Solar Events Activity Key

*** For ease of use during class the Teacher Key pages are numbered the same as the Student Activity Book pages.

I. Introduction

The sun gives us light and warmth, but it also gives us problems. The sun sends ions (charged atoms) and electrons into space at incredible speeds. When these particles interact with Earth's atmosphere, they cause several major problems ranging from power failures to zapped satellites.

Continue with this activity to see how the sun is not only beneficial but how it can be harmful.

Get Info Objectives

1. List effects of solar events.
2. Describe solar effects on human activities
3. Describe solar effects on electric companies.

Gather Data Objectives

A. Describe the relationship of geomagnetic disturbances to solar events.
B. Use averaged solar data to determine the best time to debug electronic equipment.
C. Compute the diameter, escape velocity, and surface speed of the sun.

Application Objectives

1. Explain observations of the average sunspot number.
2. Justify the cost of an early warning system for geomagnetic storms.
3. Explain the international nature of solar event problems.

Before doing anything else, add the NOAA Research "Solar Events" page to Bookmarks or Favorites on your web browser.

II. Get Info

A. General information on solar problems

- Click on the "Solar Events" site.
- Read the information and answer the following question.

1. What problems do solar events cause?

Interrupt HF, VHF, UHF, LF, and VLF radio communications;

Interferes with geomagnetic surveys for minerals;

Pipelines corrode faster during geomagnetic storms;

Power grids could fail;

Satellites could get dragged into the atmosphere and burn;

Satellite controls could be disrupted;

Astronauts could be injured or killed;

Solar events produce the Aurora Borealis.

- Click "Back" to return to the Solar Events "Get Info" web page.

B. Details of Solar Events

- Click on the "Space Environment" site.
- Scroll down to the "Coronal Holes" section.
- Read from "Coronal Holes" through the end of the page and answer the following questions as you read.

1. What effect do coronal holes have on the solar wind?

   Coronal holes increase the solar wind.

2. What types of energy do solar flares release?

   Gamma, X-ray, visible light, and radio waves

3. Aurora are also called the Northern Lights and Southern Lights. How are the lights formed?

   The solar wind energizes electrons and ions in the magnetosphere. These particles usually enter the Earth's atmosphere near the polar regions. When the particles strike the molecules and atoms in the thin high atmosphere, some of them start to glow in different colors.

4. What causes geomagnetic storms on Earth?

   Portions of the solar wind's energy is transferred to the magnetosphere, causing the Earth's magnetic field to change rapidly in direction and intensity.

5. What does the ionosphere usually do to help communication that is changed by geomagnetic storms?

Many communication systems utilize the ionosphere to reflect radio signals over long distances.

6. What dangers are there due to geomagnetic storms' disruption of the ionosphere?

Airline communication could be disrupted; Military Over-the-Horizon radar could be disrupted; Planes and ships could incorrectly determine their positions.

7. How do geomagnetic storms affect satellites?

Storms cause the atmosphere to expand, creating drag on the satellite and letting it fall into a lower orbit where it could burn up in Earth's atmosphere; Microchips that control the satellite's computers could be damaged and therefore affect its navigation.

8. How can airlines be in danger due to geomagnetic storms?

They could lose radio communication with the ground; they might not know where they are in relation to other planes or mountains and crash.

- Click "Back" to return to the Solar Events "Get Info" web page.

C. Solar "Power" Problems

- Click on the "University of Michigan Power Grid" site.

1. Why do geomagnetic storms affect structures made by people more than they affect natural structures?

Igneous rock doesn't conduct electricity well. Current induced in the Earth by solar events travels through pipelines instead of through the rock layers.

- Click "Back" to return to the Solar Events "Get Info" web page.
- Scroll to the bottom of the page and click "Return."
- Click "Gather Data."

III. Gather Data

A. Solar Flares and Magnetic Disturbance

- Click on the "Solar Flare Effect" site.
- Scroll down to the graph.

1. Describe the relationship between x-ray radiation and the magnetic field variation.

x-ray flux and the magnetic field variation occur at the same time.

- Click "Back" to return to the Solar Events "Gather Data.1" web page.

B. Sunspots and Geomagnetic Storms

- Click on "Occurrence of Geomagnetic Disturbances" site.
- Scroll down to the graph.

1. Describe the relationship between the sunspot number and the number of days with geomagnetic storms.

   As the sunspot number increases, the number of days that have geomagnetic storms also rises. The number of storms rises after the sunspot number has peaked and is declining.

- Click "Back" to return to the Solar Events "Gather Data.1" web page.

C. Monthly Storms

- Click on the "Seasonal Distribution" site.
- Scroll down to the graph.

1. What two months have the highest number of geomagnetic storms?

   March and April

2. What three months have the lowest average of geomagnetic storms?

   January, December, and July

3. Recalling the effects of geomagnetic storms, in what months would you want to test a new computer network?

   January, December, and July

4. Why did you choose these months?

Geomagnetic storms can cause power grid failure and can affect sensitive electronic equipment.

- Click "Back" to return to the Solar Effects "Gather Data.1" web page.
- Click "Forward" at the bottom of the screen.

D. Annual Sunspot Numbers

- Click on the "Yearly Average Sunspot Numbers" site.
- Read the legend below the graph for help answering the questions.

1. Yearly sunspot numbers have been calculated using the average of the daily number of sunspots. Which solar minimum year had the lowest yearly average? 1954 at 4.4

- Click "Back" to return to the Solar Events "Gather Data.2" web page.

E. Math Facts and Solar Measurements

- Click on the "Solar Facts" site.

1. The gravity on earth is 9.8 meters per second per second. How much stronger is the gravity on the surface of the sun?

290 ÷ 9.8 = 29.6 times as much gravity on the sun as on the Earth

2. Escape velocity is how fast you have to go to escape the sun's gravity and not get sucked back into the sun. What is the escape velocity of the sun in kilometers per hour?

$$\frac{100\ m}{km} \times \frac{60\ min}{hour} \times \frac{60\ sec}{minute} \times \frac{618{,}000\ m}{second} = 2.2248 \times 10^{12}\ km/hr$$

3. What is the diameter of the sun? 1.4×10^{9} meters

$7 \times 10^{8} \times 2 = 1.4 \times 10^{9}$ meters

4. Use the diameter you found in question 3 to find the circumference of the sun. ($C = \pi d$)

$C = \pi d\ (3.14 \times d)$
$C = 3.14 \times 1.4 \times 10^{9}$ meters
$C = 4.396 \times 10^{9}$ meters

5. Use the rotation period of the sun, the number of hours in a day, the number of meters in a kilometer, and the circumference of the sun to figure out what the surface speed of the sun is in kilometers per hour. (How fast is it moving on the surface?)

$$\frac{1 \text{ day}}{24 \text{ hours}} \times \frac{1 \text{ revolution}}{27.3 \text{ days}} \times \frac{4.396 \times 10^9 \text{ m}}{\text{revolution}} \times \frac{1 \text{km}}{1000 \text{ m}} = 6{,}709 \text{ km/hr}$$

6. Use the fact that there are about 1.6 kilometers per mile to convert the speed you found in question 5 to miles per hour.

4,193 miles per hour

- Click "Back" to return to the NOAA Research "Solar Events" main page, or choose "Solar Events" from your Favorites or Bookmarks.
- Click on "Application".

IV. Application

A. Variation

- Click on the "Variation" web page.
- The "aa" index is used to measure the geomagnetic disturbances on Earth.

1. What does the graph seem to tell us about the average number of geomagnetic disturbances? The number is increasing

2. Besides the explanation that there are more disturbances, what other explanation is possible to explain the fact that the number of disturbances measured is increasing?

We are building better instruments to observe sunspots so we see more of the sun.

- Click "Back" to return to the Solar Events "Application" web page.

B. Cost vs. Cost

- Click on the "University of Michigan Solar Storm Cost" site.

1. What kinds of problems can be avoided if power companies get early warnings of coming geomagnetic storms?

Public transportation that uses electricity for power would stop. Security systems would be shut down. Heating and cooling systems would be shut down.

- Click "Back" to return to the Solar Events "Application" web page.
- Click on the "Start-Up Problem" site.

2. Why should you turn off your electric appliances whenever there is a power failure?

The power demand at startup is much greater than the normal operating power demand.

- Click "Back" to return to the Solar Effects "Application" web page.

C. International Accord

1. Explain why the cost for maintaining an early warning system for geomagnetic storms is justified.

The cost of not having a warning system could be millions of dollars and human lives lost.

2. Why should all industrialized nations work together to set up the warning system?

All industrialized nations have power grids, shipping interests, and airlines. They all use radio communications, so they should all help keep the system operational. The system needs to be monitored from several places on Earth to be most effective.

- Click "Back" to return to NOAA Research "Solar Events" home page or click "Return" at the bottom of the page.
- Click "Enrichment."

V. Enrichment Activities

A. Research

1. Research the Aurora Borealis. Find out when, where, and how they occur. Draw a diagram showing the areas on Earth where they occur most often.

2. Research when the next solar eclipse will be. What locations on Earth will see a total eclipse? A partial eclipse?

3. Research Earth's escape velocity. What is it and how is it different from the Sun's escape velocity? Ideally, satellites would be launched from the equator. What difference does it make where you launch a satellite?

4. Find out about ancient cultures and how they created calendars and measured time based on the sun.

B. Interviews

1. Interview an astronomer at a local planetarium about locally-see eclipses.

2. Work in groups and list all the songs you can think of that mention the sun.

- Click "Forward" to go to the "Enrichment.2" web page.

C. Related Web Sites

1. NASA Eclipse Homepage
   http://sunearth.gsfc.nasa.gov/eclipse/eclipse.html

2. SEC Frequently Asked Questions
   http://www.sec.noaa.gov/info/FAQ.html

3. NASA Eclipse Resource Page
   http://sunearth.gsfc.nasa.gov/eclipse/resource.html

4. National Geophysical Data Center site on geomagnetic data
   http://www.ngdc.noaa.gov/seg/potfld/geomag.html

5. Technically oriented National Geophysical Data Center site on cosmic rays
   http://www.ngdc.noaa.gov/stp/SOLAR/COSMIC_RAYS/cosmic.html

6. Meteors and Meteor Showers
   http://csep10.phys.utk.edu/astr161/lect/meteors/showers.html