

## **Review of “Decreasing trends of ammonia 1 emissions over Europe seen from remote sensing and inverse modelling”**

### **Summary**

This paper adds to the growing body of literature on monitoring ammonia from space. The analysis uses the CFPR NH<sub>3</sub> product derived from CrIS radiances in an inversion process that uses an LPDM within a Bayesian approach to derive monthly emissions in Europe during the 2013-2020 period. The authors show seasonal variability and calculate trends in emissions over the entire continent (excluding Russia and Turkey) and regionally, and demonstrate that overall there has been a marked decrease in emissions, attributed mainly to due to control strategies adapted by the European Union. This is an important result for policy makers to use in justifying these often unpopular controls. The use of an LPDM to tackle the problem of estimating NH<sub>3</sub> emissions from satellite data is, to my knowledge, the first time this approach has been applied to ammonia from space.

The paper is well organized and well written. The quality of the graphics is quite high. It needs only minor revisions to be accepted for publication.

### **Technical issues**

Figure 2: the posterior emissions in the upper two panels are in units ng/m<sup>2</sup>/s while they are in Gg in the two lower panels. This implies integration as well as averaging; please describe how these values were obtained in the text.

Line 292: the sentence starting with “It should be noted is not correct”. If NO<sub>x</sub> and SO<sub>2</sub> decreased during the pandemic, more NH<sub>3</sub> would remain in the atmosphere, since there would be less sulphuric and nitric acid for it to react with. NH<sub>3</sub> emissions may well decrease in urban areas (see Cao et al., 2022 (<https://pubs.acs.org/action/showCitFormats?doi=10.1021/acs.estlett.1c00730&ref=pdf>) but not because SO<sub>2</sub> and NO<sub>x</sub> decreased.

Line 344: Emission may appear to increase in Scandinavia in winter because emission of OH and O<sub>3</sub> concentrations are much lower, so the rate of converting SO<sub>2</sub> to sulfate is much slower, less sulfate is made and thus more NH<sub>3</sub> stays in the gas form.

Line 346: this paragraph is a bit confusing. Does the standard deviation come out of the least squares solution for Equation 4?

### **Minor edits**

Line 130: 10000 retrievals per day per level seems reasonable for this product but what does the number 2920 indicate?

Line 135: ... to 2000 per day per level for 6 vertical levels.

Line 177: ... and one hour temporal resolution.

Line 185: the more common usage is **difference** rather than **distance**.

Line 186: between the CrIS vertical profile observations, denoted as  $v^{\text{sat}}$ , and the simulated retrieved profiles,  $v^{\text{ret}}$ . The latter are obtained by applying an instrument .....

Line 199: within a circle around each grid cell for computational efficiency. We chose circles with a radius of approximately 445 km, which is shown ....

Line 212: What are the dimensions of the matrices in this equation?

Line 218: don't the authors mean into Equation 2 and then into Equation 1?

Line 226: Does NaN here indicate missing? Please clarify.

Line 236: Does the avgEENV prior vary by year? Or is the inversion done separately each year for computational reasons?

Figure 1: temporal variability.

Line 331: Rewrite sentence starting with "Especially" as :

The NE emissions dominate the a priori emissions that were used here (avgEENV), because their winter peak in the north is extreme (emissions decline from 35 Gg in winter to 12 Gg in summer). Therefore, due to the strong prior that we use in Northern Europe there is a strong dependence of the posterior seasonality of ammonia on the prior in this region.

Line 358: The current figure 4 should come after the current figures 5 and 6.

Line 411: cannot be resolved at the spatiotemporal resolution of CTM and FLEXPART.

Line 447: A uni-directional dry deposition scheme ignores the impacts of ...

Line 475: Rewrite sentence starting at: "Here we examine" as

Here we used satellite observations from CrIS and a novel inverse modelling algorithm to study the spatial variability and seasonality of NH<sub>3</sub> emissions over Europe. We then evaluated the overall impact of such strategies on the emissions of ammonia for the period 2013–2020.

Line 481: industrial activities

Line 479: The highest emissions overall ...

