Interactive comment on "The Advanced Infra-Red Water Vapour Estimator (AIRWAVE) version 2: algorithm evolution, dataset description and performance improvements" by Castelli *et al.*, 2018

Anonymous Referee

<u>General comments</u>

This paper describes a new version of the AIRWAVE algorithm and the retrieved Total Column Water Vapour (TCWV) product from the Along-Track Scanning Radiometer (ATSR) instruments. TCWV is obtained from the thermal infrared channels at 10.8 and 12 µm, the nadir and oblique views, and over sea surfaces. Validations are carried out based on aggregated products at 0.25 deg resolution and worldwide.

Overall, the reading of this paper leaves me in two minds. On the one hand, the value is principle very high due to the legacy of the very long time series of dataset provided by the ATSR series and the importance of deriving TCWV. The retrieval approach seems interesting too with the decomposition of the inverse model into a linear analytical equation. And the apparent evaluation results given at the end seem encouraging for this product and associated retrieval approach. But on the other hand, the added value and independency of this new manuscript w.r.t the requirements of the AMT journal and work already done and presented in the pre-existing studies, on which this manuscript relies, seem relatively little. I cannot at this stage recommend publication in AMT, and would like first to encourage the authors to address the major comments listed below:

- As emphasized by Referee #1, figures and layout of this manuscript are almost identical to the paper of Papandrea *et al.* (2018). The main difference is the evaluation of the v1 dataset, while here the focus is on v2. Apart of the generation of v2 (and associated new simulations), the present paper does not provide new works and innovations compared to the mentioned previous works.
- In several parts of this manuscript, the writing is a bit too qualitative, and even sometimes a bit ambiguous. Efforts shall be made to add more quantitative elements.
- The reader is sort out invited to check the improvements between AIRWAVE v1 and v2 by himself with the few lines given on Page 9. This is a bit unusual. A direct and explicit inter-comparison shall be provided here, with an explicit estimation of the bias reduction and precision improvements worldwide, per areas, and for different conditions.
- One of the expected improvements is the across-track variability. However, this element is not quantified in terms of uncertainty reduction on the TCWV. Same regarding the latitude dependency. Also please clarify sometimes if you are talking about bias, precision, overall uncertainty, etc…
- To warrant a new publication and invite the use of this new dataset, I think this manuscript should go beyond the previous ones by providing more validation exercises with new additional TCWV dataset instead of repeating similar work: from other satellite instruments: e.g. MODIS (Diedrich *et al.*, 2015), MERIS (*e.g.* Lindstrot *et al.*, 2012), ENVISAT Radiometer, MSG SEVIRI, and / or ground-based sensors (AERONET, GNSS, or other radiosondes), and / or ECMWF reanalysis. The approach proposed by AIRWAVE shall critically be analysed and compared with more "classically achieved" with other thermal infrared sensors to be in line with the ambitious title. Furthermore, what about the different sensitivities to the atmospheric layers of the different spectral ranges (*i.e.* thermal infrared and microwave). Does it allow, prevent, or limit in a certain range the comparison of the associated total columns?
- The evolutions in the AIRWAVE equations in Sect. 2.1., *i.e.* "latitude dependencies and across-track variations", do not explicitly appear. It is quite hard for the reader to be able to make the link between these, the given variables, and their physical meanings. The authors shall better

help the reader to establish these connections. Furthermore, I am a bit surprise that across-track and along-track viewing angles were not already considered in the previous version. And adding this in the update seems quite natural I think. As far as I can see, every atmospheric retrieval approach based on satellite sensors always needs to consider the sensor geometries to characterize accurately the average light path followed by the detected photons. Given how the air mass thickness varies with the geometry, the consideration of the viewing angles does not sound as very innovative to me, but rather quite natural. Other (precipitable) water retrieval from ATSR2, *e.g. Li et al.*, 2003, although over land, Ren *et al.* (2015) or even from SEVIRI (*e.g.* Sobrino *et al.*, 2007) already considered the variations of zenith angle at the surface for both nadir and forward views.

Specific comments

1. Abstract line 4: "performs the TCWV retrieval" => Please rephrase more direct *e.g.* "retrieves TCWV"
2. Abstract line 5: "combining nadir and forward observation geometries": The verb "combine, here and elsewhere in the manuscript, sounds overstated for me. Both geometries are not considered strictly combined in a way it helps to retrieve 1 single TCWV value, But both views are considered individually and independently for deriving TCWV per observation geometry…
3. Abstract line 7: "almost no bias" => Please be more quantitative and less qualitative. What does it mean "no bias"? I do not know any retrieval with an exactly null bias.
4. Abstract line 9: "these problems" => Which ones?
5. Abstract line 14: "significant improvements…" => Again, be quantitative. How much is the improvement overall? RMSE not defined previously. Clarify overall that AIRWAVE is over sea, no land!
6. Introduction line 36: Why AIRWAVE v1 is only available aggregated at the coarse resolution of 2x2 deg, and not for all the individual retrievals?
7. Introduction line 38 "good results" & line 42 "good quality": again, please be more specific and quantify. What the range of bias and precision for which you consider this is a good result?
8. Introduction line 44: "by accounting for latitudinal and angular variations of the retrieval": Not clear, retrieval estimations always vary with respect to geometry and latitude variation of the airmass. You probably mean the dependency of your forward & fitted model?
9. Introduction line 48: "spread" => Do you mean precision? Or uncertainty? Or spread of the differences with respect to another dataset?
10. Section 2 line 58 "average retrieval parameters": Which ones are you talking about here? Please be more specific. At this stage, the read haven't read it the equations in Sect. 2.1…
11. Section 2 line 66: again please clarify. Retrievals always vary with seasons and latitudes (water vapour properties). Do you mean that you explicitly consider the spatial and temporal variability of the some of the input parameters (e.g. H2O & temperature profiles)?
12. Section 2 line 70 "We recall': Was never said earlier in this paper.
13. Section 2.1 line 83 "F includes the atmospheric and surface radiance contribution". What is exactly F? This is not clear. Do you mean this is related to the temperature profile? Sea surface emissivity is already included later in the equation, so what is left? The temperature surface?
14. Section 2.1 line 93 "relative effective absorption cross-section": what do relative and effective mean here? Do you mean the absorption cross-section integrated along the average light path (by opposition to the vertical atmospheric layers)?
15. Section 2.1 line 104 "We verified…": Where is it shown? Please support your claimed verifications with adequate figures to convince the reader. Quantify this linearity (e.g. high correlation coefficient value).
16. Section 2.1 line 110 "average of all the G values obtained with different water vapour content": Please clarify the series of values for H2O content that you used or the list of

atmospheric conditions. Where do appear the zenith angles? They should already be, in theory, in G. J, emissivities, and F no?

17. Section 2.1 line 117 "sort of effective water vapour cross section": Please reformulate more properly. Such a description is rather vague and ambiguous. What do you mean by effective here?

18. Section 2.1 Eq.s 10 et al: Please be more specific by adding clearly all the angles in each equation: each view has a specific viewing angle. Furthermore, do you consider exactly the right zenith angle per pixel sensor? Or do you have a kind of average zenith angle for nadir and forward views? The Nadir view (*cf.* "NAD") cannot have only 1 zenith angle, or I miss something…

19. Section 2.1 line 136 "direct effect on the retrieval precision": And accuracy as well?

20. Section 2.2 line 173 "fixed wind speed": Why is it fixed? Why this value?

21. Section 2.2 line 235 and further: "a good correlation is obtained against both datasets, as highlighted by the correlations and bias values reported in the same figure". Please don't let the reader thinking and looking by himself for these numbers. Report them adequately in the relevant paragraphs.

22. Section 2.2 line 260: How the new algorithm reduces the impact of the sensor noise? This is not explained before. Any evidence?

23. Section 2.3 lines 184-185: I don't fully understand here. What do you interpolate exactly? I guess that now for each individual sensor pixel, you use the adequate zenith angle right?

24. Section 4 and appendix: Section 4 deserves more quantitative results with rigorous evaluation and validation of the AIRWAVE v2 to be in line with the title. More dataset, and more quantitative analyses per scan angle (since this is one of the claimed improvement). Also, how well does this approach achieve w.r.t to more classical approaches considered on thermal infrared sensors (e.g. Landsat, METEOSAT, etc…)? Moreover, I don't understand why Section 5 is here reported as an appendix. Some claims are written in the conclusion section, but were never reported before. I had to find out that some additional works were done in this appendix which is not obvious. Also what about the impact of the sea temperature surface? And H2o profile? Does it play a rule somewhere?

25. Table 1: What are the considered zenith angles considered here for the nadir and forward views?

26. Table 3: Please check and correct the units. Wind speed and temperature profile cannot be in kg/m2.

27. Apart of illustrations, what are the purposes of Figs1-4? I don't see any additional validations with them? Seem they take space with a lot of redundant information. I would advise to group them in 1 single plot with 4 panels. So then you can add more validations that would be kore relevant for this paper.

28. Fig5: What are the differences between "mean" (left panel) and "bias" (right panel)?

29. Figs5-6-7: Please precise the time period associated with all these figures. And the considered areas for Fig.5.

Proposed additional bibliography

Zhao-Liang Li, Li Jia, Zhongbo Su, Zhengming Wan & Renhua Zhang (2003) A new approach for retrieving precipitable water from ATSR2 split-window channel data over land area, International Journal of Remote Sensing, 24:24, 5095-5117, DOI: 10.1080/0143116031000096014

J. A. Sobrino & M. Romaguera (2008) Water-vapour retrieval from Meteosat 8/SEVIRI observations, International Journal of Remote Sensing, 29:3, 741-754, DOI: 10.1080/01431160701311267

Lindstrot, R., Preusker, R., Diedrich, H., Doppler, L., Bennartz, R., and Fischer, J.: 1D-Var retrieval of daytime total columnar water vapour from MERIS measurements, Atmos. Meas. Tech., 5, 631-646, https://doi.org/10.5194/amt-5-631-2012, 2012.