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

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This paper describes a method to convert the three modern weather hyper-spectral sounder instruments to a common spectral grid. These instruments have radically different characteristics; however, they have very similar information content. Therefore, this approach may have many operational applications and potentially is the best method to archive these data for future use. I recommend that this paper be accepted for publication. I recommend that the authors consider the changes described below to enhance the readability and applicability of this paper. This reviewer would be happy to waive anonymity, if the editor agrees, to discuss these comments directly with the author – since many of these comments might be easier to resolve verbally.

Note: l/r.h.s. == lef/right hand side

p.1 Line.14 r.h.s.: It would be useful to introduce here, rather than on p.3 and p.6, that the CrIS instrument has two modes of operation, the nominal and full spectral resolution (NSR and FSR, respectively). It should also be mentioned that CrIS was in the NSR from launch in 10/28/2011 through Dec. 2014 or Dec. 2015 (after bit-trim mask upgrade, depending how much detail you want to cover here.

p.1 Line.60 r.h.s.: "The SRFs are not necessarily symmetrical, especially at the high end of the band. The SRFs are not necessarily symmetrical due to fringing in the AIRS entrance filters, especially at the high end of the band" is repetitive and can be combined into one sentence.

p.1 Section 1: It might be best to simply include a table of significant instrument attributes for AIRS, IASI, and CrIS. Things like type (grating or interferometer), spectral sampling, resolution, launch dates, number of channels, and NEDN at selected frequencies.

p.2 Fig.1: It might be worth plotting this on a vertical log scale. The real AIRS SRF's have a long tail that is not adequately demonstrated in a linear vertical scale. The "significant overlap" mentioned on p.1 was by design as a Nyquist sampled spectrum was desired (as is IASI and CrIS) but there is additional significant overlap caused by the long-tail. These details should be briefly mentioned so the reader is not misled into thinking that AIRS can be represented by a simple Gaussian function in the equation that follows later on this page.

p.2 line 25 r.h.s.: on the first uses of the $||r||_2$ it would be helpful to let the reader know this is a Euclidian norm or even more obvious, a root sum square.

p.2 line 37-39 r.h.s.: The "c" in this equation is not the same as the "c" used above (in Sb*rj = c). Suggest that a different symbol be used to avoid confusing the reader.

p.3 line 45-50 r.h.s.: The CrIS NSR mode will ultimately become a historical oddity for S-NPP. It is irrelevant for JPSS-1 to JPSS-4 (ultimately to be known as NOAA-21, 22, 23, 24 if they survive launch) as the NSR will no longer be processed. Thus, the authors need to justify why they would degrade the entire AIRS 2002 to 2016 and S-NPP/NOAA-20+ record from 2016 to 2030's instead of potentially finding an alternative higher resolution grid. For example, consider the loss of spectral information in the AIRS carbon monoxide spectral domain when going from AIRS SRFs to CrIS NSR – the CO band information is completely lost. Similar loss occurs in the 2390 cm-1 R-branch that affects lower tropospheric temperature information.

p.3 Fig.4: I had a tough time understanding exactly what was plotted here and I think the text and caption could be improved. I believe AIRS is the original AIRS radiance. Kcarta is the 0.0025 cm-1 LBL representation, the Gauss and decon are a comparison of the 0.1 cm-1 intermediate resolution where Gauss is derived from direct convolution of k-Carta and decon is derived by the pseudo-inverse process – but I am not sure if I have Gauss/Decon flipped. It would be best if the plot labels and text were identified explicitly.

p.4 line 34 l.h.s.: given that Hamming apodization is reversible there cannot be any loss in spectral resolution. Thus, the appearance of the radiances in unapodized (or deapodized since there is self-apodization effects with CrIS) versus Hamming apodized only has to do with non-local ILS effects (i.e., side-lobes of the SRF) and not resolution. The 15 micron band line spacing is a resonance that is aliased with the CrIS OPD, such that the sinc() function produces a distortion of that band (i.e., the peaks and troughs are exaggerated).

p.4 line.34 l.h.s.: The AIRS SRF is a modified Gaussian that is mostly a local function. It seems odd that the authors would propose convert AIRS to a unapodized SRF since the sinc() function is a lon-local function. That is, all AIRS channels would be necessary to produce a CrIS sinc() function. Alternatively, if one were to convert the AIRS channels to CrIS Hamming channels then each CrIS channel would be reconstructed from a small and local set of AIRS channels. The Hamming apodized radiances could then be converted to unapodized via a transformation as suggested in Barnet, C.D., J.M. Blaisdell and J. Susskind 2000. Practical methods for rapid and accurate computation of interferometric spectra for remote sensing applications. IEEE Trans. Geosci. Remote Sens. v.38 p.169-183.

p.4 line 39-56 l.h.s.: this discussion adds confusion. It looks like the 49 set will be used for training and the 7377 is the independent set. Seems like this could be said most succinctly.

p.4 line 54-59 r.h.s. Could the authors give some explanation as to the physical basis for the statistical correction they are about to discuss. I was completely lost as to why this should be necessary. One concern came to mind and I will share it here. It seems like this “ringing” or “regularity” could be caused by trying to compute a sinc() function from a regularly spaced intermediate Gaussian (that also has side-lobes). The fact that it is diminished by Hamming says it might be an artifact caused by the sinc() side-lobes or band edges. Maybe this is a naïve idea (or at least it might give you a clue how to improve this discussion), but why did you not consider 0.1 cm-1 boxcars for the intermediate spectrum that would have perfect localization?

p.6 line 48-55 l.h.s. and p.8 line 52-55: For most applications the noise spectral correlation is something that needs to be specified. Since you have used linear transformations you have potentially altered the amplitude of the random component of NEDN and potentially added significant correlation (see Barnet 2000 reference for a discussion of this in the application of apodization). Any data assimilation or retrieval application would be strongly impacted by this correlation. Given that one application of this methodology is for climate data records, it is worth discussing if the NEDN can be accurately translated. The AIRS, IASI, and CrIS have similar information content in the signal-to-noise; however, if only the signal (radiance spectra) are transformed and not the noise than this process could, in fact, alter the information content such that AIRS, IASI, and CrIS cannot be combined in a meaningful manner. This thought is tied to the comments given on p.3 line 45-50 r.h.s. above.

p.6 line 47-48 r.h.s.: see comment for p.3 line 45-50 r.h.s. – this seems worthy of a bit more discussion given that this approach has been advertised as a solution for a climate data record.

p.10 line 38-58 l.h.s. (and p.4 line 47-49 r.h.s): this is a trivial point. The conventional interpolation would be the wrong thing to do. For interferometers an exact transformation could be done via cosine transforms (presumably what you are doing for the IASI-to-CrIS transformations). The issue here is what is the best manner to transform a grating instrument with non-ideal SRF's to an interferometer system. Maybe this discussion is leading towards an alternate solution – converting all instruments to an idealized SRF which preserves the signal-to-noise as best as possible. This would be an ideal localized function that is Nyquist sampled and has minimum noise correlation (similar to the discussion on p.7 l.h.s., but with the noise component discussed also). The AIRS is nearly a localized, Nyquist sampled, spectrum whereas the CrIS and IASI unapodized (or more properly deapodized) spectrum is not-ideal and introduces significant spectral distortion. The CrIS and IASI apodized spectra is nearly localized by the Hamming function has significant (1%) side-lobes that diminish somewhat slowly (see Barnet 2000 for discussion).