Assessing the Accuracy of Geodetic Coordinates of Control Points Using Precise Point Positioning (PPP) Method in Sri Lanka

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Key words: GNSS/GPS

SUMMARY

Abstract

Sri Lanka's geodetic control networks have evolved significantly since the first triangulation-based network was established in 1857. The most recent update, the Sri Lanka Datum 1999 (SLD99), was implemented using differential GPS techniques. However, advancements in Global Navigation Satellite Systems (GNSS) and Precise Point Positioning (PPP) technology now allow for centimeter-level accuracy without the need for base stations. This study evaluates the accuracy of geodetic control points in Sri Lanka using five free online PPP services (CSRS-PPP, AUSPOS, OPUS, Magic GNSS, and IGN) with varying observation periods (1, 6, 12, and 24 hours). Data from three Continuously Operating Reference Stations (CORS) (Colombo, Kegalle, Ratnapura) were processed and analyzed. Results indicate that relative accuracy between reference points is at the centimeter level, while absolute coordinates exhibit meter-level discrepancies due to differences in reference systems. The study identifies CSRS-PPP and AUSPOS as the most reliable services for high-precision geodetic positioning in Sri Lanka, with 24-hour observations providing optimal accuracy. The findings support the potential for PPP to modernize Sri Lanka's geodetic infrastructure, aligning it with global standards such as ITRF2020.

Keywords: Precise Point Positioning, GNSS, Geodetic Control, CORS, Sri Lanka, ITRF

Introduction

Geodetic control networks serve as the foundation for national mapping, infrastructure development, and scientific research. Sri Lanka's geodetic framework has undergone several transformations since its inception in 1857, when the first triangulation-based network was established. The most recent update, the Sri Lanka Datum 1999 (SLD99), was implemented using differential GPS techniques, providing horizontal control but lacking a vertical datum.

With the advent of multi-constellation GNSS (GPS, GLONASS, Galileo, BeiDou) and advanced processing techniques such as Precise Point Positioning (PPP), it is now possible to achieve centimeter-level accuracy without relying on base stations. PPP corrects satellite orbit and clock errors using global reference networks (e.g., International GNSS Service, IGS), making it a cost-effective alternative to traditional differential methods.

Motivation

The SLD99 system, while functional, has limitations:

1. Limited GNSS Utilization: Established using only GPS, missing benefits from modern multi-constellation systems.

2. Reference Frame Issues: The primary base station was tied to a DORIS point, which was difficult to access, potentially introducing errors.

3. Need for ITRF Alignment: Updating to ITRF2020 ensures compatibility with global geodetic standards.

4. Improved Accuracy: Modern GNSS receivers and processing software offer superior precision.

This study explores PPP as a solution to these challenges, assessing its feasibility for updating Sri Lanka's geodetic network.

Objectives

1. Evaluate the relative accuracy of geodetic control points using PPP.

2. Assess the impact of observation duration (1, 6, 12, 24 hours) on positional accuracy.

3. Compare the performance of five free online PPP services.

Methodology

Study Area and Data Collection

• CORS Stations: Colombo, Kegalle, Ratnapura (part of SLD99).

• Instrumentation: Topcon NET G5 GNSS receivers (dual-frequency, multi-GNSS tracking).

• Observation Periods: 1, 6, 12, and 24-hour sessions (23–24 September 2022).

PPP Processing Workflow

1. Data Conversion: TPS files → RINEX using TPS2RIN.

2. Epoch Adjustment: 1-second → 30-second intervals (TEQC).

3. Online PPP Processing:

o CSRS-PPP (Canada)

Accuracy Assessment

• Relative Accuracy: Differences between computed and mean coordinates.

• Error Metrics:

o 2D RMS (Horizontal)

o 3D RMS (Horizontal + Vertical)

Results

Coordinate Comparisons (24-hour Sessions)

Service	Colombo (Lat/Lon Δ, mm)	Kegalle (Lat/Lon Δ, mm)	Ratnapura (Lat/Lon Δ, mm)
CSRS-PPP	3.8 / 1.9	-0.1 / -3.4	-1.4 / -1.1
AUSPOS	1.4 / 5.3	-0.01 / -0.4	1.9 / 3.1
IGN	6.2 / 0.2	-0.3 / -9.7	0.4 / -1.8

Impact of Observation Duration

• 1-hour Sessions: High errors (IGN: 26.7 mm lat, 120.3 mm lon).

• 6-hour Sessions: CSRS/AUSPOS maintained <5 mm 2D RMS.

• 12-hour Night Sessions: Lowest errors (CSRS 2D RMS: 0.3 mm).

• 24-hour Sessions: Optimal stability (CSRS 2D RMS: 3.0 mm).

Service Performance Summary

Service	Avg. 2D RMS (mm)	Avg. Vertical RMS (mm)	Best For
CSRS-PPP	3.0	23.4	High-precision surveys
AUSPOS	3.9	0.4	ITRF alignment
Magic GNSS	2.9	1.4	Multi-GNSS processing
OPUS	5.2	34.4	Regional projects
IGN	4.2	59.4	Tropospheric studies

Discussion

Key Findings

1. CSRS-PPP and AUSPOS provided the most consistent results.

2. 24-hour sessions minimized ionospheric/tropospheric errors.