Response to reviewers

Title: Trends and seasonal variability of ammonia across major biomes inferred from long-term series of ground-based and satellite measurements
Author(s): Money Ossohou et al.
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MS type: Research article

Dear Editor-in-Chief :

The authors would like to thank the editor and the reviewer for this second round of revision of our manuscript. Statistical tests applied to the manuscript have shown that ground-based NH_3 concentrations at INDAAF sites are decreasing, while vertical NH_3 total column densities from IASI show increasing trends. The contrasting trends between INDAAF and IASI are due to the spatial extent of the measurements. INDAAF measurements are located at a precise point, while IASI covers a much wider area (7,854 square km). As result, IASI also takes into account NH_3 emissions (1) far from the INDAAF site and (2) at altitude. We hope you find this second round of review suitable for publication and look forward to hearing from you.
Below, we provide a point-by-point response explaining how we have addressed each of the reviewer comments. Note that our responses to the comments are in blue.

Yours sincerely, Money Ossohou, Jonathan E. Hickman, Lieven Clarisse, Pierre-François Coheur, Martin Van Damme, Marcellin Adon, Véronique Yoboué, Eric Gardrat, Maria Dias Alvès and Corinne Galy-Lacaux
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Anonymous Referee

I would like to thank the authors for taking the time to address the reviewers' comments. I am mostly satisfied with the authors' response and the revised manuscript, but I do have a few more comments:

• Line 75: Why do you say the number from Levine (1996) is the best guess, and what is the uncertainty of the estimate? Do you get the same number if you sum up the emissions in GFED4?

We sincerely appreciate this valuable comment. We believe that this reference to global NH_3 emissions from biomass burning needs to be updated. We have therefore replaced it with a more up-to-date reference ''*Bray et al. (2021)*''.

In now line 74 : ''Recently, Bray et al. (2021) estimated average NH_3 emissions from biomass burning at a global scale over the period 2001-2015 at 4.53±0.51 Tg yr^{-1}.''

• Line 310: The fact that monthly averaged IASI total columns can be negative is confusing. Maybe add a note to explain why you can get negative numbers from IASI.

Now in line 191 : ''It is important to note that monthly IASI NH3 total columns can be negative. The negative columns are related to measurement noise, inherent to any type of measurement.

In the ANNI product, noise is translated both to positive and negative columns, unlike some other measurement products that translate noise always to positive columns, resulting in positive biases (*Whitburn et al., 2016*). On average, such noise averages out over long time periods, resulting in a column close to zero over remote regions. The few negative monthly values that are observed here, are close to zero, and occur during months with low ammonia and low measurement sensitivity. Note that these few negative values do not drive the observed trends.''

Whitburn, S., Van Damme, M., Clarisse, L., Bauduin, S., Heald, C. L., Hadji-Lazaro, J., Hurtmans, D., Zondlo, M. A., Clerbaux, C., and Coheur, P.-F.: A flexible and robust neural network IASI-NH₃ retrieval algorithm: New IASI-NH₃ NN Retrieval Algorithm, Journal of Geophysical Research: Atmospheres, 121, 6581–6599, https://doi.org/10.1002/2016JD024828, 2016.

• Line 424: It doesn't look like either the r or p-value between "Ground-based and GFED4" is significant enough to say that biomass burning has an influence on ground-based concentrations at Bomassa and Zoétélé.

Thank you for your comment. We want to say that « These results show that NH3 emissions from biomass burning influence ground-based concentrations of NH_3 in Lamto, and total column densities of NH_3 in the Lamto, Bomassa and Zoétélé areas » We have modified the sentence in **now line 431** to be more clear.

• Line 445: Since you mentioned satellite observations are influenced by a lot of non-local dynamics, I think a 100 km diameter may be too large for the purpose of comparing satellite and ground-based trends. This is probably why you keep seeing a lack of correlation between IASI and ground stations throughout the analysis. Have you tested how sensitive the correlation is with respect to the diameter you choose (100 km vs 50 km vs 25 km, for example) ?

We thank the reviewer for this valuable comment. Indeed, a diameter of 100km centered around each site could be large, but the sentivity test (*table below*) shows that :

- This diameter does not hide any significant correlation
- We obtain the lowest percentage of data that does not meet our selection criterion (number of observations >= 20)

Site (diameter of the circle centered on the site)	**Correlation coefficient (*p-value*)**	**Percentage of missing values (counter<20)**
Banizoumbou (100km)	**0.28 (<*0.01*)**	0
Banizoumbou (50km)	**0.31 (<*0.01*)**	12
Banizoumbou (25km)	0.29 ***(0.04)***	42
Katibougou (100km)	0.06 (*0.5*)	0
Katibougou (50km)	0.1 (*0.25*)	5
Katibougou (25km)	0.07 (0.5)	50
Djougou (100km)	0.03 (*0.7*)	2

Djougou (50km)	0.08 (*0.4*)	16
Djougou (25km)	0.01 (0.9)	54
Lamto (100km)	**0.55 (<*0.01*)**	14
Lamto (50km)	**0.60 (<*0.01*)**	41
Lamto (25km)	-	80
Bomassa (100km)	0.18 (*0.07*)	2
Bomassa (50km)	0.18 (*0.14*)	39
Bomassa (25km)	-	100
Zoétélé (100km)	**0.34 (<*0.01*)**	27
Zoétélé (50km)	**0.51 (<*0.01*)**	32
Zoétélé (25km)	-	99

• Line 529: Now I'm a little concerned about the decreasing trends you get from ground-based concentrations given all the evidence in this paragraph showing NH3 emissions should increase over the years. This suggests to me that maybe the ground stations are not capturing the overall trend that is occurring in the region, while IASI does capture it to a certain extent. Moving forward, what do you think can be done to improve the assessment of NH3 concentrations and trends at the surface? Having more ground stations certainly will help answer these questions better.

Indeed, to better assess ground-based NH_3 concentrations and trends, we need more measurements in the areas of INDAAF sites. In addition, Chemistry transport models (CTMs) can be used to estimate and predict NH_3 concentrations at the surface, but also to assess NH_3 trends over a given period. The results of the INDAAF program can be used as input data for these models.

In Lamto (Côte d'Ivoire), we plan to install active NH_3 analyzers to better compare ground-based data and IASI NH_3.

• Line 555: I suggest keep the units consistent (avoid switching between km and miles), and SI units (km) are generally preferred.

Sorry for this switching. We have replaced 100 squre miles to 7,854 square km in **now line 562**.

• Line 579: You made corrections to these correlation coefficients earlier in the text and I believe it should be Lamto (r=0.55), Bomassa (r=0.18) and Zoétélé (r=0.34).

We apologize to the reviewer. We have made the corrections in **now line 586**.