

Satellite technology is everywhere! Right now, there are over 1587 working satellites orbiting Earth. They represent over \$160 billion in assets to the world's economy. In the United States alone, satellites and the many services they provide produce over \$225 billion every year. But satellites do not work forever. Typically they have to be replaced every 10 to 15 years as new services are created, and better technology is developed. Satellites in the lowest orbits, called Low Earth Orbit (LEO) orbit between 300 to 1000 kilometers above the ground. Because Earth's atmosphere extends hundreds of kilometers into space, LEO satellites eventually experience enough frictional drag from the atmosphere that at altitudes below 300 km, they fall back to Earth and burn up. The table below gives the number of LEO satellites that re-entered Earth's atmosphere, and the average sunspot number, for each year since 1969.

Year	Sunspots	Satellites
2004	43	19
2003	66	31
2002	109	38
2001	123	41
2000	124	37
1999	96	25
1998	62	30
1997	20	21
1996	8	22
1995	18	20
1994	31	17
1993	54	28
1992	93	41
1991	144	40
1990	145	30
1989	162	45
1988	101	33
1987	29	13
1986	11	16
1985	16	17
1984	43	14
1983	65	28
1982	115	19
1981	146	32
1980	149	41
1979	145	42
1978	87	33
1977	26	18
1976	12	16
1975	14	15
1974	32	21
1973	37	14
1972	67	12
1971	66	19
1970	107	25
1969	105	26

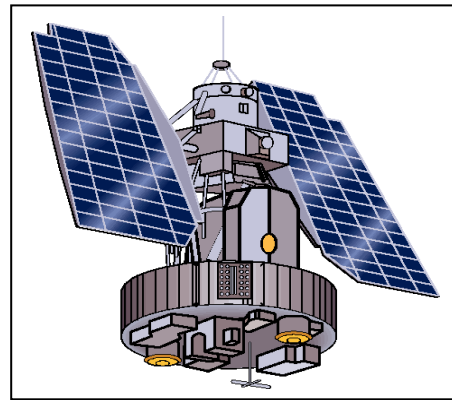


Figure: A typical weather satellite

**Question 1:** On the same graph, plot the number of sunspots and decayed satellites (vertical axis) for each year (horizontal axis). During what years did the peaks in the sunspots occur?

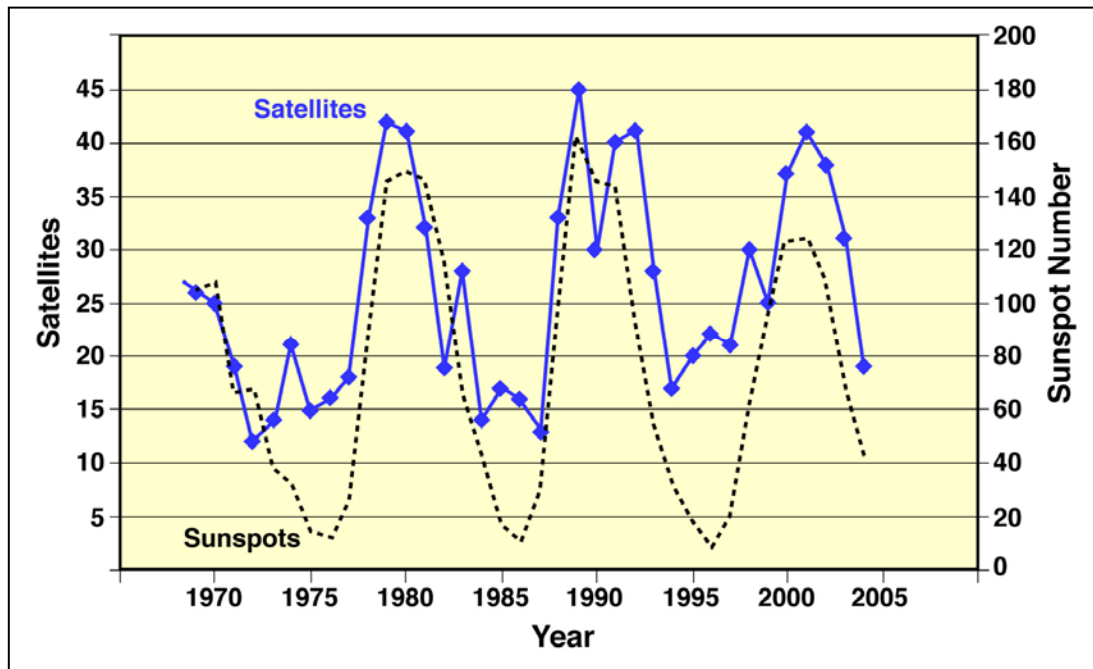
**Question 2:** When did the peaks in the satellite re-entries occur?

**Question 3:** Is there a correlation between the two sets of data?

**Question 4:** If you are a satellite operator, should you be concerned about the sunspot cycle?

**Question 5:** Do some research on the topic of how the sun affects Earth. Can you come up with at least two ways that the sun could affect a satellite's orbit?

**Question 6:** Can you list some different ways that you rely on satellites, or satellite technology, during a typical week?



**Question 1:** On the same graph, plot the number of sunspots (divided by 4) and decayed satellites for each year. During what years did the peaks in the sunspots occur? **Answer:** From the graph or the table, the 'sunspot maximum' years were 2000, 1989, 1980 and 1970.

**Question 2:** When did the peaks in the satellite re-entries occur? **Answer:** The major peaks occurred during the years 2001, 1989, 1979 and 1969.

**Question 3:** Is there a correlation between the two sets of data? **Answer:** A scientist analyzing the two plots 'by eye' would be impressed that there were increases in the satellite decays that occurred within a year or so of the sunspot maxima years. This is more easy to see if you subtract the overall 'trend' line which is increasing from about 10 satellites in 1970 to 20 satellites in 2004. What remains is a pretty convincing correlation between sunspots numbers and satellite re-entries.

**Question 4:** If you were a satellite operator, should you be concerned about the sunspot cycle? **Answer:** Yes, because for LEO satellites there seems to be a good correlation between satellite re-entries near the times of sunspot maxima.

**Question 5:** Do some research on the topic of how the sun affects Earth. Can you come up with at least two ways that the sun could affect a satellite's orbit? **Answer:** The answers may vary, but as a guide, space physicists generally believe that during sunspot maxima, the sun's produces more X-rays and ultraviolet light, which heat Earth's upper atmosphere. This causes the atmosphere to expand into space. LEO satellites then experience more friction with the atmosphere, causing their orbits to decay and eventually causing the satellite to burn-up. There are also more 'solar storms', flares and CMEs during sunspot maximum, than during sunspot minimum. These storms affect satellites in space, causing loss of data or operation, and can also cause electrical blackouts and other power problems.

**Question 6:** Can you list some different ways that you rely on satellites, or satellite technology, during a typical week? **Answer:** Satellite TV, ATM banking transactions, credit card purchases, paying for gas at the gas pump, weather forecasts, GPS positions from your automobile, news reports from overseas, airline traffic management, tsunami reports in the Pacific Basin, long distance telephone calls, internet connections to pages overseas.