Review of "Establishment of a regional precipitable water vapor model based on the combination of GNSS and ECMWF data", by Yao, Xu, and Hu

General comments

This article outlines a method for combination of ECMWF re-analysis estimates of integrated water vapour (IWV) over Hong Kong with IWVs derived from GNSS zenith total delay (ZTD) data in combination with auxiliary data from meteorological sensors installed at the GNSS sites.

It is not clear what the goal is. Is it to enhance knowledge about historic IWV values over Hong Kong above what is available from the ECMWF re-analysis product? Is it to set up a system capable of producing current IWV maps for usage in operational meteorology? Who are the users, how will the new product help them? There are some unclear points regarding the combination and the verification.

For this reason I recommend rejection of the current manuscript, but encourage the authors to make a revision and re-submit.

Some aspects to consider in a revision

The authors refer only to use of GNSS ZTD in regional NWP. However, GNSS ZTDs are certainly, since many years, assimilated into the NWP global models at Meteo France and the UK Met Office. I'm almost certain the situation is the same at NCEP, Environment Canada and the Japan Meteorological Office. (In the Met Office global NWP the total impact from ground-based GNSS ZTD is modest compared to several other observation systems, but the impact per GNSS ZTD observation is very large compared to most other observation types. This indicates the observations are very usefull for the NWP model, but the number of available observations is at present low compared to the number of other observations. It would be nice if the GNSS ZTDs from Hong Kong were added to the ZTDs shared internationally for NWP assimilation.)

In some equations appear variables not defined in the text.

What is meant by "earth surface"? (line 168 for example). Are you converting from the ECMWF NWP surface to the real altitude at that geographical location, or to mean sea level?

You are combining two different sources of IWV. They have different error characteristics with respect to the true IWV. When combining them the weight given to each of them is important for the end result. What determines the weight given to each of them?

You use the radiosonde (RS) and GNSS site CORS for validation. In doing so you use a specific formula to correct for altitude differences between the IWV model gridpoints and the location of the RS and CORS sites. I expect this formula to perform less well than average for mountainous regions on days with significant orographic forcing. In addition the IWV field might vary over Hong Kong due to the weather pattern, even if Hong Kong was flat. For these reasons I recommend to do a more detailed validation, in order to see if the distance to the RS and CORS has an impact on the score, likewise whether the altitude difference between the RS and CORS versus the model points has an impact.

Many people have looked for relations between IWV and precipitation, for example in the hope of making a nowcasting tool. However, it takes both water vapour and cooling (e.g., caused by buoyancy or orographic forcing) to create precipitation, the amount of cooling necessary in part depending on relative humidity, making purely IWV based approaches in general not sucessfull. This does not rule out exceptions, that for a certain specific region one might be lucky and identify a special pattern in the IWV time variations that often relates to subsequent precipitation. However, that would require looking at a much longer time period than in this study.

Regarding potential users: The user is not likely to be an institution running an NWP model. In NWP one prefers to assimilate data in their original format. In other words assimilate GNSS ZTD directly, not an IWV value found by combining GNSS data with other data. If there is a barometer at the GNSS site, one would assimilate also that pressure observation, not use it to convert GNSS ZTD to something else.

Detailed comment

The driver of the weather is the sun. But don't speak about an engine. Just say water vapour is important because of its direct relation to precipitation, its role as a transport agent of energy, and its role as a green house gas. Three good causes to get more observations of water vapour.