Aerosol-Radiation-Chemistry Interactions: The Effect of Size-Resolved Particle Microphysics

Atmospheric aerosols impact air quality, radiation, tropospheric oxidation capacity, and the Earth’s climate. Aerosol-radiation-chemistry is an interactive system and there exist large uncertainties in our understanding of aerosol-radiation-chemistry interaction processes. The representation of size-resolved particle microphysics in global models has been identified as an important step toward reducing this uncertainty. Under the support of a prior NASA-ACMAP grant, our group has developed a size-resolved (sectional) advanced particle microphysics (APM) model and has successfully incorporated it into GEOS-Chem. In our previous applications, the impacts of aerosols on photolysis and heterogeneous chemistry were calculated based on aerosol properties predicted by the bulk aerosol scheme, which runs in parallel to APM. Here we propose to add the option in GEOS-Chem-APM to consider the impact of the aerosols on photolysis and chemistry based on APM predicted aerosol properties and then study its effect on aerosol-radiation-chemistry interactions.

There are five specific tasks/objectives that this project will include. (1) We will analyze a variety of satellite and suborbital data sets and ground-based measurements to derive data that can be used to constrain and verify the modeling studies to be carried out under Tasks 2-4. (2) We will compare and assess the ability of GEOS-Chem based on two aerosol schemes (default bulk and size-resolved APM) in capturing observed aerosol optical depth (AOD). We will also develop a climatology of secondary particle sizes, so that it can be used in the GEOS-Chem bulk aerosol scheme to better capture the spatial and seasonal variations of particle sizes and AOD. (3) We will modify the GEOS-Chem-APM to add the option to use AODs and particle surface areas calculated from size-resolved microphysics in Fast-J radiative transfer code and heterogeneous chemistry calculations. We will study how much the size-resolved microphysics affects the impact of aerosols on UV actinic fluxes, tropospheric oxidation capacity, and chemistry. (4) We will study how much the change in OH and other oxidants associated with the size-resolved microphysics (Task 3) will affect the production and concentration of aerosol precursors, and thus, the formation, growth, and properties of particles. (5) We will recalculate aerosol direct and first indirect radiative forcing based on the GEOS-Chem-APM, improved under Tasks 2-4, especially with regard to the impacts of size-resolved microphysics on photolysis and chemistry, which are not considered in our previous calculations of aerosol radiative forcing.
Relevance to NASA ACMAP: The above proposed researches are highly relevant to the research strategic objectives of NASA ACMAP that encourage the studies of aerosol characteristics with respect to their impacts on actinic fluxes and tropospheric chemical processes as well as the effects of air quality on climate.