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Research Article

Precision comparison for Different GNSS PPP solution using online services and open-source software processing

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Abstract: In order to properly post-process data from the Global Navigation Satellite System, it is crucial to evaluate the dependability by means of online free processing tools because the development of GNSS offers satellite navigation consumers around the globe promising benefits. The purpose of the study is to assess the precision of several online processing tools, including GSIPOST, AUSPOS, IBGE, Magic GNSS, CSRS-PPP, and open-source software. Three stations' worth of RINEX 2 data were subjected to field observations utilising GNSS observations from IGS, with an observation time of 30 seconds. After that, both online and open-source software was used to analyze the collected data, using GPS and GPS and GLONASS. The relative differences and accuracy of the coordinates generated by each software were then assessed by comparison with those acquired from reference stations. coordinates in the ITRF14 standard for the X, Y, and Z directions. Online GNSS processing services don't require GNSS data processing skills and are easy to use, and provide more accurate results for engineering and geodetic uses. RINEX 3 data must be checked for better resolution.

Keywords: GNSS; Online processing services; AUSPOS; IBGE; Magic GNSS; CSRS-PPP; PPPH

1. Introduction

With the creation of satellite-based global navigation systems, also known as global navigation satellite systems, a new and stimulating age in location, timing and navigation was ushered in. Everyone now has access to accurate estimations of position, velocity, and time almost instantly, continuously, easily, and affordably [1]. GNSS is used for many purposes, including navigation and surveying. Because of this, creating and maintaining a network of permanent stations via traditional methods is expensive. The International GNSS Service (IGS), on the other hand, offers extremely accurate satellite orbits, clock corrections, or atmospheric products [2]. In order to determine a point's position, Satellite receiver intersystem communication is necessary for real-time based methods like Systems for wide-area enhancement, real-time kinematic (RTK), and differential GPS (DGPS). This kind of differential positioning is important for situations where quick outcomes are required. After collecting the GPS data, the post-processing actions dealing with the correction [1].

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The data RINEX file can be provided to web services for post processing if it was collected using a double frequency GNSS receiver and observed from any location on Earth. Additionally, some services support a variety of data formats. However, in order to receive high accuracy results for the coordinates of the submitted points, the user must take a number of factors into account, including data, the method of processing, the mathematical model used in post-processing, the accuracy of the products, additional data, such as reference station coordinates, satellite clock and orbit correction, the length of the observed file, and the quality of the observed data [3].

The various accuracies of GNSS location call for research in order to assess its accuracy for various applications. While certain applications call for centimetre level location, others do not. Real-time kinematic techniques are susceptible to multipath, unstable data links from the reference point, and poor satellite visibility, two GNSS receivers must be used in order to ensure accurate positioning, and the data must also be post-processed using professional or commercial software. Online processing services have now replaced scientific and commercial software in the processing of GNSS data due to their simplicity of use and lack of need for GNSS post-processing expertise [4].

2. Experimental programme

2.1 *Online Post-Processing Services*

Nowadays, many people employ GNSS internet processing services in place of the conventional processing approach. The ease of use, lack of cost (or low-cost fee), lack of need for a licence, and lack of expertise of GPS processing have all contributed to the popularity of these processing services. The GNSS data that has been acquired by users of these services must be converted to Receiver Independent Exchange (RINEX) format before being sent via email or uploaded to a specific website. The coordinates can be simply acquired a few minutes after the data has been uploaded via the user's registered email. These free web-based processing engines make it possible to handle data for both static and kinematic location modes today [5].

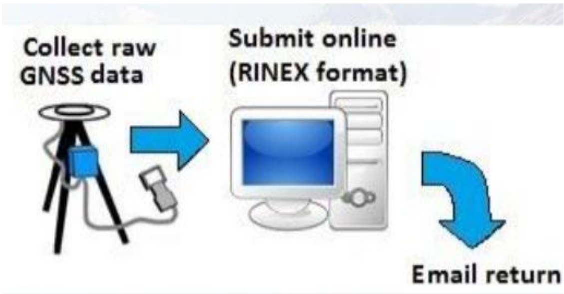


Figure 1. Online Based GNSS Processing [5]

AUSPOS

Geoscience Australia developed the free online GNSS processing tool known as AUSPOS. It makes use of the network of IGS stations, the IGS product line, and appropriate data collected from any place on Earth. The Bernese GNSS Software is used to analyze baselines. An easy-to-use web interface is used to input the antenna height and type as well as an email address for the reimbursed report set. You can utilize the AUSPOS service on website at http://www.ga.gov.au. [6].

Magic GNSS

Magic GNSS is an online tool that processes both GLONASS and GPS observations. For data processing It was created by the firm GMV Aerospace and Defence and made available on the website of the company in static and kinematic form at two frequencies. It only supports observations with dual frequencies. The benefits of using online post-processing tools include: Irrespective of the type of computer used, post processing may be carried out whenever and wherever there is access to the internet or email, customised software does not need to be installed, and results and reports are sent back to the sender quickly [7].

CSRS-PPP

The online tool provided by CSRS-PPP for post-processing GNSS data allows users can use their original witnessed data to calculate highly precise locations. Carrier phase or code pseudo-range data from single and dual frequency sensors are used to calculate CSRS values. Users can upload witnessed data in RINEX format from single- or dual-frequency sensors running in static or kinematic mode for further analysis online [8].

2.2 *PPPH MATLAB based program*

To combine PPP processing for multi-GNSS data (including GPS, GLONASS, Galileo, and Bei-Dou), PPPH was established in the MATLAB environment. Fundamentally, PPPH seeks to be a user-friendly, reliable, and effective software solution. In order to let users, choose the navigation files, decide how to handle, and evaluate the outcomes, PPPH offers a user-friendly GUI. The five primary components of PPPH are each displayed by a separate tab in the GUI, along with any associated options. The key components and their functions are shown in the operating flowchart of PPPH in Figure 2. The final component is used to assess and present the findings. The four components listed at first use linked concepts and theories to produce GNSS solutions [9].

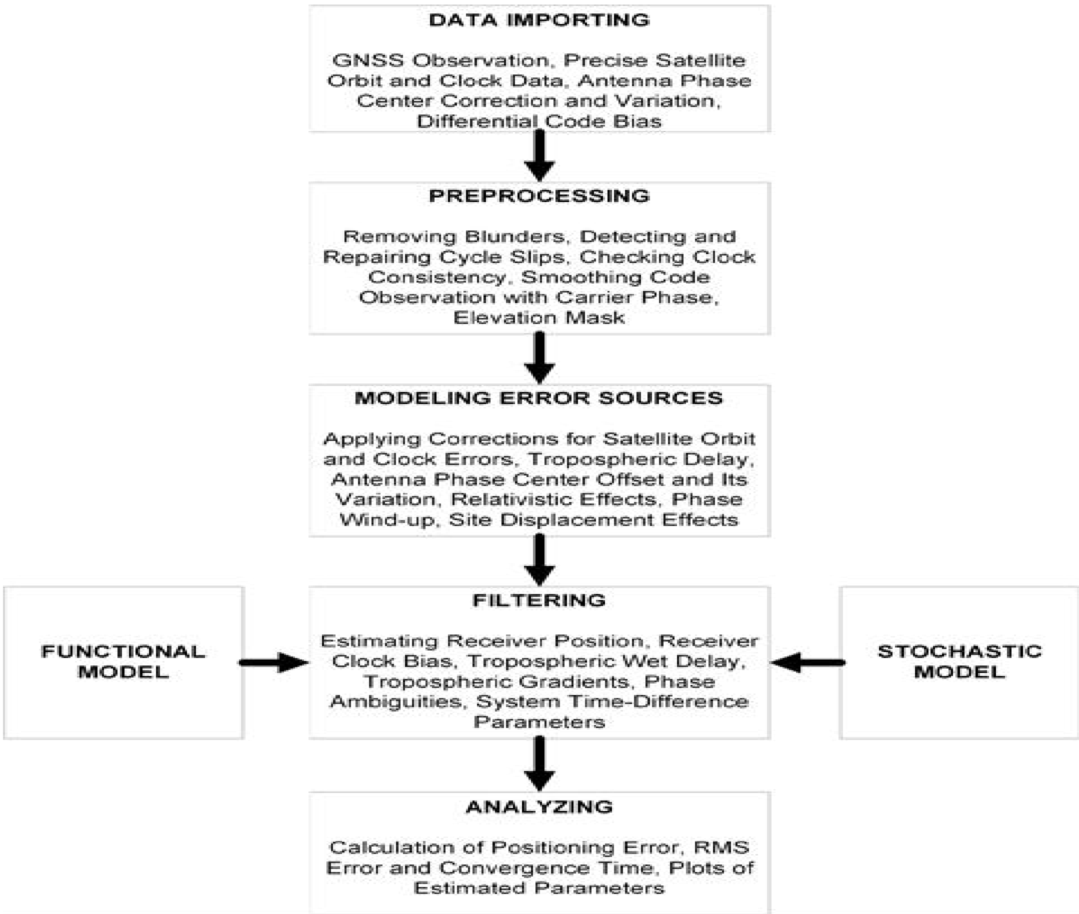
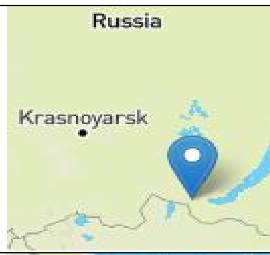


Figure 2. PPPH processing steps

After completing all process steps like in fig 2. The estimated values for each epoch are contained in the result file that PPPH offers. Furthermore, The GUI's Analysis option allows you to generate and process data like root mean square error, positioning error, and convergence time in related to user-defined ground truth. A broad range of charts, including those for tropospheric zenith total delay, positioning error, receiver clock estimation, satellite number, and dilution of precisions, can be generated with PPPH to assess the epoch-by-epoch differences in estimated parameters and their data. The IGS stations that are depicted in table 1 were included in our study.

Table 1. IGS station information

Station	receiver	Antenna	Location
ABMF	SEPTPOLARX5	TRM57971	
BADG	JAVADTRE-3	JAVRINGANT-DM	
DAEJ	TRIMBLENETR9	TRM59800	

3. Experimental tests

Station locations in the ITRF frame and ZTD values at the user station are supplied by the web PPP services. Analysis and assessments are carried out in order to assess the success of the products or services with respect to a variety of various variables. To assess the precision of static PPP for protracted observation periods, static positioning results through daily observation data sets from IGS sites are compared with IGS reference values. Analysis of PPP efficiency, precision and convergence for brief observation periods is done via contrasting static PPP processing outcomes for various short observation periods with standard values. We analyze the positioning error, zenith delay, and clock estimation for different solutions [10].

To contrast and evaluate the variations among software using the IGS reference values and the online PPP static solutions, the findings and reference data are determined. The charts and diagrams show the disparity and its root error in the mean square. In conclusion, it can be seen from Fig. 3 and 4, as well as Tables 2 and 3, that, when used with daily observation data sets, the precision of the (X, Y, Z) components can be measured to the centimeter and millimeter levels when compared to standard values. Regarding coordinate estimations, there isn't much of a difference between online PPP services and software; essentially all of them can get down to the centimeter or millimeter level.

4. Results and Discussions

Table 2. Difference in cartesian coordinates between reference stations and GPS only solutions using online and PPPH

STATION	coordinate	ON LINE			Software
		AUSPOS	IBGE	Magic GNSS	PPPH
ABMF	X	0.147	0.285	0.191	0.768
	Y	-0.001	0.087	-0.059	0.260

	Z	-0.911	-0.605	-0.894	-0.521
BADG	X	0.604	0.614	0.614	-0.138
	Y	0.050	0.012	0.010	1.824
	Z	0.114	0.072	0.086	2.001
DAEJ	X	0.405	0.381	0.299	0.187
	Y	0.038	0.022	0.009	0.846
	Z	0.249	0.176	0.278	1.179

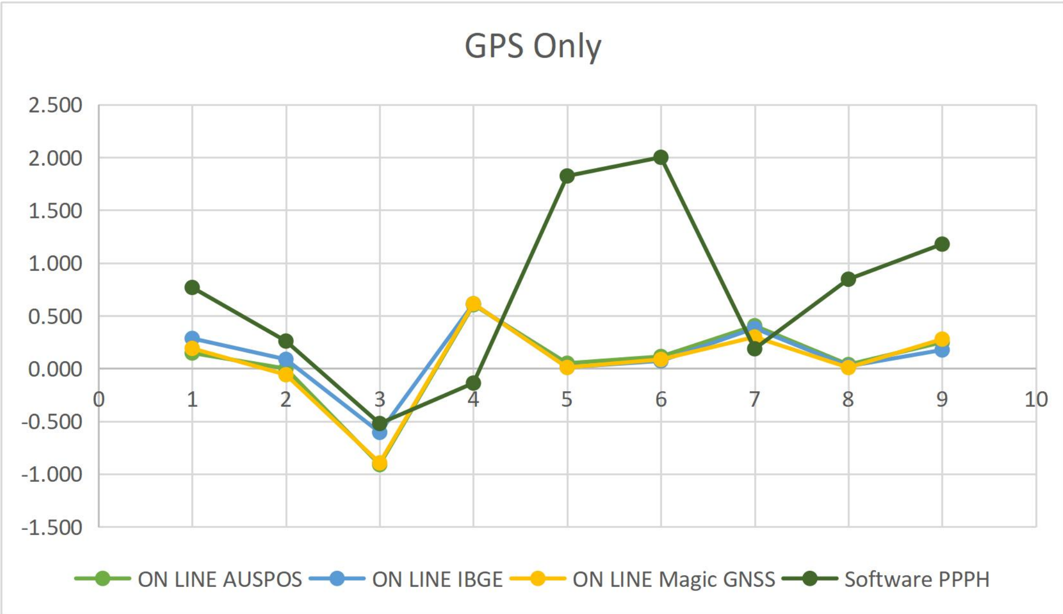


Figure 3. Difference in cartesian coordinates between reference stations and GPS only solutions using online and PPPH

Table 3. Difference in Cartesian coordinates between reference stations, online solutions and open-source software using GPS and GLONASS

STATION	coordinate	ON LINE		Software	
		CSRS -PPP	Magic GNSS	GSIPOST	PPPH
ABMF	X	0.18	0.199	-0.281	0.658
	Y	-0.032	-0.048	-0.756	0.21
	Z	-0.905	-0.877	-1.536	-0.299
BADG	X	0.612	0.613	-0.501	-0.13
	Y	0.018	0.016	2.156	2.034
	Z	0.074	0.088	1.183	2.004
DAEJ	X	0.325	0.422	0.327	0.180
	Y	0.048	0.049	0.014	0.785
	Z	0.388	0.249	0.988	1.219

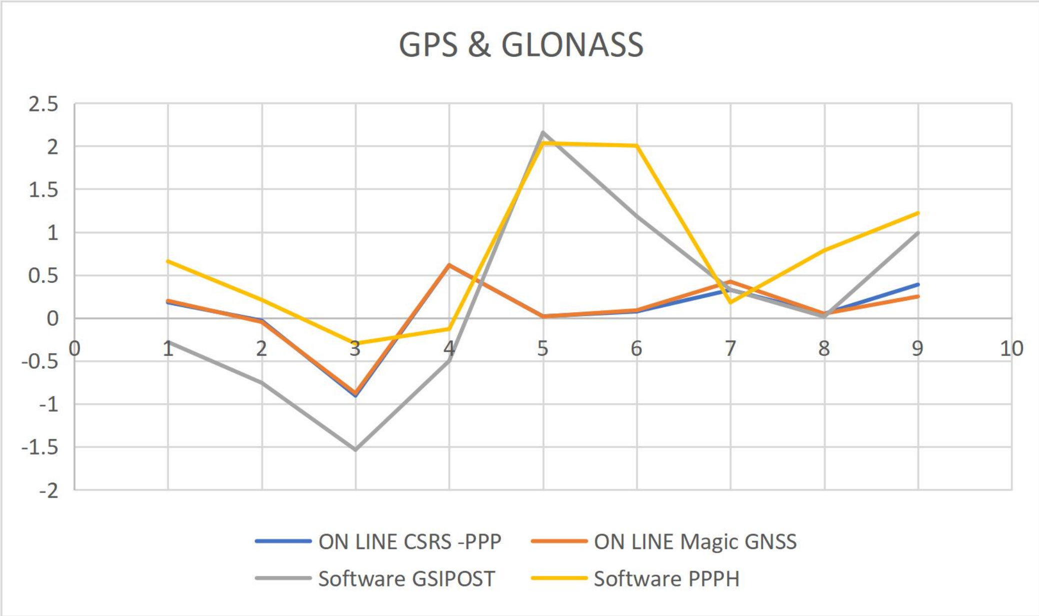


Figure 4. Difference in Cartesian coordinates between reference stations, online solutions and open-source software using GPS and GLONASS

A frequently employed metric for contrasting values derived from different groups of measurements is the RMSE. The RMSE combines these distinct variations, also referred to as residuals, into a single number for the extrapolative power. As a result, the square root of the mean squared error is employed for calculating the RMSE of the generated coordinates (which was obtained by GNSS software) when compared to the observed coordinates found with IGS reference station. With declining RMSE estimates, the 3D coordinates attained from the GNSS processing tools become more accurate. The RMSEs of the GNSS processing software are listed in the accompanying table [11].

Table 4 RMSEs of the GNSS processing software

GNSS Processing Software	GPS Only	GPS& GLONASS
AUSPOS (Online)	0.403	-
IBGE (Online)	0.336	-
Magic GNSS (Online)	0.393	0.400
CSRS -PPP (Online)	-	0.407
PPPH	1.076	1.075
GSIPOST	-	1.099

5. Conclusion

All of the free online PPP systems can deliver centimeter- or millimeter-level accuracy for a single location over an extended observation period when operating in static mode. In comparison to IGS solutions, online PPP services' daily horizontal component estimation accuracy can be millimeter-level.

Users of the free internet PPP services don't need to invest in software; positioning accuracy of centimeters or even millimeter level can be achieved with just a single receiver.

PPP options can be offered by software for customer multi-GNSS combinations. Within the software's GUI, users can also define choices, models, and parameters. additionally offers a number of analysis tools and an output file with the predicted parameters for each period individually so that the findings can be quantitatively evaluated. Additionally, it offers more PPP processing functionality than online options, and its powers can be expanded to effectively meet the needs of sophisticated users.

Online processing software outperforms PPP software in the X, Y, and Z directions with computed root mean square findings.

References

[1] Herbert, T., Ugochukwu, N. I., & Olatunji, R. I. (2020). Assessing the Accuracy of Online GNSS Processing Services and Commercial Software on Short Baselines. 9(2), 321–332.

[2] ÖĞÜTCÜ, S., SHAKOR, A., & FARHAN, H. (2021). Investigating the effect of observation interval on GPS, GLONASS, Galileo and BeiDou static PPP. International Journal of Engineering and Geosciences, March. https://doi.org/10.26833/ijeg.980148

[3] Wielgocka, N., Hadas, T., Kaczmarek, A., & Marut, G. (2021). Feasibility of using low-cost dual-frequency gnss receivers for land surveying. Sensors, 21(6), 1–14. https://doi.org/10.3390/s21061956

[4] Dao, T., Harima, K., Carter, B., Currie, J., McClusky, S., Brown, R., Rubinov, E., & Choy, S. (2022). Regional Ionospheric Corrections for High Accuracy GNSS Positioning. Remote Sensing, 14(10), 2463. https://doi.org/10.3390/rs14102463

[5] Alkan, R. M., & Ozulu, I. M. (2016). Web - based GNSS Data Processing Services as an Alternative to Conventional Processing Technique Web-based GNSS Data Processing Services as an Alternative to Conventional Processing Technique (8270) Reha Metin Alkan , Veli Ilci and I . Murat Ozulu (Tur. May, 2–6.

[6] Sayer, K. (2011). A Practical Guide to Financial A Practical Guide to Financial. March, 73–86.

[7] Oluyori, P. D., Ono, M. N., & Eteje, S. O. (2019). Comparison of OPUS, CSRS-PPP and magicGNSS Online Post-processing Software of DGPS Observations for Geometric Geoid Modelling in FCT, Abuja. FIG Working Week, 1(1). https://doi.org/10.5281/zenodo.2642571

[8] Abdallah, A. T., & Schwieger, V. (2016). Performance of IGS Final Satellite Data for Kinematic Applications Using BENESE GNSS Software and CSRS-PPP Online Service. April.

[9] Bahadur, B., & Nohutcu, M. (2018). PPPH: a MATLAB-based software for multi-GNSS precise point positioning analysis. GPS Solutions, 22(4), 1–10. https://doi.org/10.1007/s10291-018-0777-z

[10] Guo, Q. (2015). Precision comparison and analysis of four online free PPP services in static positioning and tropospheric delay estimation. GPS Solutions, 19(4), 537–544. https://doi.org/10.1007/s10291-014-0413-5

[11] Charoenkalunyuta, T., Satirapod, C., Lee, H. K., & Choi, Y. S. (2012). Performance of network-based RTK GPS in low-latitude region: A case study in Thailand. Engineering Journal, 16(5), 95–103. https://doi.org/10.4186/ej.2012.16.5.95