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Analysis of GNSS Accuracy of Relative Positioning and Precise Positioning Based on Online Service

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Abstract: ***Nowadays, Global Positioning System (GPS) has been used effectively in several engineering applications for the survey purposes by multiple disciplines. Web-based online services developed by several organizations; which are user friendly, unlimited and most of them are free; have become a significant alternative against the high-cost scientific and commercial software on achievement of post processing and analyzing the GPS data. When centimeter (cm) or decimeter (dm) level accuracies are desired, that can be obtained easily regarding different quality engineering applications through these services. In this paper, a test study was conducted at EUROPE network; in order to figure out the accuracy analysis of the most used web based online services around the world (namely OPUS, AUSPOS, , CSRS-PPP, TRIMBLE RTX). These services use relative and precise point positioning (PPP) solution approaches. In this test study, the coordinates of fourteen IGS stations were estimated by using different online services and by The International Terrestrial Reference Frame (ITRF) web site which it taken as a reference from 24-hour GPS data in 1/1/2015 set and then the coordinate differences between the online services solution and the International Terrestrial Reference Frame ITRF result. From the evaluations, it was seen that the results for each individual differences were less than 12 mm regarding relative online service, and less than 31 mm regarding precise point positioning service. The accuracy analysis was gathered from these coordinate differences and standard deviations of the obtained coordinates from different techniques and then online services were compared to each other. The results show that the position accuracies obtained by associated online services provide high accurate solutions that may be used in many engineering applications and geodetic analysis. In conclusion, web-based online services are able to produce final coordinates at the accuracy of a few millimeters to centimeters and they can be applied for geodetic application and analyses.***

Keywords: GPS; Precise Point Positioning (PPP); Post-Processing; Relative Positioning; Web-Based Online Services

1. Introduction

In order to process GPS data and analyze of them, many scientific or commercial software with different qualities and high cost have been used by GPS professionals. Besides having high costs of these soft wares, they also require experiences and training processes for the users. Therefore, as being an alternative solution, user-friendly free web-based online service software have been developed by several organizations in order to estimate high accurate point positions such as cm-dm level and to evaluate the GPS data easily **(GAO and SHEN, 2002; TSAKIRI, 2008; EL-MOWAFY, 2011).**

The raw data collected from anywhere around the world by using a double frequency geodetic grade GPS receiver have been converted into Receiver Independent EXchange (RINEX) format, then they may be submitted to these web based online services and processed into them. Also, some services accept other formats, for instance Hatanaka. However, in order to estimate high accurate point coordinates; some factors such as data processing solution technique and algorithm (mathematical model) of the used service, the accuracy of the other data and products (e.g., reference station coordinates, satellite orbit and clock corrections), observation duration and quality of the collected data play significant role. While these services have a lot of advantages for the users, they have also been useful assistants to the classical GPS surveying and processing in terms of software, hardware, equipment, personnel and logistics costs **(EL-MOWAFY, 2011; TSAKIRI, 2008).**

As is seen in Figure 1, the users may submit data using either to these services' web pages via internet. The results obtained by the service software are sent to the users via e-mail including typically estimated point coordinates and standard deviation values. Some of these services also send comprehensive analysis reports including graphical illustration of these results. Although many of these services are free, some of them require free membership for accessing with a user name and password lie CSRS-PPP. They usually use high accurate and precise International GNSS Service (IGS) data and products for computations. While IGS makes important contributions to the development and enhancement of the Global Navigation Satellite System (GNSS) standards around the world, it also holds a significant mission by collecting, archiving and presenting the high accuracy GPS/GLONASS ephemerides, satellite and station clocks, earth rotation parameters (ERP), coordinates and velocities of IGS tracking stations, atmospheric parameters to the users.

Online services present two types of solutions, which are relative solution approach and precise point positioning (PPP) solution approach. The services that are based on relative solution approach use national Continuously Operating Reference Stations (CORS) or IGS stations as reference control points. The services that are based on PPP solution approach use GPS-only or GPS+GLONASS products (such as orbit & clock corrections). Both of the solution types have been used widely and effectively for monitoring the deformations such as on landslides, structural behaviors and mining, marine applications (i.e.

hydrographic surveys), geographic information systems (GIS), engineering surveys, mapping applications, as-built surveys etc. In recent years, coordinates obtained from these services have been used for geodetic analyses that require high accuracy as well.

In this study, the most known and widely used four different online services in the world have been presented with their general features and web addresses, and then the accuracy analysis tests of them have been handled for accuracy researches on estimation of the point coordinates (Figure 2). For this purpose, 24-hour data in static mode of fourteen IGS stations at EUROPE Network has been used. First, station coordinates have been computed to provide high-accuracy using ITRF web site in the same date. Latter, analyses depending on the four web-based online services have been conducted for the same data, and then the coordinate differences as reference to ITRF web site solutions are estimated for each web-based online service. An accuracy analyses for each station and web-based online service are carried out according to comparing these coordinate differences and the standard deviations of the coordinates obtained from online services.

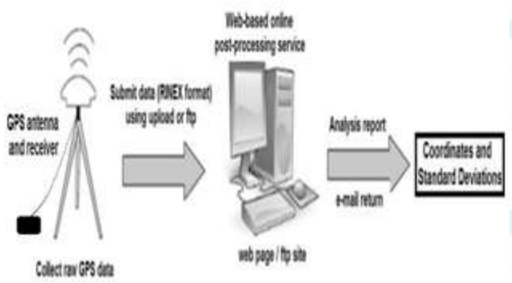

Figure 1: The main working illustration of web-based online services.

2. Web-Based Online GPS Data Processing Services

2.1 Services using relative solution approach

Traditionally, most of the professional GPS users have used relative positioning technique to provide high accuracy. However, this technique has some disadvantages related to PPP technique, such that minimum two or more GPS receivers should be used and the true coordinates of the reference stations should be known. Addition to this, increase of the distance between reference station (base) and rover station has reduced the position accuracy **(ABD-ELAZEEM et al., 2011).**

The strategy of setting up CORS networks for processing GPS data in relative positioning technique has provided important advantages. These networks, which are set up and have operations in global, regional, national and local levels, eliminate the requirement of constructing reference stations in far away locations from GPS surveying areas. Nowadays, by the help of both reference stations that collect continuously 7 day x 24 hour data and established networks, producing new control points by relative positioning technique is used frequently. The coordinates of new points have been estimated easily by using continuous and seamless daily.

RINEX data belonging to these stations for many surveying applications. Furthermore, web-based online services using relative solution approach, which present free computation tasks, have been constructed through these stations and networks. Services using relative solution approach estimate the point coordinates with double-difference technique by using data from either global IGS network or national CORS networks. The formulation of the double-difference technique for phase measurements can be given as follows:

$$\Delta\varphi\, t = r(t, t-\tau) + ds(t-\tau) - \text{diono} + \text{dtropo} + \Delta\lambda N + \Delta\varepsilon(\varphi) \quad (1)$$

where;
Δ is the double difference operator at the time of receiving data
φ is the phase measurement
(t) is the time of receiving data
(t-τ)is the satellite time
τ is the travel time from the satellite to the receiver
r(t, t-τ) is the true geometric range
ds is the orbital prediction error
diono and dtropo are the ionospheric and tropospheric errors, respectively
λ is the wavelength
N is the integer phase ambiguity
ε is the noise components

In Table 1, full names and organizations of the OPUS and AUSPOS services, which are the most commonly known services and have been using the relative solution approach, is given. These services also include the scientific software (process engine), which provides long base solutions in global networks. Owing to the fact that providing high accuracies at mm level, these services have been also used commonly for geodetic analyses in recent years.

OPUS uses RINEX data including dual-frequency observations for processing. OPUS processors make the solutions either static (2 hours < for data < 48 hours) or rapid static (15 minutes < for data < 2 hours) according to users' observation file durations. Users submit information such as their e-mail addresses, used GPS receiver antenna type and antenna's reference point (ARP) antenna height via web interface. The systematical errors such as undefined antenna type or height cannot be monitored. OPUS will require three NGS CORS stations; if the observation file is collected from U.S. Users may also select any of these CORS stations to be used in the computation process. If data to be uploaded is from somewhere outside the U.S., OPUS uses three IGS network stations as reference stations. The results that are referred to IGS08, International Terrestrial Reference Frame 2000 (ITRF2000) and North American Datum 1983 (NAD83) datum and observation epochs, are sent to the users through e-mail (www.ngs.noaa.gov/OPUS).

AUSPOS uses completely IGS Network data and products (final, rapid, ultra-rapid depending on availability precise orbit parameters, Earth orientation parameters and coordinate solution IGS products are used) for data processing. Users may submit RINEX data in static mode either using “upload” or “ftp”. Up to twenty different RINEX data files with antenna types and heights may be submitted to the system simultaneously. However, some restrictions may appear depending on the length of GPS data. System processor uses Bernese software for all computations. The coordinates of points are provided in Geocentric Datum of Australia 1994 (GDA94) and ITRF (http://www-b.ga.gov.au/bin/gps.pl).

Table 1: Online services using relative solution approach.

Service Short Name	Service Long Name	Organizations	Web Pages (Augest, 2017)
OPUS	Online Positioning User Service	NOAA-NationalGeodetic Survey (NGS)	http://www.ngs.noaa.gov/OPUS/
AUSPOS	Online GPS Processing	Geoscience Australia	http://www.ga.gov.au/scientific-topics/positioning-navigation/geodesy/auspos

2.2 Services using PPP solution approach

According to the developments on satellite geodesy, precise satellite ephemerides and clock products are obtained by organizations such as IGS, *JetPropulsion Laboratory* (JPL), Natural Resources Canada (NRCan) etc., and theseare presented to the users.

Due to this development, PPP technique becomes the most effective and novel method on GPS positioning. PPP is an absolute positioning technique, which provides cm or dm level point accuracy in static or kinematic mode depending on observation duration with a dual-frequency receiver. PPP uses undifferencedionospheric-free both carrier-phase (Φ) and code pseudorange (P) observations collected by dual-frequency receiver for data processing. This technique provides precise positioning by using precise ephemeris and clock products provided by IGS and other organizations and by considering other corrections such as satellite effects (satellite antenna offsets and phase wind-up), site displacement effect (solid earth tides, polar tides, ocean loading, earth rotation parameters) and compatibility considerations (products formats, reference frames, receiver antenna phase center offsets, modeling/observation conventions) **(ZUMBERGE et al., 1997; KOUBA and HÉROUX, 2001; KOUBA, 2009; ABD-ELAZEEM et al., 2011).**

As stated in both Zumberge at al.(1997) and Kouba and Heroux (2001), the ionospheric-free combinations of dual-frequency GPS pseudorange (*P*) and carrier-phase observations (*Φ*) are related to the user position, clock, troposphere and ambiguity parameters according to the following simplified observation equations:

$$P = \rho + C(dT- dt) + T_r + \varepsilon_P \quad (2)$$

$$\Phi = \rho + C(dT-dt) + T_r + N\lambda + \varepsilon_\Phi \quad (3)$$

where;
P is the ionosphere-free combination of P1 and P2 pseudoranges (P3)=(2.546P1-1.546P2)
Φ is the ionosphere-free combination of L1 and L2 carrier-phases (L3)=(2.546 λ_1 Φ_1-1.546 λ_2 Φ_2)

ρ is the geometrical range computed as a function of satellite and station coordinates C is the vacuum speed of light
dT is the station receiver clock offset from the GPS time dt is the satellite clock offset from the GPS time

T_r is the signal path delay due to the neutral-atmosphere (primarily the troposphere) N is the non-integer ambiguity of the carrier-phase ionosphere-free combination $\lambda_{1,}$ $\lambda_{2,}$ λ are the of the carrier-phases L1, L2 and L3-combined (10.7 cm) wavelengths, respectively.

$\varepsilon_{P,}$ ε_Φ are the relevant measurement noise components, including multipath, observable-dependent receiver bias and observable-dependent satellite bias and other effects.

The obtainable position accuracy depends on the used mathematical model on PPP software, the quality and content of the observation file. In table 2, the full names and organizations of the most commonly known PPP services can be seen. In table 3, software type of PPP services for static mode can be seen.

CSRS-PPP uses precise GPS orbit and clock products provided by IGS and Natural Resources Canada (NRCan), and estimates single station positions in static and kinematic modes. CSRS estimations are computed from carrier phase or code pseudorange observations of both single and dual frequency receivers. Since there is an option for users to select datum in results, the solutions of PPP coordinates are represented in both NAD83 and ITRF2008 reports. This service has actively processed GLONASS data from 4 October 2011 and accepted user provided ocean tidal loading (OTL) correction files from 14 February 2012. In order to facilitate freely from this service, users should take user name and password from the site for membership (www.geod.nrcan.gc.ca/ online_data_e.php).

Table 2: Online services using PPP solution approach.

Service Short Name	**Service Long Name**	**Organizations**	**Web Pages (Augest, 2017)**
CSRS-PPP	Canadian Spatial Reference System-Precise Point Positioning	Natural Resources Canada (NRCan)	http://www.geod.nrcan.gc.ca/online_data_e.php
Trimble RTX	The CenterPoint RTX post-processing service	Trimble Company	http://www.trimblertx.com/

Trimble RTX services have processed GPS data in static mode only. it does not require any membership for use. The data formats accepted include Trimble proprietary data formats (e.g. DAT, T01, T02, Quark) and the standard RINEX 2 and RINEX 3 data formats and for optimal processing results, it is recommended to provide at least 60 minutes of observations. The data files cannot exceed 24 hours in length, Data files must contain dual frequency pseudorange and carrier phase observations (L1 and L2), the data must have been collected after 14 May 2011, and BeiDou data is included since 04 Jun 2014, and Galileo data is included since 01 Jan 2017, the solution is send to the user by e-mail.

3. Experimental Work

The results of processing the GPS data collected in static mode have been examined in many studies, and the effects of the observation duration, baseline length and selected software have been investigated for high accuracy coordinate estimation such as mm or cm level ac curacies **(SO YCAN and O CALAN, 2011).** This study aims to test the accuracy analysis of the web-based online services especially using relative and PPP solution approaches and compares it with the commercial processing software's.

For this purpose, fourteen IGS reference stations from IGS organization located at Europe were selected as test points and an experimental study was conducted. 24-hour GPS data in static mode collected from IGS organization for IGS stations station s namely GRAS, GENO, WAB2, TLSE, UZHL, WTZZ, GOPE, ZIMM, RIGA, POLV, PENC, YEBE, MORP and ONSA on January 1, 2015 (epoch 2015.00) were selected for the accuracy analysis.

The data- sampling interval was 30 second. The aim of using long period observation data is to eliminate the errors that may occur depending on short period observation durations.

Firstly, point coordinates have been estimated for high accuracy by The International Terrestrial Reference Frame (ITRF) web site and all of points are IGS stations from IGS network, here, all computed coordinates were based on the IGS realization of ITRF2008 reference frame epoch 2015.00 on January 1, 2015. Precise Cartesian coordinates (X, Y, Z) of fourteen stations in ITRF2008 reference frame and epoch 2011.9986 have been computed by The International Terrestrial Reference Frame (ITRF) and assigned as reference coordinates to control with web-based online services results for comparative purposes.
The data belonging to the fourteen stations have been submitted on APRIL 2017 separately to the four online services, some of which are using relative solution approach namely OPUS, AUSPOS and, some of which are using Solution approach namely CSRS-PPP and Trimble RTX. Therefore, final products (IGS/JPL) have been used in processing with online services. The solution reports have been received via e-mail, then point coordinates and standard deviations have been obtained separately from each service.

4. Results and Analysis

Both of relative solution and PPP solution used online services were used to compute the test points coordinates by using IGS and JPL's high accurate final orbit and clock products. The standard deviations of the coordinates obtained from different online services are given in Table. (3)

Table 3: The standard deviations of the coordinates (mm)

Station	ITRF			OPUS			AUSPOS			C			Trimble RTX		
ID	SX	SY	SZ	SX	SY	SZ	SX	SY	SZ	SX	SY	SZ	SX	SY	SZ
GRAS	1	1	1	4	13	2	3	3	7	4	2	10	5	3	4
GENO	1	1	1	1	2	4	3	3	8	7	3	13	7	7	6
WAB2	1	1	1	2	2	5	3	3	7	3	7	13	7	7	6
TLSE	1	1	1	9	3	7	3	3	7	4	2	10	5	3	4
UZHL	1	1	1	8	1	11	4	3	8	2	4	10	8	8	8
WTZZ	1	1	1	8	11	10	3	3	7	4	2	10	10	11	10
GOPE	1	1	1	8	3	8	3	3	8	4	2	11	5	5	5
ZIMM	1	1	1	7	2	14	3	2	7	7	3	13	6	4	6
RIGA	1	1	1	9	7	15	3	3	8	2	4	9	4	4	5
POLV	1	1	1	7	9	5	3	3	7	2	4	9	4	4	5
PENC	1	1	1	5	7	8	3	3	7	2	4	10	5	5	5
YEBE	1	1	1	12	16	10	3	3	8	3	7	14	7	4	6
MORP	1	1	1	3	3	6	3	3	8	3	7	14	6	4	7
ONSA	1	1	1	8	6	4	3	3	7	2	4	9	4	4	5

The coordinates and standard deviations were obtained from the online services. The standard deviations of the The standard deviations of the coordinates (X and Y) obtained from OPUS service varied from about 1 mm to 16 mm and from 2 mm to 15 mm for (Z coordinates) At the same time, the standard deviations of the coordinates (X and Y) obtained from AUSPOS service were varied from about 2 mm to 3 mm and from 7mm to 8mm for (Z coordinates).

OPUS services were used 3 reference points for the solutions, but AUSPOS service were used 15 or 16 reference points. Therefore, the standard deviations were less than other relative service.

It is also provided as the standard deviations of the coordinates are small for the PPP solution services, too. The standard deviations of the coordinates (X and Y) obtained from CSRS-PPP service were range between 2 mm and 7 mm and from 9mm to 13mm for (Z coordinates) The standard deviations of the coordinates (X and Y) obtained from Trimble RTX service were changed between 3 mm and 11 mm. and from 4mm to 10mm for (Z coordinates).

Trimble RTX	CSRS-PPP	AUSPOS	OPUS	Service
(X) mm	(X) mm	(X) mm	(X) mm	Service
(Y) mm	(Y) mm	(Y) mm	(Y) mm	
(Z) mm	(Z) mm	(Z) mm	(Z) mm	
11.8	7.593	5.285714	3.071429	Means of absolute differences (mm)
6.6	2.965	3.928571	4.071429	
9.3	7.6	4.214286	4.571429	

To investigate the accuracy of the web based online services, coordinate differences between computed by (ITRF) web site and web-based online service solutions are computed. The coordinates by (ITRF) web site solutions are taken as true point coordinates, and used as references. For differencing purpose, this Equation is used. Difference ( ) = ITRF solution – Online service solution.

The graphical representation of computed differences in mm depending on differencing Equation can be seen in Figures.(2), (3), (4), (5), (6) and (7).

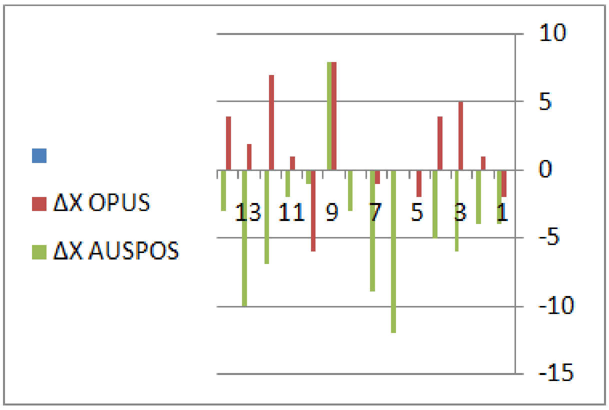

Figure 2: The differences of the estimated coordinates for relative positioning solution (X) (mm)

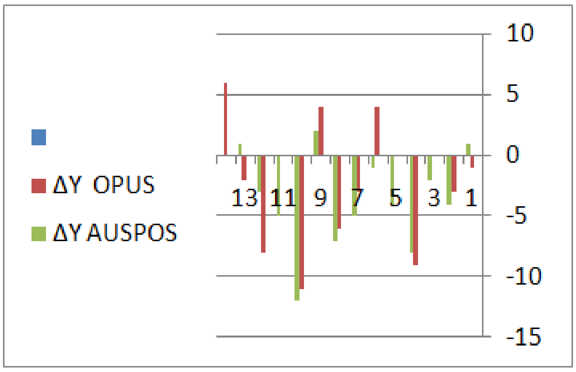

Figure 3: The differences of the estimated coordinates for relative positioning solution (Y) (mm).

Table 4: The means of the absolute differences for all services

Trimble RTX	CSRS-PPP	AUSPOS	OPUS	Service
(X) mm	(X) mm	(X) mm	(X) mm	Service
(Y) mm	(Y) mm	(Y) mm	(Y) mm	
(Z) mm	(Z) mm	(Z) mm	(Z) mm	
11.8	7.593	5.285714	3.071429	Means of absolute differences (mm)
6.6	2.965	3.928571	4.071429	
9.3	7.6	4.214286	4.571429	

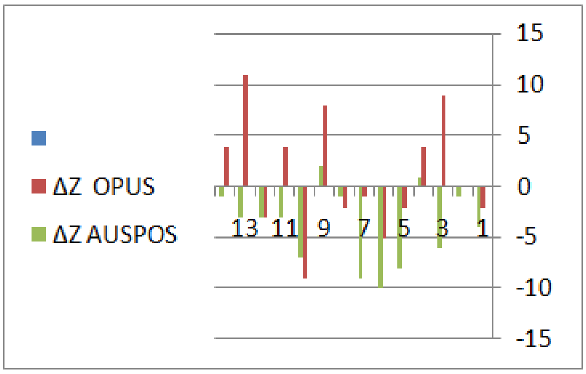

Figure 4: The differences of the estimated coordinates for relative positioning solution (Z) (mm)

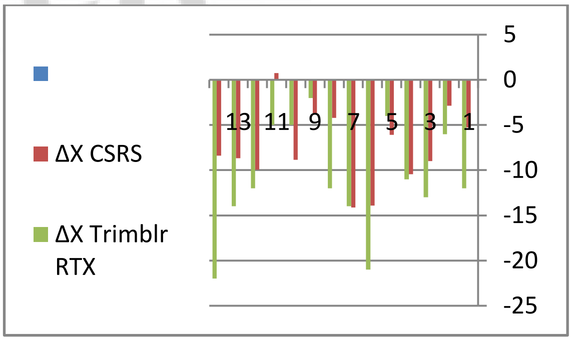

Figure 5: The differences of the estimated coordinates for precise point positioning solution (X) (mm).

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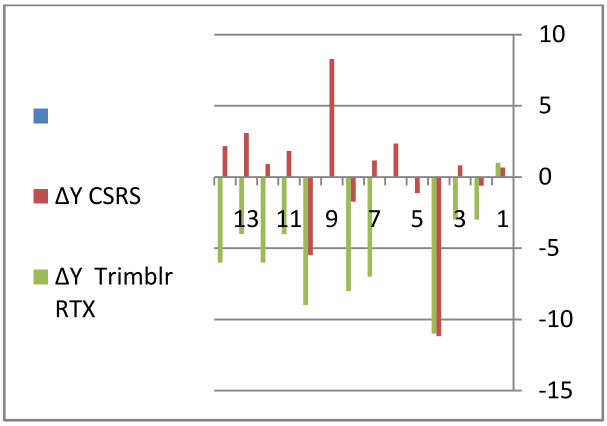

Figure 6: The differences of the estimated coordinates for precise point positioning solution (Y) (mm)

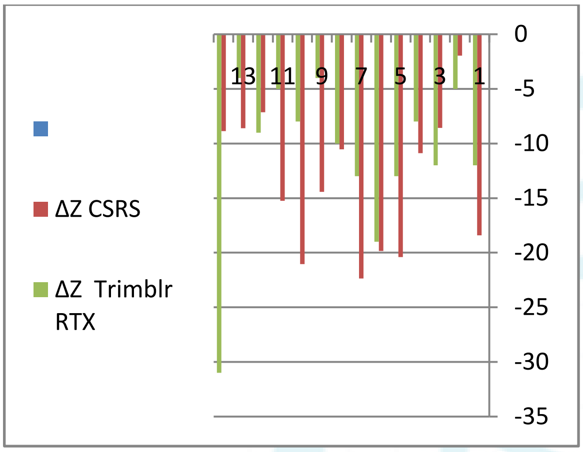

Figure 7: The differences of the estimated coordinates for precise point positioning solution (Z) (mm)

The absolute means of the differences of various services and the R can be also used to investigate the accuracy of these web based online services to, and equation (4) and (5) represent absolute mean and R:

Absolute Mean=Σ|ΔX or Y or Z|/N (4)

Where

Σ is Sigma, which means to sum up
|| (the vertical bars) mean Absolute Value, basically to ignore minus signs
ΔX or Y or Z is the difference between every online site result and ITRF solution (reference solution) for X, Y, Z for each coordinates

N is the number of values

R=√Δx2+Δy2+Δz2 (5)

Where

Δx is the difference between every online site result and ITRF solution (reference solution) for X
Δy is the difference between every online site result and ITRF solution (reference solution) for Y
Δz is the difference between every online site result and ITRF solution (reference solution) for Z

the means of the absolute differences and R for all services are given in Table.(4) & Figure.(8) and the differences of R for relative positioning solution and PPP solution for each point are given in figures.(9), (10)

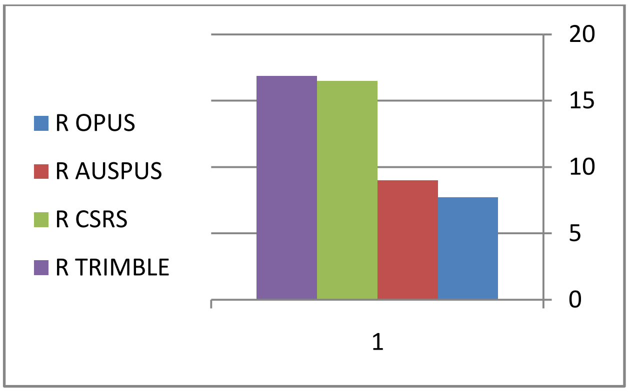

Figure 8: The absolute mean of R for all services

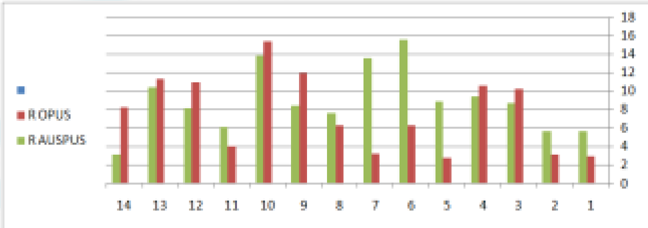

Figure 9: The differences of R for relative positioning solution (mm)

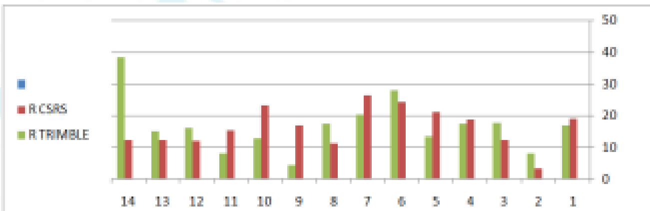

Figure 10: The differences of R for precise point positioning solution (mm)

To more accuracy for evaluate web-based online services Statistical Package for the Social Sciences (SPSS) program used by Correlation between vectors of values. This measure is a pattern-similarity measure.

These techniques used equation (6):

CORRELATION(x, y)=Σi(ZxiZyi)N−1 (6)

Where Zxi is the Z-score (standardized) value of x for the ith case or variable, and N is the number of cases or variables.
The results of Proximity Matrix of correlation by SPSS for all service for x, y, z given in tables. 5 & 6 &7 and R for the correlation for each service given in table 8., figure.(9)and figure (10)

Table 5: Proximity Matrix for X

	Euclidean Distance				
	X ITRF (ref)	X OPUS	X AUSPOS	X CSRS	X Trimble RTX
X ITRF (ref)	0.000	.015	.024	.032	.046
X OPUS	.015	0.000	.030	.039	.054
X AUSPOS	.024	.030	0.000	.019	.030
X CSRS	.032	.039	.019	0.000	.022
X Trimble RTX	.046	.054	.030	.022	0.000

Table 6: Proximity Matrix for Y

	Euclidean Distance				
	Y ITRF (ref)	Y AUSPOS	Y OPUS	Y CSRS	Y Trimble RTX
Y ITRF (ref)	0.000	.020	.019	.016	.021
Y OPUS	.020	0.000	.012	.015	.016
Y AUSPOS	.019	.012	0.000	.017	.011
Y CSRS	.016	.015	.017	0.000	.020
Y Trimble RTX	.021	.016	.011	.020	0.000

Table 7: Proximity Matrix for Z

	Euclidean Distance				
	Z ITRF (ref)	Z AUSPOS	Z OPUS	Z CSRS	Z Trimble RTX
Z ITRF (ref)	0.000	.021	.020	.055	.048
Z OPUS	.021	0.000	.026	.059	.054
Z AUSPOS	.020	.026	0.000	.040	.037
Z CSRS	.055	.059	.040	0.000	.033
Z Trimble RTX	.048	.054	.037	.033	0.000

Table 8: R for the correlation for each service

Service	OPUS	AUSPOS	CSRS	Trimble RTX
X	.015	.024	.032	.046
Y	.020	.019	.016	.021
Z	.021	.020	.055	.048
R	0.032496	0.035972	0.065237	0.07015697
(1-R) %	96.75%	96.4%	93.4%	93%

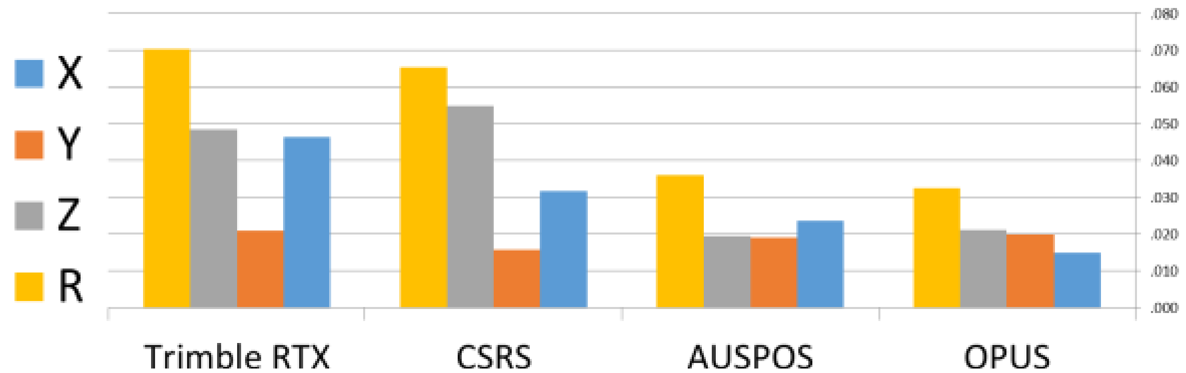

Figure 9: Correlation of X, Y, Z and R for all services

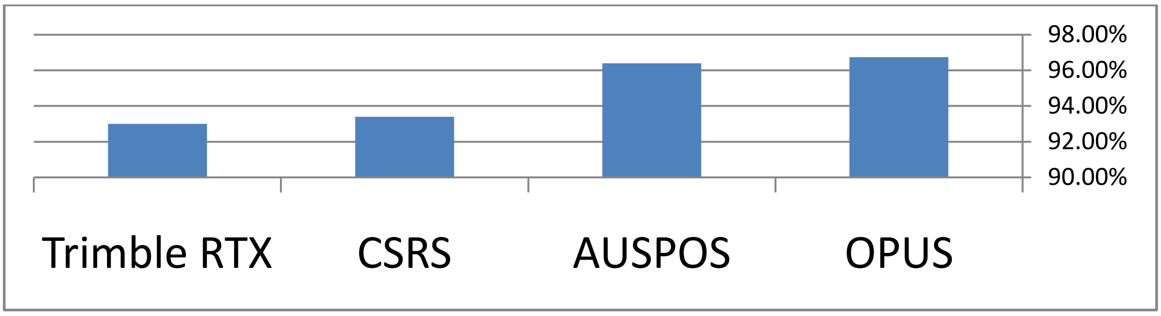

Figure 10: Correlation (1- R) % for all services

For the relative positioning solutions, the result of SPSS program, OPUS service has more reliable results than AUSPOS service as the result of R after correlation for OPUS was 0.032496 and for AUSPOS was 0.035972

OPUS service has more reliable results than the AUSPOS service. Although AUSPOS service has differences that are approximately less than OPUS service for Z and approximately the same for Y but the differences for X is bigger than the OPUS service.

The means of the absolute differences for OPUS are the minimum values for X and approximately the same of AUSPOS for Y. It has max absolute differences for X, Y and Z as as 12mm, 12mm and 10mm respectively. AUSPOS service has max absolute differences for X, Y and Z as 8 mm, 11mm and 11 mm, respectively.

For the absolute mean of R , OPUS service results is less than AUSPOS results as it was 7.72 mm and 9 mm respectively.

For the precise point positioning the result of SPSS program, CSRS service has more reliable results than Trimble RTX service as the result of R after correlation for CSRS was 0.065237 and for Trimble RTX was 0.07015697

CSRS PPP service has max absolute differences for X, Y and Z as 14 mm, 11 mm and 18 mm, respectively.

Trimble RTX service has max absolute differences for X, Y and Z as 22 mm, 11 mm and 31 mm, respectively.

The means of the absolute differences for CSRS are the minimum values for X, Y and Z differences. For the absolute mean of R , CSRS service results is less than AUSPOS results as it was 16.48446mm and 16.85681 mm respectively.

5. Conclusion

In recent years, web-based online services for GPS data processing have become widely used.

These services, which process the GPS data freely through internet and require any prior software knowledge, provide significant contributions to the users in terms of software, hardware, equipment, personnel and logistics costs. New developments over algorithms of GPS point positioning and accuracy enhancement of the products provided by organizations (IGS etc.) increase the number and the quality of these services.

In this study, a test study was conducted by considering some of famous web-based online services, which are used frequently and widely in the world. For this purpose, fourteen different stations data belong to IGS stations in Europe network were determined by using two relative solution approach services and two PPP solution approach services. 24-hour GPS data was considered. The true station coordinates were computed by The International Terrestrial Reference Frame (ITRF) web site. The accuracies provided by services were obtained by comparing online service coordinates with true station coordinates. According to the results, the relative positioning services has more reliable results than the precise point positioning service as considering the differences between The International Terrestrial Reference Frame solution (true station coordinates) and web based online solution. Also, the results of the OPUS service are nearest to ITRF web site solution. CSRS has the more reliable results among the Trimble Rtx PPP services. According to obtained results web based online services are able to produce final coordinates at the accuracy of a few millimeters to centimeters and they can be applied for geodetic application and analyses.

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