

Responses to Anonymous Referee #2

Received and published: 28 September 2020

The manuscript titled: "1. Improvement in tropospheric moisture retrievals from VIIRS through the use of infrared absorption bands constructed from VIIRS and CrIS data fusion" by E. Borbas et al. reads well, the methodology is sound and the results are clearly explained. I strongly suggest that this manuscript is accepted for publication, pending minor revisions outlined below.

To make the manuscript science question more urgent, I would like to suggest that the authors added more text in the introduction to describe why this data fusion product is important. For example, could the authors say a few more words on the need for such a data fusion product rather than just using water vapor estimates from the CrIS sensor? Can they provide a reference to similar existing products from MODIS in support of the applicability and/or user request of this product? The author could simply add a few sentences on the benefit of TPW estimates at a high spatial resolution (750m) versus the coarser spatial resolution of the CrIS sensor and state why high spatial resolution TPW is important for end- users' applications. Continuity of the MODIS data record is also important, but the authors only mention it in the conclusion remarks. It would be useful to state it upfront, in the introduction section as well. This is a minor addition but would make the paper a lot more relevant in the framework of TPW near real time or long-term applications.

Response: thank you for the suggestions. Given the positive results described in this article and continuing work, we plan to replace the operational VIIRS+NUCAPS moisture products with the fusion derived moisture products to be able to provide continuation of the MODIS MOD07 data record. The benefits associated with the continuation of such a high spatial resolution product include, for example, the observation of high spatial scale weather phenomena (weather forecasting), urban heat islands (Hu and Brunsell, 2015), and in determining atmospheric correction for high spatial resolution remote sensing products, such as the MODIS land surface temperature products (Proud et al, 2010, Hulley et al, 2017; Wen, 2010). This text has been added to the end of the Introduction section.

Page 2, line 2. "estimates" should replace "determination"

Response: The word "determination" was replaced by "retrieval" where it appeared in the manuscript.

Page 3, line 2: a definition of "split-windows" could help non-expert readers.

Response: Text has been added to explain the term "split window".

Page 3, line 2: what is a k-d tree search algorithm?

Response: k-d refers to multidimensional search, which is a standard routine in the computer science world. We included an appropriate reference to the text: J. L. Bentley, "Multidimensional binary search trees used for associative searching," *Commun. ACM* 18(9), 509–517 (1975), <http://dx.doi.org/10.1145/361002.361007>.

Was the data fusion technique applied to clear sky only pixels or all-sky scenes?

Response: The data fusion technique is applied to every pixel regardless of scene type, i.e., all sky.

Page 4, line 10 says: "the scene must be high confidence clear" Is it just the way the validation was done, that is a clear-sky only validation? Same question for the scan angles: "must be less than 50 degrees". Or is it because the data fusion technique only applies to clear-sky, less than 50 degrees pixels?

Response: The comparison between Aqua MODIS and VIIRS fusion radiances was performed only where the cloud detection process for both sensors deemed a pixel to be high confidence clear. This validation, or comparison, approach was also limited to VIIRS scan angles $\leq 50^\circ$, so that fusion radiances were well within the CrIS swath. The text has been updated.

Figure 2 (a) and (b). What do these differences mean? Can the author provide a comparison, on the same figures, with respect to the instrument noise of the VIIRS and MODIS instrument?

Response: RMS values have been found to be within 1.1 K for the water vapor bands and within 0.5 K for the CO₂ bands. Text now indicates this. Text also notes that MODIS radiance comparisons with respect to IASI over six years found that the water vapor bands showed scatter up to 1.0 K in the H₂O bands and 0.5 K in the CO₂ bands (with a reference to Moeller et al., 2014).

Page 8, line 3: This sentence: "A clear sky regression relationship is established between TPW and VIIRS IR window brightness temperatures (BTs) and the NUCAPS TPW soundings calculated from a global training radiosonde-based profile data set." might not be entirely clear. What is the training ensemble, what are the predictors?

Response: the predictors are the VIIRS IR window brightness temperatures and the NUCAPS TPW soundings calculated from the training dataset; they are regressed against TPW. The text has been modified accordingly.

Page 8, line 5. Can the author provide more description on the use of the surface emissivity database, when they state: "A high spatial resolution surface emissivity database (Borbas et al, 2018) is used to help differentiate surface emission and atmospheric moisture absorption."

Response: To help differentiate surface emission and atmospheric moisture absorption and to get better surface characteristics in the forward model calculation, surface emissivity for the VIIRS channels used in the regression method has been assigned for each profile in the training dataset from the University of Wisconsin high spatial resolution surface emissivity database (Borbas et al, 2018). The text has been updated.

Page 16, line 10: "CO₂ absorption IR spectral bands" is this part of the sentence necessary to the extent of moisture retrieval products?

Response: Both water vapor and CO₂ bands are used in the moisture retrievals.

A general comment about Figure 6. The VIIRS+CrIS product improves significantly over the VIIRS only and VIIRS+NUCAPS, in terms of both mean and sdv when compared to the MODIS product. Can the authors explain the impact of this improvement in terms of continuity of the data record. Are there specificities requirements? This remark would strengthen the value of figure 6 and, more importantly, the very final conclusion remark.

Response: The VIIRS+CrIS compares with MODIS TPW within the MODIS product accuracy of determined from CART site comparison (MODIS Atmospheric Products ATBD, 2011), thus VIIRS+CrIS is a viable source for MODIS moisture product record continuation. Text now states this.