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Dynamical Evolution of Troughs and Ridges within Rossby Wave Packets: A Composite Study

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Rossby wave packets (RWPs) are a fundamental ingredient of midlatitude dynamics and organize the formation, propagation and decay of midlatitude weather systems. They may also constitute precursors to high-impact weather events. It is often expected that RWPs, as large-scale flow features obeying balanced dynamics, exhibit a large degree of predictability. Recent work, however, has shown that there is increased forecast uncertainty, in particular associated with the impact of moist processes, which may compromise medium-range predictability in the downstream region.

As a contribution to an improved understanding of these inherent uncertainties, we employ a quantitative potential vorticity (PV) – potential temperature framework to quantify different processes governing the evolution of troughs and ridges. This PV framework allows to fully separate the dynamics into four processes, namely the group propagation of Rossby waves, baroclinic growth, the impact of upper-tropospheric divergent flow, and direct diabatic PV modification.

The dynamical evolution of the amplitude of troughs and ridges within RWPs is examined from a composite perspective. The composite is based on the new ERA5 dataset and comprises 7164 RWPs. The direct diabatic contribution is estimated by the physical tendencies of the ‚Year of tropical convection' (YOTC) data. Additional to baroclinic downstream development, the composite analysis reveals a first-order impact of upper-level divergent flow for the amplification of ridges and the decay of troughs. We interpret divergent outflow as an indirect diabatic process associated with latent heat release below. Based on these results, we suggest extending the prevailing paradigm of downstream baroclinic development to include the systematic impact of moist processes. In the end potential implications for the predictability of RWPs are shown.