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Evaluation of 2021 Air Quality over Asia using the WRF-Chem Model and the Impacts of Pollutant Boundary Conditions

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Air quality over Asia in 2021 is simulated using the WRF-Chem modeling system and evaluated against various observational datasets. Particulate matter with an aerodynamic diameter less than 2.5 um ($PM_{2.5}$), primary pollutants (NO_2 and SO_2), and ozone (O_3) concentrations are analyzed. The simulated pollutant concentrations are evaluated using a wide range of data including Tracking Air Pollution in China (TAP), China High Air Pollutants (CHAP), Air Korea, long-term daily ground $PM_{2.5}$ concentrations in India (LongPMInd), and Moderate Resolution Imaging Spectroradiometer (MODIS) aerosol optical depth (AOD). The results show that $PM_{2.5}$, NO_2, and SO_2 are well-simulated (r = 0.83, 0.78, and 0.80 for $PM_{2.5}$, NO_2, and SO_2, respectively), while O_3 is underestimated by the model with a mean bias error of −18.26 ppb (r = 0.49) in Beijing-Tianjin-Hebei region. In Yangtze River Delta region, $PM_{2.5}$ and SO_2 are well-simulated (r = 0.70 for $PM_{2.5}$ and 0.80 for SO_2), but the model shows relative low performance for O_3 and NO_2 (r = 0.58 and r = 0.33 for respectively O_3 and NO_2). Over South Korea, $PM_{2.5}$ and NO_2 are well-simulated (r = 0.73 for both PM2.5 and NO2), while the model shows relative low performance for O_3 and SO_2 (r = 0.58 for O_3 and r = 0.42 for SO_2). Additionally, sensitivity experiments in which climatological mean (2013 – 2022) pollutant boundary forcing is used instead of the time-dependent reanalysis forcing are conducted to examine the influences of pollutant boundary conditions on air quality over Asia. The most significant differences are found for O_3, with a maximum difference of greater 10 ppb near the surface within the domain. Further detailed analyses will be presented and discussed.

Key words: WRF-Chem, $PM_{2.5}$, air pollutant, evaluation, boundary forcing