
Space Weather Technical Forecast

Issued on Monday, 26 June 2023 at 01:29 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales <https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales>

Space Weather Forecast Headline: Isolated R1/R2 Radio Blackouts likely. Slight chance of G1/Minor Geomagnetic Storm conditions on day 2 (27 Jun).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Low with a peak C8.5 flare from AR3341 at 24/1218 UTC. This region contains a large H-spot, with a number of very small spots or pores at a distance from the main spot. The most notable and largest region is AR3340 in the northwest, which has seen notable growth, with continued strengthening umbra in the trailer, and an overall growth and intensity in magnetic looping seen on SDO imagery. A large asymmetric penumbra has formed in the trailer along with a weak delta spot and harbours the potential for more significant flaring than has recently been observed from the region. AR3337 in the far northwest remains a very small region, but with a magnetic alignment that is conducive to instability due to an east-west orientated neutral line. The region was responsible for a C6.8 flare at 25/2208 UTC. To the south, a minor flare from AR3338 around 25/2030 UTC appears to have resulted in a CME, although we await more imagery to confirm this, although it is not expected to be Earth-directed. Another minor flare around 25/2145 UTC from AR3346, also in the northwest, resulted in more notable coronal dimming in SDO AIA-211 imagery. It is likely that a CME has resulted from this, with greater chance of being Earth-directed, although again, no imagery is yet available to corroborate this. This is also some coronal dimming seen from Ex-3349 in the northeast around 25/1700 UTC, however, no clear CME signature was seen in coronagraph imagery in the hours following the event.

Solar Wind / Geomagnetic Activity: The solar wind as measured by DSCOVR at L1, showed the continued signature of a CME arrival, likely a glance from the CME from the X1.1 flare on 20 Jun. Speeds were observed at slightly elevated to elevated levels, between 480-550km/s. Density was initially above average, with a peak of 20 ppcc, but has gradually lowered to become average to below average. The total IMF strength, Bt, was largely Moderate with a peak of 12nT at 25/1221 UTC, but became Weak late in the UTC day on 25 Jun. The north-south component Bz was initially negative (southward) with a peak of -9nT, although a rotation to northward (positive) values followed around 25/0100 UTC with maximum observed 7nT. A further period of mainly Moderate negative values was seen between 25/1300-1700 UTC, varying weakly since then. Geomagnetic activity was at G1/Minor Storm levels from 25/0000-0300 UTC, reducing to Quiet to Unsettled (Kp1-3) through the rest of the period.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV), as observed by GOES16, was at Background. High energy electron flux (greater than 2MeV), as observed by GOES16 was at Background to Moderate levels with a peak value of 399pfu at 24/1640 UTC. The associated 24-hour fluence showed a steady then largely declining trend through the day, reaching 1.22e7 integrated pfu at 26/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to be Low to Moderate, with isolated M-class flares likely and just a very slight chance of activity reaching Strong levels.

Solar Wind / Geomagnetic Activity: There is a CME that may glance Earth very late on day 1

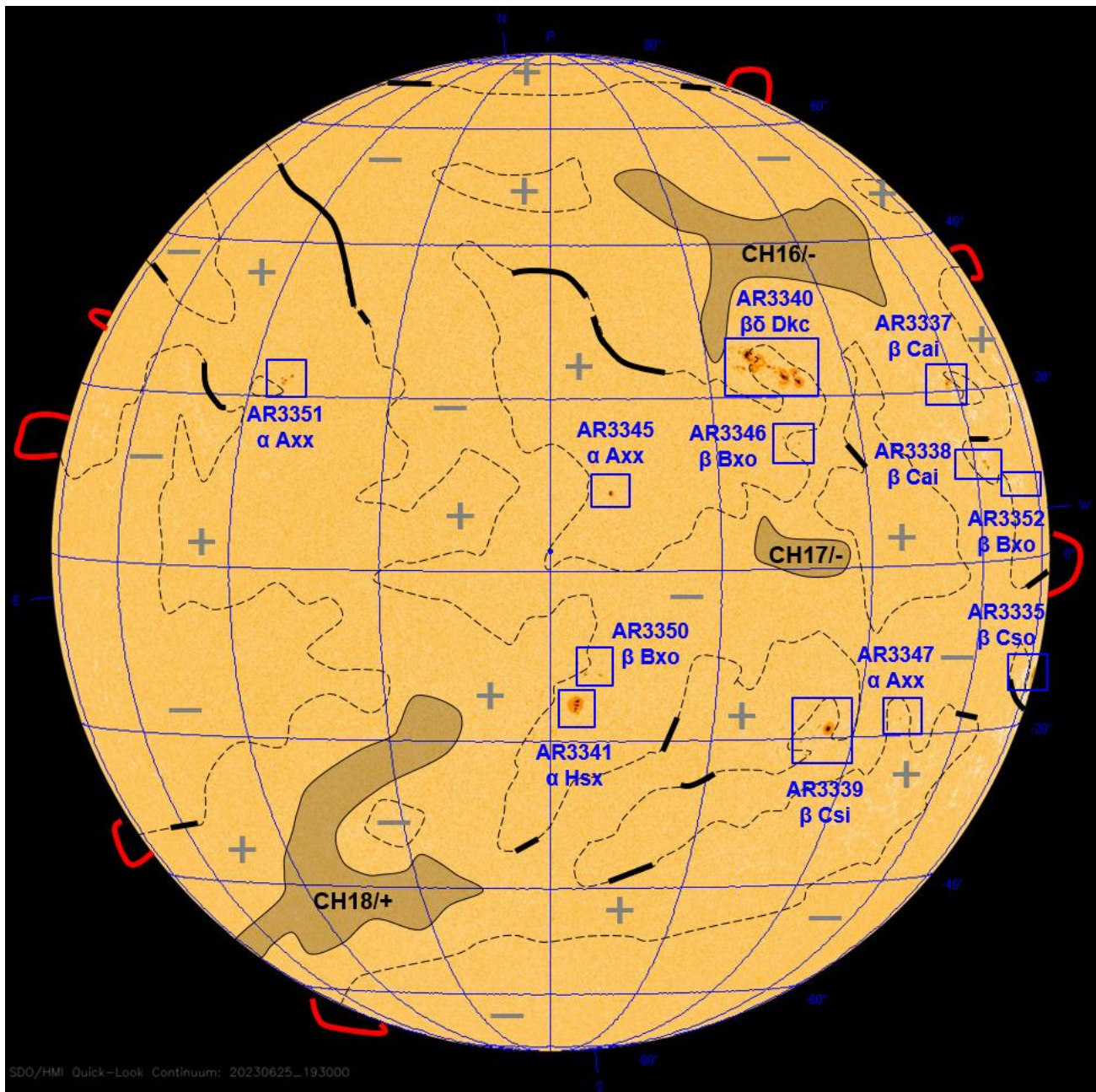
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(26 Jun) or more likely on day 2 (27 Jun), from the M4.8 flare and associated filament eruption from AR3341 on 22 Jun. It is possible that further Earth-directed CMEs may have left the sun late on 25 Jun, however, further coronagraph imagery is required to confirm this. Currently slightly elevated to elevated solar winds are expected to ease to persistently slightly elevated levels. Further coronal hole sourced enhancements are then possible from day 2 (27 Jun) onward however these are low confidence.

Geomagnetic activity is expected to be mainly Quiet to Unsettled before activity potentially increases to Unsettled to Active, with a slight chance of G1 Minor Storms. This is most likely on day 2 (27 Jun) with any slight coronal hole enhancement between days 2 to 4 (27-29 Jun) or potential CME arrivals between days 1 and 4 (26-29 Jun).

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at Background levels with a very slight chance of rising if any notable flare activity occurs, primarily from AR3340. High energy electron flux (greater than 2MeV) is expected to see current Background to Moderate levels continue. The corresponding 24-hour integrated fluence expected to remain under the Active threshold throughout.

Figure 1. Solar Analysis Valid 25/1930 UTC.



Key: Filament ___, Prominence ___, Magnetic Field Line - - -, Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α - β - $\beta\gamma$ - $\beta\gamma\delta$ and Zurich-McIntosh Axx etc.

Geomagnetic Storms:

There is at least one potentially glancing CME in the forecast, albeit with low confidence. This was produced by the M4.8 flare from AR3341 in the southeast disc on 22/2344 UTC and the associated filament eruption. The majority of the CME is missing behind and below Earth, likely reaching 1AU early on day 2 (27 Jun) however a glancing interaction is likely as this passes. A coronal dimming associated with a flare from AR3346 in the northwest around 25/2145 UTC may have produced an Earth-directed CME, however, further coronagraph imagery is required to corroborate this. A minor flare from AR3338 in the far northwest around 25/2030 UTC appears to have resulted in a CME, although, again we await more imagery to confirm this, however it is unlikely to be Earth-directed. This is also some coronal dimming seen from Ex-3349 in the northeast around 25/1700 UTC, however, no clear CME signature was observed in coronagraph imagery in the hours following the event.

Solar winds are currently slightly elevated to elevated at 480-510km/s due to the ongoing influence of the CME arrival late on 24 Jun. These winds are expected to ease, likely falling to around 400km/s day 1 (26 Jun). The forecast is then low confidence due to uncertain coronal hole and CME analysis. Considering the former, this is due to sunspots in the northwest disc obscuring the view of CH16/-, and also the presence of a very small equatorial coronal hole, CH17/- in the western hemisphere. Enlil suggests that Earth either doesn't encounter the HSS of either region, or that any enhancement is very limited. This is also supported by 27-day persistence. However, given the location of these holes, a potential connection is possible on day 2 (27 Jun) alongside any CME arrival (most likely day 2, but perhaps late on day 1). The potential CMEs mentioned late in the UTC day on 25 Jun are awaiting further coronagraph imagery to determine if any are Earth-directed.

Geomagnetic activity is expected to be mainly Quiet to Unsettled before activity potentially increases to Unsettled to Active, with a slight chance of G1 Minor Storms. This is most likely on day 2 (27 Jun) with any slight coronal hole enhancement between days 2 to 4 (27-29 Jun) or potential CME arrivals between days 1 and 4 (26-29 Jun).

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	5	10	5	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
23/0714	Partial	M4.8 flare and filament	SE	493 km/s	27/0000 +/- 12 hours	Low confidence. Glancing impact.

Radio Blackouts - X-Ray Flares:

There are twelve sunspot regions on the disc with isolated M-flares likely, resulting in Low to Moderate Activity. There is a very slight chance that activity could increase to become Strong during the period.

The main region of interest is AR3340 in the northwest, with continued flux emergence and penumbra development. There are some signs of increased complexity with the looping observed in SDO AIA imagery. A large asymmetric penumbra has formed in the trailer along with a weak delta spot. The region has been the source of a number of C-class flares, and is the most likely source of further significant flare activity.

The majority of the other sunspots are smaller, simpler and stable, with a couple of exceptions. AR3337 in the far northwest has produced several C-class flares and a marginal M-flare in recent days. This remains a small and indistinct region, however its east-west aligned magnetic neutral line is typical of unstable regions with an ongoing chance of similar small flares. The area appears to be magnetically connected to AR3338 to the south.

AR3341 near the Earth-Sun line in the southern hemisphere was responsible for the largest flare in the past 24-hours with a peak C8.5 flare. This region contains a large H-spot, with a number of very small spots or pores at a distance from the main spot.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	60	60	60	60
Very Active	R3 to R5 X Class	No	10	10	10	10

Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux, as observed by GOES16, is at Background levels and expected to remain so throughout the period. This is despite the number of sunspots in the western disc, as they remain small and relatively simple and unlikely to produce significant flares. The possible exception is developing AR3340, which currently provides the main risk of producing any proton events.

Radiation Storms	Level (cm ⁻² sr ⁻¹ s ⁻¹)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ S1	No	5	5	5	5
Very Active	≥ S3 *	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = cm⁻²sr⁻¹s⁻¹)

High Energy Electrons Event (≥ 2MeV):

High energy (greater than 2MeV) electron flux is expected to follow its recent trend Background to Moderate, This perhaps rising a little day 1 (Jun 26) as solar winds ease after the recent CME arrival, with a slight chance of briefly reaching High at diurnal max. A further suppression of observed flux is then likely day 2 and into day 3, (Jun 27-28) from any glancing CME or weak HSS arrival, before perhaps rising again towards the end of the period although this is very low confidence by this stage.

The associated fluence is expected to remain below the Active level at least until day 3 (27 Jun), This is supported by REFM, which gives a good indication of expected fluence in the absence of any further solar wind enhancements and CME arrivals.

GEO Electron Environment	Level (cm ⁻² sr ⁻¹ day ⁻¹)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ 1x10 ⁸	No	1	1	5	5
Very Active	≥ 2 MeV ≥ 1x10 ⁹	No	1	1	1	1



Figure 3: GOES-16 Electron Flux and associated fluence with REFM

