

## ***Interactive comment on “Comparison of GPS tropospheric delays derived from two consecutive EPN reprocessing campaigns from the point of view of climate monitoring” by Zofia Baldysz et al.***

### **Anonymous Referee #2**

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#### General comments:

The authors analyzed data obtained from two GPS reprocessing campaigns (2008 and 2015) and investigated the differences in the resulting ZTD in term of seasonal signals and long term changes (linear trends). They found that the ZTD time series obtained by two different reprocessing campaigns have almost same annual and semiannual signals while the ZTD trends given by the old campaign were generally higher than the ones from the new campaign. The paper addresses a very important part of the GPS meteorology. There are many data reprocessing ongoing now a days while however no so many studies have been carried out in order to investigate the resulting accuracy of the ZTD and/or IWV due to differences in the data processing, i.e., updates of the

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reference frame and applied models, different elevation cutoff angle, different mapping functions, and different processing strategies.

The authors conclude that the trend differences are caused by the differences in the data processing strategies applied in two campaigns. However, they have only investigated one factor, the mapping function, further and found out that it has insignificant impact in terms of the resulting ZTD trends. Although they suggested for further works, I still strongly recommend that more works should be carried out (at least using a few sites) for this paper where the authors can introduce the updated models (i.e., application of atmospheric loadings, elevation cutoff angle, and high order of ionospheric correction) one by one in order to figure out which factor has the largest impact on the resulting ZTD trends. By doing so, they can give some primary results and recommendations for future work.

Detailed comments below:

Page 1 line 1: Change "Tropospheric" to "Total" Page 1 line 11: "the trends values were generally higher than the values from the other one". Is this same for both two lengths of the ZTD time series (16 yrs and 18 yrs) Page 2 line 19-25: It is true that the inconsistencies due to the data processing-related changes, i.e., updates of the reference frame and applied models, different elevation cutoff angle, mapping functions, and processing strategies, can be significantly reduced by reprocessing the whole data series homogeneously. However, there are also site-related changes, e.g., antenna changes and/or radome changes, which can cause inconsistencies in the data time series. Have authors considered those types of changes in their study? What would be the impact on their results if such changes exist in their network? Some more discussion regarding this issue is necessary.

Page 3 line 12, 15, and 22: The characters "c", "N", "ki" and "e" should be Italic.

Page 3 line 14: The specific gas constant of the dry constituent ( $R_d$ ) is missing in the first term of Equation (2).

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Page 4 line 2-6: Depending on different applications, the requirement on the accuracy of the estimated ZTD is different. For climate research, it is crucial to have high accurate estimates with minimized biases in order to obtain correct long-term trend. Therefore a higher elevation cutoff angle is recommended in the study carried out by Ning and Elgered (2012) for the data processing in order to minimize the impact of the multipath. A few sentences are good to be added here in order to discuss this issue and address which parameters (mapping function? elevation cutoff angle? or others?) are interested to be investigated, in term of the impact on the resulted ZTD trends, in this study.

Page 5 Table 1: Change “Gamit GPS” to “GPS”.

Page 5 line 6-7: The parameters which are elevation dependent (mapping functions, PCV, and elevation cutoff angle) will have immediate impact on the resulted ZTD. How can the authors be sure that the biggest differences between two reprocessing occurred in mapping functions? Has any investigation regarding this issue been carried out? Can you present any values regarding resulting ZTD differences?

Page 6 line 3: “assumption” for what? Maybe use “decision”.

Page 6 line 11: What is reason to choose two standard deviations as the up limit of the outliers? Why not use one or three standard deviations?

Page 9 line 5: Do you mean that the maximum of ZTD occurred for ALL 52 stations at the same day or you mean that for each station, the maximum of ZTD occurred at the same day for both campaigns, and it is true for all 52 stations?

Page 9 line 7: VIL0 is a Swedish station. Change “Iceland” to “Sweden”.

Page 10 line 1 and 2: Change “vapor” to “vapour” in order to be consistent to others.

Page 10, line 1: For a given ground-based GPS station, the ZTD value actually is more decided by the height of the station and the ground pressure. The sentence “Consequently, high values of the ZTD mean are correlated...” is true only when we

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compare GPS sites having the same height as well as the same ground pressure.

Page 10 line 18: A space is missing between “of” and “the”

Page 10 line 28-32: I am confused by the results from the Mann-Kendall trend test. When looking into Table 2, the ZTD trend for TRO1 from Repro2 is 0.05 mm/decade and the mean ZTD is 2329 mm while the one from Repro1 is 0.02 mm/decade and the mean ZTD is 2354 mm. No matter we compare the ZTD trend in absolute value or in relative value (in percentage to the ZTD mean), the ZTD trend from Repro2 is more significant than the one from Repro1. How come the trend from Repro1 passed the test while the one from Repro2 did not? Can the authors explain on this?

Page 11 line 1-4: In the text, the ZTD trends are 5.5 and 5.8 mm/decade for the stations BZRG and GLSV, respectively. However, in Table 2, the corresponding values are 0.55 and 0.58 mm/decade. Which are the correct values? The same question refers to the station GOPE.

Page 11 line 9: Remove “nature”

Page 12, Figure 5 and also Figure 7: Make the map in black and white. Otherwise, it is difficult to see the green arrows.

Page 13 Figure 6, also for others: Either in the caption of the figure or in the figure itself it is good to point out that the result is given by “Repro 2 ÷ Repro 1”

Page 15 line 14-16. Ning and Elgered (2012) compared the IWV trends obtained from the GPS data to the ones given by the radiosonde data at nearby sites, not the VLBI data.

Page 16 line 1-17: If the choice of mapping functions is not critical for the ZTD trend estimation, the authors could try to do more tests in order to see if the trend differences come from other parameters, e.g. elevation cutoff angle. At least you could try tests for one or two sites where you reprocess the data for the whole time period for one campaign but using exactly same elevation cutoff angle from the other campaign and

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then compare the resulting ZTD trend one more time. – Page 17-18: The authors conclude that the trend differences are caused by the differences in the data processing strategies applied in two campaigns. However, they have only investigated one factor, the mapping function, further and found out that it has insignificant impact in terms of the resulting ZTD trends. Although they suggested for further works, I still strongly recommend that more works should be carried out (at least using a few sites) for this paper where the authors can introduce the updated models (i.e., application of atmospheric loadings, elevation cutoff angle, and high order of ionospheric correction) one by one in order to figure out which factor has the largest impact on the resulting ZTD trends. By doing so, they can give some primary results and recommendations for future work.

Page 22-24: All estimated ZTD trends have corresponding uncertainties which however are never mentioned and discussed in the text. In addition, all trends have almost same value of the uncertainty (0.02 mm/decade) and which is really insignificant compared to the trends. How did the authors get these uncertainties? When calculating the trend uncertainty, have the authors considered the short term variations of the water vapour which are not correctly presented by the model used for the trend estimation (see Nilsson and Elgered, 2008)? Some more texts regarding this issue should be added.

Page 23: Compared to others, there are some sites, i.e. TERS, VIS0, WTZR, ZECK, and ZIMM having larger differences in ZTD mean between Repro1 and Repro 2 where TERS has a difference of 242 mm. What is reason to cause such significant differences?

Page 24, Table 3: Four sites (JOZE, KIRU, METS, and RIGA) have extremely large ZTD trends (over 70 mm/decade) from Repro2. Are these values correct? In addition, Table 3 has never been mentioned in the text.

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