SOLAR INDICES BULLETIN

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♦ SOLAR RADIO EMISSIONS

The quiet Sun emits radio energy with a slowly varying intensity. These radio fluxes, which stem from atmospheric layers high in the chromosphere and low in the corona, change gradually from day-to-day, in response to the number and size of spot groups on the solar disk. The table below gives daily measurements of this slowly varying emission at selected wavelengths between about 1 and 100 centimeters. Many observatories record quiet-sun radio fluxes at the same local time each day and correct them to within a few percent for factors such as antenna gain, bursts in progress, atmospheric absorption, and sky background temperature. At 2800 megahertz (10.7 centimeters) flux observations summed over the Sun's disk have been made continuously since February 1947.

♦ SOLAR FLUX TABLE

Numbers in parentheses in the column headings below denote frequencies in megahertz. Each entry is given in solar flux units--a measure of energy received per unit time, per unit area, per unit frequency interval.

One solar flux unit equals $10^{-22}\ J/m^2 Hz\,sec$. During periods of low solar activity, the flux never falls to zero, because the Sun emits at all wavelengths with or without the presence of spots. The lowest daily Ottawa flux since 1947 occurred on November 3, 1954. On that day the observed noon value dropped to 62.6 units; the highest observed value of 457.0 occurred on April 7, 1947.

The preliminary observed and adjusted Penticton fluxes tabulated here are the "Series C" values reported by Canada's Dominion Radio Astrophysical Observatory in Penticton, British Columbia. Observed numbers are less refined, since they contain fluctuations as large as ±7% from the continuously changing sun-earth distance. Adjusted fluxes have this variation removed; they show the energy received at the mean distance between the Sun and Earth. Gaps in the Palehua, Hawaii (PALE), data reflect equipment problems. Fluxes measured either at Sagamore Hill, Massachusetts, or at San Vito, Italy, will be substituted for frequencies at which many Palehua values are missing.

JANUARY 2015 PRELIMINARY SUNSPOT NUMBERS AND SOLAR RADIO FLUX / DECEMBER 2014 FINAL FLUX

Day	Sunspot Number Intl	Obs Flux Pentic (2800)	Solar Flux Adjusted to 1 Astronomical Unit: RSTN (15400)	RSTN (8800)	RSTN (4995)	Pentic (2800)	RSTN (2695)	RSTN (1415)	RSTN (610)	RSTN (410)	RSTN (245)	Dec. 2014 Final Flux: Observed Pentic (2800)	Adjusted Pentic 2800
01	75	138	576	320	173	138	119	91	72	52	39	168.1	163.4
02	89	146	577	323	180	146	131	97	73	51	27	167.7	163.0
03	74	149	577	323	184	149	134	93	79	65	45	154.2	149.8
04	74	150	585	319	183	150	136	96	80	60	44	157.6	153.0
05	66	142	587	322	181	142	131	102	80	56	42	136.8	132.8
06	64	142	593	321	174	142	132	104	81	54	26	128.7	125.0
07	74	147	570	297	166	147	137	112	79	47	21	131.8	127.9
08	74	157	591	325	187	157	145	121	92	63	39	132.6	128.7
09	81	151	587	319	184	151	136	113	84	54	23	139.7	135.5
10	81	152	585	319	182	152	139	116	90	55	23	149.8	145.3
11	88	154	592	326	189	154	140	117	89	53	57	147.5	143.0
12	92	159	595	330	189	159	144	117	93	58	22	154.2	149.4
13	72	0	585	324	177	146	128	111	84	51	19	159.8	154.9
14	58	140	580	325	172	142	126	109	83	51	21	166.4	161.2
15	43	131	546	289	159	131	125	117	85	50	20	169.3	164.0
16	38	125	574	303	156	125	113	97	82	54	25	184.6	178.8
17	29	122	569	312	156	122	106	100	82	53	22	198.5	192.3
18	47	126	584	303	159	126	115	100	81	54	24	213.2	206.4
19	48	128	576	314	166	130	115	98	84	54	24	215.7	208.9
20	38	126	590	306	160	126	116	98	80	53	22	203.2	196.7
21	32	124	590	316	163	124	111	95	76	54	29	205.8	199.2
22	37	120	578	300	156	120	107	90	67	47	21	179.2	173.4
23	42	121	571	299	154	121	107	90	66	44	18	165.9	160.5
24	41	126	450	250	135	125	104	88	68	50	25	151.4	146.5
25	44	127	581	314	157	127	113	94	70	43	23	145.3	140.6
26	80	147	589	321	174	147	130	107	74	55	19	137.o	132.5
27	91	156	594	325	183	158	135	105	76	54	23	134.1	129.7
28	98	161	594	337	198	159	142	113	76	57	28	132.6	128.2
29	103	170	592	339	198	165	148	118	80	58	39	131.5	127.1
30	102	157	590	327	185	159	144	116	75	51	42	130.4	126.0
31	101	155	595	328	183	154	139	121	77	46	20	133.6	129.2
Mean	44.7	142	579	315	173	142	127	105	79	53	28	158.9	153.9

♦ SUNSPOT COUNTS

In 1848 the Swiss astronomer Johann Rudolf Wolf introduced a daily measurement of sunspot number. His method, which is still used today, counts the total number of spots visible on the face of the Sun and the number of groups into which they cluster, because neither quantity alone satisfactorily measures the level of sunspot activity.

An observer computes a daily sunspot number by multiplying his estimated number of groups by ten and then adding this product to his total count of individual spots. Results, however, vary greatly, since the measurement strongly depends on observer interpretation and experience and on the stability of the Earth's atmosphere above the observing site. Moreover, the use of Earth as a platform from which to record these numbers contributes to their variability, too, because the Sun rotates and the evolving spot groups are distributed unevenly across solar longitudes. To compensate for these limitations, each daily international number is computed as a weighted average of measurements made from a network of cooperating observatories. The international sunspot numbers tabulated on page 1 are provisional values taken from a bulletin prepared monthly by the SOLAR INFLUENCE DATA CENTER, RINGLAAN 3, 1180 BRUSSELS, BELGIUM. (http://sidc.oma.be)

♦ HISTORICAL SUNSPOT COUNTS

How do sunspot numbers in the table on page 1 compare to the largest values ever recorded? The highest daily count on record occurred December 24-25, 1957. On each of those days the sunspot number totaled 355. In contrast, during years near the spot cycle minimum, the count can fall to zero. Today, much more sophisticated measurements of solar activity are made routinely, but none has the link with the past that sunspot numbers have. Our archives, for example, include reconstructed daily values from January 8, 1818; monthly means from January 1749; and yearly means beginning in 1700.

SMOOTHED (OBSERVED AND PREDICTED) SUNSPOT NUMBERS: CYCLES 23 AND 24

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
2000	113	117	120	121	119	119	120	119	116	115	113	112	117
2001	109	104	105	108	109	110	112	114	114	114	116	115	111
2002	114	115	113	111	109	106	103	99	95	91	85	82	102
2003	81	79	74	70	68	65	62	60	60	58	57	55	66
2004	52	49	47	46	44	42	40	39	38	36	35	35	42
2005	35	34	34	32	29	29	29	27	26	26	25	23	29
2006	21	19	17	17	17	16	15	16	16	14	13	12	16
2007	12	12	11	10	9	8	7	6	6	6	6	5	8
2008	4	4	3	3	4	3	3	3	2	2	2	2	3
2009	2	2	2	2	2	3	4	5	6	7	8	8	4
2010	9	11	12	14	16	16	17	17	20	23	27	29	18
2011	31	33	37	42	48	53	57	59	60	60	61	63	50
2012	66	67	67	65	62	59	58	58	58	59	60	61	61
2013	59	58	58	58	60	63	66	69	73	75	75	75	66
2014	77	78	81	82	81	80	79	77	75	73	71	69	77
								(3)	(4)	(6)	(9)	(11)	(3)
2015	67	65	64	62	61	58	56	54	52	51	50	48	57
	(11)	(10)	(8)	(8)	(8)	(9)	(10)	(10)	(11)	(11)	(12)	(13)	(10)
2016	47	45	44	42	40	39	39	38	37	35	34	32	39
	(14)	(16)	(18)	(20)	(20)	(20)	(21)	(21)	(21)	(22)	(23)	(24)	(20)

♦ SUNSPOT NUMBER PREDICTIONS

For the end of Solar Cycle 23, and the beginning of Cycle 24, the table gives smoothed sunspot numbers up to the one calculated that first uses the most recently measured monthly mean. These smoothed, observed values are based on final, unsmoothed monthly means through June 2010 and on provisional ones thereafter. We compute a smoothed monthly mean by forming the arithmetic average of two sequential 12-month running means of monthly means.

Table entries with numbers in parentheses below them denote predictions by the McNish-Lincoln method. This method estimates future numbers by adding a correction to the mean of all cycles that is proportional to the departure of earlier values of the current cycle from the mean cycle. (See page 9 in the July 1987 supplement to *Solar-Geophysical Data*). We use and predict only smoothed monthly means, because we believe the errors are too great to estimate any values more precisely. In the table above, adding the number in parentheses to the predicted value generates the upper limit of the 90% confidence interval; subtracting the number from the predicted value generates the lower limit. Consider, for example, the August 2011 prediction. There exists a 90% chance that in August 2011, the actual smoothed sunspot number will fall somewhere between 18 and 62.

The McNish-Lincoln prediction method generates useful estimates of smoothed, monthly mean sunspot numbers for no more than 12 months ahead. Beyond a year these predictions regress rapidly toward the mean of all 14 cycles used in the computation. Moreover, the method is very sensitive to the date defined as the beginning of the current sunspot cycle, that is, to the date of the most recent sunspot minimum.