Impact of Geo-magnetic Storms on ADS-B and GPS Integrity

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Abstract

Geomagnetic storms(GMS) are disturbances in the Earth's Magnetosphere caused by solar winds. These storms are known to cause interference with the performance of the Global Positioning system (GPS). We analyze a parameter called Navigation Integrity Category (NIC):an uncertainty metric, transmitted by the aircraft's ADSB sensor to check, if there are any significant differences on reported flight parameters (velocity, altitude, distance, position etc.). The poster demonstrates a comparison of impact to GPS Units during the occurrence of GMS days and normal days. The preliminary results indicate that there is deviation due to GMS events based on analyzed flights.

Index Terms: ADS-B, Uncertainty NIC, Geomagnetic storms

Geomagnetic storms

There is continuous stream of protons and electrons in a plasma state in an outward direction around the sun, these particles contain the sun's magnetic field embedded within them. These stream are called solar winds. When there is a very effective exchange of energy in the space surrounding the earth from solar winds, there is a major disturbance in the Earth's Magnetosphere. This is a Geomagnetic storm.

Measurement of these storms are carried out by multiple observatories around the earth, using magnetometers. The measurements from these observatories are out together to calculate a global average to represent the intensity of geomagnetic storms. They measured as Kp and range between the range of 0-9, 9 meaning more intensive.

The yellow vertical lines are the sun's magnetic field carried by solar winds. The earth's magnetic field is shown in blue.

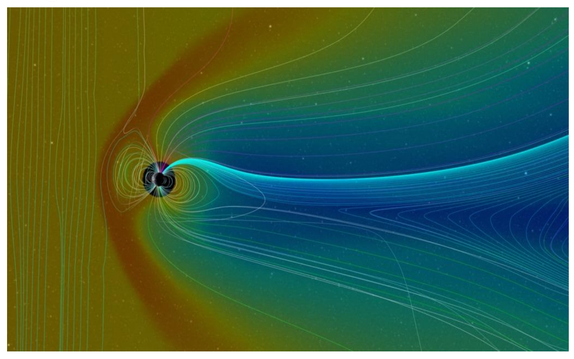

Fig 1 The magnetosphere and solar winds around the earth. Courtesy: [3]

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Open Sky Network

Open sky network is a non-profit, crowd sourced, off the shelf ADS-B receiver network that collects data from volunteers all over the world since 2013. This data is processed and stored in a central database. The database contains positional – Airborne and Surface, Identification, Velocity, operational status, and uncertainty metrics transmitted by aircrafts with ADS-B in the range of volunteer operated sensors.

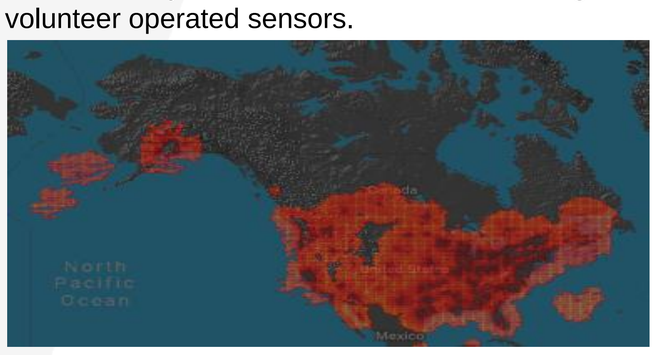

Figure 2. The Coverage of Open Sky receivers in USA.

ADSB

The ADS-B is a device or unit on aircrafts that broadcasts aircraft state parameters at regular intervals without interrogation, which is an improvement on the previously used Mode S which required interrogation for message transmission. Automatic is a reference to the fact that the ADS-B transmits information without the need of operator intervention and Dependent indicates that the ADS-B depends on other air data systems like altimeters and GNSS Global Navigation Satellite Systems (GNSS) like the Global Positioning System (GPS) etc. to obtain the information that it transmits.
The ADSB Transmits the following details of an aircraft as State parameters: **Callsign, Wake Vortex Category, Position, Altitude, Position, speed and track angle, Vertical rate, GNSS and Baroaltitude difference, Ground Speed, Air Speed and operational status messages.**

Uncertainty Metrics transmitted by the ADSB includes Navigation integrity category (NIC), an indicator of the accuracy the transmitted position. The higher the value of NIC, higher the position accuracy, and vice versa.
Navigation Accuracy Category (NAC) a complementary indicator of NIC and can be used to determine the horizontal and vertical bounds of the position. **Surveillance Integrity Level (SIL)** Probability estimation of measurements exceeding the containment radius.

NIC is a clear indication of the accuracy of the position obtained by the on board GNSS system (Z. Liu et al. n.d.). The acceptable value of NIC is 7. Any values of 6 and below are indicators of abnormality (Federal Aviation Administration 2016. In the figures to follow, we present our analysis of the NIC metric of aircrafts on days with and without high geomagnetic activity.

27/09/2022

Figure 3: The distribution of Kp on 09/27/2022

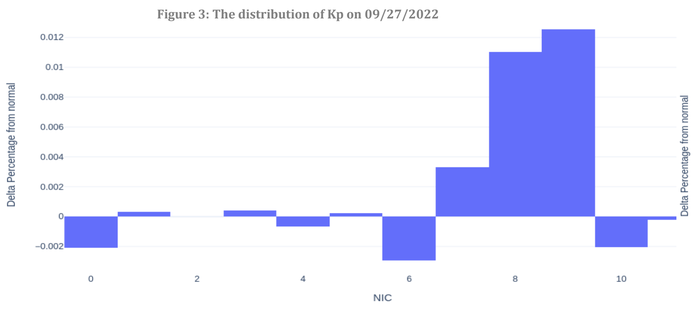

Figure 4. Distribution of Delta NIC % @ Mid-Lat: Hour 6, K- index: 2.

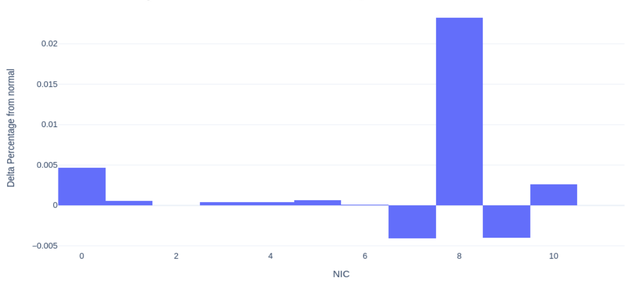

Fig. 5 Distribution of Delta NIC % @ Mid-Lat: Hour 15, K- index: 7

09/09/2022

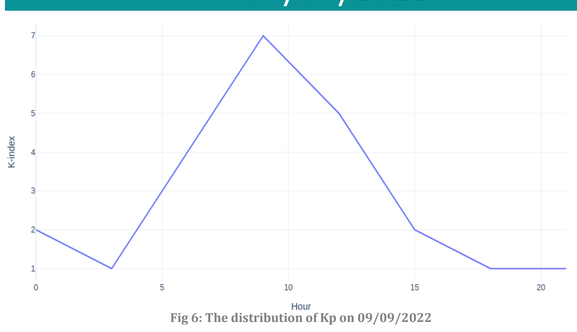

Fig 6: The distribution of Kp on 09/09/2022

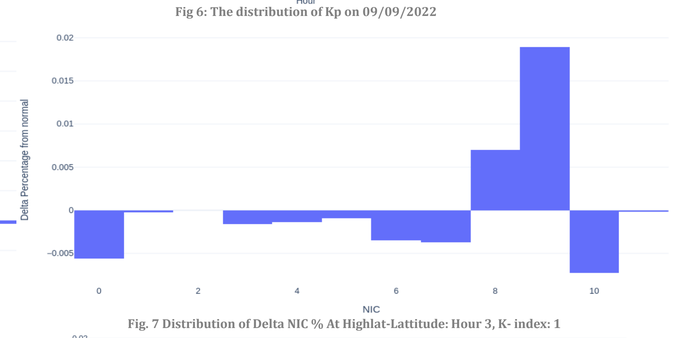

Fig. 7 Distribution of Delta NIC % At Highlat-Lattitude: Hour 3, K- index: 1

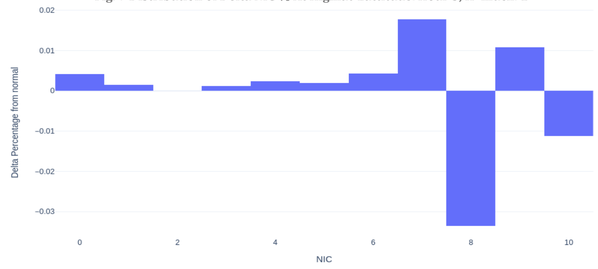

Fig. 8 Distribution of Delta NIC % At High-Latitude: Hour 15, K- index: 7

Discussion

On 27/09/2022 and 09/09/2022, the Kp values ranged between 2 and 6. On these days, a comparison of difference in % of NIC values between hours of geo magnetic activity and hours without geomagnetic activity was made and it was found that the percent of aircraft whose NIC was above and below the permissible threshold varied. It was also found that aircrafts at higher altitudes also experienced a drop in NIC during hours of geomagnetic activity.

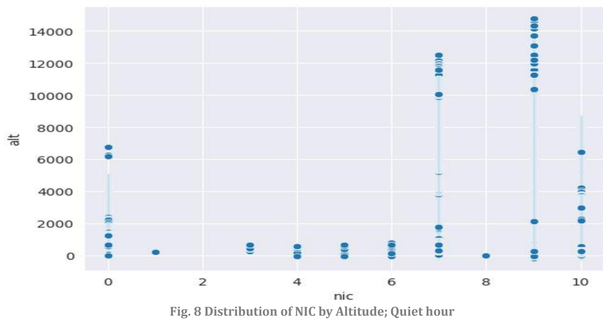

Fig. 8 Distribution of NIC by Altitude; Quiet hour

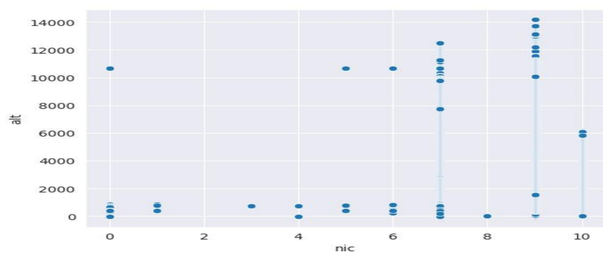

Fig. 8 Distribution of NIC by Altitude; hours with geo magnetic activity

Conclusion

On 09/09/2022 and 09/27/2022, the Kp varied from a high of 6 to a low of 2. The count of aircrafts for each individual NIC value was queried, and compared as percentages to allow for varying aircraft counts. It was found that there was a difference in percentage of aircrafts whose NIC dropped and whose NIC did not on hours with and without Geomagnetic Activity. This drop in NIC was also found on higher altitudes.

Key References

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[5] Public ADS-B Performance Report (PAPR) User's Guide https://adsbperformance.faa.gov/PAPRUsersGuide.pdf

[6] The 1090Mhz Riddle: Junzi Sun https://mode-s.org/decode/

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