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The role of atmospheric aerosols on precipitation processes

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Cloud microphysics is inevitably affected by the smoke particle (CCN, cloud condensation nuclei) size distributions below the clouds. Therefore, size distributions parameterized as spectral bin microphysics are needed to explicitly study the effects of atmospheric aerosol concentration on cloud development, rainfall production, and rainfall rates for convective clouds. Recently, a detailed spectral-bin microphysical scheme was implemented into the Goddard Cumulus Ensemble (GCE) model. The formulation for the explicit spectral-bin microphysical processes is based on solving stochastic kinetic equations for the size distribution functions of water droplets (i.e.,

cloud droplets and raindrops), and several types of ice particles [i.e. pristine ice crystals (columnar and plate-like), snow (dendrites and aggregates), graupel and frozen drops/hail]. Each type is described by a special size distribution function containing many categories (i.e., 33 bins). Atmospheric aerosols are also described using number density size-distribution functions.

The model is tested by studying the evolution of deep cloud systems in the west Pacific warm pool region, the sub-tropics (Florida) and midlatitudes using identical thermodynamic conditions but with different concentrations of CCN: a low "clean" concentration and a high "dirty" concentration. Results indicate that the low CCN concentration case produces rainfall at the surface sooner than the high CCN case but has less cloud water mass aloft. Because the spectral-bin model explicitly calculates and allows for the examination of both the mass and number concentration of species in each size category, a detailed analysis of the instantaneous size spectrum can be obtained for these cases. It is shown that since the low CCN case produces fewer droplets, larger sizes develop due to greater condensational and collection growth, leading to a broader size spectrum in comparison to the high CCN case. Sensitivity tests were performed to identify the impact of ice processes, radiation and large-scale influence on cloud-aerosol interactive processes, especially regarding surface rainfall amounts and characteristics (i.e., heavy or convective versus light or stratiform types). In addition, an inert tracer was included to follow the vertical redistribution of aerosols by cloud processes.

We will also give a brief review from observational evidence on the role of aerosol on precipitation processes.