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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Influence of satellite-derived photolysis rates and NO_x emissions on Texas ozone modeling" *by* W. Tang et al.

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The authors would like to thank Reviewer 1 for the thoughtful comments and constructive suggestions about investigating further into the main uncertainties in the inversion process and adjusting the constraints on the inversion.

The discrepancies between the base model and satellite retrieved NO2 columns arise primarily because of the lower modeled than observed NO2 in rural areas. As noted in the review by Streets et al. (2013), wider spreads between urban and rural NO2 in models than in satellite observations have been reported in other studies. We note in

Section 3.3 our methods of alleviating such discrepancies by adjusting the OH+NO2 reaction rate and correcting CAMx's low bias for upper tropospheric NO2 based on the findings of earlier studies. However, additional model shortcomings likely remain (ENVIRON, 2013). In addition, while the NASA OMI NO2 product, version 2.1, used in this study is the latest available retrieval, it does have some errors that vary spatially and temporally (Lamsal et al., 2014) and retrieval algorithms continue to be refined. It is beyond the scope of this study to fully diagnose or correct all the causes of uncertainties and discrepancies, and to quantify the possible errors in the retrieval processes over our modeling domain.

We have analyzed the influence on the region-based inversion caused by each of the adjustments we made either to the OMI retrieval product or the CAMx a priori simulations (Table R1). It shows that, in this case, missing emission sources (lightning, aviation and soil NOx emissions) had the largest effect on the inversion results, especially in rural areas. Using the updated OMI product (with higher resolution) had the second largest effect on the inversion results. Since the new OMI NO2 narrowed the urban-rural spread, the adjustments over most urban areas and rural areas decrease. The adjustments made in the CAMx model such as decreasing the OH+NO2 reaction rate and adding an artificial NO2 layer in the upper troposphere had smaller effects on the inversion results compared to the other changes (Table R1).

The seven inversion regions, five urban regions encompassed by two large rural regions, were carefully designed using sensitivity simulations to ensure NOx emissions in each inversion region is mostly responsible for its NO2 concentrations (Tang et al., 2013). In addition, the five urban regions were chosen to correspond to the urban ozone control regions that are relevant for regulatory attainment and emission control efforts in Texas SIP. The number of source categories is limited by the categorization of emissions in the TCEQ emission inventory. Visual inspection and pseudo-data testing of the categorized emissions were conducted to ensure that the source categories had sufficiently distinct spatial patterns to enable the Kalman filter to distinguish among the sources.

Following are our responses to each of the reviewer's general and specific comments (shown in italics):

General comments: 1. Both region-based and sector-based NOx emission adjustments were made in the paper, but only "sector-based" approach is mentioned in the abstract.

A sentence "The region-based DKF inversion suggests increasing NOx emissions in most regions, deteriorating the model performance in predicting ground-level NO2 and O3" was added to the abstract.

2. In the Introduction section, more references should be added when discussing "studies using satellite NO2 measurements to create top-down NOx emissions for atmospheric modeling".

References to Martin et al., (2003); Müller and Stavrakou, (2005); Jaeglé et al., (2005); Lin et al., (2010); Konovalov et al., (2006, 2008); Napelenok et al., (2008); Kurokawa et al., (2009); Zhao and Wang, (2009); Chai et al., (2009); and Zyrichidou et al., (2015) were added to the Introduction and Reference sections.

Specific comments:

1. Please check equation 5 (last term).

The last term is correct, because we need to consider the difference between prediction and observation at each iteration. The term "Sx" reflects adjustments after each iteration.

2. Page 24491, line 23, "while it adds 50% ...": Should it be 49% ?

We have changed the number to 49% in the sentence.

3. Page 24493, line 16, "0.09 reduction in both modeled NMB ...": Is it 0.09 reduction

in NMB? Table 5 shows that it is from 0.09 to -0.02.

We have changed the sentence to "The model performance is also improved compared against P-3 measurements. For NO2, NMB is reduced from 0.09 to -0.02, and NME is reduced by 0.09. For NOy, NMB is reduced by 0.16 and NME is reduced by 0.11 (Table 5)."

4. Table 3: Are the "overall" evaluation statistics based on the data from all regions listed above them? Then, the "overall" numbers do not seem to be right. The values should fall between the minimums and the maximums of the separate regions. For instance, in the last column, the NMEs are all above or equal to 0.30, but the overall NME is shown as 0.16.

We double checked the numbers, and they are correct. The "overall" statistics are calculated based on data from all inversion regions, including two large rural regions that encompass the five urban regions presented in the tables. The OMI observations cover each grid cell, and thus the two large rural regions influence the overall statistics in Table 3. For Tables 4 and 6, there are few observation sites outside the five urban regions, making the overall values more similar to the urban values.

References

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Wecht, K. J.: Emissions estimation from satellite retrievals: A review of current capability. Atmos. Environ., 77, 1011–1042, 2013. Tang, W., Cohan, D. S., Lamsal, L.N., Xiao, X., and Zhou, W.: Inverse modeling of Texas NOx emissions using space-based and ground-based NO2 observations. Atmos. Chem. Phys., 13, 11005-11018, 2013.

Interactive comment on Atmos. Chem. Phys. Discuss., 14, 24475, 2014.

Table R1. Scaling factors for NO_x emissions in each region under alternate inversion cases.

Region-based inversion					
Emission region	Scaling factor (unitless)				
	Missing emission sources[a]	W/ additional emission sources[b]	Using updated OMI product[c]	Decreasing $OH+NO_2$ rate[d]	Adding a 40ppt layer[e]
HGB	1.31	1.03	1.21	1.18	1.11
DFW	1.32	1.14	1.04	0.98	0.97
BPA	1.90	1.75	1.70	1.72	1.49
NE Texas	1.40	0.56	1.12	1.20	1.10
Austin and San Antonio	1.90	1.70	1.21	1.24	1.15
N rural	2.88	1.98	1.45	1.48	1.24
S rural	3.84	1.72	1.25	1.15	0.98

a. Inversion conducted based on OMI v.2.1 and a priori simulation using base case NO_x emissions; adopted from Tang et al. (2013).
b. Inversion conducted based on OMI v.2.1 and a priori simulation using base case with added lightning and aviation and doubled soil NO_x emissions; adopted from Tang et al. (2013).
c. Inversion conducted based on updated OMI v.2.1 (using an a priori NO_2 profile generated from nested GEOS-Chem simulations with a 2005 emission inventory) and a priori simulation with NO_x emissions from b.
d. Inversion conducted based on updated OMI v.2.1 and a priori simulation with NO_x emissions from b and decreased $OH+NO_2$ reaction rate.
e. Inversion conducted based on updated OMI v.2.1 and a priori simulation from d with an added 40ppt layer in the upper troposphere.

Fig. 1. Table R1. Scaling factors for NOx emissions in each region under alternate inversion cases.