Biases of aerosol simulation in the AerChemMIP models over China and impact of emission uncertainties

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Biases of aerosol simulation by models participating the Aerosol and Chemistry Model Intercomparison Project (AerChemMIP) were identified over China. Although the yearly trend of simulated aerosol optical depth (AOD) agrees with the MODIS satellite retrievals for the country-wide averages, this agreement is an offset between the underestimation of AOD over eastern China and the overestimation of AOD over western China. The AODs were underestimated over the Northeastern China Plain and the North China Plain all year along and overestimated over Sichuan Basin in the winter. These model biases were persistent over multiple years from 2002 to 2015. We attempt to evaluate the impact of emission uncertainties on model simulated aerosol properties and aerosol radiative forcing by comparing the simulations by the Community Earth System Model version 2 (CESM2) with the default inventory developed by the Community Emission Data System (CEDS) and with a country-level inventory (Multi-resolution Emission Inventory for China, MEIC). It turns out that the differences between simulations with the two emission inventories are much smaller than the differences between simulations and observations. Low-bias of precursor gases (e.g., SO₂), too strong convergence of wind field, too strong dilution and transport by summer monsoon circulation, too much wet scavenging by precipitation, and too weak aerosol swelling due to low-biased relative humidity are suggested to be responsible for the biased AOD in eastern China. This indicates that the influence of emission inventory uncertainties on aerosol radiative forcing can be overwhelmed by influences of biased meteorology and aerosol processes. Therefore, it is necessary for climate models to perform reasonably well in the dynamical, physical and chemical processes in order to estimate the aerosol radiative forcing.