

## ***Interactive comment on “Towards validation of ammonia (NH<sub>3</sub>) measurements from the IASI satellite” by M. Van Damme et al.***

**Anonymous Referee #2**

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The following is an review of the paper titled, “Towards validation of ammonia (NH<sub>3</sub>) measurements from the IASI satellite”, authored by Van Damme et al.. The paper is well suited for AMT and provides valuable insight on the quality of the IASI NH<sub>3</sub> retrievals through various and extensive comparison datasets. This information is very valuable to the expanding satellite NH<sub>3</sub> user community (i.e. air quality monitoring and modeling). Finding coincident observations that are representative of the satellite observations that can be used to “validate” satellite retrievals can be very challenging. I recommend that the paper be published in AMT providing that more clarity is provided on the capability of the IASI NH<sub>3</sub> measurements in order to better interpret the comparison results, especially at the surface and under “clearer” conditions where IASI has limited sensitivity.

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### A) General Comments

1) The main goal of this comparison paper is to provide the user with insight on the uncertainty and biases of the Van Damme (2014) IASI-NH<sub>3</sub> retrieval approach given the limitation of the direct validation observations. Often in the paper the comparison results are provided only for retrievals that have errors less than 100%. This brings up the question of how well the IASI-NH<sub>3</sub> retrievals performs when all the possible data is included as the filtering can create biases, and users will often like to utilize all available retrievals set for a given purpose. I don't suggest that the authors need to perform any additional analysis (like was nicely done in Table 3 that showed the filtered and unfiltered results) as this might be a large effort, but suggest that it would be very valuable to at least add in the percentage of all the possible IASI pixels that were used (filtered) for each statistic that is reported. Also, please justify why a 100% error criteria was selected as a filter.

2) In Section 2.1 it would be very helpful in interpreting the comparisons if additional IASI-NH<sub>3</sub> measurement characteristics were provided in the article in addition to just “The detection limit of NH<sub>3</sub> depends on both thermal contrast and vertical distribution of NH<sub>3</sub>, an illustration of this can be found in Fig.5 of Van Damme et al. (2014)”. It is well known that the sensitivity of infrared observations depends on the condition of the atmospheric state being observed (i.e. temperature, thermal contrast, atmospheric concentrations, clouds, etc.). However, what are the common conditions under which IASI would not be able to detect NH<sub>3</sub> (i.e. NH<sub>3</sub><??, thermal contrast < ??), and what part of the column is IASI typically sensitive. For example, Clarrise et al. (2010) noted that, “Based on this analysis we can put a lower bound on the detection of ammonia to surface concentrations of about 3ppb for large thermal contrasts.” Since both the vertical sensitivity in the column and the minimum detectability are fundamentally governed by the line-by-line radiative transfer, and not the specific inversion retrieval approach, simple forward model Jacobians (either analytic or finite difference) show the general lack of sensitivity at the surface, and when there is typically no detectable

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signal in the IASI spectra. This is important as it indicates the dependence on additional information not directly provided by the satellite observations themselves (i.e. profile shape, etc.) in the inversion. For example, satellite comparisons at the surface with ground-based observations under conditions when IASI is not sensitive to surface concentrations provides some insight on the assumed profile shape (correlation in height) utilized in the retrieval, but does not validate the actual information provided by IASI observations themselves. Thus, in order to help explain the potential differences with other observations the IASI sensitivity components should be explicitly stated. For example, this type of information would also help support statements such as (P12139:line 5-7) "...for such small concentrations in a region associated with low thermal contrast, cannot be reliably detected by IASI." Also, the smaller variations in the IASI-NH<sub>3</sub> observations can be due to a number of potential reasons as noted in the article. However, it should also be noted that the inherited minimum detectability of satellite infrared observations under cleaner conditions, and the lack of sensitivity to surface concentrations might help explain the reduction in the variation in the satellite observations due to non-detects, especially if the data is filtered.

#### B) Specific Comments and Technical Edits

1) P12127:line 13: comma before "but" and remove "that"

2) P12128:line 26 to P12129:line 5: There are recent global GEOS-Chem results that contain both bi-directional and diurnal nh<sub>3</sub> profiles, so these recent improvements are not limited to regional models as implied in these lines.

For example: Liye Zhu, Daven K. Henze, Jesse O. Bash, Karen E. Cady-Pereira, Mark W. Shephard, Gill-Ran Jeong, Robert W. Pinder, Mingzhao Luo. (2012) Evaluation of bi-directional ammonia exchange with the GEOS-Chem model. AGU Fall Meeting, San Francisco, CA.

There is also new ACPD article submitted on this work.

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3) P12129: line 19: The sentence might read a little better to put the "Therefore" at the start of the sentence. For example, "Therefore, the spatial coverage of these networks and campaigns is strongly ..."

4) P12130: line 12: should also include the NPP CrIS as an instrument with high density of observations (i.e. Shephard and Cady-Pereira, 2014). Shephard, M. W. and Cady-Pereira, K. E.: Cross-track Infrared Sounder (CrIS) satellite observations of tropospheric ammonia, *Atmos. Meas. Tech. Discuss.*, 7, 11379-11413, doi:10.5194/amtd-7-11379-2014, 2014.

5) P12130: line 18-19: "While NH<sub>3</sub> satellite measurements have started to be used by models, their validation has yet to be performed." Although there has been very little "validation" analysis, this general statement is not completely true. Since satellite "validation" in this paper includes ground-based surface comparisons, there are satellite NH<sub>3</sub> comparisons with ground-based observations (i.e. Pinder et al., 2011; Shephard and Cady-Pereira, 2014). Thus, either change the sentence to be specifically "...IASI-NH<sub>3</sub> satellite measurements..." or state that there are very few "validations" and reference previous examples.

Pinder, R. W., J. T. Walker, J. O. Bash, K. E. Cady-Pereira, D. K. Henze, M. Luo, G. B. Osterman, and M. W. Shephard (2011), Quantifying spatial and seasonal variability in atmospheric ammonia with in situ and space-based observations, *Geophys. Res. Lett.*, 38, L04802, doi:10.1029/2010GL046146.

6) P12132: lines 17-19: What impact does pixels with 25% cloud cover have on the NH<sub>3</sub> retrievals? For example, depending on the optical depth and altitude of the clouds this can significantly impact the weak spectral signature of NH<sub>3</sub>, especially if the cloud radiances are taken into account in the forward model/retrieval.

7) P12133: line 26: suggest rewording sentence "...this network which have started to provide..." to something like, "...this network, which started providing..."

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8) P12138: line 10: suggest rewording “Overall, however, IASI observes. . .” to something like “However, overall IASI observes. . .”

9) P12114: lines 16-26: Again the underlying reason, which encompasses some of the reasons provided for the high bias at surface under “clean” conditions, is the simple fact that no infrared satellite instrument is not sensitive to NH<sub>3</sub> under these conditions, especially at the surface.

10) P12142 lines 2-3: suggest putting a column before the two “but” in these sentences.

11) P12142 line /8: The sentence might read better to mover the “however” to put it at the start of the sentence with a comma after it.

12) P12146 lines 14-15: As mentioned before, not just “weak signal”, but also cases with no nh<sub>3</sub> signal at all, which will bias the statistics.

13) P12147 lines 4-10: “. . .-the most relevant quantity available from the satellite measurements. . .” This is not true in general. This is likely the case for this Van Damme (2014) IASI-NH<sub>3</sub> retrieval approach, but is not the case for other NH<sub>3</sub> retrieval approaches. For example, an optimal estimation retrieval approach with a quality forward model can directly utilize aircraft profiles in comparisons (i.e. Rodgers, 2000) and explicitly take into consideration the satellite vertical resolution and the information content provided by the satellite observations themselves. Since optimal estimation retrievals are commonly applied (even to IASI), these lines should be removed or modified to explicitly state that column data are require for the Van Damme (2014) NH<sub>3</sub> type of retrieval. Rodgers, C. D.: Inverse Methods For Atmospheric Sounding: Theory and Practice, World Sci., Hackensack, N. J., 2000.

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Interactive comment on Atmos. Meas. Tech. Discuss., 7, 12125, 2014.