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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/m²Hzsec. 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 <u>observed</u> and <u>adjusted</u> Penticton fluxes tabulated here are the "Series C" values reported by Canada's Dominion Radio Astrophysical Observatory in Penticton, British Columbia. <u>Observed</u> numbers are less refined, since they contain fluctuations as large as $\pm 7\%$ from the continuously changing sun-earth distance. <u>Adjusted</u> 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.

DECEMBER 2012 PRELIMINARY SUNSPOT NUMBERS AND SOLAR RADIO FLUX

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	Sunspot	Obs Flux	Solar Flux Adjusted to 1 Astronomical Unit								
Day	Number Intl	Pentic (2800)	RSTN (4.5.400)	RSTN (8800)	RSTN (4005)	Pentic	RSTN	RSTN	RSTN (610)	RSTN (410)	RSTN (245)
Day 01	38	102	(15400) 555	(8800) 261	(4995) 138	(2800) 102	(2695) 94	(1415) 81	(610) 57	(410) 39	(245) 23
02	36 34	98	561	263	135	98	94 88	78	57 57	38	23 19
02	32	96 97	540	203 151	133	96 97	90	76 79	57 53	36 37	23
03	32 39	9 <i>1</i> 96	540 548	259	134	97 96	90 86	79 79	56	39	23 18
05	39 43	96 96	546 551	259 257	133	96 96	89	79 78	50 52	39 39	20
05	43	96	551	257	133	96	69	70	52	39	20
06	20	97	566	266	135	97	89	81	55	40	20
07	22	97	556	263	135	97	90	80	58	38	18
08	36	101	555	259	138	101	96	82	54	38	19
09	30	101	550	265	141	101	95	85	56	35	24
10	31	104	556	264	139	104	95	84	50	38	23
10	31	104	550	204	139	104	93	04	30	30	23
11	34	104	568	264	140	104	96	87	60	36	20
12	48	112	570	271	147	112	102	91	61	40	21
13	52	117	562	272	151	117	107	94	63	40	33
14	43	119	572	279	156	119	110	96	63	43	29
15	45	122	562	277	158	122	107	98	61	40	25
10	70	122	002	211	100	122	107	50	01	40	20
16	47	120	567	276	155	120	109	96	65	43	52
17	53	115	467	243	138	115	115	91	61	43	24
18	43	116	562	273	153	116	109	94	68	45	30
19	39	113	548	272	148	113	105	92	53	44	65
20	40	114	583	283	138	114	108	89	61	43	27
21	43	115	560	268	148	115	104	91	59	40	27
22	56	115	568	275	157	115	110	90	58	40	25
23	57	114	573	270	153	114	104	88	56	39	24
24	41	113	563	271	155	113	104	93	57	33	23
25	38	113	527	267	152	113	100	85	58	39	22
26	41	110	566	269	149	110	100	86	57	39	21
27	39	107	562	262	145	107	98	82	56	38	21
28	38	106	567	262	145	106	98	92	55	38	21
29	40	104	559	268	146	104	96	84	56	37	21
30	40	107	550	268	150	107	98	86	57	37	20
31	64	108	552	274	155	114	104	87	58	42	21
Mean	40.8	108	556	267	145	108	100	87	58	39	25

Observed Adjusted Pentic (2800) 2800) 98.4 96.8 96.5 94.9 93.3 91.8 95.0 93.4 96.6 94.9 98.7 96.9 101.7 99.8 104.1 102.2 115.1 112.9 122.2 119.8 133.3 130.6 143.8 140.8 146.2 143.1 142.1 139.1 141.7 138.6 138.3 135.2 135.5 132.4 141.0 137.7 133.9 130.7 141.2 137.8	
98.4 96.8 96.5 94.9 93.3 91.8 95.0 93.4 96.6 94.9 98.7 96.9 101.7 99.8 104.1 102.2 115.1 112.9 122.2 119.8 133.3 130.6 143.8 140.8 146.2 143.1 142.1 139.1 141.7 138.6 138.3 135.2 135.5 132.4 141.0 137.7 133.9 130.7 141.2 137.8	
98.4 96.8 96.5 94.9 93.3 91.8 95.0 93.4 96.6 94.9 98.7 96.9 101.7 99.8 104.1 102.2 115.1 112.9 122.2 119.8 133.3 130.6 143.8 140.8 146.2 143.1 142.1 139.1 141.7 138.6 138.3 135.2 135.5 132.4 141.0 137.7 133.9 130.7 141.2 137.8	
96.5 94.9 93.3 91.8 95.0 93.4 96.6 94.9 98.7 96.9 101.7 99.8 104.1 102.2 115.1 112.9 122.2 119.8 133.3 130.6 143.8 140.8 146.2 143.1 142.1 139.1 141.7 138.6 138.3 135.2 135.5 132.4 141.0 137.7 133.9 130.7 141.2 137.8	
93.3 91.8 95.0 93.4 96.6 94.9 98.7 96.9 101.7 99.8 104.1 102.2 115.1 112.9 122.2 119.8 133.3 130.6 143.8 140.8 146.2 143.1 142.1 139.1 141.7 138.6 138.3 135.2 135.5 132.4 141.0 137.7 133.9 130.7 141.2 137.8	
95.0 93.4 96.6 94.9 98.7 96.9 101.7 99.8 104.1 102.2 115.1 112.9 122.2 119.8 133.3 130.6 143.8 140.8 146.2 143.1 142.1 139.1 141.7 138.6 138.3 135.2 135.5 132.4 141.0 137.7 133.9 130.7 141.2 137.8	
96.6 94.9 98.7 96.9 101.7 99.8 104.1 102.2 115.1 112.9 122.2 119.8 133.3 130.6 143.8 140.8 146.2 143.1 142.1 139.1 141.7 138.6 138.3 135.2 135.5 132.4 141.0 137.7 133.9 130.7 141.2 137.8	
98.7 96.9 101.7 99.8 104.1 102.2 115.1 112.9 122.2 119.8 133.3 130.6 143.8 140.8 146.2 143.1 142.1 139.1 141.7 138.6 138.3 135.2 135.5 132.4 141.0 137.7 133.9 130.7 141.2 137.8	
101.7 99.8 104.1 102.2 115.1 112.9 122.2 119.8 133.3 130.6 143.8 140.8 146.2 143.1 142.1 139.1 141.7 138.6 138.3 135.2 135.5 132.4 141.0 137.7 133.9 130.7 141.2 137.8	
101.7 99.8 104.1 102.2 115.1 112.9 122.2 119.8 133.3 130.6 143.8 140.8 146.2 143.1 142.1 139.1 141.7 138.6 138.3 135.2 135.5 132.4 141.0 137.7 133.9 130.7 141.2 137.8	
104.1 102.2 115.1 112.9 122.2 119.8 133.3 130.6 143.8 140.8 146.2 143.1 142.1 139.1 141.7 138.6 138.3 135.2 135.5 132.4 141.0 137.7 133.9 130.7 141.2 137.8	
115.1 112.9 122.2 119.8 133.3 130.6 143.8 140.8 146.2 143.1 142.1 139.1 141.7 138.6 138.3 135.2 135.5 132.4 141.0 137.7 133.9 130.7 141.2 137.8	
122.2 119.8 133.3 130.6 143.8 140.8 146.2 143.1 142.1 139.1 141.7 138.6 138.3 135.2 135.5 132.4 141.0 137.7 133.9 130.7 141.2 137.8	
143.8 140.8 146.2 143.1 142.1 139.1 141.7 138.6 138.3 135.2 135.5 132.4 141.0 137.7 133.9 130.7 141.2 137.8	
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141.2 137.8	
140.4 127.0	
1404 1370	
127.7 124.5	
126.7 123.5	
118.0 115.0	
121.6 118.4	
121.0 110.4	
121.8 118.6	
117.1 114.0	
114.3 111.2	
113.1 110.0	
110.6 107.5	
120.9 118.3	

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.

ONIOOTHED	COCCEDITED AND	DDEDIOTED	OLINIODOT NILINADEDO	0)/01 E0 00 AND 04
SWICHELL	CORCEDVED AND		SUNSPOT NUMBERS:	(V() E C () 3 ANII) 7/1
SIVICOTTIED			I SONSI OT NONDENS.	CICLES 23 AND 24

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
44	49	53	57	59	62	65	68	70	71	73	78	62
83	85	84	86	91	93	94	98	102	108	111	111	95
113	117	120	121	119	119	120	119	116	115	113	112	117
109	104	105	108	109	110	112	114	114	114	116	115	111
114	115	113	111	109	106	103	99	95	91	85	82	102
81	79	74	70	68	65	62	60	60	58	57	55	66
52	49	47	46	44	42	40	39	38	36	35	35	42
35	34	34	32	29	29	29	27	26	26	25	23	29
21	19	17	17	17	16	15	16	16	14	13	12	16
12	12	11	10	9	8	7	6	6	6	6	5	8
4	4	3	3	4	3	3	3	2	2	2	2	3
2	2	2	2	2	3	4	5	6	7	8	8	4
9	11	12	14	16	16	17	17	20	23	27	29	18
31	33	37	42	48	53	57	59	60	60	61	63	50
66	67	67	65	62	59	61	63	66	68	68	70	65
						(4)	(7)	(11)	(17)	(21)	(24)	(7)
72	74	75	75	75	76	76	75	74	74	75	76	75
(28)	(30)	(32)	(33)	(35)	(37)	(39)	(39)	(36)	(36)	(37)	(37)	(35)
75	74	73	73	72	71	70	60	67	65	63	62	70
								_				(32)
	44 83 113 109 114 81 52 35 21 12 4 2 9 31 66	44 49 83 85 113 117 109 104 114 115 81 79 52 49 35 34 21 19 12 12 4 4 2 2 9 11 31 33 66 67	44 49 53 83 85 84 113 117 120 109 104 105 114 115 113 81 79 74 52 49 47 35 34 34 21 19 17 12 12 11 4 4 3 2 2 2 9 11 12 31 33 37 66 67 67 72 74 75 (28) (30) (32) 75 74 73	44 49 53 57 83 85 84 86 113 117 120 121 109 104 105 108 114 115 113 111 81 79 74 70 52 49 47 46 35 34 34 32 21 19 17 17 12 12 11 10 4 4 3 3 2 2 2 2 9 11 12 14 31 33 37 42 66 67 67 65 72 74 75 75 (28) (30) (32) (33) 75 74 73 73	44 49 53 57 59 83 85 84 86 91 113 117 120 121 119 109 104 105 108 109 114 115 113 111 109 81 79 74 70 68 52 49 47 46 44 35 34 34 32 29 21 19 17 17 17 12 12 11 10 9 4 4 3 3 4 2 2 2 2 2 9 11 12 14 16 31 33 37 42 48 66 67 67 65 62 72 74 75 75 75 (28) (30) (32) (33) (35)	44 49 53 57 59 62 83 85 84 86 91 93 113 117 120 121 119 119 109 104 105 108 109 110 114 115 113 111 109 106 81 79 74 70 68 65 52 49 47 46 44 42 35 34 34 32 29 29 21 19 17 17 17 16 12 12 11 10 9 8 4 4 3 3 4 3 2 2 2 2 2 3 11 12 14 16 16 31 33 37 42 48 53 66 67 67 65 62 59 72 74 75 75 74 75 75 76 75 77 71	44 49 53 57 59 62 65 83 85 84 86 91 93 94 113 117 120 121 119 119 120 109 104 105 108 109 110 112 114 115 113 111 109 106 103 81 79 74 70 68 65 62 52 49 47 46 44 42 40 35 34 34 32 29 29 29 21 19 17 17 17 16 15 12 12 11 10 9 8 7 4 4 3 3 4 3 3 2 2 2 2 2 3 4 9 11 12 14 16 16	44 49 53 57 59 62 65 68 83 85 84 86 91 93 94 98 113 117 120 121 119 119 120 119 109 104 105 108 109 110 112 114 114 115 113 111 109 106 103 99 81 79 74 70 68 65 62 60 52 49 47 46 44 42 40 39 35 34 34 32 29 29 29 29 27 21 19 17 17 17 16 15 16 12 12 11 10 9 8 7 6 4 4 3 3 4 3 3 3 2 2 2 2 2 3 4 5 9 11 12<	44 49 53 57 59 62 65 68 70 83 85 84 86 91 93 94 98 102 113 117 120 121 119 119 120 119 116 109 104 105 108 109 110 112 114 114 114 115 113 111 109 106 103 99 95 81 79 74 70 68 65 62 60 60 52 49 47 46 44 42 40 39 38 35 34 34 32 29 29 29 27 26 21 19 17 17 17 16 15 16 16 12 12 11 10 9 8 7 6 6 4 4 3 3 3 4 3 3 3 2	44 49 53 57 59 62 65 68 70 71 83 85 84 86 91 93 94 98 102 108 113 117 120 121 119 119 120 119 116 115 109 104 105 108 109 110 112 114 12 14 16 15 16 16 14 14 12 12 11	44 49 53 57 59 62 65 68 70 71 73 83 85 84 86 91 93 94 98 102 108 111 113 117 120 121 119 119 120 119 116 115 113 109 104 105 108 109 110 112 114 114 114 114 116 115 113 114 115 113 111 109 106 103 99 95 91 85 81 79 74 70 68 65 62 60 60 58 57 52 49 47 46 44 42 40 39 38 36 35 35 34 34 32 29 29 29 27 26 26 25 21 19 17 17 17 16 15 16 16 14 13	44 49 53 57 59 62 65 68 70 71 73 78 83 85 84 86 91 93 94 98 102 108 111 111 113 117 120 121 119 119 120 119 116 115 113 112 109 104 105 108 109 110 112 114 114 114 114 116 115 114 115 113 111 109 106 103 99 95 91 85 82 81 79 74 70 68 65 62 60 60 58 57 55 52 49 47 46 44 42 40 39 38 36 35 35 35 34 34 32 29 29 29 27 26 26 25 23 21 19 17 17 17

♦ 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.

Although every effort has been made to ensure that these data are correct, we can assume no liability for any damages any inaccuracies might cause. Subscriptions to this monthly bulletin are available free of charge. To become a subscriber either call (303) 497-6761, or write to the NATIONAL GEOPHYSICAL DATA CENTER, Solar-Terrestrial Physics Division (E/GC2), 325 Broadway, Boulder, Colorado 80305-3328, USA. Solar Indices Bulletin can also be accessed online via the .ftp link at: www.ngdc.noaa.gov/stp/solar/sibintro.html.