High Latitude Signatures of SI and SSC Events

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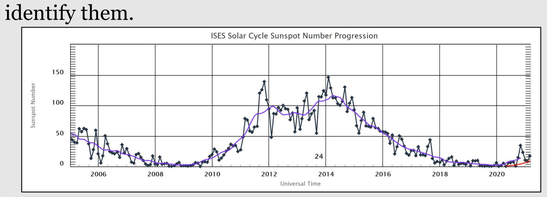
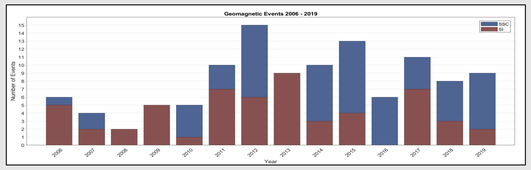
Abstract

Sudden Impulse (SI) events and Sudden Storm Commencements (SSC) are rapid geomagnetic variations associated with a compression of the magnetic field. Starting in 2006 Ebre Observatory, the IAGA international database on rapid magnetic variations, began to differentiate SI events from SSCs. These events have different magnetic characteristics depending on local time and latitude. Starting in 2006 and ending with the last definitive published dataset, the module SeaPy within Python is used to perform a superposed epoch analysis on SI events and SSCs for high latitude stations and low latitude stations. In relation to low latitude station onset times, we find systematic behavior of the total field strength and North-South component of the magnetic field at high latitudes. Specifically, the SI and SSC signatures are delayed, and the compression signature can be highly variable from event to event.

Motivation

Sudden Impulse (SI) events and Sudden Storm Commencements (SSCs) are both a form of rapid magnetic variation that are characterized by a compression of the magnetic field. SSCs are followed by a geomagnetic storm while SI events are not. The official catalog of SI events and SSCs are compiled by the Ebre Observatory and the occurrence frequency of SI events and SSCs roughly follow the solar cycle as expected, but the relative number of SI events and SSCs are highly variable. Since SI events and SSCs are thought to be the leading cause of rapid geomagnetic variations, we analyze the signature of high latitude magnetic stations to see how similar they are to each other and to the classic low-latitude signature used to identify them.

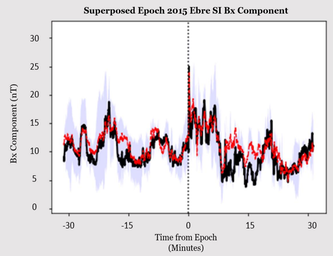


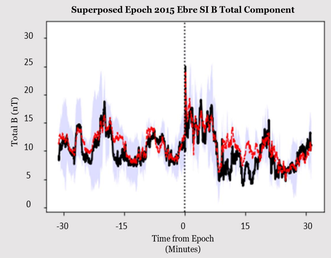


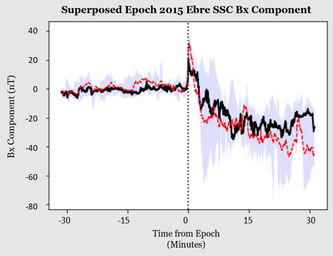
Methods

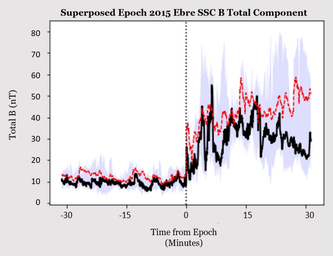
The year of interest for the beginning of this study is 2015. In this year there are four documented SI Events and 13 SSCs which are examined. The module SeaPy within the package SpacePy, a package designed for space sciences, is utilized to perform a superposed epoch analysis for given datasets. Superposed epoch analysis is a technique used to compare signals of similar form to one another relative to points of interest. The technique is dependent on epochs – points of interest, a window – the timeframe on either side of the epoch, and delta – the resolution for the analysis. With the three dependencies along with a time dependent dataset, such as the magnetometer data associated with the study, the module then computes and plots the results for interpretation. In the interpretation, the area of interest is the wave forms of same classifications and how they compare to one another. This study will focus on the magnetometer in Ebro Spain, the latitude of the official catalog, and Igloolik Canada, a high latitude station.

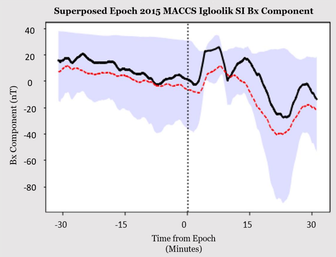
Results

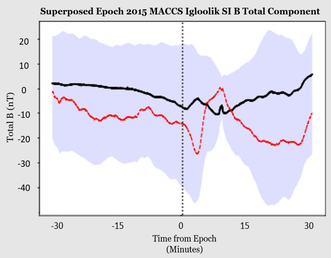


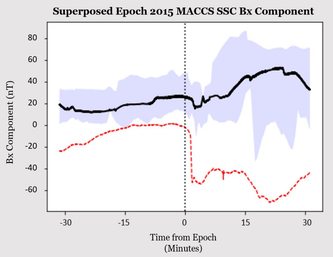


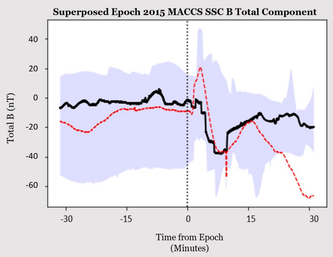












Year	Date/Time (UTC)	Type	Qualification	Year	Date/Time (UTC)	Type	Qualification
2015	1/7/2015 06:16	SSC	2 2 2 1 2	2015	8/15/2015 08:29	SSC	2 2 2 2 2
2015	1/26/2015 08:34	SI	1 0 1 1 1	2015	9/20/2015 06:04	SSC	2 2 2 1 1
2015	3/7/2015 04:45	SSC	3 3 3 3 3	2015	10/24/2015 18:54	SI	2 2 2 2 2
2015	3/31/2015 08:32	SI	2 0 2 2 1	2015	11/3/2015 01:34	SSC	1 0 1 1 2
2015	5/6/2015 01:41	SSC	2 2 2 1 1	2015	11/6/2015 18:18	SSC	2 2 2 2 2
2015	6/12/2015 13:16	SI	2 0 2 1 1	2015	12/14/2015 13:20	SSC	1 0 1 1 1
2015	6/21/2015 16:44	SSC	2 2 2 2 2	2015	12/19/2015 16:16	SSC	2 2 2 2 2
2015	6/22/2015 05:44	SSC	2 2 2 1 2	2015	13/31/2015 00:49	SSC	1 2 2 2 0
2015	6/22/2015 18:33	SSC	3 3 3 3 3				

Superposed Epoch Key

- Median
- Mean
- Interquartile Range

Conclusion

In this initial analysis of one-year, that contained four SI events and 13 SSCs, we find that the North-South component (Bx) for the SI magnetic signature is delayed by several minutes and the North-South component for the SSC magnetic signature is highly variable in from event to event. We also find that the compression signature (B Total) is highly variable in time from the onset of the SI and SSC events.

Future Work

In continuation of this study, a greater understanding of SeaPy's capabilities will be used to develop more in-depth visualizations. Line plots will be created to analyze outlier events at multiple latitudes. Outliers will be evaluated and categorized relative to their presumed cause. Data will also be expanded to cover the years beginning from when SI events were separated from SC's in 2006 to the last definitive data set in 2019. As more data are finalized further expansion is possible. The study may also expand to reach other high latitude stations available through the MAACS database. The day/night variations will be evaluated at the high latitudes of the MACCS stations as it is expected that there should be a longer delay when the high latitude stations are near midnight compared to noon.

MACCS Data Stations		
Cape Dorset	Gjoa Haven	Pangnirtung
Clyde River	Igloolik	Pelly Bay
Coral Harbour	Nain	Repulse Bay

Magnetometer Locations

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