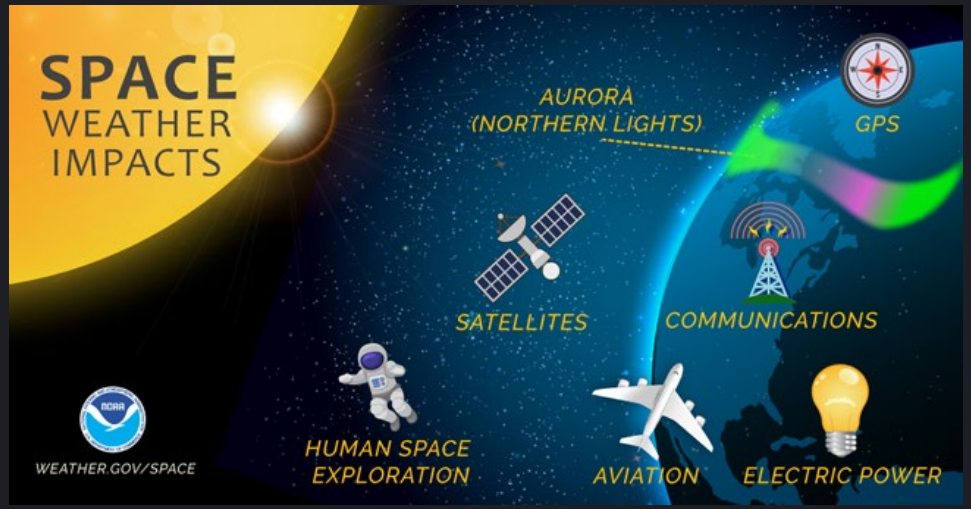
Investigating the Space Weather Impact of the 2003 Halloween Geomagnetic Storm by the Ground Magnetic Field Variations: a Global View

By: Hongyi Hu



Introduction

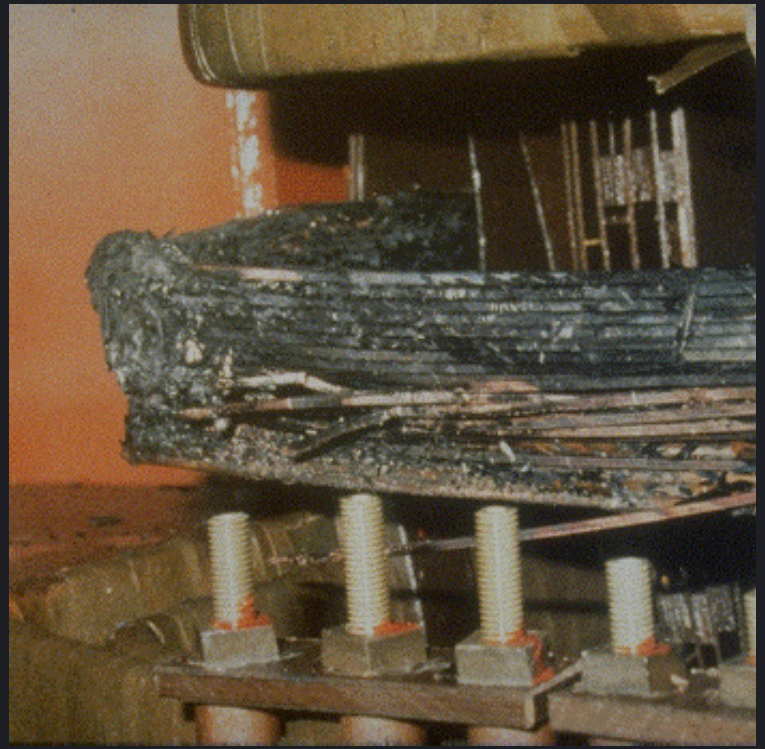
* **Space Weather** is the phenomenon of solar storms and other events in space that can have an impact on Earth
* Corona Mass Ejection (CME)
* Solar Flare
* **Impact on our society**

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

* Starlink satellites falling caused by a minor geomagnetic storm hit Earth



Research question

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

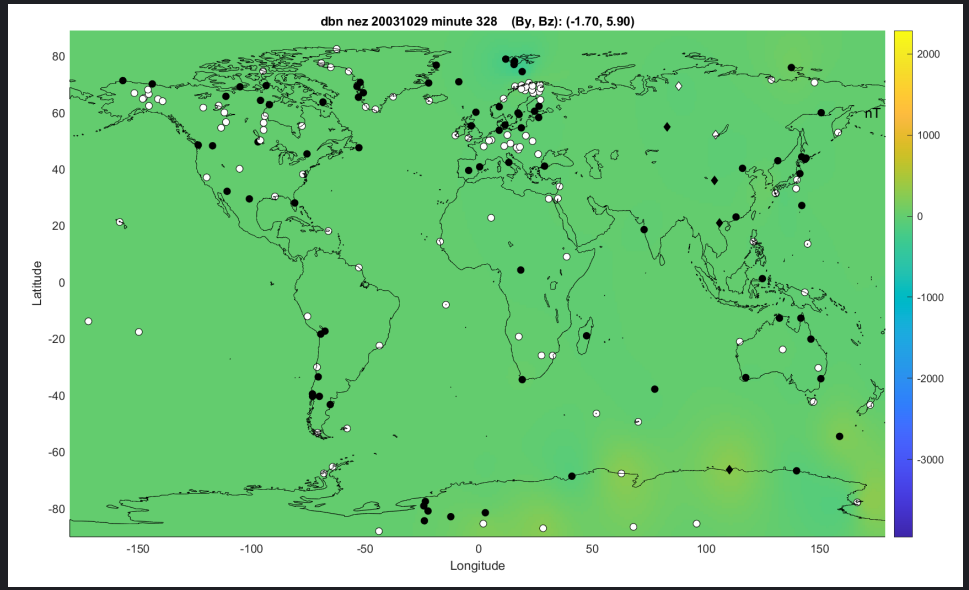
* How did the 2003 Halloween storm impact the regions of the Earth in the point of view of magnetic field variations?

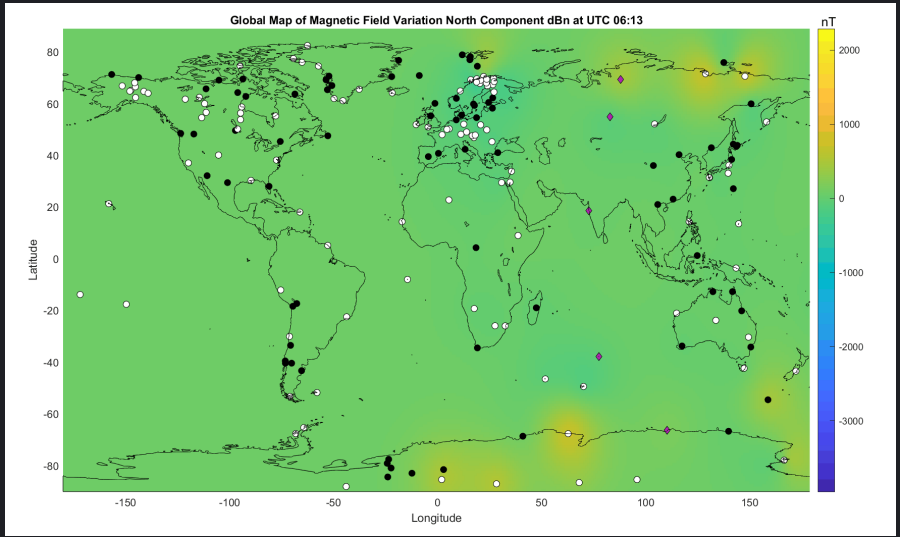
* What is the correlation between the magnitude of impact between the different latitude and longitude regions?

* Are there regions impacted more than the others?

Methodology an

* Global map of magnetic field variations
* Cross-correlation
* Data for geomagnetic variation: Magnetometer measurements, SuperMAG
    * global map
    * latitude and longitude chains
* Data for solar storm/solar wind conditions: NASA satellite



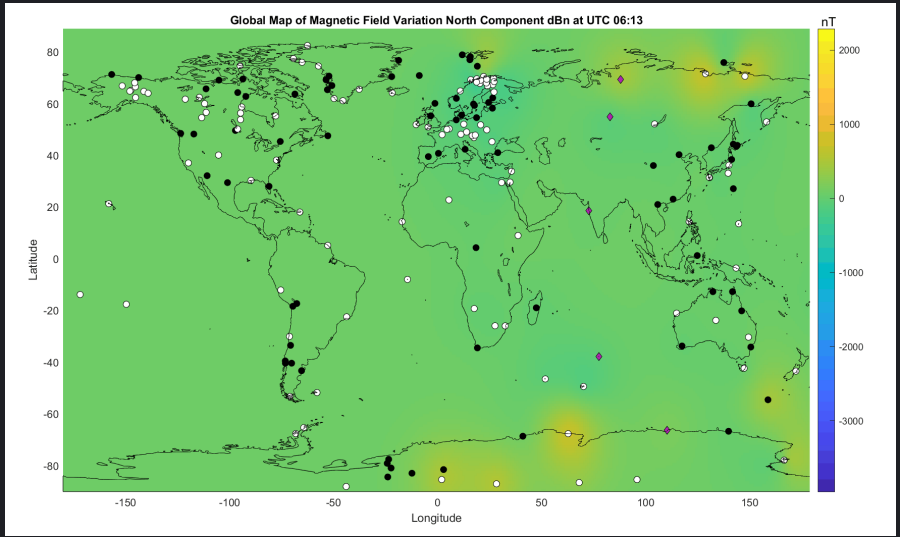


Results: Global Map

* Using data from 205 magnetometer observatories (downloaded from SuperMAG)

-Generated global maps of the Halloween Storm on 29 Oct 2003.

(everything can be found on https://www.github.com/PythonOrC/SpaceWeather)



Results: Global Map

* Started in high latitude
* Expanded to mid and low latitude
* High latitude is impacted the most

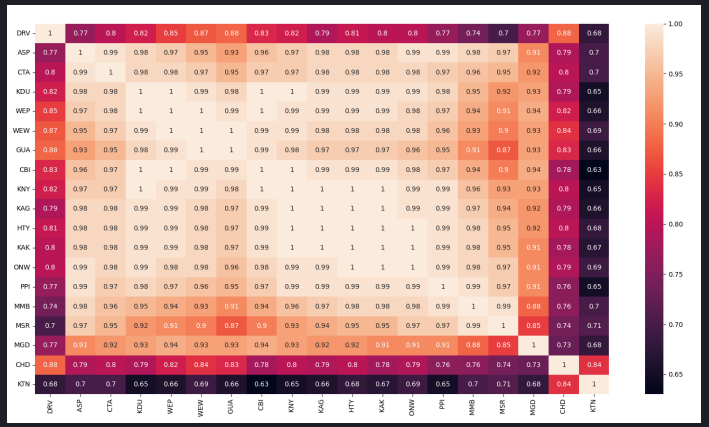
(everything can be found on https://www.github.com/PythonOrC/SpaceWeather)

Results X Correlation

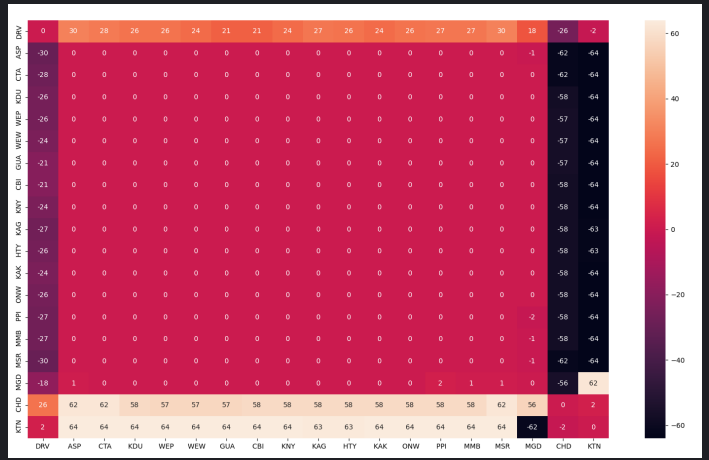
Storm-2 after midnight chain

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

* Impacts at high-latitude regions are different.



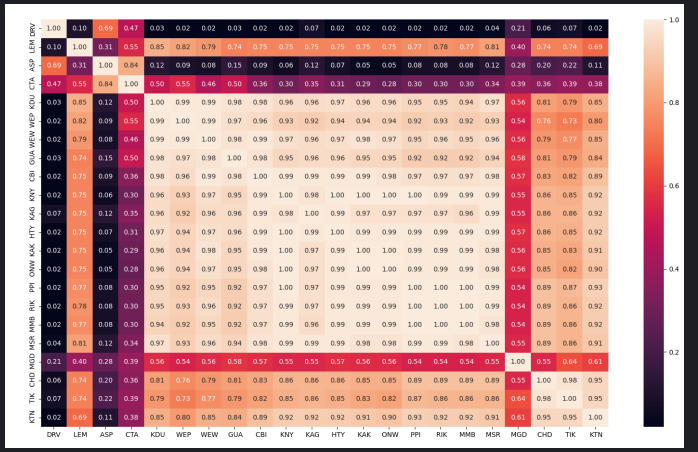
17:24 After Midnight X Correlation

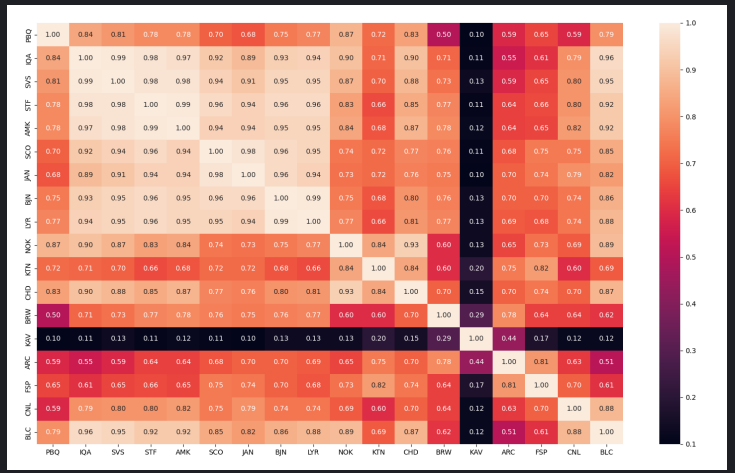


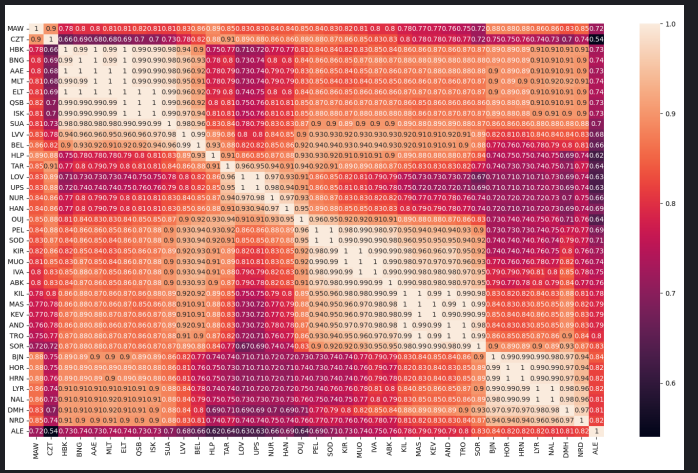
17:24 After Midnight X Correlation Lag

Results: Correlation

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

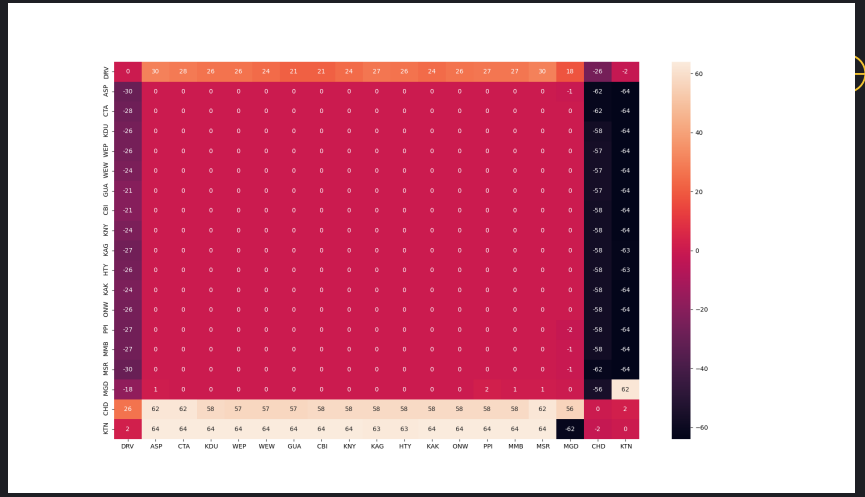


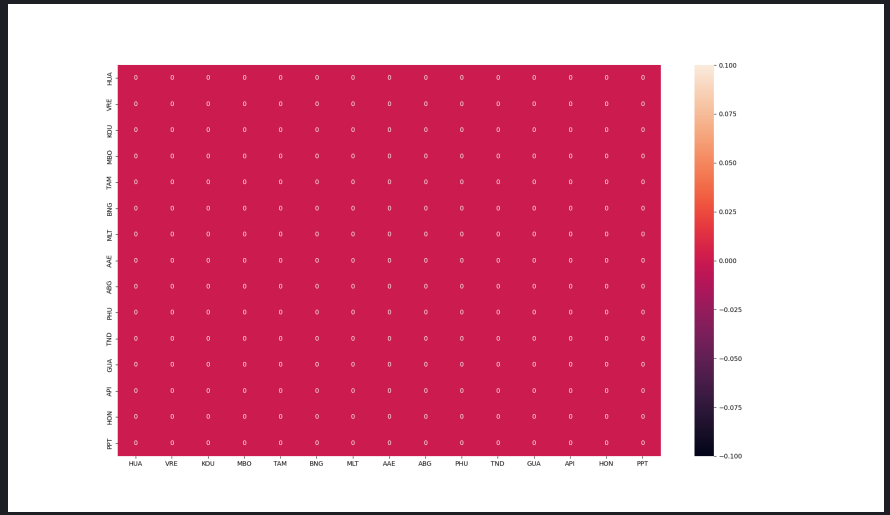


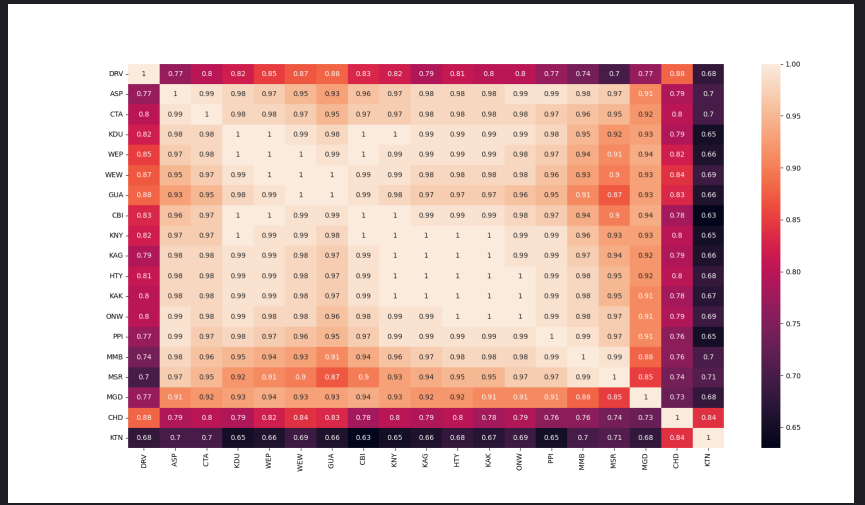


Results: Correlation

* Global patterns in mid and equatorial regions and regions of milder impact (Storm-1 Afternoon, Storm-2 After-midnight, equatorial chains)







Limitations

* Sparse stations lead to less accurate Kriging Interpolation
* Ideally 1-second temporal resolution with 100km-by-100km coverage
* Number of Stations is decreasing every year due lack of funding

* 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.

* The global maps will be made available to the public as a tool for storm events study.

Discussion and Conclusion