Comments:

This paper is analyzing hourly variation of NH_3 concentrations and quantifying surface NH_3 concentrations and NH_3 emissions in China, using observations from GIIRS and IASI. A three parameter Gaussian function is used to fit NH_3 vertical profiles from GEOS-Chem and get information of NH_3 concentration at different heights. Surface NH_3 concentrations and total NH_3 emissions are estimated based on the mass balance method and ratio from GEOS-Chem.

It was found that diurnal NH_3 concentrations are larger than nightly NH_3 concentrations. A good agreement is obtained between the ground measurements and the estimated. The NH_3 emissions range from 12.99 to 17.77 Tg N yr^{-1} between 2008 and 2019 in China. The paper also discussed the uncertainties and capabilities of the method. The topics of paper fits the scope of ACP and the scientific idea is new. The article is generally well written and easy to follow. I have the following comments of the paper but I am supportive of publications if these aspects can be addressed.

We thank the reviewer for your time and helpful comments. Our point-by-point response is enclosed.

Major concerns:

1. Please indicate the basis for the satellite data quality screening and the number of valid pixels after eliminating invalid pixels. If the proportion of remaining valid pixels is low, the study results will be misleading and appropriate data supplementation should be performed.

We thank the reviewer for the comment. Since the quality of satellite data was greatly affected by cloud cover, we deleted all data with recorded cloud cover >20%, which was more stringent than previous studies (Wang et al., 2020). Besides, the quality of satellite data was also affected by other factors, such as retrieval method and inversion algorithm. We also deleted the observations with the uncertainty higher than 50% (Fortems - Cheiney et al., 2016).

We performed relatively stringent screening of the observations. Further quality constraint is feasible, but more satellite observations will be missing, affecting the spatial continuity of the NH_3 column and the estimated NH_3 emissions. We supplemented Fig. S1 showing the effective pixel count of GIIRS and IASI with the above filtering conditions. The total number of pixels covered by GIIRS (spatial resolution 0.5°) in China is about 3840, and the total number of pixels covered by IASI (spatial resolution of 0.1°) is about 96170.

Fig. S1a shows the number of effective pixels for the monthly average NH_3 column of GIIRS in each overpass period (defined as 2 hours interval) during 2019.11-2020.10. The red dotted line represents the total number of pixels (the sum of the records of 10 overpass periods with 2 hours interval), and the inside of the bar graph is marked as the ratio of the number of valid pixels to the total pixels in a single overpass period. All the monthly average NH_3 column of GIIRS accounted for more than half of the total effective pixels, and the minimum value of the effective pixels for each overpass period exceeded 25%. GIIRS had the higher number of effective pixels in March, April, and May, while the number of effective pixels in January, July, and December were relatively low, which was consistent with the results (Fig. 3) of monthly average surface NH_3 concentration by GIIRS in China. It should be noted that due to the lack of the observations at 24:00, the observations at 23:00 were not shown in the Fig. S1a (the observaed coverage is extremely limited).

Fig. S1b shows the effective pixel count of monthly average NH_3 column by IASI from 2008 to 2019. The red dotted line represents the total number of pixels, and the outer labels of the pie chart represent the ratio of the effective pixels to the total pixels over China. Here, we only marked a few months with the high proportion in the pie chart. The effective pixels of IASI NH_3 column showed an overall increasing trend during 2008-2019. The number of IASI NH_3 effective pixels was significantly higher in summer than in winter, and the effective pixel in July 2015 accounted for the highest proportion (>50%). Although the proportion of IASI NH_3 valid pixels was generally lower than GIIRS, most of which were around 35%, the spatial distribution of IASI NH_3 effective pixels in China was relatively uniform without concentration. We had performed interpolation processing to ensure the spatial continuity and integrity of IASI NH_3 column. In general, the number of available pixels from GIIRS and IASI met the analysis requirements.

We added the following sentences and figure in supplement.

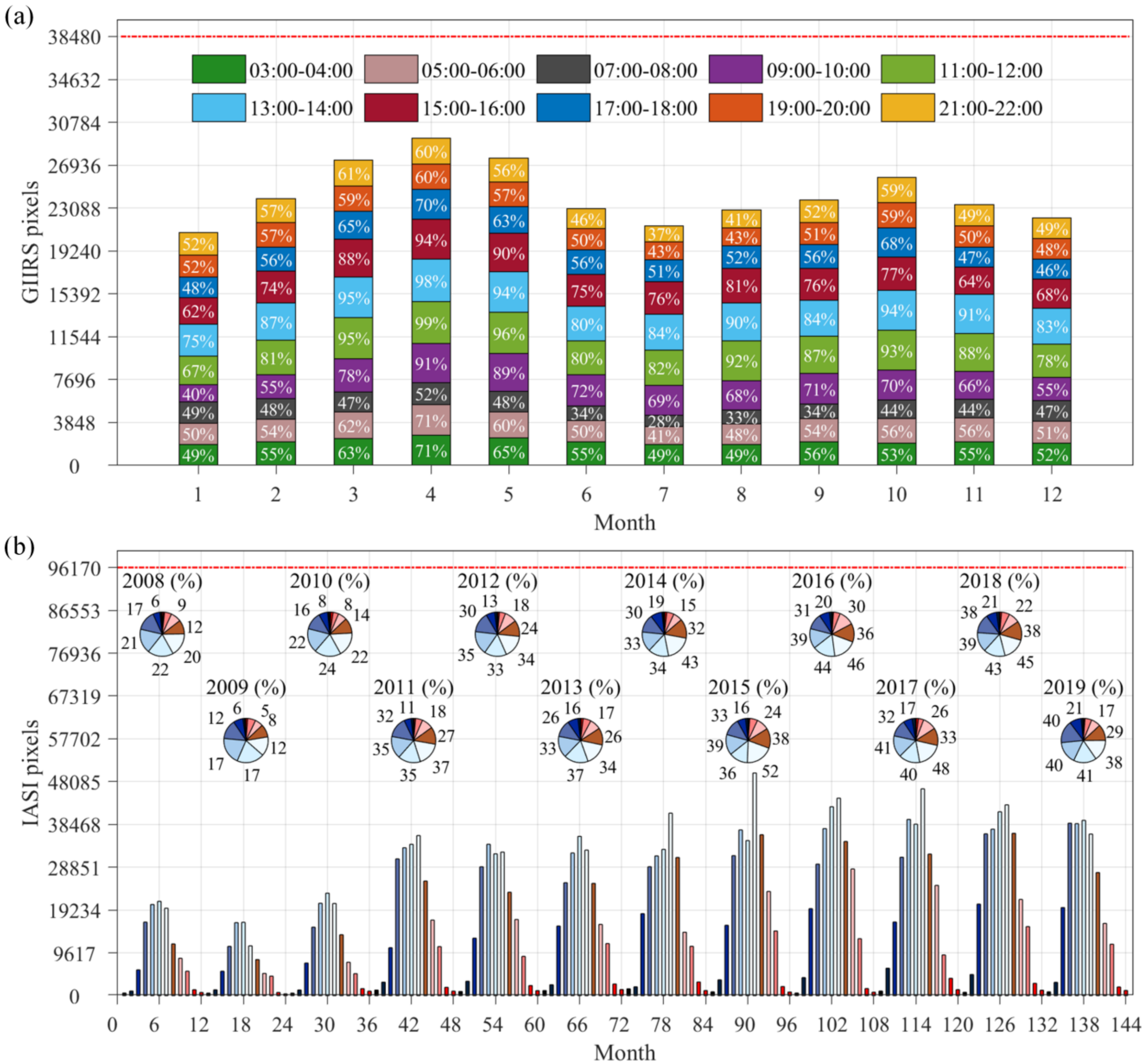

Figure S1. The variation of valid pixels after quality control. (a) Effective pixels of the monthly average NH_3 column by GIIRS in each overpass period (2 hours interval) during 2019.11-2020.10; (b) Effective pixels of monthly average NH_3 column by IASI from 2008 to 2019.

2. In the paper, two kinds of satellite observations are using to estimate surface NH_3 concentration. Figure. 3 and Figure. 7 show the differences in spatial distribution and numerical magnitude between them. Although there are problems of scale conversion, the comparison of the estimation results is of great necessity, especially at similar satellite overpass time.

We thank the reviewer for the comment. Clarisse et al. (2021) compared the v3 version of the IASI NH_3 dataset (Van Damme et al., 2021) and GIIRS for NH_3 retrieval in terrestrial areas (Fig. 9). Observations with the difference in measurement time within 15 minutes and the pixel center distance within 2 km are considered as corresponding observations. Overall, the regression slope was found to be 1.14, the correlation coefficient of R_2 was greater than 0.65, and the bias was small. The reasons for the inconsistency included instrument calibration, HRI calculation, processing of surface temperature, systematic biases of neural network, and different observed geometries.

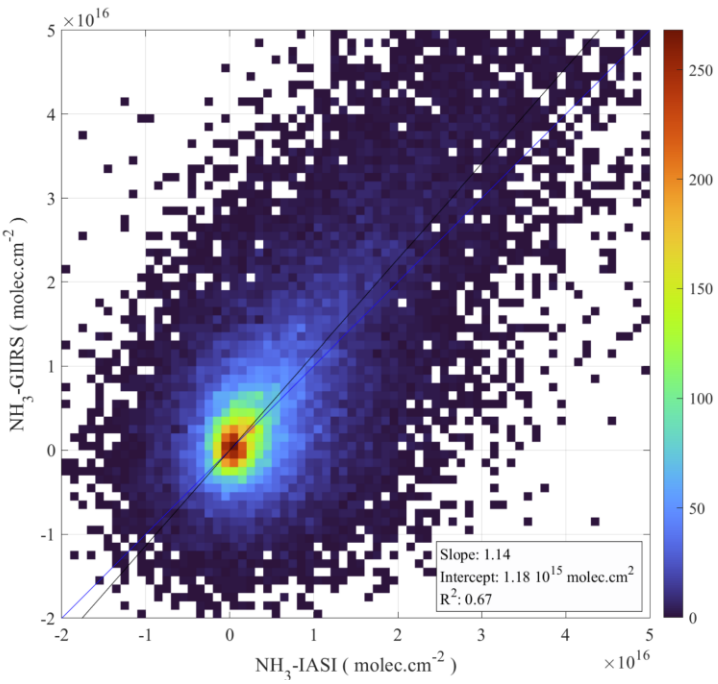

Figure 9. Comparison of IASI and GIIRS NH_3 retrievals in terrestrial regions (Clarisse et al., 2021).

3. Figure. 8 shows an abrupt change of surface NH_3 emissions in China during 2014-2015. The value of surface NH_3 emission is estimated around 17 Tg in 2019, which may be overestimated compared to previous findings. Its accuracy is questionable, and I suggest extending uncertainty analysis.

We agree with the reviewer that NH_3 emissions over China in 2019 may be overestimated. In this study, estimated total NH_3 emissions of China reached 17.77 Tg N yr^{-1} in 2019, which was a high value and had the potential to be overestimated. We added the following sentences into our manuscript.

“Second, we used a relatively fixed average conversion ratio (Fig. S2) to estimate surface NH_3 concentrations and NH_3 emissions in China, ignoring the time-series variation of the feedback ratio, due to the temporal constraint of emission inventory. In this case, non-emission factors led to higher satellite observed NH_3 column, for example, emission reductions of SO_2 and NO_2 led to increased NH_3 column (Lachatre et al., 2019; Fu et al., 2020), which can introduce uncertainty into NH_3 emission calculations using concentration as the main parameter.”

4. The quality of the figures in the paper needs to be improved, and there are errors and inconsistencies in the graphic descriptions, which should be carefully corrected.

We thank the reviewer for the comment. We have further checked and updated all figures in the paper, and revised inconsistencies between the descriptions and figures.

Minor comments:

Page 2, line 32: Change "To provide a scientific basis of…" to "To provide a scientific basis for…".

We have changed it as suggested.

Page 3, line 43: Change "Some studies have carried out…" to "Some studies have carried out conducted…".

We have changed "carried out" to "conducted".

Page 3, line 52: "China's cultivated land area accounts for only 8% of the world, but it consumes about 30% of the world's nitrogen (N) fertilizer". Please add article references.

We have added references as suggested.

"China's cultivated land area accounts for less than 10% of the world, but it consumes about 30% of the world's nitrogen (N) fertilizer (Peng et al., 2002)."

Page 5, line 103: Change "are" to "is".

We have changed it as suggested.

Page 7, line 126: There is a misuse of symbols in units (molec·cm^{-2}).

We have changed it as suggested.

Page 8, line 151: Describe the information of sites in tabular form.

Table S1. The information of the collected hourly measured sites.

Name	Class	Lat	Lon	Period	Reference
Xianghe	rural	39.75 °N	116.96 °E	2017.12 -2018.2	(He et al., 2020)
Fudan University	urban	31.30 °N	121.50 °E	2013.7-2014.9	(Wang et al., 2015)
Dianhushan	rural	31.09 °N	120.98 °E	2014.3-2014.6	(Wang et al., 2015)
Gucheng	urban	39.15 °N	115.73 °E	2016.3-2017.5	(Kuang et al., 2020)
Jinshan Chemical Industry Park	industrial	30.73 °N	121.27 °E	2014.1-2014.6	(Wang et al., 2015)

Page 9, line 168: Change "is" to "are".

We have changed it as suggested.

Page 9, line 175: Check the following formula format.

We have fixed it as suggested.

Page 14, line 242: Description in 3.2 is not fitting to Figure. 5.

We have fixed it as suggested.

“Monthly regression R^2 between the satellite-derived NH_3 concentration and the measured NH_3 was 0.38-0.84. The regression R^2 reached the higher value (>0.80) in July and August. The RMSE ranged from 2.29- 3.36 μg N m^{-3}, which reached the maximum value of 3.36 μg N m^{-3} in July, and reached the smallest in March (2.29 μg N m^{-3}). The bias is basically less than 31% for all months, and reached the minimum value of -0.67% in February, indicating that the monthly IASI-derived surface concentration obtained are consistent with measurements.

Page 15, line 248: There are any errors in Figure. 5, suggest reconstruction.

We have revised and updated Figure. 5.

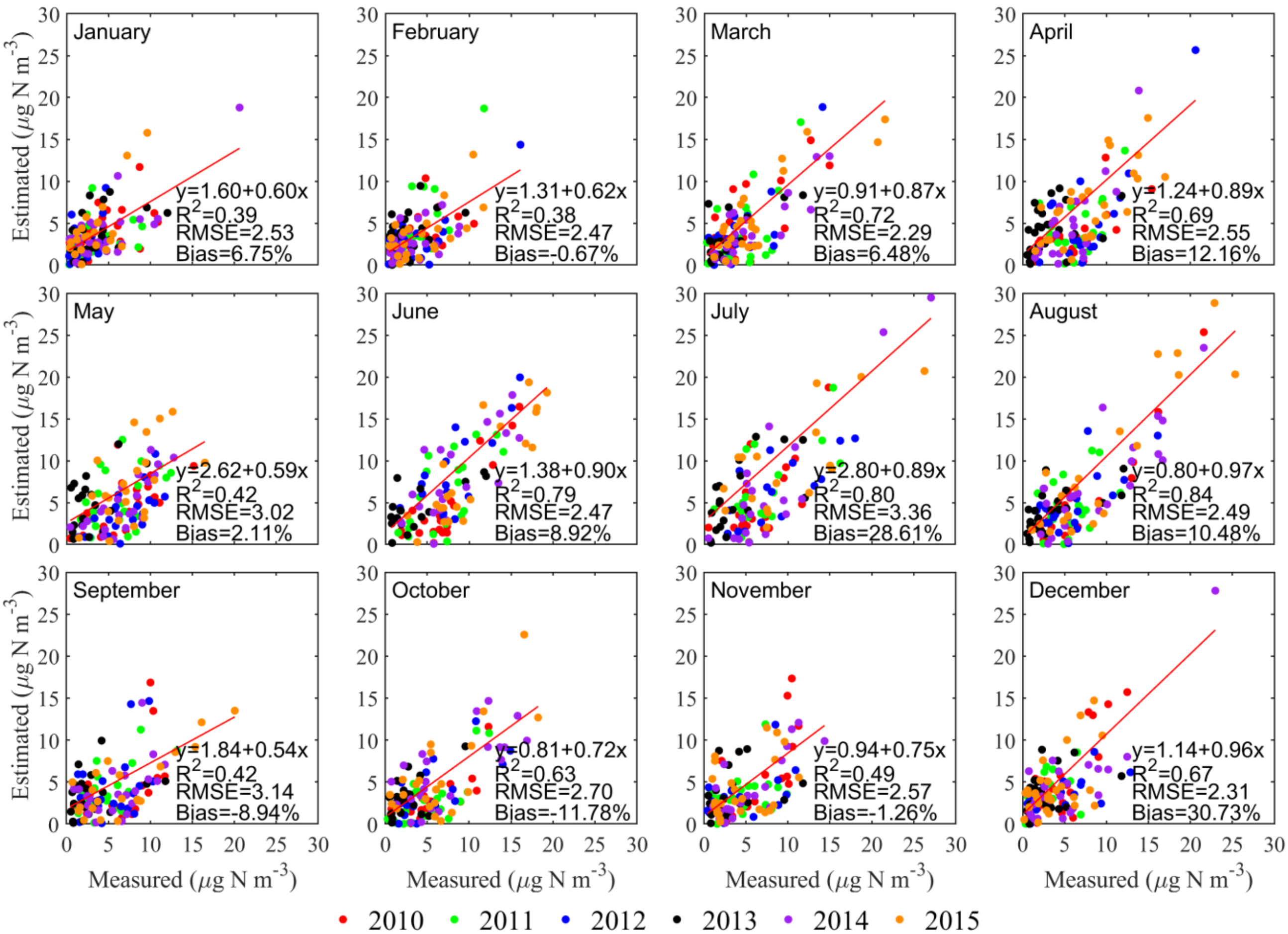

Figure 5. Comparison of monthly average values of IASI-derived and observed NH_3 surface concentrations in 2010-2015.

Page 20, line 304: Why is the time series of the Fengyun geostationary satellite data so short? Can you give an explanation?

Clarisse et al. (2021) reported the first observations of daily atmospheric NH_3 over Asia by satellite FY-4A GIIRS. The fast NH_3 retrieval method originally developed for IASI was used on a full year of GIIRS observed retrieval from November 2019 to October 2020. The dataset of atmospheric NH_3 columns from the FY-4A GIIRS is a short time series product and FY-4A is nearing the end of its lifespan, but it's promising given the future landscape of geostationary sounders.

Page 20, line 305: Change "are" to "is".

We have changed it as suggested.

Reference

Clarisse, L., Van Damme, M., Hurtmans, D., Franco, B., Clerbaux, C., and Coheur, P. F.: The diel cycle of NH_3 observed from the FY-4A Geostationary Interferometric Infrared Sounder (GIIRS), Geophys. Res. Lett., 48, e2021GL093010, https://doi.org/10.1029/2021GL093010, 2021.

Fortems-Cheiney, A., Dufour, G., Hamaoui-Laguel, L., Foret, G., Siour, G., Van Damme, M., Meleux, F., Coheur, P. F., Clerbaux, C., Clarisse, L., Favez, O., Wallasch, M., and Beekmann, M.: Unaccounted variability in NH_3 agricultural sources detected by IASI contributing to European spring haze episode, Geophys. Res. Lett., 43, 5475-5482, https://doi.org/10.1002/2016GL069361, 2016.

Fu, H., Luo, Z., and Hu, S.: A temporal-spatial analysis and future trends of ammonia emissions in China, Sci. Total Environ., 731, 138897, https://doi.org/10.1016/j.scitotenv.2020.138897, 2020.

He, Y., Pan, Y., Zhang, G., Ji, D., Tian, S., Xu, X., Zhang, R., and Wang, Y.: Tracking ammonia morning peak, sources and transport with 1 Hz measurements at a rural site in North China Plain, Atmos. Environ., 235, 117630, https://doi.org/10.1016/j.atmosenv.2020.117630, 2020.

Kuang, Y., Xu, W., Lin, W., Meng, Z., Zhao, H., Ren, S., Zhang, G., Liang, L., and Xu, X.: Explosive morning growth phenomena of NH_3 on the North China Plain: Causes and potential impacts on aerosol formation, Environ. Pollut., 257, 113621, https://doi.org/10.1016/j.envpol.2019.113621, 2020.

Lachatre, M., Fortems-Cheiney, A., Foret, G., Siour, G., Dufour, G., Clarisse, L., Clerbaux, C., Coheur, P.-F., Van Damme, M., and Beekmann, M.: The unintended consequence of SO_2 and NO_2 regulations over China: increase of ammonia levels and impact on PM 2.5 concentrations, Atmos. Chem. Phys., 19, 6701-6716, https://doi.org/10.5194/acp-19-6701-2019, 2019.

Peng, S., Huang, J., Zhong, X., Yang, J., Wang, G., Zou, Y., Zhang, F., Zhu, Q., Buresh, R., and Witt, C.: Challenge and opportunity in improving fertilizer-nitrogen use efficiency of irrigated rice in China, Agric. Sci. China, 1, 776-785, 2002.

Van Damme, M., Clarisse, L., Franco, B., Sutton, M. A., Erisman, J. W., Kruit, R. W., Van Zanten, M., Whitburn, S., Hadji-Lazaro, J., Hurtmans, D., Clerbaux, C., and Coheur, P.: Global, regional and national trends of atmospheric ammonia derived from a decadal (2008–2018) satellite record, Environ. Res. Lett., 16, 055017, https://doi.org/10.1088/1748-9326/abd5e0, 2021.

Wang, S., Nan, J., Shi, C., Fu, Q., Gao, S., Wang, D., Cui, H., Saiz-Lopez, A., and Zhou, B.: Atmospheric ammonia and its impacts on regional air quality over the megacity of Shanghai, China, Sci. Rep.-UK, 5, 1-13, https://doi.org/10.1038/srep15842, 2015.

Wang, Z., Uno, I., Osada, K., Itahashi, S., Yumimoto, K., Chen, X., Yang, W., and Wang, Z.: Spatio-temporal variations of atmospheric NH_3 over east Asia by comparison of chemical transport model results, satellite retrievals and surface observations, Atmosphere, 11, 900, https://doi.org/10.3390/atmos11090900, 2020.