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Change in diurnal variations of meteorological variables induced by anthropogenic aerosols over the North China Plain

Meigen Zhang (1), Yi Gao (1), Xiaohong Liu (2), and Lili Wang (1)

(1) LAPC, Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing, China (mgzhang@mail.iap.ac.cn), (2) Department of Atmospheric Science, University of Wyoming, Laramie, WY, USA

This study investigates the impacts of all anthropogenic aerosols and anthropogenic black carbon (BC) on the diurnal variations of meteorological variables in the atmospheric boundary layer over the North China Plain (NCP) during June to August 2008, using a coupled meteorology and chemistry model (WRF-Chem). The results of the ensemble numerical experiments show that surface air temperature decreases by about 0.6 to 1.2 K with the maximum decrease over the Beijing urban area and the southern part of Hebei province, and the surface relative humidity (RH) increases by 2–4 % owing to all anthropogenic aerosols. On the contrary, anthropogenic BC induces a small change of temperature and RH at surface. Averaged for Beijing, Tianjin, and Hebei province (BTH region) and High Particle Concentration (HPC) periods when PM2.5 surface concentration is more than 60 μg m$-$3 and daily AOD is more than 0.9, all anthropogenic aerosols decrease air temperature under 850 hPa and increase it between 500 and 850 hPa, while anthropogenic BC increases it for whole atmosphere. The maximum changes occur at 08:00–20:00 (local time). Aerosol-induced surface energy and diabatic heating change leads to a cooling at the surface and in the lower atmosphere and a warming in the middle troposphere at 08:00–17:00, with reversed effects at 20:00–05:00. BC cools the atmosphere at the surface and warms the atmosphere above for the whole day. As a result, the equivalent potential temperature profile change shows that the lower atmosphere is more stable at 08:00 and 14:00. All anthropogenic aerosols decrease the surface wind speed by 20–60 %, while anthropogenic BC decreases the wind speed by 10–40 % over the NCP with the maximum decrease at 08:00. The aerosol-induced stabilization of the lower atmosphere favors the accumulation of air pollutants and thus contributes to deterioration of visibility and fog–haze events.