

Editor's Comments on amt-2019-49

Atmospheric ammonia retrieval from the TANSO-FTS/GOSAT thermal infrared sounder by Yu Someya, Ryoichi Imasu, Kei Shiomi, and Naoko Saitoh

Thank-you for your detailed responses to the comments of the two referees. I have reviewed them and the revised manuscript and have some follow-up comments below. Please submit a brief response addressing each of these comments and a new version of the manuscript.

The order of comments below corresponds to the order in the response to referees.

Response to Referee #1

Page 8, line 26 and Figure S2: "The spectra are V shaped, which are spectral characteristics of dusty conditions."

- It's not clear what is meant by a "V-shaped spectrum" nor how this is seen in Figure S2. Please use a more informative description.

Page 7, line 29 to page 8, line 9: This entire paragraph needs careful revision, as follows:

"The spectral resolution of GOSAT is higher than that of IASI, AIRS, and CrIS, which have fine coverage.

- It is not clear what is meant by "fine coverage". Clarify. Could restate the values of resolution for each instrument here.

"Because fine spectral resolution provides a stronger signal in the spectra, it provides a high signal-to-noise."

- Is this referring to GOSAT or the other sensors? This is ambiguous given the preceding sentence. Doesn't higher spectral resolution give higher noise and lower SNR? See, e.g., <https://www.osapublishing.org/ol/abstract.cfm?uri=ol-39-1-60>. Correct this sentence.

- "signal-to-noise" should be changed "signal-to-noise ratio" throughout the manuscript (e.g., page 7, line 8 – do a search and replace).

"Moreover, high spectral resolution can reduce the contaminations from interfering species, such as water vapor, by channel selection."

- Would be clearer to say something like: "by selecting narrower fitting windows that exclude spectral features of other gases."

"The maximum signal is approximately 0.04 K or 0.05 K for a spectral resolution of 0.5 or 0.6, which corresponds to AIRS, IASI, and CrIS. On the other hand, it is approximately 0.1 K for a resolution of 0.2, which corresponds to GOSAT (Fig. S3). This indicates that the signal of ammonia in the GOSAT spectra is approximately twice as strong as those in the other sounders. In Sect. 2.1, we assumed a spectral noise of 0.3 K."

- Add units: "0.5 or 0.6 cm^{-1} " and "0.2 cm^{-1} ".

- Is the “maximum signal” actually the maximum noise, and “the signal of ammonia” the noise? Noise should increase and signal should decrease with spectral resolution, which is the opposite of what is stated in this sentence, although the “spectral noise of 0.3 K” implies that it is the noise that is being described. Is it the GOSAT signal or the GOSAT noise that is twice as large as the other sounders? Please check this text carefully and revise.

“If the relation between the signal and the ammonia concentration is linear, then the ammonia column amount corresponding to this is approximately 1.4×10^{16} molec/cm².”

- Briefly explain how this column amount is derived from the spectral noise of 0.3 K.

“This corresponds to a value lower than 0.1 K in the spectra.”

- A value of what? Random noise? State this.

Referee #1, comment 3:

- It is unfortunate that there are so few GOSAT TIR coincidences with the NDACC FTIR stations. This is a bit surprising given that these stations have been used to validate GOSAT SWIR and GOSAT TIR measurements (e.g., <https://www.atmos-meas-tech.net/10/3697/2017/>). Are there fewer GOSAT TIR NH₃ measurements than TIR CH₄? Page 3, line 5 implies that there are NH₃ measurements in the same spatial footprints as CH₄. What coincidence criteria were used?

- The referee is correct in that it is preferable to include some validation comparisons for a new product. The term “validation” is not used anywhere in the manuscript although Section 3.2 describes comparisons with IASI. Do these qualify as validation of the GOSAT NH₃ product? Could add a sentence noting the need for validation, the lack of coincidences with NDACC FTIR (note time period and coincidence criteria considered), the relevance of the IASI comparisons for this purpose, and scope for comparisons with other satellite measurements of NH₃.

Page 3, line 6: “Therefore, the combinational use of concentrations of ammonia and these products within the same footprint can be useful to study carbon cycles.”

- Is NH₃ part of the carbon cycle? Perhaps rewrite as: “Therefore, the combination of NH₃, CO₂, and CH₄ measurements within the same spatial footprint may be useful for studying linkages between the nitrogen and carbon cycles.”

Page 10, line 7: Please check that the correct wording has been used for the acknowledgement of IASI data products.

- For example, this website <https://iasi.aeris-data.fr/data-use-policy/>, gives specific wording for minor use (e.g., a plot) of IASI NH₃:

“IASI is a joint mission of EUMETSAT and the Centre National d’Etudes Spatiales (CNES, France). The authors acknowledge the AERIS data infrastructure for providing access to the IASI data in this study and ULB-LATMOS for the development of the retrieval algorithms.”

- However, given that comparisons with IASI are an important part of this manuscript, this may qualify as “substantial use (ie the results would have been different without the IASI dataset). Please contact the principal investigator to offer co-authorship to the team: NH₃ Lieven Clarisse lclariss@ulb.ac.be, Pierre-François Coheur pfcoheur@ulb.ac.be”. If the authors have not

contacted the IASI team, I strongly recommend doing so to ask whether co-authorship is warranted.

Response to Referee #2

Page 8, line 14: “On the other hand, IASI retrieval uses a priori profiles from the model calculations, and these vertical gradients are larger than those of the AFGL profile.”

- What model calculations? Provide more information here.

“Although differences between the profile shapes of GOSAT and IASI are equally present across the globe, the magnitude of relations between the estimated values vary for each area.”

- Rewrite this sentence to clarify what is meant by “equally present” (implies the same everywhere) and “magnitude of relations”.

“This suggests that this effect is not so apparent in the other causes.”

- This sentence is ambiguous. What effect? What other causes. Rewrite to be more specific.

Page 9, line 12: “The optimal estimation, which iteratively minimize the difference between the calculated and the observed spectra, was used for analysis.”

- Change to: “The optimal estimation method, which iteratively minimizes the difference between the calculated and the observed spectra, was used for analysis.”

Additional Comments

Page 2, line 19: “Currently, the five space-borne nadir satellite sounders, namely, the Atmospheric Infrared Sounder (AIRS), Tropospheric Emission Spectrometer (TES), Infrared Atmospheric Sounding Interferometer (IASI), Thermal and Near-infrared Spectrometer for Observation-Fourier Transform Spectrometer (TANSO-FTS), and Cross-track Infrared Sounder (CrIS), are available to observe atmospheric ammonia.”

- TES ended in January 2018 (<https://tes.jpl.nasa.gov/mission/>) so this sentence should be revised, e.g., “Five space-borne nadir satellite sounders, namely, the Atmospheric Infrared Sounder (AIRS), Tropospheric Emission Spectrometer (TES), Infrared Atmospheric Sounding Interferometer (IASI), Thermal and Near-infrared Spectrometer for Observation-Fourier Transform Spectrometer (TANSO-FTS), and Cross-track Infrared Sounder (CrIS), have provided observations of atmospheric ammonia that overlap with the GOSAT mission.”

Page 3, line 16: Spectral resolution can be defined in multiple ways. I think for GOSAT, it is the full width at half maximum of the instrumental line shape – add this information.

Page 3, line 17: “spectral accuracy” is ambiguous – is this the accuracy of the spectral radiance in units of brightness temperature? State this clearly.

Page 3, line 18: “Kataoka et al. (2013) reported that it is 0.5 K”

Page 3, line 20: “optimal estimation method”

Page 3, lines 20-21: “As noted in Sect. 2.2, we assumed that [what? the accuracy of the spectral radiance in units of brightness temperature? state explicitly] is 0.3 K in the spectral range used in the ammonia retrieval.”

Page 3, line 21: “Earth’s surface”

Page 7, Section 4: This section is somewhat speculative. Consider whether the discussion might be tightened up.

Page 7, line 9: “(4) assumed ammonia profile”

- Clarify whether this means the assumed ammonia profile shape, the assumed ammonia a priori profile, or something else.

Page 19, line 6: “data are” (not is, data are plural)

Page 22, line 5: Change caption to “Figure S1. An example of the averaging kernel matrix for the GOSAT TIR ammonia profile retrieval using the AFGL ammonia profile and mid-latitude summer atmosphere.”

Page 22, line 8: “An example of a GOSAT TIR spectrum affected by ...”

Page 23, line 1: add units for “spectral resolutions of 0.2 – 0.6”. Perhaps rewrite this caption, changing

“Figure S3. Brightness temperature differences between the case assuming and not assuming ammonia for spectral resolutions of 0.2 – 0.6. Mid-latitude summer profile was used and ammonia column amount of 4.56×10^{15} molec/cm² was assumed. The instrumental line shape function was assumed as that of GOSAT.”

to

“Figure S3. Brightness temperature differences between spectra simulated with and without including ammonia, using the GOSAT instrumental line shape function with spectral resolutions between 0.2 and 0.6 cm⁻¹ as indicated in the legend. These simulations used a mid-latitude summer profile for ammonia with a total column of 4.56×10^{15} molec/cm².”