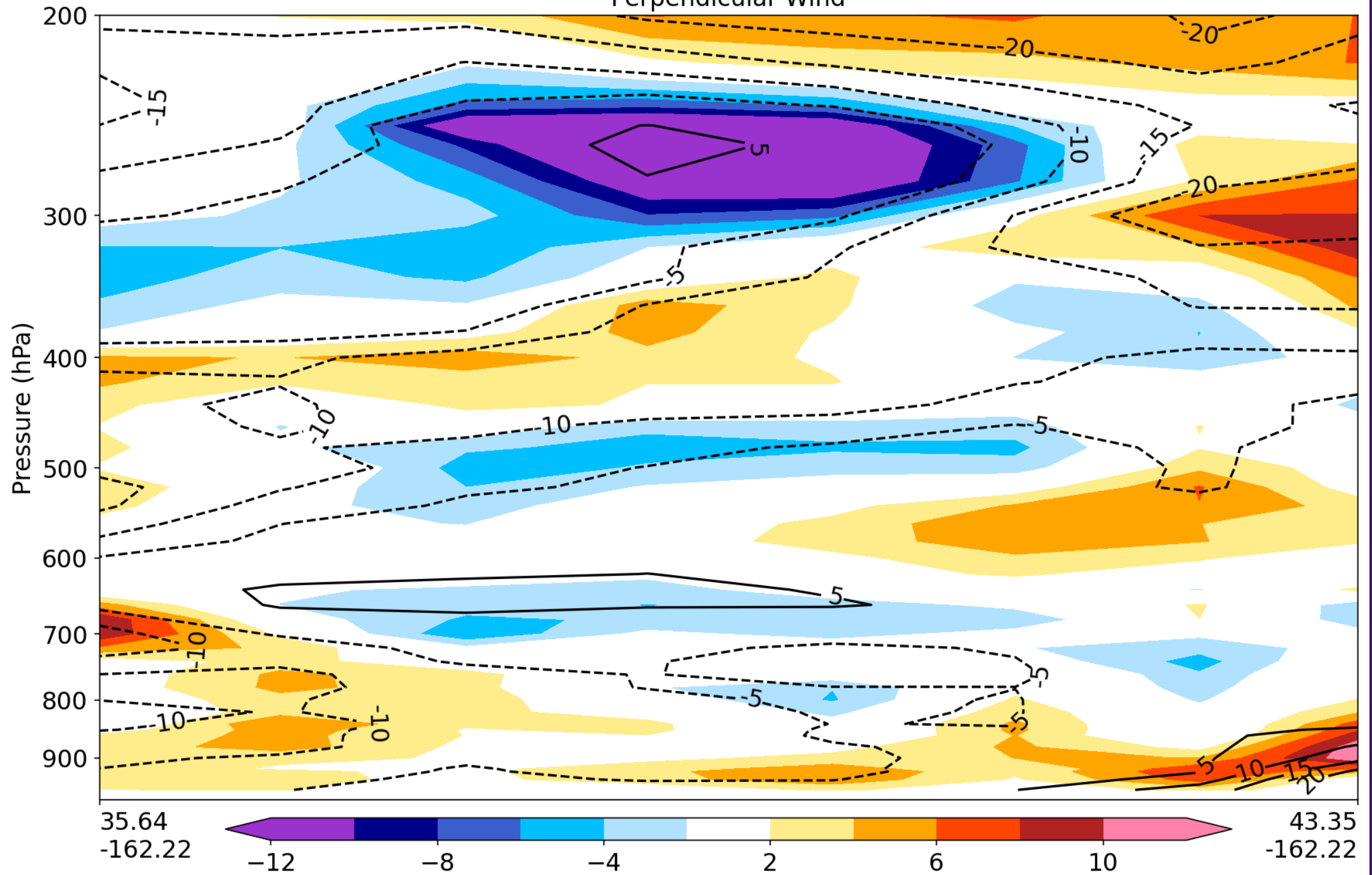
24 h forecast 250 hPa divergent wind



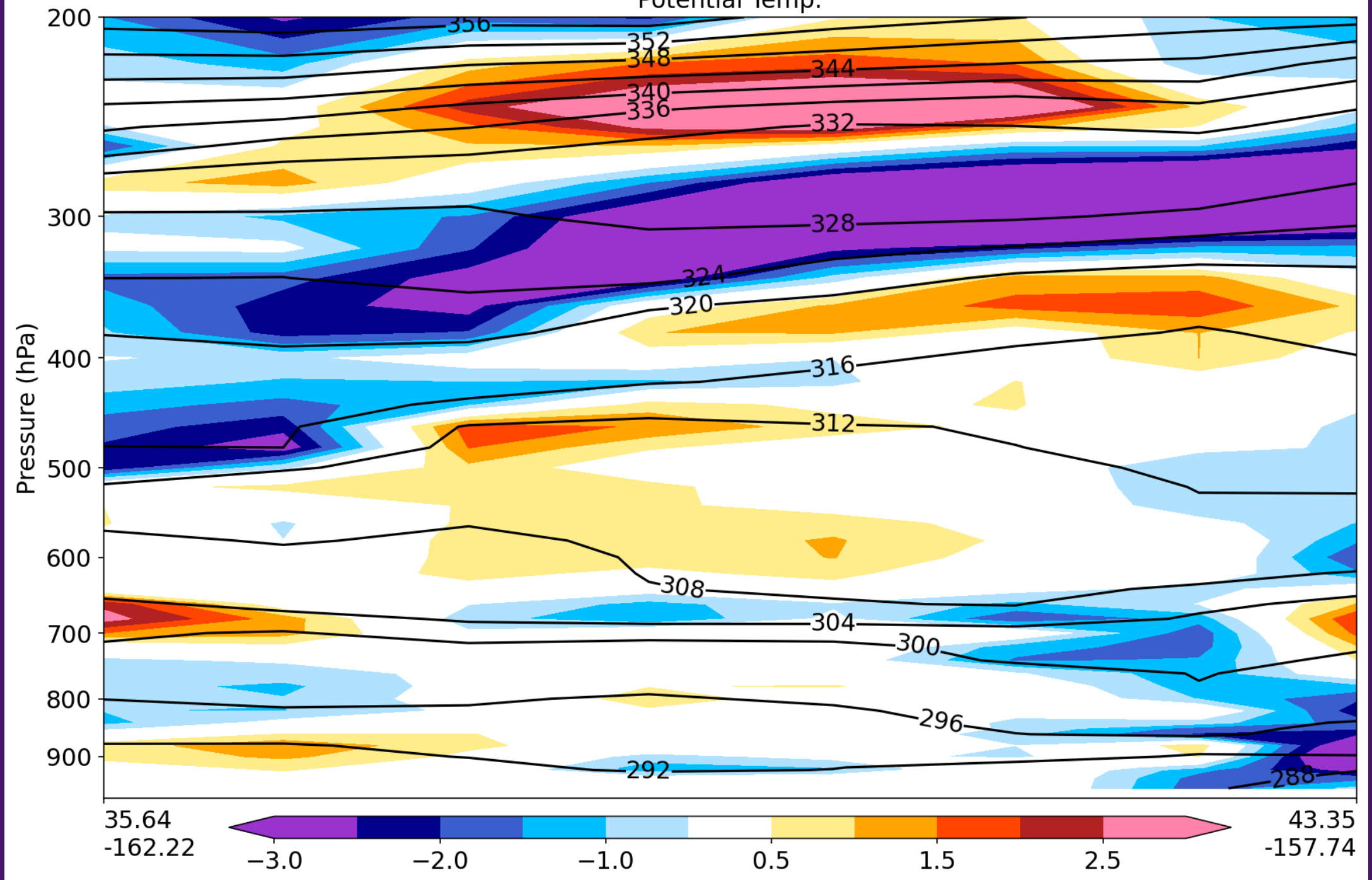
Normal Wind



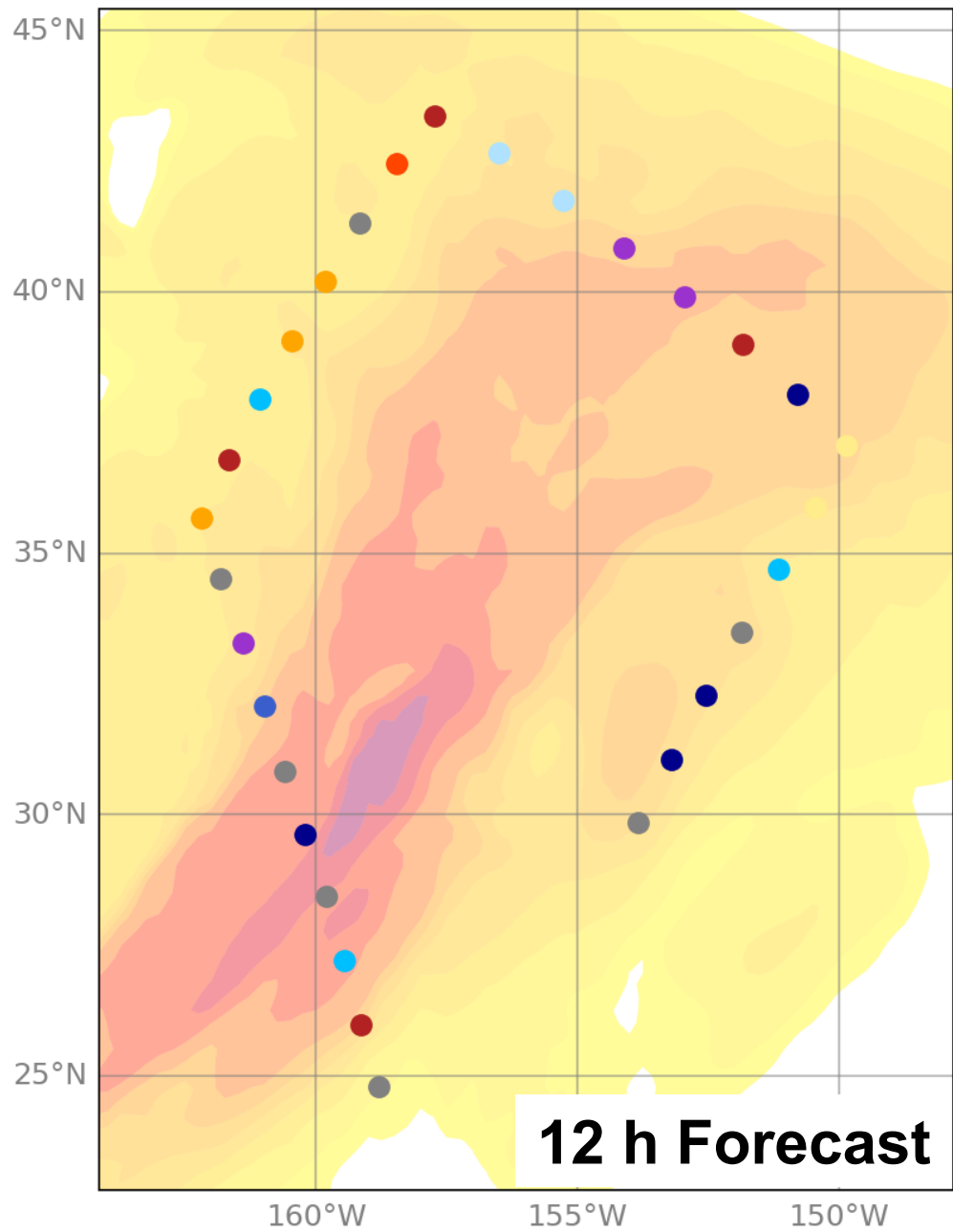
Perpendicular Wind



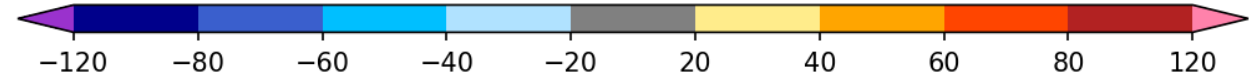
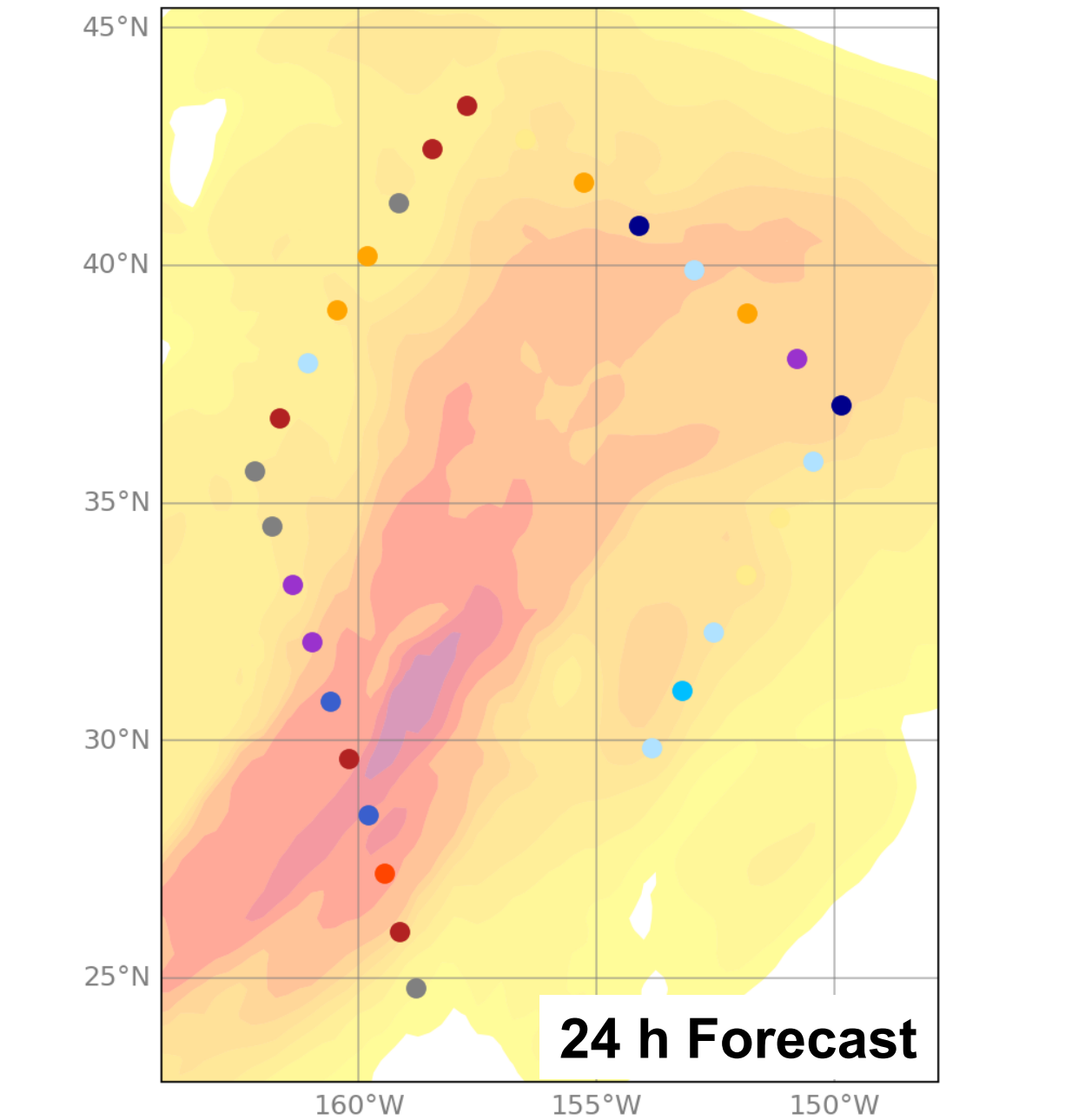
Potential Temp.



12 h forecast IVT



24 h forecast IVT

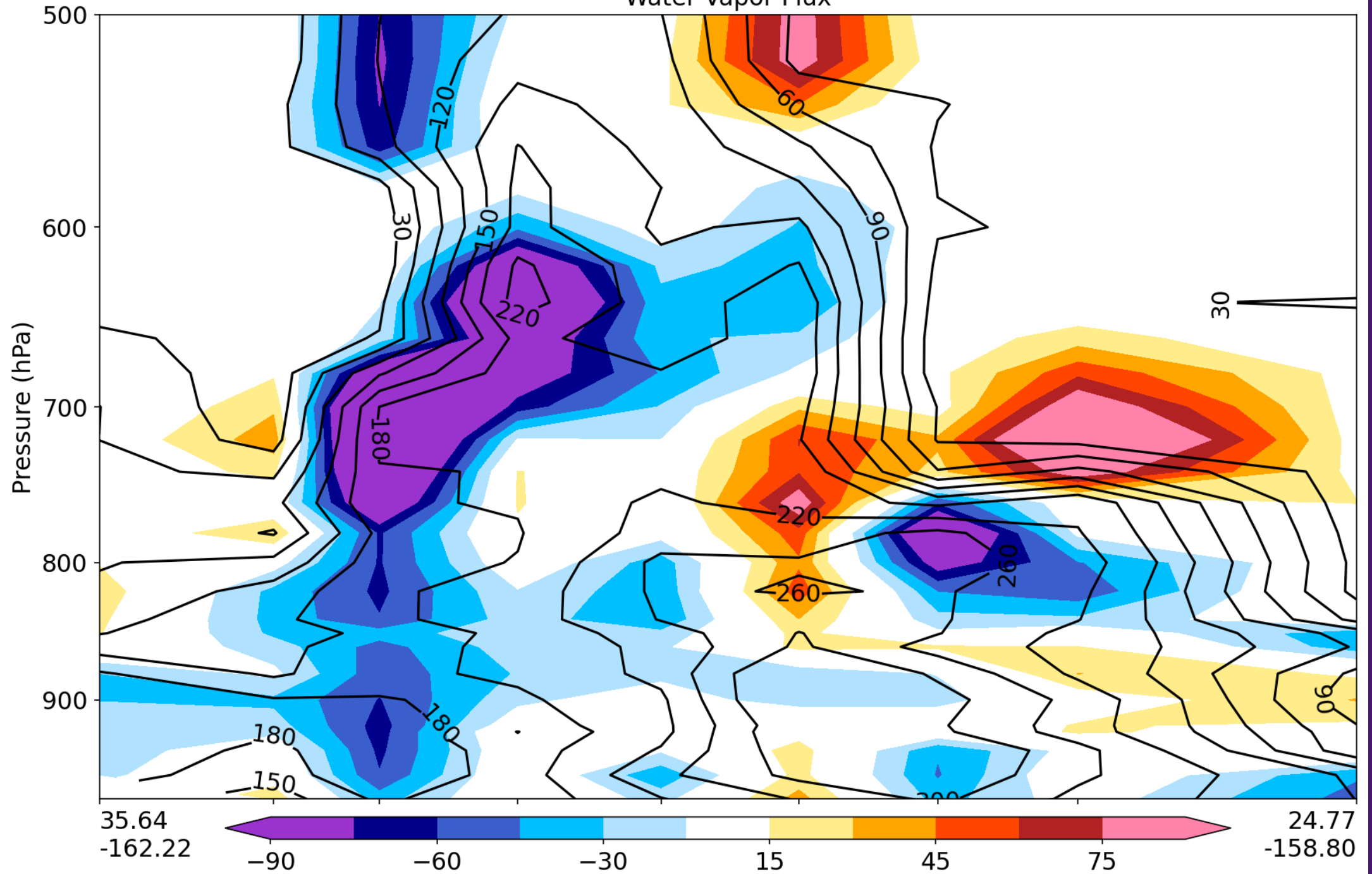


Summary

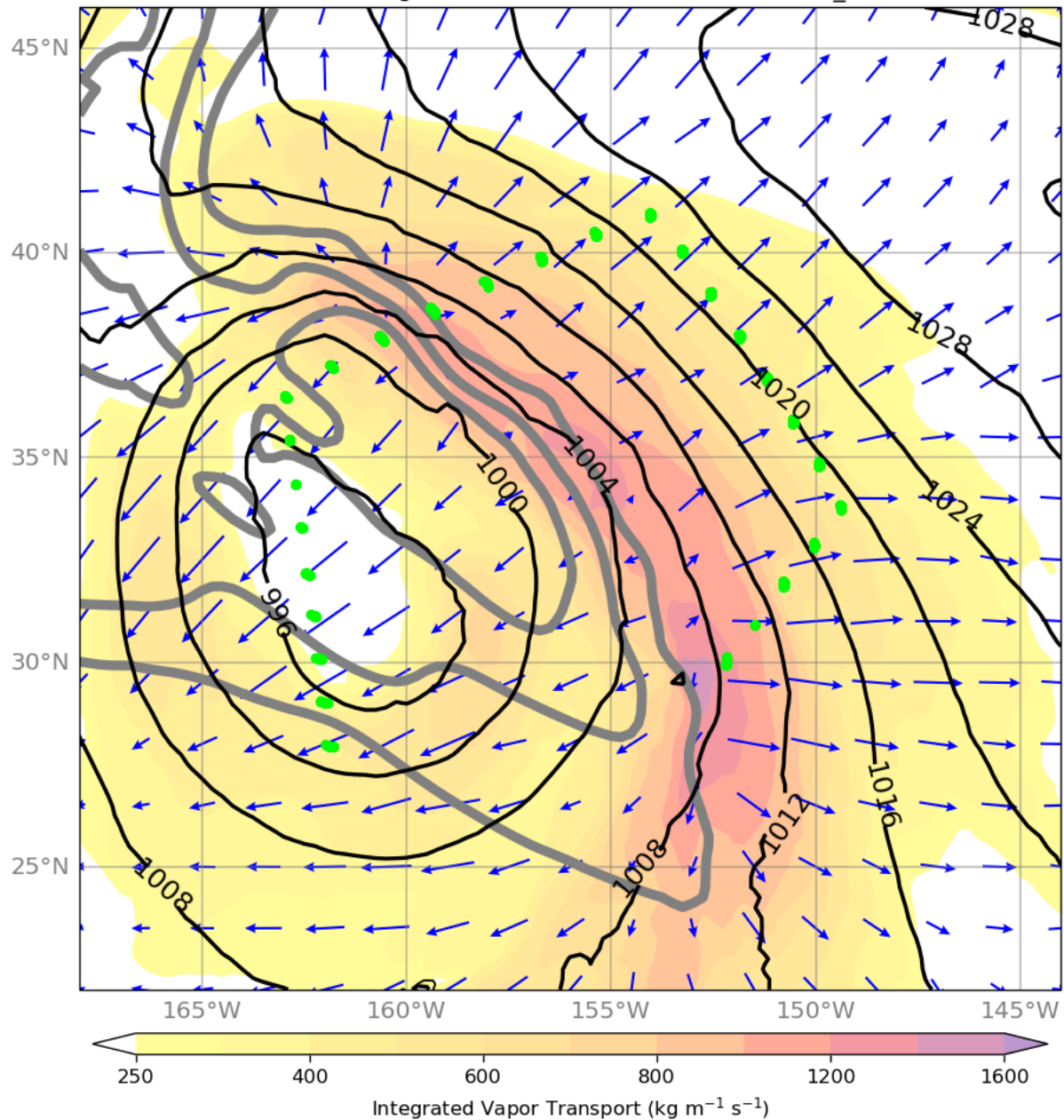
- Bulk divergence can be estimated from dropsondes collected during 4 AR Recon IOPs
- For WY2025 IOP 22, ECMWF IFS forecasts systematically underestimate upper tropospheric divergence
- Largest differences in normal wind are where divergent wind is perpendicular to flight track (i.e., near PV gradient)
- Similar results for two of three other cases
- Future Work: Evaluate potential sources of bias and how this impacts downstream forecasts

Questions/Comments: rtorn@albany.edu

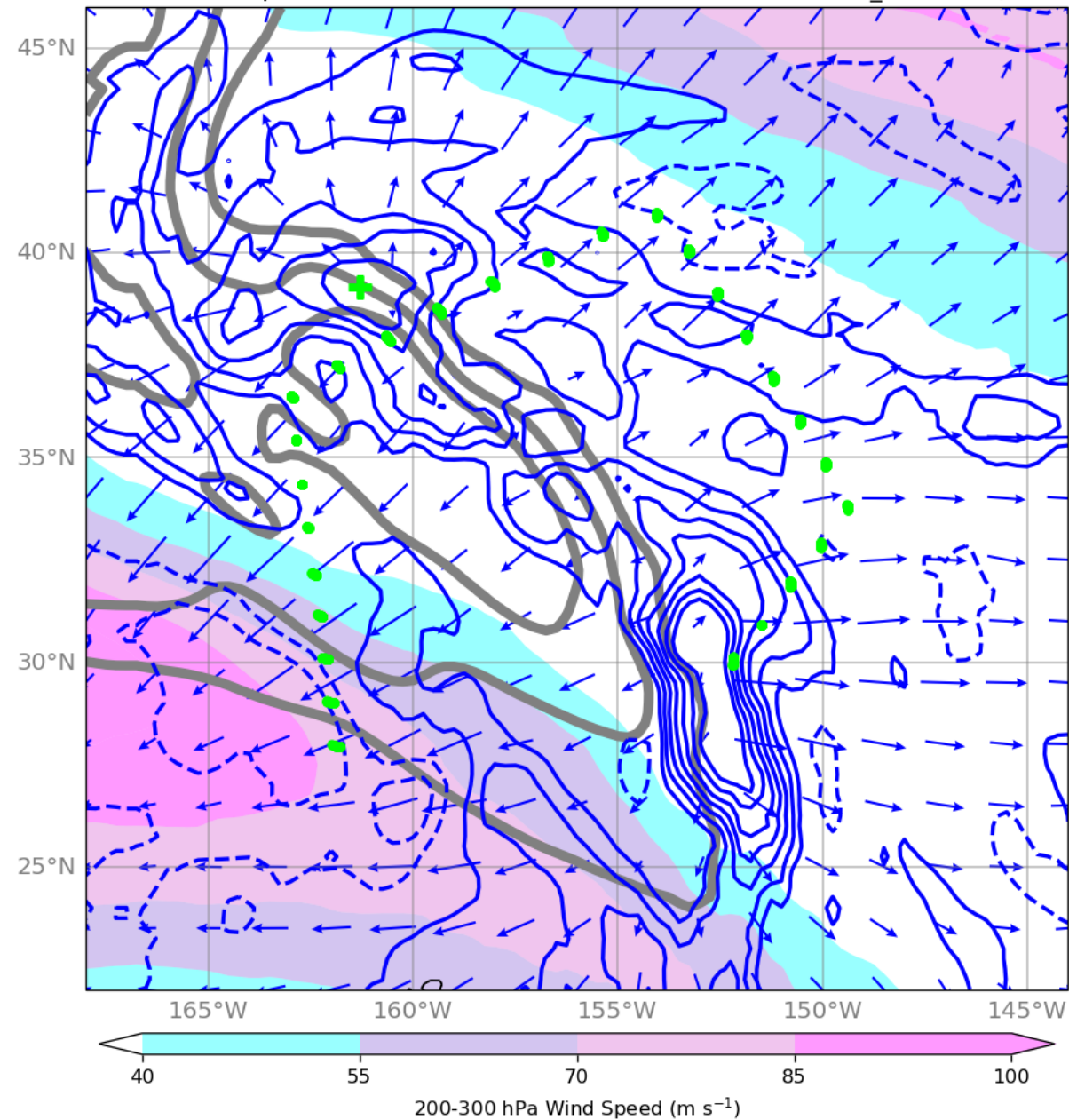
Water Vapor Flux

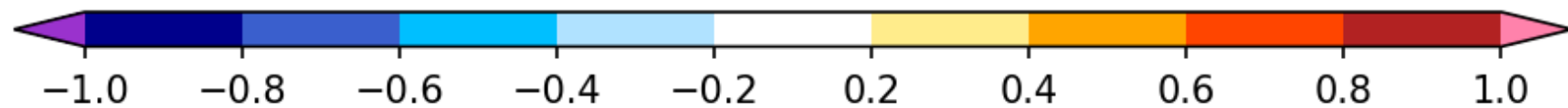
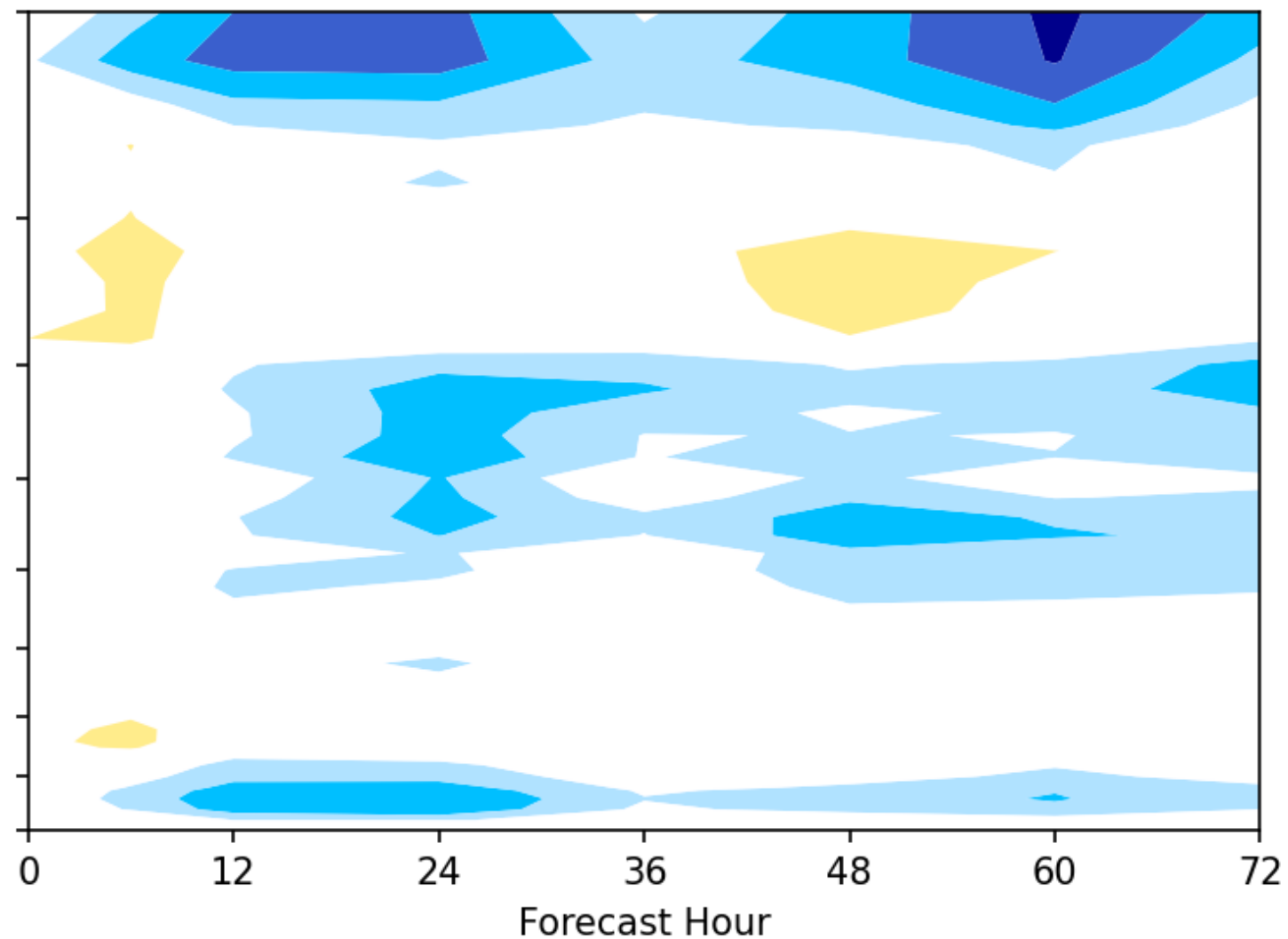
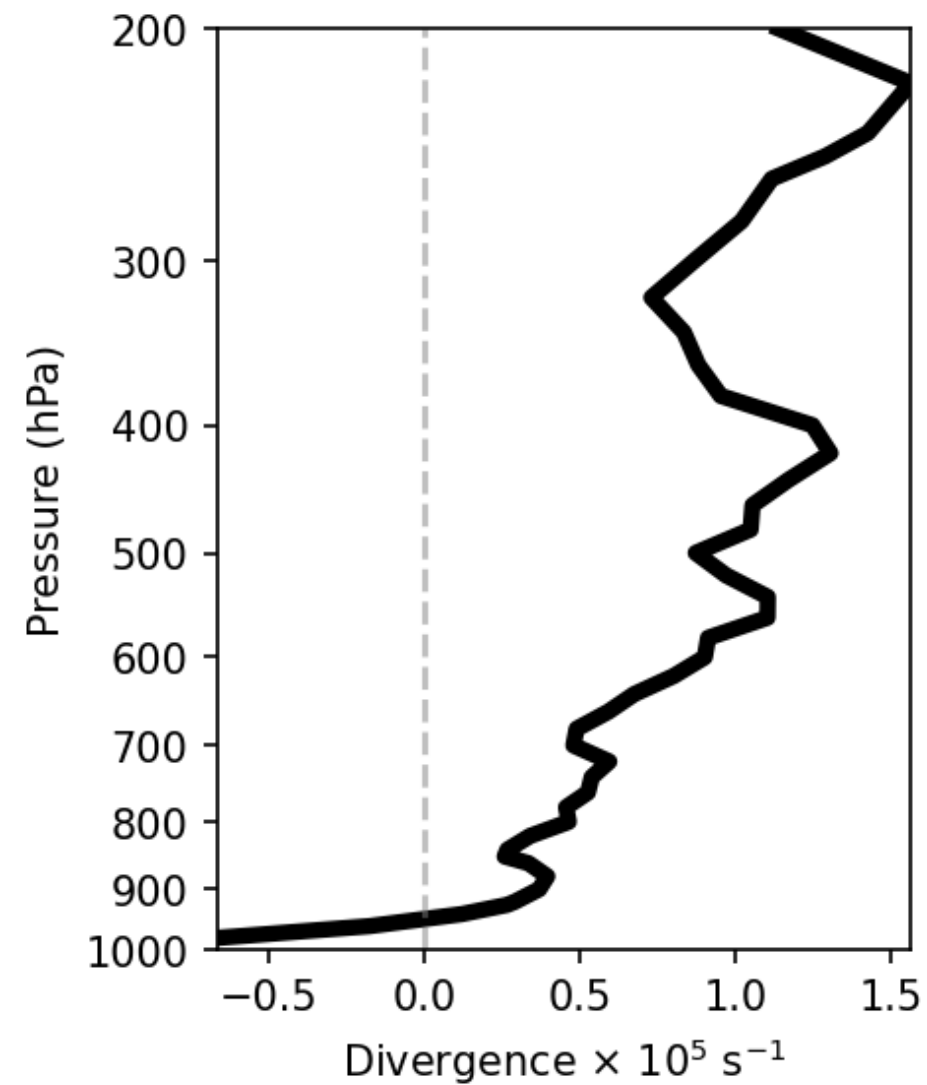


MSLP, IVT, 200-300 hPa Divergent Wind and PV, valid: 2024-01-10_00.00.00 (Hour: 000)

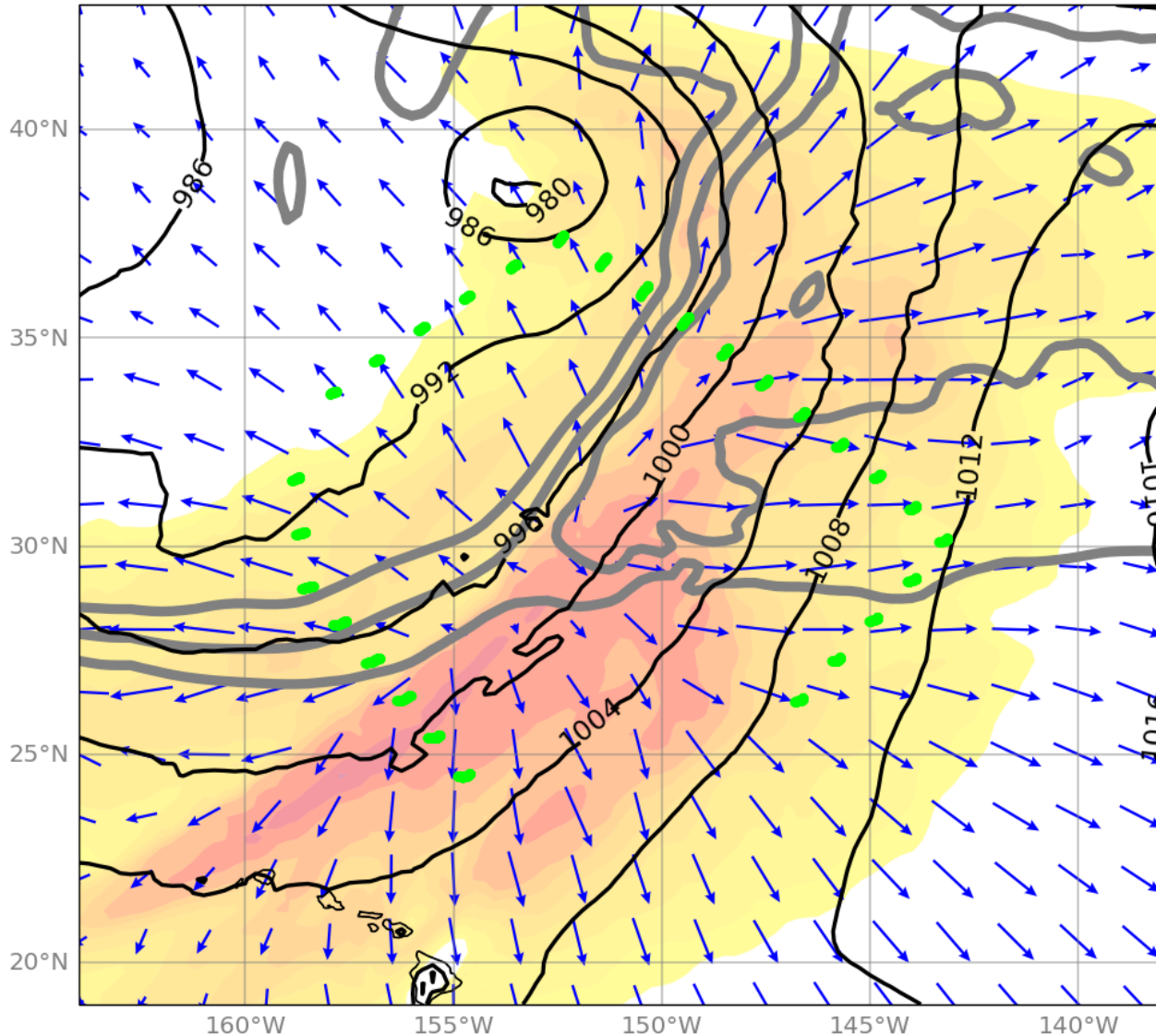


200-300 hPa Wind Speed, Diver., Diver. Wind and PV, valid: 2024-01-10_00.00.00 (Hour: 000)

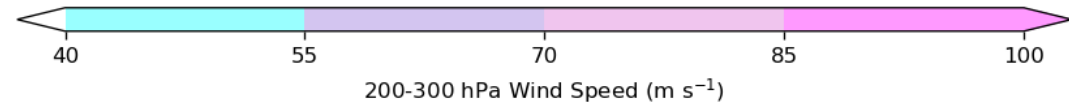
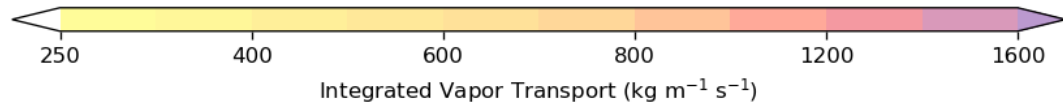
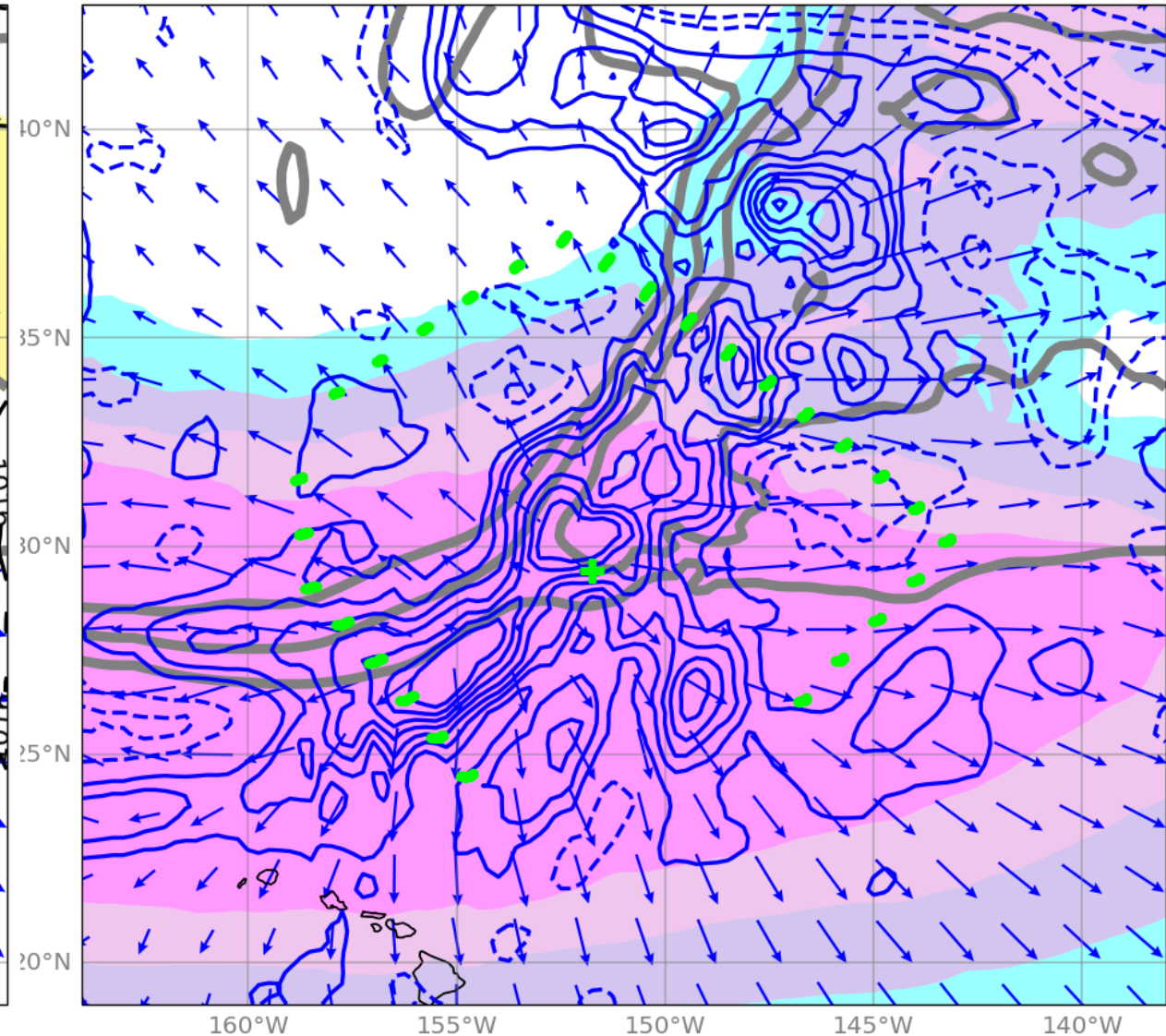


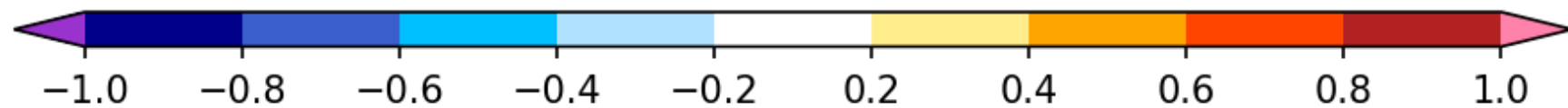
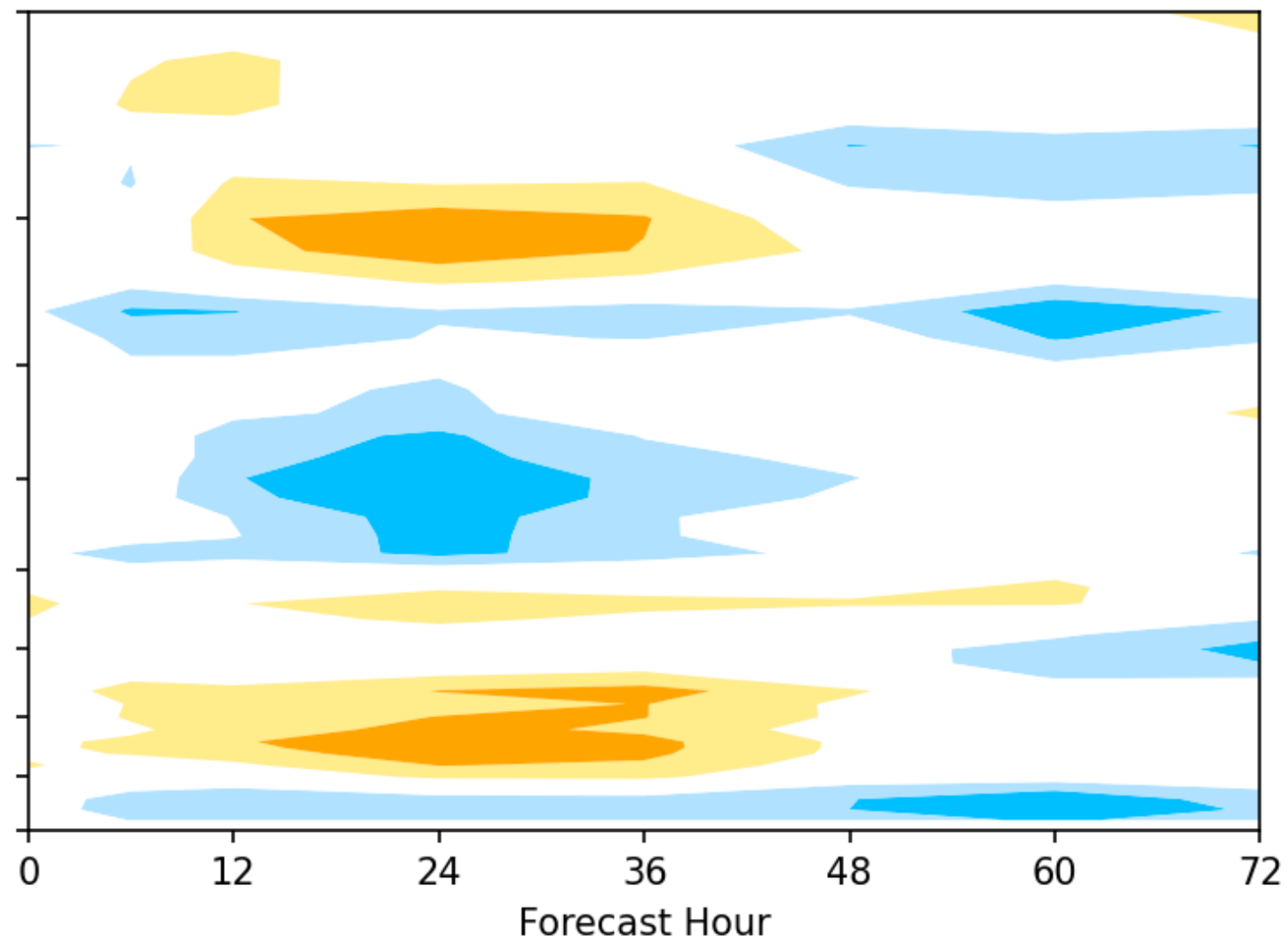
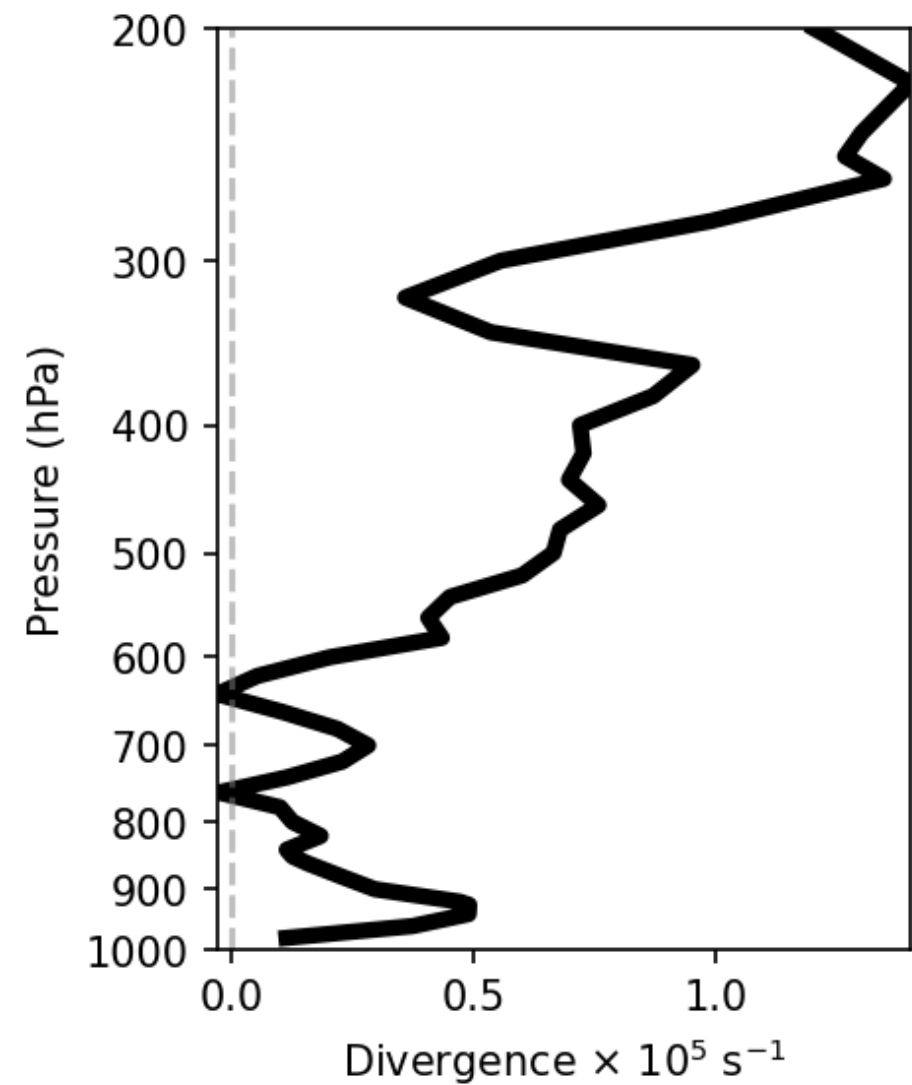


MSLP, IVT, 200-300 hPa Divergent Wind and PV, valid: 2024-01-17_00.00.00 (Hour: 000)



200-300 hPa Wind Speed, Diver., Diver. Wind and PV, valid: 2024-01-17_00.00.00 (Hour: 000)





MSLP, IVT, 200-300 hPa Divergent Wind and PV, valid: 2025-01-30_00.00.00 (Hour: 000) 200-300 hPa Wind Speed, Diver., Diver. Wind and PV, valid: 2025-01-30_00.00.00 (Hour: 000)

