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Modeling stratospheric aerosol with the GEOS-5 Chemistry Climate Model

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Volcanic eruptions constitute the major source of aerosol in the stratosphere. The detection of a region of enhanced aerosol extinction over Asia during the monsoon period, however, suggests that convective lifting of tropospheric aerosol can also be an important source of aerosols in the lower stratosphere. Additionally, photolysis and oxidation of carbonyl sulfide (OCS) produces a layer of aerosol between 20 km and 30 km altitude.

We present here an assessment of the new model capabilities of the Goddard Earth Observing System Chemistry Climate Model (GEOSCCM) to simulate stratospheric aerosol, which include a new parameterization for the formation of sulfate aerosol from OCS, improved scavenging, and the implementation of the microphysical model CARMA. We performed simulations spanning the period from 2000 to present, including natural and anthropogenic emissions of precursor gases and tropospheric aerosols (sulfate, black carbon, organic carbon, dust, and sea salt), volcanic sulfate emissions, and stratospheric sulfate aerosol resulting from the photolysis and oxidation of carbonyl sulfide (OCS). In these simulations we ran two aerosol modules: the bulk model GOCART, which prescribes a fixed aerosol radius, and the microphysical model CARMA, which simulates the aerosol size distribution with a sectional approach. By comparing results from GOCART and CARMA to observations of extinction coefficients by OSIRIS and OMPS/LP we were able to assess the importance of an explicit simulation of the aerosol size distribution in reproducing the observed the vertical transport of volcanic plumes and of the improved scavenging in the transport of tropospheric aerosol across the tropopause in convective systems. From the size distributions simulated by CARMA we also derived a simple parameterization for bulk models that ties the effective radius of stratospheric aerosol to its mass mixing ratio. Such a parameterization will be useful for models that cannot afford the computational costs of a microphysical model in order to perform long climate simulations.