Global data assimilation of multi-species satellite measurements for atmospheric chemistry analysis

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Information on tropospheric ozone and its precursors are important for human health, ecosystem, and climate studies. The combined use of satellite measurements of ozone and its precursors has great potential to provide comprehensive information on the tropospheric chemistry system on various spatial scales. In this study, we present the results of global data assimilation of multi-species measurements (O_3, NO_2, CO, HNO_3, and SO_2) from multi-satellite sensors (OMI, GOME-2, SCIAMACHY, MOPITT, TES, and MLS) using the ensemble Kalman filter approach (Miyazaki et al., 2015). We demonstrated that increasing horizontal resolution from 2.8 to 0.56 degree is necessary for capturing high concentrations of NO_2 in the megacities, whereas 1.1-degree resolution is more suitable for optimizing tropospheric chemistry system on regional and global scales considering the current computational resources (computational cost was larger by a factor of 10 at 0.56-dgree resolution than at 1.1-degree resolution). Using the data assimilation system at 1.1-degree resolution, we constructed an updated version of tropospheric chemistry reanalysis (TCR-2; Miyazaki et al., in prep.) data for 2005—2017, which provide valuable information on decadal changes in air pollutant concentrations and emissions. The estimated NO_x emissions were strongly increased from 2005 to 2011 (+37%/decade) and decreased from 2011 to 2017 (-37%/decade) in China, while the emissions exhibited decreasing trends in Europe (-11%/decade) and the United States (-27%/decade) and an increasing trend in India (+23%/decade) during 2005—2017. A post peta-scale supercomputer such as post-K computer will facilitate the data assimilation calculation to produce tropospheric chemistry reanalysis data at 0.56-degree resolution for air pollutions on a megacity scale globally in a consistent way, which will benefit future study of atmospheric environment on various spatial scales.

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