Aerosol Impacts on Clouds, Temperature and Precipitation in Summer over East Asia

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Along with rapid economic development, East Asia has been experiencing severe aerosol pollution in recent decades. Apart from aerosol direct effect referring to aerosol scattering and absorbing of radiation, aerosol indirect effect on climate refers to aerosol modifying microphysical and radiative properties of clouds and precipitation processes. We conducted ten-member ensemble simulations over East Asia for the period from June to August (JJA) 2008 by using a coupled meteorology-chemistry model (WRF-Chem) to investigate anthropogenic aerosol indirect effect on cloud and precipitation over this region. Model simulation can generally reproduce the observed cloud liquid water path (LWP) and precipitation in June, July and August 2008. The results of the ensemble simulations with and without anthropogenic aerosol emission shows that for JJA 2008, anthropogenic aerosol increases cloud droplet number concentration and decreases cloud effective radius over most region of developed areas of East Asia. For LWP and low cloud fraction, anthropogenic aerosol reduce them over north and south China while increase them along Huai River between 30˚N and 35˚N and southwest China. As a result of the change of cloud fraction and LWP, net cloud forcing decreases by 0 ~ 10 W m-2 over north and south China and increases by 0 ~ 10 W m-2 along Huai River between 30˚N and 35˚N and southwest China. The net clear sky aerosol forcing (direct and indirect) is about 0 ~ -10 W m-2 at the top of atmosphere (TOA), -20 ~ -40 W m-2 at the bottom and 5 ~ 20 W m-2 in the atmosphere over East Asia.

The JJA averaged surface temperature decrease by 1 ~ 2 K over Huai river between 30˚N and 35˚N and decrease by 0.2 ~ 0.5 K or increase slightly by 0 ~ 0.2 K over north and south China because of the cooling of aerosol radiative forcing at surface. Although anthropogenic aerosol reduce surface temperature over most region of East Asia, the heating rate from solar radiative within Planetary Boundary Layer along Huai River of China at the latitude between 30˚N and 35˚N is about 0.6 ~ 0.8 K/day which is much larger than that at higher latitude (north China) and lower latitude (south China). The surface cooling can reduces the land-sea thermal contrast and weakens the East Asia summer monsoon but the heated air along Huai River rises and strengthen summer monsoon. As a result of the change of thermal structure, the JJA averaged precipitation decreases by 1.5 mm/day over north and south China and increases by 1 mm/day along Huai River between 30˚N and 35˚N.

Keywords: Aerosol, Cloud, Summer monsoon