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Interactive comment on "On the information content in linear horizontal delay gradients estimated from space geodesy observations" *by* Gunnar Elgered et al.

Anonymous Referee #1

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The study of the horizontal variability of the atmosphere is currently of great interest. Linear horizontal delay gradients are considered advanced GNSS meteorology products and it has been proved that they are a powerful tool to identify problems with GNSS data tracking. Although not yet assimilated into NWP models, they are fundamental for the reconstruction of the slant delay and, in turn, in the 3D water vapour fields derived by tomographic inversion of GNSS based slants. The analysis of the causes of the time variability on different time scales, from months to minutes, reported in the manuscript adds new insights in the research area of these advanced GNSS meteorology products. In the manuscript, tropospheric gradients estimated from GPS observations are evaluated with respect to independent techniques as WVR and VLBI and independent

data as ECMWF in order to assess their quality. I think it would be interesting in future to repeat the same kind of analysis in other regions. However, I would raise the following issues, which have to be clarified prior to the publication.

1. Mapping functions: GPS and VLBI data are analysed using different mapping functions: VMF1 for GPS and Niell for VLBI. No information about the gradient mapping function is given. I guess that in GPS data processing Bar-Sever et al. (1998) gradient mapping function is used, while in VLBI Chen and Herring (1997) gradient mapping function is applied. Kacmarik et al. (2018) recommend to agree on the gradient mapping function when tropospheric gradients derived from various sources are to be compared, since a systematic effect up to 0.3 mm is observed between Bar-Sever et al. (1998) and Chen and Herring (1997) gradient mapping functions. Having this in mind, I think that information on the gradients mapping function has to be provided in the manuscript and properly discussed.

2. Elevation cut-off: GPS data are processed at 100 and 200 elevation cut-off angle, while no info is provided for VLBI. Kacmarik et al. (2018) obtained better results using 30 elevation cut-off angle and GPS+GLONASS data. I recommend to process at least 1 GPS station with 30 elevation cut-off angle and evaluate the results. Should geodetic data processed with different cut-off angles depending on the application and on the tropospheric parameter of interest (ZTD or gradient)? A comment on this is really appreciated. The manuscript is within the scope of this special issue.

Kačmařík et al (2018), Sensitivity of GNSS tropospheric gradients to processing options, Ann. Geophys. Discuss., https://doi.org/10.5194/angeo-2018-93

Below specific comments.

Introduction Page 2 Line 6. I suggest adding the amount of improvement of multi-GNSS gradients compared to GPS-only gradients.

Cause of horizontal gradient In the manuscript, the mathematical model used to de-

scribe the tropospheric path delay is not reported. This can be added in this section and the title should be changed in 'model and cause of horizontal gradient'.

Instrumentation and data Page 3 Line 11-12. Complete the sentence 'We compare. . ...' adding at the end '. . .with respect to VLBI estimates, WVR and ECMWF data' I suggest adding in the section a table summarizing the characteristics of the instruments used for the evaluation, referring to the specific sub-section for further details.

GPS In this section, and also somewhere else in the manuscript, the term 'site' is used both referring to a local geographical area or referring to a unique geodetic marker. Please review it and use site for a local geographical area, where one or more geodetic markers are available, and station to indicate a unique geodetic marker at a site. Figure 2. You present the sky plot of GPS observation for May 12, 2014. Why did you select this specific day?

Gradients during the CONT14 VLBI campaign Figure 14. Add mean and std of the differences (GPS-VLBI), are these values affected by the different gradient mapping function?

Typos

Pag.2 Line 4: delete ')' after VLBI

Table 2 replace 'igs_1740.atx' with 'igs08_1740.atx', correct?

Pag.22 Line 20: horisontal -> horizontal?

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