

Solar Flares on Your Birthday*

Introduction

The Sun is our nearest star and our proximity to it allows us to study it in great detail. Observations reveal that the Sun is extremely dynamic. Solar flares are among the fastest and most energetic events, producing the biggest explosions in the solar system. A solar flare occurs when magnetic energy that builds up in the Sun's atmosphere is suddenly released. Charged particles are accelerated at high speeds traveling along the Sun's magnetic field lines. Flares produce all forms of electromagnetic radiation from radio waves to X-rays and gamma rays. The frequency of solar flares varies with the Sun's 11-year cycle. When the solar cycle is at a minimum, very few flares occur. As the Sun approaches the maximum part of its cycle, flares occur more and more frequently. The biggest flares are as powerful as billions of hydrogen bombs exploding at the same time! We still don't know what triggers them or how they release so much energy in such a short time.

Solar flares have a direct effect on the Earth's upper atmosphere (ionosphere). For instance, long distance radio communications can be disrupted by the effect the flares have on the Earth's ionosphere. In addition, energetic particles accelerated in solar flares are dangerous to astronauts who are outside the protection of the Earth's magnetic field and to electronic instruments in space.

Procedure

In this hands-on activity, you will discover the solar cycle through an investigation of solar X-ray flares. From the *GOES* satellite X-ray data, you will record the total number of solar flares in your birth month over 11 years and compute the percentage of high class flares which occur for each year. Then you will graph your findings to help identify the long-term pattern of flare activity on the Sun.

Scientists use a series of letters to classify the energy level of an X-ray flare with **A** being the weakest and **X** being the strongest. For this activity, we will only use **M** class flares.

*This is a modified version of "Data Analysis and Measurement: Having a Solar Blast! http://connect.larc.nasa.gov/connect_bak/pdf/01_3.pdf

Materials

- Excel or Calculator
- Monthly **M** solar flare data from 1990-2001
- Solar Flare Data for November 2001
- Excel or Graph paper

Instructions

- You can investigate this in more detail or download instructions from:
http://cse.ssl.berkeley.edu/hessi_epo/html/Flares/XrayCandles.html
- Break into groups according to your birth month. If a group is too large, your teacher will break it up to cover unassigned months.

Analyzing the November 2001 Data

- Add the *total number of flares* that occurred on each day, and record that number in the last column of each row.
- Add the *total number of B, C, M and X-class flares*, and the *total number of flares* and record the sums in the row marked **Total**.
- Compute the percentage of each class of flare. This is done by dividing the number of each class by the total number of flares and multiplying that number by 100. Record on the data table.

Analyzing the Monthly M-class solar flare data from 1990-2001

- Use Excel, if possible. Make a table with columns:
 - ❖ Year,
 - ❖ Total number of **M** class flares in their birth month for each year,
 - ❖ Total number of flares for the month, and
 - ❖ Percentage of **M** class flares for the month
- Fill in the table.
- Find the percentage of **M** class flares by dividing the number of **M**-class flares by the total number of flares for that month and multiplying that number by 100. Record the percentage of **M**-class flares for the month.
- Use Excel or graph paper to plot the percentage of **M**-class flares for your birth month versus year. The year should be along the horizontal axis, and the percentage of **M**-class flares along the vertical axis.

When finished with the graph, answer the questions on the worksheet. Turn in both the answered questions and the graph.

Solar Activity and Space Weather: Student Version—Solar Flares on Your Birthday

Solar Flair Data for November 2001							
Date			B Flares	C Flares	M Flares	X Flares	Total
Nov	1	2001	0	5	5	0	
Nov	2	2001	0	8	1	0	
Nov	3	2001	0	10	0	0	
Nov	4	2001	0	5	0	1	
Nov	5	2001	0	7	4	0	
Nov	6	2001	0	14	4	0	
Nov	7	2001	0	7	5	0	
Nov	8	2001	0	14	4	0	
Nov	9	2001	0	7	6	0	
Nov	10	2001	0	7	2	0	
Nov	11	2001	0	11	1	0	
Nov	12	2001	0	8	1	0	
Nov	13	2001	0	6	1	0	
Nov	14	2001	0	9	1	0	
Nov	15	2001	0	4	0	0	
Nov	16	2001	0	6	0	0	
Nov	17	2001	0	2	1	0	
Nov	18	2001	0	3	0	0	
Nov	19	2001	0	8	0	0	
Nov	20	2001	0	9	0	0	
Nov	21	2001	0	12	0	0	
Nov	22	2001	0	7	3	0	
Nov	23	2001	0	5	0	0	
Nov	24	2001	0	16	0	0	
Nov	25	2001	0	16	0	1	
Nov	26	2001	0	9	0	0	
Nov	27	2001	0	9	1	0	
Nov	28	2001	0	14	1	0	
Nov	29	2001	0	18	2	0	
Nov	30	2001	0	6	3	0	
		Total					
		Percent					

Summary of Flare Counts

Date	Total Flares	M Class Flares
Jan-01	197	10
Feb-01	107	1
Mar-01	253	37
Apr-01	212	38
May-01	181	11
Jun-01	241	13
Jul-01	149	3
Aug-01	325	22
Sep-01	262	50
Oct-01	264	32
Nov-01	310	46
Dec-01	205	47

Date	Total Flares	M Class Flares
Jan-00	149	9
Feb-00	202	14
Mar-00	343	37
Apr-00	210	11
May-00	235	20
Jun-00	222	21
Jul-00	273	51
Aug-00	168	3
Sep-00	232	14
Oct-00	174	11
Nov-00	200	17
Dec-00	253	7

Date	Total Flares	M Class Flares
Jan-99	243	10
Feb-99	152	6
Mar-99	200	11
Apr-99	165	5
May-99	199	16
Jun-99	202	17
Jul-99	249	23
Aug-99	225	23
Sep-99	135	2
Oct-99	212	8
Nov-99	250	40
Dec-99	192	9

Date	Total Flares	M Class Flares
Jan-98	176	5
Feb-98	144	0
Mar-98	235	10
Apr-98	143	4
May-98	236	15
Jun-98	155	4
Jul-98	159	3
Aug-98	187	14
Sep-98	170	9
Oct-98	177	3
Nov-98	241	15
Dec-98	225	12

Date	Total Flares	M Class Flares
Jan-97	10	0
Feb-97	55	0
Mar-97	46	0
Apr-97	88	1
May-97	76	1
Jun-97	14	0
Jul-97	56	0
Aug-97	94	1
Sep-97	202	6
Oct-97	86	0
Nov-97	267	11
Dec-97	147	1

Date	Total Flare	M Class Flares
Jan-96	72	0
Feb-96	10	0
Mar-96	32	0
Apr-96	41	1
May-96	49	0
Jun-96	12	0
Jul-96	68	2
Aug-96	75	0
Sep-96	2	0
Oct-96	2	0
Nov-96	70	1
Dec-96	77	0

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Date	Total Flares	M Class Flares	Date	Total Flares	M Class Flares	Date	Total Flares	M Class Flares
Jan-95	169	0	Jan-94	279	11	Jan-93	135	2
Feb-95	157	5	Feb-94	104	2	Feb-93	281	17
Mar-95	208	1	Mar-94	178	0	Mar-93	256	13
Apr-95	100	2	Apr-94	100	0	Apr-93	220	3
May-95	120	0	May-94	77	0	May-93	204	5
Jun-95	102	0	Jun-94	75	1	Jun-93	211	13
Jul-95	40	0	Jul-94	140	1	Jul-93	152	4
Aug-95	43	0	Aug-94	158	8	Aug-93	139	1
Sep-95	46	0	Sep-94	106	0	Sep-93	116	2
Oct-95	106	3	Oct-94	160	1	Oct-93	233	3
Nov-95	25	0	Nov-94	77	0	Nov-93	197	3
Dec-95	8	0	Dec-94	154	1	Dec-93	284	8
Date	Total Flares	M Class Flares	Date	Total Flares	M Class Flares	Date	Total Flares	M Class Flares
Jan-92	235	39	Jan-91	277	32	Jan-90	168	25
Feb-92	290	47	Feb-91	254	52	Feb-90	175	10
Mar-92	176	4	Mar-91	367	103	Mar-90	261	28
Apr-92	197	8	Apr-91	218	41	Apr-90	195	21
May-92	161	5	May-91	252	39	May-90	205	28
Jun-92	193	7	Jun-91	308	66	Jun-90	174	21
Jul-92	255	12	Jul-91	266	29	Jul-90	161	13
Aug-92	309	12	Aug-91	217	33	Aug-90	186	25
Sep-92	273	33	Sep-91	272	24	Sep-90	172	16
Oct-92	300	24	Oct-91	314	53	Oct-90	244	11
Nov-92	216	7	Nov-91	238	27	Nov-90	358	25
Dec-92	210	4	Dec-91	341	91	Dec-90	331	50

Name _____ Period _____ Date _____

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Concerning the November 2001 data

1. Is there any pattern if the occurrence of solar flares with a particular day?
2. In examining the percentages of the different classes of flares, do you see any patterns? Give an explanation.

Concerning the monthly M-class solar flare data from 1990-2001

1. What year had the lowest percentage of M class flares? What year had the highest? What is the difference between those two percentages?
2. In general, the Sun goes through a regular solar cycle of approximately every 11 years. Based on the graph, did you see this? Explain.

