Contribution of GLONASS Observations on Precise Point Positioning

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Introduction

In recent years thanks to modernization of GLONASS, especially increasement of the satellite number, it becomes worthwhile to investigate the usability of GLONASS on global positioning in terms of accuracy and precision. Many researches have been performed for investigating the GPS and GLONASS positioning performance. These researches mostly consist of Double Difference (DD) and Real Time Kinematics (RTK) positioning studies. In the last decade the Precise Point Positioning (PPP) method has become an attractive method for researchers. In the PPP method, while at first only GPS observations can be used, lately by the help of recently popular web based GNSS softwares, GLONASS observations can also be used for positioning.

In this research, in order to investigate the usefulness of GLONASS together with GPS in the PPP method, 3 IGS stations have been selected in different latitude regions and processes have been performed by using magicGNSS software that is quite favourite web based GNSS software. Results have been investigated.

Positioning with PPP

Precise point positioning is a relatively new technique, theoretical basis was first given by Zumberge et. al. (1997). PPP is a special case of zero difference processing. It is different from other precise positioning approaches like RTK or DGPS in that no base stations or reference stations are needed. The only observation data that must be processed is the user receiver data itself. Thus, the time loss is reducing.

In PPP, precise orbits and clock products are used. This is important for precise coordinate estimation. In recent years, by the help of various international centers like International GNSS Service (IGS), Center for Orbit Determination for Europe (CODE), Jet Propulsion Laboratory (JPL), which produce more precise orbits and clock product when compared to the past, accuracy and precision of PPP results have become better.

PPP method is generally used in software packages and web based GNSS softwares. MagicGNSS, CSRS-PPP and GAPS can be given examples of web based GNSS softwares, Bernese and GrafNav are examples of software packages. Detailed information about software packages and web based GNSS softwares are given by Huber et. al.(2010)

PPP Results

In this study, three stations have been chosen from different latitude regions:

SOFI (*mid latitude)*

SVTL *(high latitude)*

WIND *(equatorial)*

Processes have been performed for 2011,DOY 100. GPS and GPS/GLONASS PDOP values for pertinent day, are given in figure 1.

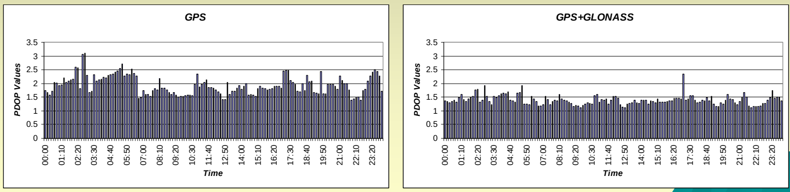

Figure 1: GPS and GPS/GLONASS PDOP values

There is strong correlation between ionospheric variations and geomagnetic activity. This relationship is used to monitor ionospheric disturbances related with atmosphere. The geomagnetic activity is shown by using kp indices. Kp indices are estimated for 3h durations.In order to investigate the comparison of GPS and GPS/GLONASS PPP results better, quiet time period (2011, DOY 100) has been selected. Kp index values for pertinent day are given in figure 2.

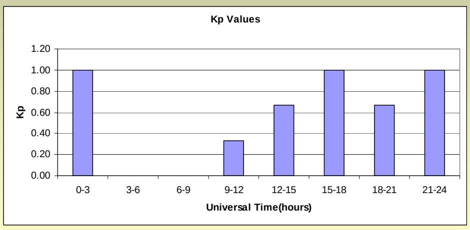

Figure 2: Kp values for 2011, DOY 100

Firstly, 24 hourly GPS observations have been processed by using Bernese 5.0 PPP modul.

Table 1:Estimated station coordinates and standard deviations (GPS only)

Stations	X	Y	Z	mx	my	mz
SOFI	4319371.9850	1868687.8990	4292064.0008	0.0011	0.0008	0.0010
SVTL	2730155.2448	1562364.8232	5529989.3364	0.0006	0.0006	0.0009
WIND	5633708.7797	1732017.8363	-2433985.6580	0.0014	0.0010	0.0007

24 hourly GPS+GLONASS and GPS observations have been processed by magic GNSS PPP modul at first. Differences between magicGNSS results and measurement epoch coordinates, which were computed from ITRF 2008 reference epoch coordinates, are given in table 2

Table 2:Differences between known and estimated coordinates (24 hourly observations)

Stations	***GPS/GLONASS***			***GPS***		
	dx	dy	dz	dx	dy	dz
SOFI	0.6	5.6	1.4	2.2	7.9	-0.4
SVTL	-0.7	2.1	9.7	0.3	-1.2	4.3
WIND	12.1	-21.8	11.9	-3.9	-5.8	5.9

Table 3:Differences between Bernese and magicGNSS coordinate results (24 hourly observations)

Stations	GPS/GLONASS			GPS		
	dx	dy	dz	dx	dy	dz
SOFI	3.7	4.8	8.7	5.3	7.1	6.9
SVTL	5.1	5.3	19.9	6.1	2.0	14.6
WIND	11.9	-29.0	11.7	-4.1	-13.0	5.7

Then 4,2 and 1 hourly GPS and GPS/GLONASS observations have been processed.

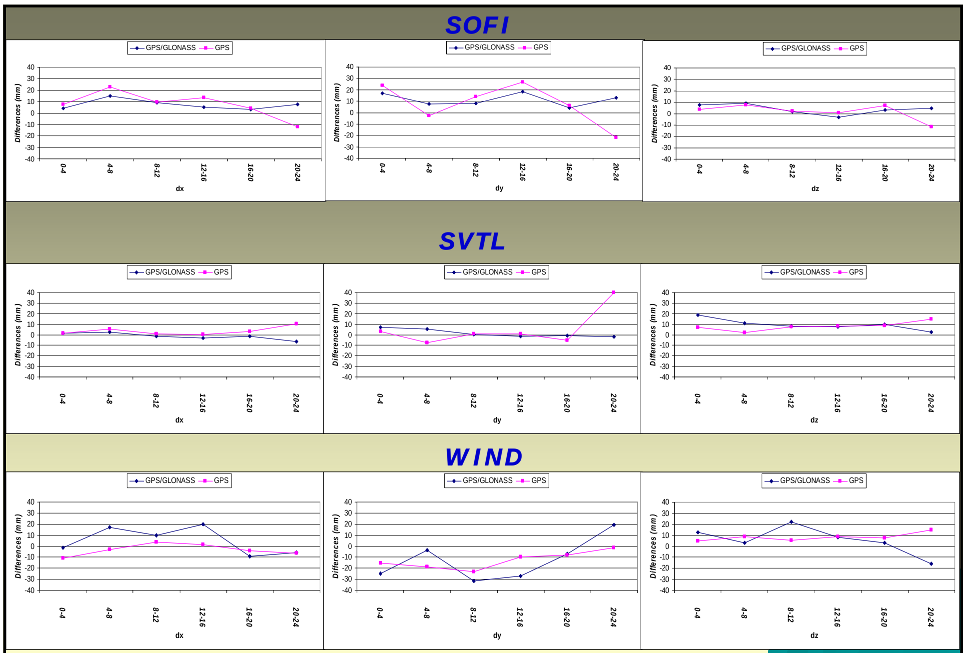

Figure 3:Differences between known and estimated coordinates (4 hourly observations)

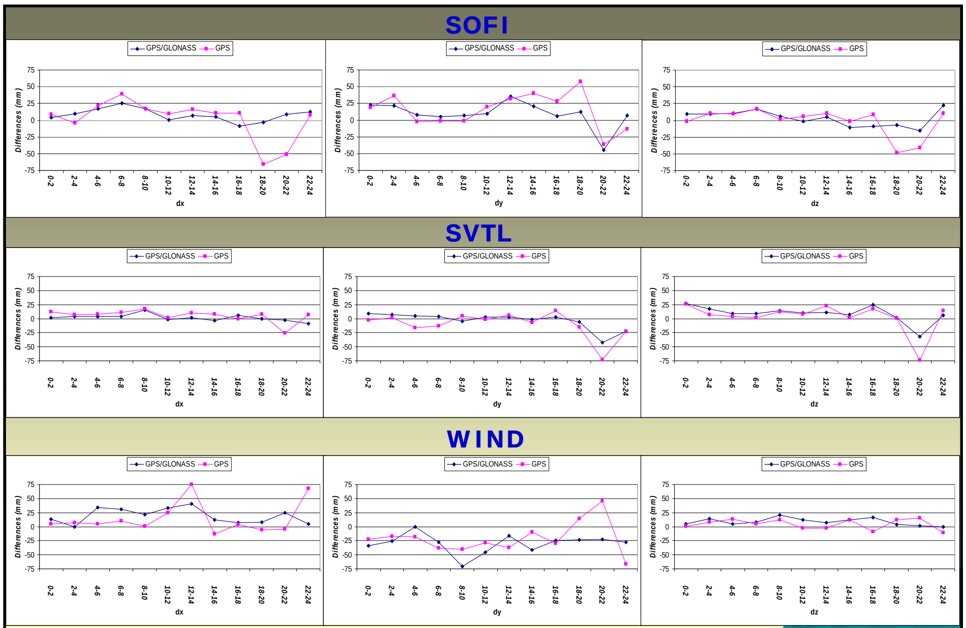

Figure 4:Differences between known and estimated coordinates (2 hourly observations)

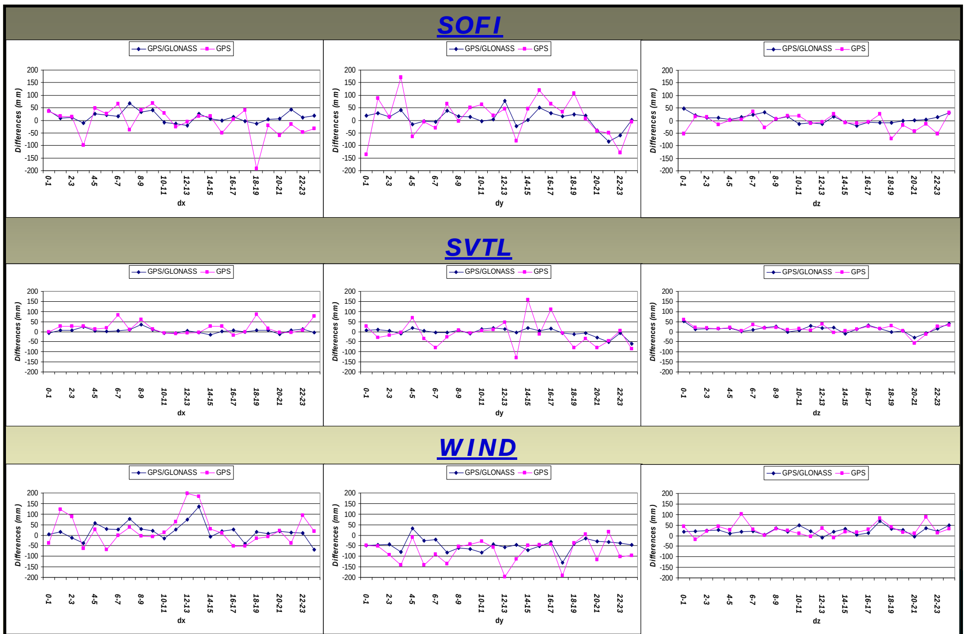

Figure 5:Differences between known and estimated coordinates (1 hourly observations)

In order to investigate the repeatabilities, standard deviations of coordinate components computed by using equation and listed in table 4.

$$m = \sqrt{\frac{[vv]}{n-1}}$$

Where; v is the difference from the average value, n is the number of measurement

Table 4:Standard deviations of coordinate components for all time segments

	Time Intervals	GPS/GLONASS			GPS		
		mx	***my***	***mz***	***mx***	***my***	***mz***
SOFI	1 Hourly	25.1	35.2	18.2	58.1	76.5	29.2
	2 Hourly	12.6	21.6	12.2	30.1	30.6	20.9
	4 Hourly	9.2	13.6	6.1	14.3	20.0	7.1
SVTL	1 Hourly	11.6	20.4	21.8	35.3	64.1	26.6
	2 Hourly	6.2	15.1	17.3	12.0	24.9	26.0
	4 Hourly	3.6	4.0	11.7	5.5	18.4	9.8
WIND	1 Hourly	45.2	57.8	29.1	75.1	97.4	40.7
	2 Hourly	24.0	35.6	11.2	31.9	36.0	10.2
	4 Hourly	13.3	23.6	14.0	6.3	16.1	9.6

Concluding Remarks

Contribution of GLONASS on global positioning has been investigated by considering PPP method and by using magicGNSS web based software, which allows processing GPS and GPS/GLONASS observations.

Three stations, which are located in different regions have been considered. 24 hourly and for investigating the repeatabilities; 4, 2 and 1 hourly observations have been chosen.

When the 24 hourly observations considered for SOFI and SVTL, located in mid-latitude and high latitude regions respectively, GPS/GLONASS results are better but for the station which is located in equatorial region, WIND, GPS results are generally better than GPS/GLONASS. This situation may be associated with the regional location of the stations. But more investigation is needed.

Results also confirmed that, addition of GLONASS observation has advantages on positioning especially for short time periods at all regions.