An overview of the largest geomagnetic storm in 20 years on 10th May 2024

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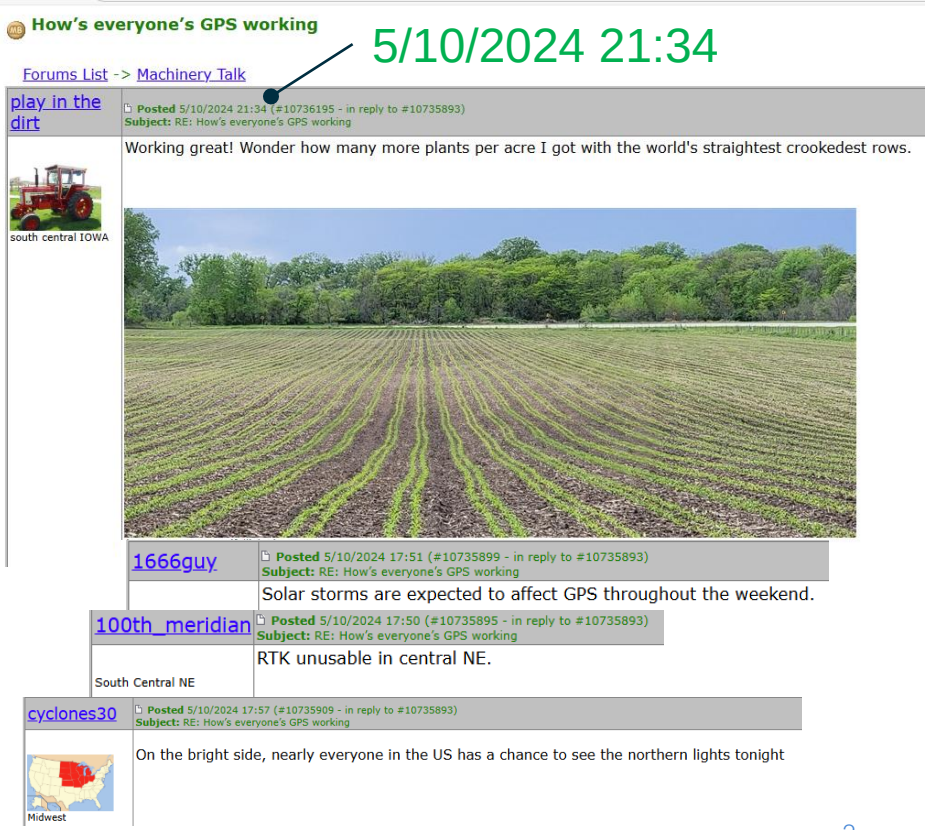
Agenda

- What are geomagnetic storms and why do they occur?
- Details on the May 2024 storm event
- Implications for the global magnetic declination variations during this event
- Magnetograms of declination plus statistics of declination deviations during the storm as recorded at magnetic observatories from around the world



Overview of Geomagnetic Storms

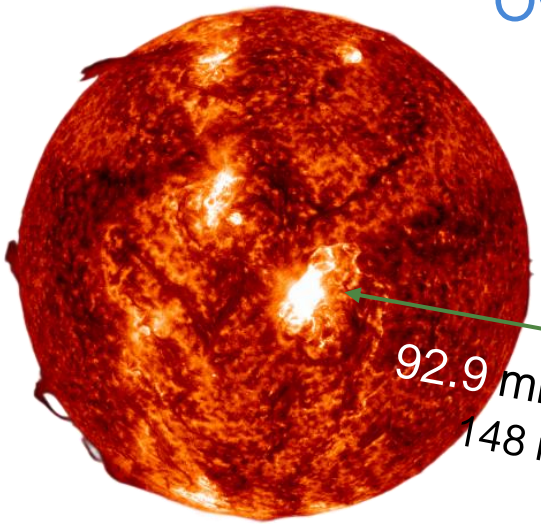


Image Courtesy of Solar Dynamic Observatory (NASA)

92.9 million miles / 19-96 hours
148 million km

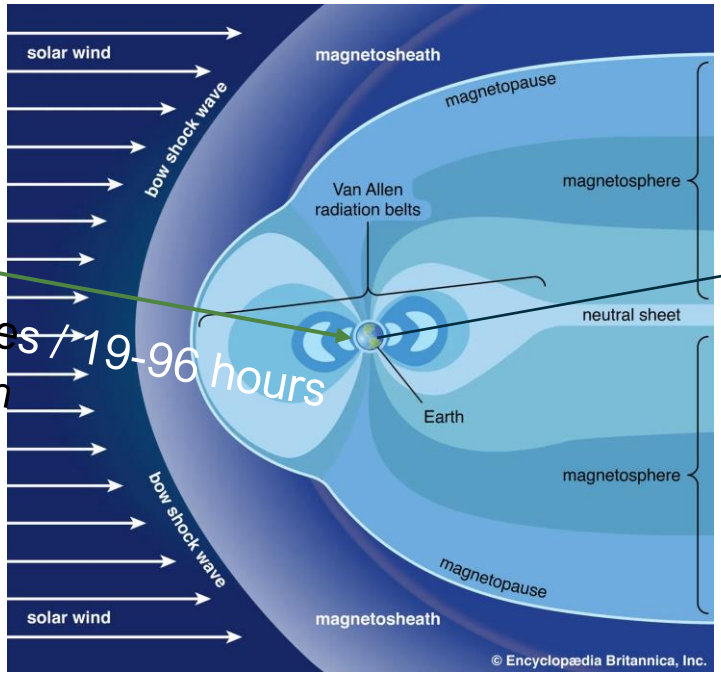
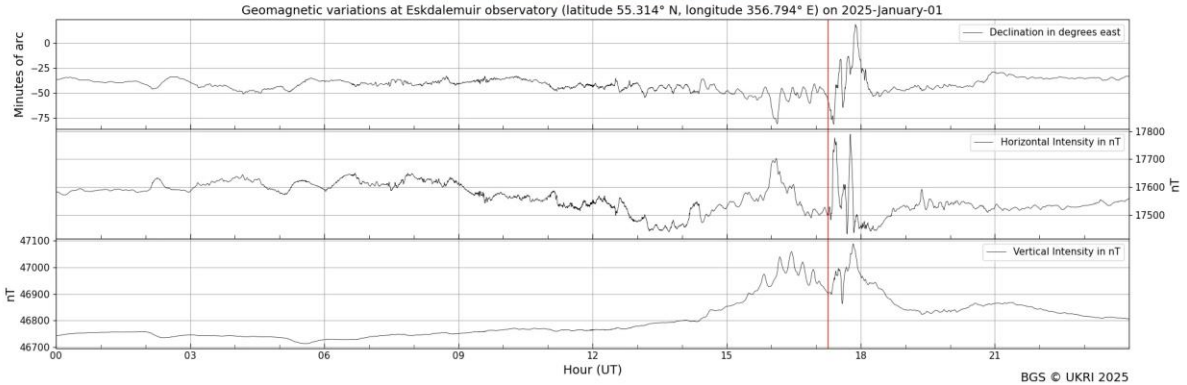
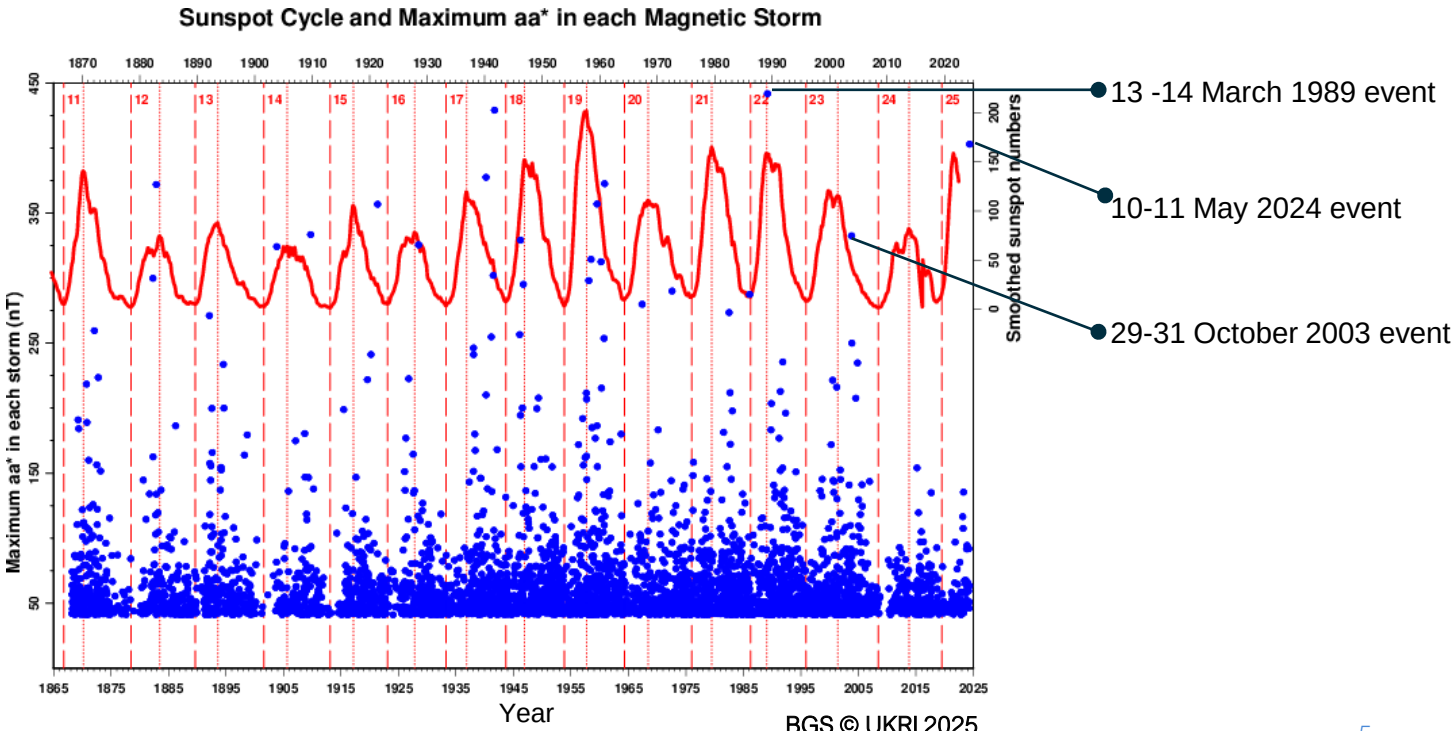


Image Courtesy of Stewart McWilliams

Aurora and Magnetogram in the UK during small to moderate geomagnetic storms

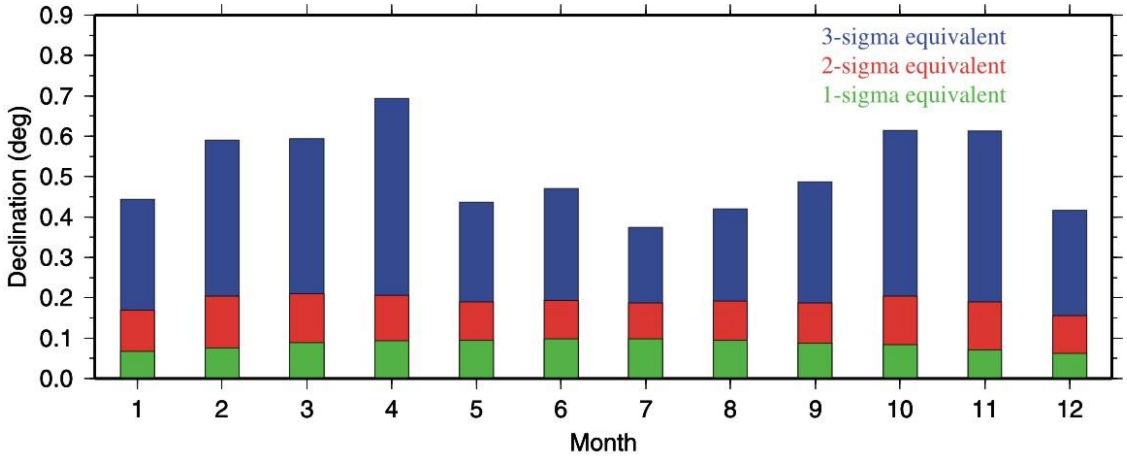


Sunspot Cycle over the last 156 years

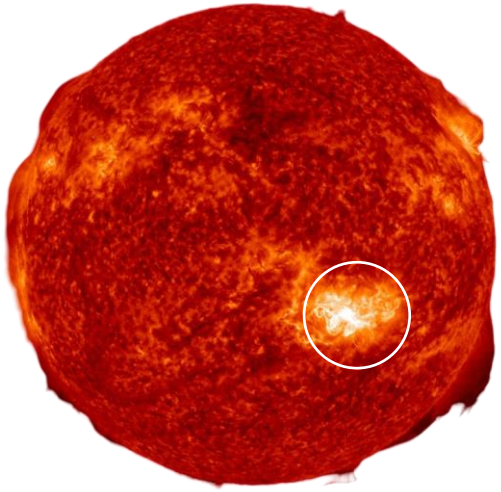


Time-dependent external field uncertainties

Geomagnetic Storms are more likely to occur close to the equinoxes (spring and fall). This feature is prevalent throughout the solar cycle.

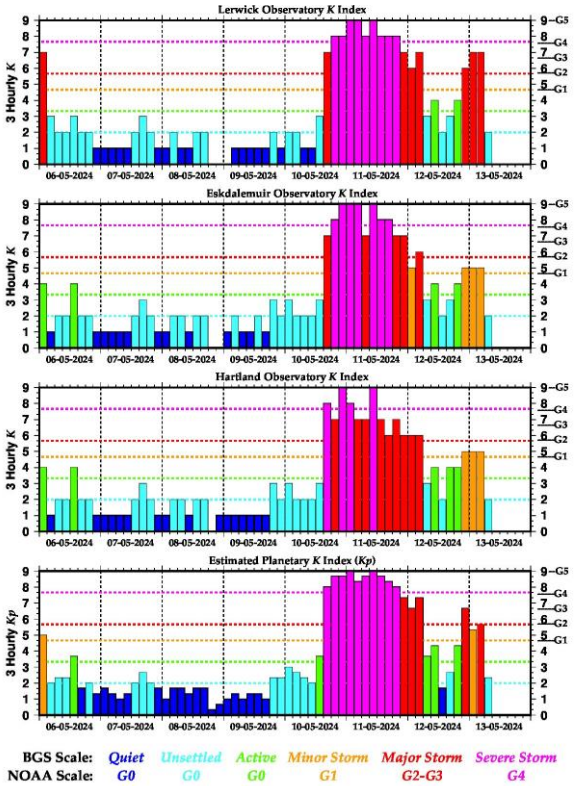


G5 Storm of 10th and 11th May 2024



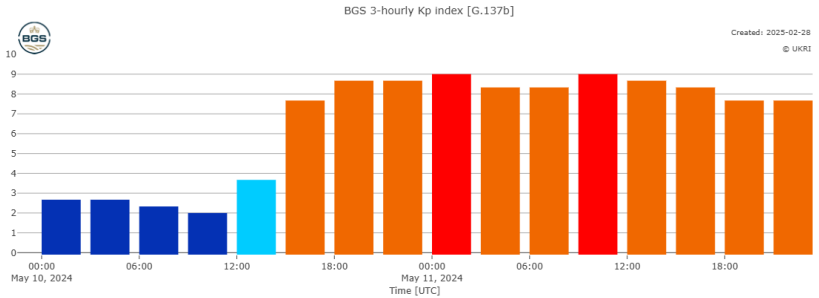
Courtesy of Solar Dynamic Observatory (NASA)

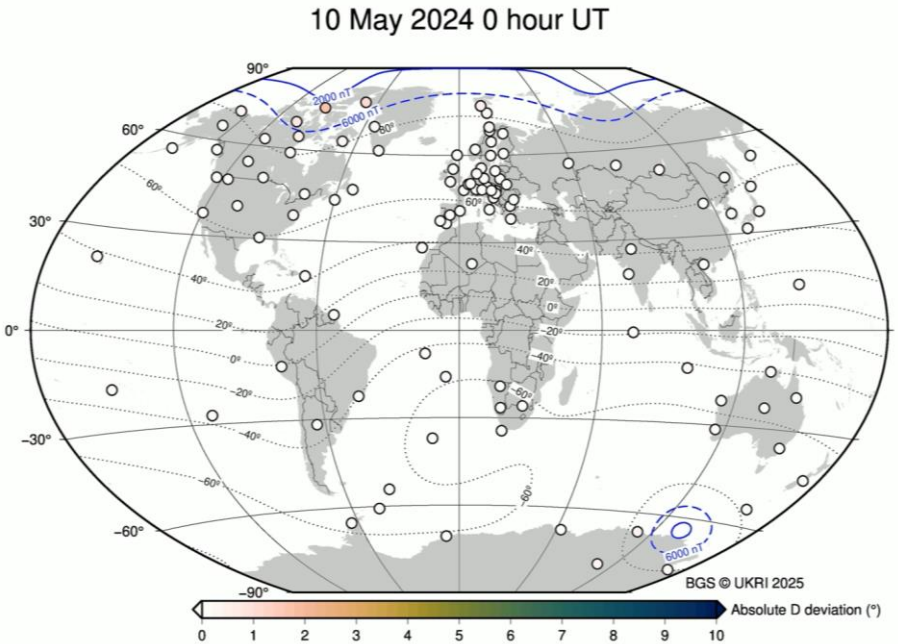
Coronagraph imagery showing full-halo CMEs observed on the 8th May 2024. Images from SOHO/LASCO (ESA/NASA) and SDO (NASA)



Activity:	Quiet	Unsettled	Active	Minor Storm	Major Storm	Severe Storm
Kp Scale:	0-1	2-3	4	5	6-7	8-9

Hour-by-hour Movie of Maximum Declination Deviation 10th-11th May



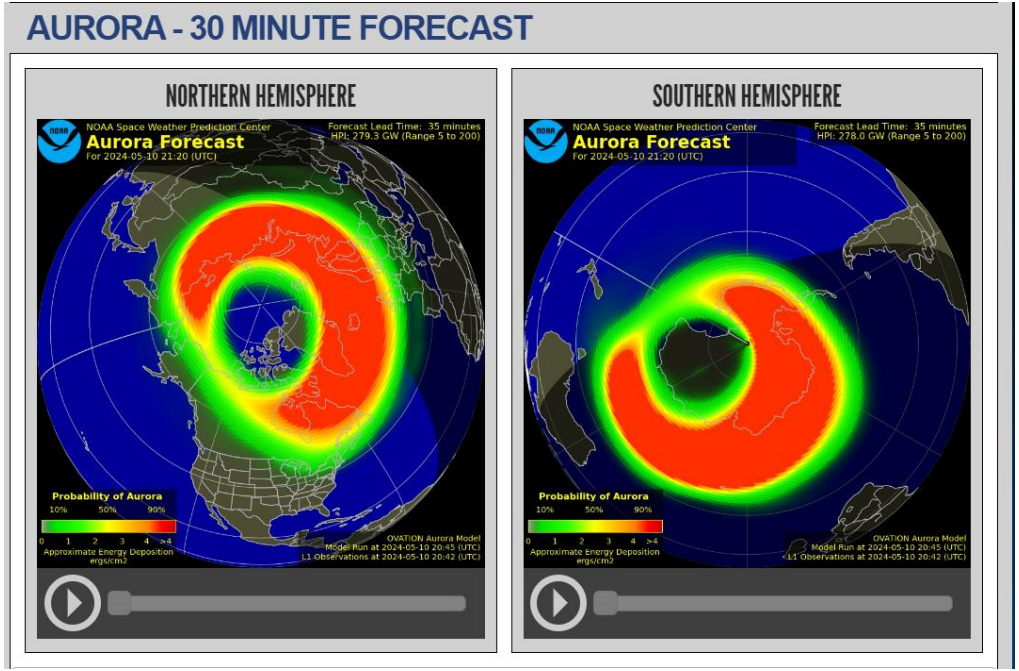


G5 Storm of 10th and 11th May 2024: Aurora Oval

The duration and intensity of this event pushed the leading edge of the auroral oval to lower latitudes.

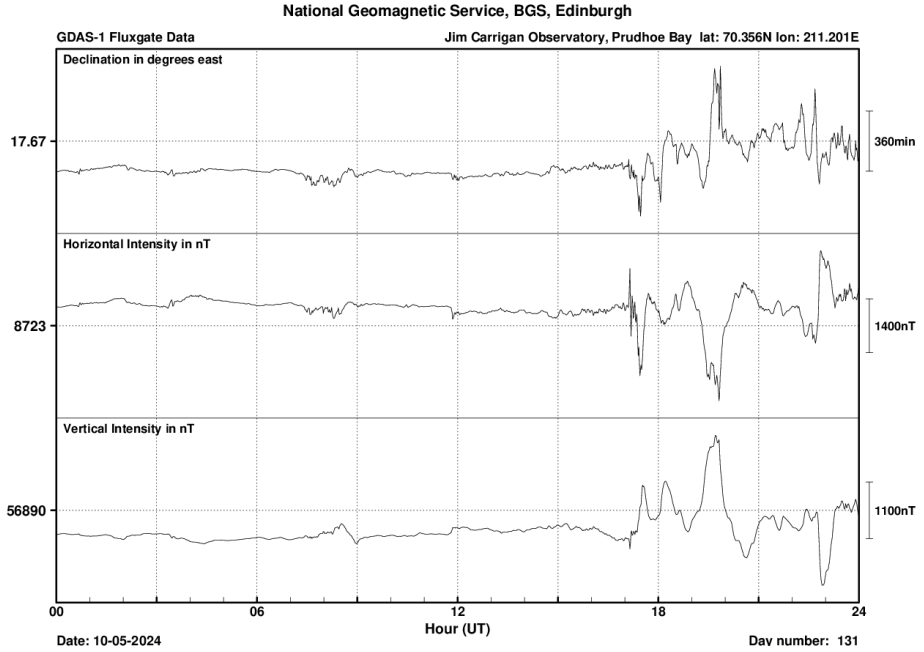
Latitudinal progression of the storm related to the expansion of the auroral oval.

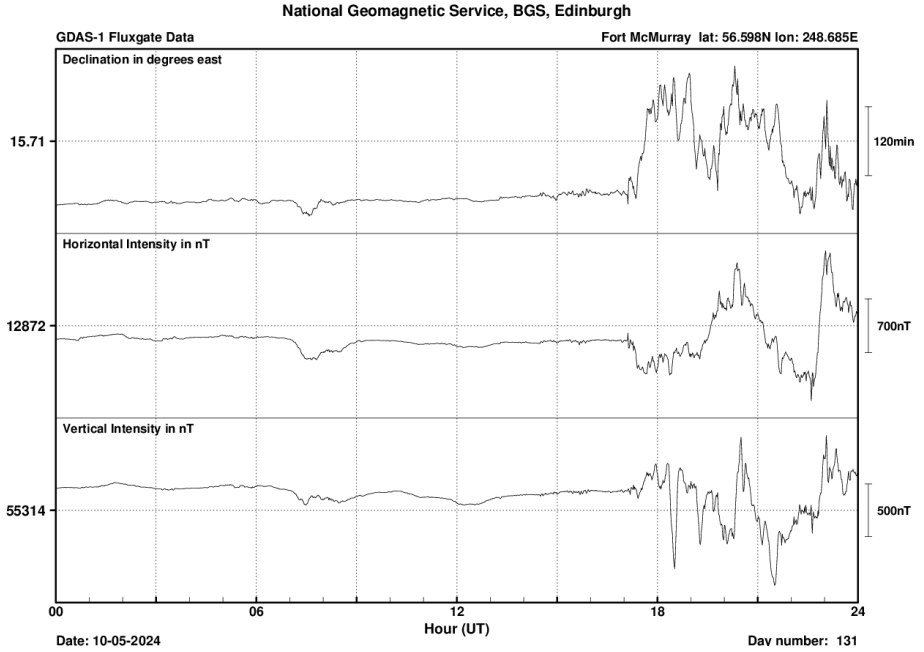
Aurora image (right) is a snapshot and evolves constantly in time.



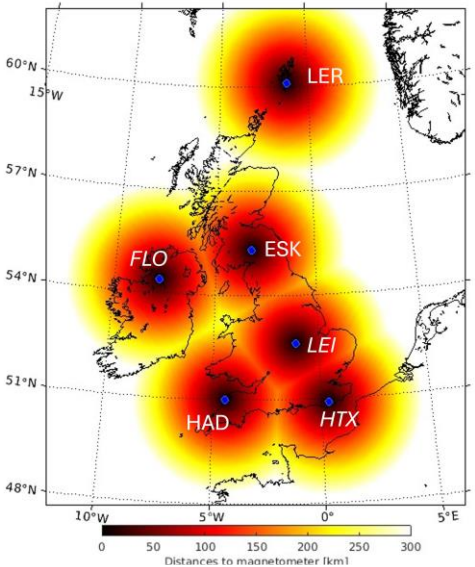
Courtesy of SWPC NOAA

Dec, Dip and Total Field changing at Fort McMurray (Alberta) and Jim Carrigan Observatories (Alaska) on 10th May 2024

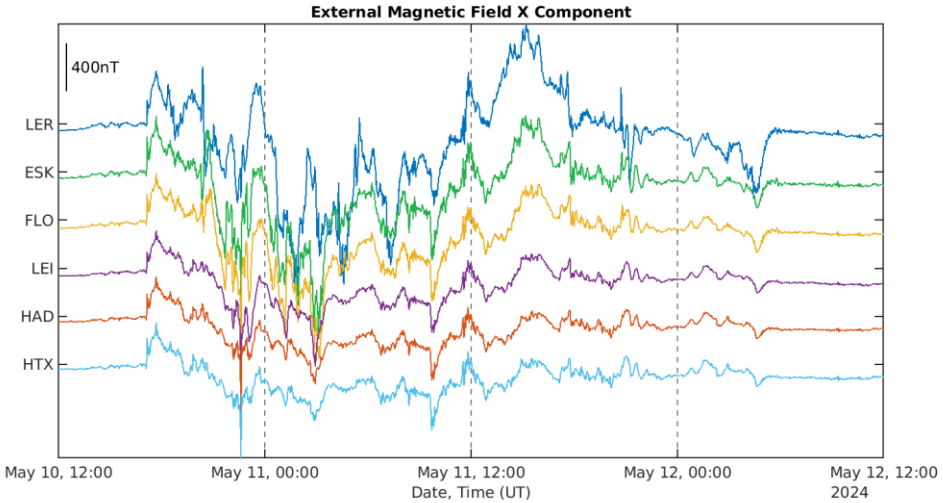




Spread of auroral oval in the UK (60.138° N to 50.995° N)

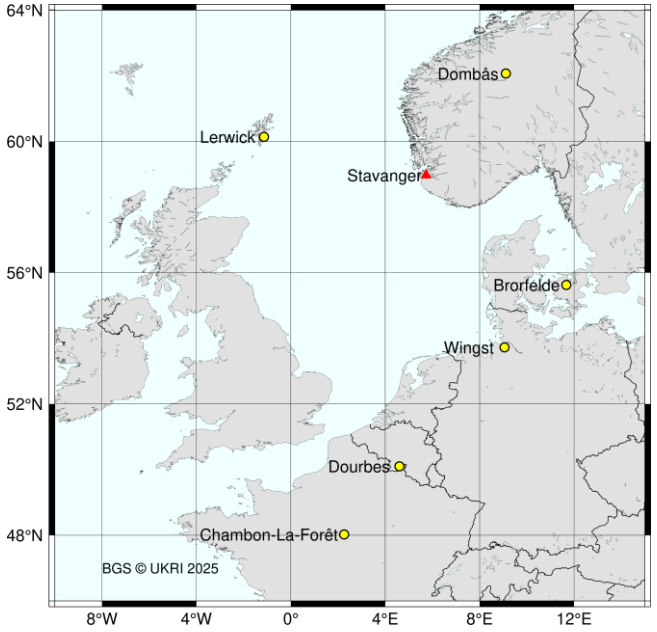


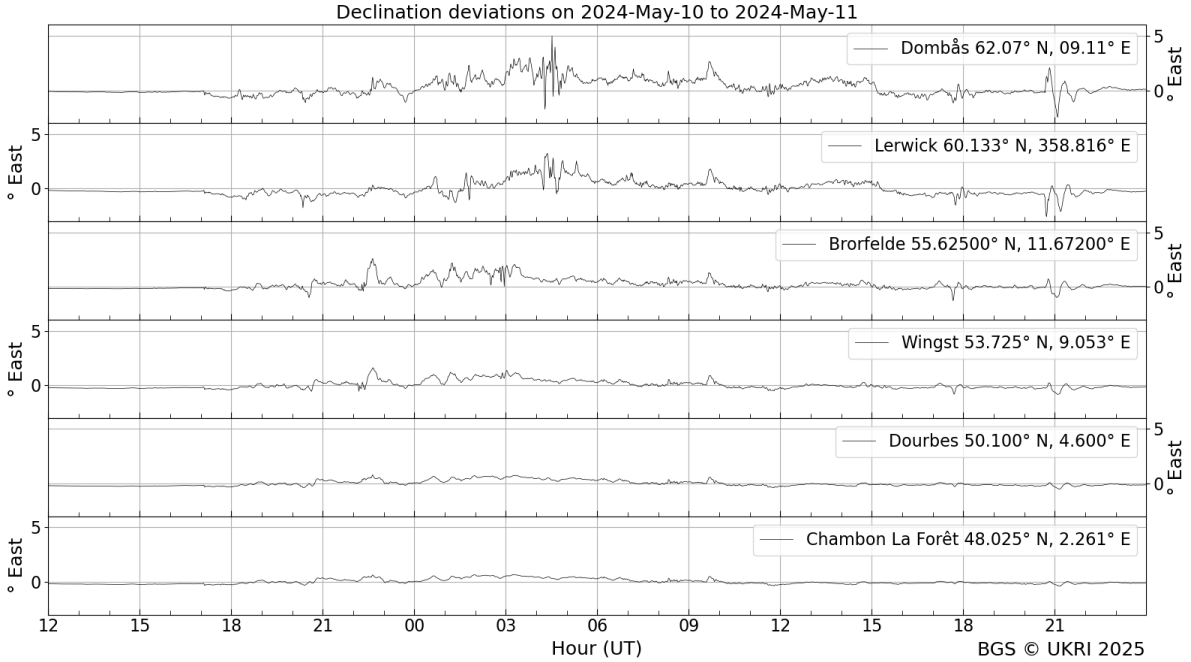
Locations of UK geomagnetic observatories: Lerwick (LER), Eskdalemuir (ESK), Hartland (HAD) and magnetic variometers stations: Florence Court (FLO), Market Harborough (LEI) and Herstmonceux Castle (HTX). From Lawrence, *et al* (2025)



Lawrence, *et al* (2025) Frontiers of Space Weather

Declinations in Western Europe on 10th-11th May 2024





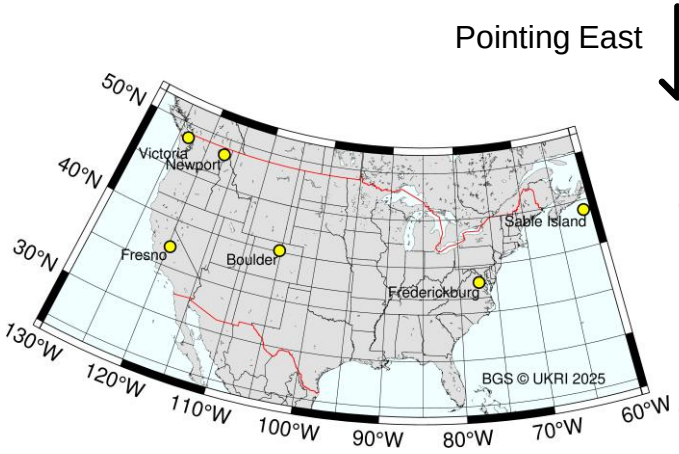
Auroral oval got furthest south in UK and above southern Europe

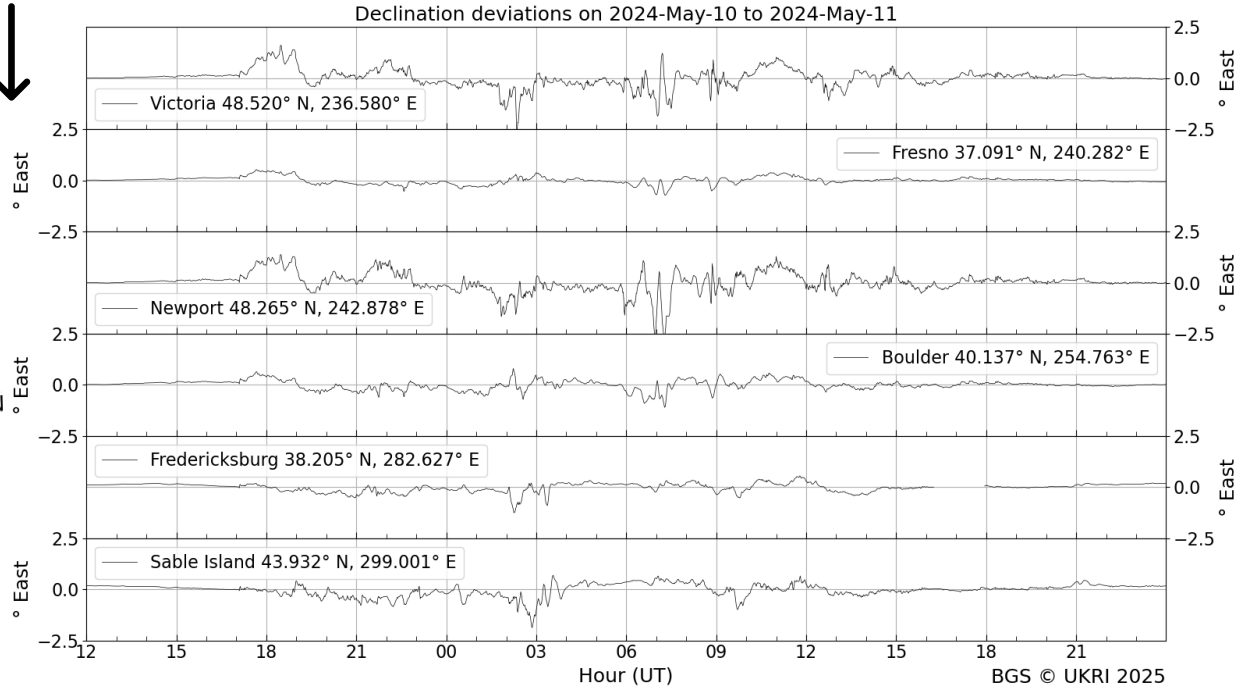
Declination Deviations Before, During and After the Storm: Western Europe

OBSERVATORY	Geomagnetic Latitude (°)	11:00-12:00 UT 10 May 2024	18:00-19:00 UT 10 May 2024	01:00-02:00 UT 11 May 2024	01:00-02:00 UT 14 May 2024	Max D Deviation 10-11 May 2024	Hour and Date (UT) of Max D Deviation
Dombås (NOR)	59.25	0.090°	0.828	2.314	0.107	4.991	04:00-05:00 **11** May 2024
Lerwick* (GBR)	57.56	0.085°	0.925°	1.625°	0.055°	3.415°	04:00-05:00 **11** May 2024
Brorfelde (DNK)	51.99	0.135°	0.347°	2.201°	0.064°	2.607°	22:00-23:00 **10** May 2024
Wingst (DEU)	49.85	0.113°	0.327°	1.357°	0.067°	1.747°	22:00-23:00 **10** May 2024
Dourbes (BEL)	45.67	0.111°	0.259°	0.849°	0.059°	0.919°	22:00-23:00 **10** May 2024
Chambon-la-Forêt (FRA)	43.23	0.108°	0.232°	0.762°	0.052°	0.762°	22:00-23:00 **10** May 2024
Ebro (ESP)	34.66	0.102°	0.218°	0.528°	0.038°	0.528°	01:00-02:00 **11** May 2024

*BGS observatories

Declination in Observatories (US mainland + CAN) Across Different UTM zones



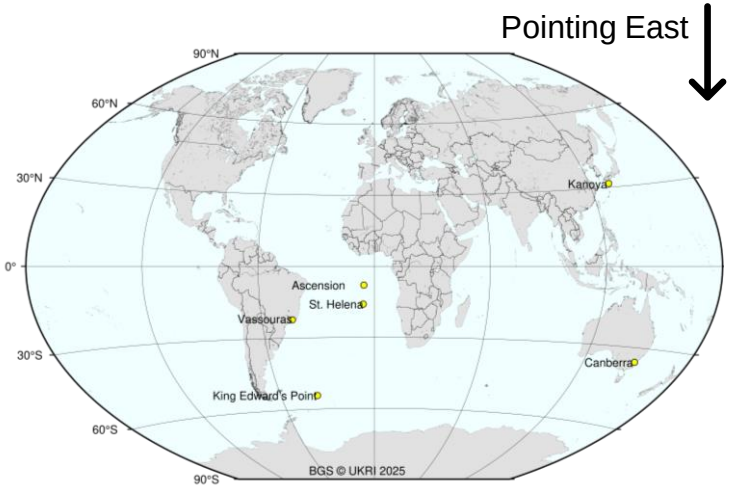


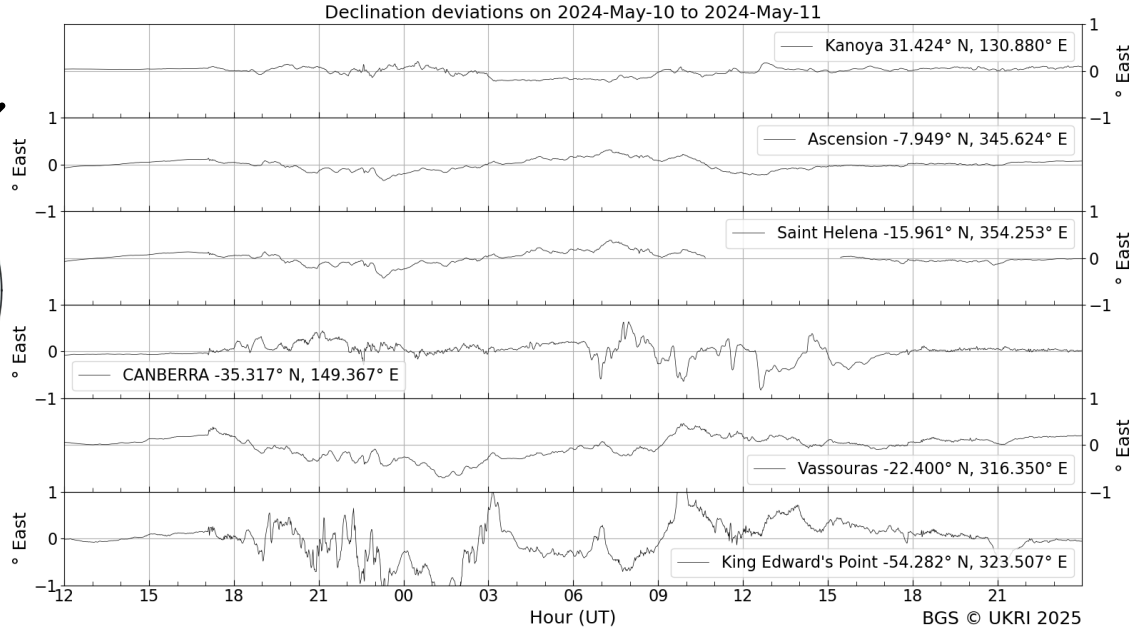
Declination Deviations Before, During and After the Storm: USA & CAN

OBSERVATORY	Geomagnetic Latitude (°)	Geographic Longitude (° E)	11:00-12:00 UT 10 May 2024	18:00-19:00 UT 10 May 2024	0100-02:00 UT 11 May 2024	01:00-02:00 UT 14 May 2024	Max D Deviation 10-11 May 2024	Hour and Date (UT) of Max D Deviation
Victoria (BC)	53.21	236.58	0.053°	1.623°	1.557°	0.117°	1.867°	07:00-08:00 **11** May 2024
Newport (WA)	54.13	240.282	0.055°	1.405°	1.645°	0.055°	1.645°	01:00-02:00 **11** May 2024
Fresno (CA)	42.61	242.878	0.358°	0.518°	0.332°	0.072°	0.532°	22:00-23:00 **10** May 2024
Boulder (CO)	48.08	254.763	0.039°	0.469°	0.571°	0.041°	1.131°	07:00-08:00 **11** May 2024
Fredericksburg (VA)	46.90	282.627	0.071°	0.339°	0.369°	0.029°	1.229°	02:00-03:00 **11** May 2024
Sable Island* (NS)	48.97	299.01	0.116°	0.474°	0.544°	0.044°°	2.024°	02:00-03:00 **11** May 2024
Stannis Space Centre (MS)	40.01	270.360	0.036°	0.264°	0.214°	0.024°	0.444°	08:00-09:00 **11** May 2024

*BGS Observatories

Declinations in Lower Latitude and Southern Hemisphere Observatories Across Different UTM zones on 10th -11th May 2024





Declination Deviations Before, During and After the Storm: Worldwide

OBSERVATORY	Geomagnetic Latitude (°)	Geographic Longitude (° E)	11:00-12:00 UT 10 May 2024	18:00-19:00 UT 10 May 2024	0100-02:00 UT 11 May 2024	01:00-02:00 UT 14 May 2024	Max D Deviation 10-11 May 2024	Hour and Date (UT) of Max D Deviation
Kanoya (JPN)	24.91	130.880	0.008°	0.122°	0.172°	0.048°	0.272°	03:00-05:00 **11** May 2024
Phuthuy (VNM)	15.44	105.960	0.020	0.080	0.190	0.090	0.190	01:00-02:00 **11** May 2024
Ascension* (GBR)	-20.31	345.62	0.135°	0.085°	0.235°	0.005°	0.325°	12:00-13:00 **11** May 2024
Vassouras (BRZ)	-21.93	316.350	0.064°	0.354°	0.924°	0.054°	0.924°	01:00-02:00 **11** May 2024
Hermanus (ZAF)	-42.47	19.230	0.109°	0.251°	0.399°	0.059°	0.929°	22:00-23:00 **10** May 2024
Canberra (AUS)	-45.05	149.360	0.045°	0.335°	0.645°	0.085°	0.835°	12:00-13:00 **11** May 2024
King Edward's Point* (GBR)	-46.24	323.507	0.099°	0.379°	1.309°	0.021°	1.331°	09:00-10:00 **11** May 2024

*BGS Observatories

Summary

- In the May event, we observe rapid equatorward progression of geomagnetic storm based on magnetic observatory measurements causing severe impacts on GNSS and on magnetic field variations
- We are at solar maximum NOT geomagnetic activity maximum (~1.5-year lag); we are likely to experience more frequent occurrences of geomagnetic storms
- Consider the impact from irregular external field variations during storm periods by incorporating real time data of declination, dip, and total field intensity to further improve MWD accuracy because the primary sources *should* be accounted for (to the best of our knowledge)

"… research shows that a super-storm can happen more often than we thought. Don't be misled by the stats (referring to the periodicity of these events), it can happen any time… …" Professor Richard Horne, British Antarctic Survey

Find out more effects of Geomagnetic Storms on Technology

Scan the QR code to visit
https://geomag.bgs.ac.uk/research/space_weather/spweather.html

BGS Geomagnetic Storm Forecast

Forecast period (noon-to-noon GMT)	Forecast Global Activity level	
	Average	Max
10 MAY-11 MAY	STORM G2	STORM G4
11 MAY-12 MAY	STORM G2	STORM G4
12 MAY-13 MAY	STORM G1	STORM G3

For more information about the forecast and activity categories see
geomag.bgs.ac.uk/education/activitylevels.html

Activity during last 24 hours

Global				Local (UK)		
Date	Average	Max	At time (UTC)	Average	Max	At time (UTC)
9 MAY-10 MAY	QUIET	QUIET	18:00-06:00	QUIET	QUIET	00:00-06:00

Additional Comments

There are several Earth-directed coronal mass ejections (CMEs) currently heading our way! All originated from the same, centrally located active region. Three were observed on 08-May, two on 09-May and one earlier this morning which still awaits further analysis.

They will most likely combine into one large arrival late on 10-May or early 11-May resulting in significant and prolonged increase in geomagnetic activity, potentially reaching up to STORM G4 levels over the weekend.

Find out more effects of Geomagnetic Storms on Technology

Scan the QR code to visit
https://geomag.bgs.ac.uk/research/space_weather/spweather.html