Responses to Anonymous Referee #1

General:

The introduction and conclusion should clarify the scope of this paper, i.e. to test a first attempt to aim continuity with MODIS humidity products by attempting retrievals from data fusion. But with further work needed for validation (e.g. longer periods, use of independent reference measurements...) and possibly for the retrieval method itself. It is surprising that IR+MW retrievals (NUCAPS) gives so large dry biases compared to the other products. Because it is the only product exploiting microwave measurements, one would expect good precision here. Can the authors discuss these observations a little bit? In particular drawing from respective validation papers and reports published in the past. Is it envisaged at some stage to perform retrievals from multi-spectral data fusion: VIIRS+CrIS+ATMS? I.e. to try and exploit the maximum information content and enable production in cloudy conditions too. A line or two to comment on this, e.g. in the conclusion/outlook or a brief discussion in what no added-value may be expected would give useful perspective to the reader.

Response: The VIIRS+NUCAPS retrievals refer to a combination of VIIRS-only split window TPW retrievals supplemented by NUCAPS retrievals in cloudy regions. A clear-sky regression relationship is established between total precipitable water vapor (TPW), and VIIRS IR window brightness temperatures (BTs) and NUCAPS water vapor soundings calculated from a global training radiosonde-based profile data set. NUCAPS TPW is added in clear and partly cloudy regions to enhance the TPW depiction and to extend the coverage. It is not the NUCAPS retrieval. We intend to evaluate the utility of the ATMS data in future work.

Specific:

P4.L13-14 /Fig.2: clarify if the "mean clear-sky BTDs" is a bias (=mean) or a standard deviation ("increasing measurement noise" of L17). If mean=bias, then what is the actual dispersion, which is the real noise increase.

Response: RMS values are found to be within 1.1 K for the water vapor bands and within 0.5 K for the CO_2 bands. Text now indicates this.

P5.L8: not the object of this paper, but 15000 training patterns seems rather small in common ML approaches nowadays. Can the authors comment about possible limitations with this approach?

Response: Our goal is to work towards routine atmospheric retrievals of TPW and UTH from VIIRS+CrIS data. However, there is a really big difference in using a ML approach and something like our approach for routine operational use. If a problem develops in the software, one has to find it, evaluate it, and fix it quickly. With an AI or ML approach, this is much more difficult. To

the question, the construction of 15,000 profiles is a major undertaking, and it is sufficient for training purposes. Having said this, it would be interesting to compare our results with those from a ML approach at some point.

P8.L16: "also performs well ... but ..." I suggest avoiding to say that a product performs well on the reason that it compares better to MODIS. In particular here, we should expect that the utilisation of microwave together with hyperspectral infrared sounders offers higher capabilities for accurate TPW characterisation than the MODIS imager on its own. Especially in very moist to cloudy atmospheres. Sampling effects of CrIS/ATMS vs MODIS resolution may however explain small dry bias in moist atmospheres and conversely. It would be instructive to compute spatial averaging of MODIS products at CrIS spatial resolution to see if the dry bias on the moistest atmospheres remains.

Response: Text has been changed to "compare well." We agree that it is a good idea to compute spatially averaged MODIS products at CrIS spatial resolution to see if the dry bias still exists. We will perform such a study in the future.

A comparison to e.g. ground-based TPW sensing (Bedka et al. 2010 or Roman et al. 2016) is advisable to be able to conclude on the final respective skills of the fusion and the single products. It is however an interesting results to match closely MODIS retrievals with the fusion products, which can be highlighted as such.

Response: The immediate goal of this work is to establish the feasibility of extending the MODIS derived TPW and UTH products into the future with VIIRS/CrIS fusion. The validation of MODIS products with respect to ground based measurements is implicit in the VIIRS/CrIS fusion comparisons with MODIS. Initial validation of ABI/CrIS fusion products with ground-based measurements has begun with the newly-published work of Anheuser et al (2020); they compared soundings with radiosondes at the CART site. We intend to undertake a global comparison of VIIRS/CrIS moisture products with ground-based measurements in the future.
A sentence has been added to the Summary and Conclusions section.

P13.L12 - P14.L1-2: the link between the former results (2011...) and the present study and the conclusion asserted is not clear. The argument would deserve some elaboration. VIIRS+CrIS TPW could agree very well with MODIS TPW even in the absence of a 3rd reference dataset. However it would be difficult to infer which one is closer to the truth.

Response: Please see previous answer. Comparison of VIIRS/CrIS fusion with MYD08 within earlier bias and rms with respect to radiosondes suggests the feasibility to continue MODIS TPW and UTH records into the future.

P14.L12 and P16/L16: clarify if MODIS UTH is really MYD07 or indeed MYD08 as per manuscript introduction. If MYD07, some more details of that version vs MYD08 would be useful to the reader to interpret the results.

Response: In the Introduction, we added this text: "The MYD07 is a Level-2 swath product that provides temperature and water vapor profiles at 5-km spatial resolution, while the MYD08 provides water vapor on an 8-day global grid at 1˚ x 1˚ resolution." Both MYD07 and MYD08 are used in this manuscript. In this particular place MYD08 was used. Thank you for pointing out this error.

The conclusion should open to validation against fiducial reference measurements to conclude on the differences between MODIS and the fusion products, or explain in what this is judged not necessary, if so.

Response: Closer comparison of VIIRS/CrIS fusion with MODIS results over VIIRS-only is the goal of this work. Validation against ground measurements is implicit in the MODIS publications cited in the references. Explicit validation is planned and is stated in the text.