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A STATISTICAL STUDY OF SUNSPOT CYCLES

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ABSTRACT

The study of sunspots is very important as they are connected with other solar events like flares and coronal mass ejections (CMEs). A solar flare is a sudden release of energy from the sun, while a CME actually shoots hot plasma from the sun into space. The precise mechanisms that trigger flares and CMEs are not yet known, but the bigger the group of sunspots, the more intense such solar weather tends to be. Flares and CMEs can send enormousamounts of energy and charged particles hurtling into collision with the Earth's atmosphere, where they can cause magnetic storms that disrupt or alter radio and cell phone communicationand can wreak havoc with electrical grids. Smoothed sunspots number was examined during 1999 to 2017and the solar maximum was found during the years 2000 and 2014.The 23rd and 24th solar cycles were compared. The number of sunspots in 24th solar cycle is very less as compared to those in 23rd solar cycle. Theimpact of the solar cycles is much more when it is at its peak.

Keyword: sunspot, solar cycles, CMEs, solar flares

INTRODUCTION

Sunspots are the dark regions on the surface of sun. They are cooler than the surrounding areasand hence looks darker. The reason for sunspots being cooler than the surrounding areas is thatthey are areas of intense magnetism. They are darker only in comparison to their surroundings.However, if we isolate them from the surrounding photosphere, they appear brighter than the full moon. Sunspots usually appear in pairs. The two sunspots of a pair have different polarities, one wouldbe a magnetic north and the other is a magnetic south, and can be joined by magnetic field lines. The number of sunspots that can be seen on the surface of sun increases and decreases ina regular pattern known as a solar cycle with a maximum number of sunspots occurring every 11.5 years. Sunspots have two parts: the central umbra, which is the darkest part, where the magnetic field is approximately vertical (normal to the Sun's surface) and the surrounding penumbra, which is lighter, where the magnetic field is more inclined.

The sunspots are one of the strongest pieces of evidence for the solar cycle which describes a variation in solar activity over an 11 years period. The possibility of a solar cycle was first noticed in 1843 by Samuel Schwabe after counting the number of sunspots present on the Sun over 17 years. He noticed that the number of sunspots visible at any one time was not a constant, but rose and fell gradually over time. The number of sunspots that can be seen on the surface of sun increases and decreases in a regular pattern known as a solar cycle with a maximum number of sunspots occurring every 11 years. Solar variations cause changes in space weatherand to some degree weather and climate on Earth. It causes a periodic change in the amount ofirradiation from the sun. The solar cycle (or solar magnetic activity cycle) is the periodic changein the sun's activity (including changes in the levels of solar radiation and ejection of solar material) and appearance (visible in changes in the number of sunspots, flares, and other visiblemanifestations). Solar cycles have duration of about 11 years.

Forecasting of the peak of the sunspot cycle is highly important for space weather applications. At the present time, precursor methods are the most favored for the prediction of the strength of the next solar cycle (Kane 2008; Hathaway 2009). These precursor techniques often relate to geomagnetic activity levels near, or before, the time of solar cycle minimum (Sargent 1978; Ohl & Ohl 1979; Feynman 1982; Gonzalez & Schatten 1987; Thomson 1993; Wilson et al. 1998). Predicting the amplitude of a solar cycle can be done using polar fields from the previous cycleas ‘‘precursors’’ of the next cycle

(Schatten & Sofia 1987). The other class of precursor techniques that do not need apriori a physical understanding of the causal relations (i.e., that do not require any knowledge of the physics involved) is based on finding particular sunspot number characteristics that serve as indicators of the size of the next cycle (Ramaswamy 1977;Lantos 2006; Cameron & Schu¨ssler 2008; Brajsˇa et al. 2009).

The physical explanation for how precursor methods work was suggested by Schatten et al. (1978), who used the reversed polar field built up after the solar maximum as a precursor indicator to the next solar cycle strength.

Svalgaard et al. (2005) have reported about correlation between polar fields and sunspot activity of the next cycle

Data , Methodology and Analysis

To understand about 23rd and 24 th sunspot solar cycle the monthly mean sunspot numbers fromWDC-SILSO, Royal Observatory of Belgium, Brussels (sidc.oma.be/silso/home) has been taken. The observed values are smoothed using 13 months running filter. Observed smoothed values precede the estimated values while predicted smoothed values follow the estimated values. Following analysis is done for understanding the trend of sunspot cycle:

Monthly sunspots number during the year 1999 to 2008 (23rd solar cycle)

Monthly sunspots number during the year 2008 to 2017(24th solar cycle)

Comparison between 23rd and 24th solar cycle

Monthly sunspot numbers during the year 1999 to 2008 (23rd solar cycle)

The 23rd solar cycle begins in August 1996 and ends in December 2008.It lasts for 12.3years. The Solar maximum was observed in the year 2000.During this year about 170 sunspots were observed. The sunspot numbers in next two years is also very high. Then the sunspot numbers are decreasing very rapidly. To understand the 23rd solar sunspot cycle monthly comparison of sunspot numbers havebeen done.

For the year 1999: It was found that the sunspots during this year are continuously increasing. The maximum numbers of sunspots were observed for the month November, as shown in Figure 3. The minimum numbers of sunspots were observed for the month January.

For the year 2000: During this year it was found that the sunspots initially increases and becomes maximum in the month of April. From April to August the sunspots number is almostconstant, as shown in Figure 1. Then the sunspots starts decreasing again. The sunspots numberis very high during this year. **For the year 2001:** The maximum numbers of sunspots were observed in the month of November. The trend shows that the sunspots number is increasing during this year,

For the year 2002: The solar maximum was observed in the month of February. Then there isdecrease in the number of sunspots and are minimum in the month of December.

For the year 2003: The maximum number of sunspots were observed in the month of January.Then there is decrease in the number of sunspots and are minimum in the month of December

For the year 2004: The maximum number of sunspots were observed in the month of Januaryand then the number of sunspots goes on decreasing (as shown in Figure 1). The minimum number of sunspots were observed in December. **For the year 2005:** the maximum number of sunspots were observed in the month of Januaryand minimum number of sunspots were observed in the month of December. The sunspot number was almost constant for three months (May, June, July)

For the year 2006: The maximum number of sunspots were observed in January. Initially, there is quite rapid decrease in sunspots number and then there is not much difference between the sunspots in in consecutive months, as shown in Figure 2.

For the year 2007: The maximum and minimum number of sunspots were observed in January and December respectively. The sunspots decrease almost linearly during this year.

For the year 2008: There number of sunspots during this year were very less. Since during this year the 24th solar cycle stars, so this year was expected to have very a smaller number of sunspots.

Monthly sunspot numbers during the years 2008 to 2017(24th solar cycle)

The 24th solar cycle begins on December 2008 and the solar maximum was observed in the

year 2014.During this year 107.2 sunspot were observed. The 24th Solar cycle started with god number of sunspot numbers but the manner which would have been expected the numbers werenot so. To understand the 24th solar cycle monthly comparison of sunspot numbers have been done

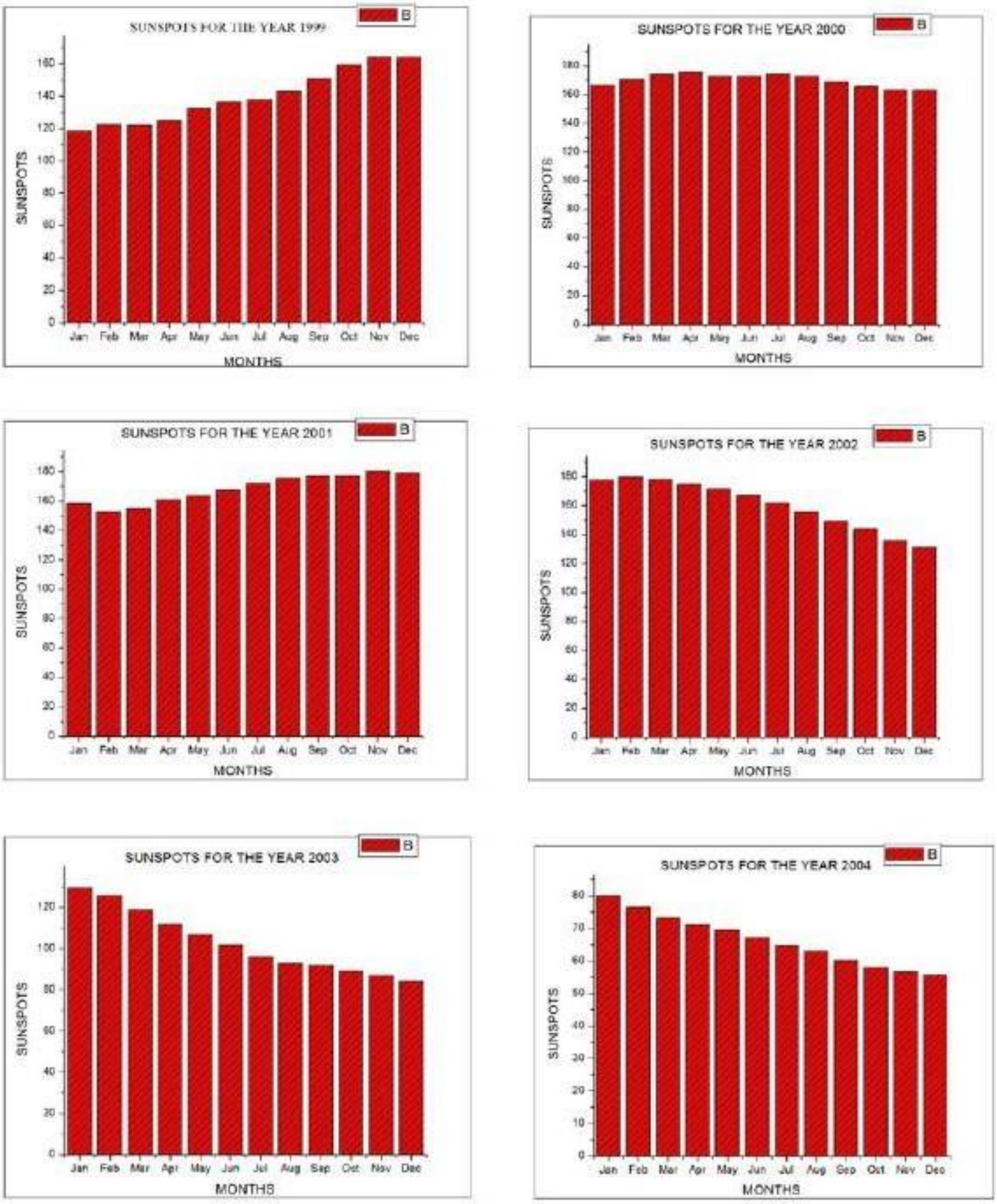

Figure 1: Monthly sunspot numbers during the year 1999 to 2004.

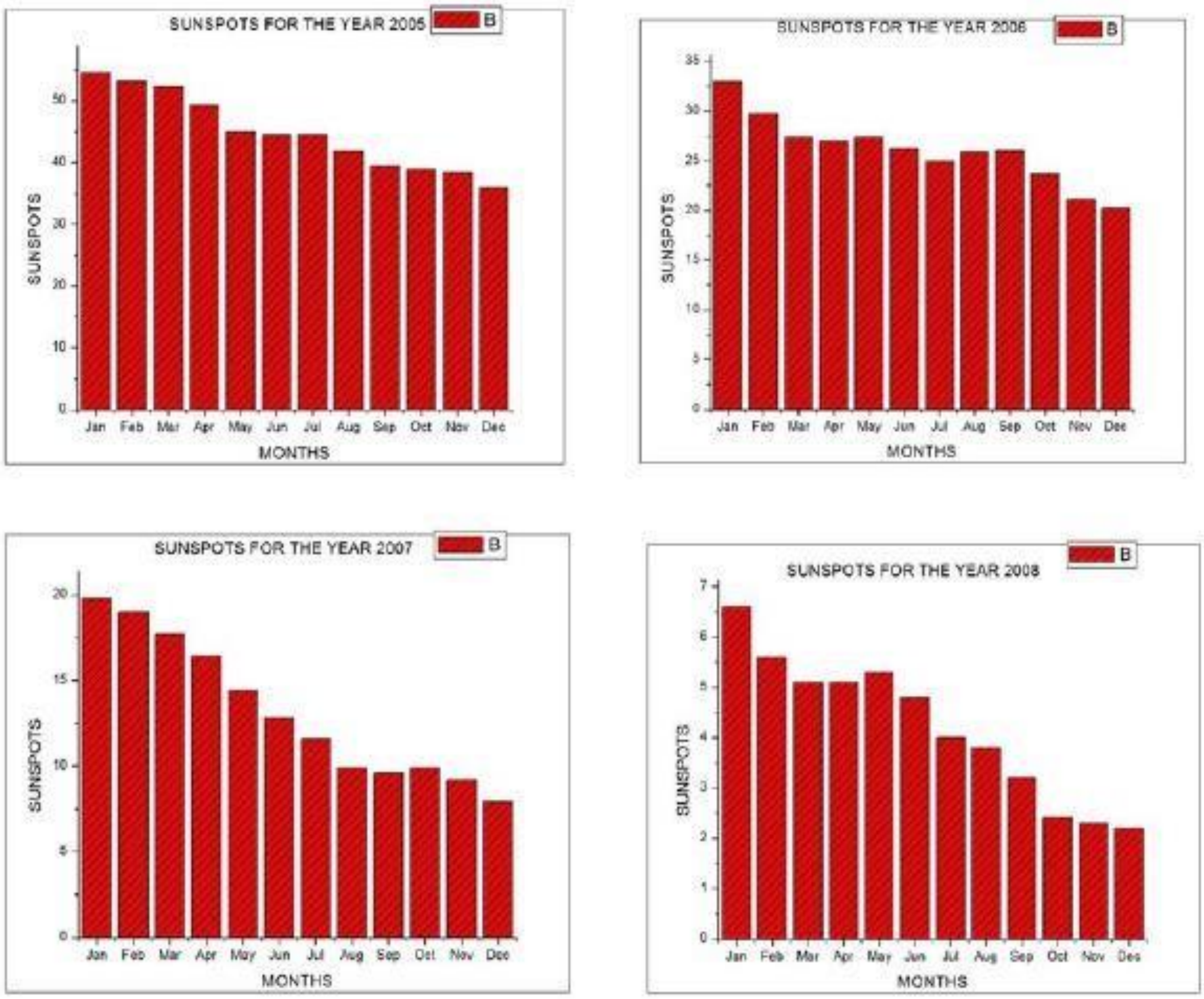

Figure 2: Monthly sunspot numbers during the year 2004

For the year 2009: The maximum number of sunspots were observed in the month of December. Initially the number of sunspots were very less and then goes on increasing.

For the year 2010: The sunspots increase linearly during this year. In January, there were only 14 sunspots. Maximum numbers of sunspots were observed in the month of December.

For the year 2011: The trend shows that the sunspots initially increase linearly and then remains almost constant during the latter half of the year. The maximum number of sunspots were observed in the month of December. decreasing andbecomes minimum in the month of July and then again starts increasing. The minimum numberof sunspots were observed in July and maximum in March.

For the year 2012: The sunspot initially increases up to March and then starts

For the year 2013: The maximum numbers of sunspots were observed in the month of December. The trend shows that initially the **For the year 2015:** The maximum and minimum numbers of sunspots were observed in the months of January and December respectively. The trend shows that the number of sunspots goes on decreasing.

For the year 2016: The trend is almost similar to the previous year. The maximum and minimum numbers of sunspots were observed in the months of January and December respectively.

For the year 2017: The numbers of sunspots during this year are comparatively lesser than the previous year. The trend shows that the number of sunspots goes on decreasing. In January, the

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sunspot number is maximum about 28.

Comparison of 23rd and 24th solar cycle

The number of sunspots in 23rd solar cycle is very less as compared to the 24th solar cycle. I was predicted by many scientists predicted that the solar activity for cycle 24 will be lower than cycle 23 (Schatten 2005; Choudhuri et al. 2007; Javaraiah 2007).The results estimated for the 24th solar is in agreement with the forecast based on the polar field precursor (Svalgaardet al. 2005).

The maximum number of sunspots observed in the 24th solar cycle is around 110 whereas in 23rd solar cycle this number is around 170. So, there is a huge difference between the sunspotsnumber for these two cycles.

sunspots are almost constant and then starts increasing.

For the year 2014: During this year the numbers of sunspots were very high. The trend showsthat the sunspots initially increase and becomes maximum in the month of April and then goes on decreasing and becomes minimum in December.

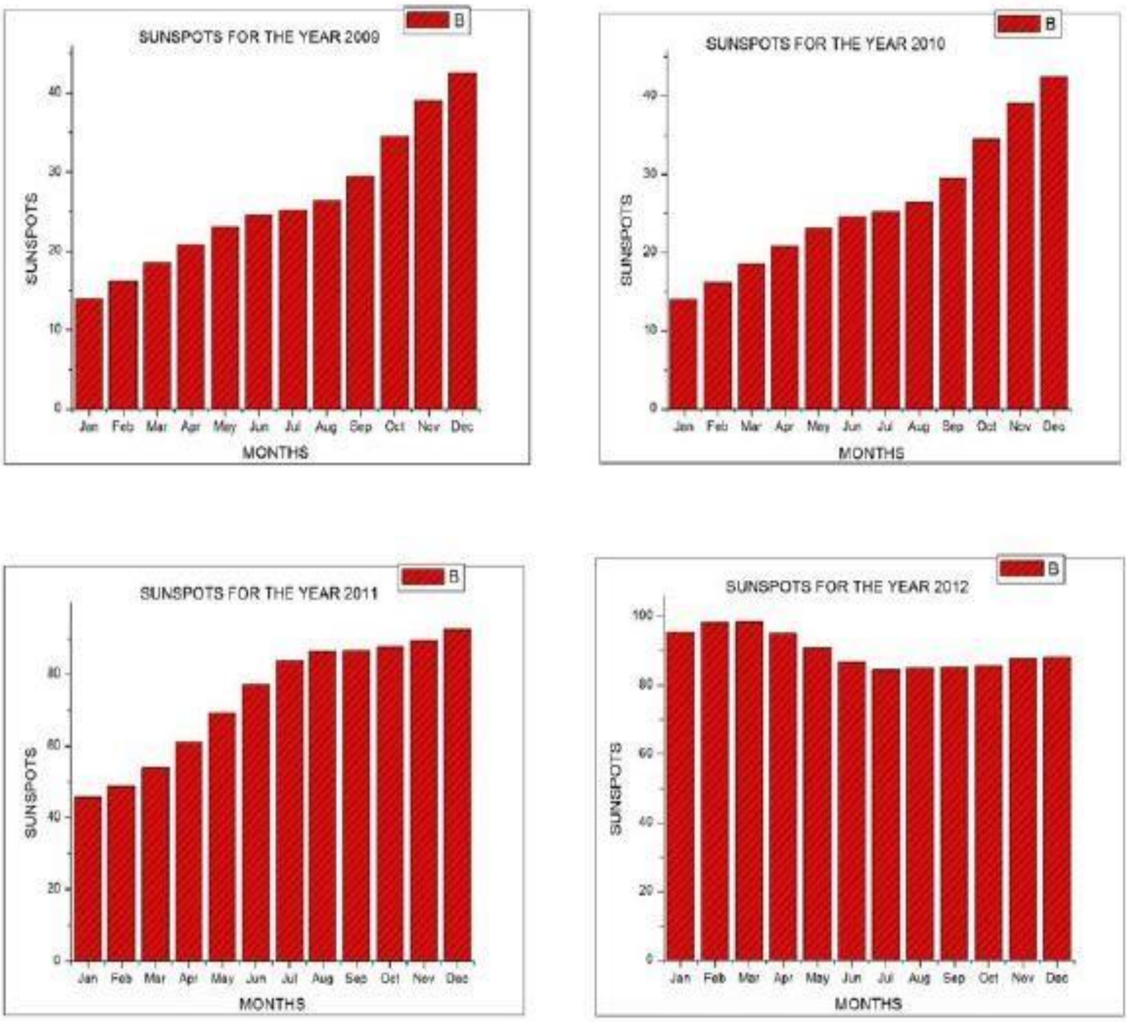

Figure 3: Monthly sunspot numbers during the years 2008 to 2012

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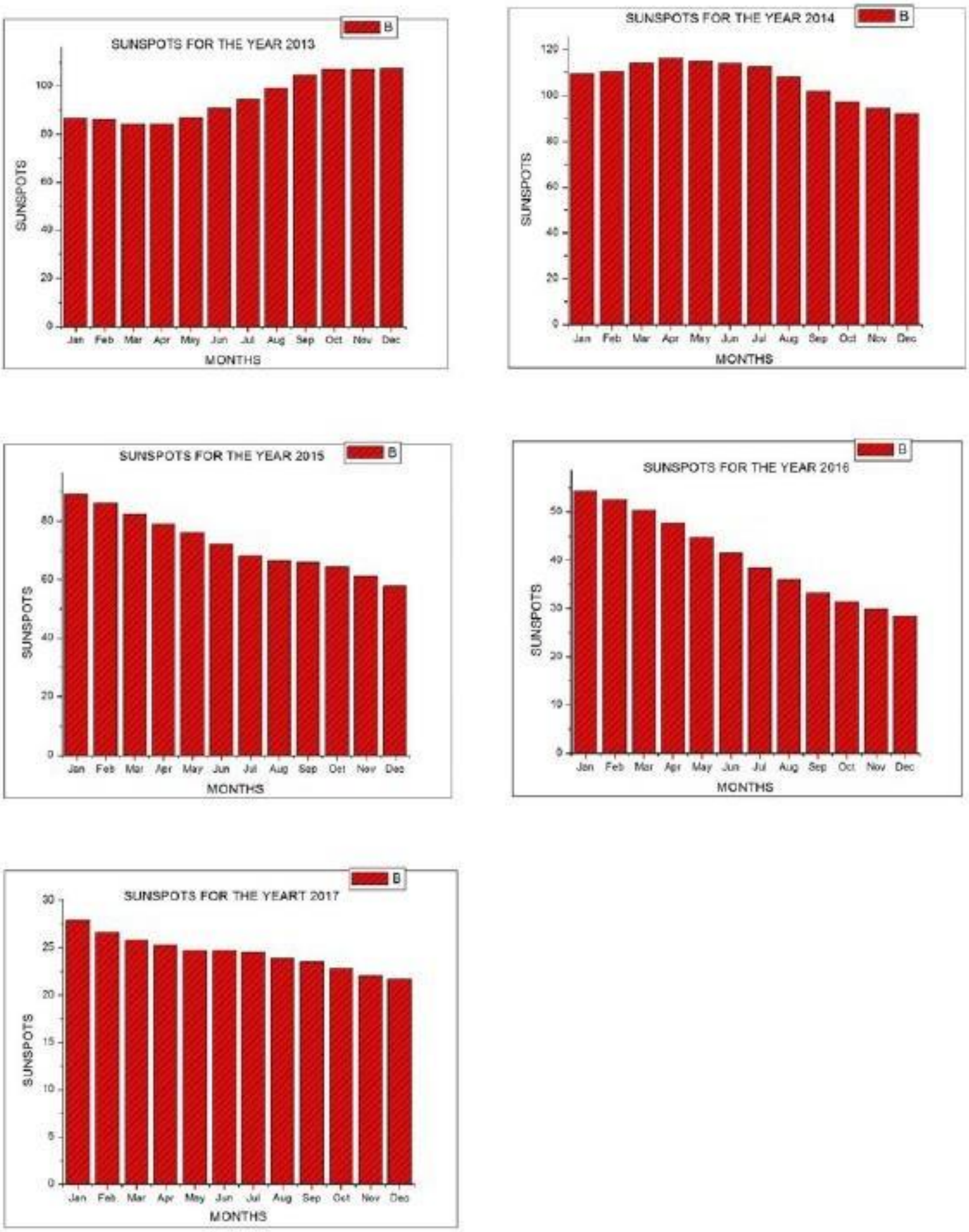

Figure 4: Monthly sunspot numbers during the years 2013 to 20

CONCLUSIONS

The solar activity for the 23rd and 24th solar cycle was observed and it was found that less number of sunspots were compared to the 23rd solar cycle. Analysis shows that for the year 2018 the solar activity for cycle 24 will be still lower than cycle 23 (Schatten 2005; Choudhuri et al. 2007; Javaraiah 2007). Our result is in agreement with the forecast that is based on the polar field precursor. Accordingto it the cycle 24 will be the smallest in the last 100 years (Svalgaard et al. 2005). On using theconcept of solar dynamo precursor method, Schatten & Tobiska (2003) predict a rapid declinestarting with cycle 24. Maris et al. (2003) observing the flare energy release during the declining phase of the precedent cycle indicated that the Sun might be heading toward a ‘‘Maunder’’ type of minimum. he result of the 23rd and 24th solar cycles reveals that there were not significant numbers of sunspot number so it could lead to the colder periods of the Little Ice Age, which lasted from about 1450 to 1820. As sunspot are very import to understand and all the solar activity depends on sunspot numbers. If the number of sunspots is more then the possibility of major activity is also more. So sunspotcycles could be also very tool in understanding the climate affect too.

Ohl AI, GI Ohl. A new method of very long-term prediction of solar activity, NOAASolar-Terr Pred Proc, 2, 268–263, 1979.

Ramaswamy G. Sunspot cycles and solar activity forecasting, Nature, 265, 713–715, 1977.

Sargent HH. A prediction for the next sunspot ctcle, 28th IEEE Vehicular Tech Conf Proc,490–496, 1978

Schatten K, S Sofia. Forecast of an exceptionally large even-numbered solar cycle,Geophys Res Lett, 14, 632–635, 1987

Schatten K. Fair space weather for solar cycle 24, Geophys Res Lett, 32, L21106, 2005

Schatten KH, PH Scherrer, L Svalgaard, JM Wilcox.

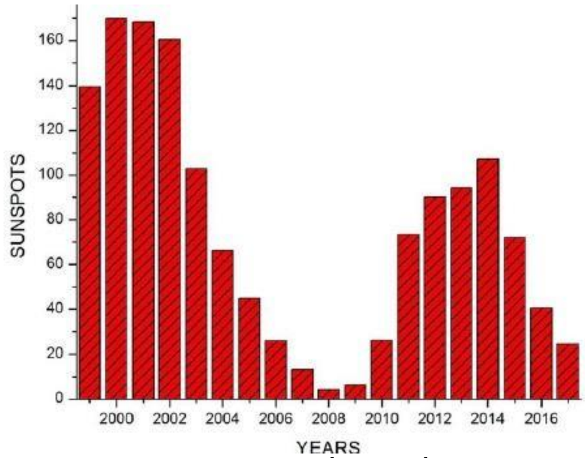

Figure 5: Comparison of 23rd and 24th solar cycle

REFERENCES

103, 6595–6603, 1998.

Brajša, R, H Wöhl, A Hanslmeier, G Verbanac, D Ruždjak, E Cliver, L Svalgaard, M Roth. Prediction for the 24th Solar Cycle, Central European Astrophys Bull, 33, 95–98, 2009.

Cameron R, M Schüssler. A robust correlation between growth rate and amplitude ofsolar cycles: consequences for prediction methods, The Astrophys J, 685, 1291–1296, 2008

Choudhuri AR, P Chatterjee, J Jiang. Predicting solar cycle 24 with a solar dynamomodel, Phys Rev Lett, 98, 131103, 2007

cycle maximum using solar cycle lengths. Sol Phys,248:203–209.

Feynman J. Geomagnetic and solar wind cycles, 1900–1975, J. Geophys Res, 87, 6153–6162, 1982.

Gonzalez G, KH Schatten. Using geomagnetic indices to forecast the next sunspotmaximum, Solar Phys, 114, 189–192, 1987.

Hathaway DH (2009). Solar cycle forecasting. Space Sci Rev, 144:401–412.

Javaraiah J. North-south asymmetry in solar activity: predicting the amplitude of the next solarcycle, Mon Not R Astron Soc, 377, L34–L38.

Kane RP (2008). Prediction of solar Using dynamo theory to predictthe sunspot number during solar cycle 21, Geophys Res Lett, 5, 411–414, 1978

Svalgaard L, E W Cliver, Y Kamide. Cycle 24: the smallest sunspot cycle in 100 years?Geophys Res Lett, 32 (1), L01104, 2005.

Thomson RJ. A technique for predicting the amplitude of the solar cycle, Solar phys, 148, 383–388, 1993

Wilson RM, DH Hathaway, EJ Reichmann. An estimate for the size of cycle 23based on near minimum conditions, J Geophys Res,