# Author's Response to Reviewer #2

AIRS Deconvolution and the
Translation of AIRS to CrIS Radiances
with Applications for the IR Climate Record

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## 1 General Remarks

We thank the reviewers for their thoughtful comments and have tried to incorporate or respond to all suggestions and questions. In the remainder of this section we summarize the main changes we've made. Section 2 consists of reviewer's comments followed by our responses.

The discussion of reference truth for the deconvolution (starting on page 3 line 30 RHS of the original submission) was not clear. We have updated the labels in figures 3 and 4 from "gauss" to "decon ref" to better indicate we are showing the deconvolution reference truth. We updated the associated discussion to emphasize that the deconvolution reference truth is intended as validation of the deconvolution—we don't need it to do the deconvolution or for subsequent reconvolution to CrIS or other targets.

We corrected the relationship of standard deviation and full-width half-max (FWHM), $s = \text{FWHM}/(2\sqrt{2\ln 2})$ in the original submission, to $s = \text{FWHM}/(2\sqrt{2}\,(\ln 2)^{1/(2p)})$. The latter is correct for the generalized Gaussian. The difference is small for the range of values $p$ we used. As noted above this does not effect the accuracy of the translations, just (to a very small degree) reference truth for the deconvolution and the basis functions for our L1d "idealized grating model".

The section on regression translation has been revised and shortened. We dropped the paragraph on adding noise since we don't show those results. The direct and principal component regression matrices are now shown only for the MW, enough for an overview. The regression matrices are are now for apodized radiance, matching the residuals. The interpolation section in the appendix has been revised to show apodized residuals and to emphasize the advantage of using both the source and target response functions.

## 2 Response to Comments

- 1. Page 2 right column, line 26, $||r_0||_2$ should be $||r_0||^2$, there are several other places need to be corrected.

  REPLY: $||r_0||^2$ would typically be the square of the Euclidian distance. That would be harmless in our inequality $||r_0||_2 \leq ||r_j||_2$ but not what we want for condition number $||S_b||_2||S_b^{-1}||_2$ in the next sentence. $||r||_2$ is a common notation for the $L^2$

norm, and for vectors is simply Euclidian distance. The notation used in the paper is taken from the Wikipedia articles for the Moore-Penrose inverse and mathematical norm, and we've added both as citations.

- 2. Page 2, right column, lines 36-39 in the generalized Gaussian equation, please replace $c$ with other symbol.

  REPLY: Agreed, we replaced this with $s$.

- In Fig 3 subplots 2 and 3: why do we see some overshoot and ringing in the deconvolution, especially at the shortwave $CO_2$ absorption lines?

  REPLY: The ringing or overshoot at 2310 $cm^{-1}$ is caused by a change in the L1c channel spacing from 1.02 $cm^{-1}$ to 0.92 $cm^{-1}$ at that point. We added a comment in the paper to that effect. These jumps occur at the AIRS focal plane module boundaries. The first subplot of figure 2 shows channel spacing as a function of frequency, and the jump at 2310 $cm^{-1}$ is one of several such discontinuities.

  Of course then you can ask why should a change in the channel spacing cause ringing or overshoot. We see this at band edges and bigger channel gaps, too—any time the L1c channels are not regularly spaced. This is simply a limitation of the deconvolution. We start with channel radiances and our tabulated SRFs $S_b$ and deconvolve $c$ by solving $S_b r = c$ for $r$. Since $n < m$, the system is underdetermined, and we might get some $r$ that we don't want. We tried some different smoothing constraints and found the Moore-Penrose property of giving $r_0$ such that $||r_0||_2 \leq ||r_j||_2$ for all $r_j$ satisfying $S_b r_j = c$ worked best. There are still some problems but these are reduced significantly by the subsequent reconvolution, and so probably acceptable for our application.

- 4. The AIRS L1c channel spacing and resolving power R is around 1200 in Fig 2 (after deconvolution), why the direct convolution choose a resolving power of 2000 instead of 1200? The generalize Gaussian function could be adjusted to use a resolving power of 1200 to better match the deconvolved radiances.

  REPLY: The direct convolution is reference truth for the deconvolution, and is now labeled "decon ref" in the plots. We choose 2000 because this is an approximate match to the resolving power of the deconvolution. Resolving power of the deconvolution is a property of the deconvolution—we just want to measure it. We compared the deconvolution with reference truth for a range of resolving powers from 1200 to 2400 and chose 2000 because the residuals do not decrease much beyond that point.

  We don't use the Gaussian basis for the AIRS deconvolution or the AIRS to CrIS translation—it is used as a measure to see how well the deconvolution step alone works. The deconvolution reference truth for a resolving power of 1200 is a very close match to the AIRS radiances before deconvolution.

- 5. Page 4 right column, line 46, "The constant or DC bias is..." What is DC?

  REPLY: DC is direct current. We dropped this because we are doing statistics, not signal processing, and now just say "the constant bias".

- 6. Page 4 right column, lines 53-54, "Up to this point there as been no statistical..." please correct this sentence

REPLY: OK, fixed.

- 7. Page 5, regarding the NEdN. I am not clear how do you measure the AIRS-to-CrIS NEdN. If you know AIRS NEdN at 280 K, how do you translate that NEdN to CrIS observation? I dont understand the sentence: "This is done repeatedly and the noise after translation is measured".

  REPLY: We modified the sentence to say "We can give a good estimate of noise equivalent differential radiance (NEdN) for the translation by adding noise with a normal distribution at the AIRS NEdN to blackbody radiance at 280K, translating this to CrIS, and measuring the noise of the translation."

  For a little more detail, the steps are (1) generate blackbody radiance at 280 K, at the AIRS channel set, (2) generate a set of $n$ normally distributed noise vectors at the AIRS NEdN spec and add these to the noise-free 280 K spectra, giving a set of $n$ noisy spectra, (3) translate this set from AIRS to CrIS, and (4) measure the standard deviation of the translation. As a sanity check we also measure the standard deviation before the translation, to verify that it agrees with our AIRS NEdN spec.