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B 会場 ： 11/25　AM2（11:05-12:35）
11:05〜11:20:00

#髙橋 透 [1)], 西山 尚典 [2)], 北村 光教 [1)], 斎藤 享 [1)], 橋本 大志 [2)], 坂井 丈泰 [1)]
([1)]ENRI, MPAT, ([2)] 国立極地研究所

Impact of ionospheric disturbances on next generation SBAS broadcast from QZSS in the Arctic

#Toru TAKAHASHI[1)], Takanori NISHIYAMA[2)], Mitsunori KITAMURA[1)], Susumu SAITO[1)], Taishi HASHIMOTO[2)], Takeyasu SAKAI[1)]
([1)]Electronic Navigation Research Institute, MPAT, ([2)]National Institute of Polar Research

Aviation and maritime activities in the Arctic are growing with the decline in Arctic Sea ice. This decline in the Arctic Sea ice leads to increase maritime activities regarding ocean resources and vessel traffic. Aviation activity is also expected to increase with the increase in maritime activities. A model study suggested that the Global Navigation Satellite System (GNSS), which operates with the augmentation system such as the Satellite-based augmentation systems (SBAS) and Advanced Receiver Autonomous Integrity Monitoring (ARAIM), is effective for the navigation of aviation and maritime in the Arctic because of poor infrastructures. However, the current L1 SBAS broadcasts augmentation messages from geostationary (GEO) satellites, which are not available practically in the polar region at a latitude of 72 degrees or higher. The Dual Frequency Multi Constellation Satellite Based Augmentation System (DFMC SBAS) has been standardized by the International Civil Aviation Organization (ICAO). Broadcasting augmentation messages from the Inclined Geosynchronous Orbit (IGSO) satellite is considered to be included in the future updates. The Electronic Navigation Research Institute (ENRI) developed a DFMC SBAS prototype based on the draft standards, and test messages are broadcast from the Japanese Quasi-Zenith Satellite System (QZSS).

An evaluation of the performance of DFMC SBAS broadcast from QZSS was conducted in Oslo, Norway (10.72 deg. E, 59.94 deg. N) from 24 February 2021 to 17 March 2021. They successfully received the DFMC SBAS messages from QZSS, and GPS, Galileo, GLONASS, and BeiDou signals. They analyzed the errors in the position solutions as well as vertical and horizontal protection levels by using GPS L1/L5 and Galileo E1/E5a signals augmented by the DFMC SBAS. The positioning errors did not exceed the protection level, and the availability was 84.8% for the LPV 200 during this time interval. In this study, they concluded that the augmentation message could be used in the Arctic region, and suggested that the availability will be improved if three or more monitor stations are newly installed in the European region.

As the next step of our investigation, we installed a GNSS receiver, a DFMC SBAS receiver, and a software-defined radio receiver in Ny-Ålesund, Norway (78.9° N, 11.9° E) on August 7, 2024. In this high-latitude location, augmentation messages from GEO satellites are not practically receivable. In contrast, QZSS satellites reach an elevation angle of approximately 20 degrees and remain visible for nearly 24 hours per day. The ionosphere above Ny-Ålesund is frequently disturbed by geomagnetic activity, often leading to fluctuations in the GNSS carrier phase, known as phase scintillation.

The aim of this study is to evaluate the performance of the DFMC SBAS broadcast by QZSS satellites and to assess the impact of geomagnetic disturbances on DFMC SBAS performance in the Arctic region. The GNSS ranging signals were collected using a JAVAD DELTA GNSS receiver, which was synchronized to a 10 MHz reference clock generated by a Stanford Research FS-725 rubidium atomic clock. This high-stability reference enabled the detection of phase scintillations associated with plasma density irregularities in the ionosphere. For the reception of DFMC SBAS messages, we employed a CORE Chronosphere receiver. A Tallysman Veraphase 6000 antenna, capable of tracking signals in the L1, L2, and L5 frequency bands, was used for both receivers.

Stable observations have been continuously carried out over one year. Several geomagnetic disturbances occurred within the observation period. During this time interval, an enhancement of phase scintillation index was observed in Ny-Ålesund. Although signals from QZSS also fluctuated due to ionospheric disturbances, there is no errors in reception of the DFMC SBAS messages. This suggests that the reception of DFMC SBAS messages broadcast from QZSS in the Arctic region is possibly unaffected by ionospheric disturbances such as auroras. However, it is necessary to conduct a statistical study that examines DFMC SBAS message reception. Furthermore, a comparison of positioning solutions using augmentation messages with the horizontal and vertical protection levels is also essential to verify the integrity and availability of DFMC SBAS.

In this study, we will report whether GPS and Galileo satellites, augmented by the DFMC SBAS as well as QZSS, were affected by ionospheric disturbances during the observation period by our measurements and ionospheric observation at Ny-Ålesund and Longyearbyen. Based on this analysis, we will discuss the impact of ionospheric disturbance on the performance of DFMC SBAS.