Detectability of aerosol-cloud interactions in complex high-resolution models and observations of convective clouds

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Abstract:

Atmospheric aerosol are a fundamental component for cloud formation in the atmosphere as they provide nuclei for condensation or freezing of water. The profound spatial and temporal variability of aerosol particle concentrations influences the number of cloud droplets and ice nuclei formed in clouds and can alter the clouds' microphysical, geometric and radiative properties. While a significant impact of aerosols on cloud properties and precipitation formation is demonstrated in many modeling studies, convincing observational evidence of aerosol impacts on clouds remains rare and focusses mainly on the direct impact on hydrometeor number. Observational evidence is important to constrain the model results, which are subject to significant uncertainty in the model formulations and simplistic representations of cloud microphysical processes. An important aspect in obtaining observational evidence for aerosol-cloud interactions is the co-variability of aerosol and meteorological conditions.

In order to address this aspect, we conducted high-resolution ensemble simulations with a numerical weather prediction model and an advanced bulk microphysics scheme with interactive aerosols. This approach allows us to quantify the impact of perturbations in meteorological and aerosol initial conditions and assess their relative importance for different aspects of proposed aerosol-cloud interactions, such as changes in hydrometeor number concentration, cloud fraction, cloud depth or precipitation rate. By sampling the model in a similar way than observations sample the real atmosphere, we further investigate if and how conclusive observational evidence of aerosol-cloud interactions could be obtained for similar, but not identical, meteorological conditions.