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## Space Weather Technical Forecast

Issued on Saturday, 10 June 2023 at 13:23 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>**

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**Space Weather Forecast Headline: Chance of M-class flares (R1-R2/Minor-Moderate radio blackouts) throughout. Slight chance of G1/Minor Geomagnetic Storms 11-12 June.**

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

**Solar Activity:** Solar activity has been Moderate over the past 24 hours. The largest event was an impulsive M2.5 flare at 09/1711UTC originating from AR3331 in the southeast quadrant. This produced a CME which analysis suggests may have a slight Earth-directed component. Otherwise, background activity has seen occasional minor C-class flares. There are currently nine sunspot regions on the visible disc, with AR3331 the largest group on the disc. AR3327 in the southwest remains the most complex region, although appears to be stabilising having recently lost its gamma configuration. AR3329 in the northwest is the only other significant region, however it has shown little change in the past 24 hours. The remaining regions are all relatively small and/or stable and inactive. No other CMEs that are likely to be Earth-directed have been observed on available coronagraph imagery. However, a filament began lifting off of the northeast quadrant around 10/1020UTC which may have produced an eruption that is not yet visible on available imagery.

**Solar Wind / Geomagnetic Activity:** Solar wind at L1, has been at ambient levels and on a slow rising trend, initially 280 km/s and currently around 320km/s. Density has fluctuated largely between average and below average levels, but with a peak of 12ppcc at 09/2126UTC. Total magnetic field strength has been weak, with the north-south component initially near neutral, before fluctuating between +5/-5nT from around 09/1500UTC. Phi angle was initially predominately positive (away from the Sun), however since 09/1824UTC has been largely negative (towards the Sun) most likely the result of a solar sector boundary crossing (SSBC). Geomagnetic activity was Quiet (Kp 0-2) throughout.

**Particles / Solar Radiation:** High energy proton flux (greater than 10MeV), as observed by GOES16, has remained at background levels. High energy electron flux (greater than 2MeV), as observed by GOES16 has been at mainly background levels with a diurnal peak at moderate levels. The associated 24-hour fluence has remained well below the Active threshold (1e8 integrated pfu), with 2.66e6 integrated pfu observed at 10/0001UTC.

### Four-Day Space Weather Forecast Summary

**Solar Activity:** Mainly Low to Moderate solar activity is forecast, with only a small number of significant regions on the solar disc. AR3327 and AR3329 in the central disc and AR3331 in the southeast, responsible for the most recent M-class flare, pose the greatest risk of significant flaring as they continue to transit into more geoeffective positions. A new region is emerging across the southeast limb which may be strong, this will continue to be monitored for any development.

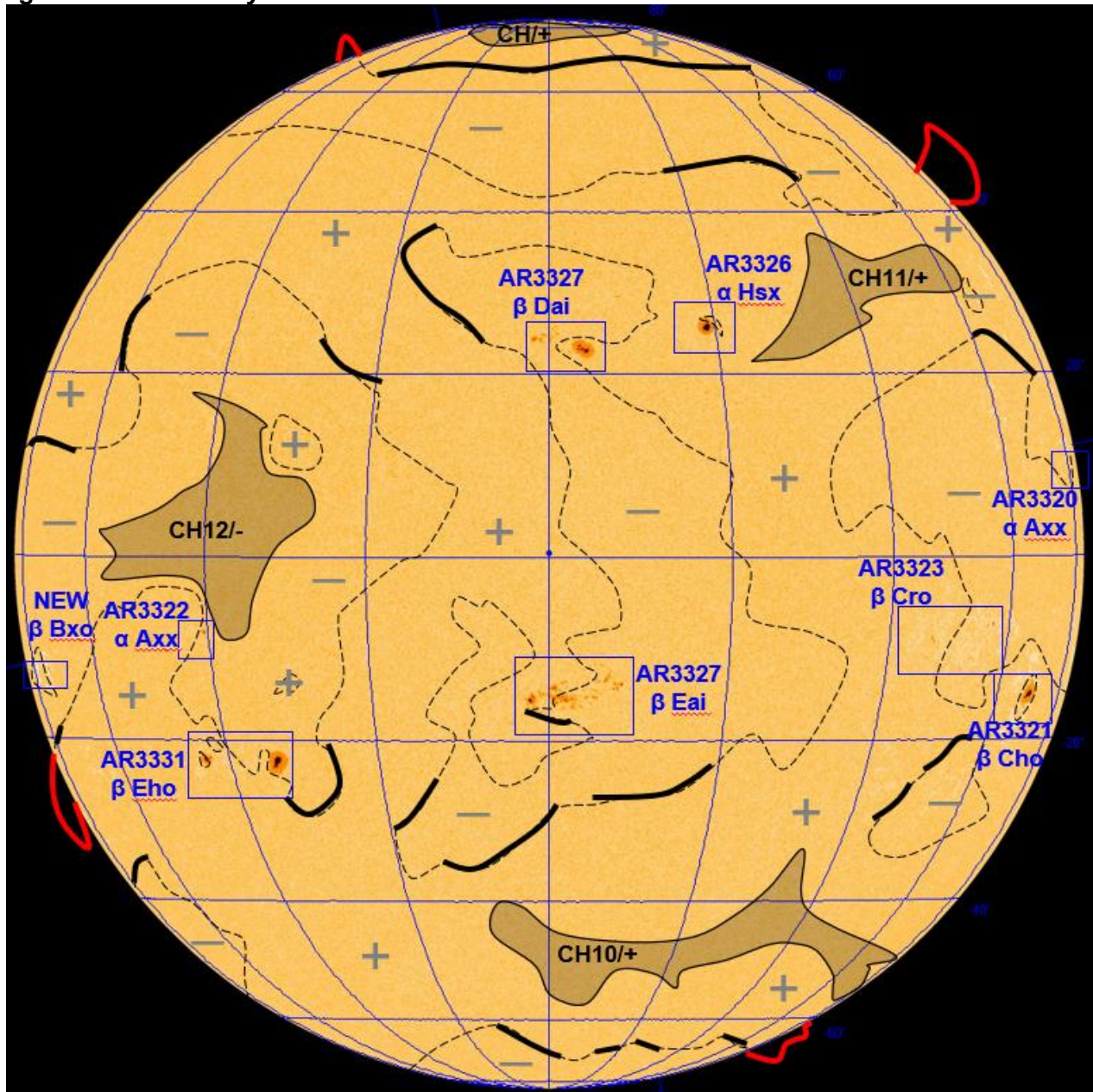
**Solar Wind / Geomagnetic Activity:** No Earth-directed CMEs are expected to affect the Earth. Moderate risk of a glancing blow on Day 2 (11 June), or possibly Day 3 (12 June). Coronal hole high speed streams from either CH10/+ or CH11/+, may affect the Earth from Day 1-2 (10-11 June), possibly giving speeds of 400-450km/s but with low confidence. Geomagnetic activity is

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forecast to be mainly Quiet (Kp 0-2) throughout, with a slight chance of Active (Kp 4) or of a G1/Minor Storm interval (Kp 5), mainly on Days 2-3.

**Energetic Particles / Solar Radiation:** The high energy (greater than 10 MeV) proton flux is expected to remain at Background levels, however there is a very slight chance of reaching the S1/Minor Storm threshold should any larger flares occur. High energy electron flux (greater than 2MeV) is expected to remain at background to moderate levels, but may increasingly exceed the high threshold on diurnal peaks later in the period. Electron fluence is expected to persist below the Active ( $1e8$  integrated pfu) threshold, but with an eventually increasing trend.

**Figure 1. Solar Analysis Valid 10/0800UTC.**



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

**Geomagnetic Storms:**

No Earth-directed CMEs are expected in the forecast period. However, a filament eruption that left the Sun on 07 June may give a glancing blow at Earth on Day 2 or 3 (11 or 12 June). A number of Enlil ensemble members suggest an arrival later on Day 2, however, solar wind parameters currently observed at STEREO-An are indicative of a CME arrival there, which would support a potential arrival at Earth on Day 2. One other recent CME that emerged from the southwest of the disc on coronagraph imagery on 09 June may have an Earth-directed component, however, this is not expected to have any effects during this forecast period.

High speed streams from CH10/+ and CH11/+ are forecast to connect with Earth Days 1-2 (10-11 June), with both at geoeffective longitudes. However, their positions to the south and north of the solar equator respectively and the proximity to the solstice may result in only minor enhancement, despite the coronal holes appearing stronger and more distinct than on the previous rotation, when speeds of 500km/s were observed. Enlil is modelling the high speed streams from these features as missing the Earth, which is considered reasonable guidance. Any connection to the HSS may see winds reach 400-450km/s but this is considered only a moderate probability.

Mainly Quiet conditions are forecast through the period, with a slight chance of Active or G1/Minor Storms due to the connection to the high speed streams, glancing CME or a low confidence combination of both.

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	10	15	10	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

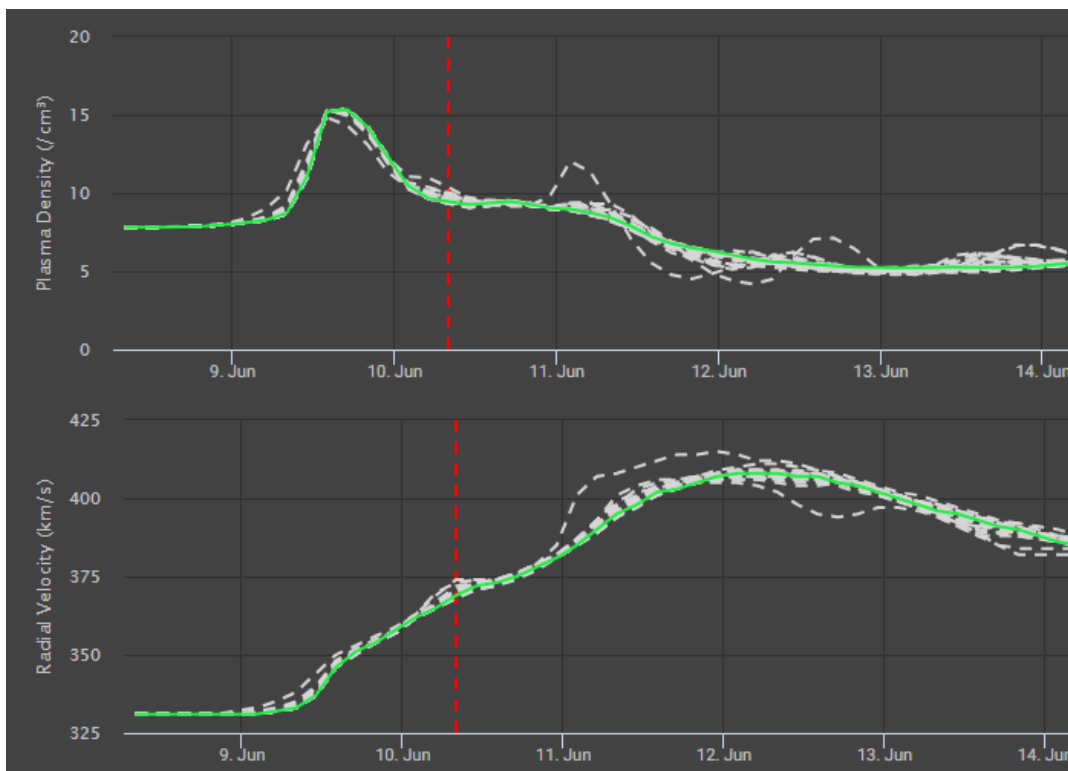
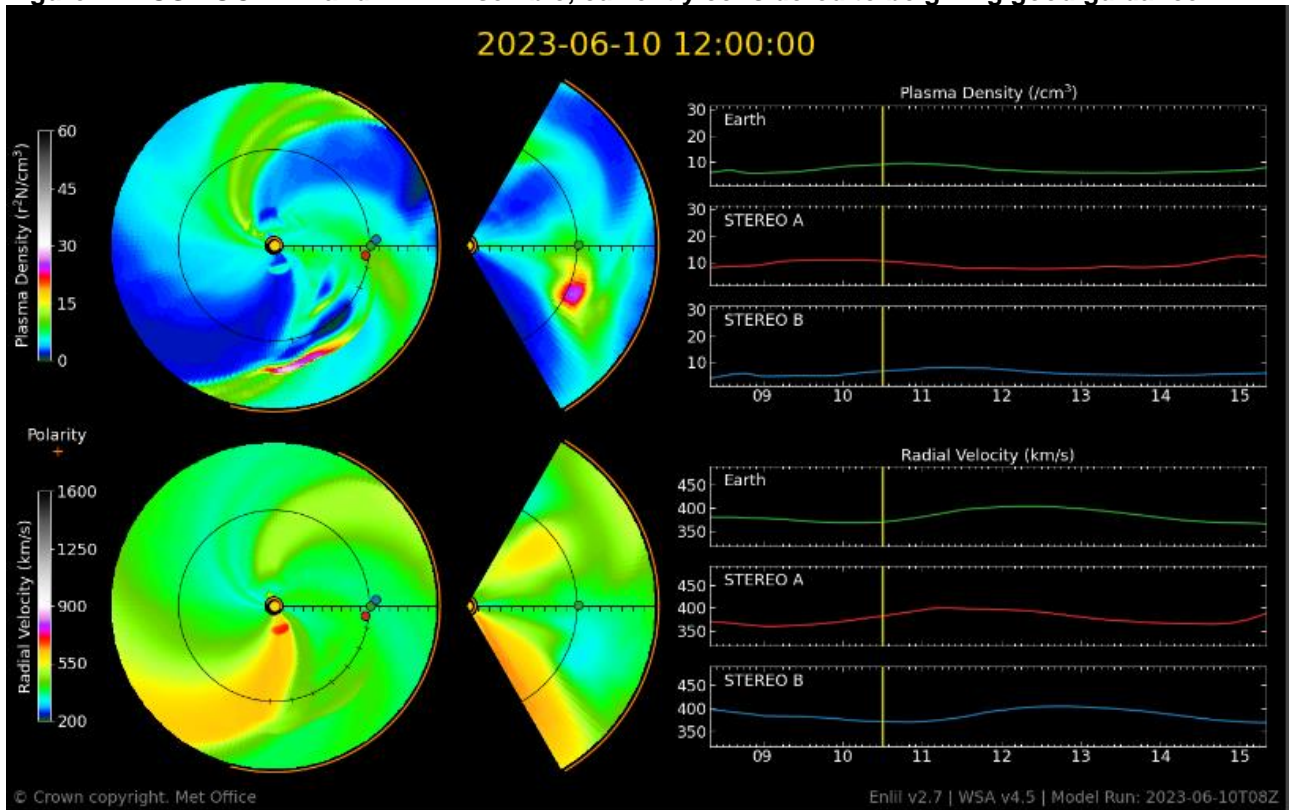
**Geomagnetic Activity - Earthbound Coronal Mass Ejections**

No Earth-directed CMEs are expected in the forecast period. See 'Geomagnetic Storm' section for discussion surrounding potential glancing blow at Earth 11-12 June.





Figure 2: MOSWOC Enlil and Enlil Ensemble, currently considered to be giving good guidance.

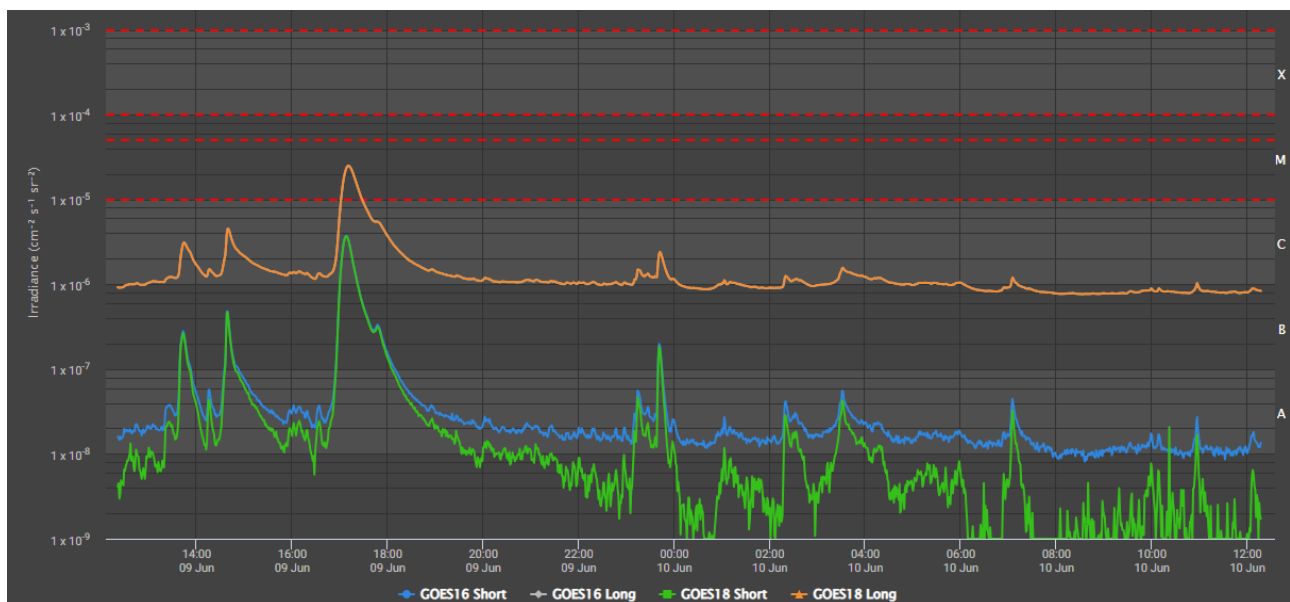


## Radio Blackouts - X-Ray Flares:

There are currently nine sunspot regions on the visible disc. AR3331 in the southeast is the largest and most active region on the disc, having produced a M2.5 flare at 09/1711UTC. AR3327 has seen a proliferation of minor intermediate spots, and remains the most complex region on the disc, despite exhibiting signs of weakening and recently losing its gamma configuration. AR3323 in the southwest quadrant has weakened significantly, with only faint penumbra visible. AR3321 in the southwest has seen the re-emergence of weak trailing spots of an opposite polarity to the large, strong, lead spot. A new region is currently emerging across the southeastern limb, however, viewing angle currently restricts confidence in classification. Helioseismology is forecasting a strong region to rotate onto the southeast limb during Day 1 (10 June), as such, this new region will need to be monitored for development as it emerges further onto the disc. A minor region may also arrive across the northeast limb through Day 2 (11 June), a small region on STEREO EUVI imagery supports this. Mainly Low to Moderate solar activity is forecast, with a slight chance of isolated Strong flares.

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	Yes	45	40	40	40
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3: GOES-16 & GOES-18 24-hour X-Ray trace



## Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux is at Background levels where it is expected to remain. There is a very slight chance of S1/Minor Radiation Storms should any larger flares occur, with the most likely source being the moderately large and complex region AR3327, which will be transiting across the central portion of the disc into a more geoeffective position over the forecast period.

Radiation Storms	Level (cm <sup>-2</sup> sr <sup>-1</sup> s <sup>-1</sup> )	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	10	10	10	10
Very Active	≥ S3 <sup>*</sup>	No	1	1	1	1

<sup>\*</sup> S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = cm<sup>-2</sup>sr<sup>-1</sup>s<sup>-1</sup>)

## High Energy Electrons Event (≥ 2MeV):

High energy flux (greater than 2MeV) is expected to be at mainly background levels through the period. Should connection to high speed streams from either CH10/+ or CH11/+ occur, then flux levels may increase to moderate to high (1e3 pfu) levels, with the high threshold being increasingly exceeded on diurnal peaks. This is low confidence however.

Electron fluence is not expected to exceed the Active (1e8 integrated pfu) threshold with any high speed stream expected to be relatively muted. The MOSWOC REFM model suggests that any fluence levels will remain well below the Active threshold, and the British Antarctic Survey Radiation Belt Model (BAS-RBM) supports the idea that the greatest populations of electrons will be below GEO.

GEO Electron Environment	Level (cm <sup>-2</sup> sr <sup>-1</sup> day <sup>-1</sup> )	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 <sup>8</sup>	No	1	5	5	10
Very Active	≥ 2 MeV ≥ 1x10 <sup>9</sup>	No	1	1	1	1

**Figure 4: MOSWOC REFM**

