AIRS Module 12 Average SRF Fits For Data PHS386

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1 Overview

This document is really just an informal memo to George Aumann - it won't make much sense to anybody else.

Here are some observations on retrieving the AIRS SRF from an average of the M12 Bruker SRF "PHS386" data. The average SRF used in the fits is a simple average over the "good" channels without any attempt to shift or stretch the individual channel measurements. For M12, this makes very little difference to the average SRF (the main effect of stretching the SRFs to match the widths is to partially wash out the more distant fringes in the wings). The wavenumber scale is somewhat arbitrary; we treat the average SRF as a channel at exactly 650 cm-1.

We are explicitely modeling the Bruker spectral response function by integrating over the Bruker solid angle (including any offset due to mis-alignment). The resulting Bruker SRF is then convolved with the trial parameterized AIRS SRF function George came up with (sum of a pseudo- Lorentz and Gaussian functions with the same half widths, and a total of 3 adjustable parameters). The least-squares fit can simultaneously vary the 3 AIRS SRF parameters, and any Bruker mis-alignment angle.

2 Figure 1

Figure 1 shows the results of our attempt to retrieve the AIRS SRF. The fit returned a Bruker off-axis angle of $\approx$0.5 degrees. This is around 5 times larger than Lockheed-Martin's estimate of the the maximum off-axis angle.

In the top plot, the Bruker response and retrieved AIRS SRF have been shifted (0.104 and 0.029 cm-1 respectively) to force the maxima to line up with the measured SRF. This was done for sake of presentation, since they are in fact shifted because of the Bruker off-axis angle and FOV. The middle plot is a blowup of the bottom few percent of the convolved fit (AIRS and Bruker) SRF and data. The bottom plot shows the difference between the data and the computed convolution of the best-fit AIRS SRF with the Bruker SRF.

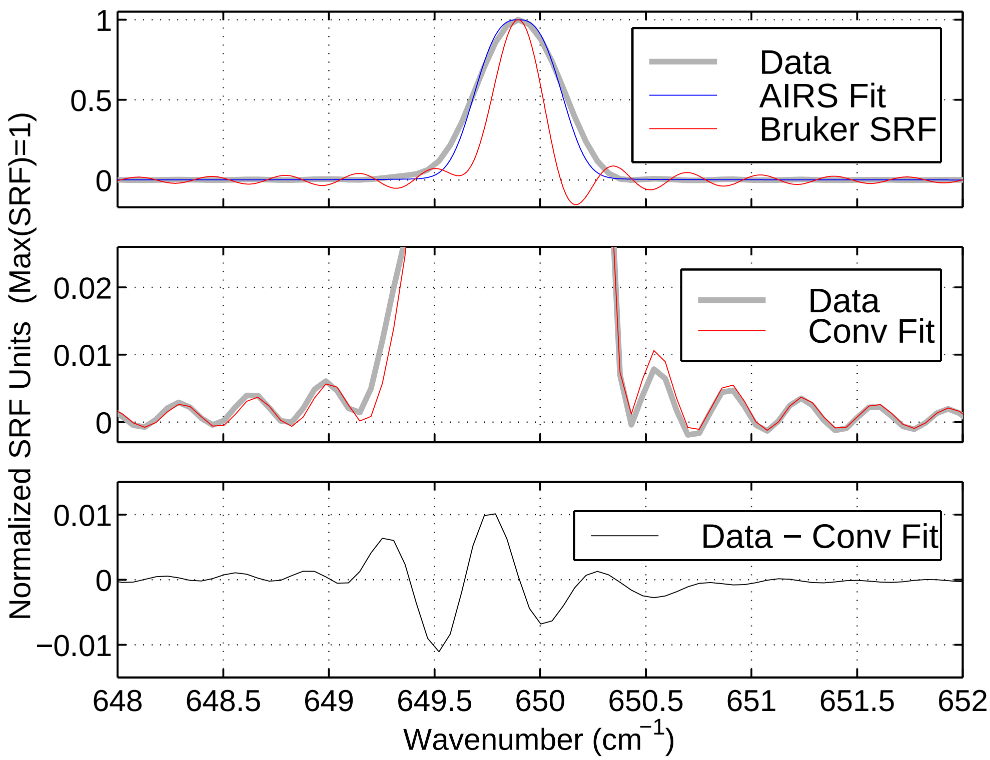

Figure 1: Average SRF Fit that converged to a 0.5 degree Bruker off-axis angle.

3 Figure 2

Figure 2 is similar to Figure 1, except the fit has been done with the Bruker off-axis angle fixed at zero degrees. In the top plot, the AIRS SRF has been shifted by 0.104 cm-1 to align with the data and Bruker SRF peaks. Compare the middle and bottom plots to those in Figure 1; the results in Figure 1 are noticeably better. This seems to suggest that there is either a significant off-axis angle of $\approx$0.5 degrees, or, that the AIRS SRF is not perfectly symmetric.

4 Figure 3

Figure 3 shows the effect of uncertainty in the retrieved SRF *width* on a simulated AIRS radiance. The bottom plot shows the difference in observed radiances for two different SRFs; (1) George's SRF derived from a direct fit to the Bruker data (basically just ignoring any broadening effects by the Bruker) and (2) the same SRF as in (1) except its width was scaled down to account for the broadening of the AIRS SRF by the Bruker. This plot just illustrates what was already known, namely that the Bruker at 3 cm OPD broadens the AIRS SRF enough that it must be accounted for.

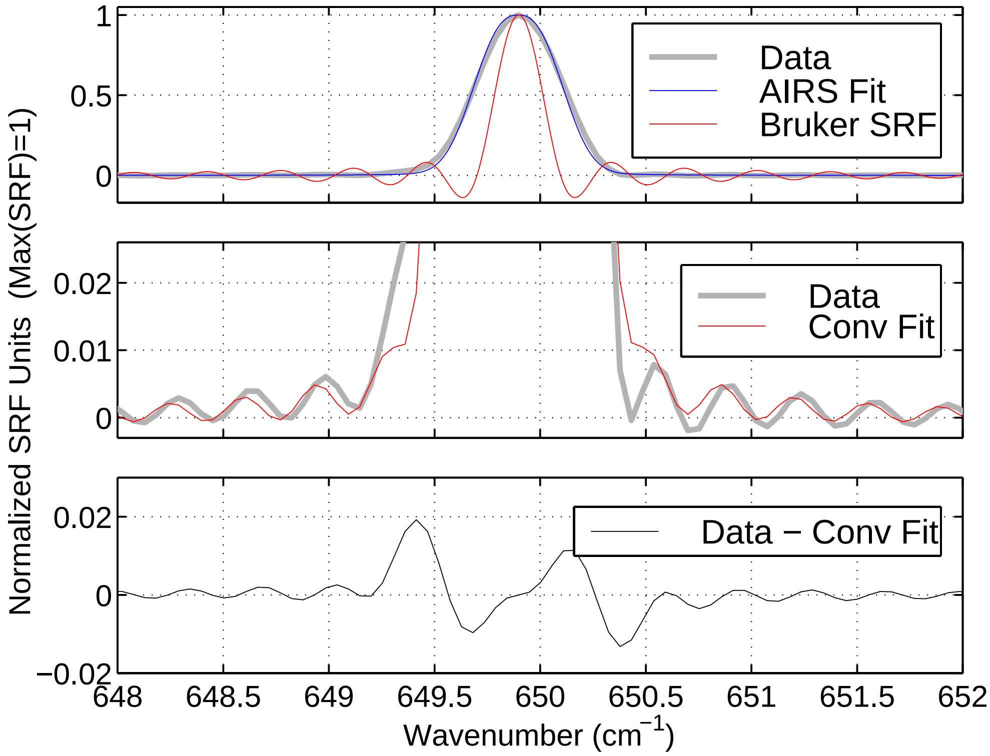

Figure 2: Average SRF Fit with the Bruker off-axis angle set to zero.

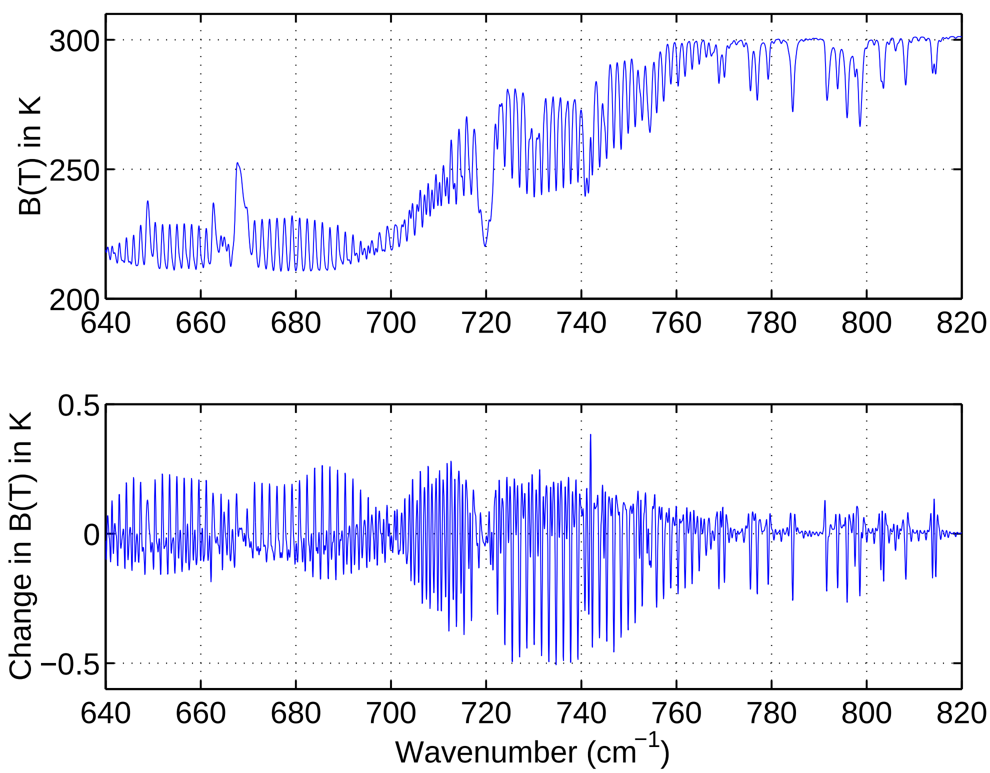

Figure 3: Effect of ignoring broadening by the Bruker in the AIRS SRF measurements.

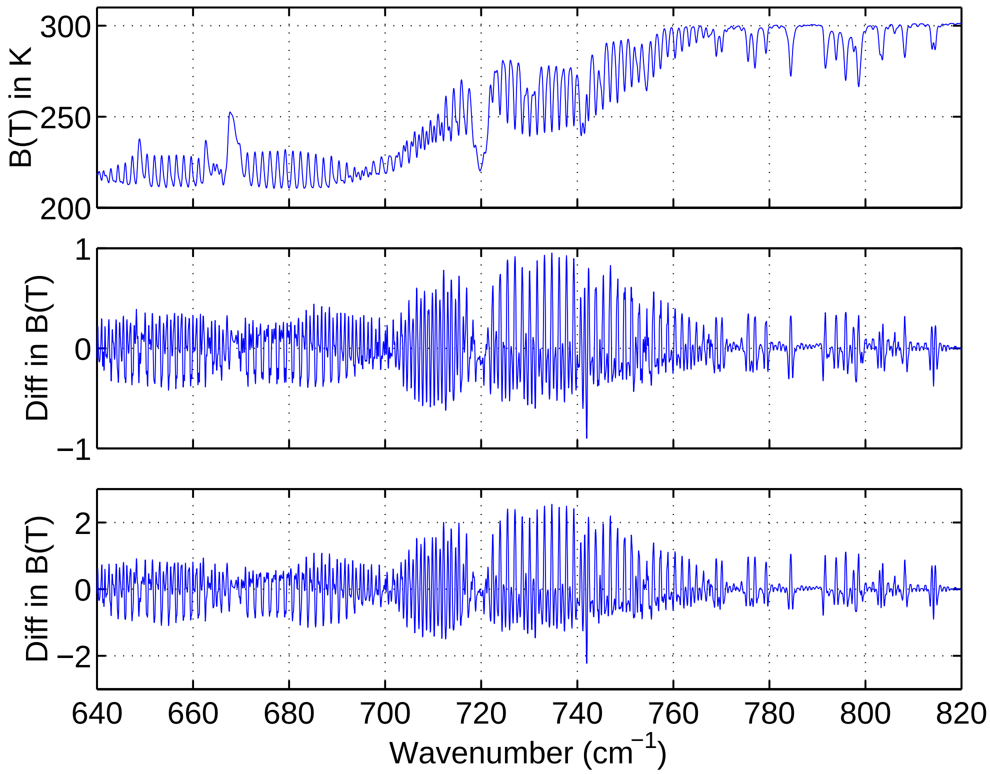

Figure 4: Sensitivity of radiances to various SRF fitting methods. See text for details.

5 Figure 4

Figure 4 shows the effect of uncertainty in the retrieved SRF's *shape and width* on a simulated AIRS radiance.

The middle plot shows differences in radiances computed using; (1) a SRF fit directly to the Bruker data (George's SRF) subsequently reduced in width to account for the broadening by the Bruker, compared to using; (2) our (UMBC) fitted SRF which takes the Bruker broadening (sinc function) into account during the fit. George's SRF width was reduced so it had the same width as our fitted SRF. The Bruker off-axis angle was set to zero for the UMBC fit.

The bottom plot shows how two different UMBC fitted SRFs affect radiances. One SRF was the same as in the middle plot, namely with the Bruker off-axis angle set to zero degrees. The other SRF came from a fit where the Bruker off-axis angle was varied, giving a best off-axis angle of 0.5 degrees. These two fits result in slightly different AIRS SRF widths, but identical convolved widths (AIRS convolved with the Bruker SRF).

6 Conclusions

At this point, we cannot really say if the AIRS SRF is slightly asymmetric, or if the Bruker off-axis angle is significantly larger than expected. The results presented here do suggest that further testing (longer OPD for the Bruker?, smaller FOV?) may be needed to adequately characterize the long-wave AIRS arrays. These small, somewhat subtle effects do produce differences in the observed radiances larger than requirements, some are almost *10x* larger than the single-spot noise.

Examination of short-wave SRF data might tell us more about any asymmetry in the AIRS SRF since broadening by the Bruker will be less important for these arrays. However, it is not clear that we should expect similar asymmetries in the AIRS SRF in different arrays. If these asymmetries are due to optics they could vary (smoothly?) across the focal plane?

Simultaneous gas cell, SRF measurements could also tell us more definitive information about any Bruker off-axis mis-alignments. More work is needed to determine exact procedures for these test, especially at 15 μm.

We also need to see if different AIRS SRF parameterizations fit the data the same, but produce significantly different radiances. We might try using a voigt function (convolution of a Gaussian and Lorentz) instead of George's sum of a Lorentz and Gaussian as an example. It may be that the shorter-wave SRF data will help us choose the best parameterization for the AIRS SRF shape if we can show that the SRF shape does not vary significantly over the focal plane.

In addition, 15 μm gas cell data should give us some good information on the AIRS SRF shape, at least down to the 1%? level or so.