

**Space Weather Technical Forecast**

Issued on Friday, 16 June 2023 at 01:26 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 R1/R2 Radio Blackouts throughout. Chance of G1/Minor geomagnetic storm conditions early today.**

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

**Solar Activity:** Solar activity has been Low. There are currently eight numbered sunspot regions on the visible disc, and one new small and weak region in the northwest quadrant. The largest region is AR3333, a moderately complex Esi/beta-gamma classification. However, the largest flare during the period was a C9.7 at 15/1255 UTC from AR3335, which is slightly smaller and magnetically slightly simpler region (Eai/beta). AR3335 is close to AR3336, which is also a moderately complex region (Dao/beta-gamma), and magnetic complexity of the combination of these two regions may have led to the C9.7 flare. Remaining regions are small, weak and simple. There are also a number of large filaments on the Earth-facing disc, with the potential to produce Earth-directed CMEs if they were to erupt. Currently no Earth-directed CMEs have been observed using available imagery.

**Solar Wind / Geomagnetic Activity:** During the first 12 hours the solar wind at L1 was at background levels around 350 km/s. However, during the second half of the day the solar wind increased, gradually at first but then with a sharp rise during the evening, when the wind peaked at 726 km/s at 15/2142 UTC. The solar wind ended the day at strong levels around 610 km/s. Other changes in the solar wind parameters also confirmed the onset of a high speed stream (HSS) associated with a large equatorial coronal hole. After starting below average the density increased to above average (peak 50ppcc at 15/1337 UTC). The total IMF, Bt was initially Weak, but increased to reach Strong levels from early afternoon, peaking several times at 20 nT from 15/2046 UTC. The north-south component was weakly negative until early afternoon, and then fluctuated between +15nT and -13nT. The phi angle was positive (away from the Sun) during the first half of the day, then early afternoon started fluctuating before settling as negative (towards the Sun) from 15/1414 UTC. Geomagnetic activity was Quiet (Kp 1-2) during the morning, then steadily increased to become Active to G1/Minor Storm (Kp 4-5).

**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 levels to moderate levels, with a peak of 150 pfu at 15/0010. The associated 24-hour fluence remained below the Active threshold (1e8 integrated pfu), with a gradually decreasing trend, and 1.95e6 integrated pfu observed at 16/0000UTC.

**Four-Day Space Weather Forecast Summary**

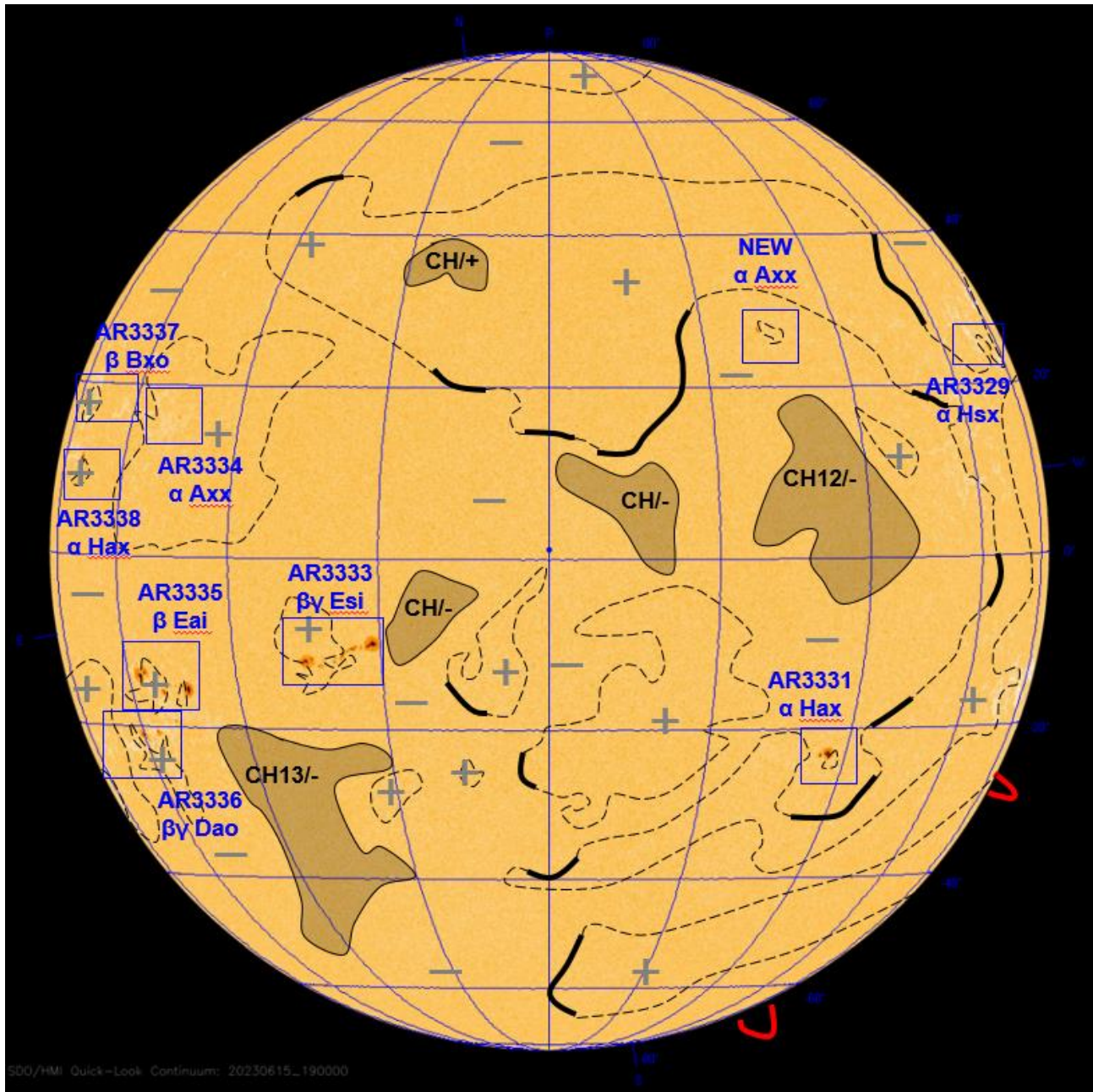
**Solar Activity:** Low activity is most likely to continue, however there is a chance of this increasing to Moderate with isolated M-flares (R1/R2 Radio Blackouts) especially as new regions are likely to rotate onto the visible disc later in the period.



**Solar Wind / Geomagnetic Activity:** There are no Earth-directed CMEs currently expected. Solar winds will start at Strong levels, under the continued influence of a HSS from CH12/-, then gradually decreasing Elevated to Strong tomorrow (17th), then to slightly elevated or elevated levels for days 3 and 4 (18th and 19th), as further coronal hole influence is likely. Geomagnetic activity is forecast to be G1/Minor Storm (Kp 5) to G2/Moderate Storm (Kp 6) at first, decreasing to Unsettled to Active (Kp 3-4) later today, but with a chance of isolated G1/Minor storm intervals during the coming night. Geomagnetic activity is expected to further decline, becoming Quiet to Unsettled (Kp 2-3) during days 3 and 4 (18th and 19th).

**Energetic Particles / Solar Radiation:** The high energy (greater than 10 MeV) proton flux is expected to remain at background. High energy electron flux (greater than 2MeV) is expected to continue at largely background levels at first, until after the fast wind enhancement. Then likely becoming Moderate, perhaps briefly High from day 3 onwards (18th Jun). Electron fluence is expected to remain below the Active ( $1e8$  integrated pfu) threshold, but with an increasing chance of rising above.

**Figure 1. Solar Analysis Valid 15/1900 UTC.**



**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:

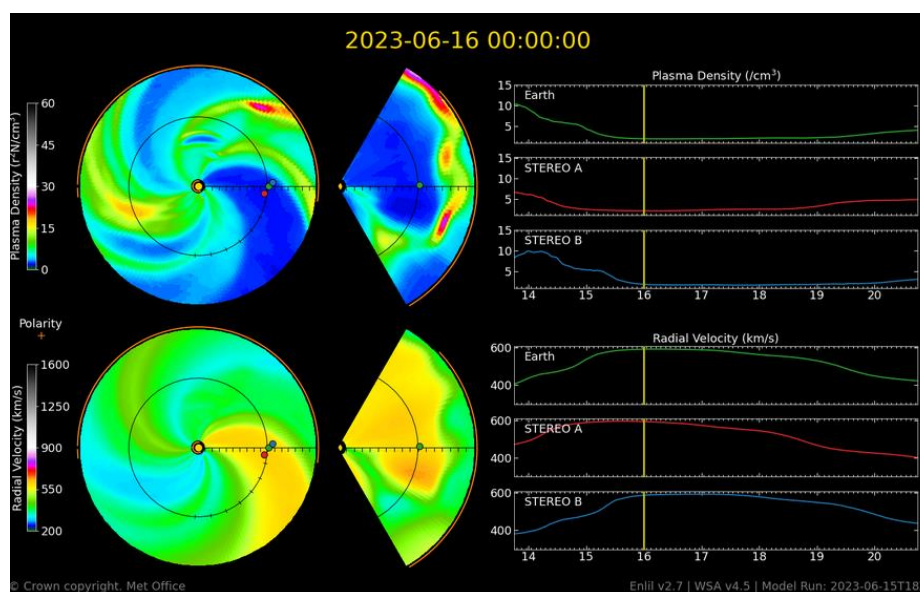
There are no Earth-directed CMEs expected.

The HSS associated with CH12/- has arrived and Enlil is providing a good guidance, with the current strong winds around 600 km/s represented. CH12 is large feature and extends quite a way across the western hemisphere, and therefore the influence of the HSS is likely to persist for much of this forecast period. Solar winds will start at Strong levels, then gradually decrease to Elevated to Strong levels tomorrow (17th), and to slightly elevated or elevated levels for days 3 and 4 (18th and 19th). Geomagnetic activity is forecast to be G1/Minor Storm (Kp 5) to G2/Moderate Storm (Kp 6) at first, decreasing to Unsettled to Active (Kp 3-4) later today, but with a chance of isolated G1/Minor storm intervals during the coming night. Geomagnetic activity is expected to further decline, becoming Quiet to Unsettled (Kp 2-3) during days 3 and 4 (18th and 19th).

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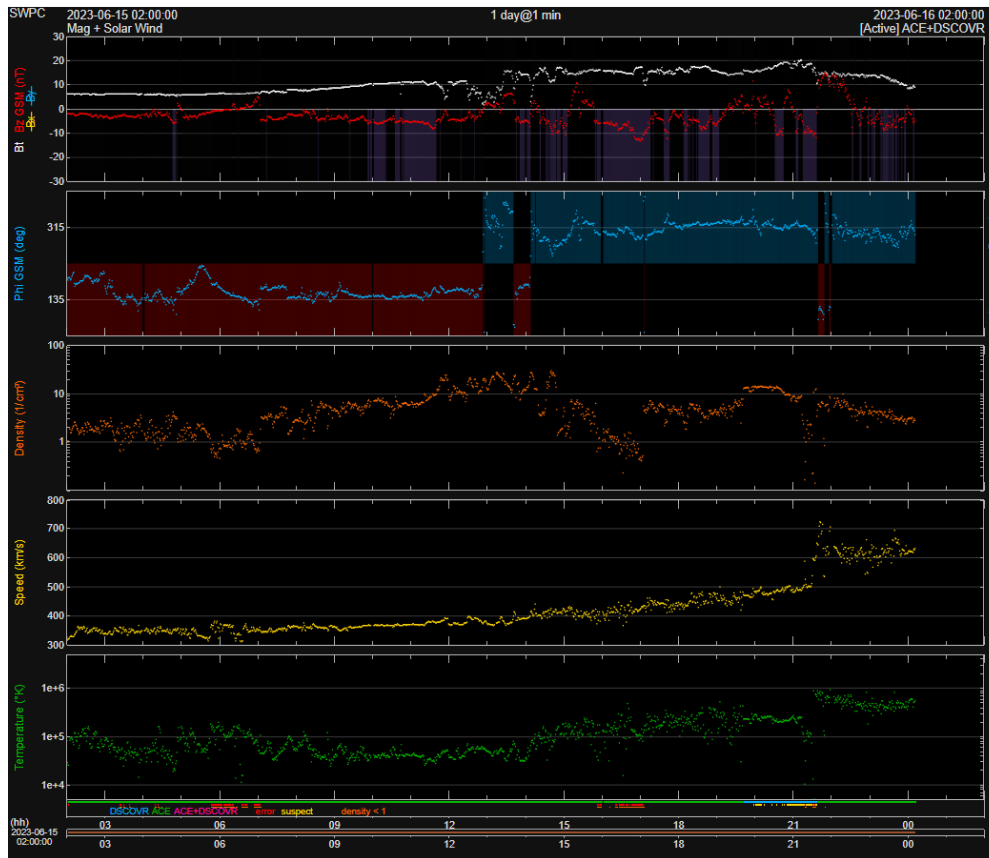
| Geo-Magnetic Storm       | Level    | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) | Day 2 (00-24 UTC) | Day 3 (00-24 UTC) | Day 4 (00-24 UTC) |
|--------------------------|----------|------------------------|-------------------|-------------------|-------------------|-------------------|
| Probability (Exceedance) |          |                        | (%)               | (%)               | (%)               | (%)               |
| Minor or Moderate        | G1 to G2 | Yes                    | 80                | 30                | 5                 | 1                 |
| Strong                   | G3       | No                     | 5                 | 1                 | 1                 | 1                 |
| Severe                   | G4       | No                     | 1                 | 1                 | 1                 | 1                 |
| Extreme                  | G5       | No                     | 1                 | 1                 | 1                 | 1                 |

**Figure 2: MOSWOC ENLIL.**





**Figure 3: Past 24 hours of solar wind parameters, showing the arrival of the HSS from CH12.**



## Radio Blackouts - X-Ray Flares:

There are eight numbered regions on the visible disc, including two newly numbered regions. Previous region AR3326 has rotated out of view, while a new weak region has emerged in the northwest quadrant.

AR3333 has increased slightly in area, and now measures slightly greater than 10 degrees across and so is now classified as Esi/beta-gamma. AR3335 remains classified as an Eai/beta with a number of intermediate spots which are small, but fairly strong with penumbra. There has also recently been a slight increase in small and weak intermediate spots within AR3335. This region is close to another group, AR3336 which has some magnetic complexity and is a Dao/beta-gamma. The close proximity of AR3335 and AR3336 could enhance latitudinal magnetic shear across the two regions, greater than would be expected than if both sunspot regions were more remote to each other. Newly numbered AR3337 appears small, simple and weak. Recently numbered region AR3338 is currently classified as Hax/alpha, but may well be slightly more complex than this. Confidence in the assessment of these features will improve as they rotate into clearer view in the coming days. Remaining regions are small, weak and simple. Further regions are also potentially approaching the east limb as inferred by brighter flux regions in STEREO A and SDO imagery.

Solar activity has been Low in the last 24 hours with a number of C-class flares observed, peaking C9.7 at 15/1255 UTC from AR3335. There is a chance of activity rising to Moderate due to isolated M-flares.

| X Ray Flares | 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  |                     |                           | (%)                  | (%)                  | (%)                  | (%)                  |
| Active       | R1-R2<br>M Class    | No                        | 30                   | 30                   | 30                   | 30                   |
| Very Active  | R3 to R5<br>X Class | No                        | 2                    | 2                    | 2                    | 2                    |

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

The high energy (greater than 10MeV) proton flux is at Background levels and is expected to continue at this level, with only small, simple and weak sunspots currently in a geo-effective location on the Earth-facing disc. Therefore there is only a very small chance of a high energy proton event occurring.

| Radiation Storms            | Level<br>(cm <sup>-2</sup> sr <sup>-1</sup> s <sup>-1</sup> ) | 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                      | ≥ S1                                                          | No                        | 3                    | 3                    | 3                    | 3                    |
| Very Active                 | ≥ S3<br>*                                                     | No                        | 1                    | 1                    | 1                    | 1                    |

\* 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 electron flux (greater than 2MeV) is expected to largely be at Background, until at least later on day 2 (17 Jun). The onset of the fast wind enhancement from CH12/- may connect sufficiently to increase electron counts through the Van Allen Belts. This may then result in occasionally Moderate flux at GEO from late day 2 (17 Jun) onwards, perhaps becoming High at diurnal max.

The associated 24 hr electron fluence is expected to remain steady and below the Active (1e8 integrated pfu) threshold days 1 and 2 (16 and 17 Jun), with the REFM model currently providing generally good guidance for this period. Thereafter an increasing trend is preferred, and not shown by the REFM model, but the forecast of keeping the fluence below the Active threshold is accepted.

| GEO Electron Environment | Level<br>(cm <sup>-2</sup> sr <sup>-1</sup> ) | Past 24 Hours | 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) | day <sup>-1</sup>                            | (Yes/No) | (%) | (%) | (%) | (%) |
|-----------------------------|----------------------------------------------|----------|-----|-----|-----|-----|
| Active                      | $\geq 2 \text{ MeV}$<br>$\geq 1 \times 10^8$ | No       | 1   | 1   | 10  | 20  |
| Very Active                 | $\geq 2 \text{ MeV}$<br>$\geq 1 \times 10^9$ | No       | 1   | 1   | 1   | 1   |

**Figure 4: Latest Met Office REFM.**

