Responses to Reviewer #1 (RC2) comments (black text) are given below, in blue text. Please note that the revised manuscript includes very minor updates resulting from a slight refinement in the computational methodology. These adjustments lead to very small numerical differences that do not alter the overall conclusions or interpretations presented in the original analysis.

General comments

In this study, the authors investigate global ammonia (NH3) emissions from 2019-2022 by using satellite observations from IASI and a chemistry-transport model called LMDZ-INCA. The study updates nh3 emissions use the finite difference mass-balance through an atmospheric inversion technique. They use averaging kernels from the latest IASI data to improve accuracy when comparing model simulations to the satellite measurements. The research finds that existing emission inventories may significantly underestimate global anthropogenic NH3. Furthermore, the paper examines regional variations in NH3 emissions and their seasonality, noting discrepancies with current inventories and potential influences from COVID-19. The manuscript is well-structured and is well-written. However, there are certain things to be clarified before the MS can be accepted.

We are very grateful to the reviewer for the positive assessment of our manuscript, valuable comments, and helpful suggestions. We have addressed all the comments and revised the manuscript accordingly.

Specific comments:

L240-242: You mentioned that you use NOx and NH3 from CEDS for eleven sectors including the agricultural sector, and you also mentioned that CEDS emissions of NO and NH3 from agricultural soils with both synthetic and manure fertilizers. Are the NO and NH3 from agricultural soil emissions not included in the agricultural sector and provided separately?

The CEDS dataset reports NOx and NH_3 emissions by sector, including an agricultural sector that encompasses emissions from agricultural soils, and in particular those arising from the use of synthetic and manure fertilizers. These agricultural soil emissions are not provided separately but are included within the broad agricultural sector in the CEDS inventory. We do not include another independent estimate of NO and NH_3 emissions from agricultural soils and these emissions are not double-counted in our framework, but the text potentially raised confusion regarding this. We have clarified this point in the revised manuscript.

L247-248, you use the CO2 data from the Carbon Monitor dataset to calculate emission growth rates of other species. This leads to noticeable variation in emissions of SO2 and NOx. Did you compare the changes with other inventories (such as global cams) to check if the changes are realistic? It would be nice if you could provide a figure in the supplement.

We have examined the changes in SO_2 and NOx emissions from 2019 onwards, and found that the trends derived using CO_2 emissions growth rates from the Carbon Monitor dataset are broadly consistent with CAMS emissions. Since our primary focus is on NH_3, we have opted not to include an additional figure. However, we do mention in the main text that our NH_3-specific analysis including prior CEDS and CAMS comparisons with our IASI-constrained NH_3 emissions.

L267, finish the sentence.

Thank you for noticing this error. It is corrected now.

L335-340, to select the grid cells with dominant NH3 emissions, do you use monthly emissions or yearly emissions?

The original dataset is at monthly scale, and it is uniformly distributed into hourly values in input of LMDZ-INCA simulations. Therefore, we use daily (which is implicitly equivalent to monthly) emissions for such selection. This is now clarified further in the revised manuscript.

Figure 3, please provide the figure with a higher resolution. The legends in the sub-figures are not easy to read.

We have provided this figure and all others with better resolution.

Section 4.1 you compared your results to other emission datasets including emissions derived from CrIS. The overpass times of IASI and CrIS are different. The emission rates are different at the two overpass times. How accurate is the diurnal cycle of NH3 emissions in the model? I guess this could also be another reason for the difference in emissions deriving from IASI and CrIS.

Thank you for this insightful comment. You are correct that differences in satellite overpass times (IASI ~09:30 LST, CrIS ~13:30 LST) can lead to differences in retrieved NH_3 due to the potentially strong and quite uncertain diurnal variability in NH_3 emissions and atmospheric concentrations. However, in the current setup of our model (LMDZ-INCA), the anthropogenic NH_3 emissions are derived from a 1-month resolution inventory which is uniformly distributed in time at the hourly resolution, without incorporating diurnal cycles. This lack of diurnal variations in the input prior emissions could indeed enhance the discrepancies between IASI- and CrIS-based emission estimates. In a study by Dammers et al. (2019), they utilized both IASI and CrIS satellite observations to estimate ammonia (NH_3) emissions, lifetimes, and plume widths from major agricultural and industrial point sources. Their findings indicate that CrIS-derived emission estimates are, on average, slightly higher than those obtained from IASI-A and IASI-B observations. However, these differences remain within the overall uncertainty range of the estimates. The differences in the emissions from CrIS and IASI could be due to the bias between the satellite NH_3 retrievals, as well as the potential influence of the different overpass times of these satellites in combination with the strong diurnal cycles of the emissions. We have discussed this in section 4.1 of the revised manuscript.

Section 4.3. The uncertainties in emissions and limitations are discussed without quantifying the uncertainties of the estimated emissions. It would be nice to provide a simple estimate of errors/bias caused by uncertainties/ bias from satellite data. Furthermore, the gap-filling for the emissions can also introduce bias and errors.

As mentioned briefly in the “Uncertainties and Limitations” section, the current framework of our atmospheric inversions does not provide uncertainty in our estimates. However, there are a few studies (Cooper et al., 2017; Koukouli et al., 2018) which tried to get some information about the uncertainties in their estimates using basic or FDMB approach, propagating the observation errors. While implementing a similar approach could be considered in future work, it is beyond the scope of the current study. We have discussed this limitation further in the revised manuscript. As noted by the reviewer, the gap-filling procedure can also introduce additional biases and uncertainties, which we have now discussed more explicitly in section 4.3 of the revised manuscript.