A Discussion of the Threshold for Issuing Space Weather Advisories at ICAO

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The International Civil Aviation Organization (ICAO) is establishing Space Weather Global Centers in 2019 to distribute advisories on space weather. Currently, advisories are issued when thresholds are exceeded for information on shortwave communications, satellite positioning, and human exposure.
Discussions on the thresholds are ongoing in the Meteorology Operation Group under the ICAO Meteorology Panel. Currently, fixed values of Moderate 125 and Severe 175 are used for the Total Electron Count (TEC), which is used as an indicator for satellite positioning. On the other hand, TEC varies significantly depending on local time, season, and region, and it is questionable whether fixed threshold values are sufficient.
Currently, NeQuick, Krobucher, and other ionospheric models are used for satellite positioning, and when there is a large discrepancy between these models and the actual ionospheric conditions, the satellite positioning error increases. Therefore, it is better to use the difference between this model and the actual TEC as a new indicator.
Currently, I-scale has been proposed by Nishioka et al. (2017). This is a statistical method to process the TEC at a specific location and use the deviation from the median value as an indicator of ionospheric storms. We applied this indicator and examined the difference from the NeQuick and Krobucher model. In my presentation, I would like to discuss how the domain dependence should be handled and how its impact on the system should be evaluated.

Key Words: Satellite Positioning, ICAO, Ionospheric Disturbances

1. Introduction

Ionospheric disturbances make the error of satellite positioning. The ionospheric density significantly varies spatially and temporally during ionospheric storm. The signal radio wave delays in the ionosphere and it can be estimated with model in normal situation. However, when the difference between the model and actual situation become large when the ionospheric disturbances occurs, positioning error become significant. There are several source of positioning error, e.g., clock and positioning error, tropospheric delay and multi pass, but ionospheric delay is the most significant.

The International Civil Aviation Organization (ICAO) started space weather information services since November, 2019. In present, four global centers, US, PECASUS, ACFJ and CRC change the responsibility every two weeks for providing space weather alert for GNSS, Radiation and HF propagation.

For GNSS, vertical TEC is used for the parameter of ionospheric delay and set 125 and 175 for moderate and severe condition, respectively for ICAO advisory. On the other hand, ionosphere varies daily, seasonally and depends on the location. Is it appropriate to use TEC itself to represent the ionospheric condition? The most critical parameter is NOT the value of TEC itself, but the difference between observational results and the value estimated by the model.

From this discussion, we propose a new index for describing ionospheric disturbances which actually affect on the precision of satellite positioning as follows.

$$TEC_{diff} = TEC_{obs} - TEC_{model(NeQuick2)}$$

Where

TEC_{obs}: $Observed\ TEC$
$TEC_{model(NeQuick2)}$: $Estimated\ TEC\ with\ NeQuick2\ Model$

2. Discussion

Equatorial anomaly is one of the easiest phenomena for estimating by numerical models. Event I is one of the good examples for that, in spite of the significant event, the NeQuick2 model estimated the enhancement of ionosphere very well. However, with the current threshold for space weather alert in ICAO, the alert should be issued even in Event which can be ignored with cancelling with the model. This means that there could be unnecessary alerts which lose the flight opportunities in the equatorial region.

One of the advantages of this method is that we can set the threshold from acceptable distance error in the system.

Usually, we set the threshold with standard deviation and think how often the events occur. But in this case, we have an advantage that we can set the threshold from acceptable distance error in the system. For example, when the acceptance distance error is 5m, it is equivalent to 30 TEC_{diff}.