Intercontinental Geoinformation Days

http://igd.mersin.edu.tr/2020/

Comparison of Static PPP Performance of CSRS-PPP Float and Trimble RTX-PP Services

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Keywords
PPP
GNSS
Online GNSS Processing Services
CSRS-PPP
Trimble RTX-PP

ABSTRACT

Although various positioning methods are used in many engineering projects, Precise Point Positioning (PPP) technique, which enables more economical and accurate positioning, stands out among these positioning methods. The most important criteria affecting the positioning accuracy during the solution of the PPP are the quality of the precise satellite products, as well as the resolution of the phase ambiguity as fixed or float. The aim of the study is to test the static PPP performances of the online services under different satellite constellations as a function of occupation time. Within the scope of this study, PPP solutions were carried out with Canadian Spatial Reference System Precise-Point Positioning (CSRS-PPP) and Trimble CenterPoint Real Time eXtended Post-Processing (Trimble RTX-PP) web-based online GNSS processing services. The daily observations of the International GNSS Service (IGS) stations ANKR, ISTA, IZMI, MERS and KRS1, which are in Turkey, dated January 1, 2020 were used. The daily observations were divided into 1, 2, 4, 8, and 12 hour sub-sessions, and each observation session was processed with the aforementioned services using GPS-only and combination of GPS and GLONASS satellites data. As a result of the solutions, it has been shown that although CSRS-PPP provides PPP float solution, it offers a better solution than the Trimble RTX-PP, but still these two online tools were suitable for applications that require centimeter accuracy. Regarding the occupation time, the study revealed that at least 2 hours of observation period was necessary to determine the horizontal position and height with a few cm accuracies. Besides GPS and GLONASS combined PPP solutions provided more accurate results than GPS-only solutions.

1. INTRODUCTION

Precision Point Positioning (PPP) is a technique that makes it possible to determine centimeter-level accuracy with only single GNSS receiver without the need for any reference station data. In this method, GNSS observations with only single receiver are processed with the precise satellite orbits and clocks data produced by global or regional analysis centers to determine high accurate static or kinematic positioning. Although PPP was introduced by J. Anderle in the 1970s, developments in positioning systems such as web-based online data processing services, multi-GNSS and precise clock and orbit data, made it possible to produce high accurate positional information with economical and easier way. PPP is widely used in many applications including surveying, mapping, landslide monitoring, crustal movements monitoring, establishing early warning systems, glacial movements monitoring, agriculture, structural deformation monitoring, marine survey, photogrammetric studies and UAV measurements and so on.

There are various type of PPP processing software and web-based online services are available, but in this study, Canadian Spatial Reference System Precise-Point Positioning (CSRS-PPP) and Trimble CenterPoint Real Time eXtended Post-Processing (Trimble RTX-PP) services were used. In order to understand the effect of multi-GNSS and occupation time on static PPP performance, GPS-only and GPS&GLONASS combination, with different observation time, were processed in the study.

2. WEB-BASED PPP SERVICES

PPP's current form was defined by Zumberge et al. in 1997, although it was first put forward by Anderle (1976). Since then, the PPP technique has been used successfully in many different scientific and practical

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Cite this study

Mutlu B., Erol S. & Alkan R. M. (2020). Comparison of Static PPP Performance of CSRS-PPP Float and Trimble RTX-PP Services. Intercontinental Geoinformation Days (IGD), 173-176, Mersin, Turkey

applications all over the world. (Zumberge et al. 1997; Héroux and Kouba 2001; Choy, et al. 2017; Kiliszek et al. 2018; DeSanto et al. 2019; Katsigianni et al. 2019; Dawidowicz 2020; Facio and Berber 2020).

Nowadays, there are various web-based GNSS processing services operated by different organizations, institutes and research centers. The main advantages of web-based GNSS services are that they are free, accurate and easy to use. It does not require any additional software or specific features on the computer. Besides the PPP services work without the need for data from any reference station (Bahadur and Üstün 2014). Many scientific articles have revealed that the web-based online services provided cm to dm level of accuracy mainly depend on the type of used data, precise products, occupation time and observation conditions (Alkan et al. 2020; İnyurt and Ulukavak 2020). In this study, the PPP solutions were performed by using the CSRS-PPP and Trimble RTX-PP services, which use different precise products and ambiguity solution types.

2.1. Canadian Spatial Reference System-Precise Point Positioning (CSRS-PPP)

The CSRS-PPP service operated by Natural Resources Canada (NRCan) has been providing static and kinematic multi-GNSS PPP solutions to all users around the world since 2003. It is a web-based online service that allows the user to easily make a PPP solution even without a GNSS data processing background (Klatt and Johnson 2017). The service process the single/dual-frequency GPS or GPS&GLONASS data using the best available precise satellite orbit and clock products (ultra-rapid, rapid or final) produced by IGS or NRCan and calculates PPP coordinates as static or kinematic. CSRS-PPP service has provided solutions based on ambiguity-float until October 20, 2020. After this date, started to offer ambiguity-fixed solutions. In this study, the solutions were obtained as ambiguity-float because it was processed before October 2020.

2.2. Trimble CenterPoint RTX Post-Processing Service (Trimble RTX-PP)

The Trimble RTX-PP service that was operated by Trimble Inc., enables free processing of the multi-GNSS data collected in only static mode. RTX-PP service calculates the PPP coordinates of the points with the ambiguity-fixed solution. This situation significantly shortens the convergence time. The service uses its own precise products (Doucet et al. 2012).

3. CASE STUDY

In this study, ANKR, ISTA, IZMI, KRS1 and MERS stations, which included in IGS Network were used. All stations are located within the borders of Turkey (Fig. 1). Observation files were obtained from EUREF Permanent GNSS Network website.

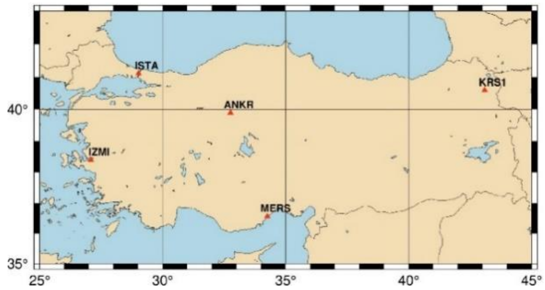

Figure 1. Distribution of used stations on the map. (Wessel et al. 2019)

The daily observation data at 1st day of 2020 (GPS Day 1) for all IGS stations in Turkey were split into different shorter sessions as 1, 2, 4, 8 and 12 hours with respect to satellite systems as GPS-only and GPS&GLONASS (Fig. 2). For this purpose, the GFZRNX software was used (Nischan 2016).

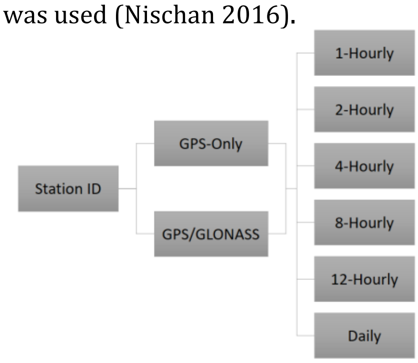

Figure 2. File hierarchy of the used data sessions

All the 24 hourly and 1, 2, 4, 8 and 12-hour sub-session RINEX data files were uploaded to the online services. After a short time, the PPP-derived coordinates were retrieved via e-mail. In the results, there were no solutions for some epochs of ANKR station, because the number of tracked GPS satellites from the station was limited for each epoch. So that, ANKR station was not taken into consideration in this study. Statistics for the number of satellites and mean PDOP values were emphasized in Table 1.

Table 1. The number of used satellites and DOP values.

Station ID	GPS-Only				GPS&GLONASS			
	Min.	Mean	Max.	PDOP	Min.	Mean	Max.	PDOP
ANKR	5	6	8	8.4	9	13	17	2.1
ISTA	10	12	14	1.8	18	21	25	1.3
IZMI	10	12	14	1.8	17	19	22	1.4
KRS1	10	12	14	1.7	16	20	23	1.3
MERS	10	12	15	1.8	19	22	26	1.3

3.1. GPS-Only Results

The static PPP-derived coordinates obtained from CSRS-PPP and Trimble RTX-PP services were compared with the reference (known) coordinates of the IGS station. Calculated horizontal (2D) and height difference values are given in Fig. 3 and Fig. 4 for each station, considering the observation time and the used service.

Figure 3. 2D positional differences between known-coordinates and online services for GPS only constellation (*left*; CSRS-PPP, *right*: Trimble RTX-PP).

Figure 4. Height differences between known-coordinates and online services for GPS only constellation (*left*; CSRS-PPP, *right*: Trimble RTX-PP).

3.2. GPS&GLONASS Combined Results

The PPP-derived coordinates by processing of the GPS&GLONASS GNSS data were compare to the known values and the differences were plotted. The calculated horizontal (2D) and height differences are given in Fig. 5 and Fig. 6 for each station considering the observation time and the used service.

Figure 5. 2D positional differences between known-coordinates and online services for GPS&GLONASS combination (*left*; CSRS-PPP, *right*: Trimble RTX-PP).

Figure 6. Height differences between known-coordinates and online services for GPS&GLONASS combination (*left*; CSRS-PPP, *right*: Trimble RTX-PP).

4. DISCUSSION

In this study, GPS-only and GPS&GLONASS combined observations with different observation time interval were evaluated by using CSRS-PPP and Trimble RTX-PP online services. The differences between the obtained coordinates and reference coordinates are given in the Fig. 3-6.

It has been observed that the number of GPS&GLONASS satellites is higher than GPS-only and accordingly DOP values have improved. Consequently, significant improvements have been achieved in the solutions of GPS&GLONASS data groups in both 2D position and height components when compared to GPS-only solutions. With the observation time of 1 hour, it is possible to obtain differences below the decimeter. In the 2-hour GPS-only data groups, with some exceptions, the differences were below 4 cm in both 2D and height components for both services. Besides, in 2-hour GPS&GLONASS data groups, the differences were below 2.5 cm for both two components and two services, with some exceptions. According to using GPS-only and GPS&GLONASS constellations with both services, the differences in horizontal position and height were decreased from 2 cm to 1-2 mm in the 4, 8, 12 and 24-hour data groups, respectively. Although CSRS-PPP performs an ambiguity-float solution, its accuracy was found higher than Trimble RTX-PP. The reason for this is considered to be that CSRS-PPP uses IGS final precise products, while the Trimble RTX-PP uses its own precise products.

5. CONCLUSION

This study has investigated the performance of static Precise Point Positioning (PPP) using different GNSS constellations with different online processing services. As a result of the processing results, the CSRS-PPP service was provided better performance than the Trimble RTX-PP service, although the differences between the services were not significant. Within the scope of any project where accuracy under decimeter is sought, the 1-hour observation time obtained from the combination of GPS&GLONASS is sufficient for both CSRS-PPP and Trimble RTX-PP web-based services. In cases where an accuracy of a few centimeters is required, observation should be made for at least 2 hours or more.

As a conclusion, it is emphasized that any projects requiring centimeter-level accuracy can be conducted by using PPP technique very easy and economically.

ACKNOWLEDGEMENT

The authors thank CSRS-PPP and Trimble RTX-PP web-based online GNSS PPP services.

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