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Interactive comment on "Wintertime Spatial Distribution of Ammonia and its Emission Sources in the Great Salt Lake Region" *by* Alexander Moravek et al.

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We thank Reviewer #1 for their overall positive feedback on our manuscript. We addressed their comments as follows:

Comment: *Page 4, line 10 – What is the instrument time response and what makes it suitable for aircraft measurements? The reference Hacker at al. 2016 is incomplete in the reference list making it impossible for the reader to verify these claims.*

Response: We did not include details on the time response and other technical details of the QCL measurements in order to keep the manuscript as concise as possible. However, we thank the Reviewer for pointing out to that there is a strong interest to include these. In the design of the presented setup we performed extensive time response tests. With the aim to reduce the weight of the QCL setup, a faster time response could be achieved by introducing a bypass inlet flow. We added this explanation and the time constants further below in the paragraph. Furthermore, we updated the references on Hacker et al. (2016). To our knowledge they were the first to successfully use a QCL for ammonia on a light-weight aircraft, which is why they are cited here. Recently, Pollack et al. (2019) showed the suitability of the QCL for aircraft NH_3 measurements for different inlet conditions. We included this reference in the manuscript.

Comment: *Page 5, line 5 – How fast does the Twin Otter fly? Is a 30 s averaged from that that platform or is it just smearing multiple point sources?*

Response: The nominal flight speed of the Twin Otter was 60 m/s. Due to the distance of the Twin Otter from the surface, we observed that distinct NH_3 peaks from point sources were typically of longer than a 1 min duration, which indicates that the QCL time resolution was sufficient.

To clarify, our analysis was based on the 1-Hz high frequency data (e.g. as used in the Fig, 4 frequency distributions). However, for the comparison with the STILT model, a 1 min average was applied, centered on the time of the STILT model particle release.

Comment: *Page 4, lines 14-15 – It is not clear how using a smaller pump has any influence on the measurement or analysis presented here. It is the pumping curve, i.e. pumping speed as a function of pressure, which is important to the measurement, not the weight of the pump. How has the pump change affected the measurement?*

Response: We agree that the pumping curve determines the performance of the pump, however, as mentioned, a smaller pump was primarily chosen due to its reduced weight and power consumption. Due to the lower sample flow rate of this smaller pump, the time response of the NH_3 measurement becomes worse. As mentioned further below in the paragraph, we introduced a bypass inlet flow to compensate for the impaired time response with the smaller pump. We added the achieved overall time response in this part of the manuscript. Since the bypass was upstream of the critical orifice, the air pressure in the bypass line was only slightly under ambient pressure, which is why a light-weight membrane pump could be used.

Comment: *Page 5, line 6 – Vibrations and g-force accelerations during extreme events made the observations unreliable. What criteria are used to evaluate the level flying segments to ensure there are no vibrational effects? This is not addressed here or in the supplemental.*

Response: The NH_3 time series were filtered manually for periods of strong vibrations and g-forces. For this, periods of fast ascents/ descents were identified through the Twin Otter's altitude profile. In manual checks of individual adsorption spectra we compared the fringe pattern to the retrieved NH_3 fit. Since the fringe pattern changes under strong vibration/ g-forces, this procedure allowed us to decide whether an absorption feature was real. We added a note on this procedure in the manuscript. Since at higher altitudes, where most of spiraling ascents/ descents occurred, the NH_3 mixing ratio could be assumed to be near zero, bad data quality periods could also be detected by unrealistic drifts in the NH_3 mixing ratio. Periods of take-off and landing were always discarded.

Comment: *Page 6, line 15 - Why does it take 24 hrs of over-flowing zero air to determine the AIM-IC background, if it reports hourly data? Is that a relevant background?*

Response: A 24 hrs background for the AIM-IC was performed to ensure that the PFA tubing from the zero air tank to the AIM-IC inlet was fully free of contaminants and to retrieve meaningful statistics for the AIM-IC detection limit determination. In the data processing, the average background peak areas are subtracted from the ambient air peak areas for each analyte.

***Comment:** Page 13, line 12 - This statement seems to contradict Page 5, line 4, which states that the 30 s precision is 90 pptv. The precision should decrease for a 1 minute average, unless the precision is not limited by counting statistics, which has not been discussed.*

Response: We thank the Reviewer for noting this apparent inconsistency. We found from the Allan variance analysis that the precision for 30 s and 1 min averages was very similar. The precision (1σ) for 1min was about 25 pptv, we corrected this in the manuscript. The 90 pptv for 30s averages given on Page 5 refers to the limit of detection (3σ), showing that the 1σ precisions for 30 min and 1 min averaging intervals were very close.

***Comment:** Page 15, line 26 – These two sentences are not a separate paragraph.*

Response: We joined them to the previous paragraph.

***Comment:** Page 19 – The Hacker reference is incomplete. The complete reference list should be checked.*

Response: The reference was completed.

***Comment:** Page 24, Figure 3 – The top panel is difficult to differentiate between the*

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Discussion paper

gray and purple traces. The symbols and their error bars are very hard to read.

Response: We changed the color of the NH_3 ground mixing ratio trace and the Twin Otter NH_3 error bars.

Comment: *Page 25, Figure 5 – In the caption the units of the flux sensitivity footprint are given as (in ppmv/(mol m^{-2} s^{-1}) but in the test on Page 8, line 17 the units are given as (in pptv/(mol m^{-2} s^{-1})). This appears to be an inconsistency.*

Response: We changed the unit on Page 8 to ppmv/(μmol m^{-2} s^{-1}), which was the unit the data was provided in.

References

Hacker, J. M., Chen, D., Bai, M., Ewenz, C., Junkermann, W., Lieff, W., Mcmanus, B., Neininger, B., Sun, J., Coates, T., Denmead, T., Flesch, T., Mcginn, S. and Hill, J.: Using airborne technology to quantify and apportion emissions of CH4 and NH3 from feedlots, Anim. Prod. Sci., 56, 190–203, 2016.

Pollack, I. B., Lindaas, J., Robert Roscioli, J., Agnese, M., Permar, W., Hu, L. and Fischer, E. V.: Evaluation of ambient ammonia measurements from a research aircraft using a closed-path QC-TILDAS operated with active continuous passivation, Atmos. Meas. Tech., doi:10.5194/amt-12-3717-2019, 2019.

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