Radiative heating from low-level and high-level clouds creates tug-of-war on midlatitude cyclones

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"All models are wrong. Some are wrong in useful ways.” (adapted by from George Box, 1979) In this contribution, we take advantage of an error in the ICON atmosphere model to elucidate how cloud-radiative heating affects the intensity of idealized midlatitude cyclones.

We present baroclinic life-cycle simulations with two versions of the global atmosphere model ICON. The simulations use either no radiative heating or the cloud-radiative heating inside the atmosphere, but no clear-sky radiative heating. This allows for a clean investigation of the dynamical impact of cloud-radiative heating. Both ICON versions simulate the same cyclone when run without radiative heating, but disagree when cloud-radiative heating is taken into account. Cloud-radiative heating weakens the cyclone in ICON2.1 but strengthens it in ICON2.6. The two model versions simulate very different low-level clouds, with many more low-level clouds and much more negative cloud-radiative heating in the boundary layer in ICON2.1. Negative cloud-radiative heating from low-level cloud tops weakens the cyclone by increasing static stability, while negative cloud-radiative heating from high-level cloud tops strengthens the cyclone by decreasing stability. Our results indicate that clouds and the vertical distribution of their radiative heating influence the dynamics of midlatitude cyclones.

Our results call for future work that investigates the impact of cloud-radiative heating on “real” cyclones in the midlatitude storm track regions of Earth’s atmosphere. Such work should also address the interactions between cloud-radiative heating on the one hand and latent heating and cloud microphysics on the other hand.