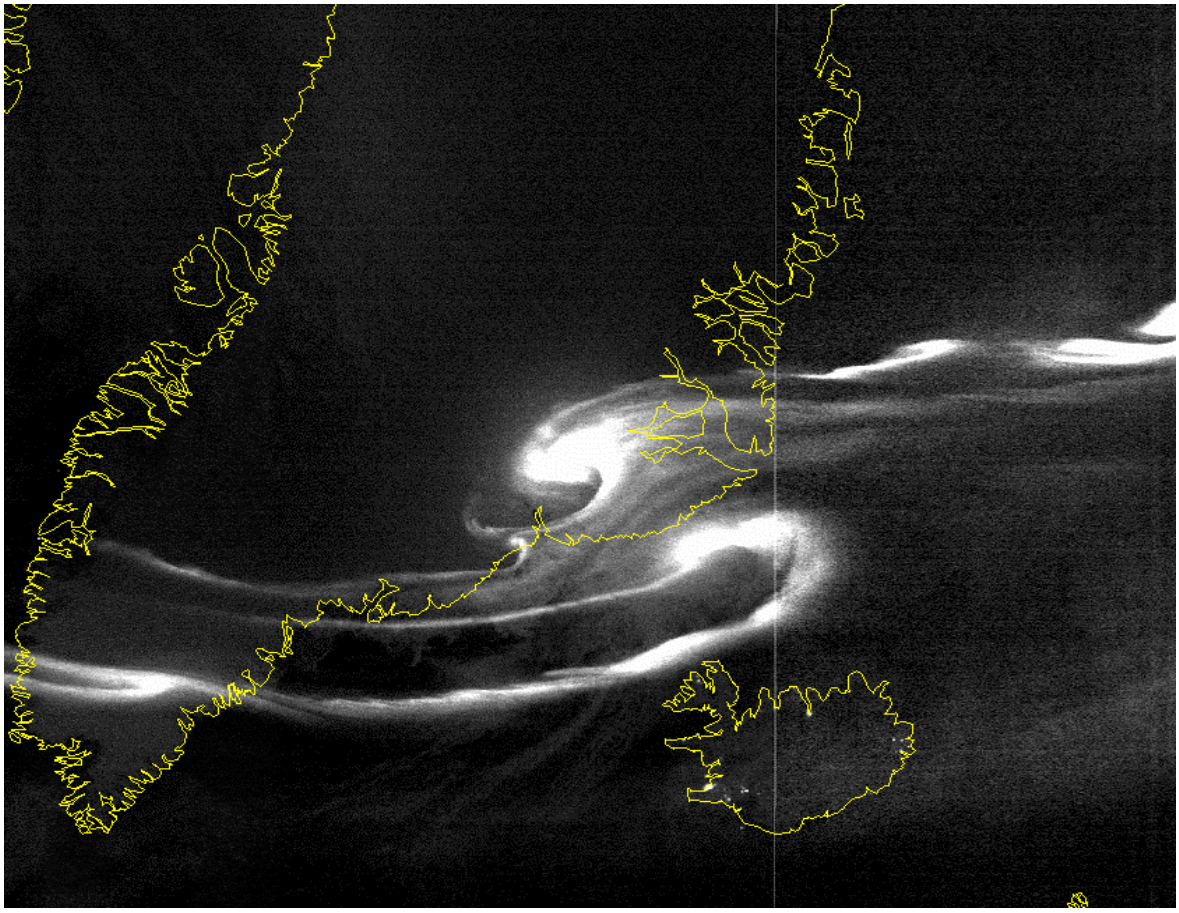
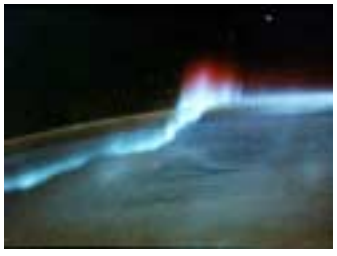
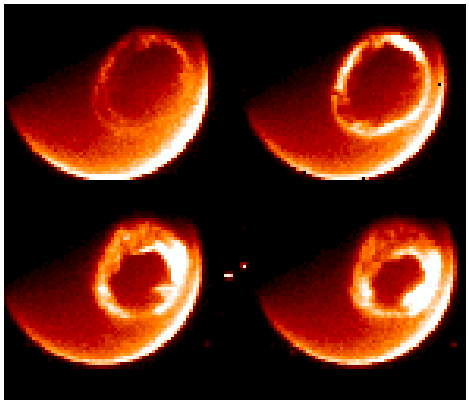
THE NORTHERN LIGHTS







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.

Writers:
Dr. Sten Odenwald *(NASA/IMAGE)*
Ms. Susan Higley *(Cherry Hill School)*
Mr. Bill Pine *(Chaffey High School)*

Students:
Emily Clermont *(Holy Redeemer School)*
Denali Foldager *(Seward Elementary School)*
Sonta Hamilton *(Mt. Edgecumbe High School)*

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 9 Auroral Activity and Latitude

Over the last 100 years, scientists have recognized that there is a relationship between the appearance of the aurora and the amount of disturbance to Earth's magnetic field. As the magnetic field becomes more disturbed, the Northern Lights will be visible the farther south from the Arctic region. By measuring these disturbances, we can predict what the latitude of the southern edge of the Northern Lights will be. This activity lets students use a geographic plot of aurora location and activity, to create their own forecasting relationship for a selected longitude in North America.

Objectives:

Math is essential to science for such purposes as access to outer space, sample collection, measurement, storage, and computation.
Graphs can show a variety of possible relationships between two variables.
Find answers by substituting numerical values in simple algebraic formulas.
Use computers for providing tables and graphs and for making spreadsheet calculations.
Find locations on maps using rectangular and polar coordinates.

Materials:

Graphing calculator
Student page
Calculator instruction pages
Map

Procedures:

Students apply map reading skills to complete a table of values.
Students graph the table of values and determine a possible correlation between the Kp index and the latitude of the auroral oval.
Students use the graphing calculator (if available) or determine a line of best fit based on the data values.
Students draw the line of best fit.
Students use the line of best fit to determine various latitudes given a specific Kp index value.
Students use the equation for the line of best fit to calculate the latitude for a given Kp value. Students use the equation for the line of best fit to calculate the Kp index when the latitude is given.
Students write a summary of the correlation between the Kp index and the latitude of the auroral oval.

Teacher's Answer Key:

3. Describe the shape of the graph. Is this a linear function? Does a relationship between the Kp index and the auroral oval latitude seem evident?

The shape of the curve looks like half a parabola that opens downward. The relationship appears to be that as the Kp index increases, the latitude decreases. The rate does not appear to be constant.

4.Write an equation for the line or curve of best fit.

$Y = -0.25X^2 + 0.8X + 48.95$

6. What does the entry in column one row two mean?

This entry means that for a Kp index of 2, the auroral latitude is around 49.55 degrees at a particular longitude.

7. Use the above equation to predict the auroral oval latitude when the Kp index is nine.

$Y = -0.25(9)^2 + 0.8(9) + 48.95$

$Y = -20.95 + 7.2 + 48.95$

$Y = 35.2$

The auroral oval latitude is around 35.2 degrees when the Kp index is 9.Answers will vary based on the selected auroral latitude.

8. Predict the Kp index, using the equation of best fit, when the auroral oval latitude is 45 degrees (Hint: use the quadratic formula).

$Y = -0.25X^2 + 0.8X + 48.95$

$45 = -0.25X^2 + .8X + 48.95$

$X = -2.685$ or $X = 5.885$

In this situation, the Kp index would be between 5 and 6. According to the table, the 45 degrees latitude would be between a Kp value of 5 and 6. This is a reasonable prediction.

9. Select another Kp value from the table in problem five, and show how to determine the auroral oval latitude using your equation of best fit.

Answers may vary based on the student selection of a Kp value.

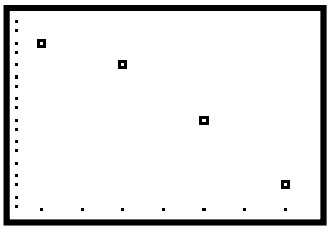
10. Select an auroral oval latitude and determine the Kp index.

Hint: problem 8.

Answer for Question 1

Kp index	Latitude
3	49
5	47
7	42
9	36

Answer for Question 2



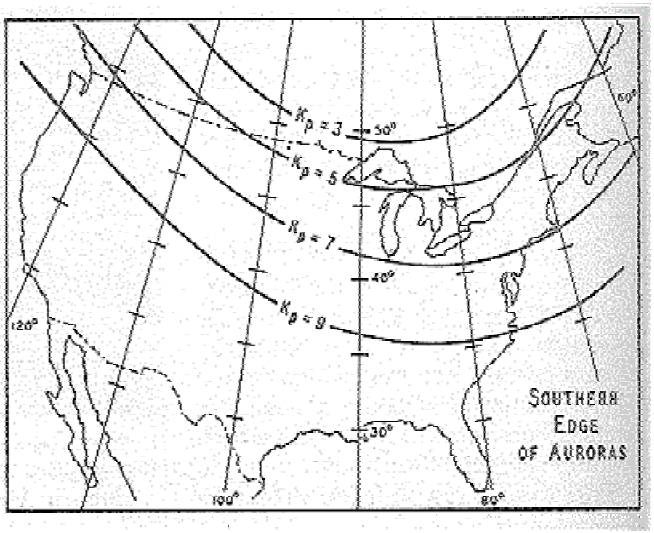
Answer for Question 5

Kp index	Latitude
1	49.5
2	49.6
3	49.1
4	48.2
5	46.7
6	44.8
7	42.3
8	39.4
9	35.9

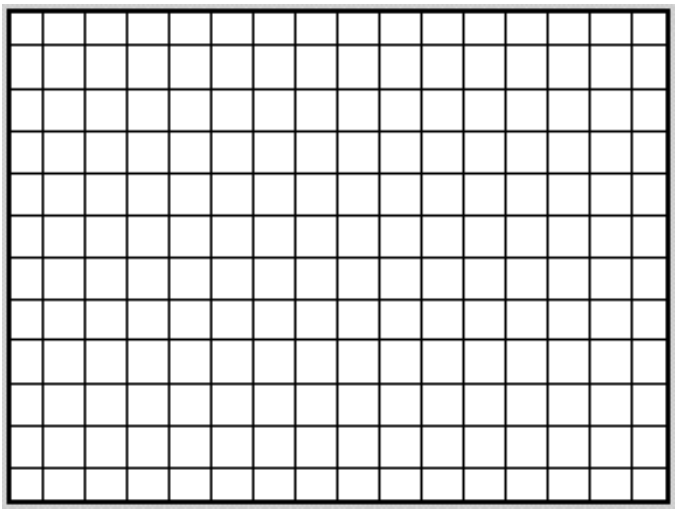
Student Name _____ Date _____

1. From the map on the right, select a longitude, and determine the latitude for each given Kp value. Complete the table below.

Kp index	Auroral Latitude
3	
5	
7	
9	



2. Plot the data values on the graph below. Remember to label the axes!



3. Describe the shape of the graph. Is this a linear function? Does a relationship between the Kp index and the auroral latitude seem evident?

4. Write an equation for the line or curve of best fit.

Student Name _____ Date _____

5. Complete the table to the right, based on the curve of best fit. Round your answer to the nearest tenth.

Predicted latitude

Kp index	Latitude
3	
5	
7	
9	

6. What does the entry in column one row two mean?

7. An equation for the curve of best fit is $Y = -0.25X^2 + 0.8X + 48.95$, where X is the Kp index and y is the auroral oval latitude. Use the equation to predict the auroral latitude when the Kp = 9. Example: For Kp = 3 then X = 3, and $Y = -0.25(3)^2 + 0.8(3) + 48.95 = 49.1$

8. Predict the Kp index, using the equation of best fit, when the auroral oval latitude is 45 degrees (Hint: use the quadratic formula).

9. Select another Kp value from the table in problem five, and show how to determine the auroral oval latitude using your equation of best fit.

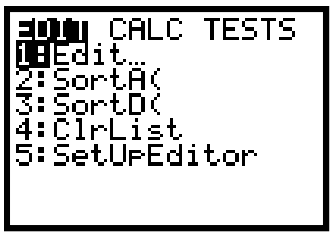
10. Select an auroral latitude and determine the Kp index. (Hint: problem 8)

Determining a Line Of Best Fit Using The TI - 83 Graphing Calculator

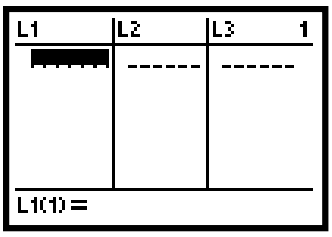
It is important to note that the keystrokes needed are displayed in boxes [ ] and the picture displayed below is what the students should be viewing.

- Enter the data from the table into the calculator. The Kp index will be in List 1 (L1) and the auroral latitude will be in List (L2).

STAT



ENTER



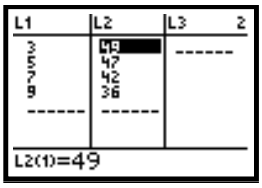
- When entering a data value in List 1, type the data value and press **ENTER**. For example,

3 **ENTER** **5** **ENTER** **7** **ENTER** **9** **ENTER**

- Arrow over to the right to access List 2. Enter List 2's data values by typing the data value and then pressing ENTER for each number.

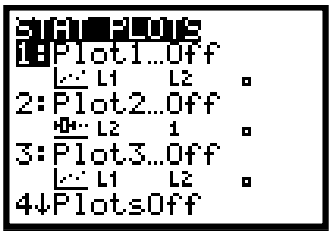
4 **9** **ENTER** **4** **7** **ENTER** **4** **2** **ENTER** **3** **6** **ENTER**

- The completed screen would appear like this:

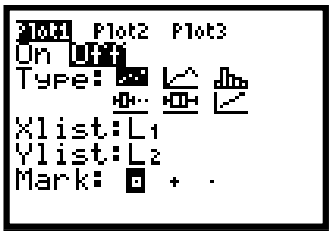


- In order to view the graph, it is necessary to turn on the statistics plot feature on the calculator. Follow these steps.

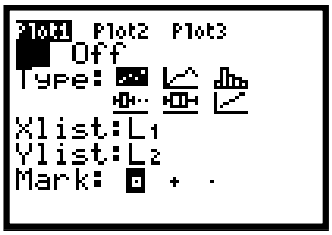
2nd **y =**



ENTER



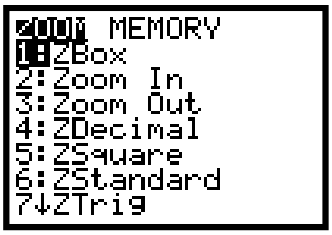
ENTER



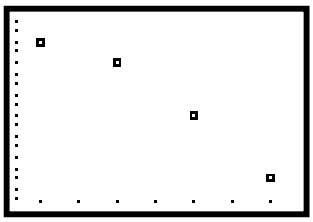
- In order to view the graph, push the **GRAPH** key. **GRAPH**

- The graph may or may not be visible at this point. In order to fit the data to the calculators window, do the following:

ZOOM

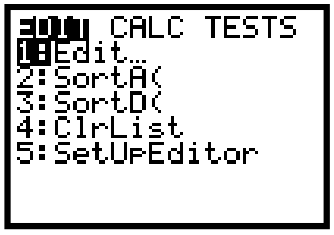


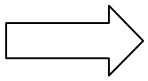
9

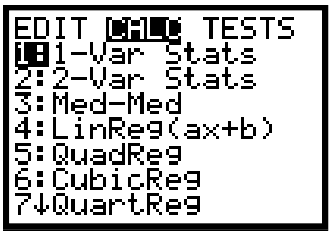


The graph appears to be curved downward, like half of a parabola opening downward. Therefore, a quadratic regression line is necessary.

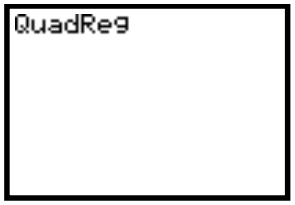
STAT



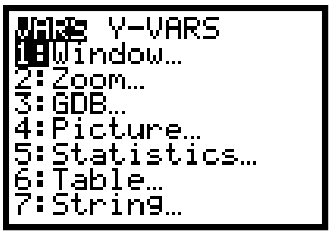


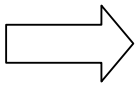


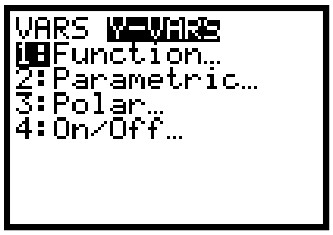
5



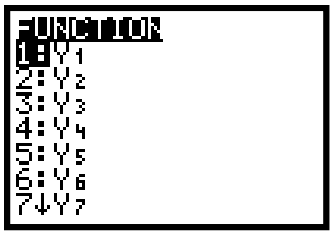
VARS





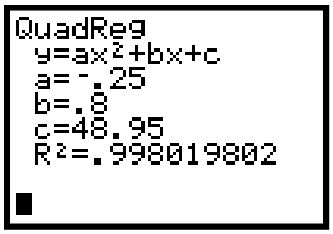


ENTER



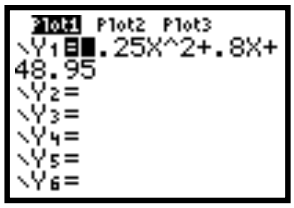
ENTER

ENTER

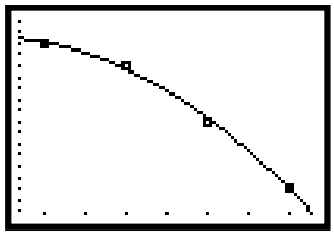


- The screen will display the following information, where a is the quadratic terms coefficient, b is the linear terms coefficient, and c is the constant.

- To view the equation in standard form: **Y =**

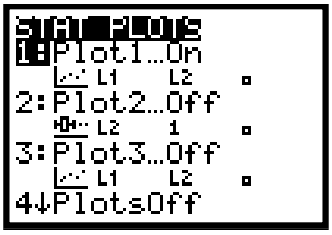


To view the graph, push **GRAPH**

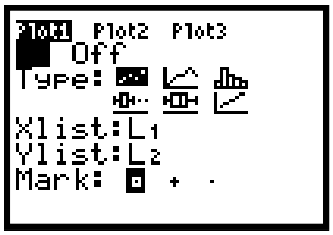


- Next, it would be feasible to use the line to predict the auroral oval latitude using a given Kp index. It is necessary to turn off the stat plots in order to use the regression line. When turning off the plots

2nd **y =**

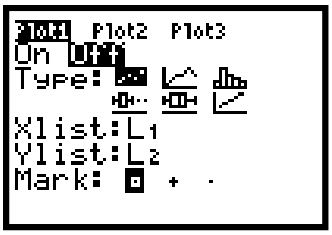


ENTER

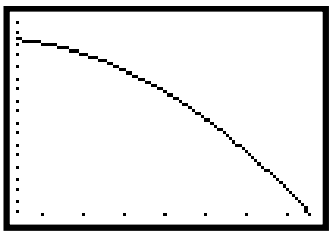


- Arrow over so the cursor is over OFF,

ENTER

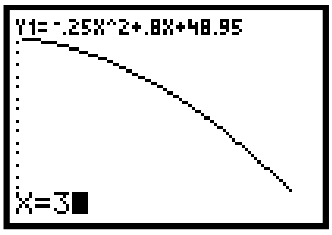


- Go back to the graph **GRAPH**

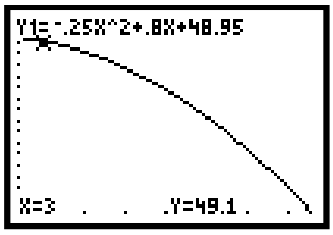


- Press **TRACE** and a blinking cursor will appear on the line. Now use the graph to make predictions. Type in a Kp value such as

TRACE **3**

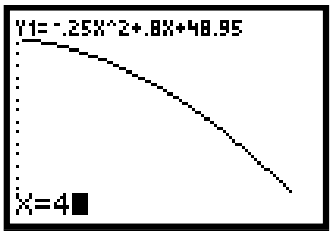


ENTER

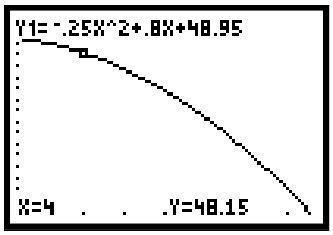


Y = 49.1

4



ENTER

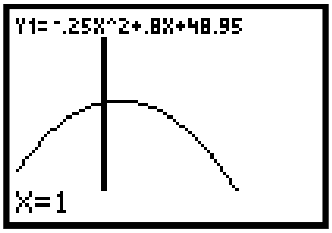


Y = 48.15

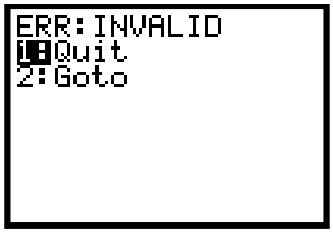
- Continue to type in the Kp values up to 9. Record the y values in your table under the Auroral Oval Latitude.

However, when predicting the latitude for a Kp index of a 1 or a 2, the calculator will give you an error message.

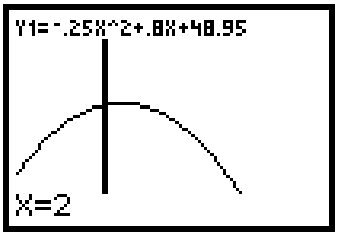
1



ENTER

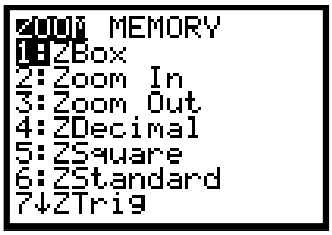


2

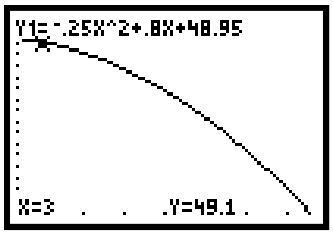


This will bring back the graph window the cursor flashing over the entered value. This message indicates that the window range is not appropriate for that value. In order to adjust for these values it is necessary to expand our viewing window.

ZOOM



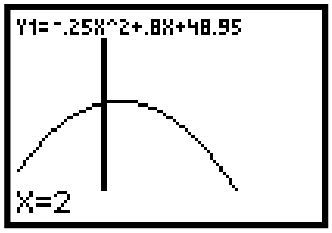
3 **ENTER**



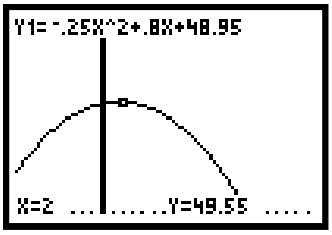
Y = 49.1

The display window will automatically adjust so that the Y-axis is visible.

TRACE **2**

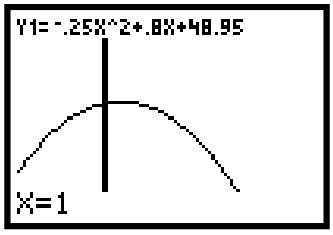


ENTER

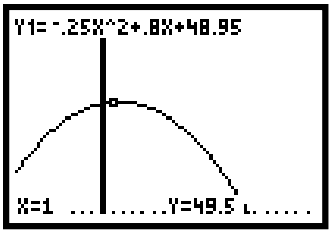


Y = 49.55

1



ENTER



Y = 49.5

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