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The impact of coupled moist eddy dynamics on the meridional energy transport

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The poor representation of clouds in modern day climate models yields uncertainties in related physical fields and processes such as radiation and latent heat release. The present study investigates how the atmospheric dynamics is influenced by a spatial misrepresentation of midlatitudinal latent heat release and what the consequences are for the climatological state of the general circulation.

Simulations are done with the Planet Simulator, an Earth-system Model of Intermediate Complexity, using an aqua-planet set-up with prescribed SST. Atmospheric moisture is allowed to evolve freely but clouds are assumed to be transparent to both solar and terrestrial radiation. Two simulations are performed, which are identical in all aspects except that the midlatitudinal temperature tendencies from latent heat release either follow the pattern controlled by the model physics or set to their zonal mean values on every time-step in the model integration. Changes in the zonal mean climatological state are interpreted in terms of modifications in the meridional transports of energy.

The zonalized simulation is slightly warmer in the midlatitudinal boundary layer but cooler in the free troposphere. The redistributed vertical temperature gradient leads to an increased stability in the boundary layer and thereby attenuated vertical motions in the region with the highest water vapor concentration. The convective precipitation is therefore reduced and a higher specific humidity is observed in the lower mid-troposphere. There is also a general cooling in high latitudes with focal point in the mid-troposphere poleward of the zonalized region. This temperature anomaly is related to changes in the transient eddy fluxes of temperature and specific humidity, which are both generally weakened in the zonalized simulation but the latter show a more complex vertical structure.

The results demonstrate that the localization of the latent heat release has important feedbacks on the atmospheric circulation, and thus it is an essential process to capture in a climate simulation. Misrepresentations of the spatial distribution of latent heat release can have large effects both on the atmospheric stability and the meridional eddy fluxes leading to erroneous temperature and moisture distributions in the troposphere.