TESTING HEIGHT ACCURACY IN CORS-TR TECHNIQUE

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Key words: CORS-TR; Orthometric height, Leveling

SUMMARY

GPS positioning has been actively used in mapping applications since 1980s. In the beginning, while local reference stations were using the necessary methods and techniques, a new and modern system that provides faster, more economical and accurate results has started to be used nationwide. This system, which is an abbreviation of English expression of Continuous Observing Reference Station words, is known as CORS (Continuously Operating Reference Stations) system. This system has reference points spread all over the country. Consistent GNSS receivers have been deployed at these known locations. The obtained data is transmitted to a control center via ADSL or GPRS / EDGE. Atmosphere and other errors are modeled in the control center and RTK / DGPS corrections are calculated in real time and sent to mobile GNSS receivers over GPRS / EDGE. In the CORS-TR system, a single-frequency GNSS receiver uses a DGPS dataset with decimeter accuracy, while a dual-frequency GNSS receiver uses an RTK dataset to determine a horizontal position of 1 to 10 centimeters. The accuracy of the height component in the GNSS system is lower than the horizontal position accuracy. This also applies to the CORS-TR technique. This work involves testing the validity of the CORS-TR technique. Heights will be determined and compared with the geometric leveling as well as the CORS-TR technique at the selected test points. In this study, the accuracy of the height determination by the CORS technique was obtained in centimeter values.

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1. INTRODUCTION

Today, GNSS is widely used in determining point locations. Some applications are implemented with post-process GNSS solutions, while others require real-time location. The RTK system offers real-time positioning.

With the Network-RTK system designed for the development of the RTK system, real-time location has become much more widely used. In many countries, constantly observing stationary GNSS stations (CORS - Continuously Operating Reference Station) have been installed (Inal et al., 2014). Horizontal position information can be obtained with high accuracy by using corrections received from these stations.

Some of surveying applications are about height determination. In many applications, orthometric height information is needed. Orthometric height data can be obtained by using ellipsoidal altitude information obtained from the GNSS system and geoid heights. The orthometric height information of the point can be obtained from the stationary reference stations by using instant positioning techniques. The height accuracy obtained by this method varies between 1-10 cm. This accuracy lies within the bounds of accuracy required for many cartography applications.

Our country also has a network of constantly observing constant GNSS stations (CORS - Continuously Operating Reference Station), which has been operating since May 2009 and is called TUSAGA-Active. This network is a network of 146 stations covering the entire country (CORS-TR) (İnal et al., 2014).

2. TUSAGA-ACTIVE (TURKEY NATIONAL PERMANENT GPS STATIONS) NETWORK

Unlike the classic RTK, which is made with a single reference receiver, the Point-to-Point facility is provided in the Network-RTK system by utilizing the data of a large number of reference stations. Atmospheric modeling of a specific region in this system removes the disadvantages of the Classical RTK and provides the possibility of real-time location and accuracy of cm at base lengths of up to 50-100 km (İnal et al., 2014).

The main purpose of the continuous RTK GNSS networks (CORS) is to remove disturbing errors (ionosphere, troposphere, orbit, etc.) depending on the distance and thus to obtain high accuracy coordinates in real time (Kahveci, 2009).

Constant observation stations also record data at the control center. It is mainly used in two ways (İnal et al., 2014).

Calculation of the operation and correction parameters of the TUSAGA-Active system is carried out in the control and analysis centers. Data collected from all stations is transferred to data centers via ADSL and GPRS / EDGE (ADSL will be enabled when not in use), where correction parameters are calculated and presented to all users. The servers in the control centers make atmospheric modeling using the instantaneous data from all the stations and calculate the DGPS / RTK correction data. The correction data are transferred via GPRS to mobile receivers in the field. In this way, a single-frequency GPS receiver locates in the range of 1 to 2 centimeters using DGPS data, and a dual-frequency GPS receiver using the RTK data.

In the CORS-TR system, three techniques are used for real-time instantaneous positioning. These; FKP, VRS, MAC technique (İnal et al., 2014).

In the area correction approach known as FKP (Flachen Koorectur Parameter), atmospheric corrections and carrier phase corrections are calculated at every station using the entire CORS network. The rover picks up the network correction from one of the stationary stations and identifies this station as the center of the two-way communication (İnal et al., 2014).

A prerequisite for VRS (Virtual Reference Stations) implementation is two-way communication between the control center and the mobile receiver in the CORS network. The rover sends approximate coordinates to the control center and uses the whole network information at the center to form the VRS reference data for the location of the corresponding touring place. In this method, corrections are published via a virtual reference station, which is formed in the immediate vicinity of the navigator (İnal et al.2014).

The MAC (Master Auxiliary Concept) technique is based on the determination of the roaming receiver's location within a network consisting of one master station and a plurality of auxiliary stations. In the MAC technique, the base station does not have to be the closest station to the roaming receiver. What is important is that observations have been made to the same conditions. Because there is no specific task in calculating the corrections of the base station, it has a role mainly in the publication of corrections. If data can not be obtained from the main station for any reason, one of the assistant reference stations undertakes this task (Kahveci, 2009).

All GPS receivers that have the ability to use the corrections published by Cors systems receive corrections from the Tusaga-Active (Cors-TR) system (Yıldırım et al., 2011).

To be smaller than the optimum distance of 100km to station points conditions in Turkey, the establishment of provinces where users are busy center, to be on stable ground logistics support to provide energy and be eligible for means of communication, allowing the monitoring of plate motion has been considered the circumstances. According to these criteria a total of 146 units in Turkey TUSAGA active station location is determined. The station locations and the areas to be covered are shown in Figure 1 (Yıldırım et al., 2011).

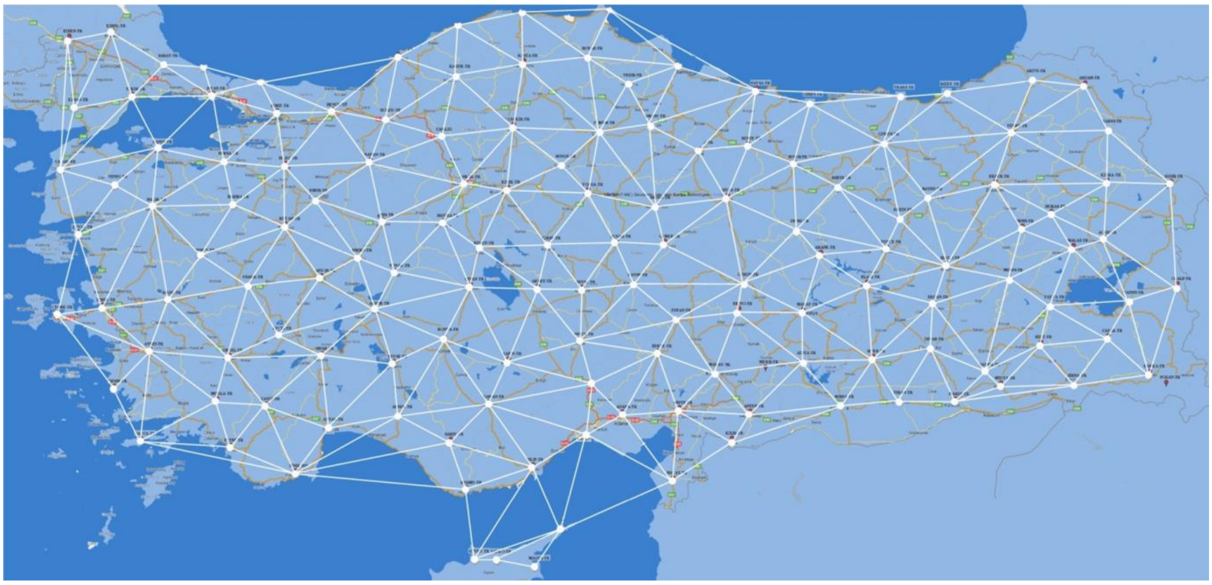

Figure 1. CORS-TR Stations (146 stations, 80-100 km) (Yıldırım et al., 2011).

2. EXPERIMENT AND DATA PROCESS

In this study, Cors-TR and Geometric level measurements were made at fixed points in the horizontal position and height of the campus of YTÜ-Davutpaşa. The measured heights are compared to each other and to the exact heights of the points. Coordinates and heights of fixed points in the campus of YTÜ-Davutpaşa are given in Table 1.

Table 1. Fixed Point Coordinates and Elevations

Point	East (m)	North (m)	H(m)	Point	East (m)	North (m)	H(m)
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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In this study horizontal coordinates and orthometric heights were obtained with CORS-TR VRS at fixed points of interest around the Faculty of Civil Engineering. The obtained data are shown in Table 2. GPS measurements were carried out twice at different times in accordance with "Large Scale Map and Map Information Production Regulations" (BÖHHBÜY). Mean errors of the measurements were examined and the mean values of the two measures were used. In figure 2, the actual heights of the elevations and points obtained by CORS-TR VRS are plotted graphically.

Table 2. Point Coordinates Obtained from GPS Measurements

Point	East (m)	North (m)		H(m)	Point	East (m)	North (m)	H(m)
N.2	406451,529	4543888,690		75,902	N.34	406323,445	4543689,659	71,997
N.6	406541,800	4543815,609		76,702	N.36	406313,703	4543730,610	71,859
N.13	406576,245	4543794,996		76,167	N.38	406337,900	4543765,239	73,266
N.15	406618,499	4543759,209		74,932	N.40	406348,956	4543817,202	73,988
N.24	406585,444	4543728,198		76,116	N.41	406355,606	4543843,701	74,687
N.25	406538,510	4543664,147		76,501	N.43	406364,502	4543872,561	75,305
N.32	406334,954	4543653,932		72,893	N.49	406388,010	4543931,056	75,279

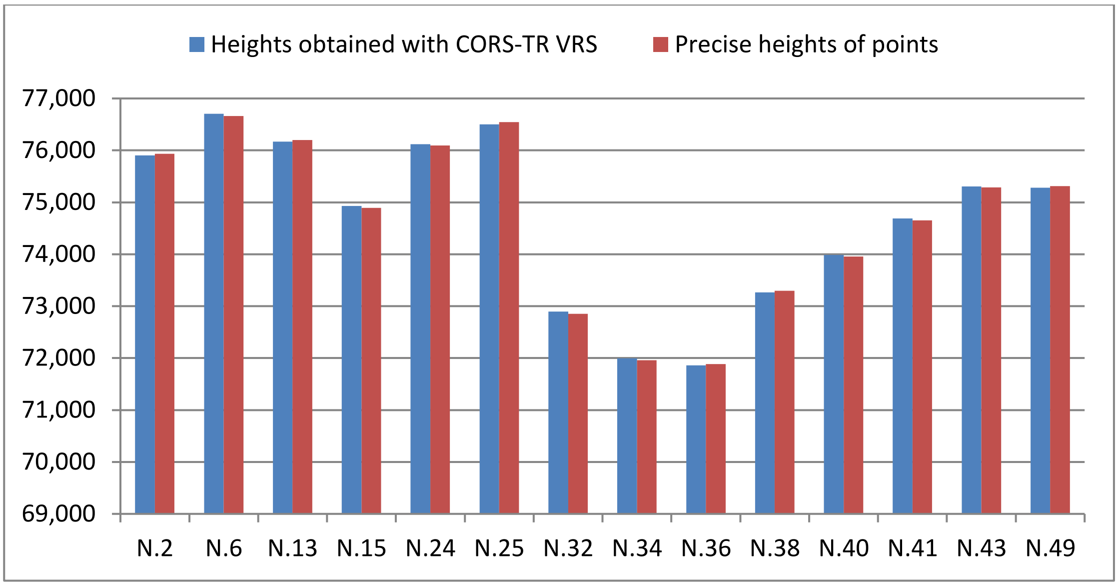

Figure 2. Representation of the precise heights of the points and the heights from the CORS-TR

Point heights were determined by making a round-trip geometric leveling at fixed points. At the determined point heights, 3 main landmark points in the campus are used as references. Point heights were determined by taking the average of the values obtained from the round-trip geometric leveling. These values are shown in Table 3. The actual height values of the heights and points obtained by the leveling in FIG. 3 are graphically shown. In figure 4, fixed point heights and height values obtained from 2 different measurement methods are shown together.

Table 3. Height Obtained from Geometric Leveling

Point	H (m)	Point	H (m)
N.2	75,939	N.34	71,954
N.6	76,664	N.36	71,869
N.13	76,199	N.38	73,287
N.15	74,895	N.40	73,951
N.24	76,093	N.41	74,652

N.25	76,541	N.43	75,282
N.32	72,845	N.49	75,306

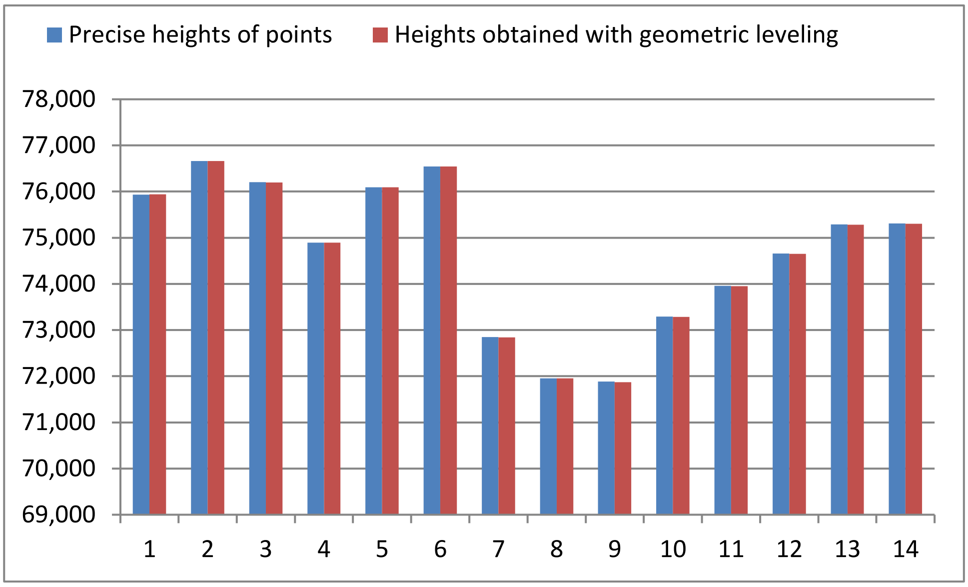

Figure 3. Precise heights and heights obtained from the geometric leveling

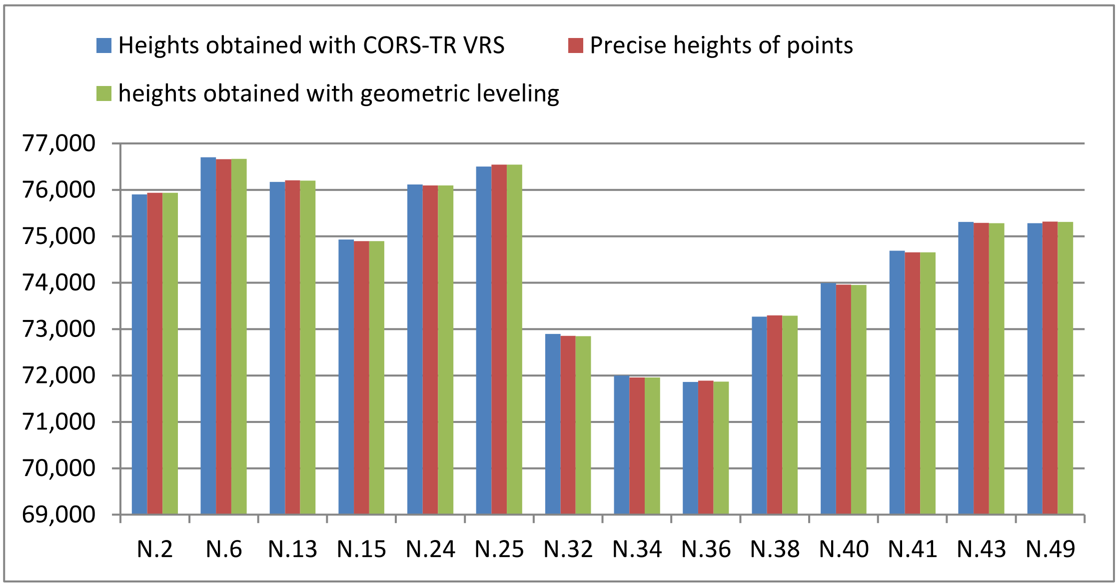

Figure 4. Precise heights and height values obtained from 2 different measurement methods

3. RESULT AND ANALYSES

In order to compare the heights of the Geometric Levels with the precise heights, the heights of the fixed points and the heights of the Geometric Levels are shown in Table 4. These comparison results show that the height differences are minimum ± 0.3 mm maximum ± 15.9 mm.

Table 4. Differences between precise heights and heights in the leveling

Point	DH(mm)	Point	DH(mm)
N.2	-1.7	N.34	3.3
N.6	-4	N.36	15.9
N.13	3.2	N.38	7.9
N.15	0.3	N.40	6.9
N.24	3.2	N.41	3.5
N.25	2.4	N.43	5.5
N.32	5.2	N.49	7.3

To compare the elevations found with the CORS-TR VRS system to precise heights, the elevations from the CORS-TR VRS with fixed-point heights are shown in Table 5. The comparison results show that the height differences are minimum ± 29 mm, maximum ± 43 mm.

Table 5. Differences between precise heights and heights from CORS-TR VRS

Point	DH(mm)	Point	DH(mm)
N.2	35	N.34	40
N.6	42	N.36	29
N.13	35	N.38	29

N.15	37	N.40	30
N.24	20	N.41	32
N.25	42	N.43	-18
N.32	43	N.49	34

The heights obtained from both measurements were compared with fixed points and the results are shown in tables. Table.6 summarizes the height values obtained from both measures and their differences from the actual values in tabular form.

Table 6. Comparison of heihgts obtained from the leveling and CORS-TR VRS system with the precise values

Point	**Precise Heights (m)**	**Heights found with leveling (m)**	**Heights obtained from CORS-TR System (m)**	**Difference between precise height and leveling (mm)**	**Difference between precise height and CORS-TR (mm)**
N.2	75,937	75,9387	75,902	-1.7	35
N.6	76,66	76,664	76,702	-4	42
N.13	76,202	76,1988	76,167	3.2	35
N.15	74,895	74,8947	74,932	3	37
N.24	76,096	76,0928	76,116	3.2	20
N.25	76,543	76,5406	76,501	2.4	42
N.32	72,85	72,8448	72,893	5.2	43

N.34	71,957	71,9537	71,997	3.3	40
N.36	71,885	71,8691	71,859	15.9	29
N.38	73,295	73,2871	73,266	7.9	29
N.40	73,958	73,9511	73,988	6.9	30
N.41	74,655	74,6515	74,687	3.5	32
N.43	75,287	75,2815	75,305	5.5	-18
N.49	75,313	75,3057	75,279	7.3	34

CONCLUSIONS

The result of this comparison is that the orthometric heights obtained from the Geometric Nivelman and Cors-Tr systems are consistent with the precise heights in the 0 - 5 cm range. These results show that the heigths obtained from CORS-TR VRS can be used for applications that do not require very high accuracy.

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