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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Regional CO pollution in China simulated by the high-resolution nested-grid GEOS-Chem model" *by* D. Chen et al.

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We would like to thank Referee 1 for careful reading of the manuscript and for thoughtful comments. We have addressed the comments below: original reviews are in italics followed with our responses. (The revised paper and new figures are attached as the supplement *.zip file)

This manuscript describes the application of a high-resolution nested-grid GEOS-Chem simulation to simulation of carbon monoxide over China, and specifically the Beijing-Tianjin-Hebei (BTH) city cluster. The authors demonstrate the benefits of a higher resolution simulation over a region with strong emission gradients and then use this simulation to (1) examine the pollution over the BTH region in summer 2005 (showing that model underestimates can largely be attributed to excessive winds) and (2)

estimate the seasonal import/export of pollution between regions in China, India and South Asia. This study is thorough and clear. The examination of export fluxes from Asia is compelling and connects this study of urban air quality to the regional-scale. The only major issue I would raise is the lack of observational validation (see below for my suggestions).

MAJOR COMMENTS

Comments 1: The authors demonstrate the expected outcome that a higher resolution simulation will produce stronger gradients over a region with spatially varying emissions. However, they do not provide any observational evidence that this simulation is "superior" to the coarse resolution simulation. While in situ observations over the entire region may not be readily available, a number of satellite data sets (AIRS, MOPITT, TES) would provide a basis for assessing the spatial patterns in CO simulated here. I would strongly recommend that the authors consider adding such a comparison to Figures 3 and 4.

Reply: This is a good suggestion. In the revised manuscript, we added comparison of model results with MOPITT CO columns, in Section 3.2 (Pg. 12, line 206-220)

"In this section, we evaluate the spatial patterns in CO simulated by the nested-grid model by comparing tropospheric CO columns between model results and MOPITT satellite retrievals. MOPITT data used here are Level-3 monthly averaged daytime (10:00-12:00 local time) CO columns at $1^\circ \times 1^\circ$ resolution (http://www.acd.ucar.edu/mopitt/products.shtml). Daily model outputs sampled at the same time of MOPITT overpasses are processed and averaged at the same resolution as MOPITT. Spatial distributions of daytime tropospheric CO columns for Aug 2005 are presented in Figure 2. The figure includes results from the high-resolution nested-grid model (Figure 2a), the intermediate-resolution global model (Figure 2b) and MOPITT (Figure 2c). Results from the coarse-resolution global model ($4^\circ \times 5^\circ$) are similar to those from the intermediate-resolution model ($2^\circ \times 2.5^\circ$) and are not in-

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cluded. Spatial patterns of the two models are similar to those retrieved by MOPITT, with high column densities in regions of high anthropogenic emissions, notably central and eastern China. The correlate coefficients are about 0.9 between MOPITT and models of $0.5^\circ \times 0.667^\circ$ or $2^\circ \times 2.5^\circ$ resolutions. However, the higher resolution simulation produces stronger gradients over the Asia region with spatially varying emissions, in particular over the North China Plain, more consistent with the MOPITT data."

Comments 2: In order to contrast the performance of the high-resolution simulation with the standard coarse resolution, it would be helpful if the authors included the $2^\circ \times 2.5^\circ$ results in Figure 4b. With regards to this figure, the authors suggest that the model simulates the variability in the observations (pg. 5864, line 25) but this does not seem so from the figure. I recommend that the authors include the correlation coefficient here between the modeled and observed time series for both the high-resolution and coarse resolution simulations to highlight whether the resolution improves the ability of the model to capture the variability in the observations.

Reply: We have added the $2^\circ \times 2.5^\circ$ results in comparison. In the revised manuscript, following suggestions by the other reviewer, we chose to compare the percentage anomalies from the mean CO between model and observations, focusing thus on the ability of the model to capture the variability of observations. This and further information is included in Section 4.1 (Pg. 17-18, line 315-331).

"To examine whether increasing spatial resolutions improves the model's ability to capture the variability, the percentage anomalies from the mean CO for observation and model are compared in Figure 6b. The Figure includes results from the high-resolution nested-grid model and the intermediate-resolution global model. When the observed CO levels are lower than 1500 ppbv, the high-resolution nested-grid model performs better than the global model in capturing the temporal variability of observations, such as for Jul 3, 14 and 26. For other days with observed CO exceeding 1500 ppbv, the performance of the two models is almost the same in comparison to observations. The correlate coefficients between model and observations for July 2005 are 0.5 and

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0.4 for the high-resolution and inter-mediate resolution simulations, respectively, while the correlate coefficients for the whole summer are around 0.60 for both models. The day-to-day variability of CO simulated by the models are generally weaker than observations, which is often the case when point measurements are compared with grid-averaged model predictions, since the DL site is impacted frequently by urban pollution plumes whose exact timing and scale are difficult to simulate at the spatial resolution of the nested-grid model. Other possible explanations for the bias of the model results include uncertainties in CO emissions (both in spatial and temporal distribution)."

MINOR COMMENTS

Comments 1: Pg 5854, line 24: grammar correction "influences of physical"

Reply: Corrected

Comments 2: Pg. 5855, line 7: semantics: it is IMPOSSIBLE not just "difficult" to "simulate the variation of species concentrations at scales smaller than model resolution"

Reply: Corrected

Comments 3: Pg. 5856, line 2: typo "embed" not "imbed"

Reply: Corrected

Comments 4: Section 3.1: Are the emissions year-specific or a climatology? If year-specific, please indicate how the scaling was done.

Reply: It's year-specific and for the year 2006, no scaling is done.

Comments 5: Pg. 5860, line 19: grammar correction"characteristics of fossil fuel and biofuel combustion, spatially"

Reply: Corrected

Comments 6: The x-axis on Figures 4 and 6 are too small.

Reply: The figures are reprocessed and the size of the x-axis looks better now.

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Comments 7: Figure 4c and 4d indicate 14:00 but the text suggests that this is “daily wind speed” (pg. 5865, line 10). Please reconcile

Reply: The data are for the 14:00 and it is clarified (Pg. 18, line 333).

Comments 8: Pg. 5866, lines 15-17: This discussion of correlations between tracers seems out of place here. Perhaps it could be integrated in the following paragraph if the objective of the authors is to argue something about directional influence related to wind

Reply: We think the correlations between tagged CO tracers are related to the day-to-day contributions described in the next paragraphs of the paper. During periods of heavy pollution the Beijing, Tianjin-Hebei, Shandong, and Hebei regions were particularly important source regions, so the high correlations will be a good explanation.

Comments 9: Pg. 5866, line 23: Given the data shown in Figure 6, “Most days” should be replaced with “All days”

Reply: Changed.

Please also note the Supplement to this comment.

Interactive comment on Atmos. Chem. Phys. Discuss., 9, 5853, 2009.