Semi(?) annual variations of geo-magnetic storms

Leer, Kristoffer; Dumbovic, M.; Vennerstrøm, Susanne; Veronig, A.; Rodriguez, L.; Sudar, D.; Vrsnak, B.

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Semi(?)-annual variation of geo-magnetic storms

K. Leer[1], M. Dumbovic[2], S. Vennerstrom[1], A. Veronig[3], L. Rodriguez[4], D. Sudar[2], B. Vrsnak[2]

1) DTU Space, Technical University of Denmark , Denmark
2) HVAR Observatory, Faculty of Geodesy - University of Zagreb (HVAR), Croatia
3) University of Graz (UNIGRAZ), Austria
4) Royal Observatory of Belgium (ROB), Belgium

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Abstract

The distribution of Coronal Mass Ejections and geomagnetic storms are studied during solar cycle 23. There is no seasonal variation of CMEs but there is an annual variation of storms. It is suggested that the dependence can be annual and also dependent on solar activity.

Introduction

It has long been known that for instance the H-component of Earth magnetic field and indices like Kp and Ap vary semi-annually (Mursula et al 2005) peaking in March and September. When forecasting the geo-effectiveness of Coronal Mass Ejections (CMEs) it is important to understand if the time of year is influencing the risk for a geomagnetic storm. This study is a part of understanding how these variations should be treated when forecasting geo-effectiveness of CMEs. CMEs and storms in the period 1997-2010 are here considered. Based on sunspot number two subgroups have been identified, one for solar maximum (1997-2003) and one for solar minimum (2004-2010). A list of storms in the entire time span has been created and compared to the SOHO/LASCO catalogue (CDAW).

Data set

Table 1 gives the statistics of the two data sets. The division is based on both sunspot number and also keeping the two time periods equally long.

Parameter	Solar Max (1997-2003)	Solar Min (2004-2010)
Total CMEs (v>200 km/s)	7261	5730
Total Storms (dst<-30 nT)	317	134
CMEs/day	3.32	2.67
Storms/day	0.145	0.0610
CME Speed (km/s)	541	546
Ap peak	82.7	80.7
Ap mean	58.5	60.4
Mean DST (nT)	-77	-75

Table 1: Overview of data sets

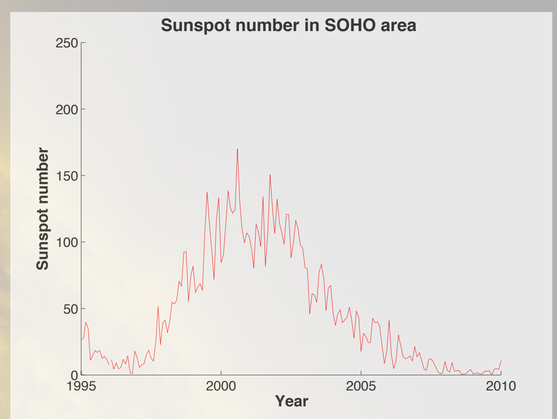

Figure 1: Sunspot number i SOHO area

Results

The smallest events have been removed from the data sets, so that only CMEs with speed greater than 200 km/s and storms with dst less than -30 nT are considered. For each month in the two time intervals the number of events in each month has been counted and plotted in figure 2 and 3. The reduced χ^2 has been calculated in order to test wether the number of events is evenly distributed over each month. The number of CMEs has been corrected for SOHO downtime and given as CMEs/day.

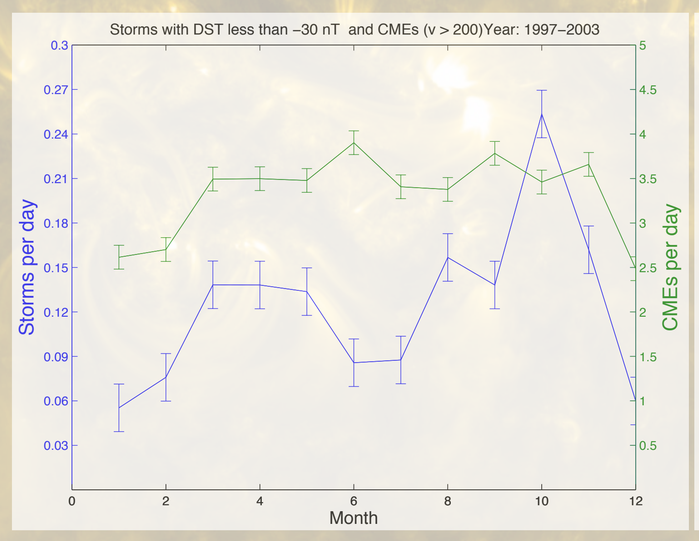

Figure 2: The monthly distribution of CMEs and storms in solar maximum.
Prob (χ^2=5.1)=82% (CMEs)
Prob (χ^2=133)=0% (Storms)

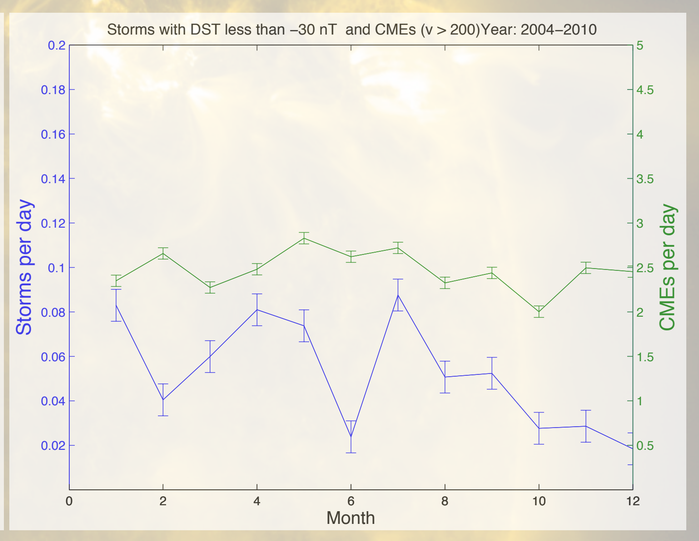

Figure 3: The monthly distribution of CMEs and storms in solar minimum.
Prob (χ^2=2.4)=98% (CMEs)
Prob (χ^2=59.4)=0% (Storms)

Discussion

The CME rate is even with a 5% significance level evenly distributed over each month. The storms on the other hand have variations over time. It is interesting to see that the distribution varies during the solar cycle. In solar maximum we find most storms in october. It can be discussed wether there is a peak in spring as well or if there only is a seasonal variation. During solar minimum there is no clear maximum

Alternative approach

Another data set has been created to test the results. 211 CMEs has been randomly selected in the time 1996-2010. For each an average dst has been found regardless wether the CME was geo-effective or not. The norm of the DST is plotted in figure 4. It is seen that the distribution of DST is very similar to the distributions of storms found in fig 2.

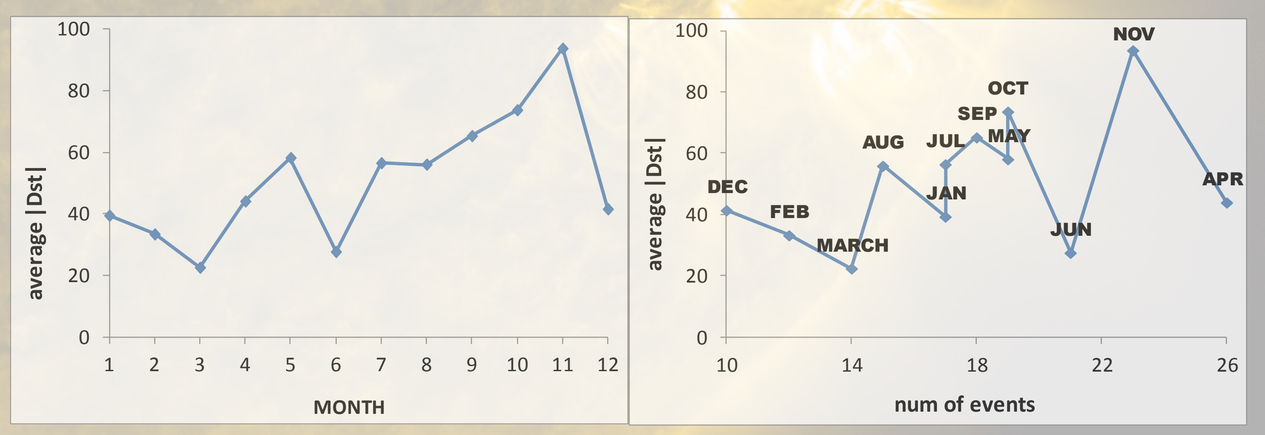

Figure 4: DST distribution over the year in the periode 1996-2010. Dst peaks only once per year in this study.

References

Mursula, K. and A. Karinen (2005), Explaining and correcting excessive semiannual variation in the Dst index, Geophysical Res. Lett. 32, L14107, doi: 10.1029/2005GL023132

CDAW - weblink: http://cdaw.gsfc.nasa.gov

"This CME catalog is generated and maintained at the CDAW Data Center by NASA and The Catholic University of America in cooperation with the Naval Research Laboratory. SOHO is a project of international cooperation between ESA and NASA."

Conclusion

- CME rate has no seasonal variation
- Geomagnetic storm distribution vary both over the year and solar cycle
- Is there an annual variation and not semi-annual variation?

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