Atmospheric
Measurement
Techniques
Discussions

Interactive comment on "Inter-technique validation of tropospheric slant total delays" *by* Michal Kačmařík et al.

Anonymous Referee #2

Received and published: 26 January 2017

This manuscript describes inter-comparisons of slant total delays (STDs) derived from GNSS solutions, numerical weather models (NWM), and radiometers (WVR). In comparisons between GNSS software, the authors found most of them show good agreements with each other. Moreover, they recommend no use of raw post-fit residuals whereas STDs without residuals and with cleaned residuals are better. As for NWM and WVR, the authors concluded they are not reliable due to their large errors. I roughly agree with their conclusions. However, since I have to point out some weaknesses in this manuscript, it should be published after major revisions.

Major comments 1) Residuals STD is decomposed with ZTD, gradients (G) and residuals. Since Equation 1 only represents the first two terms, the residual term should be added.

Since the horizontal scales of ZTD, G, and residuals are 500, 50, and 5 km (Shoji et al. 2004), it is important to add residuals into STDs when convective activities are considered in any studies using STDs like this manuscript. From the view point of this, the authors have no chance to avoid residuals in processing STDs. In addition, residuals should be cleaned as pointed by Shoji et al. (2004). Therefore, I don't agree that "the usage of the information content from the post-fit residuals for the reconstruction of the STDs remains an open question" in this study (L5 P5). The authors should re-consider the effect of post-fit residuals in their formulation and re-organize this manuscript from the view point that they really need to investigate the effect of post-fit residuals in this study.

2) Comparison in the zenith direction The authors compared STDs in the zenith direction using mapping functions. Sine these functions were made statistically (excluding gradient on the day), I recommend the authors to use STDs only in high elevation angles (> 60 or 70 degree) for the comparisons. This is especially useful in comparison of GNSS vs WVR, because it is able to avoid errors of surface pressure gradient in calculating STDs from WVR.

3) Comparison with NWM There are three models appeared in this manuscript: ERA-Interim, NCEP GFS, and ALADIN-CZ. To help the readers understand the discussion on this topic, please describe more settings on these models.

- Within these, only ALADIN is a regional model, and others are global. State their general characteristics more. - Do all of these models assimilate GNSS data for their initial conditions or not? - How large are their grid spacings? - ERA-Interim is the ECMWF re-analysis data produced 6 hourly. I guess GFS is 6 hourly operational analysis data at NCEP. What is ALADIN-CZ? - Does ALADIN-CZ have large domain enough to produce STDs? I concern that STDs at low elevation angles might penetrate the lateral boundary of the model and need special treatment like STDs over the top of the model. - ALADIN-CZ may be a cloud-permitting model (this depends on its resolution) with explicit cloud microphysics. In this case, it is possible to calculate STDs with hydrometer

effect. Is this right? If yes, I suggest to do this (see the major comment 5). P7 section 4 There are two error sources in this comparison; STD solutions and NWMs. I suggest the authors to employ single STD solution with three NWMs and then compare the results with observed STDs. This makes error sources reduced single (only NWM) and discussion much easier (section 7.2).

4) Figures and discussion Although there are many graphs appeared in this manuscript, some of them are not appropriate for discussion. For instance, though Figure 12 displays 30 lines in 12 panels, the authors made a discussion only in single paragraph (P30 L10). Another example. Although the authors showed small number of figures in connection with GNSS versus NWM comparison, they discussed many points (stations) without figures in section 7.2. I recommend to re-organize discussion and figures.

5) Assessment of components in the atmosphere Although the discussion on the effect of each component of the atmosphere (section 4.4) is important, the authors did not show any conclusion. I suggest to examine the same effect using NWMs additionally and illustrate useful information.

Minor comments P1 L21: "between GNSS a NWM" Reword to "between GNSS and NWM".

P1 L29: "along his path" Reword to "along the path"

P4 L8: "was operating only" Reword to "was operated only" (?)

P6 L91: "three variants of the solution" I don't think that it is worth to examine "nonRES" case in this paper. See my major comment.

P8 L4: "mix ratio of liquid" mixing ratio of liquid

P10 L24: "The contribution of water – neglected in the total delay." As I mentioned in my major comments, I suggest the author to examine these contributions.

P11 Figure 1 Enlarge the land names.

P12 L4: "Figure 2 shows simulated STDs" P12 L9: "The respective differences of STD… are presented in Figure 2." These are different. I guess the latter is correct. The differences were defined between each observation and their minimum, which was observed at a certain azimuth. This definition provides a kink in the graph at the minimum azimuth and then leads to miss-understandings. I suggest that the differences are made between each observation and its average. There is not the land name (POTS) in the body.

P12 Figure 2 It was difficult for me to understand what x- and y-axis labels (Difference of slant delays (mm)) represented (actually, these are not labels for x- and y-axis). Improve locations these labels appear.

P13 Figure 13 This was also made between observations and their minimum. See comment above.

P13 L8: "These values" When were these observed? I guess the observed time were different for each contribution.

P13 L10+1: "the variation range of " The standard deviation and average are better to illustrate such variation statistically. Raw variations may include outliers.

P14 L7: "GPS" Is there any reason to use GPS specifying the US navigation system?

P20 L25: "Note also that ROB_V is consistent with TUO_G." I feel that this sentence is not fear. The authors should list TUO_G at the same sentence (L23).

P22 L16: "orography representation" I guess grid spacings of these three models were different and ALADIN-CZ adopted the smallest. This means the topography of ALADIN-CZ is the most similar to real one. Please show modelled topography of each model and/or modelled altitude in comparison with real one.

P22 L17: "ranging from -3 mm to +7 mm" It is quite difficult to measure these values

from Fig. 8, because there are no scale auxiliary lines for the y axis. Please add the lines not only to Fig. 8 but also other similar figures needed.

P22 L30: "The probable reason . . . negative effect of underestimated delays." There is no evidence for this discussion. The authors should show any figures or numbers.

P24 L1: "Chyba! Nenalezen zdroj," Remove these Czech.

P24 section 7.2.2 The authors should reorganize and polish this section, because evidences for discussion in this section are missed by (not presented) or no figures. I would like to point out that one of major error sources in comparison between real and modelled STDs is super refraction in the actual atmosphere. Please examine this point.

P29 This paragraph is not well discussed, because, for instance, there is no figures in the sentence "The biases stay very stable " (L4). It is recommended to show numbers and/or figures in discussion, otherwise, the readers would have to be frustrated to see tables.

P30 This paragraph should be enhanced, because Figure 12 contains much information whereas the discussion is poor.

P31 Conclusions If the authors illustrate discussion sections in connection with these conclusive remarks, it is happy for the readers to see discussion with evidences.

P32 L2: "for STDs to the zenith direction" It is better to use STDs at high elevation angles instead of mapped STDs.

P32 L13: "The impact was" I don't understand what "the impact" illustrates.

P32 L17-18: "The origin was identified as " I did not see any related discussion with this conclusion.

P32 L18-19: "Their values varied at all . . . 15 degrees" Is there any discussion on this conclusion?

P33 L15: "hardly as reliable as in needed" Needed for what? State clearly.

Please also note the supplement to this comment:
http://www.atmos-meas-tech-discuss.net/amt-2016-372/amt-2016-372-RC1-supplement.pdf