LDi: A LOCAL DISTURBANCE INDEX FOR SPACEWEATHER FORECASTING PURPOSES

SPACE WEATHER FORECAST VERIFICATION (S12)

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Abstract

Real time monitoring of geomagnetic field is relevant for space weather purposes. Although some geomagnetic indices as *Dst*, *ap* or *Kp* are estimated in real time as proxies of global magnetic activity, in some cases, as GICs, local geomagnetic disturbances better comply with the phenomena than with the global ones. As a consequence, local magnetic activity timely available is essential for accurate forecasting of this kind of events. In this work a new index is proposed: the '**Local Disturbance index**' during geomagnetic storms time, obtained from the *H* component of geomagnetic field measured at a determined observatory. The requirements for a real time index for Spain guide us also to compare data recorded at three magnetic observatories (**SPT, EBR and GÜI**) spread in longitude and latitude, looking for a relationship among them with the aim of providing a national local disturbance index. The results of this study are shown in this poster.

INTRODUCTION AND METHOD

Local magnetometers always provide a wealth of data. These ground magnetometers are not useful only as data providers in different networks for global indices elaboration (as *Dst*, *ap* or *Kp*) but for tracking local magnetic disturbances that may affect the ground, originating GICs and different problems, such power grid failures.
The method presented in this poster has been published in **[1]**. Since the aim was creating a clean magnetogram baseline signal to correct local magnetograms to study superstorms and recovery phases, we will present the method and explain its applicability.

Data processing made consists of obtaining a "Local Disturbance index," i.e., an ***index (i)*** with ***local (L)*** information of the ***disturbance (D)*** during the storm time, from the *H* component of geomagnetic field measured at a determined observatory. The ***LDi*** is obtained in a similar procedure to *Dst* [5,7] but only from one geomagnetic observatory. The first step is to define a baseline, *H_baseline*, for each storm and observatory. Our baseline consists of removing the periodic 1-day variation and quiet time *H* value. Classification of days as "quiet" or "disturbed" is not available before 1932.
We remove the periodic variation as follows:
*First, selecting the current month of the storm to determine the quietest days.
*Then, calculating the absolute value of the running difference for the hourly *H* data |*H(i + 1)-H(i)*|.
*Next, smoothing |*H(i + 1)-H(i)*| with a 24-h window to find the minima. We should be aware that the window width does not alter the position of the minima; it just eliminates noise to visualize better the variation. The obtained minima will be the so-called quietest days. They are always selected avoiding discontinuities and recovery phases. Five quiet days, consecutive or not, are desirable in the selection.
*Once the quiet days are selected,they are averaged to form a "quiet day model." This one is replicated to create a synthetic periodic variation, i.e., the *H_baseline*. Then the *H_baseline* is subtracted from the original magnetogram signal. The hourly ***LDi*** is finally obtained as taking the *LDi* as the local latitude-weighted *H*. $LDi(t) = \frac{H(t) - H_{baseline}}{\cos\varphi}$
*They are also local-time corrected by the expression in [6] . θ_h is the local time, an the expression is given below. The final index is the final corrected magnetogram or ***LDi***.

Event #2

Event #4

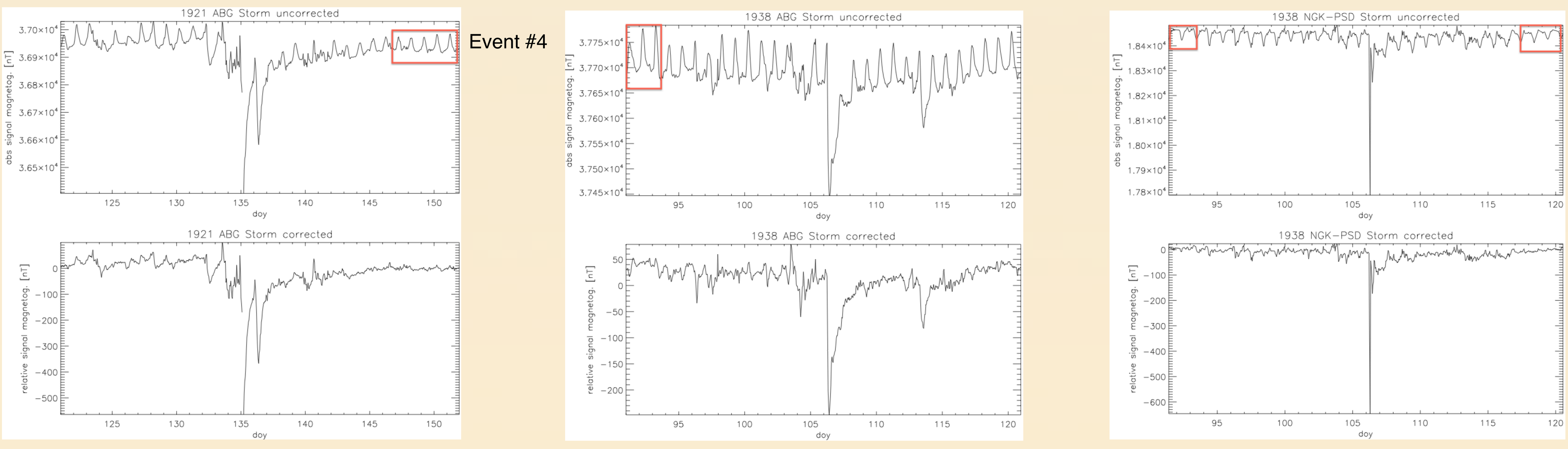

Fig 1. Local magnetometers showing uncorrected *H* (top) and corrected *H* (bottom). The red box indicates the 5-quiet-day choice for each case.

RAW MAGNETOGRAM DATA H(t) → **DAILY VARIATION REMOVAL (FINDING QUIET DAYS TO CORRECT)** →

***COMPUTING ||H (i+1)-H(i)||**
***SMOOTHING THE RESULT**
***FIND MINIMA--> QUIET DAYS**
***TAKE 5 QUIETEST DAYS**
***AVERAGE THEM TO FORM A QUIET-DAY MODEL**
***REPLICATE TO COVER A MONTH**

→ **MAGNETIC-LATITUDE AND LOCAL TIME DEPENDENCE REMOVAL**

$$LDi(t) = \frac{H(t) - H_{baseline}}{\cos\varphi}$$

LDi_final= $\delta \cdot$ **LDi**

$$\delta(\theta_h) = 0.9995 - 0.0149\cos\left(2\pi\frac{\theta_h}{24}\right) - 0.1803\sin\left(2\pi\frac{\theta_h}{24}\right) + 0.0157\cos\left(4\pi\frac{\theta_h}{24}\right) - 0.0130\sin\left(4\pi\frac{\theta_h}{24}\right)$$

→ **FINAL MAGNETOGRAM**

METHOD APPLIED TO GEOMAGNETIC SUPERSTORMS

Event #	Year	Month	Day	Observatory	*H* Range (nT)	Geomagnetic Latitude[a]
1	1859	September	1–2	Bombay	1720	9.74
2	1921	May	13–16	Alibag	>700	9.46
3	1928	July	7	Alibag	780	9.45
4	1938	April	16	Alibag	530	9.37
5	1957	September	13	Alibag	580	9.29
6	1958	February	11	Alibag	660	9.29
7	1989	March	13	Kakioka	640	26.6

Table 1 displays the 7 studied superstorms, with their characteristic observables.

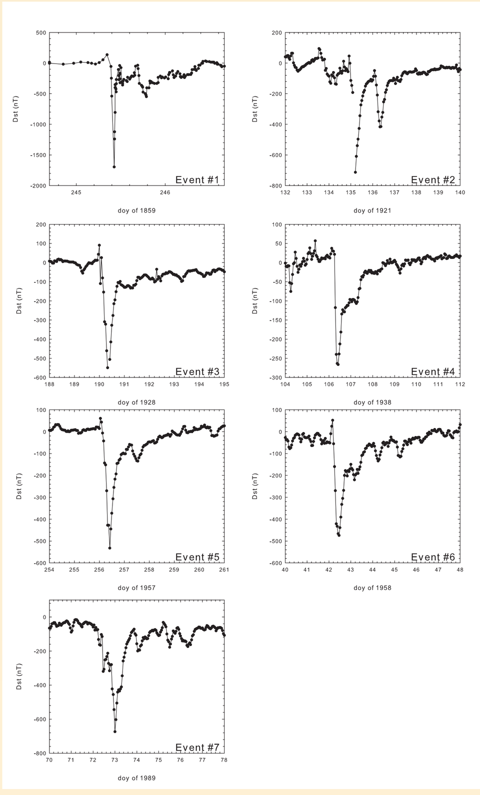

Figure 2: Extreme storms included in Table 1.

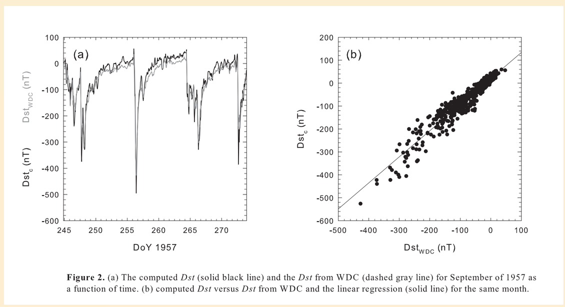

Figure 3: Original *Dst* (gray line) and *LDi* (solid **black** line). The correlation is shown in the right panel.

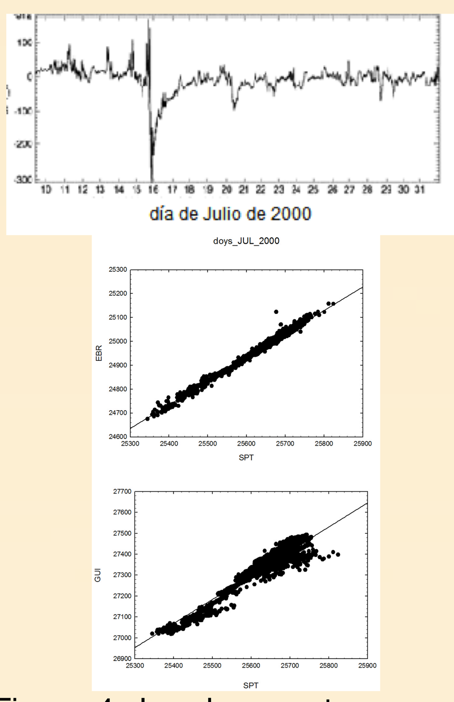

Figure 4: Local magnetograms of the Spanish observatories SPT, featuring a geomagnetic storm, and correlations with EBR and GUI

-See plenary talk of Consuelo Cid et al. (S6, Extreme SW Events) on Monday 18.
Table 1 shows the set of analysed superstorms (storms exceeding -250 nT [3]) with their minimum local magnetometer *H* component. These extreme storms present very conspicuous recovery phases. Figure 2 shows these 7 extreme events with their calculated *LDi*, i.e, *H* corrected of local effects of latitude and local time.

From local magnetometers to global indices. *Dst* can also be corrected from local-time influence to be more accurate without losing its identity as a global index. In Figure 3 displays *the original Dst* from WDC *and LDi* over a month.

Figure 4 belongs to the **Concluding remarks** section. A local Spanish magnetogram from the SPT observatory features the geomagnetic storm of July 2000, along with the correlations with the corresponding magnetograms from geomagnetic observatories from EBR and GUI (see acronyms and details below.)

CONCLUDING REMARKS

The application of this method was used for different magnetic latitudes to study geomagnetic superstorms. However, the future application will be to create a local spanish index. We study data of three magnetometers in Spain: Ebre [EBR (81.28ºE, 43.21ºN)] in mag. coord; San Pablo Toledo [SPT (75.96º E, 42.83ºN)]; and Güímar, Tenerife [GUI (60.54ºE, 33.84ºN)] (the two latter belonging to the Instituto Geográfico Nacional, IGN). As shown in Figure 4, the correlation for a given storm is very high. Therefore, SPT can be considered as representative of the Spanish magnetometers, and basis of the *LDi* for Spain. This index will provide valuable information for mid-latitude ground local effects.

ACKNOWLEDGEMENTS

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