Session: B6 Oral presentation

Aerosol-cloud interactions in climate models

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Some general circulation models (GCMs) (e.g., GFDL CM3, NCAR CAM5) simulate cloud-aerosol interactions using physically based principles for aerosol activation, i.e., aerosol activation is a function of supersaturation and atmospheric composition as predicted by fundamental principles of microphysics and aerosol science. Applying these principles has required that the cloud macrophysics in these GCMs represent supersaturation-generating dynamical processes, which occur on much smaller scales the the GCM grid. The application of these principles will be illustrated using GFDL CM3, which deals with this issue using probability density functions (PDFs) for vertical velocity to determine supersaturation for both its convective and stratiform clouds. CM3's aerosol climatology and clear-sky surface radiation budgets agree better with observations than earlier-generation GFDL climate models without aerosol-cloud interactions, which relied on aerosol direct effects only to limit warming during the 20th century. Large-eddy simulations suggest that aerosol-dependent interactions between precipitation and cloud dynamics can limit cooling associated with aerosol-cloud interactions. These interactions are not captured well by current macrophysical parameterizations in CM3. Multi-variate PDFs with dynamics and microphysics can be used to parameterize boundary layers and clouds. For some thermodynamic conditions, e.g., GCSS DYCOMS stratocumulus with light precipitation, multi-variate PDFs simulate reduced liquid water paths at higher aerosol concentrations. This limitation on cooling by cloud-aerosol interactions occurs by increased entrainment when precipitation onset is blocked at higher aerosol concentrations, capturing the mechanism indicated by large-eddy simulations. GFDL CM3 with aerosol-cloud interactions warms somewhat less than observed during the 20th century. Using multi-variate PDFs for CM3's boundary layers and cloud macrophysics would introduce a limitation on cooling associated with its cloud-aerosol interactions.