
Space Weather Technical Forecast

Issued on Wednesday, 21 June 2023 at 01:17 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: R1/R2 Radio Blackouts Likely throughout. Slight Chance of Minor Geomagnetic Storm G1 Days 2 & 3.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been High in the last 24 hours, with an impulsive X1.1 flare observed at 20/1709UTC and originating from AR3341. There are now up to ten sunspot regions on the disc, some of which display a rather large north-south extent and may yet be partitioned into separate groups, namely AR3340 and AR3341. The largest and most complex region remains AR3335 however it has been largely inactive and has somewhat reduced in size over the last few hours. There are two active regions, AR3341 and AR3342. AR3341 has recently emerged in the south-east quadrant, whereas AR3342 has grown rapidly in the past 24 hours and is now a potential marker for heightened activity. Two other regions have developed rapidly in the last 24 hours, AR3344 in the north-west and AR3345 in the north-east. Developed AR3338 and AR3343 have both faded in the past 24 hours.

There are numerous filaments on the disc at present. Perhaps the most obvious event was a large prominence lift-off from the north-western limb around 20/0500UTC. In addition to this, a rapidly emerging filament was then seen in H-Alpha imagery in the western solar hemisphere between 20/0400-0500UTC, although this did not culminate in any lift-off at the time of writing. Also of note was movement in filaments near the solar meridian in the southern solar hemisphere through the current UTC morning, although there is again no evidence of any resulting CME in coronagraph imagery.

At present then, there are no new confirmed Earth-directed CMEs.

Solar Wind / Geomagnetic Activity: The solar wind, as measured by DSCOVR and ACE at L1, showed probable ongoing connection to a negative polarity fast wind. The phi angle was accordingly mostly negative (towards the Sun). DSCOVR in particular has recently shown slight discontinuities in its speed trace, one of which occurred at 20/1900UTC - this was not very well reproduced at ACE, and while these may be instrument errors, they are perhaps more likely to be variation within negative polarity coronal holes.

The solar wind speed was relatively steady and confined to Slightly Elevated levels, between 410-460km/s. The solar wind density was mostly around average, while the IMF was at or below 8nT. The north-south component, Bz, ranged from +6 and -6nT, with an erratic behaviour. The net effect of the above solar wind measures was Quiet with two provisional Unsettled intervals, one in the 20/00-03UTC period and the next one at 20/21-24UTC.

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 mainly Moderate and High flux, with a diurnal peak of 2130pfu observed at 20/1725UTC. The
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associated 24-hour fluence displayed a slight rising trend but remained below the Active threshold. The observed fluence at 21/0001UTC was 5.58e7.

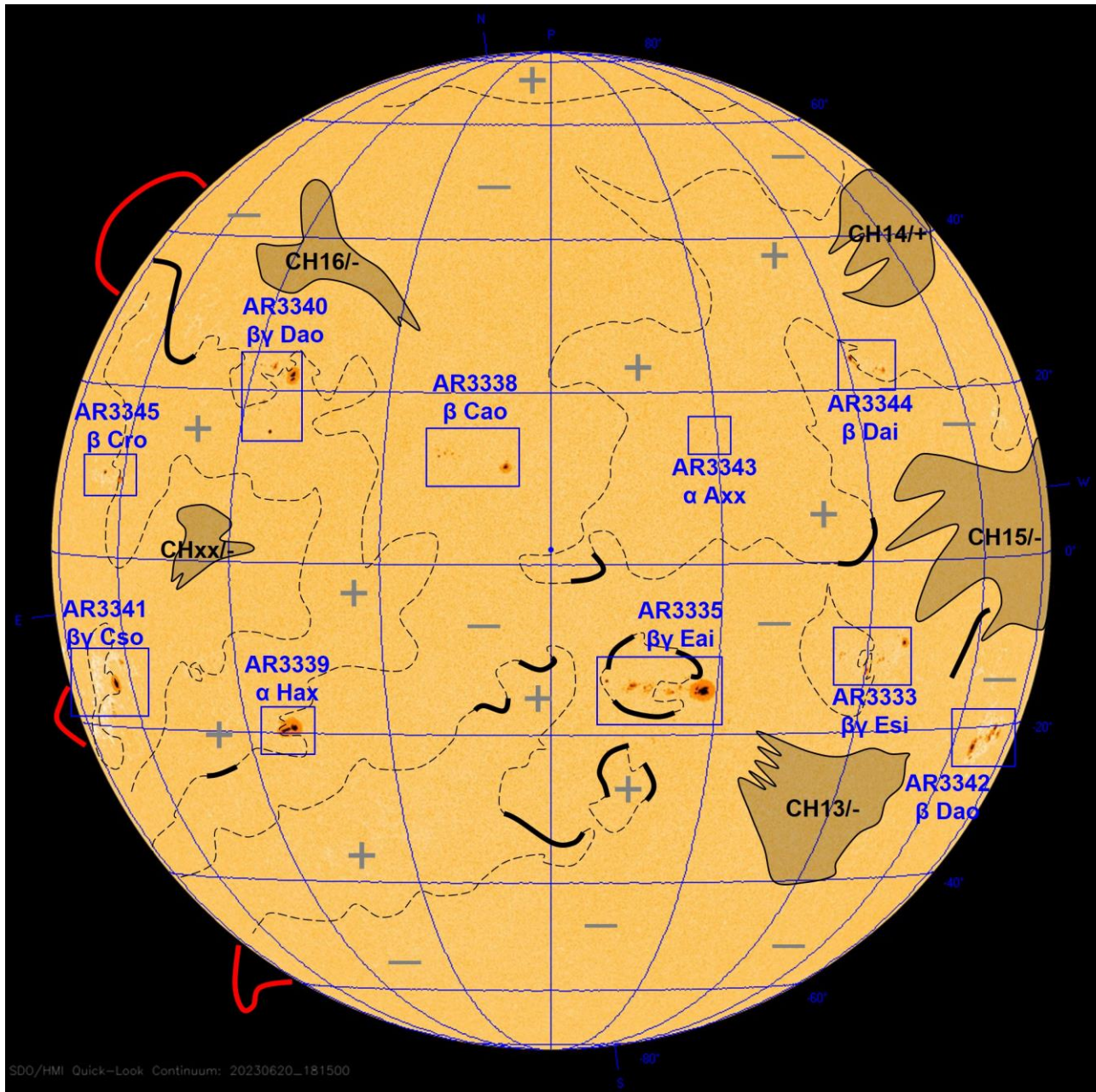
Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to remain Moderate, with isolated or occasional M-class flares and a slight chance of X-class flares. The risk may reduce after mid-week as AR3342 rotates over to the far side.

Solar Wind / Geomagnetic Activity: The geomagnetic forecast carries lower-than-average confidence. While mostly Quiet to Unsettled conditions are expected overall, there is a chance of an Active or even a slight chance of a G1/Minor Storm interval on Days 2 & 3 (22nd & 23rd), under the combined influence of an expected fast wind and also perhaps additive glancing from some minor peripheral CMEs.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at Background levels, with a daily Slight Chance of S1 or greater. High energy electron flux (greater than 2MeV) is expected to become confined to low and moderate levels, and the 24-hour integrated fluence to remain most likely than not under the Active threshold.

Figure 1. Solar Analysis Valid 20/2000UTC.



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:

The geomagnetic forecast carries low confidence for the upcoming forecast period. The reasons for this are two-fold: firstly, in terms of persistence, the geometry of the upcoming coronal holes has changed relative to last pass, and the successor to CH15 is further south than on its last outing, now that AR3333 has closed the flux lines to its north. Not only has the geometry changed, but possibly spurious discontinuity signals from L1 may be the result of a faint switch from CH15 into CH13, in which case this event was underwhelming and the chances of G1 from this have essentially passed. These signatures are currently felt to be more likely instrument errors or natural variation within CH15 & CH13. Whether outstanding or not, the risk of activity from coronal holes should end on Day 2.

The second main part of the forecast is perhaps even lower confidence, with the Sun having released several peripheral CMEs in recent days. These are showing in the latest MOSWOC Enlil widget and ensemble but the model has proved very volatile in this respect in recent runs, and it remains the case that the deterministic favours an essentially unperturbed coronal hole fast wind starting on Day 1.

STEREO A MAG and PLASTIC currently shows a deviation from a negative to a positive phi angle around the 20/0950UTC, which would possibly suggest the tail end of CH15, without however giving any indications whether Earth is about to transit into CH13's influence.

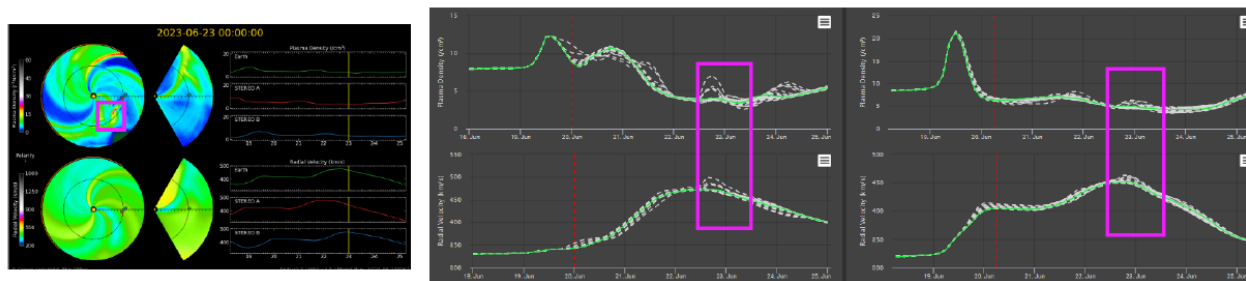
All considered, while mostly Quiet to Unsettled conditions are expected overall, there is a chance of an Active or even a slight chance of a G1/Minor Storm interval on Days 2 & 3 (22nd & 23rd), under the combined influence of an expected fast wind and also perhaps additive glancing from some minor peripheral CMEs

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	5	10	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

Most likely NIL

Figure 2: Latest MOSWOC Enlil run (20/0600UTC badge time), showing one of the possible glancing incidence CMEs in the period boxed magenta. Also shown are the 00 and 02UTC ensemble runs, showing the same CME boxed and serving to illustrate the volatility in magnitude with this feature. The timing of other CMEs also varies in addition to the magnitude, and it remains the case that the deterministic run is the preferred course of events.



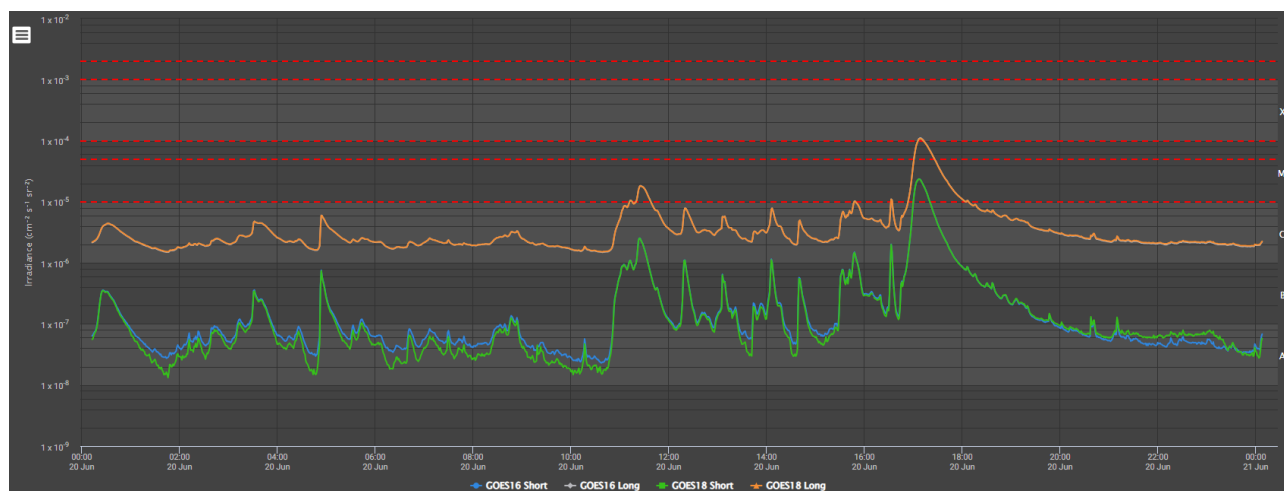
Radio Blackouts - X-Ray Flares:

The number of sunspot regions on the Earth-facing disc is now in double figures. AR3341 and AR3342 have been particularly active over the past 24 hours, generating occasional M-Class flares and even an X-class flare, observed at 20/1709UTC. It was a bit of a surprise, mostly because it originated from a Dso/Beta-Gamma region that is not prone to generating that level of flares. This region, AR3341, has since been reanalysed as Cso/Beta-gamma, which is a step down although it remains large and potentially susceptible to develop further. AR3342 has grown rapidly in the past 24 hours and is also a potential marker for heightened activity. In addition to this, two other regions have developed rapidly in the last 24 hours, AR3344 in the north-west and AR3345 in the north-east although these remain slightly smaller.

While there are some returns from far-side soundings suggesting arrivals are possible in the period, these are less numerous and less expansive than in the recent past, and the signs are that the facing hemisphere is perhaps the busier one in terms of spots. STEREO A's view of the arriving eastern limb is now very 'last minute' given its proximity to Earth, however there are no major signs of imminent arrivals to compensate for the soundings' inherent lack of perception near the limb. Given these factors, and the volatility in growth/fading trends across the disc (rather than being wholesale growth for example) means that depopulation of the front side is the main driver of changes to flare risk in the period, and AR3342 is expected to depart through the UTC day of Thursday 22 June, leading to a step-wise decrease thereafter.

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	60	60	55	50
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3: Latest X-Ray Flare Activity, as observed from GOES-16



Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux is expected to remain at Background levels. However there is a daily slight chance of reaching the S1/Minor Storm threshold given the number and complexity of some sunspot regions, perhaps increasing very slightly over time.

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	10	15	20	20
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 ($\geq 2\text{MeV}$):

The upcoming forecast carries greater-than-average uncertainty given the number of possible minor interruptions from peripheral CMEs, as hinted at in the MOSWOC Enlil ensemble, which is proving volatile from run to run.

Also complicating the electron forecast is the transition of the fast wind from CH15 into CH13. There is a chance that this may have already occurred, with both magnitude and density proving insufficient to populate the Van Allen belts. The High energy electron flux (greater than 2MeV) may have exceeded High levels over the last 24 hours but it fell sharply during the evening UTC and displayed a slightly lower diurnal peak compared to previous days.

All considered and with an absence of significant geomagnetic activity over the following days, the high energy electron flux is most likely to become confined to low and moderate levels, the result being the fluence more likely than not to remain under the Active threshold and perhaps display a slight decreasing trend over time.

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	40	30	20	10
Very Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^9$	No	1	1	1	1

Figure 4: Electron Flux over the last 7 days, as observed from GOES-16

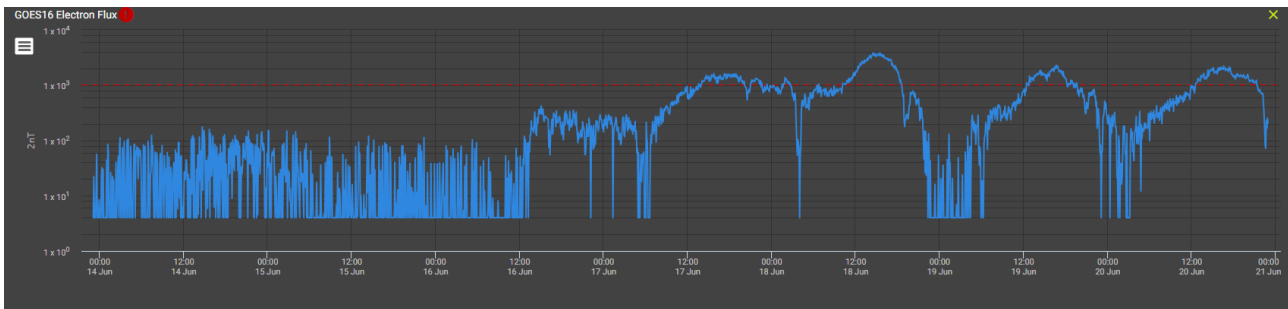


Figure 5: Latest REFM output

