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Source attribution of PM2.5 for Korea during the KORUS-AQ campaign using GEOS-Chem adjoint model

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An intercontinental cooperative air quality field study in Korea, KORUS-AQ was held in 2016, where extensive observations of PM2.5 concentrations and its precursors were conducted. In this study, we investigated source contributions to PM2.5 in Korea under various meteorological conditions during the KORUS-AQ campaign using the GEOS-Chem 3-D global chemical transport model and its adjoint. First, we updated the model with the latest regional emission inventory, KORUS ver.2.0, diurnally varying NH_3 emissions, a new photolysis of particulate nitrate, and secondary organic aerosol formation from oxidation of aromatic species (benzene, toluene, and xylene). We evaluated the updated model against average PM2.5 and its chemical constituents measured at six ground sites (Bangnyung, Olympic, Bulkwang, Gwangju, Ulsan, Jeju). The updated features improved the performance in simulating nitrate and organic aerosol, which had been overestimated and underestimated, respectively. Next, we conducted an adjoint sensitivity analysis for surface PM2.5 at five ground sites (except for Bangnyung because of its small population) under four different meteorological conditions: dynamic weather, stagnancy, extreme transport and pollution, and blocking pattern. The analysis calculated relative contributions of emission sources to population exposure to PM2.5 in Korea from each species/sector/grid sell in the model. Regional contributions varied greatly with synoptic meteorological conditions. We found that the Chinese contribution accounted for almost 70% of PM2.5 in Korea during the efficient transport period of the campaign, whereas the stagnant period showed much enhanced contributions from domestic sources. Last, we examined effective control measures for improving PM2.5 air quality in Korea, among which the reduction of domestic anthropogenic NH_3 emissions is most effective in reducing population exposure to PM2.5 in Korea followed by the reduction of anthropogenic SO_2 and NH_3 emissions from Shandong region.