Solar Proton Events can cause satellite damage and produce harmful radiation dosages for astronauts working and traveling in space. The table below lists all the SPEs between 1997 and 2004 with intensities greater than 300 pico-Flux Units (pFU). Study this table and answer the questions that follow.

Date	SPE Intensity	Solar Flare Brightness
Nov 7, 2004	495	200.0
Jul 25, 2004	2,086	10.0
Nov 4. 2003	353	2800.0
Nov 2, 2003	1,570	
Oct 28, 2003	29,500	1700.0
Oct 26, 2003	466	100.0
Nov 9, 2002	404	40.0
Aug 24, 2002	317	300.0
May 22, 2002	820	5.0
April 21, 2002	2,520	100.0
Dec 26, 2001	779	70.0
Nov 22, 2001	18,900	90.0
Nov 4, 2001	31,700	100.0
Oct 1, 2001	2,360	90.0
Sep 24, 2001	12,900	200.0
Apr 18, 2001	951	2.0
Apr 10, 2001	355	200.0
Apr 2, 2001	1,110	2000.0
Nov 24, 2000	942	200.0
Nov 8, 2000	14,800	70.0
Sep 12, 2000	320	10.0
July 14, 2000	24,000	500.0
Nov 14, 1998	310	1.0
Sep 30, 1998	1,200	20.0
Aug 24, 1998	670	100.0
May 6, 1998	210	200.0
April 20, 1998	1,700	10.0
Nov 6, 1997	490	900.0

Question 1: What is the range of the SPE intensities recorded for the period from 1997 to 2004?

Question 2: What is the frequency of SPE events for each year?

Question 3: Is there a relationship between the SPE intensity and the solar flare brightness?

Question 4: Do the brightest solar flares produce the most intense SPEs? Give examples that demonstrate your answer.

Question 5: The sunspot cycle had the largest number of sunspots during 2000. What is unusual about the frequency of SPEs and 'sunspot maximum'?

Question 6: Are there more SPEs during certain months of the year?

Applying what you have learned.

Satellites lose 2% of their electrical power for every SPE brighter than 15,000 pFUs. If a satellite was launched in 1997, how much power loss will it have suffered by the end of 2004?

If the satellite systems require 4500 watts to operate, how could the designers have insured that the satellite received all the power it needed by the end of 2004?

Once in a while. the sun lets loose with a powerful burst of energy similar to a solar flare, but potentially far more lethal. Solar Proton Events (SPEs) are streams of protons that are accelerated to high energies near the solar surface, lasting from hours to as much as a day or two. As these protons arrive at Earth, they can scour solar panels on satellites costing them several years worth of power. When the particles slam into metal in satellites or in spacecraft, they can produce secondary nuclear particles and electrons that can damage delicate circuitry, or even endanger astronaut health. This activity will have students examine a list of the SPEs since 1996 from the archive at http://image.gsfc.nasa.gov/poetry/weekly/SEPsince1976.htm which was produced by scientists at the National Geophysical Data Center. Students will analyze the table and answer questions on its statistical content.

Question 1: What is the range of the SPE intensities recorded for the period from 1997 to 2005? **Answer:** The range is [210, 31700]

Question 2: What is the frequency of SPE events for each year? **Answer:** 1997 = 1, 1998 = 5, 1999 = 0, 2000 = 4, 2001 = 8, 2002 = 4, 2003 = 4, 2004 = 2, which can be bar-graphed.

Question 3: Is there a relationship between the SPE intensity and the solar flare brightness? **Answer:** No. The most intense SPEs can have solar flares that span nearly the entire brightness range for flares.

Question 4: Do the brightest solar flares produce the most intense SPEs? Give examples that demonstrate your answer. **Answer:** No. See, for example November 4, 2003 and Nove,ber 4, 2001.

Question 5: The sunspot cycle had the largest number of sunspots during 2000. What is unusual about the frequency of SPEs and 'sunspot maximum'? **Answer:** There are far more SPEs after sunspot maximum than before sunspot maximum.

Question 6: Are there more SPEs during certain months of the year? **Answer:** Yes. November and April have more SPEs!

If a satellite was launched in 1997, how much power loss will it have suffered by 2005? **Answer:** There were 5 SPEs during this time that were brighter than 15,000 pFUs so the satellites lose 5 x 2% = 10% of their electrical power between 1997-2005.

If the satellite systems require at least 4500 watts to operate, how could the designers have insured that the satellite received all the power it needed by 2005? **Answer:** Just make the solar panels 10% larger to they produce 4900 watts at launch. By the end of 2004, the power will have declined 10% to 4500 watts which is still enough power to keep the equipment operating!