Assessing the Quality of IGS Final and Rapid Products via PPP-AR Derived Solutions

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INTRODUCTION

Precise Point Positioning with Ambiguity Resolution (PPP-AR) has significantly enhanced GNSS positioning by enabling high-accuracy solutions with reduced convergence times. The success of this technique relies heavily on the quality of external products, such as satellite orbits, clocks and phase biases, provided by the International GNSS Service (IGS). These products are distributed by different Analysis Centers (ACs) in different classes such as Final, Rapids and Ultra-Rapid which vary in latency and precision. Evaluating the consistency between classes of these product classes is essential for ensuring reliable geodetic results.

OBJECTIVE

To perform a statistical comparative analysis of PPP-AR solutions using Final and Rapid products from different Analysis Centers (CODE, CNES and WUHAN).

METHODS

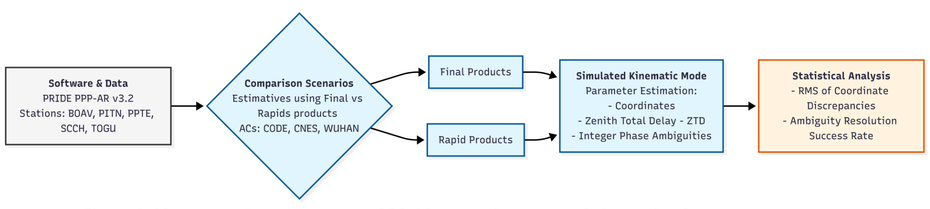

Figure 1: Methodological workflow for PPP-AR processing and statistical validation.

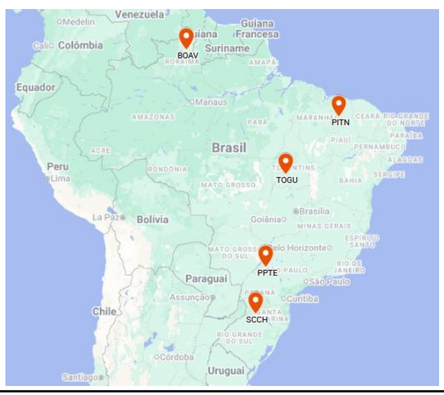

Figure 2: Geographic distribution of the GNSS stations selected for the PPP-AR study. *The network covers different latitudinal regions in Brazil, including equatorial (BOAV, PITN) and low-latitude/subtropical zones (TOGU, PPTE, SCCH). Source: Map data ©2026 Google.*

How Does This Research Matter?

GNSS satellites support navigation, agriculture, infrastructure monitoring, and climate studies.

This research shows that Rapid IGS products can provide highly accurate positioning almost equivalent to Final products, while being available faster for near real-time applications.

Real-World Benefits

Reliable and faster GNSS solutions help build safer, smarter, and more sustainable societies.

RESULT

The comparative analysis across different Analysis Centers (CODE, CNES, and WUHAN) reveals a high level of consistency between Final and Rapid products.

Coordinate RMS errors (East, North, Up) showed sub-centimeter agreement, with the “Up” component consistently, as expected, presenting the largest magnitude.

Ambiguity Resolution (AR) success rates remained robust across all latitudinal zones, typically exceeding 85%, confirming the reliability of Rapid phase bias products.

Regarding tropospheric delay estimation, the ZTD discrepancies remained within a sub-millimeter range (overall RMS of 0.42 mm), indicating that Rapid products are fully suitable for high-precision meteorological GNSS applications in the Brazilian sector

Coordinate RMS errors

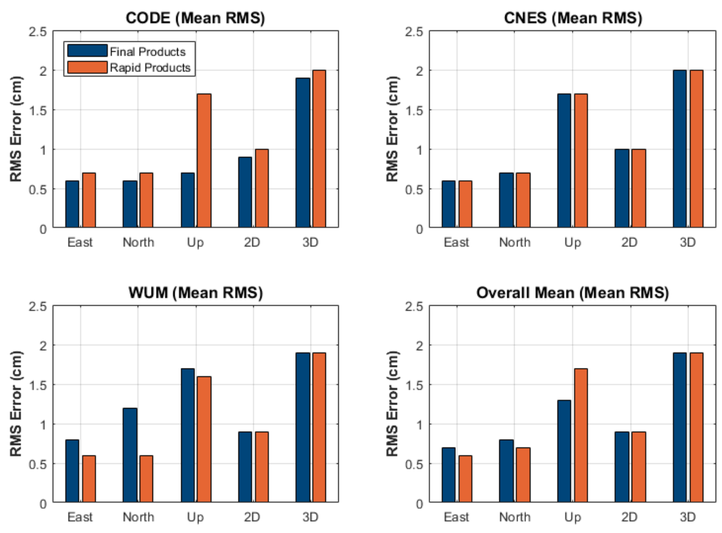

Figure 4. Mean RMS errors (cm) for Final vs. Rapid IGS products. *Comparison of coordinate components (East, North, Up) across different Analysis Centers. The results demonstrate the high level of agreement and reliability of rapid products for PPP-AR positioning in the Brazilian territory.*

Ambiguity Resolution (AR)

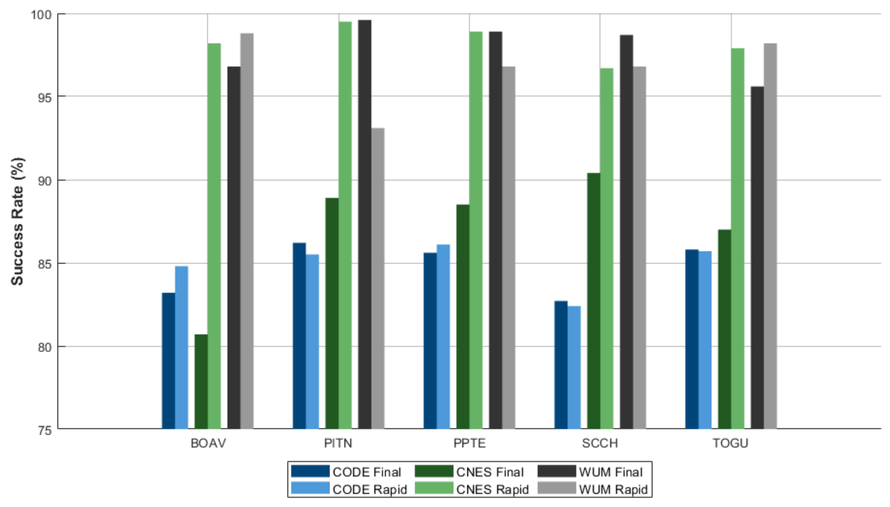

Figure 3. Ambiguity Resolution (AR) success rates for Final vs. Rapid products. *Comparison across five Brazilian stations, categorized by Analysis Center (CODE, CNES, and WUM). Darker shades represent Final products; lighter shades represent Rapid products.*

Zenithal Tropospheric Delay (ZTD)

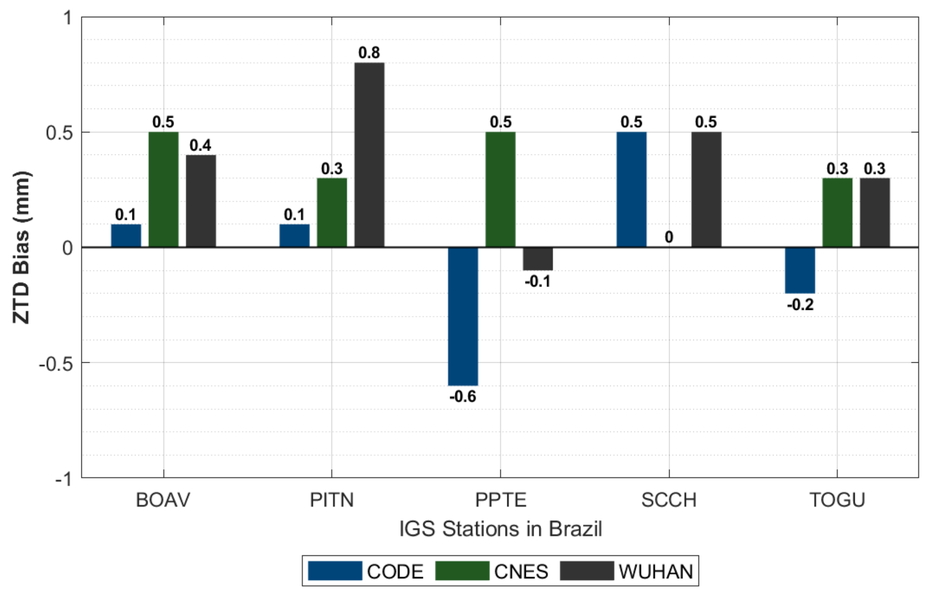

Figure 5: ZTD bias (Rapid minus Final) by station and Analysis Center. *Results demonstrate sub-millimeter consistency across all Brazilian stations, regardless of latitude.*

Analysis Center	Means Bias (mm)	RMS (mm)	Max Deviation (mm)
CODE	-0.02	0.02	0.60
CNES	0.35	0.35	0.50
WUHAN	0.37	0.37	0.80

Table 1: Statistical summary of ZTD discrepancies (mm). *Overall mean bias and RMS values confirm the high accuracy of IGS Rapid products compared to Final solutions for all centers.*

CONCLUSIONS

- **IGS Rapid products** from CODE, CNES, and WUHAN centers provided a positioning performance highly comparable to Final products for PPP-AR processing in Brazil.
- **The 3D accuracy and AR success rates** remained robust and stable at **approximately 2.0 cm** and **above 85%** across all latitudinal zones, outperforming the nominal IGS specifications (~ 2.5 cm) and confirming the geometric consistency between Final and Rapid solutions.
- **The tropospheric ZTD estimates** achieved sub-millimeter agreement **(RMS < 1.0 mm)**, validating the reliability of Rapid products for near real-time atmospheric monitoring.
- **The results support the feasibility** of high-accuracy geodetic applications using rapid products, reducing the latency for orbit and clock availability without compromising the final solution quality.

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