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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Accounting for non-linear chemistry of ship plumes in the GEOS-Chem global chemistry transport model" *by* G. C. M. Vinken et al.

Anonymous Referee #2

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The paper "Accounting for non-linear chemistry of ship plumes in the GEOS-Chem global chemistry transport model" by Vinken, et. al. addresses the important problem of correctly representing the effects of nonlinear chemistry in the atmosphere due to the existence of ship plumes at fine spatial and time scales in global chemical transport models (CTMs). The authors take a sensible approach to introducing the effects of the ship plume chemistry in a global CTM without creating a large computational burden for the running of the model. They compare their results with other modelling approaches. They use in-situ observations to test the dispersion model PARANOX which is the key to the parameterisation of the ship plume chemistry in their proposed model. I recommend this article for publication after revisions are made as suggested in the

general and specific comments made below. In particular, I think that the paper could be improved by producing and reporting a more quantitative analysis of the results of the model intercomparison.

General Comments

1. Pg 17800 L 22-27. Could you suggest/describe a meteorological situation where the combination of "low speed winds" and "low marine boundary layer (MBL) height" might exist? How low? Would this be a likely situation to exist in areas where there are high ship emissions? I can see that later in the same section the authors analyse the GEOS-Chem model results and describe the frequency of occurrence of the combination of low wind speed and low MBL height as 4%. But it would be good to paint a physical picture with some quantitative numbers of what such events really look like and how common they are in nature. This would give us some ideas of the limitations of the PARANOX model in its current state.

2. Pg 17804 L 14-15 Could you please be more specific when describing figure 4. Is it the median value of the NOx concentrations that is "in between the values simulated with the instant dilution and no ship emissions..."? Or are all the quantiles of the LUT approach in between the values of the no ship emissions and instant dilution cases? Stating the actual numbers and comparing them would be better than just referring to the figure, especially since the values appear to be so close.

3. For the discussion of NOx concentrations given in Figure 4, can you be more quantitative about the distribution of values presented. Can you quantify in a statistical sense how different the LUT approach is to the standard approach? And how alike are the results using the standard approach and the no ship-emissions approach? Perhaps you could use a Mann-Whitney-Wilcoxon (also known as Wilcoxon rank-sum) test or some other type of non-parametric statistical test to compare the experimental results. In other words, it would be good at this point to make a stronger case for why the LUT approach is superior to the standard approach. Because if the "temporal mismatches

are likely to contribute to the differences between simulated and observed values", then we can't make conclusions by comparing the observations to the simulated values.

4. For O3 in Figure 5, the it is particularly hard to see from this figure alone a better match from LUT approach to the observations than any other approach. Have the authors quantified the differences between the median O3 in each experimental approach with the observations? A look at the errors (absolute or relative) in the median would be helpful at establishing the goodness of the match.

5. Pg 17805 L6-7. Again, to conclude that the best simulation is with LUT using the observations, some more error measurements should be reported in the text or in another figure. Comparing the median or mean values, any quantities, would help make the argument stronger.

Specific comments are as follows.

1. Abstract:

Line 10. Could you be more specific and tell what the "standard model" is exactly? Is it the GEOS-Chem model with its standard approach to parameterising ship emissions? If so, how does it normally parameterise ship emissions. Would be helpful to say something like "Model X will be referred to as the standard model." I can see that the original model is defined in section 4.1.2. I think that it would be helpful to define it earlier in the paper.

Lines 11-15. Please clarify. The figure 0.1 ppbv is given as a 90% increase in NOx and then 0.1ppbv is given as a 50% overestimate in NOx. I am unsure how to interpret this. How can the 0.1 ppbv increase be an improvement and then the 0.1 ppbv increase when using instant dilution be an incorrect over-estimate.

2. Introduction:

pg 17792 L 8 Should read "...a factor of 1.6."

pg 17792 L 28-29 Sentence could be clearer as: "..., but does not account for either the effects of temperature or ambient concentrations of ..." Which species make up these ambient concentrations the authors refer to? Are they the same as those species in Table 2?

3. Model description:

pg 17794 L 6-7 Should read "...entrainment of ambient air into the plume."

pg 17794 L 8 Should explain that you are using 2K2 as an abbreviation for the year 2002. Sometimes you also use 2k2 (see page 17795, line 12). Should make the use consistent or simply use the year 2002.

4. Use of Model to create look-up tables:

pg 17797 L21 Typo with the chemical species HO2NO2.

Section 3.1 when the spatial integrals are described as "cross-plume" does this mean that the integral over each of the 10 rings is taken and then the 10 integrated values are averaged? Line 17 refers to an average over the 10 rings; this is why I ask.

Pg 17799 L 11. Define J(.) explicitly. For example, define the term in words, for example, "J(NO2) is the photolysis rate constant for NO2."

Pg 17800 L20. Time t = -5h should be t = 5h, no negative sign.

Pg 17800 L22. Should be space between words "low" and "marine".

5. Results:

Pg 17801 L 23. Need subscript for HNO3.

Pg 17802 L 16-17. Authors should explicitly name the seven environmental parameters that they investigate.

Pg 17802 L 21-23. Might be clearer if re-written. One suggestion is "Both the calculated fraction of NOx remaining and the integrated NOPE are used to compute the

reduction in NOx emissions and the amount of O3 and HNO3 produced; this is done to appropriately simulate the effects of original emissions that took place 5h earlier and have been subject to nonlinear chemistry and dilution during the 5h period."

Pg 17804 L 9 Should read "(0 up to 1.2 km)".

Pg 17804 L 14 Typo "... with the our LUT..."

Pg 17805 L 19. It might be helpful to point out that the areas frequently travelled by ships are visible in the figure as almost straight lines across ocean basins. It is remarkable how closely the percent difference follows those ship tracks!

6. Conclusions:

Pg 17807 L24. In my opinion, the intercomparison referred to here needs to be more quantitative (as suggested in the general comments) before it can be called "comprehensive".

7. Tables

Table 1 Footnote: Fourth sentence should read "In reaction (R1),..."

Table 2 ITCT 2k2. I think should be ITCT 2002.

8. Figures:

Figure 2, Caption. Several issues here: Should read "The shaded areas in ... correspond to.." Units on NOx emission strength have a typo; the number one should be in superscript. The next to last sentence is not a complete sentence. Should read " ... wind velocity is taken to be..." and so forth. Should define Theta_0 and Theta_5 as the solar zenith angle at the initial time and the solar zenith angel 5 hours later.

Figure 4, Caption. Second sentence. "Each box shows..."

Interactive comment on Atmos. Chem. Phys. Discuss., 11, 17789, 2011.