

## ***Interactive comment on “The global tropospheric ammonia distribution as seen in the 13 year AIRS measurement record” by J. X. Warner et al.***

**J. X. Warner et al.**

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Reviewer #3 (Comments to Author):

Reviewer: The authors of this paper describe the algorithm to derive ammonia from AIRS measurements using inversion theory pioneered by C. D. Rodgers, and present spatial and temporal (in seasonal sense) analysis of global ammonia distributions. This is important work and the paper should be published. The paper, however, could have been better written and data analyzed more thoroughly (e.g., just noting a particular phenomenon and merely speculating the cause is not enough). I have specific comments below that I would like the authors to address. I recommend the publication of the paper after these comments are addressed. The revisions that I am recommending

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are not major and should not take more than a month or two to implement. I highlight my concerns below:

Authors: We thank Reviewer #3 for providing insightful comments, which we believe will improve the manuscript.

Reviewer: The paper needs editorial work. Many blatant errors and sentences with poor word choices are present in the paper and need to be resolved. For example, on page 4, “R’Honi et al. (2013) discussed the exceptional emissions of NH<sub>3</sub> and HCOOH in the 2010 Russian wildfires.” Another example is the reference to 13-yr time period as long-term. It so happens that there is a 13-yr record of AIRS ammonia retrievals. However, that does not define what a long-term record is. Because the 13-yr record is close to a decade, that could be used in a general sense perhaps?

Authors: We changed the first sentence to “R’Honi et al. (2013) discussed the elevated concentrations of NH<sub>3</sub> and HCOOH emitted by the 2010 Russian wildfires.” We took out the work longterm and changed the sentence to “Global ammonia sources and variability based on continuous monitoring with longer than a decade record (13 years) have not been available.”

Reviewer: Algorithm should be discussed in general terms instead of repeating material from Rodgers book/papers. The methodology should be conceptually explained for ammonia and also other trace gases that are generally simultaneously retrieved inverting hyperspectral infrared radiances.

Authors: We aim to provide details so that the process for the retrieval can be repeated.

Reviewer: Validation of the retrievals is only done for two weeks. I understand that not many ground measurements of ammonia exist but the DISCOVER-AQ field campaign data provided the authors with profiles covering 2-week time period. The comparisons are very encouraging. To explain the differences between retrieved and aircraft observed profiles for some cases, the authors revert to spatial variability of ammonia in

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a 45-km grid space (aircraft captures that variability but satellites can't resolve it). It would be nice if the authors can actually demonstrate the spatial variability of ammonia (from models or other ground observations) to explain the usability of AIRS ammonia product. Does this mean that AIRS ammonia retrievals at 45-km resolution (is it larger at scan edges?) are of no use to high resolution air quality models for forecasting applications? Are the retrievals more useful in regions where spatial variability is not that high? I think a discussion on these validation results from the application perspective will be very useful. Or perhaps the retrievals are only useful to document trends in ammonia and not for real time applications in models?

Authors: The AIRS NH<sub>3</sub> current products are at 45 km resolution to recover cloudy pixels, and therefore, increasing global coverage. However, AIRS NH<sub>3</sub> retrievals for single view pixels at 13.5 km resolution are possible for clear-sky only cases. The resolution of 45 km is higher than many global models, and when applied to high resolution localized models, cautions need to be taken so the spatial resolutions are matched. We believe our products provide significant value to the modeling field not only in the trend studies, but also spatial distribution by validation to the modeled properties.

Reviewer: I am also a little concerned that the authors have not compared global maps of ammonia from AIRS to other correlative measurements from other satellites (IASI for example). Although instrument and algorithm differences can exist, readers can look at the comparisons in a qualitative sense and decide for themselves if the product is useful for certain applications or not. Also, for validation results please provide information on the geographic location for each profiles to get a sense on where these observations taken (terrain, surface emissivity, etc.)

Authors: We have carried out preliminary comparison with IASI's published results. It is in our plan to carry out detailed quantitative comparison, which should results in a separate manuscript. We added the following sentence to describe the environment of the central valley location where DISCOVER-AQ CA took place: "The in-situ NH<sub>3</sub> vertical profiles were made in the Southern San Joaquin Valley of California. This

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region inside the central valley of California, between the coastal mountains in the west and the Sierra Nevada Mountains in the east, consists largely of farmland with scattered dairy farms. Although most of the area is rural, the profiles were made near the small cities of Hanford and Corcoran."

Reviewer: The authors presumably are continuing their collaboration with field campaign programs and therefore should recommend to the campaign that future experiments should focus doing multiple spirals within a short distance of each other in a 45-km box to understand sub-grid variability of ammonia.

Authors: Great suggestion.

Reviewer: In Figure 4, the color bar is referred to as x-axis.

Authors: We have corrected this.

Reviewer: There is a lot of discussion on the relevance of biomass burning and ammonia distribution observed in global maps. I think the authors are correct in drawing those correlations but would be nice to correlate with MODIS fire activity maps. Without corroboration from other sources of information, it becomes speculative at best. I say this because in Russia and Siberia, there seem to be elevated ammonia in all seasons and number of retrievals (days of data available) low. Could it be that there are some retrieval issues owing to the persistent snow on the ground? Again, this is why it is important to compare AIRS ammonia retrievals with other satellite retrievals to establish biases as a function of season and location. The 2-week time period is not enough to capture the dynamic range, seasonal, and regional variability seen in ammonia to validate the product.

Authors: We agree that continued validation and intercomparisons are important and they are in our plans to do. This manuscript aims to introduce the AIRS NH<sub>3</sub> new product and document the algorithm applied. Even though we did not have the space to show the verification of this product with MODIS fire counts as well as correlation with

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other trace gas species (i.e., carbon monoxide), this has been in our regular practice in the algorithm development stage. Any potential retrieval artifacts were taken care of in the algorithm.

Reviewer: Minor comment: The few sentences dedicated to World Bank data on page 12 can become a footnote to avoid distracting the reader.

Authors: We have removed the sentences and added them as a footnote.

Reviewer: Figure 9 is cited twice. Should there be a Figure 10?

Authors: There is only Figure 9, and we have made sure they are used in the right content.

Reviewer: In global season maps, African biomass burning appears to show up prominently in MAM season. However this March peak is absent in Figure 9 for SH. Is it masked by the global averaging? Should this analysis be stratified into crop lands, forests etc. to separate agricultural burning vs. wildfires? I think this stratification will gel nicely with the way the results are presented in Figure 6. In summary, this is important work that should be published after addressing the comments above.

Authors: We divided NH and SH at the equator, so most of the African fires in MAM fall into the NH average. To separate agricultural burning vs. wildfires, and to study the land type vs. emissions require in depth study that is beyond the scope of this paper.

Authors: We appreciate very much reviewer #3 for believing that this is an important work. More research of this new product is needed from a greater community once the data is distributed upon preliminary validations.

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