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Simulation of aerosol changes in Asia with a chemistry-aerosol coupled climate model

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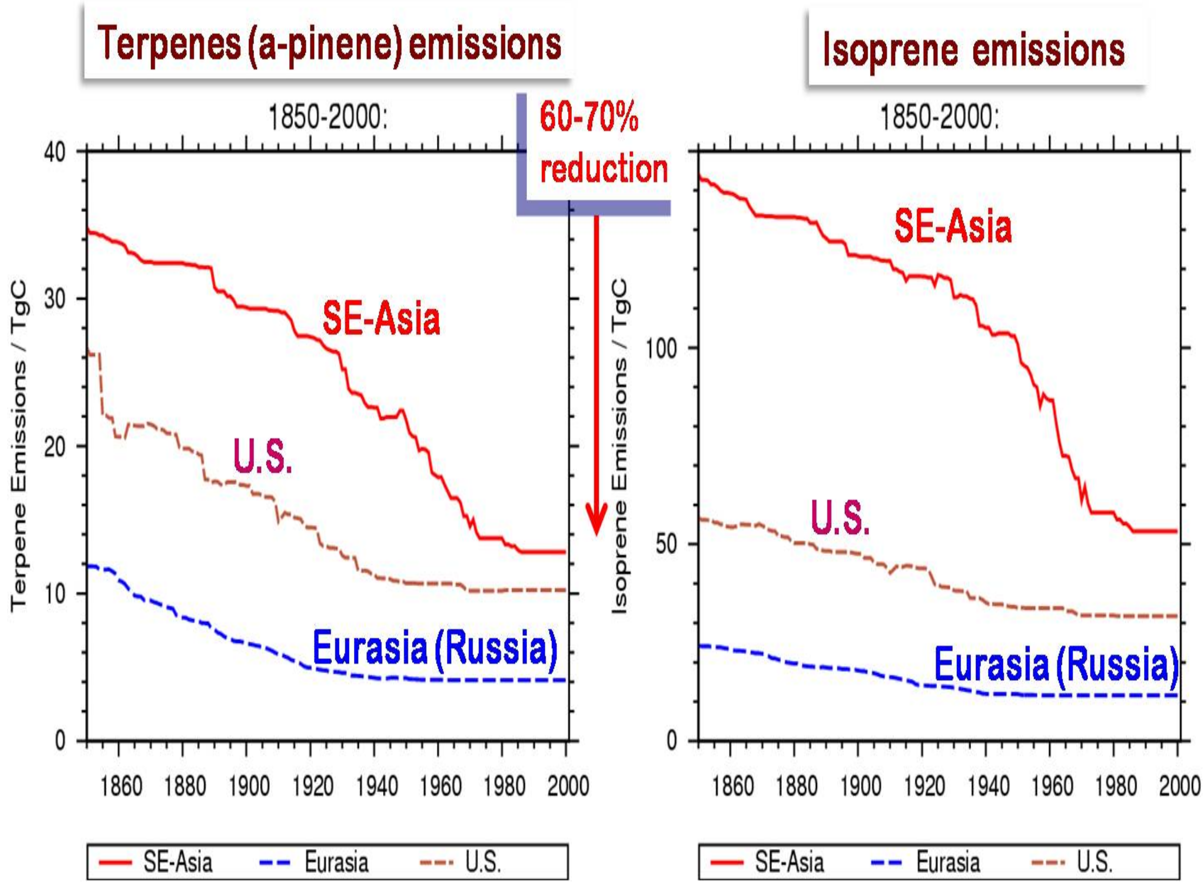

This study assesses the roles of aerosols in the past/present changes in Asian climate and monsoon, isolating impacts of individual aerosol components in the framework of the CCSR/NIES/FRCGC climate model (MIROC). Many recent studies suggest that increases in anthropogenic aerosols such as black carbon and sulfate may play a crucial role in Asian climate change as observed. Our previous studies also demonstrate the significance of aerosol increases (sulfate and carbonaceous aerosols) in the simulated precipitation changes in Asia (e.g., Arai et al., 2009). In this study, we particularly focus on the changes of nitrate and secondary organic aerosols (SOA) which are tightly linked to land use change in regions like Asia, but not treated in our previous aerosol studies. We newly introduced simulation of nitrate aerosol in our climate model. Our simulation shows that there are anomalously high concentrations of nitrate aerosol in South Asia (particularly around India and Bangladesh), coming from abundant ammonium and less sulfate components in this region. In India, free tropospheric mixing ratio and number concentration of

nitrate in fine mode are both larger than those of sulfate in winter to early summer. Our study estimates large cooling (1-2 W m-2) in South Asia due to nitrate increase in terms of direct radiative forcing for 1850-2000. This result suggests nitrate aerosol may play an important role in the observed changes in Asian monsoon. In addition, we estimate changes in biogenic VOCs emissions associated with land use change during 1850-2000; biogenic VOCs like terpenes and isoprene are important precursors of SOA. We estimate significant reduction (50-70%) in terpenes and isoprene emissions in the central Eurasia, North America, and Asia due to intense cultivation and deforestation in these areas (Fig.1). Responding to the VOCs decreases during 1850-2000, our model calculates large reduction of SOA, leading to a positive direct radiative forcing (warming) of 0.5-3 W m-2 in South Asia. This warming from SOA and cooling from nitrate aerosol which are both linked to land use change may compensate for each other in Asia.

Keywords: aerosol, monsoon, chemistry climate model, aerosol climate model,
secondary organic aerosol, SOA