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Atmospheric Measurement Techniques Discussions

Interactive comment on "Characterization and verification of ACAM slit functions for trace gas retrievals during the 2011 DISCOVER-AQ flight campaign" *by* C. Liu et al.

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We would like to thank George for his constructive comments to improve the paper. We have addressed all his comments as detailed in the following point-to-point response:

1. P2/7 I would replace "improve" with "assure" since the slit function should be determined not just to improve the analysis, but rather as an essential element of the analysis.

Response: Done.

2. P2/23 SO2 was not also part of the measurement?

Response: Yes. SO2 is not one of the major target trace gases for the DISCOVER-AQ campaigns.

3. P3/13 "... that pass through he atmosphere and are affected by atmospheric . . .

Response: We made the change as you suggested.

4. P3/21 perhaps add ". . . narrow band lasers . . ." . I see on reading further that there is a telescope (?) – if so, were the measurements of the ACAM slit function made with the telescope installed – see note further down. I gather from p5/18 that the measurements were performed with the telescope on?

Response: We add "tunable narrow band" before "lasers." There is no telescope on ACAM. There is a scan mirror that reflects the incoming light into the spectrometers' optical fiber.

5. P3/23 ". . . available for comparison. . ."

Response: We made the change as you suggested.

6. P4/22 please give the manufacturer of the two C-T spectrometers

Response: The manufacture is Ocean Optics, which is added to the text.

7. P4/24 I cannot tell if these are scanning systems or if they have a CCD type detector. I assume CCD type detector – please identify type.

Response: It uses a scanner rather using CCD type detector as it was mentioned later in the same paragraph "ACAM scans across the track . . ."

8. P4/29 concerning observing modes, one assumes there is a telescope on the system. If so, you might want to mention illumination qualities of the telescope on the spectrometer system since that illumination quality will affect the measurement of slit function.

Response: Since we have no telescope (just scan mirror), I do not think it is necessary.

AMTD

7, C4561–C4567, 2015

We mention the scan range and instantaneous FOV of 3.6° x 5.6° which should suffice.

9. P5/4 remove the reference to HSRL unless it is important in the manuscript

Response: Done. It was there because HSRL information was used in an early version of the manuscript.

10. P5/23 why was a skewed Gaussian line profile chosen for the fits? Were any other parameterizations investigated? Slit functions are not always Gaussian-like, so some comment on why it is applicable to ACAM would be useful.

Response: Other parameterizations were investigated (e.g., Gaussian, triangular, and Cauchy). But the skewed Gaussian was deemed best based on goodness of fit results. Non-Gaussian functions were required due to the asymmetry in the measured slit functions across the entire spectral range.

11. P5/25 a 3rd order polynomial was selected for the dispersion fits – why was this chosen. If another order was chosen, how much difference would this make in the results?

Response: This functional form was chosen due to the non-linearity in the measured dispersion seen mostly near the edges of the spectral range. Higher order polynomials were tried with insignificant reduction in the fit residuals while lower order fits would increase the standard deviation of the residuals by a factor of 2.

12. P5/26 I would add "... 0.03nm/0.04FWHM ..." to emphasize the number with respect to actual slit width FWHM

Response: Done.

13. P6/3 "... and fitting trace gas absorptions to retrieve trace gas columns"

Response: Done.

14. P6/8 minimize the differences between spectral simulation and the observed spec-

AMTD
7, C4561–C4567, 2015

trum?

Response: Yes. We changed to “between simulated and observed radiance spectra”

15. P6/29 might want to comment on the effect of the lab cross section measurement slit function – i.e. the resolutions of the various lab cross sections used in the analysis are sufficiently high that the slit functions of the lab measurements can be ignored

Response: Done. We added “ (neglecting the slit functions of the laboratory measurements due to their much higher resolutions) ” before “with instrument slit functions”

16. P7/9 Initial comparison of derived with measured slit functions . . .

Response: Done.

17. P7/23 please clarify the comment about delta lambda =0 as always the slit peak? It is not clear if there is an asymmetric slit representation that the slit function is properly centered on the correct wavelength?

Response: Based on equation 5, when delta lambda = 0, S is 1. The asymmetric slit representation is reflected in different slit widths between left and right sides.

18. 8/13 the residual fits after consideration of Ring and gas absorption are really large at 0.2% and 0.34%. Why? Spectral systems routinely achieve spectral residuals below 0.1% these days.

Response: This is because in the spectral fitting for deriving slit functions, the measured spectrum is fitted against the convolved high-resolution solar reference spectrum. Systematic radiometric differences between high-resolution reference and ACAM measurements can cause relatively large fitting residuals. This is unlike the spectral fitting for trace gas retrievals that typically use a reference spectrum measured by the same instrument. We added that “Note that the large residuals even with absorption and Ring effect is due to systematic radiometric differences between ACAM measurements and the high-resolution reference.”

AMTD

7, C4561–C4567, 2015

19. P8/20 what is the effect of other parameterizations than the 5 parameters chosen?

Response: We also derived the slit functions assuming asymmetric Gaussian and found that the impacts of including absorption and Ring effect on slit widths and wavelength shifts are similar to the use of broadened Gaussian slit functions. So we added at the end of the paragraph: "The impacts of including absorption and Ring effect on slit widths and wavelength shifts are very similar when assuming asymmetric Gaussian slit functions."

20. P10/14 why 6th order? Perhaps a comment on this choice?

Response: This is because a 6th-order polynomial provides better minimization to match the derived average wavelength shifts than using 2nd-5th, and 7th-order polynomials. We changed "we fit a 6th-order polynomial to the average wavelength shifts and add it to the initial wavelength grid to define the new wavelength grid" to "we fit a 6th-order polynomial to the average wavelength shifts because it provides a better minimization than lower or higher order polynomials. We then add it to the initial wavelength grid to define the new wavelength grid."

21. P10/20 50 ground pixels

Response: Done.

22. P12/10 please remove the advertisement for the following paper

Response: Done.

23. General comments: P8 the laboratory cross sections of absorptive gases have wavelength errors – what effect on the analysis do those errors have? A statement recognizing this as a potential problem

Response: Agree. We added a sentence at the end of section 3.1 "A potential problem of including absorption in the wavelength calibration is that wavelength errors in the laboratory cross sections especially for the major absorbers can propagate to affect

AMTD
7, C4561–C4567, 2015

the derived wavelength shifts."

24. P8 the authors have chosen ground pixels for comparison for the obvious reason of increased gas absorption. But why not use the zenith sky observations where the scene is quite uniform so spectrometer illumination is quite uniform and there are still gas absorptions of at least ozone and NO2 at 8.5km a/c altitude. See p9/1-11

Response: This is because ACAM zenith-sky measurements have some instrumental or calibration issues that we could not even use them as reference spectra for retrievals. In our previously submitted version of the manuscript, we have a section to discuss the issues with zenith-sky measurements (relative to nadir-viewing measurements), but it was removed in the current version to focus on the slit function characterization following another reviewer's comments.

25. P10 and p11 the authors discuss the DSCD changes using derived and measured slit functions. What effect is there on the spectral residuals which seem quite large from the ACAM instrument?

Response: Unlike the fitting residuals using high-resolution solar reference spectrum to derive slit functions, the retrieval residuals in Figure 6 are small (typically $\sim$0.12% for O3 and CH2O, and $\sim$0.10% for NO2). The effects of using different slit functions on spectral residuals are small, similar to the effects on fitting precisions shown in the figure legends.

In the revision, we added "Due to the use of reference spectra measured by the same instrument, the fitting residuals are much smaller than those in Figure 1, $\sim$0.12% for O3 and CH2O and $\sim$0.1% for NO2" after "Figure 6 compares . . ..". We changed "comparable fitting precisions" to "comparable fitting precisions/residuals" and "clear improvement in CH2O fitting precision" to "clear improvement in CH2O fitting." In the figure 6 legends, instead of showing mean precisions and their standard deviations, we showed mean precisions together with mean fitting residuals.

AMTD
7, C4561–C4567, 2015

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