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The Study of Present Solar Cycle 24 – Future Aspects

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Abstract

In this paper we have studied about the present Solar Cycle 24 in comparison with previous solar cycles. The progression of present Solar Cycle 24 at late 2008 to 2015, indicates that the solar minimum is similar to the Dalton Minimum. The predictions of Solar dynamo, sunspot numbers are mostly used as basic solar activity index which is responsible for variation in space-weather. It is observed that the solar minimum between solar cycle 23 and 24 during the period of 2007 to 2009 has been longest at least since for the last 100 years and it looks that Sun is going to the next super centurial minimum solar cycle. Our aim is to investigate the facts of solar activity behavior during the period of present solar cycle 24.

Keywords: Sunspot numbers (SSN), Solar cycle (SC), Dalton minimum (DM), Gleissberg minimum (GM)..

Introduction

The sunspot numbers (SSN) are used as basic parameter for knowing the behavior of solar activity which appears in the photosphere of the Sun. It consists with very high magnetic fields up to thousand Gauss and their temperatures are much lower than their surroundings, therefore it looks as dark spots in the photosphere of the Sun. The Sunspot numbers are usually calculated by daily Wolf number or Zurich number R_z which is expressed as:

$R_z = k (10g + s)$

Where: S is the number of individual spots, G is the number of sunspot groups, and K is a factor that varies with location and instrumentation[1].

The space weather variations depend on the solar variability, mostly expressed by sunspot numbers (SSN). The sunspot cycles seems on the photosphere of the solar disk with an average period of 11.2 years cycle, during this period polarity of the magnetic field of the sunspots changes to opposite sign in a northern hemisphere to southern hemisphere. The polarities of the preceding spots shifts from one cycle to the next as the solar field reverses polarities within ~ 22 years period (Hale cycle)[3]. It is great to study the behavior of the solar activity of solar cycle 24 with respect to the period of solar minima, such as the Maunder minimum (1645-1715), Dalton minimum (1790-1830), and Gleissberg minimum (1889-1923) in which observed minimum solar activity[2,4].

Solar cycle 24 began after an unusually deep minimum solar activity during the descending period of solar cycle 23 from 2007 to 2008 and ascending period of solar cycle 24 from 2008 to 2009. In fact, during 2008 and 2009 there were almost negligible sunspots observed, causing a very unusual situation during solar minimum for almost a century. The maximum activity of cycle 24 and its unusual pattern are discussed with reference to earlier solar cycles[5]. Continuous decrease in solar flare activity has been found from solar cycles 20 to 23[6].

It has been observed that the solar activity cycle is an important factor for study of heliospheric atmospheric conditions which mainly depends on the sun spot numbers, its area and magnetic property appears in the photosphere of the Sun. It is therefore important for long-term space-weather predictions to understand the rate of formation of different types of sunspots during a solar cycle and the possible consequences for the long term behavior of geomagnetic activity in an ascending and descending phase of the solar cycle[7, 8, 9, 10].

For the present study we have selected the solar activity parameter SSN from 1700 to 2015. It is observed that from descending and ascending period of solar cycle 23 and 24, such as 2007 to 2008 and 2008 to 2009, there were almost no sunspots observed for 265 days and 262 days respectively, this unusual solar activity occurs after almost a century and seems to progress like a period of Dalton minimum[11, 12,13].

Data and Method of Analysis

In this work, we have taken the solar indices data of monthly mean and smoothed monthly mean count of sunspot numbers (SSN) during the period of 1750 to 2015, and yearly mean sunspot numbers (SSN) during the period of 1700 to 2015 from the website of NOAA which is available in the public domain for a long period of time and it is publishing "Solar Geophysical Data" every month from NOAA, Boulder Colarado, USA.

In this paper we have selected the solar activity parameter sunspot numbers (yearly mean, monthly mean and smoothed monthly mean of SSN) during the period of Dalton minimum (1790-1830), Gleissberg minimum (1889-1923), and period of solar cycle 20 to present solar cycle 24. We have compared the long term behavior of sunspot cycle during the period of Dalton minima and present solar cycle 24. The data available for the cycle 24 from 2008 to till now shows a strange behaviour in respect to solar activity during minima and maxima of solar cycle. The maximum sunspots have been counted up to 102 only till now, and it seems that the present cycle now going to follow decline phase.

We have plotted line –graph by taking the Year as (common) axis and SSN as Value axis for the period of Dalton Minimum, Gleissberg Minimum, and present solar cycle 24. We have plotted separate graph for comparing the behavior of solar cycle 24, by taking yearly mean (from 1700-2015) and smoothed monthly mean values (from 1750-2015) of sunspot numbers. The facts of solar activity during the periods of solar minima of various solar cycles are shown in the Table-1.

Table-1
Maximum monthly mean Sunspot numbers (SSN) observed during the period of various solar cycles.

Period of minimum Solar activity	Solar Cycle	Monthly mean SSN /Year
Dalton minimum (1790-1830)	SC-5	62.3 (Oct. 1804)
	SC-6	96.2 (March 1817)
	SC-7	106.3 (April 1830)
Gleissberg minimum (1889-1923)	SC-12	129.2 (Aug. 1893)
	SC-13	108.2 (Feb. 1907)
	SC-14	154.5 (Aug. 1917)
Present Solar Cycle (2008-2015)	SC-24	96.7 (Nov. 2011) 1st peek 102.3(Feb. 2014) 2nd peek

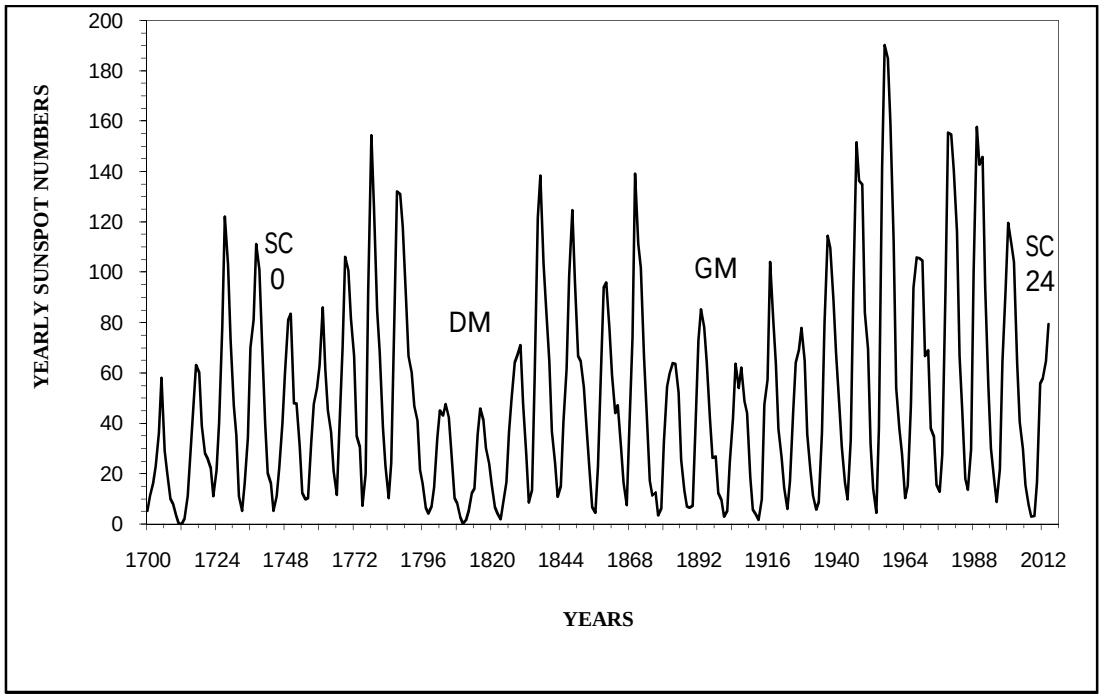

Figure-1
Shows the yearly mean value of sunspot numbers from 1700 to 2015, indicating the period of Dalton minimum and Gleissberg minimum

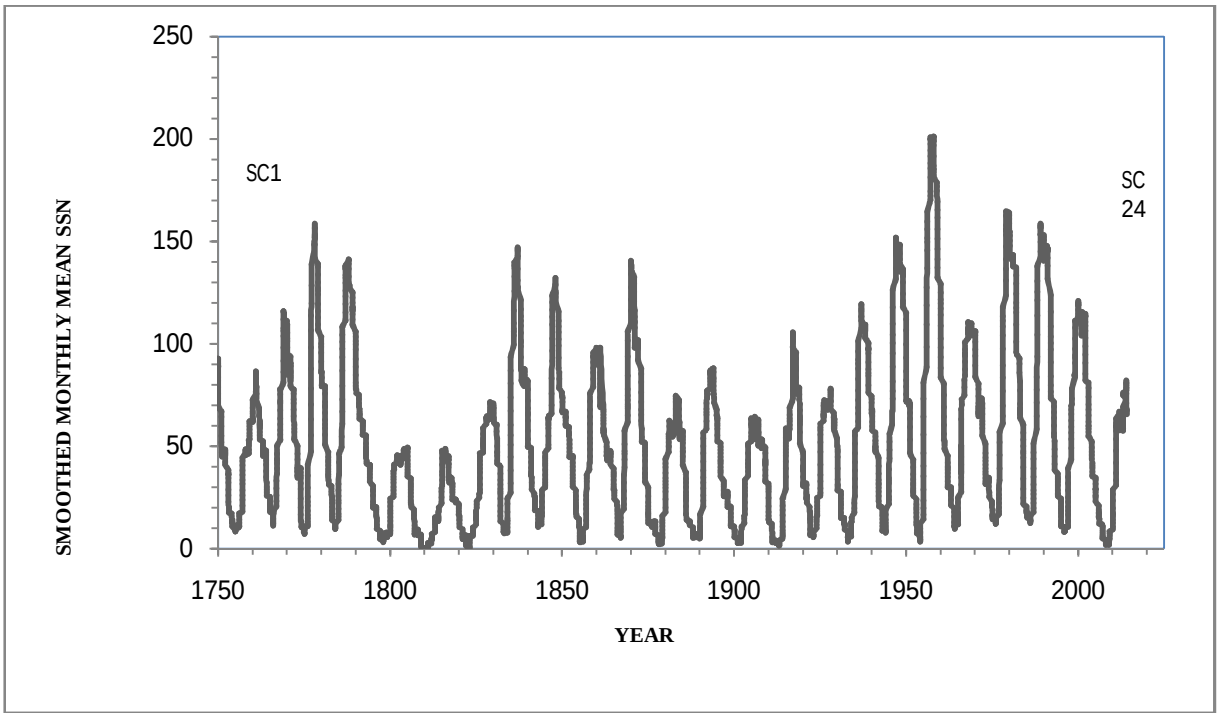

Figure-2
Shows the smoothed monthly mean sunspot numbers from 1750 to 2015

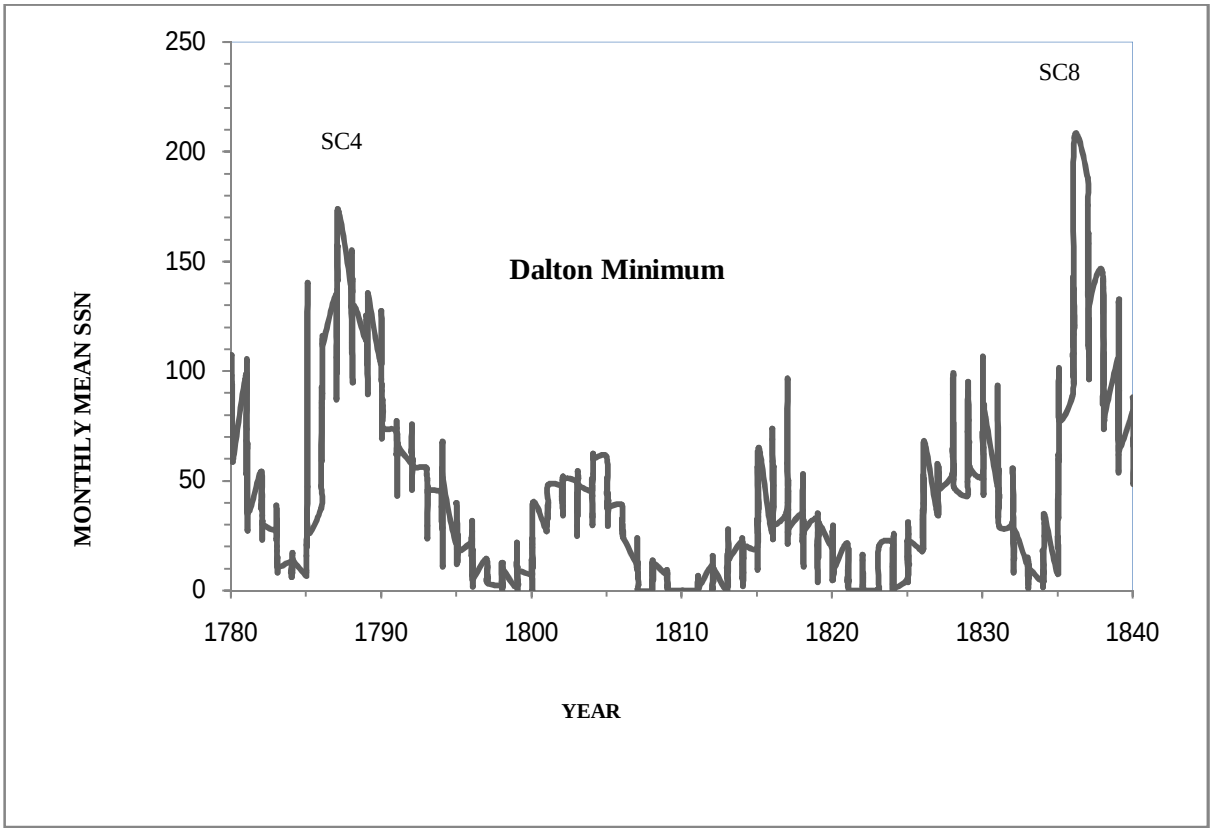

Figure-3
Shows the monthly mean count of sunspot numbers for the period of Dalton minimum from 1790 to 1830 observed minimum solar activity for solar cycle 5, 6 and solar cycle 7

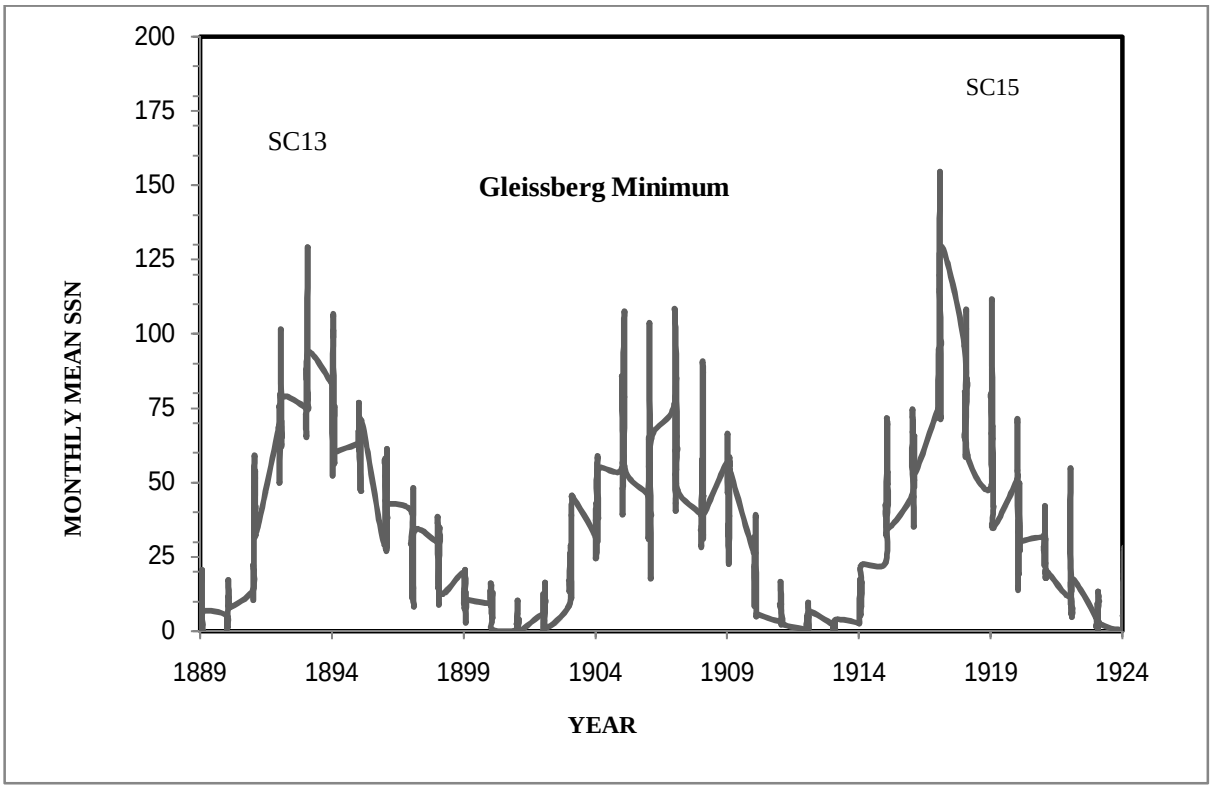

Figure-4
Shows the monthly mean sunspot numbers for the period of Gleissberg minimum from 1889 to 1923 as low solar activity cycle for solar cycle 13 to solar cycle 15

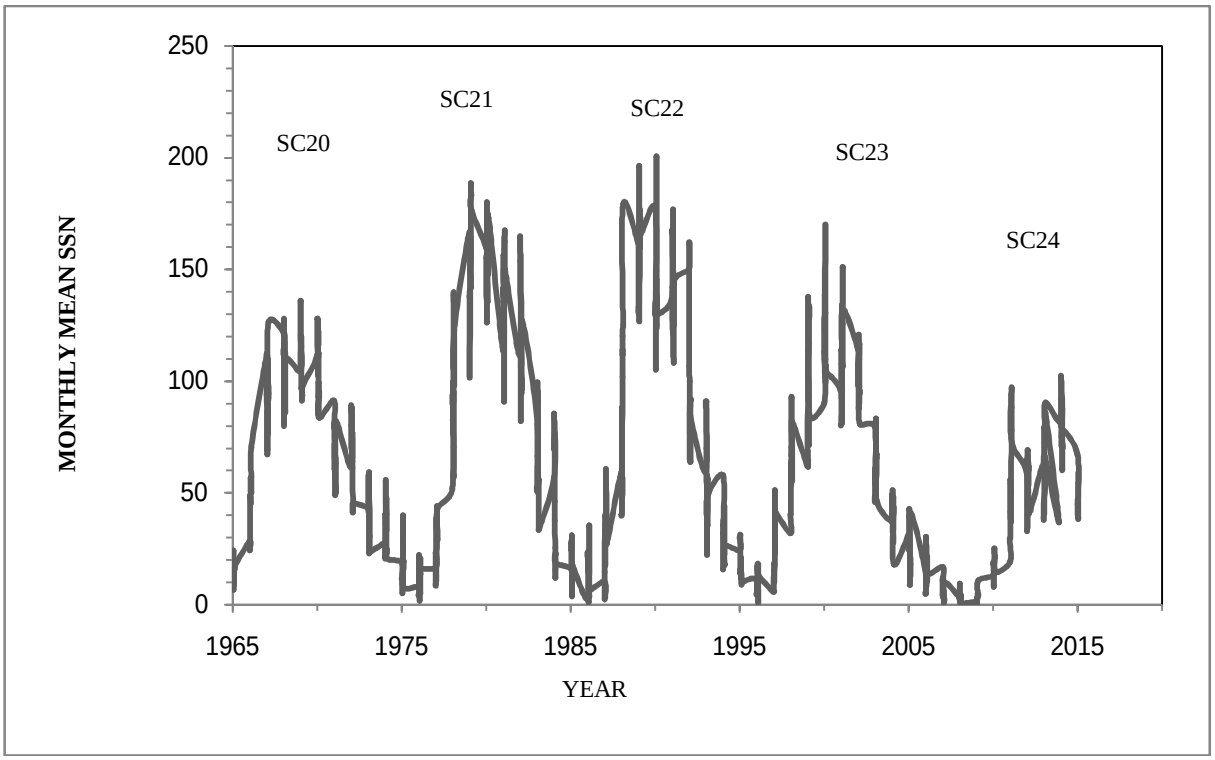

Figure-5
Shows the monthly mean count of sunspot numbers from the solar cycle 20 to solar cycle 24

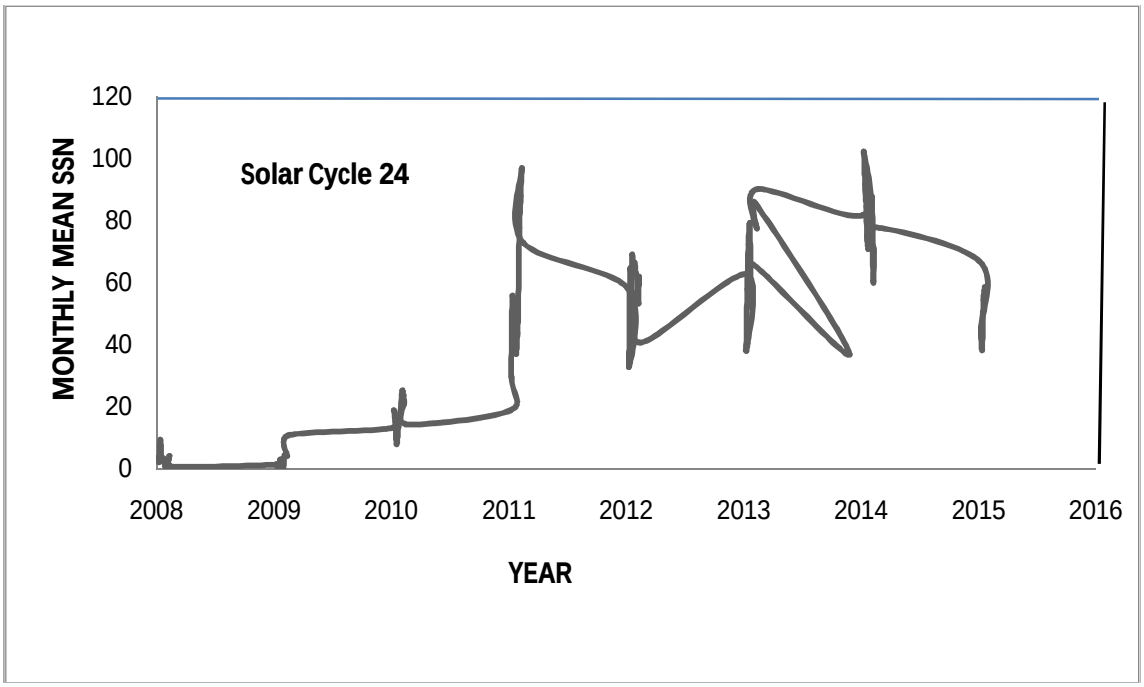

Figure-6
Shows the 1st and 2nd peak values as monthly mean count of sunspot numbers of solar cycle 24

Result and Discussion

It is found that from the time series analysis of long term behavior of sunspots data set of about 265 years from the period of 1750 to 2015, the solar activity of present solar cycle 24 is progresses similar to the solar activity of the period of Dalton minima. In Table-1 maximum monthly mean sunspot numbers observed in minimum solar activity period is shows that the behavior of present solar cycle 24 is more close to the age of the Dalton minima. In Dalton minimum period the maximum sunspot numbers has been observed (96.2 in march 1817 and 106.3 april1830) which is more close to the 1st and 2nd peek values observed (96.7 and 102.3) of present solar cycle (Figure-6) as well as to Gleissberg minimum period. These findings of the low solar activity of solar cycle 24, which is in decline phase, passes more than half age of the period of 11 years cycle shows in fig.6, it is clearly apparent that the present solar cycle is minimum solar activity cycle and it is progresses to become a minimum solar activity cycle after a century. By comparison of solar activity behavior of the Dalton minimum (Figure-3). Gleissberg minimum (Figure-4) and present solar cycle (Figure-5and 6) is strongly validates our prediction. Figure-1 and 2, indicates that the present solar cycle 24 is continuously in declining phase and a very week solar activity cycle, which influences the space weather, outer atmospheric conditions of the Earth.

Conclusion

The prediction on present solar cycle 24 is based on the analysis of historical data set of the length of 265 years. Solar cycle 24 appears to progresses as Dalton type minimum solar activity cycle. It already passes more than half age of 11-years cycle which strongly validate that its solar activity is very weak and it influence the space-weather condition. The continuous long duration and constant low solar activity of present solar cycle during all over the cycle period to till now, could provide us an unique opportunity for understanding the solar variation.

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