GPS STATIC-PPP POSITIONING ACCURACY VARIATION WITH OBSERVATION RECORDING INTERVAL FOR HYDROGRAPHIC APPLICATIONS (ASWAN, EGYPT)

Ashraf Farah

Associate Professor,College of Engineering, Aswan University, Egypt , ashraf_farah@aswu.edu.eg

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. 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 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 using high cost dual frequency receivers. PPP using low cost GPS single-frequency receivers is an area of great interest for millions of users in developing countries such as Egypt. This research presents an evaluation study for the variability of GPS static PPP precision based on different observation recording intervals (1sec to 30 sec) using single and dual frequency GPS observations.

Keywords: Static, PPP, GPS, Observation recording interval,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 standard Differential positioning technique requires collecting observations simulatensouly at a reference station and the unknown station (rover) using two receivers which considers high cost positioning technique but gives the highest accuracy.

PPP (Zumberge et. al., 1997 & Soycan and Ata, 2011) is an enhanced single point positioning technique for code or phase measurements using precise orbits and clocks instead of broadcast data. To compensate for ionospheric effects (the largest source of error for GPS observations), dual frequency measurements are used for an ionosphere free combination. PPP provides comparable positioning accuracy to Differential GPS with safe in cost and time. PPP precision varies based on positioning technique (static or kinematic), observations type (single or dual frequency) and the duration of observations among other factors. The PPP convergence period defined as the duration of time required from a cold start to a decimeter-level positional solution is typically about 30 minutes under normal conditions and significantly longer for converging to the few centimeter level. PPP accuracy improves with the length of the data collection period. A minimum period of good quality GPS data (no loss-of-lock) is required to permit convergence and/or resolving ambiguities, which in turn can improve the accuracy of the entire dataset. The minimum period and the accuracy attainable will depend on the type of GPS equipment, the site (multipath, obstructions) and atmospheric conditions. Extending the data collection past this minimum period should further improve accuracy, but more so with dual-frequency receivers than with single frequency receivers. The duration of collected observations should be decided according to the accuracy required. The duration of collected observations depends mainly on the receiver recording interval which varies from 0.05sec to 30 sec. PPP was first developed for use in static applications and has been studied extensively in recent years (Colombo et al., 2004; Bisnath and Gao, 2008; Geng et al., 2010; Soycan, 2012). Table 1 presents the PPP biases and errors that have to be considered (Rizos et al., 2012).

Table 1: The PPP biases and errors that have to be considered (Rizos et al., 2012).

The PPP biases and errors that have to be considered		
Satellite specific errors Precise satellite clock corrections Satellite antenna phase centre offset Satellite antenna phase centre variations Precise satellite orbits Satellite antenna phase wind-up error	Receiver specific errors Receiver antenna phase centre offset Receiver antenna phase centre variations Receiver antenna phase wind-up error	Atmospheric modelling Troposphere delay Ionosphere delay (L1 only) Geophysical models Solid earth tide displacements Ocean loading Polar tides Plate tectonic motion

2 CANADIAN SPATIAL REFERENCE SYSTEM (CSRS) - PPP SERVICE

The Canadian Spatial Reference System (CSRS) Precise Point Positioning (PPP) service (CSRS-PPP, 2017) provides post-processed position estimates over the Internet from GPS/GLONASS observation files submitted by the user. Precise position estimates are referred to the CSRS standard North American Datum of 1983 (NAD83) as well as the International Terrestrial Reference Frame (ITRF). Single station position estimates are computed for users operating in static or kinematic modes using precise GPS orbits and clocks. Currently, users need only specify the mode of processing (static or kinematic) and the reference frame for position output. Since the ionosphere delays L1 CODE observations, an Ionospheric model is required for correction. The source of ionospheric corrections selected for the L1 processing by the on-line application are the combined global ionospheric maps produced at 2-hour intervals in IONEX format by IGS with an accuracy of (± 2-8) TECU-level (range errors in the order of 30 cm to 1 m) . The L1&L2 processing uses the L1&L2 ionospheric-free combination of the code& phase observations and does not require input of an external source of ionospheric information.

3 TEST STUDY

GPS static- dual frequency observations (16 hours in total) was observed on (17/1/2017) (GPS day 19322) at college of Engineering, Aswan University, 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 two files; one contains single frequency GPS observations and the other file contains dual frequency GPS observations. Each of the two files was divided based on different observation recording interval into 11 observation sessions (1 sec., 2 sec., 3 sec., 4 sec., 5 sec., 6 sec., 10 sec., 12 sec., 15 sec., 20 sec. and 30 sec.). The PPP solutions were estimated for observation sessions through Canadian Spatial Reference System (CSRS) Precise Point Positioning (PPP) service (CSRS-PPP, 2017).

4 RESULTS & DISCUSSION

Table 2 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.

Table 2. The average no. of visible satellites and average DOP values during observations collection period.

Average no. of visible satellites	Average HDOP	Average VDOP	Average PDOP
8	0.979	1.716	1.986

Table 3 and 4 present PPP-Static precision variation with different observation recording interval for GPS dual and single frequency observations respectively. Figures 1 and 2 present PPP-Static precision variation with different observation recording interval for GPS dual and single frequency observations respectively.

Table 3: Static-PPP accuracy variation with observation recording interval from dual frequency GPS observations.

Recording interval (sec)	Static-PPP accuracy variation		
	Sigma (95%) Latitude (m)	Sigma (95%) Longitude (m)	Sigma (95%) Ellipsoidal height (m)
1	0.006	0.013	0.025
2	0.008	0.018	0.035
3	0.010	0.021	0.042
4	0.011	0.024	0.048
5	0.013	0.027	0.052
6	0.013	0.029	0.057
10	0.017	0.036	0.070
12	0.019	0.039	0.077
15	0.020	0.043	0.084
20	0.023	0.048	0.096
30	0.028	0.056	0.113

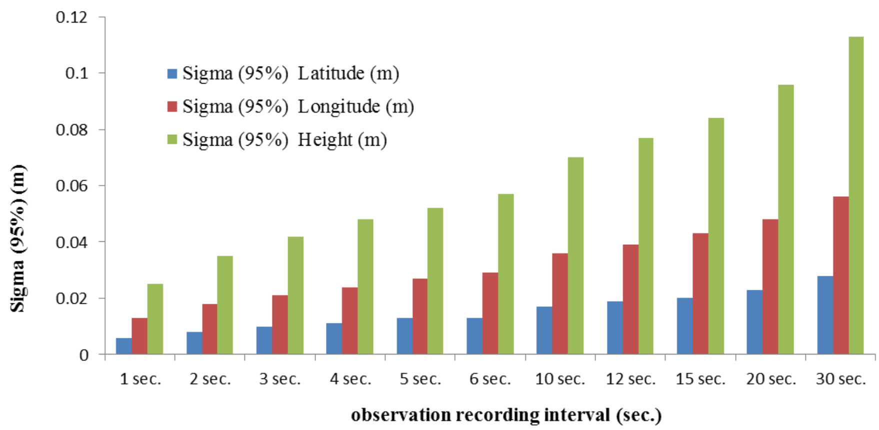

Fig 1: Static-PPP accuracy variation with recording interval period using GPS dual-frequency observations.

Table 4. Static-PPP accuracy variation with observation recording interval from single frequency GPS observations

Recording interval (sec)	Static-PPP accuracy variation		
	Sigma (95%) Latitude (m)	Sigma (95%) Longitude (m)	Sigma (95%) Ellipsoidal height (m)
1	0.187	0.174	0.460
2	0.265	0.246	0.651
3	0.324	0.301	0.798
4	0.374	0.347	0.921
5	0.418	0.388	1.029
6	0.458	0.425	1.128
10	0.591	0.549	1.455
12	0.648	0.602	1.595
15	0.725	0.673	1.784
20	0.836	0.776	2.058
30	1.026	0.952	2.524

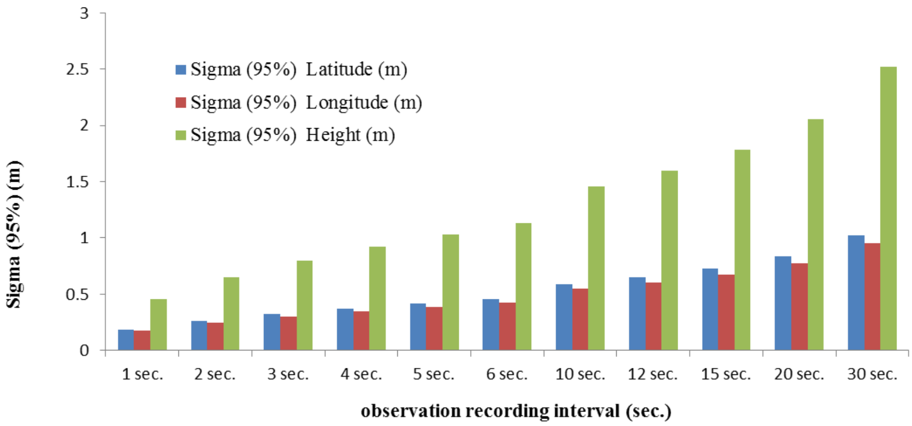

Fig 2: Static-PPP accuracy variation with recording interval period using GPS single-frequency observations.

It can be concluded that there's a clear relation between the static-PPP accuracy and the observation recording interval for the same observation duration. The static-PPP accuracy is inversely proportional to the observation recording interval. The effect of this relation is more visible when using single frequency observations rather than dual frequency observations.

Dual frequency GPS observations (recording interval of 1 sec.) offers static-PPP accuracy of 6mm, 13mm and 25 mm for latitude, longitude and height coordinates. This accuracy reduced by an average of 200% when using recording interval of 10 sec to be (17 mm in Lat., 37mm in Long., 70 mm in Height). The 1 sec. recording interval accuracy reduced by an average of 400% when using recording interval of 30 sec to be (28 mm in Lat., 56 mm in Long., 113 mm in Height).

Single frequency GPS observations (recording interval of 1 sec.) offers static-PPP accuracy of 18cm, 17 cm and 46 cm for latitude, longitude and height coordinates. This accuracy reduced by an average of 180% when using recording interval of 10 sec to be (59 cm in Lat., 55 cm in Long., 145 cm in Height). The 1 sec. recording interval accuracy reduced by an average of 350% when using recording interval of 30 sec to be (103 cm in Lat., 95 cm in Long., 252 cm in Height).

5 CONCLUSIONS

This research presents an evaluation study for the variability of GPS static-PPP precision based on different observation recording intervals (1sec, 2sec, 3sec,4sec,5sec,6sec,10sec,12sec,15sec,20sec and 30 sec) using single and dual frequency GPS observations. For dual frequency GPS observations, the average percentage of reduction in static-PPP accuracy from 1sec to 10 sec (recording interval) is 200%. The average percentage of reduction in static-PPP accuracy from 1sec to 30 sec (recording interval) is 400%. For single frequency GPS observations, the average percentage of reduction in static-PPP accuracy from 1sec to 10 sec (recording interval) is 180%. The average percentage of reduction in static-PPP accuracy from 1sec to 30 sec (recording interval) is 350%. The mathematical relations between static-PPP accuracy and observation recording interval could be derived for both types of observations.

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