

Geomagnetic Storm Precursors

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1 Prior work

[Takahashi et al., 2010] state that spikes in the Disturbance Storm Time (DST) index coincide with significant changes in equatorial mass density. They look at five specific storms over a 20 day period with evidence that two had density spikes after the DST drop, two had density spikes before the drop, and one showed no effect.

2 Our work

Our work takes the datasets from [Denton, 2007] and [Kondrashov et al., 2014], uses a mean interpolation to take the mass density parameter from a highly non-uniform 15 minute grid of the former to the contiguous one hour grid of the latter, and looks for storms based on the definition of storm periods provided by [Takahashi et al., 2010], namely when $DST < -50nT$. The former has a time coverage of 1980-1991, but covered by different satellites in different years (sometimes with overlap), and the latter data set covers 1972-2013. By then looking at an hourly average of variables from 24 hours before storm onset to 48 hours after, trends in storms can be discerned.

2.1 DST Storm

Two storm indicators are looked at in this study. The first is looking for a drop in DST below the threshold of $-50nT$ specified in [Takahashi et al., 2010]. This method finds 668 such periods between May 1983 and August 1991 with an average duration of 9 hours and a median duration of 3 hours. A subset of long duration storms will be looked at later. Figure 1 shows the average values of B_Z , V_{SW} , DST , $F_{10.7}$, and Mass Density for a period of 24 hours before and 48 hours after a storm onset.

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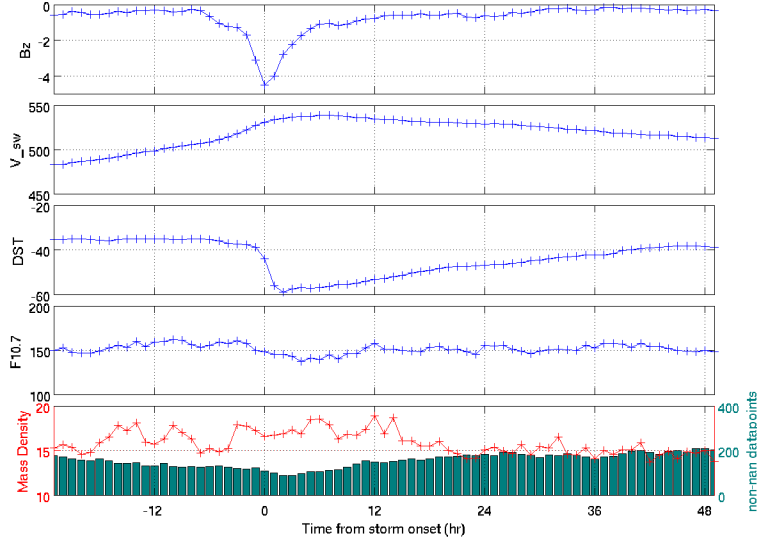


Figure 1: DST Storms

This figure shows a definite spike in the Z component of the magnetic field, as well as the defined drop in DST , but no obvious change in mass density as [Takahashi et al., 2010] loosely suggests.

2.2 Mass Density Storm

Figure 2 shows this same algorithm, but looking for a rise in mass density over a value of $40g/cm^3$. This results in 130 storms with a mean duration of 32 hours and a median duration of 17 hours, marked in red on the left figure.

This shows that when using all data for mass density derived storms, almost no significant changes can be seen around storm onset.

3 More specific storms

It's hypothesized that progressively picking more specific storm criteria will allow for the possibility of more significant results, at the expense of more bias in the selection process and potentially less overall usefulness of the results. That said, the predictability of extreme storms is of definite interest, so an attempt has been made to find some reproducible method of prediction. Looking at storms that

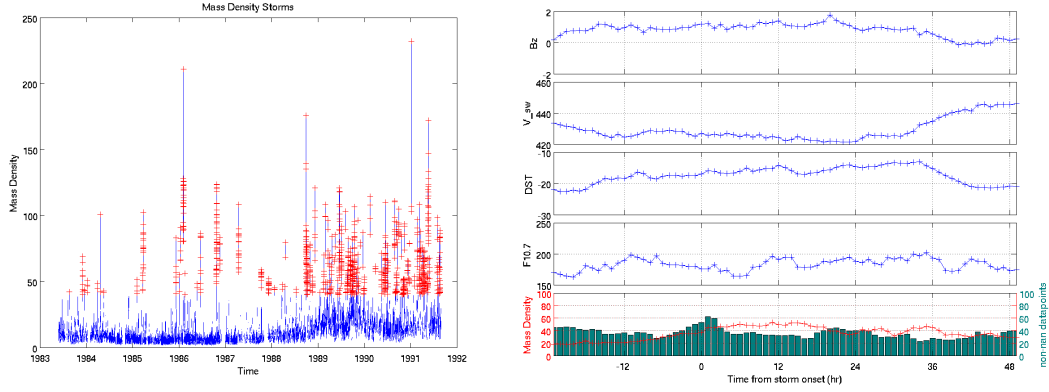


Figure 2: Mass Density Storms

last longer than 12 hours and storms with an onset threshold greater than $70g/cm^3$ results in the left and right sides of Figure 3 respectively.

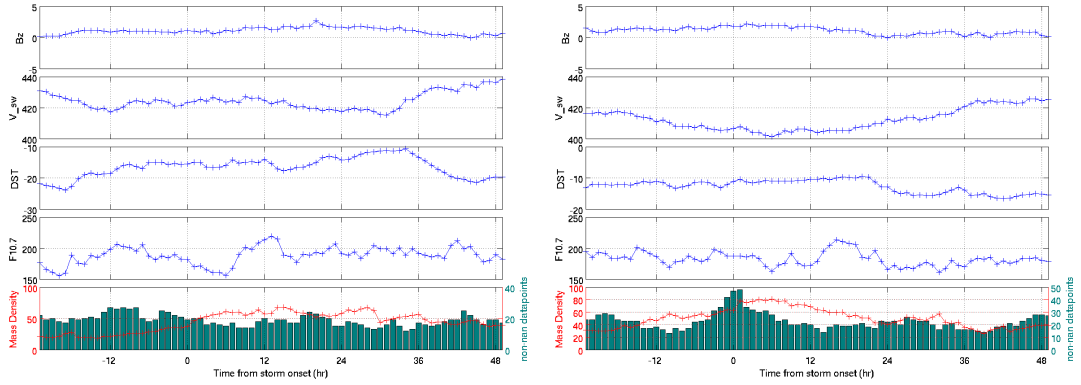
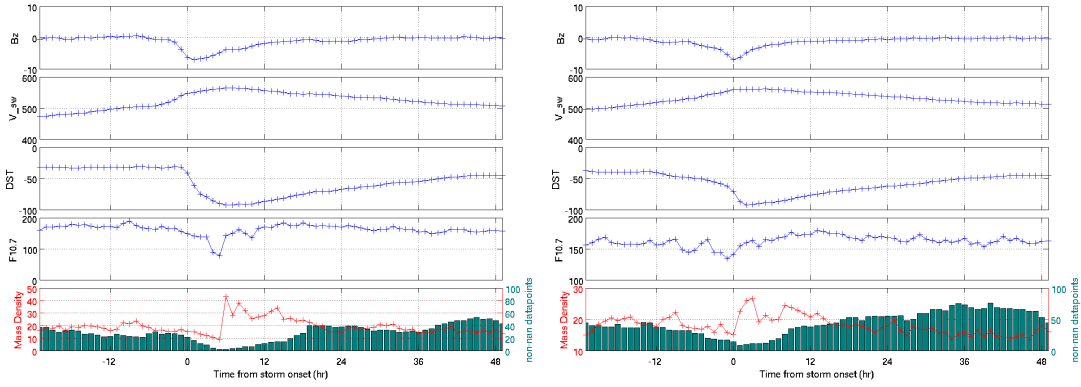


Figure 3: Specific Mass Density Storms

Neither of these seem to indicate anything too significant, so looking at *DST* storms instead to look for something that causes a significant change in Mass Density results in Figure 4. This shows that by either looking only at *DST* storms that last longer than an hour (left) or at storms where the onset condition is $DST < -80nT$, a spike in mass density is seen, but also a definite lack of data availability.

Figure 4: Specific *DST* Storms

References

- K. Takahashi, R. E. Denton, and H. J. Singer. Solar cycle variation of geosynchronous plasma mass density derived from the frequency of standing Alfvén waves. *Journal of Geophysical Research (Space Physics)*, 115:A07207, July 2010. doi:[10.1029/2009JA015243](https://doi.org/10.1029/2009JA015243).
- R. Denton. Database of Input Parameters for Tsyganenko Magnetic Field Modles, 2007. URL <http://www.dartmouth.edu/~rdenton/magpar/index.html>. Retrieved 2013-10-28.
- D. Kondrashov, R. Denton, Y. Y. Shprits, and H. J. Singer. Reconstruction of gaps in the past history of solar wind parameters. *Geophysical Research Letters*, 41:2702–2707, April 2014. doi:[10.1002/2014GL059741](https://doi.org/10.1002/2014GL059741).