Impact of Mixing States on Aerosol Direct Radiative Forcing and Heating Rate Based on GEOS-Chem-APM

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Introduction

• Mixing state of aerosol particles is an important factor influencing aerosol optical properties and direct radiative forcing (DRF), especially for black carbon (BC) particles (Bond et al., 2006; Ma et al., 2012). In fact, a core-shell configuration with BC particles serving as the core and other soluble particles functioning as the shell, is considered to be more realistic. However, most aerosol models, especially in regional scale, still use the assumptions of internal (all aerosol components are completely mixed, i.e. 100 % mixing) or external mixing (particles of different components totally separated, i.e. zero mixing) instead of core-shell mixing.

• In this study, the effects of aerosol mixing states on DRF and heating rate over China are explored by using nested GEOS-Chem-APM model.

GEOS-Chem-APM Model

• GEOS-Chem-APM (Yu and Luo, 2009) is an advanced multi-type, multi-component, size-resolved global particle microphysics model. The microphysical processes include nucleation, condensation/evaporation, coagulation, equilibrium, and dry and wet deposition.

• Pre-calculated look-up tables are extensively used for nucleation rate and coagulation kernel calculations, which substantially reduce the computing time.

• Prognostic aerosol compositions include secondary particles (SP), BC, primary organic carbon (OC), sea salt, and mineral dust. The coating of secondary species on primary particles (sea salt, BC, POC, and dust) is explicitly simulated.

• Model version: Nested GEOS-Chem-APM v10-01
• Horizontal resolution: 0.25° × 0.3125°
• Simulated time: 2014.10.15 – 2014.10.25
• Nested domain: 15°S ~ 55°N, 70°E ~ 140°E

Results

• Impact of aerosol mixing states on DRF – all sky

• Impact of aerosol mixing states on DRF – clear sky

Conclusions

✓ Core-shell mixing enhances atmospheric absorption, but reduces atmospheric scattering and total extinction.
✓ DRF at atmosphere for all sky increases by up to 6 W m⁻² in coating experiment, which implicates a strong atmospheric warming effect caused by core-shell mixing.
✓ DRF at TOA for all sky become less negative, while DRF at surface become more negative in coating experiment.
✓ Absolute value of AOD and DRF change are positively correlated to both BC and SP (coated on BC) burden.
✓ Heating rate of core-shell mixing is higher than that of external mixing, which is more evident at the height with high BC concentrations; e.g. at 950-1000 hPa.