# 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.

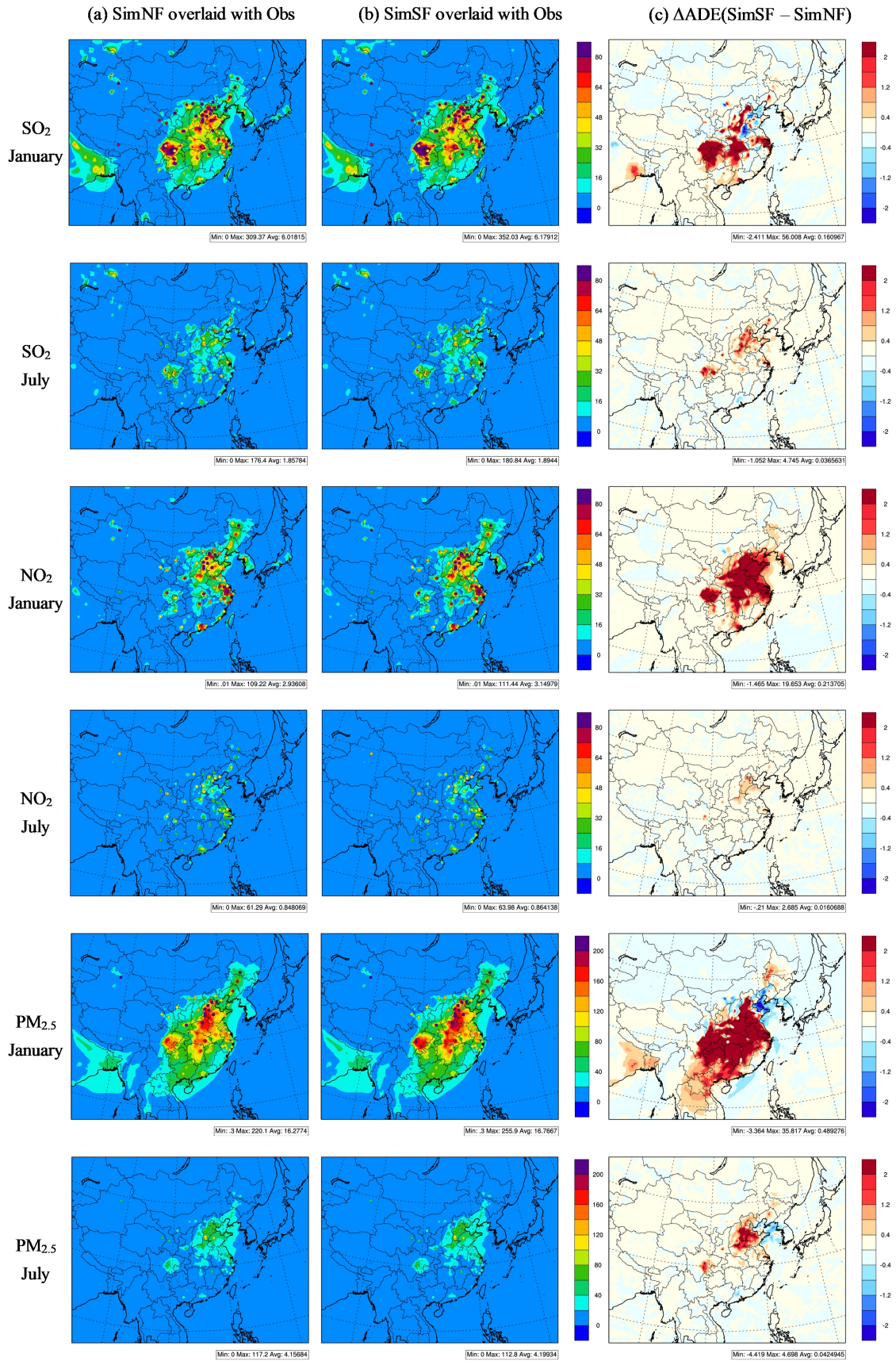


Figure S1. Observed and simulated $SO_2$, $NO_2$ and $PM_{2.5}$ and their responses to ADE (monthly mean, μg $m^{-3}$)

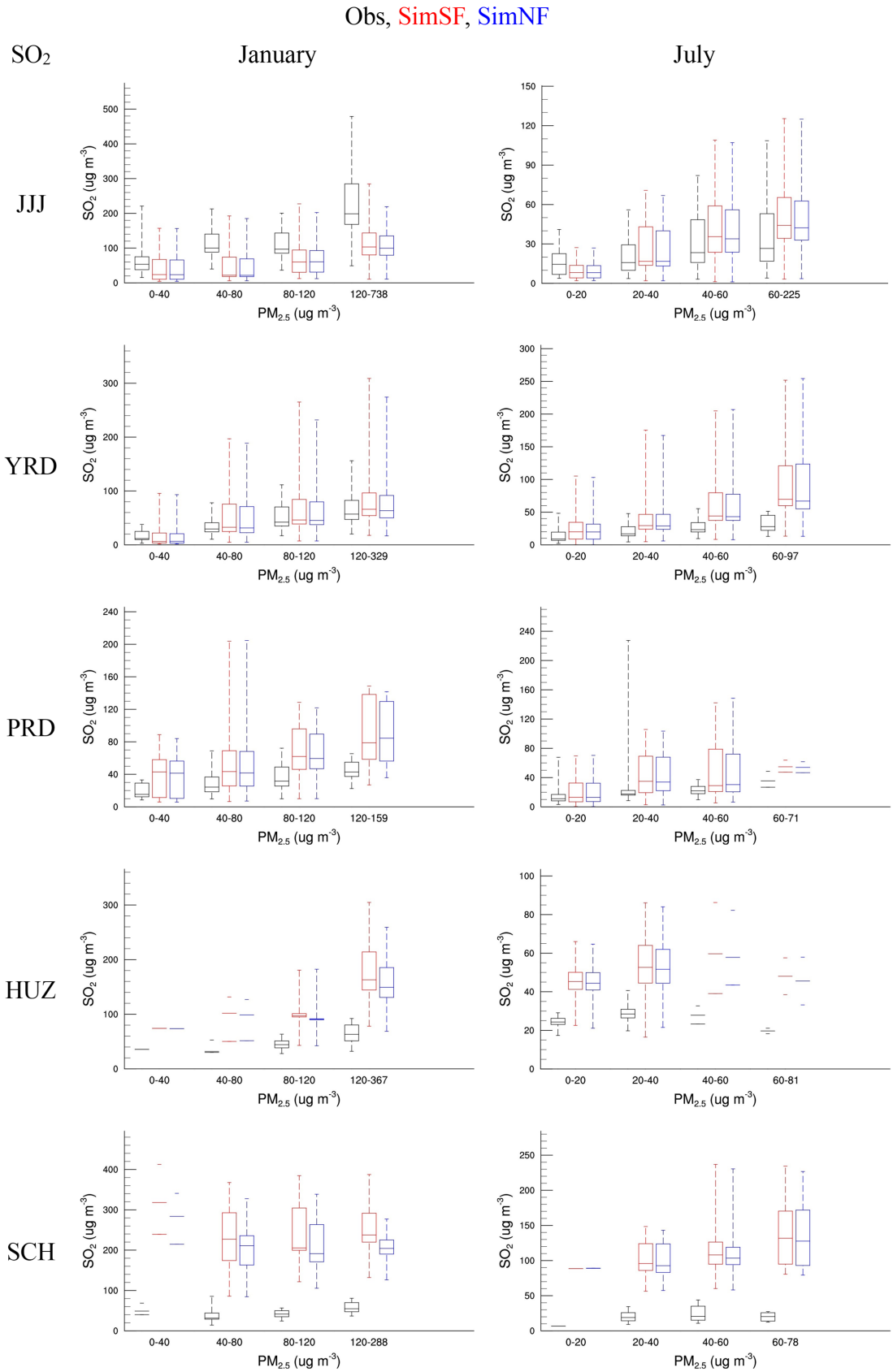


Figure S2 Observed and simulated surface $SO_2$ concentration against $PM_{2.5}$ concentration (monthly mean, μg $m^{-3}$)

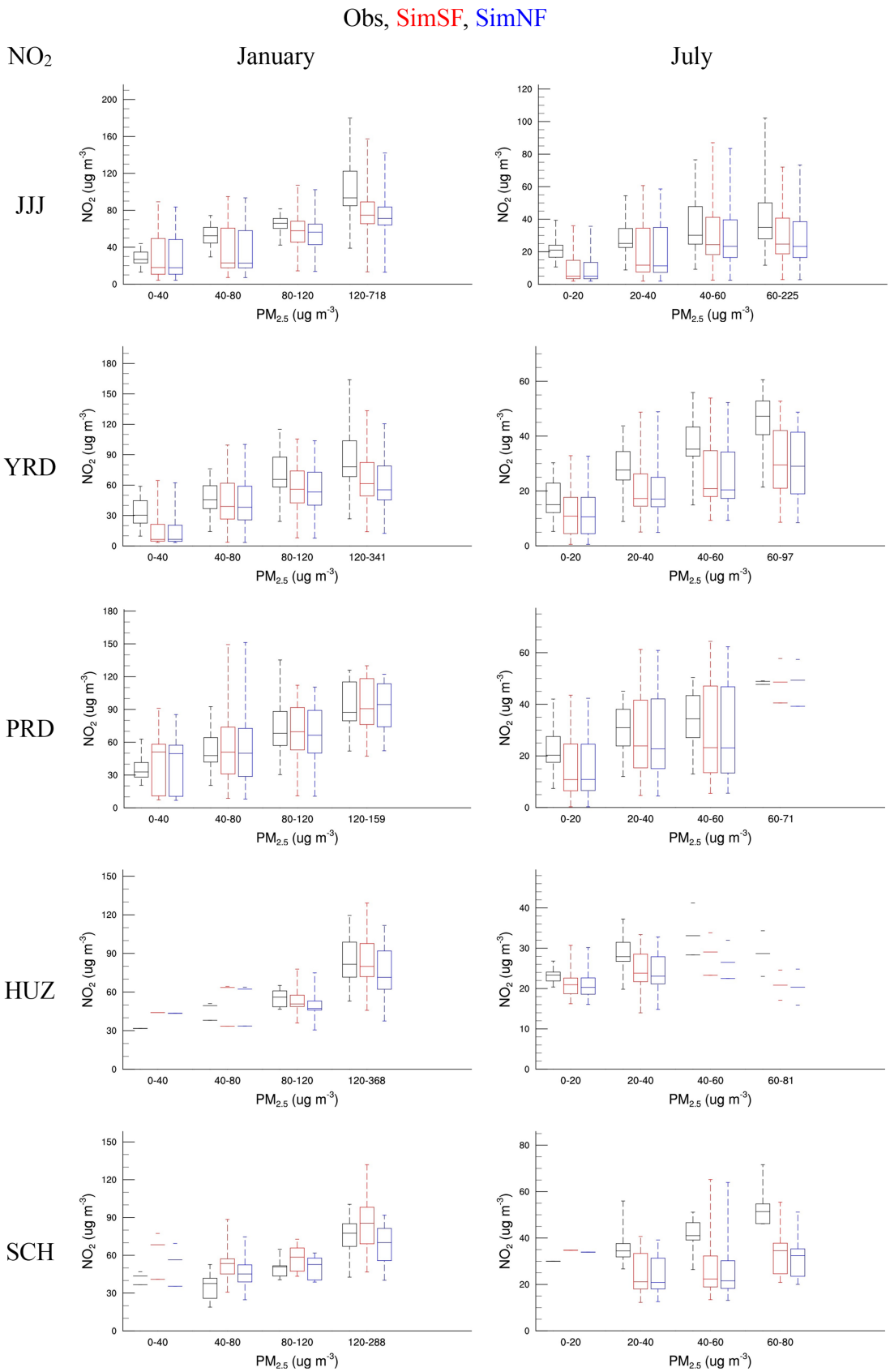


Figure S3 Observed and simulated surface $NO_2$ concentration against $PM_{2.5}$ concentration (monthly mean, μg $m^{-3}$)

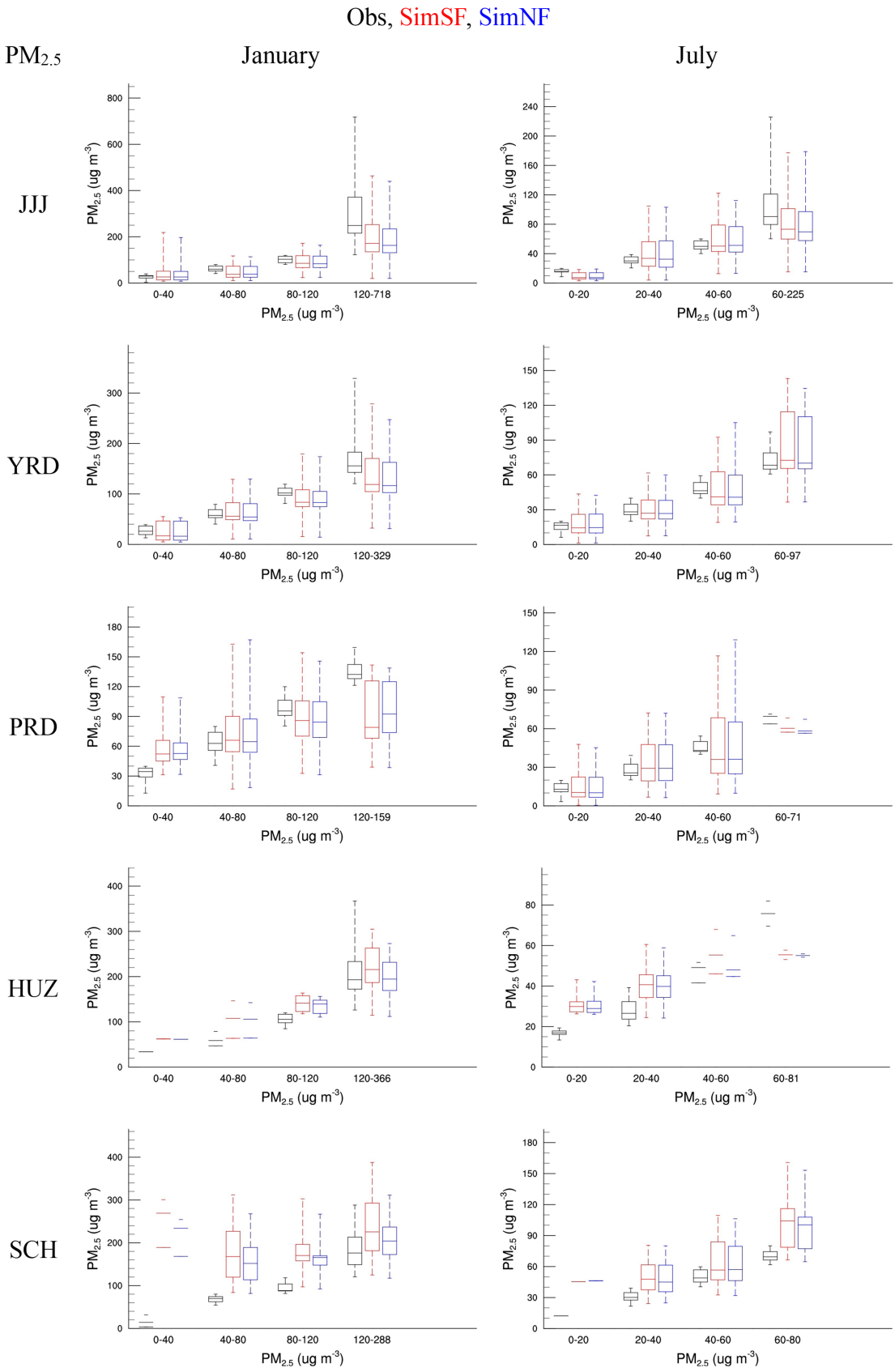


Figure S4 Observed and simulated surface $PM_{2.5}$ concentration (monthly mean, μg $m^{-3}$)