SolarLab – Unit 4

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4. Solar activity

Introduction

Understanding solar activity is relevant because the physical phenomena that cause it cannot be studied on Earth, and also because it allows us to predict space weather. Solar storms (coronal mass ejections) carry large amounts of charged particles that form auroras and can also damage satellites and, if they are very intense, even power grids.

The Sun began to be studied in 1609 when Galileo Galilei invented the telescope (he studied it by projecting it onto a white surface, since looking directly at the Sun can cause serious and permanent damage to the eyes). Since the discovery of sunspots, many astronomers have devoted themselves to collecting data through prints or illustrations that accurately represent what they see.

To quantify solar activity in a simple way, the Wolf number is used, named after the Swiss astronomer who first used it in 1848 to obtain the period of solar activity. This value serves to keep a record of the daily state of the Sun.

Evolution of the solar activity

The Wolf number and other indicators are used to quantify solar activity on a given day. The process can be continued by keeping a daily record of observations to see how the Sun evolves over several days, months, or even years. This monitoring has been going on since the 19th century, but the data we have goes back to the invention of the telescope in 1610, thanks to the fact that the Wolf number is easy to obtain with a detailed drawing like those of Galileo or Scheiner. Let's see what these records tell us.

There are three fundamental questions we want to answer by studying solar activity over time: whether there are changes (does it evolve), on what timescale they occur (minutes, weeks, centuries, etc.), and what they are like (whether activity increases or decreases, whether the changes are orderly or unpredictable, etc.)

Let's answer those questions with real data. The following tables show the Wolf number on different time scales. They can be plotted on a graph of solar activity versus time using a spreadsheet or a simple program such as *Graph.*

Each graph can be used to answer the following questions:

- Does the Wolf number change significantly over this time scale?
- Can you see any patterns in the change?
- What other data can we examine to verify our results?

Table 1. Time scale in days

Daily data on Wolf number in May 1983

Day	W	Day	W
01	114	17	93
02	104	18	99
03	94	19	88
04	85	20	105
05	95	21	110
06	88	22	104
07	92	23	102
08	98	24	111
09	110	25	98
10	114	26	100
11	101	27	85
12	114	28	68
13	132	29	88
14	125	30	68
15	130	31	60
16	99	-	-

Table 2. Time scale in months

Monthly average Wolf number observed between February 1983 and July 1984.

(The month is given by placing the year before the position of that month in the calendar. For example, February 1983 would be 198302).

Month	W	Month	W
198302	51	198311	33.4
198303	66.5	198312	33.4
198304	80.7	198401	57
198305	99.2	198402	85.4
198306	91.1	198403	83.5
198307	82.2	198404	69.7
198308	71.8	198405	76.4
198309	50.3	198406	46.10
198310	55.8	198407	37.40

Table 3. Time scale in years

Monthly average Wolf number between January 1977 and December 1990

Month	W	Month	W	Month	W	Month	W
197701	16.4	198007	136.3	198401	57.0	198707	33.0
197702	23.1	198008	135.4	198402	85.4	198708	38.7
197703	8.7	198009	155.0	198403	83.5	198709	33.9
197704	12.9	198010	164.7	198404	69.7	198710	60.6
197705	18.6	198011	147.9	198405	76.4	198711	39.9
197706	38.5	198012	174.4	198406	46.1	198712	27.1
197707	21.4	198101	114.0	198407	37.4	198801	59.0
197708	30.1	198102	141.3	198408	25.5	198802	40.0
197709	44.0	198103	135.5	198409	15.7	198803	76.2
197710	43.8	198104	156.4	198410	12.0	198804	88.0
197711	29.1	198105	127.5	198411	22.8	198805	60.1
197712	43.2	198106	90.9	198412	18.7	198806	101.8
197801	51.9	198107	143.8	198501	16.5	198807	113.8
197802	93.6	198108	158.7	198502	15.9	198808	111.6
197803	76.5	198109	167.3	198503	17.2	198809	120.1
197804	99.7	198110	162.4	198504	16.2	198810	125.1
197805	82.7	198111	137.5	198505	27.5	198811	125.1
197806	95.1	198112	150.1	198506	24.2	198812	179.2
197807	70.4	198201	111.2	198507	30.7	198901	161.3
197808	58.1	198202	163.6	198508	11.1	198902	165.1
197809	138.2	198203	153.8	198509	3.9	198903	131.4
197810	125.1	198204	122.0	198510	18.6	198904	130.6
197811	97.9	198205	82.2	198511	16.2	198905	138.5
197812	122.7	198206	110.4	198512	17.3	198906	196.2
197901	166.6	198207	106.1	198601	2.5	198907	126.9
197902	137.5	198208	107.6	198602	23.2	198908	168.9
197903	138.0	198209	118.8	198603	15.1	198909	176.7
197904	101.5	198210	94.7	198604	18.5	198910	159.4
197905	134.4	198211	98.1	198605	13.7	198911	173.0
197906	149.5	198212	127.0	198606	1.1	198912	165.5
197907	159.4	198301	84.3	198607	18.1	199001	177.3
197908	142.2	198302	51.0	198608	7.4	199002	130.5
197909	188.4	198303	66.5	198609	3.8	199003	140.3
197910	186.2	198304	80.7	198610	35.4	199004	140.3
197911	183.3	198305	99.2	198611	15.2	199005	132.2
197912	176.3	198306	91.1	198612	6.8	199006	105.4
198001	159.6	198307	82.2	198701	10.4	199007	149.4
198002	155.0	198308	71.8	198702	2.4	199008	200.3
198003	126.2	198309	50.3	198703	14.7	199009	125.2
198004	164.1	198310	55.8	198704	39.6	199010	145.5
198005	179.9	198311	33.4	198705	33.0	199011	131.4
198006	157.3	198312	33.4	198706	17.4	199012	129.7

Table 3. Time scale in decades

Annual average Wolf number from 1900 to 2000

Año	W	Año	W	Año	W	Año	W
1900	9.4	1925	44.4	1950	83.9	1975	15.5
1901	2.7	1926	63.9	1951	69.4	1976	12.6
1902	5.1	1927	68.8	1952	31.5	1977	27.5
1903	24.4	1928	77.8	1953	13.9	1978	92.5
1904	42.1	1929	64.9	1954	4.4	1979	155.4
1905	63.3	1930	35.6	1955	38.0	1980	154.6
1906	54.1	1931	21.1	1956	141.7	1981	140.5
1907	61.7	1932	11.1	1957	190.2	1982	115.9
1908	48.5	1933	5.5	1958	184.8	1983	66.8
1909	43.9	1934	8.7	1959	159.0	1984	45.7
1910	18.5	1935	36.1	1960	112.3	1985	18.0
1911	5.7	1936	79.7	1961	53.9	1986	13.4
1912	3.6	1937	114.4	1962	37.5	1987	29.4
1913	1.4	1938	109.6	1963	27.9	1988	100.2
1914	9.6	1939	88.8	1964	10.2	1989	157.6
1915	47.4	1940	67.8	1965	15.1	1990	142.6
1916	57.0	1941	47.5	1966	47.0	1991	145.7
1917	104.2	1942	30.4	1967	93.8	1992	94.3
1918	80.8	1943	16.3	1968	105.9	1993	54.6
1919	63.5	1944	9.7	1969	105.5	1994	29.9
1920	37.6	1945	33.2	1970	104.5	1995	17.5
1921	26.1	1946	92.6	1971	66.6	1996	8.6
1922	14.2	1947	151.6	1972	68.9	1997	21.5
1923	5.8	1948	136.3	1973	38.0	1998	64.3
1924	16.7	1949	134.7	1974	34.5	1999	93.3

Based on these graphs, can you give a value for the period of a cycle of solar activity?

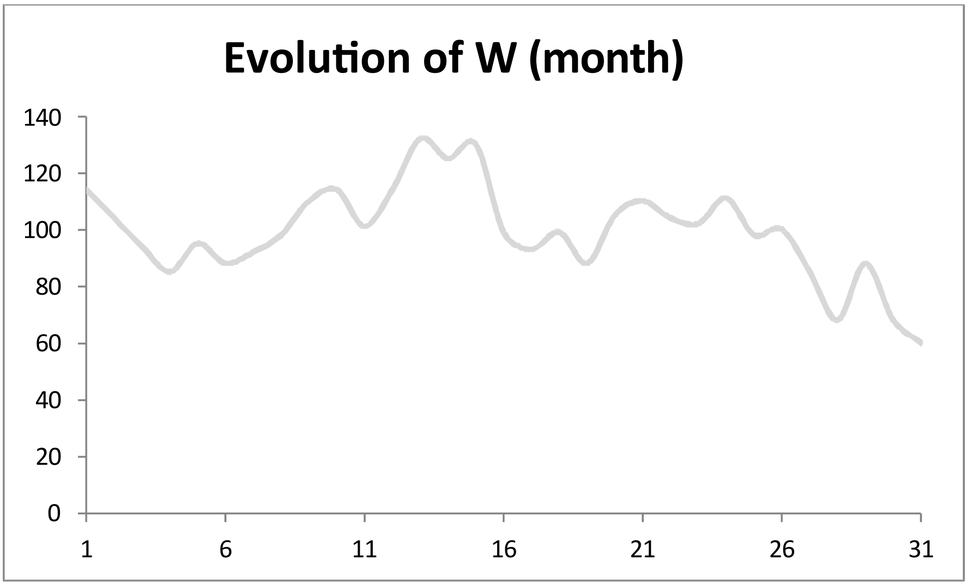
Links

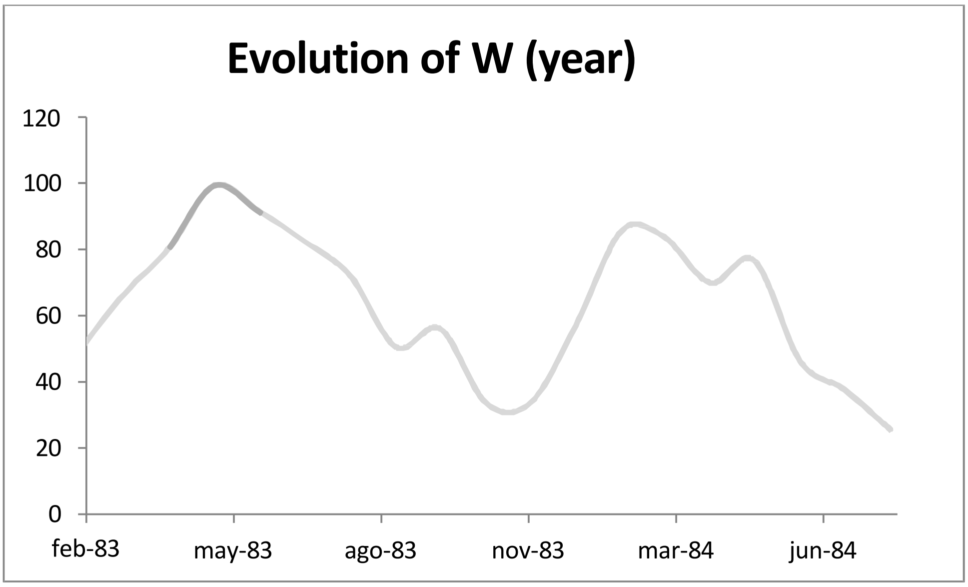
Wolf's numbers have been extracted from the Greenwich Observatory database.

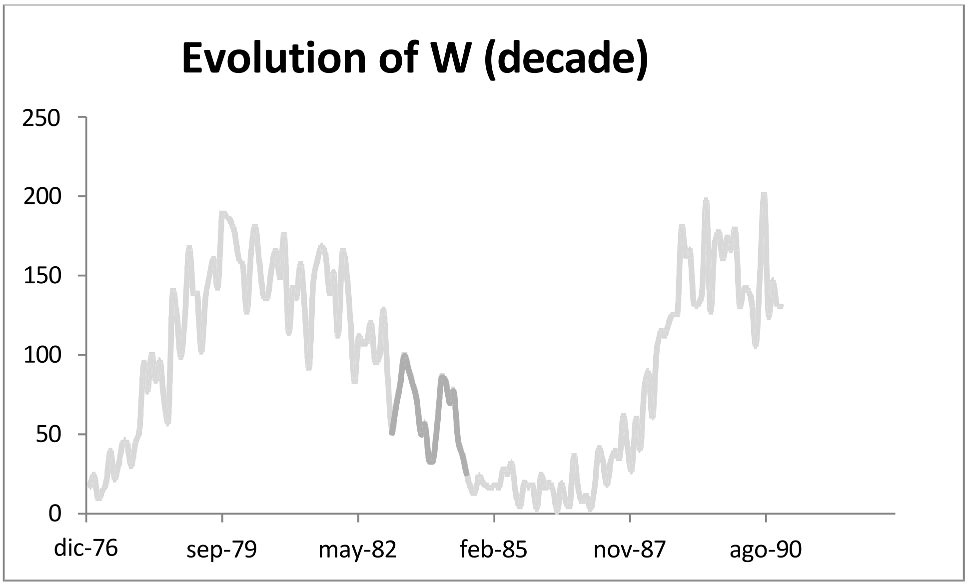
http://solarscience.msfc.nasa.gov/greenwch.shtml

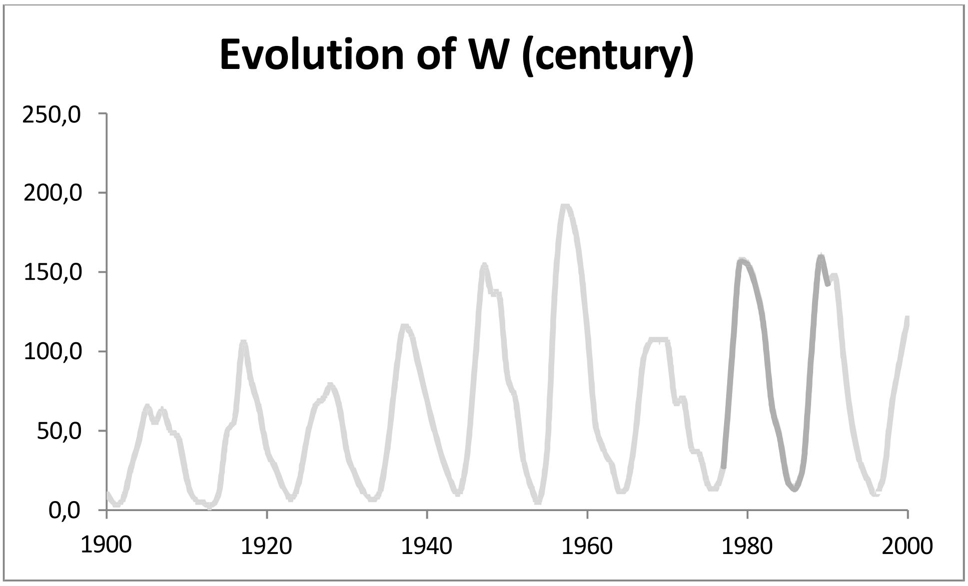
Clarification to Unit

The graphs resulting from each of the tables are shown below.






Evolution of W (decade)
250
200
150
100
50
0
dic-76
sep-79
may-82
feb-85
nov-87
ago-90


Evolution of W (century)
250,0
200,0
150,0
100,0
50,0
0,0
1900
1920
1940
1960
1980
2000

Reflection and data analysis

The objective of this activity is to acquire a scientific perspective for learning how to interpret data. The first graph does not show any particular behavior, but when we look at the evolution over the course of a year, patterns begin to emerge. It would be easy to deduce a value for the solar cycle period of about 7 to 9 months. However, it can be refined further, either by representing the evolution over another year to see if it repeats itself, or by extending the data to a full decade. This allows us to discuss the importance of repeatability in science. Results must be replicated in different contexts to be considered valid.

This data can also help us understand other scientific studies, such as those on climate. Indeed, sometimes it may seem to us that the climate is colder or warmer because we have random fluctuations. This can lead us to erroneous conclusions, such as that the planet is not warming when we have a particularly cold winter. But if we look over a longer period of time, we can see that these fluctuations are diluted to form a much clearer graph.

This also helps us to refute arguments based on specific scientific studies, which do not have the same value as meta-analyses or the accumulation of several coinciding results, as is again the case when we consider that there is scientific consensus on the anthropogenic origin of climate change.