
Space Weather Technical Forecast

Issued on Thursday, 15 June 2023 at 13:28 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. Chance of G1/Minor geomagnetic storm conditions 15 Jun.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Low with peak flare C6.6 at 14/2239 UTC from the plage region of ex-AR3327 in the far southwest. AR3333 in the southeast quadrant is the most complex sunspot group of the seven regions on the disc, with the greatest potential for notable flares. AR3335 and AR3336 in the far southwest are also of note, although they remain difficult to assess given their current viewing angle. Further detail is expected to become apparent as they move to a less oblique viewing angle. A small filament eruption occurred from the SW-disc around 14/1800 UTC with an associated coronal dimming, although no Earth-directed CMEs have been observed. There are a number of other large filaments on the Earth-facing disc, with the potential to produce Earth-directed CMEs if they were to erupt.

Solar Wind / Geomagnetic Activity: The solar wind at L1 was predominantly indicative of a background slow wind regime, however solar parameters increasingly now suggest the beginning of the onset of a high-speed stream associated with a large equatorial coronal hole. Solar wind speed, as observed by ACE, remained around 350km/s for much of the period with density below average. From around 15/0830 UTC density has increased to average levels and later above average (peak 25ppcc at 15/1154 UTC) with the solar wind increasing to between 370-400km/s. The total IMF, Bt was largely Weak, but increased to Moderate levels from around 15/0800 UTC with the north-south component varying weakly between +6nT and -8nT. The phi angle was mostly positive (away from the Sun). Geomagnetic activity was Quiet (Kp0-2).

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. The associated 24-hour fluence remained below the Active threshold (1e8 integrated pfu), with 3.64e6 integrated pfu observed at 15/0000UTC.

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).

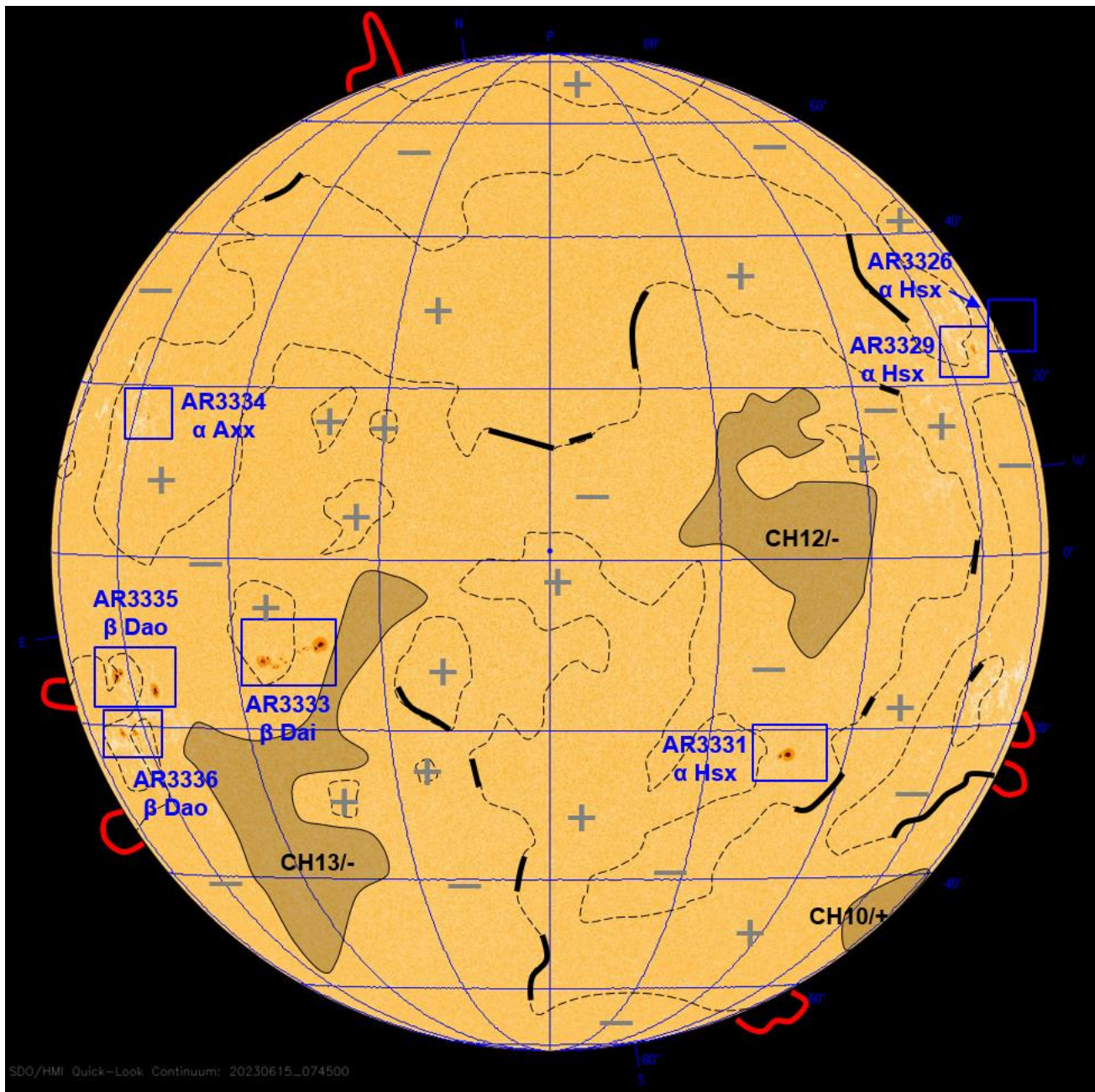
Solar Wind / Geomagnetic Activity: There are no Earth-directed CMEs. Solar winds are forecast to increase on day 1 (15 Jun) from background to elevated or perhaps strong levels by early day 2 (16 Jun), this resulting from the fast wind enhancement from the large, equatorial CH12/-. Peak winds of around 550-600km/s are forecast. Winds gradually declining into days 3 and 4 (17 and 18 Jun) to slightly elevated or background levels. Geomagnetic activity is forecast to be Quiet initially, but probably rising on day 1 (15 Jun) to become Unsettled with Active spells with the fast wind enhancement. There is a chance of isolated G1/Minor Storm intervals, mainly later on day 1 (15 Jun), but with a slight chance early on day 2 (16 Jun). Activity then easing to Quiet with Unsettled intervals day 3 and 4 (17-18 Jun).

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

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continue at largely background levels initially, until after the fast wind enhancement. Then likely becoming Moderate, perhaps briefly High from day 2 onward (16 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 15/0745 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:

There are no Earth-directed CMEs.

The onset of the fast wind associated with the High-Speed Stream (HSS) of CH12/- is starting to take place. Confidence in this assessment is high due to the solar data sampled by STEREO-A approximately half a day upwind of Earth in the Parker Spiral. The IMF there peaked at 22nT at 15/0326 UTC and a Bz of -19nT at 15/0324 UTC. Wind speeds increased to around 550-600km/s, although there has been no solar wind speed data available from STEREO-A since around 15/0330 UTC.

Solar winds at Earth should increase on day 1 (15 Jun) from ambient background levels to similar speeds observed at STEREO-A (so around 550-600km/s). Winds may peak during the early part of day 2 (16 Jun) before declining through the remainder of the period, likely back towards slightly elevated or background speeds. 27-day persistence is currently a poor guidance due to a combination of altered CH structure, along with CME contamination on the last rotation. Enlil is providing a good representation expected arrival times, albeit with winds below current anticipated speeds of 550-600km/s.

Geomagnetic activity is forecast to be Quiet initially, but probably rising on day 1 (15 Jun) to become Unsettled with Active spells with the fast wind enhancement. There is a chance of isolated G1/Minor Storm intervals, mainly later on day 1 (15 Jun), but with a slight chance early on day 2 (16 Jun). Activity then easing to Quiet with Unsettled intervals day 3 and 4 (17-18 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 | 30 | 15 | 1 | 1 |
| 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 - Nil

Radio Blackouts - X-Ray Flares:

Low activity is expected to continue, with a chance of isolated M-flares.

There are seven numbered sunspot regions. AR3333 (Dai/Beta) in the southeast quadrant is the most complex region currently on the disc, a bipolar group with minor growth of some small intermediate spots. Other bipolar groups in the southeast include AR3335 (Dao/Beta) and AR3336 (Dao/Beta). AR3336 is of particular interest as it appears to be an 'Anti-hale' region with positive lead and negative polarity trailer spots. This combined with its proximity to the more typical (Hale region) AR3335 close to the north may provide strong latitudinal magnetic shear through interaction between the two. This increases the chance for significant flares. Both regions also possess a small number of weak intermediate spots at this time and these will be closely monitored for any further development.

All other regions are smaller and simpler at this time. Two small regions are currently emerging over the northeast limb, however are significantly foreshortened in available imagery and are difficult to confidently assess at present. Further regions are also potentially approaching the northeast and southeast limbs as inferred by brighter flux regions in STEREO A and SDO imagery.

| 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 | 30 | 30 | 30 | 30 |
| Very Active | R3 to R5 X Class | No | 2 | 2 | 2 | 2 |

Figure 2: GOES-16/18 X-ray flux

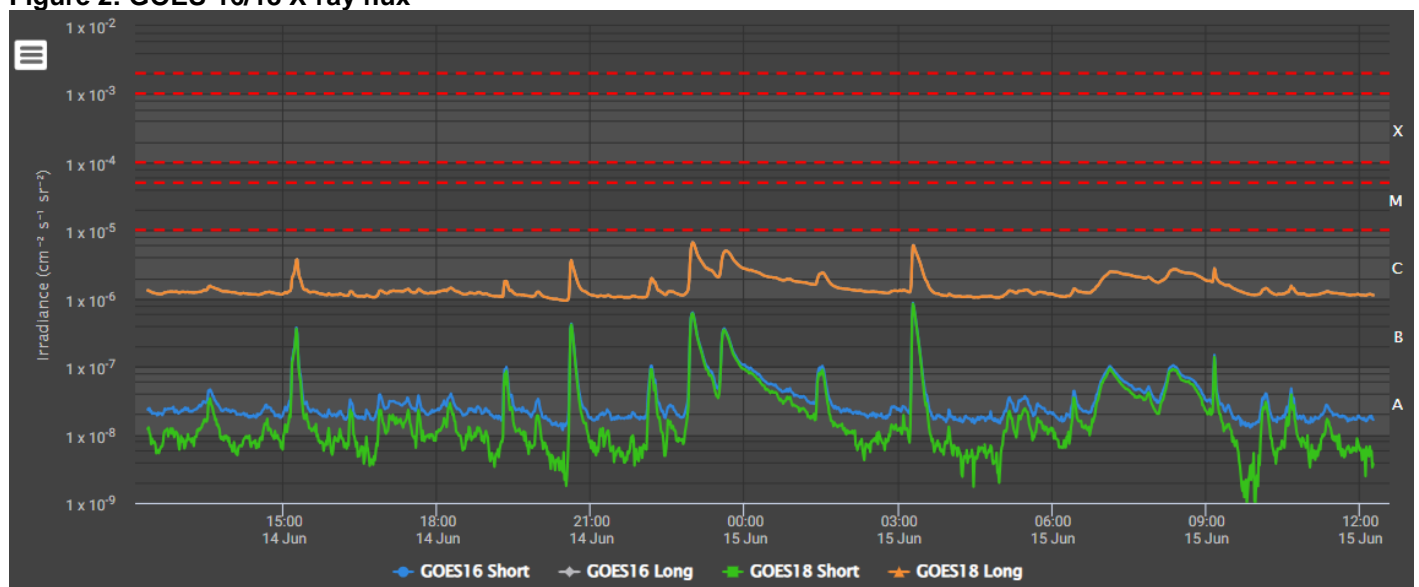
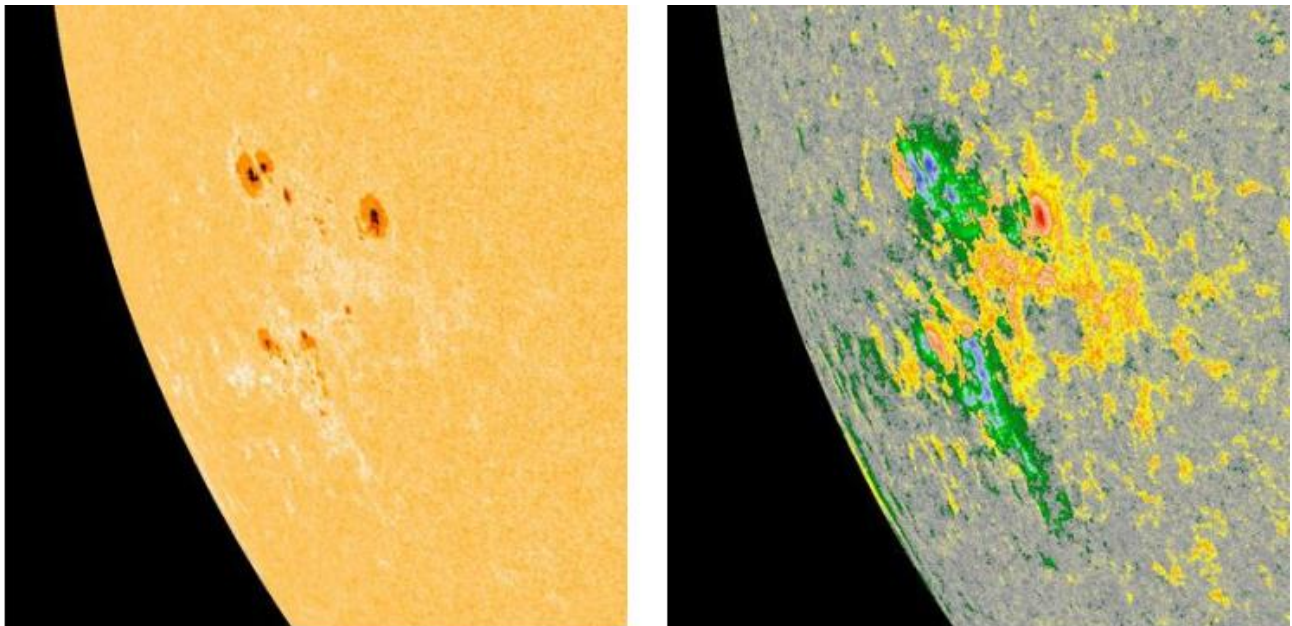


Figure 3: HMI-Intensitygram Flat (Orange) and HMI-Colorized Magnetogram (right) for AR3335 and AR3336. AR3336 in the south has the opposite sunspot dipole as compared to a typical southern hemispheric region in Solar Cycle 25.



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 declining sunspots currently in a geo-effective location on the Earth-facing disc.

| 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 | 3 | 3 | 1 | 1 |
| 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 largely be at Background, until at least later on day 2 (16 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 (16 Jun) onwards, perhaps becoming High at diurnal max.

The associated 24 hr electron fluence is expected to remain steady and below the Active ($1\text{e}8$ integrated pfu) threshold days 1 and 2 (15 and 16 Jun), with the REFM model currently providing generally good guidance for this period. A mainly increasing trend is then expected from day 2 through to day 4 (16-18 Jun), but most likely remaining below the Active threshold.

| 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 | $\geq 2 \text{ MeV}$ $\geq 1 \times 10^8$ | No | 1 | 1 | 10 | 20 |
| Very Active | $\geq 2 \text{ MeV}$ $\geq 1 \times 10^9$ | No | 1 | 1 | 1 | 1 |

Figure 4: GOES-16 24hr $>2\text{MeV}$ Electron Fluence and REFM with recurrence.

