

Accuracy assessment of free web-based online GPS Processing services and relative GPS solution software

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Abstract: Recently many organizations give a free automatic processing web based online services for processing the GPS observations for any place in the world whether relative GPS Processing solution or Precise Point Positioning (PPP) technique. In this research, baseline lengths of GPS network in Egypt are obtained by using the free automatic processing web based online services and compared with the baseline lengths computed by relative solution using the Trimble Baseness Center (TBC) commercial software at different observation times 1,2,3 and 4 hours. The automatic processing web based online services used in this research are with relative GPS solutions (AUSPOS and Trimble CenterPoint RTX post-processing) and with PPP technique (CSRS-PPP). The network baseline lengths at different observation times 1,2,3 and 4 hours are compared with the baseline lengths computed by a total time of observations by using the above different approaches. The maximum vector length errors obtained by using TBC, Trimble RTX, AUSPOS and CSRS-PPP at 1 hour are 0.015 m, 0.093 m, 0.235 m and 0.075 m respectively, at 2 hours are 0.009 m, 0.066 m, 0.033 m and 0.061 m respectively, at 3 hours are 0.008 m, 0.017 m, 0.033 m and 0.016 m respectively and at 4 hours are 0.005 m, 0.019 m, 0.014 m and 0.021 m respectively. The relative GPS solution software (TBC) are observed to give better result at all observation times.

Keywords: Trimble Center Point RTX post-processing, AUSPOS, CSRS-PPP, TEQC (Translation, Editing, and Quality Checking), Precise Ephemeris and Trimble Baseness Center (TBC) software

1. Introduction

Traditionally, most of the professional GPS users have used relative (differential) positioning technique to provide high accuracy. However, this technique has some limitations. 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 the reference station (base) and rover station has reduced the position accuracy. For instance, while in differential GNSS (DGNSS) technique where single-frequency code (pseudo range) observations are used, decimeter level positioning accuracy can be achieved, in real time kinematic (RTK) techniques where dual/multi-frequency carrier phase observations are used, centimeter level positioning accuracy can be derived. To obtain more accurate positioning, GPS observations should be collected in relative static surveying mode, and then computed with different post-processing scientific or commercial software (Ocalan, 2016). However, the usage of such software is also quite difficult because they generally require deep knowledge of the GNSS and experience in the processing. Furthermore, they mostly need a licensing fee. Regarding the improvements in information technology and GNSS data processing methodology, many new opportunities have been offered to the users. In this respect, several institutions, research centers or organizations have developed web-based online GNSS processing services and they have started to become a strong alternative to the conventional data processing method. The only requirement for using these services

which are generally provided free of charge with limitless usage, is a computer having an Internet connection and web browser. These services are designed to be as simple as possible for the user and with minimal input. Users of such systems have to perform uploading/sending of their collected RINEX data by using the web site of these services, e-mail or ftp sites to the system and selecting a few options such as static/kinematic modes, datum, antenna etc. With these services, when the data is received to the service, processing starts and the results (together with the coordinates, process reports along with other necessary information for analyzing the results) are sent to the user in a short amount time. Some of these services process not only the GPS but also the data of other systems, particularly those of GLONASS, and provide resilience and a higher accurate positioning service in certain cases to their users. As of today, there are several web-based online GNSS processing services, in which some of them calculate the coordinates with a relative solution approach (e.g. Trimble RTX, AUSPOS, OPUS.); or with the PPP technique (e.g. CSRS-PPP, magicGNSS, APPS) (Alkan et al., 2016).

2. Study area and data sources

The major aim of this research is to assess the automatic processing web based online services Trimble CenterPoint RTX post-processing, AUSPOS and CSRS-PPP with relative GPS processing solution software (TBC) by using a network of stations in Egypt see figure 1.

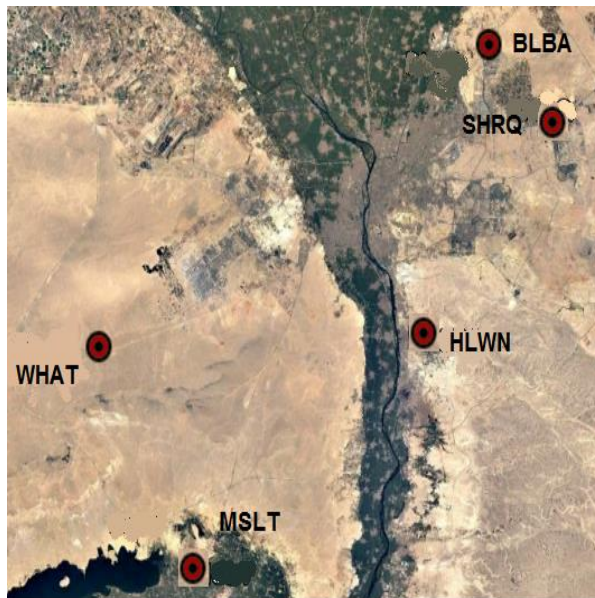


Figure 1: Study area, a network of stations in Egypt

The data used for this test are stated in the following items:

- 1- The rinex files of data observations for BLBA, MZLT and WHAT stations. The time of observation is approximately 48 hours.
- 2- The rinex files of data observations for SHRQ and HLWN stations. The time of observation is approximately 24 hours.
- 3- Using the TEQC (Translation, Editing, and Quality Checking) software (UNAVCO, 2017) to divide the observation files into numbers of observation files with different time of observations (1, 2, 3 and 4 hours).
- 4- Using the Trimble Baseness Center (TBC) commercial software to process the network stations in Egypt by relative solution.
- 5- Precise satellite ephemerides (final orbits) for GPS observations on days 4-3-2013 and 5-3-2013.

3. Automatic GNSS processing web based online services

GNSS users prefer the relative positioning method in surveying applications if high accuracy is needed. All GNSS methods depending on the relative positioning principle require simultaneous observations occupied at least one reference station whose coordinates are well known. The primary factors for point positioning accuracy are the baseline length between two receivers and the observation duration. Relative positioning determines the point coordinates by using double differencing on phase measurements (Ocalan et al., 2016). However, in recent years, a method, namely PPP, has become an alternative technique to relative and differential techniques to provide high precision positioning. GPS PPP technique, which is a developed type of absolute positioning has been implemented effectively by users (Ocalan, 2016).

In this research, the relative solution using the Trimble Baseness Center (TBC) commercial software in addition to some web-based online GNSS processing services are used. The following paragraph illustrates the web-based online GNSS processing services used to compute the positions in this study by using a relative solution approach (e.g. Trimble RTX, AUSPOS) and PPP technique (e.g. CSRS-PPP).

3.1 Relative solution approaches

3.1.1 AUSPOS online GPS processing service

AUSPOS is a free online GPS data processing service provided by Geoscience Australia. AUSPOS takes advantage of both the IGS Stations Network and the IGS product range, and works with data collected anywhere on earth; users submit their dual frequency geodetic quality GPS RINEX data observed in a static mode to your GPS data processing system. The service aims to assist a variety of users from the private and public sector who require GDA94 and ITRF coordinates. This includes people undertaking surveys such as:

- DGPS reference station positioning
- Remote GPS station positioning
- Ultra-long GPS baseline positioning
- GPS connections to IGS and ARGN stations
- High accuracy vertical GPS positioning
- GPS network quality control

Finally, this service does not process real time, kinematic, or single frequency GPS data (Geoscience Australia. AUSPOS - Introduction, 2017).

AUSPOS uses the Bernese GNSS Software for processing baselines, IGS orbits and IGS network stations. Solutions are available for anywhere on the earth (gpsworld.com, 2013).

3.1.2 Trimble centerpoint RTX post-processing

Trimble RTX is a global GNSS technology that provides centimeter-level positioning, worldwide, at any time. This application allows you to upload GNSS observation data to the CenterPoint RTX post-processing service and receive positioning calculations. The positioning calculations are performed in ITRF2008 current epoch. Transformation can be performed by selecting a different coordinate system and tectonic plate (trimblertx.com, 2017).

The Trimble RTX technology utilizes real-time data from a Trimble owned global reference station infrastructure to compute and relay satellite orbit, satellite clock, and other system adjustments to the receiver. This results in centimeter level positions that deliver repeatable high accuracy positions worldwide. These adjustments are transmitted to the receiver via satellite, Internet Protocol (IP or Cellular), while post-processed results are sent to the user via email or a client interface.

The achievable accuracy is very closely correlated to the length of the observation file. It is recommended to use data sets that are a minimum of 1-hour in length to achieve

2 cm horizontal accuracy. Data sets less than 1-hour will result in less accurate position results. Data sets longer than 1-hour will yield even greater accuracy and can approach 1 cm. The CenterPoint RTX post-processing service does not accept observation files that are longer than 24 hours in length (Trimble CenterPoint RTX post-processing FAQS, 2016).

3.2 Precise Point Positioning (PPP) technique

According to the developments on satellite geodesy, precise satellite ephemerides and clock products are obtained by organizations such as IGS, Jet Propulsion Laboratory (JPL), Natural Resources Canada (NRCAN) etc., and these are presented to the users. Due to this development, PPP technique becomes the most effective 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 (Ocalan et al., 2013).

The Canadian Spatial Reference System (CSRS) PPP service provides post-processed position estimates over the internet from GPS observation files submitted by the user. Precise position estimates are referred to the CSRS standard North American Datum of 1983 (NAD83) as well as the International Terrestrial Reference Frame (ITRF). Single station position estimates are computed for users operating in static or kinematic modes using precise GPS orbits and clocks. The online PPP positioning service is designed to minimize user interaction while providing the best possible solution for a given observation availability. Currently, users need only to specify the mode of processing (static or kinematic) and the reference frame for position output (NAD83 (CSRS) or ITRF). CSRS PPP service is processing both single and dual frequency observations from GPS and GLONASS (Farah, 2016).

4. Methodology

GPS observation data were collected from 13:00 Hrs. on day 4-3-2013 to 01:00 Hrs. on day 5-3-2013 for a period of 12 Hrs. for all the five stations. The data were split using TEQC (Translation, Editing, and Quality Checking) software into different observation time interval of 1, 2, 3 and 4 hours. The GPS observations data of all the five stations HLWN, BLBA, SHRQ, MZLT and WHAT were processed using Trimble CenterPoint RTX post-processing (trimblertx.com, 2017), AUSPOS (Geoscience Australia, 2017) and (CSRS) PPP (Natural Resources Canada, 2017) web based online processing services. Since the BLBA station data were collected for a period of 48 hrs instead of 12 hrs. the station is identified as base station for the estimation of the co-ordinate of other stations. Above mentioned web based online services were used to process observation files having 1 hour, 2 hour, 3 hour and 4 hour observation periods. GPS data was also processed using the Trimble Business Centre (TBC) commercial software for all the 5 stations.

5. Results and analysis

The estimated co-ordinates using TBC software are provided in the WGS-84 co-ordinate system, while the web based online services computed co-ordinates are provided in ITRF-2008 co-ordinate system. This discrepancy in co-ordinates leads to small difference between the coordinates of a position in ITRF and the WGS-84 (Trimble CenterPoint RTX post-processing FAQS, 2016). It may be noted that the difference in coordinate systems in this research between the automatic processing web based online services and the results obtained by TBC software do not have any effect on the results, since the analysis has been performed to compare baseline lengths between stations instead of the absolute co-ordinates.

The Vector Length Error (VLE) obtained by using TBC processing software gave the best results for all baseline lengths and all time of observation sessions. The figures 2 to 5 illustrate the Vector Length Errors (VLE) computed from subtracting the baseline lengths obtained by using the total time of observations and baseline lengths obtained by using observation time at each 1 hour on time periods 1 PM on 4-3-2013 to 1 AM on 5-3-2013 using the four processing approaches.

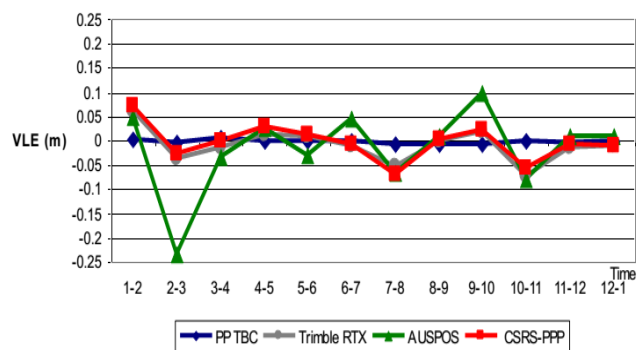


Figure 2: Vector Length Errors (VLE) for base line BLBA - SHRQ by using the four processing approaches at (1h) and base line whose length is 17.52

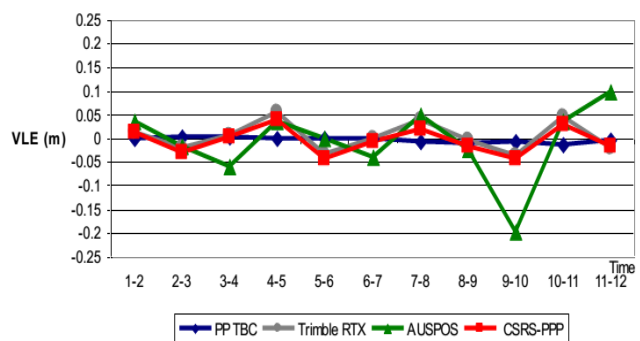


Figure 3: Vector Length Errors (VLE) for base line BLBA - HLWN by using the four processing approaches at (1h) and base line whose length is 48.793 km.

Table 1 summarizes the minimum and maximum values of VLEs at all baseline lengths processed by the four approaches. Through these figures and table note that, the vector length errors at 1h for different baselines obtained by TBC processing software gave a better result compared to the all free automatic processing web based online services. Where the maximum VLE obtained by TBC software is 0.015 m and the results obtained by using automatic processing web based online services approved that, the VLE of CSRS-PPP and Trimble RTX are better than AUSPOS.

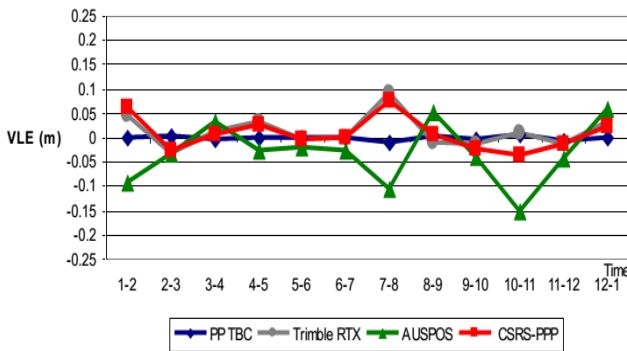


Figure 4: Vector Length Errors (VLE) for base line BLBA - WHAT by using the four processing approaches at (1h) and base line whose length is 91.279 km

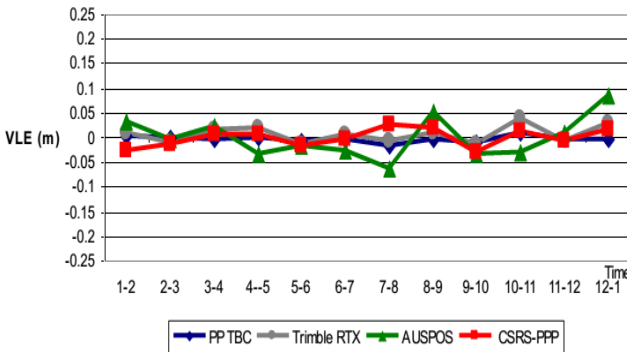


Figure 5: Vector Length Errors (VLE) for base line BLBA - MZLT by using the four processing approaches at (1h) and base line whose length is 102.777 km

Table 1: The Maximum and Minimum Vector Length Errors (VLE) for Different Baseline Lengths at 1h by Using the Four Processing Approaches

Processing Approaches								Baselines
CSRS-PPP		AUSPOS		Trimble RTX		PP TBC		
Max VLE (m)	Min VLE (m)	Max VLE (m)	Min VLE (m)	Max VLE (m)	Min VLE (m)	Max VLE (m)	Min VLE (m)	
0.073	-0.0005	-0.235	0.009	-0.072	-0.0002	0.008	-1E-06	BLBA - SHRQ
-0.043	0.002	-0.197	-0.001	0.057	0.0003	-0.012	-5E-05	BLBA - HLWN
0.075	0.001	-0.150	-0.020	0.093	0.0001	-0.011	0.0004	BLBA - WHAT
-0.031	-0.004	0.086	-0.003	0.039	-0.005	-0.015	-0.0002	BLBA - MZLT

From figure 6 to 9 and table 2 it is clear that, the use of TBC processing software at two hours of observation over the 12 hours is better than the automatic processing web based online services. In addition to the improvement in accuracy results obtained from the increased observational time from one hour into two hours, made VLE obtained by TBC software to be 0.009 m and VLEs obtained by processing web based online are improved with 2 hours of observation time.

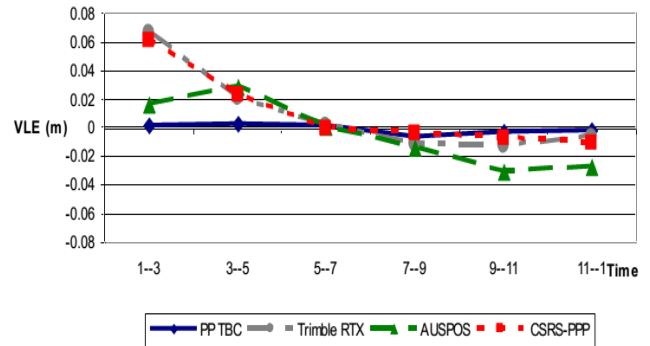


Figure 6: Vector Length Errors (VLE) for base line BLBA - SHRQ by using the four processing approaches at (2h) and base line whose Length is 17.523 km

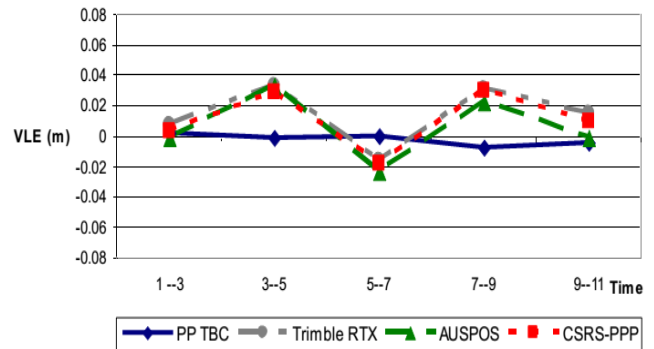


Figure 7: Vector Length Errors (VLE) for base line BLBA-HLWN by using the four processing approaches at (2h) and base line whose length is 48.793 km

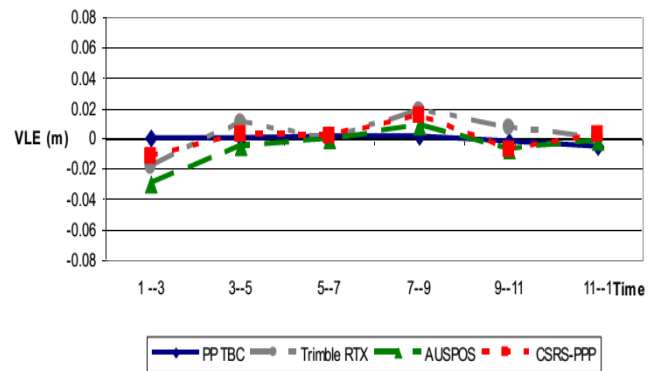


Figure 8: Vector Length Errors (VLE) for Base Line BLBA - WHAT by Using the Four processing approaches at (2h) and Base Line Whose Length is 91.279 km

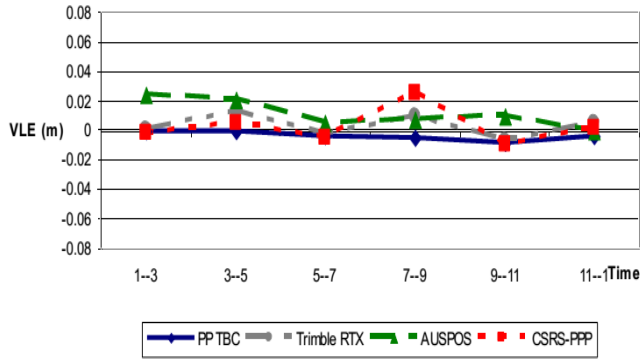


Figure 9: Vector Length Errors (VLE) for base line BLBA-MZLT by using the four processing approaches at (2h) and base line whose length is 102.777 km

Table 2: The Maximum and Minimum Vector Length Errors (VLE) for Different Baseline Lengths at 2h by Using the Four Processing Approaches

CSRS-PPP		AUSPOS		Trimble RTX		PP TBC		Baselines
Max VLE (m)	Min VLE (m)	Max VLE (m)	Min VLE (m)	Max VLE (m)	Min VLE (m)	Max VLE (m)	Min VLE (m)	
0.061	-0.0001	-0.031	0.0006	0.066	0.002	-0.006	0.001	
0.0293	0.0033	0.033	-0.0007	0.0333	0.0078	-0.008	-2E-04	BLBA - HLWN
0.0155	0.00132	-0.030	-0.0008	0.0187	0.0002	-0.006	3E-04	BLBA - WHAT
0.0251	0.00156	0.0240	-0.0008	0.0126	0.001	-0.009	-1E-04	BLBA - MZLT

The figures 10 to 13 and table 3 shows that most results obtained by Trimble RTX are better than CSRS-PPP and CSRS-PPP is better than AUSPOS at 3h time of observations.

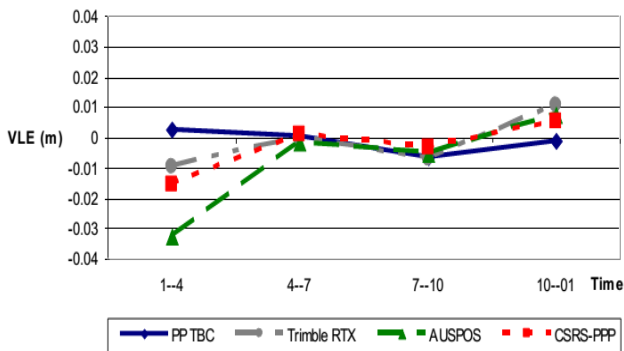


Figure 10: Vector Length Errors (VLE) for base line BLBA - SHRQ by using the four processing approaches at (3h) and base line whose length is 17.523 km

At 4h of observation time illustrated in figures (14) to (17) and table (4) the VLEs computed by AUSPOS is better than Trimble RTX and CSRS-PPP. To obtain the VLE less than 1 cm for baseline lengths less than 110 km the TBC processing software at 2h time of observations can be used.

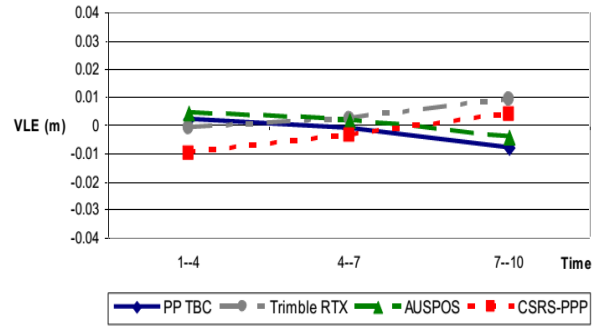


Figure 11: Vector Length Errors (VLE) for base line BLBA-HLWN by using the four processing approaches at (3h) and base line whose length is 48.793 km

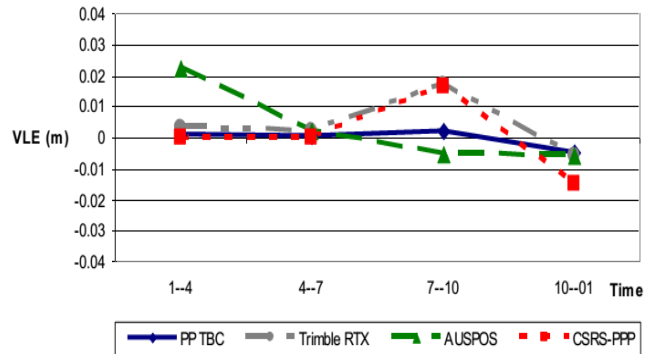


Figure 12: Vector Length Errors (VLE) for base line BLBA-WHAT by using the four processing approaches at (3h) and base line whose length is 91.279 km

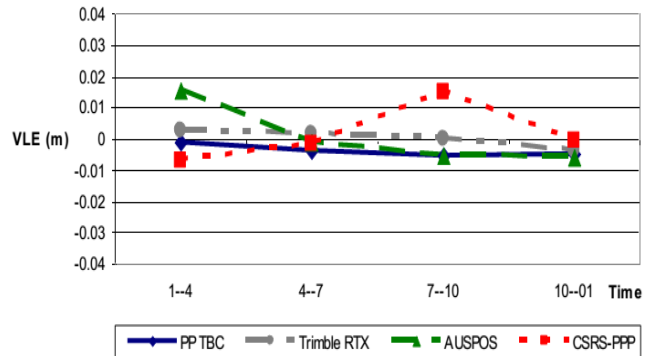


Figure 13: Vector Length Errors (VLE) for base line BLBA-MZLT by using the four processing approaches at (3h) and base line whose length is 102.777 km

Table 3: The Maximum and Minimum Vector Length Errors (VLE) for different baseline lengths at 3h by using the four processing approaches

CSRS-PPP		AUSPOS		Trimble RTX		PP TBC		Baselines
Max VLE (m)	Min VLE (m)	Max VLE (m)	Min VLE (m)	Max VLE (m)	Min VLE (m)	Max VLE (m)	Min VLE (m)	
-0.016	0.0012	-0.033	-0.0018	0.0104	-8E-05	-0.006	7E-04	
-0.001	0.0037	0.0040	0.0013	0.0089	-0.001	-0.008	-0.001	BLBA - HLWN
0.016	9.2E-05	0.0222	0.0021	0.0173	0.0021	-0.005	7E-04	BLBA - WHAT
-0.015	-0.0004	0.0153	-0.0011	-0.0035	-0.0002	-0.005	-9E-04	BLBA - MZLT

The automatic processing web based online services gives the VLE within 2 cm at the 4h time of observations with the baseline lengths less than 110 km. The classical relative solution using GPS software's is better than the automatic processing web based online services with relative GPS solutions (AUSPOS and Trimble CenterPoint RTX post-processing) and with PPP technique (CSRS-PPP).

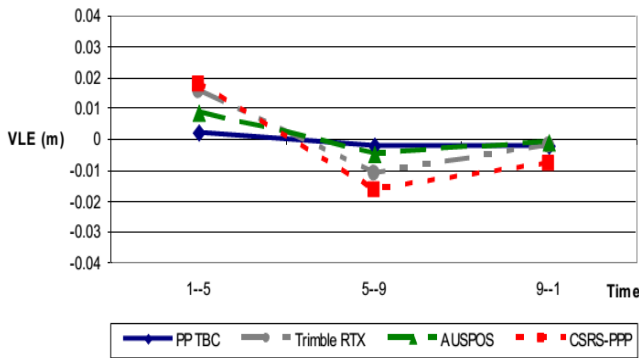


Figure 14: Vector Length Errors (VLE) for base line BLBA-SHRQ by using the four processing approaches at (4h) and base line whose length is 17.523 km

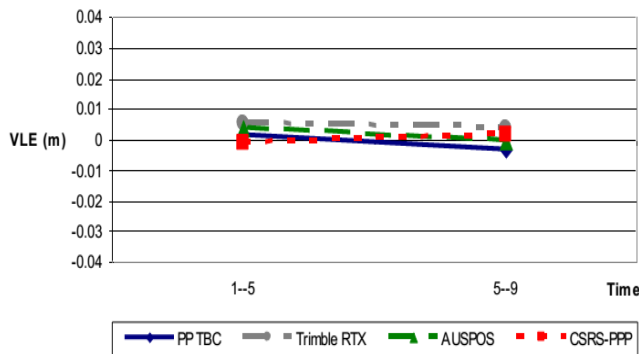


Figure 15: Vector Length Errors (VLE) for base line BLBA-HLWN by using the four processing approaches at (4h) and base line whose length is 48.793 km

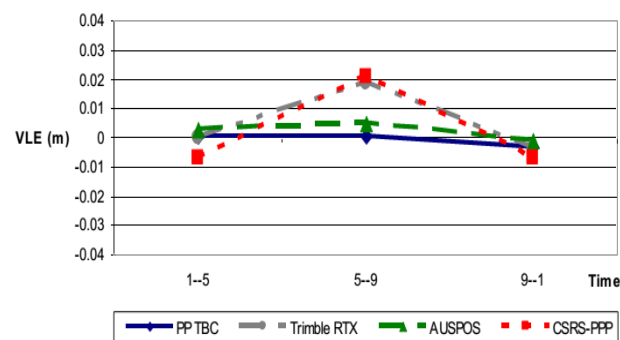


Figure 16: Vector Length Errors (VLE) for base line BLBA-WHAT by using the four processing approaches at (4h) and base line whose length is 91.279 km

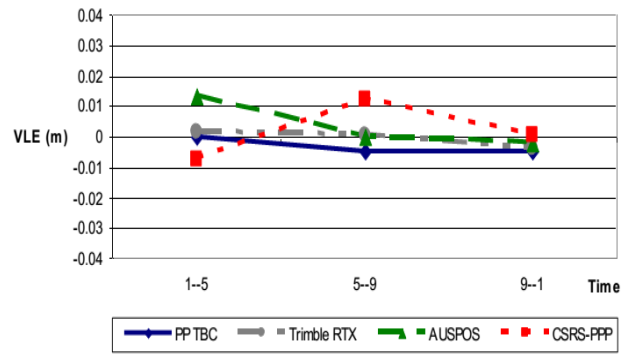


Figure 17: Vector Length Errors (VLE) for base line BLBA - MZLT by using the four processing approaches at (4h) and base line whose length is 102.777 km

Table 4: The Maximum and Minimum Vector Length Errors (VLE) for different baseline lengths at 4h by using the four processing approaches

Processing Approaches								Baselines
CSRS-PPP		AUSPOS		Trimble RTX		PP TBC		
Max VLE (m)	Min VLE (m)	Max VLE (m)	Min VLE (m)	Max VLE (m)	Min VLE (m)	Max VLE (m)	Min VLE (m)	
0.0177	-0.009	0.009	-0.0011	0.0154	-0.0023	0.002	0.002	BLBA - SHRQ
0.002	-0.001	0.004	-0.0004	0.0053	0.004	-0.003	0.002	BLBA - HLWN
0.021	-0.007	0.005	-0.0001	0.019	-0.0001	-0.003	8E-04	BLBA - WHAT
0.0120	0.0007	0.014	-2.3E-05	-0.004	0.0005	-0.005	-1E-04	BLBA - MZLT

6. Conclusions

The relative GPS solution software (TBC) are observed to give better result at all observation times. The maximum vector length errors obtained by using TBC, Trimble RTX, AUSPOS and CSRS-PPP at 1 hour are 0.015 m, 0.093 m, 0.235 m and 0.075 m respectively, at 2 hours are 0.009 m, 0.066 m, 0.033 m and 0.061 m respectively, at 3 hours are 0.008 m, 0.017 m, 0.033 m and 0.016 m respectively and at 4 hours are 0.005 m, 0.019 m, 0.014 m and 0.021 m respectively.

It is suggested to carry out further work by using long baseline lengths and use GPS data of different seasons to study the effect of the atmosphere.

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