GPS/GLONASS COMBINED PRECISE POINT POSITIOINING FOR HYDROGRAPHY – CASE STUDY (ASWAN, EGYPT)

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ABSTRACT

Global Positioning System (GPS) is ideally suited for inshore and offshore positioning because of its high accuracy and the short observation time required for a position fix. Precise point positioning (PPP) is a technique used for position computation with a high accuracy using a single GNSS receiver. It relies on highly accurate satellite position and clock data that can be acquired from different sources such as the International GNSS Service (IGS). PPP precision varies based on positioning technique (static or kinematic), observations type (single or dual frequency) and the duration of observations among other factors. PPP offers comparable accuracy to differential GPS with safe in cost and time. For many years, PPP users depended on GPS (American system) which considered the solely reliable system. GLONASS's contribution in PPP techniques was limited due to fail in maintaining full constellation. Yet, GLONASS limited observations could be integrated into GPS-based PPP to improve availability and precision. As GLONASS reached its full constellation early 2013, there is a wide interest in PPP systems based on GLONASS only and independent of GPS This paper investigates the performance of kinematic PPP solution for the hydrographic applications in Egypt based on GPS/GLONASS combined constellations as well as investigation the performance of kinematic PPP solution based on GLONASS constellation solely.

Keywords: GPS/GLONASS, Precise Point Positioning, Kinematic, Hydrography

1 INTRODUCTION

hydrography is the branch of applied science which deals with the measurement and description of the physical features of the navigable portion of the earth's surface [seas] and adjoining coastal areas, with special reference to their use for the purpose of navigation. Global Positioning System (GPS) is ideally suited for inshore and offshore positioning because of its high accuracy and the short observation time required for a position fix. The horizontal position requirements for marine surveys vary between a few decimetres and several tens of metres. To meet these requirements, different observation and processing techniques using pseudo-ranges and/or carrier phases must be employed.

Precise point positioning (PPP) is an enhanced single point positioning technique for code or phase measurements using precise orbits and clocks instead of broadcast data. PPP became viable with the existence of the extremely precise ephemerides and clock corrections, offered by different organizations such as the IGS (International GNSS Service) (Zumberge et al., 1997; Bisnath S. and Gao Y., 2008; Geng et al., 2010). The PPP technique (Zumberge et. al., 1997) aims at correcting the observations errors and overcome the DGPS limitations. Current PPP techniques are mainly based on GPS which considered the solely reliable system for many years, GLONASS limited observations could be integrated into GPS-based PPP to improve availability and precision (Tolman et al., 2010). As GLONASS reached its full constellation early 2013 (GLONASS, 2017), there is a wide interest in PPP systems based on GLONASS only and independent of GPS. Further, the investigation of GLONASS-based PPP will help the development of GPS and GLONASS combined PPP systems for improved precision and reliability (Cai and Gao, 2013).

2 TEST STUDY

A kinematic track of 27.5 km (Figure 1) was observed using combined GPS/GLONASS dual frequency observations (4 hr, 34 min.) on (6/3/2017) (GPS day 19391) at the Nile river, Aswan, Egypt. Aswan is a city sited in south Egypt (24.0889° N, 32.8997° E) using Leica Viva GS15 receiver (Leica Viva, 2017) with 1 sec observation recording interval and 10^o elevation mask angle. The observations file was undergoing quality check using the software TEQC "translate, edit, quality check" GNSS data tool (TEQC, 2017) . The observations file was divided into three files using TEQC software; combined (GPS/GLONASS) file, GPS-only file and GLONASS-only file.The PPP solutions were estimated for the three files through Canadian Spatial Reference System (CSRS) Precise9 Point Positioning (PPP) service (CSRS-PPP, 2017).

Figure 1. The Nile River observed kinematic track using dual-frequency combined (GPS/GLONASS) (6/3/2017) (GoogleEarth, 2017).

Table 1 shows the average number of visible satellites and Dilution of Precision (DOP) values; Horizontal DOP, Vertical DOP and Position DOP (HDOP&VDOP&PDOP) during observations collection period for GPS, GLONASS and combined GPS/GLONASS.

Table 1. The average no. of visible satellites and average DOP values for tested constellations.

Constellation	Average no. visible satellites	Average HDOP	Average VDOP	Average PDOP
GPS	7	1.094	1.980	2.266
GLONASS	6	1.286	2.586	2.930
GPS/GLONASS	14	0.749	1.340	1.540

Figures 2 to 7 show variation of the average number of visible satellites and Dilution of Precision (DOP) values during observations collection period for GPS, GLONASS and combined GPS/GLONASS constellations.

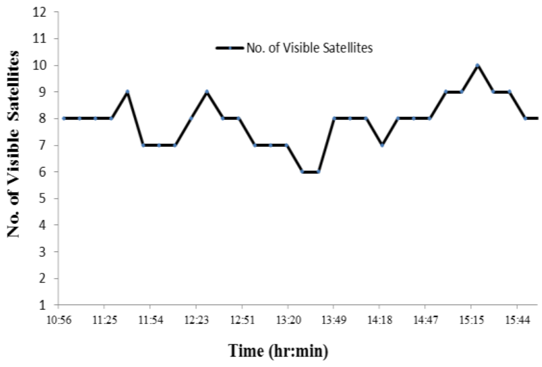
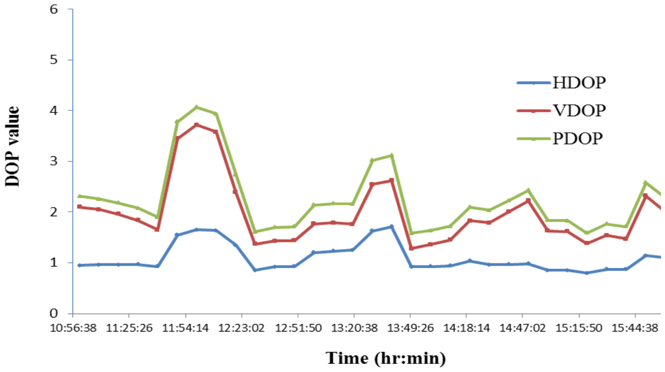


Fig.(2): Number of GPS Visible Satellites During Kinematic Observations Collecion Period (6/3/2017).



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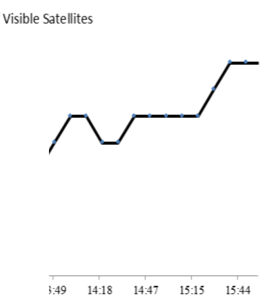

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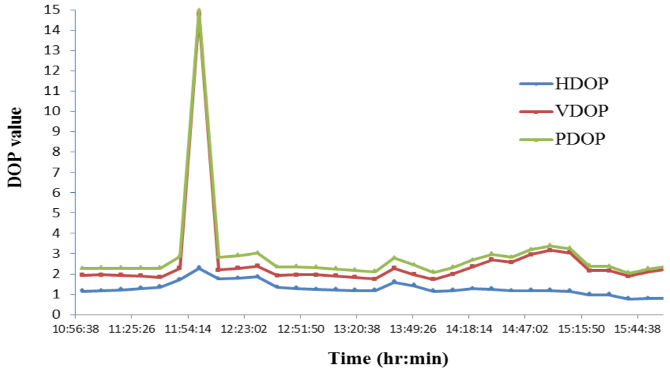

Fig. (5): Variation of GLONASS -DOP values (HDOP & VDOP & PDOP)
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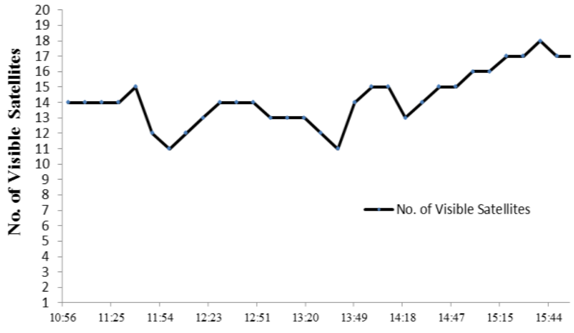


Fig.(6): Number of Visible Satellites (GPS/GLONASS combined constellation) During Kinematic Test Observations Collecion Period (6/3/2017)

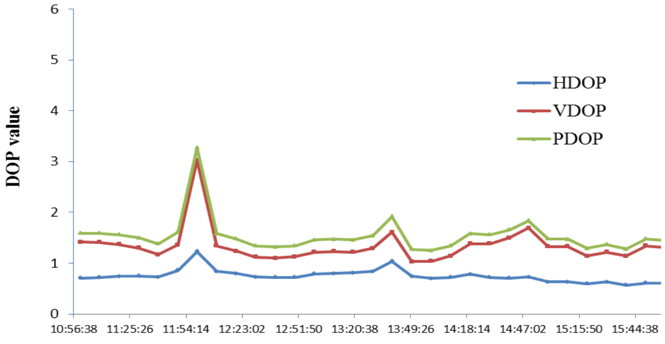
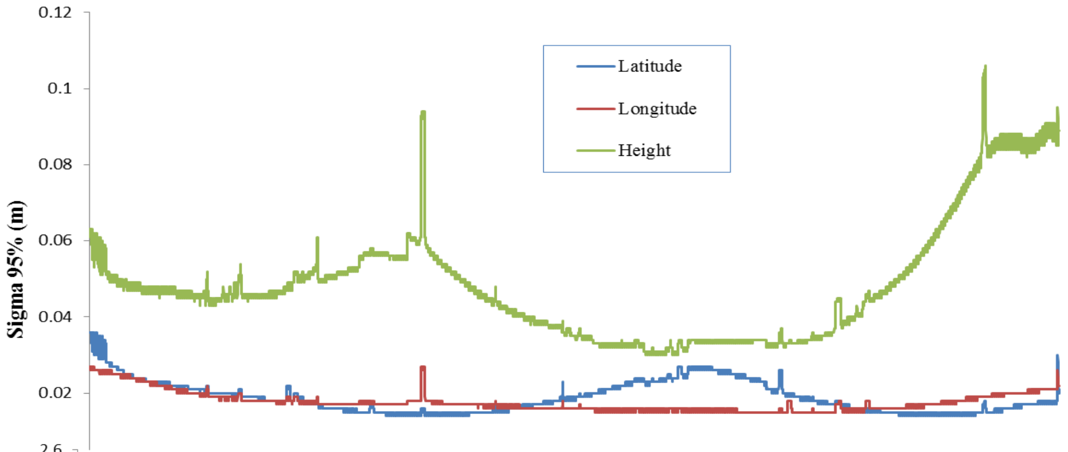


Fig. (7): Variation of combined (GPS/GLONASS) -DOP values) (HDOP & VDOP & PDOP) During Kinematic Test observations collection period (6/3/2017).

3 RESULTS & DISCUSSION

Figures 8 to 10 present PPP-kinematic precision variation using different constellations; GPS, GLONASS and combined GPS/GLONASS.Table (2) presents statistical analysis for kinematic-PPP precision using different constellations.



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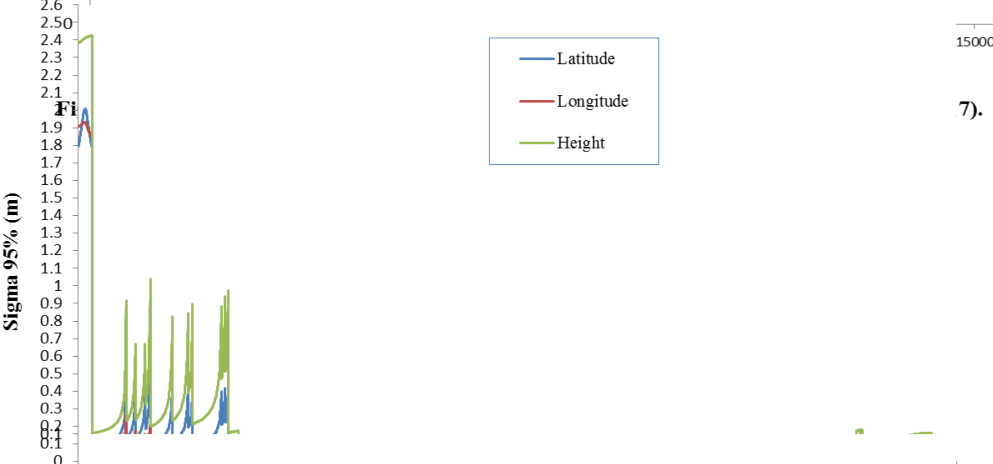

Fig. (9)

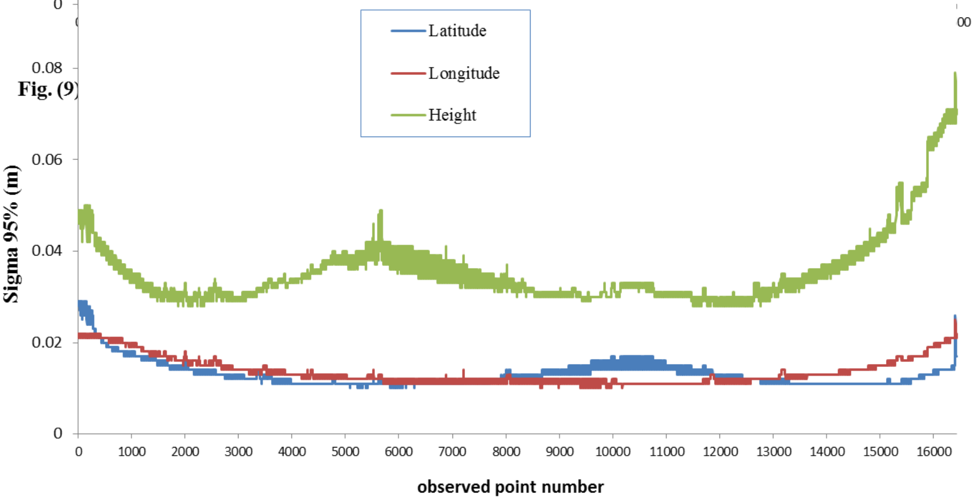

Fig. (10): Kinematic-PPP Positioning Precision for dual frequency mixed GPS/GLONASS observations (6/3/2017).

Table 2: Statistical Analysis for Kinematic-PPP precision variation using different constellations.

Constellation	**GPS**			**GLONASS**			**Combined GPS/GLONASS**		
Sigma (m)	**Sigma latitude**	**Sigma longitude**	**Sigma height**	**Sigma latitude**	**Sigma longitude**	**Sigma height**	**Sigma latitude**	**Sigma longitude**	**Sigma height**
Maximum(m)	0.036	0.027	0.106	0.591	0.288	1.038	0.029	0.025	0.079
Minimum(m)	0.014	0.014	0.015	0.018	0.019	0.062	0.010	0.010	0.028
Average(m)	0.019	0.018	0.049	0.049	0.036	0.129	0.013	0.014	0.037
St. Deviation(m)	0.004	0.003	0.016	0.063	0.019	0.107	0.003	0.003	0.008

4 CONCLUSIONS

This research presents an evaluation study for the variability of kinematic-PPP precision for hydrography using dual frequency observations based on different constellations; GPS, GLONASS and combined (GPS/GLONASS).GPS offers average precision of 18.5 mm, 49 mm for Hz. and vertical coordinates respectively. GLONASS offers average precision of 43.5 mm horizontally and 129 mm vertically. Combined GPS/GLONASS constellation offers average precision of 13.5 mm horizontally and 37 mm vertically. GPS constellation offers better no. of visible satellites and DOP values comparing with GLONASS which improves kinematic-PPP precision by 60%. Combined constellation offers more number of visible satellites and better DOP values which improves kinematic-PPP precision by 26% over GPS constellation and 71% over GLONASS constellation.

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