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Assessing the sensitivity of moist convection to climate change within an idealized cloud-resolving modeling framework

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The use of parametrization schemes for the representation of moist convection implies major uncertainties in current climate projections. Here we introduce an idealized cloud-resolving modeling (CRM) framework for the study of mid-latitude diurnal convection over land. The framework is used to assess the sensitivity of the soil-moisture precipitation feedback and associated heavy precipitation events from first principles. The model is run for 30 days. Using a relaxation strategy, approximate equilibrium is reached after about 16 days. In this state, termed "diurnal equilibrium", the diurnal cycle of moist convection repeats itself more or less from day to day.

Using this framework we investigate the sensitivity of the diurnal convection and resulting cloud development to changes in atmospheric temperature, lapse-rate and soil moisture content that could result from anthropogenic climate change. We find that the temperature stratification of the environment has a dominant influence on the depth and intensity of convection. If the background profile is more stably stratified, more clouds develop and the intensity of convection increases considerably. More unstable profiles in contrast lead to deeper convection that continues over a longer time span. For warmer atmospheres, the increase of water vapor enhances moreover cloud amount.
A decrease of soil moisture reduces precipitation amounts and leads to the development of very localized precipitation patches. Concerning the distribution of precipitation intensities, we find an increase of heavy precipitation events if a warming of the atmosphere goes together with a stabilization of the atmosphere as is projected by many climate models. These increases are however smaller than expected from Clausius Clapeyron scaling. Reductions of soil moisture on the other hand decrease precipitation over all intensities.