

***Interactive comment on* “Experimental total uncertainty of the derived GNSS-integrated water vapour using four co-located techniques in Finland” by Ermanno Fionda et al.**

Anonymous Referee #1

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General Comments

The manuscript presents a multisensor comparison of the Integrated Water Vapour (IWV) in the atmosphere using GPS, radiosondes, and two ground-based microwave radiometers. The focus is on the GPS, but also calibration of the microwave radiometers and the so called dry bias effect for the radiosondes are mentioned. The work does not (to my knowledge) present any new knowledge in terms of significantly different conclusions compared to previously published comparisons using these types of sensors. I characterise the manuscript as being the basis for a "confirmation paper". The data are unique and - as the authors also state in the manuscript - "it is useful

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to periodically repeat comparison campaigns between datasets". Having said that I think that the manuscript is well structured and focused on the important issues. My only concern in terms of length of the text is the conclusions. There is no need to repeat many of the results, especially since it is a short paper. My suggestion is to keep the text on page 9 and delete the text on page 10 (some rewring on page 9 will be necessary because of this). You may want to modify the text on page 9 in order to specifically mention that the real differences between the two sites dominate the observed differences (as least during the wetter part of the year), depending how you handle the suggestions below.

I think there is a potential for improvement of the manuscript and some suggestions are given below. Specifically I think the true variability in the IWV between the GPS site and the site of the other sensors could be taken further, although I cannot predict how interesting the result(s) will be.

Specific comments

The abstract is unnecessarily long and includes introductory information. I think you can ignore to mention the name of the experiment as well as how the GPS data were processed. Such information is already, as it should be, in Section 2.

The 20 km distance between the GPS and the other instruments is in several aspects a disadvantage but it does allow to try to separate the true RMS difference between the sites and the instrumental errors. Together these two effects cause the observed differences and it would be more clear if you would refer to the total RMS differences between GPS and the other sensors rather than RMS Error (RMSE). Part of the observed differences between GPS and the other sensors are signals, not errors. Following the same thought I recommend not to use the term representativeness error but rather true differences, or something similar.

You state that the GPS and MWR data were averaged for 15 minutes around the RAOB launch time. It would make more sense to make the average for a period starting at

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the lunch time because that is the time when the RAOB sampling starts and it needs many minutes to rise through the layers with the main part of the water vapour.

I miss information about bandwidths, system noise temperatures, and integration times for the different radiometer channels? Since the radiometers are main instruments in the comparisons I think such information shall be in the paper rather than just a reference to an older paper.

I am confused by the description of the retrieval uncertainty for the MWR. First you say that it is expected to be 0.5 kg/m^2 and with the addition of the high frequency channel it can be reduced to 0.4 kg/m^2 (page 5, lines 8-9). Thereafter, (same page line 20) you say that the best retrieval algorithm resulted in an SD of 0.72 kg/m^2 . I must have missed a crucial point, please explain.

You mention the dry bias correction when describing the RAOB data, but it is unclear if you applied any correction, and if so which one?

You present a short data segment from March 26, 2014, in Figure 2. Why did you select this specific period? Is it a typical period, or perhaps a period that is very stable (with low variability)?

You say that the different height of the GPS site was accounted for (page 7), but you do not explain how?

Technical Corrections

page 1, line 13: In this work, we examine → We examine

page 1, line 26 (and many other places): there shall be a space between the value and the unit (also the % unit) according to SI rules.

page 3: you may want to mention that the 89 GHz frequency is not only more sensitive to water vapour, but also to liquid water (clouds) which is a potential problem. This text could perhaps make more sense in Subsection 2.1 where the MWR is described.

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page 3, end of introduction: it is common practise to refer to the section numbers when the structure of the papers is presented. It is helpful for the reader.

page 3: A better title for Subsection 2.1 could be "Microwave radiometers and radiosondes" ? It will match the title of Subsection 2.2.

page 4, line 30: the lunch times seem strange? I expect 6 h between the launches?

page 5, line 17: in zenith delay → in the zenith delay

page 7, line 29: low differences → low mean differences ? smallest differences → smallest mean differences ?

page 8, line 7: Differences → Mean differences

page 8, line 10: representativeness errors due to → the true differences caused by

page 9, line 22: one RAOB → RAOBs ?

Figure 1: I suggest to remove the text from the picture frame and describe which instruments (from left to right) that are seen in the figure caption. You may also want to mention the third instrument, the one to the right?

Figure 3: It is very difficult to see more than one of the time series. An alternative would be to show only one time series for the IWV and present the others as differences from this one in individual subgraphs below.

Figure 4: I would prefer to have the important quantitative information either in the figure caption or in a separate table, if you regard it as important.

Figure 7: Some of the red squares are hard to see. Plot them with larger symbols and perhaps a more light red colour. And since they are few, plot them on top of the black circles.

Figure 8: Mean and standard deviation of the measurement of each instrument → RMS differences for each instrument pair vs the mean IWV.

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— End of Comments

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