Forecast The Solar Maximum for Solar Cycle 24

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Summary

Applying a precursor technique the solar maximum for the solar cycle 24 is forecasted. This method is based on correlations between phenomena observed on the Sun or originating from the Sun, using geomagnetic disturbance indices which are indicatives of solar phenomena . The solar and the geomagnetic activities are measured by sunspot numbers and the Ap* index.
The previous method indicates that the next solar cycle (N = 24) would have a peak value of 132 ±35 and would be at 2011. This result agrees with prior results.

Introduction

To predict Maximum Amplitudes of solar cycles we consider the predictor technique which is very interesting for studies of the relationship between Sun and Earth.
In the present study the Ap* indices which characterize geomagnetic storms are considered and the solar activity is measured by sunspot numbers.
The observation of annual distribution of the Ap* indices results maximum values where the values of magnetic storms are high. In order to calculate it, aa indices are taking a three-hour period; when the average exceeds 40 nT a magnetic storm is regarded as being in progress. Arbitrarily it is decided that such storm continues until the mean value decreases from 40 nT. The maximum value is referred to Ap*. Considering the average of 24 hours of disturbance of maximum geomagnetic storms, it is possible to obtain tables of these indices in the NOAA home page. The predictor method has been used among others by Thompson, 1992. The present paper considers the observations of the activity up to the present time also utilizing this Ap* index as a measure of geomagnetic storms. There exist different publications about the forecast of the maximum amplitude of the solar cycle using the most diverse methods (see Gleissberg 1942; Joselyn et al 1997; Silbergleit 1998; Silbergleit and Larocca 2000).

Description of the method

The number of geomagnetic storms during each solar cycle depends on the maximum amplitudes of the solar cycle during which it is observed, and the next solar cycle. The data have been analyzed taking into account this fact and considering the Ap* indices of geomagnetic activity (that characterize geomagnetic storms, the values of which exceed 40 nT) Table I Shows the maximum amplitudes of each solar cycle for the same period.
Using the linear relationship:

$$\alpha = A + B\,\eta + C\,\mu \qquad (1)$$

By applying the method of the multiple linear regression to the series of data shown in the previous table, the constant values equal to: A= -92 ± 60, B= 1.2 ± 0.4 and C= 0.9 ± 0.3 for the Equation (1) are obtained, where α is the number of magnetic storms, η the amplitude of the current solar cycle and μ the amplitude of the next solar cycle.
The best adjustment indicates that:

$$\alpha = (-65 \pm 30) + (0.68 \pm 0.12)\,(1.2\,\eta + 0.9\mu) \qquad (2)$$

The coefficient of the linear correlation turned out to be 0.783. The amplitude of a solar cycle can be forecast using Equation (2).Figure 1 shows the relation between Ap* index and Maximum value of Solar Cycle. The α value it represents the number of magnetic storms observed up to the minimum of the solar activity, previous to the beginning of the new cycle. Them, we obtain the amplitude of the Solar Cycle Number 24 : (132 ± 35).
There is a spectrum of periodicities: a recurrence tendency of seven cycles was observed (Silbergleit et al,2000).Two lagged values appear in a multiple regression adjusted to the solar cycle amplitude. One is associated with the Glussberg period, also observed in the maximum sunspot number and the other is coincident with the periodicities in the C^{14} time record which is associated with solar activity variation (Ana G. Elias and Nieves Ortiz de Adler. 1998).
Using the multiple regression method applied to:

$$Am(N) = \varepsilon + \beta\,Am(N-12) + \delta\,Am(N-7) \qquad (3)$$

the constants are calculated and the values found are $\varepsilon = 285 \pm 65$ $\beta = -0{,}91 \pm 0{,}49$ $\delta = -0{,}55 \pm 0{,}32$.
Where Am(N-7) is the amplitude of solar cycle number N-7, Am(N-12) is the amplitude of solar cycle number N-12 and Am(N) is the amplitude of solar cycle number N.
Equation (3) allows us to make an estimate of the maximum amplitude to be expected during solar cycle number 23, it is found that for the next solar cycle its peak value would be (135± 65) sunspots.
We have separated the solar cycle length in two phases: the rise time and the fall off time and analyzing the spectrum of periodicities we forecasted the maximum

solar activity date for the predicted cycle. It would be in 2011.

Conclusion

The present article presents a quick manner to evaluate the upper limit of the maximum solar cycle 24 by using two methods one of them is the predictor method and we obtain the following result: Am(Cycle 24) = 132 ±35 and the other is the spectrum of periodicities: Am(Cycle 24) = 135 ±65 .Both agrees considering these results within the limits of calculated error.

As the occurrence of magnetic disturbances not only depends on the solar activity during the cycle in which those disturbances are observed but also on the previous cycle, it is important to take this effect into account. Many applications of the precursor technique only consider the final period of the previous cycle.

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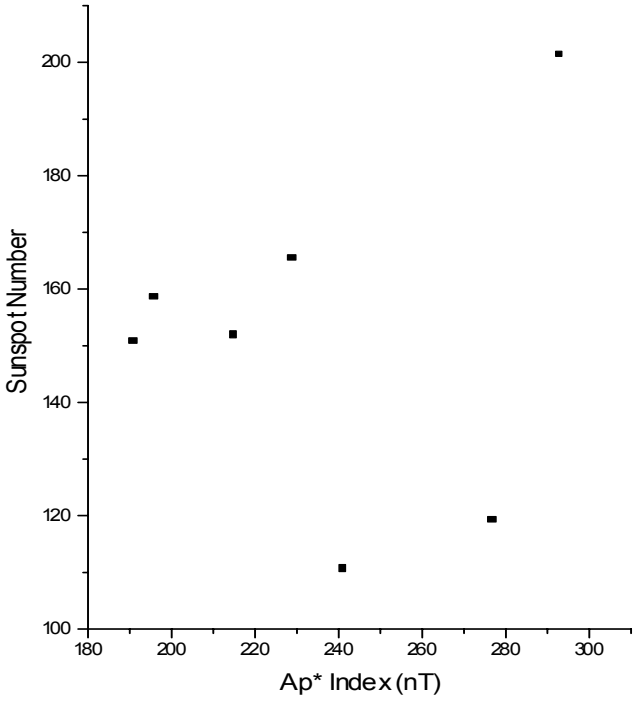

Fig.1 Maximum Solar Cycle amplitude vs. Ap* Index

SOLAR CYCLE NUM.	AMPLIT.OF SOLAR CYCLE	NUMBER OF STORMS (Ap*)
17	119,2	277
18	151,2	215
19	201,3	293
20	110,6	241
21	164,5	229
22	158,5	196
23	150,7	191

Table I Maximum amplitudes and numbers of storms of each solar cycle.

The number of geomagnetic storms during each solar cycle depends on the maximum amplitudes of the solar cycle during which it observed and the next solar cycle. Applying precursor technique the solar maximum for the Solar Cycle 24 is forecasted.