
Space Weather Action Center

FLIP CHART GUIDE (Version 3)



SWAC Flip Chart Guide

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Introduction:

This Flip Chart Guide provides a snapshot of all four student flip charts: Sunspot Regions, Storm Signals, Magnetosphere, Aurora. Each section also contains a brief overview, helpful tips and copy of the questions from the student Data Collection Sheets. All student flip charts and data collection sheets can be downloaded from the SWAC website at: <http://sunearthday.gsfc.nasa.gov/swac/gettingstarted/download.php>

Each of the SWAC flip charts has been carefully designed to enable students easily move through the sequence of events that occur during typical Solar Storm and are therefore comprised of the following four main sections: Sunspot Regions, Storm Signals, Magnetosphere, Auroras. Each set of flip chart cards also includes 'easy to follow' **INSTRUCTION CARDS** and **INFORMATION CARDS**.

INSTRUCTION CARDS contain every step necessary to obtain, analyze and record all required online data.

INFORMATION CARDS contain a variety of sample images and helpful tips when interpreting and analyzing the data.

The flip charts may be downloaded and printed on a single 8x11 sheet of paper. Assemble your flip chart by inserting 2 flip chart sheets (back to back) into plastic sleeves. Place the plastic sleeves in a loose-leaf notebook; turning the notebook in a horizontal direction with the binding at the top.

A smaller flip chart can be assembled by reducing the printout sizes: 2 or 4 to a sheet depending on the size you prefer. Cut out and fasten the smaller flip chart sheets together. We suggest that you laminate or insert each sheet into a plastic sleeve for continued use.

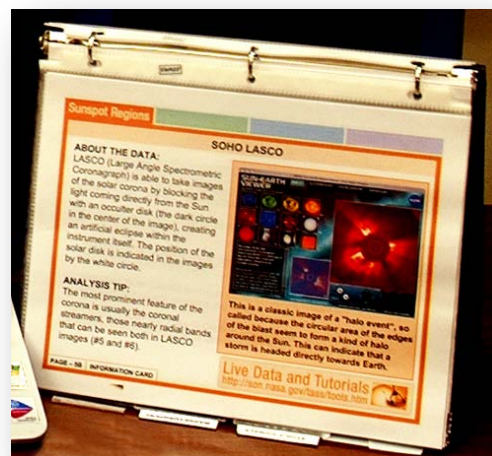


Figure 1: Sample Flip Chart

SPACE WEATHER DATA

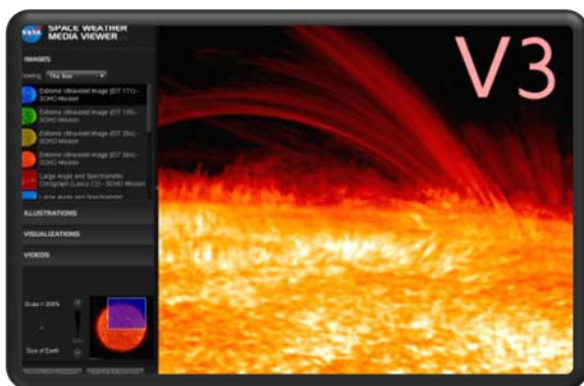
All of the data links required to make your space weather observations are located on this single webpage. Beside each of the 'live data' links on that page you will also find 'tutorial' links containing easy to read tutorials that that will help you when interpreting the data. You can always find your place by returning to this page referred to throughout each of the flipcharts.

The screenshot shows the top navigation bar of the Space Weather Action Center website. The navigation bar includes links for HOME, GETTING STARTED, FOR EDUCATORS, and SPACE WEATHER DATA. Below the navigation bar is a banner with the text "Space Weather Action Center" and images of a satellite, the Earth, and a student reporter. The main content area is divided into four color-coded sections: SUNSPOT REGIONS (orange), STORM SIGNALS (green), MAGNETOSPHERE (blue), and AURORAS (purple). Each section contains a list of data links and tutorials, along with an "Additional Data" section.

SUNSPOT REGIONS	STORM SIGNALS	MAGNETOSPHERE	AURORAS
<ul style="list-style-type: none">H-Alpha Full Disk Image of the Sun: (Live Data) - (Tutorial)MDI with numbers: (Live Data) - (Tutorial)MDI Magnetogram: (Live Data) - (Tutorial)Extreme Ultraviolet Image: (Live Data) - (Tutorial)Large Angle and Spectrometric Coronagraph (LASCO): (Live Data) - (Tutorial)	<ul style="list-style-type: none">University of Florida Radio Observatory: (Live Data) - (Tutorial)GOES X-ray Flux (5 min data): (Live Data) - (Tutorial)	<ul style="list-style-type: none">Kp Index (Estimated Planetary K-index): (Live Data) - (Tutorial)Magnetosphere Graph: (Live Data) - (Tutorial)	<ul style="list-style-type: none">Auroral Activity on Earth - NOAA POES: (Live Data) - (Tutorial)Kiruna All-Sky camera: (Live Data) - (Tutorial)
Additional Data <ul style="list-style-type: none">Global High-Resolution Network: (Live Data) - (Tutorial)	Additional Data <ul style="list-style-type: none">RadioJove Archives: (Live Data) - (Tutorial)Wind Waves: (Live Data) - (Tutorial)Latest Events: (Live Data) - (Tutorial)SOHO CME Archives: (Live Data) - (Tutorial)	Additional Data <ul style="list-style-type: none">Tromso, Norway: (Live Data)Alaska: (Live Data)Tixie Bay, Russia: (Live Data)ACE Bz Archive: (Live Data) - (Tutorial)	Additional Data <ul style="list-style-type: none">The Aurora Today ♦ Ground View From Alaska: (Live Data)Poker Flat Allsky Camera: (Live Data)SGO: Real-time Data: All-Sky Cameras: (Live Data)

COLOR CODING

We have divided all of the Space Weather Action Center resources into four 'color-coded' categories: **Sunspot Regions** (orange), **Storm Signals** (green), **Magnetosphere** (blue) and **Aurora** (purple). The same color code scheme is used in the flipchart, the data collection sheets and on the Live Data and Tutorials webpage. You can always know which section you're in with one quick glance!



THE SPACE WEATHER MEDIA VIEWER

The Space Weather Media Viewer is one of the main observation tools that you will be using. Once this online tool is open, we recommend that you simply keep it open in a separate browser tab or window for faster data access when needed.

Sunspot Regions Flip Chart

Overview

Sunspots are the first indicators that a storm from the Sun is a possibility. However, not all sunspots cause problems for Earth. By following the steps in this flip chart your students will soon be able to answer the big question, **“Do sunspot regions exist today that could be a source of solar storms?”**.

In the Sunspot Regions Flip Chart there are 5 sets of data:

- H-Alpha Full Disk Image of the Sun
- MDI with Numbers
- MDI Magnetogram
- Extreme Ultraviolet Image
- Large Angle Spectrometric Coronagraph (LASCO)

In this section students will learn how to:

- Obtain and interpret data from ground-based professional observatories.
- Obtain and interpret data from NASA satellites.

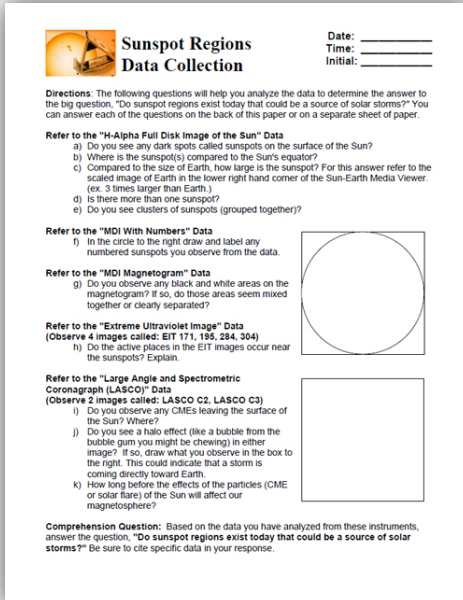
Data Collection Sheet:

Each flip chart has a corresponding Data Collection Sheet that can be downloaded from the SWAC website. They are designed to help students quickly record and analyze necessary sets of data. A comprehension question at the bottom of each data sheet provides an opportunity for students to summarize the data and make a prediction for verification over the next several days.

Keep a set of **Data Collection Sheets** and/or clipboards nearby in order for students to collect all of the information they will need to complete their Space Weather News Report!

Space Weather Data:

The SWAC website is an extremely robust 'one stop shopping' learning tool complete with step-by-step tutorials on how to interpret live or 'near real time' space weather data from 10 missions and 36 instruments. All of the data links required to make your space weather observations are located on a single webpage called Space Weather Data. Beside each of the 'live data' links you will also find 'tutorial' links containing easy to read tutorials that that will help you when interpreting the data. A link to this webpage is at the bottom of every INSTRUCTIONAL CARD in the flip chart.



The image shows a 'Sunspot Regions Data Collection' sheet. It includes a title, a date and time field, and a set of directions. The directions are divided into five sections, each with a set of questions and a corresponding diagram or image. The first section is for 'H-Alpha Full Disk Image of the Sun' data, with questions about sunspots and their size. The second section is for 'MDI With Numbers' data, with a question about sunspots in a circle. The third section is for 'MDI Magnetogram' data, with a question about black and white areas. The fourth section is for 'Extreme Ultraviolet Image' data, with a question about active places. The fifth section is for 'Large Angle and Spectrometric Coronagraph (LASCO)' data, with questions about CMEs and halo effects. A comprehension question is at the bottom.

Sunspot Regions Data Collection

Date: _____
Time: _____
Initial: _____

Directions: The following questions will help you analyze the data to determine the answer to the big question, "Do sunspot regions exist today that could be a source of solar storms?" You can answer each of the questions on the back of this paper or on a separate sheet of paper.

Refer to the "H-Alpha Full Disk Image of the Sun" Data

- Do you see any dark spots called sunspots on the surface of the Sun?
- Where is the sunspot(s) compared to the Sun's equator?
- Compared to the size of Earth, how large is the sunspot? For this answer refer to the scaled image of Earth in the lower right hand corner of the Sun-Earth Media Viewer. (ex. 3 times larger than Earth.)
- Is there more than one sunspot?
- Do you see clusters of sunspots (grouped together)?

Refer to the "MDI With Numbers" Data

- In the circle to the right draw and label any numbered sunspots you observe from the data.

Refer to the "MDI Magnetogram" Data

- Do you observe any black and white areas on the magnetogram? If so, do those areas seem mixed together or clearly separated?

Refer to the "Extreme Ultraviolet Image" Data (Observe 4 images called: EIT 171, 195, 294, 304)

- Do the active places in the EIT images occur near the sunspots? Explain.

Refer to the "Large Angle and Spectrometric Coronagraph (LASCO)" Data (Observe 2 images called: LASCO C2, LASCO C3)

- Do you observe any CMEs leaving the surface of the Sun? Where?
- Do you see a halo effect (like a bubble from the bubble gum you might be chewing) in either image? If so, draw what you observe in the box to the right. This could indicate that a storm is coming directly toward Earth.
- How long before the effects of the particles (CME or solar flare) of the Sun will affect our magnetosphere?

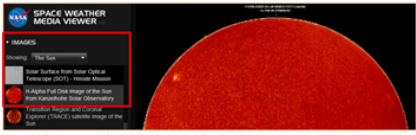
Comprehension Question: Based on the data you have analyzed from these instruments, answer the question, "Do sunspot regions exist today that could be a source of solar storms?" Be sure to cite specific data in your response.

H-Alpha Full Disk Image of the Sun

Sunspot Regions

H-Alpha Full Disk Image of the Sun

1. Open "Space Weather Data" and select "H-Alpha Full Disk Image of the Sun (Live Data)". The Space Weather Media Viewer will open. Under the 'IMAGES' section of the Viewer select "Showing: The Sun" in the small drop-down menu. Select the image called, "H-Alpha Full Disk Image of the Sun from Kanzelhohe Solar Observatory".



2. Look for any visible signs of sunspots.
3. Refer to your 'Sunspot Regions Data Collection' sheet to answer questions (a) through (e).
4. Keep the Viewer open for your next set of observations.

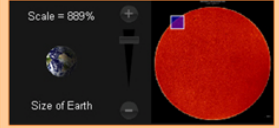
PAGE-1A INSTRUCTION CARD Observatory Data

PAGE-1A

Sunspot Regions

H-Alpha Full Disk Image of the Sun

ABOUT THE DATA:
Kanzelhohe Solar Observatory allows us to look at the sun through a ground based telescope using a special Hydrogen-alpha filter. These filters allow us to look safely at the Sun by filtering out all light except a specific wavelength of red light. These particular images of the Sun are updated every day if viewing conditions are good.



ANALYSIS TIP:
The size and position of sunspots can tell us about solar activity that might produce solar flares and coronal mass ejections.

With any image in the Space Weather Media Viewer you can zoom and pan. This feature allows you to see sunspots on the Sun in great detail along with the relative size of Earth. Some small sunspots may not be visible until you zoom. If you zoom in and pan down to the left, you can see the exact date and time of the image. It is important to check the date and time because the images are not updated if viewing conditions are poor (cloudy) at the Kanzelhohe Solar Observatory.

Space Weather Data
sunearthday.nasa.gov/swac/data.php

PAGE-1B INFORMATION CARD

PAGE-1B

The Kanzelhohe Solar Observatory in Treffen, Austria, provides the near-real time images that you see in the Space Weather Media Viewer.

Tips

- Your students can use these images to compare with the NASA satellite images they will retrieve in the next few sections.
- Kanzelhohe Solar Observatory allows us to look at the sun through a ground based telescope using a special Hydrogen-alpha filter. These filters allow us to look safely at the Sun by filtering out all light except a specific wavelength of red light. These particular images of the Sun are updated every day if viewing conditions are good.

Questions from the Student Data Collection Sheet

- a) Do you see any dark spots called sunspots on the surface of the Sun?
- b) Where is the sunspot(s) compared to the Sun's equator?
- c) Compared to the size of Earth, how large is the sunspot? For this answer refer to the scaled image of Earth in the lower right hand corner of the Sun-Earth Media Viewer. (ex. 3 times larger than Earth.)
- d) Is there more than one sunspot?
- e) Do you see clusters of sunspots (grouped together)?

MDI with Numbers

Sunspot Regions

MDI with Numbers

1. Under the 'IMAGES' section of the Viewer select "Showing: **The Sun**" from the small drop-down menu. Select the image called, "MDI with Numbers – SOHO Mission".
2. On your 'Sunspot Regions Data Collection' sheet answer question (f) by drawing any sunspots that you observe. Also, include any given sunspot region numbers.
3. Keep the Viewer open for your next set of observations.

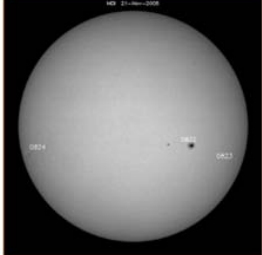
PAGE – 2A INSTRUCTION CARD Satellite Data

PAGE – 2A


Sunspot Regions

MDI with Numbers

ABOUT THE DATA:
"MDI with Numbers" shows black and white SOHO MDI images with sunspot numbers printed next to the sunspots. Each sunspot region is given a number by scientists to help them communicate with each other better.



ANALYSIS TIP:
You should use these numbers as you refer to sunspots in your reports.

 **Space Weather Data**
sunearthday.nasa.gov/swac/data.php

PAGE – 2B INFORMATION CARD

PAGE – 2B

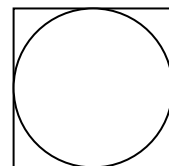
MDI with Numbers (Michelson Doppler Imager) produces images that appear most nearly as the Sun would look at sunrise or sunset. The most prominent features are the sunspots. Each sunspot region is given a number by scientists to help them communicate better with each other.

Tips

- The easiest way to view this image is by opening the [Space Weather Media Viewer](#). In the "IMAGES" section select "The Sun" from the small drop-down menu. Select the image called, "MDI with Numbers- SOHO Mission". Don't forget to zoom in and pan to the top center of the image in order to see the exact date and time of the image.
- "MDI with Numbers" shows black and white SOHO MDI images with sunspot numbers printed next to the sunspots.
- You should encourage students to use these numbers when referring to sunspots in their reports.

Questions from the Student Data Collection Sheet

- f) In the circle to the right draw and label any numbered sunspots you observe from the data.



MDI Magnetogram

Sunspot Regions

MDI Magnetogram

1. Under the 'IMAGES' section of the Viewer select "Showing: **The Sun**" from the small drop-down menu. Select the image called, "MDI Magnetogram – SOHO Mission".
2. Answer question (g) on your "Sunspot Regions Data Collection" sheet.
3. Keep the Viewer open for your next set of observations.

Observation Note:
When black and white areas within an observed region of this image are clearly separated, there is less chance of a solar eruption. When they are mixed together, there is a better chance for a solar eruption from that location.

PAGE – 3A | INSTRUCTION CARD | Satellite Data

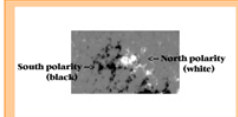
PAGE – 3A

Sunspot Regions

MDI Magnetogram

ABOUT THE DATA:
The fields and forces of magnetism are invisible to our eyes, so how can we see them? The **Michelson Doppler Imager (MDI)** instrument aboard the SOHO spacecraft 'can' detect the strength and locations of magnetic fields on the Sun and represent that information in specialized images called magnetograms. These images demonstrate the intensity of magnetic twisting in the solar photosphere.

ANALYSIS TIP:
Think of a bar magnet. One end of a bar has a north magnetic pole and the other end has a south magnetic pole. In a magnetogram white areas show regions of north magnetic poles while black areas show regions of south magnetic poles. The gray color shows an absence of magnetic fields.



The areas of black, white, and gray are artificially colored to represent the magnetic field lines.

Space Weather Data
sunearthday.nasa.gov/swac/data.php

PAGE – 3B | INFORMATION CARD

PAGE – 3B

The MDI (Michelson Doppler Imager) instrument aboard the SOHO spacecraft 'can' detect the strength and locations of magnetic fields on the Sun and represent that information in specialized images called magnetograms.

Tips

- The easiest way to view this image is by opening the [Space Weather Media Viewer](#). In the "IMAGES" section select "The Sun" from the small drop-down menu. Select the image called, "MDI Magnetogram- SOHO Mission". Don't forget to zoom in and pan to the top center of the image in order to see the exact date and time of the image.
- These images demonstrate the intensity of magnetic twisting in the solar photosphere. When the black and white areas next to each other are clearly separated, there is less chance of a solar eruption. When black and white areas are mixed together, there is a better chance for a solar eruption from that location.
- Students in grades K + 4 can understand that the MDI images are pictures of the Sun, and they can make observations of the spots on the Sun and watch the spots changes position and size.

Questions from the Student Data Collection Sheet

- g) Do you observe any black and white areas on the magnetogram? If so, do those areas seem mixed together or clearly separated?

Extreme Ultraviolet Image

Sunspot Regions

Extreme Ultraviolet Image

1. Under the **'IMAGES'** section of the Viewer select "Showing: **The Sun**" from the small drop-down menu. Select and observe the first 4 images called, "**Extreme Ultraviolet Image (EIT 171, 195, 284 and 304)**".
2. At certain times these images will be inactive due to instrument recalibration and you will see the words "CCD BAKEOUT" over the EIT images. When this happens refer to the image in the same section of the Viewer called, "**Transition Region and Coronal Explorer (TRACE)**".
3. On your "**Sunspot Regions Data Collection**" sheet answer question (h).
4. Keep the Viewer open for your next set of observations.

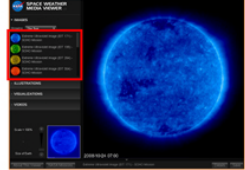
PAGE - 4A INSTRUCTION CARD Satellite Data

PAGE - 4A

Sunspot Regions

Extreme Ultraviolet Image

ABOUT THE DATA:
The first 4 images in the Space Weather Media Viewer show images from the SOHO EIT instrument (Extreme Ultraviolet Imaging Telescope). EIT uses filters to allow the camera to record only particular kinds of ultraviolet light. Ultraviolet light is invisible to our eyes and has no color as we know it. These images are artificially colored to help scientists know what filter was used.



ANALYSIS TIP:
Bright spots in these images tell you that there is a lot of ultraviolet light being emitted. Dark regions show little activity. You should compare these four EIT images to each other and to the SOHO MDI image that that you observed earlier.

Space Weather Data
sunearthday.nasa.gov/swac/data.php

PAGE - 4B INFORMATION CARD

PAGE - 4B

The first four images in the Space Weather Media Viewer are from the SOHO EIT instrument (Extreme Ultraviolet Imaging Telescope). This instrument uses filters to allow the camera to record only particular kinds of ultraviolet light. These images are artificially colored to help scientists know what filter was used. (Ultraviolet light is invisible to our eyes and has no color as we know it.)

Tips

- The bright spots in these images tell you that there is a lot of ultraviolet light being emitted. Dark regions show little activity. You should compare the four EIT images to each other and to the SOHO MDI images that show you where sunspots are.
- At certain times these images will be inactive due to instrument recalibration and you will see the words "CCD BAKEOUT" over the EIT images. When this happens refer to the image called, "Transition Region and Coronal Explorer (TRACE)". It is important to note that these images are updated about every two hours. However, not all images are updated at the same time. This means that an image might be a few hours before or after others. You can download full size images and save them by clicking on the "Save" button in the lower right side of the viewer.
- In the images taken at 304 Angstroms (orange image) the bright material is at 60,000 to 80,000 degrees Kelvin. In those taken at 171 Angstroms (blue image), the bright material is at 1 million degrees. 195 Angstrom (green image) images correspond to about 1.5 million Kelvin. 284 Angstrom (yellowish image) images correspond to 2 million degrees. The hotter the temperature, the higher you look in the solar atmosphere.

Questions from the Student Data Collection Sheet

- h) Do the active places in the EIT images occur near the sunspots? Explain.

Large Angle and Spectrometric Coronagraph (LASCO)

Sunspot Regions

Large Angle and Spectrometric Coronagraph (LASCO)

1. Under the 'IMAGES' section of the Viewer select "Showing: **The Sun**" from the small drop-down menu. Select and observe 2 images called, "Large Angle and Spectrometric Coronagraph (LASCO C2 and LASCO C3)".
2. Refer to your 'Sunspot Regions Data Collection' sheet to answer questions (i) through (k) and the (Comprehension Question).
3. Return to 'Space Weather Data'.


PAGE - 5A INSTRUCTION CARD Satellite Data

PAGE - 5A

Sunspot Regions

Large Angle and Spectrometric Coronagraph (LASCO)

ABOUT THE DATA:
LASCO (Large Angle Spectrometric Coronagraph) is able to take images of the solar corona by blocking the light coming directly from the Sun with an occulter disk (the dark circle in the center of the image), creating an artificial eclipse within the instrument itself. The position of the solar disk is indicated in the images by the white circle.



ANALYSIS TIP:
The most prominent feature of the corona is usually the coronal streamers, those nearly radial bands that can be seen both in LASCO images.

This is a classic image of a "halo event", so called because the circular area of the edges of the blast seem to form a kind of halo around the Sun. This can indicate that a storm is headed directly towards Earth.

Space Weather Data
sunearthday.nasa.gov/swac/data.php

PAGE - 5B INFORMATION CARD

PAGE - 5B

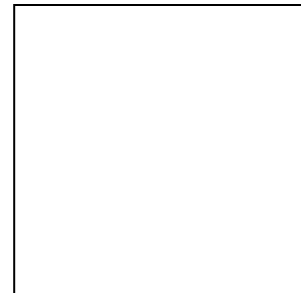
LASCO (Large Angle Spectrometric Coronagraph) is able to take images of the solar corona by blocking the light coming directly from the Sun with an occulter disk (the dark circle in the center of the image), creating an artificial eclipse within the instrument itself.

Tips

- In the Space Weather Media Viewer students should observe the 2 images called, "Large Angle and Spectrometric Coronagraph (LASCO C2 and LASCO C3)". It is important to note the date and time for each image. If the images become speckled with white specks or a halo around the image appears, this can indicate that a storm headed directly toward Earth.
- While viewing the LASCO images, don't forget to look for the constellations and planets that can be seen behind the Sun!

Questions from the Student Data Collection Sheet

- i) Do you observe any CMEs leaving the surface of the Sun? Where?
- j) Do you see a halo effect (like a bubble from the bubble gum you might be chewing) in either image? If so, draw what you observe in the box to the right. This could indicate that a storm is coming directly toward Earth.
- k) How long before the effects of the particles (CME or solar flare) of the Sun will affect our magnetosphere?



Comprehension Question: Based on the data you have analyzed from these instruments, answer the question, "**Do sunspot regions exist today that could be a source of solar storms?**" Be sure to cite specific data in your response.

Storm Signals Flip Chart

Overview

When a solar flare or CME erupts from the Sun, a radio signal is emitted that reaches Earth in a little over 8 minutes! By following the steps in this flip chart your students will soon be able to answer the big question, **“Have signals been recorded today due to a flare or CME that could affect Earth?”**

In the Storm Signals Flip Chart there are 2 sets of data:

- University of Florida Radio Observatory
- GOES X-ray Flux (5 minute data)

In this section students will learn how to:

- Obtain and interpret radio emissions from ground-based professional observatories.
- Obtain and interpret radio, x-ray and ultraviolet emissions from NASA satellites.

Data Collection Sheet:

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Storm Signals Data Collection

Date: _____
Time: _____
Initial: _____

Directions: The following questions will help you analyze the data to determine the answer to the big question, "Have signals been recorded today due to a flare or CME that could affect Earth?" You can answer each of the questions on the back of this paper or on a separate Storm Signals Answer Sheet.

Refer to the "University of Florida Radio Observatory" Data

- Were solar flares or coronal mass ejections detected today?
- Did the intensity of radio waves from the Sun change since your last entry? If so, explain.
- Draw an example of what your red line looks like in the box below.
- Do you think you are observing a solar storm using this data? Why or why not?

Refer to "GOES X-ray Flux (5 minute data)" Data

- Did the intensity of x-ray emissions from the sun increase over the last few days?
 - If yes, record the dates and levels (A, B, C, M or X)
- When can we expect to see the visible sign (aurora) of the solar storm on Earth?

Comprehension Question: Based on the data you have analyzed from these instruments, answer the question, "Have signals been recorded today indicating that a solar storm might be headed towards Earth?" Be sure to cite specific data in your response.

University of Florida Radio Observatory

Storm Signals

University of Florida Radio Observatory

1. Open **'Space Weather Data'** and click on **'University of Florida Radio Observatory'** (live data). The "Internet Jupiter Radio Observatory" website will open.
2. Click on the word **[Run]** in the third line. You will see a graph with several multi-colored lines showing data from several different antennas.
3. Adjust the graph so that it only shows data coming from the ground-based radio receivers in Florida. This can be done by using the 'drop down' lists in the upper left hand side of the webpage:
 - From the **'Time Span'** list, select **'RJ 15'**
 - From the **'Refresh Rate'** list, select **'30'** seconds. (You can select faster or slower refresh rates if desired.)
 - Click **'Run'**
4. You should now see a single red graph. This is the Radio JOVE receiver in Florida. (NOTE: If you see a *straight red line*, the data is currently unavailable. Simply move on to the next section, **"GOES X-ray Flux (5 minute data)"**)
5. Refer to your **'Storm Signals Data Collection'** sheet to answer questions (a) through (d).
6. Close the current window and return to **'Space Weather Data'**.


PAGE – 1A INSTRUCTION CARD Observatory Data

PAGE – 1A

Storm Signals

University of Florida Radio Observatory

ANALYSIS TIPS:

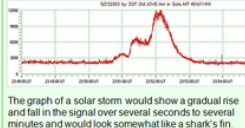


Sharp spikes in the graph are usually due to man-made signals or lightning strokes.

ABOUT THE DATA:

When a solar flare or coronal mass ejection erupts, hot, charged particles are accelerated away from the Sun. When this happens, a radio signal is emitted that reaches Earth in a little over 8 minutes providing the first signal that a solar storm is headed our way. However, the particles from that same storm usually take up to 3 days to reach Earth.

Solar flares and Coronal Mass Ejections (CMEs) emit a broad range of light. Most of this light is invisible to us. To detect solar storms we will use radio waves, x-rays, and ultraviolet light. Radio waves are especially useful because they can be measured by instruments on the Earth and in interplanetary space.



The graph of a solar storm would show a gradual rise and fall in the signal over several seconds to several minutes and would look somewhat like a shark's fin.

Space Weather Data
sunearthday.nasa.gov/swac/data.php

PAGE – 1B INFORMATION CARD

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The ground-based radio antennas at the University of Florida provide real-time measurements of radio emissions from the Sun and archives of results from earlier measurements. Radio waves are especially useful because they can be measured by instruments on the Earth and in interplanetary space.

Tips

- At times this graph will show a straight red line which indicates that the data is currently unavailable. When this happens simply move on to the next section, **"GOES X-ray Flux (5 minute data)"**.
- When a solar flare or coronal mass ejection erupts, hot, charged particles are accelerated away from the Sun. When this happens, a radio signal is emitted that reaches Earth in a little over 8 minutes providing the first signal that a solar storm is headed our way. However, the particles from that same storm usually take up to 3 days to reach Earth.
- To conduct research on past solar storms, visit the [RadioJove Archives](#) under **"Additional Data"** on the **"Space Weather Data"** webpage.

Questions from the Student Data Collection Sheet

- a) Were solar flares or coronal mass ejections detected today?
- b) Did the intensity of radio waves from the Sun change since your last entry? If so, explain.
- c) Draw an example of what your red line looks like in the box below.

- d) Do you think you are observing a solar storm using this data? Why or why not?

GOES X-ray Flux (5-min data)

Storm Signals

GOES X-ray Flux

1. Open 'Space Weather Data' and 'minute data' (live data). Observe the line indicates the level of solar activity.
2. Using the solar x-ray activity scale on the side of the graph, determine the level of solar activity.
 - Levels A and B indicate that the solar activity is in higher latitudes.
 - Level C indicates that *Aurora* is visible in the southern states.
 - Levels M and X indicate that the solar activity is far south as Texas!
3. Refer to your 'Storm Signals Data Collection Sheet' questions (e), (f), and the (Comprehension Question).
4. Close the current window and return to the main page.

PAGE - 2A INSTRUCTION CARD

Storm Signals

GOES X-ray Flux

ABOUT THE DATA:
X-rays are continually emitted from the Sun. The intensity of those x-rays can provide an indication of solar activity. We have developed a simple rating system for the intensity of solar x-ray emissions. The levels are A, B, C, M, and X. The levels A and B indicate that the solar activity is in higher latitudes. Level C indicates that *Aurora* is visible in the southern states. Levels M and X indicate that the solar activity is far south as Texas!

Even though X is the highest level, the number of flares at this level is very low. In fact, there was an X17.2 flare followed several days later by an X2.2 flare. It was actually so strong it was hard to measure.

PAGE - 2B INFORMATION CARD

Storm Signals

GOES X-ray Flux (5 minute data)

ANALYSIS TIP:
Two GOES satellites record solar x-ray emission, GOES 10 and GOES 12. The red plot from GOES 12 is the one we want to use.

REMEMBER:
This is a 3-day plot. It usually takes 3 days for solar storms to reach Earth.

ABOUT THE DATA:
It is important to find out if these flares were on the side of the Sun facing us. Flares from the side of the Sun facing us are more likely to disturb Earth's magnetosphere than flares that erupt from the edges. You can use images 1-6 on the Sun-Earth Viewer to evaluate the location of the emissions from the Sun.

PAGE - 2C INFORMATION CARD

Space Weather Data
sunearthday.nasa.gov/swac/data.php

X-rays are continually emitted from the Sun. The GOES satellites, while primarily studying Earth and Earthly weather, monitor the Sun for x-ray radiation and provide us with information about the solar wind and space weather.

Tips

- Two GOES satellites record solar x-ray emission, GOES 10 and GOES 12. However, GOES 12 x-ray data is a good indicator that a solar storm is likely coming toward Earth and should be used to verify the student data from the Radio JOVE. When observing the data from the GOES 5 Min X-ray Plot, the red plot from GOES 12 is the one we want use.
- In the “**Storm Signals**” section of the “**Space Weather Data**” web page you will find “**Additional Data**”. This section contains a link to [The Latest Events](#) web site that offers a wealth of data over several days in one place. You will also find a links to several easy to use archives including the [Latest Events Archives](#) and the [SOHO CME Archives](#).

Questions from the Student Data Collection Sheet

- e) Did the intensity of x-ray emissions from the sun increase over the last few days?
 - i) If yes, record the dates and levels (A, B, C, M or X)
- f) When can we expect to see the visible sign (aurora) of the solar storm on Earth?

Comprehension Question: Based on the data you have analyzed from these instruments, answer the question, "**Have signals been recorded today indicating that a solar storm might be headed towards Earth?**" Be sure to cite specific data in your response.

Magnetosphere Flip Chart

Overview

*Solar storms can cause fluctuations in the magnetosphere called magnetic storms. These magnetic storms have disabled satellites and burned out transformers shutting down power grids. By following the steps in this flip chart your students will soon be able to answer the big question, “**Has there been a measurable disturbance in Earth’s magnetic field?**”*

In the Storm Signals Flip Chart there are 2 sets of data:

- University of Florida Radio Observatory
- GOES X-ray Flux (5 minute data)

In this section students will learn how to:

- Obtain and interpret data from ground-based professional observatories.
- Obtain and interpret data from NASA satellites.

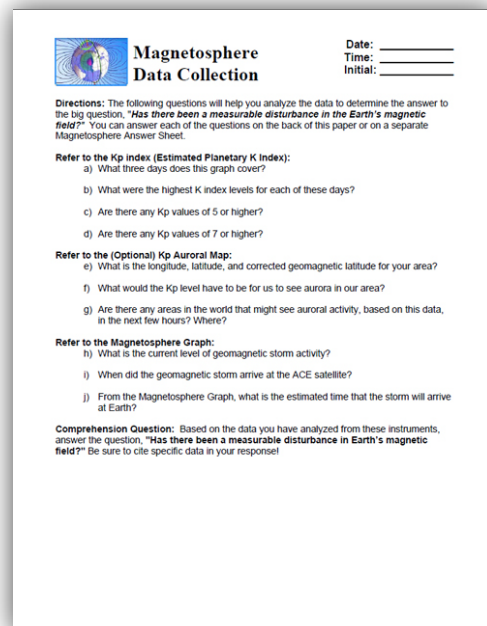
Data Collection Sheet:

Each flip chart has a corresponding Data Collection Sheet that can be downloaded from the SWAC website. They are designed to help students quickly record and analyze necessary sets of data. A comprehension question at the bottom of each data sheet provides an opportunity for students to summarize the data and make a prediction for verification over the next several days.

Keep a set of **Data Collection Sheets** and/or clipboards nearby in order for students to collect all of the information they will need to complete their Space Weather News Report!

Space Weather Data:

The SWAC website is an extremely robust "one stop shopping" learning tool complete with step-by-step tutorials on how to interpret live or 'near real time' space weather data from 10 missions and 36 instruments. All of the data links required to make your space weather observations are located on a single webpage called Space Weather Data. Beside each of the 'live data' links you will also find 'tutorial' links containing easy to read tutorials that that will help you when interpreting the data. A link to this webpage is at the bottom of every INSTRUCTIONAL CARD in the flip chart.



The image shows a 'Magnetosphere Data Collection' sheet. It includes a small globe icon, a title, and a form for recording 'Date', 'Time', and 'Initial'. Below this, there are directions and a list of questions. The questions are: 'Refer to the Kp index (Estimated Planetary K Index):' with sub-questions a) through d); 'Refer to the (Optional) Kp Auroral Map:' with sub-questions e) through g); and 'Refer to the Magnetosphere Graph:' with sub-questions h) through j). At the bottom, there is a 'Comprehension Question' asking students to determine if there has been a measurable disturbance in Earth's magnetic field based on the data they have analyzed.

Kp Index (Estimated Planetary K-Index)

Magnetosphere

Kp Index (Estimated Planetary K-index)

1. Open **'Space Weather Data'** and click on **"Kp Index"** (live data)". A webpage containing a bar graph called the **"Estimated Planetary K-index (3-hour data)"** will appear. Observe the graph for any deviations. (K-indices of 5 or higher indicate 'storm-level' geomagnetic activity. Values of 7 or higher indicate a severe geomagnetic storm.)
2. Refer to your **'Magnetosphere Data Collection'** sheet to answer questions (a) through (d).
3. Close the current window and return to **'Space Weather Data'**.

PAGE – 1A INSTRUCTION CARD Observatory Data

PAGE – 1A

Magnetosphere

Kp Index (Estimated Planetary K-index)

ABOUT THE DATA:
This bar graph contains the estimated 3-hour planetary K-index. It is derived at the U.S. Air Force Space Forecast Center using data from 10 ground-based magnetometers at:

- Meadok, Canada
- Sitka, Alaska
- Glenies, Canada
- Saint Johns, Canada
- Ottawa, Canada
- Newport, Washington
- Fredericksburg, Virginia
- Boulder, Colorado
- Fresno, California

The values of the K-index are monitored minute by minute with alerts going out when levels reach 6, 7, and 8.

FACT:
Geomagnetic storms have been associated with satellite surface charging and increased atmospheric drag.

ANALYSIS TIPS:
The Kp index can be used to predict where you might see an aurora. The higher the Kp number the stronger the disturbance. A large disturbance in Earth's magnetic field is likely to produce strong aurora that extend further toward the equator.

The bars are green when the Kp is less than 4, yellow when the Kp equals 4, and red when the Kp is greater than 4. The red bars indicate a storm warning.

Updated: 2013 May 21 02:45:04 UTC 01MAY1301 Boulder, CO 9154

PAGE – 1B INFORMATION CARD sunearthday.nasa.gov/swac/data.php

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The Kp Index combines the disturbances in the Earth's magnetic field measured at 9 separate observatories in North America. It is the easiest way to find out if there has been a disturbance in the Earth's magnetic field and how severe the disturbance was.

Tips:

- In this section of SWAC you will be using real-time data from magnetic observatories located around the world. These data are updated every few minutes so that you can see exactly how Earth's field is changing right now.
- The Kp index can be used to predict where you might see an aurora. The higher the Kp number the stronger the disturbance. A large disturbance in Earth's magnetic field is likely to produce strong aurora that extend further toward the equator.
- Scientists measure the strength and direction of Earth's field with sensitive instruments called magnetometers. They put 'magnetic observatories' all over the world, but most are in the polar regions of Earth where the field is known to change rapidly. Magnetic disturbances often indicate that a solar storm has occurred. Strong magnetic disturbances can cause brilliant auroras that we can easily see from the ground.

Questions from the Student Data Collection Sheet:

- a) What three days does this graph cover?
- b) What were the highest K index levels for each of these days?
- c) Are there any Kp values of 5 or higher?
- d) Are there any Kp values of 7 or higher?

(Optional) Kp Auroral Map

Magnetosphere

(Optional) Kp Auroral Map

1. You can access the optional “**KP Auroral Map**” inside the “**Kp Index (tutorial)**” or by going directly to <http://www.swpc.noaa.gov/Aurora/globeNW.html>.
2. Click anywhere on the map to determine the geographic latitude, longitude and corrected geomagnetic latitude for your area.
3. Refer to your ‘**Magnetosphere Data Collection**’ sheet to answer questions (e) through (g).
4. Close the current window and return to ‘**Space Weather Data**’.

PAGE – 2A INSTRUCTION CARD Observatory Data

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Magnetosphere

(Optional) Kp Auroral Map

ABOUT THE DATA:
The Kp map is an optional tool that shows the connection between the Kp index and the predicted southern edge of the aurora in North America. With a Kp of 5, auroras can be expected south to the green line. With a Kp of 9, auroras can be expected south to the red line.

NAVIGATION TIPS:
You can click on any location on the map and automatically find the longitude and latitude.
Based on the data from the Kp Index, you can use this map to determine where aurora can be seen.

Space Weather Data
sunearthday.nasa.gov/swac/data.php

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This map shows the connection between ‘Kp index data’ and the predicted southern edge of the aurora in North America.

Tips:

- You can click on any location on the map and automatically find the longitude and latitude. Based on the data from the Kp Index, you can use this map to determine where aurora can be seen.
 - **Kp of 3:** Aurora could be expected south to the BLUE line.
 - **Kp of 5:** Aurora could be expected south to the GREEN line.
 - **Kp of 9:** Aurora could be expected south to the RED line.
 - **Kp of 9+:** Aurora could be seen as far south as Texas and Florida.

Questions from the Student Data Collection Sheet:

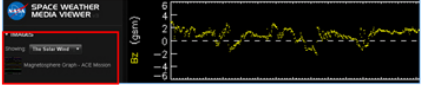
- e) What is the longitude, latitude, and corrected geomagnetic latitude for your area?
- f) What would the Kp level have to be for us to see aurora in our area?
- g) Are there any areas in the world that might see auroral activity, based on this data, in the next few hours? Where?

Magnetosphere Graph

Magnetosphere

Magnetosphere Graph

1. Open "Space Weather Data" and select "Magnetosphere Graph (Live Data)". The Space Weather Media Viewer will open. Under the 'IMAGES' section of the Viewer select "Showing: The Solar Wind" in the small drop-down menu. Select the image called, "Magnetosphere Graph - ACE Mission".
2. You should see 4 different graphs. Locate and observe the yellow graph labeled 'Bz'. (Each time the yellow line in that graph drops below the dashed white line labeled '0', we know that our magnetosphere has been affected by the solar wind.)
3. Refer to your 'Magnetosphere Data Collection' sheet to answer questions (h) through (j) and the (Comprehension Question).
4. Close the current window and return to "Space Weather Data".



PAGE - 3A INSTRUCTION CARD Satellite Data

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Magnetosphere

Magnetosphere Graph

ABOUT THE DATA:
This graph explains the solar wind's effects on Earth's magnetosphere. When the solar wind magnetic field is opposite the Earth's, it is called a southward field and is considered to be negative in sign. You can monitor the ACE data in this graph to identify times when this happens.

The 'Bz' component, the second plot from the top and labeled in yellow, is the one that carries information about the North-South part of the solar wind magnetic field.

You can use the following levels to determine the intensity of the storm:

Low	(0 to -2)
Medium	(-2 to -4)
High	(-4 to -6)

ABOUT THE MISSION:
The ACE satellite is positioned about 1 million miles from Earth, and is always directly between Earth and the Sun. The data includes the time the disturbance arrives at ACE. It can provide scientist on Earth approximately one hour advance warning of geomagnetic storms.

ANALYSIS TIP:
As the solar wind leaves the Sun, it moves out in all directions into space affecting the entire solar system. The amount of disturbance experienced by the earth's magnetosphere is dependent on several factors: solar wind speed and duration, a negative Bz. However, scientists have discovered that the most intense effects upon Earth's magnetic field occur when the solar wind's magnetic field is directed opposite to Earth's magnetic field and the intensity is 'large'.

Space Weather Data
sunearthday.nasa.gov/swac/data.php

PAGE - 3B INFORMATION CARD

PAGE - 3B

The ACE Satellite, positioned about one million miles from Earth, and always directly between Earth and the Sun, monitors the speed, composition and magnetic field of the solar wind. This graph explains the solar wind's effects on Earth's magnetosphere.

Tips:

- The easiest way to view this image is by opening the [Space Weather Media Viewer](#). In the 'IMAGES' section select "The Solar Wind" in the small drop-down menu. Next, select the image called, "Magnetosphere Graph-ACE Mission". In this image you will see 4 different graphs. Locate and observe the yellow graph labeled 'Bz'. (Each time the yellow line in that graph drops below the dashed white line labeled '0', we know that our magnetosphere has been affected by the solar wind.)
- This graph explains the solar wind's effects on Earth's magnetosphere. When the solar wind magnetic field is opposite the Earth's, it is called a southward field and is considered to be negative in sign. You can monitor the ACE data in this graph to identify times when this happens. Visit the [Magnetosphere Graph Tutorial](#) for more information.

Questions from the Student Data Collection Sheet:

- h) What is the current level of geomagnetic storm activity?
- i) When did the geomagnetic storm arrive at the ACE satellite?
- j) From the Magnetosphere Graph, what is the estimated time that the storm will arrive at Earth?

Comprehension Question: Based on the data you have analyzed from these instruments, answer the question, "**Has there been a measurable disturbance in Earth's magnetic field?**" Be sure to cite specific data in your response!

Auroras Flip Chart

Overview

By following the steps in this flip chart your students will soon be able to answer the big question, **“Have auroras been seen within the last 24 hours due to a solar storm?”**

In the Auroras Flip Chart there are 2 sets of data:

- Auroral Activity on Earth – NOAA POES
- Kiruna All-Sky Camera

In this section students will learn how to obtain and interpret:

- Data from NASA satellite that provide an estimate of the location, extent, and intensity of the auroral oval in the northern hemisphere.
- Data from a ground based “all-sky camera”.

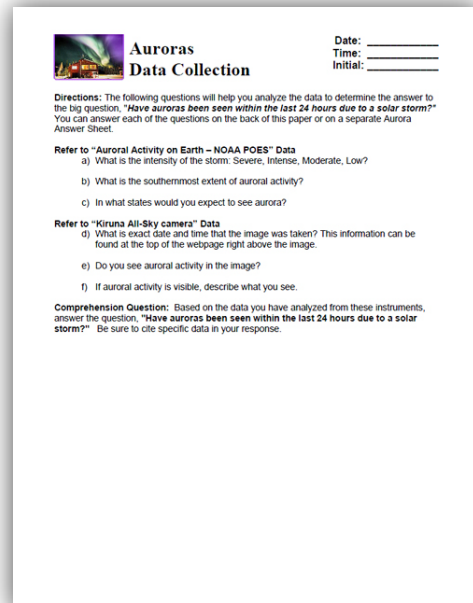
Data Collection Sheet:

Each flip chart has a corresponding Data Collection Sheet that can be downloaded from the SWAC website. They are designed to help students quickly record and analyze necessary sets of data. A comprehension question at the bottom of each data sheet provides an opportunity for students to summarize the data and make a prediction for verification over the next several days.

Keep a set of **Data Collection Sheets** and/or clipboards nearby in order for students to collect all of the information they will need to complete their Space Weather News Report!

Space Weather Data:

The SWAC website is an extremely robust 'one stop shopping' learning tool complete with step-by-step tutorials on how to interpret live or 'near real time' space weather data from 10 missions and 36 instruments. All of the data links required to make your space weather observations are located on a single webpage called Space Weather Data. Beside each of the 'live data' links you will also find 'tutorial' links containing easy to read tutorials that that will help you when interpreting the data. A link to this webpage is at the bottom of every INSTRUCTIONAL CARD in the flip chart.



The image shows a 'Data Collection' sheet for auroras. It includes a small image of an aurora, a title 'Auroras Data Collection', and fields for 'Date:', 'Time:', and 'Initial:'. Below these are directions and two sets of questions. The first set is titled 'Refer to "Auroral Activity on Earth – NOAA POES" Data' and contains three questions (a, b, c). The second set is titled 'Refer to "Kiruna All-Sky camera" Data' and contains two questions (d, e). At the bottom is a 'Comprehension Question'.

Auroras Data Collection

Date: _____
Time: _____
Initial: _____

Directions: The following questions will help you analyze the data to determine the answer to the big question, “Have auroras been seen within the last 24 hours due to a solar storm?” You can answer each of the questions on the back of this paper or on a separate Aurora Answer Sheet.

Refer to “Auroral Activity on Earth – NOAA POES” Data

a) What is the intensity of the storm: Severe, Intense, Moderate, Low?
b) What is the southernmost extent of auroral activity?
c) In what states would you expect to see aurora?

Refer to “Kiruna All-Sky camera” Data

d) What is exact date and time that the image was taken? This information can be found at the top of the webpage right above the image.
e) Do you see auroral activity in the image?
f) If auroral activity is visible, describe what you see.

Comprehension Question: Based on the data you have analyzed from these instruments, answer the question, “Have auroras been seen within the last 24 hours due to a solar storm?” Be sure to cite specific data in your response.

Auroral Activity on Earth – NOAA POES

Auroras

Auroral Activity on Earth – NOAA POES

1. Open “Space Weather Data” and select “Auroral Activity on Earth (Live Data)”. The Space Weather Media Viewer will open. Under the ‘IMAGES’ section of the Viewer select “Showing: Auroras” from the small drop-down menu. Select the image called, “Auroral Activity on Earth – NOAA POES”.
2. Using the Pan and Zoom controls in the lower left side of the Viewer. Zoom in on the oval image to determine the intensity of the auroral activity.
3. Locate the southern most extent of auroral activity.
4. Refer to your ‘Aurora Data Collection’ sheet to answer questions (a) through (c).
5. Close the current window and return to “Space Weather Data” .

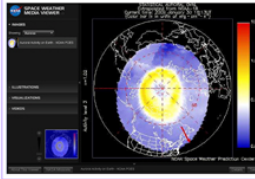
PAGE – 1A INSTRUCTION CARD Satellite Data

PAGE – 1A

Auroras


Auroral Activity on Earth – NOAA POES

ABOUT THE DATA:
This image provides an estimate of the location, extent, and intensity of aurora. If the red-orange extends down into the northern most states of the United States, you can expect to see auroras in these states. If there is a severe magnetic storm, you could expect to see aurora extend into the middle of the United States. If there is a severe geo-magnetic storm you can expect to see aurora as far south as Texas and Florida.



ANALYSIS TIPS:
The image shows the current extent and position of the auroral oval in the northern hemisphere.

- The red arrow in the plot points toward noon
- Red and orange indicate intense auroral activity
- Yellow indicates moderate activity
- Blue indicates low auroral activity

 **Space Weather Data**
sunearthday.nasa.gov/swac/data.php

PAGE – 1B INFORMATION CARD

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This plot shows the current extent and position of the auroral oval in the northern hemisphere, extrapolated from measurements taken during the most recent polar pass of the NOAA POES satellite. This data also provides an estimate of the location, extent, and intensity of aurora.

Tips:

- In this image you should be able to see an auroral 'oval,' roughly centered on the north magnetic pole. Bright areas in this region are the 'Northern Lights.' During intense magnetic storms, the aurora can expand to lower latitudes causing brilliant auroras across the lower United States.
- Use the data from the Kp index and the ACE satellite to determine the best possibility of seeing aurora. The POES satellite will show the location and intensity of the storm from space.
- It is important to note that auroras are present all of the time. When the Earth's magnetosphere is calm and stable, the aurora at the North and South poles are roughly over the Arctic and Antarctic Circle and are dim even in dark, remote wilderness. Observers in the far north see aurora quite regularly and may not consider a sighting worth reporting. However, when the Earth's magnetic field is disturbed by especially energetic solar winds, the auroral oval moves outward from the poles and becomes brighter. Auroras cannot be seen during the day, no matter how energetic they are.

Questions from the Student Data Collection Sheet:

- a) What is the intensity of the storm: Severe, Intense, Moderate, Low?
- b) What is the southernmost extent of auroral activity?
- c) In what states would you expect to see aurora?

Kiruna All-Sky Camera

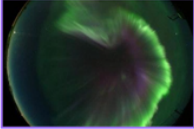
PAGE – 2A INSTRUCTION CARD

1. Open 'Space Weather Data' and click on 'Kiruna All-Sky camera (L)'
2. Observe the image for any activity. Don't forget to check the image found at the top of the page.
3. Refer to your 'Aurora Data' and answer questions (d) through (f) through 'Comprehension Questions' in 'Space Weather Data'.
4. Close the current window and return to the 'Space Weather Data' page.

PAGE – 2B INFORMATION CARD

Kiruna All-Sky Camera

ABOUT THE DATA:
An all-sky camera has been operating in Kiruna since the International Geophysical Year in 1957 (Stoffregen, 1962). In 1977 the camera was replaced with a new more automated type. The camera is controlled by a camera control computer and the image data is transferred to an archival computer, where it is made available to the wide web. (a 1 -2 day delay)



ANALYSIS:
Use the data from the satellite to determine if you are seeing auroral activity in the location space.

PAGE – 2C INFORMATION CARD

Kiruna All-Sky Camera

AURORA VIEWING TIPS:

- Aurora viewing is affected by a variety of other factors, such as cloud cover, moonlight, and urban light pollution.
- During the northern summer, sunlight prevents viewing the aurora at high northern latitudes. As the sun climbs in the sky until June 21st and then descends, the nights are too light to see the aurora
- The most active auroras form near local midnight and come in waves, these are referred to as sub-storms. It is not unusual even during an active storm to have a lull in activity that becomes intense within an hour.

AURORA FORECASTING TIP:
For more information on Aurora forecasting and the best times to view Aurora in the Northern Summer, visit <http://www.gedds.alaska.edu/AuroraForecast/>. The forecasts deal with the average level of activity expected within the prediction period. The sun occasionally produces bursts of unforeseen intensity, so the most spectacular auroral displays can come with little warning.

Space Weather Data
sunearthday.nasa.gov/swac/data.php

An all-sky camera has been operating in Kiruna since the International Geophysical Year in 1957. The image refreshes once every minute and can provide visual proof that a solar storm is in progress!

Tips:

- For more information on Aurora forecasting and the best times to view Aurora in the Northern Summer, visit <http://www.gedds.alaska.edu/AuroraForecast/>. The forecasts deal with the average level of activity expected within the prediction period. The sun occasionally produces bursts of unforeseen intensity, so the most spectacular auroral displays can come with little warning.
- Aurora viewing is affected by a variety of other factors, such as cloud cover, moonlight, and urban light pollution. The most active auroras form near local midnight and come in waves; these are referred to as sub-storms. It is not unusual even during an active storm to have a lull in activity that becomes intense within an hour. Auroral forms are more than 80 km (55 miles) above the earth, so they can be seen from as far as 400 km (250 miles) away.

Questions from the Student Data Collection Sheet:

- d) What is exact date and time that the image was taken? This information can be found at the top of the webpage right above the image.
- e) Do you see auroral activity in the image?
- f) If auroral activity is visible, describe what you see.

Comprehension Question: Based on the data you have analyzed from these instruments, answer the question, "*Have auroras been seen within the last 24 hours due to a solar storm?*" Be sure to cite specific data in your response.

For More Information:

The Space Weather Action Center is brought to you by the Sun-Earth Connection Education Forum. For more information visit the Space Weather Action Center website at <http://sunearthday.nasa.gov/swac> .

Questions or Comments? Contact producers Elaine Lewis (elaine.m.lewis@nasa.gov) and Troy Cline (troy.d.cline@nasa.gov).