The role of latent heating in ascending air streams for atmospheric blocking

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Blocking anticyclones represent a challenge to numerical weather and climate forecasting because they may lead to high impact weather in a situation of increased forecast uncertainty. Our understanding of the dynamical mechanism involved in blocking formation and persistence is limited. Recent studies show that strongly ascending air streams can modify the mid-latitude flow and contribute to the amplification of upper-level ridges. This ascent goes along with cloud formation and latent heating, which results in net upward transport of lower-tropospheric air with low potential vorticity (PV) to the tropopause. In this study we explore the role of cloud-diabatic processes for atmospheric blocking, which are not taken into account in current theories, using a combination of Eulerian and Lagrangian diagnostics.

A 37-year blocking climatology based on ERAInterim reanalysis data and model sensitivity experiments for selected blocking events is used to illustrate the details of the link between latent heat release and blocking formation. The climatological analysis reveals 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. The case-to-case variability is substantial as some blocks have small diabatic contribution (e.g., winter blocks over the Asian continent) and for some it even reaches values larger than 70%. Latent heating is especially important during blocking onset, and can contribute to the maintenance of the block by repeated injections of low-PV air. Ascending air masses tend to arrive on the western flank of the block, and the associated diabatically driven outflow contributes to the stationarity of the system. Finally, sensitivity experiments of selected blocking events with altered latent heat release in a weather prediction model are used to demonstrate the causal relationship between latent heating and blocking. The results of this study corroborate the crucial role of diabatic processes for atmospheric blocking.