Rossby wave packets (RWPs) are fundamental to midlatitude dynamics and govern weather systems from their individual life cycles to their climatological distributions. Renewed interest in RWPs as precursors to high-impact weather events and in the context of atmospheric predictability motivates this study to revisit the dynamics of RWPs. A quantitative potential vorticity (PV) framework is employed. Based on the well established PV-thinking of midlatitude dynamics, the processes governing RWP amplitude evolution comprise group propagation of Rossby waves, baroclinic interaction, the impact of upper-tropospheric divergent flow, and direct diabatic PV modification by nonconservative processes. An advantage of the PV framework is that the impact of moist processes is more directly diagnosed than in alternative, established frameworks for RWP dynamics. The mean dynamics of more than 6000 RWPs from 1979-2017 are presented using ERA5 data, complemented with nonconservative tendencies from the 'Year of tropical convection' data (available 2008-2010).

Confirming a pre-existing model of RWP dynamics, group propagation within RWPs is consistent with linear barotropic theory, and baroclinic and divergent amplification occur most prominently during the mature stage and rather towards the trailing edge of RWPs. Refining the pre-existing model, the maximum of divergent amplification occurs in advance of maximum baroclinic growth and baroclinic interaction tends to weaken RWP amplitude towards the leading edge. ‘Downstream baroclinic development’ is confirmed to provide a valid description of RWP dynamics in both, summer and winter, although baroclinic growth is substantially smaller (about 50%) in summer. Longwave radiative cooling makes a first-order contribution to ridge and trough amplitude. This large impact, however, is only weakly coupled to other governing processes and is thus interpreted as a climatological background process. The direct impact of other nonconservative tendencies, including latent heat release, is an order of magnitude smaller than longwave radiative cooling. Arguably, latent heat release still has a substantial impact on RWPs by invigorating upper-tropospheric divergence. The divergent flow amplifies ridges and weakens troughs. This impact is of leading order and larger than that of baroclinic growth. To the extent that divergence is associated with latent heat release below, we argue that moist processes contribute to the well-known asymmetry in the spatial scale of troughs and ridges. For ridges, divergent amplification is strongly coupled to baroclinic growth and enhanced latent heat release.
We thus propose that the life cycle of ridges is best described in terms of 'downstream moist-baroclinic development'. Finally, our results demonstrate that divergent ridge amplification does not only depend on the magnitude of latent heat release but also on its relative location to the jet ('phasing').