Simulation of climate change through aerosol direct and indirect effects – focusing on aerosols from soil and vegetation –

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Atmospheric aerosols may affect climate change by the direct, semi-direct, indirect, and other aerosol-induced effects. The direct effect is that aerosols scatter and absorb the solar and thermal radiation. The semi-direct effect is that stability of the atmosphere changes due to aerosols which absorb the radiation. An increase in the aerosol number concentration has the effect on cloud microphysics by forming smaller and numerous cloud droplets reducing precipitation and increasing cloud lifetime – that is the indirect effect. The other aerosol-induced effects are, for example, reduction of the insolation at the Earth surface results in decreases in the surface temperature, evaporation, and availability of water vapor to form clouds.

In this presentation the climate effects through the aerosol direct, semi-direct, and indirect effects simulated by the global aerosol climate model, SPRINTARS (Takemura et al., 2000, 2002, 2005, 2008), are discussed. The model is coupled with MIROC which is a general circulation model (GCM) developed by Center for Climate System Research (CCSR)/University of Tokyo, National Institute for Environmental Studies (NIES), and Frontier Research Center for Global Change (FRCGC) (K-1 Model Developers, 2004). The horizontal and vertical resolutions are T106 (approximately 1.1 by 1.1 degrees) and 56 layers, respectively. SPRINTARS includes the transport, radiation, cloud, and precipitation processes of all main tropospheric aerosols (black and organic carbons, sulfate, soil dust, and sea salt). The model treats not only the aerosol mass mixing ratios but also the cloud droplet and ice crystal number concentrations as prognostic variables, and the nucleation processes of cloud droplets and ice crystals depend on the number concentrations of each aerosol species. Changes in the cloud droplet and ice crystal number concentrations affect the cloud radiation and precipitation processes in the model.

Taking cooperation between MAHASRI and iLEAPS into consideration, this presentation focuses on aerosols originating from soil and vegetation and their effects on the climate system. SPRINTARS treats soil dust from deserts, carbonaceous aerosols and sulfur dioxide (SO_2) from natural and anthropogenic biomass burning, and secondary aerosols from dimethylsulfide (DMS) and volatile organic compounds (VOC) emitted from oceanic phytoplankton and land vegetation. Sulfate aerosols formed from oxidation of DMS and SO_2 and organic aerosols from VOC mainly scatter the solar radiation, and soil dust aerosols not only scatter but also weakly absorb the solar and thermal radiation. Sulfate and organic aerosols act as cloud condensation nuclei, and soil dust aerosols may act as ice nuclei. Also their emissions may fluctuate with the climate change.

References

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