

## Evaluation of ozone in the upper troposphere and lower stratosphere derived from multi-species satellite data assimilation

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Ozone ( $O_3$ ) in the upper troposphere and lower stratosphere (UTLS) has a stronger greenhouse effect than in the lower troposphere. However, information on  $O_3$  in the UTLS from observations with the global coverage is still limited. Multi-species satellite data assimilation of stratospheric  $O_3$ , and tropospheric  $O_3$  and its precursors is expected to provide better constraints on  $O_3$  in the UTLS, because  $O_3$  in the UTLS is controlled by stratospheric  $O_3$  intrusions,  $O_3$  transport from middle and lower troposphere, and in-situ  $O_3$  chemical production. In this study, we evaluate  $O_3$  in the UTLS derived from the multi-species data assimilation with horizontal resolutions of 2.8, 1.1, and 0.56 degree using ozonesonde observations (not used for data assimilation) in April 2008. 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. At 200 hPa, 300 hPa, and 500 hPa, the data assimilation at 0.56-degree resolution reduced root mean square errors (RMSEs) against ozonesonde observations in the northern midlatitudes by 32%, 31%, and 13%, respectively, compared to the model simulation without data assimilation. The overall data assimilation performance for  $O_3$  concentrations is not sensitive to horizontal resolution in the altitudes between 200 hPa and 500 hPa (i.e., the RMSEs were within 7% at all resolutions). Meanwhile, the data assimilation at 0.56-degree resolution improved agreements with ozonesonde observations at 300 hPa by up to 55% compared to 1.1- and 2.8-degree resolutions during a deep stratospheric intrusion episode at Trinidad Head (124°W, 41°N) through resolving small-scale transport processes. These results confirm that  $O_3$  analyses derived from multi-species data assimilation are suitable for understanding spatial and temporal variations in  $O_3$  in the UTLS and their controlling processes.

Keywords: Satellite data assimilation, Ozone, Atmospheric chemistry