Response to Reviewer 1 Comments

General Comments: In this study, the accuracies of GPS, Galileo, and BDS3 real-time satellite orbit and clock error products from four Analysis Centers (ACs) were evaluated and the real-time positioning performance and Zenith Tropospheric Delay (ZTD) accuracies for GPS, Galileo, and BDS3 were analyzed. This study is essential for selecting precise SSR products from different ACs for real-time ZTD retrieval. While the paper is generally well-written, there are still some issues that need clarification or modification to enhance its quality. Once follow issues are addressed, the manuscript can be accepted.

Response: Thanks to the reviewer for the encouraging comments. We have made a point-by-point response to each of the reviewer's comments in the following section.

Point 1:

- In this study, only IGMAS stations were used for ZTD accuracy and usability evaluation. Why weren't IGS stations used for verifying ZTD accuracy and usability?

Response 1:

✓ Thank you for the reviewer's question. IGMAS is an open technology platform for the collection, storage, analysis, and management of observation data. However, it lacks effective verification when it comes to analyzing the impact of different SSR products on the accuracy of real-time PPP-ZTD. To conduct a comprehensive analysis and study of this issue, we chose to use IGMAS for verification.

Point 2:

- Page 3, Line 29: "verifying the performance of PPP, assessing different SSR products, and verifying the performance of RT-PPP using the results obtained by post-processing PPP and PRIDE PPPAR." It seems that PRIDE PPPAR is used in this research; however, it is not mentioned in Section II. Please include a description of PRIDE PPPAR in that section.

Response 2:

✓ Thanks for the reviewer's suggestion. We have added an explanation of the PRIDE PPPAR. Please see in P3L33-P4L1.

Point 3:

- The accuracies of RT satellite orbit and clock error products from four ACs were evaluated. Why were data from only four analysis centers used?

Response 3:

✓ Thank you for the reviewer's question. Due to the incomplete real-time data from other analysis centers during the DOY 355 in 2023 to DOY 14 in 2024, real-time data from four analysis centers are used in this study. We have added corresponding description to the manuscript. Please see in P8L8-9.

Point 4:

■ Page 16, Fig. 10: In the figure, besides the missing data at the XIA station mentioned in the paper, there are also some "breakpoints." Please explain the occurrence of these "breakpoints."

Response 4:

✓ Thank you for the reviewer's suggestion. The "breakpoints" in Figure 10 are caused by occasional disconnections between the local network and the mount-point, which result in data loss. We have added an explanation for the "breakpoints." Please refer to P15L20-22.

Point 5:

■ Page 5, Fig. 2. The meaning of "IGS" and "IGS Stations for PPP validation" in the legend is unclear. Please clarify their definitions.

Response 5:

✓ Thank you for the reviewer's reminder. "IGS" refers to all IGS stations in China and the surrounding areas, while "IGS Stations for PPP validation" refers to the specific IGS stations selected for this study. We have added an explanation of "IGS" and "IGS Stations for PPP validation" in the legend. Please refer to P4L12-14.

Point 6:

■ Page 5, Equation (1). The does not seem to be defined. Please add the descriptions about the .

Response 6:

✓ Thanks for the reviewer's reminding. We added the explanation of t_0 . Please see in P5L5.

Point 7:

■ Page 14, Tab. 8. Table provides a detailed breakdown of convergence time statistics for four ACs. It's recommended to add the mean values for different ACs to make the statistical result clearer.

Response 7:

✓ Thanks for the reviewer's reminding. We added the average convergence time for all sites for different analysis centers in Table 8. Please see in P14T8.

Point 8:

- Page 17, Line 8: “The differences distribution of RT-PPP-derived ZTDs based on the other ACs were also counted, and the bias was nearly 0 mm”. It’s recommended to add more descriptions (such as figures) for other ACs to make the error distribution of different analysis centers more intuitive.

Response 8:

- ✓ Thanks for the reviewer’s reminding. We have added error distribution for different analysis centers to the manuscript and added corresponding descriptions. Please see in P18F12.

Point 9:

- Page 18, Fig. 12. The “*”that appears in the graph seems to indicate that station lacked observation data, but there is no explanation for the “*” in the Fig .12. Please add an explanation of the “*” to the Fig. 12.

Response 9:

- ✓ Thanks for the reviewer’s reminding. We have revised Figure 12 and added an explanation for "*". Please see in P19F13.

Point 10:

- Page 18, Line 9: “Figure 12. The availability of RT-PPP-derived ZTDs from WHU SSR products at seven IGMAS stations/mm”. The unit of the gravity acceleration should be “%”.

Response 10:

- ✓ Thanks for the reviewer’s reminding. We have revised "mm" to "%". Please see in P19L17.
- ✓ In addition, We inspected the manuscript and revised all the similar errors in the whole manuscript.

Response to Reviewer 2 Comments

General Comments: In this study, the authors utilise real-time precise point positioning (RT-PPP) based on multi-GNSS data from IGMAS stations to evaluate the positioning performance and ZTD accuracies across different analysis centers. The findings provide a valuable reference for selecting SSR products in RT-PPP-derived ZTD. The results appear promising, and the logical structure of this study is well-organised. In general, the findings of this study have the potential to be encouraging for researchers in this field. However, at this stage, before recommending it for publication, I would suggest that the authors carefully address the following specific comments.

Response: Thanks to the reviewer for the encouraging comments. We have made a point-by-point response to each of the reviewer's comments in the following section.

Point 1:

- P2, L52: "SSR products have led to a remarkable 50% improvement in RT-PPP positioning accuracy compared to IGS ultra-fast products". It is recommended that the authors provide additional descriptions or cite relevant references to enhance the clarity of expression. Since this is a key point and a primary motivation for the study, expanding on it will help to make the statements more comprehensive and easier for readers to understand.

Response 1:

✓ Thanks for the reviewer's suggestion. We have added more descriptions and references to explain how SSR data improves the positioning accuracy of real-time PPP. Please see in P2L17-20.

Point 2:

- P10, L224: "The RT clock errors of G03 provided by CNE and WHU are excluded from this study due to their gross errors". This study indicates that the RT clock errors for G03 provided by the CNE and WHU are excluded; however, in Fig. 7, the RT clock errors for G03 provided by the CAS are similarly excluded. Could you please clarify this discrepancy? It would also be helpful to understand the reasoning behind the exclusion of the CAS data in this context.

Response 2:

✓ Thank you to the reviewer's reminder. We apologize for any confusion caused by our mistake. The G03 from CAS was not excluded; the issue occurred due to an unintentional error while creating Figure 5. We have now corrected Figure 5. Please see in P11F5.

Point 3:

- P7, Equation (10). The formula for the determination of Pearson correlation coefficient appears to be incorrect. I suggest that the authors double-check and correct it.

Response 3:

✓ Thank you to the reviewer's reminder. We have corrected equation (10) and proofread the other equations in the manuscript.

Point 4:

- P9, Fig. 3. Although this is a minor issue, the legend in Fig. 3 partially obscures the statistical data/points. I would suggest adjusting the position of the legend to improve clarity. Additionally, please ensure that all the figures presented in this manuscript are of high quality and resolution to maintain the overall readability of the manuscript.

Response 4:

✓ Thank you to the reviewer's reminder. We have modified the location of the legend in Figure 3. Please see in P9F3. In addition, we have revised similar errors throughout the manuscript.

Point 5:

- Generally, when utilising PPP technology, the selection of an appropriate elevation angle is crucial, as it directly affects the quality and coverage of the data. In this study, a 10° cut-off elevation was adopted, which is certainly acceptable. However, I would suggest that the authors provide a more detailed explanation of the rationale behind this choice, particularly in relation to the application and the specific characteristics of the selected study region.

Response 5:

✓ Thanks for the reviewer's question. Regarding the selection of the cut-off elevation, we referred to several studies (Li et al., 2022; Yu et al., 2022). We have explained it in the manuscript and cited the relevant literature. Please see in P13L1-2.

References:

Li, B.-F., Ge, H.-B., Bu, Y.-H., Zheng, Y.-N., and Yuan, L.-T.: Comprehensive assessment of real-time precise products from IGS analysis centers, Satellite Navigation, 3, 12, 2022.

Yu, C., Zhang, Y.-Z., Chen, J.-P., Chen, Q., Xu, K.-X., and Wang, B.: Performance assessment of multi-GNSS real-time products from various analysis centers, Remote Sensing, 15, 140, 2022.

Point 6:

- P17, L335: Please remove any unnecessary punctuation here and thoroughly double-check for any related errors.

Response 6:

✓ Thanks for the reviewer's reminding. We have removed redundant punctuation. Please see in P17L13. In addition, we have corrected similar errors throughout the manuscript.

Point 7:

- Please be mindful of the use of abbreviations throughout the manuscript. For example, in the abstract, some unnecessary abbreviations have been defined, e.g., SISRE, AC, and IGS, even though they are not used in this section. Conversely, some abbreviations that are used, e.g., STD and RMSE, have not been clearly defined. To further enhance readability, I suggest minimising the use of abbreviations, unless absolutely necessary, as an excess of them can burden readers and disrupt the flow of the manuscript. Additionally, please revise the manuscript to ensure that all abbreviations are clearly introduced and consistently used throughout. This will make the content more accessible and easier to follow.

Response 7:

✓ Thanks for the reviewer's reminding. We have added definitions for ill-defined abbreviations and deleted abbreviations that are used less frequently.