Study of aerosol direct and first indirect radiative effects with GEOS-Chem-APM

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There exist large uncertainties in both direct radiative forcing (DRF) and indirect radiative forcing (IRF) of atmospheric aerosols, which hamper our efforts to predict climate sensitivity and future climate change. The climatic impacts of anthropogenic aerosols depend strongly on their properties such as particle size distribution, composition, hygroscopic properties, and mixing state. The need to improve the accuracy and capability of model simulation of aerosols (including components and processes) has been identified as one of the key research priorities in order to reduce the uncertainty in the assessment of aerosol-climate impacts. Seeking to improve the representation of major processes affecting aerosol properties important for their climate impacts, we have developed a size-resolved advanced particle microphysics (APM) model and incorporated it into a global chemistry transport model (GEOS-Chem). A number of computationally efficient schemes have been implemented, which enable the APM model to capture the main particle properties (sizes, compositions, coating of primary particles by secondary species, hydroscopicity parameters, scattering and absorption coefficients, etc.) important for their climate impacts while keeping the computational costs affordable. GEOS-Chem-APM is one of the global aerosol models participating in the AeroCom Phase II microphysics, organics, and DRF comparisons. Very recently we have developed a scheme to calculate aerosol first IRF within GEOS-Chem-APM by linking predicted cloud condensation nuclei (CCN) with cloud droplet number concentrations and radius (3-D liquid water path and cloud fraction from GEOS-5 assimilated meteorology). In this presentation, we will first describe key features of aerosol properties predicted by GEOS-Chem-APM and comparisons of these properties with a wide range of measurements (total particle and CCN number concentrations, size distribution, AOD, CALIPSO vertical profiles of extinction coefficients, etc.). We will then discuss the anthropogenic DRF and first IRF values derived from GEOS-Chem-APM simulations, focusing on the contributions of individual aerosol components (including nitrate and SOA) to the forcings, uncertainties, and the influence of secondary particle formation and growth processes.