Simulation of global atmospheric dust distribution in the Last Glacial Maximum by a aerosol climate model

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Data from ice cores shows that a larger amount of soil dust aerosol in the atmosphere existed in the glacial ages than in the interglacial ages, especially in the Last Glacial Maximum (LGM). It is estimated from the Vostok ice core that the dust concentration in the LGM is one to two orders larger than in the present. It is also suggested that the amount of dust transport from Africa to the Atlantic and of dust deposition in the polar region in the LGM is three to five times and twice to twenty times as large as in the present, respectively. Their main reasons are increases in the emission and transport fluxes due to strong wind, suppression of precipitation, and expansion of dust sources.

It is said that the low temperature in the glacial ages results from decreases in the solar radiation due to a variation in an angle of the earth's axis and in the CO_2 concentration. Moreover, the increase of dust can cause the low surface temperature due to larger extinction of the solar radiation back to space. Therefore, in this study, global aerosol radiation-transport model, SPRINTARS, simulates dust distributions in the LGM. The results are compared with data from ice and marine sediment cores to validate the simulation. Then the simulation with a slab ocean model is done to estimate contribution of dust to climate system in the LGM.

SPRINTARS is a global model which treats transport and radiation processes and interaction with climate of main tropospheric aerosol of black and organic carbons, sulfate, soil dust, and sea salt (Takemura et al. 2000, 2002, 2005). This is based on the ocean-atmosphere coupled general circulation model, MIROC, developed in the Center for Climate System Research (CCSR), University of Tokyo/National Institute for Environmental Studies (NIES)/Frontier Research Center for Global Change (FRCGC) (K-1 Model Developers 2004). The dust emission flux is calculated inside the model with the vegetation index, surface wind, soil moisture, snow amount, and leaf area index.

This study uses a detailed land surface model, MATSIRO (Takata et al. 2003). Results from a dynamic global vegetation model (DGVM), which can simulate vegetation depending on the climate condition, are also used as boundary conditions to represent a difference in the distribution of vegetation between the present and LGM. The monthly mean data of the sea surface temperature (SST) and sea ice as boundary conditions and the initial condition are conformable to the Paleoclimate Modeling Intercomparison Project (PMIP). On the other hand, SST and sea ice are prognostic parameters in the simulation coupled with the slab ocean model.

The simulated result shows that the annual total dust emission in the LGM is 2.2 times as large as in the present on the global mean, especially the increase is remarkable in the Saharan and Asian regions. This is because not only strong wind in the LGM but also expansion of arid regions to the north in Asia. The dust concentration is generally larger in the LGM mainly due to the increase in the emission flux. A rise in the dust concentration is conspicuous in the arctic region because of not only the expansion of arid regions to the north in Asia, as mentioned above, but also an increase in the transport flux due to strong wind and the dry condition in the tundra. The simulated dust deposition is in general agreement with DIRTMAP data, which is database of ice and marine sediment cores, and it is suggested that it is important to use results of the DGVM. Detailed results including an experiment coupled with the slab ocean model will be addressed in the conference.

References

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