Reviewer #1

Thank you very much for your positive assessment of the manuscript and your comments, which have been addressed as detailed below (in blue).

The study detailed in this paper describes an evaluation tool to investigate the optimum configuration for a dedicated satellite based NH3 sounding instrument. A modelled spectral simulation, using line-by-line radiative simulation, is used to identify a selection of optimal configurations for a hypothetical spaceborne imager capable of high spatial resolution measurements with sufficient NH3 retrieval sensitivity to identify and isolate single point NH3 emission sources.

The authors apply these configurations to existing data sets acquired by IASI and Hyper cams to compare and contrast NH3 identification over a large geographical range for IASI and for selected regional sites in the case of Hyper-cams.

The observational data sets from the IASI instrument on METOP-B and the Hyper-Cam LW system on a Cessna T207A aircraft are degraded to simulate measurements from low resolution and descoped spectral range instruments. System noise, background "clutter", signal-to-noise and False alarm rates are defined and used to assess NH3 column retrieval capability as the observed spectral resolution is reduced over a continuous spectral range and/or a combination of selective bands within a given spectral range are isolated.

The authors demonstrate that low-cost descoped instruments, with sufficient retrieval sensitivity for NH3 emissions monitoring can be achieved.

The paper is very well written and structured. The description of methodology, application and results are clear and the assessment and conclusion sound. I believe the evaluation tool offers a new and solid base to undertake future instrument optimisation.

I recommend this paper for publication with some minor modifications.

The overall paper can be a little improved if the authors could discuss the current state-of-the-art to put this tool into a real-world perspective, for instance some detail on the available narrow-band filters/detector combinations that might be required to isolate spectral bands, and their efficiency would be informative. Will these form part of an FTS system, to provide the spectrally resolved measurements after isolating individual bands?

We thank the reviewer for this valuable suggestion, but our study focuses on evaluating theoretical performance rather than specific instrument implementations (which are also outside our domain of expertise). However, we agree that this is an important consideration for future work.

The authors indicate that only the 9:30 local time IASI data were used for this study. Is this to better match a daytime peak in NH3 emissions? was the 21:30 overpass ever considered to evaluate the capability to observe a diurnal cycle in emission or does the reduction in thermal contrast make this unfeasible. Emissions in April 2020 would have been impacted by the COVID lockdown, given these may therefore not be typical emission scenarios, i.e. potential for reduced background levels, are there any implications for the comparison.

We chose to use only the morning measurements because the thermal contrast is stronger during the day, which is essential for infrared NH_3 monitoring. Since our study focuses on the design of a dedicated NH_3 sounder, we assume it would observe the Earth under optimal thermal contrast conditions, ideally between 11:00 and 14:00. It was therefore natural to select the morning IASI data for our analysis.
We chose a day in April 2020 without worrying about the covid lockdown, as NH_3 emissions are predominantly due to agricultural activities, which were largely unaffected by lockdown measures. Moreover, our study is based on relative comparison between original and downsampled data, rather than absolute concentration levels. Therefore, any potential reduction in the background level does not affect our results.

4.1 From simulated spectra

Reading through the description on the measurement uncertainty as a function of range and resolution, figure 1b indicates to me that, for the two ranges indicated, the resolution should not be higher than 1.21 cm-1 for the given NH3 retrieval baseline at the specified noise(temperature) level. I think this can be more explicitly stated. Hyper-Cam is then shown to be on the edge of this limit and gives a good justification for the pixel averaging used later.

In Figure 1b, the black curves (left axis) show the measurement uncertainty as a function of spectral sampling for a fixed noise level (100 mK), while the orange curves (right axis) show the required noise level to achieve a fixed uncertainty ($3x10^{15}$ $molec.cm^{-2}$). The two axes are independent, and so the crossing point of both curves is arbitrary.
With this figure, we understand that the finer the spectral resolution, the higher the instrumental noise can be to achieve the same measurement uncertainty (orange); and vice versa that for a given instrumental noise, that coarser spectral resolution gives rise to a larger measurement uncertainty (black). This simulation shows that if we do not take into account uncertainties due to other parameters (which is done in the next sections), any measurement uncertainty can be achieved at any spectral resolution, provided the instrumental noise is sufficiently low. This is also expressed in Equation 11.

line 208: missing units on the 2 (cm)
It is now corrected, thank you.

4.2 From IASI

This comparison of simulated instrument configurations is very informative. If IASI at its native resolution is to be taken as "truth", as shown in figure 2, reducing the number of bands and moving towards courser spectral resolution leads to a smoothing of the variance in geographical NH3 column, this is seen in a relative enhancement of NH3 over Eastern Europe near Hungary. Taking this in context of not just reproducing NH3 distribution but also monitoring of emissions and emission levels, these results indicate that a minimum of 4 channels targeting both major NH3 absorption bands at a resolution of 2 cm-1 would be a suitable configuration

We think that the relatively higher NH_3 levels observed over Hungary in Figure 4d are artefacts likely due to the random noise that was applied. We agree that the 4 channels of 2 cm^{-1} yield an NH_3 distribution that closely matches the original IASI distribution, however as pointed out in the text, 3 well-chosen bands of 1 cm^{-1} are associated with even better performance metrics (SNR, FAR and σ_{abs}).

4.3 From Hyper-Cam

This section extends that undertaken in section 4.2 to Hyper-Cam measurements and shows essentially similar behaviour in sensitivity to variable spectral resolution and limited band number, with some interesting outliers associated with higher scene resolution, as seen over the resolved rooftop.

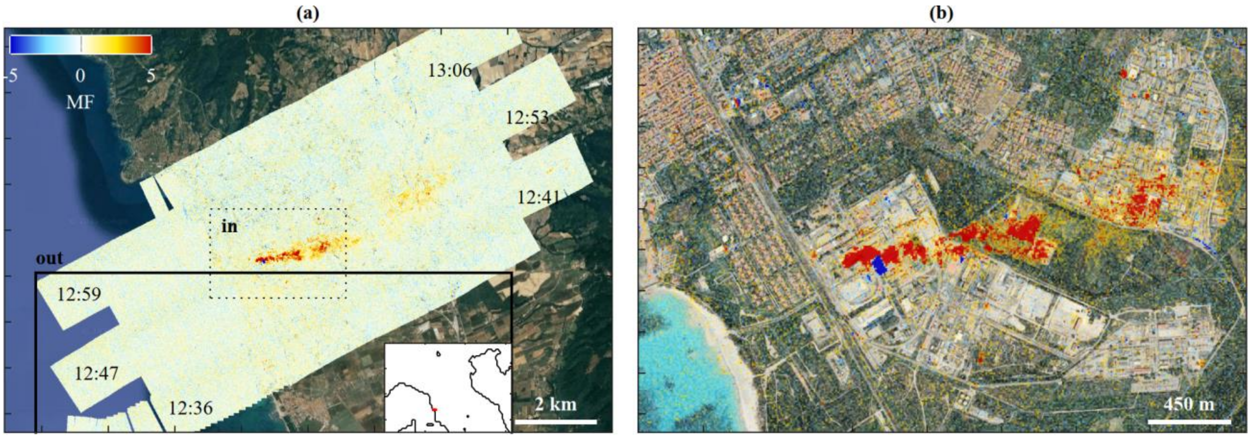
Would such a fine spatial scale from space be feasible? If the hypothetical instrument, this study provides tools to evaluate, were based on a Hyper-Cam in low Earth orbit at 600 km, the single pixel spatial scale increases from 5 m x 5 m to 100 m x 100 m, with no equivalent improvement in spectral noise. It might be insightful to average the Hyper-Cam pixel measurements to simulate the spatial resolution of measurements from low Earth orbit and re-run the sensitivity study. Alternatively, can the authors provide an explanation of how this might impact the behaviour in MF, σ(abs), SNR and FAR shown in the study using the Hyper-Cam.

Within the phase 0 study supporting the Nitrosat project, it was shown that a spatial resolution of 500 m x 500 m is a realistic target with current technologies. This is not the case for a resolution as fine as 100 m x 100 m.

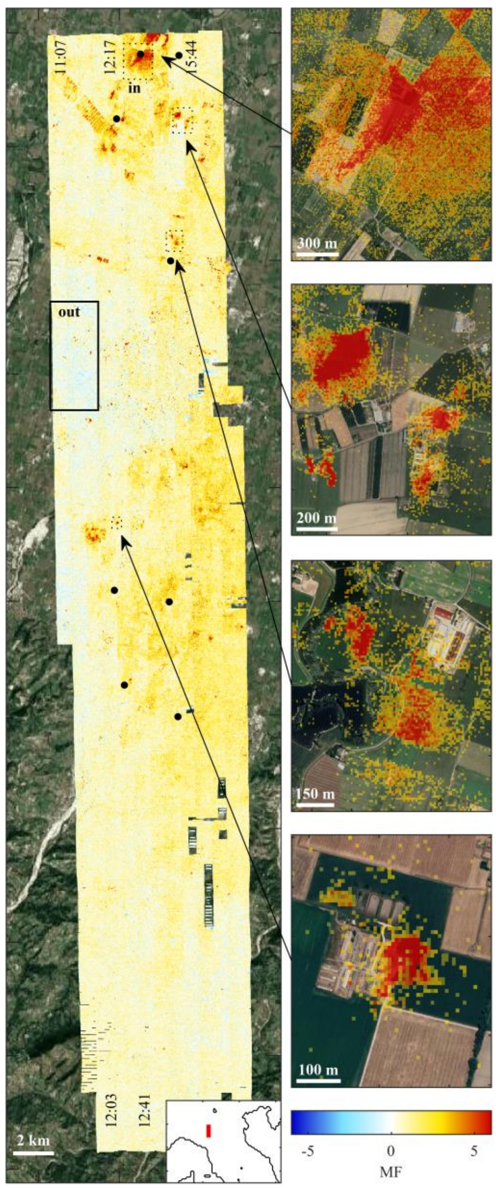
Downgrading Hyper-Cam at such a resolution may not be representative of what would be observed from space, as satellite instruments would differ in technology, and benefit from a more stable platform. The analysis presented in Section 4.2 from IASI measurements provides a more realistic view of what can be expected from spaceborne measurements. The Hyper-Cam analysis complements this by showing that spatial resolution does not impact the drawn conclusions.

I would like to see a little more detail on how the Hyper-Cam measurements shown were obtained, the timeframe and flight tracks.

Following this comment, we added the starting time of some flight tracks on Figures 7 and 8 (see updated figures below), allowing better to distinguish the different flight tracks and directions of flight, and complementing the brief description of Hyper-Cam measurements available in Section 2 of the manuscript.



Updated figure 7



Updated figure 8