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Direct radiative effects of dust aerosols emitted from the Tibetan Plateau on the East Asian climate

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The regional climate model (RegCM4.1) coupled with a dust module was used to simulate the spatial-temporal distribution of dust aerosol, originated in the Tibetan Plateau (TP), and its radiative effects on East Asia summer monsoon (EASM) during strong/weak dust years. Two experiments were carried out for the past two decade (1990–2009) with dust emission turned on (control experiment, CON) and off (sensitivity experiment, SEN) in the TP. The CON simulated spatial-temporal distribution, seasonal and interannual variation of dust aerosol optical depth (AOD) were consistent with satellite and in situ observations in East Asia. Simulated dust AOD was higher in spring and summer, lower in autumn and winter. It was more than 0.6 in the deserts surrounding the TP such as Taklimakan Desert, Gobi Desert, and the Great Indian Desert. Besides, it was higher in Qaidam Basin in spring over the TP. The simulated difference between CON and SEN showed that there were two maximum dust column burden centers over the TP, located in Qaidam Basin and the northwest TP with their center value greater than 70 mg m-2 in summer for strong dust years. The dust column burden over the northwest TP in weak dust years was much less than that in strong dust years. Our simulation results indicated a significant negative correlation between the plateau dust column burden produced by local emission of the TP and the corresponding anomaly of EASM index (r=-0.46). The EASM was weakened (enhanced) when the dust aerosol over the TP increased (decreased). The radiative cooling effects of dust aerosol over the TP caused a negative center of atmospheric heating rate anomaly in middle troposphere (600–400 hPa) of the central TP in summer for strong dust years, thus reduced the surface and atmosphere temperature by 0.6 °C in the TP. Therefore, the summer land-sea thermal contrast and EASM were weakened, leading to reduced precipitation by 27 % in the southern part of EASM region. The reducing effects of dust aerosol on the EASM in weak dust years was weaker than that in strong dust years due to less dust aerosol over the TP, but summer precipitation was still reduced by 8 % in the southern EASM region. Furthermore, the dust aerosol produced on the TP delayed the onset of EASM by 1 pentad both in the northern and southern monsoon regions in China.