S002-19
A 会場 ：11/26　AM2 （10:30-12:00）
11:05〜11:25

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Ionospheric disturbances and their impact on aeronautical GNSS applications following the geomagnetic storms occurred in 2023-2024

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Global Navigation Satellite System (GNSS) is now widely used in the society. In the field of air navigation, GNSS is now one of the essential elements. However, ionospheric disturbances are major error sources in GNSS-based air navigation in which only single-frequency GNSS equipment is available.

Since the safety is very important for air navigation, strict standards are defined by International Civil Aviation Organization (ICAO). To provide safe GNSS-based services, the standards defines how to mitigate the ionospheric impacts. To design safe and available systems, how the ionosphere can change must be defined, which is threat model. In other words, air navigation systems are designed to be safe within the defined, usually very conservative, threat models.

Even if the threat models are defined with the best available historical data and knowledge, it is still necessary for the threat models to be checked against newly occurring phenomena. It is also important to check if the geophysical mechanisms behind the new phenomena is consistent with our common knowledge on which the threat model is based.

As the solar activity approaches to its peak, different types of ionospheric disturbances occur over Japan. Occurrence of equatorial plasma bubble occur frequently in low latitude Japan. Even in the lower mid-latitude Japan, strong ionospheric disturbances are frequently observed associated with severe geomagnetic storms.

One of the GNSS-based air navigation systems which requires stringent bounding of ionosphere-induced errors is the GNSS ground-based augmentation system. It can support precision approach and landing guidance of aircraft which is the critical phase of aircraft operation. Since it is based on the range-domain differential GNSS technique, spatial gradients in the ionospheric delay (or equivalently total electron content (TEC)) is the critical error source. We have evaluated ionospheric delay gradients for the three unusual ionospheric disturbances on 5 November 2023, 1 December 2023, and 11 May 2024, all of which are associated with severe geomagnetic storms and compared with the existing threat model for the Asia-Pacific region recommended by ICAO. Furthermore, we have evaluated impacts of the ionospheric disturbances on the aircraft surveillance system called ADS-B (Automatic Dependent Surveillance - Broadcast), although it would not be expected to be significantly impacted, because the required error levels for ADS-B is not so stringent.

Mechanisms of the ionospheric disturbances are investigated by using the three-dimensional ionospheric tomography based on a dense GNSS network.