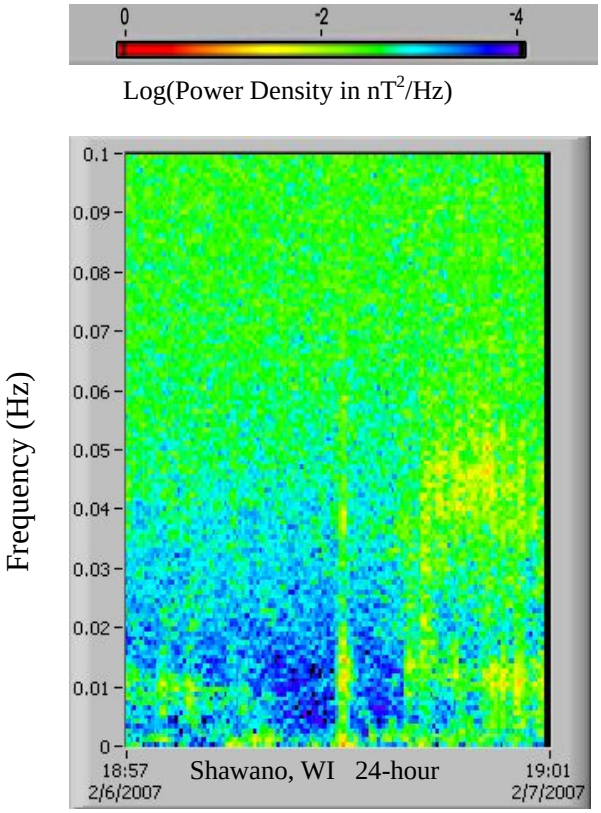
Activity 20 – Spectrogram Plots and Magnetic Storminess

Teacher's Guide:

The THEMIS magnetometer produces a second data product called the **Spectrogram**. Interpreting this data may be beyond the needs and or level of the students but it can be used to entice the students into wondering about the magnetometer data because of its colorful display. It can also be used to indicate magnetic activity. In this activity students learn how to read the spectrogram plots as an indicator of magnetic activity versus human activity for a 24 hour plot. For a more complete description of what the spectrogram represents, see the spectrogram background section at the end of this activity



Here is a brief description of the spectrograms: time is on the x-axis ***in Universal Time***, either 30 minutes or 24 hours depending on the spectrogram chosen. Waves in Earth's magnetic field have a frequency and that is given on the y-axis. The color represents the amount of power in the waves with red indicating a lot of power and blue very little power. A green-yellow solid background is noise in the magnetometer. Red or yellow often indicates interesting space weather. Red can also indicate cars passing by the school or other moving metal nearby the magnetometer. The wave power is obtained from the waves in the X panel of the line plot every 10 minutes for the 24-hour spectrograms and every 1 minute for the 30-hour spectrograms (see XYZ plot). Each spectrogram plot represents magnetic wave data observed at a particular school around the country, as indicated by their school name.

Materials

- Overhead transparencies or computer projection of the sample spectrograms
- Access to the internet
- Student worksheet

Procedure

1. Before this activity, have the students do the "Magnetic Storms" activity in the "Space Weather" THEMIS teacher's guide. (see http://ds9.ssl.berkeley.edu/themis/classroom.html) .
2. Show the students examples of quiet wave activity, medium active wave activity, very active wave activity, and human activity using the overhead transparency pages.
3. Describe the x and y axes of the spectrograms and the difference between the different levels of activity.
4. Have students follow the procedure on the student worksheet page.

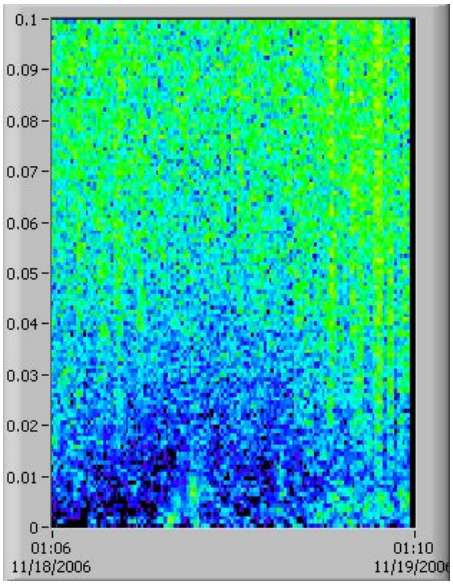
Answer Key

6.

Day in Jan. 2007	Max. Kp for the day	Description of Spectrogram: Note that the background (no magnetic activity) is blue and green.	Human Made Signature?
1	3	Little orange, some yellow	No
2	5	Little red, some orange, half yellow	No
3	4	Little red, some orange, half yellow	No
4	4	Little red, little orange, some yellow	No
5	3	Little red, little orange, some yellow	No
6	2	Little red, little orange, little yellow	No
7	1	Little yellow	Maybe
8	2	Little orange, some yellow	Maybe
9	2	Little yellow	No
10	3	Little yellow	No
11	2	Little yellow (orange on human sig)	Yes
12	3	Tiny yellow	Maybe
13	0	(green line on human sig)	Yes
14	1	Little orange, little yellow	Maybe
15	6	Little red, some orange, some yellow	No
16	5	Little red, some orange, mostly yellow	No
17	5	Little red, little orange, some yellow	Maybe
18	4	Little red, mostly yellow, (orange on human sig)	Yes
19	4	Little red, little orange, half yellow	Maybe
20	3	Little orange, some yellow	Maybe
21	3	Little orange, some yellow	Maybe
22	1	Little orange, some yellow	No
23	1	Little orange, some yellow	No
24	1	Tiny orange, some yellow	No
25	1	(orange line on human sig)	Yes
26	1	Tiny orange, some yellow (red line on human sig)	Yes
27	2	Tiny yellow	Yes
28	2	Tiny yellow – maybe human sig	Maybe
29	7	One third red, some orange, half yellow	No
30	5	Some red, some orange, half yellow	No
31	3	Some red, some orange, some yellow	No

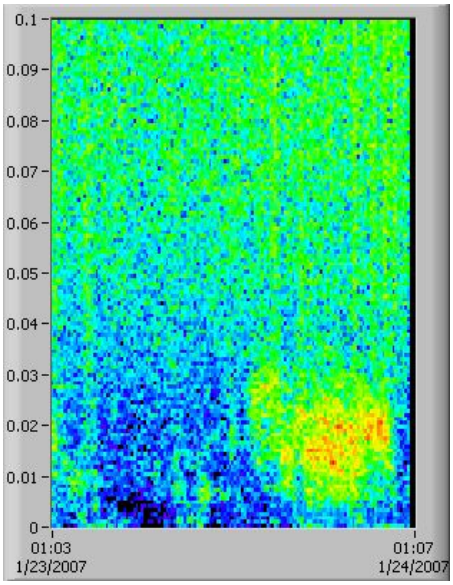
7.a) These days had strange vertical lines (to know for sure if they were human-made signatures we would need to check with other magnetometer sites): Jan 7th, 8th, 11th-14th, 17th-21st, 25th-28th,
b) Jan. 2nd-4th, 15th-19th, 29th, 30th had kp=4 or greater
c) All these days in b) had red areas on the spectrogram.
d) Jan. 5th: Kp=3; Jan 6th: Kp=2; Jan 31st: Kp=3 also had red on the spectrogram.
e) These days were days following days with magnetic stormy times, days of Kp of 4 or greater.
f) Jan. 29th: Kp = 7 had the most red.
g) Jan 13th: Kp=0; Jan. 25th: Kp=1 had only background color on the spectrogram.
h) The magnetosphere continues to produce waves after the global magnetic storm has ended because the magnetic field is still vibrating or “ringing” like a violin string that has been plucked.

9. From this month of data, it appears that the spectrograms can indicate global magnetic storminess only at the beginning of a magnetic stormy time and can only be used to roughly guess the Kp index (Kp=0; Kp=1-3; Kp=4-6; Kp=7-9).



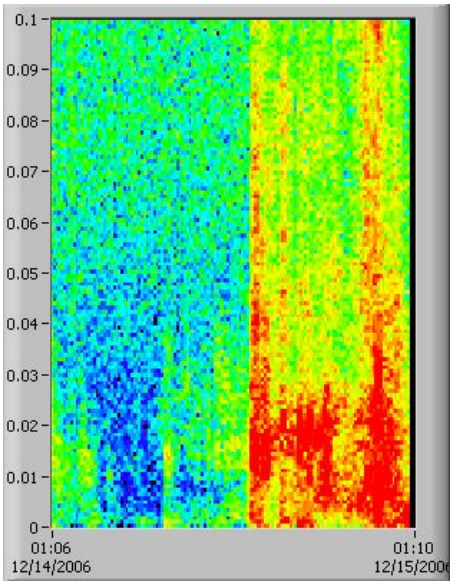
Quiet Magnetic Wave Activity in Ukiah, OR

The spectrogram mostly shows all green or blue with very little red. This indicates that there are not many waves and interesting currents occurring in space reaching Ukiah.



Medium Magnetic Wave Activity in Ukiah, OR

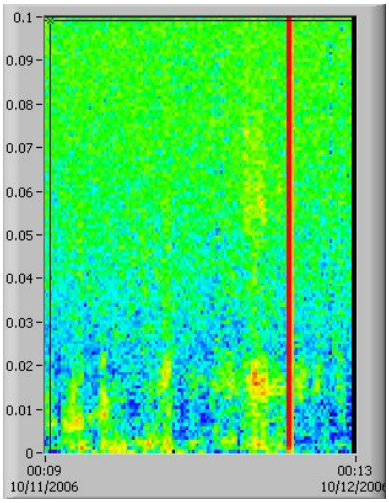
The spectrogram mostly shows all green or blue with some stripes of red. This means there is some magnetic wave activity from space reaching Ukiah.



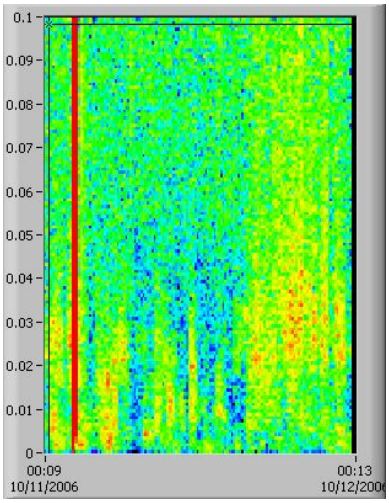
Active Magnetic Wave Activity in Ukiah, OR

The spectrogram shows some interesting red horizontal and vertical lines on the right of the plot. This indicates there are some interesting magnetic waves occurring in space reaching this magnetometer in Ukiah in the second half of the day.

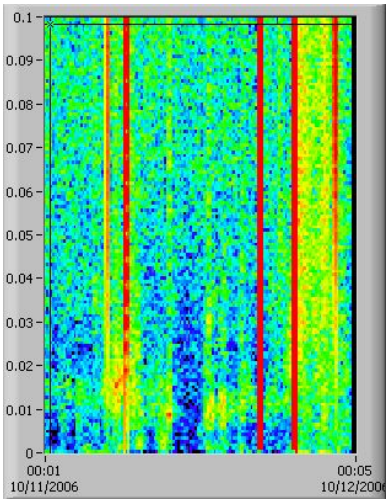
Overhead Transparency 2



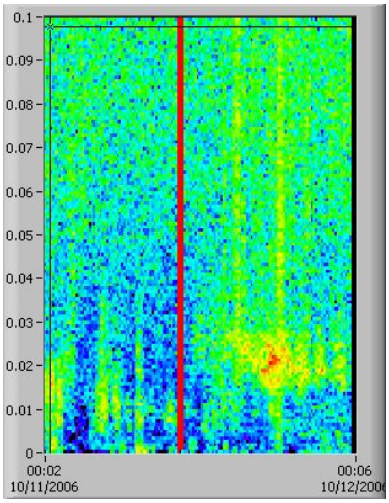
Petersburg, Alaska



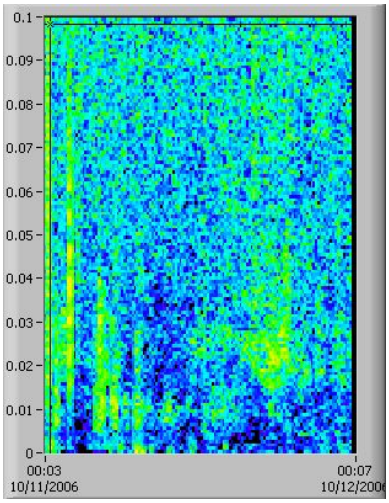
Shawano, Wisconsin



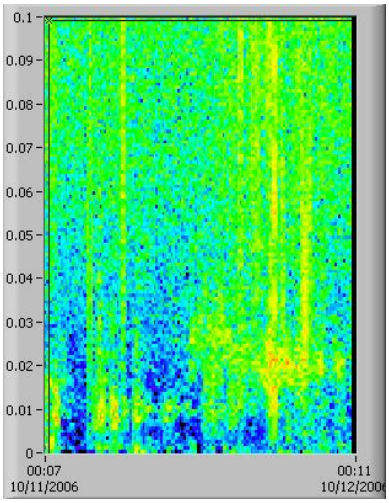
Remus, Michigan



Ukiah, Oregon



Carson City, Nevada



Pine Ridge, S. Dakota

Human-made signatures on a spectrogram most often show up as a vertical red or orange bar.

To determine if the signature on a spectrogram comes from some human event versus a space or atmospheric event, compare red lines with spectrograms from other magnetometers around the country

Above are six spectrograms from October 11, 2006 at six different locations around the country. Notice that when there are red vertical lines, they all happen at different times during the day, indicating they are due to human events locally at each school location.

Student's Name _____ Date _____

By comparing Planetary Kp indices with the local magnetometer spectrogram plots, you will answer the question: "Can local spectrogram plots be used to determine the global magnetic storminess?"

1) Go to: **http://ds9.ssl.berkeley.edu/themis/classroom_geons_data.html**

2) Read about the spectrogram plots.

3) Find the link to the archive data page and click on it

4) Fill in the form to find the 24-hour spectrogram plot for Ukiah, OR for Jan. 1, 2007. Keep this window open on a computer.

5) Go to **http://ds9.ssl.berkeley.edu/themis/classroom_kp2007.html**

6) Look at each plot of Kp indices and compare each day of indices with the 24-hour spectrogram from Ukiah, OR in January 2007, starting with Jan. 1 (see step 4). Make a table with 3 columns for: 1) the date, 2) the maximum Kp index, 3) a description of the amount of yellow, orange and red on each spectrogram for each day (note that a gradation from green (top, higher frequencies) to blue (bottom, lower frequencies) are background colors and mean there is no magnetic signature), and 4) if there was a "human-activity" signature for that day. Highlight the rows of days with red on the spectrograms.

7) Using the table you created in step 6, answer the following questions:
   a) What days may have signatures made from human-interactions around the magnetometer?
   b) What days had one or more 3-hour period of Kp=4 or greater?
   c) Of the days with Kp=4 or greater, how many had red areas on the spectrogram?
   d) What days had at least one 3-hr interval of Kp<4 with a spectrogram which had red on it and what were the kp-indices for these days?
   e) What was special about the days with red on the spectrogram and a Maximum Kp of 3 or less associated?
   f) Which day had the most red and what was the maximum Kp index for that day?
   g) What days had no color besides the background color of the spectrogram and maybe a human-made signature and what was the maximum Kp index?
   h) Why might the spectrogram continue to show red after a magnetic storm has subsided?

8) Look at the real-time spectrogram (the one made today) and from your previous research, guess the range of values of the Kp index. Write that down here:

9) Go to: **http://www.sec.noaa.gov/rt_plots/kp_3d.html**. Look up the Kp indices for today to see if your guess was correct. Explain if it was or not and whether you think local spectrograms can be used as an indication for global magnetic storminess.