

---

**Space Weather Technical Forecast**

Issued on Saturday, 24 June 2023 at 13:01 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: Chance of R1/R2 Radio Blackouts throughout. Slight Chance of G1 Geomagnetic Storm to start and especially to end the four days.**

**Analysis of Space Weather Activity over past 24 hours**

**Solar Activity:** Solar activity has been Low in the last 24 hours, with only minor C-class flares observed.

There are currently fourteen sunspot regions on the visible disc. The most active, AR3341 (Beta/Cso), still appears relative simple magnetically, but occupies a large plage area that may harbour some complexity. The largest group remains AR3340 in the north-centre-disc, with a Dsi/Beta configuration and a spreading tendency visible. There was some reconfiguration within AR3345, AR3340 and AR3335, with no significant areal change. The remaining spots showed little change. Three newly numbered sunspots emerged during this period, with AR3346 (Beta/Cro) re-emerging quite rapidly just south of AR3340. AR3352 and AR3353 were also numbered, although these are relatively small and appear to be stable.

The filament mentioned immediately to the east of AR3341 in recent guidance lifted off with the sunspot region's M4.8 flare of 22/2344UTC. In part because of SOHO manoeuvres rendering C2 difference imagery less useful, and also because the bulk of the ejecta heading southeast of the Sun-Earth is hidden by the mirror mount for Lasco C3, analysis has proven difficult. Having said this, a reasonable match for modelling was obtained to the estimated Type II speed of 534km/s. A Type IV radio burst was also observed with the flare.

This has been modelled using limited imagery but shows as a possible glancing blow around the turn of the UTC day late 26 June, (or more likely) into early 27 June.

**Solar Wind / Geomagnetic Activity:** The solar wind, as measured by DSCOVR and ACE at L1, showed a declining but then a resurgent connection to a negative polarity coronal hole high speed stream. The precise source remains uncertain, but is either the diffuse tail of CH15/-, or the more pole-ward CH13/-. The phi angle was accordingly mainly negative (towards the Sun). Solar wind speeds started the period, at background levels, around 380km/s, with a rising trend into slightly elevated levels, between 400 and 450km/s. The solar wind density has been within typical background levels in single figures ppcc, but with a slight fall observed as the speed rose. The IMF initially followed a steady trend near 6nT before increasing to 11nT, with the north-south component erratic between +/-9nT. The net result of the above solar wind measures was for mostly Quiet to Unsettled geomagnetic activity (Kp2-3).

**Energetic Particles / Solar Radiation:** High energy proton flux (greater than 10MeV), as observed by GOES16, was at Background levels.

High energy electron flux (greater than 2MeV), as observed by GOES16 ranged between Normal Background and High levels, with a peak value of 1450pfu at 23/1730UTC. The associated 24-hour fluence showed a slightly declining trend through the day, reaching 3.05e7

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: [moswoc@metoffice.gov.uk](mailto:moswoc@metoffice.gov.uk)

integrated pfu at 24/0001UTC.

#### **Four-Day Space Weather Forecast Summary**

**Solar Activity:** Solar activity carries a Chance of returning to Moderate, with isolated M-class flares most likely from AR3341, as in recent days.

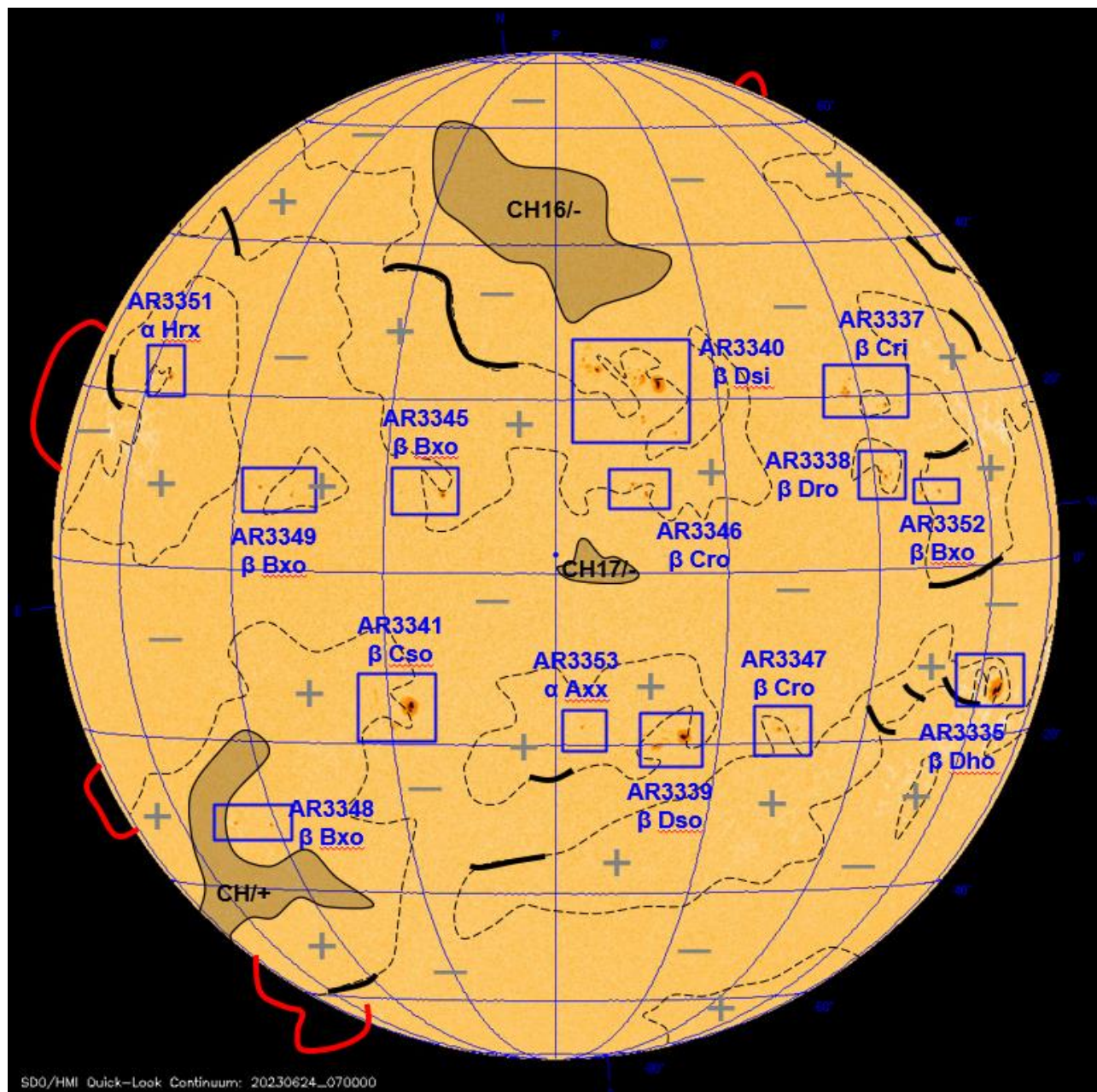
**Solar Wind / Geomagnetic Activity:** Both the CME and fast wind parts of the forecast are relatively intertwined in the coming days.

A glance from the 20 June CME may combine with an expected slightly enhanced solar wind currently observed at STEREO A, around half a day upstream of Earth in the Parker Spiral. These may give a Slight Chance of G1/minor storm on day 1 (24 June). Activity should be more reliably Quiet later in the UTC weekend and at first into the new working week, however the 22 June M4.8 filament CME may also glance Earth late on day 3 (26 June) or more likely into early day 4 (27 June) to give a second Slight Chance of G1/minor storm, with this too perhaps riding on an enhancement from either CH16 or CH17's CIR.

**Energetic Particles / Solar Radiation:** The high energy (greater than 10 MeV) proton flux is expected to remain at Background levels, with a slowly increasing daily Slight Chance of S1 or greater.

High energy electron flux (greater than 2MeV) is likely to remain near currently observed levels in the period. The corresponding 24-hour integrated fluence to most likely remain under the Active threshold.

Figure 1. Solar Analysis Valid 24/0700 UTC.



**Key:** Filament \_\_\_\_, Prominence \_\_\_\_, Magnetic Field Line - - -, Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-γ-δ and Zurich-McIntosh Axx etc.

**Geomagnetic Storms:**

Both the CME and fast wind parts of the forecast are relatively intertwined in the coming days, and are treated as one entity below.

It is possible that CMEs emitted east of the Sun-Earth line earlier this week (20 June) may bring a glancing blow within day 1 (24 June), as shown by a minority of MOSWOC Enlil ensemble members. This not the favoured forecast, and the deterministic unperturbed run is preferred. Having said this, STEREO A MAG and PLASTIC measurements have shown a recent enhancement within a negative phi angle sector, perhaps a transition between negative coronal holes, although this is conjectural. CH15/- ought to have passed given its position on the west limb, and CH13 was assumed to have taken over, but a late arrival of the latter may be the cause of STEREO's enhancement. Whatever the cause, The IMF may increase in the coming hours, perhaps prolonging the Slight Chance of G1/minor storm still further into the UTC weekend when considered with any 20 June CME, although the magnitude of solar wind speed should not appreciably increase from current Slightly Elevated levels.

In addition to the above, there is now a second glancing incidence CME in the forecast - that emitted from the southeast-directed filament tied to the 22/2344UTC M4.8 from AR3341. This also shows as a glancing blow, but with significantly more MOSWOC Enlil ensemble members favouring its arrival (compared to the 20 June CME). This 22 June CME is expected to pass 1AU around the turn of the UTC day late 26 June (or more likely) into early 27 June. This gives a Slight Chance of G1 partitioned between the two days, with a bias towards the latter.

This 22 June CME may arrive in conjunction with a minor CIR leading either CH16 or 17 to bolster its effects. CH17 is a small negative coronal hole currently near the solar meridian on the solar equator, while CH16/- lies at the same solar longitude and may alternatively impart some influence. Neither is expected to be particularly impactful on their own given our proximity to the solstice, and in the absence of any CME there is perhaps a Chance of Active intervals at peak.

The fact that the Type II signature was marginally faster than the speed obtained from CME fitting (534 Type II versus 493km/s fitted) implies that the CME may have slightly more of an Earth-directed component than the deterministic run suggests, hence the slight tendency to favour the minority of members with more direct incidence.

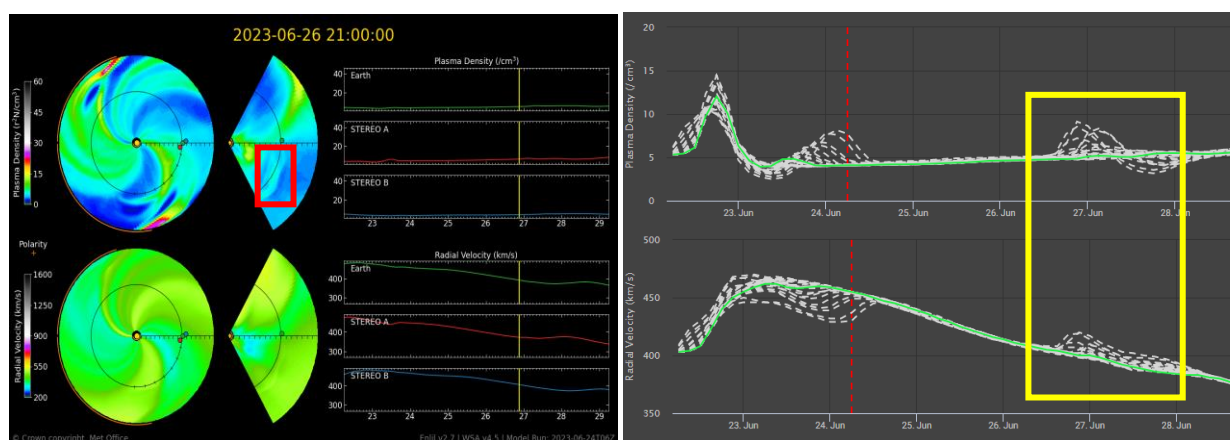
| Geo-Magnetic Storm          | Level    | Past 24 Hours<br>(Yes/No) | Day 1<br>(00-24 UTC) | Day 2<br>(00-24 UTC) | Day 3<br>(00-24 UTC) | Day 4<br>(00-24 UTC) |
|-----------------------------|----------|---------------------------|----------------------|----------------------|----------------------|----------------------|
| Probability<br>(Exceedance) |          |                           | (%)                  | (%)                  | (%)                  | (%)                  |
| Minor or Moderate           | G1 to G2 | No                        | 10                   | 1                    | 10                   | 20                   |
| 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<br>21.5R (UTC) | Halo: Full or<br>Partial | Source  | Source<br>Location | Estimated<br>Speed | Estimated<br>Arrival Time                  | Comments  |
|--------------------------|--------------------------|---|--------------------|--------------------|--|---|
| 23/0714UTC               | Partial                  | Filament<br>Eruption<br>triggered by<br>M4.8 flare<br>from AR3341 | SE quadrant        | 476km/s            | Turn of UTC<br>day 26 June<br>into 27 June | Glance from<br>significant<br>minority of<br>MOSWOC<br>Enlil<br>members |

**Figure 2: MOSWOC Enlil (left) and ensemble (right) – shows the 22 June M4.8 filament CME. This may give a glancing blow at Earth either late on the 26 June or (more likely) 27 June. This event mostly supported by the significant number of ensemble members (yellow box) rather than the deterministic model (red box).**



## Radio Blackouts - X-Ray Flares:

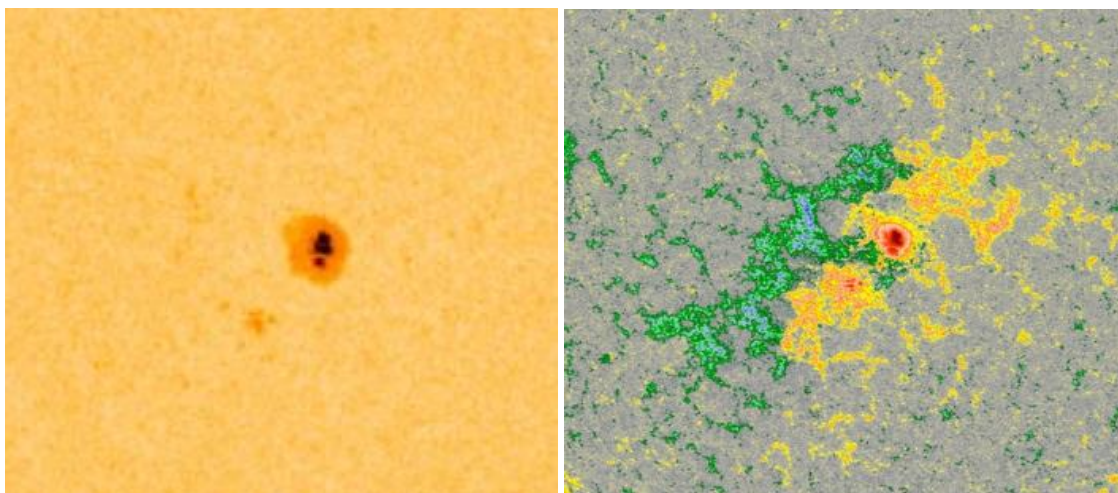
There are now fourteen numbered sunspot regions on the disc. The Penticton 10.7cm flux has fallen for the fourth day in succession to reach 170sfu, down from a high of 180 on 20 June when AR3341 produced its X1.1 flare.

Far-side soundings and STEREO A EUVI195 imagery both suggest that there is nothing imminent due over the eastern solar horizon from an Earth perspective, while only one of the fourteen current Earth-facing regions (AR3335) is due to depart. On balance then, because of recent trends in current spots and the expected net loss of sunspot regions, there is a daily Chance of M-class flares that should reduce into the new working week, barring any new developments.

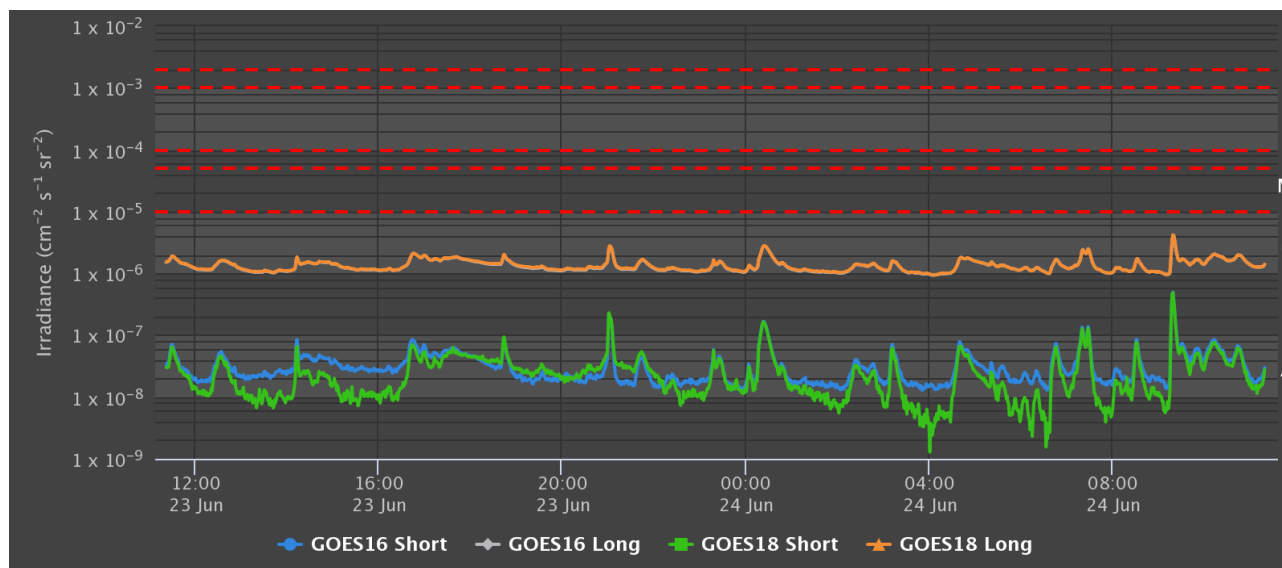
Despite its appearance, flares are still considered most likely from AR3341, which remains on the front side throughout.

| 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                     | 40                | 40                | 40                | 40                |
| Very Active  | R3 to R5 X Class | No                     | 5                 | 5                 | 5                 | 5                 |

**Figure 3: AR3341 (which produced the M4.8 on the 20 June) shown in the intensitygram (left) and the magnetogram (right). Despite its appearance, it does show some complexity magnetically, which isn't visible on the surface.**



**Figure 4: GOES X-ray flares – only minor C-class flares observed in the past 24 hours.**



## 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.

There remains a daily Slight Chance of reaching the S1/Minor Storm threshold given the sheer number of (bipolar) regions and complexity of the current front-side. On balance the risk is also felt to rise slightly, as fewer large sunspots are moving away from the western limb (on the far side) than are moving towards it (on the front side), leading to a gradual increase in risk, although it remains the case that no recent proton-generating events have been observed.

| Radiation Storms            | Level<br>( $\text{cm}^{-2} \text{sr}^{-1} \text{s}^{-1}$ ) | Past 24 Hours<br>(Yes/No) | Day 1<br>(00-24 UTC) | Day 2<br>(00-24 UTC) | Day 3<br>(00-24 UTC) | Day 4<br>(00-24 UTC) |
|-----------------------------|--|---------------------------|----------------------|----------------------|----------------------|----------------------|
| Probability<br>(Exceedance) |  |                           | (%)                  | (%)                  | (%)                  | (%)                  |
| Active                      | $\geq \text{S1}$   | No                        | 10                   | 10                   | 15                   | 15                   |
| Very Active                 | $\geq \text{S3}$<br>*                                      | No                        | 1                    | 1                    | 1                    | 1                    |

\*  $\text{S3} \geq 10 \text{ MeV} \geq 1000 \text{ pfu}$  and / or  $\geq 50 \text{ MeV} \geq 10 \text{ pfu}$ . (pfu =  $\text{cm}^{-2}\text{sr}^{-1}\text{s}^{-1}$ )

## High Energy Electrons Event ( $\geq 2\text{MeV}$ ):

High energy electron flux (greater than 2MeV) is likely to continue to follow its recent trend of diurnal variation between Normal Background and High flux. While the geomagnetic forecast is relatively complex for the period, it is not expected to be especially impactful, particularly with regard to electrons. Any fast wind enhancement is expected to be of a similar magnitude to that seen at present, i.e. around 450km/s. Probably the most impactful part of the forecast is not expected until the end of the period - any influence from the 22 June CME on days 3 and 4, and any subsequent effects on electron fluence will probably fall outside of this forecast period.

MOSWOC REFM is currently offering a forecast significantly below persistence levels, which is accepted, although the influence of glancing CMEs on the geomagnetic forecast lowers confidence in values somewhat.

| GEO Electron Environment | Level ( $\text{cm}^{-2} \text{sr}^{-1} \text{day}^{-1}$ ) | 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                   | $\geq 2 \text{ MeV}$<br>$\geq 1 \times 10^8$              | No                     | 20                | 20                | 10                | 10                |
| Very Active              | $\geq 2 \text{ MeV}$<br>$\geq 1 \times 10^9$              | No                     | 1                 | 1                 | 1                 | 1                 |

Figure 5: MOSWOC REFM electron fluence – observations, forecast and recurrence.

