The Sun and Sunspots (GROUP A)

By Abbie Chadwick, Patrick Heartless and John Buckley.

Our research

One interesting aspect of the Sun is its sunspots. Sunspots are areas where the magnetic field is about 2,500 times stronger than Earth's, much higher than anywhere else on the Sun. Because of the strong magnetic field, the magnetic pressure increases while the surrounding atmospheric pressure decreases. This in turn lowers the temperature relative to its surroundings because the concentrated magnetic field inhibits the flow of hot, new gas from the Sun's interior to the surface.

Sunspots tend to occur in pairs that have magnetic fields pointing in opposite directions. A typical spot consists of a dark region called the *umbra*, surrounded by a lighter region known as the penumbra. The sunspots appear relatively dark because the surrounding surface of the Sun (the photosphere) is about 10,000 degrees F., while the umbra is about 6,300 degrees F. Sunspots are quite large as an average size is about the same size as the Earth.

Sunspots increase and decrease through an average cycle of 11 years. Dating back to 1749, we have experienced 23 full solar cycles where the number of sunspots have gone from a minimum, to a maximum and back to the next minimum, through approximate 11 year cycles

Sunspots do not appear everywhere on the Sun. They usually concentrated in two bands, about 15-20 degrees wide in latitude, that go around the Sun on either side of the solar equator. The average latitude of those bands varies with the solar equator. The average latitude of those bands varies with the solar cycle. Just after the minimum of the solar cycle, sunspots appear at an average latitude of about 25-30 degrees (both north and south of the equator). As the solar cycle progresses, newer sunspots appear closer to the equator. The last sunspots of the solar cycle appear closer and closer to the equator. The last sunspots of the solar cycle appear at an average latitude of about 5-10 degrees. During all stages of the solar cycle, sunspots are almost never found altitudes greater than about 70 degrees.

Our Task

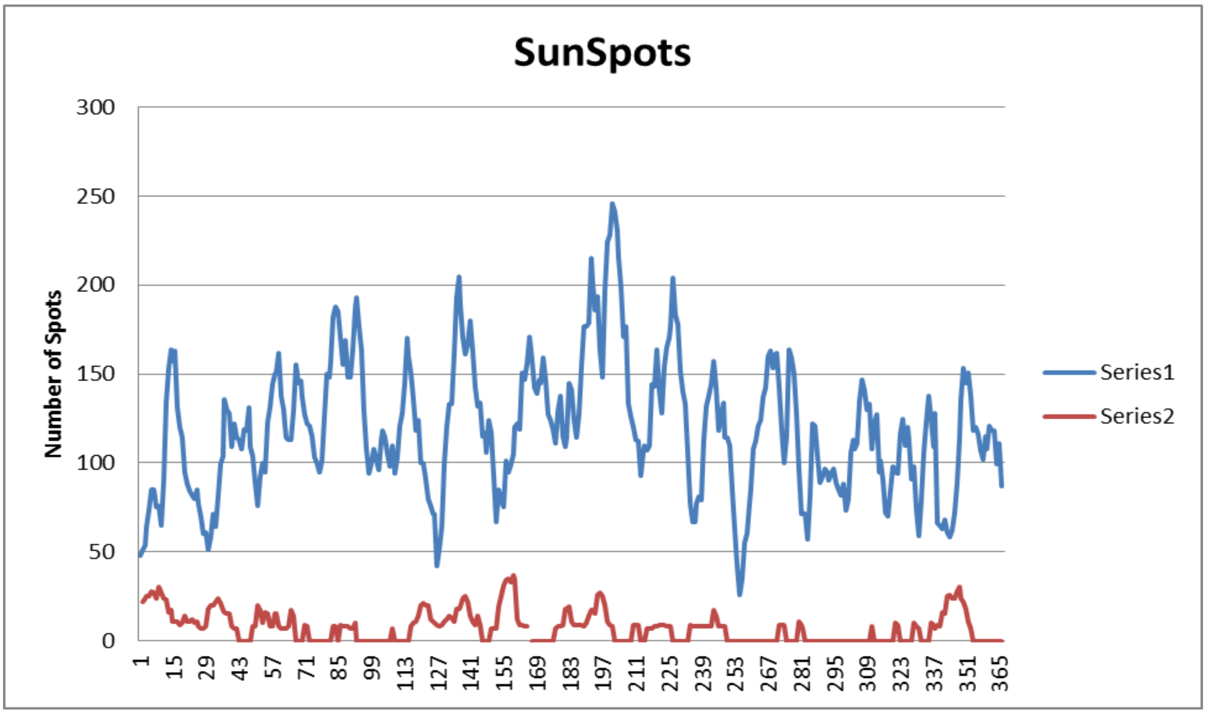
Our task was to determine the rotation period of the Sun using data from the GONG solar telescope on Tenerife, and to investigate one hundred years of sunspot data, to see if any patterns emerge.

How we got the results?

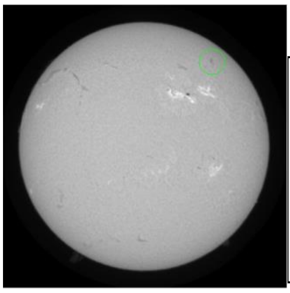
We were presented with data of the number of sunspots for each month spreading over a 108 year period. As well as .FITs file of the sun, from these we had to determine the rotation period of the sun. The images we had were taken by the GONG solar telescope in Tenerife. To do this we had to use ds9, this is an astronomical imaging and data visualization application. In order to determine the rotation period of the sun we picked a feature on the sun, so in this instance we used a sunspot. In order to ensure we had the same sunspot after the rotation we took the longitude and latitude of the spot, if after the full rotation the spot was in the same place we would identify the frame it first appeared on and the day it re-appeared. By doing this we could identify the rotation period of the sun, at the equator we got a reading of 26 days. Whereas at the pole the rotation period appears to be longer, this for us was, 32 days. This data we collected corresponds to those found earlier; the reason for the polar rotation being longer is the differential rotation of the sun. The further you go from the equator the slower the rotation appears to be.

Our other data was 108 years of Sunspots from 1900 to 2008. For each year there were 12 different pieces of data indicating the amount of sun spots per month, we then took the average for each of the years, once the averages had been taken for all of the years. They were then put into a graph which is represented below.

There was also information about sunspots from 2000 and 2007. For each of these years there 365 pieces of data, this was the amount of sunspots per day. These pieces of information were put into a graph which again is represented below.



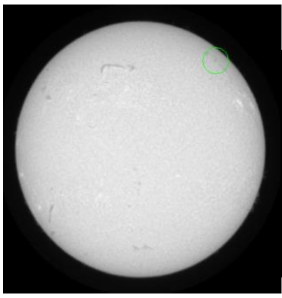
For the rotational period we have a polar period of 32 days, the method has already been explained above. The circle on the picture shows the solar flare we chose.



This is day 9.

X=1512.857

Y=1638.306



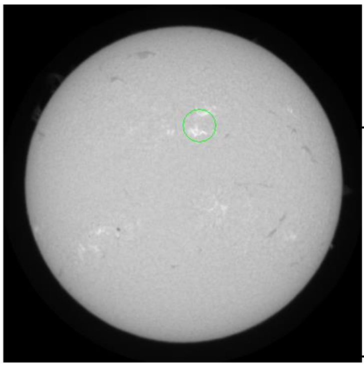
This is day 41.

X= 1631.201

Y=1638.306

This is an approximation for the polar cycle as more accurate ways of tracking the sun spot would be needed in order to make the results more precise.

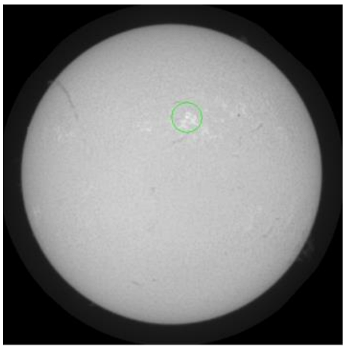
The solar period of rotation is less than the period of the equator; this is due to the differential rotation of the sun. We found the period to be 26 days; we did this using the same method as the polar.



This is day 1.

X=1117.925

Y=1364.177

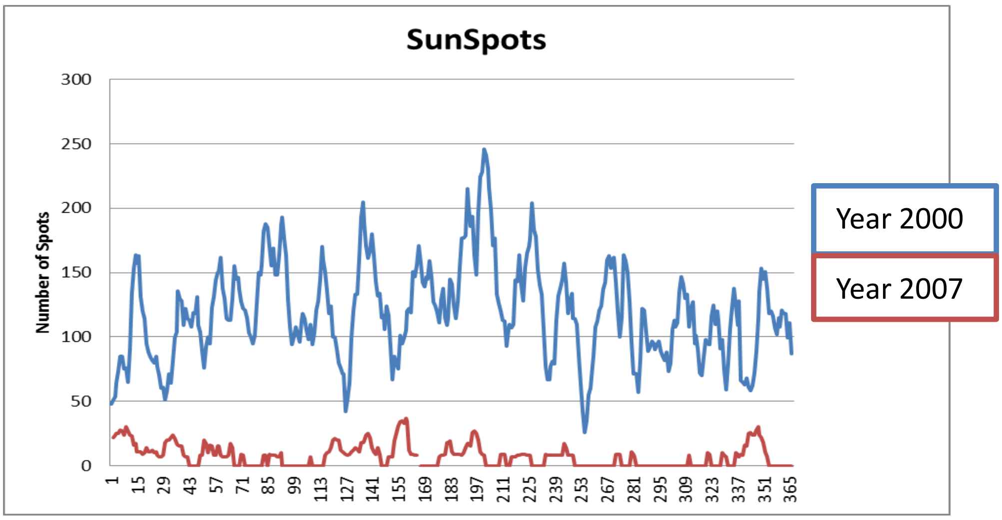


This is day 27.

X=1117.925

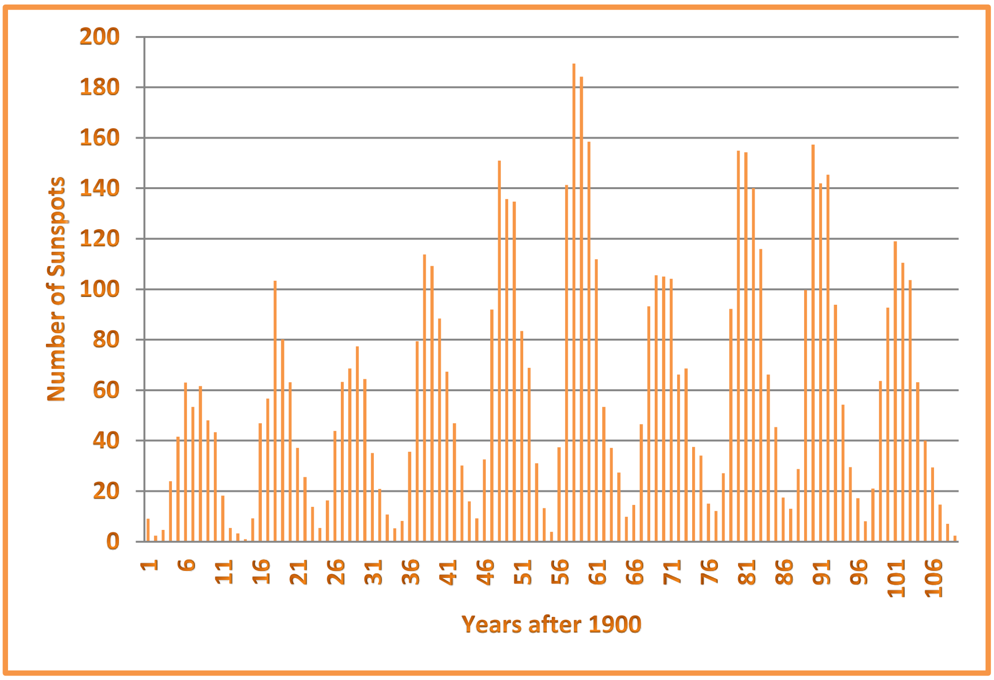
Y=1384.234

The other part of our task was to look at trends in the amount of sunspots over the 108 years of data. We found that there is a cycle of 11 years. At the start of the cycle there is very low activity and minimal sunspots. After 5.5 years, the amount of sunspots reaches its peak then decreases back again at the 11 year end point. The amount of sunspots seems to increase from 1900 up until the 1960s were this reaches a maxima, this is known as the modern maxima.

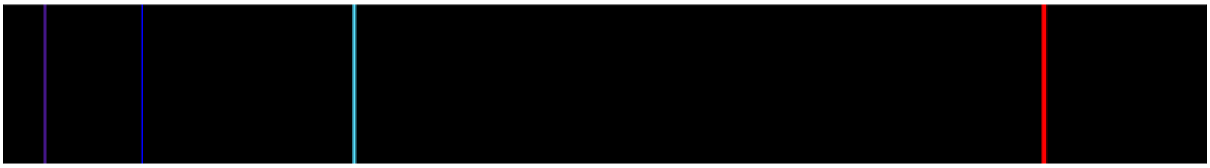


Seemingly after this maximum the number of sunspots starts to decrease. We then had a set of 2000 and 2007 sunspot data. As mentioned prior there are 365 sets of data this is the days. So we have a record of the number of sunspots per day for each of the years.

This graph shows that the sunspot activity in 2000 is a lot higher than the activity from 2007. After further research we have found that in the year 2000 it was the last flare up in the sunspot activity upon the sun. In the year 2007 it was a period of minimum sunspots, just like we have seen in our data through the fluctuation on an 11 year basis. In 2011 there was supposed to be another flare up but there has been a prolonged period of minimum with no large peak. This has no obvious reason and so is the cause of many physicists and mathematicians across the world.



The data was taken from the GONG telescope in Tenerife using a H-Alpha filter. A H-Alpha has a wavelength of 656.281m and so can be detected by using a specific filter. Astronomers use this method as it is the easiest way to trace ionised hydrogen content in the gas clouds of a planet or star. H-Alpha is visible in the red part of the electromagnetic spectrum and is shown in the diagram below as the red line on the far right after ionisation.



The hydrogen atom takes almost as much energy to excite from n=1 to n=3 as it does for actual ionisation, this means that the probability of the electron being excited to n=3 without being removed it very small. After being ionised, the electron and proton recombine to form a new hydrogen atom and within the new atom the electron will be in any energy level and so will try to cascade to the ground state (n=1). This emits photons of a corresponding wavelength according to the discrete values of the energy level jumps. Within this will be the cascade of n=3 to n=2 which will emit the H-Alpha wavelength of light.

External Research

As part of this project we undertook some external research that would help us to complete our main project. These were to investigate the sun and sunspots; safe ways of observing the sun as well as the GONG solar networks. The Global Oscillation Network Group (GONG) is a community-based program to conduct a detailed study of solar internal structure. GONG is a six-station network of extremely sensitive and stable velocity imagers located around the Earth to obtain nearly continuous observations of the Suns "oscillations", or pulsations. There are many safe ways to observe the sun these include; using eclipse glasses or welders goggles rated 14 or higher; Specially designed solar telescopes or binoculars; Specially approved solar filters and pinhole projectors. Sun spots have already been detailed in our introduction

Conclusion

While conducting our work we have noticed that within the sunspot data there has been a clear 11 year cycle of diminishing number of sunspots followed by a large peak in number normally in the middle two-three years. Along with this we have noted that outside of the smaller fluctuations there seems to be a clear incline overall in the number of sunspots culminating in the largest peak of all. After this, within our data, there is a dramatic dip in the number of sunspots for the following eleven years. This cannot be proven as our sample size for our data, though large by normal standards, is relatively small in the grand scheme of the eleven year cycle. When looking at our graph from 1900-2008 there are the beginnings of a larger cycle of maybe around one hundred years where the overall number of sunspots is rising before peaking then dropping overall.

The rotational time period of the sun was found by following two sunspots, one at the equator and one at the poles, cross the frames of the sun through a H-Alpha filter. It is the H-Alpha filter that allows our images show very clearly the sunspots as there is not as much emission of hydrogen from the areas of sunspot formation.

References

https://en.wikipedia.org/wiki/Sunspot

http://en.wikipedia.org/wiki/Eddy_current_brake

http://en.wikipedia.org/wiki/Eddy_currents

http://www.space.com/15614-sun-observing-safety-tips-infographic.html

http://www.icstars.com/HTML/SolarSection/HAlpha/

http://www.thesurfaceofthesun.com/sunquakes.htm?

http://www.space.com/11506-space-weather-sunspots-solar-flares-coronal-mass-ejections.html