Delta University Scientific Journal
Journal home page: https://dusj.journals.ekb.eg

Comparison of PPPH MATLAB based program vs Online GNSS Services

Mahmoud El-Mewafi[1], Ahmed zaki[2], Ashraf G. Shehata [3]* Mariem A. Elhalawani [3]

[1] *Professor, Department of Public Works, Faculty of Engineering Mansoura University, Egypt*.
2 Civil Engineering Dept, Faculty of Engineering, Delta University for Science and Technology
Gamasa City, Egypt
[3] *Teaching Assistant Civil Engineering Dept, Faculty of Engineering, Delta University for Science and Technology, Gamasa City, Egypt*

*** Correspondence:** E-mail address: Teaching Assistant Civil Engineering Dept, Faculty of Engineering, Delta University for Science and Technology, Gamasa City, Egypt ashrafgamal847@gmail.com.

ABSTRACT

The modernization of GNSS provides promising improvements to satellite navigation users across the world, it is important to determine the reliability of using free online processing software for the Global Navigation Satellite System post-processing. The study aims at assessing the accuracy of two free online processing software, GAPS, and CSRS-PPP and Open-source software, PPPH MATLAB based software, and GNSS solutions. Field observations were carried out on data from three stations using GNSS observation from IGS with an observation period of 30 seconds the acquired data were post-processed using both online and open-source software. The coordinates generated from each software were then compared with the ones obtained from station to determine their relative discrepancies and accuracies. for GAPS and CSRS-PPP both in X, Y, and Z direction in ITRF14 reference. Online GNSS processing services are easy to use, do not require the knowledge of GNSS data processing and can be adopted for engineering and geodetic applications. Initial time must be checked for better resolution.

Keywords: Online processing services, GNSS, GAPS, CSRS-PPP, PPPH

I. Introduction

Global Navigation Satellite Systems (GNSS), is a generic term for all the satellite-based global navigation systems at the end of the twentieth century, which started a new and exciting era in positioning, navigation, and timing. Accurate estimates of position, velocity, and time have become available to all virtually instantaneously, continuously, inexpensively, and effortlessly.

At present, GNSS including the GPS, GLONASS, Galileo, and BeiDou, establish the foundation for contemporary positioning applications such as agriculture, mapping, public safety, military, surveying purposes and Geographical Information System (GIS). Some of these applications necessitate a precise geodetic observation that cannot be accomplished with raw measurements. Therefore, the error sources from the satellite system, the receiver system, and the signal path must be eliminated. This can be achieved through an effective correction process which is divided into real-time based and post-processing based. The real-time based techniques such as differential GPS (DGPS), Real-Time Kinematic (RTK) and the wide-area augmentation system, use satellite receiver intersystem communication to generate the position of a point. This type of differential positioning is significant in the applications that necessitate immediate results. The post-processing procedures apply the corrections after the GPS data has been collected. [6]

The diverse accuracies of GNSS positioning necessitate its study to evaluate its accuracy for different applications. Some applications require meter level positioning, while others require centimetre level. However, to ensure accurate positioning, two GNSS receivers need to be employed and post-processing of the data with scientific or commercial software while one receiver is needed with online processing services due to the vulnerability of real-time kinematic techniques to poor satellite visibility, multipath and unreliable data link from the reference station. Due to the ease of use and no requirement of experience in GNSS post-processing, online processing services have now become an alternative to the scientific and commercial software in GNSS data processing. [3]

II. Online Post-Processing Services

GNSS online processing services are now widely used as an alternative to the traditional processing method. The use of these processing services has become widely popular because of their ease of use, is free of charge (or requiring a low-cost fee) and no requirement of a license and knowledge of a GPS processing. The users of these services need to convert the acquired GNSS data to Receiver Independent Exchange (RINEX) format and send through email or upload it to a particular website. After uploading the data, the coordinates can easily be obtained a few minutes later via the user's registered email. It is nowadays possible of data processing for both positioning modes, static and kinematic, via these free online web-based processing engines. Figure 1 shows the online-based GNSS processing method. [3]

Fig 1 Online Based GNSS Processing Method

2.1 GAPS

In GAPS the package has been configured to accept an observation file in the RINEX 2.10 or 2.11 formats. IGS product files necessary for processing the observations are automatically retrieved from one of the IGS global data centres.

The main goal in developing GAPS was to come up with a state-of-the-art positioning tool; however, GAPS showed itself to be much more versatile than that, allowing innovative data analysis and quality control procedures. [5]

2.2 CSRS-PPP

CSRS-PPP provides an online service for GNSS data post-processing allowing users to compute high precision positions from their raw observed data. CSRS estimates are computed from carrier phase or code pseudo-range observations of both single and dual-frequency receivers. Users can submit observed data in RINEX format from single or dual-frequency receivers operating in static or kinematic mode over the internet for onward processing. [3]

In table 1 we can see the parameters of online serves.

Table 1 Online solutions parameters

Feature	GAPS	CSRS-PPP
Developer	University of New Brunswick (UNB)	Natural Resources Canada (NRCan)
Web site	http://gaps.gge.unb.ca/	http://www.geod. nrcan.gc.ca/
Latest version	GAPS V5.2.0	CSRS-PPP V1.05_34613
Supported process mode	Static, kinematic	Static, kinematic
Observation data	Dual-frequency	Single or dual- frequency
Limitations of uploaded file	–	B100 Mb
Constellation	GPS	GPS ? GLONASS

Coordinate frame	ITRF2008/NAD83	ITRF2008/NAD83-
Precise satellite products	IGS	IGS
Tropospheric delay model and mapping function	UNB-VMF1; UNB3	Dry delay: Davis
	MF: VMF1-gridded	Wet delay: Hopf
Estimation of tropospheric delay	Zenith total tropospheric delay	Zenith total tropospheric delay

III. 3.PPPH MATLAB BASED PROGRAM

PPPH was developed in MATLAB environment to integrate multi-GNSS (GPS, GLONASS, Galileo, and Bei-Dou) data for PPP processing. Fundamentally, PPPH aims to be an easy-to-use, robust and efficient software package. Accordingly, PPPH provides a user-friendly GUI to assist users in selecting the navigation files, determining the pro- cessing options and analysing the results. PPPH consists of five main components, and each component along with its related options is represented by a separate tab in the GUI. Figure 1 presents the operation flowchart of PPPH as including the main components and their functionalities. The first four components utilize related models and theory to provide multi-GNSS PPP solutions, while the last one is employed to evaluate and visualize the results. [1]

Fig 2 PPPH processing steps

After completing all process steps like in fig 2. PPPH provides a result file containing the estimated parameters for each epoch. More- over, through the Analysis tab of GUI, the statistics about the process, such as positioning error, root mean square error and convergence time, can be calculated with respect to user- defined ground truth. To evaluate the epoch-by-epoch variations of estimated parameters and their statistics, PPPH is able to produce several plots, e.g., positioning error, tropospheric zenith total delay, receiver clock estimation, satellite number and dilution of precisions. [4] our analysis included the IGS station that are shown in Fig. 3

A. Fig. 3 Geographical location of IGS station used in this study

IV. EXPERIMENTAL RESULTS

In order to represent and compare the differences between the online PPP static solutions and PPPH by the IGS reference values, the results and the reference values are calculated. The figure shows that the mean biases of N/E components are less than 1 cm in table 5 and the mean biases of H components are about 1.0–4.0 cm.

In summary, from Fig 4 and 5 and Table 2 ,3 and 4 we can see that compared with reference values, the precision of (X, Y, Z) components of using daily observation data sets can reach the centimetre level, and we can see that compared with reference values, the precision of N/E components of using daily observation data sets can reach the millimetre level, and the precision of H components reaches about 1–4 cm. There is no obvious difference between the online PPP services and PPPH as to coordinate estimations, basically all can reach centimetre to millimetre level.

Table 2 Difference in Cartesian coordinates between reference stations, online solutions and PPPH

station	Difference in Cartesian (X, Y, Z)		
solution	CSRS	GAPS	PPPH
X	27.79	17.1	27.31
Y	6.29	5.87	4.46
Z	30.05	16.74	30.48

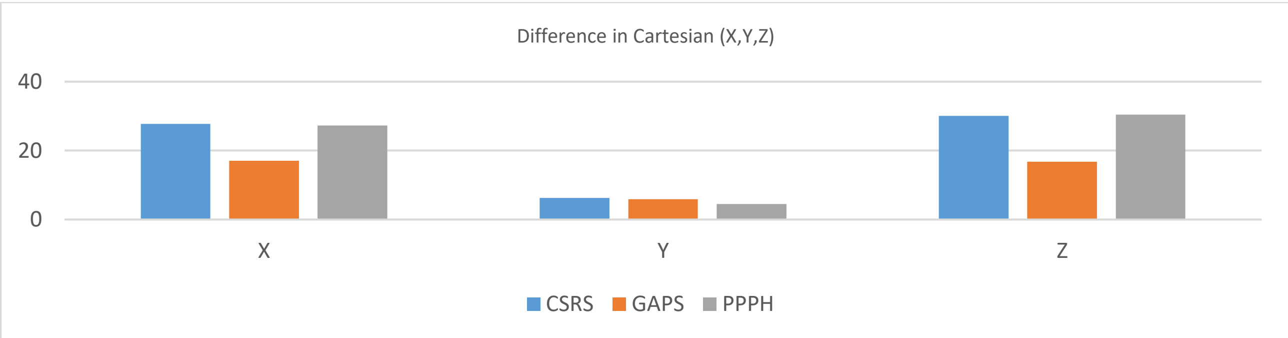


Fig 4 Difference in Cartesian coordinates between reference stations, online solutions and PPPH

Table 3 Difference in Cartesian coordinates between reference stations, online solutions and PPPH

station	Difference in Cartesian (X, Y, Z)		
solution	CSRS	GAPS	PPPH
X	11.9695	11.9716	11.9264
Y	-21.4455	-21.4478	-21.4409
Z	41.5647	41.5518	41.5825

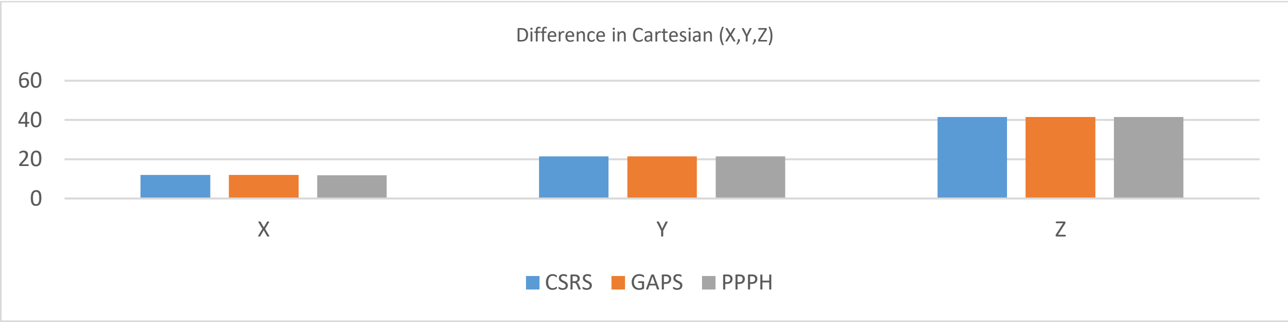


Fig 5 Difference in Cartesian coordinates between reference stations, online solutions and PPPH

Table 4 Difference in Cartesian coordinates between reference stations, online solutions and PPPH

station	Difference in Cartesian (X, Y, Z)		
solution	CSRS	GAPS	PPPH
X	42.6413	42.6486	42.6424
Y	-9.385	-9.3779	-9.3624
Z	-37.5912	-37.5971	-37.5873

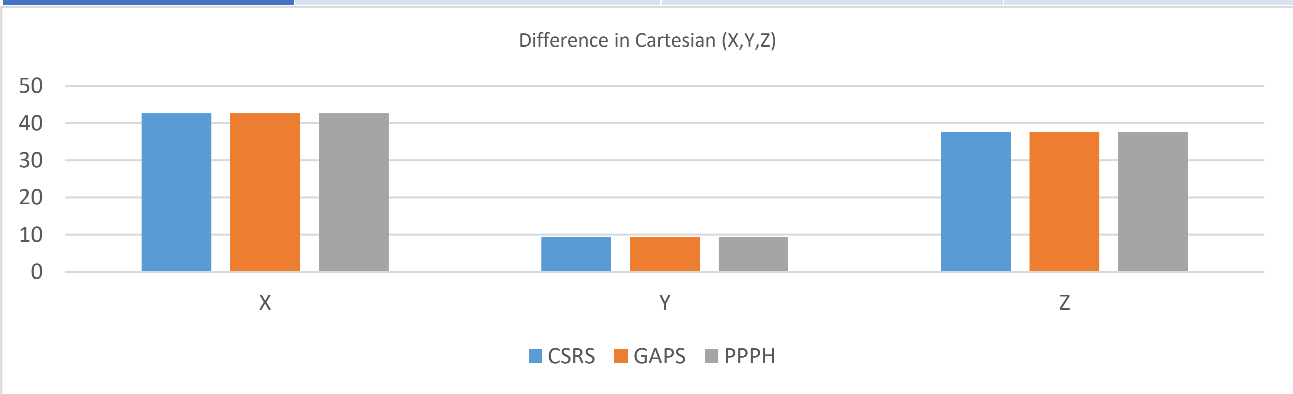
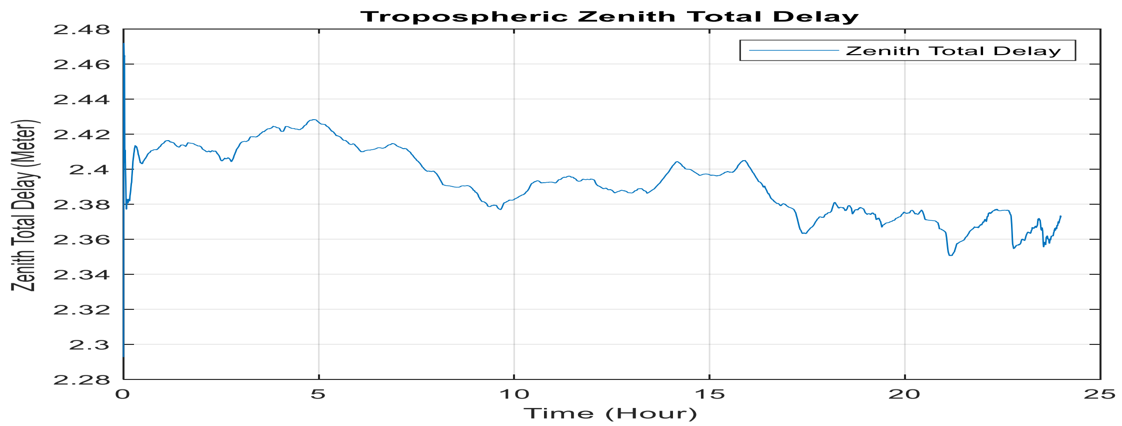


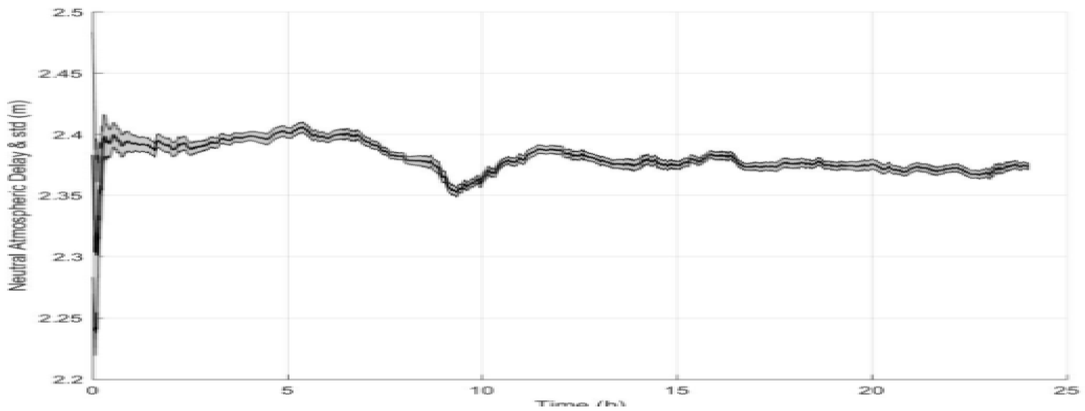
Fig 6 Difference in Cartesian coordinates between reference stations, online solutions and PPPH

The online PPP services provide station coordinates in the ITRF frame and ZTD estimates at the user station. In order to evaluate the performance of the services, analysis, and comparisons are conducted regarding aspects. static positioning results using daily observation data sets of IGS station are compared with IGS reference values to analyse the precision of static PPP for long observation periods. static PPP processing results for various short observation periods are compared with reference values to analyse PPP performance of precision and convergence for short observation periods. Comparison of positioning errors, zenith delay and clock estimation for different solutions. [2]

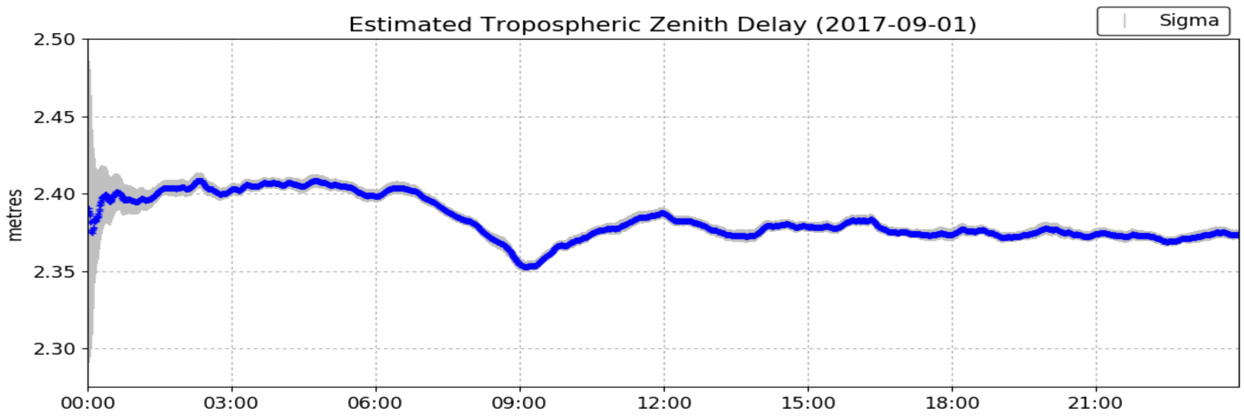
PPPH zenith delay



GAPS zenith delay



CSRS zenith delay



V. Conclusions

- The free online PPP services of GAPS and CSRS-PPP all can provide centimetre level even millimetre level precision of single station with long observation period in static mode. Compared with IGS solutions, the precision of daily solutions of horizontal components estimated by the online PPP services can reach the millimetre level.
- With the free online PPP services, users do not require software investment; positioning precision with 1–2 cm even millimetre level can be obtained only using single receiver.

- PPPH is capable of providing PPP solutions for user multi-GNSS combinations. Users can also specify the options, models, and parameters within the GUI of the software. PPPH also provides an output file involving the estimated parameters for each epoch separately and a number of analysis tools to assess the results statistically.
- Although PPPH has many functionalities for PPP processing than online solutions and the capabilities of PPPH can be extended to meet the demands of advanced users efficiently considering.
- MATLAB environment is one of the most popular programming tools among engineers and scientists worldwide more program must be done to improve PPP GNSS solutions.

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