Atmospheric Measurement Techniques Discussions

Atmos. Meas. Tech. Discuss., author comment AC2
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Reply on RC2

Chaiyaporn Kitpracha et al.

Author comment on "Validation of tropospheric ties at the test setup GNSS co-location site in Potsdam" by Chaiyaporn Kitpracha et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2022-238-AC2, 2023

The paper is another contribution to the ongoing discussions and developments related to colocation of space techniques and/or different array of equipment making use of similar neutral-atmospheric conditions, aka, tropospheric ties. The paper presents and analysis two experiments made by the group at GFZ Potsdam, one concerned with effects of GNSS radomes and differential height among antennas, and the other mostly concerned with different GNSS antenna types. The analysis is fair and the results tend to confirm what other previous studies have found. Overall, I consider it a useful contribution as we need much more work to realy understand and make good use of the potential of atmospheric ties.

Response:

First of all, we would like to thank you for your time to read our manuscript in detail and for your insightful comments. We carefully considered your comments and addressed all your points in the paper.

A few suggestions, comments and questions are posed below.

Are atmospheric ties a function of the GNSS receiver or of the GNSS antenna?

Response:

Theoretically, the tropospheric tie model contains (1) the expected tropospheric parameters differences between instrument's reference point as quantifiable by meteorological information, particularly depending on the height difference. In this study, we assess what other sources are present in estimated parameters. There might be an (2) instrumental bias, which would be simply due to different antenna types, leading to discrepancy between meteorological tropospheric tie and observed tropospheric parameter differences. The bias mainly occurs depending on the type of antenna. Whereas for different receivers we find much smaller impact. We have added these sentences in section 4.2 in the manuscript.

"Furthermore, the difference in mean biases between A17F and A17G was on the sub-

millimeter level for all experiment antennas and when compared to two reference stations in this study. This demonstrates that the impact of using a different GNSS receiver is insignificant when compared to the impact of using a different GNSS antenna."

The abstract refers to a " previous study" apparently not referenced.

Response:

We changed the sentence as:

"The bias on GNSS-derived zenith delays and tropospheric gradients differences agrees with the result of the first experiment in this study."

Better to use " elevation angle" instead of just " elevation"

Response:

Done.

The data collection was mostly during the "cold season." Any exprected differenceif the experiment took place in summer?

Response:

We expected that the mean bias would not significantly change from the results in the manuscript if the experiment took place in the summer. However, we only expected an increase in variation since the humidity in the atmosphere is higher during the summer than the winter. We have added relevant sentence into the last paragraph in conclusion.

"Note that both experiments were conducted during middle European winter season. During the corresponding summer season, we expect higher temperatures on average and larger zenith wet delays and fluctuations thereof, accordingly. For instrumental and tropospheric results obtained in this study, however, we do not expect a significant impact depending on the seasonality."

The word uncertainty used in Table 3, does it refer to RMS at 1-sigma?

Response:

Yes, they were empirically determined with respect to the meteorological sensor and computed RMS for each meteorological information for the GPT3. The uncertainty of meteorological sensors are the ones from the sensor datasheets. Regarding NWM, we obtained uncertainties from publications, such as Balidakis (2019). All the information regarding the uncertainties are reported in Section 3.3 of our manuscript, where it is written:

"Regarding the formal errors of NWM, we obtained the uncertainties from Balidakis (2019). However, these numbers are valid only for this experiment because the formal errors of NWM vary with location and time. Unfortunately, it is impossible to extract formal errors from GPT3 as this information is not provided. Therefore, we determined formal empirical errors of GPT3 by computing the differences w.r.t the meteorological sensor for each meteorological information. Then, the RMS of the differences was extracted. We applied these values as formal errors for GPT3. Therefore, these numbers are only valid for this experiment."

Suggesting to write "This suggests that using highER elevation angles"

Response:

We have revised the sentence according to your suggestion:

"This suggests that using higher elevation angles reduces the impact of elevation-dependent systematic errors on the GNSS-derived ZTD differences."

Suggesting towrite "This finding agrees with previous studies, such as ..." (there are more than the study quoted)

Response:

We have revised the sentence according to your suggestion:

"This finding agrees with previous studies, such as Ning and Elgered (2012)"

What does empirical standard deviation mean?

Response:

We have removed the term 'empirical' from the sentence:

"The bias between A201 and A203 for S0 was -1.5 mm, with a standard deviation of 1.7 mm"

What does " standard deviation of S0" mean?

Response:

S0 is the study case without applying any tropospheric ties. The study cases are introduced in Table 4. To prevent a confusion, we have rephrased the sentence in manuscript.

"Meanwhile, the biases for S1, S2, S3, and S4 were roughly -0.2 mm. Furthermore, the standard deviations for S1, S2, S3, and S4 were agreed upon with the standard deviation of S0."

Why are biases caused by different atmospheric conditions since they are under the same? What do the authors mean by using the word "atmospheric"? Does ionosphere or space weather affect that too?

Response:

The observed ZTD differences were in good agreement with the tropospheric tie model, according to the results of the A20 experiment. Consequently, the bias on observed ZTD differences in the A20 experiment was primarily a result of height differences and tropospheric conditions, which are the assumption of tropospheric ties. To avoid confusion, we changed the word 'atmospheric' to 'tropospheric' in the manuscript.

Are the biases high or comparable to other experiments?

Response:

The biases are comparable for both experiments in the manuscript. We also have stated the answer in section 4.2.

"Figure 9 shows a comparison between POTS and POTM, which are the reference stations in this experiment. The bias and standard deviation of ZWD differences were -0.56 and 1.45 mm, respectively. This result agrees with the results from the A20 experiment where different antenna types were used together with a height offset of less than one meter."

Table 6: are the gradients values significant numbers?

Response:

Since the magnitude of tropospheric horizontal gradient is very small. We assess the significant of the mean bias of tropospheric gradient differences by calculating the ration between mean bias and variations. We found that the ratio were less than one for all comparison cases. Therefore, the mean bias of tropospheric gradient differences are not significant in this study. We have added this paragraph into manuscript in section 4.1.2.

"One might question if the results from the comparison is significant because the magnitude of tropospheric horizontal gradients is small (less than one millimeter). As a result, the ratio between mean bias to variation was calculated in order to interpret the significance of mean bias in tropospheric horizontal gradient differences. The ratio between mean bias and WRMS was less than one for all comparison cases, according to the results in Tab. 6. Therefore, the unexpected discrepancies in tropospheric horizontal gradient differences are not statistically significant in this study."

Figure 13: Why gradients not shown as table to be consistent with what was done before?

Response:

We have changed from figure into table according to your suggestion. Please, see the table 7 in the manuscript.