Evaluating the Capability of a Global Chemical Transport Model (TM4-ECPL) in Simulating Tropospheric Ozone Trends and the Influence of Meteorological Field Inputs

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Abstract

Global chemical transport models (CTMs) are invaluable tools to simulate long-term changes in tropospheric ozone and to explore their influencing factors. Relevant model results can support future ozone pollution mitigation provided that their performance in reproducing the observed trends of ozone levels is acceptable. In this study, the capacity of a global CTM, TM4-ECPL, in simulating tropospheric ozone trends in the period of 2013-2017 was evaluated against multiple observational datasets, including ground-based O_x (ozone+NO_2) monitoring at over 10,000 sites globally and ozonesonde measurements. The simulations were driven independently by the two widely-used ECMWF meteorological re-analysis products, ERA5 and ERA-Interim. Based on the observations, near-ground O_x mixing ratios reduced across most continents during the studied period, but for different regions, it is attributed to varied changes in ozone and NO_2. Generally, TM4-ECPL reproduces well the five-year changes in ozone, NO_2 and O_x, suggesting a satisfactory performance of the model in simulating the trends of primary emissions as well as the responses of ozone to meteorological and emission changes. The usage of ERA5 improves the capability of the model in reproducing the variability of near-ground O_x in comparison to the ERA-Interim-driven results. However, discrepancies between the observed and modeled O_x changes are still evident in South Asia and Latin America, highlighting the need for improved representation of pollutant emissions and ozone-related processes (i.e., chemistry, transport, and deposition) in these regions. Additionally, the model is able to reproduce the five-year changes of ozone mixing ratios in the mid- and upper troposphere, with these in the ERA5-driven model results aligning closer to the ozonesonde measurements compared with ERA-Interim. Through the analyses of ozone budget, we examined the changes in the contributions of ozone-related processes to the ozone burden across various regions, providing insights into the mechanisms leading to the observed changes in ozone levels.

Early Career Scientist

YES, I am an early career scientist.

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TOAR: Tropospheric Ozone Assessment Report