Australian Government

Bureau of Meteorology

SPACE WEATHER SERVICES

SOLAR

AND

GEOPHYSICAL

SUMMARY

May 2023

Solar Activity

A total of 60 solar flares of magnitude R1-R2 were observed in May 2023. No R3 flares or higher were observed during the month. The two largest flares both R2 class, were an M9.6 at 1643UT on 16-May and an M8.9 at 1235UT on 20-May. Solar flare activity was at R2 level on 1,3,9,16,19 and 20-May. Solar activity was at the R1 level on 4,5,8,10,11,18 and 22-26, 27, 28, 30 and 31-May. Solar region AR3296 contributed to solar flare activity earlier in the month from 4-10 May, this region showed decline as it rotated off disk 14-15 May and failed to return on 27-28 May. Later in the month solar region AR3311 contributed greatly to the month's flare activity during 18-26 May, declining from 22-May and then rotated off disk at the end of the month. The solar wind speed during May was elevated at the start of the month then slowly declined until 6-May, with Earth transiting coronal mass ejections (CME) observed on 6, 7, 10, 12, 13, and during 19-22 May. The solar wind enhancement on 6-May is considered to have a contributing component from a coronal hole wind stream. Most of these CMEs induced only minor activity. A CME and coronal hole wind stream induced activity during the period late 19-22 May which induced the strongest activity for the month. Peaks in solar wind speeds were observed on 10-May (~650km/sec - highest speed for the month), 20-May, 22-May, and 25-May. Coronal holes of significant area were at or near the solar central meridian on 3,4 and 21, 29 and 30-31 May. CME solar wind shocks were observed on 06-May at 0026UT, 09-May at 2207UT and 12-May at 0549UT. The CME solar wind shock late on 19-May was unusual with the jump in solar wind speed and temperature occurring after the increase in the other (density and magnetic field) solar wind parameters preventing automatic detection. S1-Minor solar proton events were observed during the interval 8-11 May, the first event reached a peak flux of 38.4PFU at 9/0150UT and following long duration M1 flares on 7-May, the second a peak flux of 83.5PFU was observed at 10/1250UT following an M4 flare on 09-May.

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
01 May 23	M1.1		0121UT	
01 May 23	M7.1		1309UT	1302-1313UT
03 May 23	M4.2/SF		0927UT	0915-0933UT
03 May 23	M3.1		1014UT	1003-1019UT
03 May 23	M7.2		1045UT	1036-1049UT
03 May 23	M1.7		1235UT	
03 May 23	M2.2/1B		1350UT	
04 May 23	M3.9/SB		0844UT	0805-0908UT
05 May 23	M2.1		0801UT	
05 May 23	M1.2/1N		1531UT	
07 May 23	M1.5		2234UT	
07 May 23	M1.6		2323UT	
08 May 23	M2.3/2B		2025UT	
08 May 23	M1.6		2323UT	
09 May 23	M6.5/1N		0354UT	0342-0405UT
09 May 23	M1.2		0613UT	
09 May 23	M1.3		1020UT	
09 May 23	M4.2/1B		1858UT	1820-1924UT
09 May 23	M5.0/1N		2052UT	2032-2104UT
10 May 23	M2.2/SF		1421UT	
11 May 23	M2.1		0901UT	
11 May 23	M1.8/1N		1829UT	
16 May 23	M9.6		1643UT	1631-1651UT
18 May 23	M1.0		0626UT	
18 May 23	M1.2		0655UT	
18 May 23	M2.2		1147UT	
18 May 23	M1.6		1249UT	
18 May 23	M1.1		1751UT	
18 May 23	M3.8		2023UT	2012-2051UT
18 May 23	M4.5		2105UT	2051-2116UT
19 May 23	M5.3/1N		0043UT	0041-0054UT
19 May 23	M1.6/SN		0312UT	
19 May 23	M2.5/1N		0458UT	
19 May 23	M2.3/SF		2006UT	
19 May 23	M2.7		2026UT	
20 May 23	M1.0/SF		0702UT	
20 May 23	M6.4/1N		0732UT	0716-0736UT
20 May 23	M1.1		0927UT	
20 May 23	M1.6		1054UT	
20 May 23	M8.9		1235UT	1225-1240UT
20 May 23	M5.6		1500UT	1454-1504UT
20 May 23	M1.1		1903UT	
20 May 23	M5.1		2306UT	2252-2321UT
21 May 23	M1.4/SN		0223UT	

21 May 23	M2.6/1N	1604UT	
22 May 23	M1.9/SF	1337UT	
23 May 23	M3.0	1213UT	1207-1217UT
23 May 23	M1.9	1337UT	
24 May 23	M1.0/SN	0958UT	
24 May 23	M1.8/1F	1721UT	
24 May 23	M1.0/SF	1800UT	
25 May 23	M1.1/1N	1446UT	
26 May 23	M1.3	2303UT	
28 May 23	M1.0/1N	1036UT	
30 May 23	M1.2/SF	0810UT	
30 May 23	M1.3	1022UT	
30 May 23	M1.4/1B	1338UT	
31 May 23	M1.3	0438UT	
31 May 23	M1.0	1226UT	
31 May 23	M4.2	2252UT	2214-2312UT

FLARE ALERT	SWF ALERT
01 May 23	
03 May 23	
04 May 23	
05 May 23	
08 May 23	
09 May 23	0350-0418UT
10 May 23	
11 May 23	
13 May 23	
16 May 23	
17 May 23	
18 May 23	
19 May 23	
20 May 23	
21 May 23	
22 May 23	
23 May 23	
24 May 23	
25 May 23	
26 May 23	
28 May 23	
30 May 23	
31 May 23	

PROTON ALERT

BEGIN DATE	BEGIN TIME	END DATE	END TIME	ENERGY THRESHOLD
08 05 2023	1220UT	08 05 2023	1405UT	10MeV (S1)
08 05 2023	1435UT	09 05 2023	1220UT	10MeV (S1)
09 05 2023	2325UT	11 05 2023	0350UT	10MeV (S1)

Ionospheric Activity

No significant ionospheric depressions were observed this month. Spread F was frequently observed during local night hours in the southern Australian region. A positive ionospheric response was observed on 20-May following the onset of geomagnetic activity. Transpolar HF communication may have been degraded at times by increased absorption of the polar cap ionosphere during 08-11-May, in association with S1-Minor solar proton events. No significant shortwave fadeouts were observed during the month. A brief HF fadeout was observed 09-May 0350-0418UT. A minor fadeout was observed at Niue in association with the M4.2 flare at 2252UT on 31-May and to a lesser extent also at Darwin, impacting lower HF frequencies. Despite the frequent flare activity observed this month, the number of fadeouts was small due to most of the flare activity occurring outside local day time in the Australian mainland region, greatly reducing the impact on daytime Australian regional HF communication. Longer distance international HF communication may have been more frequently impacted. Towards the end of the month lower frequencies of ionospheric support together with spread F were observed during local night hours.

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

IONOSPHERIC DISTURBANCES (MUFs for the Australian region)

27 May 23: Northern region MUFs Depressed by 15%
29 May 23: Northern region MUFs Depressed by 15%

RADIO COMMUNICATIONS WARNINGS

DATE	Nº.	BEGIN	END
01 May 23	41	01 May 23	03 May 23
03 May 23	42	03 May 23	05 May 23
05 May 23	43	06 May 23	08 May 23
09 May 23	44	09 May 23	11 May 23
09 May 23	45	11 May 23	12 May 23
18 May 23	46	18 May 23	20 May 23
19 May 23	47	20 May 23	22 May 23
21 May 23	48	22 May 23	24 May 23
22 May 23	49	23 May 23	25 May 23
25 May 23	50	26 May 23	28 May 23
25 May 23	51	26 May 23	28 May 23
28 May 23	52	29 May 23	31 May 23

Geomagnetic Activity

The strongest regional disturbance for the month was observed on 10-May with a local A index of 20 reached with the ASWAS G1 level reached for one Australian regional (KAus) K-index period. The planetary (Kp) K-index also reached G1 on 10-May. Earlier in the month the planetary Kp index reached G2 on 06-May. Later in the month during 20-21 May the planetary Kp index again reached G2. However, during both these G2 periods the Australian region geomagnetic field remained below G1. The planetary Kp K-index also reached G1 on 6,8 and 9-May. The planetary daily Ap index reached 30 on 06-May, 26 on 10-May, 35 on 20-May, 28 on 21-May. Activity in the Australian region was generally considerably weaker also remaining below G1 on these days.

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

DATE	GEOMAGNETIC DISTURBANCES (for the Australian region)
10 May 23	ASWAS G1

GEOMAGNETIC WARNINGS AND ALERTS

DATE	Nº.	BEGIN	END	ISSUED
05 May 23	22	06 May 23	07 May 23	Warning
06 May 23	23	06 May 23	08 May 23	Warning
06 May 23	24	06 May 23	08 May 23	Warning
08 May 23	25	10 May 23	11 May 23	Warning
09 May 23	26	10 May 23	12 May 23	Warning
10 May 23	27	10 May 23	12 May 23	Warning
10 May 23				Alert
19 May 23	28	20 May 23	20 May 23	Warning
21 May 23	29	22 May 23	22 May 23	Warning
22 May 23	30	23 May 23	24 May 23	Warning
28 May 23	31	28 May 23	28 May 23	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 May	148	5	91	16 May	134	4	101
02 May	157	6	97	17 May	138	1	88
03 May	156	1	96	18 May	151	0	89
04 May	162	2	98	19 May	165	5	88
05 May	162	2	97	20 May	170	16	112
06 May	152	13	111	21 May	163	13	97
07 May	157	9	108	22 May	162	14	102
08 May	172	9	111	23 May	155	7	92
09 May	180	6	114	24 May	164	8	96
10 May	170	20	119	25 May	152	7	91
11 May	163	5	109	26 May	149	4	82
12 May	149	14	107	27 May	157	1	74
13 May	144	7	108	28 May	151	7	87
14 May	140	4	106	29 May	154	1	75
15 May	135	2	104	30 May	162	2	86
				31 May	161	5	93

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
Jun 22	117	5.4	59.8	70.5	81	3
Jul 22	125.8	6	63.9	91.4	84.9	7
Aug 22	118.1	6.9	52.5	75.4	92.2	29
Sep 22	135.1	7.9	74.6	96.3	96.2	13
Oct 22	133.5	7.9	82.1	95.4	99.1	19
Nov 22	123.4	7.3	76.1	77.6	101	6
Dec 22	132.3	8.1	83.5	113.1	104.5	43
Jan 23	182.3	7.1	118.6	143.6	107.1	42
Feb 23	173.5	10.3	115	110.9	109.5	51
Mar 23	157.2	9.3	131.5	122.6	111.9	21
Apr 23	145.8	8.3	119.3	96.4	113.5	9
May 23	156	6.5	97.7	137.9	115.7	60
					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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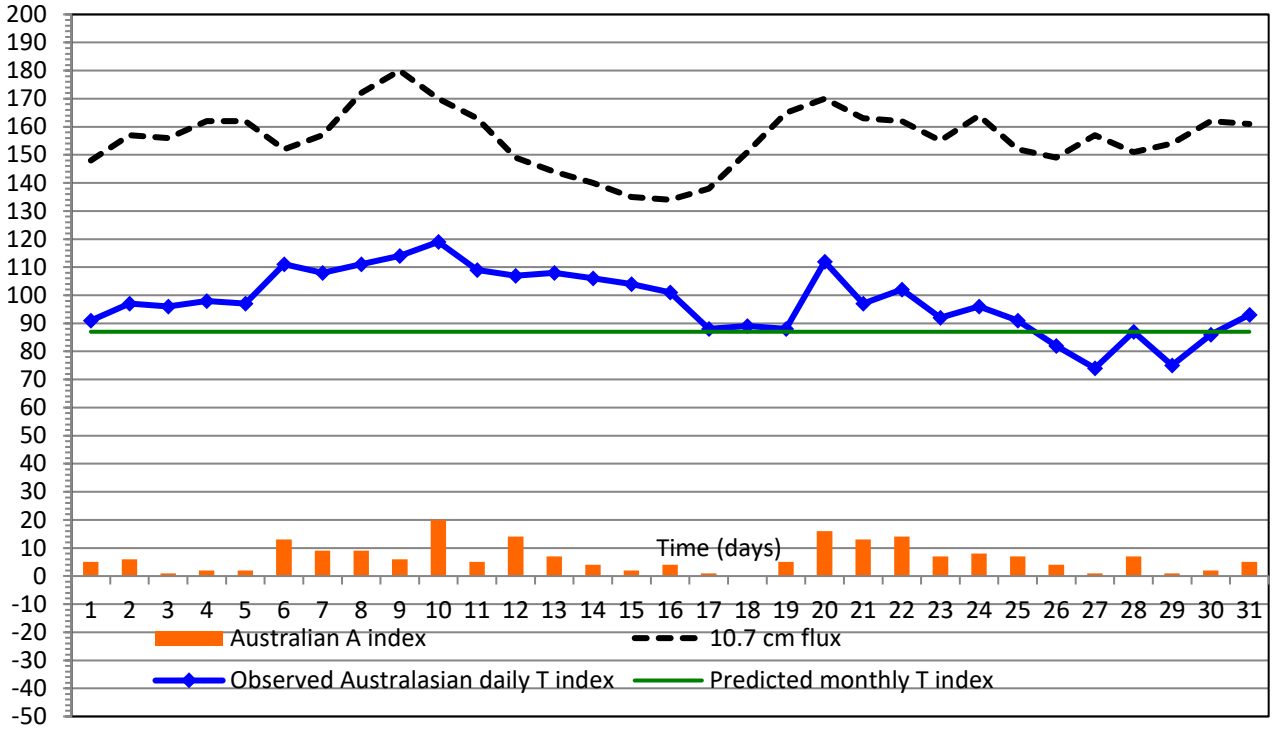
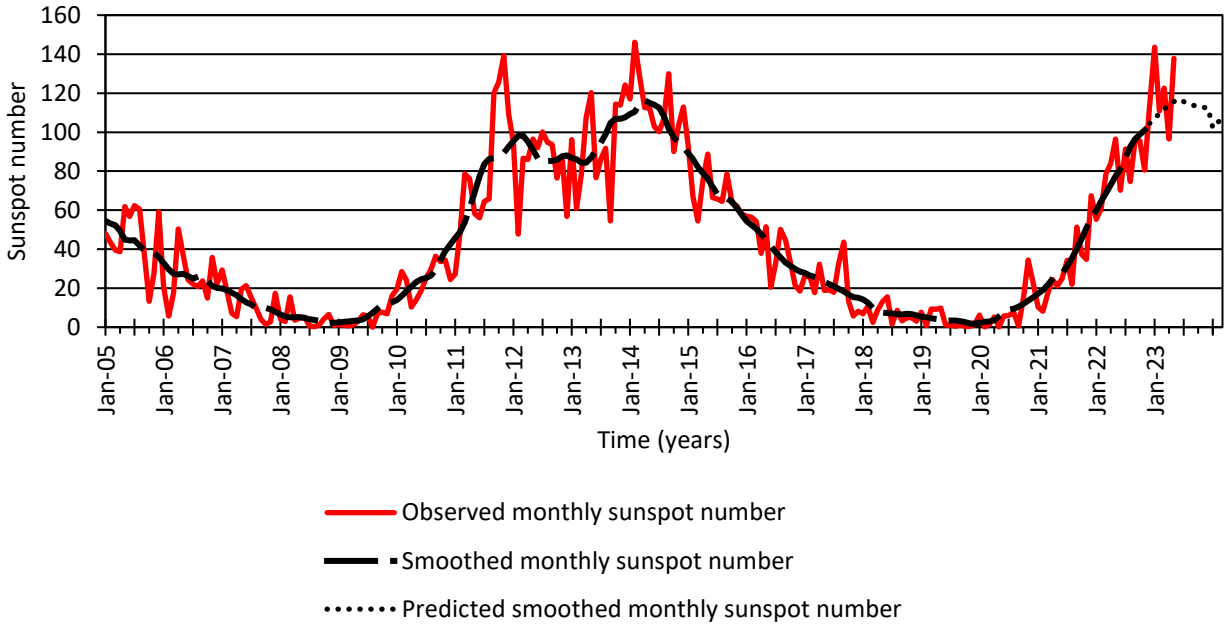
SWS WORLD T-INDICES

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2018	8	2	3	-2	-6	-3	-3	-8	-6	-10	-15	-9
2019	-5	-3	-4	-4	-9	-14	-11	-14	-11	-14	-16	-12
2020	-2	-5	2	-1	-7	-7	-9	-2	-6	-6	7	12
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	87	88	88	85	82	80	80	80
	SWS predicted T-index				* New observed data. T-index value may have changed							

Solar and Geophysical Indices - May 2023



Solar Cycle



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