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Impact of interactive radiation on idealized mid-latitude storms

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The evolution of mid-latitude storms is controlled by the interacting impacts of large-scale advection, vertical motion and diabatic processes. It is widely accepted that understanding and accurately representing the diabatic impact of latent heating is crucial for capturing storm dynamics and their response to climate change. By contrast, little, if any, work has been done to study how radiative heating might impact storms. Here, we address this question by comparing idealized baroclinic lifecycles in the state-of-the-art global atmosphere model ICON in full spherical geometry when radiation is included and when radiative effects are neglected. Following previous work, the level of initial moisture is varied to study possible interactions between latent and radiative impacts.

We find that in contrast to latent heating, radiation slows the evolution of the storm and leads to an overall weaker storm. Specifically, including radiation leads to a 10 hPa higher storm central pressure and a 30% to 50% weaker domain-averaged eddy-kinetic energy. The overall weakening impact of radiation is independent of the initial moisture content. However, there is some indication that radiation changes the qualitative evolution of the storm when initial moisture is high. For example, with radiation the low-level eddy-kinetic energy and the storm central pressure are non-monotonic functions in time and show a double peak at day 5 and day 7. This does not occur when radiation is neglected, or when the initial moisture is set to zero. Further simulations will be presented to disentangle the radiative impact of clouds, and to investigate the impact of low-level vs. high-level clouds. Moreover, an analysis of the surface pressure tendency equation will be applied to analyze and compare the impact of adiabatic processes, latent heating and radiative heating.

Overall, our results show that radiation, while so far neglected, can play a first-order role for the evolution of individual storms.