

Interactive comment on “Comparison of total water vapour content in the Arctic derived from GPS, AIRS, MODIS and SCIAMACHY” by Dunya Alraddawi et al.

Anonymous Referee #2

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In this manuscript, authors compare the water vapor product (level 3, monthly means) from several satellite instruments (AIRS, MODIS and SCIAMACHY) against GPS monthly means for over a decade (2004-2014) for three arctic stations (Ny-Alesund, Sodankyla, and Thule). Biases and correlations are analyzed at a monthly and seasonal scale. Cloud impact on satellite TCWV observations is also analyzed by studying the correlations between biases and cloud cover. The topic is interesting because there are no such studies in the Arctic region, which of great interest because of its special features. The writing is clear, although there are several grammatical errors that must be corrected. I think that the article is appropriate for AMT, since it covers one of the main subject areas of the journal's scope. I have, however, some minor reservations

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that should be address before the article is ready for publication.

SUGGESTIONS:

Suggestion 1. I think you should mention the temporal period of study in the abstract.

Suggestion 2. A figure showing time series of cloud cover could be clarifying.

Suggestion 3. Section 2.1 should explain the meaning of " $f(\lambda, h)$ ".

Suggestion 4. Why do you use only cloud cover from AIRS? This way it is only measured at AIRS passes, and this could influence your results. This should at least be discussed in the paper, or changed to use reanalysis cloud cover or cloud cover from the same satellite (AIRS cloud cover with AIRS TCWV; MODIS cloud cover with MODIS TCWV). Notice for instance that SCIAMACHY removes data with $AMF < 0.8$ where most cloud scenes are screened out, so it is quite difficult that SCIAMACHY product is affected by cloud cover (except for sampling effects).

Suggestion 5. Section 3.1: You could compare with other regions of the world to see if the positive bias in MODIS is something typical of cold regions or it also happens in other regions. See for example Iberian Peninsula references [1], [2]

Suggestion 6. In several occasions in the results section, you mention possible problems with albedo, specially at Sodankyla. Could you get albedo information (from the satellite products, or from reanalysis) in order to check whether your hypothesis are valid or not?

Suggestion 7. I think you should provide a "theoretical" explanation of the effect that cloud cover should have on the satellite measurements, based on their respective retrieval method. If, for example, clouds are expect to introduce just noise, then you should repeat your calculations of biases vs cloud cover correlations using absolute biases (mean absolute error for example, or the bias without sign). Then you might find more correlations.

Suggestion 8. It would be good and clarifying to have a time series figure of the cloud cover evolution.

Suggestion 9. Page 10, line 31, you mention a correlation that is positive but not significant. I think that if it is not significant, it should not be mentioned. If it is not significant it could be either positive or negative, we cannot say anything about it, no matter that the estimate is positive.

QUESTIONS:

Question 1. Section 2.1: Is there a reason for you to use $0.75^\circ \times 0.75^\circ$ horizontal resolution? I think Era-Interim products can be downloaded with more resolution (up to $0.125^\circ \times 0.125^\circ$).

Question 2. Section 2.2: Authors say the product is from Terra platform. Why is not any MODIS Aqua data used?

Question 3. Last paragraph of page 6: it should be more deeply explained. I understand that this is number of cloudy measurements divided by the number of measurements, but what is the limit to consider a cloudy measurement? $CF > 0$? $CF > 0.05$?

Question 4. Section 3.3, Page 8, line 36. wet bias in drier periods and dry bias in moister periods was observed for several satellite instruments in [3], and associated to different spatial resolution (GNSS is local while satellite measurements cover an area of several km). Do you think it could be explained by that reason?

Question 5. From your analysis from Section 4, it does not seem to me that clouds are the only reason behind the satellite TCWV biases. Sure there is some influence, but in the majority of cases the correlations are not significant. So there is probably another factor responsible for the biases.

Question 6. Page 10, line 35, you say "inversely linear". Do you mean linear with negative slope?

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TECHNICAL CORRECTIONS:

- A. Page 2, line 29: "satellite data" instead of "satellites data".
- B. I think you should move Page 2, Line 13 to Section 2.
- C. Page 3, Lines 22, 23, use "Zenith", not "Zenithal" (as in Bevis et al. 1992).
- D. Page 5, Line 29, Reference without parenthesis.
- E. Page 5, line 33: "collocation" instead of "colocation".
- F. Page 6, line 9. Specify that 1.30 PM is local time (if it is).
- G. Page 6, line 26. "small" instead of "s mall".
- H. Page 6, line 29. "version² 6" I gues something is wrong there.
- I. Page 7, Line 12. Write the biases with sign (+0.4), to make clearer that the biase is positive.
- J. Page 7, line 25. "bias", not "biases".
- K. Page 7, line 33. "pointed" instead of "point".
- L. Page 7, line 34. "contain" instead of "contained".
- M. Page 11, line 16. Rephrase "is getting better with latitudes".
- L. Check references. For instance, page 12, lines 25-30, the reference has several question marks (?) in the authors names.

REFERENCES:

[1] Vaquero-Martínez, J., Antón, M., Ortiz de Galisteo, J. P., Cachorro, V. E., Costa, M. J., Román, R., & Bennouna, Y. S. (2017). Validation of MODIS integrated water vapor product against reference GPS data at the Iberian Peninsula. International Journal of Applied Earth Observation and Geoinformation, 63(July), 214–221.

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<https://doi.org/10.1016/j.jag.2017.07.008>

[2] Bennouna, Y. S., Torres, B., Cachorro, V. E., Ortiz de Galisteo, J. P., & Toledano, C. (2013). The evaluation of the integrated water vapour annual cycle over the Iberian Peninsula from EOS-MODIS against different ground-based techniques. *Quarterly Journal of the Royal Meteorological Society*, 139(October), 1935–1956. <https://doi.org/10.1002/qj.2080>

[3] Vaquero-Martínez, J., Antón, M., Ortiz de Galisteo, J. P., Cachorro, V. E., Álvarez-Zapatero, P., Román, R., ... Noël, S. (2017). Inter-comparison of integrated water vapor from satellite instruments using reference GPS data at the Iberian Peninsula. *Remote Sensing of Environment*. <https://doi.org/10.1016/j.rse.2017.09.028>

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