Characterizing Geomagnetic Storm Data for Machine Learning Models of Geomagnetically Induced Currents

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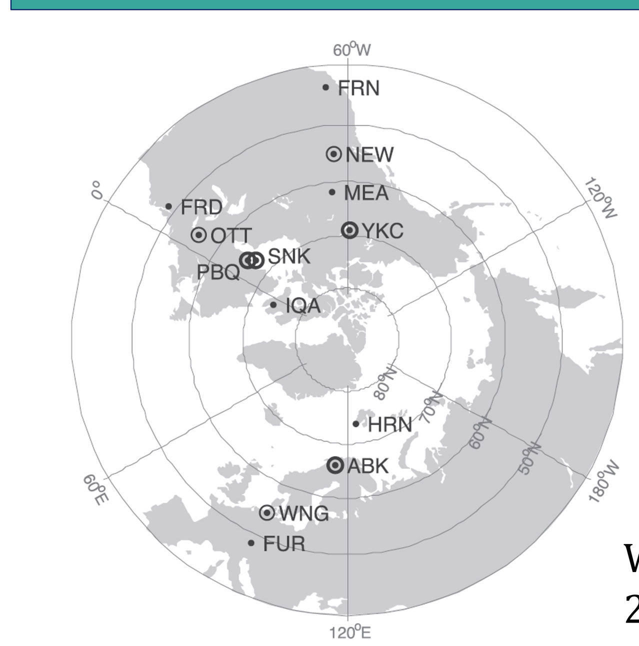
Machine Learning Algorithms for Geomagnetically Induced Currents in Alaska and New Hampshire

Introduction

- The solar wind's interaction with the Earth's magnetic field can cause Geomagnetically Induced Currents (GICs) at ground level, which are hazardous to power and communications infrastructure.
- Fast, accurate, and precise forecasts of GICs are needed as they could allow providers to mitigate damage to their networks.
- Recent ML forecasting models are trained on solar wind parameters for inputs and ground-level horizontal component of the magnetic field $\mathbf{B}_H$ for targets (*e.g.,* from SuperMAG stations).
- However, ML algorithms are not always the most accurate due to multiple factors impacting the data, so detailed analysis on the data is needed in order to figure out where the underlying patterns are.
- Here we look at the MLT distribution of dB_H/dt from SuperMAG stations during five geomagnetic storms of interest

Stations and Storms

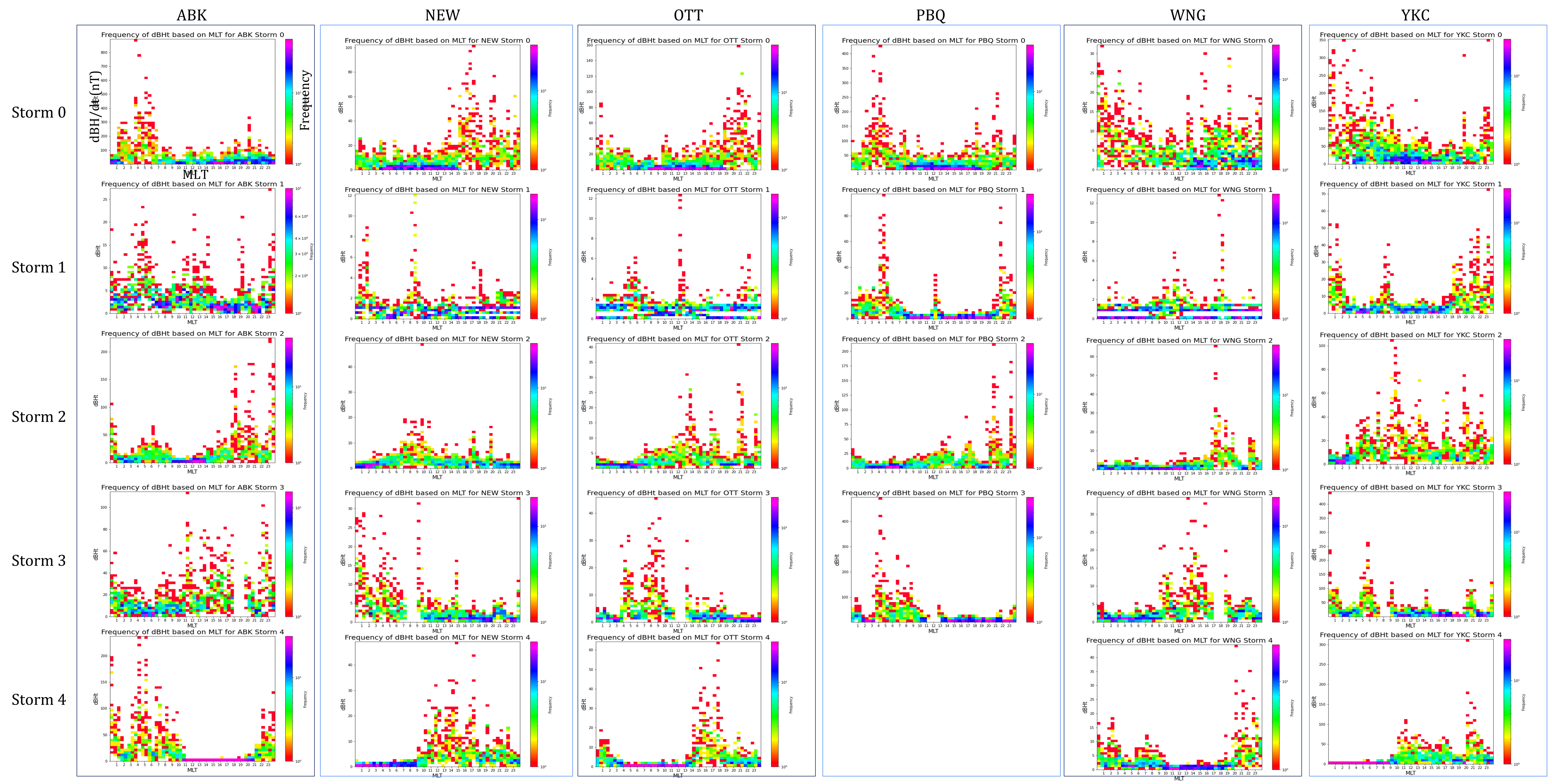


High Latitude: ABK (68.35), PBQ (55.28) , YKC (62.48)
Mid Latitude: NEW(48.27), OTT (45.4), WNG (53.75)

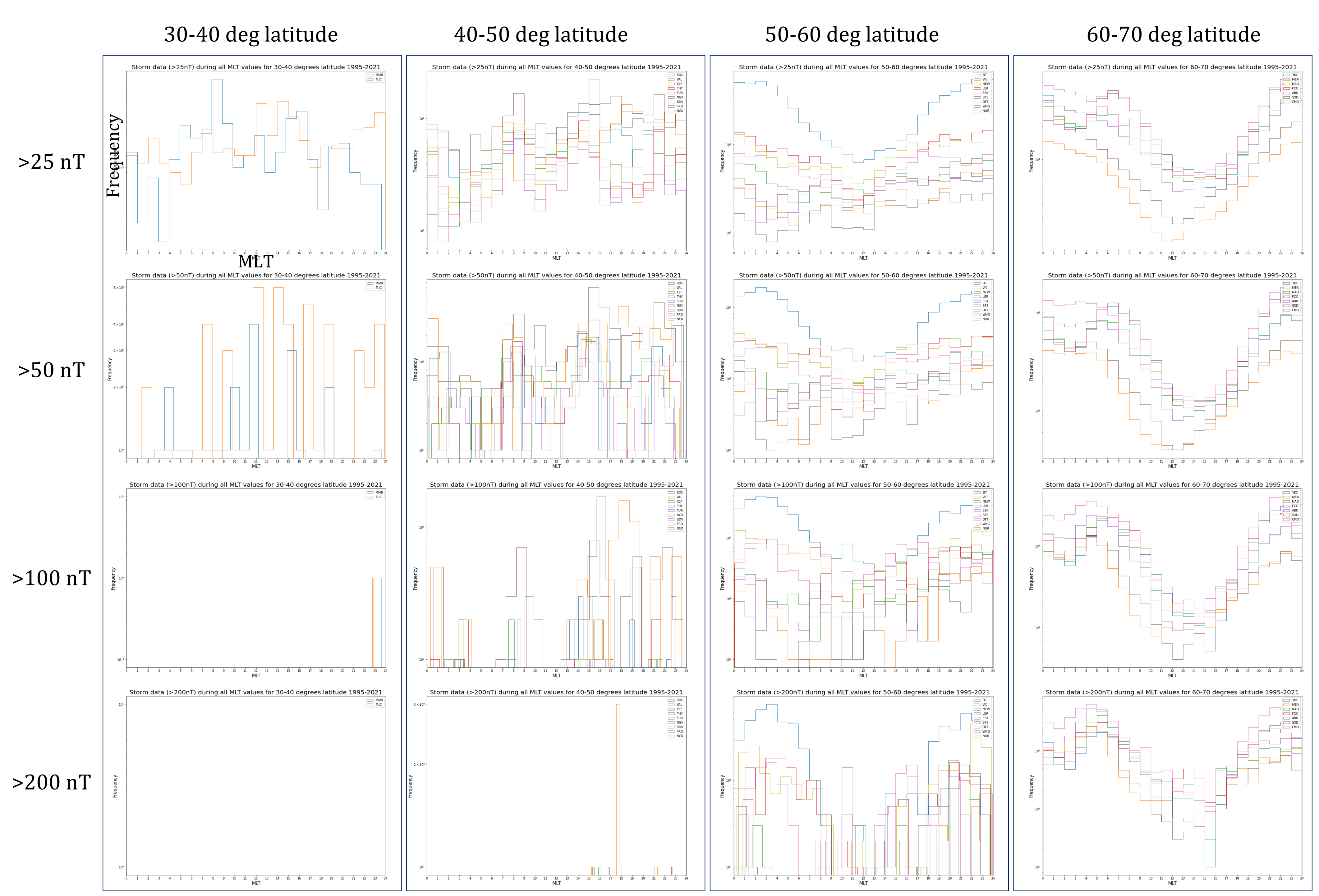
Event #	Date and Time	Min (*Dst*)
1	29 October 2003 06:00 UT–30 October 06:00 UT	–353 nT
2	14 December 2006 12:00 UT–16 December 00:00 UT	–139 nT
3	31 August 2001 00:00 UT–1 September 00:00 UT	–40 nT
4	31 August 2005 10:00 UT–1 September 12:00 UT	–131 nT
5	5 April 2010 00:00 UT–6 April 00:00 UT	–73 nT
6	5 August 2011 09:00 UT–6 Aug 09:00 UT	–113 nT

We use the stations and storms used in Pulkkinen et al, 2013. We excluded the 2003 October geomagnetic storm

Occurrence frequency of dB_H/dt based on MLT position and strength of dB_H/dt



Threshold dB_H/dt vs MLT at different latitudes



Threshold Results

- Our results show that as latitude increases so does the occurrence of dB_H/dt spikes at different thresholds
- As the latitude increases, there is a stronger dependence between MLT and strong dB_H/dt occurrences
- High latitudes station, strong dB_H/dt occurrences peak around midnight and are the strongest between 23 and 7 MLT.
- At mid-latitudes, occurrence of strong dB_H/dt events rapidly decreases as we increase the minimum required threshold. At the same time, it is very hard to identify any type of MLT dependence
- Still, at mid-latitudes there seem to be a tendency for dB_H/dt occurrences to be more frequent between 8 and 16 MLT
- Stations present slightly different behavior that could be explained the timing geomagnetic storms

Occurrence Frequency Results

- At mid-latitudes, strong dB_H/dt occurrences tend to be occur closer to midday, for all geomagnetic storms studied
- On the contrary, at high latitudes, the strong dB_H/dt occurrences seem to be more centered around midnight
- Mid-latitude dB_H/dt occurrences always occur a few MLT hours before than high-latitude occurrences
- In all the plots displayed in this work, there seems to be 3 distinctive peaks of occurrence. At high latitudes, the peaks seems to be spread out. At mid-latitudes the peaks then to be grouped together in MLT
- We expect these results to help inform decisions when trying to develop dB_H/dt models that use deep learning

Acknowledgements and References

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- OMNIWeb data taken from omniweb.gsfc.nasa.gov
- SuperMAG data obtained from supermag.jhuapl.edu