
Space Weather Technical Forecast

Issued on Wednesday, 07 June 2023 at 13:34 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 M-class flares (R1/Minor-R2/Moderate radio blackouts). Slight chance of a G1/Minor Geomagnetic Storm 08/09 June.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has increased to Moderate, with background X-ray flux at low C-class levels and an ongoing long-duration flare from AR3327 at the time of writing, with a current peak flux of M4.7 at 07/1146 UTC. There are currently twelve sunspot regions on the visible disc. AR3327 in the southeast is the most complex region, maintaining a small delta spot in its trailing region and a number of small intermediate spots of opposing polarity. AR3329 in the northeast continues to grow, with well-defined penumbra at both ends of the group, although the largest spot is now more symmetrical in appearance. AR3233 in the southern centre disc continues its slow decline, with fading of the minor interior spots and main lead and trailer spots. The unnumbered group near the southeast limb is rotating into clearer view and appears to be an Hsx/Alpha spot. This appears to be followed by another similar group, although this is not included in the present analysis. The other regions appear to be mostly small and/or simple, with only minor growth or decay.

A CME was observed leaving the sun around 07/0600 UTC closely followed by a long-duration C7.1 flare from near AR3327. Preliminary analysis suggests the CME is fairly narrow and behind earth-orbit, however, further imagery is required to be able to confirm this. Otherwise no Earth-directed CMEs were observed in available imagery during the period.

Solar Wind / Geomagnetic Activity: Solar wind parameters as observed by ACE and DSCOVR at L1 have largely been at background ambient levels. Wind speeds were initially around 380-400km/s, but have reduced to around 320km/s by the end of the period. Density has been below average throughout. Total IMF, Bt, has been weak, with a peak of 7nT at 07/2100 UTC with the north-south component, Bz, also varying weakly. Phi angle has been almost entirely positive (away from the Sun), with only very short-lived negative (towards the Sun) periods. Geomagnetic activity was Quiet (Kp 0-2).

Energetic 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 largely background levels. Associated 24-hour fluence has been below the Active threshold (1e8 integrated pfu) on a generally steady trend with a peak of 1.68e6 integrated pfu at 06/1800UTC. Electron fluence observed at 07/0000UTC was 1.51e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to remain generally Low, but there remains a chance of further M-flares producing Moderate activity, and a very slight chance of isolated X-flares. Any significant flares are most likely to originate from AR3327 in the southeast of the disc.

Solar Wind / Geomagnetic Activity: A filament lift-off starting around 04/0900UTC from the southwest quadrant resulted in an observed CME. A glancing blow at Earth is possible from this feature, although not guaranteed, most likely Day 2 (08 June) but possibly Day 3 (09 June). A

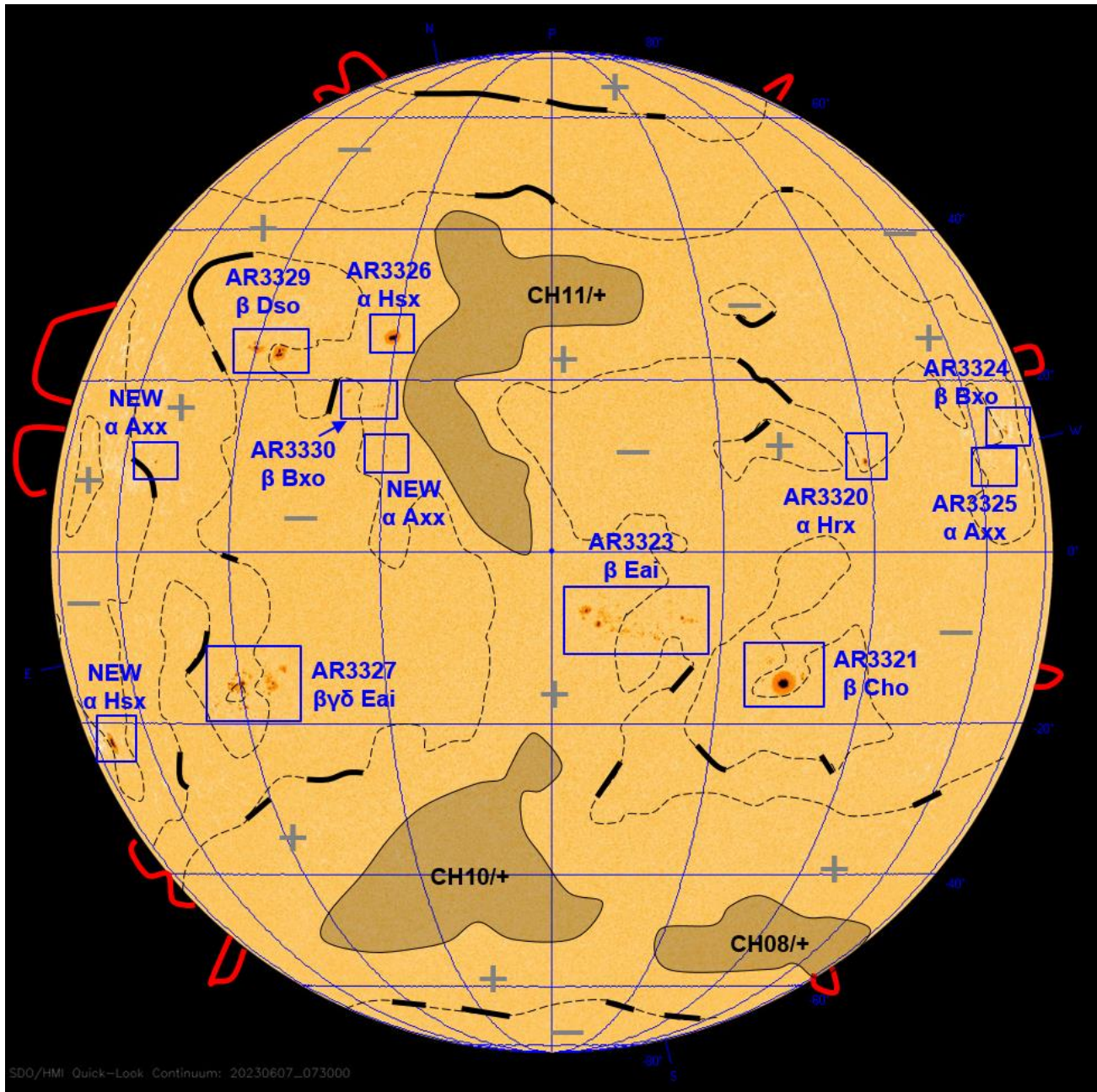
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second CME lifted off from close to the eastern limb around 06/0300UTC but is expected to miss, passing behind Earth on Day 4 (10 June). Solar winds are expected to remain at slow-ambient speeds initially. Perhaps seeing a slight enhancement Days 2-4 to slightly elevated levels given the potential for CME arrivals and a weak HSS from one or perhaps two coronal holes moving into a more geo-effective position.

Geomagnetic activity is forecast to be initially Quiet to Unsettled, with a very slight chance of Active intervals on Day 1 (07 June). Activity may increase Days 2-4 with any CME or CH effects, becoming more Unsettled with a chance of Active intervals and a slight chance of isolated G1/Minor Geomagnetic Storm intervals.

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 be at mostly background or moderate levels, but may experience charging from a possible CME glancing blow. Electron fluence is also expected to continue below the Active (1e8 integrated pfu) threshold, but likely see a gradual increase.

Figure 1. Solar Analysis Valid 07/0730 UTC.



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

Geomagnetic Storms:

A filament lift-off starting around 04/0900UTC from the southwest quadrant resulted in an observed CME. A weak glancing blow is possible, most likely to arrive on Day 2 (08 June) or very possibly early Day 3 (09 June), although a small number of Enlil ensemble members have this feature missing Earth entirely. A CME erupted from close to the eastern limb around 06/0300UTC and is expected to pass behind Earth on Day 4 (10 June). Although almost all Enlil ensemble members predict a miss, there remains a very slight possibility of a glancing blow from this feature, or for some transient effects to be observed towards the end of the period. A third CME was observed leaving the sun around 07/0600 UTC closely followed by a long-duration C7.1 flare from near AR3327. Preliminary analysis suggests the CME is fairly narrow and behind earth-orbit, however, further imagery is required to be able to confirm this.

Current solar winds are at ambient background levels. In the absence of any aforementioned CME influences, the next HSS at Earth is anticipated on Day 4 (10 June) from one or both of CH11/+ and CH10/+. Solar winds are expected to remain at slow-ambient levels through much of the next few days, with a chance of becoming slightly elevated should we observe any CME effects at Earth. Winds then more persistently increasing from Day 4, with an increased chance in enhancement to 450 km/s given the potential weak HSS arrival(s).

Geomagnetic activity is forecast to be initially Quiet to Unsettled, with a slight chance of Active intervals on Day 1 (07 June) should Earth see any early CME enhancement. Activity possibly increasing Day 2 into Day 3 should we see any CME effects, becoming more Unsettled with a chance of Active intervals and a slight chance of isolated G1/Minor Geomagnetic Storm intervals.

| 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 | 20 | 15 | 10 |
| Strong | G3 | No | 1 | 2 | 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 |
|-----------------------|-----------------------|-------------------|-----------------|-----------------|------------------------|--|
| 04/1629 | Partial | Filament Eruption | SW | 620 km/s | 08/1000 UTC | Glancing blow possible. Moderate confidence in arrival time. |

Radio Blackouts - X-Ray Flares:

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There are currently twelve sunspot regions on the visible disc. AR3327 (Eai/Beta-Gamma-Delta) in the southeast quadrant is the most complex region on the disc, with the proliferation of a large number of small spots of opposing polarity and the presence of a small delta spot in the trailing portion of the group. The region was responsible for an ongoing long-duration flare at the time of writing, with a peak flux of M4.7 at 07/1146 UTC. AR3323 (Eai/Beta) near the southern centre disc continues its slow decline, with fading of the minor interior spots and main lead and trailer spots. A new region has emerged over the southeast limb, although it remains too foreshortened in available imagery to make a confident assessment. The other regions appear to be mostly small and/or simple, with limited growth or decay since the last assessment.

Solar activity is expected to remain generally Low, but there remains a chance of further M-flares producing Moderate activity, and a very slight chance of isolated X-flares. These most likely from AR3323.

| 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 | 50 | 40 | 30 | 30 |
| Very Active | R3 to R5 X Class | No | 5 | 5 | 3 | 3 |

Figure 2: Latest HMI-Flat and HMI-Magnetogram-Color imagery for AR3327

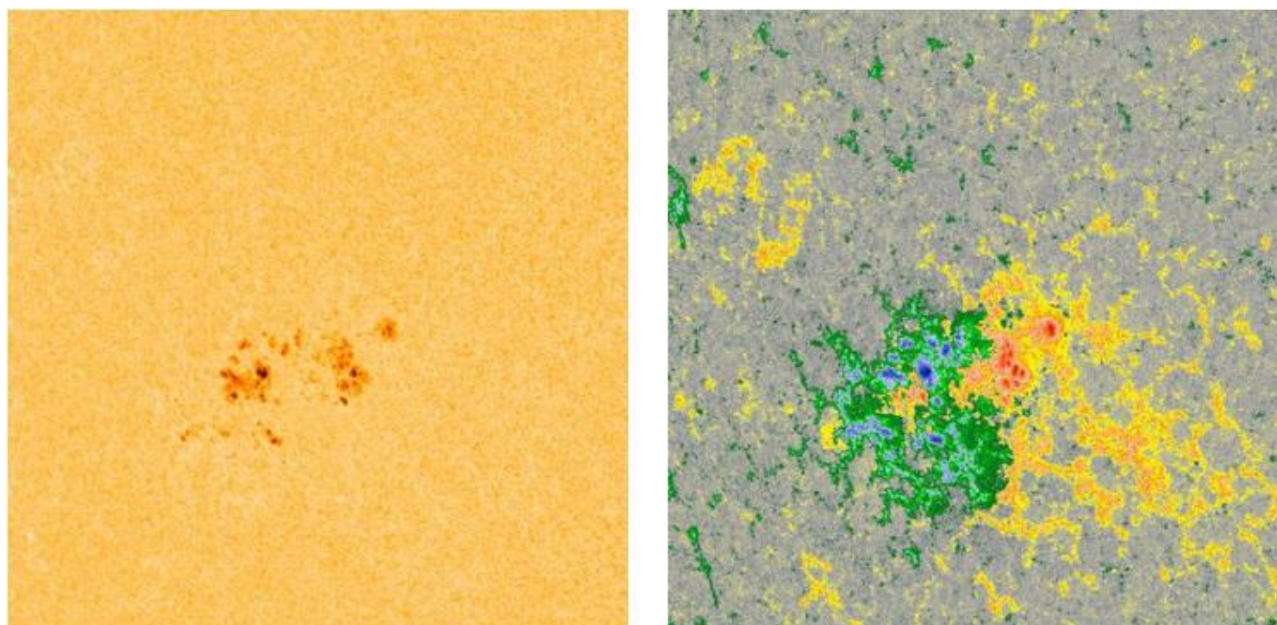


Figure 3: GOES X-ray flux data



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, especially from the most active sunspot group AR3327.

| 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 ⁻² sr ⁻¹ s ⁻¹) | | | | | | |



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

High energy electron flux (greater than 2MeV) is expected to remain at mainly background to moderate levels through the period. The possibility of a CME glancing blow Days 2-3 (08-09 June) may also keep electron levels suppressed, although could produce charging towards the end of the forecast period. Confidence in any CME arrivals is low, with a chance they may miss Earth entirely.

Electron fluence is well below the Active ($1\text{e}8$ integrated pfu) threshold. It is expected to stay below Active through this period, although a rise is possible Days 3-4 (09-10 June), but this is low confidence. MOSWOC REFM is forecasting an increasing trend, but remaining well below Active levels. This is considered to be reasonable guidance at this stage.

| 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 | $\geq 2\text{ MeV}$ $\geq 1\text{x}10^8$ | No | 1 | 1 | 5 | 5 |
| Very Active | $\geq 2\text{ MeV}$ $\geq 1\text{x}10^9$ | No | 1 | 1 | 1 | 1 |

Figure 4: MOSWOC REFM forecast

