☑ Fact-Checked Science

PAPER CHECK · ATMOSPHERIC ELECTRICITY

A storm-day rise in the air's electric field, but Earth's shield kept solar protons out

Five researchers in India and Japan report that during the great storm of 10–11 May 2024 the fair-weather electric field near the ground rose 21–34% at two sites in Japan, as solar particles reached Earth, and that lightning signals surged in eastern India; they suggest the particles played "a more direct role" than the fall in cosmic rays [1 Abstract]. The rise is in their data, but measured against two days and untested [1 l. 330]. Our analysis finds that Earth's magnetic field kept the solar particles away from all four sites [12 Table 1A][15 p. 12], that neutron monitors whose shielding brackets theirs counted fewer particles than usual all day [11], and that the lightning came on the day the most airports in the region reported thunder [22]. S0 News linked the paper on November 15, 2026 [2].

By Fact-Checked Science · Published November 15, 2026

OUR ANALYSIS marks our own reasoning and calculations: the storm's timeline from public records; the cutoff rigidities of the paper's sites and our bound on the storm's effect on them; our tests of the neutron monitors and of the authors' Bagula and Purulia data; our screens of airport weather reports in Japan and India; the values we read from the paper's figures; and the charts. The verdicts are our assessment. Everything else comes from the numbered sources. For the paper [1], l. gives a line of the preprint we read, Abstract its abstract, and Fig. and Table its figures and tables.

The rise is in the paper's data; the solar particles couldn't reach the sites

OUR ASSESSMENT

21–34%
the rise in the daily mean field at the two Japanese sites on 11 May, against 9 and 10 May, as the paper measured it, with no test [1 l. 330]

11–16 GV
the magnetic shielding at the four sites (our analysis) [12 Table 1A]; the monitors identified solar particles of at least 2.4 GV, and published fits fall off steeply above that [15 p. 6][15 p. 10]

0 of 23
hours of 11 May in which the Doi Inthanon neutron monitor, shielded like the Indian sites, counted above its pre-storm level (our analysis, a check added after our tests) [11]

THE PAPER'S CLAIMS

TRUE

"During the storm, a significant FD of ~ 13% and a subsequent SEP event were recorded"

The paper's conclusions [1 l. 500]

Both check out. Against the 48 hours before the shock, Oulu's neutron monitor fell 10.9% in hourly data, with one five-minute value at 13.7%, and the monitors at the poles about 14% [11]; the solar particles that followed made GLE 74, a ground-level enhancement [19 p. 16]. Kp reached 9o, G5 on the paper's scale [6][1 l. 244]. The paper's Dst of −412 nT is Kyoto's real-time value [19 p. 3]; the provisional index gives −406 nT [7]. Our analysis; see section 2.

TRUE

"Results show that the daily average fair-weather AEF at mid-latitude sites increased by 21-34% on May 11 with respect to the average AEF of the previous two days."

The paper's abstract [1 Abstract]

True as measured, against two days and untested. The paper's daily means give +34.6% at Kakioka and +21.2% at Chofu, and its own Fig. 3 reproduces them (our check) [1 l. 330][1 Fig. 3]. Nothing tests how often such a rise happens anyway, though the text calls it "significant" [1 l. 334]. The airports nearest both sites reported winds slightly above the paper's 8 m/s limit, 8.2–9.8 m/s, for a few hours of 11 May, though by our rule, set in advance, their reports don't separate 11 May from the two days before (our analysis) [22]. See section 3.

UNSUPPORTED

"The elevated AEF values in both sites on 11 May is likely to be caused by the sustained high-speed solar proton flux."

The paper, on Kakioka and Chofu [1 l. 347]

Protons arriving vertically need about 11 GV to reach the air over Japan [12 Table 1A], far more than the solar protons GOES measured or the most rigid solar particles the monitors identified, at least 2.4 GV, above which published fits fall off steeply [15 p. 6][15 p. 10]. The neutron monitors at Mexico City (8.3 GV) and Doi Inthanon (16.8 GV), shielded less and more than the Japanese sites, counted fewer particles than before the storm in every hour of 11 May (our analysis) [11]. A change in the whole circuit would move the field everywhere at once, yet by the paper's abstract its Indian sites showed no significant rise [1 Abstract], and a seven-station study of the storm reported changes that differed from station to station and day to day [24 Abstract]. See section 4.

MISLEADING

"However, the AEF at these two sites shows fluctuations coinciding with the SEP event around 0245 UT on 11 May, suggesting a measurable response to SEP-related atmospheric ionization."

The paper's abstract, on Bagula and Purulia [1 Abstract]

The swings are real: by our test fixed in advance, Bagula's field fluctuated more after 02:45 UT on 11 May than on any other day that week, and Purulia's rise ranked second of the seven days, first with a window starting at 01:50 UT (our analysis) [4]. But the abstract leaves out what the paper's own body shows: heavy rain at Bagula at those hours, which its discussion says likely contributed [1 Fig. 2][1 l. 375]. It also leaves out the shielding: Earth's field turns back protons arriving vertically below about 15.7 GV at both sites, more than six times the most rigid solar particles the monitors identified [12 Table 1A][15 p. 6]. The paper suggests the swings "could be due to the ionospheric conductivity changes related to SEP-driven ionization" [1 l. 511]; through the whole circuit, though, even the biggest solar particle events are expected to change the surface field by only about 5% [36 p. 6], against swings here of hundreds of V/m (our analysis) [4]. A study of earlier events did find the field rising after proton events at CASLEO, in the Argentine Andes, which the same grid shields at about 8.8 GV (our analysis) [25][12 Table 1B]. See section 5.

MISLEADING

"The AC component of the GEC, tracked through the amplitude of lightning-generated VLF atmospherics, also showed marked enhancement, with lightning activity peaking ~3 hours after the SEP flux maximum."

The paper's abstract [1 Abstract]

The measurements hold: lightning signals were stronger on 11 May, and flashes within 500 km of Bagula peaked about three hours after the high-energy protons' broad maximum [1 Fig. 7][10]. Everything about it fits ordinary weather: on 11 May more airports within 500 km of Bagula reported thunder than on any other day of April and May 2024 (12 of 20; 6 May had 11), thunderstorms were already reported at Dhaka before the protons arrived, and the peak came at the region's usual afternoon hour (our analysis) [22][1 Fig. 7]. The paper's Fig. 7 caption gives the delay as about 48 minutes [1 Fig. 7]. See section 6.

UNSUPPORTED

"The combined findings suggest that the SEP event associated with the super geomagnetic storm plays a more direct role as a possible contributing factor than the FD in modulating the GEC, particularly through enhanced ionization that alters atmospheric conductivity and facilitates lightning initiation."

The paper's abstract [1 Abstract]

No extra ionisation reached the air over the sites or over the storms near Bagula, while the Forbush decrease left the neutron monitors whose shielding brackets theirs 1.4–7.1% low all day (our analysis) [11]. A review finds that the decrease, not solar particle events, makes the larger changes in the circuit [36 p. 6]. The paper says its data "cannot establish a direct causal relationship" [1 l. 491], and whether energetic particles help start lightning is an open question [34][35]. See section 6.

1 · THE PAPER

Five researchers in India and Japan followed the air's electric field and lightning signals through May 2024's storm

Rakhijul Alam Faruque, Sujay Pal and three colleagues, at institutions in West Bengal and at the University of Electro-Communications in Tokyo, measured the fair-weather electric field near the ground at two sites in Japan and two in India, and the radio signals of lightning in India, through the storm of 10–11 May 2024 [1]. Their paper is in the November 2026 issue of the *Journal of Atmospheric and Solar-Terrestrial Physics* [3]. S0 News linked it on November 15, 2026 [2].

What we read: the submitted preprint

The journal's version is paywalled, and we didn't read it. We read the version posted on SSRN, the submitted manuscript, which numbers its lines; the site's owner downloaded it because SSRN refused our client [1]. The published text may differ. Crossref and OpenAlex list the preprint as CC BY 4.0, though the PDF itself states no licence [3]. Quotations below are from the preprint, with its line numbers.

The paper calls the quantity it measures the atmospheric electric field, AEF, and notes that it is the potential gradient, PG, of the literature [1 l. 187]. On a fair day it is about 100 V/m near the ground, held up by thunderstorms around the world, which keep the ionosphere at about 250 kV above the ground [36 p. 3]. Here we call it the field.

The four sites

SITE	WHERE	POSITION	MILL HEIGHT	DIPOLE LATITUDE	SHIELDING
KAK	near Kakioka, Ibaraki, Japan	36.24° N, 140.19° E	ground level	28.4°	10.9 GV
CHF	Chofu, Tokyo	35.65° N, 139.54° E	about 20 m	27.7°	11.1 GV
BGL	Bagula, West Bengal, India	23.33° N, 88.65° E	about 10 m, rooftop	14.6°	15.7 GV
PRL	Purulia, West Bengal	23.33° N, 86.36° E	about 20 m, rooftop	14.7°	15.7 GV

Positions and heights from the paper's Table 1 [1 Table 1], and the rooftop mounting from the authors' description of their Indian sites [5]; all four are Boltek field mills [1 l. 182]. Dipole latitudes from IGRF-14 and shielding, the vertical cutoff rigidity, from Smart and Shea's world grid for 2015: our analysis [14][12 Table 1A].

What the paper reports

At the two Japanese sites the daily mean field rose 21–34% on 11 May, against 9 and 10 May, and nothing changed at once when the cosmic rays fell. At the two Indian sites there was no such rise, but the field "shows fluctuations coinciding with the SEP event around 0245 UT" [1 Abstract]. Lightning signals at Bagula were stronger, and lightning within 500 km peaked about three hours after the solar particles' maximum [1 Abstract][1 l. 466]. The paper finds no sign of the storm's prompt electric fields in its records [1 l. 512].

It concludes that the solar particle event, through ionisation that changes the air's conductivity and helps start lightning, played "a more direct role as a possible contributing factor" than the Forbush decrease [1 Abstract].

Its data

The paper said its field and lightning-signal data "will be available in a data repository shortly" [1 l. 541]. They are, for the Indian sites only: the authors' records from Bagula and Purulia for 8–14 May 2024 are on Mendeley Data under CC BY 4.0 [4], beside their fair-weather means for 2023–24 [5]. We found no data from the Japanese sites. The lightning counts come from Earth Networks' commercial network [1 l. 222], and the weather from a reanalysis [1 l. 205]. So for Japan we rely on the paper's numbers and its own figure; for India we used the authors' data.

2 · THE STORM

The storm, the drop in cosmic rays and the solar particles are as the paper describes, with small slips

We checked the paper's account of the storm against public records [1 l. 241]. Every main element holds.

HIGHEST KP · OUR ANALYSIS
9o
at 00–03 and 09–12 UT on 11 May, in GFZ's definitive index [6]: G5, the top of the scale the paper cites [1 l. 244]

LOWEST DST · OUR ANALYSIS
−406 nT
provisional, in the hour from 02 UT on 11 May [7]; the paper's −412 nT [1 l. 270] is the real-time value [19 p. 3]

OULU'S COSMIC-RAY DROP · OUR ANALYSIS
−10.9%
in hourly data at 23 UT on 10 May, against the 48 hours before the shock; one five-minute value, at 00:20 UT on 11 May, reached −13.7% [11]

The storm, hour by hour

WHEN (UT)	WHAT HAPPENED	SOURCE
10 May, 17:04–17:05	The shock: |B| jumps from 4 to 22 nT at 17:04 UT; SSC at 17:05 UT. The storm begins	[9][19 p. 38]
10 May, 17:15	SYM-H peaks at +88 nT	[8]
10 May, 17–18	Dst +66 nT, provisional (the paper: "an abrupt rise of 61 nT")	[7][1 l. 266]
10 May, about 17:45	GOES's protons above 10 MeV at their maximum, 40 minutes after the shock, as the paper says	[10][1 l. 259]
10 May, 18–24	Kp 9−, after 8− at 15–18	[6]
11 May, 00–03 and 09–12	Kp 9o	[6]
11 May, 00:06	|B| at its highest, 70 nT	[9]
11 May, 00:20	Oulu's lowest five-minute value, −13.7% (hourly: −10.9% at 23 UT on 10 May)	[11]
11 May, 01:10–01:23	An X5.8 flare	[15 p. 13]
11 May, 01:15–02:30	GLE 74 begins at neutron monitors (at the South Pole at 01:35); polar monitors stay raised until about 10 UT	[15 Table 1][19 p. 16]
11 May, about 01:50	GOES's protons above 100 MeV begin to rise, with a first peak near 02:45	[10][20]
11 May, 02–03	Dst −406 nT, provisional (the paper: −412 nT at 02 UT); SYM-H −518 nT at 02:14	[7][8]
11 May, about 07–09	The broad maximum of protons above 100 MeV; those above 500 MeV highest in the 07 UT hour, at 07:30–07:40	[10]
11 May, about 10:30	Lightning within 500 km of Bagula at its peak, by the paper's count	[1 l. 467]
12 May, 00–06	Kp 6+, then 7o	[6]
12 May, 15–16	Dst back above −100 nT, at −96 nT (the paper: "until May 12 at 1700 UT")	[7][1 l. 272]

Our analysis of GFZ's definitive Kp [6], WDC Kyoto's provisional Dst and SYM-H [7][8], GOES-16's proton data [10] and NMDB's neutron monitors [11]. Kyoto's indices are for scientific, non-commercial use; we acknowledge the observatories that supply their data and the WDC for Geomagnetism, Kyoto, and we read no real-time value: the only real-time figure on this page is the paper's −412 nT [19 p. 3]. Our integral GOES fluxes are summed from the instrument's energy channels, so their times are good to about ten minutes. Times of the flare and the GLE's onsets are from Papaioannou and colleagues [15 p. 13].

OUR ANALYSIS

Small slips

- **Dst.** The paper's −412 nT [1 l. 270] is Kyoto's real-time value [19 p. 3]; the provisional index gives −406 nT [7].
- **Forbush decrease.** The paper reports one of "~ 13%" [1 l. 500] but also says the decrease "could not reach beyond 10% because of the SEP events" [1 l. 300]; Oulu's hourly data give 10.9%, and the polar monitors about 14% [11].
- **The shock's time.** The paper dates the sudden commencement to "around 1745 UT" from GOES's magnetometer [1 l. 261] and the storm's start to about 1700 UT [1 l. 276]; the commencement was at 17:05 UT [19 p. 38].
- **"most intense since the March 1989 storm"** [1 l. 242] holds for SYM-H, −518 nT, second only to March 1989 since 1981, but not for Dst, by which November 2003 went deeper, as our check of a paper on May 2024's grids found from Kyoto's indices [7][8].
- **"triggered by multiple Earth-directed X-class solar flares (up to X5.8)"** [1 l. 245]: the X5.8 flare erupted at 01:10 UT on 11 May, eight hours after the storm began, and launched GLE 74's particles [15 p. 13]; the storm itself came from ejections launched on 8–9 May, stacked on the way [19 pp. 10–11].
- **Kp** showed "significant geomagnetic activity between 1200 UT and 1500 UT" on 10 May, the paper says [1 l. 279]; GFZ's definitive Kp was 4− then, and 8− from 15 UT [6].

We haven't asked the authors about these slips.

Our other checks of this storm: why grids came through it well, its aurora and the equatorial ionosphere and the oxygen in its ring current; for the next ground-level enhancement, in November 2025, see our check of a paper on it and flight radiation.

3 · THE 21–34%

The rise in Japan is real in the paper's data, but it rests on two days and no test

The paper's daily means give the rise it reports, and its own figure reproduces them. What it doesn't show is how unusual such a rise is [1 l. 330].

What the paper measured

Daily mean field at Kakioka: 42.5, 40.1, 55.6 and 46.8 V/m on 9–12 May; at Chofu, 106.6, 109.4, 130.9 and 103.2 V/m [1 l. 330][1 l. 338]. Against the mean of 9 and 10 May, the paper calls 11 May "a significant ~34% increment" at Kakioka and ~21% at Chofu [1 l. 334][1 l. 341]. The values are "not corrected to the ground values" [1 l. 332]: Chofu's mill stands about 20 m up [1 Table 1].

OUR ANALYSIS

Reproduced

The paper's daily means give +34.6% at Kakioka and +21.2% at Chofu. Read from the paper's Fig. 3, whose curves hold a point every five minutes, the daily means for 9–11 May come out the same [1 Fig. 3]. The figure runs to 16:00 UT on 12 May; over the same hours, 00–16 UT, 11 May is 29% above 9 and 10 May at Kakioka and 35% at Chofu, and 12 May falls back by 11% at Kakioka and by about a fifth at Chofu, where the curve also runs off the top of the panel [1 Fig. 3].

OUR ANALYSIS

The paper's table and figure differ in places

Kakioka's mean for 12 May matches the figure over 00:00–16:05 UT, about two-thirds of the day, where Fig. 3 ends; Chofu's is close but not exact [1 Fig. 3][1 l. 330]. The paper's Table 2 gives each day's lowest and highest field, and these match the figure to within about 4 V/m except in two places. Kakioka's lowest on 11 May is 35 V/m in the table and 20.6 V/m, at 03:00 UT, in the figure. Chofu's range on 12 May is 69–127 V/m in the table; in the figure it runs from 25 V/m to off the top of the panel, above 230 V/m [1 Table 2][1 Fig. 3]. Data screened differently for the table could explain this.

The text's "11 May has a higher diurnal minimum and maximum than the other three days" [1 l. 346] matches the table. In the figure, 11 May has Kakioka's highest minimum by about 1 V/m, and Chofu's highest value of the four days comes on 12 May, above 230 V/m against 200 V/m on 11 May [1 Fig. 3]. We haven't asked the authors about these differences.

Two days, and no test

OUR ANALYSIS

No measure of how unusual

The fair-weather field changes from day to day with aerosols, humidity and the air near the ground as well as with the global circuit, which is why careful studies screen for weather and compare a storm with many quiet days [23][30]. The paper gives no measure of that variability and no test [1 l. 330]. The data from Kakioka and Chofu aren't public, so we couldn't compute one. Kakioka's own observatory recorded the field hourly from 1962 until February 2021, which would show how often a one-day rise of 21–34% happens there in May; ordering those data needs an e-mail address, which we don't send [37].

Another study of the same storm

A seven-station study of the same storm compared each station with its own non-storm days in May 2024 and corrected for running many tests [24 Abstract]. Our check of that paper found that its test, as we emulate it, also passes ordinary days, so a test needs care too.

Weather the screen didn't see

OUR ANALYSIS

The paper counted a day as fair if a reanalysis showed no rain and wind below 8 m/s [1 l. 203]. It didn't screen for cloud, mist or haze, which the standard criteria also exclude [23]. By our rule, fixed before we looked, the reports of the airports nearest the Japanese sites don't separate 11 May from 9 and 10 May on all the criteria together. But on 11 May both airports reported winds slightly above 8 m/s, 8.2–9.8 m/s, for a few hours, measured at the airports rather than taken from the reanalysis the paper used, and Chofu airfield reported light rain on the morning of 9 May (our analysis) [22].

Weather at the airports nearest the Japanese sites, 9–12 May 2024

DAY (UT)	REPORTS	ALL CRITERIA MET	WIND OVER 8 M/S	RAIN OR SHOWERS	MEAN HUMIDITY
Chofu airfield (RJTF), 2.6 km from CHF					
9 May	10	8	0	light, 00–02 UT	58%
10 May	10	10	0	none	33%
11 May	**10**	**7**	**3, 05–07 UT**	**none**	**45%**
12 May	11	9	0	showers	64%
Ibaraki (RJAH), 21 km from KAK					
9 May	25	22	0	none	69%
10 May	24	21	0	none	60%
11 May	**27**	**19**	**5, 00–04 UT**	**one shower, 23:43 UT**	**61%**
12 May	40	11	9	showers	79%

Our analysis of the airports' weather reports (METARs) [22]. "All criteria met": no precipitation, mist, haze or fog; visibility of 2 km or more; no cumulonimbus or towering cumulus and no broken or overcast cloud below 1,500 m; and wind of 1–8 m/s: our stand-ins for Harrison and Nicoll's fair-weather criteria [23]. Japan's clocks are 9 hours ahead of UT. Winds on 9 May were northerly; on 10–12 May, southerly.

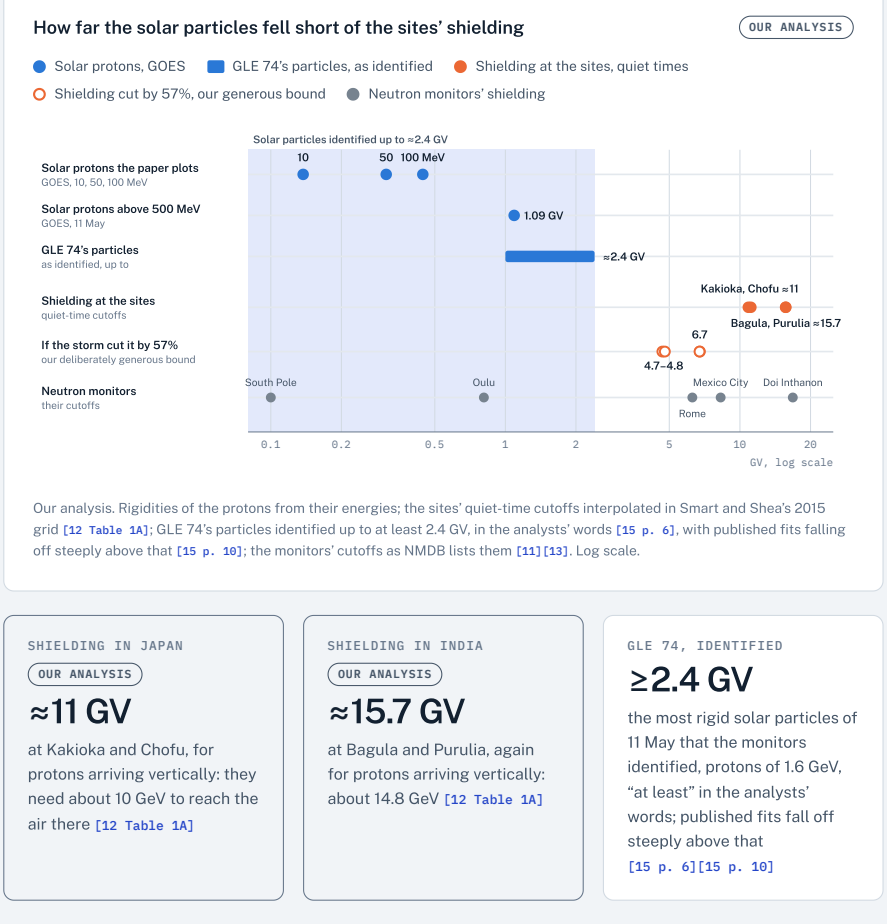
4 · THE SHIELD

Earth's magnetic field kept the storm's solar particles away from all four sites

To reach the air over a place, a charged particle needs enough rigidity, its momentum per unit charge, to get through Earth's magnetic field, and near the equator the bar is highest. The paper mentions this cutoff rigidity only for the size of a Forbush decrease [1 l. 93]; it never applies it to its own sites or to the solar particles.

How far the solar particles fell short of the sites' shielding

OUR ANALYSIS



Our analysis. Rigidities of the protons from their energies; the sites' quiet-time cutoffs interpolated in Smart and Shea's 2015 grid [12 Table 1A]; GLE 74's particles identified up to at least 2.4 GV, in the analysts' words [15 p. 6], with published fits falling off steeply above that [15 p. 10]; the monitors' cutoffs as NMDB lists them [11][13]. Log scale.

SHIELDING IN JAPAN · OUR ANALYSIS
≈11 GV
at Kakioka and Chofu, for protons arriving vertically: they need about 10 GeV to reach the air there [12 Table 1A]

SHIELDING IN INDIA · OUR ANALYSIS
≈15.7 GV
at Bagula and Purulia, again for protons arriving vertically: about 14.8 GeV [12 Table 1A]

GLE 74, IDENTIFIED
≥2.4 GV
the most rigid solar particles of 11 May that the monitors identified, protons of 1.6 GeV, "at least" in the analysts' words; published fits fall off steeply above that [15 p. 6][15 p. 10]

OUR ANALYSIS

Short by a factor of 4.5 to 35

The protons the paper plots, of 10, 50 and 100 MeV, have rigidities of 0.14–0.44 GV; even the 100 MeV protons fall 24 to 35 times short of the four sites' cutoffs, and GOES's highest channel, above 500 MeV, starts at 1.09 GV [10]. The neutron-monitor network identified GLE 74's particles up to at least 2.4 GV, in the analysts' words [15 p. 6], under a quarter of the shielding in Japan and about a sixth of India's; the published fits of its spectrum fall off steeply above that [15 p. 10].

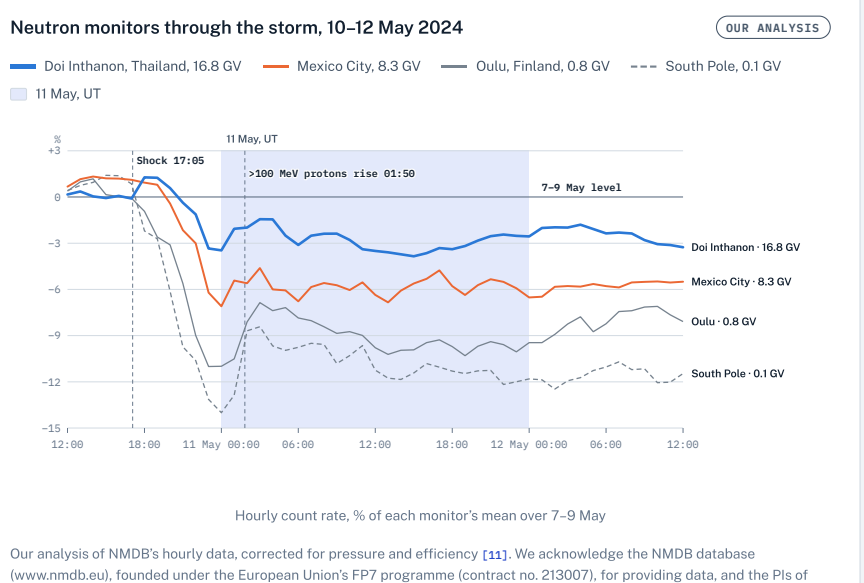
Storms lower the shield, especially at middle latitudes [17 p. 2]. The analysis of GLE 74 used storm-time cutoffs that put the Newark monitor at 1.02 GV, against 2.4 GV in quiet times [15 Table 1][15 p. 5]. Cut by the same 57%, the sites would still be shielded to 4.7–6.7 GV, two to three times the 2.4 GV identified.

Does the paper mean local ionisation, or a change in the circuit as a whole? It doesn't say. It describes ionisation "above the thunderstorm generator" [1 l. 382], particles that "penetrate relatively deep into the atmosphere" [1 l. 479] and "ionospheric conductivity changes related to SEP-driven ionization" [1 l. 511], and never mentions its sites' cutoffs. The shield works at the ionosphere's height too: the cutoff falls with the square of the distance from Earth's centre, by about 2.5% between 20 and 100 km. A change through the whole circuit, through the potential of the ionosphere, would move the field at all four sites together, and at the Indian sites, by the paper's abstract, it didn't rise significantly [1 Abstract], though a later sentence has the field elevated there all day [1 l. 515].

What the neutron monitors saw

Neutron monitors through the storm, 10–12 May 2024

OUR ANALYSIS



Our analysis of NMDB's hourly data, corrected for pressure and efficiency [11]. We acknowledge the NMDB database (www.nmdb.eu), founded under the European Union's FP7 programme (contract no. 213007), for providing data, and the PIs of individual neutron monitors at: Doi Inthanon (Princess Sirindhorn NM) (Mahidol University, Chulalongkorn University and Ubon Rajathanee University, Thailand); Mexico (Cosmic Ray Group, Geophysical Institute, National Autonomous University of Mexico, UNAM); Oulu (Sodankylä Geophysical Observatory of the University of Oulu, Finland); and the South Pole (University of Wisconsin, River Falls, USA). NMDB's data are free for non-commercial use.

OUR ANALYSIS

Fewer particles, not more

A neutron monitor counts the secondary particles made in the air by everything arriving above its cutoff, solar particles included. On 11 May every monitor we checked counted below its pre-storm level in every hour: Doi Inthanon, shielded to 16.8 GV like the Indian sites, by 1.4–3.9%, and Mexico City, at 8.3 GV, by 4.6–7.1% [11]. The Forbush decrease had removed more cosmic rays than anything added back. Only near the poles did GLE 74 show, as a rise from about 02 UT [19 p. 16].

Every monitor, Doi Inthanon included, also rose a little after 01:30 UT on 11 May, by more than anything in a quiet week, by our test fixed in advance [11]. That rise came as the storm peaked and weakened the shield, and as the Forbush decrease began to recover: the analyses of GLE 74 treat the non-polar monitors as showing no solar signal for that reason [15 p. 8][16 p. 4], and the published spectra put essentially no solar particles at 16.8 GV [15 p. 10]. So timing alone can't pick out the solar particles: everything changed at once.

How much could solar particles have added above the sites' cutoffs, at their peak? With a spectrum harder than any published fit [15 p. 10], our rough bound, a check added after our tests, is about 1% of the particles arriving above Japan's cutoff and 0.4% above India's at quiet-time shielding, or up to 5–7% and 2–3% if the storm had also cut the shield by 57%, both only at the 07 UT peak. Against that, the Forbush decrease removed 1.4–7.1% all day at the monitors whose shielding brackets the sites' [11], and the published fits fall off faster. A review finds that the larger changes in the circuit follow the Forbush decrease, with "little effect" from solar particle events, and that models put the change in the surface field from even the biggest such events at about 5% [36 p. 6].

5 · BAGULA AND PURULIA

At the Indian sites the swings were real, but the abstract leaves out the rain the paper's own figure shows

The abstract says the field at both Indian sites moved with the solar particle event "around 0245 UT" [1 Abstract]. The paper's discussion is more cautious, and the authors' published data let us test both sites [4].

In the paper's words

BGL is Bagula, PRL Purulia, AEF the field, SEP the solar particle event.

> *"the AEF at these two sites shows fluctuations coinciding with the SEP event around 0245 UT on 11 May, suggesting a measurable response to SEP-related atmospheric ionization"*
>
> Faruque et al. (2026) [1 Abstract]

> *"local weather conditions likely contributed to the BGL response, while the PRL enhancement may represent a response associated with the SEP event"*
>
> Faruque et al. (2026) [1 l. 375]

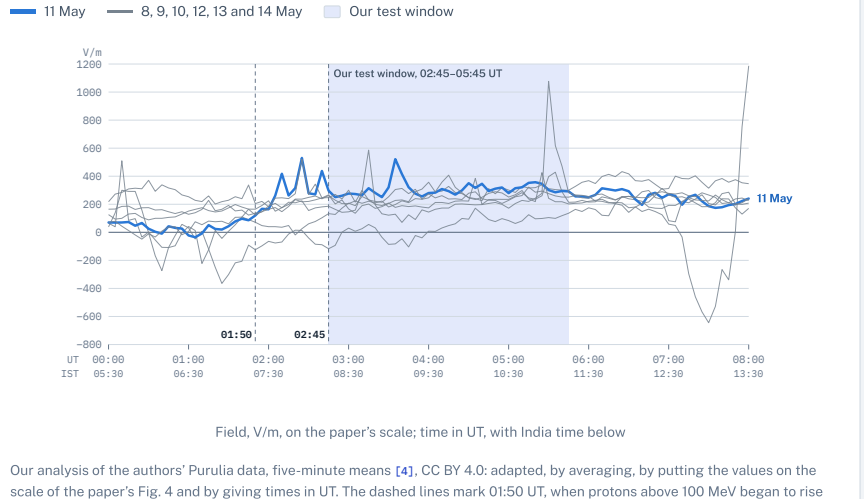
> *"could be due to the ionospheric conductivity changes related to SEP-driven ionization"*
>
> Faruque et al. (2026), on the low-latitude fluctuations [1 l. 511]

What the paper reports

At Purulia the field rose after about 02:45 UT on 11 May, with no rain and no unusual wind; at Bagula it swung and went negative while it rained [1 l. 365]. The reanalysis in the paper's Fig. 2 shows rain at both sites on each day from 9 to 12 May, and at Bagula the heaviest of 11 May at about 02:30–05:30 UT (our reading) [1 Fig. 2].

Purulia's field on the mornings of 8–14 May 2024

OUR ANALYSIS



Our analysis of the authors' Purulia data, five-minute means [4], CC BY 4.0: adapted, by averaging, by putting the values on the scale of the paper's Fig. 4 and by giving times in UT. The dashed lines mark 01:50 UT, when protons above 100 MeV began to rise at GOES [10], and 02:45 UT, the time the paper gives for the solar particle event [1 Abstract].

OUR ANALYSIS

Both sites, by our test

Our test, fixed before we looked: for each day of 8–14 May, the change in each site's mean field from 00:45–02:45 UT to 02:45–05:45 UT, and how much it fluctuated after 02:45 UT. At Purulia, on 11 May the field rose 156 V/m, the second largest of the seven days: on 8 May it rose 218 V/m, and on 9 and 12 May about 130. Its fluctuation ranked fifth, and it fluctuated less after 02:45 UT than before [4].

At Bagula the field fluctuated more after 02:45 UT on 11 May than on any other day that week, and its fluctuation grew the most, while its level change ranked second [4]. The paper's Fig. 2 has the heaviest rain of 11 May there at about 02:30–05:30 UT (our reading), and its discussion says local weather likely contributed [1 Fig. 2][1 l. 375].

The result depends on the window. Measured from 01:50 UT, when the high-energy protons began to rise at GOES [10], 11 May's rise at Purulia is the largest of the seven. With seven days, any one comes first by chance one time in seven, so neither result is evidence for or against the paper: section 4's physics is. That week the field climbed after sunrise on most mornings at Purulia, which the authors describe as an industrial town with more air pollution than Bagula [5]; their own May 2024 fair-weather means for Purulia carry standard errors of about 57 V/m an hour [5], and its daily means that week ran from −168 to 307 V/m in all weather [4].

The files of both sites are time-stamped in India time, UT plus 5 hours 30 minutes, as the files of the authors' 2023–24 dataset say theirs are [5]; this dataset's files and description don't state it, and the paper's figures are in UT [4][1 Fig. 4]. Converted to UT, the files reproduce the paper's Fig. 4 closely (our analysis). We haven't asked the authors about the time stamps.

6 · LIGHTNING

The lightning came on the day the most airports in the region reported thunder, at its usual hour

The paper's evidence for the "AC" circuit is real: stronger lightning radio signals at Bagula, and more flashes within 500 km, on 11 May [1 l. 460]. Everything about it fits ordinary weather.

What the paper reports

Very-low-frequency radio signals of lightning, sferics, at 7 and 9 kHz were stronger through most of 11 May, peaking about 10:30 UT, with spikes from nearby lightning between 05 and 09 UT; cloud-to-ground flashes within 500 km rose after about 03 UT and peaked about 10:30 UT, above 10 and 12 May and above the mean of 14 days around the storm [1 l. 457][1 l. 466]. The paper reads the time after the protons' maximum, about 07 UT, as "a possible delayed response" [1 l. 470].

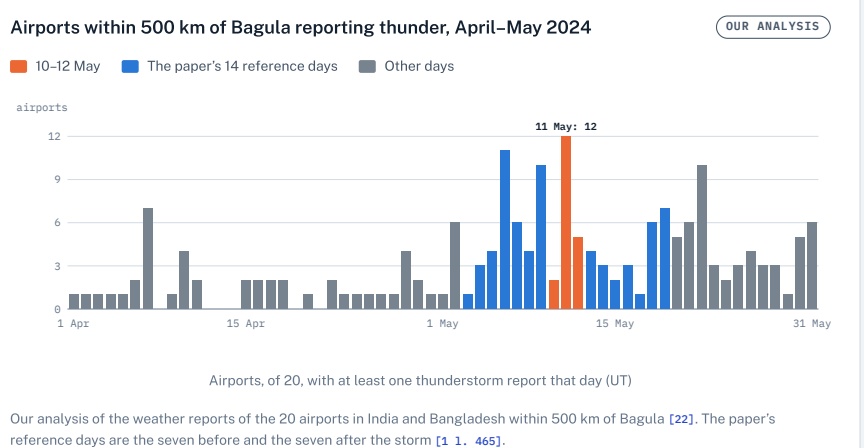
OUR ANALYSIS

The signals, checked

In the authors' sferic data, averaged over the minutes recorded on all three days, 11 May was 2.6 dB stronger than 10 May and 1.8 dB stronger than 12 May at 7 kHz; leaving out 05–09 UT, its strongest half hour ended at 10:35 UT [4]. The flash counts come from a commercial network [1 l. 223], and we found no public copy, so we couldn't check them.

Airports within 500 km of Bagula reporting thunder, April–May 2024

OUR ANALYSIS



Our analysis of the weather reports of the 20 airports in India and Bangladesh within 500 km of Bagula [22]. The paper's reference days are the seven before and the seven after the storm [1 l. 465].

OUR ANALYSIS

A stormy day, at the usual hour

On 11 May, 12 of the 20 airports reported thunder, more than on any other day of April and May 2024, though 6 May, with 11 airports, had more thunder reports, 110 against 64. The paper's 14 reference days averaged 4.6; 10 May had 2 and 12 May 5 [22]. Dhaka reported a thunderstorm with rain from 01:00 UT, before protons above 100 MeV rose at 01:50 UT [22][10], and Agartala and Chittagong followed by 03:00 UT. Nearer Bagula, Kolkata, Durgapur, Jamshedpur and Ranchi reported thunder from 08 to 15 UT, 13:30 to 20:30 India time [22].

The flash peak at 10:30 UT is 16:00 India time. In the paper's own 14-day mean, flashes peak at about 12:30 UT [1 Fig. 7]: storms here build through the afternoon. A peak a few hours after a morning event is what the daily cycle gives on any stormy day. A thunderstorm outbreak like this one is ordinary pre-monsoon weather in the region; that it fell on the day of the solar particles is one coincidence, which one day can't test.

The paper's Fig. 7 caption puts the lightning peak "~48 minutes after the GOES proton flux", and its abstract about three hours after the maximum [1 Fig. 7][1 Abstract]. In GOES-16's data as we integrated them, three hours fits the broad maximum of the protons above 100 MeV, near 07 UT; no channel peaked 48 minutes before the flash peak, the nearest maxima coming about 75 minutes before [10]. We didn't check NOAA's operational product, which the paper may have used. We haven't asked the authors which is meant.

Do energetic particles help start lightning?

How flashes start

How lightning starts is still argued over. One idea is that runaway electrons in a cosmic-ray air shower start the breakdown: Gurevich and Karashtin trace the pulses that start some flashes to breakdown "initiated by extensive atmospheric showers" [34], which only very energetic cosmic rays make, far beyond any solar particle (our note). Radio observations by Rison and colleagues found that many or possibly all flashes begin with a fast positive breakdown that "appears to be purely dielectric in nature" [35].

Space weather and lightning

A review of space weather and atmospheric electricity calls the cosmic-ray route one possible explanation and notes that such work is hampered by the natural variability of thunderstorms [36 p. 7]. Scott and colleagues, who found UK lightning rising after fast solar-wind streams, wrote that the mechanism "is still unknown" [33 p. 1].

The paper offers one day and a delay, and itself says that "the present observations alone cannot establish a direct causal relationship" [1 l. 491].

7 · SAME STORM, OTHER SITES

Other studies of the field in May 2024 found mixed responses, not one direction

Several groups measured the field near the ground through the storm. Their results differ from site to site and day to day [24 Abstract].

Seven stations worldwide

Tacza and colleagues analysed twelve instruments at seven stations and report an early drop near the shock's arrival, behaviour that changed from day to day during the Forbush decrease, and effects they call robust at only a subset of stations and days [24 Abstract]. Our check of that paper found that its robust 10 May drops come from hours before the shock.

Gar, Tibet, at 4,259 m

Fu and colleagues found the field higher at the Forbush decrease's minimum, lower during the GLE, from about 02 to 04 UT, and raised for days after, which they tie to the fast solar wind and a squeezed magnetosphere [27].

LeShan, China

Sun and colleagues report disturbances near 20:00 UT on 10 May, at the storm's onset, which they say indicate a possible effect of electrodynamic changes on the atmosphere [28].

The Arctic

Kavita and colleagues, by the paper's account, found the field lower during the Forbush decrease's minimum and higher during the GLE [1 l. 156]; we could read only the record [29].

Earlier storms

In the storm of April 2023, most of eight stations saw the field rise, and three nearby stations saw it fall [31]. At Aragats, Armenia, two storms in fair weather raised the field modestly as the Forbush decrease deepened, and weather effects can be much stronger than a storm's [30]. In Israel, two severe events left the field unchanged, which the authors put down to strong magnetic shielding at low latitudes [32]. At CASLEO, high in the Argentine Andes, intense proton events and Forbush decreases of more than 10% raised the field on average, while proton events did not at Świder, Poland [25][26].

OUR ANALYSIS

Three citations, read

Two works the paper cites report something narrower than, or different from, what they're cited for. Scott and colleagues (2014), cited for ionisation from ground-level enhancements that can enhance cloud formation and affect the circuit's AC component [1 l. 119], studied UK lightning after fast solar-wind streams, with a moderate rise in lower-energy solar protons that weren't detected at ground level [33 p. 1]; their paper doesn't discuss cloud formation [33]. Tacza and colleagues (2022), cited for a rise in the field after solar proton events [1 l. 384], report one at CASLEO, in the Argentine Andes, and none at Świder, Poland, by their abstract [25]. The paper cites Yaniv and colleagues (2023) only for background [1 l. 89]; their main finding, that two sites in Israel didn't respond to two strong proton events, which they put down to the shielding at lower latitudes [32], isn't mentioned. We haven't asked the authors about these citations.

8 · WHAT IT MEANS

Our reading: the shield held, and the storm's solar particles never touched the air the paper measured

OUR ANALYSIS

One of the space age's biggest storms, with a ground-level solar particle event on top, put no detectable solar particles into the low- and mid-latitude air this paper measured, and the cosmic radiation there fell.

For anyone weighing whether the Sun drives the weather on the ground, the storm of May 2024 is a good test case. What it did to the electric field near the ground is real research: the storm's electric fields, the Forbush decrease and local weather all play a part, and the studies of this storm find them hard to separate [24 Abstract][36 p. 6]. For what is known about such links, see our check of a 2026 forum report on space weather and the lower atmosphere, and our check of a paper on a storm's effects in the air near Moscow.

The shield matters for a catastrophist reading. Today's field kept these particles to high latitudes, where they ionise the stratosphere and above [36 p. 5]. A much weaker field, as during a geomagnetic excursion, would lower the cutoffs and let solar particles reach lower latitudes; our guide to the magnetic field covers what is known about excursions. Nothing in this paper shows solar particles driving lightning or the weather, and its authors call the link possible, not established [1 l. 491–495].

9 · LIMITS

What this check could and couldn't see

The preprint, not the published paper

We read the submitted version; the version of record is paywalled and may differ [1].

No data from Japan

Kakioka's and Chofu's records aren't public, so the 21–34% and its context rest on the paper's numbers and figure [1 Fig. 3]. Kakioka's own long record could show how ordinary such a rise is [37].

Weather by proxy

Airports 3 and 21 km from the Japanese sites stand in for them, and 20 airports for the region around Bagula; thunder heard at an airport is not a flash count [22].

Storm-time shielding

We didn't trace particle paths through the storm-time field; the 57% cut is a deliberately generous bound. Studies of this storm's cutoffs could narrow it [21][18].

Approximate proton fluxes

Our fluxes above 10, 50 and 100 MeV are summed from GOES's energy channels, so their times are good to about ten minutes [10].

One window

Our test of the Indian sites depends on its window at Purulia (section 5), and seven days can't make a strong test either way [4].

What would change these verdicts

01
Kakioka's or Chofu's field over many ordinary Mays, showing a one-day rise of 21–34% to be rare: claim 2 would gain weight, though claim 3 would still need a mechanism.

02
A published storm-time cutoff at low latitudes near 2.4 GV, or a GLE 74 spectrum that stays strong to 5 GV and beyond: claims 3, 4 and 6 would need another look.

03
Lightning counts over many events showing more lightning after solar particle events than the weather explains: claims 5 and 6 could move.

10 · REPEAT OUR NUMBERS

The rules came first; the scripts fetch the public data and recompute every number of ours

We wrote six rules files before running the tests they govern, one amendment when NMDB turned out to have no five-minute data for three monitors, and a second after a fresh review, correcting how we lined up the paper's Fig. 4 with the authors' files before we re-ran that test; their hashes were logged first. Some checks came afterwards, and say so: the window anchored at 01:50 UT, the hour-by-hour comparisons, the harder bound on the solar particles and the count of hours below normal.

PY	**fetch_inputs.py**	Downloads the 63 public inputs under a plain client name and checks each against our copy by its SHA-256; standard library · 4 KB
JSON	**inputs.json**	Every input's URL and the SHA-256 of our copy; the preprint is named, not fetched · 34 KB
PY	**ab_storm_cutoffs.py**	The sites' cutoffs, the rigidities and our bound; the neutron-monitor test; the storm's timeline from Kp, Dst, SYM-H, OMNI, GOES and the monitors; needs numpy, pandas and netCDF4 · 15 KB
JSON	**AB_results.json**	Its output; Kyoto's and NMDB's terms carry over · 16 KB
PY	**c_low_latitude.py**	The authors' Bagula and Purulia data: clock and scale, our test of the mornings, daily means and the sferics; needs numpy and pandas · 10 KB
JSON	**C_low_latitude.json**	Its output, from the authors' CC BY 4.0 data · 10 KB
CSV	**C_daily_means.csv**	Daily means at Bagula and Purulia, 8–14 May 2024, all data and screened · 1 KB
CSV	**C_prl_5min.csv**	Purulia's five-minute means in UT on the paper's scale, the chart's data; CC BY 4.0, adapted from the authors' data · 45 KB
PY	**df_weather.py**	Our screens of the airports' weather reports in Japan and India; standard library · 7 KB
JSON	**D_japan_weather.json**	The Japanese airports' reports, screened, by day · 35 KB
JSON	**F_regional_ts.json**	Thunder reports from the 20 airports around Bagula, by day · 5 KB
PY	**e_figures.py**	Reads numbers off the paper's figures, from the preprint PDF, which you get yourself; standard library · 10 KB
PY	**pdf_objects.py**	A minimal PDF reader, for e_figures.py · 8 KB
PY	**pdf_vector.py**	Reads a figure's drawing paths, for e_figures.py · 12 KB
JSON	**E_figures.json**	Values read from the paper's figures · 6 KB
PY	**prl_check.py**	An independent check of our Purulia test, in separate code; standard library · 2 KB
TXT	**prl_check_output.txt**	Its output · 1 KB
PY	**prl_check_onset_sensitivity.py**	Added after the test: the same with the window anchored at 01:50 UT · 2 KB
TXT	**prl_check_onset_sensitivity_output.txt**	Its output · 1 KB
PY	**descriptive_post_hoc.py**	Added after the tests: hour-by-hour means from the paper's Fig. 3, monitors beside Dst, winds and GOES in half hours; needs pandas and netCDF4 · 8 KB
JSON	**descriptive_post_hoc.json**	Its output · 22 KB
PY	**a5_sensitivity_post_hoc.py**	Added after the tests: the harder bound on the solar particles' share · 2 KB
JSON	**A5_sensitivity_post_hoc.json**	Its output · 1 KB
PY	**make_charts.py**	Draws this page's four charts from the outputs; standard library · 16 KB
TXT	**RULES_A_gle_access.txt**	Rules for the shielding and the neutron monitors, written before the run · 6 KB
TXT	**RULES_A_amendment_hourly.txt**	The amendment for hourly monitor data, written before any hourly value was fetched · 1 KB
TXT	**RULES_B_storm_timeline.txt**	Definitions for the storm's timeline · 3 KB
TXT	**RULES_C_low_latitude_aef.txt**	Rules for the authors' Bagula and Purulia data · 4 KB
TXT	**RULES_C_amendment_alignment.txt**	The correction to how we lined up the paper's Fig. 4 with the authors' files, written after a fresh review and before the re-run · 2 KB
TXT	**RULES_D_japan_weather.txt**	Rules for the Japanese weather screen · 2 KB
TXT	**RULES_E_figures.txt**	How we read the paper's figures · 2 KB
TXT	**RULES_F_regional_thunderstorms.txt**	Rules for the thunder count · 2 KB
TXT	**rules_sha256.txt**	The SHA-256 of each rules file as it was logged, with the time · 1 KB

Run it

`python3 -I fetch_inputs.py data` downloads the 63 public inputs, about 25 MB, checks each against our copy by its SHA-256 and unpacks the authors' data (about 220 MB). Then `python3 -I ab_storm_cutoffs.py data out`, `c_low_latitude.py data/mendeley/mfb55f2wwd_v2/extracted data/mendeley/dx2nbz6yzc_v1/extracted out`, `df_weather.py data/iem out` and the rest recompute our outputs; the first two need numpy, pandas and, for GOES, netCDF4. The preprint isn't fetched: get it from SSRN [1] for `e_figures.py` and `descriptive_post_hoc.py`. Kyoto's values for 2024 are provisional, so a later download can differ slightly.

The data and their terms

Kyoto's Dst and SYM-H: scientific, non-commercial use, with acknowledgement of the observatories and the WDC, a condition that carries over to our outputs [7][8]. **NMDB:** free for non-commercial use, with its acknowledgement [11]. **GFZ's Kp:** CC BY 4.0 [6]. **The authors' data:** CC BY 4.0 [4][5]. **GOES** [10], **OMNI** [9] and **the airports' reports** [22] are public. We host only our own derived numbers, never the paper's text or the raw data.

Related checks

FALSE More auroras from less solar input? The Disaster Cycle, Fact-Checked

Sources

Bracketed numbers refer to this list. For the paper [1], l. gives a line number of the SSRN preprint we read, the submitted version, which numbers its lines; Abstract means its abstract; Fig. and Table its figures and tables. For [12], Table 1A and Table 1B are its world grid; for [15] and [33], p. gives a page of the article; for [16], [17], [19] and [36], a page of the PDF we read. Elsewhere Abstract means the abstract of the cited work; where only an abstract or a record was read, the entry says so. UT is Universal Time; GV, gigavolts of rigidity; nT, the nanotesla; Kp is given in thirds, as 8−, 8o and 8+. Links checked November 15, 2026.

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2 SpaceWeatherNews (S0) (November 15, 2026). Solar Electromagnetic Earth Dance | S0 News Nov.15.2026. YouTube video, https://www.youtube.com/watch?v=gzYwpyefO5g. Linked the source; no transcript was available, so nothing it says is rated here.

3 Crossref's records of the SSRN preprint (posted content, created September 23, 2026, with a CC BY 4.0 licence) and of the journal article (volume 288, November 2026, "All rights are reserved"), and OpenAlex's record, which joins the two. Read November 15, 2026.

4 Pal, S., and Mondal, S. K. (2026). Atmospheric Electric Field and VLF Radio Sferics Dataset at Two Low Latitude Stations during the 10-11 May 2024 Super Geomagnetic Storm. Mendeley Data, version 2, October 2, 2026 (version 1, September 22). CC BY 4.0. The authors' field-mill records from Bagula and Purulia for 8–14 May 2024 and Bagula's sferic amplitudes for 10–12 May; nothing from the Japanese sites. Downloaded November 15, 2026; the zip matched the repository's SHA-256. Our chart and tests use it, with credit.

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METHOD

How this was checked

On November 15, 2026, we read the paper in full as its SSRN preprint, the submitted version, from a copy the site's owner downloaded because SSRN refused our client; the version of record in the *Journal of Atmospheric and Solar-Terrestrial Physics* is paywalled and wasn't read. We checked its account of the storm against GFZ's Kp, WDC Kyoto's provisional Dst and SYM-H, NASA's OMNI, NOAA's GOES-16 proton data and 11 neutron monitors in NMDB; its sites against a published grid of cutoff rigidities; its claims about the Indian sites against the authors' own published data; the weather against 24 airports' reports; and its reading of the literature against 23 papers on the storm, GLE 74, atmospheric electricity and lightning (eight read in full, 13 as abstracts, two as records): the 37 sources listed. Quotations were checked word for word against the saved sources.

The verdicts and the items tagged "Our analysis" are our own assessment, built on the cited sources: the storm's timeline; the sites' cutoffs and our bound on the storm's effect on them; our pre-registered tests of the neutron monitors, of the authors' Bagula and Purulia data and of airport weather in Japan and India; the values we read from the paper's figures; and the charts. No transcript of the S0 News episode that linked the paper was available [2], so this page reviews the paper on its own and rates nothing from the episode.

We wrote the rules for our tests before running them and logged their hashes. One amendment came when NMDB turned out to have no five-minute data for three monitors, and a second, after a fresh review, corrected how our calibration lined up the paper's Fig. 4 with the authors' files before we re-ran that test; some checks were added afterwards, and each is marked. The scripts, hosted under Repeat our numbers, fetch the public inputs, check them against our copies by SHA-256 and recompute every number of ours; on November 15, 2026, fresh downloads of a sample of the inputs matched our copies, and a separate script reproduced our Purulia test. We could recompute nothing from the Japanese sites, whose data aren't public, or from the lightning counts, which come from a commercial network; for Japan we read the paper's own figure, whose curves reproduce its daily means. No figure of the paper is redrawn. Where the page notes differences within the paper or between the paper and works it cites, and how the authors' files are time-stamped (sections 2, 3, 5, 6 and 7), we haven't asked the authors about them. A fresh reviewer then re-read the built page against the sources and recomputed our numbers with separate code, and we corrected the page where the review found errors.

This page was researched and written with Claude, an AI assistant made by Anthropic, and then re-checked against its sources in a separate verification pass.

The verdicts on this page

MISLEADING	Contains something true but leaves a false impression, usually by leaving out key context.
UNSUPPORTED	No evidence we could find backs it up, though it hasn't been strictly disproven.
TRUE	The evidence supports the claim.

All ten verdicts, and how we check

CORRECTIONS

Corrections and changes

If we get something wrong, we fix it and record the change below with the date. If a correction changes a verdict, the log says what the old verdict was.

Change log

Nov 15, 2026	Published on factchecked.science after a full check against the sources. Built from the paper's SSRN preprint, the authors' published data, public storm, particle and weather records, the literature on GLE 74, atmospheric electricity and lightning, and our own pre-registered analyses, whose scripts are hosted on the page: six of the paper's claims rated on the site's scale. The charts are our own; no figure of the paper is redrawn.

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