Interactive comment on "Global evaluation of *ammonia bi-directional exchange" by L. Zhu et al.*

Anonymous Referee #1

Received and published: 20 March 2015

General comments

The GEOS-Chem model is modified for its treatment of ammonia surface fluxes by imposing diurnal variation to livestock emissions and adding a bidirectional exchange algorithm for soil and vegetation for NH3 from fertilizer. The diurnal livestock emission variation is clearly more realistic than the constant assumption. While the bidirectional surface flux model is simpler than has been implemented in other models it still represents a significant advance of GEOS-Chem and global modeling. My main criticism of the paper is about the evaluation. None of the comparisons to surface NH3, Nitrate, or NH4+ wet deposition show any significant advantage of the bidirectional flux implementation. This is explained by noting that other parts of the ammonia emission inventory are likely underestimated by large amounts. It is demonstrated that results are improved by multiplying livestock emission by factors of 8 in April and 3 in October in the US. They also do sensitivity runs with reduced HNO3 by 50% and 20%. It seems that they have identified some key areas for improvement that would have greater impact than the developments described in the paper. Most of the plots and much of the discussion are about the differences between the base and BIDI runs. I don't see much value to this since we cannot not say which result is better.

We thank the reviewer for their comments. While we agree that implementation of the bidi scheme does not lead to improved performance in many areas, this in itself is a valuable result to report (lest people suspect it would). Also it does make improvements in some areas, such as locations with lots of fertilizers application. Moreover, it is indeed a comprehensive improvement in physical level. This helps identify shortcomings in other areas of the model to be addressed in future work.

The most interesting result is in the last plot which shows that the BIDI case has much larger area of influence of NH3 emissions.

I suggest that the difference discussions and plots be reduced and more comparisons to observations be shown.

Unfortunately for NH3 there are not many datasets to which the model can be directly compared. We have however added a comparison of the modeled to measured timeseries at the SEARCH sites, which is the new Figure 2. They have also compared to monthly average measurements of NH3 from AMoN, measurements of NO3 aerosol and NH4 wet depositions, and draw comparisons to remote sensing observations. The model difference plots help us understand how the different mechanisms (diurnal variability, bidi) contribute to these evaluations, and help us respond to additional reviewer questions

(e.g., reviewer 3's comment about section 6.1.1).

If the conclusion is that meaningful evaluation cannot be made without further improvements to the emissions and/or model chemistry, then perhaps this analysis should wait for such improvements to be developed and implemented.

Point well taken. But we believe the work presented here in terms of implementation of improved emissions mechanisms, and updating the adjoint model, are important first steps towards identifying the additional needed improvements in emissions and/or chemistry and facilitating such efforts (with the adjoint). We have added to the conclusion

"Measurements from recent (Shephard and Cady-Pereira, 2015) or future (Zhu et al., 2015) remote sensing platforms will be of value for such endeavors."

All spatial plots are much too small to see!

One of the novel aspects of this work is evaluation of the diurnal variability and bidi emissions schemes in a global model; for this reason we prefer to show arrays of global plots. We have however provided all images in vector graphics, which can be readily enlarge for further viewing as desired.

Specific Comments

P4826 ln6: should spell out acronyms for first usage.

Thanks. It is been corrected. See line 50.

P4827l ln21: Please give approximate grid spacing in km

Approximate grid spacing in km is added. See line 88-89.

P4831: The various emission inventories should be better explained and intercompared. For example, how can NEI be used for a global model when it is US only? How does NEI, Massage and the original GEOS-Chem inventories compare?

We apologize for the misunderstanding. There are different emission inventories used in global and regional (US) runs. NEI was only used in US runs. MASAGE_NH3 was only used in global runs. The original GEOS-Chem inventory was described in Section 2.1. We have added a table (Table 1) to summarize all the inventories used in study. We also updated the text as below.

"The anthropogenic emissions inventories described here are only used for base case nested grid model runs over the US. Variants will be explained in the following sections. Table 1 is a summary of the different emission inventories used in different sections of the work." See line 103-105.

"As the standard GEOS-Chem anthropogenic emissions do not distinguish the livestock

emissions sector (described in Section 2.1), we calculate the absolute NH_3 livestock emissions based on the fraction of livestock emissions in anthropogenic emissions in the 2008 NEI. " See line 172-174.

"Comparisons between the emissions of MASAGE_NH3 and GEOS-Chem standard inventories are in Paulot et al. (2014)." See line 187-188.

P4831 ln19: Should show a plot of these results (dynamic vs static) at SEARCH sites. It seems that the SEARCH sites and the TES comparisons are the only evaluation of the effects of the dynamic emissions. Why no plots of either results? Just showing differences as in Figs 2-4 is not enough especially since these plots are too small to see.

We added a figure of dynamic versus static model estimates and measurements at SEARCH sites. See the new Figure 2.

P4833 ln20: Can't see feature in Russia.

It is more obvious in northeastern China (red color in the third column of October). We changed "southeastern Russia" to "northeastern China". See line 234.

P4836 ln1-2: It might be interesting to compare fertilizer rates for the US to EPIC simulations.

This is a good suggestion. However, we should note that the fertilizer rates we used in this study are from 2000, but we use them as input to our 2008 simulations. EPIC contains a detailed soil model that calculates fertilizer rates online for multiple soil layers. It is generally used for regional and national policy analysis. Thus, comparing the fertilizer rates to EPIC simulations would require navigating differences in physical processes in soil structure, space and temporal resolutions. We may get to this in a future analysis.

P4844 ln6: what is IASA?

Sorry for the omission -- Infrared Atmospheric Sounding Interferometer. This has been updated in the text as:

"Observations from the Infrared Atmospheric Sounding Interferometer (IASI) remote sensing instrument"