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Necmettin Erbakan University Continuously Operating Reference Station

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ABSTRACT

The Continuously Operating Reference Stations (CORS) are geodetic grade Global Navigation Satellite System (GNSS) receivers with permanently installed antennas, that are collecting GNSS data 24/7. Today the CORS, has vital importance in the GNSS community, whether for civilian users or researchers. Global CORS networks were established such as International GNSS Service's network. Also, most of the countries are established their own CORS networks e.g. Turkish CORS-TR. With the CORS networks, access to GNSS data for different purposes has become easier. In addition, for educational or some other research purposes it can be necessary to establish a CORS station. For this purpose, a CORS station was established at the rooftop of Necmettin Erbakan University. NEU-CORS station can track GPS, GLONASS, Galileo, BDS and SBAS satellites. The collected data is archived in the standard formats, and a real-time data stream via the Internet is provided. In this study, NEU-CORS station was introduced. The specification of the reference receiver, antenna and data formats are explained in detail. However, sample data is presented to examine the SNR (Signal to Noise Ratio), multipath and satellite visibility.

1. INTRODUCTION

In the last decade, the use of Global Navigation Satellite System (GNSS) has been drastically increased. With the development of new methods and algorithms, Continuously Operating Reference Station (CORS) has emerged. The CORS stations are geodetic grade GNSS receivers with permanently installed antennas. With the CORS stations, users are allowed to collect GNSS data for research or civilian purposes on 7/24. Hereby, the necessity to set a reference station is substantially eliminated. Today, CORS has become a remarkable tool for geosciences with enhanced usages such as real-time applications (Erenoglu 2017), structural health monitoring (Akpinar et al. 2017), datum defining (Altamimi and Collilieux 2009) and seismic monitoring (Bitharis et al. 2016). Global CORS networks were established for the datum consistency on a global scale such as the International GNSS Service (IGS) network. Also, most of the developed countries established their own CORS networks such as Turkish CORS-TR (Eren et al. 2009). Rizos 2008, proposed a classification between the permanent GNSS reference stations. According to this, IGS network is in Tier 1 stations, national networks are in Tier 2 stations and other regional or private reference stations are in Tier 3 (Rizos 2008).

CORS networks can provide real-time centimeter-level positioning accuracy with the Network-RTK (Real-Time Kinematic) corrections (Ogutcu 2014). Besides, the GNSS data is archived in RINEX (Receiver Independent Exchange Format) format. The collected data can be used for post-process positioning. In addition to benefits in the positioning, the monitoring of the atmosphere has been possible by estimating tropospheric wet delays (Zheng et al. 2018) or estimating total electron content (TEC) in the ionosphere layer (Nykiel et al. 2017).

Even there are many CORS networks, institutes can establish their own networks for different research purposes such as seismogeodetic networks. Also, on the university side, a CORS station can be established for educational and research purposes. Therefore, a CORS station is established at the rooftop of Necmettin Erbakan University, hereafter called NEU-CORS.

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In this study, NEU-CORS station is introduced in detail. The data formats and technical specifications of the station are explained. Also, as a sample, the data of DOY 290 in 2020 is presented. The sample data is examined with the SNR (Signal to Noise Ratio), multipath and satellite visibility graphics.

This paper is organized as follows. In Section 2 the main features of NEU-CORS station are given. The sample data is presented in Section 3. The discussions and conclusions are given in Section 4.

2. NEU-CORS STATION

The NEU-CORS station is installed at the rooftop of the Engineering and Architecture Faculty of Necmettin Erbakan University, in Konya. NEU-CORS station is managed and operated by the Department of Surveying Engineering. The location of the station is shown in Figure 1.

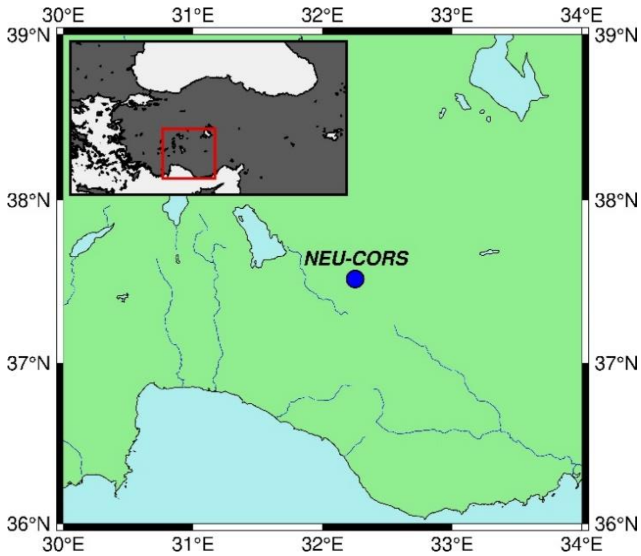

Figure 1. The location of NEU-CORS station

The station has a CHC N72 multifrequency GNSS receiver which can track 220 channels. CHC N72 receiver is equipped with CHC C220GR GNSS choke ring antenna. The choke ring antenna is placed on an iron pillar at the roof whereas the receiver is placed in a cabinet. A power supply and internet connection are provided to the cabinet. The cabinet and the antenna are given in Figure 2 and Figure 3, respectively.

Figure 2. The cabinet of NEU-CORS station

Figure 3. The antenna of NEU-CORS station

The receiver can provide an update rate of 1 Hz to collect GNSS data. The trackable constellations are GPS, GLONASS, BDS, Galileo and SBAS. More detailed specifications of the N72 GNSS receiver are given in Table 1 (CHC 2015).

Table 1. The detailed specifications of the N72 receiver

Feature	Specification
GNSSs	GPS, GLONASS, Galileo, BDS and SBAS
Frequencies	GPS: L1 C/A, L2C, L2E, L5 GLONASS: L1 C/A, L1P, L2 C/A, L2P Galileo: E1, E5a, E5b BDS: B1, B2 SBAS: WAAS, EGNOS, MSAS
Channel number	220 channels
Pseudorange measurement	High precision multi-correlator
Carrier phase measurement	Very low noise <1 mm precision in 1 Hertz
Positioning capacity	RTK: 8 mm + 1 ppm RMS for horizontal and 15 mm +1 ppm RMS for vertical Static: 2.5 mm + 0.5 ppm RMS for horizontal and 5 mm +0.5 ppm RMS for vertical
Data storage	16 GB internal storage and 1 TB external storage
Power	Connected to a power supply and up to 17 hours with integrated battery
Connections	Ethernet, Wireless and Bluetooth
Processor	IBMX287 450 MHz processor based on embedded Linux

As default, the receiver is set to record data in three different modes. In recording mode 1, data is archived in CHC's binary format, so-called HCN format, with a 5 s sample interval. In recording mode 2, data is archived in RINEX 3.02 format with a 5 s sample interval. In recording mode 3, RINEX 2.11 file format is used with a 30 s sample interval. For all recording modes, the elevation cut-off angle is set to 0 degree, PDOP mask is set to 6 and GPS, GLONASS, Galileo and BDS satellites are activated. Whereas SBAS is supported, in default data recording is not used. Also, different sample interval options -up to 1 Hz- and satellite configurations can be selected. The recorded data is sent to a server and accessible via FTP (File Transfer Protocol).

The observation types obtained for each satellite system in default data recording are provided in Table 2. For the GPS system, as default P-code observation is used instead of C/A-code due to the lower noise of P-code observation. Therefore, L2P is used but L2C option can be selected instead of L2P.

Table 2. The measured observation types

Satellite System	Observation Types
GPS	C1C L1C D1C S1C C2P L2P D2P S2P C5X L5X D5X S5X
GLONASS	C1C L1C D1C S1C C2P L2P D2P S2P
Galileo	C1X L1X D1X S1X C5X L5X D5X S5X C7X L7X D7X S7X C8X L8X D8X S8X
BDS	C1I L1I D1I S1I C7I L7I D7I S7I C6I L6I D6I S6I

In addition to static data recording in RINEX or binary formats, real-time GNSS data format, so-called the RTCM SC-104 (The Radio Technical Commission for Maritime Services- Special Committee 104) format, can be utilized. RTCM SC-104 is a standard data format to broadcast differential corrections and raw GNSS observations (Heo et al. 2009). RTCM data is streamed via the Internet using the NTRIP (Networked Transport of RTCM via Internet Protocol). For NEU-CORS, with the NTRIP service single base RTK can be performed.

For the specific studies, apart from the default data recording, some other options can be provided on demand.

3. RESULTS

The NEU-CORS station is assessed in terms of observation data quality. For this purpose, sample data belong to the DOY 290 in 2020 is examined. The satellite visibilities, SNR and multipath values are derived by RTKPLOT module of RTKLIB open source software (Takasu 2013). Maximum, minimum, and mean satellite visibilities for each satellite system are given in Table 3.

Table 3. The satellite visibilities for DOY 290

Satellite System	Max	Min	Mean
GPS	14	7	10.3
GLONASS	11	5	8.2
Galileo	7	1	4.6
BDS	15	4	10.5

According to Table 3, average visible satellite for each constellation is above 8, except for Galileo. SNR graphics for GPS, GLONASS, Galileo and BDS satellite systems using L1 frequencies are shown in Figures 4-7.

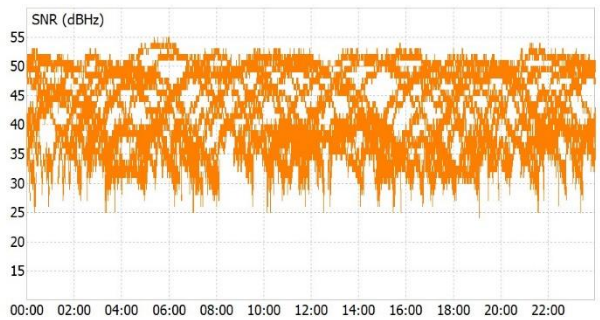

Figure 4. SNR (dBHz) for GPS

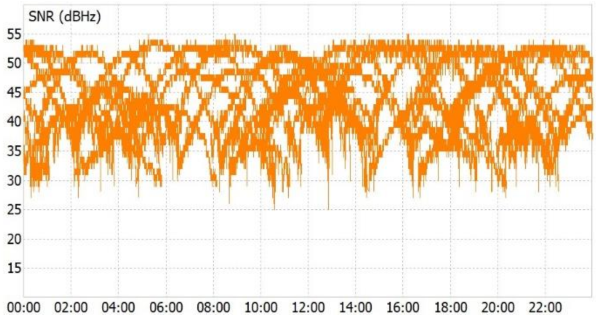

Figure 5. SNR (dBHz) for GLONASS

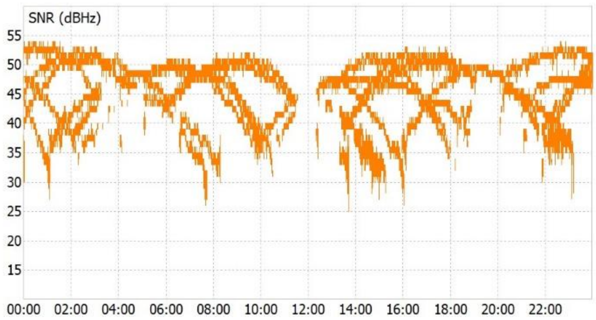

Figure 6. SNR (dBHz) for Galileo

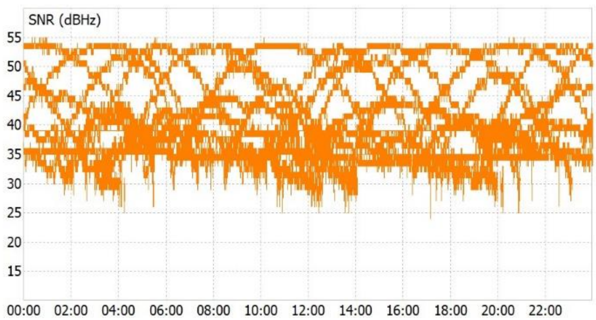

Figure 7. SNR (dBHz) for BDS

As seen from the Figures 4-7, the SNR values for each satellite system are similar and between 25 dBHz and 55 dBHz. The multipath values derived by RTKPLOT are provided in Figure 8-11.

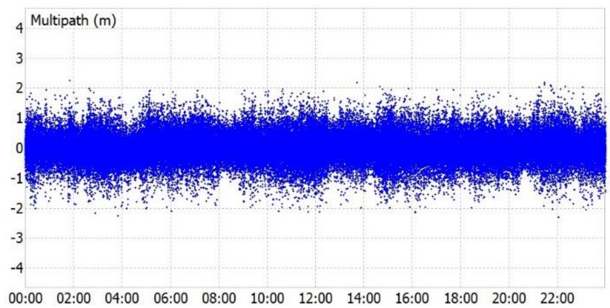

Figure 8. Multipath value for GPS

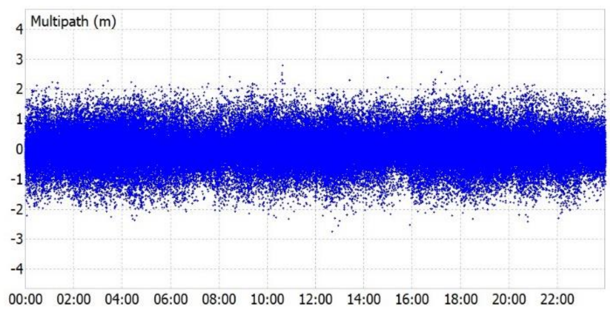

Figure 9. Multipath value for GLONASS

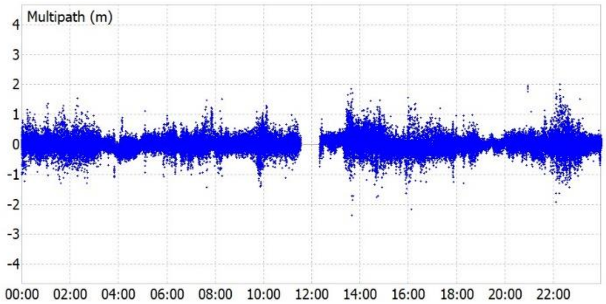

Figure 10. Multipath value for Galileo

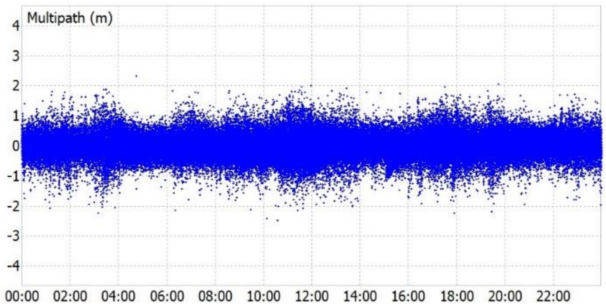

Figure 11. Multipath value for BDS

L1 signals of each satellite system is used for multipath plot. Galileo has the lowest multipath value whereas GLONASS has the biggest multipath value. Also, as the elevation angle and SNR value of the satellites increased the multipath decreased.

4. DISCUSSION AND CONCLUSION

A new continuously operating reference station (NEU-CORS) was established in Konya, Turkey. The reference station was introduced in detail and a sample data analysis was conducted. NEU-CORS station is considerable because of the multi-GNSS support. Also, the station has the ability of streaming real-time data. With this it is possible to perform RTK positioning via Internet.

Furthermore, the operators of NEU-CORS station is open to data sharing and any cooperation. Those interested can get contact with the corresponding author of this manuscript.

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