Can a Smartphone Magnetometer Capture Space Weather?

Jannetta (Jae) Robinson[1], Richard (Rick) Saltus[2] , Anna Liao[3]
Red Rocks Community College, National Oceanic and Atmospheric Administration

Goal: Record the magnetic field's time variation with the CrowdMag app and identify a space weather signal in noisy smartphone data.

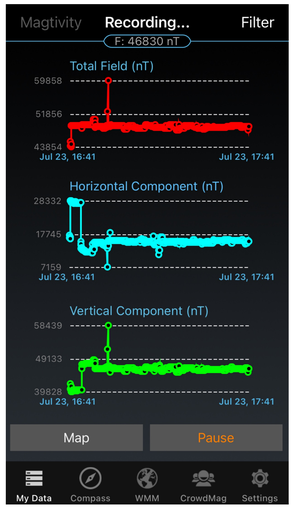
Introduction

Earth's magnetic field experiences space weather activity due to energy streaming from the Sun known as geomagnetic storms. These storms cause the auroras, can also disrupt power grids, navigation, electronics, radio, and satellite operations[2].

There are only a handful of observatories and satellites that track space weather[1]. However, smartphones can be used to gather data on the magnetic field with the use of its magnetometer through applications like CrowdMag. In theory, smartphones can be used to collect space weather data in observatory mode, but it is a big challenge to figure out how to filter noisy smartphone data.

If we can figure out how to use smartphones to gather space weather data, this could provide additional data to further the study of these storms and allow us to be better equipped to handle them.

Screenshot of the "Graph" page in the CrowdMag application recording data in real time.

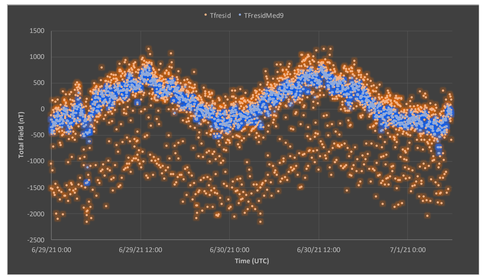


References

1. Kerridge, David. 2001 INTERMAGNET: worldwide near-real-time geomagnetic observatory data. [Poster] In: *ESTEC SWW 2002, ESTEC, Noordwijk, The Netherlands, 16-18 December 2001*. (Unpublished)
2. National Weather Service, 2016: Space Weather. NOAA's National Weather Service. Accessed 5 July 2021 https://www.weather.gov/phi/spacewx.
3. United Nations Office for Outer Space Affairs. (n.d.). *Space Weather*. Un-Spider Knowledge Portal. photograph. https://un-spider.org/disaster-type/space-weather.

Methods

- **Systems:** Measurement of magnetic field through CrowdMag application ran on Apple iPhone 11 device and Android phone Samsung S7 Edge.
- **Locations:** Data collected in Boulder, CO and Fairbanks, AK compared with Fairbanks Observatory and Boulder Observatory, respectively.
- **Time:** CrowdMag ran for 22-hour intervals in Colorado and 3-day intervals in Alaska.
- **Notes:** Devices set in area with little to no electrical currents: This includes things like running electronics, light switches, or near walls with lots of circuits.
- **Data analysis:** Visualization, analysis development, and comparison performed in Excel. Filtering techniques including polynomial trends, median filtering, and moving averages.

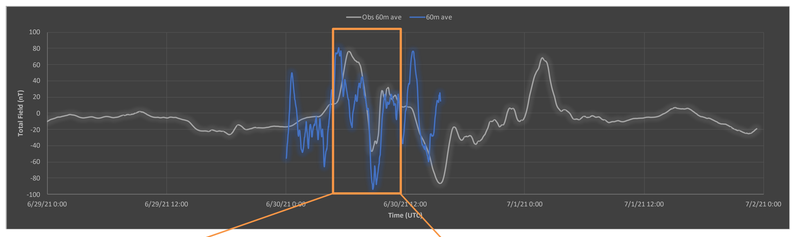


- Date: June 29th to July 1st
- Location: Fairbanks, AK
- Device: Samsung S7 Edge
- Blue: Median filtered CrowdMag data
- Orange: Raw CrowdMag data

Results

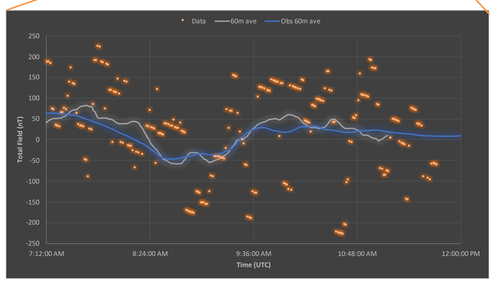
Data from the Boulder observatory shows a maximum variation of 74.8 nT while the Fairbanks observatory shows a maximum of 4251.9 nT from June 1st to July 25th.

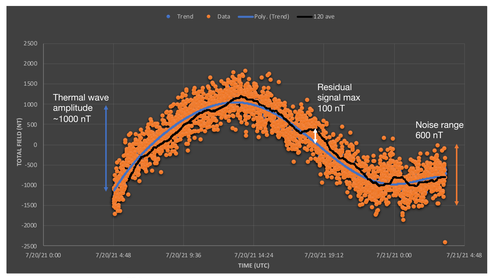
There is strong correlation between the signal found from the phone and the observatory in Fairbanks. Finding the correlation depends on the day (if space weather is active enough to see) and how close to the pole data is being collected (magnetic field's waves are greater closer to the pole).



- Date: June 29th to July 1st
- Location: Fairbanks, AK
- Device: Samsung S7 Edge
- Blue: CrowdMag filtered data
- Grey: Observatory filtered data
- Orange: Raw data
- Filtering: median, polynomial trend removed, 60-min. average smoothing.

Filtering limited longer data sets.





- Date: July 20th at 4:48am to July 21st around 4:48 am
- Location: Boulder, CO
- Device: iPhone 11
- Orange: Raw data
- Blue: Thermal wave removed with a polynomial trend
- Black: Residual made with 120-pt. average

Conclusions

Preliminary results suggest that the space weather signal is too small to be found in phone data. After further testing and experimentation it was determined that it is possible to filter the noisy CrowdMag data to reveal features that correlate with space weather signals measured at nearby magnetic observatories. Our studies suggest variation of more than 100 nT is needed in order to filter the signal from CrowdMag data.

Since the signals are difficult to isolate, a solid formula for data processing that is applicable in all situations has not yet been discovered. Given the inherent noise in data from a single phone, it is more probable to find a signal if the devices are closer to the poles of the magnetic field or with a mass collection of data using co-located phones with newer battery lives.

Future Work

There are promising early results, but collection of more time variation data is needed to be able to see the long-term patterns of space weather in a phone.

More studies can be done into how battery health of a phone affects the amount of data being recorded by CrowdMag as well as using temperature as a variable.

Data analysis in Python can be explored more to set up code that automatically runs the data through filtering methods.

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For more information, contact jrobinson241@student.cccs.edu