Interactive comment on “Radiometric consistency assessment of hyperspectral infrared sounders” *by* L. Wang et al.

Anonymous Referee #2

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The paper describes and intercomparison of radiance measurements from four differ- ent hyperspectral instruments based on colocated pixels viewed almost simultaneously and through similar, near-nadir slant paths. Care has been taken to allow for the dif- ferent spectral resolutions and spatial inhomogeneities (although I have some doubts about the details of the methods used).

Similar intercomparison exercises, using similar techniques, have already been per- formed with these instruments, but it is a question of sufficient importance that an independent study is justified to check the reproducibility of the results.

GENERAL QUESTIONS & CONCERNS ——————————————————-

1) The authors note that there have been several very similar intercomparison studies with these instruments yet, apart from a few specific details and qualitative comments, very little attempt is made to put the new results into the context of previous work. What did the other authors conclude, and are these results consistent? I would have expected to see another section of discussion devoted to this.
A: We agree. A section has been added to discuss the results.

2) The authors also claim that a key feature of this work is the improved accuracy arising from applying tighter coincidence criteria. However, I would have liked to have seen some proof of the importance of this by way of plots showing how the biases and/or scatter change as a function of relaxing the criteria. The criteria used seem to have been arbitrarily chosen and may be too tight in terms of reducing the amount of data available for comparison (with the associated loss of representativeness and geographical coverage, particularly for the IASI comparisons).

A: Using CrIS-IASI/B dataset as an example, we performed sensitivity tests to check how the BT difference (CrIS-IASI) at 900 cm^{-1} changes as a function of relaxing the criteria as this reviewer suggested. First, the all the collocated data are filtered by limiting the standard deviation to mean ratio of the VIIRS radiances (M16) less than 0.05% but relaxing other collocation criteria (FOV distance to 13.0 km, time difference to 10 minutes, no angle limitation at all). Figure R1 shows the BT differences varying with FOV distance in the range from 0 to 13.0 km. Figure R2 shows the BT difference varying with time distance in the range from 0 to 150 seconds. Figure R3 shows the BT differences varying with angle distance (abs(cos(zen1))-cos(zen2))) in the range from 0 to 0.002.

Based on the above figures and Figure 5 in the paper, the following conclusions can be drawn. First, the FOV distance and collocation environment uniformity are the major factors that control the scattering pattern of BT differences and sample number. Second, the time differences of all the samples are less than 150 seconds. The 120 second threshold value only filtered out a few points. Third, since we only use the FOVS in two fields of regard (FOR) that have smallest scan angles (±1.67 degree), the CrIS 3X3 FOVs' satellite local zenith angles range from 0.6-3.36 degree and IASI 2x2 FOVs angles range from 1.3-2.7 degree. As a result, all the samples meet the angle difference criteria. We made these points clear in the revised manuscript.

3) Scene Uniformity. It seems that the identification of uniform scenes is based entirely on the variability within the CrIS pixel, without regard for the uniformity within the IASI or AIRS pixel which may only have a 50% overlap. A better approach would have been to extend the VIIRS uniformity test to included the area covered by both pixels or, in the case of IASI, also apply a similar test using the colocated AVHRR radiance cluster analyses. As applied, though, I would expect a number of IASI/AIRS pixels to contain some cloud contamination and therefore have a net cold bias. Could this explain some of the observed CrIS-IASI warm bias in the window regions?

A: We apologized that this part is not clearly described in text. Actually, we use the VIIRS data to check scene uniformity of a circular area centered at CrIS pixels with 14.0 km radii. This area includes both collocated CrIS and IASI or AIRS FOVs and actually is the environment surrounding the collocated measurements. A spatially uniform environment surrounding the collocated measurements is desirable to compensate for minor violations of collocation and coincidental criteria as well as to reduce the uncertainties caused by and navigation errors.

Furthermore, it avoids a potential threat of non-uniform features (e.g., moving clouds) to the collocation. We re-wrote this part to make it clear in the revised manuscript.

4) AIRS data gaps. The approach in simply averaging the AIRS spectra over missing spectral points is questionable and requires some justification. For example, using LBLRTM simulated spectra for a variety of scenes it should be possible to establish the magnitude of the error associated with this assumption. In particular, whether there is any geographical distribution to this error which might contribute to the observed CrIS-AIRS differences.

A: First, the GAP-filling technique involves LBLRTM simulation. So far, the uncertainty of this method has not been well understood and reported in the literature. Second, CrIS-AIRS inter-comparison studies from other groups also use the simple average method at the comparison spectral regions. It is much easier to compare our results with theirs if all follow the similar method. Third, the simply averaging the spectra match method has been carefully studied by choosing the appropriate spectral regions. Their uncertainties are at a controllable level for inter-comparison as shown in Figure 8.

5) Section 2: Overall the summary of instruments and datasets reads like extracts from relevant documentation. There should be some attempt to present the information in a more uniform manner, eg FOV size and shape, equatorial crossing time, specified radiometric and spectral accuracy for each instrument. A sketch of the superimposed instrument FOVs would be useful.

A: We made efforts to make this part consistent for all three instruments. However, most information can be found in the corresponding references related to instruments. Therefore, we don't want to repeat too much information here.

6) 'Nadir': I'm a little unclear about the meaning of 'nadir' in SNO. I would expect it to mean some subset of the instrument observations, presumably restricted by the zenith angle about the vertical. However, on p7167/25 it mentions that during SNOs the satellites view the same area from different altitudes but doesn't explicitly state that the angle is also the same. So what range of angles is included in the definition of nadir? And is this just an ad-hoc definition or if there is some objective basis for setting the range. Table 2 suggests that for intercomparisons, zenith angles also have to match within cos(zen) = 0.01 - comparing sec(zen) seems more logical since this translates more directly to airmass - but how does this 0.01 variation fit within the +/- variation assumed within the definition of 'nadir' observations? On p7169, it mentions that the CrIS swath width is wider than AIRS because the satellite is higher. I assume this comment refers to the geographical width of the swath within the definition of 'nadir' otherwise, of course, the absolute swath width is set by the instrument design rather than being particularly limited by altitude.

A: For CrIS and IASI, their orbits on the ground cross each other at relatively large angles (see Figure 3). In order to reduce the uncertainties due to the orientation of matchup data, only FOVs in FOR 14 and 15 from CrIS and IASI with smallest scan angles (±1.6 degree) are used. The CrIS 3X3 FOVs' satellite local zenith angles range from 0.6-3.36 degree and IASI 2x2 FOVs' angles range from 1.3-2.7 degree. As a result, all the samples meet the angle difference criterion.

For CrIS and AIRS, which are both in afternoon orbits, their ground tracks cross each other at a relatively small angle (almost parallel). Therefore, we use the FOVs in CrIS FOR 14 and 15 to check AIRS matched FOVs through collocation criteria. Therefore, the CrIS 3X3 FOVs' satellite zenith angles range from 0.6-3.36 degree. To meet the angle difference threshold ((abs(cos(zen1))-cos(zen2))) less than 0.01), the collocated AIRS FOVs' satellite zenith angles range from 0.5 to 8.0 degree.

Finally, we agree with the reviewer on CrIS swath width. This is determined by many factors (scan angles, satellite altitude, FOV rotations …). Therefore, this statement is removed in the revised manuscript.

SPECIFIC COMMENTS ————————–

p1765/27, p1766/12: I assume all three instruments are on sun-synchronous platforms otherwise the notion of equator crossing time would make no sense, but this is only specifically mentioned for IASI and CrIS.

A: All three instruments are on sun-synchronous satellites. We added this point for AIRS. It reads: "The AIRS IR spatial resolution is 13.5 km from the nominal altitude of 705.3 km on a sun-synchronous satellite with an ascending node at 1330 local solar time (LST)."

p7167/17: so what is the effective spectral resolution of CrIS data after apodization with the Hamming function?

A: With the Hamming apodization, the spectral resolution is equal to 1.8152/(2*MPD*) = 1.125 cm^{-1}. It reads, "It should be noted that, after the Hamming apodization, the effective spectral resolution increases by a factor of 1.82."

p7169/25: if you're going to say 'well corrected' rather than just 'corrected' I would expect some reference to work which demonstrates that the correction is exceptionally accurate rather than merely part of the L1 processing.
A: We agree. "well" was removed.

p1766/13: 1.30pm and 1.30am - say which is the ascending and descending node.

A: We specified the ascending and descending node. It reads, "CrIS is a step-scan Fourier transform spectrometer onboard Suomi NPP spacecraft at a nominal altitude of 824 km in a Sun-synchronous orbit with local equatorial crossing times of ~1:30 P.M. (ascending) and ~1:30 A.M (descending)."

p7170/29: While Fig 6b shows that CrIS and IASI exhibit the same spectral features, it would indeed be remarkably bad spectral calibration from one instrument or the other if they didn't. So saying 'spectral lines well matched' is perhaps too positive, and un- necessary a statement.

A: We agree. This sentence was removed.

p7171/4: 'to date' - specify the date on which this comment applies.

A: It reads now as "To the date when this manuscript was finalized".

p7173/9: 290K seems remarkably warm for >70degN - add some comment on where/when these data originate.
A: We checked the data, which happened at 04:00-05:30UTC on 2013-08-03 around location [94E, 72N] (the north of Middle Siberia),

Table 1: it would be helpful to say whether these equator crossing times are ascending or descending.
A: Yes. We made this point clear.

Figure 3: Strictly speaking, the IASI and CrIS FOVs are superimposed on the VIIRS image rather than the other way around. 'image at M16 band' would read better as the 'image from the M16 band' and it would also be helpful to note here that this is the 11.8micron window region, and to give the approximate geographical location (which appears to be over northern Canada). And what is the significance of the larger circle in the Figure?
A: It reads now,
"Figure 1 An example of a SNO event of *SNPP* and *MetOp-A* at 18:22:22 UTC on 27 August 2013. The blue circles indicate the IASI FOVs and the red ones denote CrIS FOVs at nadir view, while the big black circle indicates the searchable range for CrIS and IASI immurements. The VIIRS image at M16 band is superimposed as background. It clearly shows the CrIS and IASI orbits cross each other near north Canada region."

Figure 4: what is the significance of the large cross in the figures?
A: The black plus symbols indicate their orbital crossing positions. We described it in figure caption.

Figure 5: a useful addition to this plot would be, instead of having the horizonal red line showing the mean difference, have a line showing the mean difference as a function of the VIIRS STD/AVG threshold, and add further lines/shading showing the SD about this mean. I expect this would back-up the claim that the mean and SD converge for STD/AVG<0.05 but also demonstrate the sensivity to the choice of threshold value.
A: We tried to make the plot that the reviewer suggested. However, the standard deviation is

strongly dependent on the sampling number. Therefore, it really depends on how to bin the data. It turns out that the plot is not good as current one. Thus we still keep the current one.

Figure 6: How many spectra have been averaged here?

A: Seven pairs of CrIS and IASI collocated spectra are averaged here.

Figure 9: For comparison, it would be useful if the lower panels included some & Fig

10 estimate of the expected contribution to the SD due to instrument noise. Also, the caption should explain the significance of the shading.

A: Given sufficient number of collocations, the radiometric noise on each instrument should be canceled out - and therefore should not contribute to the mean difference. Therefore, we don't think that it is helpful to show noise curve here. The colorful shading areas indicate the CrIS SNO spectral distribution.

GRAMMATICAL/TYPOGRAPHICAL ERRORS ——————————–

p7164/18: 'sounde's' should be 'sounder's'
A: Corrected (This is only happened in the PDF file).

p7164/27: 'hypepsectral' should be 'hyperspectral'
A: Corrected (This is only happened in the PDF file).

p7165/4: 'briefs', also line 8 'briefed'. The verb 'brief' does not mean to 'provide a brief summary', which is how it is being used here. I suggest replacing with 'summarises' and 'summarised'.
A: They were changed as suggested.

p1765/9: 'passtime' - 'crossing time' is more conventional, and the term which is actually used in Table 1.
A: It was changed as suggested.

p1765/10: 'channel number' suggests the identification number of a particular channel. I would use 'number of channels'
A: It was changed as suggested.

p7166/9-10: Either 'Hereafter', or 'in the following parts', but not both in the same sentence.
A: It was changed as suggested.

p7166/14: 'Fields of Regards' should be 'Fields of Regard'
A: It was corrected as suggested.

p7167/4: 'mode since 4 December' should be 'mode on 4 December', or better to rephrase as 'CrIS has been operating in FSR mode since 4 December'
A: It was changed as suggested.

p7167/5: 'different altitude' should be 'different altitudes'
A: It was changed as suggested.

p7186/Fig 2 caption: 'ARIS' should be 'AIRS'
A: It was changed as suggested.

p7169/23: 'self-apodizatio' should be 'self-apodization'.

A: Corrected (This is only happened in the PDF file).

p7169/26: 'instrumen's' should be 'instrument's'.

A: Corrected (This is only happened in the PDF file).

p7169/26: 'affects ILS' should be 'affects the ILS'.

A: It was changed as suggested.

p7169/26: ’product’ should be ’products’

A: It was changed as suggested.

p7170/22: rather than ’full resolution mode operated for SNPP’ I think it should read ’SNPP was operated in full resolution mode’.

A: This sentence was re-written.

p7173/6: ’composed by’ should be ’composed of’

A: It was corrected.

p7173/6: ’and and’ repeated

A: It was corrected.

p7173/9: ’less’ should be ’fewer’
A: It was corrected.

p7192/Fig 8 caption: ’byLBLRTM’ should be ’by LBLRTM’.

A: It was corrected.

p7175/1: ’is no’ should be ’are no’

A: It was corrected.

p7175/1: ’implies for’ should be ’applies to’
A: It was corrected.

p7184 Table 3: ’Differences at 25’ should be ’Differences in 25’
A: It was corrected.

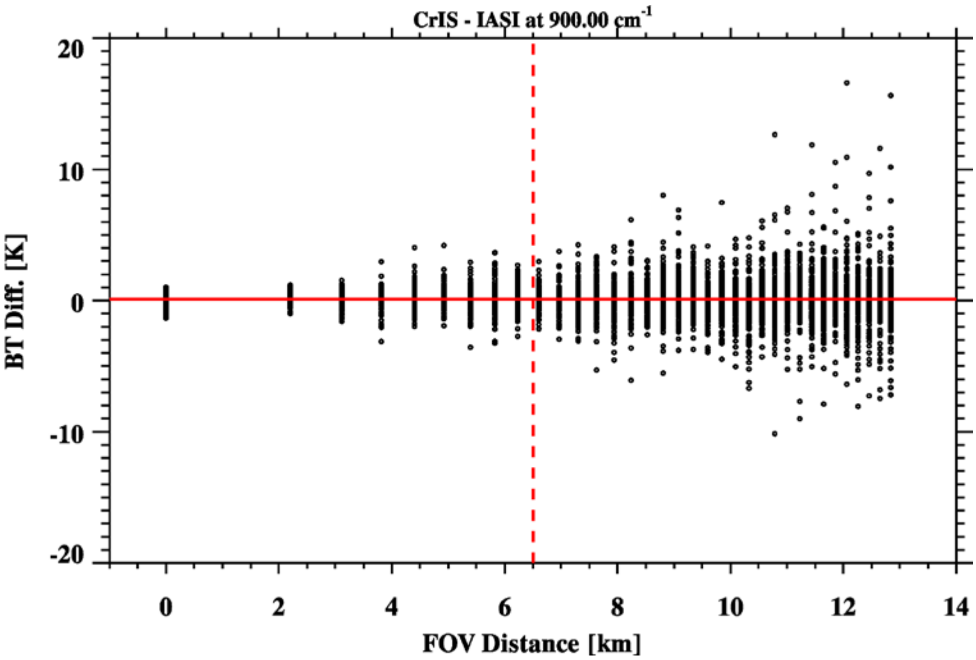

Figure R1 BT differences varying with FOV distance in the range from 0 to 13.0 km.

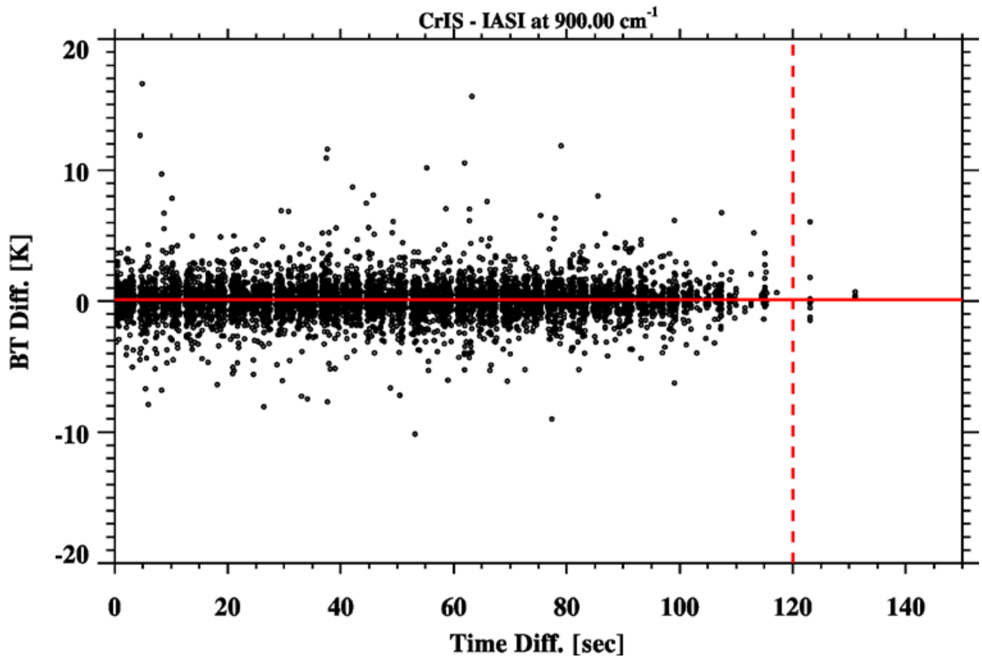

Figure R2 BT differences varying with observational time difference.

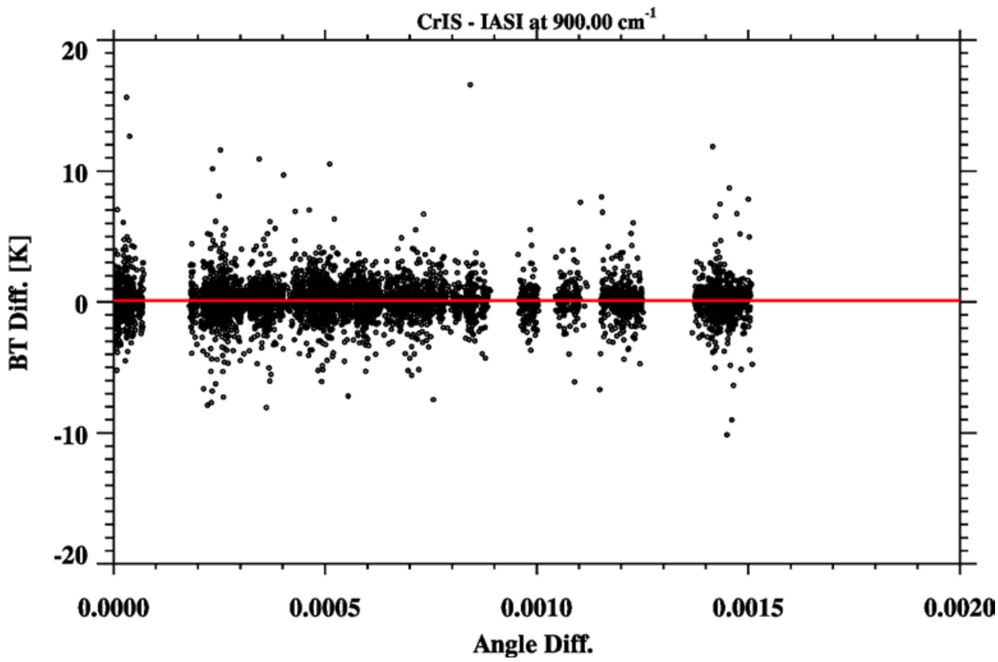

Figure R3 BT differences varying with angle distance (abs(cos(zen1))-cos(zen2))) in the range from 0 to 0.002.