Australian Government

Bureau of Meteorology

SPACE WEATHER SERVICES

SOLAR

AND

GEOPHYSICAL

SUMMARY

February 2024

Solar Activity

Solar activity was predominately at R1-R3 levels this month, with 44 R1, two R2 and five R3 level flares observed. The largest flare of the month was an X6.3 observed on 22-Feb, which was also the largest flare of solar cycle 25 so far. Several shortwave fadeouts were observed in the Australian region throughout the month, including strong fadeouts on 16, 21 and 22-Feb in association with X-class solar flares. Active regions AR3575, AR3576 and AR3590 were the main sources of the flare activity observed, with all regions harbouring beta-gamma-delta magnetic complexities. S2 solar radiation storms were observed on 9, 10, 11 and 13-Feb following flare and CME activity.

Several coronal mass ejections (CMEs) were observed in February, but none were significantly Earth-directed. CME shock arrivals were observed in solar wind data on 04, 11 and 24-Feb, but only a single period of G1 geomagnetic conditions was observed in both planetary and Australian regions on 27-Feb.

M and X class flares for the month are listed below. Please see our homepage https://www.sws.bom.gov.au for a link to an explanation of the Australian Space Weather Alert System (ASWAS) scales.

DATE	FLARES CLASS M	CLASS X	FLARE MAX	FADEOUT POSSIBLE ON DAYLIGHT CIRCUIT
02 Feb 24	M1.1		0301UT	
04 Feb 24	M1.4/SF		1153UT	
04 Feb 24	M1.5		1638UT	
04 Feb 24	M1.3		1712UT	
04 Feb 24	M1.1		1829UT	
04 Feb 24	M1.2		2057UT	
04 Feb 24	M2.1		2228UT	
04 Feb 24	M2.7		2237UT	
05 Feb 24	M2.1/SF		0428UT	
05 Feb 24	M1.4/SF		0622UT	
06 Feb 24	M2.2		0228UT	
06 Feb 24	M4.2		0312UT	0237-0337UT
06 Feb 24	M1.3		1849UT	
07 Feb 24	M5.1/SF		0331UT	0304-0411UT
07 Feb 24	M1.3		1805UT	
08 Feb 24	M3.4		1312UT	1241-1337UT
08 Feb 24	M1.2		1418UT	
08 Feb 24	M1.8/1F		1523UT	
08 Feb 24	M1.3/1F		1902UT	
09 Feb 24	M3.1/1N		0041UT	0036-0045UT
09 Feb 24		X3.3	1314UT	1253-1332UT
09 Feb 24	M1.2		1800UT	
09 Feb 24	M3.9		2355UT	2316-0036UT
10 Feb 24	M1.5/SF		0051UT	
10 Feb 24	M3.4		0354UT	0304-0429UT
10 Feb 24	M9.0/1F		2307UT	2256-2314UT
11 Feb 24	M1.0		2245UT	
12 Feb 24	M6.5/2B		0348UT	0323-0353UT
12 Feb 24	M1.1		1308UT	
12 Feb 24	M1.4/1F		1548UT	
12 Feb 24	M2.6		2117UT	
14 Feb 24	M1.0		0310UT	
14 Feb 24	M1.0/SF		0735UT	
15 Feb 24	M1.8		1707UT	
16 Feb 24	M1.5		0251UT	
16 Feb 24		X2.5/1N	0653UT	0642-0658UT
16 Feb 24	M3.0		2209UT	2157-2216UT
21 Feb 24		X1.8	2307UT	2252-2314UT
22 Feb 24		X1.7/2B	0632UT	0617-0640UT
22 Feb 24	M4.8/2B		2046UT	2029-2103UT
22 Feb 24		X6.3	2234UT	2208-2243UT
23 Feb 24	M1.5		0014UT	
23 Feb 24	M1.0		1328UT	
23 Feb 24	M1.4/1N		1553UT	

23 Feb 24	M2.6/1N	1747UT	
24 Feb 24	M4.5	0634UT	0621-0644UT
24 Feb 24	M2.2	1057UT	
24 Feb 24	M3.6	1118UT	1103-1125UT
24 Feb 24	M1.0	1159UT	
25 Feb 24	M2.0/1N	1722UT	
28 Feb 24	M1.5	1854UT	

FLARE ALERT	SWF ALERT
02 Feb 24	0259-0303 UT
04 Feb 24	
05 Feb 24	0424-0446 UT
06 Feb 24	0217-0458 UT,0458-0507 UT
07 Feb 24	0312-0506 UT
08 Feb 24	
09 Feb 24	2331-0124 UT
10 Feb 24	0331-0506 UT,2302-2329 UT
11 Feb 24	
12 Feb 24	0344-0416 UT
14 Feb 24	0307-0315 UT
15 Feb 24	
16 Feb 24	0248-0256 UT,0649-0707 UT
21 Feb 24	2259-2345 UT
22 Feb 24	0627-0744 UT
23 Feb 24	2221-2358 UT
24 Feb 24	0628-0652 UT
25 Feb 24	
28 Feb 24	

PROTON ALERT

BEGIN		END		ENERGY THRESHOLD
DATE	TIME	DATE	TIME	
09 02 2024	1515UT	11 02 2024	1750UT	S1
09 02 2024	1810UT	09 02 2024	1900UT	S2
09 02 2024	2300UT	10 02 2024	1610UT	S2
11 02 2024	0230UT	11 02 2024	0345UT	S2
12 02 2024	0755UT	14 02 2024	1930UT	S1
13 02 2024	0545UT	13 02 2024	0635UT	S2
13 02 2024	0830UT	13 02 2024	0900UT	S2

Ionospheric Activity

The deepest ionospheric depression in the Australian regional ionosphere was observed on 26-Feb. The depression in ionospheric frequencies of support was restricted to east coast Australia during local daylight hours. Numerous shortwave fadeouts were observed during the month, impacting the lower HF frequencies. However, strong HF fadeouts were observed in association with R3 flare activity, in particular the R3 (X6.3) flare on 22-Feb. Ionospheric equatorial scintillation was observed at Darwin/Weipa on 08,15,16,19,22,23 and 25 Feb.

Ionospheric depressions listed below are calculated using foF2 data from the ASWFC ionosonde network.

IONOSPHERIC DISTURBANCES (MUFs for the Australian region)

02 Feb 24: Australian west coast MUFs depressed by 15-25%
26 Feb 24: Australian east coast MUFs depressed by 20-30%
29 Feb 24: Australian east coast MUFs depressed by 15-20%

RADIO COMMUNICATIONS WARNINGS

DATE	Nº.	BEGIN	END
01 Aug 23	73	01 Aug 23	03 Aug 23
02 Feb 24	12	04 Feb 24	05 Feb 24
02 Feb 24	13	02 Feb 24	03 Feb 24
05 Feb 24	14	05 Feb 24	07 Feb 24
08 Feb 24	15	08 Feb 24	10 Feb 24
10 Feb 24	16	11 Feb 24	12 Feb 24
11 Feb 24	17	11 Feb 24	12 Feb 24
13 Feb 24	18	14 Feb 24	15 Feb 24
13 Feb 24	19	13 Feb 24	15 Feb 24
14 Feb 24	20	15 Feb 24	16 Feb 24
22 Feb 24	21	22 Feb 24	24 Feb 24
25 Feb 24	22	25 Feb 24	27 Feb 24
26 Feb 24	23	26 Feb 24	26 Feb 24
29 Feb 24	24	01 Mar 24	03 Mar 24

Geomagnetic Activity

Mostly G0 geomagnetic conditions were observed during the month of February. An isolated period of G1 geomagnetic Australian regional conditions was observed on 11-Feb and an isolated period of planetary G1 conditions was observed on 27-Feb. The activity on 11-Feb was due to a component arrival of a southwest solar limb CME observed on 09-Feb. The activity on 27-Feb was associated with an interval of southward interplanetary magnetic field conditions.

Weak CME arrivals were observed on 04 and 24-Feb, but none of these events were associated with significant geomagnetic activity. Several other CMEs were observed throughout the month, however only a small number contained Earth-directed components. No significant increases in solar wind speed were observed due to coronal holes this month. The maximum planetary A-index observed during February was 15 on 11-Feb with the maximum Australian A-index reaching 17 on this day.

Disturbances with Australian A indices greater than or equal to 16 are reported below.

DATE	GEOMAGNETIC DISTURBANCES (for the Australian region)
11 Feb 24:	G1 (Australian region)
27 Feb 24:	G1 (planetary)

GEOMAGNETIC WARNINGS AND ALERTS

DATE	Nº.	BEGIN	END	ISSUED
02 Feb 24	04	04 Feb 24	05 Feb 24	Warning
10 Feb 24	05	12 Feb 24	13 Feb 24	Warning
11 Feb 24	06	11 Feb 24	11 Feb 24	Warning
11 Feb 24				Alert
13 Feb 24	07	13 Feb 24	14 Feb 24	Warning
22 Feb 24	08	24 Feb 24	25 Feb 24	Warning
29 Feb 24	09	02 Mar 24	03 Mar 24	Warning

Solar And Geophysical Indices

DATE	10cm FLUX	AUSTRALIAN A-INDEX	AUSTRALIAN T-INDEX	DATE	10 cm FLUX	AUSTRALIAN A-INDEX	AUSTRALIAN T-INDEX
01 Feb	137	5	140	16 Feb	169	4	154
02 Feb	143	1	129	17 Feb	170	2	147
03 Feb	156	1	147	18 Feb	157	2	143
04 Feb	170	6	145	19 Feb	152	0	151
05 Feb	173	7	148	20 Feb	153	4	148
06 Feb	190	6	158	21 Feb	170	3	127
07 Feb	188	3	142	22 Feb	173	4	145
08 Feb	185	3	159	23 Feb	173	3	134
09 Feb	183	4	138	24 Feb	179	6	136
10 Feb	194	4	139	25 Feb	181	9	126
11 Feb	180	16	157	26 Feb	172	7	89
12 Feb	208	2	134	27 Feb	168	8	102
13 Feb	195	10	144	28 Feb	180	2	109
14 Feb	184	3	140	29 Feb	164	2	109
15 Feb	178	3	145				

DATE	10cm FLUX	AUSTRALIAN A-INDEX	AUSTRALIAN T-INDEX	SUNSPOT NUMBER		FLARES
	Monthly Average	Monthly Average	Monthly Average	Monthly Average	13-month smoothed	>M1.0
Mar 23	157.2	9.3	131.5	122.6	121.2	21
Apr 23	145.8	8.3	119.3	96.4	123.4	9
May 23	156	6.5	97.7	137.9	124.9	60
Jun 23	161.7	5.5	97.5	163.4	125.6	21
Jul 23	177.1	4.9	103.5	159.1	124.4	52
Aug 23	153.7	4.6	114.5	114.9	124	27
Sep 23	154.5	9.8	104.3	133.6	124.7	33
Oct 23	142.6	6.1	130.3	99.4	125.8	7
Nov 23	153.9	8.7	113.9	105.4	126.2	17
Dec 23	151.3	8.4	110.9	114.2	123.8	25
Jan 24	163.9	5.1	142.8	123	120.3	31
Feb 24	173.3	4.5	137.4	124.6	118.6	51

Predicted sunspot numbers

SPECIAL NOTE
In June 2015, WDC-SILSO, Royal Observatory of Belgium, Brussels, adjusted their original observed sunspot numbers (Version 1.0) to a Version 2.0 series in which the sunspot numbers are higher. In the Version 1.0 data series, some of the sunspot numbers were weighted. The new (Version 2.0) sunspot numbers are unweighted sunspot number counts (for more information see: www.sidc.be/silso/home). The Bureau of Meteorology SWS solar cycle prediction is now based on the Version 2.0 values. As a result of this recalibration, the observed monthly and observed and predicted smoothed sunspot numbers are higher in the monthly table and solar cycle graph.

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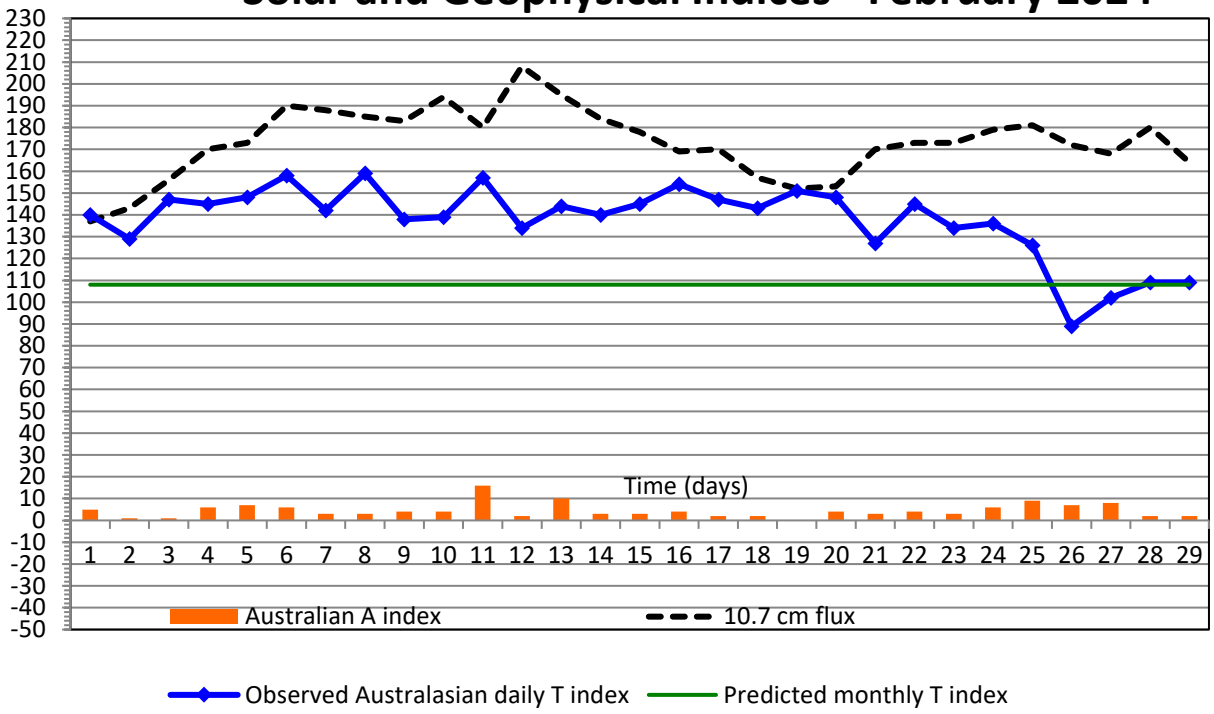
SWS WORLD T-INDICES

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2021	12	4	10	6	6	12	21	12	23	23	17	28
2022	41	52	63	71	81	65	67	56	72	75	65	71
2023	107	114	119	105	101	110	118	118	107	113	97	95
2024	122	123*	111	112	112	113	113	111	112	110	109	107
2025	106	104	102	99	97	96	95	94	92	91	90	89
2026	88	87	86	85	84	82	80	78	75	72	69	66

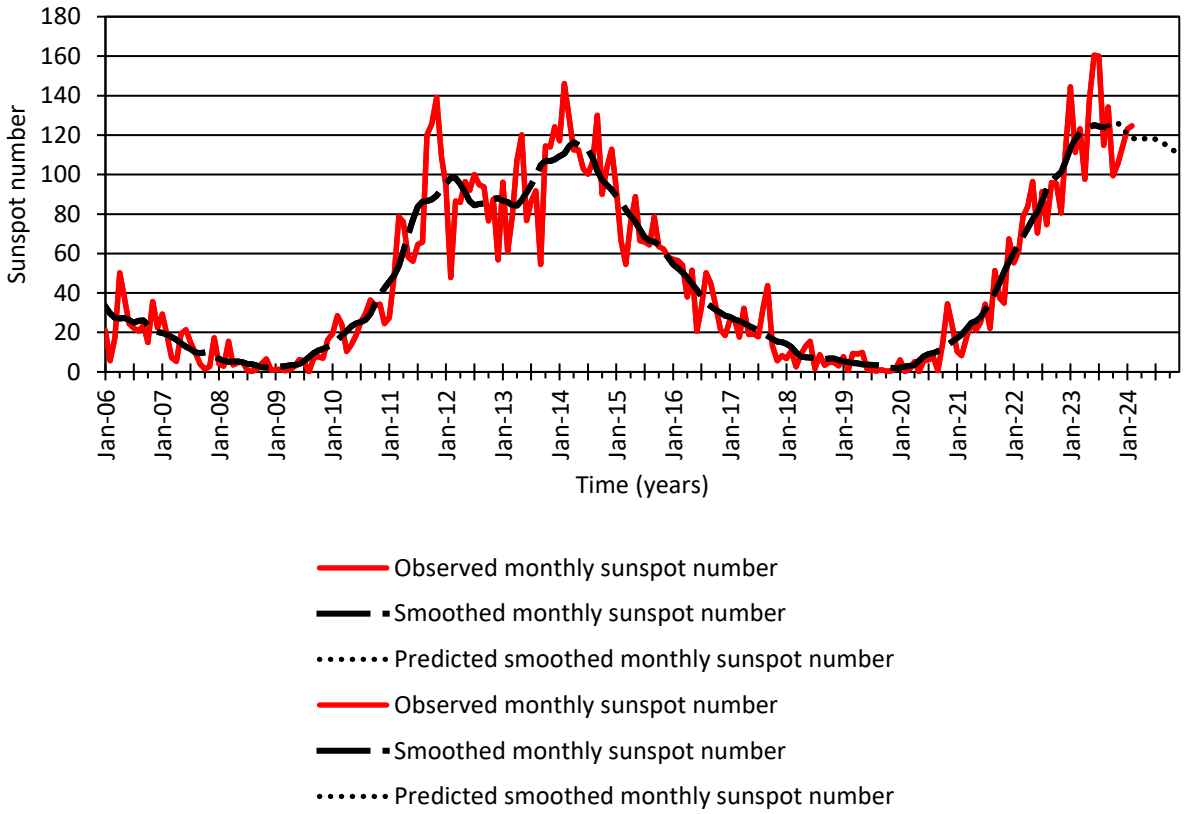
SWS predicted T-index

* New observed data. T-index value may have changed

Solar and Geophysical Indices - February 2024



Solar Cycle



Observed monthly sunspot numbers courtesy of WDC-SILSO, Royal Observatory of Belgium, Brussels (www.sidc.be/silso/home)

NOTES - notes - NOTES - notes - NOTES - notes

a. Times quoted in this publication are all Universal Time (UT).

b. The values of all indices are provisional. Final values are not available for several months.

c. M or X class flares refer to the X-ray classification system for solar flares. In this system, X class flares are more energetic than M class flares.

FLARE CLASS	X-RAY FLUX DENSITY	
	Ergs/cm^2/sec	W/m^2
M	0.01-0.1	10^{-5} to 10^{-4}
X	>0.1	> 10^{-4}

d. Class M flares, particularly the less energetic ones, are likely to cause a fadeout on only the lowest frequencies. Class X flares are likely to cause a fadeout over the entire HF spectrum. It should be noted that a fadeout will only occur on those circuits having a reflection point in the daylight hemisphere of the earth. Circuits having only night hemisphere reflection points will not be affected no matter the energy of the solar flares.

e. The 10cm flux is the radio power of the sun at a frequency of 2800 MHz (wavelength 10.7 cm). This flux is a good indicator of solar activity and is widely used in place of the sunspot number. The values are measured by the Penticton radio observatory, Canada. Unlike the sunspot number, the 10cm flux never drops to zero even during solar minimum. With no sunspots visible on the solar disk, the 10cm flux will still have a value of around 67. The table below gives a (statistical) comparison between 10cm flux and sunspot number. The 10cm flux is measured in solar flux units (10^{-22} W m^{-2} Hz^{-1}).

SUNSPOT No.	10 cm FLUX
0	67
20	78
40	93
60	110
100	147
150	195
200	243

f. Ionospheric disturbances refer to measurements made across Australia, but are generally applicable to mid-latitude Southern Hemisphere conditions. Spread F conditions indicate tilts in the ionosphere, which may result in multipath fading on some HF circuits.

g. The magnetic A-indices are for the Australian region. Large values for the A index correspond to disturbed conditions. Levels of magnetic disturbances are described in the following terms.

A INDEX VALUE	DESCRIPTION
0 up to 7	Quiet
8 up to 15	Unsettled
16 up to 24	Active
25 up to 35	Minor Storm
36 and above	Major Storm

h. The Australian daily T-index is a measure of the average of the ionospheric critical frequencies available on a particular day - the higher the value of the T-index, the higher the ionospheric critical frequencies (and Maximum Usable Frequencies on HF circuits) for that day. The T-index is based on data from Australian ionospheric stations and so is most applicable to HF circuits with reflection points in the Australian region.

i. The SWS monthly observed T-index is derived from the observed monthly median values of foF2 for each hour from ionospheric stations worldwide.

The predicted smoothed monthly T-indices are computed by using a statistical analysis of the observed monthly T-indices for all solar cycles since 1938.

The SWS T-indices may not be updated each month but only when sufficient new data becomes available.

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