Stability and Convergence Gains from Multi-Constellation GNSS in Precise Point Positioning Using 2 Hz Data

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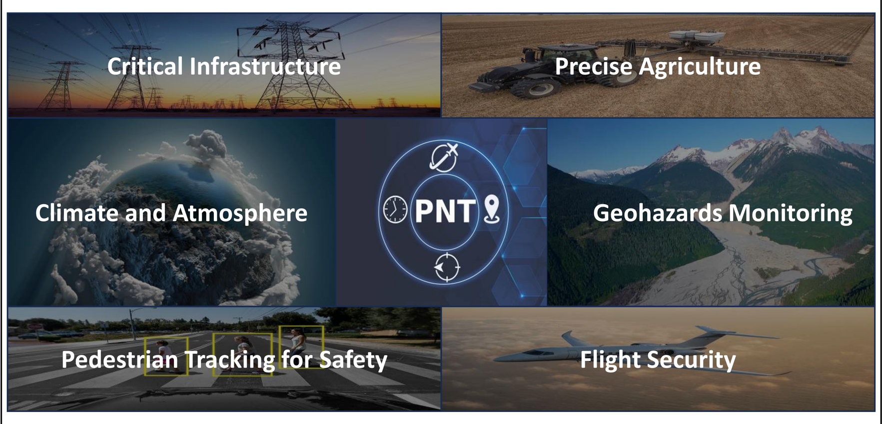
UN-GGCE Communication Contribution

Why does better GNSS positioning matter?

Satellites help us know exactly where we are.
This work improves Precise Point Positioning (PPP) by combining signals from GPS, GLONASS, Galileo, and BeiDou.

More satellites mean better positioning.
With more GNSS constellations, the position can become more stable, faster, and more reliable.



GNSS signals can help estimate atmospheric water vapor, which is useful for weather and climate studies. PPP can support the monitoring of ground movements related to landslides, earthquakes, and other natural hazards. Using 2 Hz GNSS data allows rapid tracking of position changes, which is useful when fast and reliable information is needed.

In simple words:
By using more satellite systems together, we can obtain faster, safer, and more stable positioning information to support society and the environment.

INTRODUCTION

Multi-constellation GNSS improves PPP by increasing satellite availability and enhancing observation geometry.

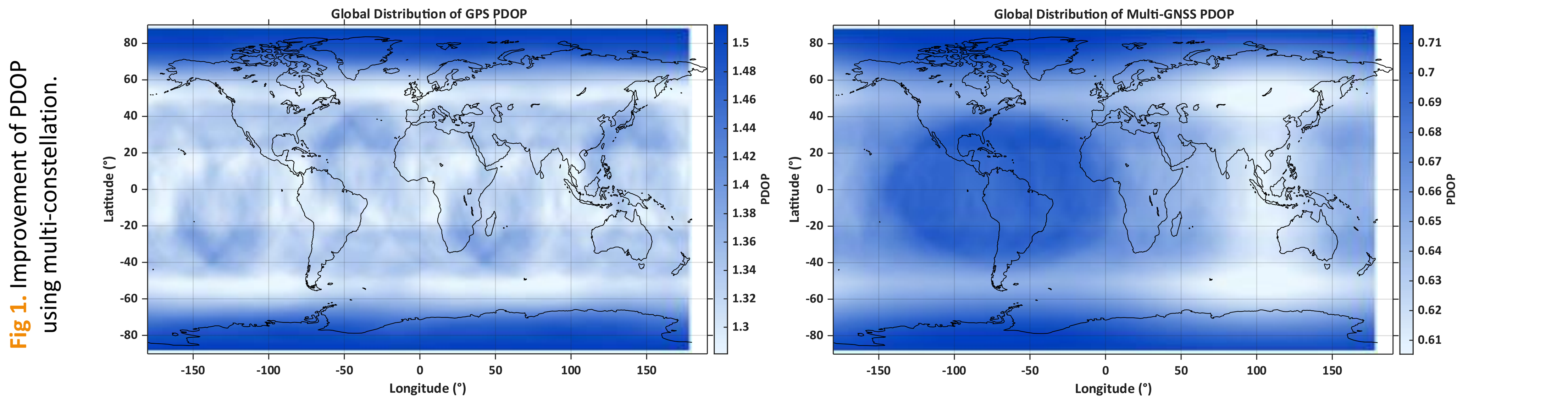
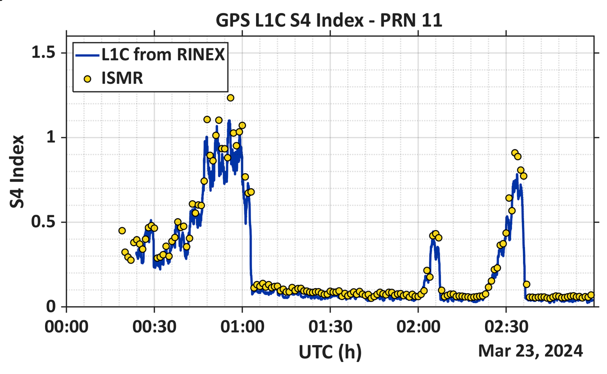


Fig 1. Improvement of PDOP using multi-constellation.

Using high-rate 2 Hz data, it is possible to evaluate short-term signal behavior and the stability of estimated PPP parameters.



OBJECTIVE

To assess the stability and convergence gains provided by GPS, GLONASS, Galileo, and BeiDou integration in PPP using 2 Hz GNSS data.

METHODS

Fig. 2. Magnetometer indexes of the processing period.

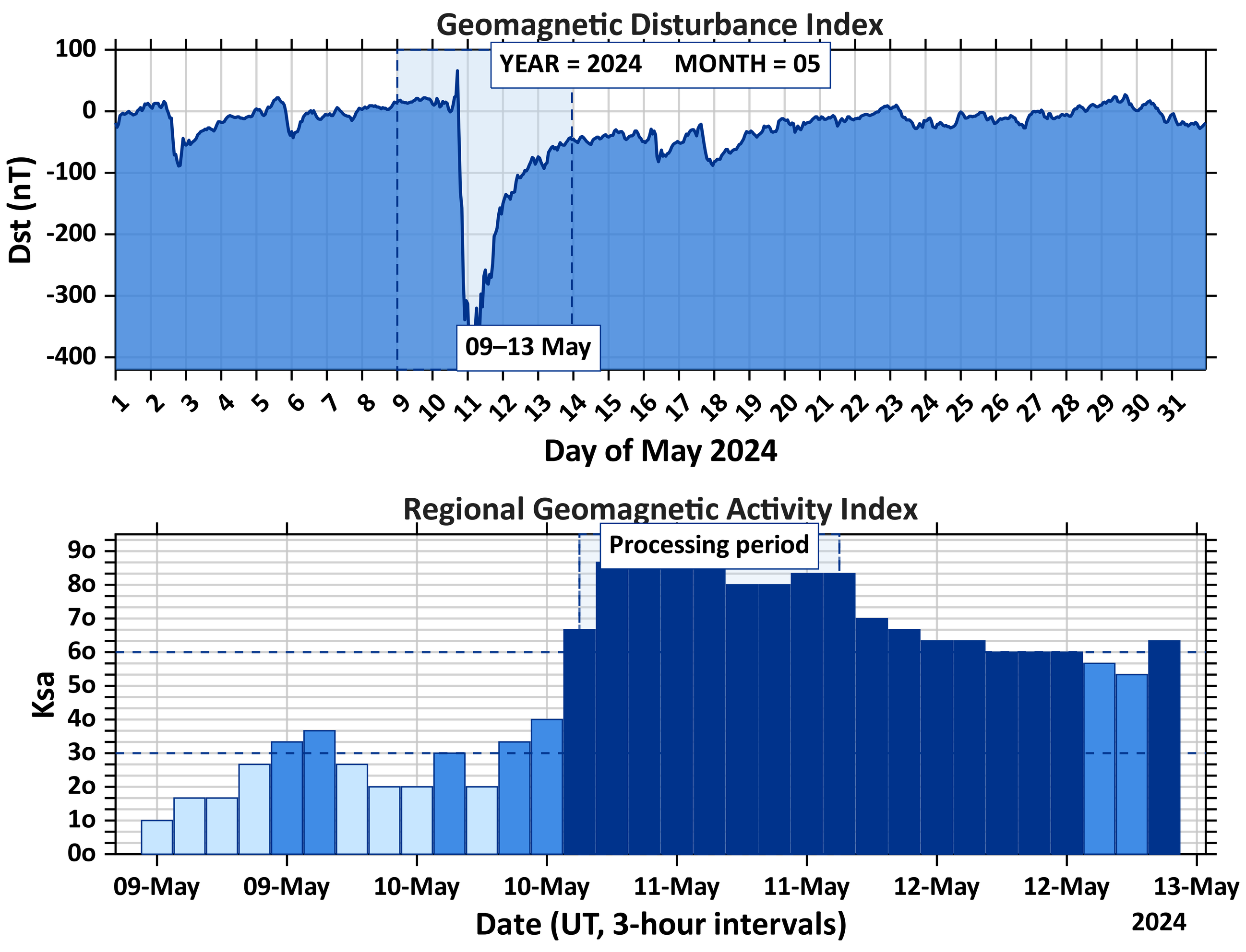
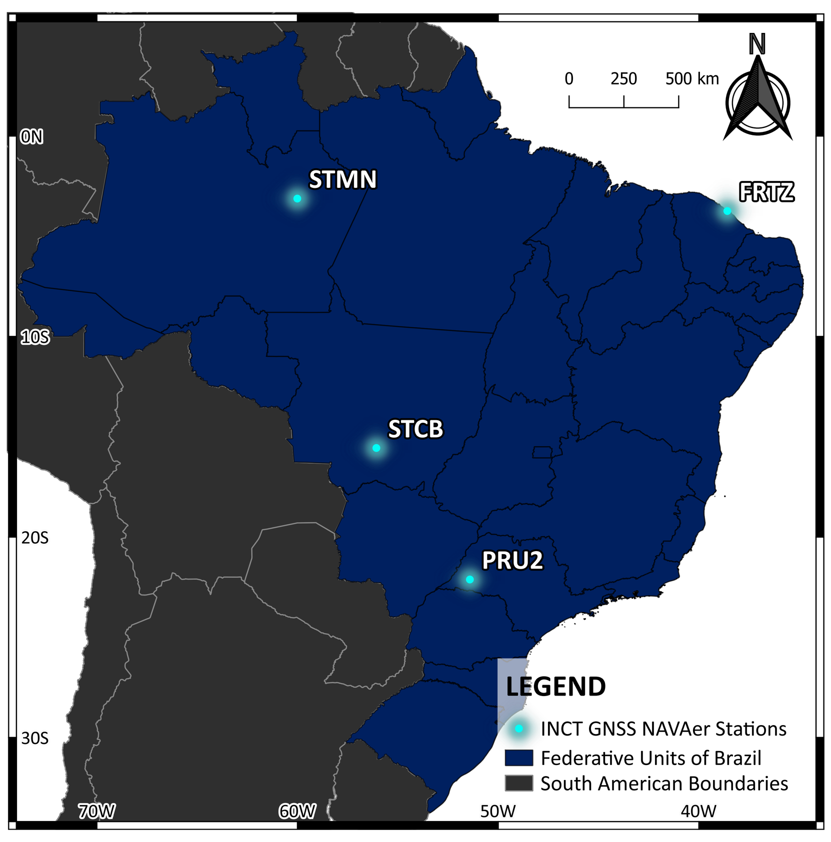
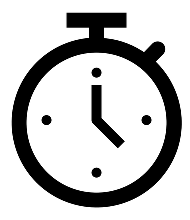


Fig. 3. Selected stations.



APPPOLO



24h of collected data

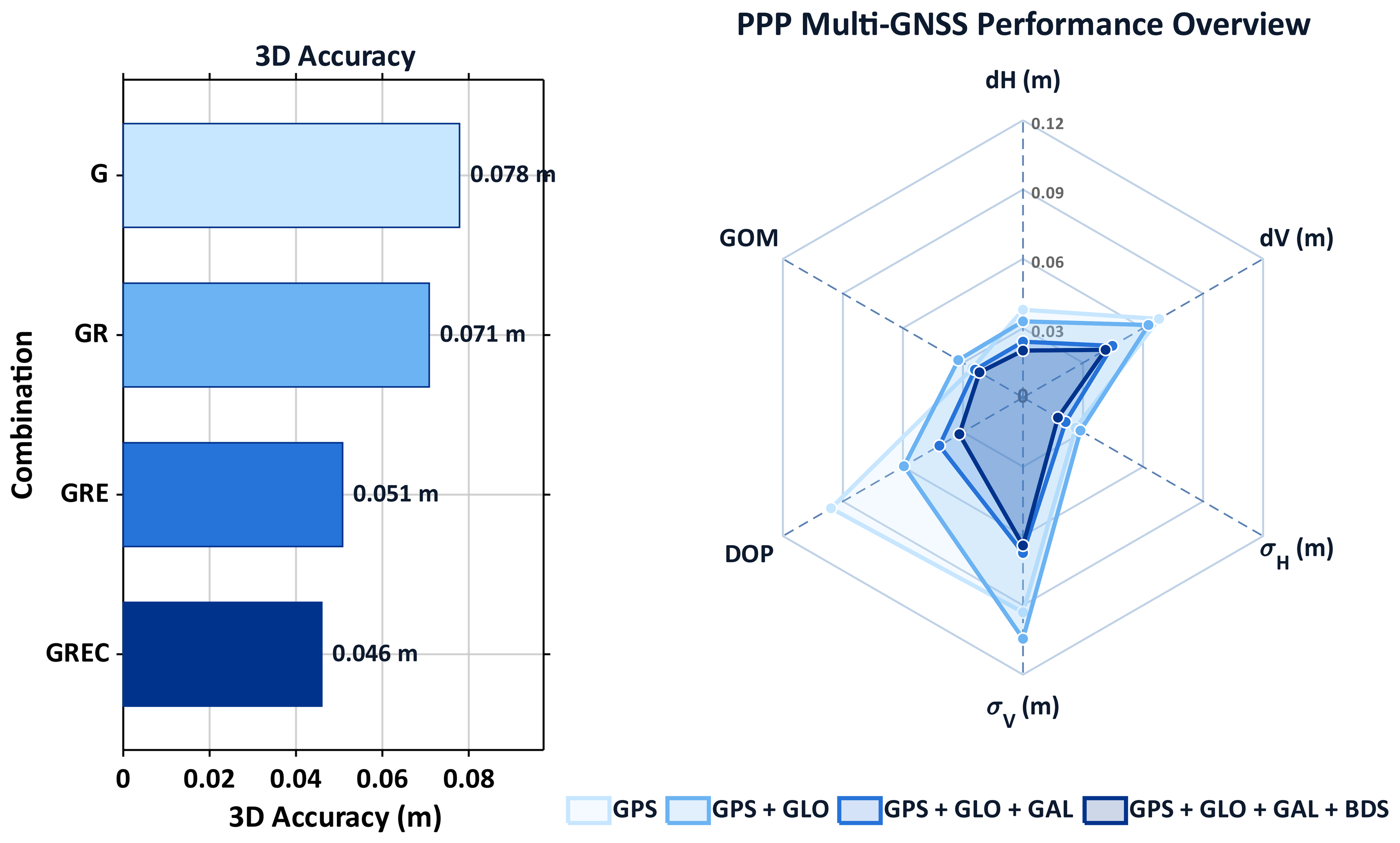
2Hz data from SEPT POLARX5S

Table 1. PPP settings on APPPOLO software for the Experiment.

Parameter	Configuration
Orbit and Clock	CODE SP3 (orbits) and CLK (clocks) products.
Ionosphere	Eliminated by the ionosphere-free linear combination (ion-free).
Neutrosphere	VMF3 + residual component estimated as random walk.
Observables	GPS: L1 C/A, L2 P(Y); GLONASS: G1, G2; Galileo: E1, E5a; Bei-Dou: B1, B3. Elevation-dependent weighting.
Other Systematic Effects	Wind-up, Sagnac, PCO (Phase Center Offset), PCV (Phase Center Variation), OSB (Observable Specific Bias), terrestrial and ocean tides, and relativistic effect on clock and distance.

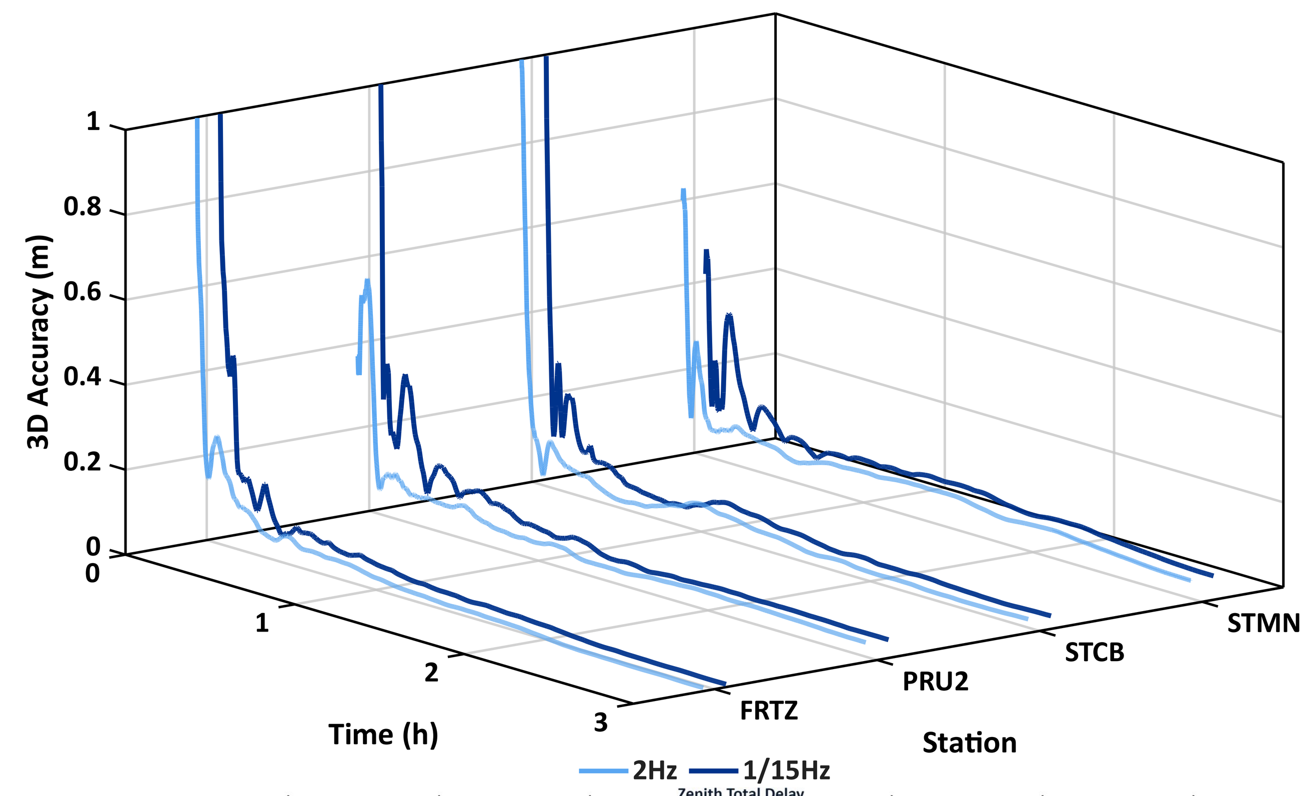
RESULT

Fig. 4. Mean Results of Kinematic PPP for the 4 selected stations.



Multi-GNSS integration reduced the 3D positioning error by 41%, from 7.8 cm with GPS-only to 4.6 cm with GREC.

Fig. 5. Static PPP Multi-GNSS 3D Accuracy.



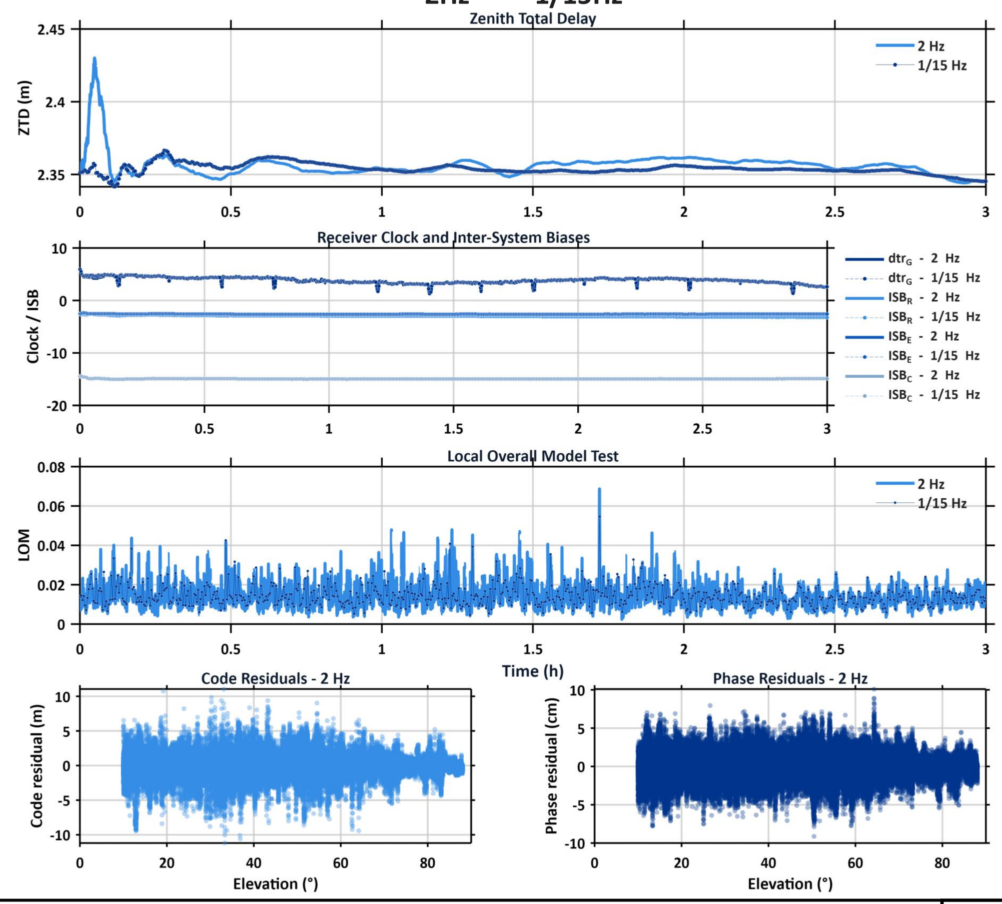


Fig. 6. PRU2 Static PPP Multi-GNSS Analysis.

CONCLUSIONS

Multi-GNSS PPP showed improved performance by strengthening satellite geometry, increasing observation redundancy, and supporting a more stable estimation process. Results indicate that multi-GNSS is effective for enhancing the reliability and robustness of high-rate PPP applications.

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