Review of : "Data assimilation of CrIS-NH3 satellite observations for improving spatiotemporal NH3 distributions in LOTOS-EUROS"

Accurate NH3 emissions and validation data sets are important inputs for modelers seeking to understand seasonal and spatial variability and long term trends in NH3 concentrations. While this holds true for many trace gases it is especially the case for NH3; NH3 varies rapidly in time and space, and with the exception of western Europe, there are few in situ networks. This data gap can be filled to some extent with satellite data, which can provide global coverage, albeit at a fairly coarse resolution (on the order of 15 km is typical for infrared sensors), for extended periods. This paper seeks to demonstrate and validate a method for improving NH3 estimates from LOTOS-EUROS using the retrieved NH3 profiles from the CrIS sensor on the SNPP platform. The method uses CrIS surface values to adjust the day-to-day variability in the emissions, and assimilates CrIS profiles using Local Ensemble Transform Kalman Filter approach. The model output before and after the updates, is evaluated against in situ data from various networks in the Netherlands, Belgium and Germany, which provide a mix of observations from passive samplers, miniDOAS and wet-only samplers, with varying temporal resolution, from hourly to monthly.

The paper provides an excellent picture of NH3 emissions, surface concentrations and total columns, as well as NHx deposition in northwestern Europe as modelled by LOTOS-EUROS: both magnitudes and variability are well characterized. The use of the CrIS data to attempt to improve model performance is in general well explained and the validation results are interesting. The shift in the emissions peak from spring to later summer/fall is notable and improves the agreement with the in situ data in the Netherlands.

The one disappointing conclusion of the paper is that this method works best for regions where emissions are fairly well known; in these areas it can provide useful adjustments. Otherwise it appears to have little application.

The paper should be published after the minor revisions suggested below have been made.

Medium comments

Comment 1: The authors should explain how the temporal variability is calculated in the background runs and why improving it is important; it took a few readings to understand that it is not the hourly profile that is being changed.

Minor edits and comments

Line 18: column data can be interpreted as total column; maybe use profile instead here and throughout?

Line 63: spatial and temporal distribution…

Line 73: Need to check if NH3 products are being generated from IASI-NG

Line 74: CrIS has greater sensitivity to near-surface…

Line 76: These trace gas measurements have opened up…

Line 89: for the daily distribution …

Line 91: Using a Local …

Line 92: approach as a data-assimilation system, which enhances existing spatial patterns. (can the authors explain why?)

Line 99: that can …

Line 124: has greater sensitivity to NH3 close to the surface due to its low spectral noise … and its 1:30 pm observation time, which coincides with the time of day with highest thermal contrast.

Line 161: Gaussian curve to scale NH3 surface concentrations(see section 2.3.3) from CrIS in each cell.

Line 175: that are mainly dependent…

Line 186: to adjust the daily variability in the hourly profiles

Line 186: Explain what qflag=3 entails and why it was chosen (to increase the number of available points?)

Line 194: differs by region…

Line 195: and chemical conditions.

Line 196: The factor is derived from …

Line 200: Colors in Figure S2 are not defined

Line 201: Explain a bit why it is important to avoid flattening the spring peak

Line 232: What does linearization of h(x) to x mean here?

Line 235: The ~N(0,R) is not familiar to all readers

Line 240:

Line 241: Define G

Line 246: The connection between eq. 8 and eq. 9 is not well made

Line 264: Explain why QF=5 is being used here.

Line 310: the time factors alone

Line 367: Similarly

The statistics in Figures 12 and 13 should be presented also in a table, with the most important results highlighted.

Also need a table here showing the type of instruments in each location.

Line 625: In this study….. This is a good point.