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The influence of convection parameterisations under alternate climate conditions

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In the last decades several convection parameterisations have been developed to consider the impact of small-scale unresolved processes in Earth System Models associated with convective clouds. Global model simulations, which have been performed under current climate conditions with different convection schemes, significantly differ among each other in the simulated precipitation patterns due to the parameterisation assumptions and formulations, e.g. the simplified treatment of the cloud microphysics. Additionally, the simulated transport of short-lived trace gases strongly depends on the chosen convection parameterisation due to the differences in the vertical redistribution of mass. Furthermore, other meteorological parameters like the temperature or the specific humidity show substantial differences in convectively active regions.

This study presents uncertainties of climate change scenarios caused by different convection parameterisations. For this analysis two experiments (reference simulation with a CO_2 concentration of 348 ppm; 2xCO_2-simulation with a CO_2 concentration of 696 ppm) are calculated with the ECHAM/MESSy atmospheric chemistry (EMAC) model applying four different convection schemes (Tiedtke, ECMWF, Emanuel and Zhang-McFarlane - Hack) and two resolutions (T42 and T63), respectively. The results indicate that the equilibrium climate sensitivity is independent of the chosen convection parameterisation. However, the regional temperature increase, induced by a doubling of the carbon dioxide concentration, demonstrates differences of up to a few Kelvin at the surface as well as in the UTLS for the ITCZ region depending on the selected convection parameterisation. The interaction between cloud and convection parameterisations results in a large disagreement of precipitation patterns. Although every 2xCO_2 -experiment simulates an increase in global mean precipitation rates, the change of regional precipitation patterns differ widely. Finally, analysing the cloud radiative forcing a huge spread of the cloud-induced radiative flux change is found in the warm pool region due to a change of the convection parameterisation.