

The Anti-AR of March 2026: Dynamics Leading to Extreme Heat Over the Western U.S.

Chris Davis

University of Massachusetts Amherst

Paros Center for Atmospheric Research

NSF NCAR

World Weather Research Programme (WWRP)

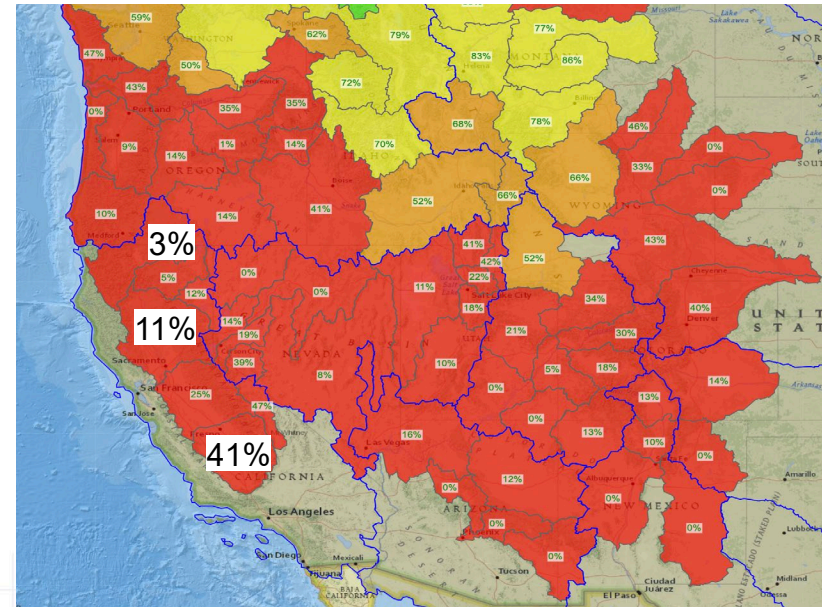
June 30, 2026

This work was supported by the California Department of Water Resources through grant 4600015671, subaward 706906

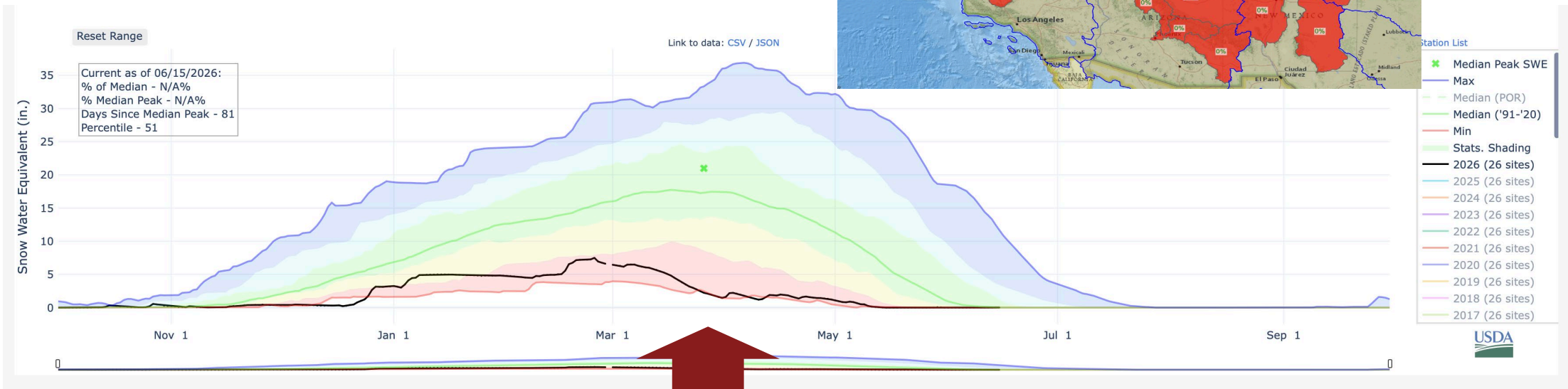
March 2026: Dry and Warm

Unprecedented
Snowpack Minima in
many Places

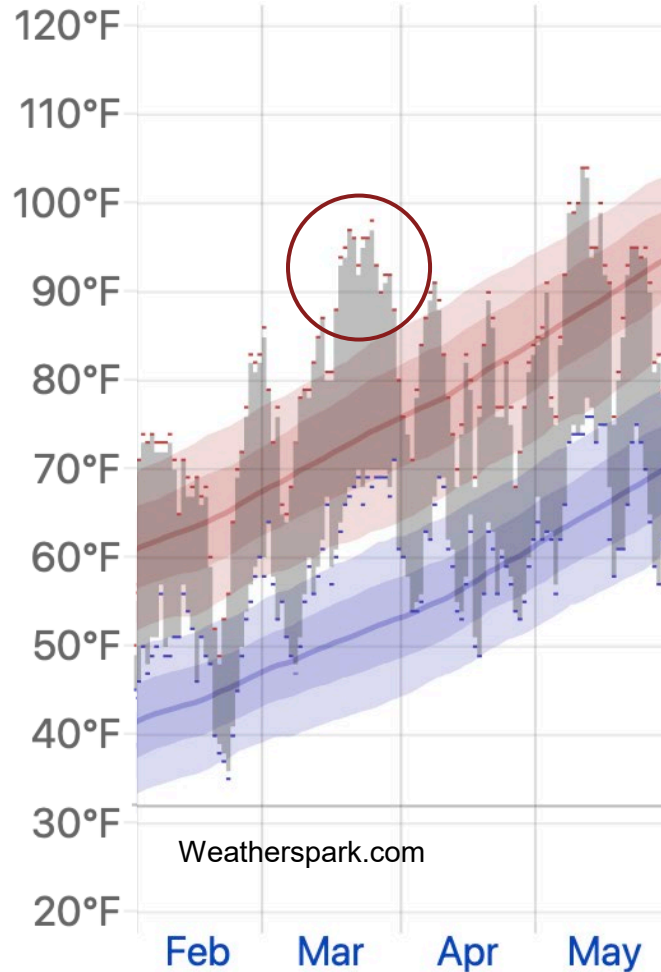
Basin Snowpack
fraction of Normal
March 28, 2026



Seasonal Evolution for 26 Sites in California

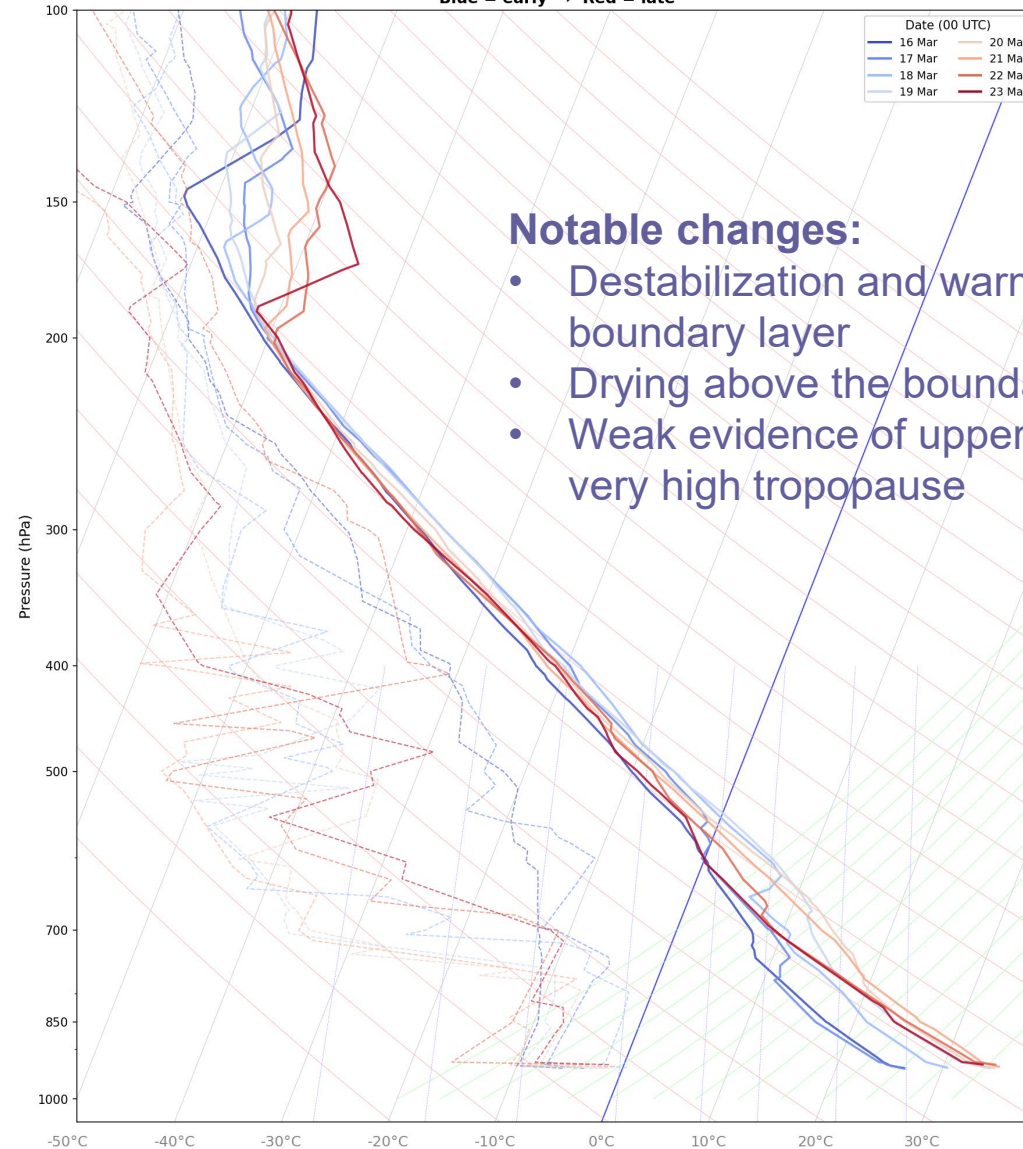


Las Vegas, Nevada: Record High Temperatures; Subtle Sounding Changes



Las Vegas, NV (VEF 72388) — All 00 UTC Soundings — March 2026

Solid = Temperature • Dashed = Dewpoint
Blue = early → Red = late



Notable changes:

- Destabilization and warming of the boundary layer
- Drying above the boundary layer
- Weak evidence of upper-level front, very high tropopause

Questions

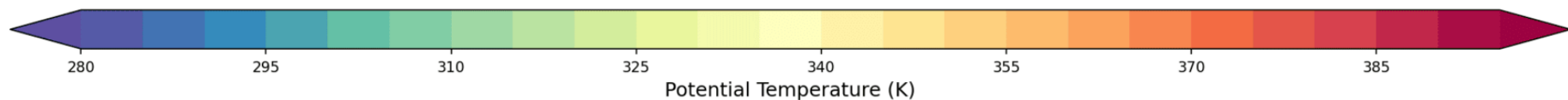
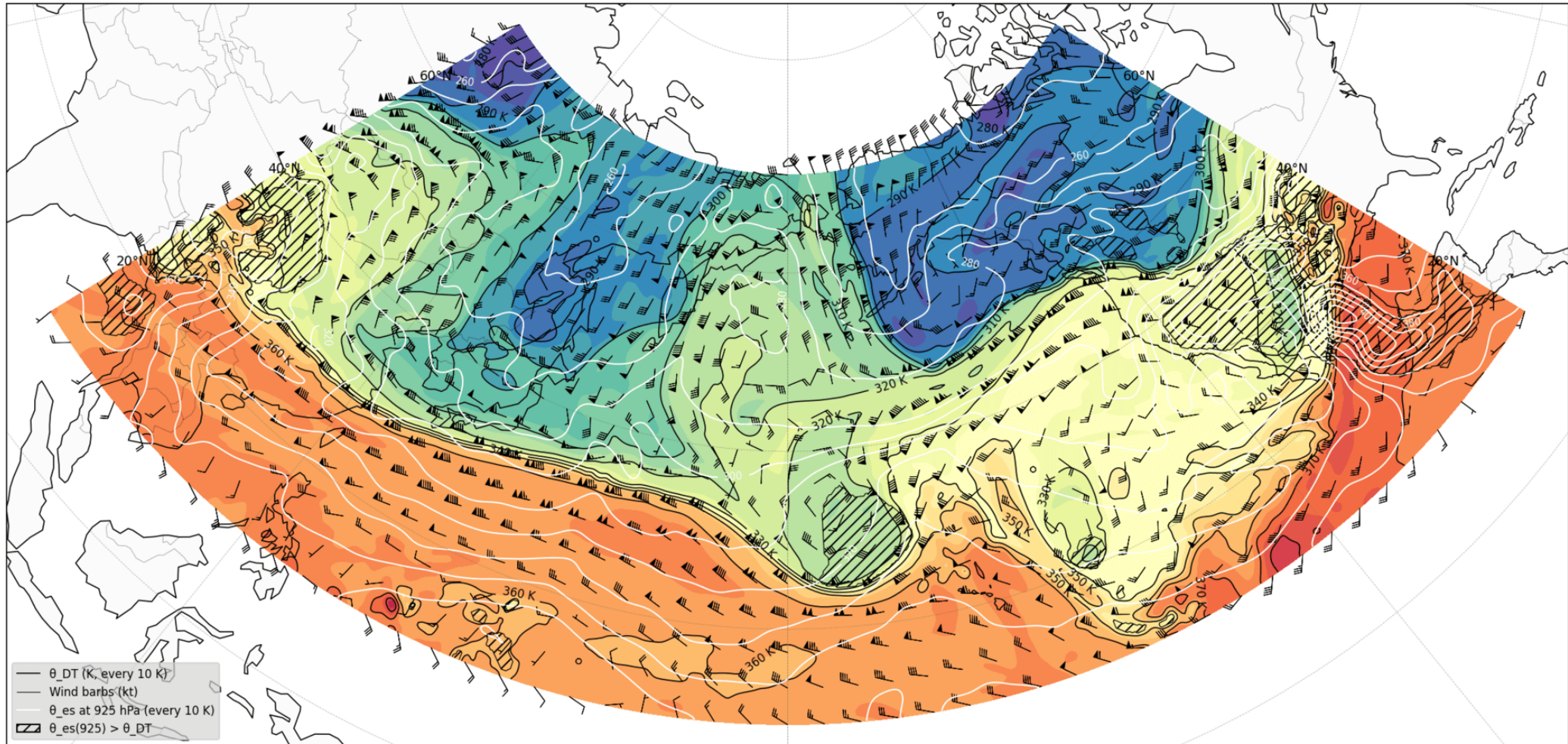
- What created the extremely warm and dry conditions?
- Did atmospheric rivers play a role?
- Can we infer the importance of diabatic processes?

Data and Methods

- ERA5 reanalysis – $\frac{1}{4}$ -degree
- NCEP operational analysis
- Field soundings
- Examine dynamic tropopause (DT) and tropospheric moist processes
 - DT maps
 - DT hovmoller diagrams

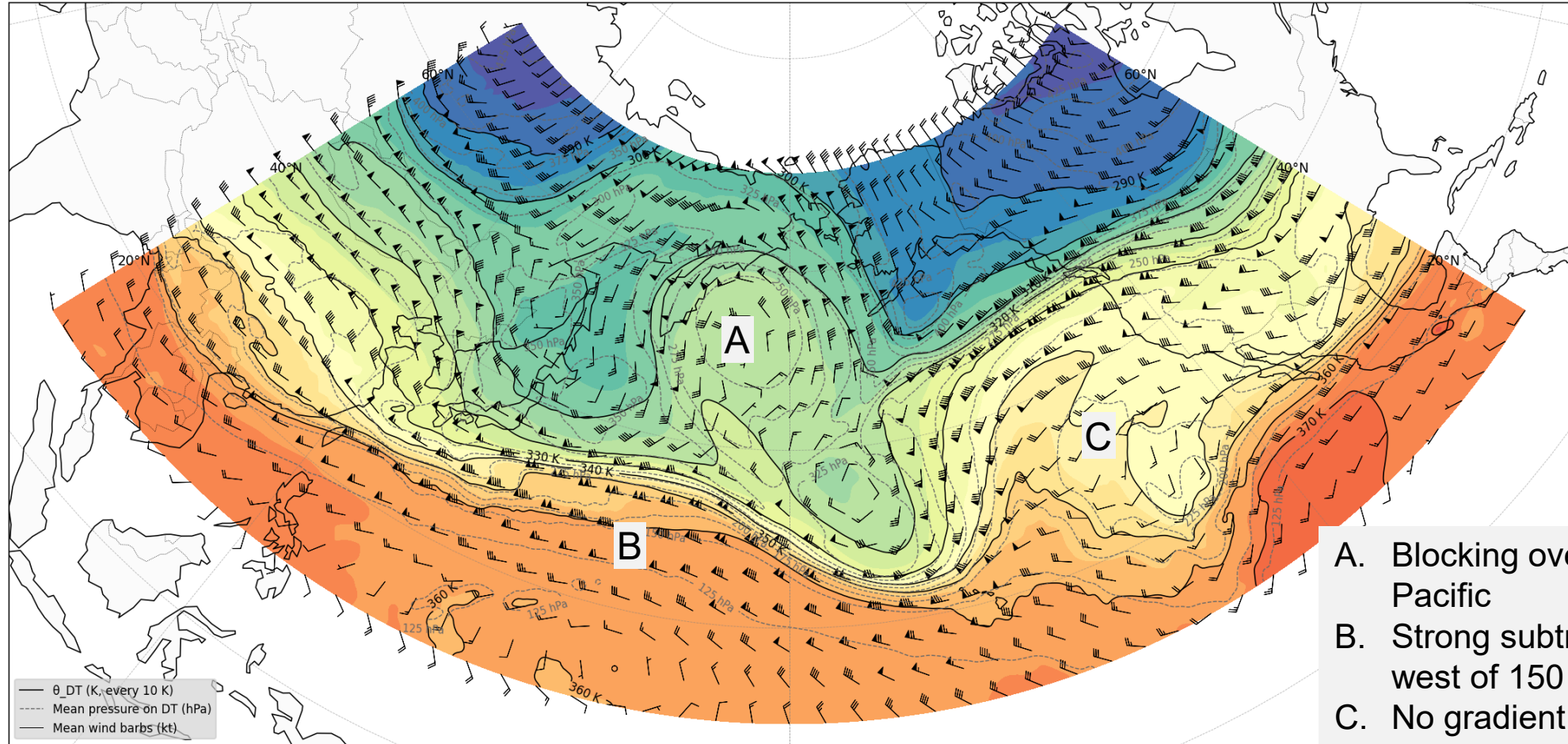
Huge Ridge Develops over the West Coast of U.S.

Potential Temperature on the Dynamic Tropopause (2 PVU)
ERA5 0.25° • ERA5 PV used directly • Valid: 2026-03-11 00:00 UTC
White = θ_{es} at 925 hPa • Barbs = wind (kt)

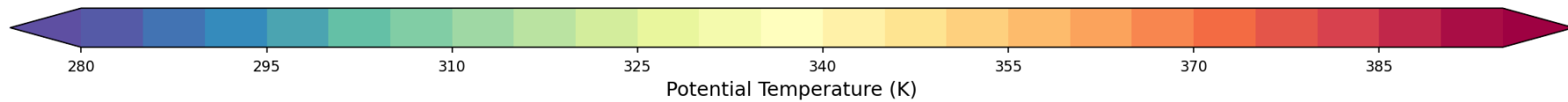


Five-day Mean Prior to the Heat Wave Onset

Time-Averaged Potential Temperature on the Dynamic Tropopause (2 PVU)
ERA5 0.25° • ERA5 PV • 41 time steps averaged
Window: 2026-03-11 00:00 to 2026-03-16 00:00 UTC
Black = θ_{DT} (K) • Gray dashed = p (hPa) • Barbs = mean wind (kt)

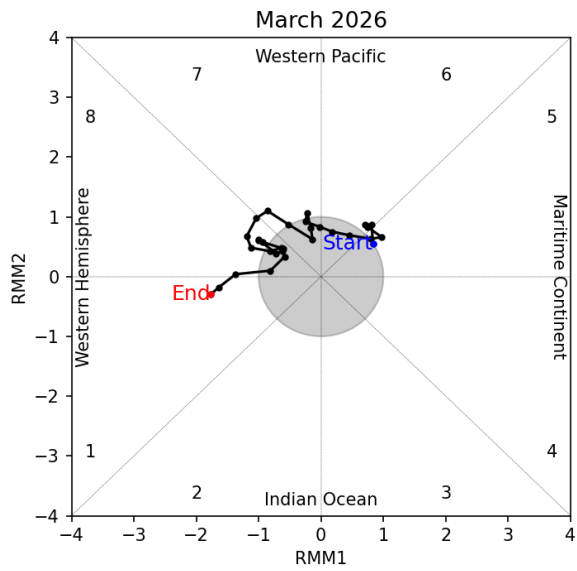
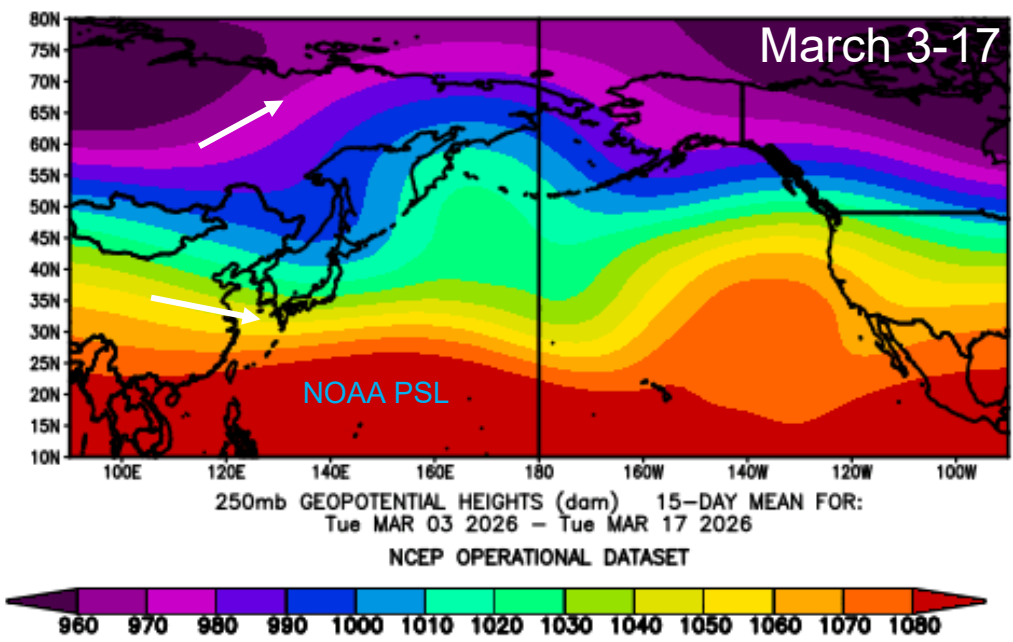
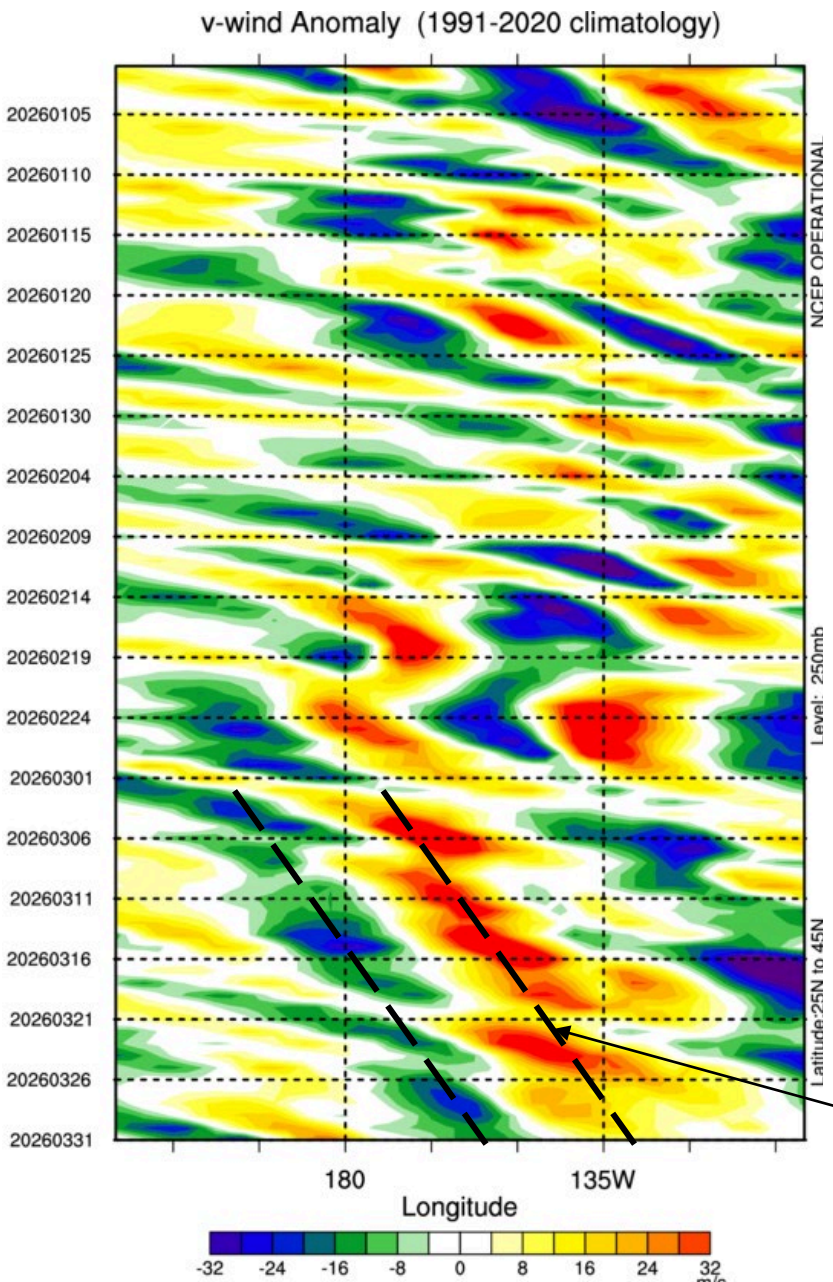


- A. Blocking over NW Pacific
- B. Strong subtropical jet west of 150 W
- C. No gradient of θ south of 45N over Eastern Pacific



Time-longitude Diagrams Show Slowly Advancing Large-scale Pattern

250 hPa
25N-45N
NOAA PSL



Relatively inactive MJO (data from BoM, Australia)

Hovmoller Diagrams on the Dynamic Tropopause Show Block Clearly

Hovmöller Diagram — Dynamic Tropopause (2 PVU)

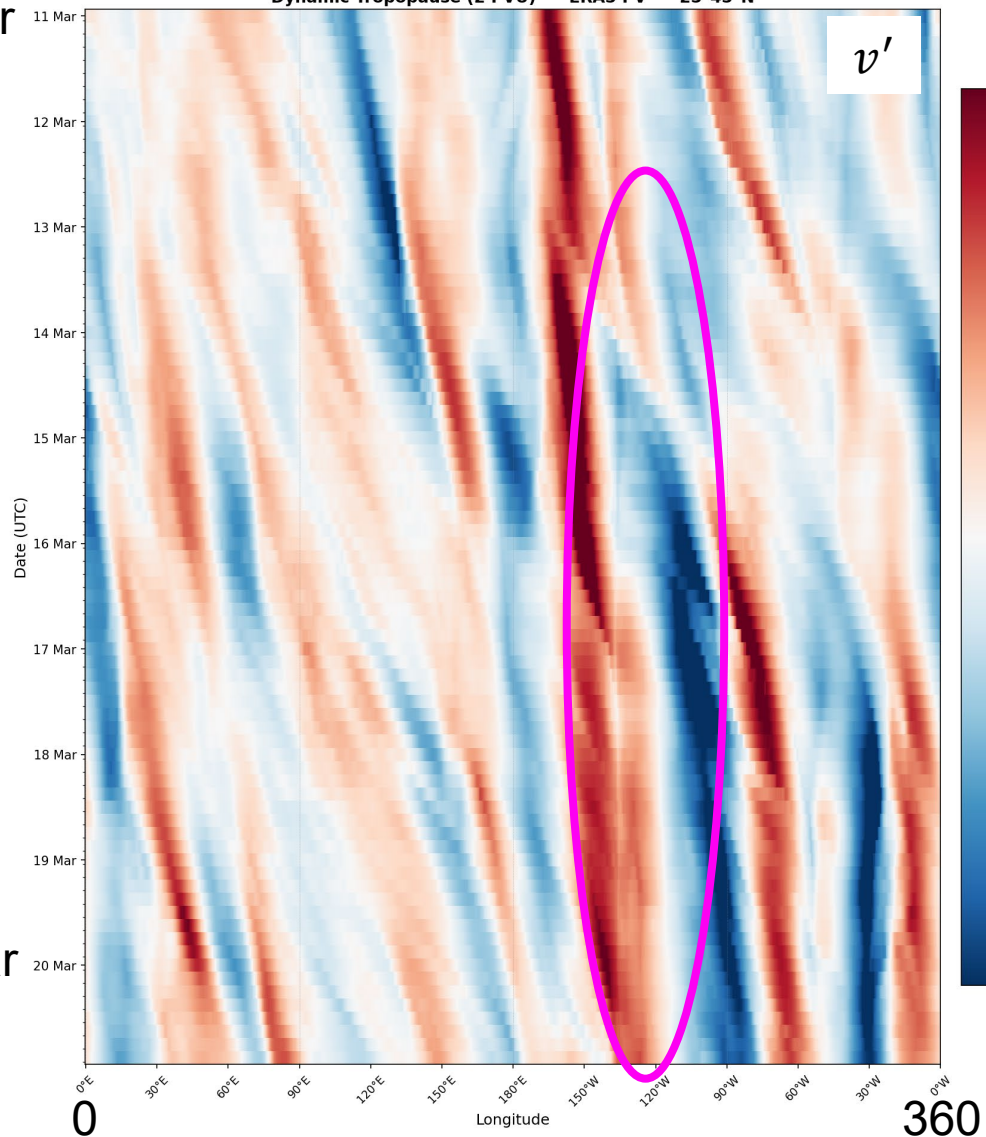
ERA5 0.25° • ERA5 PV used directly • 11 Mar 2026 to 20 Mar 2026

25-45°N cosine-weighted mean • Deviation from zonal mean • Time increases downward

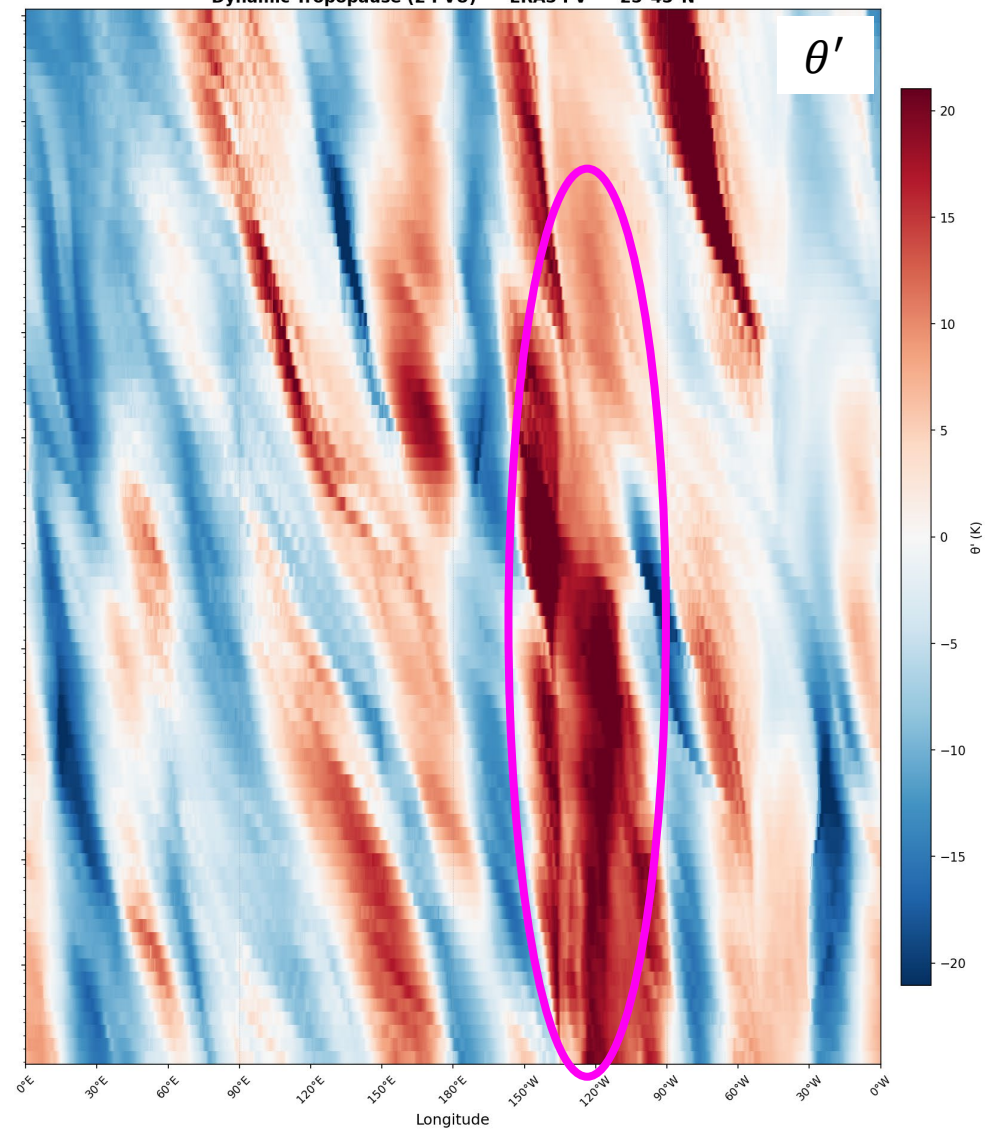
Meridional Wind Deviation from Zonal Mean
Dynamic Tropopause (2 PVU) • ERA5 PV • 25-45°N

Potential Temperature Deviation from Zonal Mean
Dynamic Tropopause (2 PVU) • ERA5 PV • 25-45°N

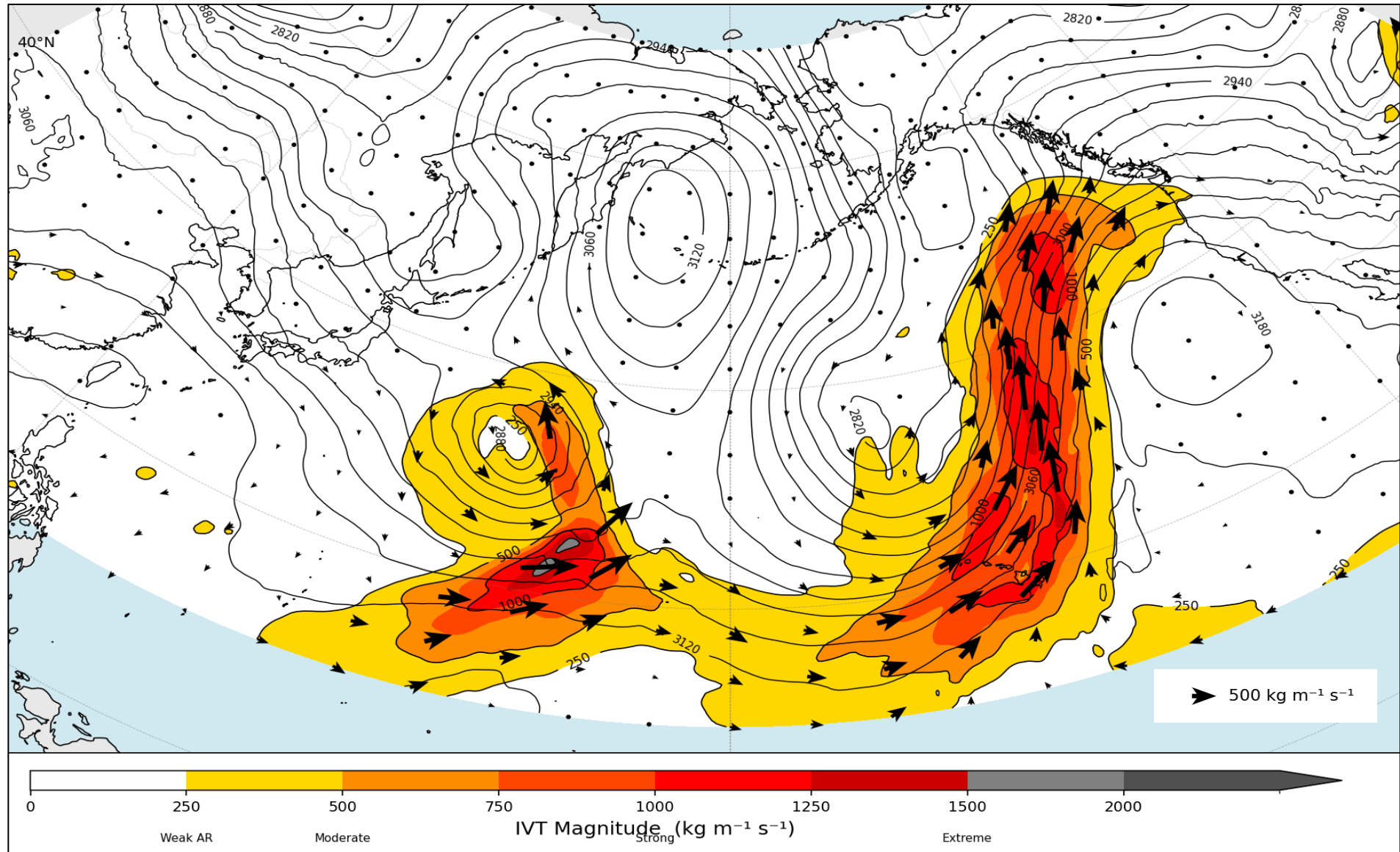
11 Mar



20 Mar

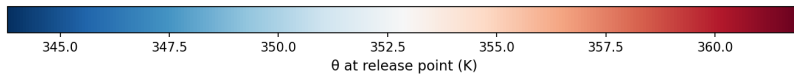
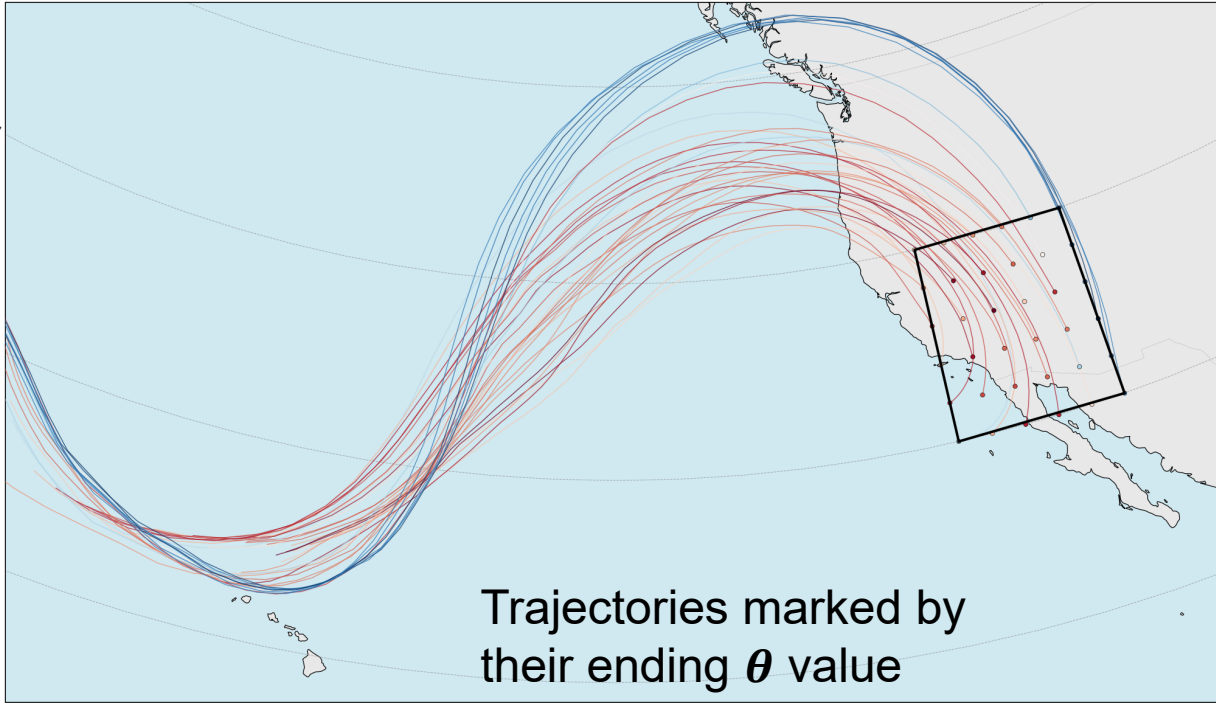


Large IVT Upstream of the Developing Ridge: Diabatic Heating?

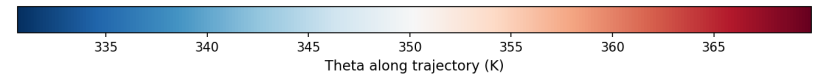
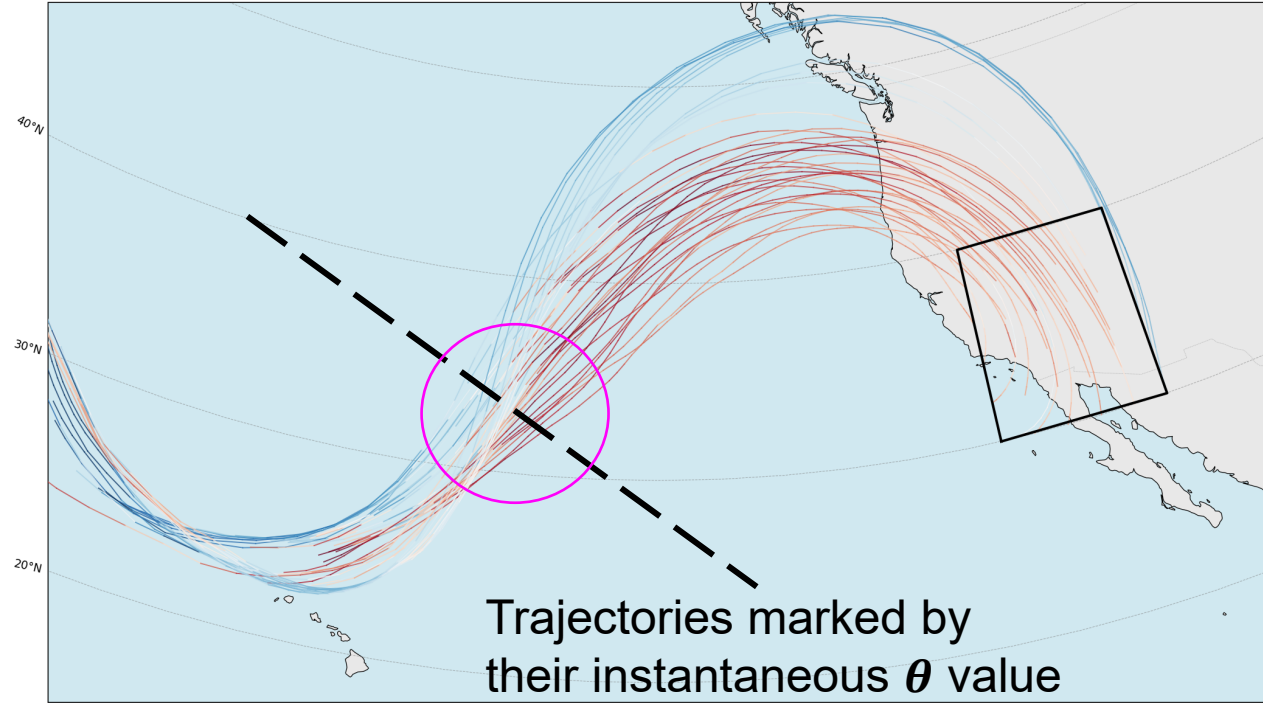


Trajectories on Dynamic Tropopause Show Evidence of PV/ θ Non-conservation

Backward Trajectories — Dynamic Tropopause (2 PVU)
Release: 17 Mar 2026 00Z • Duration: 2 days
RK4 with 1-h interpolated winds • 36 trajectories • Color = θ at release (K)



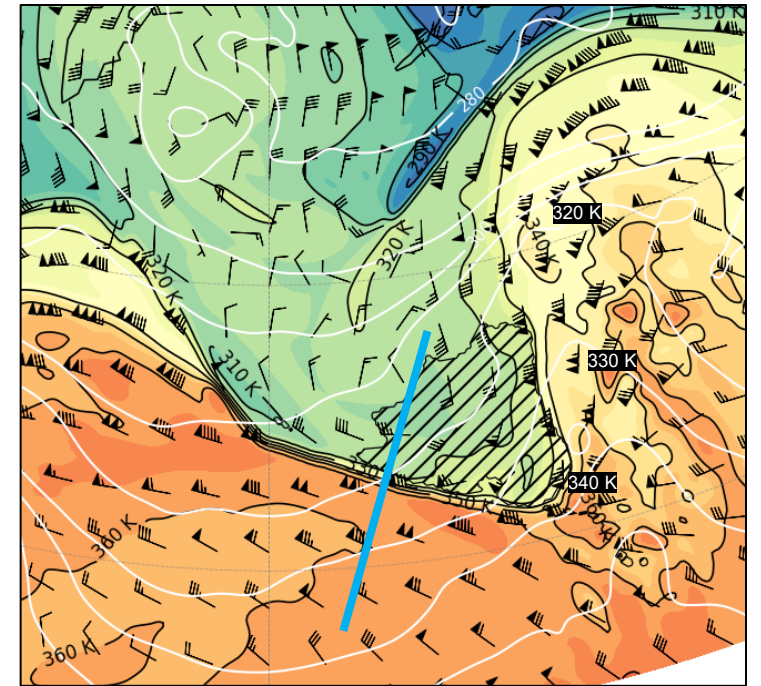
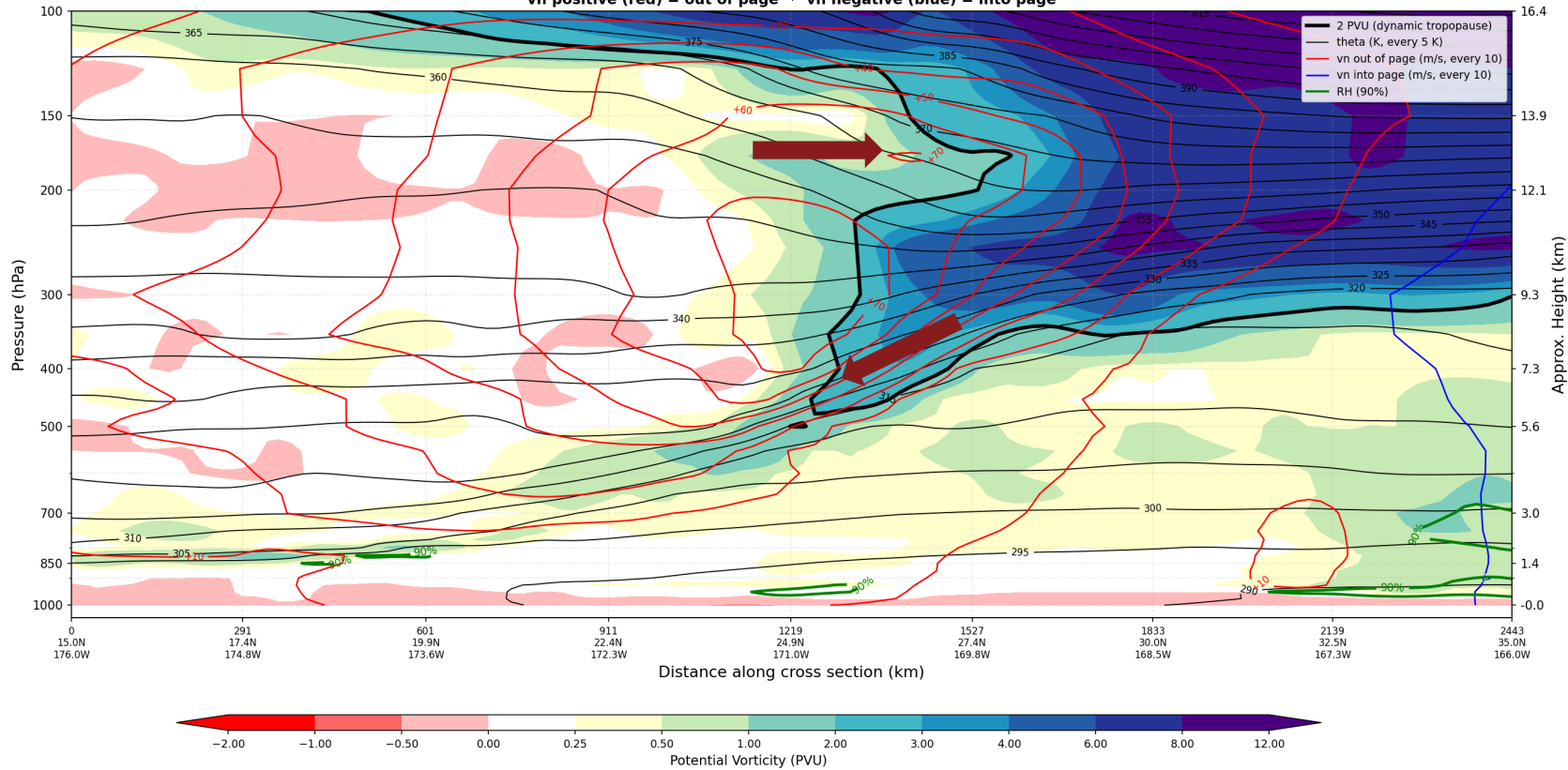
Backward Trajectories — Dynamic Tropopause (2 PVU)
Release: 17 Mar 2026 00Z • Duration: 2 days
Color = theta along trajectory (K)



Cross Section Through Northwesterly Jet

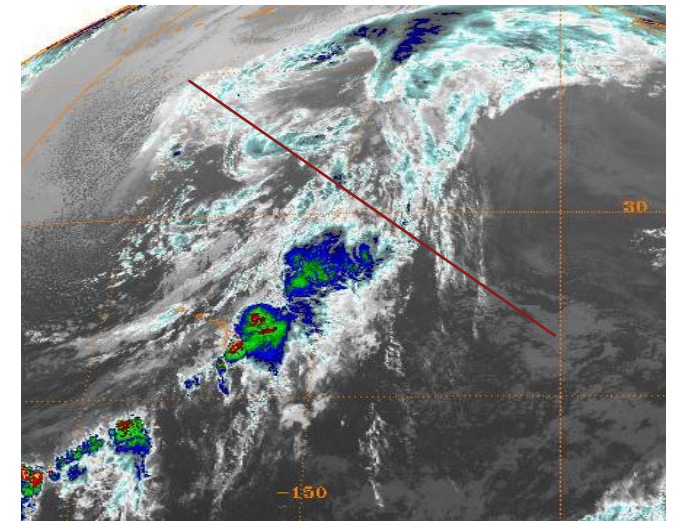
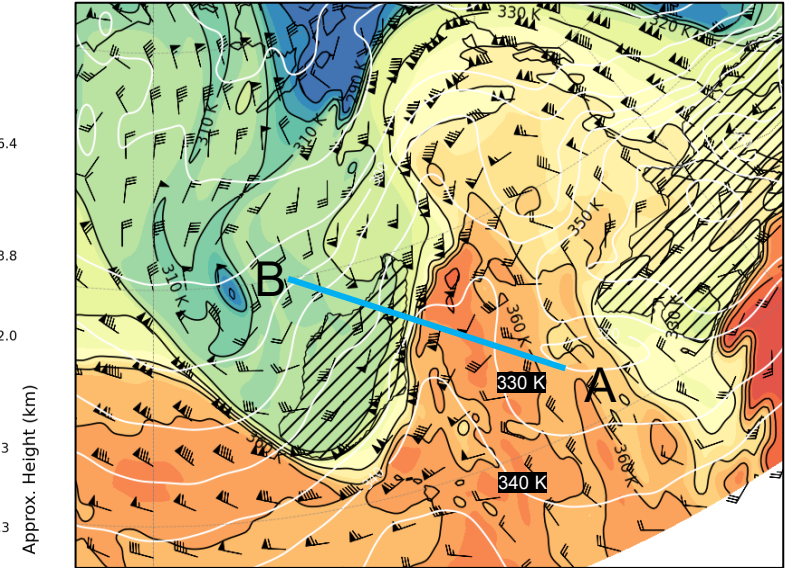
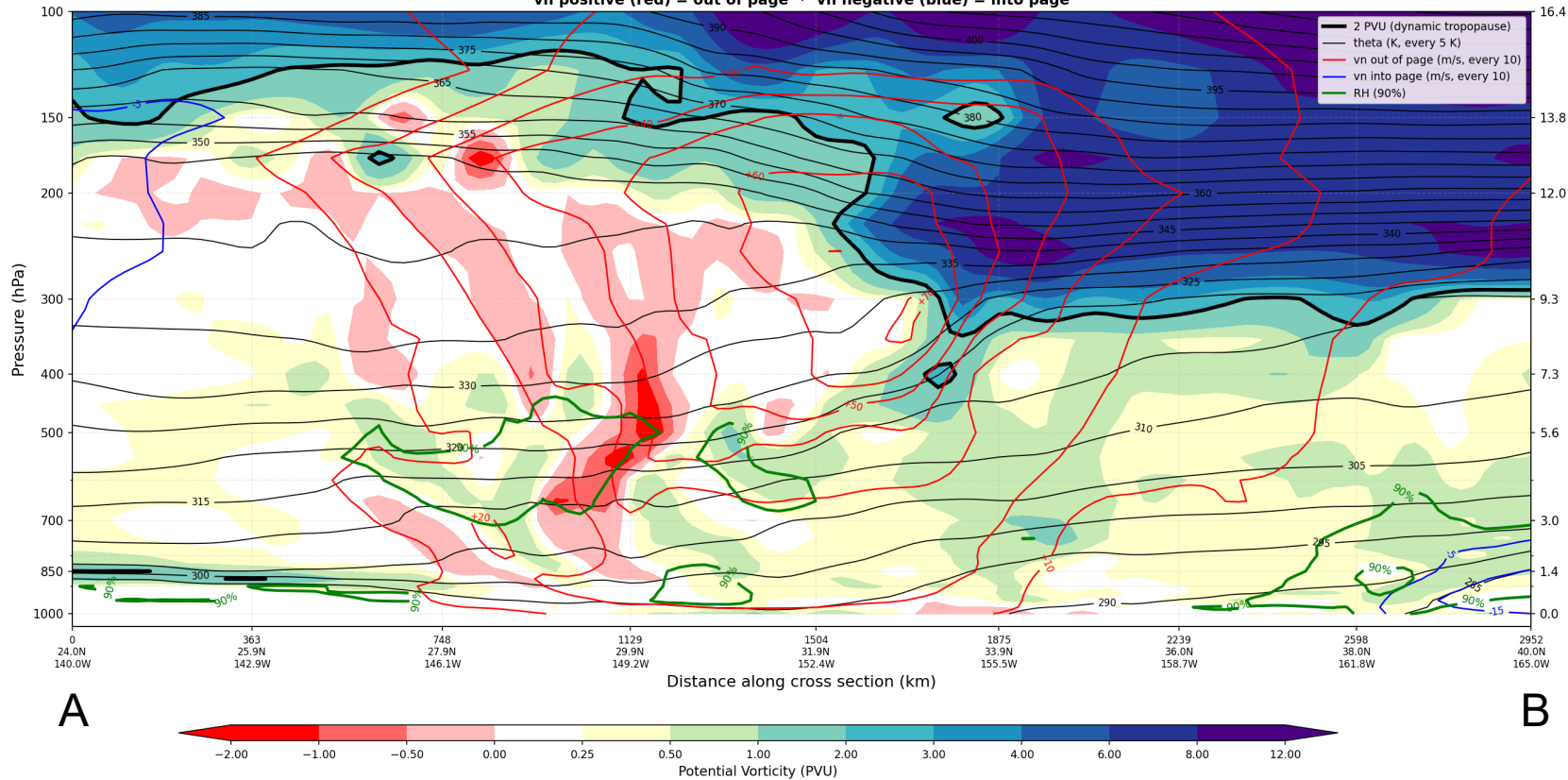
Multi-valued dynamic tropopause

Vertical Cross Section * ERA5 0.25 deg * ERA5 PV used directly * 2026-03-14 12:00 UTC
 Left: (15.0N, 176.0W) -> Right: (35.0N, 166.0W) [2443 km, 24 deg from north] * Normal avg: 200 km, 9 strips
 vn positive (red) = out of page * vn negative (blue) = into page



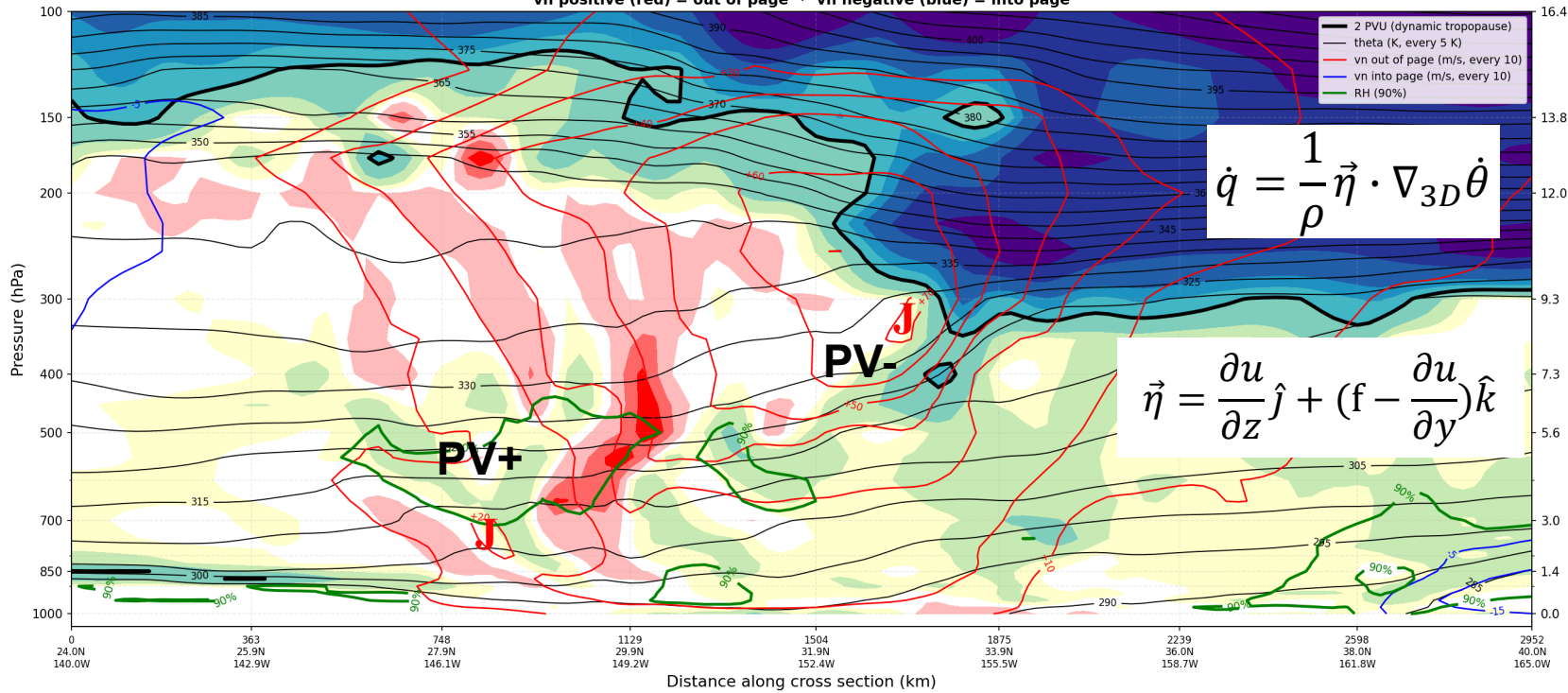
Cross Section Through AR, Region of Non-conservation of PV

Vertical Cross Section * ERA5 0.25 deg * ERA5 PV used directly * 2026-03-15 12:00 UTC
 Left: (24.0N, 140.0W) -> Right: (40.0N, 165.0W) [2952 km, -53 deg from north] * Normal avg: 200 km, 9 strips
 vn positive (red) = out of page * vn negative (blue) = into page



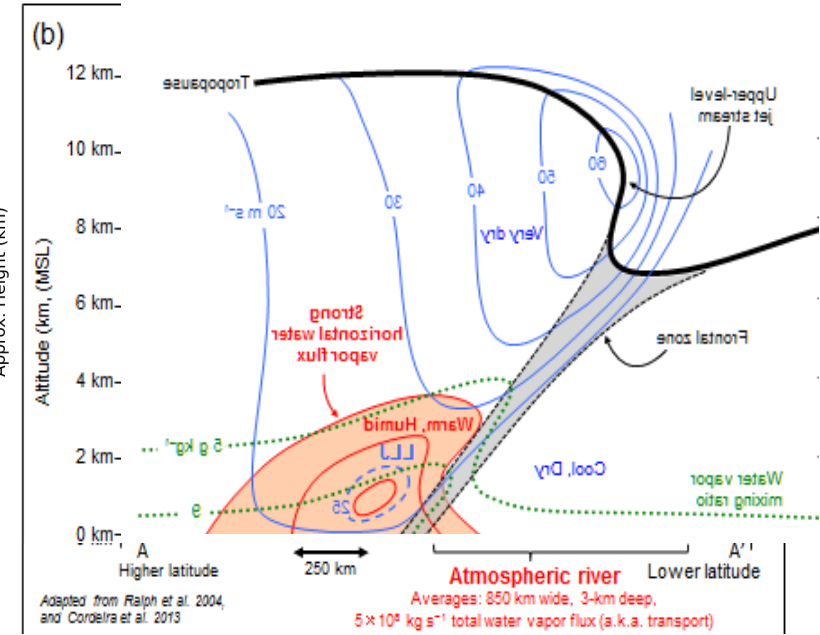
Cross Section Through AR, Region of Non-conservation of PV

Vertical Cross Section * ERA5 0.25 deg * ERA5 PV used directly * 2026-03-15 12:00 UTC
 Left: (24.0N, 140.0W) -> Right: (40.0N, 165.0W) [2952 km, -53 deg from north] * Normal avg: 200 km, 9 strips
 vn positive (red) = out of page * vn negative (blue) = into page



$$\dot{q} = \frac{1}{\rho} \vec{\eta} \cdot \nabla_{3D} \theta$$

$$\vec{\eta} = \frac{\partial u}{\partial z} \hat{j} + (f - \frac{\partial u}{\partial y}) \hat{k}$$



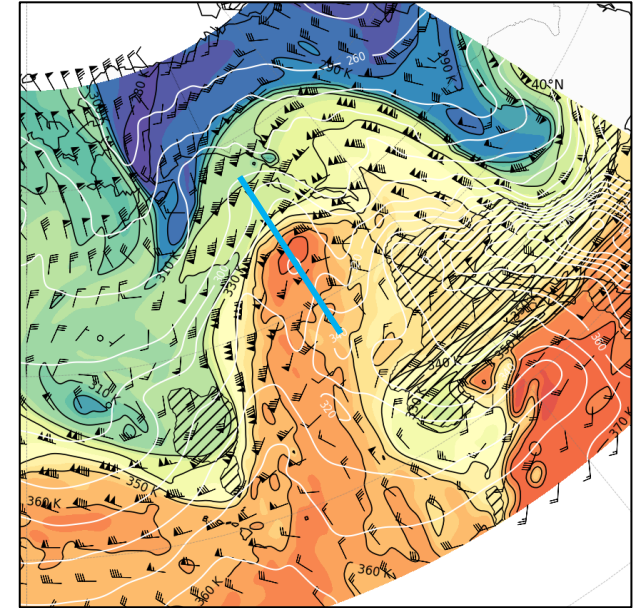
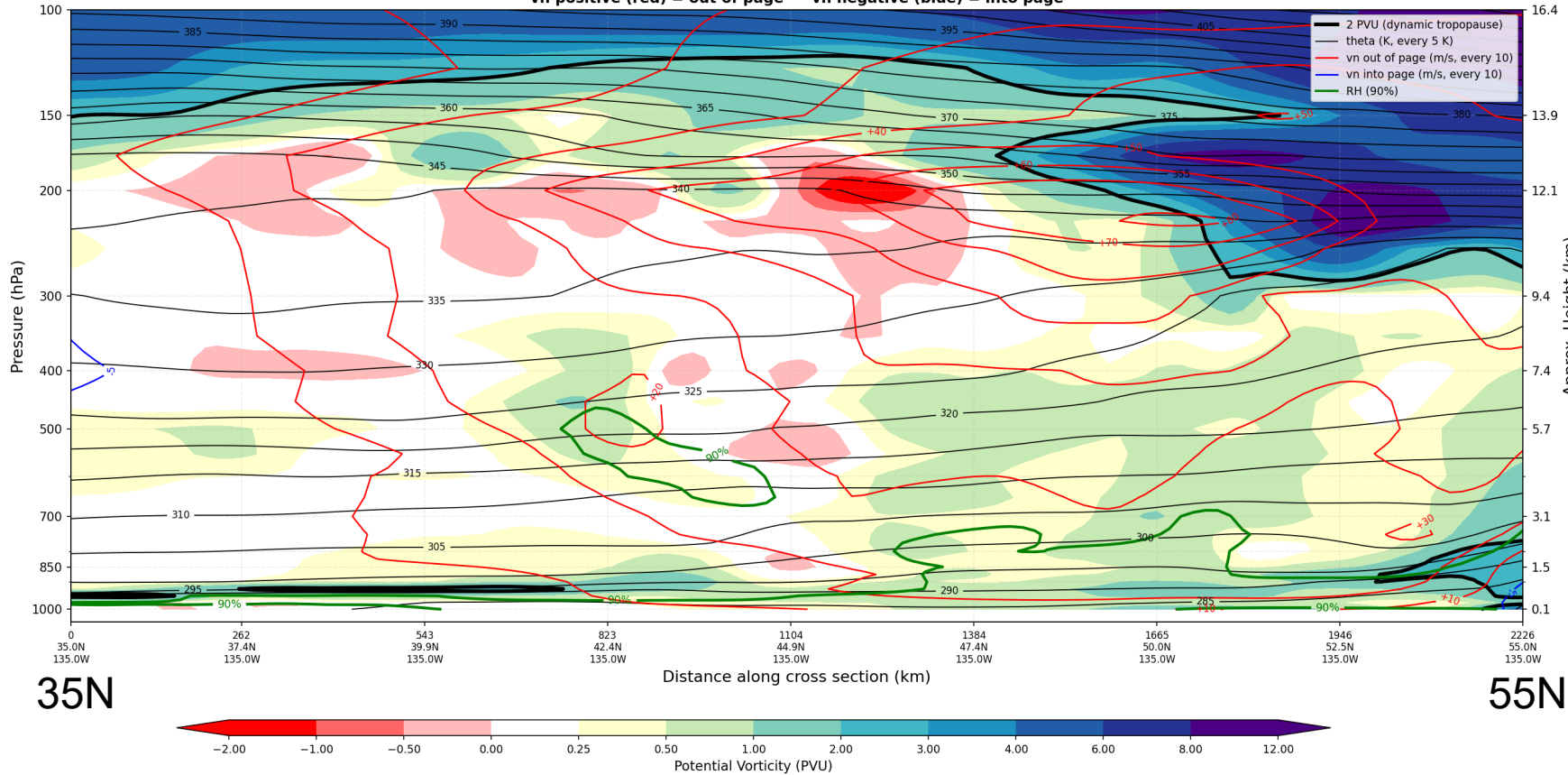
$$f - \frac{\partial u}{\partial y} \sim 0.00003$$

θ decreases

$$\frac{\partial u}{\partial z} \sim 0.01 \text{ s}^{-1}$$

Weak Temperature Gradients Remain in Ridge: Dynamic Tropopause Remains Very High

Vertical Cross Section * ERA5 0.25 deg * ERA5 PV used directly * 2026-03-16 00:00 UTC
 Left: (35.0N, 135.0W) -> Right: (55.0N, 135.0W) [2226 km, 0 deg from north] * Normal avg: 200 km, 9 strips
 vn positive (red) = out of page * vn negative (blue) = into page



Summary

- Local "cause": quasi-persistent blocking anticyclone over the Western US for most of March, reinforced by impinging eddies
- "Upstream" influence blocking anticyclone in NW Pacific (Omega block at times)
 - Created anomalously strong subtropical jet
 - Link between simultaneous blocking events is unclear
- High values of Theta on DT are NOT due to condensation heating directly.
 - PV within upper-level frontal zone is reduced; High DT "emerges"
 - Tropospheric PV homogenized
 - Dynamic tropopause remains very high