Tracking Sun Spots

Grade: 9
Curriculum Outcome: 312-6 Describe the effects of solar phenomena on Earth – sunspots

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Tracking Sun Spots

Sunspots are planet sized regions on the Sun`s photosphere, or surface, that appear as dark areas. Sunspots have been observed since ancient times, having been well recorded as far back as 350 BC. There are even a few earlier writings and drawings that depict them. These early observations were performed using the naked eye, which is very dangerous to the eye's light sensitive membrane, the retina.

Perhaps one of the most famous observers of sunspots was Galileo who, in 1610, first saw sunspots magnified though the telescope he had just invented.

A picture of Sunspots across the surface of the Sun. They only appear dark in contrast with the brightness of the background, in reality they are still very bright.

The inner part of the sunspot is the darkest in colour and is called the umbra, whereas the outer part is lighter in colour and is referred to as the penumbra. The middle of a sunspot can reach temperatures as 'cold' as 4000°K, or 3700°C. Sunspots are only dark compared to the bright Sun and if you were to remove the average sunspot from the sun and place it into the sky it would still be as bright as a full moon.

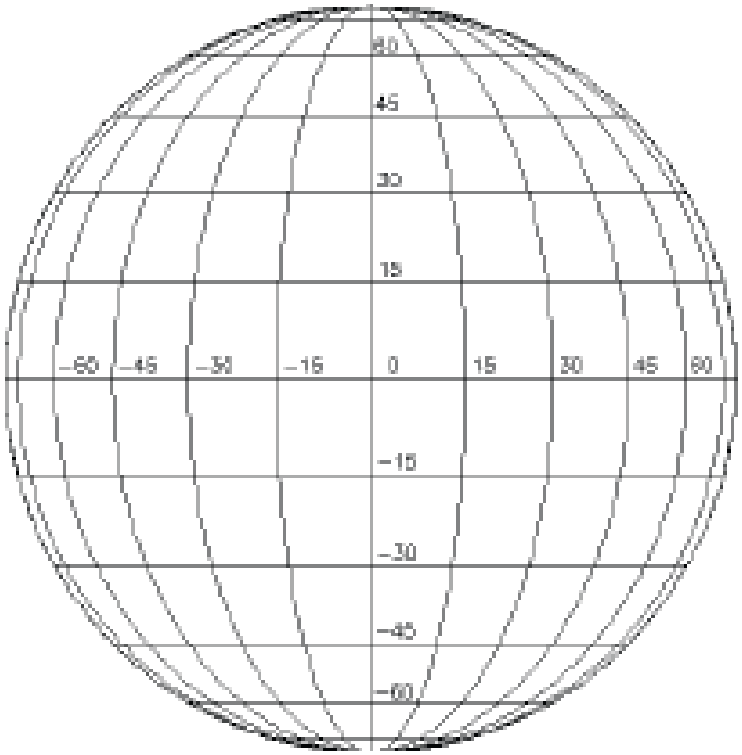
Sunspots can vary in size and sometimes are so large that they can be seen with the naked eye. While this is possible, it is not recommended without the use of a light-shielding filter. Sunspot diameters tend to range anywhere between 4,000 to 30,000 kilometres, while their shapes can be anywhere from circular to more complex. Sunspots typically occur in pairs and they can exist for different lengths of time. Historical records show that a sunspot cycle exists, in which the number of sunspots observed on the sun's surface can increase or decrease over a period of 11 years. While some cycles may exhibit many sunspots, others may reveal very few.

Sunspots are caused by the sun`s magnetic field approaching the sun`s visible surface. These magnetic fields around the sunspots produce something known as active regions. Active regions are usually comprised of multiple sunspots

Sunspots can typically be found between -35 degrees south, and +35 degrees north of the Sun's equator. They tend to form at high latitudes at the beginning of a new solar cycle (away from the equator), but as the cycle reaches a maximum the spots form at lower latitudes (nearer the equator).

Activity 1:

Draw the location of your identified sunspot.
Make sure to plot them as
accurately as possible



Day 1 Observations:

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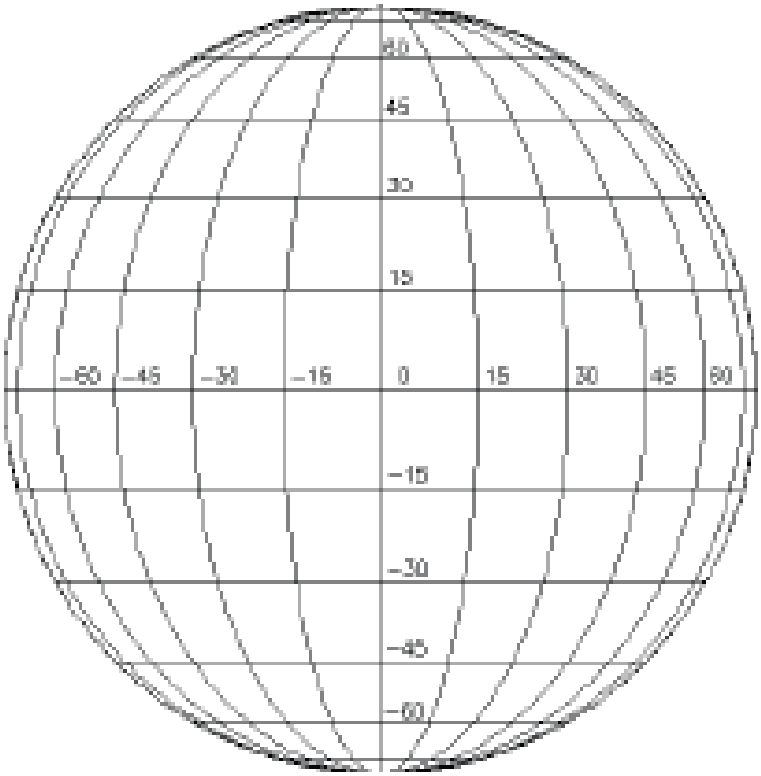
_____

_____

_____



Day 7 Observations:

_____

_____

_____

_____

Activity 1:

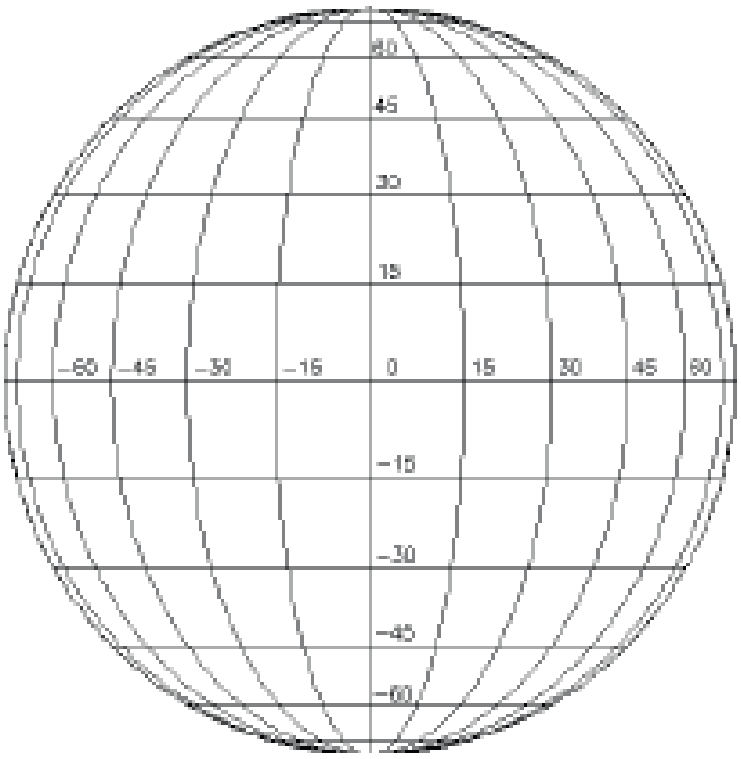
Day 14 Observations:

_____

_____

_____

_____



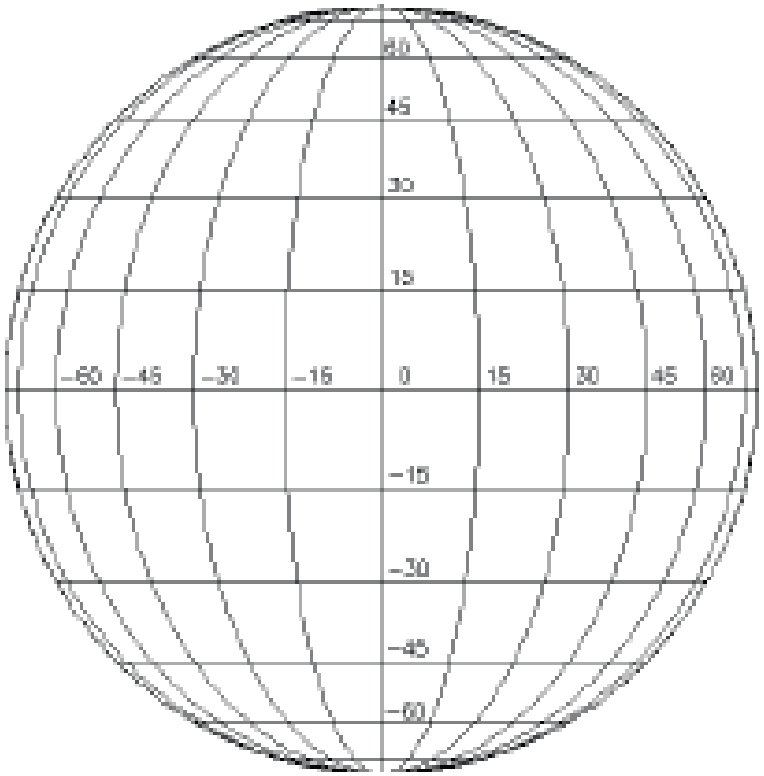
Day 21 Observations:

_____

_____

_____

_____



Activity 1 Data Recording Worksheet

Using your observed sunspot information, create a data table. Be sure to include the sunspot name, date, coordinates (longitude/latitude) and any comments referring to changes.
The following has been provided as an example of a data table:

Sunspot Data Recording Worksheet

Name: _____ Date: _____

Complete one of these each day of your observations

For Each Sunspot Group			
Spot Group/ID *Give each group an identifying name*	Latitude	Longitude	Comments/Changes Observed

Consider the following questions:

What happened to the position of the sunspot over time? _____

Did the latitude or longitude change with time? If yes, describe. _____

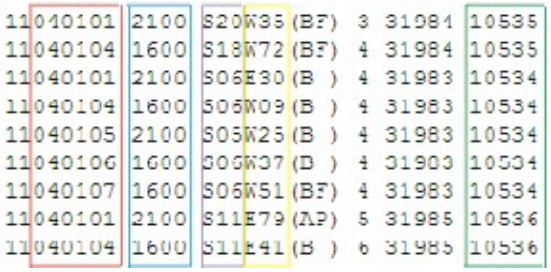
Were you able to observe the sunspot for the full period of time? _____

Based on your research what might have caused the sunspot to change? _____

Activity 1 Alternative

Solar Sunspot Regions - National Geophysical Data Center

Sunspot regional activity has been documented by observatories since 1874. This data is now available online. This data includes information on the area of the sunspot region and it's location on the sun. Certain observing locations and years present more data than others. Choose a location that provides an adequate amount of recorded data. Upon selecting a specific location and year to review data, e.g., Mt. Wilson, CA, USA, 2004, you will see several columns of data. In this case, the group number (columns 34-38, the last column, shown in green below) represents a particular sunspot region being observed continuously.



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11 040101 2100 S20W35 (BF)  3 31981 10535
11 040104 1600 S18W72 (BF)  4 31984 10535
11 040101 2100 S06E30 (B )  4 31983 10534
11 040104 1600 S06W09 (B )  4 31983 10534
11 040105 2100 S05W25 (B )  4 31983 10534
11 040106 1600 S06W37 (B )  4 31983 10534
11 040107 1600 S06W51 (BF)  4 31983 10534
11 040101 2100 S11E79 (AP)  5 31985 10536
11 040104 1600 S11E41 (B )  6 31985 10536
```

Columns of data represent the following information about the sunspot. The only information that we are concerned with is the year, month, day, time, and the coordinates (latitude/longitude).

SUNSPOT GROUP REPORTS Mt Wilson Jan 1962 - Present
USAF/NOAA Dec 1981 - Present

Column	Fmt	Description
1-2	I2	Data Code: always 11 for sunspot data
3-4	I2	Year
5-6	I2	Month
7-8	I2	Day
9	A1	Blank
10-13	T4	Universal Time of observation
14	A1	Blank
15	A1	N or S for north or South
16-17	I2	Heliographic latitude
18	A1	E or W for East or West
19-20	I2	Central meridian distance (= longitude)

Using the data from the National Geophysical Data Center, create a table to simplify the data for the sunspot group you have chosen. Be sure to include coordinates, sunspot code/name and date.

Sunspot Data Recording Worksheet

Name: _____ Date: _____

Complete one of these each day of your observations

For Each Sunspot Group			
Spot Group/ID *Give each group an identifying name*	Latitude	Longitude	Comments/Changes Observed

Calculating the Sun's Angular Velocity

Regardless of whether you completed Activity 1, or the Alternate Activity 1, you will have observed that sun spots move as a result of the rotation of the Sun. We can use the movement of the sunspot to assess the *rate* of rotation of the sun.

Sketches of the sunspot will help you determine how many degrees the Sun has rotated over the time period you made your observations.

The Sun's angular velocity is calculated by measuring the longitude degrees that the sunspot has moved divided by the time that it took for the sunspot to travel that distance.

$$\text{Angular Velocity (degrees/day)} = \frac{\text{Degrees}}{\text{Time (days)}}$$

A full rotation is 360 degrees. Thus, we can determine its rotation rate (the time it takes for a full rotation):

$$\text{Rate of Rotation} = 360 \text{ degrees} / \text{angular velocity}$$

Tracking Sun Spots – Teacher's Guide

While many students may be familiar with the rotation of the Earth, Moon as well as other planets, very few students know that the Sun also spins on an axis. In this activity, students will use a telescope with a solar filter (i.e. the Thousand Oaks Solar Filter) to observe their sunspots. Other manners of observing sunspots without using a telescope or sun filter can be researched on the internet and include using welder's glass.

The important thing to remember when you are doing this activity is that there is a sunspot cycle, where the number of sunspots does fluctuate based on the calendar year. A typical cycle will last 11 years; therefore some students will experience a higher number a sun spot counts, while others will experience very few. Some months will show no signs of sunspots at all, so it is important to take this into consideration before conducting this activity.

So how do you know if you are in the middle of a sun spot lull? Well, 2008 was considered the minimum of the present sun spot cycle, so the number of sunspots available for our viewing pleasure will increase following this period, for ~5 years. Nevertheless, for any given week or month in which you conduct this experiment you may still see few sunspots. If you happen to complete this activity when there *are* some sunspots visible, have your students track not only one, but multiple sunspots, as they often appear and disappear over the period of the observation. Also let the students know that it is best to start tracking a sunspot that is initially on the upper left side of the Sun. In this way they will get to see it move to the right across the entire face of the sun, owing to its rotation direction. Students will record their observations on Day1, Day7, Day 14 and Day 21, therefore you will require two to three weeks to complete this activity.

We have provided an alternative activity, in case you find yourself observing in a period of no sunspots. In 'Activity 1 Alternative', Students retrieve data from the National Geophysical Data Centre (NGDC) database to plot coordinates of a chosen sunspot over time. The NGDC holds data from solar observatories all over the world, dating back as far as 1874. The data is organized by Solar Observatory and year. Students will have to peruse the database to find a sunspot that has been sampled numerous times (four or five samples will show the trend in the movement of the Sun spot across the solar surface). Because many sunspots fade away, there will be many spots that will only be recorded one or two times at this sample rate.

You may wish to go over the website with the students to familiarize them with the source. There are a lot of numbers on the web page and this could be overwhelming to your students. However, if you use the guide here you can extract the necessary information and give them the confidence to extract data from a professional database.

Essential in interpreting the Sun spot data is the link to the 'Format of Daily Sunspot Region Data' which lies immediately below the name of each observatory. Each observatory will record their data in a similar, but slightly different manner; however each Centre will provide a key or legend explaining how to read theirs. Without this information, you will likely be confused. With it, you and your students will gain confidence!

The clusters of sunspot groups (they commonly occur in small groups rather than as individual spots) are assigned a five digit ID number, which are awarded in the order in which the sunspots were first observed. Students will have to scan the data for multiple observations of the sunspot group of interest (i.e. multiple coordinates taken for sunspot 10534).

Having recorded the movement of their sunspot in either manner, students will now be able to complete 'Calculating the Sun's Angular Velocity.' Students can define how many degrees the sunspots have moved across the face of the sun either using their plots (possibly using trigonometry if you want to be really accurate, and only if the spots have moved across a wide latitudinal range, not just west to east)). They can then divide this value by the amount of time it took for the Sun spot to be displaced to get the sun's average angular velocity.

You might ask the students if the angular velocity for sunspots at the equator is the same as the angular velocity for sunpots as far from the equator as possible. It should not be. Interestingly, the sun's surface does not rotate in a regular patterns from pole to equator. Which moves faster… the equatorial surface or the mid-latitudes? Have them hypothesize and then test their hypothesis with their observations.

Resources for Activities:

National Geographic Data Center
http://www.ngdc.noaa.gov/stp/SOLAR/ftpsunspotregions.html

Stanford Solar Center
http://solar-center.stanford.edu/spin-sun/index.html

University Corporation for Atmospheric Research (UCAR)
http://www.windows.ucar.edu/tour/link=/teacher_resources/sunspotplot_edu.html