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Improving the representation of convective clouds in climate models

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Convective clouds are a challenging problem in atmospheric modeling on the scale of global climate models since they cannot explicitly be resolved. This leads to large uncertainties in the understanding of climate change. The current parameterizations (bulk mass flux approach) in most cases reduce cloud spectra to one single mean cloud that is assumed to represent the integral characteristics of the cloud spectrum. This produces problems not only for the simulation of precipitation, but also for convective transport and latent heat release. While it is possible to parameterize these cloud spectra by cloud resolving sub-models, this is computationally far too expensive for long climate simulations. The use of a new Convective Cloud Field Model (CCFM) allows cloud spectra to be explicitly simulated without prescribing the spectrum properties from observations or cloud resolving models. The CCFM results in explicit convective transport and microphysics including the fate of soluble and non-soluble species and the effects of aerosols on cloud properties. CCFM has been successfully implemented and tested within the global atmospheric model ECHAM.

The cloud spectrum calculation is based on single cloud simulations that are performed with an entraining parcel model.In this model entrainment is described by a constant entrainment parameter. Detrainment only occurs at cloud top. To reduce model biases we improved the description of entrainment in a physically realistic fashion and to allow for detrainment of cloudy air during the parcel's accent. The cloud resolving model ATHAM was used to determine the free coefficients introduced by this new description of entrainment and detrainment. The improved CCFM was evaluated against high resolution simulations with ATHAM and against observations of convective episodes in a single column mode.