Interactive comment on "Cross-track Infrared Sounder (CrIS) satellite observations of tropospheric ammonia" by M. W. Shephard and K. E. Cady-Pereira

Anonymous Referee #1
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We would first like to thank the Reviewer for taking their time to review the article and provide helpful suggestions and comments. We have addressed all the Reviewer's comments below and edited the manuscript as required.

This manuscript describes an ammonia retrieval algorithm for CrIS. The algorithm is well developed, described, and evaluated. The data from the retrieval are expected to be of high value for further analyses. Valuable guidance is offered in section 4 on the comparison of the retrieved profile with other profiles. I recommend publication after minor revisions.

1. *Section 3.1 briefly notes that the retrieved profile values are expressed as the natural log of the volume mixing ratio.*
    a. *Does it make sense to explicitly specify the use of natural log in equation 1?*

    Given the large range in magnitudes of ammonia values from the surface up to the tropopause it is preferable to perform the retrievals in log space instead of linear space as the sensitivity (i.e. averaging kernels) and errors represent fractional changes in the VMR rather than absolute changes in VMR. However, equation (1) remains general whether or not the "x" values are specified in linear or log space. The important thing to keep in mind when the retrieval is performed in log space is that the resulting products out of the retrievals (i.e. averaging kernel, retrieved profile, etc.) are all in log space (i.e., when applying observational operator for comparisons). Also, if desired for a particular purpose, one can generally linearize the retrieved products and then apply the equations in linear space. As the form of the equations remains the same whether they are written in linear or log space, we decided to keep them general.

    b. *What are the potential implications of the use of the natural log? Could it contribute to the retrieval bias by allowing errors to have more influence in a positive direction than a negative direction?*

    This is a good question that we have also asked ourselves from time-to-time when we get a positive bias. As mentioned above, the main benefit of using the natural log in the retrieval is to better handle the large range in magnitudes of the retrieved ammonia profile. In general one would not expect the ln(VMR) to create a positive bias for retrievals that are far enough from zero. However, since ammonia values are very small ~~I~~

~~don't think~~ the impact cannot be totally ruled out. However, it is likely that setting the initial guess profile large enough so that the retrieval does not start in null space and then iterating back down to clean atmosphere has greater potential for creating a positive bias. It should be noted that similar algorithms with TES data for other minor species with weak infrared atmospheric signals (i.e. formic acid and methanol) do not appear to have a positive bias, which provides some circumstantial evidence that the use of the natural log is not a large contributor to any positive bias.

2. *Section 6.2.2, what is the significance of scaling the surface measurements by 1/6? Some of the figure text is small and hard to read.*

   The reason for scaling the surface values by 1/6 is solely for the purpose of using the same scale on the figure for visual correlation comparison purposes. The reason why the values need to be reduced is that the in-situ QCL values represent surface values whereas the satellite observations represent values closer to 1-2 km above the surface, and given the typical sharp decrease in ammonia with height the values can be much smaller aloft.

   To make this more apparent in the manuscript we changed the sentence to: "Note, that since the QCL measurements are at the surface and the satellite measurements represent more boundary layer values at ~1-2km where the ammonia concentrations are much reduced, the QCL observations are scaled by 1/6 for relative comparison purposes only."

3. *p11380, l6, retrieved ammonia*

   Corrected as suggested.

4. *p11384, l9, an across*

   Corrected as suggested.