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Comparison of web based online GNSS data evaluation services

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Abstract

RINEX - Receiver Independent Exchange Format is a data exchange format for raw GNSS data. The first RINEX version was developed in 1989 by W. Gurtner (Teunissen and Montenbruck 2017). In parallel with the GNSS concept, versions such as RINEX 2.XX, RINEX 3.XX, RINEX 4.XX have been developed. There are different methods for processing RINEX data. These methods are classical GNSS data evaluation software and web-based online data evaluation services as an alternative to this software. In the study, different web-based online evaluation services will be compared and their usability in measurement applications will be examined. Online services using PPP (Precise Point Positioning) and relative technique will be used to evaluate the data. 30 seconds of RINEX data obtained from a point belonging to the CORS-TR network will be sent to different web-based online GNSS evaluation services and the services will be evaluated by comparing the coordinate values from these services.

1. Introduction

The global positioning system (GNSS) provides great convenience in scientific studies thanks to the data it provides. Satellite-based positioning systems can instantly determine the coordinates of the location with precision. These systems are generally used for navigation, surveying, geodetic measurements, determination of earth crust movements, earthquake studies, etc. extensively used in areas such as (URL1 2023). Satellite-based positioning system consisting of GPS (Global Positioning System), initially operated only by the United States; With the activation of different satellite-based systems such as Russia's GLONASS, China's COMPASS, Japan's QZSS, European Union's Galileo and India's IRNSS, a large global positioning system called GNSS (Global Navigation Satellite System) became like that (Alkan et al. 2017). Some time ago, simultaneous measurements had to be made using at least two receivers, the first of which was a reference, in order to determine the position with centimeter accuracy. In this method, which is called the relative technique and applied based on phase measurements, a data evaluation software was needed to determine the coordinates. Today, with the widespread use of systems called CORS (Continuously Operating Reference Station) and Network RTK, which emerged with the addition of RTK (Real Time Kinematic) feature to networks consisting of fixed stations that make continuous GNSS observations, users' need for a fixed receiver has largely disappeared (Alkan, Ozulu, and İlçi 2017).

Sensitive satellite orbit and clock information with different accuracy levels is produced by many organizations, especially the International GNSS Service (IGS), and presented to the users. With these data; With the application of corrections such as carrier wave phase rotation, satellite antenna phase center, solid earth tides and ocean loading, another technique that allows determination of bias with an accuracy that will be sufficient for many measurement applications is PPP (Precise Point Positioning) (Alkan et al. 2017). With the PPP technique, it is possible to determine the position kinematically or statically with centimeter accuracy (Xiaohong, Jiahuan, and Xiaodong 2020). GNSS evaluation software should be used for PPP and Relative position determination. There are commercial and scientific software for GNSS evaluation. Most of this software require a license fee. At this point, online GNSS evaluation services, which are available for free, are very useful and useful. These services evaluate on the basis of PPP or relative technique. When looking at online GNSS services, services using relative techniques such as AUSPOS, OPUS; There are services that use PPP (Precise Point Positioning) technique such as APPS, CSRS-PPP. A point data of the CORS-TR network was sent to these GNSS evaluation services and the coordinates obtained

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from the services were compared. The advantages of these services compared to each other are examined and the results are presented.

2. Method

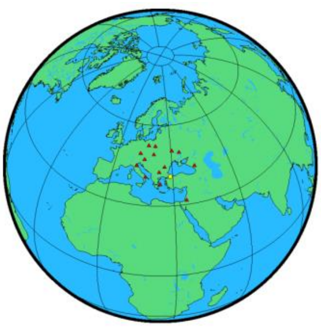
RINEX data obtained from BOL1, ERZ2, ISTN, TOK1 TUSAGA-Active points were sent to OPUS and AUSPOS using relative technique, APPS and CSRS-PPP using PPP (Precise Point Positioning) technique, and the obtained coordinate values were examined. Precision Point Positioning is a positioning technique that uses widely and easily available GNSS orbit and clock corrections. The PPP technique is different from the differential GNSS positioning technique. Because differential techniques require access to observations of one or more reference stations whose coordinates are known (Grinter and Roberts 2011). PPP technique generally has simplified operational logistics as well as a reduction in labor and equipment costs (Gao 2006).

2.1. OPUS

NOAA's Online Positioning User Service (OPUS) provides free access to high-accuracy National Spatial Reference System (NSRS) coordinates. OPUS uses the same software which computes coordinates for the nation's geodetic control marks and the NOAA CORS Network (NCN). Under normal conditions, most positions can be computed to within a few centimeters. However, estimating the accuracy for a specific solution is difficult because formal error propagation is notoriously optimistic for GPS reductions. User errors (such as misidentification of antenna or ARP height) cannot be detected. Local multipath or adverse atmospheric conditions may also negatively impact your solution (URL3 2023). The RINEX file is loaded for processing. Antenna type, antenna height and e-mail address are entered and sent for analysis.

2.2. AUSPOS

Geoscience Australia's online GPS processing service AUSPOS analyzes RINEX data using the relative technique. The system can be used without being a member. A maximum of 20 RINEX data can be loaded at one time. The system determines the antenna type and height by scanning automatically with the scan button. The AUSPOS outputs for the ISTN point are presented in Figure 1-4.



Date	User Stations	Reference Stations	Orbit Type
2023/03/13 00:00:00	ISTN	BOR1 BUCU DRAG DYNG GANP GLSV GRAZ JOZ2 MAT1 MEDI POLV SOFI WTZR ZECK	IGS final

Figure 1. AUSPOS processing summary (ISTN)

Station	X (m)	Y (m)	Z (m)	ITRF2014 @
ISTN	4223660.665	2325015.261	4161716.362	13/03/2023
BOR1	3738358.146	1148173.996	5021815.926	13/03/2023
BUCU	4093760.543	2007794.121	4445130.150	13/03/2023
DRAG	4432980.279	3149432.340	3322110.803	13/03/2023
DYNG	4595220.042	2039434.214	3912625.874	13/03/2023
GANP	3929181.229	1455237.017	4793654.074	13/03/2023
GLSV	3512888.592	2068980.138	4888903.347	13/03/2023
GRAZ	4194423.507	1162703.019	4647245.604	13/03/2023
JOZ2	3664880.241	1409190.875	5009618.625	13/03/2023
MAT1	4641951.105	1393054.005	4133281.126	13/03/2023
MEDI	4461400.409	919593.924	4449504.973	13/03/2023
POLV	3411556.967	2348464.214	4834397.019	13/03/2023
SOFI	4319371.770	1868688.113	4292064.087	13/03/2023
WTZR	4075580.253	931854.107	4801568.310	13/03/2023
ZECK	3451174.305	3060335.696	4391955.810	13/03/2023

Figure 2. AUSPOS computed cartesian coordinates (ISTN)

Station	Longitude(East) (m)	Latitude(North) (m)	Ellipsoidal Height(Up) (m)
ISTN	0.004	0.003	0.008
BOR1	0.003	0.003	0.007
BUCU	0.003	0.003	0.006
DRAG	0.004	0.003	0.008
DYNG	0.003	0.003	0.007
GANP	0.003	0.003	0.007
GLSV	0.003	0.003	0.007
GRAZ	0.003	0.003	0.007
JOZ2	0.003	0.003	0.007
MAT1	0.004	0.003	0.007
MEDI	0.003	0.003	0.007
POLV	0.003	0.003	0.007
SOFI	0.003	0.003	0.007
WTZR	0.003	0.003	0.007
ZECK	0.004	0.003	0.007

Figure 3. AUSPOS positional uncertainty (95% C.L.) (ISTN)

Baseline	Ambiguities Resolved	Baseline Length (km)
JOZ2 - POLV	82.8 %	988.489
GLSV - JOZ2	88.1 %	687.747
BOR1 - JOZ2	87.5 %	271.436
POLV - ZECK	84.6 %	839.098
GRAZ - MEDI	85.9 %	411.680
GRAZ - JOZ2	93.0 %	687.377
BUCU - DYNG	98.0 %	732.136
BUCU - JOZ2	92.7 %	927.853
BUCU - SOFI	70.2 %	306.072
DRAG - DYNG	77.9 %	1267.725
JOZ2 - WTZR	85.0 %	663.182
BUCU - MAT1	71.9 %	880.720
BUCU - ISTN	83.6 %	444.777
GANP - JOZ2	94.8 %	344.407
AVERAGE	85.4%	675.193

Figure 4. AUSPOS ambiguity resolution - per baseline (ISTN)

2.3. CSRS-PPP

CSRS-PPP is an online application for post-processing of global navigation satellite systems (GNSS) data. It uses precise satellite orbit, clock and yaw corrections derived from a global network of receivers to determine accurate user positions anywhere in the world, regardless of proximity to reference stations. It can be processed statically and kinematically. RINEX data can be processed in zip format, with a maximum of 300 MB. The data is processed in a very short time and sent to the e-mail address you entered. The processed RINEX data is sent to the e-mail address entered in the system in zip format. The zip file sent contains clk, pdf, csv, pos, sum and tro formatted files.

- **SUM File:** Contains the parameters and the results of the PPP processing.
- **POS File:** Contains the positioning information for each epoch processed.

- **CSV File:** A comma-separated (.csv) format text file containing the positioning and clock information for each epoch processed.
- **TRO File:** Contains dry and wet zenith path delay and tropospheric gradient for each epoch processed.
- **CLK File:** A RINEX_CLOCK format file containing the receiver clock offset and the clock offset sigma (95%) for each epoch processed (URL-2, 2023).

CSRS-PPP service ISTN point outputs are presented in Table 1, Figure 5, Figure 6, Figure 7, Figure 8, Figure 9 and Figure 10.

Table 1. CSRS-PPP mode, frequency and product type

Point	Mode	Frequency	Product Type
BOL1	Static	Double	NRCan/IGS Final
ERZ2	Static	Double	NRCan/IGS Final
ISTN	Static	Double	NRCan/IGS Final
TOK1	Static	Double	NRCan/IGS Final

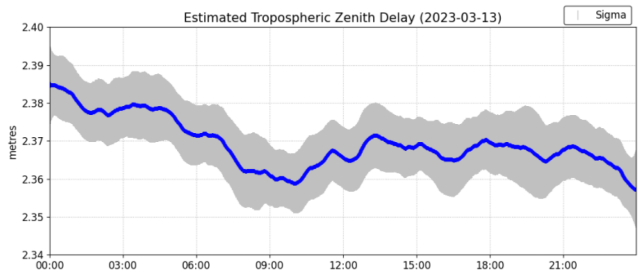


Figure 5. CSRS-PPP estimated tropospheric zenith delay (ISTN)

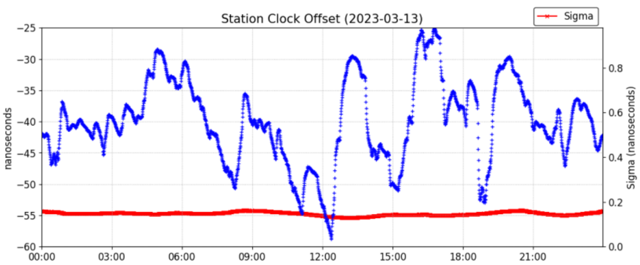


Figure 6. CSRS-PPP station clock offset (ISTN)

2.4. APPS

APPS accepts GPS measurement files, and applies the most advanced GPS positioning technology from NASA's Jet Propulsion Laboratory to estimate the position of your GPS receivers, whether they are static, in motion, on the ground, or in the air. APPS employs:

- Real-time GPS orbit and clock products from JPL's GDGPS System
- JPL's daily and weekly precise GPS orbit and clock products
- JPL's GipsyX/RTGx software for processing the GPS measurements (URL4 2023).

In order to use the APPS service, you must be a member of the service. After the RINEX file is uploaded, results can be obtained in a short time.

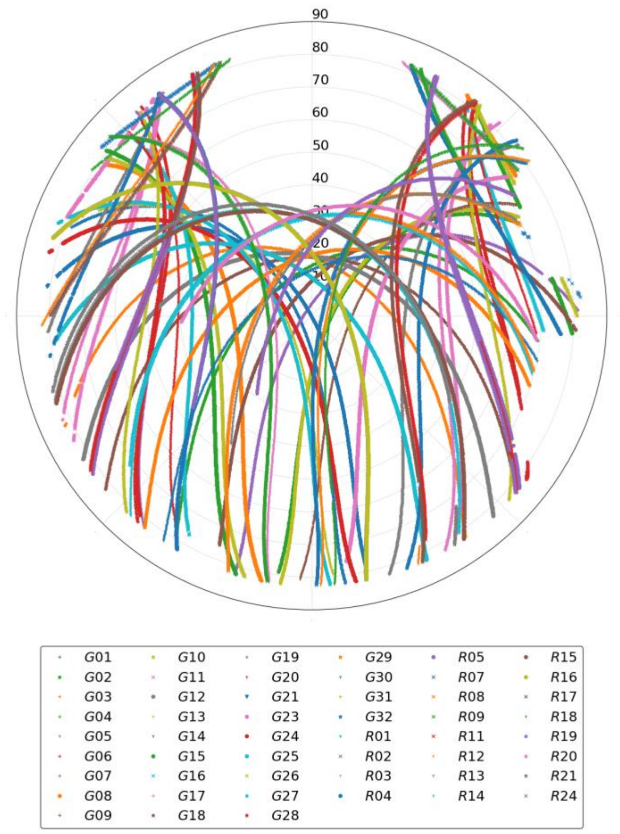


Figure 7. CSRS-PPP satellite sky distribution (ISTN)

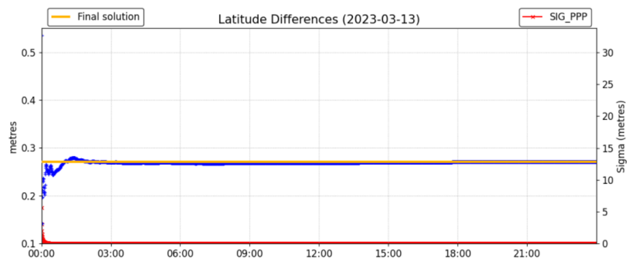


Figure 8. CSRS-PPP latitude differences (ISTN)

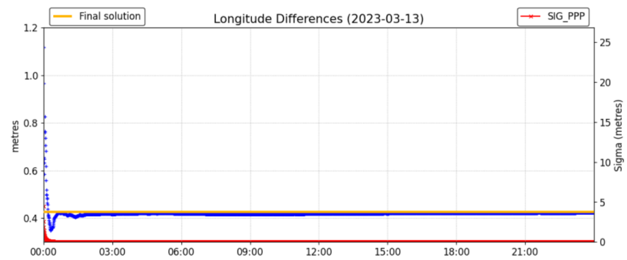


Figure 9. CSRS-PPP longitude differences (ISTN)

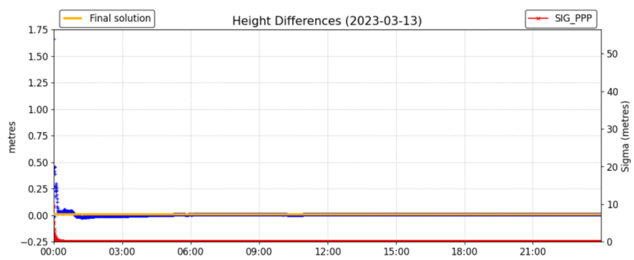


Figure 10. CSRS-PPP height differences (ISTN)

3. Results

RINEX data obtained from four CORS-TR points were sent to online GNSS evaluation services and the results in Table 2, Table 3, Table 4 and Table 5 were obtained.

Table 2. BOL1 estimated coordinates

Service	X (m)	Y (m)	Z (m)
OPUS	no solution	no solution	no solution
AUSPOS	4121753.605	2536363.599	4141652.664
CSRS-PPP	4121753.621	2536363.605	4141652.677
APPS	4121753.610	2536363.601	4141652.673

Table 3. ERZ2 estimated coordinates

Service	X (m)	Y (m)	Z (m)
OPUS	3781453.138	3139093.189	4054003.001
AUSPOS	3781453.138	3139093.193	4054003.003
CSRS-PPP	3781453.153	3139093.201	4054003.009
APPS	3781453.146	3139093.196	4054003.010

Table 4. ISTN estimated coordinates

Service	X (m)	Y (m)	Z (m)
OPUS	4223660.668	2325015.259	4161716.366
AUSPOS	4223660.665	2325015.261	4161716.362
CSRS-PPP	4223660.681	2325015.268	4161716.373
APPS	4223660.674	2325015.268	4161716.370

Table 5. TOK1 estimated coordinates

Service	X (m)	Y (m)	Z (m)
OPUS	3911480.068	2900418.942	4106499.837
AUSPOS	3911480.059	2900418.934	4106499.825
CSRS-PPP	3911480.071	2900418.942	4106499.834
APPS	3911480.060	2900418.934	4106499.827

4. Discussion

It is seen that the results obtained from the online GNSS evaluation services give very close values to each other. It has been seen that CSRS-PPP service is ahead of other services in terms of ease of application, since RINEX data can be uploaded in multiple ways as zip files up to 300 MB. When the reports sent by the services are examined, it is seen that the CSRS-PPP service provides more detailed reports than other services. In general, online GNSS assessment services have been found to process RINEX data quite quickly and easily.

5. Conclusion

It can be considered as an economical and easy-to-apply alternative that online GNSS evaluation services can determine location without the need for any data other than that collected with the GNSS receiver.

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