GIC HAZARD PREDICTION

Aurora Borealis

Aurora Borealis, or Northern Lights, are the result of collisions between gaseous particles in the Earth's atmosphere and charged particles in *solar wind*. The Earth is largely protected from solar wind by its magnetic field, which deflects most of the charged particles. However, when the Earth's magnetosphere is sufficiently disturbed by solar wind, some of the charged particles penetrate the Earth's upper atmosphere. The particles in the solar wind lose their energy in the upper atmosphere by ionizing and exciting atmospheric particles which emit light of varying colors. The most common colors of auroras are red and green.

Photo credit: https://commons.wikimedia.org/wiki/File:Aurora_borealis_above_Lyngenfjorden,_2012_March-3.jpg

SUNSPOT MAXIMUM & MINIMUM

While a full physical understanding of the processes that cause Northern Lights is still being studied, it has long been known that there is a relationship between activity on the sun's surface and the light show in the sky.

Planetary K-Index

The aurora forecast is based on the Planetary K-Index, or Kp-Index, a value that quantifies the disturbances in the magnetic field in a three-hour period of time. NOAA uses the Kp-Index to describe Geomagnetic Storms. A Kp value of 5 and is considered a minor storm with few negative impacts on power systems and satellites, whereas a Kp values of 9 is an extreme storm that may cause power system blackouts, and satellites to be offline for days.

Sunspot activity follows a predictable 11 year pattern. We are nearing the sunspot minimum of the current cycle, whereas 2013 was the peak, or maximum.

Frequencies of Kp Indices 1996

Kp	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0o	3	2	4	4	4	1	4	.	1	5	10	22
+	13	5	6	15	14	23	14	8	8	12	21	28
–	32	16	15	25	26	45	26	20	15	18	29	40
1o	32	25	18	20	39	57	41	35	17	20	28	32
+	20	21	23	30	34	46	37	33	22	16	27	13
–	24	21	33	25	41	28	48	35	23	26	23	17
2o	32	36	34	21	28	11	24	25	18	27	31	23
+	29	23	26	21	25	12	16	24	23	27	18	22
–	24	23	23	15	11	8	16	20	21	21	18	18
3o	5	24	14	14	20	4	9	22	20	17	14	15
+	14	14	17	15	2	1	7	12	10	17	5	4
–	6	8	14	14	4	2	4	8	13	13	6	8
4o	3	7	5	7		.	1	1	13	8	6	3
+	5	3	5	5		2	1	.	15	9	1	.
–	2	2	4	2				1	10	3	1	1
5o	3	1	4	4				1	7	2	1	2
+	1	1	1	2				2	2	4	1	
–			2	.				1	1	1		
6o				.					.	.		
+				.					1	.		

Using archived Kp data let's first confirm the relationship between activity on the surface of the Sun and geomagnetic disturbances on Earth.

Navigate to ftp://ftp.gfz-potsdam.de/pub/home/obs/kp-ap/kp-freq/ to view archived Kp data. Select November 1996 (sunspot minimum) and count the number of instances each of the Kp values were identified. (The Kp scale actually looks like 0o, 0+, 1-, 1o, 1+, …, 9o. Count all 1-, 1o, and 1+ values as 1s, all 2-, 2o, and 2+ values as 2s, and so on.) Record values in the table below. Repeat for November 2000 (sunspot maximum).

Does the level of solar activity have any impact on how frequent magnetic storms are in the Kp range of 4-9?

How might you have students analyze or present this data?

November 1996	
Kp	Number of occurrences
9	
8	
7	
6	
5	
4	

November 2000	
Kp	Number of occurrences
9	
8	
7	
6	
5	
4	

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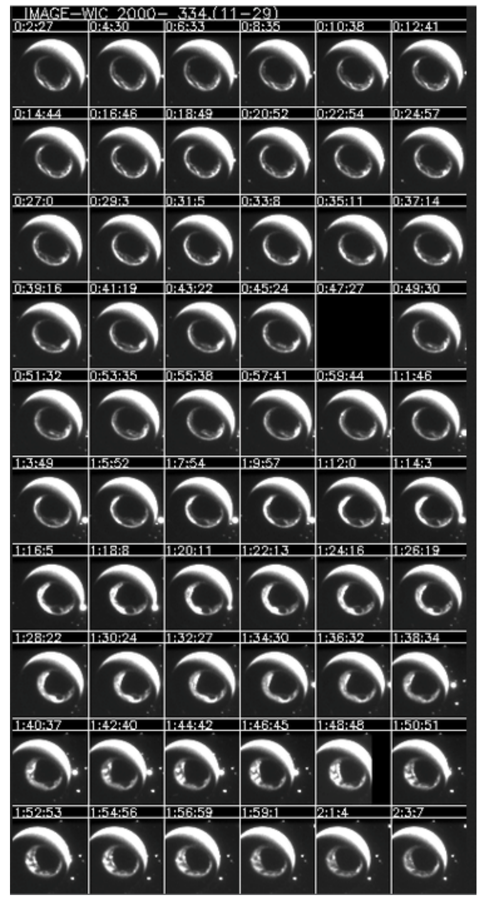
NOAA SPACE WEATHER PREDICTION CENTER

The National Oceanic and Atmospheric Administration's Space Weather Prediction Center is a comprehensive site that gives real-time data and predicts geomagnetic disturbances, or solar storms. On the homepage, you can view data from the last 24 hours of the x-rays emitted from the sun, coronal mass ejections, and aurora forecasts.

www.swpc.noaa.gov/

AURORA MONITORING



Since the 1990s, NASA has placed research satellites in orbit around the poles to monitor for signs of auroral activity. Let's explore data from the IMAGE satellite to determine whether there is a relationship between severe magnetic storms and larger auroral areas.

Navigate to http://sprg.ssl.berkeley.edu/sprite/ago96/image/wic_summary/wic_summary/ to view archived data from the Far Ultraviolet Camera. Click on the folder for Nov_2000, then click on a day of interest. For instance, WIC_2000_333_02.gif for the 333rd day of the year 2000 and is the second archive of images from that day. You should see images like the one to the right.

Measure the diameter of the Earth disk and the diameter of the auroral oval with a millimeter ruler (held up to your screen, or on printouts of the images). Given that the Earth's diameter is equal to 12774 km, calculate the linear diameter of the auroral oval. Choose a few days in November 2000 and 1996 and repeat this procedure.

Plot the maximum linear diameter of the auroral oval against the record Kp value recorded for that date and time.

How can this data be collected and analyzed by students at different grade bands?

Do more severe storms correlate to larger aurora areas?

The Bastille Day Storm of July 14-15, 2000 was one of the most powerful storms during the last solar activity cycle. Look up its Kp value. What do you imagine the auroral activity looked like on those nights? Look at the images from those nights in the archives. Were you right?

PUTTING IT ALL TOGETHER

To view current space weather forecasts, visit Space Weather Live at www.spaceweatherlive.com. The archive calendar https://www.spaceweatherlive.com/en/archive, has more recent historical data than in the other directories that we've looked at.

Find a day in the last five years with high Kp values and aurora activity. Open Helioviewer and observe the sun's surface for the same day following the steps outlined in the Helioviewer activity.

What was happening on the sun's surface on this day?

Given the Kp value, how far south do you think the aurora was seen? (Texans and Floridians only see auroras when the Kp index is greater than 8, whereas Canadians can see them when the Kp index is 5 or less.)

OTHER AURORA RESOURCES

www.aurorawatch.ca/
www.aurora-service.org/
www.swpc.noaa.gov/phenomena/aurora
www.swpc.noaa.gov/content/education-and-outreach

Some of the activities in this handout were adapted from *An IMAGE Satellite Guide to Exploring the Earth's Magnetic Field* cse.ssl.berkeley.edu/artemis/pdf/odenwald_mag_lessons.pdf