INVESTIGATION INTO THE G1 GEOMAGNETIC STORM OF JANUARY 31ST, 2019 THROUGH GNSS DATA PROCESSING

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OBJECTIVE

Highlight the relationship between geomagnetic storms and ionospheric scintillation through the analysis of processed GNSS data and proposes techniques for the identification and classification of scintillations in the mid-latitude region.

INTRODUCTION

GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS)

- There are 31 satellites used for the Global Positioning System (GPS).
- GPS has multi-industry and daily life applications.
- Rapid modification of radio waves, otherwise known as scintillation, cause loss of lock in GPS systems.

GEOMAGNETIC STORMS

- Solar events like solar flares and coronal mass ejections are known to cause fluctuations in the Earth’s magnetic field and the ionosphere.

METHOD

- Two GPS receivers were installed in SPRL to collect data.
- Real-time space weather data is used to select days with geomagnetic activities.
- Multipath removal instructions, developed by the team, was used to confirm the signals were scintillations.
- An elevation mask applied between 0-50 degrees to ignore surrounding geographical features.
- MATLAB and Python are then used to process, and graph collected data. Then all data is analyzed for correlation.
- Unsupervised clustering algorithm is implemented to provide further insight on mid-latitude scintillations

RESULTS

The following graphs show the Ionospheric Amplitude Scintillation (S4) in Figure 2. The High Rate data retrieved by the SPRL from GPS satellites 14, 26, and 31, GALILEO 25, and GLONASS 5. The Total Electron Content (TEC) was also retrieved from GPS 14 and 26. The following graphs are analyzed and compared to Aural Electrojet (AE), Disturbance Storm Time (DST) (not shown), and Kp indices of the Jan 31st G1 geomagnetic storm to find correlations and confirm that the observed event is an ionospheric scintillation.

SATELLITE SIGNAL MEASUREMENTS

- Between 17 and 19 UTC, significant peaks were observed in the S4 graph for GPS 14, GALILEO 5 and GLONASS 5 seen in Figure 2.
- High rate plots for PRNs, another term used for GPS satellites, 14, 26 and 31 also show the same activity with spikes noticed in both power and phase.
- TEC graphs exhibit similar behavior around 17 UTC on PRN 14 and PRN 26. Same results are echoed by the AE and DST Indices. The Kp max was 5 indicating that a minor geomagnetic storm was present.
- Jan 31st geomagnetic storm was during solar minimum according to sunspot data, yet notable scintillations were observed in mid-latitude.
- The storm was not that powerful seen in Figure 5. The data suggests that there is a strong correlation between the weak geomagnetic storm and scintillations.
- Since this was a weaker storm, the possibility of a stronger storm having a larger effect is likely.
- Scintillations are expected to occur more often during high solar activity.

FUTURE WORK

- Analyze multiple geomagnetic storms besides the geomagnetic storm of January 31st that might correlate with collected scintillation data.
- Continue studying GNSS scintillations at mid-latitude through data collection and analysis to identify a stronger relationship between geomagnetic storms and scintillations in the mid-latitude region.
- Develop a scintillation detection method using a supervised decision trees algorithm and further explore their characteristics in mid-latitudes through clustering and different processing techniques.
- Explore how the Earth’s ionosphere and magnetic field and solar phenomenon interact.

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