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The sensitivity of atmospheric blocking to changes in latent heating

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Moist processes, and in particular the release of latent heat in ascending airstreams, can modify the mid-latitude flow and contribute to the formation of prolonged circulation anomalies such as atmospheric blocking. Blocking represents a challenge to numerical weather and climate forecasting, because it may lead to high impact weather in a situation of increased forecast uncertainty. The causal link between latent heating and blocking is still not well understood. In this study, we explore the effect of latent heating in ascending airstreams on the characteristics of atmospheric blocking using a combination of climatological analysis and modelling approaches.

A 37-year climatology based on the ERA-Interim reanalysis data and sensitivity experiments with altered latent heating for selected blocking events are used to investigate the details of the causal link between latent heat release and blocking formation. The climatological analysis shows that 32-46 % of the air masses involved in blocking are heated by more than 2 K (< 8 K in the median) in the 3 days prior to their arrival in the blocking anticyclone, and this number increases to 60-70 % when considering a 7-day period. The ascending air masses transport low values of potential vorticity (PV) from the lower troposphere to the upper troposphere and, consequently, contribute to the amplification of upper-level negative PV anomalies. The case-to-case variability is substantial as some blocks have less diabatic contribution (i.e., summer blocks over the Asian continent) and others have a larger contribution, sometimes even exceeding 70 %. Latent heating is especially important during blocking onset and can contribute to the maintenance and stationarity of the block by the diabatic injection of low-PV air associated with mid-latitude cyclones. Sensitivity experiments reveal that changes in the latent heat release lead to distinct differences in the blocking life cycle. When latent heating is turned off, the ascent and diabatically-driven upper-level outflow are reduced, the ridge does not amplify and, in the absence of wave-breaking, the block is not initiated.
The results of this study illustrate how the physics within ascending airstreams play a crucial role in the formation of blocking anticyclones and in the upper-level wave dynamics in general.