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Atmospheric Chemistry and Physics
Discussions

# *Interactive comment on* "Global $O_3$-CO Correlations in a Chemistry and Transport Model during July—August: Evaluation with TES Satellite Observations and Sensitivity to Input Meteorological Data and Emissions" *by* Hyun-Deok Choi et al.

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We thank Referee #1 for the review and very useful suggestions. Our responses are itemized below.

"General. This study explored the ozone-CO correlations on the global scale in boreal summer using a chemical transport model (Global Modeling Initiative (GMI)), driven by three sets of meteorological data: fvGCM with sea surface temperature for 1995,



GEOS4-DAS for 2005, and MERRA for 2005. The simulations are compared with the measurements from the Tropospheric Emission Spectrometer (TES) satellite instrument so the model's capability to reproduce the TES data and sensitivity to various meteorological data were examined. Three radionuclide tracers were simulated as proxies for various transport-related processes to help untangle the simulated ozone-CO correlations and explain the differences. Sensitivity of ozone-CO correlations to various emissions was tested with GMI-MERRA simulations. This study has addressed an important issue in atmospheric chemistry. The paper is well written with logic flow of text, clear description of the method and assumptions, proper and adequate literature review, and high quality of figures. This study is novel and solid. It offers new insight on global ozone-CO correlations and underlying mechanisms."

Reply – Thanks for the comments.

"Specific. While GMI simulates tropospheric ozone reasonably well, it underestimates tropospheric CO as suggested in this and earlier studies. This underestimation may cause some biases for the ozone-CO correlations presented in this study. Please discuss."

Reply – Good point. We have revised the first paragraph of Section 5 (P19): "In this section, we examine O3 and CO relationships at 618hPa in GMI CTM. We interpret GMI simulated O3-CO correlations and their slopes in the context of emissions, photochemical transformation, and transport (e.g., convection, STE, and large-scale subsidence), using model meteorological data and radionuclide simulations. We then evaluate them with those derived from TES satellite observations. Note that the model underestimate of CO concentrations does not significantly affect the calculated O3-CO correlations although it may cause biases in the regression slopes due to the association of the latter with ozone production efficiency".

"In the model simulations, the anthropogenic emissions are kept the same (using 2005's emissions) for the simulations driven by the three sets of meteorological data.

The surface biomass and biogenic emissions are all the same for the three simulations. Therefore, the differences seen in the three simulations are due to different meteorological fields that also cause the differences in lightning emissions. As understandable, the authors placed their focus on the middle troposphere when comparing GMI and TES results because TES data are least biased at these altitudes (Figures 12-15). Therefore, showing NOX emissions from lightning in the middle troposphere horizontally (like Figure 9) would help interpret Figures 12-15."

Reply – As discussed on P15 (L15-20, Table 1), all simulations show similar lightning NOx (LNOx) emissions during July-August. However, GMI/fvGCM shows a factor of ∼ 2.5 lower LNOx emissions than GMI/GEOS4 and GMI/MERRA during May-June. The July-August LNOx emissions do not explain the discrepancy in the simulated ozone, and therefore we decide not to add a plot of LNOx emissions. We have added a sentence in the text (P15) as below: "It is noted that all simulations show hot spots of LNOx emissions over the central and eastern US, central Africa, and west Tibetan plateau (not shown)."

"For the model validation (Figure 6), please provide the values of correlation coefficients, mean biases, and root mean square error so to help evaluate the performance of each simulation quantitatively (in the figure or in a table)."

Reply – Thanks for the suggestion. We have added a new table (Table 2) and a sentence in the text (P15): "The mean differences between simulated O3 and ozonesonde observations at 500 hPa (MT) and 200 hPa (UT), respectively, are listed in Table 2."

"Page 2, Line 13, the authors claimed the simulated ozone-CO correlation patters are consistent with those derived from TES observations, except in the tropical easterly biomass burning outflow regions. This claim is not be fully supported by Figures 13 and 14. There are large regions with negative correlations in the simulations that are not shown in the TES data. There are other discernible discrepancies between TES and GMI data that should be mentioned and discussed."



Reply – Thanks for pointing this out. We have revised the text to "Despite the fact that the three simulations show significantly different global and regional distributions of O3 and CO concentrations, they show similar patterns of O3-CO correlations on a global scale. All model simulations sampled along the TES orbit track capture the observed positive O3-CO correlations in the Northern Hemisphere mid-latitude continental outflow and the Southern Hemisphere subtropics. While all simulations show strong negative correlations over the Tibetan Plateau, northern Africa, northern subtropical eastern Pacific, and Caribbean, TES O3 and CO concentrations at 618 hPa only show weak negative correlations over much narrower areas (i.e., the Tibetan Plateau and northern Africa). Discrepancies in regional O3-CO correlation patterns in the three simulations may be attributed to differences in convective transport, stratospheric influence, and subsidence, among other processes."

"Page 21, Line 3-4: The authors stated: "Strong positive O3-CO correlations are present in all simulations at 618 hPa over Indonesia (Figure 12)". Over the entire Indonesia? The positive correlations appear only over western Indonesia where simulations show high CO."

Reply – Indeed. We have revised the sentence to "Strong positive O3-CO correlations are present in all simulations at 618 hPa over western and central Indonesia (Figure 12), reflecting convective transport of biomass burning CO (Figure 8) and photochemical production of O3 from its precursors."

"Remove an extra comma near the ends for Luo et al. (2007 a and b) and Mao, H., and Talbot, R. (2004) in References."

Reply – Done.

"Word "Figure" may not be in bold in the final version."

Reply – Corrected.

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