High potential of Asian dust to act as ice nucleating particles in mixed-phase clouds simulated with a global model

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Mineral dust is recognized as the most important ice nucleating particle (INP) in mixed-phase clouds, which consist of supercooled water droplets and ice crystals. Dust INPs affect the microphysical and radiative properties of mixed-phase clouds and hence the radiative balance of the Earth. Although ice nucleating ability of dust has been measured with a cloud chamber, it is not well understood how much dust is transported to higher altitudes and acts as INPs. Asian dust (Kosa), which is emitted from arid and semi-arid regions of East Asia (e.g., the Gobi and Taklimakan Deserts), may have high potential to act as INPs because of high altitudes of the source regions and upward transport by cold frontal systems. In this study, we examined the contribution of Asian dust to global dust INP number and its effect on cloud radiative forcing (CRF) using a global aerosol model, CAM/ATRAS. We replaced the default ice nucleation scheme for mixed-phase clouds in the model with a parameterization that calculates INP number concentrations from the ambient temperature and dust number concentrations. We performed simulations for the years 2012–2017 and analyzed results for the last 5 years.
Our model well reproduces INP number concentrations measured at Tokyo Skytree during May 2017, when Asian dust was transported to Japan. The simulated emission flux of Asian dust is 283 Tg/yr, representing 7.1% of global dust emission flux. Asian dust extends from East Asia to the North Pacific, North America, and the Arctic. The annual mean atmospheric loading of Asian dust is 1.2 Tg, which accounts for 3.4% of global dust loading. In particular, this contribution increases to 13% for the temperature regimes relevant for the formation of mixed-phase clouds (i.e., between −38˚C and 0˚C). The contribution of Asian dust to global dust INP number is 15%, which is 2.1 times higher than the contribution to global dust emission flux and 4.4 times higher than the contribution to the global dust loading. These results show that Asian dust is efficiently transported into low-temperature regions and has high potential to act as INPs in mixed-phase clouds. According to sensitivity simulations, Asian dust INPs induce an annual mean positive CRF of 0.054–0.19 W/m^2 (cf. 0.092–1.0 W/m^2 for dust from other regions) in East Asia and the North Pacific.

Keywords: Asian dust, Kosa, ice nucleating particles, mixed-phase clouds, global aerosol model

