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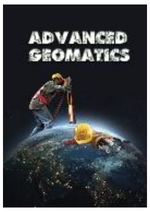

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GNSS Frequency Availability Analysis

Ceren Konukseven*[1], Sermet Öğütcü [1], Salih Alçay [1]

[1]Necmettin Erbakan University, Faculty of Enginering, Department of Geomatics Engineering, Konya, Turkey

Keywords
BeiDou,
Galileo,
GLONASS,
GPS.

ABSTRACT

In this study, three RINEX-3 daily observation data in 2021 were investigated in terms of the frequency availability of Global Navigation Satellite System (GNSS). All available frequencies in the RINEX-3 header were chosen to investigate for GPS, GLONASS, Galileo, and BDS data. The results showed that average frequency availability can be varied significantly among the frequencies and GNSSs. Availability of Galileo frequencies were found higher than the other GNSSs among the examined RINEX files.

1. INTRODUCTION

Global Navigation Satellite System (GNSS) has been used extensively for many applications such as navigation, deformation analysis, precise agriculture and etc. (Alcay et al, 2019; Guo et al, 2018). After the legacy GPS and GLONASS satellites, two newly emerged GNSSs, Galileo and BeiDou, became fully operational. Apart from these new GNSSs, the number of the new signal frequencies were also increased dramatically (Geng & Bock, 2013; Liu et al, 2019; Duong et al, 2019; Mutlu & Kahveci, 2019, Kaya et al., 2019). For more information the reader is referred to Chen and Chang, 2021.

Multiple frequencies sometimes become quite confusing, and users need to be aware that which frequencies should be chosen for processing. The emergence of the new signal frequencies was happen when the Receiver Independent Exchange Format (RINEX) 3.00 (https://files.igs.org/pub/data/format/rinex300.pdf) was introduced. RINEX 3.00 format and higher versions were especially designed for the frequencies of Galileo and BeiDou satellites. RINEX 2.00 format is the legacy format that cannot record all available GNSS frequencies (Wanninger, 2018; Yılmaz et al., 2016; Konak et al., 2020; Altuntaş & Tunalıoğlu). Despite the modernization of RINEX format, data loss frequently occurs due to the hardware and software limitations of GNSS receivers. This data loss can be divided into two categories as epoch data loss and frequency data loss. Sometimes, GNSS receivers cannot track all available epochs during the measurements due to the several reasons such as cycle slip, signal blockage and etc. Apart from the epoch data loss, sometimes GNSS receivers cannot track all available frequencies within the recorded epoch data. This data loss frequently causes some problems for navigation. For example, if the receiver cannot track the necessary frequencies within the particular epochs, navigation solutions cannot be conducted for these particular epochs.

In this study, we focused the frequency availability analysis for GPS, GLONASS, Galileo, and BeiDou GNSS data using three RINEX 3.03 format. The method of the estimated ratio of the available frequencies is described in the Materials and Methods section.

***Corresponding Author**

*(cerenkonk@gmail.com) ORCID ID 0000-0001-6598-9479
(sermetogutcu@erbakan.edu.tr) ORCID ID 0000-0002-2680-1856
(salcay@erbakan.edu.tr) ORCID ID 0000–0001–5669–7247

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2. MATERIALS and METHODS

In this study, three representative RINEX-3 daily observation data of three International GNSS Service-Multi-GNSS Experiment (IGS-MGEX) stations (CPNM, CKSV, and CKIS) were used for the frequency availability analysis of GPS, GLONASS, Galileo, and BeiDou satellites. When choosing the frequencies, all frequencies recorded in the RINEX headers were taken for each station.

Frequency availability percentages were computed as the number of available frequencies divided by the number of the theoretically available frequencies. If the recorded epoch includes the satellite PRN but doesn't include its frequencies (blank or zero), it means the frequency loss of this satellite.

Displays the frequency channels of each GNSS. For more information the reader is referred to https://files.igs.org/pub/data/format/rinex_4.00.pdf.

Table 1. Frequency channels of each GNSS

GNSS	Frequency channels
GPS	L1;L2;L5
GLONASS	G1;G1a;G2;G3
Galileo	E1;E5a;E5b;E5;E6
BeiDou-2	B1; B2; B3
BeiDou-3	B1; B2; B3; B1C; B1A; B2a; B2b; B2; B3A

As seen from Table 1, BeiDou-3 has the most frequency signals compared with the other GNSSs. In this study, L1/L2 (GPS), G1/G2 (GLONASS), E1/E5a (Galileo), and B1/B3 (BeiDou-2-3) frequencies were taken for the frequency availability analysis for phase and code observations.

3. FINDINGS

Table 2-5 summarize the average frequency availability of GPS, GLONASS, Galileo, and BeiDou GNSSs for three IGS-MGEX stations in 2021 (DOY: 100).

Table 2. Average frequency availability of GPS signals

GPS signals	Frequency availability (%)
C1C	99.7
L1C	99.5
C2W	94.6
L2W	94.4

Table 3. Average frequency availability of GLONASS signals

GLONASS signals	Frequency availability (%)
C1C	100
L1C	99.9
C2C	75.7
L2C	75.8

Table 4. Average frequency availability of Galileo signals

Galileo signals	Frequency availability (%)
C1X	100
L1X	100
C5X	99.2
L5X	99.2

Table 5. Average frequency availability of BeiDou signals

BeiDou signals	Frequency availability (%)
C1I	99.9
L1I	99.8
C7I	76.6
L7I	76.6

Commonly used dual frequencies phase (Lxx) and code observations (Cxx) were chosen for each GNSS as indicated above. As seen from the tables, Galileo has the most available frequencies compared to other GNSSs for the examined RINEX files. The less available second frequencies (75.6%) were computed for GLONASS satellites despite the availability of its first frequency was computed at nearly 100%.

4. RESULTS

The results covered in this study show that the frequency availability can be varied among the frequency channels and GNSSs. Two most used frequency channels were chosen to conduct frequency availability analysis for each GNSS. The results show that Galileo satellites have the most available frequencies compared to other GNSSs, and in terms of second frequencies, GLONASS satellites have the lower frequency availability for the examined three RINEX data in 2021, DOY 100.

Author contributions

Ceren Konukseven: Methodology, Writing-Original draft preparation.
Sermet Öğütcü: Writing-Reviewing and Editing, Validation.
Salih Alcay: Writing-Reviewing and Editing, Validation.

Conflicts of interest

There is no conflict of interest between the authors.

Statement of Research and Publication Ethics

Research and publication ethics were complied with in the study.

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