Geophysical Research Abstracts
Vol. 13, EGU2011-2288, 2011
EGU General Assembly 2011

Coupling cloud and aerosol microphysical processes in a nested climate-weather-air pollution model and its implications for the cloud and climate effects of black carbon

Mark Jacobson
Stanford University, Stanford, California, United States (jacobson@stanford.edu)

One of the greatest uncertainties in climate and air quality modeling is the effect of aerosol particles on clouds and precipitation and the feedback of clouds and precipitation back to aerosol particles. Such interactions are important, particularly for examining aerosol climate responses. Here, we discuss the development of numerical algorithms for simulating microphysics among discrete cloud and aerosol size distributions of complex composition. Several aerosol-cloud interaction processes treated include condensational and depositional growth, aerosol-aerosol coagulation, hydrometeor-hydrometeor coagulation, contact freezing by size-resolved aerosol particles, heterogeneous plus homogeneous freezing, evaporative freezing, liquid drop breakup, sedimentation, below-cloud hydrometeor shrinking and dissipation to aerosol cores, and lightning production due to size-resolved bounceoffs. All processes conserve mass, water, and energy. Aerosol components are tracked through size- and composition-resolved clouds and precipitation. A new algorithm for treating breakup of liquid drop and their aerosol constituents is described and evaluated against an analytical solution. The numerical algorithms are applied to study the radiative effect of treating black carbon (BC) inclusions in cloud drops versus treating them interstitially between drops or outside of clouds. Treating BC inclusions within cloud drops is found to give a greater heating rate than treating the same BC as interstitial, and treating BC as interstitial gives a greater heating rate than treating the same BC as clear-sky. As such, ignoring BC inclusions within cloud drops or between cloud drops results in underestimates of the climate effects of BC. Treating such inclusions in a global model results in a strong climate response of black carbon. Treating inclusions and detailed microphysics also helps to explain the boomerang effect, whereby cloud optical depths (CODs) increase with increasing aerosol optical depth (AOD) at low AOD due to indirect effects but decrease with increasing AOD at higher AOD due to radiative absorption, as observed by satellite. Treating the interactions between aerosols and clouds in detail is necessary for simulating this effect in 3-D.