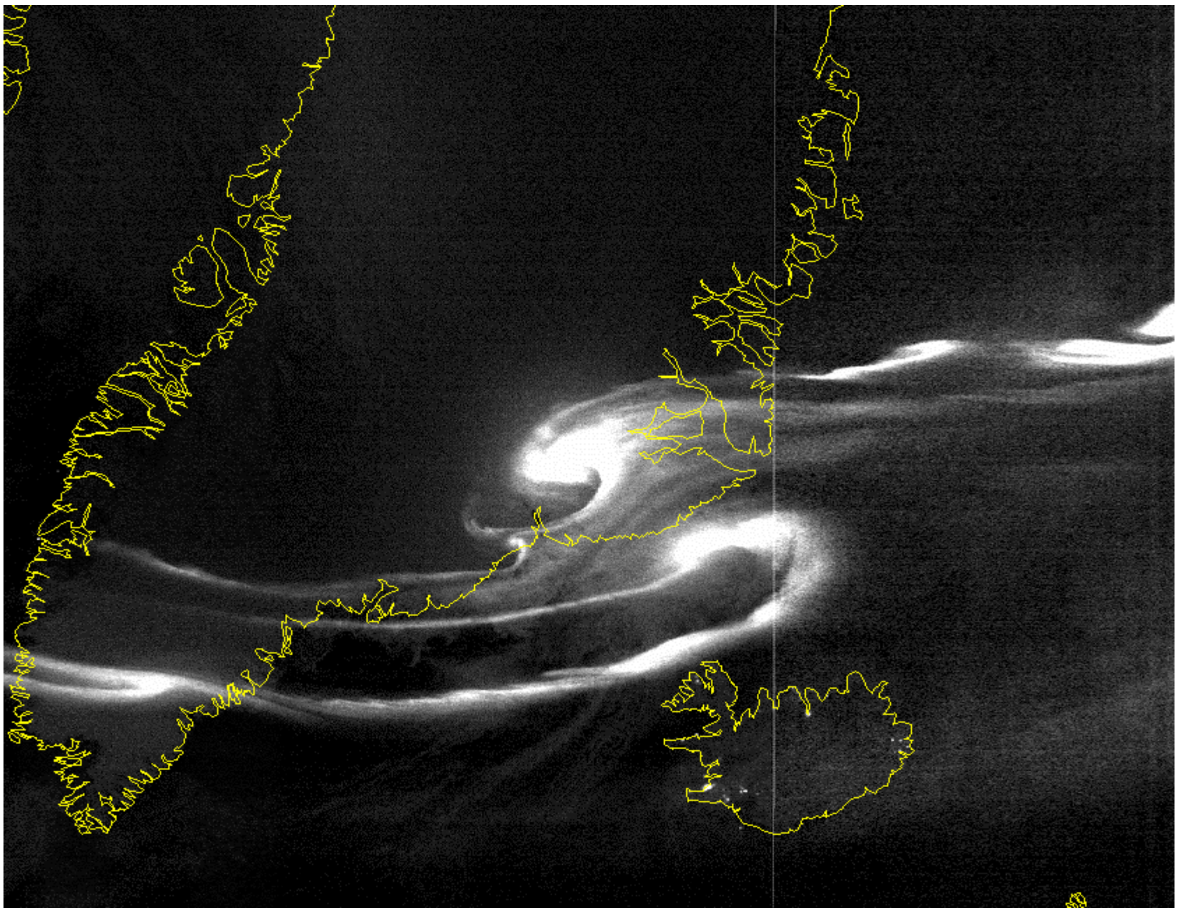
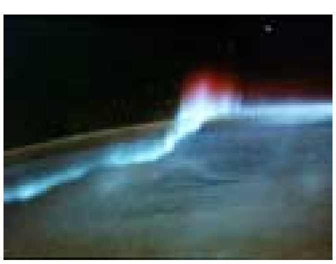
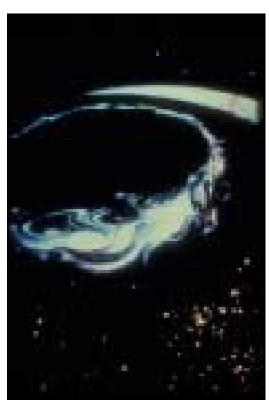
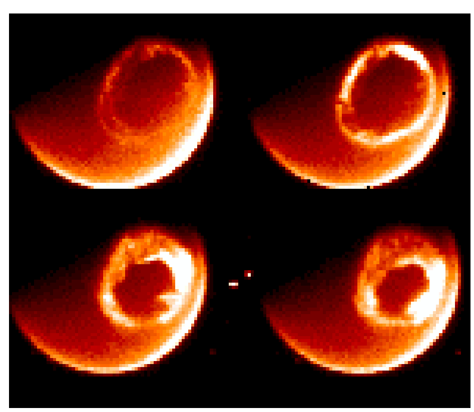
THE NORTHERN LIGHTS









A Grade 7-8 guide to understanding the Aurora Borealis through math, geometry and reading activities.

This series of activities will help students understand how the Northern Lights work, what causes them, and how to observe them.

Through a series of math and reading activities, students will learn:

- How aurora are described by scientists and by other students (Reading)
- The geographic locations of aurora based on satellite data (Geography)
- How aurora appear in the sky at different geographic latitudes (Geometry)
- The height of aurora above the ground (Geometry - parallax)
- How to predict when they will appear (Mathematics)
- What Norse Mythology had to say about aurora (symbolic code translation)

This booklet was created by the NASA, IMAGE satellite program's Education and Public Outreach Project.

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For more classroom activities about aurora and space weather, visit the IMAGE website at:

http://image.gsfc.nasa.gov/poetry

The cover shows a view from the NPOESS satellite looking down at an aurora over Greenland. *(http://npoesslib.ipo.noaa.gov/S_sess.htm)*. Viking rune inscription (http://www.commersen.se/vikingar/vardag/runor.html). The three smaller images at the bottom of the page are: (Left) an aurora borealis viewed from the Space Shuttle; (middle) portion of the auroral oval over North America viewed by the DMSP satellite showing city lights; (right) the auroral oval viewed over the Arctic region on July 15, 2000 by the IMAGE satellite.

Activity 8 How to Predict an Aurora

Up until the mid-1800's, no one really knew why aurora occur. As you can imagine, this makes it very hard to predict when they will be seen next. By combining different kinds of data, scientists in the late 1800's and early 1900's began to see patterns emerge, and were soon able to use them to predict when aurora would occur. For example, during an aurora, Earth's magnetic field changes slightly, and this can be detected on the ground as a 'magnetic storm'. For some of the most severe storms, even a simple compass can sometimes work to sense these large changes in the field which can last for several hours. With the help of dozens of specially-designed observatories around the world, especially in the northern and southern polar regions, scientists have created a magnetic storm scale that is much like the scales that other scientists use to measure hurricanes and tornadoes. The scale was designed in 1939 by the German physicist Julius Bartles and we now call it the 'Kp' scale. Another, easier to use, 'Ap' index is directly related to the amount of change in the magnetic field, and is measured in units of nano-Tesslas.

In the previous activity, we measured the largest magnetic change that occurred in a three-hour period on July 12, 2002 based on the measurements from five magnetic observatories. Every three hours, the observatories identify the largest change in Earth's magnetic field at ground level, then by averaging these numbers together with the several dozen other observatory measurements around the globe, an average magnetic storm value in nano-Tesslas is found. This is then converted into the Kp index by using a table.

When an aurora is occurring, the Kp index is usually higher than about 6 or 7. Whenever these values are exceeded during any 3-hour period, this usually means that an aurora is in progress or will soon be visible.

Benchmarks:

6-8 Technology is essential to science for such purposes as access to outer space, sample collection, measurement, storage and computation.
6-8 Most of what goes on in the universe involves some form of energy being transformed into another.
6-8 Graphs can show a variety of possible relationships between two variables.
9-12 Sometimes scientists can control conditions in order to obtain evidence. When that is not possible, they try to observe as wide a range of natural occurrences as possible to be able to discern patterns.
9-12 Increasingly sophisticated technology is used to learn about the universe.
9-12 Use charts and graphs in making claims in oral and written presentations.

Objective:

The students read and interpret graphs, average data values, and use the results to draw conclusions based on the data.

Materials:

Calculator
Access to the internet

Procedures:

1. Provide each student with a copy of the student page.
2. Guide students through the May 27, 2002 exercise on the teacher page.
3. Permit time and access to the internet to complete the exercises.
4. Discuss the student results and compare their analysis of the data.
5. Provide time for the students to develop a written summary.
6. Students can present their summary.

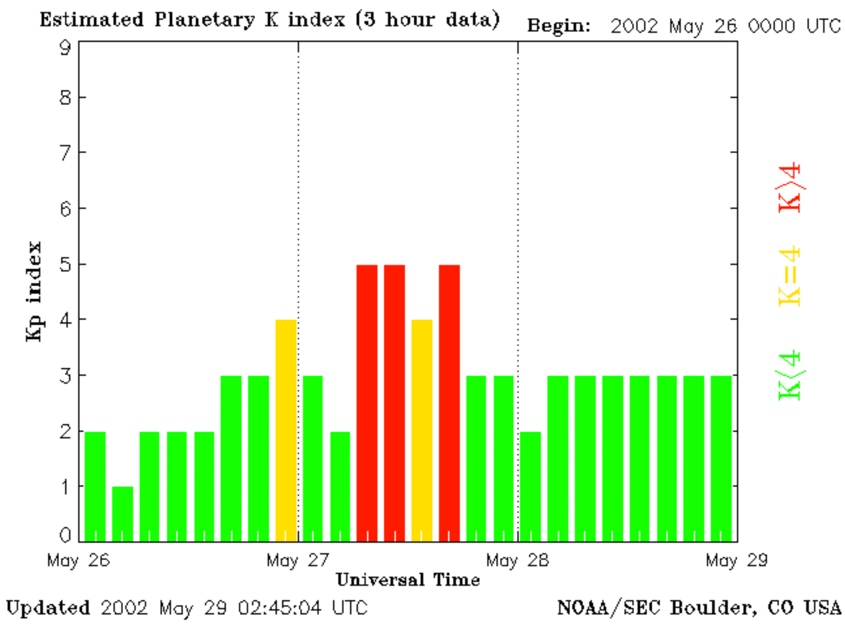
Selected Answers:

1...April 19, 2002
Ap= (27 + 27 + 27 + 80 + 80 + 48 + 48 + 48)/ 8 Ap = 48 Kp = 5
2...April 20, 2002
Ap= (140 + 140 + 140 + 80 + 27 + 27 + 27 + 7)/8 Ap = 74 Kp = 5
3...July 13, 2000
Ap= (7 + 7 + 15 + 48 + 140 + 48 + 7 + 15)/ 8 Ap = 36 Kp = 4
4...July 14, 2000
Ap=(27 + 15 + 27 + 27 + 27 + 80 + 48 + 27)/8 Ap = 35 Kp = 4
5...July 15, 2000
Ap= (27 + 27 + 48 + 48 + 80 + 400 + 400)/ 8 Ap= 129 Kp = 6

Conclusions:

Students should note that when the Ap value is larger, there is a much more observable auroral oval in the IMAGE data. The May 27, 2002 date had very little noticeable auroral oval and a low Ap value of 28. In contrast, in 2000 on July 14 and 15th there was a very significant oval and a very high A value of 129 . Furthermore, on the Kp index graphs, there were a number of Kp values that were 9 in July 2000 versus nothing higher than a 5 in May 2002.

Current Kp index plots are available at:
http://www.sec.noaa.gov/rt_plots/kp_3d.html



Kp	Ap
0	0
1	3
2	7
3	15
4	27
5	48
6	80
7	140
8	240
9	>400

Example Activity:

1. Locate the graph of the Kp index for May 27, 2002 (shown above). The website is:
   http://image.gsfc.nasa.gov/poetry/activity/NLightsA.html

2. Read the graph to determine the eight Kp values for that particular day. The eight Kp values are 3, 2, 5, 5, 4, 5, 3, 3

3. Convert the Kp value to an Ap value using the 'Kp Table'. In this case, the converted values are 15, 7, 48, 48, 27, 48, 15, 15

4. Next, average the converted values to obtain the Ap value.
   Ap = (15 + 7 + 48 + 48 + 27 + 48 + 15 + 15) / 8
   Ap = 223/8
   Ap = 27.875 round this to 28.

5. Now that the Ap value has been determined, compare the index with pictures from the IMAGE satellite on the same date. The website is:
   http://image.gsfc.nasa.gov/poetry/activity/NLightsB.html

6. Compare the auroral oval to the Kp index and the Ap value. What does the comparison suggest? Is there a noticeable correlation between the Kp index and the auroral oval seen in the satellite images?

Student Name ________________________________ **Date** _______________

In each of the following problems, locate the Kp graph for the given date, convert the Kp values to an Ap value, and compare those two variables to the IMAGE data for the corresponding dates. Analyze and compare the results for each of the given dates. Summarize the results in a written format. Be sure to include data and reasoning to support your conclusions.

Problem 1 April 19, 2002

Kp graph and IMAGE data:

http://image.gsfc.nasa.gov/poetry/activity/NLights1.html

Problem 2 April 20, 2002

Kp graph and IMAGE data:

http://image.gsfc.nasa.gov/poetry/activity/NLights2.html

Problem 3 July 13, 2000

Kp graph and IMAGE data:

http://image.gsfc.nasa.gov/poetry/activity/NLights3.html

Problem 4 July 14, 2000

Kp graph and IMAGE data:

http://image.gsfc.nasa.gov/poetry/activity/NLights4.html

Problem 5 July 15, 2000

Kp graph and IMAGE data:

http://image.gsfc.nasa.gov/poetry/activity/NLights5.html

Useful Web Resources

Exploratorium "Auroras:Paintings in the Sky"
http://www.exploratorium.edu/learning_studio/auroras/

Archive of aurora photos by Jan Curtis:
http://www.geo.mtu.edu/weather/aurora/images/aurora/jan.curtis/

Archive of aurora photos by Dick Hutchinson:
http://www.ptialaska.net/~hutch/aurora.html

Space Weather Today:
http://www.spaceweather.com/

IMAGE real-time aurora images from space:
http://image.gsfc.nasa.gov/poetry/today/intro.html
http://www.sec.noaa.gov/IMAGE/
http://sprg.ssl.berkeley.edu/image/

NOAA Auroral Activity monitor:
http://www.sec.noaa.gov/pmap/index.html

CANOPUS real-time auroral monitor:
http://www.dan.sp-agency.ca/www/rtoval.htm#TOPOFPAGE

Current solar activity report:
http://www.dxlc.com/solar/

Alaska Science Aurora page for kids:
http://www.alaskascience.com/aurora.htm

Human Impacts of Space Weather:
http://image.gsfc.nasa.gov/poetry/weather01.html

Ask the Space Scientist:
http://image.gsfc.nasa.gov/poetry/ask/askmag.html

More classroom activities:
http://image.gsfc.nasa.gov/poetry/activities.html

The Northern Lights Essay Competition:
http://image.gsfc.nasa.gov/poetry/alaska/alaska.html