

Interactive comment on “Establishment of a regional precipitable water vapor model based on the combination of GNSS and ECMWF data” by Yibin Yao et al.

Anonymous Referee #1

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General comments

1. I prefer the term 'integrated water vapor' (or IWV) to 'precipitable water vapor' although I know that various authors use the latter. In this context the word precipitable seems to be either meaningless or confusing (a reader new to the subject might think there is some split between precipitable and non-precipitable water vapor).

2. What is the purpose of the manuscript: to present an IWV product for Hong Kong? There is no discussion of who the users of such a product would be. End users are much more likely to be interested in clouds or precipitation. There is a complex link between IWV and rainfall, discussed briefly in section 4.2 but I didn't feel that I learnt

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anything new on the subject.

3. Another possible purpose is to persuade ECMWF (and others) to assimilate the GNSS data and hence improve analyses and forecasts (this is the gist of the last paragraph of the Conclusions). The authors cite various papers about the use of GNSS in mesoscale numerical weather prediction (NWP) systems but nothing about the use in larger scale or global NWP. They do not address the problem caused by the integrated nature of the measurement - a total increment has to be split up into a vertical profile of humidity increments and how this is done is important and far from trivial. I know that ECMWF has trialled assimilation of ground-based GNSS data (in the form of time delays) but the results were slightly disappointing and the data are not assimilated operationally for now, or in ERA5 (the replacement for ERA-Interim). Of course there is scope for improving humidity analyses and forecasts and GNSS data may well be part of that (along with improvements to the forecast model, and to the ensemble system indicating the likely structure of forecast humidity errors).

Some useful references on these subjects:

Andersson, E., Hólm, E., Bauer, P., Beljaars, A., Kelly, G. A., McNally, A. P., Simmons, A. J., Thépaut, J. and Tompkins, A. M. (2007), Analysis and forecast impact of the main humidity observing systems. *Q.J.R. Meteorol. Soc.*, 133: 1473-1485. doi:10.1002/qj.112 [There have been various new satellites since then and also humidity sensors on some commercial aircraft.]

Poli P, Moll P, Rabier F, Desroziers G, Chapnik B, Berre L, Healy SB, Andersson E, El Guelai F-Z. 2007. Forecast impact studies of zenith total delay data from European near real-time GPS stations in Météo-France 4DVAR. *J. Geophys. Res.* 112: D06114, doi: 10.1029/2006JD007430.

Bennitt, G. V., A. Jupp, 2012: Operational Assimilation of GPS Zenith Total Delay Observations into the Met Office Numerical Weather Prediction Models. *Mon. Wea. Rev.*, 140, 2706-2719. [Mainly about the regional model. I understand that the Met Office

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global NWP system does use the GPS ZTD data, but the effect on the forecast is small.]

Ingleby N. B., A. C. Lorenc, K. Ngan, F. Rawlins and D. R. Jackson, 2012: Improved variational analyses using a nonlinear humidity control variable, *Quarterly Journal of the Royal Meteorological Society*, 139, 676, (1875-1887) [Discusses problems with vertically integrated humidity measurements.]

4. Due to the problems mentioned in comments 2 and 3 above I recommend this manuscript for rejection (and it isn't really about measurement techniques). Because of this I will only give brief comments on a few more detailed aspects.

Detailed comments

Title: 'Establishment' seems to imply an on-going product but there is no mention of this in the text. 'local' would be more appropriate than 'regional' (and is used at various points in the text).

Abstract:

line 10: "Water vapor is the engine of the weather." Overstatement (temperature gradients are more important, although in the tropics humidity plays a more major role than in the extratropics).

12-14 "Many techniques ... water vapor ...". Putting GNSS as number two in the list is misleading. Satellite soundings (microwave and IR) are most important, followed by radiosondes and then other sources (see Andersson et al, above). "water vapor radiometer" - it isn't clear if this relates to satellite or surface radiometers (surface radiometers are too few in number to make much difference globally and would require substantial work to assimilate the data in the best way).

15 It reads almost as if "ECMWF data" is another humidity measurement rather than a synthesis of many sources of information.

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Introduction:

In several places, notably lines 48-49 and 61-62, there are "shopping lists" of references (with few after 2010). Selecting fewer might be better.

51-53 "ECMWF ... 4 times a day". There is nothing fundamental about 4 times a day, it is simply the archiving frequency chosen for ERA-Interim.

54 "the consistency and homogenous spatial coverage of ECMWF data" The homogenous coverage is a major advantage for some users, but this does not mean that the quality is homogenous (this depends on observation coverage, the synoptic situation etc). Here and in many other places it would be better to refer to "ERA-Interim data" rather than "ECMWF data".

Results:

223 "inconsistent locations" - this is a fact of life dealing with any gridded product.

234 "25 ECMWF grids": "25 ERA-Interim grid points" better (I am not sure if the grid used for archiving is the same as that used by the forecast).

Discussion:

Figures 8 and 9. I didn't feel that I learnt anything from all these plots. Just giving DOY (day of year) puts more work on the reader if they want to relate the plots to the usual calendar.

The bias between ERA-Interim and the Hong Kong radiosonde is of some interest. I would be more interested if the vertical distribution of the bias was shown (ideally for different seasons).

Interactive comment on *Atmos. Meas. Tech. Discuss.*, doi:10.5194/amt-2018-227, 2018.

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