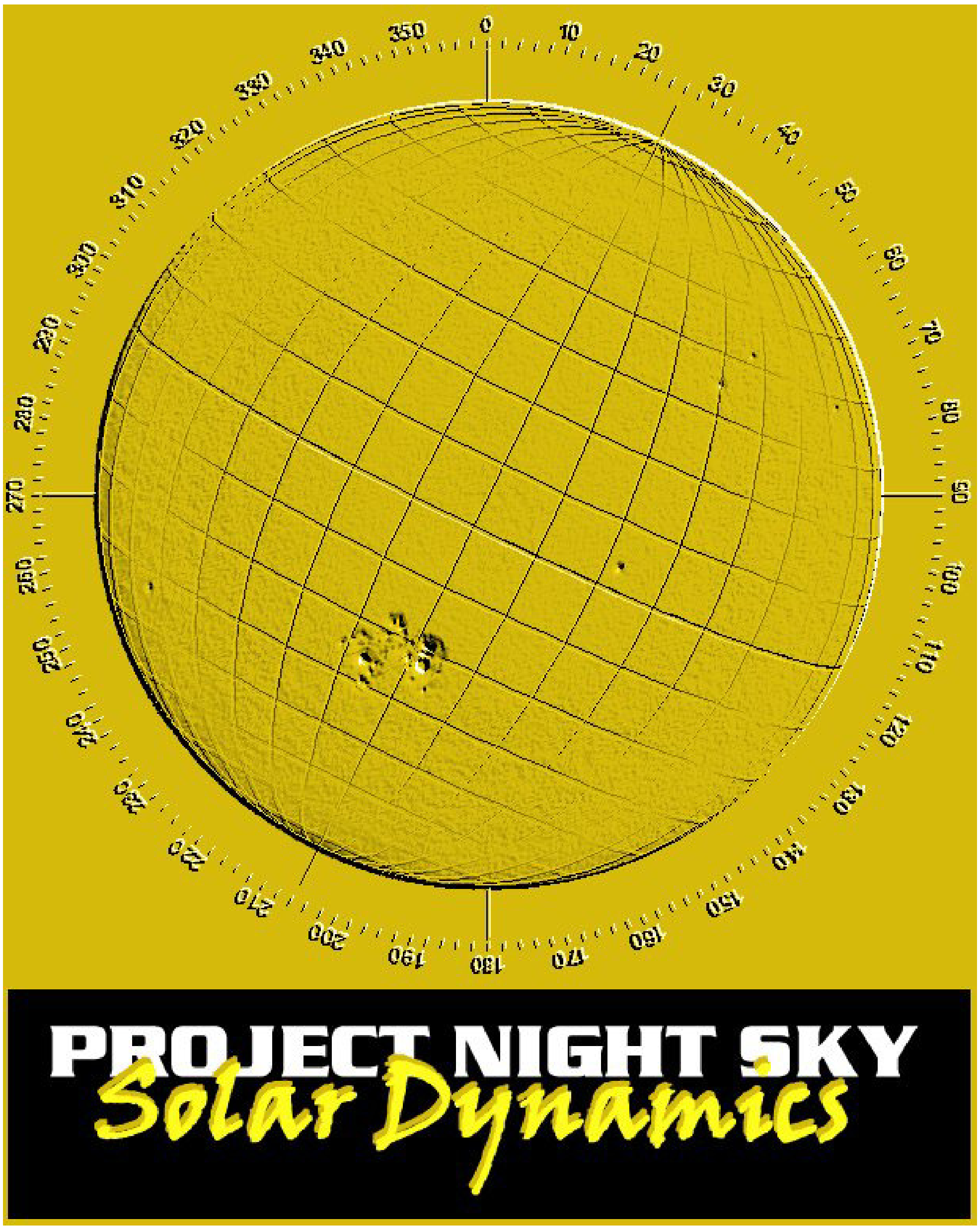
Sunspot Observations Report [2015-01-01 to 2015-06-30]



Chris J Vermeulen

Sunspot Observations Report

[1 January 2015 – 30 June 2015]

ASSA SHALLOW SKY SECTION

SUNSPOT OBSERVATIONS REPORT

1 JANUARY 2015 – 30 JUNE 2015

CONTENTS

ABSTRACT

Sunspot Groups and Numbers vary on a daily basis as they appear on the Sun's disc. This report will interpret the data collected from observations for the period 1 January 2015 to 30 June 2015.

There will be looked at the increase and decrease of both Groups and Numbers, as well as the varying trends of Sunspots as they appeared over the past 6 months. One of the problematic issues is the inaccuracy of such observations and the methods employed to curb this and provide more accurate observations.

Due to the unpredictable nature of Sunspots, it is not always easy to make accurate forecasts of the future Group and Number counts. Various methods have been used in order to make predictions on Solar Cycles.

A formula developed to make predictions based on observations done, is postulated here. It will be put to the test for observations over the next 6 months to determine the relative accuracy of observations in making forecasts.

INTRODUCTION

Sunspots [i] are a fascinating aspect of Solar Observations. They are often overlooked as much of the attention is focused on the sensational. These include the likes of flares[ii] and prominences[iii], and also CME's (Coronal Mass Ejections)[iv].

With the rising and falling of Solar Activity[v] over the average 11-year period of the Solar Cycle [vi], Solar Flares and CME's also increase and decline and this in turn affects terrestrial climate.

Most days one can observe at least one or two Sunspots/Groupings. Sunspots come in many shapes and forms and sizes, varying and evolving throughout the day as the Sun rotates.

The study of Sunspots warrants greater acknowledgement as they lay at the core of the more magnificent and spectacular outbursts on the Sun's surface.

Many studies have been done regarding Sunspots and determined patterns and trends as well as variables. These include Groupings and the formation of both Sunspots and Groups alike.

2014'S LAST QUARTER OVERVIEW

From mid to late October 2014 Solar Activity soared with the appearance of AR2912 (*Image 1*) - the largest in 24 years. This escalated the count in Numbers observed for the month, but the Group count remained steady throughout October 2014.

IMAGE 1: AR2192 as photographed on 2014-10-25

For the remainder of the last quarter of 2014 Solar Activity remained relatively low, although it must be mentioned that December 2014 did not yield many observations as only 2 observations were done.

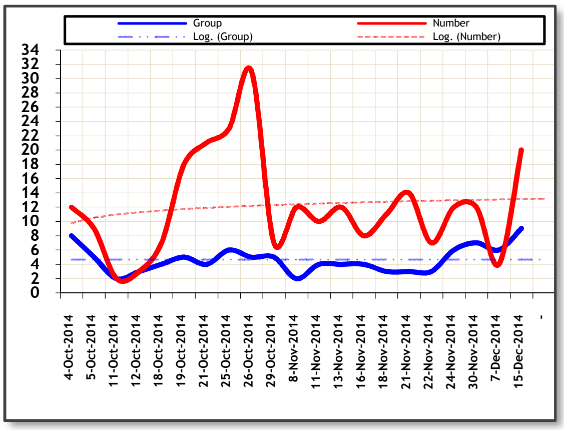


FIGURE 1: Groups and Numbers Oct-Dec 2014

The slight upward trend in Sunspot Numbers, as shown in *Figure 1*, is not to be understood as a general increase in Numbers. This upward trend is merely illustrative of the observations done and is only relative to the period 2104-10-01 to 2014-12-31.

The *Mean Daily Frequency (MDF)*[vii] for the last quarter of 2014 was calculated at 4.67 – A total of 98 Groups observed over a period of 21 days.

	Oct 2014	Nov 2014	Dec 2014
Groups	47	36	15
Observation Days	10	9	2
MDF	4.70	4.00	7.50

TABLE 1: MDF Oct-Dec 2014

Table 1 shows the values in terms of Groups and Observation days for October 2014 through December 2014, with the calculated MDF.

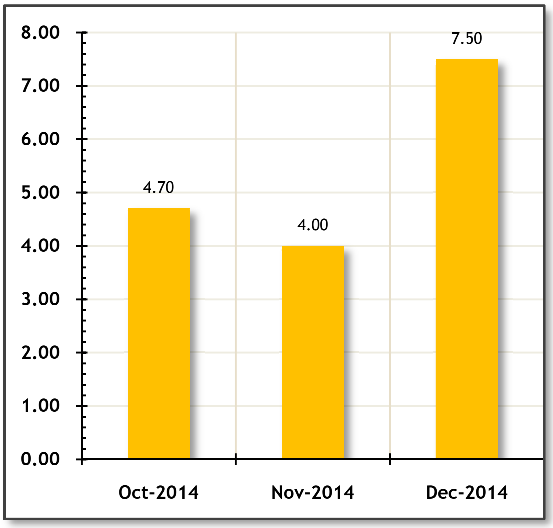


FIGURE 2: MDF Graph Oct-Dec 2014

For the period 2014-10-01 to 2014-12-31 the area from 30° North to 30° South was the most active in terms of Solar Activity, with the majority in the Southern Hemisphere – see *Figure 3*.

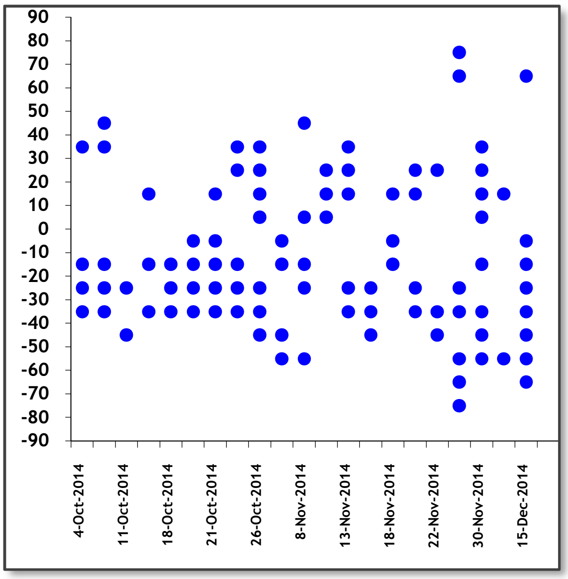


FIGURE 3: Active Latitudes Oct-Dec 2014

CURRENT CYCLE

We are currently in Cycle 24, and we are just over halfway through the cycle which commenced in 2008 and is predicted to continue until 2019.

It is the 24th Cycle since the early 1750's and its discoverer, Heinrich Schwabe, reported in 1844 a cycle of activity of about 10 years in duration[1].

Many are also of the opinion that Cycle 24 only commenced in 2011 and will continue to 2022. However, I side with the view that Cycle 24 is from 2008 to 2019. The reasoning is that a Solar Cycle is defined as the period from its minimum, preceding it maximum, to the next minimum following the maximum[2]. This is on average an 11-year cycle, although some cycles have been reported to vary between 8 to 13 years per cycle.

Following the 2008 Solar Minimum[viii], Cycle 24 appeared to have peaked around 2012, but this was followed by a second higher peak in April 2014 – the Solar Maximum[ix]. This was most unexpected and clearly shows the unpredictable nature of Solar Activity.

Now in 2015, with the Solar Minimum looming, there is still ample opportunity for Sunspot observations. The Sun has not grown quiet altogether and many Sunspots and Groups can still be observed.

Table 2 shows the number of spotless days[3], and since 2011, the spotless days were either 0, or less than 1%.

2015	0 days	0%
2014	1 day	< 1%
2013	0 days	0%
2012	0 days	0%
2011	2 days	< 1%
2010	51 days	14%
2009	260 days	71%

TABLE 2: Cycle 24 – Spotless days

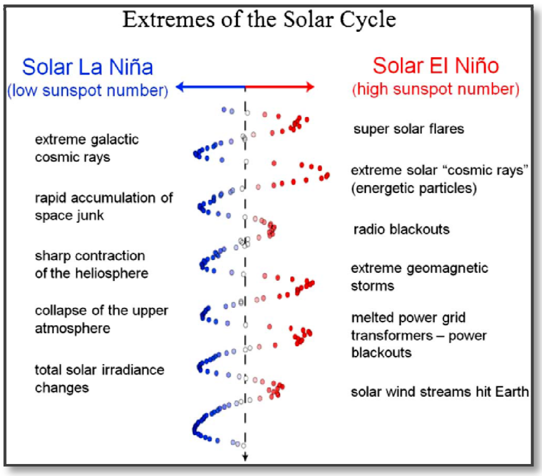


FIGURE 4: Solar Minimum & Solar Maximum

Figure 4 illustrates the opposites of Solar Minimum and Solar Maximum and the various effects that it has, not just on the terrestrial weather but also the effects it may cause on Earth[4].

[1] *David H. Hathaway, "The Solar Cycle", 2010, p.6. (www.livingreviews.org/lrsp-2010-1)*
[2] *David H. Hathaway, "The Solar Cycle", 2010, p.31.(www.livingreviews.org/lrsp-2010-1)*
[3] *SpaceWeather.com (www.spaceweather.com)*
[4] *Madhulika Guhathakurta & Tony Phillips, "The Solar Cycle turned Sideways"' 2013*

SOLAR ACTIVITY

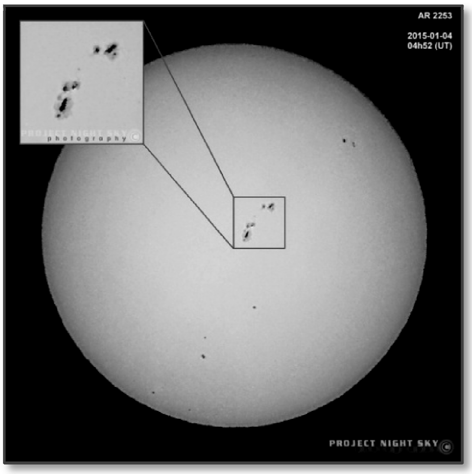


IMAGE 2: AR2292 as photographed on 2015-01-04

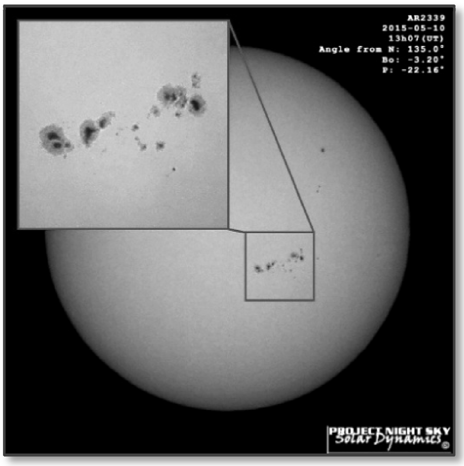


IMAGE 3: AR2339 as photographed on 2015-05-10

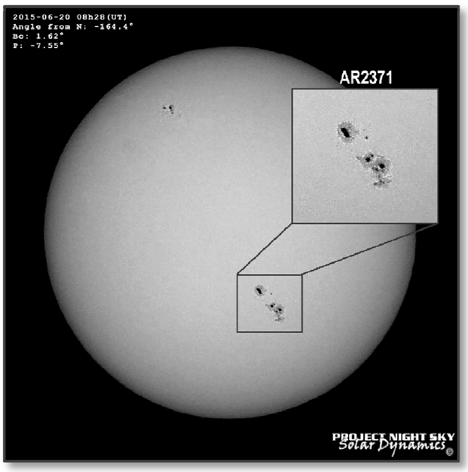


IMAGE 4: AR2371 as Photographed on 2015-06-20

Thus far the period from 2015-01-01 to 2015-06-30 has all but been quiet and many Active Regions[x] can still be observed, despite nearing the Solar Minimum. Several major Sunspots have entertained observers in these past 6 months, beginning with AR2253 in January 2015 (*Image 2*), AR2339 in May 2015 (*Image 3*) and AR2371 in June 2015 (*Image 4*).

These images not only are captivating in the sense that the Umbra[xi] and Penumbra[xii] are so clearly visible, but also that they played a significant part in the peak of the Sunspot count each month respectively.

Sunspot Groups and Numbers

The period 1 January 2015 to 30 June 2015 yielded a total of 279 Groups and 853 Numbers. *Figure 5* shows the relation to Groups and Numbers observed. The Groups remained relatively stable, while the Numbers fluctuated with several significant peaks in January 2015, May 2015 and June 2015.

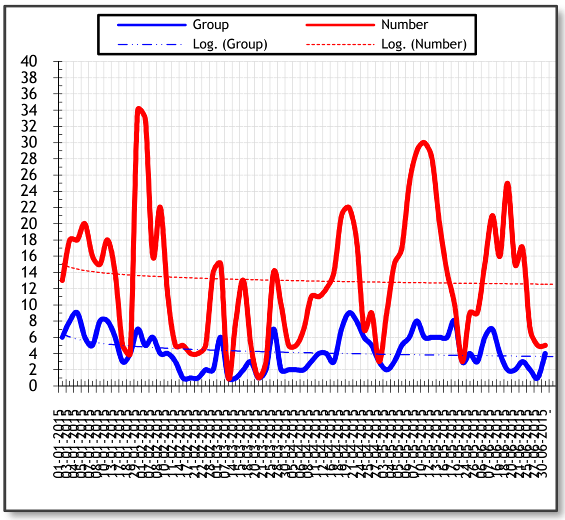


FIGURE 5: Groups & Numbers for the period 2015-01-01 to 2015-06-30

The trend as seen in *Figure 5* also shows a decline in both Groups and Numbers. This is consistent with the nearing of the Solar Minimum.

Interestingly enough is that despite the peaks in January 2015 (*Figure 6*), May 2015 (*Figure 7*), and June 2015 (*Figure 8*), the decline is prevalent even when comparing the monthly observations individually.

It is therefore argued that the increase in observations will not lead to an increase in Groups and Numbers. The number of observations for January 2015, May 2015 and June 2015 were 10, 13, and 9 respectively.

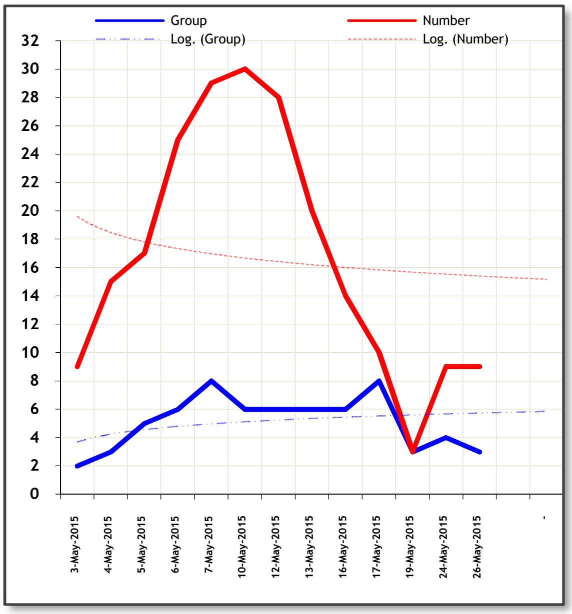


FIGURE 7: May 2015 Groups & Numbers

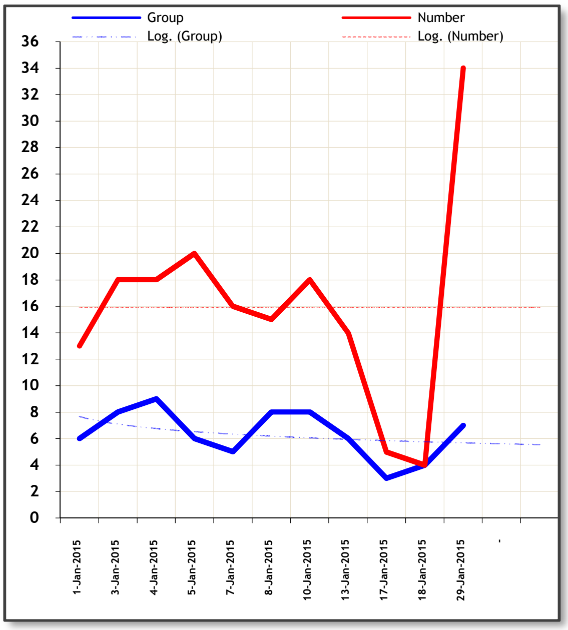


FIGURE 6: January 2015 Groups & Numbers

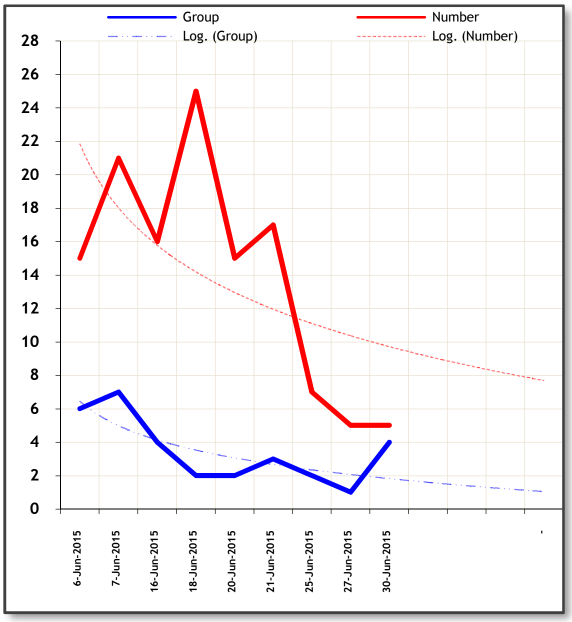


FIGURE 8: June 2015 Groups & Numbers

This is further supported when comparing to *Figure 9* and taking the April 2015 observations into consideration, where the number of observations was 12, and the trend observed showed an increase in both Groups and Numbers.

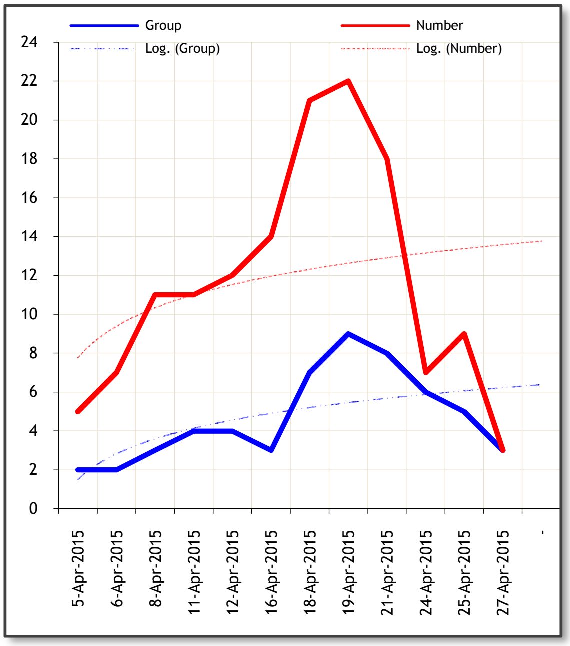


FIGURE 9: April 2015 Groups & Numbers

Mean Daily Frequency (MDF)

Sunspot cycles are very different and due to this varying nature and unpredictability, it is both challenging and exciting making observations.

One method used to provide more accurate observations is the *Mean Daily Frequency (MDF)*[5].

To demonstrate how the MDF is calculated *Table 3* shows the numbers of Groups observed for June 2015 as well as the total number of days on which observations were done.

	Jun 2015
Groups	31
Observing Days	9
MDF	3.44

TABLE 3: Mean Daily Frequency – June 2015

The MDF is calculated simply by dividing the total number of Groups observed by the number of days on which observations was done:

$$MDF = \frac{G}{D} = \frac{31}{9} = 3.44$$

The same principle was applied when calculating the MDF monthly for January 2015 through June 2015, as shown in *Figure 10*.

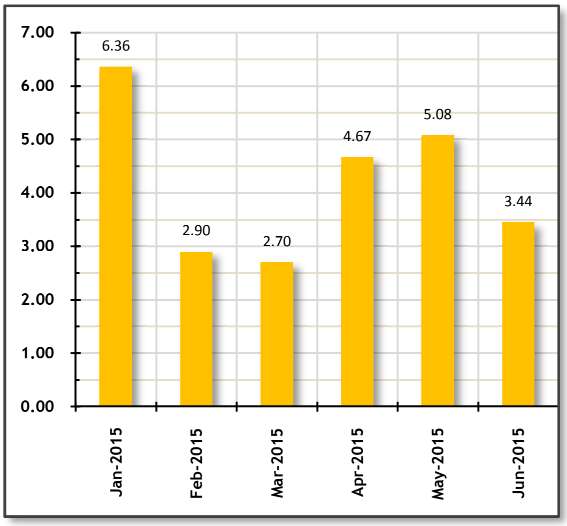


FIGURE 10: Mean Daily Frequency (Jan – Jun 2015)

[5] *Lee Macdonald, "Beginners Guide to Observing the Sun" (PDF), 2008. (www.suntrek.org/images/Beginners_Guide_to_Observing_the_Sun.pdf)*

International Sunspot Number (R_i)

Another method used to record observations is the International Sunspot Number[xiii]:

$$R_i = k(10g+f)$$

Belgium's estimates were made with a k-factor value of 1.0, presenting a departure from the Zurich value of 0.6. Since that time, it has varied from that value and is currently approximately 0.9. It is designated by the International Astronomical Union (IAU) to be one of the "official" relative sunspot numbers computed today[6].

- Therefore the value of $k = 1$.
- The value of g = the total number of groups of sunspots.
- The value of f = the total number of individual sunspots.
- *10* is the weight assigned value to the cluster of groups (According to the Wolf Index (R)[xiv]).

	Jun 2015
Groups	31
Numbers	126
R_i	436

TABLE 4: International Sunspot Number – June 2015

Remember $k = 1$ as above. If a total of 31 groups of sunspots (g=7) and a total 126 individual sunspots (f=126) were observed for June 2015 (*Table 4*), the formula will look as follows:

- $R_i = k(10g+f)$
- $R_i = 1.0((10)31+126)$
- $R_i = 1.0(310+126)$
- $R_i = 1.0(436)$
- $R_i = 436$ [Note that this is not the total number of Sunspots observed, but recorded as the International Sunspot Number for June 2015 observations.]

	Jan 2015	Feb 2015	Mar 2015	Apr 2015	May 2015	Jun 2015
Groups	70	29	27	56	66	31
Numbers	175	119	75	140	218	126
R_i	875	409	345	700	8787	436

TABLE 5: R_i – Jan 2015 to Jun 2015

The same Formula was applied for observations for the period 2015-01-01 to 2015-06-30 (see *Table 5* and *Figure 11*):

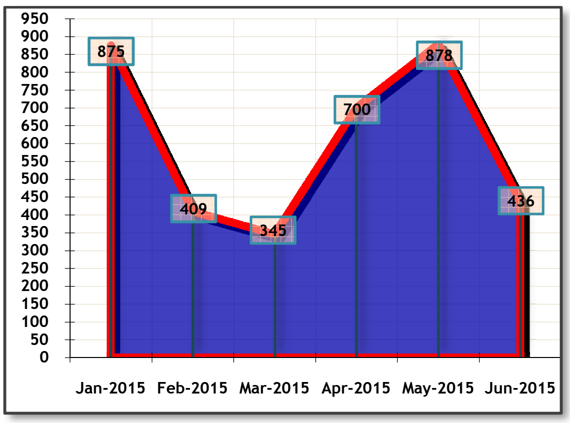


FIGURE 11: R_i January 2015 to June 2015

[6] *Carl E. Feehrer . "Dances with Wolf's: A Short History of Sunspot Indices", 2000*

ACTIVE LATITUDES

Active Latitudes[xv] are associated with the areas on opposite sides to the Sun's equator. These areas are roughly between 40° North and 40° South. The reason for this is due to the differential Solar Rotation[xvi] as the Sun does not rotate as a solid body.

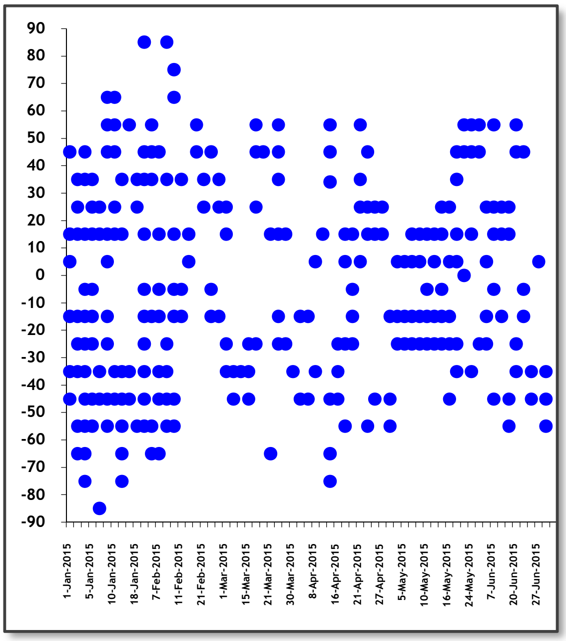


FIGURE 12: Active Latitudes Jan 2015 – Jun 2015

Figure 12 illustrates the Active Latitudes for the period 2015-01-01 to 2015-06-30. As can be seen these areas generally fall between 40° North and 40° South of the Sun's equator.

But the most significant activity appears closer to the equator in the areas between 25° North and 25° South.

It must be noted that the date provided was manually done and derived from observations over the same period and no instrumentation was used to compile the data as plotted in *Figure 12*. Therefore the accuracy is not completely guaranteed and leeway must be allowed for some variance.

Smoothing

Hathaway stated that the Solar Cycle each display different characteristics and often these are shared by other cycles, and determining these characteristics are not quite as simple as it seems[7].

Monthly averages can be '*noisy*' and may not produce the most accurate data, therefore these values must be smoothed in order to have accurate calculations which provides appropriate values.

Initially a 13-month running mean average was used, but this appeared inadequate and as a result a 24-month Gaussian Filter was applied for more consistent results[8].

Smoothed Latitude Count

I have applied a similar principle, by using a 24-month moving average, in order to calculate the frequency for Active Latitudes.

[7] *David H. Hathaway, "The Solar Cycle", 2010, p.25. (www.livingreviews.org/lrsp-2010-1)*
[8] *David H. Hathaway, "The Solar Cycle", 2010, p.29. (www.livingreviews.org/lrsp-2010-1)*

Figure 13 shows the Smoothed Latitude Count as percentage. Unfortunately this data has not been compared to any other relative studies or results in order to verify accuracy.

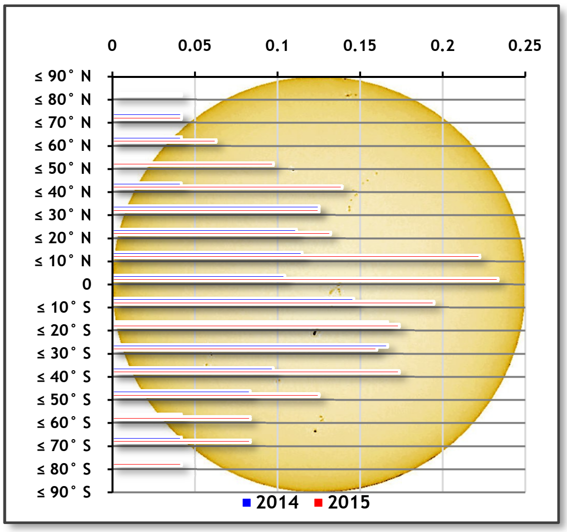


FIGURE 13: Smoothed Latitude Count

In *Figure 13* the Active Latitudes are narrowed down even more to 10° North and 10° South of the Sun's equator for 2015, as opposed to *Figure 12*, which is more broader in its spectrum.

PREDICTIONS

Predicting Solar Cycle is very difficult and there are several scientific methods and specialized equipment and instruments used to make predictions.

However, for the amateur, these means are either too expensive or out of their league. This is the reason why I have developed a formula which could assist the amateur in making predictions. The *Smoothed Predictive Daily Frequency (SPDF)* is aimed at doing just that and is as follows:

$$f = \frac{t\left(\frac{g}{d} \times \frac{r}{p}\right)}{s}$$

- ***f*** = Smoothed Predictive Daily Frequency [SPDF]
- ***t*** = Timeframe of observations done [in months]
- ***g*** = Groups observed in Timeframe
- ***d*** = Days of observation in Timeframe
- ***r*** = Rotation period of the Sun [28 Days]
- ***p*** = Forecast Period [in months]
- ***s*** = Smoothing factor [24-month moving average]

The SPDF is a prediction based on the number of observations done, specifically to assist the amateur who does observations at irregular interval on a monthly basis.

Using the data as per *Table 6*, the formula would look as follows:

	Jan 2015	Feb 2015	Mar 2015	Apr 2015	May 2015	Jun 2015	TOTAL
Groups	70	29	27	56	66	31	**279**
Days	11	10	10	12	13	9	**65**

TABLE 6: Groups & Days of Observation – Jan 2015 to Jun 2015

$$f = \frac{6\left(\frac{279}{65} \times \frac{28}{6}\right)}{24}$$

$$f = \frac{6\left(\frac{46.5}{2.32}\right)}{24}$$

$$f = \frac{6\ (20.04)}{24}$$

$$f = \frac{120.24}{24}$$

$$f = 5.01$$

According to the formula the SPDF at the end of the next 6 month period 1 July 2015 to 31 December 2015 will be 5.01 and this value is then to be interpreted as the MDF value at the end of December 2015.

CONCLUSION

Solar Observation in Southern Africa is an open field of research for amateur astronomy. There are only a few amateurs in Southern Africa that do solar observation,

We in Southern Africa are very fortunate to have much more open skies than in the northern hemisphere. Solar Observation in the northern hemisphere is far more developed than here in Southern Africa.

We can therefore contribute a lot to the science of solar activities. We need to encourage people with interest to do solar observations in different ways and build a local database, which we can share with international organisations.

At the moment members do sunspot observations and submit observations to the ASSA Shallow Sky Section.

The average number per observer per day calculates the monthly R_i Sunspot Number, for that month. The more observers participating in the counting of sunspots, the more accurate this R_i number will be.

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1. Hathaway, D.H., 2010, *The Solar Cycle*. Living Rev. Solar Phys., 7, lrsp-2010-1. (www.livingreviews.org/lrsp- 2010-1)

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3. Guhathakurta, M., and T. Phillips (2013), *The Solar Cycle Turned Sideways*, Space Weather, 11, 212–213, doi:10.1002/swe.20039

4. Lee Macdonald, *"Beginners Guide to Observing the Sun" (PDF), 2008.* (www.suntrek.org/images/Beginners_Guide_to_Observing_the_Sun.pdf)

5. Carl E. Feehrer . *"Dances with Wolf's: A Short History of Sunspot Indices"*, 2000.

TERMS AND DEFINITIONS

[i] **Sunspots**: Cooler regions of the solar surface caused by intense localized magnetic fields that bring the upward convection of internal material to a virtual standstill.

[ii] **Flares**: A sudden release of the Sun's energy which occurs in the chromosphere.

[iii] **Prominences**: A dense cloud of material that can be seen just outside the bright photosphere of the Sun.

[iv] **CME's**: A massive burst of gas and magnetic field.

[v] **Solar Activity**: Natural phenomenon appearing on the Sun and in its magnetically heated outer atmosphere.

[vi] **Solar Cycle**: the period from its minimum, preceding it maximum, to the next minimum following the maximum.

[vii] **Mean Daily Frequency**: Method of calculating the monthly average.

[viii] **Solar Minimum**: A time of quiet, when almost nothing happens.

[ix] **Solar Maximum**: A time of action, marked by massive explosions and dangerous space weather.

[x] **Active Regions**: A sunspot group which contains one or more spots is given a designated "AR" number by NOAA (the National Oceanic and Atmospheric Administration). These numbers are used to identify the sunspot groups as they cross the face of the Sun.

[xi] **Umbra**: The dark central region of a Sunspot.

[xii] **Penumbra**: The gray area which frequently, but not always, appears around an individual sunspot or group of sunspots.

[xiii] **International Sunspot Number**: A method used to record observations and compute Sunspot Numbers

[xiv] **Wolf Index**: The traditional method of counting sunspots. Count the individual sunspots. Count the number of groups. (An individual sunspot can count as a group if it is sufficiently separated from other spots or groups.) The Wolf number is ten times the number of sunspot groups plus the number of spots.

[xv] **Active Latitudes**: The areas between 40° North and 40° South when Sunspot are common.

[xvi] **Solar rotation**: The sun does not rotate as a solid body. The equator rotates in about 25 days, the polar area in about 30 days. Use about 28 days for a solar rotation at typical sunspot latitudes.

Faculae: A relatively large (greater than an arc minute) irregularly shaped light area; sometimes serpentine in shape. Sunspots are usually located in Facula.

Granulation: A fine grain structure of the solar photosphere. Grains appear to be one to two arc-seconds in diameter.

Light bridge: A bright ribbon or band that may appear to connect two sunspots.

Limb darkening: The effect of perspective where the edge of the solar disk appears darker than the center because it is a sphere.

Penumbral fibril: Fiber like lines that may appear to radiate out from an umbra into the surrounding penumbra.

Penumbral fragment: A penumbra without a sunspot.

Penumbral grain: A granular or small patchy structure that may be visible in the penumbra.

Pores: A tiny, less than one arc-second, dark areas which are not as dark as a sunspot.

Sunspot Group: A group may be anything from a single isolated sunspot to a complex elongated cluster of spots.

Wilson effect: This effect of perspective is seen when a sunspot is near the solar limb. The umbra appears displaced within the penumbra, usually toward the center of the sun.