



Modeling dust sources, transport, and radiative effects at different altitudes over the Tibetan Plateau

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Mineral dust plays an important role in the climate of the Tibetan Plateau (TP) by modifying the radiation budget, cloud macro- and microphysics, precipitation, and snow albedo. Meanwhile, the TP with the highest topography in the world can affect intercontinental transport of dust plumes and induce typical distribution characteristics of dust at different altitudes. In this study, we conduct a quasi-global simulation to investigate the characteristics of dust source contribution and transport over the TP at different altitude by using a fully coupled meteorology-chemistry model (WRF-Chem) with a tracer-tagging technique. Generally, the simulation reasonably captures the spatial distribution of satellite retrieved dust aerosol optical depth (AOD) at different altitudes. Model results show that dust particles are emitted into atmosphere through updrafts over major desert regions, and then transported to the TP. The East Asian dust (mainly from Gobi and Taklamakan deserts) transports southward and is lifted up to the TP, contributing a mass loading of 50 mg/m² at 3 km height and 5 mg/m² at 12 km height over the northern slope of the TP. Dust from North Africa and Middle East are concentrated over both northern and southern slopes below 6 km, where mass loadings range from 10 to 100 mg/m² and 1 to 10 mg/m² below 3 km and above 9 km, respectively. As the dust is transported to the north and over the TP, mass loadings are 5-10 mg/m² above 6 km.

The imported dust mass flux from East Asia to the TP is 7.9 Tg/year mostly occurring at the heights of 3–6 km. The North African and Middle East dust particles are transported eastward following the westerly jet, and then imported into the TP at West side with the dust mass flux of 7.8 and 26.6 Tg/year, respectively. The maximum mass flux of the North African dust mainly occurs in 0–3 km (3.9 Tg/year), while the Middle East within 6–9 km (12.3 Tg/year). The dust outflow occurs at East side (–17.89 Tg/year) and South side (–11.22 Tg/year) of the TP with a peak value (8.7 Tg/year) in 6–9 km. Moreover, the dust mass is within the size range of 1.25–5.0