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A full spectral cumulus cloud parameterisation including aerosol effects: The Convective Cloud Field Model (CCFM)

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The convective cloud field model is a convection parameterisation based on the representation of a full cumulus cloud spectrum using a dynamical quasi-equilibrium closure. It employs a one dimensional entraining parcel model whose properties are simulated on a refined vertical resolution ($\tilde{1}$00 m) in order to capture the complex cloud microphysical processes in convective clouds. We introduced an enhanced microphysics compared to those currently used in convection parameterisations, containing warm and mixed phase cloud microphysics processes and incorporates aerosol effects by linking the cloud droplet number concentration to the aerosol amount.
Similar to the Arakawa and Schubert (1974) quasi-equilibrium closure we allow for the mutual influence of clouds via the environment. Instead of assuming instantaneous stabilisation of the environment though, the clouds are dynamically interacting for the length of the large scale model time step without necessarily adopting an equilibrium situation.
The model is evaluated in single column mode (SCM) for continental and tropical convection using the ARM SGP and TWP-ICE cases. Moreover it is evaluated in global mode using the global atmospheric circulation model ECHAM5. For the SCM cases the precipitation, heating and moistening rates for the simulated period is better represented than with the Tiedtke massflux scheme which is the usual convection parameterisation within ECHAM5. Moreover, we find a clear response to an enhanced aerosol loading which generally leads to a reduction of convective precipitation. Globally, the CCFM produces slightly higher convective precipitation rates and especially responds better to convective instability over lower latitudes and the storm track regions.