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Technical Note

Assessing the Quality of GNSS Observations for Permanent Stations in Mexico (2020–2023)

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Abstract

A quality assessment of Global Navigation Satellite System (GNSS) observations was conducted for 95 Continuously Operating Reference Stations (CORSs) across Mexico over the period 2020–2023 using the ANUBIS software package. The evaluation was carried out according to International GNSS Service (IGS) quality indicators, including the data utilization ratio (R), multipath effect (MP), cycle slips (CSR), and signal-to-noise ratio (SNR). Stations belonging to the National Active Geodetic Network (RGNA), the government-managed geodetic network, exhibited the highest observation quality, with most meeting IGS thresholds for MP, CSR, and SNR. Nevertheless, none of the RGNA stations reached the recommended 95% threshold for data utilization ratio. In contrast, CORS-NOAA and EarthScope stations operating in Mexico generally failed to satisfy IGS standards, although acceptable SNR values were observed at some sites. Upgrades to multi-constellation receivers (GPS, GLONASS, GALILEO) did not consistently improve data quality. These findings highlight the role of processing software and configuration choices in GNSS data quality assessments and emphasize the importance of continued modernization of geodetic infrastructure in Mexico.

Keywords: GNSS; CORS; ANUBIS; IGS quality parameters; multipath; RGNA

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1. Introduction

With rapid advancements in Global Navigation Satellite Systems (GNSS) and continuous expansion of Continuously Operating Reference Stations (CORS) worldwide, the availability of high-precision positioning data has greatly improved [1]. This expansion, coupled with the increasing number of satellites in orbit, has enabled diverse scientific and engineering applications, including crustal deformation monitoring with geodetic equipment [2–5], low-cost GNSS instrumentation [6], landslides monitoring [7–9], integration of LiDAR and GNSS for precise mapping [10], multi-GNSS Real Time Kinematic (RTK) positioning [11], and ionospheric studies such as Total Electron Content (TEC) anomaly detection for seismic precursors [12,13]. The importance of precise GNSS ephemerides has also been emphasized in previous studies [14]. In Mexico, such applications are particularly relevant due to the country's high seismicity, resulting from the interaction of the North American, Pacific, Cocos, Rivera, and Caribbean plates [15,16].

The accuracy of these applications strongly depends on the quality of GNSS observations, which can be degraded by noise sources such as multipath, vegetation, surrounding infrastructure, and atmospheric disturbances. Several studies have evaluated the quality

of GNSS data. For example, Hu, et al. [17] assessed 173 GPS-CORS sites in campaign mode over four days and showed that trees, buildings, and power lines significantly bias velocity estimates, sometimes beyond the ability of post-processing to correct. In Spain, García-Armenteros, J. A. [18] conducted the first quality assessment of the Topo–Iberia geodetic network, applying International GNSS Service (IGS) quality parameters such as multipath, data completeness, cycle slips, and signal-to-noise ratio (SNR). More recently, García-Armenteros, J. A. [19] proposed an improved method of quality control, showing that increased antenna elevation correlates with higher multipath and cycle slips, often linked to poor-quality stations with elevated post-fit RMS values. Similarly, Serrano-Agila, R., et al., [20] performed a comprehensive quality analysis of REGME stations, demonstrating that CORS quality is critical for reliable tectonic monitoring, while vegetation growth near antennas can progressively degrade signal quality below IGS standards.

Multipath has also been the focus of multiple investigations. Vázquez-Becerra, G. E. et al., [21] evaluated pseudorange multipath effects in the TAMDEF network in Antarctica, while Vázquez-Becerra, G.E. et al., [22] studied 53 CORS from the National Institute of Statistics and Geography (INEGI) in Mexico over 18 years, demonstrating that hardware changes significantly impact multipath-related noise. Hernández-Andrade, D. et al., [23] evaluated 65 freely accessible CORS in Mexico using IGS parameters [24], showing that most did not meet international quality standards. Building on this, Hernández-Andrade, D. et al., [25] developed a statistical index to quantify quality values for these stations, further confirming that observation quality directly impacts GPS-derived time series analysis. Llanes-Hernández, R. M. et al., [26] extended this work by applying statistical analysis of IGS parameters to the National Active Geodetic Network (RGNA) over four years, demonstrating that RGNA stations, when evaluated with TEQC, are among the most accurate but were limited to GPS-only data.

Despite these efforts, significant gaps remain in Mexico. Regulations require that all geodesy, topography, and geomatics projects reference RGNA stations, making this network the most authoritative for official geospatial applications [27]. However, RGNA data are not publicly available, and large-scale quality assessments are scarce. A major upgrade of RGNA in 2020 expanded its capabilities from GPS-only to a true multi-GNSS, incorporating GLONASS and GALILEO constellations, while other networks in Mexico, such as EarthScope and CORS-NOAA, still operate in GPS-only mode. To date, no published study has systematically assessed RGNA station quality following this critical upgrade, and INEGI does not provide official quality evaluations or visualization tools for end-users.

Most of the research in the state-of-the-art has focused on analyzing the parameters of data utilization ratio, multipath effect, cycle slips, and sometimes also the signal-to-noise ratio using the TEQC software (version 2.6), considering GPS or, in some cases, other constellations such as GLONASS or GALILEO. However, the problem lies in the fact that the IGS parameters were established based on the algorithms integrated in the TEQC software, which dates back to the 1990s. In this sense, it is important to demonstrate the contribution of other constellations with algorithms that allow for a stricter signal analysis. In this context, the main motivation of this study is to provide the first comprehensive quality assessment of GNSS stations in Mexico, focusing on the upgraded RGNA and comparing it with EarthScope and CORS-NOAA stations over a four-year period (2020–2023) using ANUBIS software [28]. Quality was assessed using IGS-recommended parameters [24], including data utilization ratio, multipath effect, and cycle slips. Additionally, the signal-to-noise ratio was analyzed to complement the IGS metrics by quantifying signal strength. By doing so, this study not only evaluates the current performance of Mexico's official geodetic infrastructure but also establishes a framework for identifying limitations and guiding improvements in GNSS-based research and applications.

2. Method

2.1. Data Used in the Analysis

The GNSS data analyzed in this study covers the period from 2020 to 2023, which coincides with a major modernization of the RGNA. Before this upgrade, the RGNA operated in GPS-only mode, but since 2020, its stations were equipped to track multiple constellations (GPS, GLONASS, and GALILEO). This period was therefore selected as the baseline for analysis, as it marks the beginning of multi-constellation capability in the national network. Although some EarthScope and CORS-NOAA stations in Mexico were operating prior to 2020, restricting the comparison to this timeframe ensures consistency across all networks and allows a direct evaluation of the impact of multi-constellation integration. In contrast, EarthScope and CORS-NOAA have not undergone comparable upgrades and remain GPS-only networks. Importantly, the INEGI has not published any official quality assessment of the RGNA, further motivating this study.

The spatial distribution of EarthScope and CORS-NOAA stations analyzed in this study is shown in Figure 1. This map highlights the widespread geographic coverage of these networks across Mexico, but also underscores their technological limitations when compared with the upgraded RGNA.

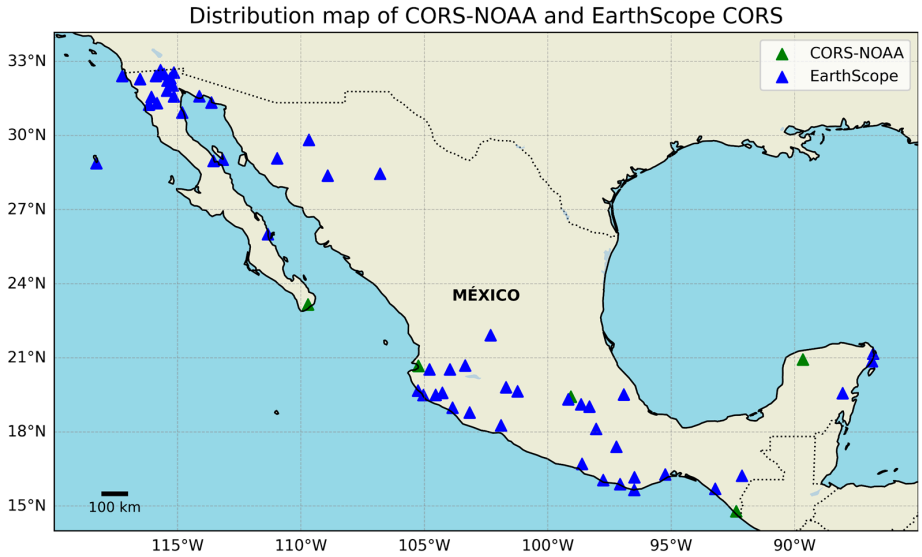


Figure 1. Distribution map of the CORS-NOAA and EarthScope CORS in Mexico. The dashed line represents the international political division.

GNSS data from EarthScope were downloaded directly from the EarthScope Consortium portal (https://www.earthscope.org/, accessed on 20 February 2025), while CORS-NOAA data were accessed from the NOAA CORS repository (https://geodesy.noaa.gov/CORS/, accessed on 20 February 2025). Automated batch processing scripts were developed in Python version 3.12.3 to manage large-scale data downloads from these repositories. For the RGNA data, a formal request had to be submitted to the Mexican government to obtain authorization, since these data are not freely accessible; the government retains ownership and restricts wide-scale dissemination. The total number of RINEX files used from each network and year is illustrated in Figure 2, which demonstrates the temporal density of observations.

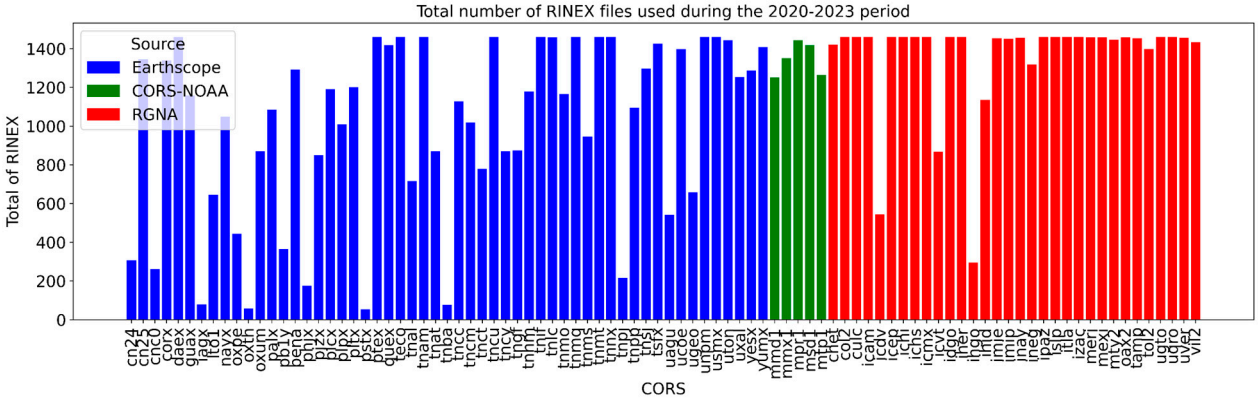


Figure 2. Total number of RINEX files used for the analysis (2020–2023).

In total, this study analyzed 55 GNSS stations from EarthScope, 8 stations from CORS-NOAA, and 31 RGNA stations. Some stations appear in both EarthScope and CORS-NOAA inventories; to avoid duplication, each station was assigned to a single primary network source for the purposes of this study. A complete list of all stations, including names, coordinates, network affiliation, receiver/antenna type, and annual RINEX file counts, is provided in Appendix A (Table A1).

The RGNA constitutes the official national geodetic framework of Mexico and provides nationwide CORS coverage with the highest positional accuracy available. According to Article 10 of the Norma Técnica para el Sistema Geodésico Nacional [27], all GNSS observations used for official surveying in Mexico must be referenced to ITRF2008, epoch 2010.0, and tied to RGNA stations. The adopted reference ellipsoid is GRS80. While ellipsoidal heights are directly obtained from GNSS measurements, orthometric heights can be derived using a geoid model such as EGM2008.The spatial distribution of the RGNA stations analyzed in this study is presented in Figure 3, which highlights its role as a key component of Mexico's geodetic reference frame.

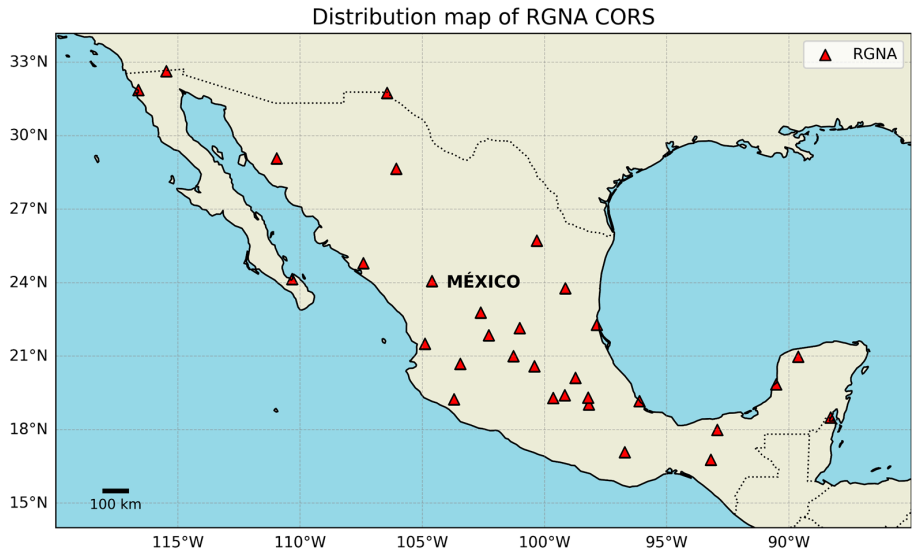


Figure 3. Distribution map of the CORS from RGNA. The dashed line represents the international political division.

Most RGNA CORS are installed on INEGI facilities, ensuring secure environments and standardized maintenance practices. The stations are equipped with Zephyr Geodetic 3 receivers and TRM115000.00 antennas, which enable multi-constellation and multi-frequency tracking. The receivers collect carrier-phase and pseudorange measurements on GPS fre-

quencies L1, L2, and L5; GLONASS frequencies L1 and L2; and GALILEO frequencies E1, E5a, E5b, and E6. Data are typically provided with a 15 s sampling interval and, for public use, a 10° elevation mask to suppress low-elevation signals most susceptible to multipath and atmospheric interference. However, INEGI archives the raw data at a 0° elevation mask, which were used in this study to comply with IGS methodological recommendations and to ensure complete evaluation of antenna surroundings. A photograph of typical RGNA CORS installed on INEGI buildings is shown in Figure 4, illustrating their standardized setup.



Figure 4. CORS belonging to the RGNA geodetic network (not all images on the INEGI website are updated).

2.2. Data Processing, Quality Assessment, and Parameter Estimation

The observation files in HATANAKA format [29] were first converted to RINEX format [30] using the CRX2RNX [31] software. To ensure consistency across stations, all files were processed with the ANUBIS 3.10 software [28] and decimated to a uniform sampling rate of 30 s. An elevation mask of 0° was applied to capture the true surrounding conditions of each antenna, in accordance with IGS recommendations. Incomplete data records were automatically excluded by ANUBIS 3.10software when data gaps exceeded one hour, or valid observations fell below 85% per day. Since less than 5% of the total files were affected, their removal does not impact on the overall results or conclusions.

Given that the CORS-NOAA and EarthScope networks in Mexico only record GPS signals, quality assessment for these stations was limited to the GPS constellation. For RGNA stations, which operate with multi-constellation receivers, additional analyses were performed using the following combinations: GPS + GLONASS + GALILEO, GPS + GLONASS, GPS + GALILEO, GALILEO only, GPS only, GLONASS only, and GLONASS + GALILEO.

ANUBIS was used to calculate the International GNSS Service (IGS) quality parameters as follows:

(1) Multipath Effect (MP): Computed as the RMS moving average from linear combinations of carrier phase and pseudorange observations, using 24 h RINEX files with a 30 s sampling rate interval. The recommended IGS threshold is $\leq$0.30 m for both L1 and L2 frequencies.
(2) Data Utilization Ratio (R): Defined as the proportion of successfully recorded observations relative to the total possible observations, with the IGS recommended minimum of 95%.
(3) Cycle Slips (CSR): Defined as discontinuities in carrier-phase observations caused by interruptions in Doppler counts. CSR was estimated following [32] using carrier-phase data, where the IGS threshold is <1 slip per 1000 observations.
(4) Signal-to-Noise Ratio (SNR): Although not formally part of the IGS parameters, SNR was included following [32] as an additional measure of signal strength. Values above 40 dBHz were classified as strong signals, while values below 28 dBHz indicated weak signals.

For each CORS, the multi-year average of each quality indicator was computed over the 2020–2023 period, ensuring consistency and excluding incomplete data records.

3. Results

Once the values of R, MP, CSR, and SNR were calculated for all CORS, they were grouped according to their managing agency to facilitate network-wide comparisons.

For the CORS-NOAA geodetic network (Figure 5), the CSR parameter is consistently high across all stations, clearly exceeding the IGS threshold of less than one slip per thousand observations. This indicates a systematic issue with cycle-slip detection and signal stability in this network. The lowest CSR value was recorded at station UNPM, which also presented comparatively better multipath values. In terms of multipath (MP), all stations surpassed the IGS limit of 30 cm, although UNPM again stood out with values closest to the recommended threshold. The R indicator revealed another major shortcoming: all CORS-NOAA stations failed to achieve the 95% data utilization benchmark, pointing to persistent data loss and reliability issues. In contrast, the SNR results were generally satisfactory, with most stations reporting strong signals; however, UNPM once again deviated by displaying a weaker signal strength. Overall, these results highlight that the CORS-NOAA network provides good raw signal strength but suffers from critical weaknesses in data completeness and multipath control, which limit its suitability for high-precision geodetic applications.

The EarthScope CORS network exhibited a more mixed performance (Figure 6). For CSR, most stations satisfied the IGS requirement, remaining below the one-slip-per-thousand threshold. However, a subset of stations, including CORX, GUAX, IAGX, TNCT, TNCY, TNMQ, TNNX, TNPJ, and TNPP, recorded CSR values above this limit, indicating uneven quality across the network. The SNR results showed a strong and consistent performance in the L1 band, with nearly all stations exceeding the recommended thresholds. However, performance deteriorated in the L2 band, where most stations failed to surpass the recommended 36 dBHz value. Notably, a group of stations such as CN24, CN25, GUAX, OXTH, TNAM, TNBA, TNCC, TNCM, TNCU, TNMQ, and USMX achieved strong signals

in both L1 and L2, marking them as relatively high-performing stations within the network. With respect to multipath, most EarthScope CORS did not meet the 30 cm threshold, reflecting similar limitations to those of CORS-NOAA, although a few stations (PJZX, PLPX, TNMO, YUMX) remained within acceptable limits. Finally, the R indicator again confirmed a general weakness in data completeness: only a small set of stations (IAGX, OXTH, PLPX, TNCU, TNNX, YUMX) achieved values above the 95% utilization threshold. Collectively, these results suggest that EarthScope CORS in Mexico provide robust SNR values on L1 but remain vulnerable to cycle slips, multipath, and data loss factors that compromise their consistency for long-term geodetic monitoring.

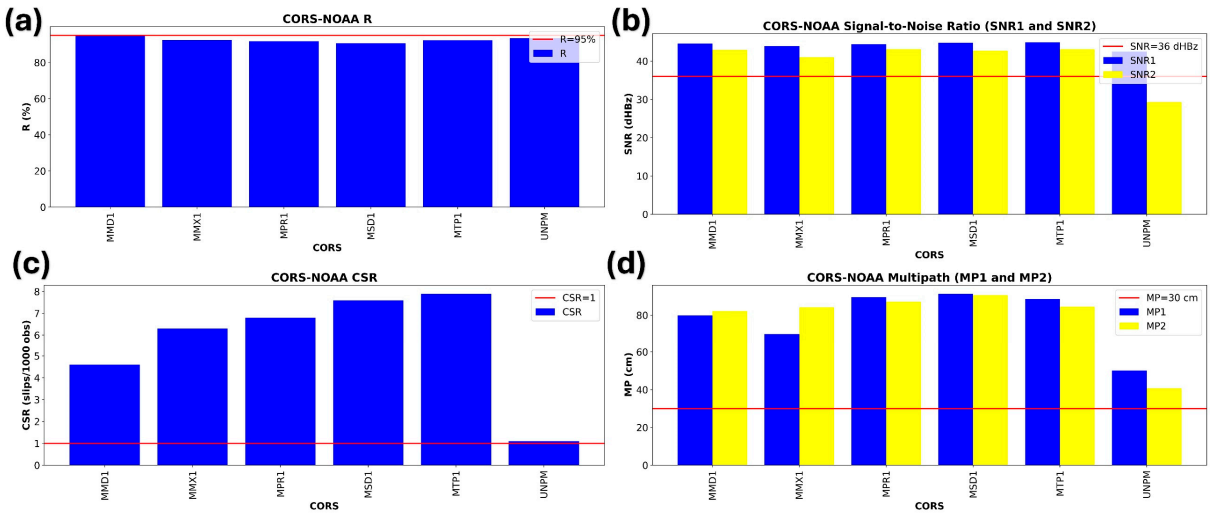


Figure 5. Calculated values for CORS-NOAA geodetic network. (**a**) Data Utilization Ratio, (**b**) Signal-to-Noise Ratio, (**c**) Cycle Slips, (**d**) Multipath effect.

For the RGNA (Figures 7 and 8), which is the most critical national geodetic infrastructure, the results are more encouraging but not without shortcomings. For CSR, only two stations (ICVT under GPS + GLONASS + GALILEO, and CHET under GPS + GLONASS) exceeded the IGS threshold of one slip per thousand observations, while all others remained within acceptable limits. Interestingly, the GALILEO constellation consistently exhibited higher CSR values, suggesting that despite its utility in providing additional satellites, it may still introduce noise under certain configurations. Multipath performance was generally strong across the RGNA stations, with most remaining below the 30 cm threshold. However, some stations (ICEP, ICHI, ICHS, IDGO, IHER for MP2 of GLONASS; ICHI, IDGO, IHER for MP1 of GLONASS; IHER for GALILEO MP7; and IHER and IMIE for GPS MP1 and MP2) did exceed the limits, highlighting localized vulnerabilities. Regarding the R indicator, none of the RGNA stations achieved the recommended >95% threshold, with most averaging around 80%. This reinforces the fact that even in the best-performing network, data utilization remains a persistent weakness, likely due to environmental obstructions in urban station settings. Finally, SNR analysis revealed weak signal strength in GALILEO SNR1 for several stations (ICDV, ICMX, ICVT, IHID, IMIP) and similar weaknesses in GPS and GLONASS SNR for a subset of sites. However, the majority of RGNA stations maintained strong signal quality across most constellations. Taken together, the RGNA demonstrates a marked improvement over CORS-NOAA and EarthScope, confirming its role as the most reliable geodetic network in Mexico, although the persistent inability to achieve full data utilization represents an area for technical and infrastructural enhancement.

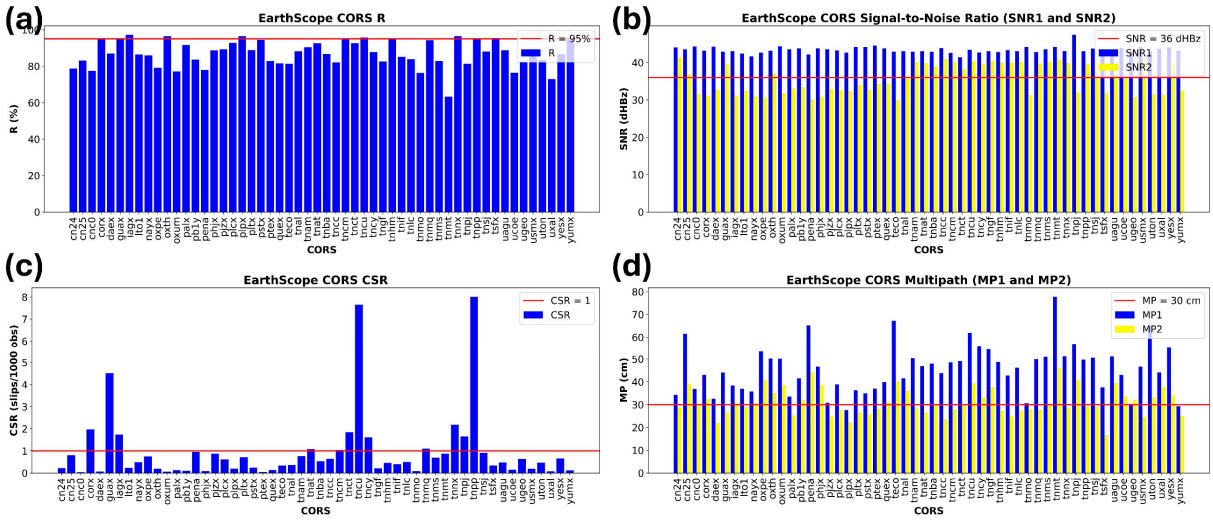


Figure 6. Calculated values for Earthscope geodetic network. (**a**) Data Utilization Ratio, (**b**) Signal-to-Noise Ratio, (**c**) Cycle Slips, (**d**) Multipath effect.

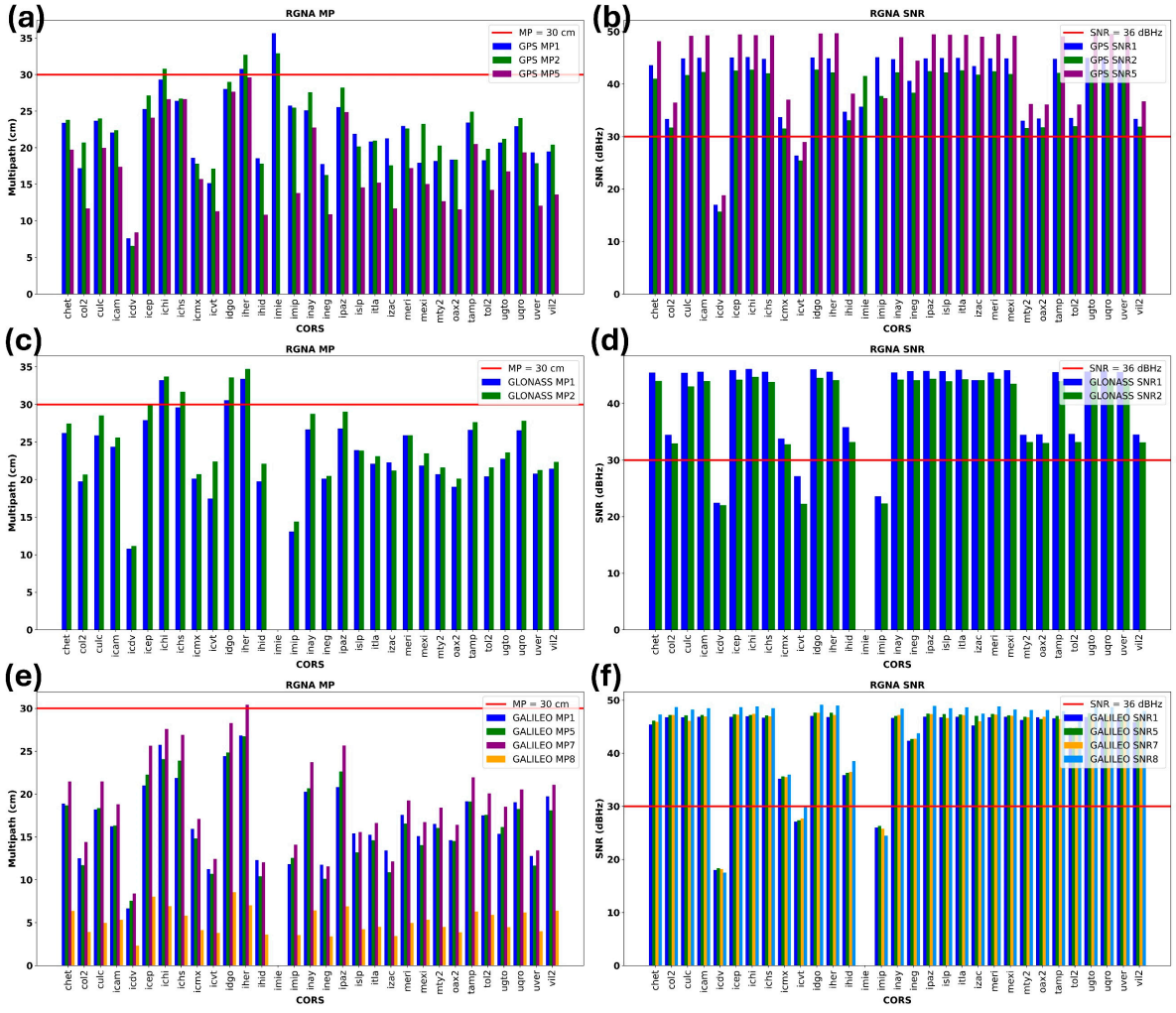


Figure 7. Calculated values of MP and SNR from RGNA CORS. (**a**) GPS multipath effect, (**b**) GPS signal-to-noise ratio, (**c**) GLONASS multipath effect, (**d**) GLONASS signal-to-noise ratio, (**e**) GALILEO multipath effect, (**f**) GALILEO signal-to-noise ratio.

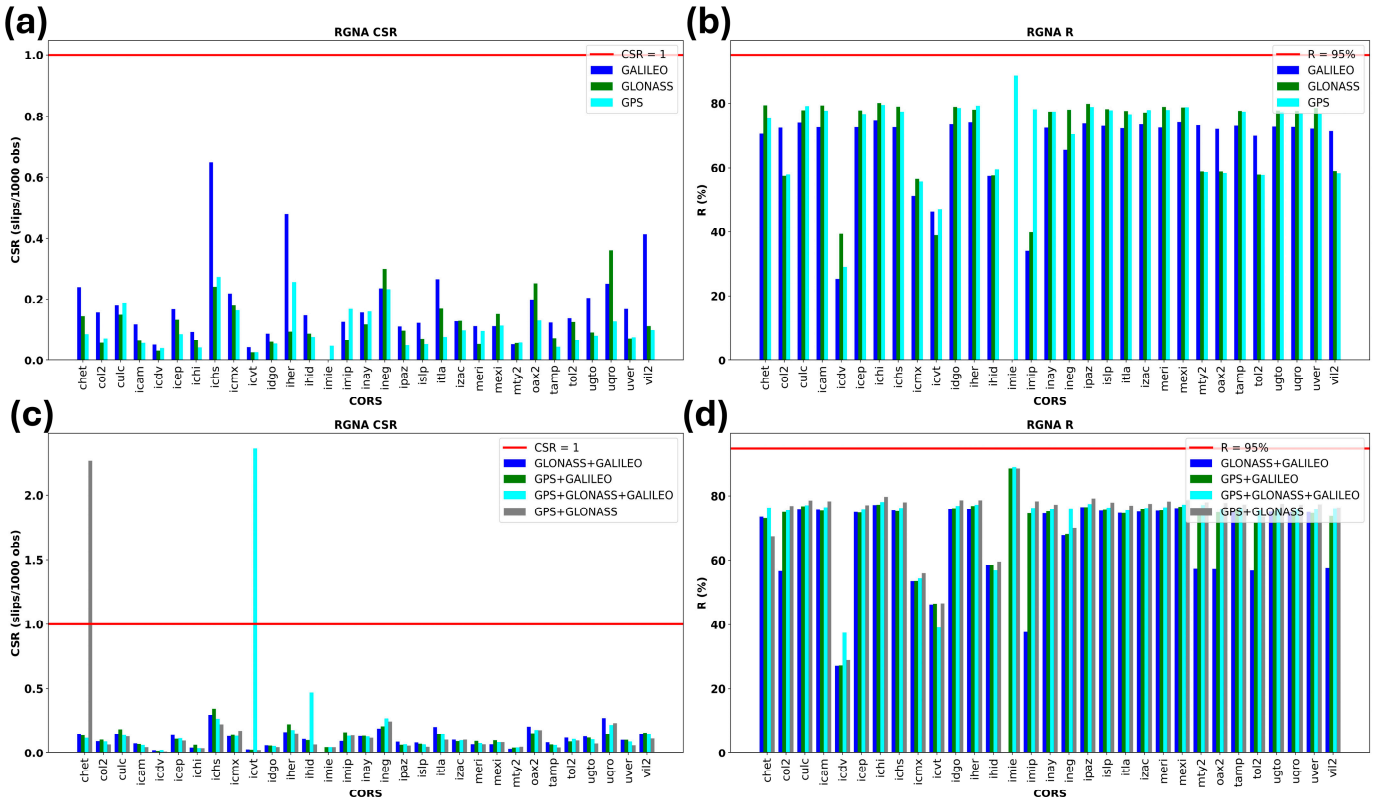


Figure 8. Calculated values of CSR and R from RGNA CORS. (**a**) GPS, GALILEO, and GLONASS multipath effect, (**b**) GPS, GALILEO, and GLONASS data utilization ratio, (**c**) Constellation combination cycle slip and data utilization ratio, (**d**) Constellation combination data utilization ratio.

In summary, the comparative assessment clearly indicates that the RGNA consistently outperforms CORS-NOAA and EarthScope stations in terms of multipath, cycle slips, and signal strength, reaffirming its role as a key component of Mexico's geodetic infrastructure. Nevertheless, the persistent shortfall in data utilization ratio across all networks highlights a systemic limitation that must be addressed through improved station siting, hardware upgrades, and maintenance strategies. These findings provide a robust baseline for interpreting the broader implications of GNSS data quality in the subsequent discussion.

4. Discussion

The results presented in this study reveal the status of CORS in Mexico, managed by various geospatial data agencies. It is evident that both the CORS-NOAA and EarthScope geodetic networks do not meet the IGS threshold values for key quality indicators such as multipath, cycle slips, and data utilization ratio.

However, these findings contrast with previous research, notably by [23,25], in which GNSS data quality check was conducted using TEQC software. In those studies, most stations did meet the IGS thresholds. The divergence between their results and ours can be largely attributed to methodological differences such as the elevation mask where [23,25] used a default elevation mask of 10°, which is commonly accepted in some research centers. In contrast, the IGS guidelines recommend a mask of 5° or even 0°, which we applied in this study. Similarly, the multipath effect computation was different, while TEQC software calculates MP as the standard deviation of the MP linear combination [33]; ANUBIS calculates MP per satellite, frequency, and elevation, resulting in a more granular and possibly stricter evaluation. In the same way, for the cycle slip detection TEQC software employs the Melbourne–Wübbena [34] and ionospheric linear combinations, with detection thresholds based on ionospheric delay change rates exceeding 0.05 m/s, which corresponds

to a 4-cycle slip in L1 at 30 s sampling [35]. In contrast, ANUBIS uses extra-wide lane, wide lane, and narrow lane combinations, applying a fixed threshold of 0.5 cycles [28]. This difference may cause ANUBIS to detect more cycle slips, especially in noisy environments.

Similarly, the IGS recommended parameters were derived using the TEQC software, which, as mentioned, is less strict. This has an impact on the quality evaluation because they were originally calculated considering only the GPS constellation; however, GNSS was not taken into account in the establishment of these parameters.

In our results, the CORS from RGNA improved the quality of the observations from its last evaluation from [22], but did not fully meet the IGS criteria, particularly the data utilization ratio (R), which remained below 95% in most cases. Beyond the quantitative quality indicators, the present findings have direct implications for the use of GNSS data in Mexico. Similarly, the crustal deformation time series are constructed under the assumption of near-total data availability may obscure short-lived anomalies, underestimate noise levels, or overstate the reliability of velocity fields.

The observed deficiencies in the data utilization ratio and multipath effects, particularly in CORS-NOAA and EarthScope stations, suggest that crustal deformation studies and seismic monitoring applications relying on these datasets may be affected by elevated noise levels and incomplete observations. For example, multipath amplification due to urban structures can bias velocity estimates, while persistent data gaps undermine time-series reliability. Conversely, the relative stability of RGNA stations reinforces their suitability as the primary reference for national geodetic, cadastral, and hazard-monitoring projects. These results underscore the necessity of prioritizing infrastructure modernization, especially antenna sitting and environmental mitigation (e.g., vegetation control, building clearance), to reduce multipath amplification. Moreover, the findings provide a framework for assessing the readiness of GNSS networks to support advanced applications such as ionospheric monitoring, real-time crustal strain mapping, and early warning systems, where data integrity and continuity are critical.

Furthermore, a recent study by [26] reported that 98% of RGNA stations met IGS thresholds. However, their analysis also used a 10° elevation mask, similar to [23,25], which inflates the percentage of successfully used observations by excluding low-elevation signals. While this study provides a comprehensive evaluation of GNSS quality in Mexico, some limitations should be acknowledged. First, the analysis was constrained to the 2020–2023 period, coinciding with the RGNA upgrade, and longer-term variations remain to be fully characterized. Second, the restricted accessibility of RGNA data limits independent replication of results, underscoring the need for more open data policies. Looking forward, future research should explore automated quality monitoring pipelines that integrate ANUBIS outputs with real-time GNSS streams, enabling continuous control of network health. At the policy level, these findings highlight the urgency of aligning Mexican GNSS infrastructure with IGS best practices, ensuring that national and regional geodetic frameworks remain robust enough to support seismic hazard monitoring, climate studies, and precision surveying in the coming decade.

5. Conclusions

This study demonstrates that the National Active Geodetic Network (RGNA) is the most stable and reliable GNSS network in Mexico in terms of observation quality. Most of its stations meet the thresholds proposed by the IGS for multipath (MP), cycle slips (CSR), and signal-to-noise ratio (SNR). However, none of the constellation combinations achieved the IGS-recommended 95% threshold for the data utilization ratio (R), likely due to urban obstructions near the stations that result in partial data loss.

Regarding constellation combinations, our results show that adding GLONASS and GALILEO to GPS does not improve quality indicators. In fact, the GPS only configuration performs comparably, and in some cases better, particularly in terms of R and CSR, while MP remains the most challenging parameter across all constellations. This suggests that, for the RGNA, expanding the number of constellations does not guarantee higher-quality observations, but rather that local conditions around stations play a more decisive role. In contrast, stations from the CORS-NOAA and EarthScope networks show significantly lower quality. Specifically, the CORS-NOAA network fails to meet any of the IGS quality parameters, although it does report strong SNR values. The EarthScope network partially complies with CSR and SNR values, but many of its stations fall short of the recommended thresholds for MP and R.

According to the results obtained, it is important to update GPS receivers to GNSS, with new firmware and software that enable the tracking of more satellites. This will allow for improved research related to geodynamic studies or the quality of the received signal. Similarly, periodic monitoring or analysis by network managers helps to identify problems related to the environment or station malfunctioning; for example, the growth of trees near a station may increase the multipath effect and thus affect the time series [17]. Likewise, the use of antennas with Choke Ring technology helps mitigate this effect; however, most stations are not equipped with such antennas.

The results show a consistent trend regarding multi-constellation performance, with no significant improvement in data quality during the period analyzed. Although the 2020–2023 interval is relatively short compared to other published studies, it provides an initial indication of the expected parameter trends if recommendations such as updating firmware and software, considering antenna location and environment, and selecting appropriate monument and antenna types are not implemented.

Regarding the methodological approach for assessing GNSS observation quality, we consider ANUBIS to be more effective than TEQC software, as it applies stricter criteria in the detection of cycle slips, particularly in environments with nearby obstructions around the antenna. This stricter detection results in differences compared with previous studies based on TEQC, which is no longer maintained and relies on less rigorous algorithms. Therefore, although both approaches provide useful insights, we believe that ANUBIS currently offers a more reliable and up-to-date framework for GNSS data quality assessment.

In conclusion, the RGNA stands out as the most reliable and geodetically stable GNSS network of public access in Mexico, providing adequate support for topographic and high-precision geodetic applications. Conversely, the CORS-NOAA and EarthScope networks would benefit from hardware upgrades and revised data acquisition strategies to improve GNSS signal quality, especially if their data is to be used for geodynamic or crustal deformation studies. Strengthening GNSS infrastructure and ensuring compliance with IGS standards will be essential for enhancing Mexico's national geodetic capacity and supporting advanced applications such as seismic hazard monitoring and real-time crustal deformation analysis.

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Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A. List of GNSS Stations Used in the Study

Table A1. Complete list of GNSS stations included in the analysis, with network affiliation (EarthScope, CORS-NOAA, RGNA), coordinates, receiver and antenna type, and number of RINEX files processed (2020–2023).

Stations	Year				Total of RINEX	Receiver and Antenna
	2020	2021	2022	2023		
				EarthScope Network		
CN24	0	1	70	236	307	TRIMBLE NETR9 and TRM59800
CN25	249	365	365	365	1344	TRIMBLE NETR9 and TRM59800
CNC0	0	0	262	0	262	TRIMBLE NETRS and TRM41249.00
CORX	365	365	365	244	1339	TRIMBLE NETR8 and TRM59800.00
DAEX	365	365	365	365	1460	TRIMBLE NETRS and TRM57971.00
GUAX	365	365	364	65	1159	TRIMBLE NETR9 and TRM59800.00
IAGX	78	0	0	0	78	TRIMBLE NETR8 and TRM59800.00
LTO1	0	49	353	244	646	TRIMBLE NETRS and TRM29659.00
NAYX	365	174	359	150	1048	TRIMBLE NETRS and TRM59800.00
OXPE	279	0	165	0	444	TRIMBLE NETRS and TRM41249.00
OXTH	58	0	0	0	58	TRIMBLE NETR9 and TRM57971.00
OXUM	348	279	244	0	871	TRIMBLE NETR9 and TRM57971.00
PALX	365	365	248	106	1084	TRIMBLE NETRS and TRM59800.00
PB1Y	0	365	0	0	365	TRIMBLE NETRS and TRM59800.00
PENA	363	361	360	208	1292	TRIMBLE NETR9 and TRM59800.00
PHJX	176	0	0	0	176	TRIMBLE NETR9 and TRM59800.00
PJZX	365	365	120	0	850	TRIMBLE NETR9 and TRM59800.00
PLCX	363	365	326	136	1190	TRIMBLE NETR9 and TRM59800.00
PLPX	365	363	280	0	1008	TRIMBLE NETRS and TRM29659.00
PLTX	365	365	365	106	1201	TRIMBLE NETRS and TRM29659.00
PSTX	53	0	0	0	53	TRIMBLE NETRS and TRM59800.00
PTEX	365	365	365	365	1460	TRIMBLE NETRS and TRM59800.00
QUEX	339	349	364	365	1417	TRIMBLE NETRS and TRM29659.00
TECO	365	365	365	365	1460	TRIMBLE NETR9 and TRM57971.00
TNAL	335	192	188	0	715	TRIMBLE NETRS and TRM57971.00
TNAM	365	365	365	365	1460	TRIMBLE NETR9 and TRM59800.00
TNAT	51	89	365	365	870	TRIMBLE NETR9 and TRM59800.00
TNBA	77	0	0	0	77	TRIMBLE NETR9 and TRM59800.00
TNCC	365	253	144	365	1127	TRIMBLE NETR9 and TRM59800.00
TNCM	242	46	365	365	1018	TRIMBLE NETR9 and TRM59800.00
TNCT	33	50	352	345	780	TRIMBLE NETR9 and TRM57971.00
TNCU	365	365	365	365	1460	TRIMBLE NETR9 and TRM59800.00
TNCY	109	32	365	365	871	TRIMBLE NETR9 and TRM59800.00
TNGF	339	365	170	0	874	TRIMBLE NETR9 and TRM59900.00
TNHM	365	84	365	365	1179	TRIMBLE NETR9 and TRM59800.00

Table A1. *Cont.*

Stations	Year				Total of RINEX	Receiver and Antenna
	2020	2021	2022	2023		
TNIF	365	365	365	365	1460	TRIMBLE NETR9 and TRM59800.00
TNLC	365	365	364	365	1459	TRIMBLE NETR9 and TRM59800.00
TNMO	365	365	365	71	1166	TRIMBLE NETRS and TRM41249.00
TNMQ	365	365	365	365	1460	TRIMBLE NETR9 and TRM59800.00
TNMS	261	0	320	365	946	TRIMBLE NETR9 and TRM59800.00
TNMT	365	365	365	365	1460	TRIMBLE NETR9 and TRM57971.00
TNNX	365	365	365	365	1460	TRIMBLE NETR9 and TRM59800.00
TNPJ	0	215	0	0	215	TRIMBLE NETR9 and TRM59800.00
TNPP	365	0	365	365	1095	TRIMBLE NETR9 and TRM59800.00
TNSJ	365	365	320	247	1297	TRIMBLE NETR9 and TRM59800.00
TSFX	365	365	365	330	1425	TRIMBLE NETR9 and TRM29659.00
UAGU	180	0	138	223	541	TRIMBLE NETRS and TRM41249.00
UCOE	365	364	365	303	1397	TRIMBLE NETR9 and TRM55971.00
UGEO	60	67	166	365	658	TRIMBLE NETRS and TRM41249.00
USMX	365	365	365	365	1460	TRIMBLE NETR9 and TRM59800.00
UTON	353	365	365	361	1444	TRIMBLE NETR9 and TRM55971.00
UXAL	365	365	365	158	1253	TRIMBLE NETRS and TRM41249.00
YESX	365	365	365	191	1286	TRIMBLE NETR9 and TRM59800.00
YUMX	316	365	365	362	1408	TRIMBLE NETRS and TRM59800.00
				CORS-NOAA Network		
MMD1	360	349	363	179	1251	NOVWAASGII and MPLWAAS225
MMX1	360	365	364	262	1351	NOVWAASGII and MPLWAAS225
MPR1	360	359	364	360	1443	NOVWAASGII and MPLWAAS225
MSD1	348	351	361	358	1418	NOVWAASGII and MPLWAAS225
MTP1	360	189	358	357	1264	NOVWAASGII and MPLWAAS225
UNPM	366	142	365	365	1237	TRIMBLE NETR9 and TRM41249.00
				RGNA		
CHET	365	326	365	365	1421	ALLOY and TRM115000.00
COL2	365	365	365	365	1460	ALLOY and TRM115000.00
CULC	365	365	365	365	1460	ALLOY and TRM115000.00
ICAM	365	365	365	365	1460	ALLOY and TRM115000.00
ICDV	345	198	0	0	543	GR10 and LEIAR10
ICEP	365	365	365	365	1460	ALLOY and TRM115000.00
ICHI	365	365	365	365	1460	ALLOY and TRM115000.00
ICHS	365	365	365	365	1460	ALLOY and TRM115000.00
ICMX	365	365	365	365	1460	ALLOY and TRM115000.00
ICVT	0	138	365	365	868	ALLOY and TRM115000.00
IDGO	365	365	365	365	1460	ALLOY and TRM115000.00
IHER	365	365	365	365	1460	ALLOY and TRM115000.00
IHGO	295	0	0	0	295	ALLOY and TRM115000.00
IHID	41	364	365	365	1135	ALLOY and TRM115000.00
IMIE	362	365	361	365	1453	ALLOY and TRM115000.00
IMIP	358	362	365	365	1450	GR10 and LEIAR10
INAY	364	364	363	365	1456	GR10 and LEIAR10
INEG	364	224	365	365	1318	ALLOY and TRM115000.00
IPAZ	365	365	365	365	1460	ALLOY and TRM115000.00
ISLP	365	365	365	365	1460	ALLOY and TRM115000.00
ITLA	365	365	365	365	1460	ALLOY and TRM115000.00
IZAC	365	365	365	365	1460	ALLOY and TRM115000.00
MERI	365	364	365	365	1459	ALLOY and TRM115000.00
MEXI	365	365	365	364	1459	ALLOY and TRM115000.00
MTY2	365	365	365	352	1447	ALLOY and TRM115000.00
OAX2	364	365	365	365	1459	ALLOY and TRM115000.00

Table A1. *Cont.*

Stations	Year				Total of RINEX	Receiver and Antenna
	2020	2021	2022	2023		
TAMP	361	365	365	362	1453	ALLOY and TRM115000.00
TOL2	303	365	365	365	1398	ALLOY and TRM115000.00
UGTO	365	365	365	365	1460	ALLOY and TRM115000.00
UQRO	365	365	365	365	1460	ALLOY and TRM115000.00
UVER	362	365	365	365	1457	ALLOY and TRM115000.00
VIL2	338	365	365	365	1433	ALLOY and TRM115000.00

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