A high-resolution global data assimilation for air pollution analysis on megacity scale using multi-sensor satellite measurements including TROPOMI NO_2 data

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Intensive human activities lead to high emissions of air pollutants at megacities, causing severe damages to human health. The number of megacities is expected to rise in developing regions in the near future. Thus, it is important to provide information on air pollutants and their emissions on a megacity scale for the globe in a consistent way. In this study, we present the results from global chemical data assimilation of multi-species satellite observations with a resolution of 0.56 degree using an ensemble Kalman filter approach (Miyazaki et al., 2015) and high-resolution global chemical transport model, CHASER (Sekiya et al., 2018). Assimilated data were obtained from the OMI, GOME-2, and SCIAMACHY for tropospheric NO_2 column, the TES for O_3 profile, the MOPITT for total CO column, the MLS for O_3 and HNO_3 profiles, and the OMI for total SO_2 column. Data assimilation at 0.56-degree resolution largely improved agreements with the observed surface NO_2 pollutions on megacity scale, with reductions of the root mean square errors (RMSEs) relative to in-situ measuring networks (AirBase, AQS, Hong Kong EPD, and NIES) by 33% for Europe, by 67% for the U.S., and by 75% for East Asia, compared to the model simulations without data assimilation. With increasing horizontal resolution from 2.8 to 0.56 degree, the global total NO_xemission estimates became lower by 10% mainly because of the effects of non-linear O_3-HO_x-NO_x chemistry, while resolving higher NOx emissions by a factor of 4-5 in most of the megacities than their surrounding areas. Using the high-resolution data assimilation system and applying advanced super-observation approach, we demonstrated that assimilation of tropospheric NO_2 retrievals from TROPOMI improved agreements of tropospheric NO_2 column with the assimilated TROPOMI data itself by 62% and with OMI by 40% (not used for data assimilation) compared to model simulation at 1.1-degree resolution for April 2018. These improvements primarily resulted from substantial emission reductions over the U.S., China and India and increases over rural regions relative to the a priori emissions (HTAP_v2.2+GFED4 +GEIA). These results demonstrated the potentials of the high-resolution global data assimilation with the combined use of advanced satellite observations to provide valuable information on spatial and temporal variations of air pollution on a megacity scale globally.

Keywords: Tropospheric NO2, Megacity, Data assimilation, Emission inversion, Satellite observation

