Evaluating Accuracy and Performance of CORS-VRS in Forested Area

Evaluación de la precisión y el rendimiento de CORS-VRS en área boscosa

Zümrüt Kurtulgu [a], **Atinç Pirti** [b*]

[a] Muğla Sıtkı Kocman University, Department of Surveying Engineering Muğla, Turkey.

* Corresponding author: [b] Yildiz Technical University, Department of Surveying Engineering Davutpasa, Istanbul, Turkey, atinc@yildiz.edu.tr

SUMMARY

The Virtual Reference Station (VRS) method utilizes a virtual station located just a few meters away from the traveling receiver, without the need for additional equipment. In this method, the observation data for the virtual reference station point are generated using data from the surrounding reference stations, as if the instrument was placed at the virtual reference station. Virtual Reference Station networks employ real-time kinematic solutions to achieve high accuracy. In this study, the coordinates obtained from the CORS-VRS network were compared with those obtained using a static technique for the same points in a forested environment. The results of the experiment show that CORS-VRS can achieve 1-2 cm horizontal accuracy and 2-5 cm vertical accuracy in forested areas. Despite the challenges posed by the tree canopy and signal loss, the results indicate that the CORS-VRS technique improves positioning accuracy in forested environments.

Keywords: GNSS, tree areas, GPS, forest surveying, forest management.

RESUMEN

El método de Estación de Referencia Virtual (VRS) utiliza una estación virtual ubicada a solo unos metros del receptor en movimiento, sin la necesidad de equipos adicionales. En este método, los datos de observación para el punto de la estación de referencia virtual se generan utilizando los datos de las estaciones de referencia circundantes, como si el instrumento estuviera colocado en el punto de la estación de referencia virtual. Las redes de Estación de Referencia Virtual emplean soluciones cinemáticas en tiempo real para proporcionar alta precisión. En este estudio, las coordenadas obtenidas de la red CORS-VRS se compararon con las obtenidas utilizando la técnica estática para los mismos puntos en un entorno forestal. Los resultados del experimento muestran que CORS-VRS puede lograr una precisión horizontal de 1-2 cm y una precisión vertical de 2-5 cm en áreas forestales. A pesar de los desafíos planteados por el dosel de los árboles y la pérdida de señal, las evaluaciones indican que la técnica CORS-VRS mejora la precisión del posicionamiento en entornos forestales.

Palabras clave: GNSS, áreas arboladas, GPS, topografía forestal, gestión forestal.

INTRODUCTION

Forest canopies can significantly impact GNSS positioning accuracy, primarily because of tree trunks, branches, and leaves, which obstruct signals. This blockage leads to increased positional dilution, particularly for vertical and three-dimensional PDOP (Positional Dilution of Precision). In forested environments, the PDOP is often too high for reliable positioning, whereas the Horizontal Dilution of Precision (HDOP) may remain at acceptable levels. The signal is weakened or attenuated by foliage, making it difficult for GNSS receivers to track the signal; in extreme cases, the signal may be entirely lost. Even when the signal is tracked, some receivers may struggle to measure the pseudorange accurately. In this context, the primary function of the forest canopy is signal obstruction, which occurs either through complete blockage (*i.e.* tree trunks or steep streams) or attenuation as signals pass through leaves. One technique used to address these issues is the Virtual Reference Station (VRS) method. VRS interpolates data from multiple reference stations to create a virtual station near the rover position. This reduces the impact of ionospheric and tropospheric refraction, satellite orbit inaccuracies, and distance-related system error. Additionally, it ensures that corrections are available even if a reference station fails, thereby shortening the time required for receivers to lock onto satellites (Hofmann-Wellenhof *et al.* 2008, Pırtı 2011, Bulbul *et al.* 2017).

In this regard, various applications of continuously operating reference station (CORS) and VRS systems, as well as related studies in the literature, have examined the efficiency and accuracy of these technologies under different conditions. A detailed analysis of the CORS network design, considering factors such as signal reception and connection continuity, showed that while horizontal accuracy was high over short distances and in open areas, vertical accuracy tended to exhibit greater errors, especially in areas with significant topographic variations such as mountainous and sloped terrains (Dardanelli *et al.* 2020). Moreover, a study involving the analysis of data from 228 points within the CORS network, using Bernese GNSS software, successfully corrected satellite, clock, and atmospheric errors, leading to higher positional accuracy (Ayele and Gedamu 2022). Additionally, research on the data quality of CORS stations, error sources, and optimal station selection has revealed the efficiency of the system. Tests conducted on 14 different CORS stations, considering the software and computational tools used, indicated that environmental factors, particularly multipath errors and carrier phase noise, significantly affected the accuracy of the system (Lau and Tai 2023). VRS systems, by utilizing the RTCM 3.0 protocol for data transmission, VRS systems provide high-accuracy positioning through an RTK solution network. The accuracy, reliability, and latency of data transmitted via RTCM 3.0 were tested, and the results indicated that the vertical GNSS accuracy was lower than the horizontal accuracy (O'Keefe and Lachapelle 2007). In another study, the horizontal positioning accuracy of NRTK positioning services in Thailand was evaluated based on the triangulation structures of GNSS CORS networks. The accuracy of the VRS in horizontal positioning was analyzed in relation to the number and distribution of GNSS satellites used. The findings indicate that while VRS is effective in enhancing horizontal positioning accuracy, factors such as the distribution of reference stations and Geometric Dilution of Precision (GDOP) values must be carefully considered (Charoenkalunyuta *et al.* 2023). Additionally, another study established 22 test points along a 52 km-long transect at 2.5 km intervals, measuring each point using both the VRS and static methods. The results indicated that the accuracy of the VRS method was maintained even as the distance between stations increased, and a higher accuracy was achieved, particularly in open areas (Tuşat 2018). Most studies have focused on measurements conducted in open areas with a high positioning accuracy achieved through VRS system error corrections. In various forested areas where GNSS signals were significantly attenuated and obstructed, location measurements were taken using smartphones and GNSS receivers. The data collected were used to assess the accuracy parameters of HDOP and Vertical Dilution of Precision (VDOP). The findings demonstrated that enclosed environments, such as forests, negatively affect the GNSS measurement accuracy. However, the use of CORS-VRS systems has been shown to improve accuracy to some extent (Tomaštík *et al.* 2017). Literature reviews typically focus on open areas and share results derived from error sources. The primary aim of this study is to evaluate the performance of CORS-VRS systems in forest environments under varying field conditions and expected signal obstructions.

METHODS

To investigate these issues; the impact of trees on CORS-VRS positioning, two experiments were conducted in the Davutpaşa area (Yildiz Technical University campus) in Istanbul, Türkiye. For this purpose, points N10, N11, N12, and N13 were placed in the project area (see figures 1 and 2). Points N11, N12, and N13 were located in the forest area, whereas point N10 was marked in the unobstructed area (figure 2). A static GNSS survey was conducted to determine the coordinates of the four points. Four static measurements were taken during an observation period of at least 2.5 hours. Topcon Magnet TOOLS software was used to perform the data processing and network adjustments. During the adjustment process, the ITRF 2005 coordinates of the ISKI CORS/PALA points were fixed (figure 1, table 1). Tables 1 and 2 list the coordinates and standard deviations of the four points as well

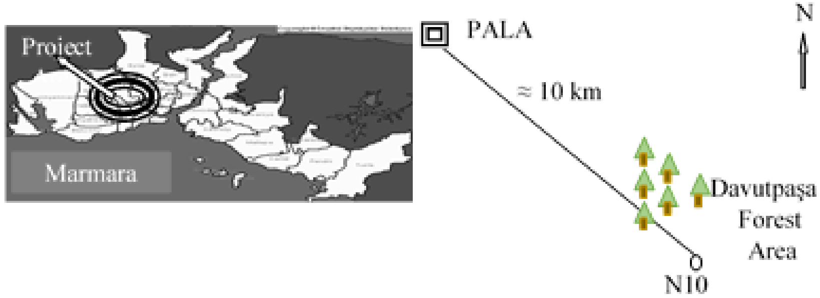


Figure 1. Study area and GNSS network.

Área de estudio y red GNSS.

Figure 2. The four points (N10, N11, N12 and N13) in the study site.

Los cuatro puntos (N10, N11, N12 y N13) en el sitio de estudio.

Table 1. Standard deviation and coordinate values of the four points by using static GNSS survey.

Desviación estándar y valores de coordenadas de los cuatro puntos utilizando levantamientos GNSS estáticos.

Point	Grid Northing-N (m)	Grid Easting-E (m)	Elevation-h (m)	Std N (m)	Std E (m)	Std h (m)
PALA	4550678.003	412881.990	170.561	0	0	0
N10	4543688.935	406723.322	107.322	0.004	0.004	0.006
N11	4543661.910	406706.387	107.981	0.005	0.005	0.007
N12	4543668.528	406695.419	108.256	0.005	0.004	0.006
N13	4543662.964	406687.861	108.289	0.005	0.005	0.007

as the date and time of the CORS-VRS observations. The GNSS equipment used for CORS measurement includes a pair of Topcon Hiper HR receivers (static (horizontal = 3 mm + 0.1 ppm, vertical = 3.5 mm + 0.4 ppm)), (RTK (horizontal = 10 mm + 1 ppm, vertical = 15 mm + 1 ppm)), (Topcon Positioning Systems 2018). For static GNSS measurements, the data receiving and processing rate was set to 30 s, and the cut-off elevation mask angle was set to 10 °. On the other hand, the two tests for the CORS-VRS survey were conducted at different times on two days (September 30, and October 1, 2020). During the test, the number of GNSS satellites tracked and their distribution are usually "normal" with 10 to 15 satellites observed, and the Precision Position Dilution (PDOP) is between 1.315 and 2.360 (table 2, figure 3). Measurements were conducted under clear and cloudless weather conditions. Additionally, information regarding the satellites available in the sky on specified dates is shown in figure 3.

Figures 4A, 4B, and 4C show the sky visibility of three points (N11, N12, and N13) in the study area, respectively. These points are located within forested areas and have a highly limited sky visibility.

Table 2. Time schedule of the CORS-VRS measurements for four points (N10, N11, N12 and N13) by using Topcon Hiper HR receiver on two days.

Cronograma de las mediciones CORS-VRS para cuatro puntos (N10, N11, N12 y N13) usando el receptor Hiper HR de Topcon en dos días.

CORS-VRS												
DateTime	Point	Easting	Northing	El.Hgt.	Ep.	Hz	SAT.	hRms	vRms	Pdop	Method	Status
2020-09-30-09:44	N10	406723.325	4543688.915	107.238	5	1	15	0.005	0.006	1.463	VRS	FIX
2020-09-30-09:50	N11	406706.405	4543661.847	107.936	5	1	12	0.006	0.008	1.763	VRS	FIX
2020-09-30-09:52	N12	406695.420	4543668.476	108.238	5	1	10	0.006	0.008	2.36	VRS	FIX
2020-09-30-09:54	N13	406687.879	4543662.952	108.190	5	1	10	0.004	0.005	1.691	VRS	FIX
2020-10-01-11:13	N10	406723.313	4543688.921	107.227	5	1	16	0.004	0.006	1.315	VRS	FIX
2020-10-01-11:15	N11	406706.370	4543661.880	107.960	5	1	12	0.005	0.008	1.485	VRS	FIX
2020-10-01-11:11	N12	406695.397	4543668.481	108.240	5	1	10	0.005	0.006	1.875	VRS	FIX
2020-10-01-11:12	N13	406687.851	4543662.929	108.180	5	1	14	0.005	0.006	1.663	VRS	FIX

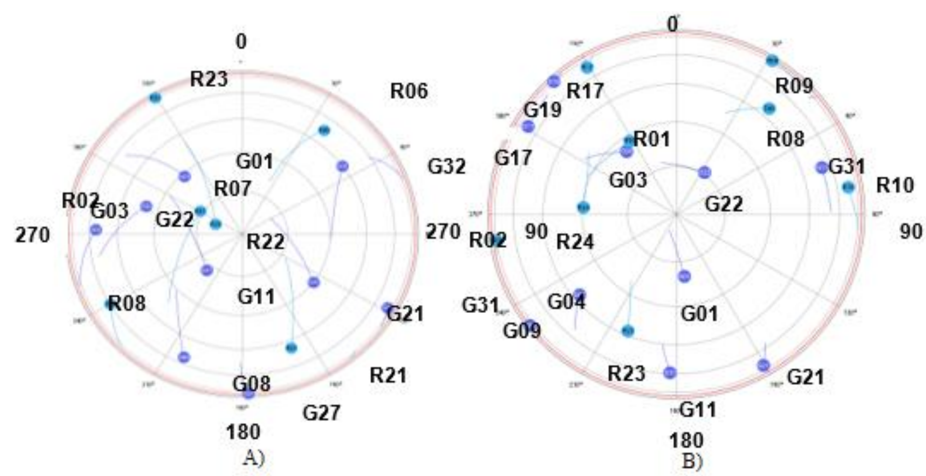


Figure 3. The skyplot, GPS (G) and GLONASS (R) satellites, in the project area on September 30, 2020 (A) and October 1, 2020 (B).

El diagrama del cielo (satélites GPS (G) y GLONASS (R)), en el área del proyecto el 30 de septiembre de 2020 (A) y el 1 de octubre de 2020 (B).

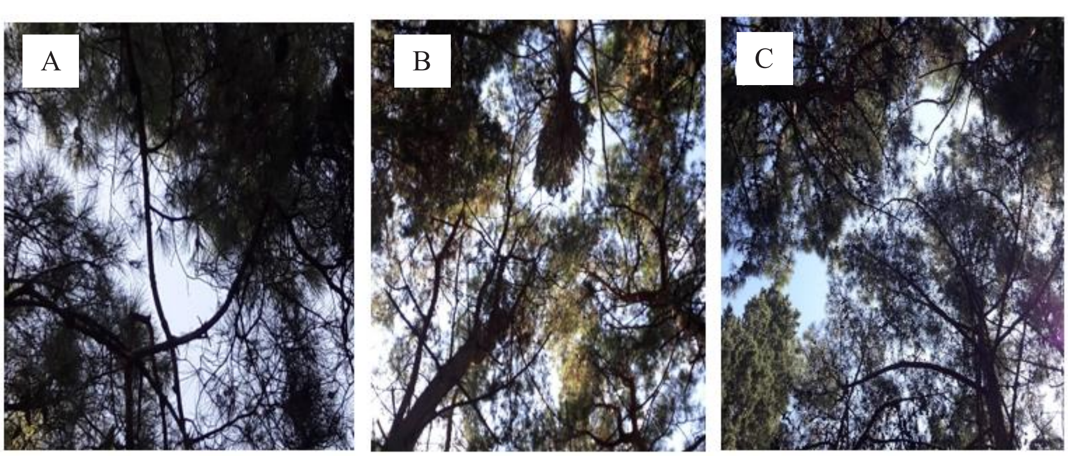


Figure 4. Sky visibility from Points N11, N12 and N13 (A, B, C), respectively.

Visibilidad del cielo desde los puntos N11, N12 y N13 (A, B, C), respectivamente.

RESULTS

The purpose of this study was to check the repeatability of CORS-VRS and assess its performance in a forest environment. The experiment included a set of four points (N10, N11, N12, and N13) on the ground. (Please note that the survey was conducted in different satellite constellations and at different times during the two days (table 2)). The data acquisition and processing rate was set to 1 s and 5 epochs, respectively, and the cut-off elevation mask angle for CORS-VRS measurement was 10 degrees. The integer ambiguity was fixed between 1 min and 45 min for each point on September 30, 2020, and October 1, 2020, using a Topcon Hiper HR receiver. The first survey was performed on September 30, 2020, using the CORS-VRS technique, whereas the second survey was performed on October 1, 2020, using the CORS-VRS technique.

Figures 5A shows the coordinate differences between the CORS-VRS survey results for the four points. Figure 5A shows the average (mean) value and standard deviation of the coordinate differences obtained from the first and second CORS-VRS measurements of these four points. The coordinate differences between the CORS-VRS survey results for the four points were located in the forest environment (N11, N12, and N13) and in the unobstructed area (N10) (figure 5A). The coordinates obtained from the first CORS-VRS survey for the four points were compared with the second CORS-VRS survey results. The coordinates of these four points (east and north) are usually very good; the standard deviation value is less than 2.2 cm, and the average value is less than 2.4 cm. The consistency of the height component was poor, sometimes at the same point between the CORS-VRS survey, with a difference of up to 5 cm. The standard deviation and mean values of the height differences of these four points are 0.9 cm and 2.2 cm, respectively (figure 5A).

Figure 5B shows the coordinate differences between the CORS-VRS survey results and static survey results for the four points. The coordinates obtained from the static survey for these four points were fixed. The coordinates obtained from the first CORS-VRS survey for the four points (September 30, 2020) were compared with the static survey results of these four points. The coordinates (Easting, Northing) of the four points were generally good, with standard deviation values of less than 2.5 cm, mean values of less than 3.7 cm. The consistency of the height components is poor, sometimes at the same point between the CORS-VRS survey, which differs by up to 10 cm. The standard deviation and mean height of the four points were 3.7 cm and 6.1 cm, respectively.

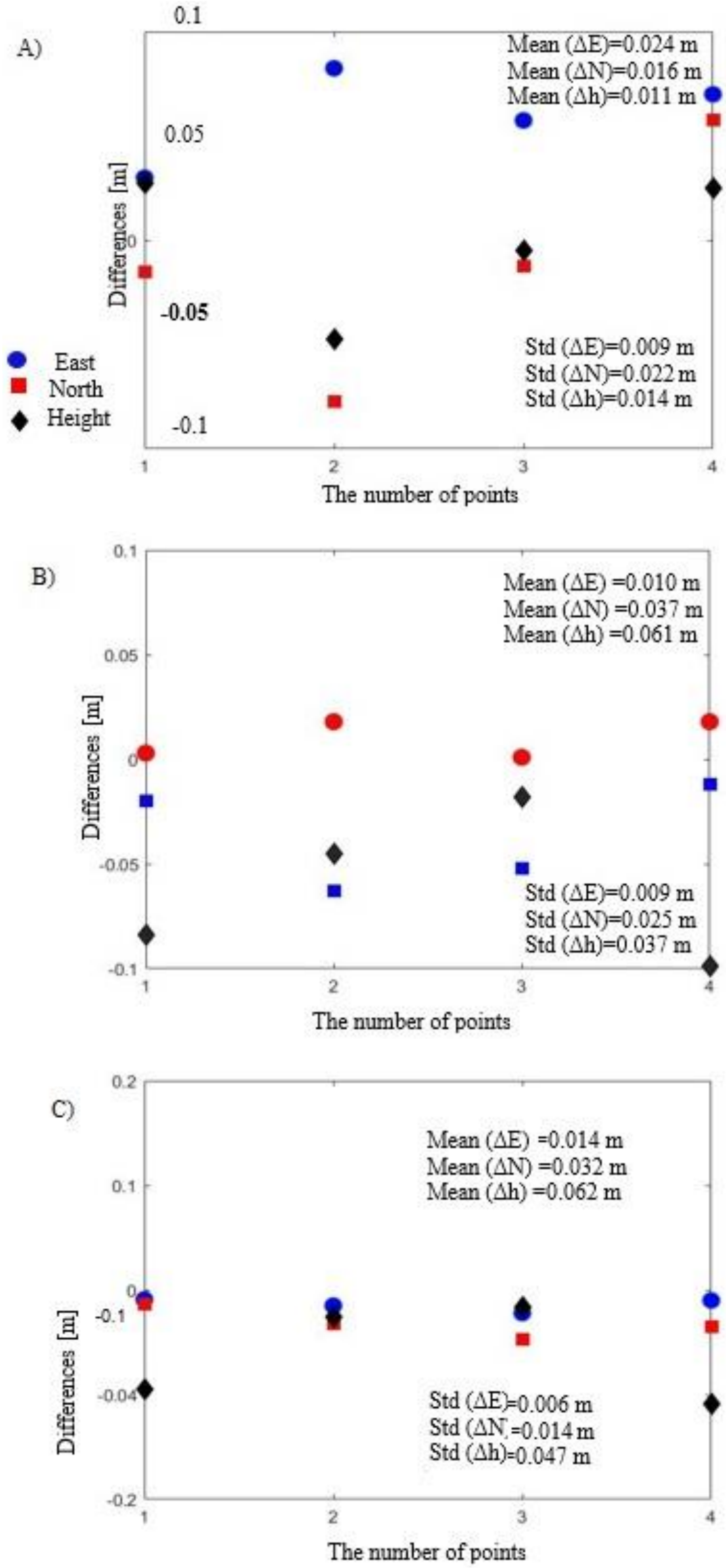
Figure 5C shows the coordinate differences between the CORS-VRS survey results and static survey results for the four points. The coordinates obtained from the static survey for these four points were fixed. The coordinates obtained from the first CORS-VRS survey for the four points (October 1, 2020) were compared with the static survey results of these four points. The coordinates (Easting, Northing) of the four points were generally good, with standard deviation values of less than 1.4 cm, mean values of less than 3.2 cm. The consistency of the height components is poor, sometimes at the same point between the CORS-VRS survey, which differs by up to 10 cm. The standard deviation and mean height of the four points were 4.7 cm and 6.2 cm, respectively.

Figure 5D shows the coordinate differences between all of the CORS-VRS survey results for the four points. The coordinates obtained from the first CORS-VRS survey (September 30, 2020) of the four points were compared with the second CORS-VRS survey results (October 1, 2020). The coordinates (Easting, Northing) of the four points were generally good, with standard deviation values of less than 2.2 cm, mean values of less than 2.4 cm. At the same point between two the CORS-VRS measurements, the height component was not consistent; sometimes, the difference was up to 5 cm. The standard deviation and mean height of the four points were 1.4 cm and 1.1 cm, respectively.

The CORS-VRS derived the coordinates of the four points compared with the obtained coordinates of the four points using static survey (figure 5E). Figure 5E shows the average and standard deviation values of the differences in the Easting, Northing, and Height coordinates. Generally, the coordinates (east and north) of all points are good, and the average standard deviation is less than 3.4 cm. As expected, the height accuracy is approximately 4 cm. At the same point between two the CORS-VRS measurements, the height components were inconsistent; sometimes, the difference was up to 10 cm (figure 5E). The results clearly show that the CORS-VRS technique is a stable system, and the centimeter level of accuracy is generally obtainable under various operational conditions.

After comparing the survey results, the horizontal coordinates of the points determined by these tests appeared to be consistent, with some variations ranging from a few millimeters to 3 cm. However, the consistency of the height component was poor, sometimes at 7 cm at the same point between two the VRS sessions. In forest environments, signal obstruction and attenuation make vertical accuracy more challenging. This is because the signal arrives parallel to the ground and may be lost, making height calculations more difficult for the device. There are several reasons why vertical positioning is usually worse than horizontal positioning.

- Satellite geometry. The arrangement of satellites in the sky usually provides better coverage and geometry for determining the horizontal position than the vertical position. Satellites tend to be distributed around the horizon, with fewer satellites directly overhead. This geometric distribution inherently provides a better accuracy in the horizontal plane.


A)
Mean (ΔE)=0.024 m
Mean (ΔN)=0.016 m
Mean (Δh)=0.011 m
Std (ΔE)=0.009 m
Std (ΔN)=0.022 m
Std (Δh)=0.014 m
East
North
Height
Differences [m]
The number of points
B)
Mean (ΔE) =0.010 m
Mean (ΔN) =0.037 m
Mean (Δh) =0.061 m
Std (ΔE)=0.009 m
Std (ΔN)=0.025 m
Std (Δh)=0.037 m
Differences [m]
The number of points
C)
Mean (ΔE) =0.014 m
Mean (ΔN) =0.032 m
Mean (Δh) =0.062 m
Std (ΔE)=0.006 m
Std (ΔN)=0.014 m
Std (Δh)=0.047 m
Differences [m]
The number of points

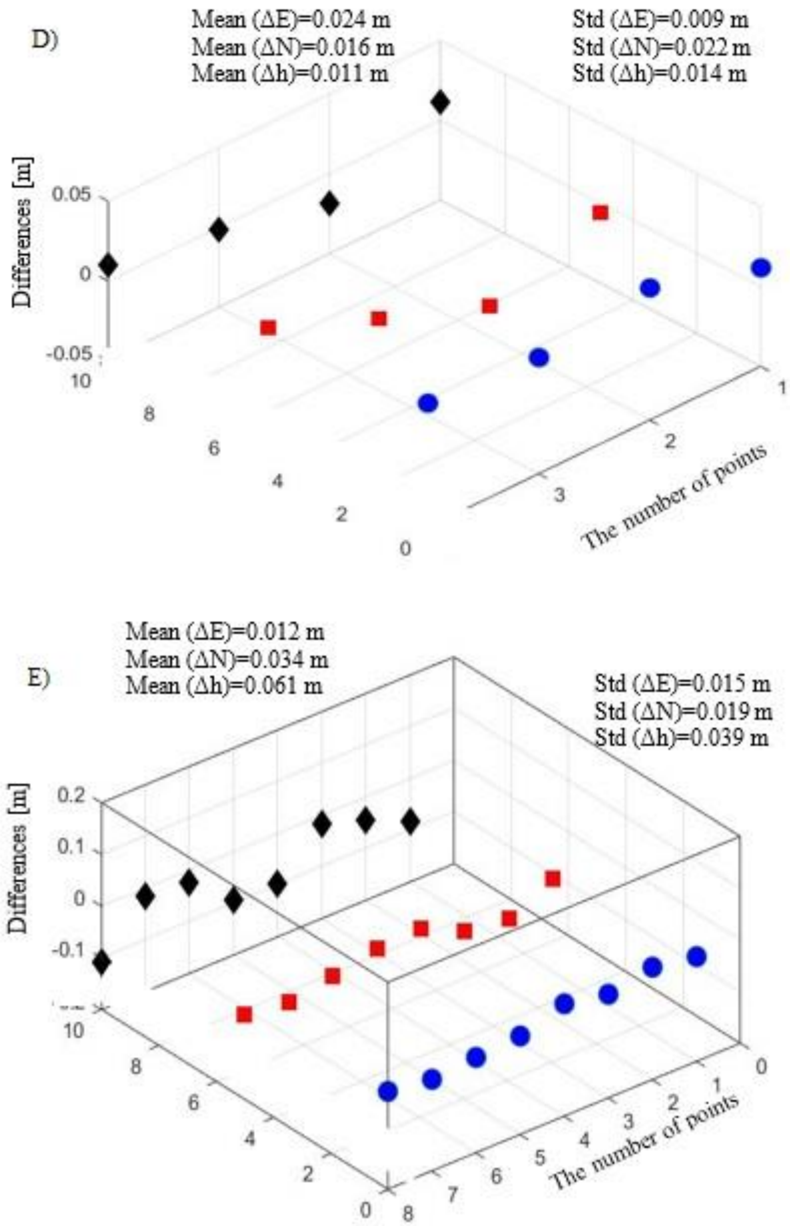


Figure 5. A) Comparison of the four points coordinates obtained from CORS-VRS survey on 30 September 2020 and 1 October 2020 (VRS-VRS), B) from VRS survey on 30 September 2020 with static survey coordinates, C) from VRS survey on 1 October 2020 with static survey coordinates, D) from the first CORS-VRS survey (30 September 2020) with the second CORS-VRS survey (1 October 2020), E) from CORS-VRS survey on 30 September 2020 and 1 October 2020 with static survey results.

A) Comparación de las coordenadas de los cuatro puntos obtenidas de los levantamientos CORS-VRS el 30 de septiembre de 2020 y el 1 de octubre de 2020 (VRS-VRS), B) VRS el 30 de septiembre de 2020 con coordenadas de levantamientos estáticos C) VRS el 1 de octubre de 2020 con coordenadas de levantamientos estáticos, D) CORS-VRS (30 de septiembre de 2020) con los segundos levantamientos CORS-VRS (1 de octubre de 2020), E) CORS-VRS el 30 de septiembre de 2020 y el 1 de octubre de 2020 con los resultados del levantamiento estático.

- Atmospheric effects: Earth's atmosphere can distort satellite signal. Both horizontal and vertical measurements are affected, but the effect on vertical accuracy is more noticeable because the variability in atmospheric conditions (such as ionospheric and tropospheric delays) has a greater effect on the angle of the received signals, which further affects the vertical measurements.
- Multipath errors: These occur when satellite signals reflect off surfaces (e.g. buildings and ground) before reaching the receiver. Because vertical signals are more likely to be reflected off horizontal surfaces, this can lead to more errors in the vertical positioning.

All the results also indicate that the canopy is harmful to the positioning of the CORS-VRS. Therefore, even if there is a good satellite window, the signal blockage caused by the tree canopy can be regarded as the main problem affecting the use of the CORS-VRS in forest areas.

DISCUSSION AND CONCLUSIONS

In the context of the increased utilization of GNSS in tree canopy environments, it is necessary to understand the accuracies that can be attained in such areas. The majority of prior GNSS evaluations have been conducted under "clear-sky" conditions, where unobstructed views of satellites are available. However, numerous scientists (Feng *et al*. 2021, Uzodinma and Nwafor 2018, Lee *et al*. 2023) have investigated the impact of terrain, tree canopies, and position dilution of precision (PDOP) on GNSS accuracy. It was determined that the open sites exhibited superior positional accuracy compared to the sub-canopy sites. Consequently, position accuracy is frequently compromised in challenging terrain conditions, often falling short of established accuracy standards and necessitating resurveying. In addition, contemporary GNSS technologies have advanced by incorporating sophisticated tracking capabilities. However, despite these advancements, the signals have become noisier, weaker, and more susceptible to multipath and diffraction effects. Despite the quality indicators showing good solutions, their positions may not be accurate. To overcome this situation, GNSS receivers are equipped with techniques to mitigate or eliminate multipath positioning errors. In addition, surveyors are required to check the GNSS results using a total station. In such challenging terrain, terrestrial surveying facilitates productivity by providing an independent positional reference, which is crucial for assessing the precision of GPS results in forest and tree canopy environments. This is due to the fact that the total station remains unaffected by canopy or multipath effects, unlike GNSS receivers.

It is impossible to use the CORS-VRS with the same level of accuracy in any environment at any time. In other words, quality assurance remains an important issue surveys. The results of this study show that these trees have a significant impact on the accuracy, precision, and performance of the CORS-VRS positioning. The tree canopy has negative effects on GNSS signals, including obstacles, attenuation, and reflections. However, the use of high-quality GNSS receivers, conducting long-duration measurements (increasing the number of epochs), utilizing a nearby CORS network, and maintaining a low PDOP value can enhance vertical accuracy. Geometric leveling remains the most reliable method for high-precision (mm accuracy) determination of heights. This method involves direct measurement of elevations, from which normal heights are determined. The results of this study show that CORS-VRS can obtain a horizontal accuracy of 1-2 cm and a vertical accuracy of 2-5 cm. These results show that CORS-VRS technology is feasible, effective, and efficient for positioning and other applications in obstructed and unobstructed areas that do not produce unsuitable conditions.

AUTHORS CONTRIBUTION

The authors confirm their contribution to the paper as follows: study conception and design: Atınç PIRTI, Zümrüt KURTULGU; data collection: Atınç PIRTI, Zümrüt KURTULGU; analysis and interpretation of results: Atınç PIRTI, Zümrüt KURTULGU; draft manuscript preparation: Atınç PIRTI and Zümrüt KURTULGU. All authors have reviewed the results and approved the final version of the manuscript.

FUNDING

No funding was received for this work.

ACKNOWLEDGEMENT

We wish to thank the staff of Topcon Paksoy Teknik Hizmetler in Turkey for their help and comments, which greatly improved the manuscript.

REFERENCES

Ayele N, A Gedamu. 2022. Optimum CORS Network Design for Geodetic Applications in Ethiopia. *Research Square* 1. DOI: https://doi.org/https://doi.org/10.21203/rs.3.rs-1760225/v1

Bulbul S, C İnal, O Yıldırım, F Basçiftçi. 2017. Velocity Estimation of Turkish National Permanent GNSS Network-Active Points Located at Central Anatolia Region. *Bilge International Journal of Science and Technology Research* 1(1): 18-25. Accessed 17 mar. 2025. Available in https://www.researchgate.net/publication/320858737_Velocity_Estimation_of_Turkish_National_Permanent_GNSS_Network-_Active_Points_Located_at_Central_Anatolia_Region

Charoenkalunyuta T, C Satirapod, R Charoenyot, T Thongtan. (2023). Geometric and Statistical Assessments on Horizontal Positioning Accuracy in Relation with GNSS CORS Triangulations of NRTK Positioning Services in Thailand. *International Journal of Geoinformatics* 19(2). DOI: https://doi.org/https://doi.org/10.52939/ijg.v19i2.2559

Dardanelli G, M Lo Brutto, C Pıpıtone. 2020. GNSS CORS network of the unıversıty of Palermo: desıgn and first analysıs of data. *Geographia Technica* 15(1): 43-69. DOI: https://doi.org/10.21163/GT_2020.151.05

Feng T, S Chen, Z Feng, C Shen, Y Tian. 2021. Effects of Canopy and Multi-Epoch Observations on Single-Point Positioning Errors of a GNSS in Coniferous and Broadleaved Forests. *Remote Sensing* 13: 2325. DOI: https://doi.org/10.3390/rs13122325

Hofmann-Wellenhof B, H Lichtenegger, E Wasle. 2008. GNSS–global navigation satellite systems: GPS, GLONASS, Galileo, and more. Springer Science & Business Media. 537 p.

Lau L, K-W Tai. 2023. A Data Quality Assessment Approach for High-Precision GNSS Continuously Operating Reference Stations (CORS) with Case Studies in Hong Kong and Canada/USA. *Remote Sensing* 15. DOI: https://doi.org/https://doi.org/10.3390/rs15071925

Lee T, P Bettinger, K Merry, C Cieszewski. 2023. The effects of nearby trees on the positional accuracy of GNSS receivers in a forest environment. *PLoS One* 18(3):e0283090. DOI: https://doi.org/10.1371/journal.pone.0283090

O'Keefe K, G Lachapelle. 2007. Network real-time kinematic performance analysis using RTCM 3.0 and the Southern Alberta_Network. *Geomatica* 61(1): 29-41. DOI: https://doi.org/https://doi.org/10.5623/geomat-2007-0003

Pırtı A. 2011. Evaluating the Repeatability of RTK GPS. *Survey Review* 43: 177-186. DOI: https://doi.org/https://doi.org/10.1179/003962611X12894696204984.

Tomaštík JJ, SJ Tomaštík, Š Saloň, R Piroh. 2017. Horizontal accuracy and applicability of smartphone GNSS positioning in forests. *Forestry: An International Journal of Forest Research* 90(2): 187-198. DOI: https://doi.org/https://doi.org/10.1093/forestry/cpw031

Topcon Positioning Systems. 2018. HiPer VR, GNSS Receiver. Operator's Manual. Accessed 17 mar. 2025. Available in https://www.manualslib.com/manual/1547068/Topcon-Hiper-Vr.html?page=5#manual

Tuşat E. (2018). A Comparison of the Accuracy of VRS and Static GPS Measurement Results for Production of Topographic Map and Spatial Data A Case Study on CORS TR. *Technical Gazette* 25(1): 158-163. DOI: https://doi.org/DOI:10.17559/TV-20160406110412

Uzodinma V, U Nwafor. (2018). Degradation of GNSS Accuracy by Multipath and Tree Canopy Distortions in a School Environment. *Asian Journal of Applied Sciences* 6. DOI: 10.24203/ajas.v6i4.5458, https://doi.org/10.24203/ajas.v6i4.5458

Recibido: 05.05.2024
Aceptado: 17.03.2025