



Investigating the Space Weather Impact of the 2003 Halloween Geomagnetic Storm by the Ground Magnetic Field Variations: a Global View

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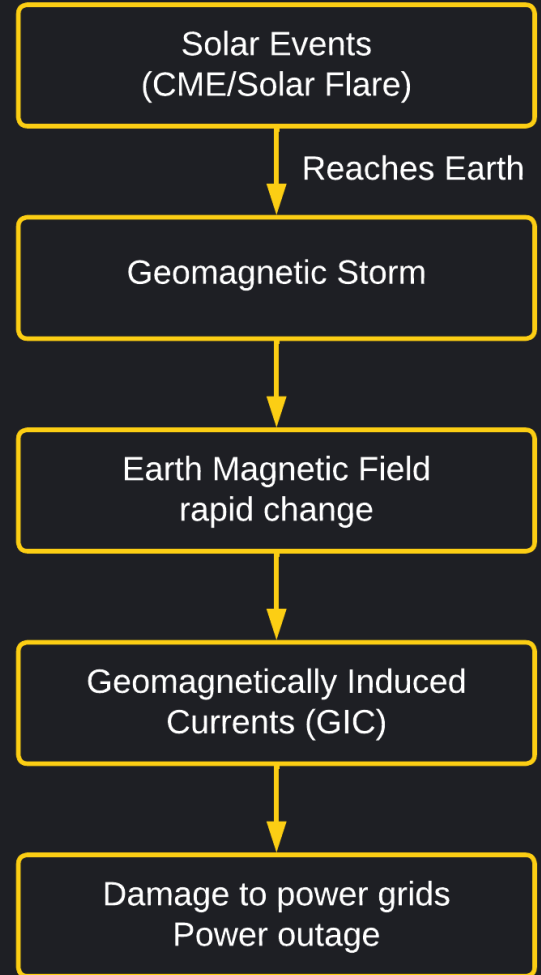
Introduction

- * **Space Weather** is the phenomenon of solar storms and other events in space that can have an impact on Earth
- * Corona Mass Ejection (CME)
- * Solar Flare
- * **Impact on our society**



Purpose

- * Understanding the impact of space weather on the modern society and mitigate the hazards cause by space weather.
- * Power blackout on Hydro-Québec's power grid tripped by geomagnetic storm in March 1989





Aurora over Colorado – October 29, 2003
(Photo by Ginger Mayfield)

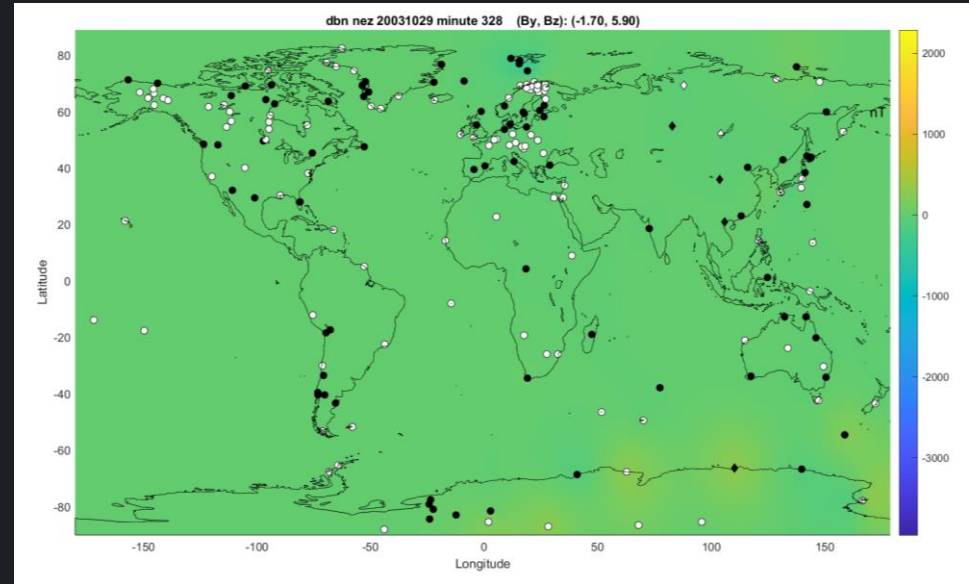
Research question

- * How did the 2003 Halloween storm impact the regions of the Earth in the point of view of magnetic field variations?
- * What is the correlation between the magnitude of impact between the different latitude and longitude regions?
- * Are there regions impacted more than the others?



Methodology and Data

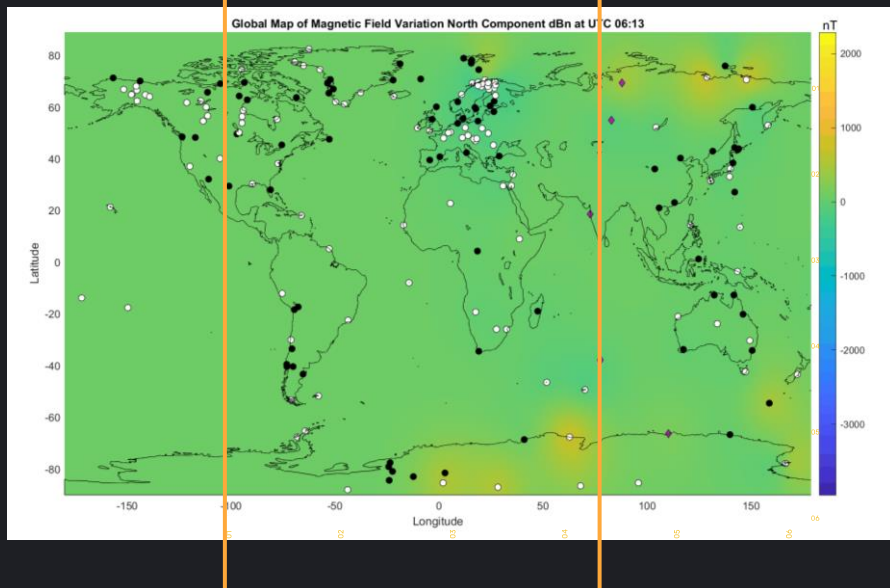
- * Global map of magnetic field variations (Kriging Interpolation)
- * Cross-correlation
- * Geomagnetic variation: SuperMAG
- * Solar storm/solar wind conditions: NASA satellite





Midnight (MLT)

Noon (MLT)



Results – Global Map 1

- ★ Started near Norway and B15 (Antarctic Station)
- ★ Moved to France and Australia
- ★ Lasted almost 2 hours

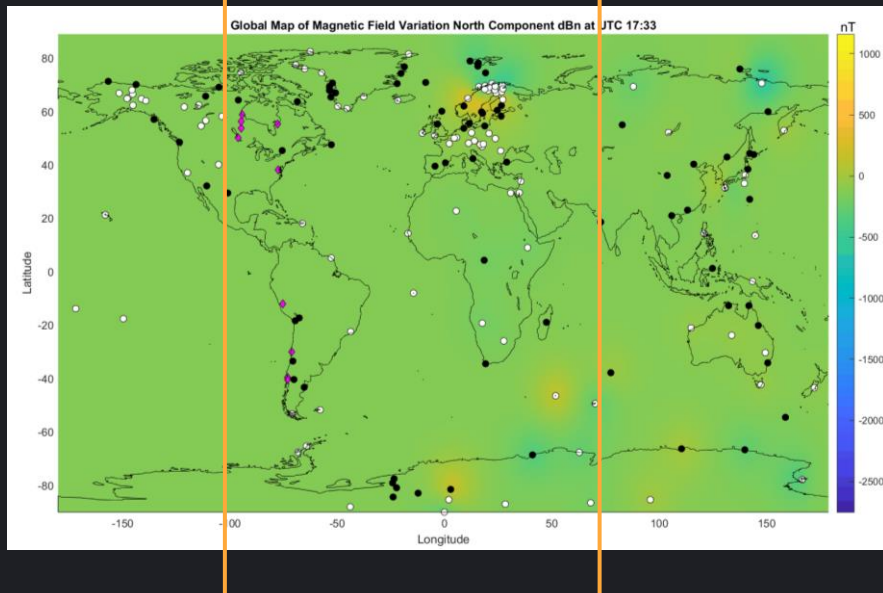


(All Figures can be found on <https://www.github.com/PythonOrC/SpaceWeather>)



Noon (MLT)

Midnight (MLT)



Results – Global Map 2

- * Multiple Substorms
- * Started near two poles
- * Move to Russia and Australia
- * More than 2 hours

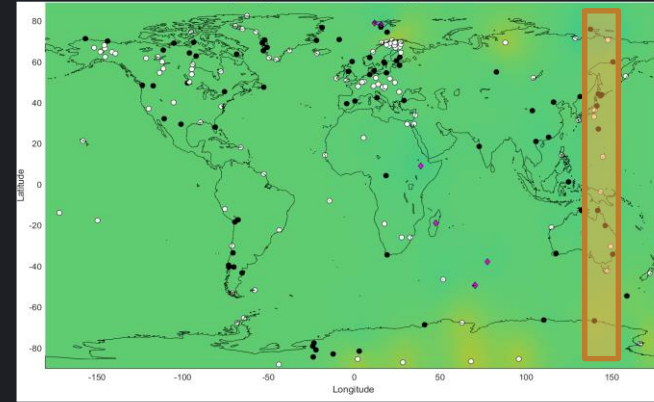


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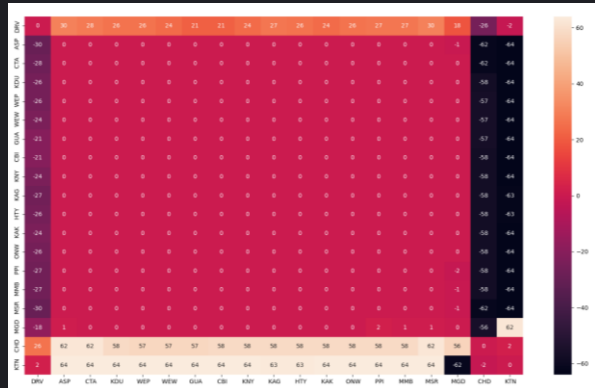
Results – X Correlation

* correlation and delay show global effects in mid- and low-latitude regions.

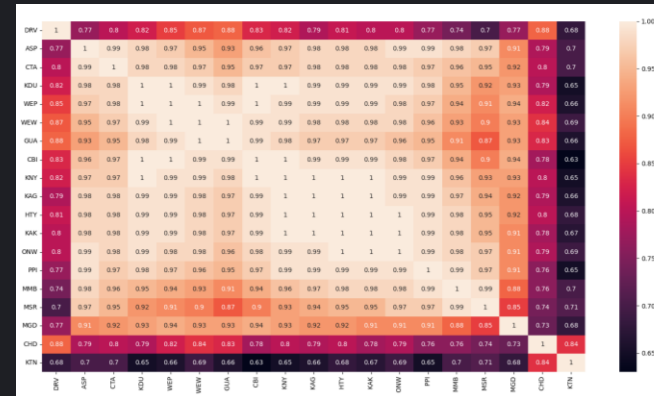
* Impacts at high-latitude regions are different.



(Presented is the Storm-2 after-midnight chain)



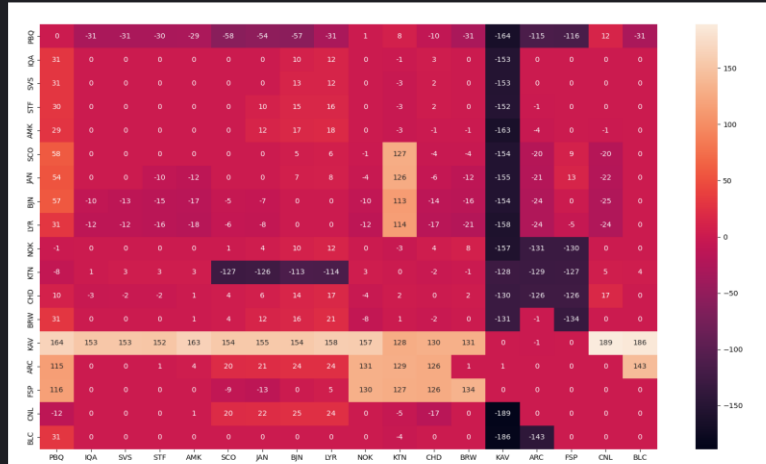
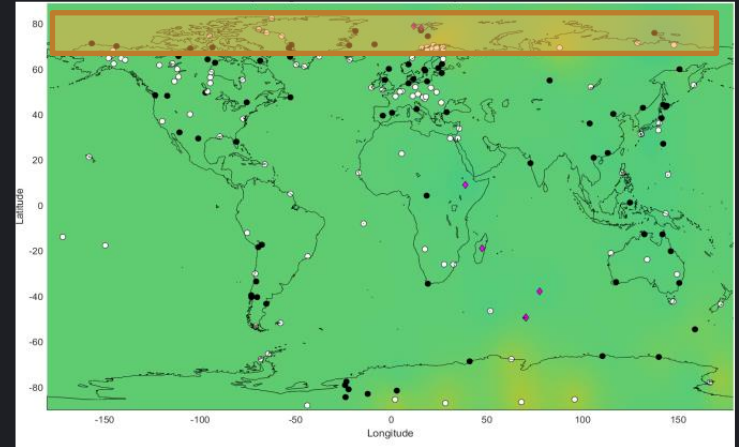
17:24 After Midnight X Correlation Lag



17:24 After Midnight X Correlation

Results – X Correlation

* Localized patterns in high-latitude and regions of intense impact (Storm-1 Prenoon, Storm-2 Pre-midnight, high-latitude chains)





Limitations

- * accuracy of Kriging Interpolation is limited by the sparse stations
- * Ideally 1-second temporal resolution with 100km-by-100km coverage
- * Expecting data of higher quality in the future



* The global view shows where the impact starts, how large the regions of impact are, and where it affects the most during the 2003 Halloween Storm.

- * Impact starts in high-latitude, expands to mid- low-latitude

- * Impact is most intense in high-latitude

- * Regional signature in high-latitude

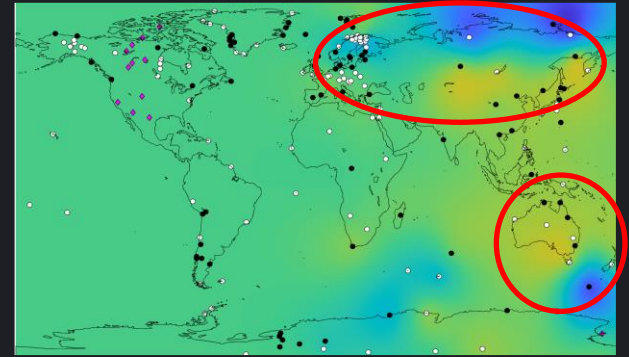
- * Global signature in mid- low-latitude

Discussion



* Contribution to space weather community:
The global maps will be made available to the public as a tool for storm events study.

- * Historical events study
- * Prediction model results verification
- * Combine with other GIS info to provide comprehensive insights to nation's critical infrastructure



Future Implications

