Sunspot Activity Case Study

Key Concepts:
- Sunspots
- Solar maximum
- Solar minimum
- Sunspot cycle

WHAT YOU WILL LEARN

1. You will identify the relationship of sunspot cycles to Sun radiation output.
2. You will relate the intensity of sunspot activity to global temperatures.
3. You will recognize that changes in solar activity cannot completely explain the persistent change in global temperature increases.
Global warming and climate change are international concerns and the sources of much controversy. Many variables, however, can contribute to the temperature changes related to global warming. All of these variables must be considered when investigating this issue. Strong evidence shows an accelerated rise in global temperatures over the past 30 years. In the media much attention is given to the fact that concentrations of the greenhouse gas, carbon dioxide, is rising. The central cause of this increase is being blamed on human activity: the burning of fossil fuels. The increase in carbon dioxide in the Earth’s atmosphere is the most frequently discussed factor in the global warming controversy. Other factors exist, however, that could be contributing to the increase in the Earth’s atmospheric temperatures. Energy from the Sun produces the heating that occurs on the Earth. The energy coming from the Sun is not always the same because the amount of energy that the Sun emits is related to the number of sunspots present on the surface of the Sun. The sunspot cycle, causes increases and decreases in the radiation from the Sun to the Earth.

1. How does sunspot activity affect the amount of solar radiation given off by the Sun?

2. How might increased radiation from the sun (sunspot cycle) affect the Earth’s temperature?

3. How might the sunspot cycle explain the recent increase in global temperature?

How has global temperature changed over time?

The graph below (Figure 1) shows the global temperature record from 1880 to 2007. Use the graph to answer the following questions.
4. Look at the temperature data from 1880 through 1920. In general, were temperatures increasing, staying the same, or decreasing over this time period?

5. Look at the temperature data from 1920 through 1977. In general, were temperatures increasing, staying the same, or decreasing over this time period?

6. Look at the temperature data from 1977 through 2007. In general, were temperatures increasing, staying the same or decreasing, over this time period?

7. During which time period do you see the most change occurring?
8. Which were the 5 warmest years?

How might Sunspot Cycles effect global warming?

About every eleven years, changes in the Sun’s magnetic fields produce what is known as a solar maximum (Figure 7). A period of a solar maximum is called “solar max”. During solar max, the activity on the sun becomes extraordinary with an increase in sunspots, solar flares, prominences, and corona mass ejections. Solar max is determined by the increased number of sunspots.

Sunspots are areas on the Sun that are cooler than the areas around them. Sunspots occur when the magnetic field of the Sun becomes very active. During solar max, other areas of the sun become brighter and solar storms become very common (Figure 8). All of this activity results in the Sun’s release of massive amounts of energy into space. This energy bombards the Earth, and this bombardment results in many outcomes, some negative and some positive. On the negative side, cell phone and radio reception can be interrupted and satellites can be rendered useless. Positive are the wonderful “sky shows” that can be observed as the Earth’s magnetic field draws in the solar wind that produces the northern lights. Important to this case study, the most significant effect of solar max are the extra amounts of radiant energy the Sun sends to the Earth’s atmosphere.

9. What effect does a solar max have on the Earth’s atmosphere?
The years between 1645 and 1715 (approximately) are referred to as the “Little Ice Age.” During this period, normally ice-free rivers froze, and snow fields lasted all year long in areas where snow normally melted in the summer. This time period corresponds to a time of very little sunspot activity. Looking at the yearly averages of sunspot numbers from 1610 – 2000 shown in Figure 9 below, you can see that very little sunspot activity occurred from 1645 to 1715.

10. Explain how sunspot activity may have caused the Little Ice Age.
Take a close look at the temperature during the period of time between 1880 and 1910, shown in the Figure 10. During this time, temperatures ranged lower than average. Now take a look at the above Figure 9 of sunspot activity for that same period. Notice that sunspot activity between 1880 and 1910 was not as great as the time before and after these periods. Remember that increased sunspot activity occurs during solar maximum and decreased sunspot activity occurs during solar minimum.

11. When there are fewer sunspots, should the Earth be warmer or cooler?

In the graphs below, a simplified picture is provided for sunspot activity (Figure 11) and global temperature (Figure 12) for the most recent time period. The global temperature appears to change with the number of sunspots from 1985 until 2000.
12. Between 2000 and 2007, was sunspot activity increasing or decreasing?

13. Between 2000 and 2007, was global temperature increasing or decreasing?

14. Does sunspot activity explain the most recent increase in temperature?

During the eleven-year cycle of sunspots, the sunspot number increases and decreases. The periods of time between solar maximums are known as solar minimums. The last solar max was in the year 2000. In March of 2006, sunspot activity was reported as almost non-existent. The Sun was experiencing a solar minimum that is predicted to continue into early 2008. Our next solar max will occur in 2011.

15. The United States has recently experienced the two warmest years on record. (This is different than the global records of 2005 and 2007.) The warmest year ever in the U.S. was 1998, and the second warmest year was 2006. How do these years compare to the years with sunspot activity?

16. If solar activity is to increase as we approach 2011, what might we expect to happen to global temperatures?
Conclusion

Climate and seasons on the Earth are primarily a function of the amount of solar radiation that is absorbed and retained by the Earth. Many factors help to determine exactly how solar radiation affects climate. The amount of solar radiation given off by the Sun will always directly affect the climate on the Earth. The Sun’s energy output is not steady, but changes over time within a cycle of maximum and minimum output.

Solar activity cycles over a period of about eleven years. The “Little Ice Age” in the late 1600’s and early 1700’s corresponds with a period of very little solar activity. During the period of time of our last solar maximum global temperatures reached new highs. We are presently in the middle of a solar minimum (2008), but global temperatures still appear to be rising. This can be partially explained by solar maximums, but not completely. Temperatures tend to drop during solar minimums, and currently they are rising. Are other factors contributing to the current temperature increases? Could increased greenhouse gases be retaining heat more intensely than before?

A complex combination of factors contributes to our climate; these factors can occur as cycles or single events. A single event occurred in June of 1991 when Mount Pinatubo, a volcano that lies near a divergent boundary in the Philippines, erupted. This eruption became known as the second largest volcanic eruption of the twentieth century. Within two hours of the major Pinatubo eruption, gases and ash reached high into the atmosphere. By the end of that year, this volcanic eruption created a high altitude particulate cloud that covered the whole Earth. These particulates reflected sunlight into space and caused a global cooling. This cooling effect lasted throughout 1992 and 1993 and might have caused the drop in temperatures during this time period. Was the drop in temperatures in 1992 and 1993 due to the volcano, or the solar minimum, or both? An El Niño event also occurred during this year that might have had a warming affect. If greenhouse gases had not been involved, would temperatures have dropped even more? If there had been no volcanic eruption, would temperatures have risen during those years? Were other factors involved?

If temperatures are consistently rising with some variations due to other cycles and events, then factors that persist need to be considered as serious ones. Greenhouse gases, especially carbon dioxide, have been shown to be steadily rising. This persistent, steady rise might better explain the observed recent temperature increase.
Reflect on What You Have Learned

17. How does sunspot activity affect the amount of solar radiation given off by the Sun?

18. How might increased radiation from the sun (sunspot cycle) affect the Earth’s temperature?

19. Can the sunspot cycle explain the recent increase in global temperature?