Seasonal and interannual variation in aerosol outflow from Asia/China and its controlling factors

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This study reveals seasonal and interannual variability in aerosol outflow from Asia and China (as the major source regions) and its controlling factors using simulations with a global chemical climate model. In the simulations, anthropogenic emissions are kept constant at the 2008 level to easily detect effects of meteorological variation. The model simulations are validated with the satellite observations of aerosol optical depth (AOD) and column burden of carbon monoxide (CO). The distributions and seasonal variations of simulated AOD both show a good agreement with satellite observations over maritime regions, while the model overestimates AOD over China in winter. On the other hand, simulated burden of CO is largely consistent with the satellite observations in the Asian regions including China.
This study also reveals the regional budgets of aerosols within Asia and China, focusing on black carbon (BC), organic carbon (OC) and sulfur oxides (SOx; SO_2 and sulfate) as aerosol components. Basically, zonal flux of aerosol is much larger than meridional one. Aerosol outflow across the east boundary of the China region, which shows significant large aerosol fluxes in 30°N-45°N, and the inflow across the west boundary of it both peak in March regardless of components of aerosols. In terms of interannual variation of aerosol outflow, the year to year change of zonal flux plays central role in total variability of aerosol outflow. Of the emitted BC, OC, and SOx from China, about 38%, 20%, and 25% are fractionally exported outside of the region, respectively. The simulated aerosol outflow is validated with diagnosis based on the satellite observation of AOD following the method by Yu et al. (2008). The simulated aerosol outflow across the boundary at the eastern edge of China agrees well with the outflow derived from the satellite observation for both quantitative level and seasonal to interannual variations. The aerosol outflow derived by this study shows a positive trend of 1-2% per year for the period of 2000-2015, which suggests increasing anthropogenic emissions in East Asia during the recent decades.
In addition, to interpret interannual variability in regional aerosol burden over Asia and China, its controlling mechanism is separated into three independent factors of emission, deposition, and export outside the region using a multiple regression analysis for total aerosol burden. The result shows that burden variation of BC in Asia and China is principally controlled by export outside the region, whereas SOx variation is by regional deposition; to OC variation, export and regional deposition equally contribute. Therefore, the BC outflow from China can affect climate and atmospheric environment in both local and remote areas.
Furthermore, to assess the aerosol effects on climate and air quality in downwind region, this study investigates controlling factors of interannual variations of aerosol outflow from China. By a composite analysis for winter, it is shown that in the phase of relatively enhanced aerosol outflow from China, a dipole-like anomaly presents exhibiting negative/positive deviation in interior of China and its downwind regions including India and Southeast Asia, respectively. It is also suggested that aerosol outflow from China has a negative correlation with the strength of Asian monsoon. Accordingly, modulation of Asian monsoon associated with climate change can cause additional climate effects through varying aerosol outflow from the polluted area.

Keywords: aerosol, long-range transport, Asian Monsoon, Chemical Transport Model, Chemistry Climate Model

