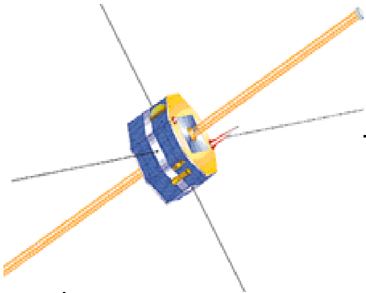


IMAGE Explores:

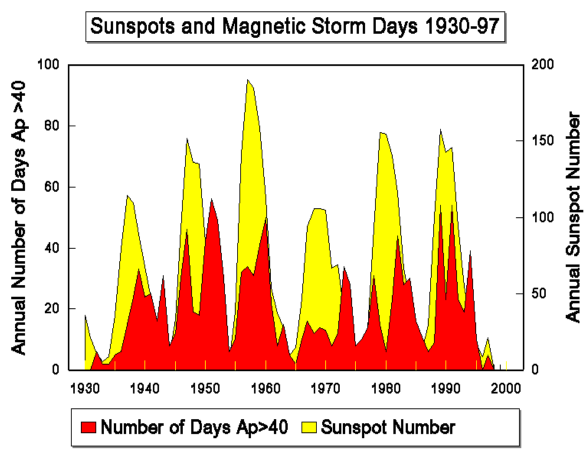
Geomagnetic Storms

The magnetic field of the Earth extends hundreds of thousands of kilometers into space, and is often buffeted by changes in the solar wind: a dilute stream of gas ejected by the Sun in all directions. These changes cause disturbances in the magnetic field that can be detected even at ground level on the Earth, with compasses or sensitive instruments called magnetometers. The *Imager for Magnetosphere-to-Auroral Global Exploration* (IMAGE) will study the space environment near the Earth during geomagnetic storms, and investigate how the particles and fields respond to solar storm conditions.

In the early 1800's Alexander von Humbolt studied these geomagnetic disturbances carefully for several years, and discovered that the ground level field would occasionally erupt in 'magnetic storms' in which compass directions could change by several degrees within an hour. Geomagnetic storms were soon found to occur at about the same time as aurora borealis displays in the northern hemisphere arctic regions. Scientists measure the strength of a geomagnetic storm by a quantity called the 'Ap index' which ranges from 0 to 400 depending on the intensity of the magnetic changes recorded at magnetic observatories.

Typically, the ground level field stays between 10-20, but occasionally storms of magnitude 70-90 occur which cause aurora and transformer problems. At a magnitude exceeding 250, blackouts are almost a certainty.

The number of geomagnetic storms, and their severity, follow the solar sunspot cycle as it increases and decreases over a roughly 11-year time period. During the most severe geomagnetic storms, electrical power networks experience transformer problems and even blackouts. A major geomagnetic storm on March 13, 1989 left six million people in Quebec without lights for up to 12 hours.



The IMAGE satellite is designed to 'photograph' the near Earth environment within the magnetosphere, and to study how trapped particles and their currents respond to changes in the solar wind and solar activity. Some of these changes lead to aurora, while others can lead to problems with satellites. Every five minutes, the satellite will return new images to scientists on the Earth to help them improve their theoretical understanding of the near-Earth environment . Forecasters will also use the data to spot 'storms in space', and provide improved predictions for space weather conditions.

For more classroom activities about space science, and information about the IMAGE satellite, visit http://image.gsfc.nasa.gov/poetry

In this activity, students will use two data tables that record the number and severity of geomagnetic storms during a solar cycle. They will plot this data and answer several questions having to do with how often geomagnetic storms occur during the year, and the frequency of their severity.

Table 1

Number of days with Ap > 40

Year	J	F	M	A	M	J	J	A	S	O	N	D	Total	Sunspot Number
1976	1	0	2	2	1	0	0	0	1	1	0	1	9	13
1977	0	0	0	2	1	0	1	2	2	1	1	2	12	27
1978	2	1	2	5	2	4	2	2	3	0	2	1	28	92
1979	1	1	3	6	0	1	0	3	1	1	0	0	17	155
1980	0	1	0	0	1	1	1	0	0	2	0	1	7	154
1981	0	1	3	4	5	1	1	1	1	5	1	0	23	140
1982	0	10	2	3	3	2	3	3	4	3	3	4	40	115
1983	1	4	5	3	6	2	1	1	2	2	4	0	31	66
1984	0	4	2	3	1	1	3	1	4	2	1	0	22	45
1985	2	2	1	4	0	1	1	1	2	1	2	2	19	17
1986	1	1	0	0	2	0	0	0	2	1	2	0	9	13
1987	0	0	0	0	0	0	1	2	3	1	0	0	7	29
1988	2	1	2	3	1	0	0	0	1	1	0	1	12	100
1989	3	1	8	2	3	2	0	4	3	1	2	2	31	157
1990	0	1	5	3	1	1	1	2	0	2	1	0	17	142
1991	0	0	1	2	3	4	5	8	4	4	5	0	36	145
1992	0	6	0	0	2	3	0	2	4	1	1	1	20	94
1993	1	1	6	1	2	1	0	1	2	1	2	3	21	54
1994	0	5	4	5	6	0	0	0	1	6	1	0	28	29
1995	2	1	2	1	4	0	1	0	2	2	0	0	15	17
1996	0	0	0	0	0	0	0	0	0	1	0	0	1	8
1997	0	1	0	0	1	0	0	0	1	1	2	0	6	21
1998	0	1	1	1	2	1	1	2	1	1	2	0	13	64
1999	1	2	0	1	0	0	1	1	3	2	1	0	12	95

Table 2

List of Storms with Ap>40

Date	Ap
96/10/22	59
97/02/27	51
97/05/14	55
97/09/30	46
97/10/10	45
97/11/06	49
97/11/22	75
98/02/17	43
98/03/10	63
98/04/23	40
98/05/03	120
98/05/04	43
98/06/25	43
98/07/23	40
98/08/06	73
98/08/26	144
98/09/24	126
98/10/19	62
98/11/07	74
98/11/13	63
99/01/13	51
99/02/18	83
99/02/28	43
99/04/16	56
99/07/30	62
99/08/16	40
99/09/12	53
99/09/22	70
99/09/26	45
99/10/11	47
99/10/21	93
99/11/13	43

Ap data archive at NOAA ftp://ftp.ngdc.noaa.gov/STP/GEOMAGNETIC_DATA/APSTAR/apstar.lst
Sunspot archive at NOAA ftp://ftp.ngdc.noaa.gov/STP/SOLAR_DATA/SUNSPOT_NUMBERS/

Table 1 gives the number of days in which geomagnetic storms were more severe than Ap=40. Example: In 1982 during February (F) there were 10 such days. Also shown is the total number of stormy days per year, and the averaged sunspot number for that year in the last two columns.

Table 2 shows the actual storms recorded for the years 1996-1999 and when they occurred. Example: The only severe storm in 1996 was recorded on October 22 with an Ap index of 59. Table 1 for the year '1996' reflects this fact under the column 'O' which shows only 1 event.

1) Graph the number of stormy days (y-axis) vs the year (x-axis). Also plot on the same graph the sunspot number during each year.

Question 1: Do the annual number of severe geomagnetic storms follow the sunspot cycle?
Question 2: Relative to the average sunspot cycle, about when does the geomagnetic storm cycle peak?
Question 3: During which months are there, on average, more geomagnetic storms?

2) Graph the severity (Ap) of the storms between 1996 and 1999.

Question 4: About how often will you see storms more severe than Ap=60? 80? 119?
Question 5: During which part of a sunspot cycle do the most severe storms seem to occur? During maximum? During Minimum? 1-2 years before maximum?
Question 6: If you were planning a once-in-a-lifetime trip to view the aurora borealis, when would be the best time to take such a trip in order to maximize your chances of actually seeing one?