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Comparative Study between Precise Point Positioning (PPP) Versus Relative Positioning

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Abstract: ***With the development of the International GNSS Service, whose primary object is to provide highest quality data and products for research, education and multidisciplinary application, the concept of Precise Point Positioning began to receive more and more interest on the problem called "positioning". Nowadays because of this development, the PPP technique it started to grow on the detriment of the relative GNSS positioning. PPP, it is able to offer point determination by processing undifferenced dual frequency receiver, combine with precise orbit and clock corrections offered by IGS to obtain centimeter accuracy. The aim of this paper is to make a comparative study between Precise Point Positioning (PPP) versus relative positioning under different conditions. The conditions or constrains used in this study are observation period and base line length. We apply base line technique in relative solution to spot the errors without adjustment that applied in network technique.***

Keywords: GNSS, IGS, Precise Point Positioning, relative positioning, accuracy

1. Introduction

Global navigation Satellite systems (GNSS) have become integral part of all applications. GNSS positioning has different errors about 1 m to 5m and these errors must be resolved to achieve an acceptable accuracy sub centimeters or millimeters **(GAO and SHEN, 2002; TSAKIRI, 2008; EL-MOWAFY, 2011)**. There are three methods of GNSS data processing to reduce or resolve the effect of some of GNSS biases, GNSS observable differencing technique, linear combinations between observables are formed and GNSS biases modeling, these processing may be in real-time or post processing. Also, some GNSS biases can be resolved through International GNSS Service (IGS) network like Orbit & Sat. clock biases can be fixed by IGS. **(Jan Kouba: "A Guide to Using International GNSS Service (IGS)")**

Every surveying projects especially geodetic projects are collecting the GNSS raw data and the surveyors need a help to make a decision which GNSS data processing method to use to achieve the acceptable accuracy. Some errors fixed by IGS products, these products may be final (igs) or rapid (igr) or ultra-rapid (igu) **(http://www.igs.org/products)**. GNSS data processing by many software's that may be commercial or scientific also they may be free. In this paper we discus one commercial software (Trimble business center v3.5) and one free online (online CSRS PPP) and help the surveyors if it can be used and which one? to achieve the acceptable accuracy.

2. GNSS Measurements

There are two methods code observations based on the travel time ΔT of the signal to propagate from the phase center of the satellite antenna (the emission time) to the phase center of the receiver antenna (the reception time) and phase observations based on number of wavelengths **(J. Sanz Subirana, J.M. Juan Zornoza and M. Hernández-Pajares,2013.**

2.1 Code observations

The pseudorange R_{P_f}measurement obtained by the receiver using this procedure includes, besides the geometric range ρ between the receiver and the satellite and clock synchronization errors, other terms due to signal propagation through the atmosphere (ionosphere and troposphere), relativistic effects, instrumental delays (of satellite and receiver), multipath and receiver noise. Taking explicitly into account all these terms, the previous equation can be rewritten as follows, where R_{P_f} represents any GNSS code measurement at frequency f (from GPS, Glonass, Galileo or Beidou **(ZUMBERGE et al., 1997; KOUBA and HÉROUX, 2001; KOUBA, 2009; ABD-ELAZEEM et al., 2011).**

$$R_{P_f} = \rho + c\left(dt_{rcv} - dt^{sat}\right) + T_r + \alpha_f STEC + K_{P_f,rcv} - K_{P_f}^{sat} + M_{P_f} + \varepsilon_{P_f} \quad (1)$$

Here:

ρ is the geometric range between the satellite and receiver Antenna Phase Centres (APCs) at emission and reception time. Note: The APC is frequency dependent, but we neglect this effect here for simplicity.

dt_{rcv} and dt^{sat} are the receiver and satellite clock offsets from the GNSS time scale, including the relativistic satellite clock correction.

T_r is the tropospheric delay, which is non-dispersive.

$\alpha_f STEC$ is a frequency-dependent ionospheric delay term, where αf is the conversion factor between the integrated electron density along the ray path (STEC), and the signal delay at frequency f. That is.

$\alpha_f = \frac{40.3}{f^2} 10^6 m_{(\text{signal delay at frequencyf})}/TECU$ where the frequency f is in Hz and 1 $TECU = 10^{16} e^-/m^2$

$K_{P_{f,rcv}}$ and $K^{sat}_{P_f}$ are the receiver and satellite instrumental delays, which are dependent on the code and frequency. M_{P_f} represents the effect of multipath, also depending on the code type and frequency, and ε_{P_f} is the receiver noise.

2.2 Phase observations

Besides the code, the carrier phase itself is also used to obtain a measure of the apparent distance between satellite and receiver. These carrier phase measurements are much more precise than the code measurements (typically two orders of magnitude more precise), but they are ambiguous by an unknown integer number of wavelengths (λN). Indeed, this ambiguity changes arbitrarily every time the receiver loses the lock on the signal ,producing jumps or range discontinuities. The carrier phase measurements ($\Phi_{L_f} = \lambda_{L_f}\varphi_{L_f}$)

$$\Phi_{L_f} = \rho + c\left(dt_{rcv} - dt^{sat}\right) + T_r - \alpha_f STEC + K_{P_{f,rcv}} - K^{sat}_{P_f} + \lambda_{L_f} \mathrm{N}_{L_f} + \lambda_{L_f}\omega + m_{L_f} + \epsilon_{P_f}$$

(2)

Here:

$\lambda_{L_f}\omega$ is the wind-up due to the circular polarization of the electromagnetic signal and the integer ambiguity N_{L_f}. The terms $K_{P_{f,rcv}}$ and $K^{sat}_{P_f}$are frequency dependent and correspond to carrier phase instrumental delays associated with the receiver and satellite, respectively. The m_{L_f} and ϵ_{P_f} terms are the carrier phase multi path and noise, respectively.

3. GNSS Data Processing

There are three methods of GNSS data processing to reduce or resolve the effect of some of GNSS biases, GNSS observable differencing technique, linear combinations between observables are formed and GNSS biases modeling, Theses processing may be in real-time or post processing. Also, some GNSS biases can be resolved through International GNSS Service (IGS) network like Orbit & Sat. clock biases can be fixed by IGS.

There are four types of IGS products, (**http://www.igs.org/products)** for example the IGS can determine the satellite true position with four accuracies based on the size of data collected.

- Predicted file type

Predicted Orbit 0.5 m (Real-Time) & Satellite clock 150 nanosecond.

- UltraRapid file type

0.25 m (Real-Time) & Satellite clock 5 nanosecond

- Rapid file type

1.05 (17 hours later) & Satellite clock 0.2 nanosecond

- Final type

< 0.05 m (13 days) & Satellite clock 0.1 nanosecond

4. GNSS Data Collection

In order to make a comparative study between Precise Point Positioning (PPP) versus relative positioning, 38 IGS stations (Figure 1) were selected for this study. These stations make a centered shape and the base line technique was applied in relative solution. These base lines have different lengths ranging from 128 kms. to 5000 kms. and the BZRG station was taken as a control point for relative solution.

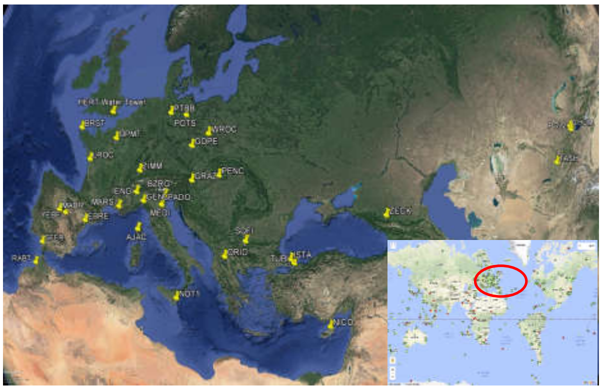

Figure 1: The selected IGS stations for analysis

4.1 Data Collection

All the IGS stations GNSS RINEX data and products are free online through the following link ftp://cddis.gsfc.nasa.gov/.. One-day observation (1/1/2015) taken as a sample day for analysis and all the IGS stations data were downloaded with their products like final precise ephemeris (igs18254d.sp3). Also, the RINEX data had been divided into segments with the observation time (24, 20, 16, 12, 6, 4, 2, and 1) hrs to get the effect of observation time Precise Point Positioning (PPP) versus relative positioning with the base line length.

4.2 Stations precise coordinates for result judgement

Through the following link http://itrf.ign.fr/ and using the station demos number, we can get the stations precise coordinates, velocities and their standard deviations in ITRF solutions at any day of year. Table 1 shows the selected IGS stations precise coordinates and their standard deviations in ITRF solutions.

Table 1: The selected IGS stations precise coordinates and their standard deviations in ITRF solutions

DATA SET EXPRESSED IN ITRF2008 FRAME				
STATION POSITIONS AND VELOCITIES AT EPOCH 2015/01/01				
DOMES NB	ID	X/σx	Y/σy	Z/σz
		m-m	m-m	m-m
43007M001	QAQ1	2170941.923	-2251830.012	5539988.45
		0.001	0.001	0.002
43005M002	KELY	1575558.899	-1941827.969	5848076.547
		0.001	0.001	0.002
10202M001	REYK	2587384.096	-1043033.542	5716564.087
		0.001	0.001	0.002
10204M002	HOFN	2679689.937	-727951.073	5722789.489
		0.001	0.001	0.001

DATA SET EXPRESSED IN ITRF2008 FRAME STATION POSITIONS AND VELOCITIES AT EPOCH 2015/01/01				
DOMES NB	ID	X/σx	Y/σy	Z/σz
		m-m	m-m	m-m
25601M001	CHUM	1228950.529	4508079.974	4327868.531
		0.001	0.001	0.001
12348M001	POL2	1239971.095	4530790.14	4302578.862
		0.001	0.001	0.001
12327M001	TASH	1695944.926	4487138.62	4190140.729
		0.001	0.002	0.002
12351M001	ZECK	3451174.48	3060335.577	4391955.74
		0.001	0.001	0.001
35001M002	RABT	5255617.595	-631745.513	3546322.694
		0.001	0.001	0.001
13402M004	SFER	5105518.917	-555145.698	3769803.515
		0.002	0.001	0.001
14302M001	NICO	4359415.533	2874117.182	3650777.955
		0.001	0.001	0.001
20806M001	TUBI	4211317.169	2377866.053	4144663.364
		0.003	0.002	0.003
20807M001	ISTA	4208830.129	2334850.487	4171267.339
		0.001	0.001	0.001
15601M001	ORID	4498451.537	1708267.18	4173591.954
		0.001	0.001	0.001
12717M004	NOT1	4934546.051	1321265.187	3806456.278
		0.001	0.001	0.001
10077M005	AJAC	4696989.299	723994.667	4239678.663
		0.001	0.001	0.001
11001M002	GRAZ	4194423.652	1162702.875	4647245.524
		0.001	0.001	0.001
13212M010	HERT	4033460.794	23537.965	4924318.36
		0.001	0.001	0.001
10004M004	BRST	4231162.463	-332746.508	4745131.041
		0.001	0.001	0.002
10001S006	OPMT	4202777.246	171368.178	4778660.311
		0.001	0.001	0.001
10023M001	LROC	4424632.449	-94175.045	4577544.195
		0.001	0.001	0.001
13410M001	EBRE	4833520.044	41537.303	4147461.673
		0.002	0.001	0.002
13420M001	YEBE	4848724.614	-261632.012	4123094.283
		0.001	0.001	0.001
13407S012	MADR	4849202.282	-360328.771	4114913.331
		0.001	0.001	0.001
11206M006	PENC	4052449.292	1417681.298	4701407.2
		0.001	0.001	0.002
11101M002	SOFI	4319371.918	1868687.97	4292064.026
		0.001	0.001	0.001
12217M001	WROC	3835751.128	1177250.112	4941605.334
		0.001	0.001	0.001
11502M002	GOPE	3979315.966	1050312.641	4857067.201
		0.002	0.001	0.002
14234M001	PTBB	3844059.803	709661.478	5023129.651
		0.001	0.001	0.001
14106M003	POTS	3800689.472	882077.545	5028791.409
		0.001	0.001	0.001
10073M008	MARS	4630532.637	433946.503	4350142.848
		0.002	0.001	0.001
12712M002	GENO	4507892.176	707621.67	4441603.626
		0.001	0.001	0.001
12724S001	IENG	4476537.277	600431.619	4488761.451
		0.001	0.001	0.001
14001M004	ZIMM	4331296.928	567556.058	4633134.056
		0.001	0.001	0.001
12711M003	MEDI	4461400.564	919593.773	4449504.884
		0.001	0.001	0.001

DATA SET EXPRESSED IN ITRF2008 FRAME STATION POSITIONS AND VELOCITIES AT EPOCH 2015/01/01				
DOMES NB	ID	X/σx	Y/σy	Z/σz
		m-m	m-m	m-m
12750S001	PADO	4388881.863	924567.647	4519588.855
		0.001	0.001	0.001
12751M001	BZRG	4312657.332	864634.832	4603844.563
		0.005	0.002	0.005
40164M001	NAIN	1671836.471	-3103473.316	5297671.308
		0.001	0.001	0.001

4.3 Software applied in analysis

Trimble business center 3.5 (TBC 3.5) for relative solution. Trimble Business Center software is your complete office solution for post-processing satellite and terrestrial survey data. Easily import field and reference data from a variety of sources including transferred data files, field devices, and the Internet. After processing, export your processed data directly to field devices or to a variety of file formats that can be imported into other design software packages. Trimble Business Center lets users easily combine and manage data from multiple sources to generate accurate, integrated survey results **(http://www.trimble.com/survey/trimble-business-center).**

CSRS for PPP solution. The Canadian Spatial Reference System (CSRS) Precise Point Positioning (PPP) tool allows the computation of higher accuracy positions of raw Global Navigation Satellite System (GNSS) data. CSRS-PPP is an online application for GNSS data post-processing allowing users to compute higher accuracy positions from their raw observation data. CSRS-PPP uses the precise GNSS satellite orbit ephemerides to produce corrected coordinates of a constant "absolute" accuracy no matter where you are on the globe, regardless of proximity to known base stations http://www.nrcan.gc.ca/earth-sciences/geomatics/geodetic-reference-systems/tools-applications/10925.

4.4 Methodology

The following Figure 2, illustrates the process applied on GNSS RINEX data using final precise ephemeris.

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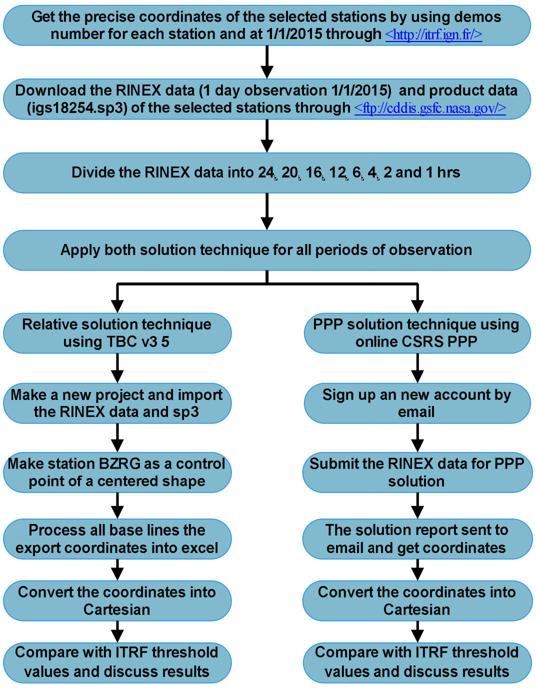

Figure 2: GNSS RINEX data using final precise ephemeris Methodology

Also Figure 3, illustrates the process applied on GNSS RINEX data using rapid precise ephemeris

5. Results Discussion and Analysis

In order to discuss the results analysis of a comparative study between Precise Point Positioning (PPP) versus relative positioning, the analysis had been divided into three main topics listed blew:

PPP with observation period.
Relative with observation period.
PPP and relative technique with observation period and base line length.

4.5 PPP with observation period using the final precise ephemeris:

All stations RINEX data submitted to online CSRS-PPP and the following figures (Figure 3, 4, 5 and 6) show the differences between the PPP resulted coordinates after the final precise ephemeris with the ITRF threshold values at all selected stations in x, y, z, and 3D directions respectively.

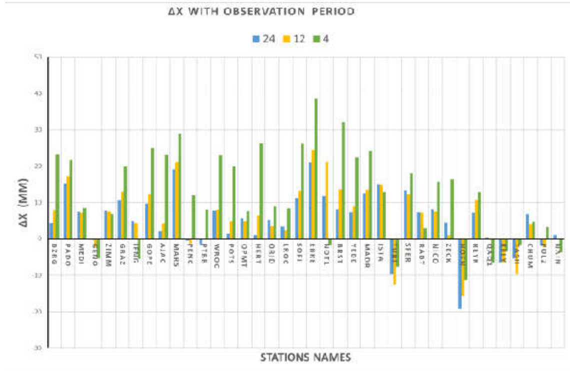

Figure 3: Station errors with observation period in PPP technique after the final precise ephemeris in x direction.

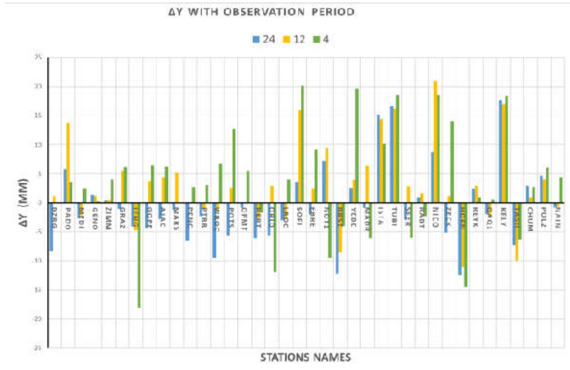

Figure 4: Station errors with observation period in PPP technique after the final precise ephemeris in y direction.

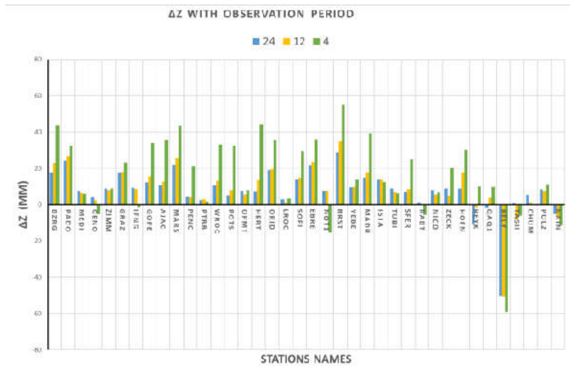

Figure 5: Station errors with observation period in PPP technique after the final precise ephemeris in z direction.

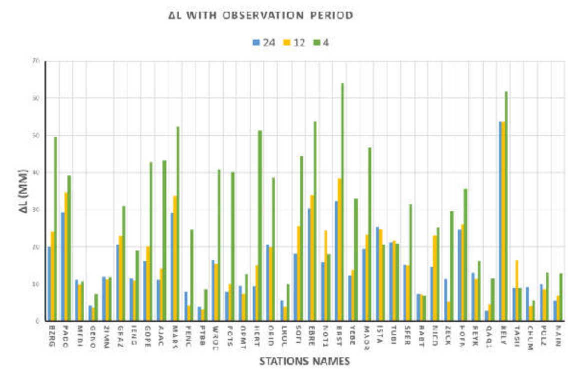

Figure 6: Station errors with observation period in PPP technique after the final precise ephemeris in 3D direction.

As it is shown in Figures 4, 5, 6 and 7, The differences between the PPP resulted values after the final precise ephemeris with the ITRF threshold values are decreased with increasing the observation period, these values are ranged between 3 mms to 54 mms for 24 hrs. period of observations. They are about 23 mms to 128 mms for 1hr period of observation. These differences show big variations especially for 1hr. and 2hrs. period of observations. These differences show mild variations especially for 4hr. and 6hrs. period of observations. These differences show very small variations especially for period of observations more than 12 hrs.

4.6 Relative with observation period using the final precise ephemeris:

Using Trimble Business Center (TBC v3.5), BZRG station was taken as a control point for relative solution. Also, the final precise ephemeris IGS products (igs18245.sp3) was downloaded and used in relative solution. The following Figure 7 shows the solution type of base lines with base line length and different observation periods of using the final precise ephemeris.

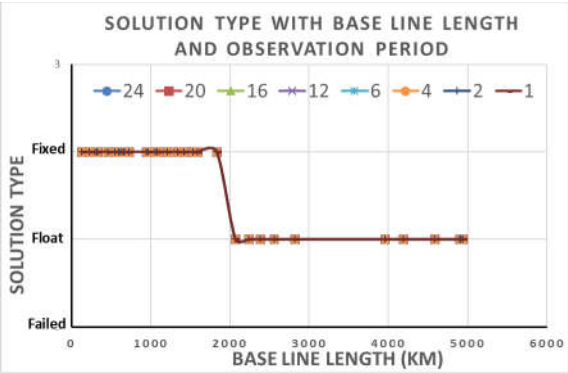

Figure 7: Station errors with observation period in PPP technique after the final precise ephemeris in z direction.

As it is depicted in Figure 7, Using final precise ephemeris, the relative solution type is fixed for all observation periods listed in this thesis (more than 1 hr.) and for all base lines less than 1800 kms.. the relative solution type is float for all observation periods listed in this thesis (more than 1 hr.) and for all base lines more than 1800 kms..

Also Figure 8, 9, 10 and 11 show the differences between the relative resulted coordinates using final precise ephemeris with the ITRF threshold values at all selected stations with different periods of observation in x, y, z, and 3D directions respectively.

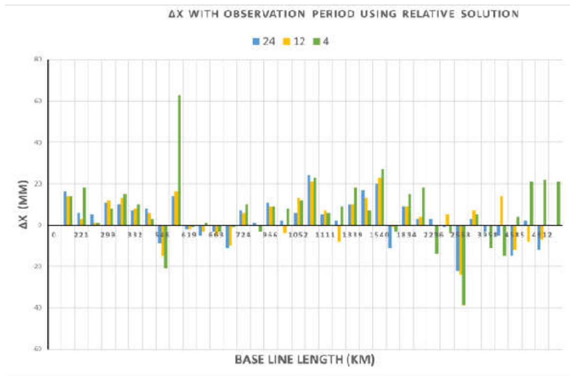

Figure 8: The differences between the relative resulted coordinates using final precise ephemeris with the ITRF threshold values at all selected stations with different periods of observation in x direction.

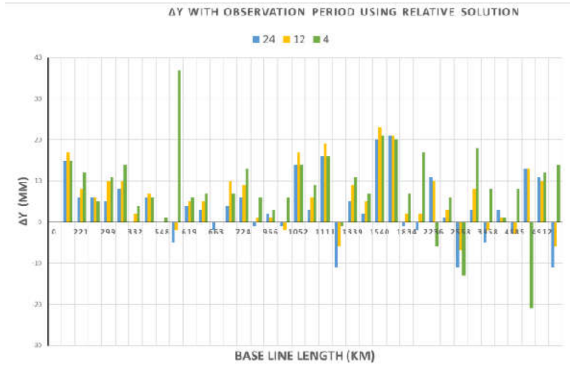

Figure 9: The differences between the relative resulted coordinates using final precise ephemeris with the ITRF threshold values at all selected stations with different periods of observation in y direction.

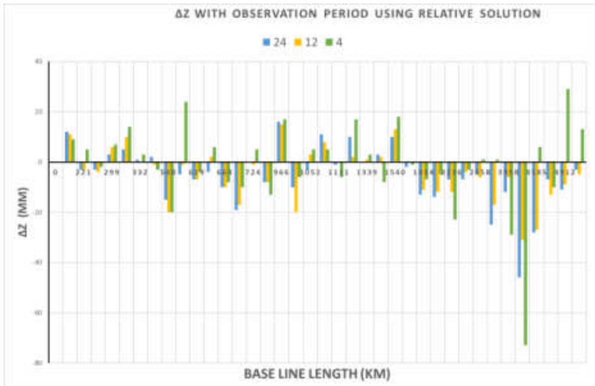

Figure 10: The differences between the relative resulted coordinates using final precise ephemeris with the ITRF threshold values at all selected stations with different periods of observation in z direction.

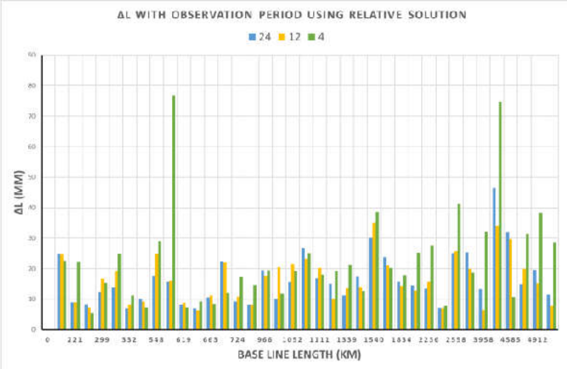

Figure 11: The differences between the relative resulted coordinates using final precise ephemeris with the ITRF threshold values at all selected stations with different periods of observation in 3D direction.

As it is shown in Figure 8, 9, 10 and 11, the differences between the relative resulted coordinates using final precise ephemeris with the ITRF threshold values are decreased with increasing the observation period, these values are 16 mms for 24 hrs period of observations. They are about 186 mms for 1hr period of observation. The values show small variations especially above 12 hrs observation period. These differences show big variations especially for 1hr. and 2hrs. period of observations. These differences show mild variations especially for 4hr. and 6hrs. period of observations. These differences show very small variations especially for period of observations more than 12 hrs.

4.7 PPP and relative technique with observation period and base line length using the final precise ephemeris:

In order to obtain the results analysis of a comparative study between Precise Point Positioning (PPP) versus relative positioning, data had been divided into segments with the observation time (24, 20, 16, 12, 6, 4, 2, and 1) hrs. to get the effect of observation time Precise Point Positioning (PPP) versus relative positioning with the base line length.

4.7.124 hrs. period of observation using the final precise ephemeris:

All stations 24 hrs. period of observation RINEX data submitted to TBC v3.5 and CSRS-PPP. After getting the final coordinates from CSRS-PPP and TBC v3.5 for each station, all coordinates compared with the ITRF threshold values at all selected stations. The following Figures 12, 13, 14 and 15 show the relation between the base line length and the differences between the PPP and relative resulted coordinates using final precise ephemeris with the ITRF threshold values at all selected stations at 24 hrs. period of observation ranged from 128 kms to 5000 kms in x, y, z, and 3D directions respectively.

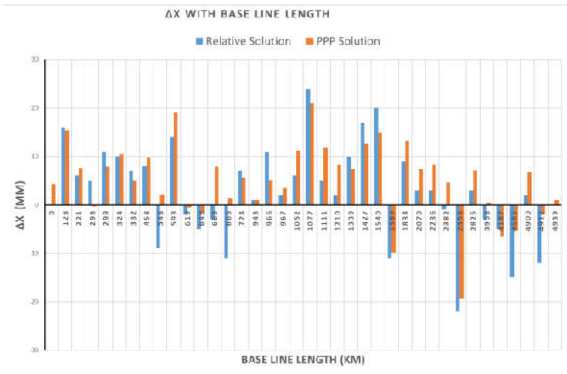

Figure 12: PPP and relative errors using final precise ephemeris with base line length at 24 hrs. period of observation in x direction.

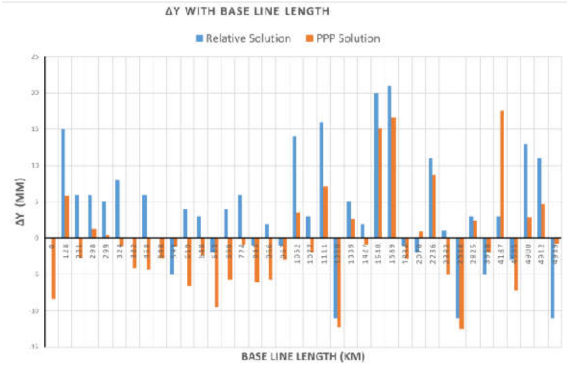

Figure 13: PPP and relative errors using final precise ephemeris with base line length at 24 hrs. period of observation in y direction.

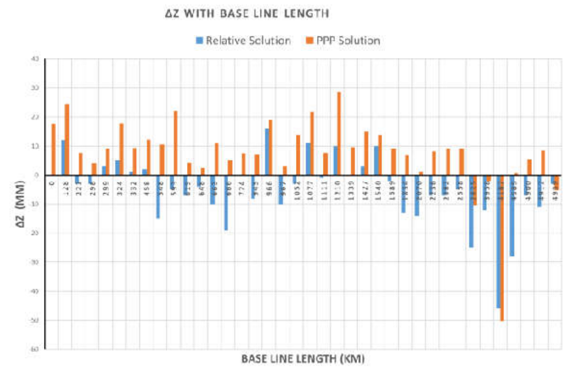

Figure 14: PPP and relative errors using final precise ephemeris with base line length at 24 hrs. period of observation in z direction.

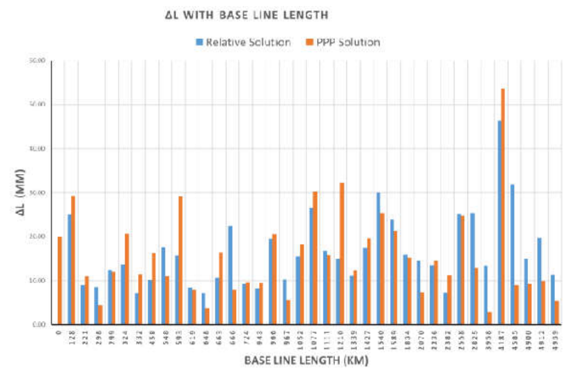

Figure 15: PPP and relative errors using final precise ephemeris with base line length at 24 hrs. period of observation in 3Ddirection.

As it is demonstrated in Figures 12, 13, 14 and 15, the PPP average errors show small variations about 15 mms. On the other hand, the aforementioned figures confirmed that the relative technique is mainly dependent on base line length. The both solutions are close to each other especially for base lines less than 2800 kms. For 24 hrs. period of observation and using final precise ephemeris, it is preferred to use relative technique especially for base lines less than 1300 kms., PPP is preferred to be used especially for base lines more than 2500 kms. and both techniques are too close to each other for base lines between 1300 kms. to 2500 kms..

4.7.212 hrs. period of observation using the final precise ephemeris:

All stations 12 hrs. period of observation RINEX data submitted to TBC v3.5 and CSRS-PPP. After getting the final coordinates from CSRS-PPP and TBC v3.5 for each station, all coordinates compared with the ITRF threshold values at all selected stations. The following Figures 16, 17, 18 and 19 show the relation between the base line length and the differences between the PPP and relative resulted coordinates using final precise ephemeris with the ITRF threshold values at all selected stations at 12 hrs. period of observation ranged from 128 kms to 5000 kms in x, y, z, and 3D directions respectively.

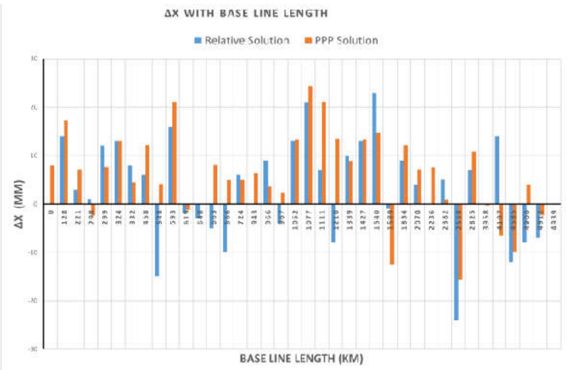

Figure 16: PPP and relative errors using final precise ephemeris with base line length at 12 hrs. period of observation in x direction.

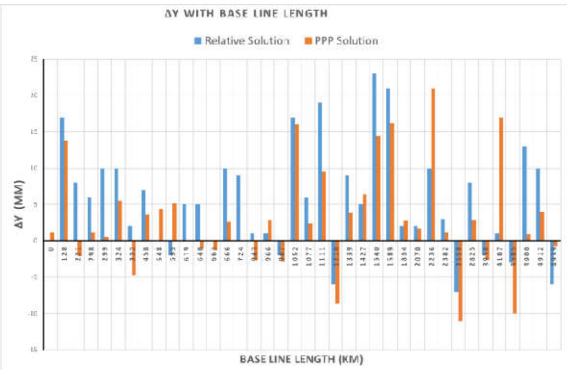

Figure 17: PPP and relative errors using final precise ephemeris with base line length at 12 hrs. period of observation in y direction.

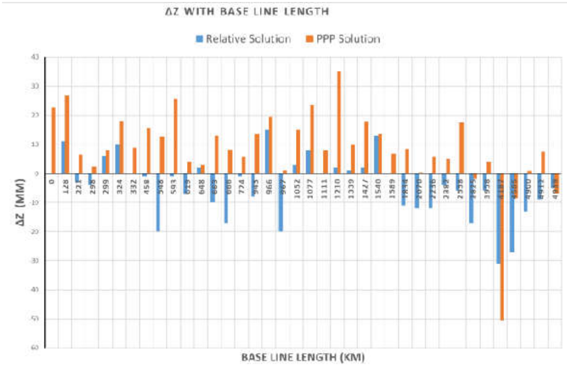

Figure 18: PPP and relative errors using final precise ephemeris with base line length at 12 hrs. period of observation in z direction.

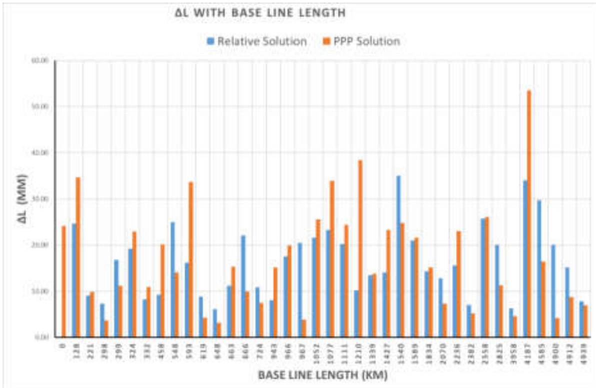

Figure 19: PPP and relative errors using final precise ephemeris with base line length at 12 hrs. period of observation in 3D direction.

As it is demonstrated in Figures 16, 17, 18 and 19, the PPP average errors show small variations about 17 mms. On the other hand, the aforementioned figures confirmed that the relative technique is mainly dependent on base line length. The both solutions are close to each other especially for base lines less than 2800 kms. For 12 hrs. period of observation and using final precise ephemeris, it is preferred to use relative technique especially for base lines less than 1300 kms., PPP is preferred to be used especially for base lines more than 2500 kms. and both techniques are too close to each other for base lines between 1300 kms. to 2500 kms..

4.7.34 hrs. period of observation using the final precise ephemeris:

All stations 4 hrs. period of observation RINEX data submitted to TBC v3.5 and CSRS-PPP. After getting the final coordinates from CSRS-PPP and TBC v3.5 for each station, all coordinates compared with the ITRF threshold values at all selected stations. The following Figures 12, 13, 14 and 15 show the relation between the base line length and the differences between the PPP and relative resulted coordinates using final precise ephemeris with the ITRF threshold values at all selected stations at 4 hrs. period of observation ranged from 128 kms to 5000 kms in x, y, z, and 3D directions respectively.

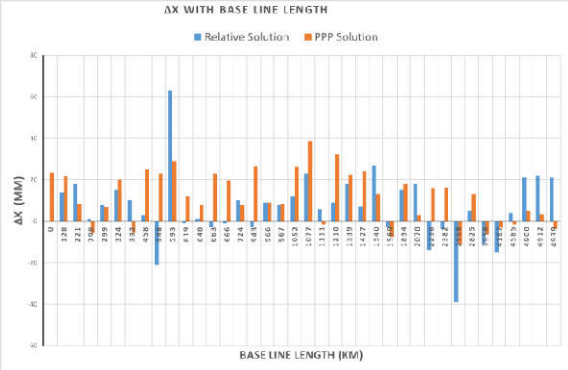

Figure 20: PPP and relative errors using final precise ephemeris with base line length at 4 hrs. period of observation in x direction.

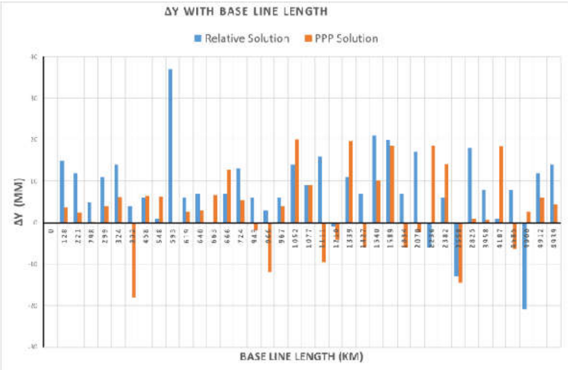

Figure 21: PPP and relative errors using final precise ephemeris with base line length at 4 hrs. period of observation in y direction.

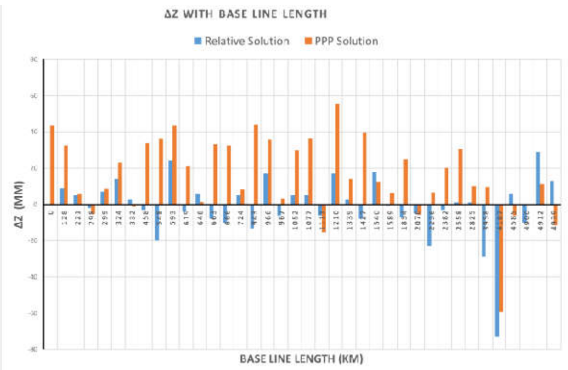

Figure 22: PPP and relative errors using final precise ephemeris with base line length at 4 hrs. period of observation in z direction.

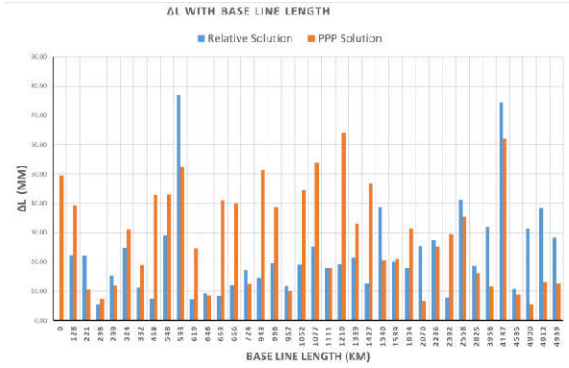

Figure 23: PPP and relative errors using final precise ephemeris with base line length at 4 hrs. period of observation in 3D direction.

As it is demonstrated in Figures 20, 21, 22 and 23, the PPP average errors show small variations about 29 mms. On the other hand, the aforementioned figures confirmed that the relative technique is mainly dependent on base line length. The both solutions are close to each other especially for base lines less than 2800 kms. For 4 hrs. period of observation and using final precise ephemeris, it is preferred to use relative technique especially for base lines less than 1300 kms., PPP is preferred to be used especially for base lines more than 2500 kms. and both techniques are too close to each other for base lines between 1300 kms. to 2500 kms..

6. Conclusion

Based on the practical results obtained and analysis, the following conclusions can be summarized:

1. Using final precise ephemeris, the differences between the PPP resulted values with the ITRF threshold values are decreased with increasing the observation period. These differences show big variations especially for 1hr. and 2hrs. period of observations. These differences show mild variations especially for 4hr. and 6hrs. period of observations. These differences show very small variations especially for period of observations more than 12 hrs.

2. Using final precise ephemeris, the relative solution type is fixed for all observation periods listed in this thesis (more than 1 hr.) and for all base lines less than 1800 kms.. the relative solution type is float for all observation periods listed in this thesis (more than 1 hr.) and for all base lines more than 1800 kms.

3. Using final precise ephemeris, the differences between the relative resulted values with the ITRF threshold values are decreased with increasing the observation period. These differences show big variations especially for 1hr. and 2hrs. period of observations. These differences show mild variations especially for 4hr. and 6hrs. period of observations. These differences show very small variations especially for period of observations more than 12 hrs.

4. For 24 hrs. period of observation and using final precise ephemeris, it is preferred to use relative technique especially for base lines less than 1300 kms., PPP is preferred to be used especially for base lines more than 2500 kms. and both techniques are too close to each other for base lines between 1300 kms. to 2500 kms..

5. For 1 hr. period of observation and using final precise ephemeris, PPP is preferred to be used for all base lines lengths listed in this thesis (more than 128 kms.).

References

[1] J. Sanz Subirana, J.M. Juan Zornoza and M. Hernández-Pajares: "GNSS DATA PROCESSING" Volume I: Fundamentals and Algorithms, pp. 65-71, 2013.
[2] Jan Kouba: "A GUIDE TO USING INTERNATIONAL GNSS SERVICE (IGS)" Geodetic Survey Division, Natural Resources Canada, pp.6, 2009.
[3] Precise Point Positioning - Natural Resources Canada, https://webapp.geod.nrcan.gc.ca/geod/tools-outils/ppp.php
[4] RINEX data collection, NASA - Crustal Dynamics Data Information System (CDDIS) ftp://cddis.gsfc.nasa.gov/.
[5] ITRF solution The, International Terrestrial Reference Frame (ITRF) http://itrf.ign.fr/.
[6] Trimble business center, **(http://www.trimble.com/survey/trimble-business-center).**
[7] 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.
[8] ZUMBERGE, J.F.; HEFLIN, M.B.; JEFFERSON, D.C.; WATKINS, M.M.; WEBB, F.H. Precise Point Positioning for the efficient and robust analysis of GPS data from large networks. Journal of Geophysical Research, v. 102, n. B3, p. 5005-5017, 1997
[9] 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