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Interaction of convection and large-scale circulation with respect to MSE variations

Tobias Becker, Bjorn Stevens, and Cathy Hohenegger
(tobias.becker@mpimet.mpg.de)

The ultimate drivers of convection - radiation, tropospheric humidity and surface fluxes - are altered both by the large-scale circulation and by convection itself. A quantity to which all drivers of convection contribute is moist static energy (MSE). Therefore, both a variance analysis of the MSE budget and an analysis of gross moist stability help understanding the interaction of precipitating convection with the large-scale environment. In addition, this method provides insights concerning the impact of convective aggregation on this coupling. The interaction is analyzed with a general circulation model as a starting point, but a model intercomparison study validating the general circulation model with large-eddy simulations is planned.

The interaction of precipitating convection with the large-scale environment is investigated by studying the influence of surface temperature and convection scheme on the MSE variance budget in a radiative-convective equilibrium version of ECHAM6. Different fixed surface temperatures lead to different specific humidities and cause a change of longwave emission height temperature. Subsidence fraction, a large-scale property that is important for radiative transfer, increases with surface temperature, indicating an increase of convective aggregation. MSE variance increases with increasing surface temperature because more water vapor in the atmosphere allows for more MSE fluctuations. In addition, the advection term in the MSE variance budget turns from a sink to a source of MSE variance. The Tiedtke and Nordeng convection scheme show similar dependencies on surface temperature, though deep convection is forming more rapidly with the Tiedtke convection scheme.

The further analysis will focus on understanding cloud-radiation and moisture-convection feedbacks within the hierarchy of models, before effective coupling parameters will be derived from cloud resolving models. These will in turn be related to assumptions used to parameterize convection in large-scale models.