EGU22-5585
https://doi.org/10.5194/egusphere-egu22-5585
EGU General Assembly 2022

Competing radiative impacts of low-level and high-level clouds on the strength of an idealized extratropical cyclone

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Extratropical cyclones are the main driver of everyday weather in the midlatitudes. These cyclones are known to be affected by latent heating and are a popular subject of research regarding possible changes in a warming climate. In contrast, the role of radiation - and especially the radiative impact of clouds - in shaping extratropical cyclones has hardly been investigated. To study how cloud-radiative heating of the atmosphere might impact cyclones, we present idealized baroclinic life cycle simulations with the global atmosphere model ICON-NWP in aquaplanet setup with prescribed sea surface temperatures. Several simulation setups are used to isolate not only the overall cloud-radiative impact but also the impacts of low-level clouds and high-level clouds. Moreover, the cloud-radiative impact is compared between two model versions, ICON 2.1 and ICON 2.6. While the model versions simulate similar cyclones when radiation is not taken into account, enabling cloud-radiation interaction leads to contradicting effects.In ICON 2.1 clouds lead to a weakening of the cyclone magnitude by 15%, whereas in ICON 2.6 they strengthen the cyclone by 7%. The different cloud impact results from a robust competition between the radiative impact of low-level clouds, which in both model versions weaken the cyclone, and high-level clouds, which in both model versions strengthen the cyclone. The difference in the overall cloud-radiative impact between the two model versions results from the fact that ICON 2.1 simulates much more low-level clouds than ICON 2.6. This shows that the vertical distribution of clouds and their radiative heating can be an important factor for the dynamics of extratropical cyclones.