Supplemental information for

The pathway of aerosol direct effects impact on secondary inorganic aerosol formation

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1 Model evaluation

The simulated concentrations of surface SO$_2$, NO$_2$ and PM$_{2.5}$ in SimNF (no aerosol feedbacks) and SimSF (which aerosol feedbacks) are compared with observed data in Figure S2. In January, high SO$_2$ concentrations are shown in JJJ, YRD, HUZ, and SCH. In general, simulated SO$_2$ concentration is underestimated in JJJ. The low-bias is getting larger under high PM$_{2.5}$ level, shown in Figure S2. JJJ region is with highest observed SO$_2$ value up to 500 µg m$^{-3}$. Meanwhile, SO$_2$ concentration is overestimated in PRD, HUZ, and SCH. The simulated SO$_2$ match pretty well with the observation in YRD. ADE increases SO$_2$ concentration in most regions, except eastern Henan and middle Shandong where is the downwind area of polluted regions. The enhanced atmospheric stability reduced the ventilation condition resulting in an increased polluted level at source area but decreased polluted level at downwind area. The increase of SO$_2$ is up to 56 µg/m$^3$ in the polluted regions. In July, high SO$_2$ concentrations are still shown in JJJ, YRD, PRD, HUZ, and SCH, but much lower than in January. SO$_2$ concentration is lower than 50 µg/m$^3$ in most cities, except Handan (south of JJJ). Model generally overestimates SO$_2$ concentration in most regions. ADE enhances SO$_2$ concentration in part of JJJ, YRD, and SCH. But SO$_2$ is decreased due to ADE in PRD. NO$_2$ also exhibits higher concentration in January and lower concentration in July. High NO$_2$ is usually located at large cities. In January, high NO$_2$ is shown in Northeast China, JJJ, HUZ, and YRD. The cities in south part of JJJ, i.e., Beijing, Tangshan, Baoding, Shijiazhuang, Xingtai, and Handan are the most polluted cities where monthly averaged NO$_2$ concentrations exceed China air quality standard of daily average NO$_2$ concentration (i.e., 80 µg/m$^3$). In general, the model slightly underestimates NO$_2$ for most regions. ADE enhances NO$_2$ concentration by over 19.7 µg/m$^3$ in JJJ, YRD, HUZ, and SCH, which improves the model performance. In July, the NO$_2$ concentration is much lower than in January. The model also underestimated NO$_2$ concentration. PM$_{2.5}$ concentrations in January exceed 160 µg/m$^3$ in all 5 regions. The model generally underestimates PM$_{2.5}$ concentrations in almost all regions. ADE enhances monthly averaged PM$_{2.5}$ concentrations by over 2 µg/m$^3$ in most area of East China. The maximum increase reached 35.8 µg/m$^3$. Compared to January, PM$_{2.5}$ concentrations in July are much lower and mostly high concentrations are located in JJJ and part of SCH. Simulated PM$_{2.5}$ concentrations match well with the observed data.
Figure S1. Observed and simulated SO$_2$, NO$_2$ and PM$_{2.5}$ and their responses to ADE (monthly mean, $\mu$g m$^{-3}$)
Figure S2 Observed and simulated surface SO$_2$ concentration against PM$_{2.5}$ concentration (monthly mean, $\mu g m^{-3}$)
Figure S3 Observed and simulated surface NO$_2$ concentration against PM$_{2.5}$ concentration (monthly mean, $\mu$g m$^{-3}$)
Obs, SimSF, SimNF

Figure S4 Observed and simulated surface PM$_{2.5}$ concentration (monthly mean, µg m$^{-3}$)