Model formulation and predictability of a variety of atmospheric aerosols

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A new aerosol chemical transport model, Regional Air Quality Model 2 (RAQM2), was developed to simulate Asian air quality. We implemented a simple version of a modal-moment aerosol dynamics model (MADMS) and achieved completely dynamical (non-equilibrium) solution of a gas-to-particle mass transfer over a wide range of aerosol diameters from 1 nm to super μm. To consider a variety of atmospheric aerosol properties, a category approach is utilized: aerosols are distributed into 4 categories, Aitken mode (ATK), accumulation mode (ACM), soot aggregates (AGR) and coarse mode (COR). Condensation, evaporation and Brownian coagulations for each category are solved dynamically.

A regional-scale simulation (Δx=60km) was conducted using an aerosol chemical transport model over Northeast Asia for the entire year of 2006, with lateral and upper boundary concentrations predicted using a global stratospheric and tropospheric chemistry climate model, with a T42 horizontal resolution (Δx~300km) and a temporal resolution of 1h. The present one-way nested global-through-regional scale model system is referred to MRI-Passive-tracers Model for atmospheric Chemistry (MRI-PM/c).

Modeled size distributions (PM$_{2.5}$/PM$_{10}$ and PM$_a$/bulk ratios) of total weight and chemical components were compared and found consistent with the observations. Nss-SO$_4^{2-}$ mixed with ATK + ACM are largest at Hedo in summer, whereas H$_2$SO$_4$ gas was efficiently condensed onto AGR in cold seasons. 98% of the modeled NO$_3^-$ was mixed with COR at Hedo, whereas 53.7% of NO$_3^-$ was mixed with sea salt at Gosan, located upwind toward the Asian continent. It is indicated that condensation of HNO$_3$ onto sea salt particles during transport over the ocean makes the difference.

We also evaluated model system performance regarding the major inorganic components in rain and snow precipitation measured at the stations of the Acid Deposition Monitoring Network in East Asia (EANET). Statistical analysis showed the model system reproduced the regional-scale emission, transport, transformation, and wet deposition processes of major inorganic components of anthropogenic and natural species, such as SO$_4^{2-}$, NH$_4^+$, NO$_3^-$, Na$^+$ and Ca$^{2+}$, successfully.