Australian Government

Bureau of Meteorology

# SPACE WEATHER SERVICES

# SOLAR

# AND

# GEOPHYSICAL

# SUMMARY

September 2017

# Solar Activity

**Increased solar activity was observed early this month, with moderate to high solar activity observed during the interval 04-10 Sep. Solar activity was very low to low on other days of the month.**

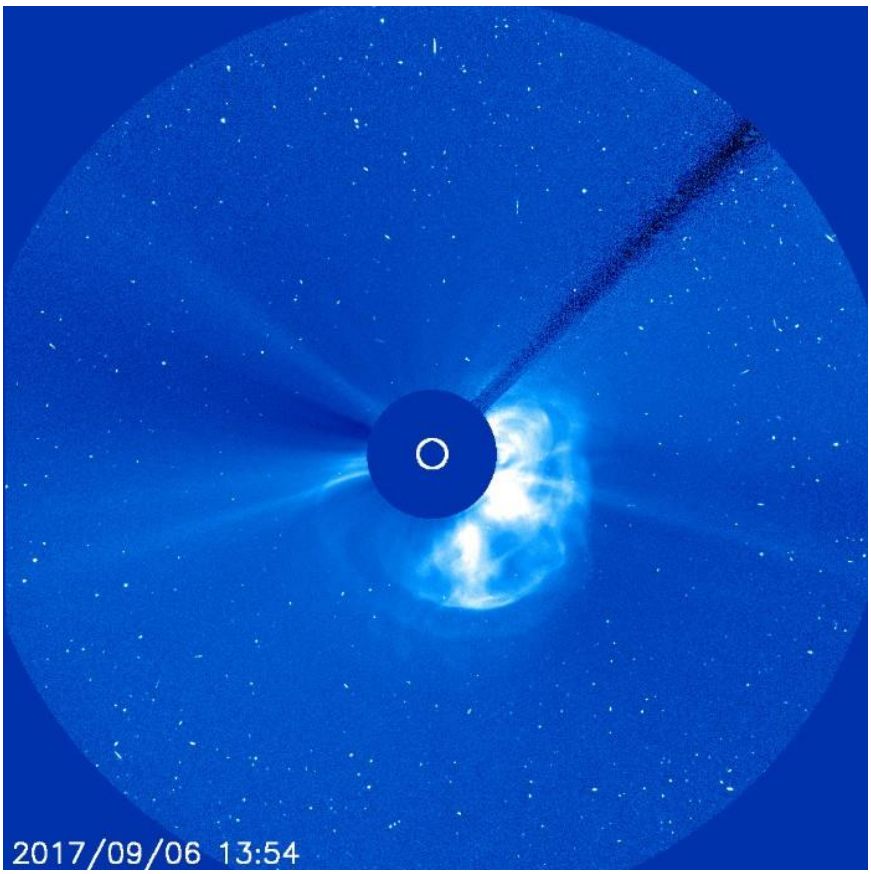
**Solar region 2673 rotated onto the solar disk after 29 August. This region then grew in size and magnetic complexity and produced significant solar flare activity during the interval 04-10 Sep. Most of the flare activity for the month was from region 2673. Significant halo solar coronal mass ejections were observed with some of the larger solar flare events. A total of 31 flare events were observed, 27 M class and 4 X class events. All of the X class events were from solar region 2673.**

**Halo coronal mass ejections were observed with the M5 flare event on 04 Sep, the X9 flare on 06 Sep and the X8 flare event on 10 Sep. The first two of these events, (in particular the second event) were geoeffective. The last event was very near the solar west limb, reducing geoeffectiveness. The X9 flare on 06 Sep was the largest flare for the month.**

**Significant solar proton events were observed in association with these significant solar flares. The solar proton events associated with the M5 and X9 events probably overlapped.**

**The other moderately large solar region of interest, solar region 2674, appeared not to have produced significant flare activity as it transited the solar disk.**

**NASA SOHO/LASCO C3 Image of the 06 Sep asymmetric halo coronal mass ejection (CME)associated with the X9 solar flare.**



M and X class flares for the month are listed below.

| DATE | CLASS M FLARES | CLASS X FLARES | FLARE MAX | FADEOUT POSSIBLE ON DAYLIGHT HF CIRCUIT |
|---|---|---|---|---|
| 04 Sep 17 | M1.2/1F | | 0549UT | |
| 04 Sep 17 | M1.5/1N | | 1530UT | |
| 04 Sep 17 | M1.0 | | 1822UT | |
| 04 Sep 17 | M1.7 | | 1937UT | |
| 04 Sep 17 | M1.5 | | 2002UT | |
| 04 Sep 17 | M5.5/3B | | 2033UT | 2028-2037UT |
| 04 Sep 17 | M2.1 | | 2214UT | |
| 05 Sep 17 | M4.2 | | 0108UT | 0103-0111UT |
| 05 Sep 17 | M1.0 | | 0351UT | |
| 05 Sep 17 | M3.2 | | 0453UT | 0433-0507UT |
| 05 Sep 17 | M3.8 | | 0640UT | 0633-0643UT |
| 05 Sep 17 | M2.3/1N | | 1743UT | |
| 06 Sep 17 | | X2.2/SF | 0910UT | 0857-0917UT |
| 06 Sep 17 | | X9.3/2B | 1202UT | 1153-1210UT |
| 06 Sep 17 | M2.5/3N | | 1556UT | |
| 06 Sep 17 | M1.4 | | 1930UT | |
| 06 Sep 17 | M1.2 | | 2339UT | |
| 07 Sep 17 | M2.4/1F | | 0502UT | |
| 07 Sep 17 | M1.4/1N | | 0954UT | |
| 07 Sep 17 | M7.3 | | 1015UT | 1011-1018UT |
| 07 Sep 17 | | X1.3/2B | 1436UT | 1420-1455UT |
| 07 Sep 17 | M3.9/2B | | 2359UT | 2350-0014UT |
| 08 Sep 17 | M1.3/1F | | 0224UT | |
| 08 Sep 17 | M1.2/SF | | 0343UT | |
| 08 Sep 17 | M8.1/2B | | 0749UT | 0740-0758UT |
| 08 Sep 17 | M2.9/1N | | 1547UT | |
| 08 Sep 17 | M2.1 | | 2345UT | |
| 09 Sep 17 | M1.1/SF | | 0428UT | |
| 09 Sep 17 | M3.7/SF | | 1104UT | 1050-1142UT |
| 09 Sep 17 | M1.1/SF | | 2353UT | |
| 10 Sep 17 | | X8.2 | 1606UT | 1535-1631UT |

| FLARE ALERT | SWF ALERT |
|---|---|
| 04 Sep 17 | |
| 05 Sep 17 | 0107-0119 UT, 0430-0524 UT |
| 06 Sep 17 | |
| 07 Sep 17 | 0500-0511 UT |
| 08 Sep 17 | |
| 09 Sep 17 | |
| 10 Sep 17 | |

PROTON ALERT

| BEGIN DATE | BEGIN TIME | END DATE | END TIME | ENERGY THRESHOLD |
|---|---|---|---|---|
| 05 Sep 2017 | 0020UT | 08 Sep 2017 | 1455UT | 10MeV |
| 08 Sep 2017 | 1645UT | 08 Sep 2017 | 2255UT | 10MeV |
| 10 Sep 2017 | 1615UT | 12 Sep 2017 | 2230UT | 100MeV |
| 10 Sep 2017 | 1635UT | 14 Sep 2017 | 1720UT | 10MeV |

# Ionospheric Activity

The deepest ionospheric depression for the month was observed on 19 Sep following coronal hole high speed wind stream induced geomagnetic activity.

The ionosphere in the Australian region appeared to have an initial strong positive storm response followed by a mild negative response to the significant geomagnetic storm activity from observed from late 07 Sep and on 08 Sep. Enhancements of up to 90% were observed early in the UT day on 08 Sep. However, the quality of HF communications is likely to have been reduced due to the ongoing geomagnetic activity, particularly during local night hours 08 Sep. Maximum usable frequencies (MUFs) then became moderately depressed on 09 Sep, southern region Australia only.

Short wave fadeouts associated with increased solar flare activity were observed on 05 Sep and 07 Sep in the Australian region.

Depressed maximum usable frequencies (MUFs) and degraded HF communications conditions may have been experienced during the interval 17-22 Sep (in particular on 19 Sep). The cause of this period of lower than normal MUFs may possibly be associated with the earlier moderately increased geomagnetic activity during the interval 14-16 Sep.

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

## IONOSPHERIC DISTURBANCES (MUFs for the Australian Region)

| | |
|---|---|
| 01 Sep 17 | Southern region MUFs Depressed by 20% |
| 02 Sep 17 | Northern region MUFs Depressed by 15% |
| 09 Sep 17 | Southern region MUFs Depressed by 25% |
| 12 Sep 17 | Northern region MUFs Depressed by 15% |
| 15 Sep 17 | Southern region MUFs Depressed by 15% |
| 19 Sep 17 | Northern region MUFs Depressed by 20% |
| | Southern region MUFs Depressed by 25% |
| 20 Sep 17 | Northern region MUFs Depressed by 15% |
| | Southern region MUFs Depressed by 15% |
| 21 Sep 17 | Northern region MUFs Depressed by 20% |
| | Southern region MUFs Depressed by 15% |
| 22 Sep 17 | Northern region MUFs Depressed by 15% |
| 28 Sep 17 | Southern region MUFs Depressed by 15% |
| 29 Sep 17 | Southern region MUFs Depressed by 15% |

## RADIO COMMUNICATIONS WARNINGS

| DATE | N°. | BEGIN | END |
|---|---|---|---|
| 03 Sep 17 | 35 | 04 Sep 17 | 04 Sep 17 |
| 05 Sep 17 | 36 | 05 Sep 17 | 06 Sep 17 |
| 06 Sep 17 | 37 | 07 Sep 17 | 08 Sep 17 |
| 07 Sep 17 | 38 | 07 Sep 17 | 09 Sep 17 |
| 07 Sep 17 | 39 | 08 Sep 17 | 10 Sep 17 |
| 11 Sep 17 | 40 | 11 Sep 17 | 11 Sep 17 |
| 27 Sep 17 | 41 | 27 Sep 17 | 27 Sep 17 |
| 28 Sep 17 | 42 | 28 Sep 17 | 29 Sep 17 |

# Geomagnetic Activity

Late on 06 Sep a coronal mass ejection arrived believed to be associated with the M5 solar flare/coronal mass ejection. However, the geoeffectiveness of the event was reduced as the north-south component (Bz) of the interplanetary solar wind magnetic field (IMF) was predominately northward post solar wind shock arrival. This orientation of the IMF is associated with reduced geomagnetic storm activity.

On 07 Sep a second coronal mass ejection solar wind shock arrived, and this time the Bz orientation was strongly southward for several hours following the solar wind shock arrival. Strongly southward orientation of the IMF is associated with increased geomagnetic storm activity. The subsequent geomagnetic storm reached major storm levels on 08 Sep. This was the most significant geomagnetic disturbance for the month, with the local geomagnetic A index reaching 35. Note that this storm appeared to be stronger in the northern hemisphere. Auroral australis displays were observed in association with this event.

Isolated minor storm periods were observed 12-16 Sep, during local night hours, possibly in association with a glancing blow from a coronal mass ejection and coronal hole high speed wind stream induced activity. Also, active to minor storm periods were observed later in the month, during the interval 27-30 Sep, possibly in association with coronal hole high speed wind streams.

| DATE | GEOMAGNETIC DISTURBANCES (for the Australian region) |
|---|---|
| 07 Sep 17 | Quiet to Major Storm |
| 08 Sep 17 | Unsettled to Major Storm |
| 14 Sep 17 | Quiet to Minor Storm |
| 15 Sep 17 | Unsettled to Minor Storm |
| 16 Sep 17 | Quiet to Active |
| 27 Sep 17 | Quiet to Active |
| 28 Sep 17 | Quiet to Minor Storm |

GEOMAGNETIC WARNINGS AND ALERTS

| DATE | N$^{o}$. | BEGIN | END | ISSUED |
|---|---|---|---|---|
| 06 Sep 17 | 42 | 06 Sep 17 | 08 Sep 17 | Warning |
| 07 Sep 17 | 43 | 08 Sep 17 | 09 Sep 17 | Warning |
| 07 Sep 17 | | | | Alert |
| 08 Sep 17 | 44 | 08 Sep 17 | 10 Sep 17 | Warning |
| 08 Sep 17 | | | | Alert |
| 12 Sep 17 | 45 | 12 Sep 17 | 14 Sep 17 | Warning |
| 14 Sep 17 | | | | Alert |
| 15 Sep 17 | 46 | 15 Sep 17 | 16 Sep 17 | Warning |
| 15 Sep 17 | | | | Alert |
| 22 Sep 17 | 47 | 23 Sep 17 | 25 Sep 17 | Warning |
| 26 Sep 17 | 48 | 27 Sep 17 | 29 Sep 17 | Warning |
| 28 Sep 17 | | | | Alert |

# Solar And Geophysical Indices

| DATE | 10cm FLUX | AUSTRALIAN A-INDEX | AUSTRALIAN T-INDEX | DATE | 10 cm FLUX | AUSTRALIAN A-INDEX | AUSTRALIAN T-INDEX |
|---|---|---|---|---|---|---|---|
| 1-Sep | 93 | 12 | 12 | 16-Sep | 72 | 16 | 12 |
| 2-Sep | 100 | 13 | 20 | 17-Sep | 72 | 10 | 6 |
| 3-Sep | 120 | 5 | 23 | 18-Sep | 72 | 12 | 6 |
| 4-Sep | 140 | 8 | 29 | 19-Sep | 71 | 5 | -2 |
| 5-Sep | 121 | 7 | 35 | 20-Sep | 74 | 7 | 3 |
| 6-Sep | 133 | 6 | 31 | 21-Sep | 73 | 4 | 4 |
| 7-Sep | 129 | 21 | 44 | 22-Sep | 78 | 2 | 7 |
| 8-Sep | 117 | 35 | 47 | 23-Sep | 81 | 2 | 15 |
| 9-Sep | 107 | 2 | 16 | 24-Sep | 87 | 5 | 21 |
| 10-Sep | 100 | 3 | 14 | 25-Sep | 90 | 3 | 22 |
| 11-Sep | 80 | 10 | 33 | 26-Sep | 91 | 3 | 25 |
| 12-Sep | 76 | 10 | 17 | 27-Sep | 91 | 17 | 32 |
| 13-Sep | 75 | 12 | 27 | 28-Sep | 91 | 24 | 21 |
| 14-Sep | 74 | 16 | 16 | 29-Sep | 90 | 8 | 16 |
| 15-Sep | 73 | 22 | 17 | 30-Sep | 89 | 11 | 17 |

| DATE | 10cm FLUX | AUSTRALIAN A-INDEX | AUSTRALIAN T-INDEX | SUNSPOT NUMBER | | FLARES |
|---|---|---|---|---|---|---|
| | Monthly Average | Monthly Average | Monthly Average | Monthly Average | Yearly Average | >M1.0 |
| Oct-16 | 86.1 | 9.1 | 9.9 | 33.6 | 31.4 | 0 |
| Nov-17 | 78.7 | 6.4 | 3.8 | 21.4 | 29.9 | 2 |
| Dec-17 | 75.2 | 7.3 | 2.5 | 19.5 | 28.5 | 0 |
| Jan-17 | 77.6 | 6.7 | 0.5 | 25.8 | 27.9 | 0 |
| Feb-17 | 76.9 | 6.3 | 10 | 26.1 | 26.6 | 0 |
| Mar-17 | 74.7 | 8.4 | 11.1 | 17.7 | 25.8 | 0 |
| Apr-17 | 81 | 7.3 | 14.4 | 32.6 | 25.3p | 7 |
| May-17 | 73.6 | 5 | 9.9 | 18.8 | 24.7p | 0 |
| Jun-17 | 74.8 | 3.4 | 9.2 | 19.4 | 24.7p | 0 |
| Jul-17 | 78 | 5.8 | 10.5 | 18.3 | 24.5p | 3 |
| Aug-17 | 78 | 7.3 | 10.4 | 33.1 | 23.9p | 1 |
| Sep-17 | 93.4 | 10.4 | 19.5 | 43.6 | 23.5p | 31 |
| | | | | | Predicted Sunspot Numbers | |

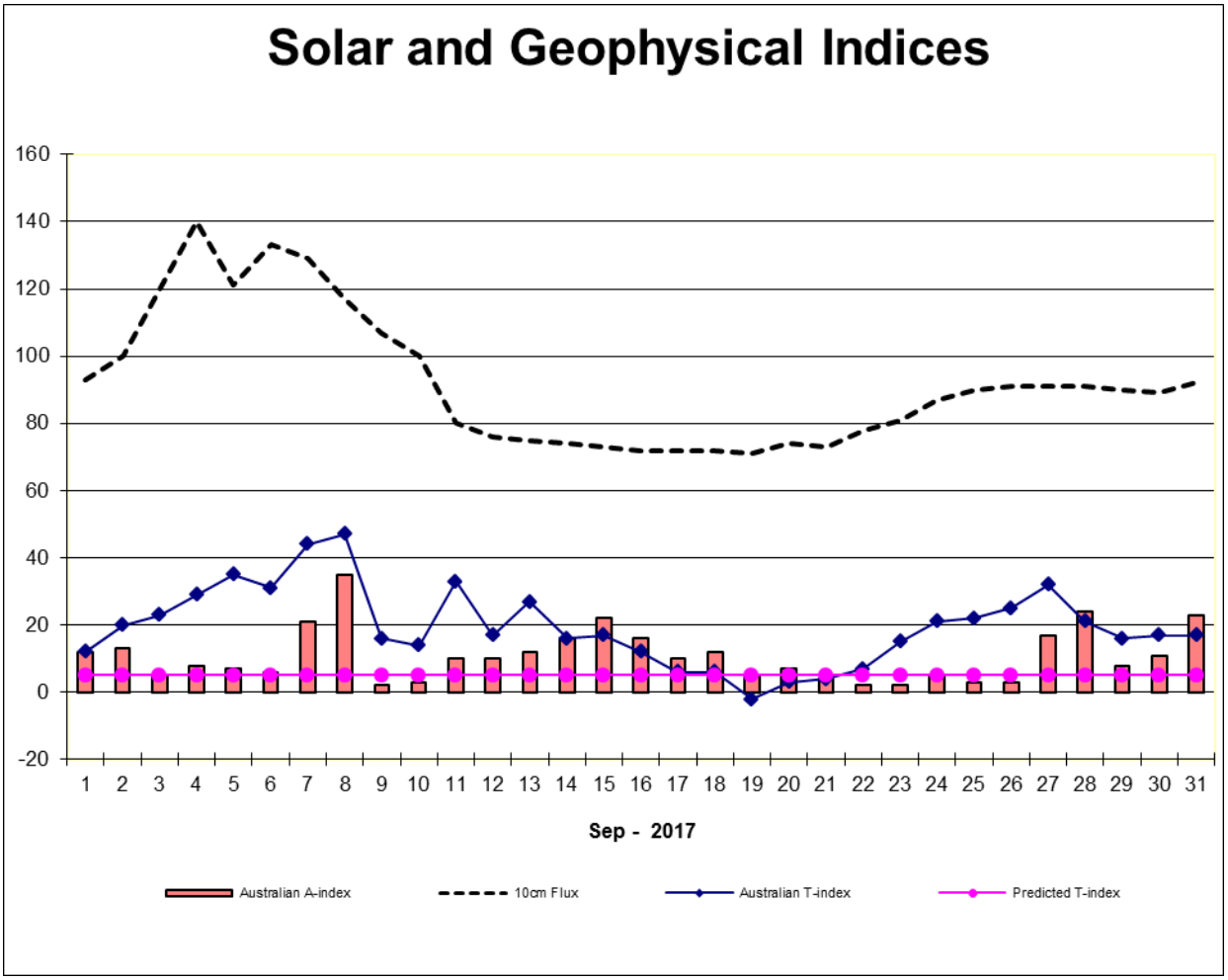
SPECIAL NOTE
In June 2015, WDC-SILSO, Royal Observatory of Belgium, Brussels, adjusted their original observed sunspot numbers (Version 1.0) to a Version 2.0 series in which the sunspot numbers are higher. In the Version 1.0 data series, some of the sunspot numbers were weighted. The new (Version 2.0) 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.

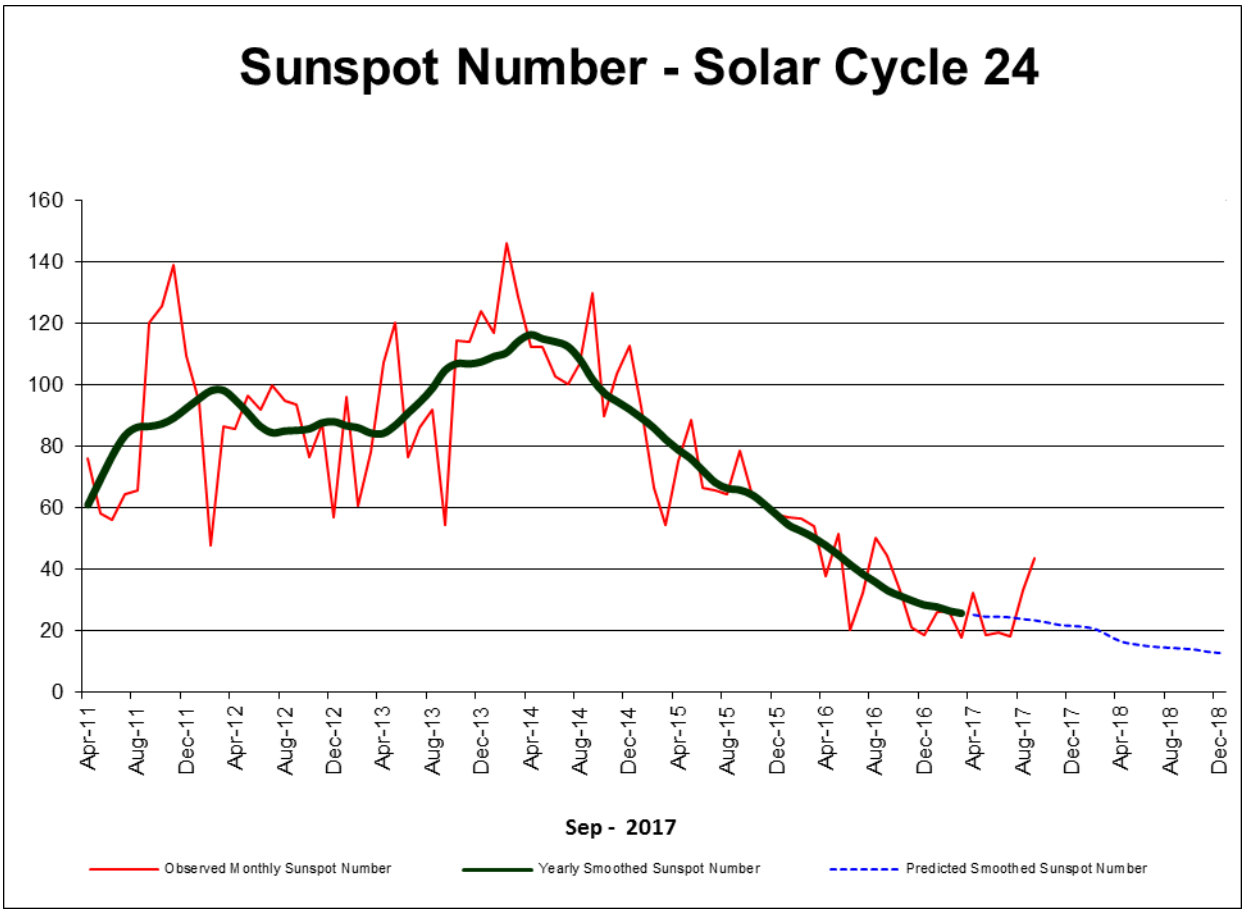
**SWS WORLD T-INDICES**

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2012 | 81 | 65 | 64 | 69 | 77 | 74 | 70 | 80 | 86 | 75 | 65 | 65 |
| 2013 | 74 | 62 | 69 | 84 | 92 | 82 | 81 | 76 | 68 | 76 | 86 | 90 |
| 2014 | 91 | 108 | 130 | 114 | 96 | 84 | 86 | 81 | 90 | 94 | 98 | 103 |
| 2015 | 92 | 101 | 91 | 97 | 85 | 79 | 71 | 48 | 40 | 43 | 53 | 50 |
| 2016 | 52 | 57 | 46 | 30 | 34 | 28 | 26 | 25 | 28 | 17 | 12 | 10 |
| 2017 | 14 | 19 | 11 | 8 | 2 | 2 | 0 | 3 | 16* | 5^ | 4 | 4 |
| 2018 | 4 | 4 | 3 | 2 | 1 | 0 | 0 | -1 | -1 | -2 | -2 | -3 |
| 2019 | -3 | -4 | -4 | -5 | -5 | -5 | -5 | -4 | -4 | -3 | -3 | -2 |
| 2020 | -1 | 0 | 1 | 3 | 5 | 7 | 9 | 11 | 14 | 17 | 20 | 23 |
| 2021 | 26 | 28 | 32 | 35 | 38 | 40 | 42 | 44 | 46 | 49 | 50 | 51 |

SWS Predicted T-Indices

* T-Indices may have changed




Observed monthly sunspot numbers courtesy of WDC-SILSO, Royal Observatory of Belgium, Brussels

# 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 T-index is a measure of the average level 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 IPS Monthly T-index for ASAPS is derived from the observed monthly median values of foF2 for each hour at up to 40 ionospheric stations worldwide. These records become available from IPS stations in Australia very soon after each month, but the majority are received up to one year later. This means that the exact observed value of the monthly T-index is not available until some months later.

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 IPS T-indices for ASAPS may not be updated each month but only when sufficient new data becomes available.

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