Analysis of the Effect of Data Intervals on GNSS Processing

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Key words: Baseline Processing, GPS, GLONASS, Data intervals

SUMMARY

Over the past decades, thousands of scientists and engineers have developed an amazing range of GPS applications providing post-process positioning with accuracy all the way down to the millimeter level. GNSS applications include different GNSS technologies and methods. According to declared GNSS plans; GPS, GLONASS and Galileo systems will be fully compatible and interoperable with each other in the near future. On the other hand, as it is well known in the surveying community, static GNSS observation and post-processing methods are the most basic and accurate GNSS applications. However, work on the effect of data ranges in post-processing is not readily available. The purpose of this paper is to analyze the effect of data intervals on GNSS solutions in static method applications. To achieve this goal, the current status of GNSS post-processing is explained briefly and the results of GNSS post-processing are presented. For this purpose, data from two different GNSS networks were used. One of these networks was established by the project team around Selcuk University as a local network. In addition to this local network, data from the GNSS points used in this study were selected from CORS-TR points as a second network which contains longer baselines. The GNSS data collected in the field and obtained from CORS-TR points were processed by using Leica Geo Office GNSS software. In the processing of different satellite systems (GPS-only, GLONASS-only, GPS+GLONASS) were compared by changing different data intervals (1, 5, 10, 15, 30 sec).

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1. INTRODUCTION

Today, with the rapid development and changes in space geodesy and satellite techniques, opportunities for choosing and using GNSS have increased, and many satellite systems are available and ready to use. Nowadays it is possible to obtain precise positioning with high accuracy by using the GNSS technique. In recent years, with the development of technology, geoscientific studies, geodetic measurements, remote sensing, geodetic and geodynamic measurements, cadastral measurements, kinematic GNSS supported photogrammetric studies, local and global deformation measurements, data collection / generation for the development and application of GIS databases GNSS systems and applications have been systematized to collect data within specific standards, to be evaluated and delivered to users for different methods. GNSS applications have been one of the most important areas of work in measurement techniques and Geodetic Science. In order to analyze the effect of data intervals of GNSS processing results with data intervals of 1, 5, 10, 15, 30 seconds, satellite systems (GPS, GLONASS) observation duration 5, 20, 120 minutes investigated how much of which effect has been interpreted.

2. GLOBAL NAVIGATION SATELLITE SYSTEMS (GNSS)

The term GNSS is now used to describe many different satellite positioning systems operated by different countries. Among them, GPS (Global Positioning System) is the most commonly known and widely used system, while others, i.e. GLONASS, Galileo etc. have started to be used or are about to be used in the near future. 20 years ago, the usage of GNSS by civilians was mainly limited to trade ship crews and surveyors, but today there are millions of receivers that use it to achieve different tasks. Moreover, GNSS technology is becoming the most effective positioning method for all types of engineering projects (Bonnor, 2012). The systems that constitute GNSS are briefly given in the following sections

2.1. GPS

The United States Department of Defense (DOD) has developed the Navstar GPS, which is an All-weather, space based navigation system to meet the needs of the USA military forces and Accurately determine their position, velocity, and time in a common reference system anywhere on or near the Earth on a continuous basis (Wooden, 1985).

GPS comprises three main components:

1. Space segment (satellite): The Space Segment of the system consists of the GPS satellites in orbit; the initial space segment was designed with four satellites in each of six orbital planes inclined at 55 degrees to the equator.
2. Control segment (ground tracking and monitoring stations): The Control Segment consists of master control stations and six monitoring stations around the world. The Master Control facility is located at Schriever Air Force Base (Formerly Falcon AFB) in the State of Colorado, in the United States of America with back up stations in Gaithersburg, Maryland.
3. User segment (air, land, and sea-based receivers): The GPS User Segment represents the ground-based GPS receiver units that process Navstar satellite signals and compute the positions and / or velocity and time estimates of the user (Michael , 2003).

As of 12 February 2007, the space segment was built-up by 30 operational satellites: 15 satellites of Block IIA, 12 satellites of Block IIR and 3 satellites of Block IIR-M (Crews, 2007).

The satellites are distributed in 6 orbital planes with an inclination relative to the equatorial plane of 55°. The orbit is nearly circular with a radius of 26650 km and the period is about 12 hours (Eissfeller et all, 2007).

2.2. GLONASS

The GLONASS (Global Navigation Satellite System or “GLObal'naya NAvigatsionnaya Sputnikovaya Sistema”) is nearly identical to GPS. The Glonass satellite-based radio-navigation System provides positioning and timing information to users. It is operated by the Ministry of Defense of the Russian Federation (GLONASS-ICD, 2002).

The various versions of GLONASS are:
1. GLONASS – launched in 1982, the satellites launched were intended to acquire weather positioning, velocity measuring and timing anywhere in the world or near-Earth space by military and official organizations.
2**.** GLONASS-M – launched in 2003, it adds the second civil code. It is important for GIS mapping receivers.
3**.** GLONASS-K – started in 2011, it has again 3 more types, namely K1, K2 and km for research. It adds the third civil frequency.
4. GLONASS-K2 – will be launched after 2015 (currently in the design phase)
5. GLONASS-KM – will be launched after 2025 (currently in the research phase) (URL4).

2.3. GALILEO

GALILEO is Europe’s initiative for a state-of-the-art global navigation satellite system, providing highly accurate, guaranteed global positioning service under civilian control. Galileo will not be too different from the other GNSS versions (modernized GPS and Glonass (Salgado et al., 2001).

Galileo's segments are almost similar to that of GPS, but with some modification. The main difference of Galileo compared to GPS is the implementation of a global/ regional segment for integrity of monitoring. The objective is to assist in providing safety for critical aircraft navigation and to locate and guide railway trains (GALILEO, 2003).

3. POSITIONING METHODS WITH GNSS

3.1. Absolute Point Positioning

Absolute positioning is the most common military and civil application of Navstar GPS for real-time navigation. When operating in this passive, real-time navigation mode, ranges to Navstar GPS satellites are observed by a single receiver positioned on a point for which a position is desired. This receiver may be positioned to be stationary over a point (static) or in motion (kinematic [such as on a vehicle, aircraft, missile, or backpack]). Two levels of absolute-positioning accuracy may be obtained, namely SPS and PPS. With specialized GPS receiving equipment, data-processing refinements, and long-term static observations, absolute-positional coordinates can be determined to accuracy levels of less than 1 meter. These applications are usually limited to worldwide geodetic-reference surveys (URL3).

3.2. Relative Point Positioning

Relative positioning is a process of measuring the differences in coordinates between two receiver points, each of which is simultaneously observing/measuring satellite code ranges and/or carrier phases from the Navstar GPS constellation. This process measures the difference in ranges between the satellites and two or more ground observation points. The range measurement is performed by phase-difference comparison, using either the carrier or code phase. The basic principle is that the absolute-positioning errors at the two receiver points will be about the same for a given instant. The resultant accuracy of these coordinate differences is at the meter level for code-phase observations and at the centimeter level for carrier-phase tracking. These coordinate differences are usually expressed as 3D baseline vectors, which are comparable to conventional survey azimuth/distance measurements. DGPS positioning can be performed in the static or the kinematic mode (URL3).

4. MATERIAL AND METHOD

In this study, data of two GNSS networks, namely, national CORS-TR and the newly established local network were used. For this purpose, a local network (Figure 1) consisting of 28 points was established in the project area. 25 of them were newly established (J1 - J25), and the other point is the existing point of the conventional TNFGN (Turkey National Fundamental GPS Network - L29-G002) and two others are points of the Konya Greater Municipality local geodetic network (M2920010 and M2910003). Processing was performed in ITRF96 datum and 2005.0 epoch. In this study the following observation plan was applied: 3 reference points (L29-G002, M2920010 and M2910003) were observed for two hours with a 1 second data interval in order to cover the 25 newly established points in the observation span. The locally established 25 new points were observed for 20 minutes statically with a 1 second data interval. The cut-off elevation angle of 0° was applied. Base lengths between all points vary between 400 m and 5 km. The 20 minute data intervals were divided into 5 minute periods in order to compare the results obtained from 20 minute solutions to shorter (i.e. 5 minutes) time spans. Information about baseline lengths and time intervals are provided in Table 1. During the observations, dual frequency geodetic GNSS receivers (JAVAD TRIUMPH-1) were used, belonging to the Selcuk University Department of Geomatics Engineering.

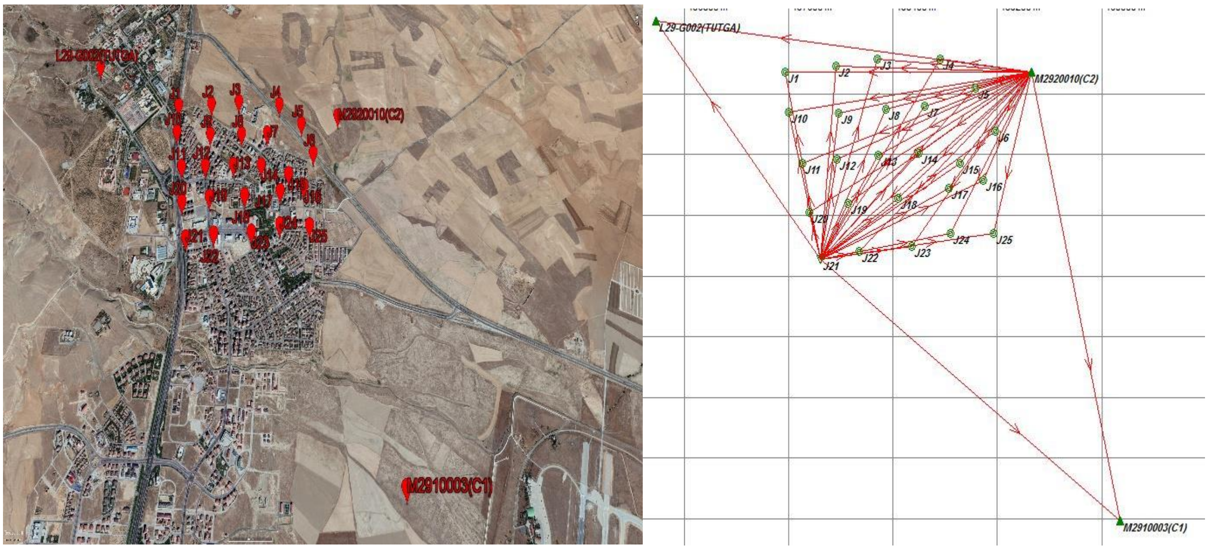

Figure 1: Local geodetic network and base solutions geometry

Table 1: Baseline lengths and time intervals

From	To	Base Lengths (m)	Duration (20 Minutes)			
			Session Time	Session Time	Session Time	Session Time
J21	L29-G002	2015.302	0-5	5-10	10-15	15-20
J21	M2910003	2867.12	0-5	5-10	10-15	15-20
J21	J1	1267.695	0-5	5-10	10-15	15-20
J21	J10	1000.92	0-5	5-10	10-15	15-20
J21	J20	324.498	0-5	5-10	10-15	15-20
J21	J9	977.334	0-5	5-10	10-15	15-20
J21	J11	649.629	0-5	5-10	10-15	15-20
J21	J12	670.805	0-5	5-10	10-15	15-20
J21	J2	1281.125	0-5	5-10	10-15	15-20
J21	J13	813.526	0-5	5-10	10-15	15-20

J21	J3	1389.298	0-5	5-10	10-15	15-20
J21	J22	299.011	0-5	5-10	10-15	15-20
J21	J19	425.875	0-5	5-10	10-15	15-20
J21	J4	1607.217	0-5	5-10	10-15	15-20
J21	J23	700.801	0-5	5-10	10-15	15-20
J21	J5	1641.532	0-5	5-10	10-15	15-20
J21	J24	1012.638	0-5	5-10	10-15	15-20
J21	J6	1581.758	0-5	5-10	10-15	15-20
J21	J25	1334.748	0-5	5-10	10-15	15-20
J21	J7	1289.363	0-5	5-10	10-15	15-20
J21	J16	1348.753	0-5	5-10	10-15	15-20
J21	J8	1108.584	0-5	5-10	10-15	15-20
J21	J17	1088.38	0-5	5-10	10-15	15-20
J21	J18	717.93	0-5	5-10	10-15	15-20
J21	J14	1027.038	0-5	5-10	10-15	15-20
J21	J15	1239.569	0-5	5-10	10-15	15-20
M2920010	L29-G002	2898.739	0-5	5-10	10-15	15-20
M2920010	M2910003	2035.752	0-5	5-10	10-15	15-20
M2920010	J21	3033.249	0-5	5-10	10-15	15-20
M2920010	J1	1886.598	0-5	5-10	10-15	15-20
M2920010	J10	1883.937	0-5	5-10	10-15	15-20
M2920010	J20	1939.052	0-5	5-10	10-15	15-20
M2920010	J9	1503.506	0-5	5-10	10-15	15-20
M2920010	J11	1857.844	0-5	5-10	10-15	15-20
M2920010	J12	1603.39	0-5	5-10	10-15	15-20
M2920010	J2	1502.969	0-5	5-10	10-15	15-20
M2920010	J13	1301.609	0-5	5-10	10-15	15-20
M2920010	J3	1187.233	0-5	5-10	10-15	15-20
M2920010	J22	1776.224	0-5	5-10	10-15	15-20
M2920010	J19	1654.109	0-5	5-10	10-15	15-20
M2920010	J4	706.342	0-5	5-10	10-15	15-20
M2920010	J23	1471.708	0-5	5-10	10-15	15-20
M2920010	J5	440.892	0-5	5-10	10-15	15-20
M2920010	J24	1233.657	0-5	5-10	10-15	15-20
M2920010	J6	481.451	0-5	5-10	10-15	15-20
M2920010	J25	1101.75	0-5	5-10	10-15	15-20
M2920010	J7	850.537	0-5	5-10	10-15	15-20
M2920010	J16	806.086	0-5	5-10	10-15	15-20
M2920010	J8	1145.29	0-5	5-10	10-15	15-20
M2920010	J17	996.899	0-5	5-10	10-15	15-20
M2920010	J18	1319.566	0-5	5-10	10-15	15-20

M2920010	J14	1018.296	0-5	5-10	10-15	15-20
M2920010	J15	818.263	0-5	5-10	10-15	15-20

Data of CORS - TR stations (AKHISAR, KONYA, CIHANBEYLI, KARAPINAR, YUNAK, and KARAMAN) used in this study were downloaded from its web-site (Figure 2). The same baselines were processed in different data intervals with different observation periods. Baseline lengths between CORS-TR points had ranges up to 120 km. All computations were performed using LGO GNSS processing software.

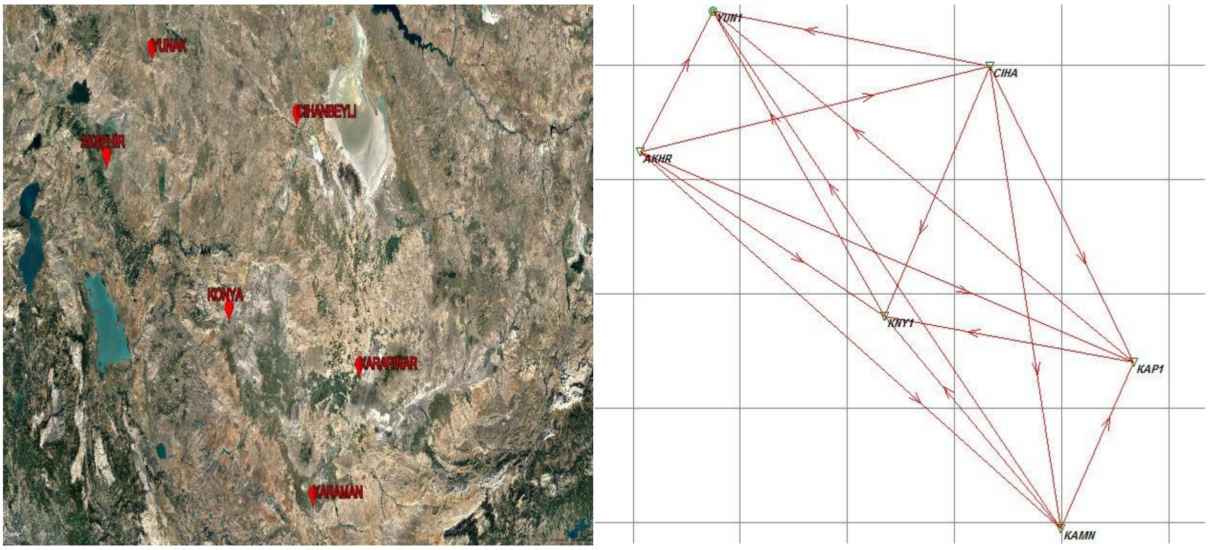

Figure 2: CORS-TR network points and baseline geometry

Table 2: Baseline lengths and time intervals

From	To	Base Lengths (m)	Duration times (24 Hourly)			
			Sessions	Sessions	Sessions	Sessions
AKHR	CIHA	133888.239	0-2	2-4	4-6	6-8
AKHR	KAMN	204745.318	0-2	2-4	4-6	6-8
AKHR	KAP1	198042.317	0-2	2-4	4-6	6-8
AKHR	KNY1	107840.583	0-2	2-4	4-6	6-8
AKHR	YUN1	56163.895	0-2	2-4	4-6	6-8
CIHA	KAMN	163844.059	0-2	2-4	4-6	6-8

CIHA	KAP1	116668.456	0-2	2-4	4-6	6-8
CIHA	KNY1	96090.247	0-2	2-4	4-6	6-8
CIHA	YUN1	105157.6	0-2	2-4	4-6	6-8
KAMN	KAP1	63943.893	0-2	2-4	4-6	6-8
KAMN	KNY1	98948.285	0-2	2-4	4-6	6-8
KAMN	YUN1	222581.333	0-2	2-4	4-6	6-8
KAP1	KNY1	94047.133	0-2	2-4	4-6	6-8
KAP1	YUN1	199188.128	0-2	2-4	4-6	6-8
KNY1	YUN1	124577.097	0-2	2-4	4-6	6-8

Collected data were converted into RINEX format in order to provide solutions using LGO software. All processing parameters are provided in Table 3.

Table 3: Processing parameters

Parameters	**Selected**
Cut-off angle:	10°
Ephemeris type:	Broadcast (CORS-TR data with precise eph)
Solution observable:	Phase
GNSS type:	GPS, GPS+GLONASS, GLONASS
Solution Method	Baseline
Frequency:	Automatic (L1, L2, L1+L2, Iono free fixed)
Fix ambiguities up to:	500 km
Min. duration for float solution (static):	300 Sec
Sampling rate:	(1,5,10,15,30) sec
Tropospheric model:	Hopfield
Ionospheric model:	Automatic
Use stochastic modelling:	Yes
Min. distance:	100 km
Ionospheric activity:	Automatic

5. PROCESSING RESULTS AND DISCUSSION

Processing results for each solution explained in Tables 1 and 2 are provided in Tables 4 – 39.

5.1. Local geodetic network results

Table 4: Differences between 1 second and 5 second data intervals using GPS-only satellites. Data and observation time is 20 minutes.

	ΔX (m)	ΔY (m)	ΔZ (m)
Minimum	-0.001	-0.001	-0.001
Maximum	-0.001	-0.001	-0.001
Average	-0.001	-0.001	-0.001
Standard deviations	-0.001	-0.001	-0.001

Table 5: Differences between 1 second and 10 second data intervals using GPS-only satellites. Data and observation time is 20 minutes.

	ΔX (m)	ΔY (m)	ΔZ (m)
Minimum	-0.001	-0.001	-0.001
Maximum	0.001	0.001	0.001
Average	0.001	0.001	0.001
Standard deviations	0.001	0.001	0.001

Table 6: Differences between 1 second and 15 second data intervals using GPS-only satellites. Data and observation time is 20 minutes.

	ΔX (m)	ΔY (m)	ΔZ (m)
Minimum	-0.001	-0.001	-0.001
Maximum	0.002	0.002	0.002
Average	0.000	0.000	0.000
Standard deviations	0.001	0.001	0.001

Table 7: Differences between 1 second and 30 second data intervals using GPS-only satellites. Data and observation time is 20 minutes.

	ΔX (m)	ΔY (m)	ΔZ (m)
Minimum	-0.001	-0.001	-0.001
Maximum	0.003	0.003	0.003
Average	0.000	0.000	0.000
Standard deviations	0.001	0.001	0.001

Table 8: Differences between 1 second and 5 second data intervals using GLONASS-only satellites. Data and observation time is 20 minutes.

	ΔX (m)	ΔY (m)	ΔZ (m)
Minimum	-0.001	-0.001	-0.001
Maximum	0.001	0.001	0.001
Average	0.000	0.000	0.000
Standard deviations	0.000	0.000	0.000

Table 9: Differences between 1 second and 10 second data intervals using GLONASS-only satellites. Data and observation time is 20 minutes.

	ΔX (m)	ΔY (m)	ΔZ (m)
Minimum	-0.001	-0.001	-0.001
Maximum	0.001	0.001	0.001
Average	0.000	0.000	0.000
Standard deviations	0.000	0.000	0.000

Table 10: Differences between 1 second and 15 second data intervals using GLONASS-only satellites. Data and observation time is 20 minutes.

	ΔX (m)	ΔY (m)	ΔZ (m)
Minimum	-0.001	-0.001	-0.001
Maximum	0.001	0.001	0.001
Average	0.000	0.000	0.000
Standard deviations	0.001	0.000	0.001

Table 11: Differences between 1 second and 30 second data intervals using GLONASS-only satellites. Data and observation time is 20 minutes.

	ΔX (m)	ΔY (m)	ΔZ (m)
Minimum	-0.001	-0.001	-0.001
Maximum	0.002	0.001	0.002
Average	0.000	0.000	0.000
Standard deviations	0.001	0.001	0.001

Table 12: Differences between 1 second and 5 second data intervals using GPS+GLONASS satellites. Data and observation time is 20 minutes.

	ΔX (m)	ΔY (m)	ΔZ (m)
Minimum	-0.001	-0.001	-0.001
Maximum	0.001	0.001	0.001
Average	0.000	0.000	0.000
Standard deviations	0.000	0.000	0.000

Table 13: Differences between 1 second and 10 second data intervals using GPS+GLONASS satellites. Data and observation time is 20 minutes.

	ΔX (m)	ΔY (m)	ΔZ (m)
Minimum	-0.004	-0.002	-0.003
Maximum	0.001	0.002	0.002
Average	0.000	0.000	0.000
Standard deviations	0.001	0.001	0.001

Table 14: Differences between 1 second and 15 second data intervals using GPS+GLONASS satellites. Data and observation time is 20 minutes.

	ΔX (m)	ΔY (m)	ΔZ (m)
Minimum	-0.003	-0.001	-0.003
Maximum	0.002	0.003	0.001
Average	0.000	0.000	0.000
Standard deviations	0.001	0.001	0.001

Table 15: Differences between 1 second and 30 second data intervals using GPS+GLONASS-only satellites. Data and observation time is 20 minutes.

	ΔX (m)	ΔY (m)	ΔZ (m)
Minimum	-0.001	-0.001	-0.001
Maximum	0.003	0.002	0.002
Average	0.000	0.000	0.000
Standard deviations	0.001	0.001	0.001

Table 16: Differences between 1 second and 5 second data intervals using GPS-only satellites. Data and observation time is 5 minutes.

	ΔX (m)	ΔY (m)	ΔZ (m)
	0 - 5 minutes		
Minimum	0.001	-0.001	-0.001
Maximum	0.001	0.001	0.001
Average	0.000	0.000	0.000
Standard deviations	0.000	0.000	0.000
	5 - 10 minutes		
Minimum	-0.002	-0.001	-0.001
Maximum	0.001	0.001	0.001
Average	0.000	0.000	0.000
Standard deviations	0.000	0.000	0.001
	10 - 15 minutes		
Minimum	-0.002	-0.001	-0.003
Maximum	0.002	0.001	0.001
Average	0.000	0.000	0.000
Standard deviations	0.001	0.000	0.001
	15 - 20 minutes		
Minimum	0.000	0.000	0.000
Maximum	0.001	0.001	0.001
Average	0.000	0.000	0.000
Standard deviations	0.001	0.001	0.001

Table 17: Differences between 1 second and 10 second data intervals using GPS-only satellites. Data and observation time is 5 minutes.

	ΔX (m)	ΔY (m)	ΔZ (m)
	0 - 5 minutes		
Minimum	-0.001	-0.001	-0.001
Maximum	0.002	0.001	0.002
Average	0.000	0.000	0.000
Standard deviations	0.001	0.001	0.001
	5 - 10 minutes		
Minimum	-0.002	-0.001	-0.002
Maximum	0.001	0.001	0.001
Average	0.000	0.000	0.000
Standard deviations	0.001	0.001	0.001
	10 - 15 minutes		
Minimum	-0.002	-0.001	-0.004
Maximum	0.002	0.001	0.002
Average	0.000	0.000	0.000
Standard deviations	0.001	0.001	0.001
	15 - 20 minutes		
Minimum	-0.002	-0.001	-0.001
Maximum	0.001	0.001	0.001
Average	0.000	0.000	0.000
Standard deviations	0.001	0.001	0.001

Table 18: Differences between 1 second and 15 second data intervals using GPS-only satellites. Data and observation time is 5 minutes.

	ΔX (m)	ΔY (m)	ΔZ (m)
	0 - 5 minutes		
Minimum	-0.002	-0.002	-0.002
Maximum	0.002	0.002	0.002
Average	0.000	0.000	0.000
Standard deviations	0.001	0.001	0.001
	5 - 10 minutes		
Minimum	-0.002	-0.001	-0.003
Maximum	0.002	0.001	0.002
Average	0.000	0.000	0.000
Standard deviations	0.001	0.001	0.001

	10 - 15 minutes		
Minimum	-0.002	-0.001	-0.002
Maximum	0.004	0.001	0.003
Average	0.000	0.000	0.000
Standard deviations	0.001	0.001	0.001
	15 - 20 minutes		
Minimum	-0.002	-0.001	-0.002
Maximum	0.001	0.002	0.002
Average	0.000	0.000	0.000
Standard deviations	0.001	0.001	0.001

Table 19: Differences between 1 second and 30 second data intervals using GPS-only satellites. Data and observation time is 5 minutes.

	ΔX (m)	ΔY (m)	ΔZ (m)
	0 - 5 minutes		
Minimum	-0.002	-0.002	-0.002
Maximum	0.004	0.003	0.003
Average	0.000	0.000	0.000
Standard deviations	0.001	0.001	0.001
	5 - 10 minutes		
Minimum	-0.003	-0.002	-0.002
Maximum	0.004	0.002	0.003
Average	0.000	0.000	0.000
Standard deviations	0.001	0.001	0.001
	10 - 15 minutes		
Minimum	-0.004	-0.002	-0.004
Maximum	0.004	0.002	0.003
Average	0.000	0.000	0.000
Standard deviations	0.002	0.001	0.001
	15 - 20 minutes		
Minimum	-0.004	-0.002	-0.004
Maximum	0.003	0.003	0.003
Average	0.000	0.000	0.000
Standard deviations	0.001	0.001	0.001

Table 20: Differences between 1 second and 5 second data intervals using GLONASS-only satellites. Data and observation time is 5 minutes.

	ΔX (m)	ΔY (m)	ΔZ (m)
	0 - 5 minutes		
Minimum	-0.001	-0.001	-0.001
Maximum	0.001	0.001	0.001
Average	0.000	0.000	0.000
Standard deviations	0.000	0.000	0.000
	5 - 10 minutes		
Minimum	-0.002	-0.001	-0.001
Maximum	0.001	0.001	0.001
Average	0.000	0.000	0.000
Standard deviations	0.000	0.001	0.001
	10 - 15 minutes		
Minimum	-0.001	-0.001	-0.002
Maximum	0.003	0.001	0.002
Average	0.000	0.000	0.000
Standard deviations	0.001	0.000	0.001
	15 - 20 minutes		
Minimum	-0.001	-0.001	-0.001
Maximum	0.001	0.001	0.001
Average	0.000	0.000	0.000
Standard deviations	0.000	0.000	0.000

Table 21: Differences between 1 second and 10 second data intervals using GLONASS-only satellites. Data and observation time is 5 minutes.

	ΔX (m)	ΔY (m)	ΔZ (m)
	0 - 5 minutes		
Minimum	-0.001	-0.001	-0.001
Maximum	0.001	0.001	0.002
Average	0.000	0.000	0.000
Standard deviations	0.001	0.001	0.001
	5 - 10 minutes		
Minimum	-0.003	-0.002	-0.002
Maximum	0.001	0.001	0.001
Average	0.000	0.000	0.000
Standard deviations	0.001	0.001	0.001

	10 - 15 minutes		
Minimum	-0.002	-0.001	-0.002
Maximum	0.003	0.001	0.002
Average	0.000	0.000	0.000
Standard deviations	0.001	0.001	0.001
	15 - 20 minutes		
Minimum	-0.002	-0.002	-0.001
Maximum	0.001	0.002	0.001
Average	0.000	0.000	0.000
Standard deviations	0.000	0.000	0.000

Table 22: Differences between 1 second and 15 second data intervals using GLONASS-only satellites. Data and observation time is 5 minutes.

	ΔX (m)	ΔY (m)	ΔZ (m)
	0 - 5 minutes		
Minimum	-0.003	-0.002	-0.001
Maximum	0.002	0.002	0.002
Average	0.000	0.000	0.000
Standard deviations	0.001	0.001	0.001
	5 - 10 minutes		
Minimum	-0.002	-0.001	-0.002
Maximum	0.002	0.001	0.002
Average	0.000	0.000	0.000
Standard deviations	0.001	0.001	0.001
	10 - 15 minutes		
Minimum	-0.002	-0.002	-0.002
Maximum	0.003	0.003	0.003
Average	0.000	0.000	0.000
Standard deviations	0.001	0.001	0.001
	15 - 20 minutes		
Minimum	-0.002	-0.001	-0.002
Maximum	0.001	0.001	0.002
Average	0.000	0.000	0.000
Standard deviations	0.000	0.000	0.000

Table 23: Differences between 1 second and 30 second data intervals using GLONASS-only satellites. Data and observation time is 5 minutes.

	ΔX (m)	ΔY (m)	ΔZ (m)
	0 - 5 minutes		
Minimum	-0.003	-0.002	-0.002
Maximum	0.004	0.003	0.005
Average	0.000	0.000	0.000
Standard deviations	0.001	0.001	0.001
	5 - 10 minutes		
Minimum	-0.002	-0.002	-0.002
Maximum	0.004	0.002	0.003
Average	0.000	0.000	0.000
Standard deviations	0.001	0.001	0.001
	10 - 15 minutes		
Minimum	-0.004	-0.002	-0.004
Maximum	0.005	0.002	0.005
Average	0.000	0.000	0.000
Standard deviations	0.002	0.001	0.001
	15 - 20 minutes		
Minimum	-0.004	-0.002	-0.004
Maximum	0.003	0.002	0.002
Average	0.000	0.000	0.000
Standard deviations	0.000	0.000	0.000

Table 24: Differences between 1 second and 5 second data intervals using GPS+GLONASS satellites. Data and observation time is 5 minutes.

	ΔX (m)	ΔY (m)	ΔZ (m)
	0 - 5 minutes		
Minimum	-0.001	-0.001	-0.001
Maximum	0.001	0.001	0.001
Average	0.000	0.000	0.000
Standard deviations	0.000	0.000	0.000
	5 - 10 minutes		
Minimum	-0.001	-0.001	-0.001
Maximum	0.001	0.001	0.001
Average	0.000	0.000	0.000
Standard deviations	0.000	0.000	0.001

	10 - 15 minutes		
Minimum	-0.001	-0.001	-0.002
Maximum	0.003	0.001	0.002
Average	0.000	0.000	0.000
Standard deviations	0.001	0.000	0.001
	15 - 20 minutes		
Minimum	-0.001	-0.001	-0.001
Maximum	0.001	0.001	0.001
Average	0.000	0.000	0.000
Standard deviations	0.000	0.000	0.000

Table 25: Differences between 1 second and 10 second data intervals using GPS+GLONASS satellites. Data and observation time is 5 minutes.

	ΔX (m)	ΔY (m)	ΔZ (m)
	0 - 5 minutes		
Minimum	-0.001	-0.001	-0.001
Maximum	0.001	0.001	0.002
Average	0.000	0.000	0.000
Standard deviations	0.001	0.001	0.001
	5 - 10 minutes		
Minimum	-0.002	-0.002	0.000
Maximum	0.001	0.001	0.001
Average	0.000	0.000	0.000
Standard deviations	0.001	0.001	0.000
	10 - 15 minutes		
Minimum	-0.002	-0.001	-0.002
Maximum	0.003	0.001	0.002
Average	0.000	0.000	0.000
Standard deviations	0.001	0.000	0.001
	15 - 20 minutes		
Minimum	-0.002	-0.002	-0.001
Maximum	0.001	0.001	0.001
Average	0.000	0.000	0.000
Standard deviations	0.001	0.001	0.001

Table 26: Differences between 1 second and 15 second data intervals using GPS+GLONASS satellites. Data and observation time is 5 minutes.

	ΔX (m)	ΔY (m)	ΔZ (m)
	0 - 5 minutes		
Minimum	-0.002	-0.002	-0.001
Maximum	0.002	0.002	0.002
Average	0.000	0.000	0.000
Standard deviations	0.001	0.001	0.001
	5 - 10 minutes		
Minimum	-0.001	-0.002	-0.001
Maximum	0.002	0.002	0.002
Average	0.000	0.000	0.000
Standard deviations	0.001	0.001	0.000
	10 - 15 minutes		
Minimum	-0.002	-0.002	-0.003
Maximum	0.003	0.001	0.003
Average	0.000	0.000	0.000
Standard deviations	0.001	0.001	0.001
	15 - 20 minutes		
Minimum	-0.002	-0.002	-0.002
Maximum	0.001	0.001	0.002
Average	0.000	0.000	0.000
Standard deviations	0.001	0.001	0.001

Table 27: Differences between 1 second and 30 second data intervals using GPS+GLONASS satellites. Data and observation time is 5 minutes.

	ΔX (m)	ΔY (m)	ΔZ (m)
	0 - 5 minutes		
Minimum	-0.002	-0.002	-0.002
Maximum	0.004	0.003	0.005
Average	0.000	0.000	0.000
Standard deviations	0.001	0.001	0.001
	5 - 10 minutes		
Minimum	-0.002	-0.002	0.000
Maximum	0.004	0.003	0.000
Average	0.000	0.000	0.000
Standard deviations	0.001	0.001	0.000

	10 - 15 minutes		
Minimum	-0.004	-0.002	-0.005
Maximum	0.005	0.002	0.005
Average	0.000	0.000	0.000
Standard deviations	0.002	0.001	0.001
	15 - 20 minutes		
Minimum	-0.004	-0.002	-0.004
Maximum	0.003	0.003	0.002
Average	0.000	0.000	0.000
Standard deviations	0.001	0.001	0.001

Table 28: Differences between 1 second and 5 second data intervals using GPS-only satellites. Data and observation time is 2 hours.

	ΔX (m)	ΔY (m)	ΔZ (m)
Minimum	-0.001	-0.001	0.000
Maximum	0.001	0.000	0.001
Average	0.000	0.000	0.000
Standard deviations	0.001	0.000	0.001

Table 29: Differences between 1 second and 10 second data intervals using GPS-only satellites. Data and observation time is 2 hours.

	ΔX (m)	ΔY (m)	ΔZ (m)
Minimum	-0.001	-0.001	0.000
Maximum	0.001	0.000	0.001
Average	0.000	0.000	0.000
Standard deviations	0.000	0.000	0.000

Table 30: Differences between 1 second and 15 second data intervals using GPS-only satellites. Data and observation time is 2 hours.

	ΔX (m)	ΔY (m)	ΔZ (m)
Minimum	-0.001	-0.001	0.000
Maximum	0.001	0.000	0.001
Average	0.000	0.000	0.000
Standard deviations	0.001	0.000	0.000

Table 31: Differences between 1 second and 30 second data intervals using GPS-only satellites. Data and observations time is 2 hours.

	ΔX (m)	ΔY (m)	ΔZ (m)
Minimum	-0.001	0.000	-0.001
Maximum	0.001	0.001	0.001
Average	0.000	0.000	0.000
Standard deviations	0.001	0.000	0.001

Table 32: Differences between 1 second and 5 second data intervals using GLONASS-only satellites. Data and observation time is 2 hours.

	ΔX (m)	ΔY (m)	ΔZ (m)
Minimum	-0.001	-0.001	0.000
Maximum	0.001	0.001	0.001
Average	0.000	0.000	0.000
Standard deviations	0.001	0.000	0.000

Table 33: Differences between 1 second and 10 second data intervals using GLONASS-only satellites. Data and observation time is 2 hours.

	ΔX (m)	ΔY (m)	ΔZ (m)
Minimum	-0.001	-0.001	0.000
Maximum	0.001	0.001	0.001
Average	0.000	0.000	0.000
Standard deviations	0.001	0.000	0.000

Table 34: Differences between 1 second and 15 second data intervals using GLONASS-only satellites. Data and observation time is 2 hours.

	ΔX (m)	ΔY (m)	ΔZ (m)
Minimum	-0.001	-0.001	-0.001
Maximum	0.001	0.001	0.000
Average	0.000	0.000	0.000
Standard deviations	0.001	0.001	0.000

Table 35: Differences between 1 second and 30 second data intervals using GLONASS-only satellites data and observation time 2 hours.

	ΔX (m)	ΔY (m)	ΔZ (m)
Minimum	-0.001	-0.001	-0.001
Maximum	0.001	0.001	0.000
Average	0.000	0.000	0.000
Standard deviations	0.001	0.001	0.000

Table 36: Differences between 1 second and 5 second data intervals using GPS+GLONASS satellites data and observation time 2 hours.

	ΔX (m)	ΔY (m)	ΔZ (m)
Minimum	-0.001	0.001	0.000
Maximum	0.001	0.001	0.001
Average	0.000	0.000	0.000
Standard deviations	0.001	0.000	0.000

Table 37: Differences between 1 second and 10 second data intervals using GPS+GLONASS satellites data and observation time 2 hours.

	ΔX (m)	ΔY (m)	ΔZ (m)
Minimum	-0.001	-0.001	0.000
Maximum	0.001	0.001	0.001
Average	0.000	0.000	0.000
Standard deviations	0.001	0.000	0.000

Table 38: Differences 1 second and 15 second data intervals using GPS+GLONASS satellites data and observation time 2 hours.

	ΔX (m)	ΔY (m)	ΔZ (m)
Minimum	-0.001	-0.001	-0.001
Maximum	0.001	0.001	0.000
Average	0.000	0.000	0.000
Standard deviations	0.001	0.001	0.000

Table 39: Differences between 1 second and 30 second data intervals using GPS+GLONASS satellites data and observation time 2 hours.

	ΔX (m)	ΔY (m)	ΔZ (m)
Minimum	-0.001	-0.001	-0.001
Maximum	0.001	0.001	0.000
Average	0.000	0.000	0.000
Standard deviations	0.001	0.001	0.000

The baseline lengths of the local network vary between 300 m to 3 km. GNSS data processed using different data intervals, namely, 1, 5, 10, 15 and 30 seconds were compared in table 4 - table 27. According to comparison results on these tables, the differences between GPS-only, GLONASS-only and GPS+GLONASS data are a maximum of 5 mm and standard deviations are on the order of 1 mm.

The baseline lengths of the CORS-TR points vary between 56 km to 125 km. GNSS data processed using different data intervals, namely, 1, 5, 10, 15 and 30 seconds were compared in Table 28 - table 39. According to comparison results on these tables, the differences between GPS-only, GLONASS-only and GPS + GLONASS data are a maximum of 1 mm and standard deviations are on the order of 1 mm.

At first sight one would think that there is a controversial situation between the results of the local and CORS-TR networks. It should be remembered that 5 mm differences on the local network is valid only for two baselines. Also, consideration should be noted that the processing period varies between 5-20 minutes. The other points and for CORS-TR points processing results represent 2 hours of data. Consequently, results provided in the Tables above are said to be consistent.

6. CONCLUSIONS

Global Navigation Satellite Systems (GNSS) technology has become vital to many applications, ranging from city planning engineering and zoning to military applications. As a result of this GNSS data contain valuable information in the field of surveying/geomatics. In this study we tried to analyze the effect of data intervals on GNSS solutions in static method applications. For this purpose, data of two different GNSS networks were used. The processing of different satellite systems (GPS-only, GLONASS-only, GPS+GLONASS) were compared by changing different data intervals (1, 5, 10, 15, 30 sec).

According to the processing results, shorter data intervals such as 1, 5 and 10 seconds do not change the results significantly when compared to processing results obtained using 15 or 30 second data intervals. Consequently, it can be said that data collected in the field with 15 or 30 second data intervals will be sufficient to obtain satisfactory results in static GNSS data observation and processing.

ACKNOWLEDGEMENTS

Mustafa Qasim's, "Analysis of The Effect of Data intervals on GNSS Processing", Thesis title which is conducted by the supervisors Assoc. Prof. Dr. Ekrem TUSAT at the Graduate School of Natural Sciences at Selcuk University. We wish to express our deepest appreciation to Prof. Dr. Muzaffer KAHVECI - lecture on surveying engineering at Faculty of Engineering - Selcuk University Turkey for their technical support.

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