

## ***Interactive comment on “Observations of precipitable water vapour over complex topography of Ethiopia from ground-based GPS, FTIR, radiosonde and ERA-Interim reanalysis” by G. Mengistu Tsidu et al.***

### **Anonymous Referee #2**

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Compared to its first version the article “Observations of precipitable water vapour over complex topography of Ethiopia from ground-based GPS, FTIR, radiosonde and ERA-Interim reanalysis” has improved considerable but still does not show the quality needed for publication. My main criticism is that the manuscript

1. still fails to motivate that one of the most interesting aspects of the GPS network in Ethiopia: it allows to analyse the quality of the most important global reanalysis, i.e. ERA-Interim. The paper still treats ERA as it is just another observation.

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2. fails to present its results in a clear way. For example in Section 3.2 the presentation of Bias, RMSE, standard deviation, correlation between the different data sets would be easiest in a Table – and not all values need to be repeated in the text!

3. misses to show the full potential of the GPS network, e.g. it should show the diurnal cycle. Even if ERA-Interim has only 4 data points such a comparison would also be interesting.

4. does not provide enough arguments to make the case that the ECMWF model convection scheme does not work sufficiently over orography.

5. suffers from poor use of scientifically precise language and contains several lengthy discussions that are distracting the reader. It needs to be reduced to the significant results.

SPECIFIC POINTS Abstract: - Acronyms not spelled out in abstract – likewise AMMA in p, 9874

p. 9871, l15 “Some studies have suggested that a substantial increase in water vapour content in the tropics could give a larger impact than a doubling of the carbon dioxide concentration (Buehler et al., 2006; Nilsson and Elgered, 2008).” These studies did not investigate doubling of CO<sub>2</sub>. If you want to say that water vapor is important just cite Stevens, B., & Bony, S. (2013). Water in the atmosphere. Physics Today, 66(6), 29-34. and keep it short. There are some statements that are not 100% correct in this paragraph but I can’t go through every sentence...

p. 9872, l3 “Atmospheric water vapour exhibits substantial diurnal variations..” What does substantial mean? To my knowledge it is not more than 2 mm (the most under continental summer conditions) and thus not much more than the uncertainty of GPS – please give a value in the text. In fact I am missing plots of the diurnal cycle at the seven stations which would be a real interesting information.

In general the introduction contains many lengthy explanations but does not make the

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point why reanalysis is important and it is therefore equally important to evaluate its quality. One example for an unnecessary statement is "In recent decades, the use of GPS has been extended to investigation of the upper and lower atmosphere." You could certainly reduce the whole introduction by a factor of 2.

P. 9874 Statements like "...they are steps in the right direction" should be omitted

p. 9875 and following: The discussion of measurement uncertainty needs to be improved and I again recommend to integrate the subsections in 3.1 into section 2 as it is more logical to present the measurement uncertainty together with the measurement description. This would also avoid unnecessary doubling of information.

p. 9875 "...carried out at Addis Ababa synoptic meteorological station for long time despite gaps.." long time is unspecific – give at least a percentage for the data availability. Suggestion is to put it into a table and refer to it.

P. 9875, l11: The motivation for use of ERA-Interim does not fit here – motivation is for the introduction..

p. 9875: It is not interesting that you get pressure data via automailer but how is it derived? Why not use ERA-Interim – how does it compare and how is it interpolated to real surface height?

p. 9876 "several biases" sounds weird – these are different sources for error

P. 9876, l20: This is not only tropospheric zenith delay! Though the stratospheric portion is probably negligible you should not reduce it to tropospheric.

p. 9877, l 12: As you say the coefficients a and b vary with temperature and humidity (only roughly and indirectly with latitude and season) – why do you then give values that you don't use – this is irritating.

p. 9878, l22. It is a bit strange that you always use different data sets for the different data sets ..Why not the same source as for the FTIR or the Tm calculation

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p. 9879 What type of humidity sensor has been used on the radiosonde? As you mention Vaisala it is most likely a capacitive one measuring relative humidity which must have been converted to dewpoint..

p. 9880, l. 5 rho at which altitude (level)?

p. 9880. Here you explain how FTIR works this should come first when you introduce it in 2.1 It is needed to understand the microwindows (mentioned at least twice). Why is the table on microwindows for the FTIR needed anyway? Therefore you need to merge 2.1 and 3.1.1 in order to avoid redundancy!

p. 9880, l16: "...strongly depend" you need to give a number if you make such a statement

p. 981, l5: Better "The retrieval algorithm allows to characterize the diff..."

P. 9882, l5: refer to table and figures for gaps of water vapour VMR can also be characterized by assessing the dif..

p. 9883, l2 PWV is just the integral of water vapor density – thus it does not formally depend on temperature ....only because you or others do conversions – but you can easily show that the rel. humidity measurement is the dominant error source. The whole idea of 3.1.3 is unclear: what is the main conclusion? Why not merge it with 2.3?

p.9883, l23. Radiosondes are assimilated – you can not judge the quality with them! As before for the soundings: I do not see any sense in having this section – what is your message? Most of it can be deleted. Why is it under Results and discussion?

p. 9883, l. 23; it is only Berrisford et al., 2009 – Paul is the first name..

p. 9884, l. 24 "it has been known from several previous studies that PWV from radiosonde is generally dry biased at the upper ends of PWV .." That needs a reference and should have been discussed in section 2 already.

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p. 9885; l. 5 “0,75 deg is not high resolution – Note, that it is not the grid point that counts! The model value represents the complete model grid cell – smoothed over the complete orography.

p. 9885 “While this deficiency (spelling!) is generally common to all high latitude regions, the major problem which is more specific to the region is lack of observations that would have been assimilated into the model for a better results” Do you mean high altitude instead of latitude? Is the statement really correct? What about Tibet or Chile?

p. 9886, l17; The correlations in PWVs from the three observations and reanalysis model at Addis Ababa imply strong correlation despite wide range of variation in PWV in the area. and the time series provide uncertainties of radiosondes from literature (see above), “ Well compared to the literature I think it is rather poor – compare to literature. Later you mention similar studies but do not give references. The end of the section should be significantly shortened

p. 9887, Section 3.3: The first part is rather lengthy and not well structured. The possible error introduced by the missing pressure measurements is interesting but never a clear number is given! In terms of data gaps it would be much easier to adjust Table 3 as suggested and then only to refer to it.

p. 9888, l.15. There are many thinks that might cause a dry/wet bias in the model from parameters in the land surface model via the turbulence to convection parameterization. Here and in the following you make to strong statements about the quality of ERA-Interim

p. 9889, l10: Is therefore a truth sounds too strong...

p. 9889, l10. I have never heard that close to lakes such an increase in IWV exists...I made a rough calculation of evaporation and would only guess a very small effect in the column – also taking t circulation effects into account should reduce this even more – do you have some more insights?

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p. 9889, l123: Figure descriptions, like “the station labels on the horizontal axis.” have nothing to do in the text. The text should only contain the results. Figures are just referred to for support. One should be able to understand the text without looking at the figures and vice versa.

p. 9890 You say that convection is the main source of moisture? What about the land module?

p. 9890, l.24: What is a silent feature? mention drift. - are there soundings at midnight to investigate dry bias - the GPS PWV quality is interesting but why are highly uncertain values not eliminated or

Section 3.4 and Conclusions The influence of the topography – and land surface type - is discussed in the text but not clearly documented. Can you exclude errors due to local installation? The statements about the convection scheme are rather strong – is this supported by PWV differences between ERA and GPS diurnal cycle?

Table 3: For the observations you should add the data availability in percent. That would also allow you to give a precise figure caption – the current one is not acceptable.

Figure 2. Could you indicate data gaps by just introducing a vertical bar and maybe the years? Or just show a PDF? As it is now I do not see an advantage showing a time series compared to a PDF. I do not understand the last sentence “Moreover, measurements on a given day are at close interval of few minutes to half an hour.” Why do you need it here?

Figures 5 to 6 – why don't you combine them in one figure? The standard deviation would certainly better characterize the agreement than the correlation coefficient.

Figure 9 and 10 (left) Start x axis at 0.7 – otherwise you do not see the interesting features.

SCIENTIFIC LANGUAGE Exemplarily I use the abstract to illustrate that the authors need to go through each sentence and check whether it is formulated in a scientifically

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sound way;

p. 4. “..but also because of its role in amplifying other feed-backs in general circulation models.” Feedbacks occur in reality and the motivation is to make climate models reproduce them,

p. 5 “In recent decades, monitoring of water vapour on regular and continuous basis is becoming possible as a result of increase in the number of deployed Global Positioning Satellite (GPS) ground-based receivers at a faster pace.” First there are also other monitoring techniques, e.g. MERIS see Lindstrot et al., 2014 and second the phrasing “at a faster pace” sounds like a commercial advertisement.

p. 13 “The PWVs from the three instruments and reanalysis show good correlation in the range from 0.83 to 0.92. “ Is this really good? I have seen several studies there its 0.95+

p.- 14 “The radiosonde PWV shows dry bias with respect to other observations and reanalysis. ERA-Interim PWV shows wet bias with respect to all while GPS PWV exhibits wet bias with respect to FTIR.” That is confusing why don’t you say

On average FTIR shows the highest PWV followed by GPS and radiosonde observations. ERA-Interim shows the highest value x mm higher than FTIR .

p. 18 “Despite the sensitivity of GPS PWV to uncertainty in surface pressure in general, observed surface pressure is used only at four GPS stations” I don’t think this has been such a conscious decision – I would reformulate and include an estimate about the uncertainty:

Only four out of seven GPS stations included simultaneous pressure observations. Neglecting pressure information in the PWV retrieval can cause errors of up to?of

p. 25 “The main cause of the variation is linked to variation in ECMWF model skill over different regions and seasons which might be related to poor observational constraint from this part of the globe and sensitivity of model convection scheme to orography.”

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A global climatology of total columnar water vapour from SSM/I and MERIS R. Lindstrot, M. Stengel, M. Schröder, J. Fischer, R. Preusker, N. Schneider, T. Steenbergen, and B. R. Bojkov *Earth Syst. Sci. Data*, 6, 221-233, 2014 [www.earth-syst-sci-data.net/6/221/2014/](http://www.earth-syst-sci-data.net/6/221/2014/) doi:10.5194/essd-6-221-2014

Interactive comment on *Atmos. Meas. Tech. Discuss.*, 7, 9869, 2014.

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