Predictability and Dynamics of Rossby Wave Packets: A first link

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Predictability of Rossby Wave Packets (RWPs)

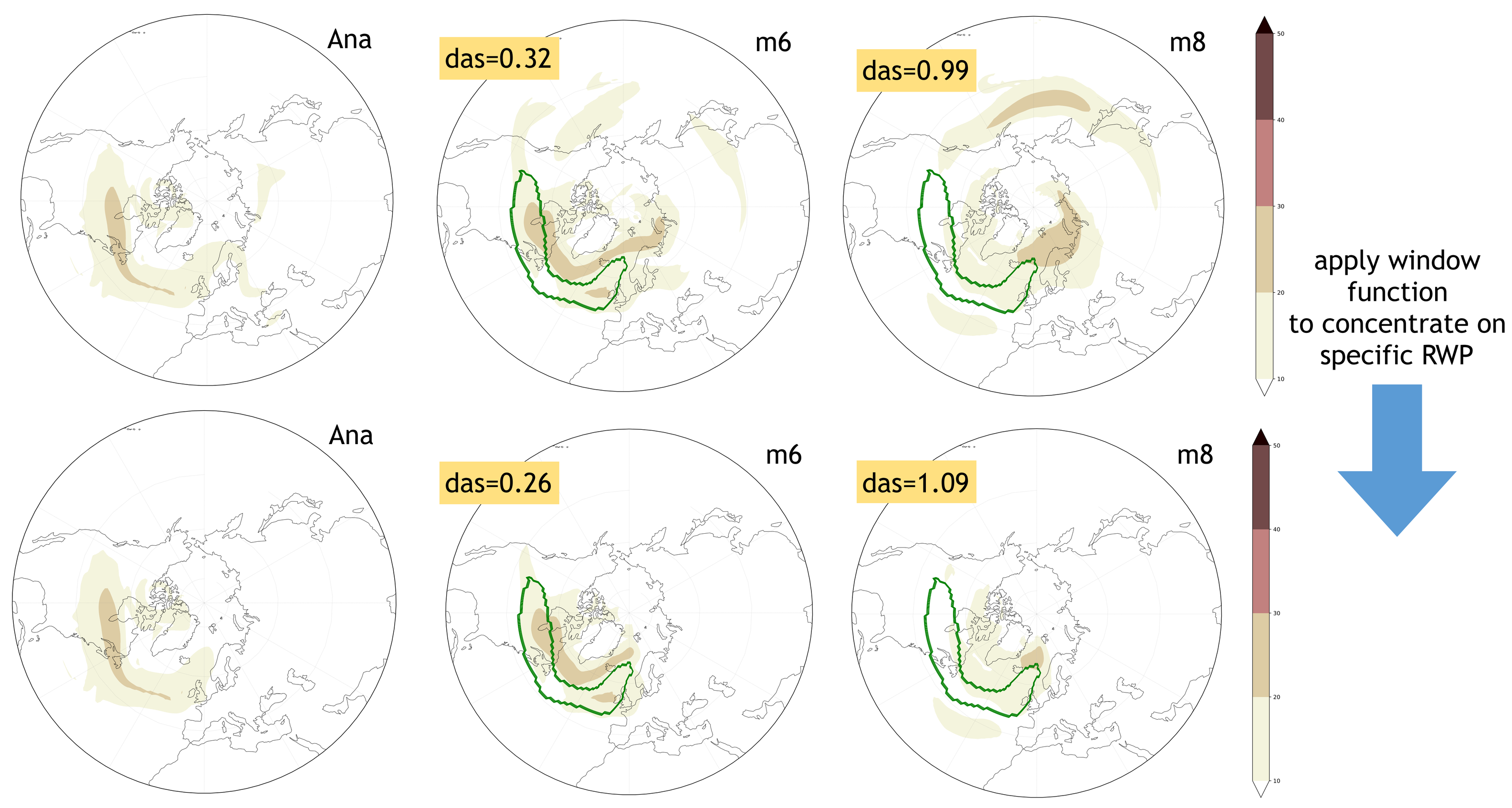
It is often expected that RWPs, as large-scale flow features obeying balanced dynamics, exhibit a large degree of predictability, which may then be inherited by smaller-scale weather features such as midlatitude cyclones. On the other hand, cyclones feed back on the evolution of RWPs, e.g. by promoting baroclinic amplification (tropospheric-deep interaction) and by ridge building due to upper-tropospheric, diabatic outflow. The latter process, in particular, is often associated with increased forecast uncertainty and may compromise medium-range predictability in the downstream region.

7183 RWPs with lifetimes of 4-15 days are selected from an existing climatology from Wolf and Wirth 2017. Anomalies with lifetimes more than 2 days are then selected to build ridge and trough composites respectively.

Additional to the general amplitude evolution of the anomalies, the dynamics of the high and low predictable RWPs from the climatology are investigated for ridges in JJA. High predictability is associated with stronger downstream baroclinic development.

DAS applied on RWPs envelope

DAS - Distance and Amplitude score (Keil and Craig 2009) applied on 300hPa RWP envelopes of 5-day forecasts taken from NOAA's ensemble reforecast 2 dataset (1984-2017)



For each member the DAS score is calculated compared to the analyses. The spread of a RWP is estimated by the standard deviation of this score. **A RWP is then defined as high or low predictable if the spread lies below the 5th or above the 95th percentile of all RWPs.**

Seasonal predictability

#RWPs	high	low
JJA	71	353
DJF	260	102

Seasonal distribution of high and low predictable RWPs

#RWPs/#Ano	high	low
JJA	123/661	141/443
DJF	218/1549	228/958

Number or RWPs and Anomalies of high and low predictable RWPs in each season

Difference between high and low predictable RWPs in JJA

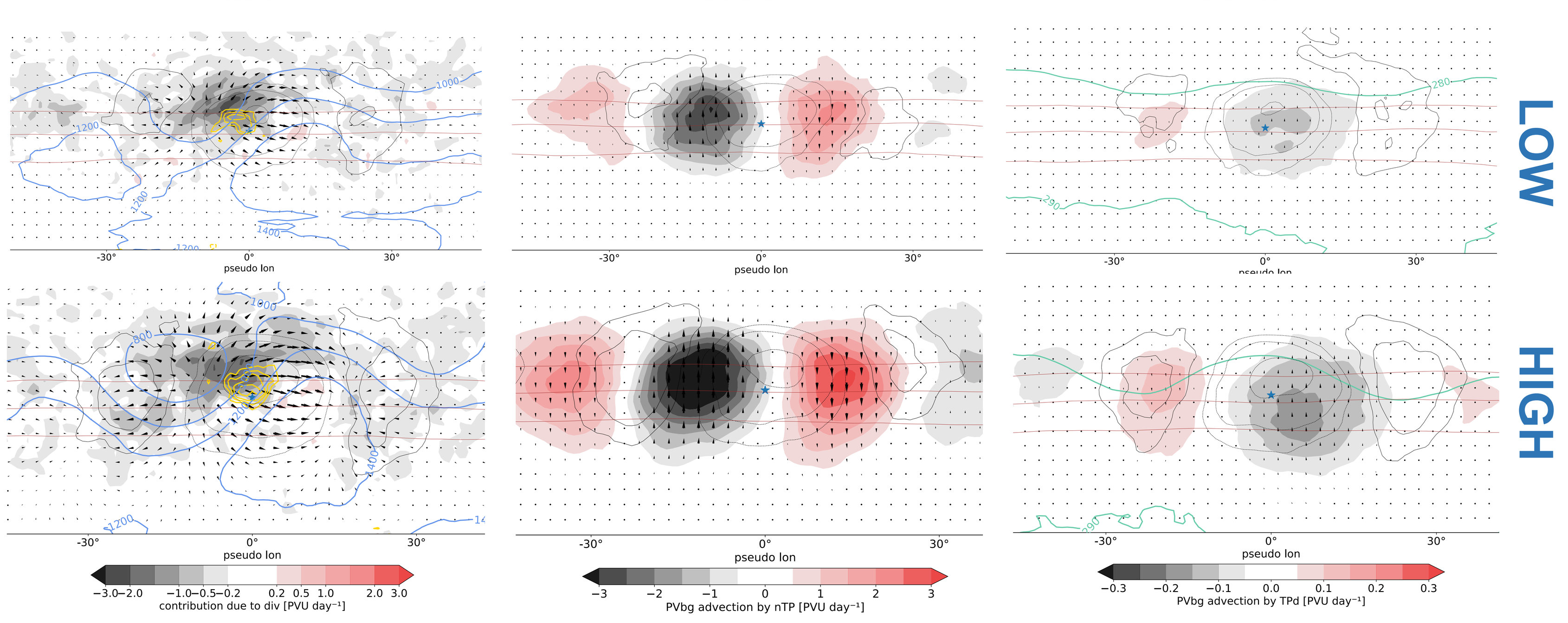
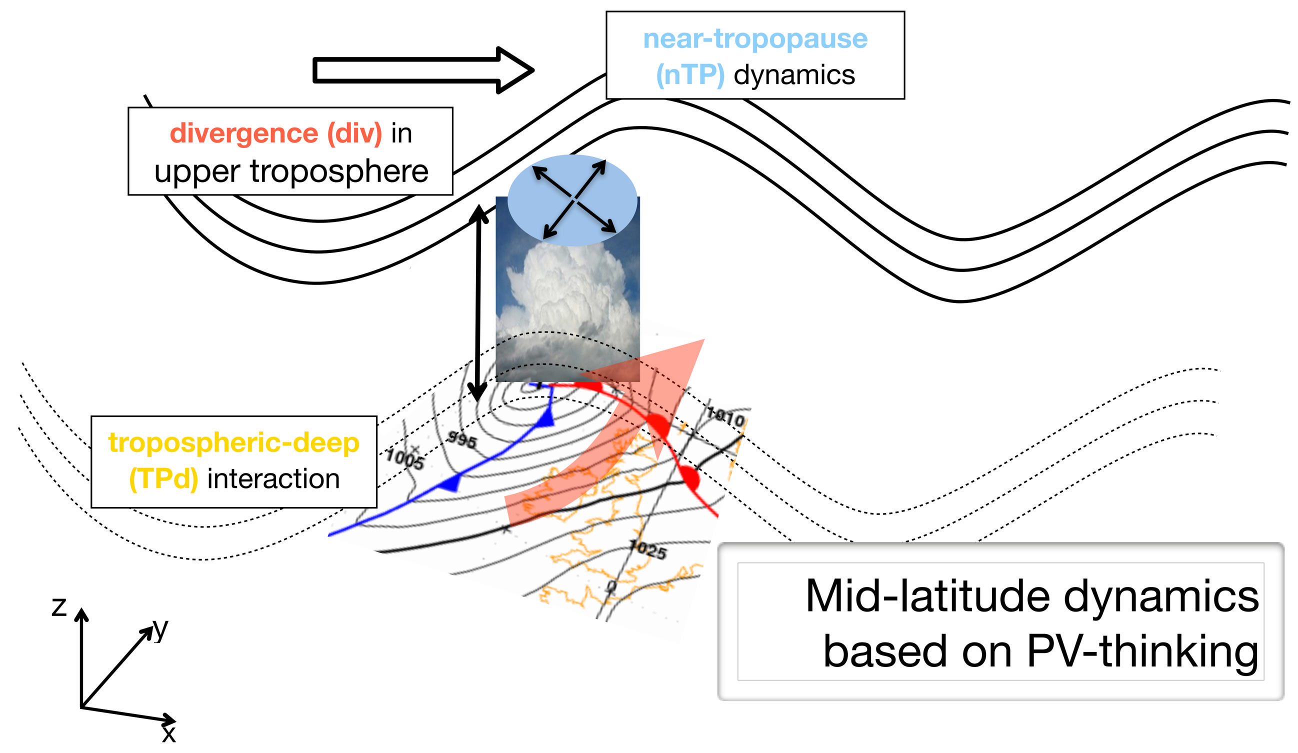


Figure description as on maps on the right

Preliminary Conclusions

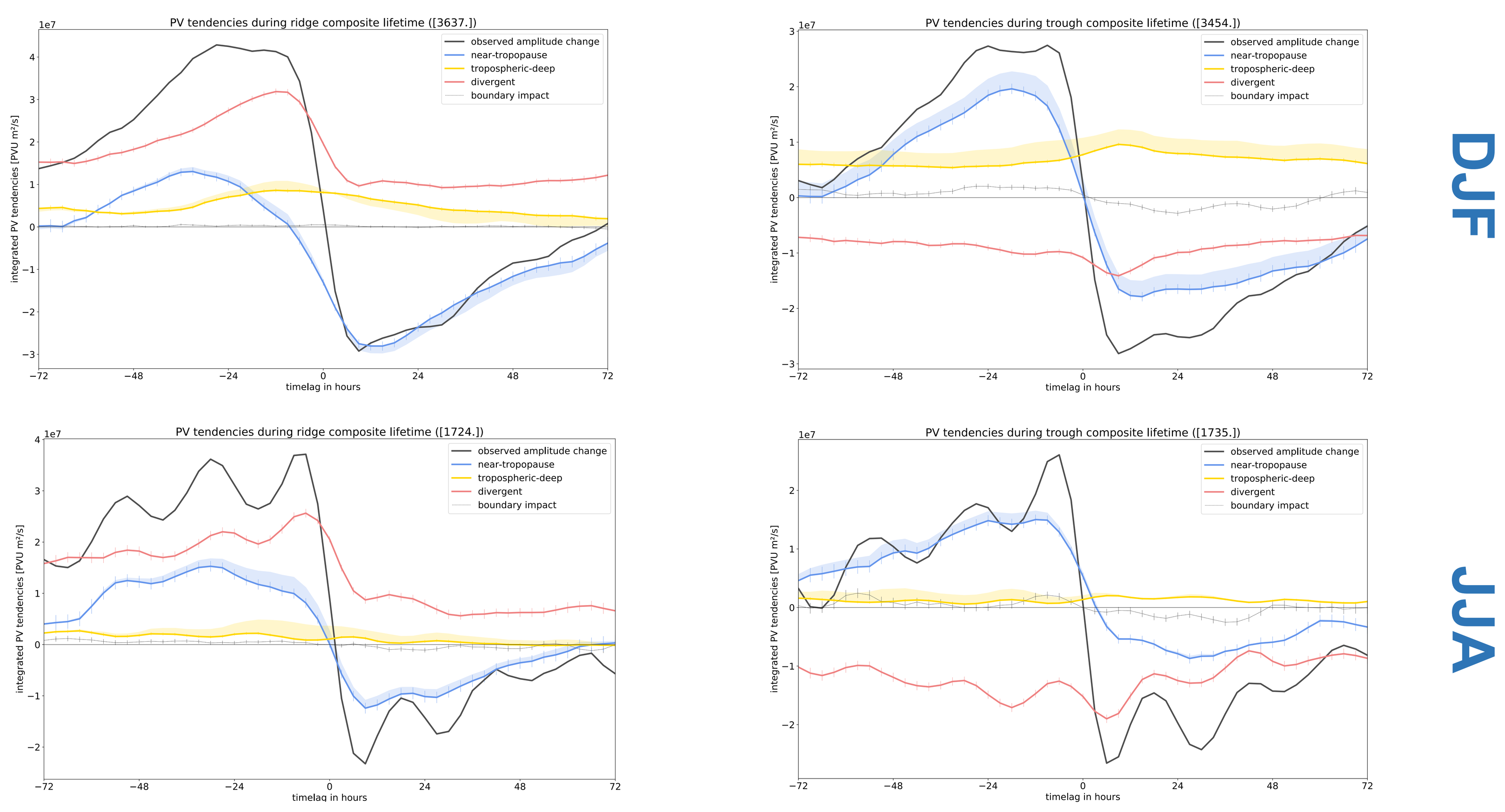
- Ridge- and Trough-Composites experience baroclinic downstream development (stronger in DJF than JJA)
- Contribution due to divergent outflow dominant process for ridge-composite evolution and leading order for trough-composite evolution
- More high predictable RWPs in DJF than JJA
- High predictable RWPs contain more anomalies → long lived RWPs? (s. Grazzini and Vitart 2015)
- High predictable RWPs in JJA associated with cyclones, low predictable not
- High predictable RWPs in JJA associated with stronger tropospheric-deep interaction
- High predictable RWPs in JJA associated with stronger near-tropopause dynamics
- → baroclinic downstream development improves predictability in JJA

Dynamics of Rossby Wave Packets



Amplitude evolution of

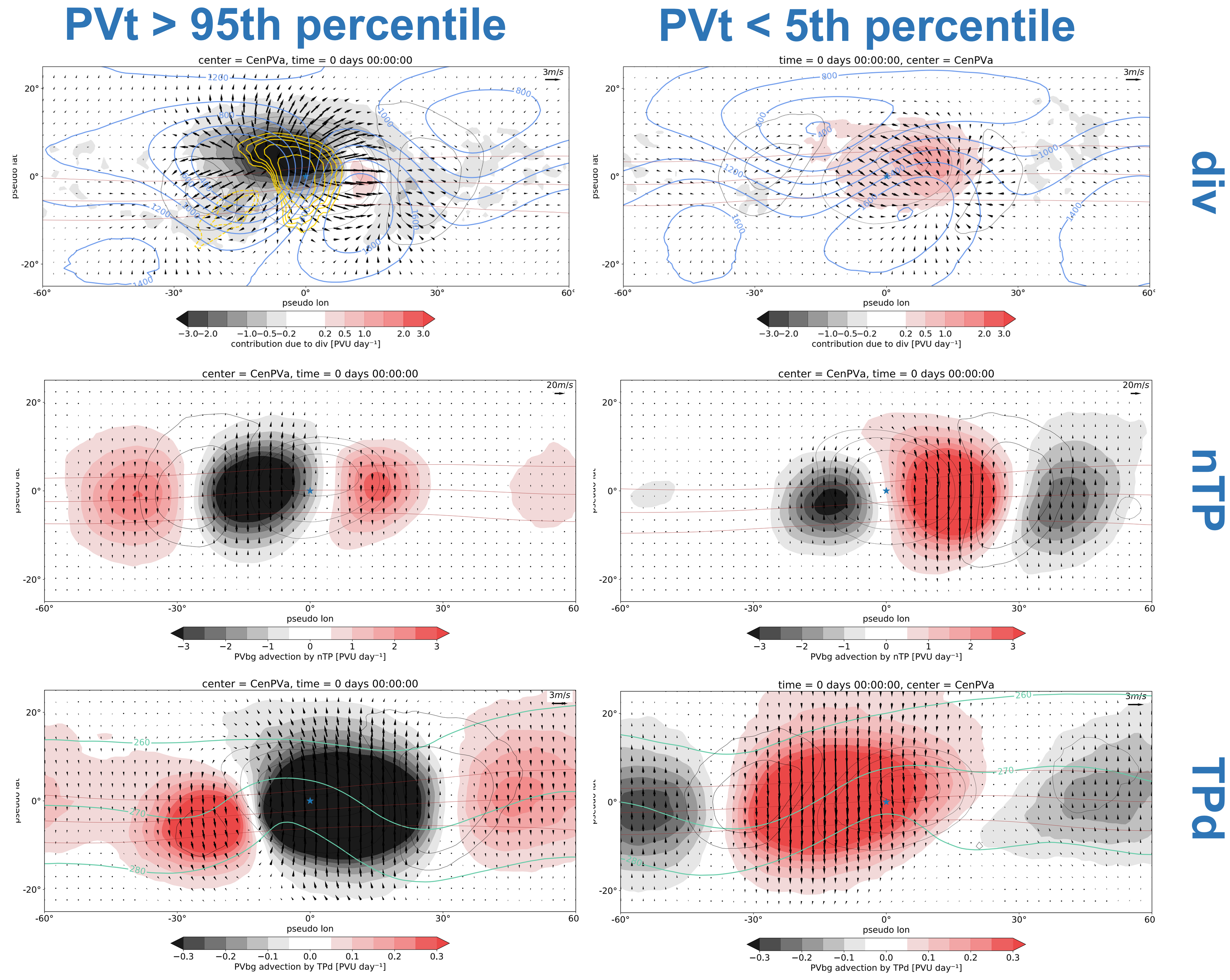
Composite-Ridge / Composite-Trough



Composite of temporal evolution of integrated PV tendencies relative to the time of maximum amplitude (lag0). The tendencies are calculated every 3-hours from the ERA5-dataset. Positive values indicate amplification both for trough- and ridge-composite. Lag < 0 refers to amplification of composite-anomalies and lag > 0 for decay.

Ridge-Composite Maps at max/min contribution

PVt > 95th percentile / PVt < 5th percentile



Shading: positive (red) and negative (black) PV tendencies. Negative tendencies amplify ridge amplitude.
Lines: Geopotential at 1000hPa, 1000-500haPa integrated water vapor transport convergence, (2,3,4)-PVU PV background, 850-800hPa potential Temperature, PV anomaly ((1,2,3)PVU - solid, (-3,-2,-1)PVU - dashed)
Arrows: For nTP and TPd only wind component perpendicular to background flow is shown

References

- Teubler and Riemer 2015, Dynamics of Rossby Wave Packets in a Quantitative Potential Vorticity–Potential Temperature Framework, JAS
- Keil and Craig 2009, A Displacement and Amplitude Score Employing an Optical Flow Technique, Weather and Forecasting
- Wolf and Wirth 2017, Diagnosing the Horizontal Propagation of Rossby Wave Packets along the Midlatitude Waveguide, Mon. Wea. Rev
- Grazzini and Vitart, 2015, Atmospheric predictability and Rossby wave packets, QJRMS

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