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Atmospheric Measurement Techniques Discussions

Interactive comment on "Atmospheric ammonia retrieval from the TANSO-FTS/GOSAT thermal infrared sounder" *by* Yu Someya et al.

Anonymous Referee #1

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Adding a GOSAT ammonia product with other already available satellite derived NH3 will be beneficial to the community. This paper demonstrates that with sufficient averaging that GOSAT can capture the general global spatial patterns of ammonia seen by other sensors and emission inventories. The paper also points out some differences between the emission inventories (e.g. over Central Asia) and with IASI. In general the paper is well written, and other authors did a good job at addressing most of the initial comments. There are three main comments, and a number of more minor ones that should be addressed.

Main Comments: 1) One nice result from this paper is the potential impact of dust on the ammonia retrievals. The paper presently states on Page 8: "The presence of dust can lead to the overestimation of ammonia because of the wavenumber dependence

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Discussion paper

of its absorption properties. Figure 13 shows an example of the observed spectra contaminated by dust aerosols over Saharan desert. The residual shows some similarity of wavenumber dependencies of ammonia signals on the spectra.". The wavelength dependence of dust in the longwave infrared being similar to sharp ammonia spectra is very surprising. In general would expect the optical properties from the dust to have broad spectral features. The authors will need to show the input optical properties of the dust (e.g. emissivity, absorption cross-sections, etc.) and the LBLRTM radiative transfer forward model calculations showing the resulting difference in the spectra with and without the dust (keeping the rest of the input atmospheric state the same).

Why does the dust only impact ammonia retrievals over some deserts around the globe? Does the moisture play a role? Is it the dust composition (e.g. type of sand)? Is there ammonia mixed in with the dust (transport)? These results can be shown in an appendix and just referred to in the paper.

2) Page 3: The authors did add in much more details on the GOSAT sensor capabilities in the revised manuscript, which is a great help in determining GOSAT for ammonia retrievals. However, it would be good to help address the question of why one might want to use GOSAT when there are other sensors with more coverage, such as IASI, CrIS, and AIRS. I would suggest highlighting the higher spectral resolution of GOSAT compared to other sensors more upfront. There is some information provided later in the paper on Page 8 the authors mention a bit about the sensitivity when discussing potential differences between GOSAT and IASI (Page 8 lines 3-7). However, the spectral resolution is only part of the signal-to-noise to determine the sensitivity of the instrument. Thus, to investigate it more fully one needs to determine how much the slightly higher spectral noise of GOSAT mitigates some of the potential sensitivity gains from the higher spectral resolution. It would be great if an estimate of the sensitivity (e.g. minimum detection limit) could computed. Again, this might be done by performing simulations where the truth is known. The forward model calculations (LBLRTM) can be run over a number of atmospheric conditions and varying ammonia amounts. Then the

ammonia spectral signal can be compared with the estimated GOSAT spectral noise (to obtain a signal-to-noise). Under conditions where the signal-to-noise is just above 1 (the NH3 spectral signature can be seen) will indicate the detection limit for GOSAT. One other thing that higher spectral resolution provides is the potential to reduce systematic errors (e.g. interfering species) as there is a greater capability to micro-window around weak spectral features from other species reducing the cross-state errors in the GOSAT NH3 retrievals. It would be good to add more to this discussion to help the community with the question of why they might want to use GOSAT NH3 observations.

3) For a new product it is best to show a little validation (e.g. surface, aircraft, or FTIR). In general most FTIR stations have relatively low concentration amounts, however, there are sites like Bremen, Toronto, Mexico City, Pasadena, that obviously have high concentrations that can be compared with GOSAT. GOSAT might even have some special stare observations for these sites as they are also part of TCCON and NDACC networks.

Minor Comments:

4) Page 1: Line 24: “Atmospheric nitrogen is taken up by animals” ???...reword

5) Page 2: Line 30: Change “(Shephard and Cady-Pereira, 2015)” to “Shephard and Cady-Pereira (2015)”

6) Page 3: Lines 2-4: “Since carbon dioxide (CO2) and methane (CH4) concentrations have been previously derived from both regions (Yoshida et al., 2011, 2013; Saitoh et al., 2009, 2016), it was possible to calculate the concentrations of ammonia within the same footprint.” Can more context be provided here as to why CO2 and CH4 needs to be retrieved for NH3. It is not directly for the retrieval of NH3 as it is mostly window region where temperature (from CO2) and water vapour retrievals are retrieved before NH3 (as stated in the paper later on).

7) Page 4: Need a “.” After (Van Damme et al., 2017).

8) Page 4: Just a comment as a future improvement: The AFGL NH3 is likely very low apriori for most hot-spot regions. That being said, ammonia is not known well globally so there is not a good “climatological” apriori fields to use. As a future GOSAT retrieval refinement, the authors might want to consider using an apriori selection process (e.g. similar to TES and CrIS).

9) Page 4: When showing averaging kernels it is common to show the rows of the averaging kernels, rather than columns of the averaging kernels. It would be useful to show the 2D averaging kernel plot included in the response to the initial Review 1 questions so that the GOSAT vertical sensitivity can be compared against other sensors such as TES, AIRS, and CrIS. Even if it is just added in as an appendix and referred to in the text relative to other sensors that produce averaging kernels.

10) For ease of comparisons, the GOSAT team might want to consider reporting the NH3 retrieval values in units commonly used by the other satellite retrievals (e.g. level values in ppbv and total column in molecules/cm2).

11) Page 5: Figures 3 and 7. Just a suggestion: Is it possible to change the colour bar slightly to highlight a few more hot-spot regions (e.g. North America and Western Europe) without making the plot look very noisy. Maybe bring the yellow and reds reach down to lower values.

12) Page 5, line 19: averaged errors: excluded when estimated concentrations were negative. . . does this mean they excluded negative concentrations in all of their analysis? As that would high bias the results.

13) Page 5: line 20: change “highconcentrations” to “high concentrations”.

14) Page 5: line 21: add in the reference for the TES global plots showing the typical hotspots (Shephard et al., 2011).

15) Page 6, line 5-6: The high concentrations can be explained by soil emissions, Hickman et al., 2018: see https://www.atmos-chem-phys.net/18/16713/2018/acp-18-

16713-2018.pdf.

16) Page 7: Discussion section: Lines 13 & 14 list possible causes for differences, and then the rest of the paragraph goes into more detail for some of them. The authors might consider merging (3) and (4) together as “signal-to-noise (spectral resolution and noise)”. Then order the more detail discussion in the rest of the paragraph in the same order as listed so it is so that it is easy to follow.

17) Page 8: See main comment above on dust.

18) Page 17: It would be good to expand the EUR to include Northern Italy and NE Spain as both are known hotspots in Europe.

19) Acknowledgements: I believe there is a user agreement on how to acknowledge the use of the IASI NH3 product. As there are no IASI NH3 product developers as coauthors there should be an acknowledgement stated here for using the IASI data.

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