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Statistical Studies of Solar Cycles and its Periodicities

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ABSTRACT
We have correlated the solar cycle length and peak sunspot number emphasizing the recent solar cycle 24. The paper examines thoroughly all the 24 sunspot cycles and the associated 12 hale cycles. It is noticed that solar cycle 23 had a deep minimum and the longest decline phase. When solar cycles 20 to 23 are compared with solar cycles 1 to 4, the forthcoming Dalton minimum can be expected. Also the predicted variation of sunspot number for the solar cycle 24 is focused. The peak amplitude of the solar cycle 24 is likely not to be below 80.
Keywords – Sunspot, Solar Cycles, Hale Cycle

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I. INTRODUCTION

Solar activity rises and falls with an 11-year cycle, which is called the Solar Cycle, that affects us in many ways. Increased solar activity includes increase in the number of solar flares and coronal mass ejections (CMEs) which in turn affects sensitive instruments in space by energetic particles accelerated in these events. Every part of the solar activity is strongly modulated by the solar magnetic cycle [1]. Sunspots occur when a concentrated portion of the solar magnetic field pokes through its surface. Coronal Mass ejections and solar flares are large explosions on the sun's surface which occur close to the sunspots zone. In this paper we have reported some typical variations of solar cycle from statistical consideration and also focused on its periodicities.

II. SOLAR VARIATION

Out of the various solar activity events the most prominent one is the 11-year solar cycle. Figure 1 shows the variation of average sunspot number and duration for sunspot cycles while figure 2 shows the variation of those two parameters for the double sunspot cycles, technically named as Hale cycles [2, 3]. The peak and the minimum values of the parameters are evident from the figure.

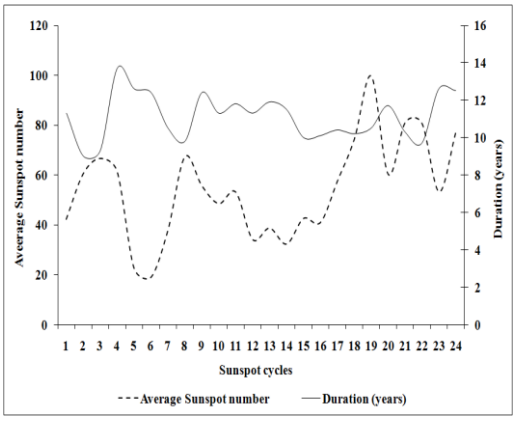

Figure 1: Variation of average sunspot number and duration (years) for sunspot cycles

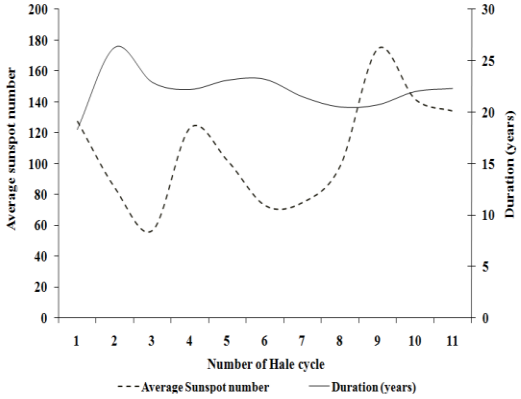

Figure 2: Variation of average sunspot number and duration (years) of the Hale Cycle

We next examine the deep minimum of solar cycle 23, the deepest during the last 140 years. This cycle was started in May 1996 and had its peak in April 2000. The decline phase of this period extended from 2002 until December 2008 which is the longest decline phase in the last 23 solar cycles. On the other hand, solar cycle 24 started in December 2008. It was started at late, about three and half years later than the average of the strong cycles in the last 20th century and almost three year later than the weak cycles of the late 19th Century. Figure 3 shows the variation of total sunspot numbers of the years 1952 to 2010 and Figure 4 shows the longest decline phase of solar cycle 23.

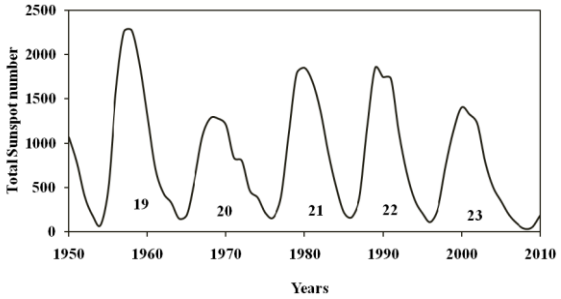

Figure 3: Sunspot cycles: Cycle 19 to Cycle 23

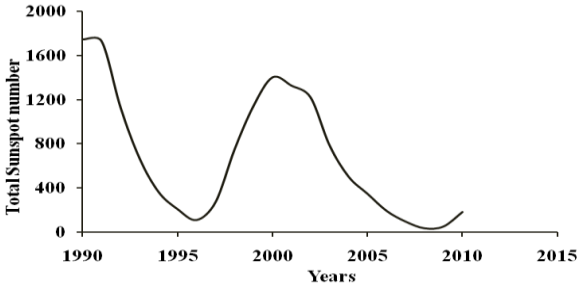

Figure 4: Solar cycle 23

III. DOES DALTON MINIMA REPEAT?

In Figure 5 we have compared solar cycles 1-4 with solar cycle 20-23. Solar cycle 5 and 6 of the Dalton Minimum are also shown. It is apparent that the solar cycle 22 and 23 are very similar to solar cycle 3 and 4 which preceded the Dalton Minimum [4, 5].

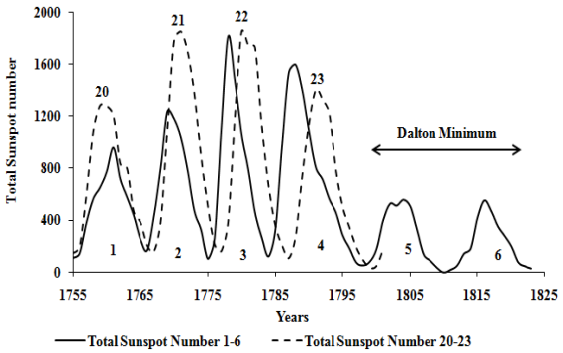

Figure 5: Comparison of solar cycles 1 to 6 with solar cycle 20 to 23

IV. PREDICTION OF SOLAR CYCLE 24

Solar cycle 24 is the current solar cycle which was started from December 2008. Figure 6 shows the variation of sunspot number over the years 1990 to 2020 which predicts the solar cycle 24. From the figure, it is clear that the peak amplitude of the 24th cycle will be less than 80. The 24th cycle may resemble the solar cycle 5, which appears from figures 5 and 6.

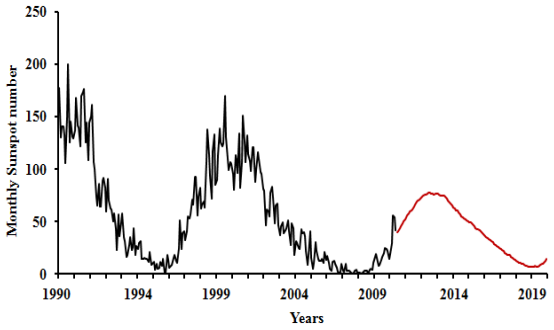

Figure 6: Monthly sunspot number observed (Black line) and predicted (Red line)

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