Interactive comment on "Improvement in cloud retrievals from VIIRS through the use of infrared absorption channels constructed from VIIRS-CrIS data fusion" by Yue Li et al.

Anonymous Referee #1
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The present manuscript describes and validates the improvement of cloud retrievals from the VIIRS instrument on board of Suomi-NPP platform using radiances from CrIS hyperspectral instrument on board of the same platform.

The authors, using a fusion methodology, extracted broadband channel information from CrIS spectrally resolved measurements to simulate MODIS channels around 15 micron and 6.7 micron. In this way they can apply methodologies developed for MODIS to VIIRS that don't cover these spectral bands for cloud detection and retrieval. This improvement is been validated with CALIPSO dataset.

The manuscript topic is for sure appropriate for the Journal but in the present form has some incompleteness that should be fixed before publication. Incompleteness can be identified divided into two main topics: Hyperspectal instruments and Validation.

- Regarding hyperspectral instruments as I said, in this work the authors use the spectrally resolved measurements of CrIS to simulate moderate resolution channels. In doing this the authors omitted to describe and acknowledge the great diagnostic power inside the spectral resolution and coverage of instruments like CrIS. For a reader who is not an expert in the field, it might appear that CrIS (and all the hyperspectral instruments) is a less accurate instrument than VIIRS because it has a worse spatial resolution. As an example, consider sentence at lines 15-21 of page 2 and lines 1-5 of page 3. It seems that CrIS has channels at 15 and 6.7 micron, missing in VIIRS instrument, but with degraded spatial resolution. I think that the authors should spend a sentence to indicate the peculiarities of hyperspectral instruments and add a figure showing a typical CrIS measurement in comparison with the spectral coverage of the channels used in the methodology described in the manuscript. Moreover I wish to recall that already 15 years ago it has been shown that with hyperspectral observation alone in the atmospheric window between 800-900 cm^{-1} is possible to detect and classify clouds. The authors can find an example in the following papers doi:10.1364/AO.41.000965 and doi:10.1016/S0022-4073(02)00083-3.

Response: We made changes to better describe CrIS, which is a highly calibrated hyperspectral sounder. As the reviewer notes, the spatial resolution is much larger than that for VIIRS. Our methodology bridges this gap between the two sensors.

For the figure showing a typical CrIS measurement in comparison with channels used in this study, please refer to Fig. 1 in Weisz et al. (2017):

Weisz, E., B. A. Baum, and W. P. Menzel, 2017: Construction of high spatial resolution narrowband infrared radiances from satellite-based imager and sounder data fusion. J. Appl. Remote Sens. 11 (3), 036022, doi: 10.1117/1.JRS.11.036022

We also included discussion of using the sounder for cloud detection and added the two papers in the Reference. New text reads "Previous studies detected the presence of clouds and retrieved cloud top height directly from sounder data (Masiello et al. 2002, 2003; Susskind et al. 2003; Li et al. 2005; Kahn et al. 2007)".

• About the validation, I have some doubts regarding the spatial distance between VIIRS and CALIPSO used for the colocation. While on the one hand I can imagine that a distance of less than 4◦ can reduce the concomitances between the two instruments, on the other a distance of 200 kilometers make the difference in spatial resolution between VIIRS and CrIS practically not appreciable. Probably a sentence that best justifies this choice is necessary. Also in relation to the results of the validation itself.

Response: In addition to the spatial distance constraint, we also adopt other constraints to ensure collocations are appropriate between the two satellites. These include time differences, a sensor zenith threshold, a parallax correction, and minimum counts of collocations. This was also described in Heidinger et al. (2019) where the same collocation technique was used.

In replying to the reviewer's concerns, we ran collocations using a tighter spatial difference of 0.1 degree and presented the results for NOAA-20 below. It can be seen that while the counts decrease, the bias, standard deviation, and mode do not vary much compared to Table 5.

As suggested, we have added discussion as follows: "This approach allows maximum collocations between the two sensors, particularly in the polar regions. Though a large spatial distance is used, nearly all collocations (>99% globally) occur within 0.5° and about 60% of collocations are within 0.1°. We also note that use of tighter temporal and spatial thresholds does not impact the results significantly."

Similar as Table 5, but using collocation with a spatial difference within 0.1 degree.

Emissivity		**Counts**	**Bias (km)**	**Standard Deviation (km)**	**Mode (km)**
0 to 0.4	**No fusion**	**19043**	**-2.27**	**1.98**	**-2.75**
	With fusion		**-1.99**	**1.77**	**-2.25**
0.4 to 0.8	**No fusion**	**5578**	**-1.91**	**1.51**	**-1.75**
	With fusion		**-1.47**	**1.20**	**-1.25**
0.8 to 1.0	**No fusion**	**73874**	**-1.12**	**1.11**	**-1.25**
	With fusion		**-1.04**	**1.07**	**-1.25**

• Page 2. Line 19. As I said before, CrIS has not only channels MODIS-like at 6.7 and 15 microns, but it covers the spectral ranges that MODIS cover with two channels with thousand channels.

Response: We added the following text to the introduction: "In general, a sounding sensor is used for retrieving accurate atmospheric temperature and moisture profiles based on its hyperspectral coverage but at a lower spatial resolution than an imager such as VIIRS. CrIS takes measurements at 1305 wavelengths from 3.92-µm to 15.38-µm. The products from the CrIS sounder show significant enhancement over NOAA's legacy HIRS sensors."

• Page 4. Line 11. Remove absorption before channel.

Response: Done

• Page 4. Line 19. The step (b) of the fusion method is not clear. The convolved sounder radiances are already at coarser spatial resolution. In the text it seems that the authors further degraded spatial resolution. Please clarify.

Response: The convolved sounder radiances are derived for each CrIS field of view (FOV), i.e., at the CrIS native resolution. The basis of our technique is to derive a relationship between the imager 11/12-µm radiances and the average of the imager 11/12-µm pixel radiances within a given CrIS FOV. We do not degrade the CrIS spatial resolution further in this step, but simply average the VIIRS 11/12-µm radiances for all the pixels that lie within each of the CrIS FOVs. This is simply part of the k-d tree search methodology for determining how to best select the CrIS FOVs that should be used for each of the VIIRS

pixels to construct the IR absorption band radiances. For more details, please refer to Weisz et al. (2017).

• Page 6. Line 16. Please insert a reference to the ACHA algorithm. If not, please place here the reference to the ATBD now at Page 7, line 2)

Response: As suggested, we moved the reference to the ATBD to where ACHA first appeared.

For these reasons I suggest to accept this manuscript subject to minor but necessary revisions.