Analysis of the Static Positioning Performance of CSRS-PPP Service

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SUMMARY

In the last decade, the use of Global Navigation Satellite System (GNSS) has been drastically increased with the development of the new GNSS systems and algorithms. The Precise Point Positioning (PPP) method has become more ubiquitous since it eliminates the reference station requirement. When 24-hourly GNSS data is used, the PPP method offers high integrity results. Further, GNSS data processing has become easier with the online services such as CSRS-PPP (The Canadian Spatial Reference System-PPP). Besides, the CSRS-PPP service had been modernized in October 2020. This modernization allowed users to process GNSS data with ambiguity resolution (AR). The PPP with ambiguity resolution (PPP-AR) method can provide more stable positioning accuracies. In this study, static positioning performance of modernized CSRS-PPP service was examined. For this purpose, 24-hourly data of 5 IGS (International GNSS Service) station for one week period was used. The dataset was processed before and after the modernization of CSRS-PPP. The results were investigated in terms of positioning accuracy.

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1. INTRODUCTION

Many advances have been made regarding the Global Navigation Satellite System (GNSS) recently, including instruments and algorithms. The Precise Point Positioning (PPP) method is one of the most recent algorithms and allows users to estimate precise positions using a standalone receiver (Zumberge et al. 1997; Kouba and Héroux 2001). When 24-hour GNSS data is used, the PPP method can provide millimeter level accuracy. Even though many software packages are developed offering PPP option such as Bernese, GipsyX, and PRIDE-PPPAR, the use of them requires profession in this field (Dach 2015; Bertiger et al. 2020; Geng et al. 2019). Today, GNSS data processing has become easier with online services such as CSRS-PPP (The Canadian Spatial Reference System-PPP). CSRS-PPP is an online PPP processing software developed by NRCan in Canada. It is free to use, and users only register with a valid e-mail address in order to receive the results (URL-1). The web interface of CSRS-PPP service is shown in Figure 1. The NRCan keeps up to date the software by performing minor/ major improvements or bug fixing (URL-2).

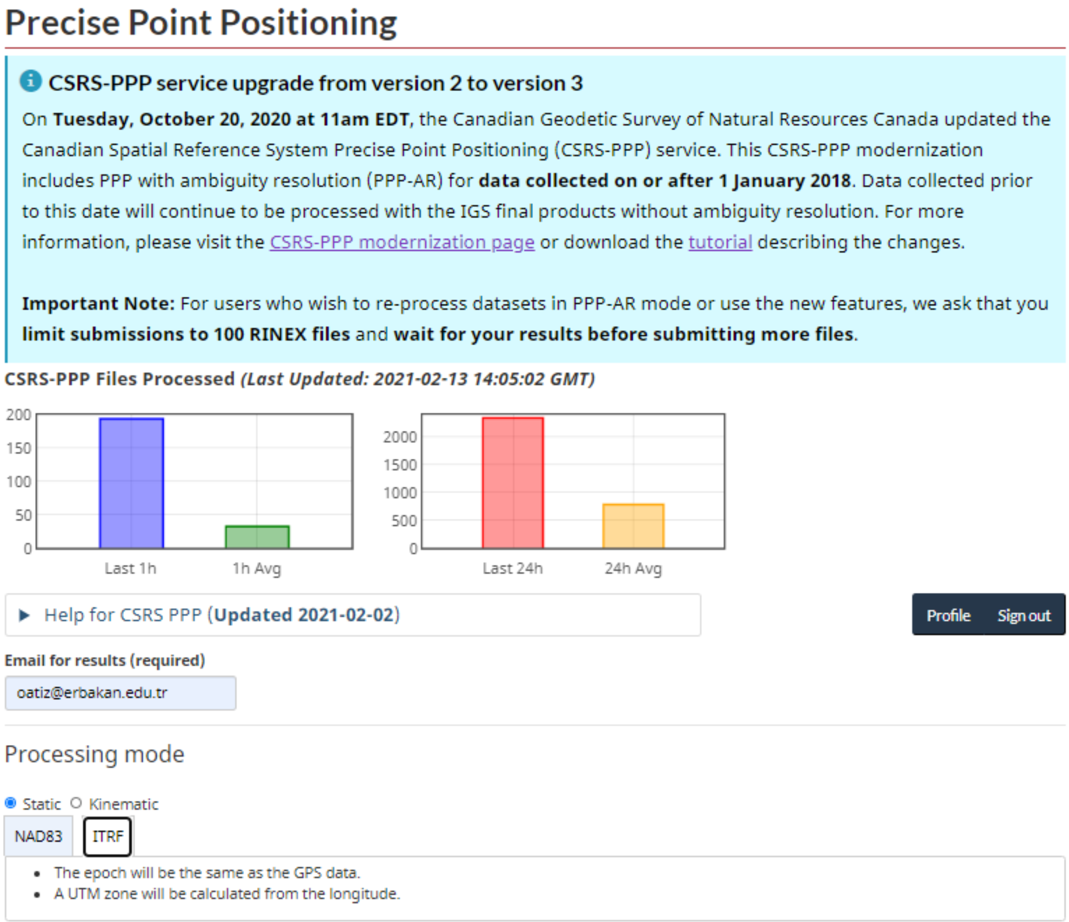

Figure 1. The web interface of CSRS-PPP service

The latest version updated in October 2020, was a major change related to PPP engine since they implemented the ambiguity resolution (AR) (Banville 2020). The ambiguity resolved PPP can offer a more stable solution in terms of accuracy. Although some software packages already support the AR, the modernized CSRS-PPP is the first online PPP service to implement AR. In particular, the unmodeled satellite hardware delays are preventing AR in PPP (Goudarzi and Banville 2018). Hence, the ambiguity resolution in PPP needs additional phase-clock bias products. CSRS-PPP becomes very beneficial since the users only upload observation files. Considering the online data processing services are more practical for regular users, it is worth testing the new CSRS-PPP software. Therefore, in this study, the latest static positioning performance of CSRS-PPP service was investigated. For this purpose, before and after the modernization of CSRS-PPP, a consecutive one-week data belonging to the 5 IGS (International GNSS Service) stations was processed. In addition, the contribution of AR to the PPP solution was analyzed. The results were evaluated in terms of positioning accuracy.

2. DATA AND PROCESSING STRATEGY

For the purpose of analyzing the static positioning performance of the modernized CSRS-PPP service, 5 globally distributed IGS stations were chosen. The DOY 328-334 of the year 2019 was chosen, considering the data availability -over %90 for each RINEX file-. The location of selected IGS stations is provided in Figure 2.

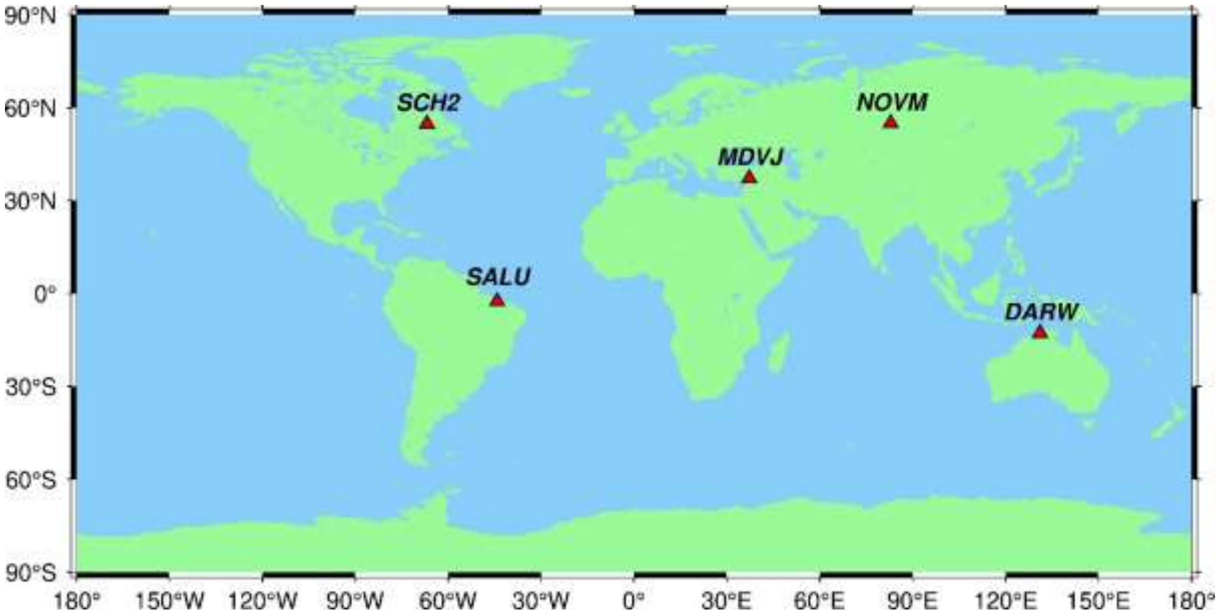

Figure 2. The location of selected IGS stations

The data processing step was carried out in two steps: before the modernization of CSRS-PPP and after the modernization of CSRS-PPP, namely PPP and PPP-AR. The processing parameters for PPP and PPP-AR options are summarized in Table 1.

Table 1. The summary of CSRS-PPP processing parameters

Parameter	PPP	PPP-AR
Constellation	GPS	GPS
Version	2.31.0	3.45.0
Processing mode	Static	Static
Epoch interval	30 s	30 s
Elevation cut-off angle	7.5°	7.5°
Observations	Phase and code	Phase and code
Frequencies	C1W; C2W; L1W; L2W	C1W; C2W; L1W; L2W
Precise products	IGS Final	NRCan/IGS Final
Phase ambiguities	Float	Fixed using the Decoupled Clock Model (Collins et al. 2010)
Reference frame	ITRF2014	ITRF2014
Antenna phase center	Corrected.	Corrected.
Troposphere estimation	Zenith total delay (ZTD)	Zenith total delay (ZTD)

In addition, IGS weekly combined solutions were used as ground truth coordinates to compare both CSRS-PPP solutions. Although CSRS-PPP supports GPS and GLONASS satellites, only GPS satellites were considered since the current version of CSRS-PPP does not apply AR for GLONASS.

3. RESULTS AND DISCUSSION

The cartesian coordinate values of each station were obtained with CSRS-PPP online service. The obtained results were converted to the topocentric coordinate system, which can be defined as north, east, and up components, whereas these components can also be used for accuracy assessment. As stated above, IGS weekly combined solutions were used as the reference for topocentric conversion. The root mean square (RMS) errors for each station were computed. For the sake of simplicity, only the RMS errors for ambiguity-float (PPP) solution is provided in Table 2.

Table 2. The RMS errors of PPP solution

Station	North (mm)	East (mm)	Up (mm)
DARW	1.67	3.54	11.13
MDVJ	1.31	2.67	8.66
NOVM	1.43	7.12	3.26
SALU	2.98	2.00	3.42
SCH2	1.06	3.92	7.03

As shown in Table 2, the accuracy of the horizontal component is approximately a few millimeters. However, the accuracy of the vertical component is slightly greater than the vertical component. When performing an ambiguity resolution, the ambiguity fixing rates become crucial. Thus, the average of integer ambiguity resolution percentages of PPP-AR solutions for each station is given in Table 3.

Table 3. The average AR percentages

Station	Integer ambiguity resolution (%)
DARW	%95.13
MDVJ	%98.62
NOVM	%96.54
SALU	%91.88
SCH2	%98.14

Table 3 indicates that over %90 of the phase ambiguities was fixed. The contribution of AR to PPP is computed by means of RMS error improvement. Therefore, the average improvement of the horizontal component for each station is shown in Figure 3.

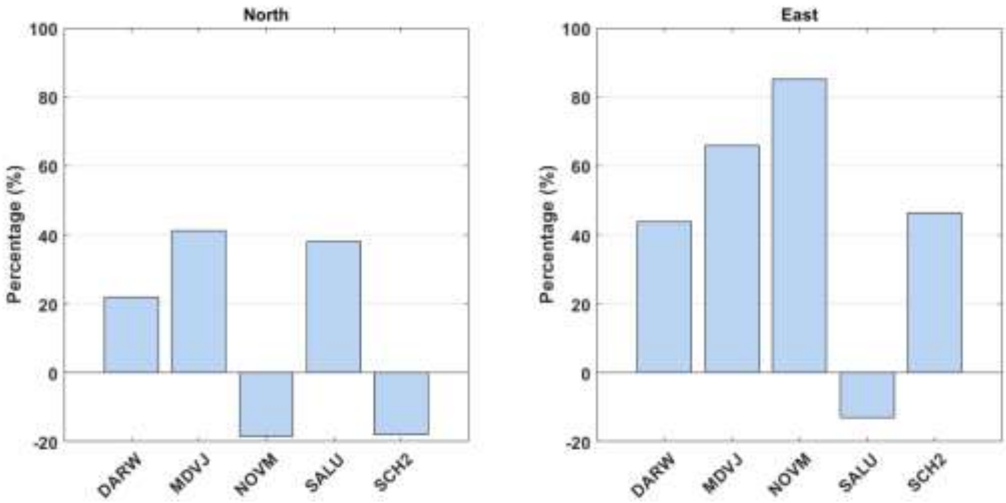

Figure 3. The average improvements for the horizontal component

For the north component, the maximum contribution of AR is %41.3 at the MDVJ station. Also, AR degraded the accuracy %18.4 and %18.0 for NOVM and SCH2 stations, respectively. The improvement for the east component is quite larger than the north component. The maximum improvement in the north component is at NOVM with 85.0%. According to Figure 3, AR improved the NOVM, MDVJ, SCH2 and DARW solutions of the east component significantly. In the same way, the average improvements for the vertical component are given in Figure 4.

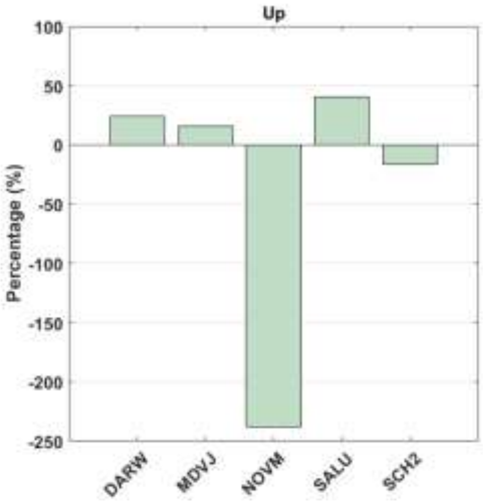

Figure 4. The average improvements for the vertical component

According to Figure 4, the maximum improvement is at the SALU station with %40.4. However, the accuracy at the NOVM station is remarkably decreased. Nevertheless, the result of DARW, MDVJ, and SALU stations significantly improved by AR.

4. CONCLUSIONS

This study investigates the static positioning performance of the modernized CSRS-PPP online GNSS data processing software which includes AR, since October 2020. For this purpose, the same dataset was processed before and after modernization. The results demonstrate that millimeter level accuracy can be obtained with the previous version of CSRS-PPP. However, the new software with AR improved the results for the east component significantly. Moreover, the improvement in the east component slightly better than the north and up components. According to the results of this study, it can be concluded that the users who want to benefit from AR on PPP can easily use version 3 of CSRS-PPP.

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