Activity 19 – Magnetic Magnitude Changes

Teacher's Guide:

The THEMIS magnetometer we will be using is a professional-grade instrument capable of revealing many different types of disturbances in Earth's magnetic field. This activity explores vectors specifically using the THEMIS XYZ plots.

Recall that magnetism, like velocity, is a quantity defined by BOTH its direction in space and its magnitude along that direction. For more information, see Part K of this manual.

To find the speed of a body, you square the three components of its velocity and add them. Then you take the square-root.

$$s = \sqrt{v_x^2 + v_y^2 + v_z^2}$$

For magnetism, we have the same relationship. A magnetometer will record the three components to the local magnetic field and give you the quantities Bx, By and Bz. The total magnetic intensity, B, is then :

$$B = \sqrt{B_x^2 + B_y^2 + B_z^2}$$

Student Objectives:

1. Observing real time data
2. Measuring and collecting data
3. Analyzing the collected data and make predictions
4. Checking with observations to validate the data

So, we can now think of Earth's magnetic field in the same way we do velocity; as a quantity that has both a magnitude and a direction. This also explains why we have to have three independent plots for the magnetometer data and not just one.

Notes to teachers:

1 - A quiet day is a matter of opinion, the only way to choose is to look at your data and find the X - plot with the least amount disturbances, yet you need data so you can not just throw out everything.

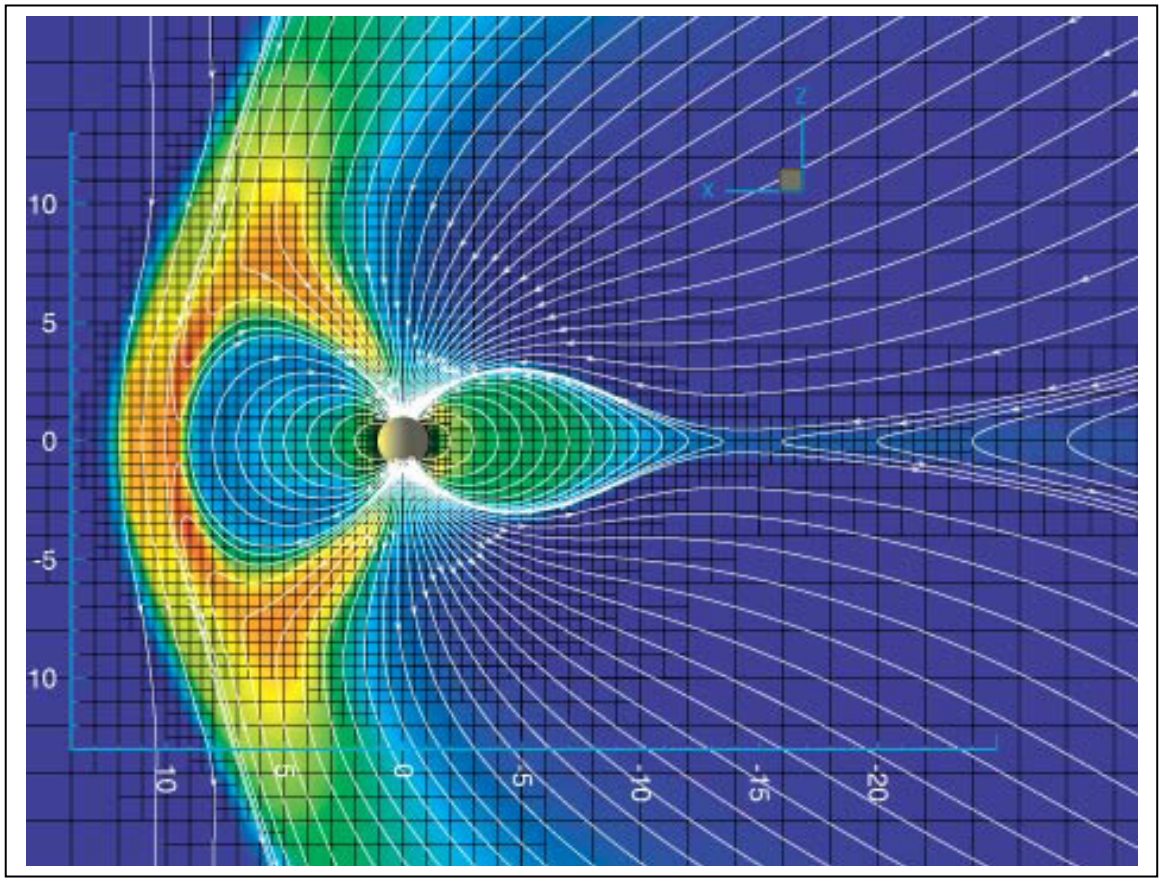
2 - You need a small (15 cm), clear, metric ruler. So that you can draw a line perpendicular to the left edge of the plot to get an precise measurement line.

3 - Print out and three hole punch the X,Y,Z, plots. This allows the students the ability to go back and double check questionable data

4 - If dividing the day into 1/2 does not simplify the estimate, the day may be too active.

5 - When you construct a comparative graph, have both the day number and actual date so you can graph the corresponding data together

Figure below of Earth's magnetic field courtesy University of Michigan, Space research laboratory. **http://www.tecplot.com/showcase/studies/2001/michigan.htm**

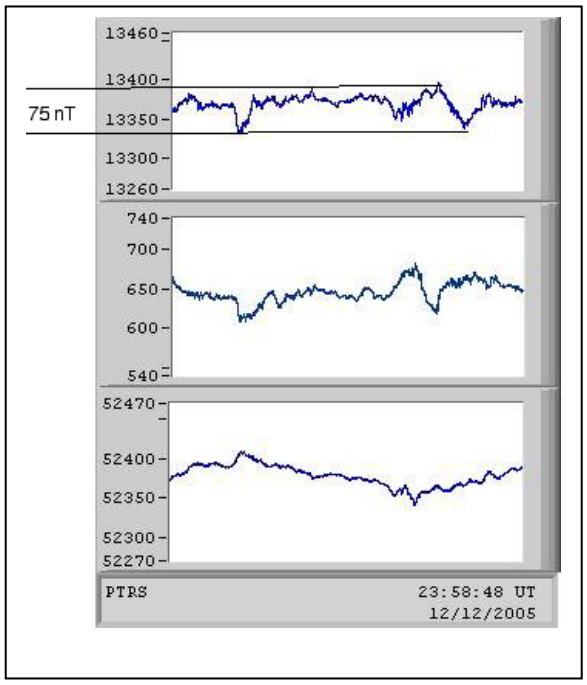


Data collection procedure:

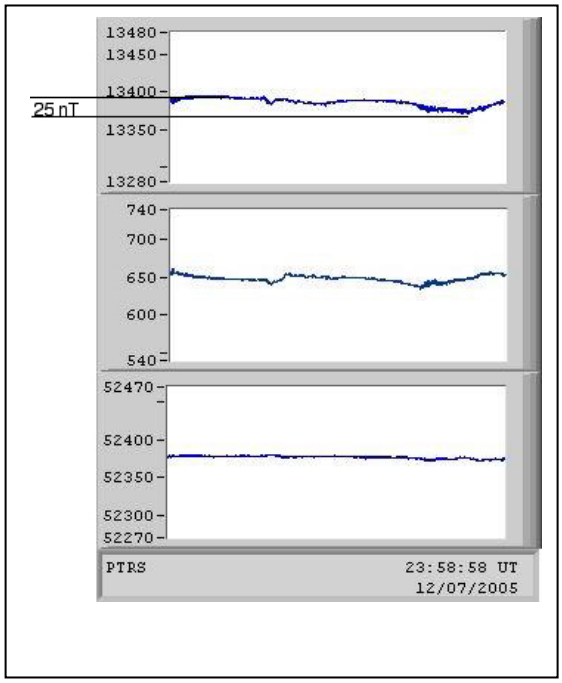
1. Make paper copies of the XYZ plots archived by THEMIS at: http://sprg.ssl.berkeley.edu/themis/GEONS (use 24 hour plot options)

2. Determine a maximum, minimum nT difference for the X component from what you would consider a quiet day. It may help to do **Activity 18** first to determine a quiet day for your data. Remember you want to determine the undisturbed magnetic field strength for your area.

A quiet day for Petersburg AK was determined to be less than 50 nT difference.
A quiet day for Loysburg PA was determined to be less than 30 nT difference.



An active day **12/12/05 Petersburg AK** shows a greater than 50 nT difference between X max and X min



An quiet day **12/07/05 Petersburg AK** shows a less than 50 nT difference between X max and X min

Data Reduction Suggestions:

Divide each quiet day X, Y, Z, plot into half days.

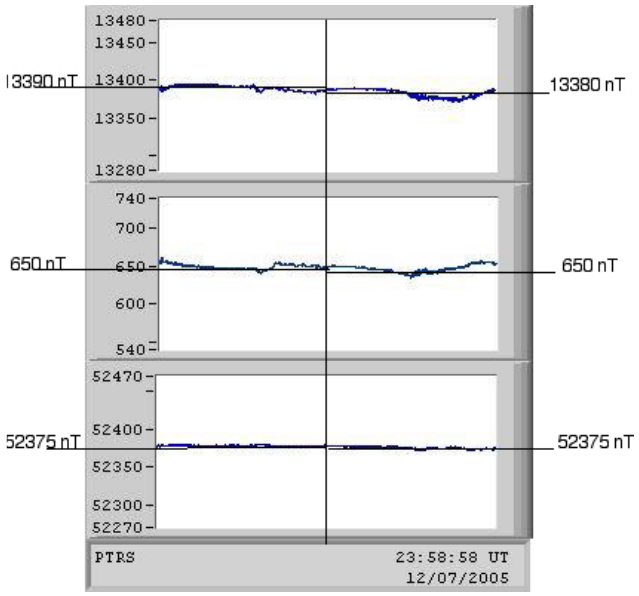
1. Using a clear metric ruler, visually determine the average nT for each half day for each X, Y, Z plot. The scale is 1mm = 5 nT, unless you resize the plots.

2. Determine the average of the two half days and then take the average for each day for X,Y,Z, plots.

X avg for the day =
13390nT + 13380 nT / 2 =
13385 nT

Y avg for the day =
650 nT + 650 nT / 2 =
650 nT

Z avg for the day =
52375 nT + 52375 nT / 2 =
52375 nT



3. Set up a spread sheet with a column for Date, X,Y,Z.

4. Using the spread sheet functions calculate B from the Pythagorean formula in the Teacher's Guide for this activity.

See the two tables that follow as examples.

	A	B	C	D	E	F	G
1		**Loysburg Pa**					
2	**Date**	**X**	**Y**	**Z**		**B value**	
3							
4	10/28/2001	22115	200	47543		52435	
5	10/31/2001	22095	200	47548		52431	
6	11/1/2001	22108	205	47540		52430	
7	11/2/2001	22095	205	47540		52424	
8	11/6/2001	22105	203	47540		52428	
9	11/7/2001	22118	203	47540		52434	
10	11/8/2001	22113	205	47540		52432	
11	11/11/2001	22105	195	47520		52410	
12	11/14/2001	22103	200	47520		52409	
13	11/15/2001	22105	200	47510		52401	
14	11/16/2001	22108	200	47515		52407	
15	11/20/2001	22095	200	47488		52377	
16	11/24/2001	22088	205	47490		52376	
17	11/25/2001	22095	203	47480		52370	
18	12/3/2001	22243	430	47385		52348	
19	12/7/2001	22240	430	47370		52333	
20	12/13/2001	22230	440	47373		52331	
21	12/16/2001	22230	425	47360		52319	
22					**2005 B Avg**		**52394**

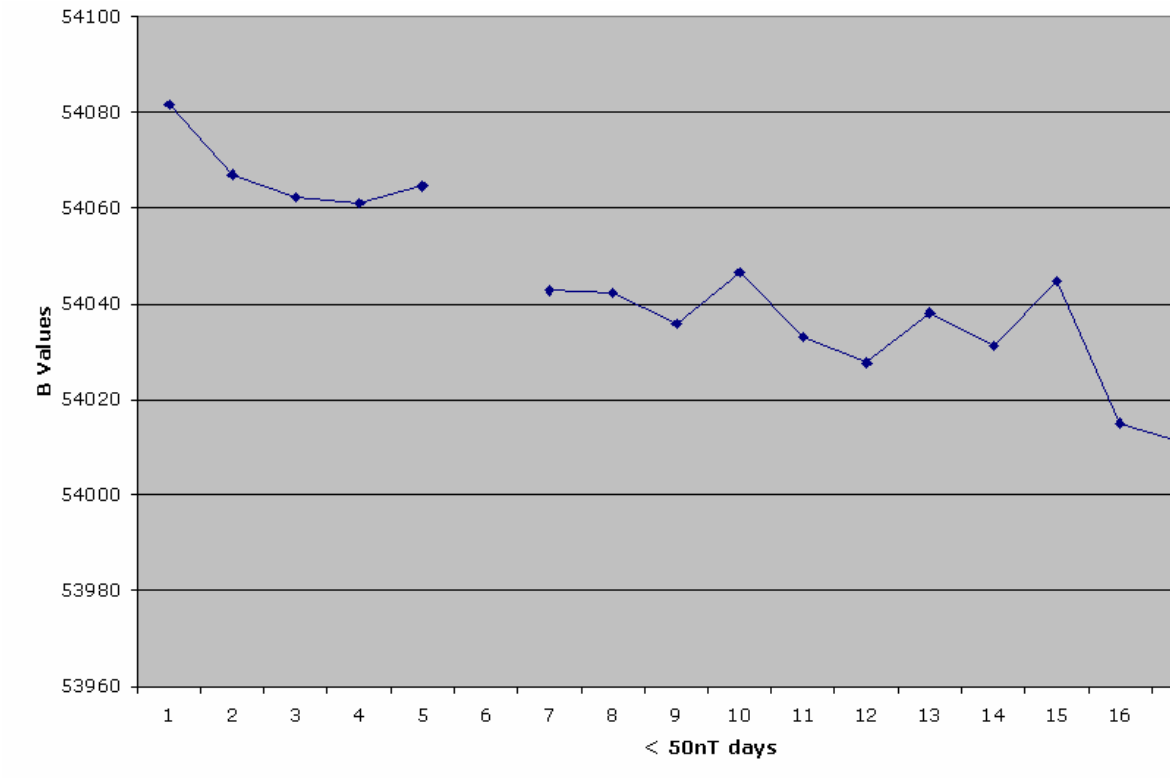
Note: Usable data for total quiet days from 10/29/05 to 4/13/06 is 45 days

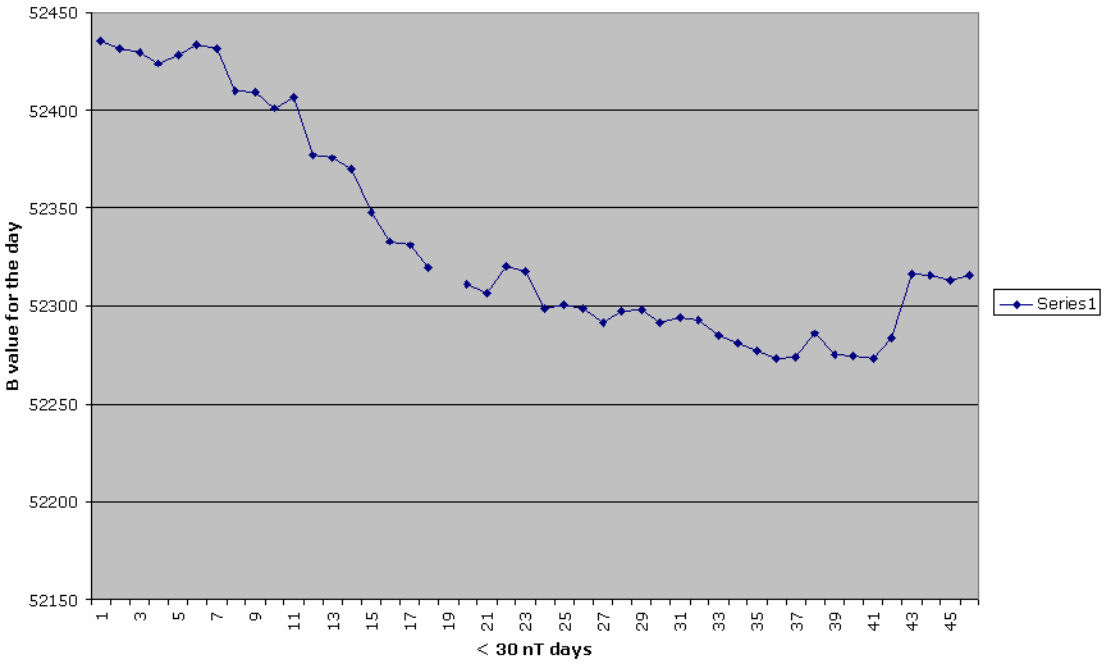
	A	B	C	D	E	F	G
23		**Loysburg Pa**					
24	**Date**	**X**	**Y**	**Z**		**B value**	
25	1/8/2002	22253	450	47340		52311	
26	1/10/2002	22263	445	47330		52306	
27	1/12/2002	22268	448	47343		52320	
28	1/13/2002	22268	443	47340		52318	
29	1/26/2002	22260	465	47323		52299	
30	1/27/2002	22260	463	47325		52301	
31	1/28/2002	22265	460	47320		52298	
32	1/29/2002	22260	460	47315		52292	
33	1/30/2002	22273	458	47315		52297	
34	2/1/2002	22265	458	47320		52298	
35	2/2/2002	22265	455	47313		52292	
36	2/4/2002	22280	463	47308		52294	
37	2/7/2002	22273	463	47310		52293	
38	2/11/2002	22275	473	47300		52285	
39	2/12/2002	22270	465	47298		52281	
40	2/13/2002	22273	460	47293		52277	
41	2/15/2002	22270	465	47290		52273	
42	2/16/2002	22260	455	47295		52274	
43	2/17/2002	22278	458	47300		52286	
44	2/22/2002	22263	473	47295		52275	
45	2/23/2002	22273	460	47290		52275	
46	2/24/2002	22270	465	47290		52273	
47	3/23/2002	22273	465	47300		52284	
48	4/7/2002	22327	548	47310		52317	
49	4/10/2002	22325	548	47310		52316	
50	4/11/2002	22320	548	47310		52314	
51	4/12/2002	22325	540	47310		52316	
52					**2006 B Avg**		**52295**

Activity A: Graph the B data on a day by day basis, is there any long term change? Is the earth's magnetic field is slowly weakening?

With enough data (very long term) this activity could be developed into an extension of Activity 8 "The Declining Magnetic Field"

The plot below shows the declining values for the Petersburg, Alaska (Top) and Loysburg, PA (Bottom) THEMIS stations.





Activity B: **Graph each X,Y,Z, plot separately and look for changes or trends. Especially the Y east-west in relationship to the X north-south. Is Earth's North magnetic pole moving?**

With enough long term data this Activity could be used as an extension of Activity 6 Geomagnetism I: "Polar Wandering"

The Bx (Top) and By (Bottom) plots below show the declining values for the Petersburg, Alaska THEMIS Station.