Estimation of Climate Effect by Global Aerosol Model with 4-Dimensional Data Assimilation

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[Abstract]

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There are still large uncertainties in estimating the aerosol effects on the climate system as reported by the latest assessment report of the Intergovernmental Panel on Climate Change (IPCC). One of the methods to overcome this problem is to adopt a data assimilation method for simulating global aerosol distributions and estimating the aerosol effects with high precision. In this study, the 4-dimentional variation (4DVAR) method, one of the data assimilation methods, was adapted to a global aerosol climate model, SPRINTARS. The original SPRINTARS treats transport processes (emission, advection, diffusion, chemical reaction, wet deposition, dry deposition, and gravitational settling) and aerosol climate effects through radiation and cloud/precipitation processes of main tropospheric aerosols in a general circulation model. General numerical climate models integrate the atmospheric field forward in time. On the other hand, it is integrated backward in time adjusting a certain parameter with observational data in SPRINTARS-4DVAR. The most important point in this study was to develop an adjoint model fitting SPRINTARS for the backward integration. After the development, twin experiments were carried out for each aerosol component with virtual observational data to verify the data assimilation system. Because of convergence of AOT and aerosol emission to true values in the twin experiments, it was confirmed that the SPRINTARS-4DVAR has a good performance of calculating aerosol distributions and estimating the aerosol emissions. Then the SPRINTARS-4DVAR was adapted with the real aerosol observation. After the assimilation, the simulated aerosol distributions were quantitatively closer to the observation, although the qualitative distributions could be simulated by SPRINTARS even without assimilation. This indicates that the SPRINTARS-4DVAR is effective in calculating the real aerosol field in the atmosphere. Spatial and temporal distributions of aerosol emission fluxes that are main origins of uncertainties in estimation of aerosol effects on climate were also inversely calculated with the SPRINTARS-4DVAR using the observation. The aerosol radiative forcings were finally estimated with the data assimilation system in this study, which is great progress in the research field of climate change. An achievement of this study contributes to reliable projection of the

future climate change and then the next IPCC assessment report. It is also expected that the trans-boundary transport of atmospheric pollutants from the Asian continent to Japan is quantitatively understood using the data assimilation system developed in this study, which provides a scientific basis to the administration of environment.