Editor comments on manuscript amt-2018-318-version 6 “On the information content in linear horizontal delay gradients estimated from space geodesy observations” by Gunnar Elgered and co-authors.

Thank you for providing a revised manuscript and answers to my comments. The main points have been well clarified. You also followed my earlier recommendation to remove section 4.3. I think this helps focusing the study on its main goals for which robust answers are now brought. Below are a few final remarks and requirements. Once these corrections are implemented the paper will be ready to go for typesetting and publication.

Comment on the text that you added in Section 3.1: “In order to investigate the impact of different constraints on the estimated gradients in addition to the value of 0.3 mm/sqrt(h) suggested by Bar-Sever et al. (1998), we also processed two days of GPS data for ONSA using the constraint values: 0.6, 0.9, and 1.2 mm/sqrt(h). The resulting gradients were compared to those estimated from the WVR data. The result shows no significant difference in the gradient amplitudes or the correlations. This is consistent with the result presented by Gradinarsky et al. (2000).”

=> How were these two days chosen? What was the meteorological context? In calm weather no significant impact is indeed expected, but in strong convective situations and/or frontal passages a larger RW parameter can make a difference (Nahmani et al., 2019). I think the choice of this parameter is still open to discussion. Don’t you think that a larger value may lead to an overall increase in the gradient variability and improve the consistency between the GPS and WVR results discussed in Section 5.2? This might be suggested along with the sentence P24L24-25 (“We conclude that the constraints and the sampling … but cannot based on these results determine their relative importance.”)

The quality of the ECWMF gradient product used in this study should still be better stated in Section 3.4 and mentioned when interpreting results in Section 4.2.

Section 3.4: suggested rewriting/reorganisation:

“The Technical University of Vienna provides hydrostatic and wet gradients based on ECMWF data for many space geodetic sites globally. The product used here is usually referred to as LHG (linear horizontal gradients) and is described by Böhm and Schuh (2007). It is available during certain time periods from the mid of 2005 and is more continuous from 2006. It is computed from profiles of hydrostatic and wet refractivity with a temporal resolution of 6 h, and a spatial resolution of 0.25 (30 km). The profile closest to the site is used together with one profile to the east and one profile to the north to calculate the refractivity gradient profiles. These are thereafter integrated to give the delay gradients. Because it was observed that on average the gradients computed in this way overestimate the more accurate gradients estimated from slant profiles, they are scaled by empirically derived factors, 0.53 for the hydrostatic gradients and 0.71 for the wet gradients (Böhm and Schuh, 2007). This computation method and rescaling provide gradient estimates of limited accuracy but they still represent valuable and independent source of information which are used here for comparisons with estimated GPS gradients.

There are alternative methods to derive gradients from Numerical Weather Model data using ray tracing methods, see e.g. (Zus et al., 2015) and references therein. More recently the Technical University of Vienna also introduced a new gradient product based on a least-squares adjustment of the ERA-Interim analyses (Landskron and Böhm, 2018).

In this study we used the LHG data from 2006 to 2016, resulting in a time series of 11 years. As an introduction, examples of the ECMWF hydrostatic and wet gradients are illustrated in Figure 8.

Worth noting is that the wet gradients dominate for the temporal resolution of 6 h and vary with the season, whereas the wet and the hydrostatic gradients show similar standard deviations (SD) for the monthly averages."

Section 4.2

P18L18-20: "When comparing the two tables it is clear that there are differences in the mean values of up 0.2 mm. These differences are mainly in the east component whereas there are consistent negative values for the north component. The SD of the GPS gradients are larger than the ECMWF gradients themselves."

=> last sentence: "The SD of the GPS gradients are larger than the ECMWF gradients by a factor of 2."

P18L20-22: "We note that the empirical factors used when calculating the ECMWF gradients (see Section 3.4) may not be correct for these stations. A related possible explanation is that not all variations in the water vapour content are detected due to the poor spatial and temporal resolutions of the ECMWF data. "

Comment on the first sentence: You don't have any clue that the empirical factors are not correct for these stations. And the issue with the empirical factors was actually not discussed in Section 3.4 (you just mentioned the values of the factors). In the proposed reformulation given above the reason for the factors is given and the limited accuracy is mentioned.

Comment on the second sentence: the operational ECMWF model is a global model with rather high resolution for a global model, hence the "poor resolution" comment is not fair… Maybe this model is just not adapted to your application?

=> Suggested rewriting of L20-22: "The differences may be explained by at least two reasons. First, the ECMWF gradient data used here have some intrinsic shortcomings (see Section 3.4). Second, not all variations in the water vapour content observed by the GPS receivers are actually represented in the ECMWF model due to its rather coarse spatial and temporal resolutions (Bock and Parracho, 2019)."

Section 5.2

P24L12-16: the revision suggested in the previous review was not clear. It was suggested to delete "requiring rapid changes" and the last sentence ("This is valid argument…regardless of the value of the constraint"). These parts of text were crossed out in the previous review but maybe this didn't appear in your copy. So the suggested rewriting is:

"(2) The WVR gradients for one 15-minute period do not depend on earlier or later estimates whereas the GPS gradients are estimated using constraints on the variability. A constraint has a similar impact as a low-pass filter (peaks with a short duration will be reduced)."

Additional references:

Bock, O. and Parracho, A. C.: Consistency and representativeness of integrated water vapour from ground-based GPS observations and ERA-Interim reanalysis, Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2019-28, in review, 2019.

Nahmani, S., Bock, O., and Guichard, F.: Sensitivity of GPS tropospheric estimates to mesoscale convective systems in West Africa, Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2018-1242, in review, 2019.