
Space Weather Technical Forecast

Issued on Tuesday, 20 June 2023 at 13:16 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 through midweek. Latent daily Slight Chance of Minor Geomagnetic Storm G1.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate over the past 24 hours, with X-ray flux detected at GOES16 showing occasional C-class flares after an early impulsive peak of M1.1 at 19/1214UTC from the southeastern limb, probably tied to the arrival of AR3341 here in the ensuing hours. At the very end of the period this was trumped by a longer-duration overlaid pair of flares from both AR3342 and AR3341, eventually peaking at M1.8 at 20/1125UTC.

The number of sunspot regions has now likely reached double figures, including two unnumbered. Some of the numbered regions also display rather large north-south extents, and may yet be partitioned into separate groups, namely AR3340 and AR3341 near the eastern solar horizon. The most significant region on the disc in terms of complexity is now perhaps AR3342 in the southwest, which is both compact and is showing a possible Mt Wilson delta spot. This region has grown rapidly in the past 24 hours, which is another possible marker for heightened activity here. Other trends were a gradual development of spots in AR3340, AR3335, as well as the emergence of the new regions. AR3332, 3337 and 3336 meanwhile, all faded to plage.

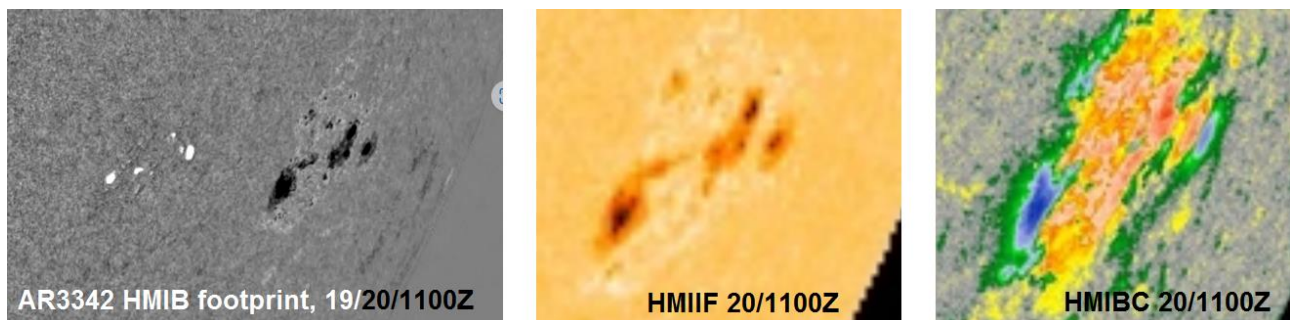


Figure 0: Helioviewer.org processed difference imagery in HMIB footprint of AR3342 in the southwest, showing marked growth in the period. Also shown are its most recent appearance in HMIIF and HMIBC, around the time of its M-class flare. A Mt Wilson delta spot appears to be developing in its intermediate portion.

There are numerous filaments on the disc at present. Perhaps the most obvious event was a large prominence lift-off from the northwestern 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. Coronagraph imagery itself shows a bright emission from the northwest disc in COR2 imagery, with this feature to be analysed once Lasco imagery becomes available.

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, probably that from CH13. The phi angle was accordingly mostly negative (towards the Sun). DSCOVR in particular has shown some slight discontinuities in its speed trace in the past 24 hours, especially at 19/1500UTC but also 19/2230UTC - these are not very well reproduced at ACE, and while these may be transitions between negative polarity fast winds, they are perhaps more likely to be variation within the current coronal hole.

The solar wind speed was mainly confined to Slightly Elevated levels within the 400s of km/s (at ACE), with a peak in the high 400s seen around the turn of the UTC day. The solar wind density was within single figures ppcc throughout, while the IMF was at or below 8nT. The north-south component, Bz, ranged from +5 and -6nT, with an erratic tendency.

The net effect of the above solar wind measures was for provisionally Quiet to Unsettled Kp indices throughout, peaking at 3+ in the 15-18UTC and 21-24UTC windows.

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 2270pfu observed at 19/1640UTC. The associated 24-hour fluence showed a fall and then slight rise in the past 24 hours - observed fluence at 20/0001UTC was 5.58e7.

Four-Day Space Weather Forecast Summary

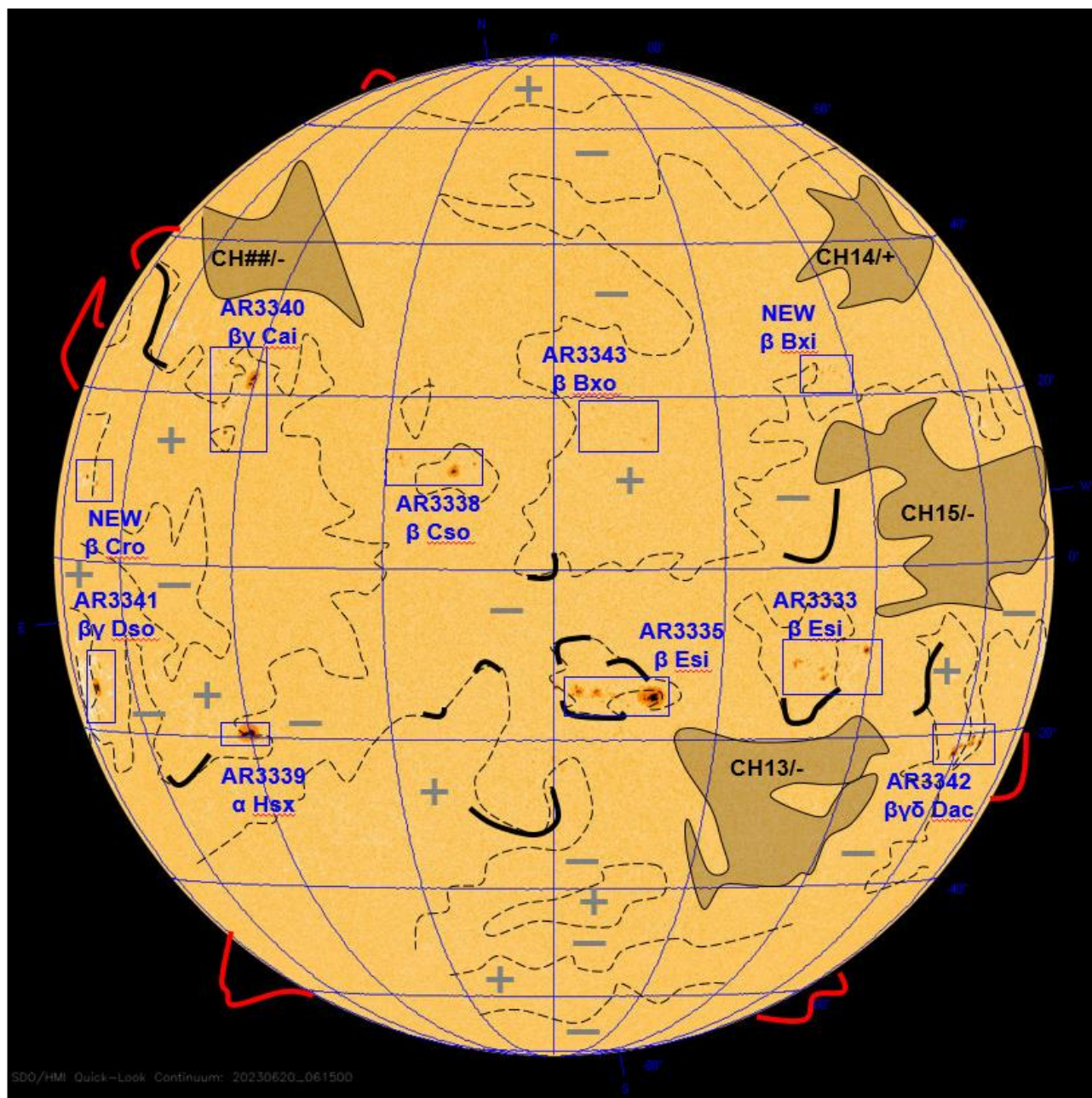
Solar Activity: Solar activity is Likely to be Moderate through midweek, with slight depopulation of the frontside later this working week perhaps reducing this risk slightly.

Solar Wind / Geomagnetic Activity: The geomagnetic forecast carries lower-than-average confidence. Current mainly Quiet conditions should give way to a latent daily Slight Chance of G1, given a combination of an expected fast wind midweek, and also perhaps additive glancing influence 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) may increase slightly in the four-day period, but is expected to suffer from low confidence inherited from the geomagnetic forecast. On balance, there is a rising Chance of breaching Active 24-hour integrated fluence, but perhaps not to the degree or as soon as suggested by MOSWOC REFM.

Figure 1. Solar Analysis Valid 20/0615UTC.



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 the same CH13. Whether outstanding or not, the risk of activity from coronal holes should peak on or before midweek UTC.

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 ensemble as three slight density and then speed increases, 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 Wednesday 21 June.

STEREO A MAG and PLASTIC currently only offer around a 12-hour lead up to any effects at L1 and Earth given the satellite's proximity to Earth. This current shows no deviation from a negative phi angle, but nor does it show any obvious possible recent CH15 into CH13 transition. It is therefore on balance perhaps more likely to have yet to occur.

All considered, initially Quiet to Unsettled activity should give way to a latent low-level risk of G1 through the four-day forecast period due to a fast wind, perhaps more likely arriving day two, Wednesday 21 June, and also glancing blows from CMEs thereafter, with confidence in their presence and phasing falling with time.

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	15	10	15
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.

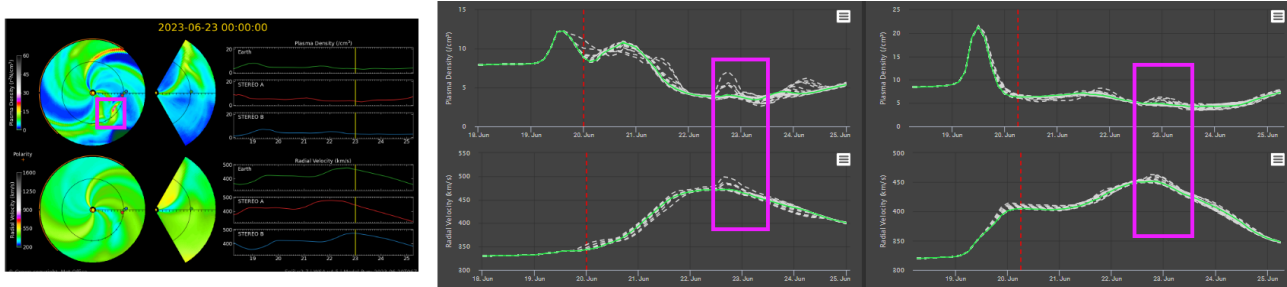
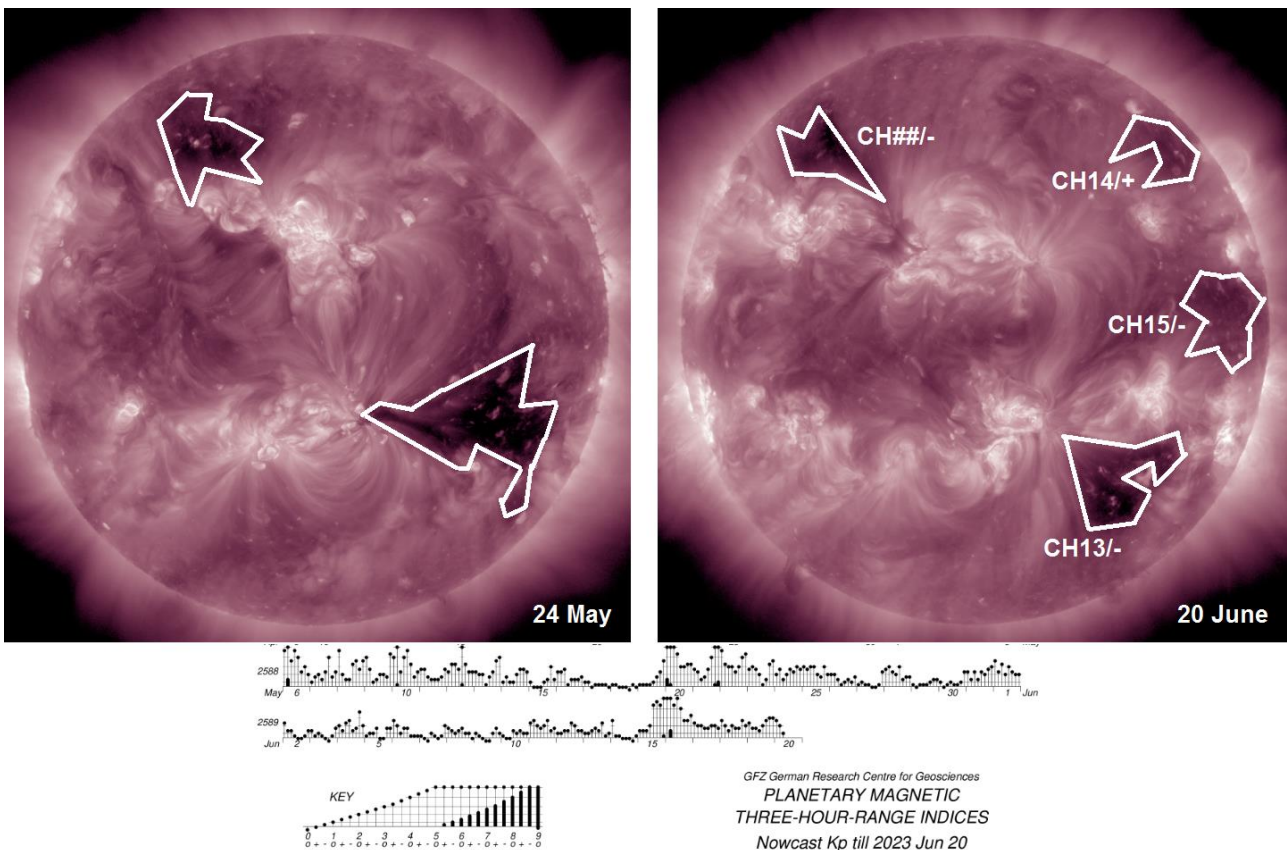


Figure 3: SDO AIA211 imagery from the previous and current rotations, as well as associated geomagnetic activity. Effects were relatively muted on last pass, but may be slightly enhanced relative to this should any of the outstanding glancing blow CMEs materialise in the forecast period.



Radio Blackouts - X-Ray Flares:

The number of sunspot regions on the Earth-facing disc is now perhaps into double figures, as although up to three regions have faded, these have been replaced by at least two 'new developers'. In addition to these changes, the partitioning of perhaps another two of the groups may be reviewed as they appear to span large expanses of solar latitude.

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

Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux is expected to remain at Background levels. The raw probability for the current disc is near 15%. This has been revised downwards a little given the relatively small magnitude of potentially generative X-ray flares observed thus far. There is an ongoing slight chance of S1, probably increasing very slightly with time with westward progression of the busier (in terms of sunspots) facing solar hemisphere.

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	10	10	10
Very Active	≥ S3 *	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = cm⁻²sr⁻¹s⁻¹)

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

High energy electron flux (greater than 2MeV) is expected to diurnally fluctuate between Normal Background and High levels at first, in the absence of significant geomagnetic activity. On current trends, the magnitude of this oscillation may increase slightly relative to the UTC day of Monday 19 June, however will now likely fall short of 24-hour Active fluence.

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 run to run. Also complicating the electron forecast is the small possibility that the influence of the expected fast wind from CH15's transition into CH13 may have already occurred, in which case both the magnitude of the wind and its ability to populate the Van Allen belts is likely to fall significantly short of Active.

All considered, there is a gradual slightly rising risk through midweek UTC of breaching Active in a nod to last rotation, however there are enough complicating factors to make this only a vague expected tendency, and the fluence is perhaps more likely than not to fall slightly short of Active, even at peak.

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



Figure 4: Past week in GOES16 high energy electrons (top), showing upward reaction to an intense fast wind (L1 speed at DSCOVR and ACE (latter yellow shaded)). Also shown is the latest MOSWOC REFM, which is offering an accepted trend, if not to this magnitude or immediacy. The numerous CME glances that may affect the forecast render electron counts low confidence.

