Long-Term Datasets for the Understanding of Solar and Stellar Magnetic Cycles
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On the Characteristics of Geomagnetic Storms Observed During the Past 415 Years

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Abstract. In this paper we will present our investigations on the characteristics of geomagnetic storms deduced from direct and proxy observations for the years 1601–2016 AD. We show that we could infer epoch of reversal of solar polar magnetic fields from geomagnetic data. Such an inference is done back to the 18th century using geomagnetic and Aurora observations. We could also infer secular changes in the intensity of geomagnetic storms for the past 415 years.

Keywords. Geomagnetic storms, polar magnetic reversal, Aurora

1. Introduction

In this paper we have used direct geomagnetic observations during 1841–2016 CE and Aurora observations during 1601–1890 CE to study long term and evolution of geomagnetic storms and solar polar magnetic fields. The important results are given below.

2. Results and Discussion

2.1. *Inference of epoch of reversal in polarity of solar polar magnetic fields using geomagnetic data*

If we plot annual mean values (aaY) of geomagnetic aa indices (NGDC, IAGA) along with yearly mean International sunspot numbers (Rs) for the sunspot cycle 23 then we can find a peak in aaY during the sunspot maximum year 2000. The second and larger peak in aaY will be during the year 2003. The reversal of solar polar magnetic fields completed during the second half of the year 2002 (Gopkumar & Girish 2010). So the peak of aaY in the year 2003 can associated with solar polar magnetic reversal phenomena. The details of the epoch of solar polar magnetic reversals inferred from geomagnetic aaY data along with the same inferred from solar observations (given brackets) for the sunspot cycles 11–23.

Solar polar magnetic reversal dates 1 : in Cycle – aaY year (solar year)
11-1872(1872), 12-1886(1885.8), 13-1894(1895), 14-NA(1908), 15-1919(1918.7), 16-1830(1929), 17-1941(1940), 18-1951(1950), 19-1960(1959), 20-NR(1971), 21-1982(1981), 22-1991(1991), 23-2003(2002)

The second major peak in aaY happens mostly within a year from the year of final solar polar magnetic reversal (SPR) for all cycles except for cycles 14 and 20.

Let MAD be annual number of days where Aurora is observed simultaneously in at least three different places in the World (Angot 1897) For the sunspot cycle 11 we could find first MAD peak during the sunspot maximum year 1870. The second peak in MAD

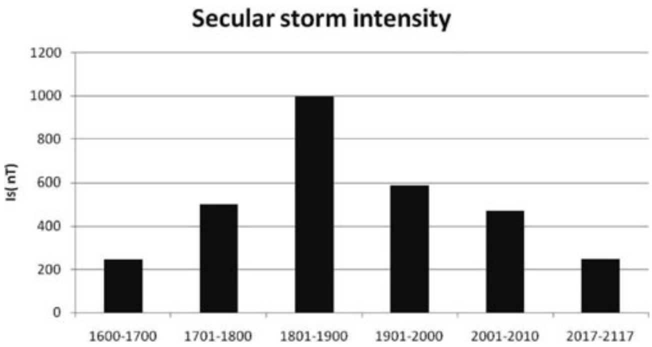

Figure 1. Secular changes in maximum geomagnetic storm intensity (Is) inferred from Aurora and geomagnetic observations for different periods since 17th century. The value for 2017–2117 is only a prediction.

occurs during their year 1872 which can be inferred as the year of solar polar magnetic reversal.

We have given below the dates of solar polar reversal for their sunspot cycles −3 to 12 (beginning of 18th century to end of 19th century) as inferred from Aurora (MAD) observations.

Solar polar magnetic reversal dates 2 : Cycle (year)
-3 (1719), -2 (1730), -1 (1741), 0 (1752), 1 (1763), 3 (1781), 6 (1819)
7 (1833), 8 (1839), 9 (1851), 10 (1862) 11 (1872), 12 (1886)

It is interesting a solar polar magnetic field reversal within the sunspot cycle 6 during the Daltons solar minima period.

2.2. *Secular changes in geomagnetic storm characteristics from 1610 CE*

In Fig. 1 we have plotted the inferred/observed maximum intensity of geomagnetic storms during different periods from 17th century onwards. We have defined the following relation to infer intensity of geomagnetic storms (Is) from Aurora data.

$$Is = (1/Lm) \times 10000 \text{ nT} \tag{2.1}$$

Lm is yearly minimum latitude of Aurora (Vazquez *et al.* 2016).

In this scaling the intensity of Carrington storm is fixed as 1000 nT and it is maximum till date. During the years 1841–1956 low latitude geomagnetic H observations and from 1957 onwards Dst data is used for finding intensity of geomagnetic storms. The last value in Figure is prediction for the coming century with a possible grand solar minima and if this is true a 400–500 periodicity in geomagnetic storm variation can be inferred.

References

Angot, A. 1897, *The Aurora Borealis*, D. Appeleton Co, New York

Gopkumar, G. & Girish, T. E. 2010, arXiv:1011.4639 [phy-gen.phy]

Vazquez, M., Vaquero, J. M., Gallego, M. C., Cartes, T. R., & Palle, P. L. 2016, *Sol. Phys.*, 291, 616–642