International Journal of Scientific Engineering and Research (IJSER)
ISSN (Online): 2347-3878
Index Copernicus Value (2015): 62.86 | Impact Factor (2015): 3.791

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

Islam A. Kandil, Mahmoud El-Mewafiand Ahmed Awaad

Department of Public Works, Facultyof Engineering, Mansoura University, Egypt

Corresponding Author: ISLAMA. KANDIL, Email: islamaboelnaga[at]hotmail.com

Abstract: ***Recently, Global Positioning System (G P S) has been used widely in various engineering fields especially for survey works by different users. The online services which established and enhancement by various organizations and these sits are easy to use and just need to make a free membership and they have become an alternative choice to the high-cost scientific software which need experience and training to get high accuracy results and commercial software which have a cost lower than the scientific software but give accuracy less than the scientific one, to can get high accuracy results for post processing data of GNSS. When a high accuracy level reach to millimeters (mm) level are wanted to reach, that could be used in various qualities of the engineering applications through these services. In this paper, a test study was done at EUROPE network; to investigate the accuracy of the online services which used in the test (namely CSRS- PPP, TRIMBLE RTX, OPUS, and AUSPOS). Some of these services use relative solution technique and others use precise point positioning (P PP) solution technique. In the test study, the coordinates of fourteen I G S stations were computed 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 differences between the coordinate from online services and the ITRF web site result are calculated. According to the results, for relative online service it was notified that the outcome for each individual difference was not exceed than 12 millimeters, and for precise point positioning service was not exceed than 31 millimeters. The accuracy analysis was evaluated from the results of the differences of the coordinate and standard deviations of them from various services and then online services were compared to ITRF web site solution. As shown in results the online service can produce a high accuracy results which can be used in engineering service which need high accurate positioning and geodetic analysis.***

Keywords: GNSS; Precise Point Positioning (P P P); Post Processing; Relative Positioning; The Online Services

1. Introduction

To post processing the GNSS data and get high accuracy results for the coordinates a lot of software are established and developed some of the are scientific and others are commercial, the problem of using these software are the high cost for th scientific software and the low accuracy of the commercial one and both of them especially the scientific need experience and training to get high accurate results. From here the online service which established and devolved and enhancement be various organization become a very public choice to post process the GNSS data and reach a very high level of accuracy and most of them are very low cost or free and easy to use by users **(G.AO and SHEN , 2002 ; TSAKIR I 2008 ; EL – MOWAFY , 2011).**

The data RINEX file which observed from any place in the earth and observed by double frequency GNSS receiver can be submitted and post processing by the online services and. By the way, some services accept different types of data format. However, to high accuracy results for the coordinates of the submitted points to the services; the user need to take some factors in consideration like data the technique of the processing operation and the mathematical model which the service used in post processing, the accuracy of the products and the other data like the coordinates of the reference station, the orbit of the satellite and the correction of the clock, the duration of the observed file and the quality of the submitted data. These services are very useful for the users and for the traditional GPS surveying and processing in terms of software, hardware, equipment, personnel and logistics costs **(EL – MOWAFY , 2011 ; TSAKIRI , 2008).**

As shown in Figure 1, the users can upload the file of the data to the online services by internet. The solutions are send to the e-mail which submitted with the data file to the web site and the results sheet are consist of the point coordinates of the point and standard deviation of each coordinates. Some of the service attached with the report of the coordinates and standard deviations the comprehensive analysis reports with the graphical explains of the solution. Some of these services need the users to make a free membership like CSRS-PPP service. This services use the precise ephemeris from the IGS organization data and the final available corrections for calculation. The IGS have a dreat role in this field by develop and enhancement the ephemerides data of the satellite and the GPS and GLONASS, and clocks station, atmospheric parameters to the users.

It is available two kind of the online services the first one use the relative technique and the second use the precise point positioning (PPP) technique. By using the IGS stations or the control points CORS as a reference solution the service which use relative technique get the results of the submitted data. By using the products of the data of GPS or the data of GPS and GLONASS like the correction of the clock and the orbit the services which using the PPP technique can get the results. The two kinds of the results have been utilize in a large scale in many applications like the deformations monitoring and in geographic information systems (GIS) and for different engineering

applications especially in survey field and mapping. Recently, because of the high accuracy of these services the results of it are used in geodetic analyses

Here, four of the famous and popular online services in the earth illustrated in details and the web sites of each one, and then the accuracy of each of them are tested for accuracy test on computing the coordinates of the points as shown in Figure 2. To investigate it, a data for twenty four hour which observed in static mode of fourteen IGS stations at EUROPE has been used. At the beginning, the coordinates of each point calculated by using ITRF web site at the same date as this solution is the most accurate solutions for the points. Then the data file submitted to the four online services and then after getting the results the differences between the solutions of the online solutions and the ITRF web site solution are calculated and compared to each other to judge the accuracy of each one of them

Figure 1: : show how to get results from the online services.

2. Post Processing Of GNSS Data by Online Services

2.1 The Online Service Using Relative Technique

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.

For relative online technique, it used mainly the IGS stations and CORS as a reference station to process the GNSS data and produce results of this data. Recently, the reference points have the data during twenty four hour of the seven days of the week and this data is very useful for using the relative solution and establishing a control points which will be very useful to process the data by this technique and can be used in different engineering services

Most of the online service which used the relative technique are free, the user just enter the type of the antenna and the height of it and the service run by the double difference technique with using the reference points even it was IGS stations or CORS network and the following equation illustrate the equation of the double difference technique :

$$\tilde{N}\,D\,F = \tilde{N}\,D\,r + \tilde{N}\,D\,dr + l\,\tilde{N}\,D\,N - \tilde{N}\,D\,d\,ion + \tilde{N}\,D\,d\,trop + \tilde{N}D\,e\,F \quad (1)$$

Where :
Ñ D represent the double difference operator.
Φ represent the measurement of the phase
λ represent the length of the wave
N represent the integer phase ambiguity
ε represent the noise components
d iono represent the ionospheric errors
d tropo represent the tropospheric errors

The long name and the name of the service provider and the web site of each of the OPUS and AUSPOS services which use the relative online technique and used in the test are shown in the In Table 1, it is worth to be mentioned that all these services used scientific software to process the data which submitted to the web site of each service.

Opus service is totally free established and enhancement by National Geodetic Survey , the data which can be used in the service must be observed with duel frequency receiver in static or rapid static mode only and in RINEX format, the data must be more than two hours and less than 48 hour for static data and for rapid static data it must be more than fifteen minutes and less than two hours , Users can upload the file of the data to the web site and should select the antenna type and enter the height of the antenna which used in the observation and the e-mail which the results will send back to after processing. The unknown antenna type or height will affect directly to the accuracy of the results. The service use 3 IGS or CORS stations for post processing the data and the user can select this stations is the observation is observed from the united states of America but if the observation out of the united states of America the service use IGS stations and it cannot be selected. The software which used in the service to process the data is PAGES software for static data and RSGPS software for rapid static data. The datum used in the result sheet is ITRF2000 and NAD83 datum and the epochs of the observation and the results send to the e-mail which the user submit with the data file to the web site of the service (www.ngs.noaa.gov/OPUS).

AUSPOS service is totally free established and enhancement by Geoscience Australia , the service use from thirteen to fifteen IGS station as a reference station for the data post processing and use the last available correction for clock and ephemeris according to the availability while the time of submitting the data to the service , the data which can be used in the service must be observed with duel frequency receiver in static mode only and in RINEX format , the service cannot process the data in kinematic mode or the data observed by single frequency receiver. Users can upload up to twenty file of data per time to the web site and should select the antenna type and enter the height of the antenna which used in the observation and the e-mail which the results will send back

to after processing. The software which used in the service to process the data is Bernese software. The datum used in the result sheet is(GDA 94) and ITRF datum (http://www-b.ga.gov.au /bin/gps.pl).

Table 1: Online services which using relative solution technique.

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/ausp

2.2 The Online Service Using PPP Technique

The precise ephemerides of satellite and the corrections of the clock errors are available and devolved and enhancement by organizations like IGS, Natural Resources Canada (NRCan) and Jet Propulsion Laboratory(JPL) and available to users to use in post processing operation.

Recently PPP technique become very popular method for post processing data as the results of it reach a very high level of accurate, the accuracy of the service depends on the duration of the observation and the type of the receiver which used for collecting the data if it single or dual frequency receiver, the dual one usually uses undifferenced ionospheric free both carrier phase (Φ) and code pseudo range (P) observations for data processing. The service which used PPP technique used the last available precise ephemeris and clock correction produced by IGS, JPL and NRCan and other corrections like the effect of the satellite , the effect of site displacement like polar tides , compatibility considerations ,earth rotation parameters ,solid earth tides, and the loading of the ocean **(ZUMBERGE et al ., 1997 ; KOUBA and HÉROUX , 2001 ; KOUBA , 2009 ; ABD - ELAZEEM et al ., 2011).**

the combinations of the ionospheric free of dual frequency receiver are the pseudo range (*P*) and carrier phase observations (*Φ*) and they affected by the poisiton of the user, , troposphere of the clock and the parameters of the ambiguity as shown in the following 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 represent the ionosphere free combination of P.1 and P.2 pseudo ranges (P.3) = (2.546P.1 - 1.546 P.2)
Φ represent the ionosphere-free combination of L.1 and L.2 carrier-phases (L.3) = (2.546 $\lambda_{.1}$ $\Phi_{.1}$ - 1.546 $\lambda_{.2}$ $\Phi_{.2}$)
ρ represent the geometrical range calculated as a function of station coordinates and satellite
C represents the velocity of the light
d T represent the station receiver clock offset from the GPS time
d t represent the clock of the satellite offset from the GPS time
T_r represents the delay of the signal path
N represents the non-integer ambiguity of the carrier-phase ionosphere-free combination
λ_1, λ_2, λ represent the carrier phases
L1 & L2 and L3-combined (10.7 cm) wavelengths, respectively.
ε_P, ε_Φ represent the component's noise, including the observable-dependent of the receiver and the multipath bias and observable-dependent satellite bias and other effects.
.

The accuracy of the results affected by the software used for post processing operation and quality of the observation and the duration of it .The long name of the PPP services which used in the study with the organization names which provide it shown in table 2.

CSRS-PPP service need the users to make a free membership to can use the service, the service use the last available ephemeris and clock corrections available from IGS and Natural Resources Canada (NRCan) organization and can process the data in static or kinematic mode and can process to the data observed by a single or dual frequency receiver. The users can select the datum which the results will represent to; the results are available in NAD83 or ITRF2008 datum. The users can submit GLONASS data from 4 -10- 2011 and accepted the correction of the ocean tidal loading (OTL) from 14-2- (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 PosItIonIngPrecise Point Positioning	Natural Resources Canada (NRCan)	http://www.geod.nrcan.gc.ca/ online_ data _e.php

Trimble RTX	The Center Point RTX post-processing service	Trimble Company	http://www.trimblertx.com/

Trimble RTX service totally free established and enhancement by Trimble Company, the service can process the static data only. The users can submit data in different formats like DAT, T01, T02, Quark, RINEX 2 and RINEX 3, to get high accuracy results it is better to submit a file of data with at least sixty minutes duration of observation and not more than twenty four hours of observation, the service cannot process a single frequency data or any data collected before 14-5-2011, and can process BeiDou data from 4-6- 2014, and Galileo data is included from 1- 1- 2017 and the results send back to the user by e-mail.

1. Case of Study

The period time of the GPS data and the length of the baselines and the used software which used for post processing operation for the static data for GPS affected directly to the accuracy of the solution of the post processing operation and have been tested many times in different studies **(SO YCAN and O CALAN, 2011).**

The purpose of the study is to test and judge the accuracy of online services which using relative technique and PPP technique and comparing each other with the true solution to can judge them.

To do that, fourteen IGS stations downloaded from IGS web site located at Europe downloaded to be tested, the study done for twenty four hours of the static data downloaded from IGS web site for IGS stations and the stations namely GRAS, GENO, WAB2, TLSE, UZHL, WTZZ, GOPE, ZIMM, RIGA, POLV, PENC, YEBE, MORP and ONSA observed on January 1, 2015 (epoch 2015.00) were selected for the accuracy test
The interval of the data was thirty second, and the purpose of the long length of the data file is to reduce the errors which may be happened because of the short length data

At the beginning the coordinates of the fourteen IGS stations computed with high accuracy by The International Terrestrial Reference Frame (ITRF) web site, all of them were represented in ITRF2008 reference frame and the data was observed on 1-1-2015 and the results of ITRF web site considered as a true solution to can compare the online service with it, then on APRIL 2017 the data of the fourteen IGS stations uploaded to the four online services, OPUS and AUSPOS services are using relative technique and CSRS-PPP and Trimble RTX are using PPP technique. All the service use the final ephemeris and the clock correction presented by IGS and JPL organizations and the reports of the results are resend back to the user e - mail which submitted with the data file to the service

4. Results and Discussion

The standard deviations for the fourteen tested points from the four services are shown in Table. (3)

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

Station ID	ITRF			OPUS			AUSPOS			C			Trimble RTX		
	S X	S Y	S Z	S X	S Y	S Z	S X	S Y	S Z	S X	S Y	S Z	S X	S Y	S Z
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

For OPUS service the standard deviations of the fourteen stations ranged from 1mm to 16mm in X and Y coordinates and ranged from 2mm to 15mm in Z coordinates and for AUSPOS service the standard deviations of the fourteen stations ranged from 2mm to 3mm in X and Y coordinates and ranged from 7mm to 8mm in Z coordinates
The reason of being the ranges of the standard deviation of AUSPOS services less than OPUS services is that AUSPOS services use for post processing operation approximately from fifteen to sixteen reference stations or control points and OPUS service use three reference stations or control points for calculation.

For the PPP technique the standard deviations of the results is small as the service use a scientific software for post processing operation, for CSRS-PPP service the standard deviations ranged from 2mm and 7mm for X and Y coordinates and from 9mm to 13mm for Z coordinates and for Trimble RTX service the standard deviation ranged from 3mm and 11mm for X and Y coordinates and from 4mm to 10mm for Z coordinates

Trimble RTX	CSRS-PPP	AUSPOS	OPUS	Service
(X) mm	(X) mm	(X) mm	(X) mm	
(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	

For the test of the online services and the accuracy of each one, the differences between the coordinates which computed by (ITRF) web site and the online service solutions are compared. The results of the (ITRF) web site considered as a reference for the fourteen stations. For calculating the difference, this Equation is used.
The differencing of solution ( ) = ITRF results – Online service results.

The Figures shown below illustrate the differences in millimeters of calculated differences depending on differencing Equation and shown in Figures. (2), (3), (4), (5), (6) and (7).

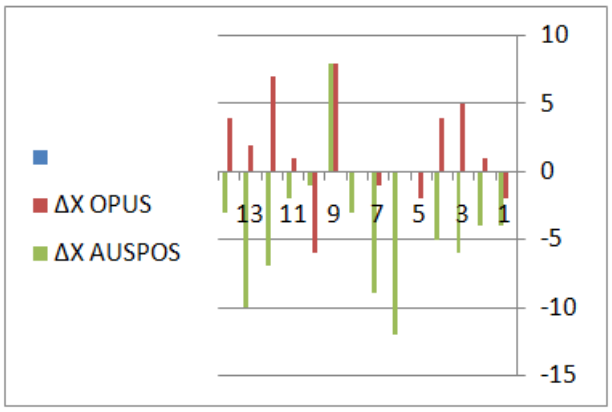

Figure 2: ΔX for online relative services mm

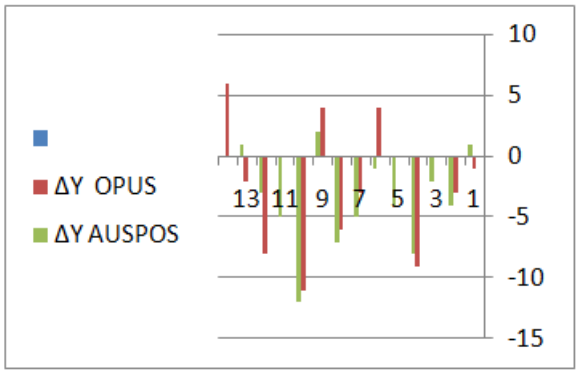

Figure 3: ΔY for online relative services mm

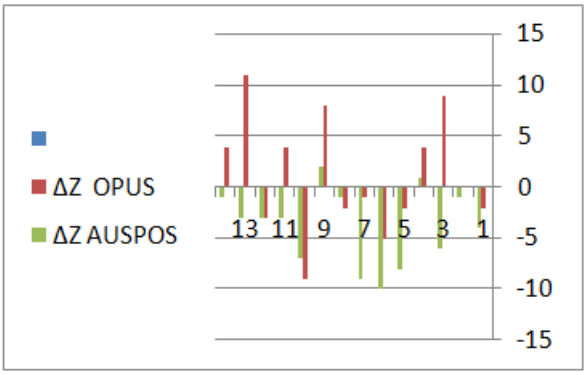

Figure 4: ΔZ for online relative services mm

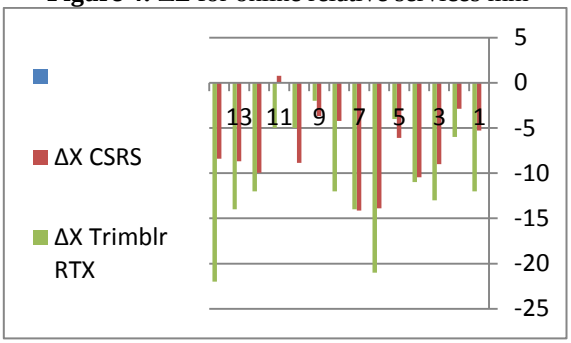

Figure 5: ΔX for online PPP services mm

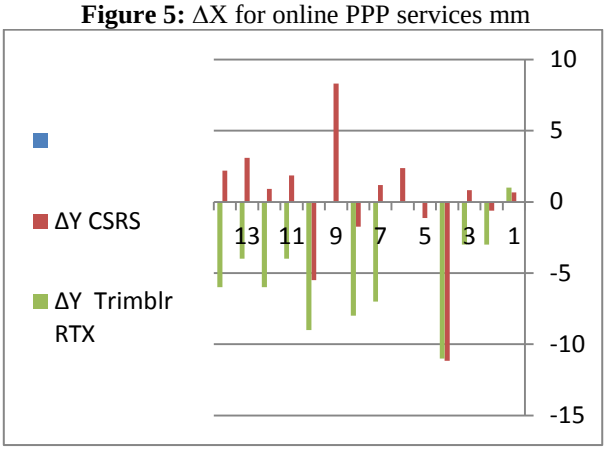

Figure 6: ΔY for online PPP services m m

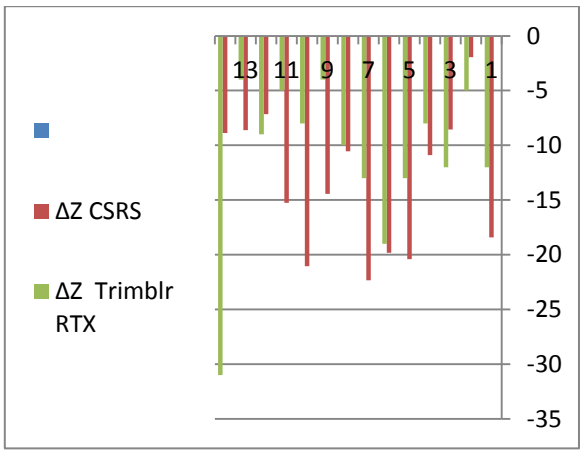

Figure 7: ΔZ for online PPP services mm

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)

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

Trimble RTX	CSRS-PPP	AUSPOS	OPUS	
(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	

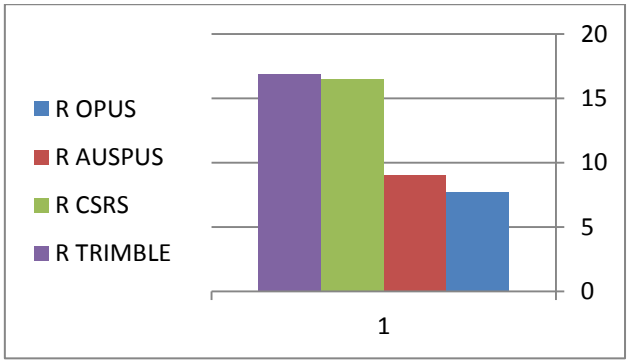

Figure 8: The absolute mean of R for all services

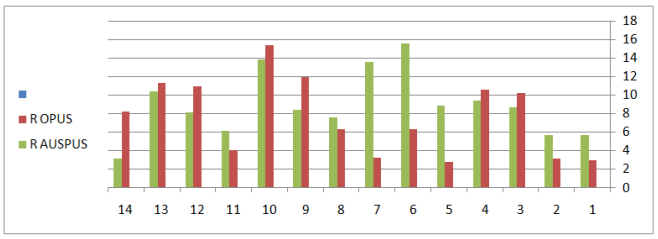

Figure 9: The differences of R for online relative results in mm

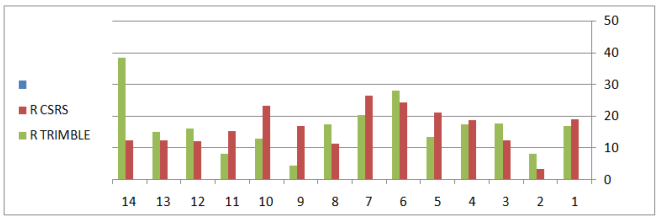

Figure 10: The differences of R for online PPP results in mm

To more accuracy for evaluate the 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 (Z xi Z yi) N − 1 (6)

Where Z xi 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%

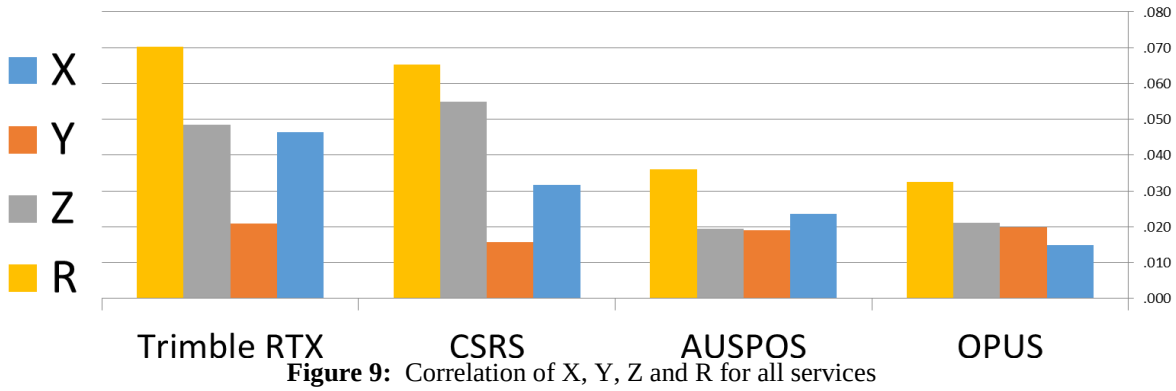

Figure 9: Correlation of X, Y, Z and R for all services

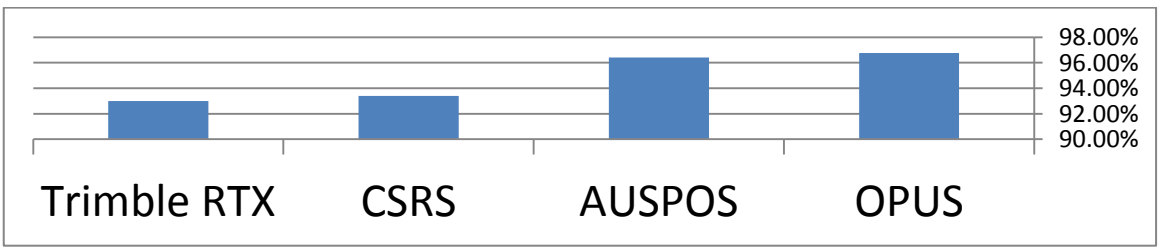

Figure 10: Correlation (1- R) % for all service

For the relative positioning solutions, the result of SPSS program, the service which give results closest to the reference solution was OPUS service as the result of R after correlation for OPUS was 0.032496 and for AUSPOS was 0.035972

The values of the means of the absolute differences for OPUS service are less than AUSPOS service for X and approximately the same for Y.

The max absolute difference for OPUS service for X was 12mm and for Y was 12mm and for Z was 10mm.

The max absolute difference for AUSPOS service for X was 8mm and for Y was 11mm and for Z was 11mm.

For the PPP solutions, the result of SPSS program, the service which give results closest to the reference solution was CSRS service as the result of R after correlation for CSRS was 0.065237 and for Trimble RTX was 0.07015697

The max absolute difference for CSRS PPP service for X was 14mm and for Y was 11mm and for Z was 18mm.

The max absolute difference for Trimble RTX service for X was 22mm and for Y was 11mm and for Z was 31mm.

3. Conclusion

Recently, many users prefer to use the online services for post processing the GNSS data as most of them are free or just need the users to make a free membership and at the same time give high accuracy results.

The advantage of using these services was that it doesn't need experience or long time of training to can use it and get high quality results.

.
By using the products of IGS and JPL and other organizations which present to the users and these services the precise ephemeris and the corrections of the clock which increase the accuracy of the online services.

In this study, To evaluate some of the online services which used for post processing GNSS data a fourteen different IGS stations were tested and the data of them downloaded from IGS web site then the data submitted to the four online services, two of them using relative technique and the other using PPP technique.

Twenty four hour of GNSS data was used for the test with thirty second interval. The reference solution was calculated by The International Terrestrial Reference Frame (ITRF) web site.

The results of each result of the services are tested by comparing the difference of each coordinate of each service with the result of ITRF web site solution which considered as a reference solution.

As appear in results, the services which using the relative technique give results closer than to the reference solutions more than the services which use PPP technique.

OPUS service give results are the closest to ITRF web site solution.

And CSRS service give results more accurate than the Trimble RTX services.

As shown the results outcome from the online service reach high level of accuracy reach to millimeters and can be used for engineering application and survey works which need high level of accuracy.

.

Acknowledgement

With the help of organizations like IGS and JPL which provide the users and online service with data and the accurate products we get high accurate results and it is important to thank them for the support and thank the online service which used in post processing operation in this study like ITRF web site , OPUS, AUSPOS, CSRS-PPP, and Trimble RTX).

References

[1] ABD-ELAZEEM, M.; FARAH, A.; FARRAG F.A. Assessment study of using online (CSRS) GPS-PPP Service for mapping applications in Egypt. Journal of Geodetic Science, v.1, n.3, p. 233-239, 2011
[2] Automatic Precise Positioning Service (APPS) web page. URL: http://apps.gdgps.net/ (14.05.2012)
[3] Canadian Spatial Reference System-Presice Point Positioning (CSRS-PPP) webpage. URL:http://www.geod.nrcan.gc.ca/online_data_e.php (14.05.2012).
[4] EL-MOWAFY, A. Analysis of web-based GNSS post-processing services for static and kinematic positioning using short data spans. Survey Review, v.43, n.323, p. 535-549, 2011.
[5] SOYCAN, M.; OCALAN, T. A regression study on relative GPS accuracy for different variables. Survey Review, v. 43, n. 320, p. 137-149, 2011
[6] The Precise Point Positioning Software Centre web page. URL: http:// gge.unb.ca/Resources/PPP/OnlinePPPs.html (14.05.2012)
[7] TSAKIRI, M. GPS Processing Using Online Services. ASCE Journal of Surveying Engineering, v. 134, n. 4, p. 115-125, 2008)

[8] Trimble CenterPoint RTX Post-Processing Webpage.
URL: http://www.trimblertx.com/