Fact-Checked Science

PAPER CHECK · ATMOSPHERIC ELECTRICITY

The May 2024 storm checks out; its mark on the fair-weather field is patchy and unproven

Twelve sensors at seven sites, from the Andes to Reading, measured the fair-weather electric field through the great storm of May 10–13, 2024, for this peer-reviewed paper [1 Abstract]. Its account of the storm checks out against public records [3][5][6][7]. The authors themselves find the response patchy, with robust effects at only some stations and days [1 §5]; by our reading of the paper's own Figure 7, May 10's robust drops began before the shock arrived, and in our emulation the test behind "robust" also passes ordinary days, so even those are less firm than they look.

By Fact-Checked Science · Published November 15, 2026

OUR ANALYSIS marks our own reasoning and calculations: our check of the storm against Kyoto's, GFZ's, NASA's, NMDB's and NOAA's records, the arithmetic on the paper's tables, the sites' cutoff rigidities, our reading of the paper's Figure 7 and the tests we ran on it, and the simulation; the verdicts are our assessment. Everything else comes from the numbered sources. For the paper [1], § gives a numbered section, App. an appendix, and Table, Fig. and Eq. its own numbering.

The storm checks out; its mark on the fair-weather field is patchy and unproven

OUR ASSESSMENT

−406 nT
the storm's lowest hourly Dst, provisional, in the hour from 02 UT on May 11, as the paper says [3][1 Abstract]

15 of 37
station-days whose field differed from the rest of May by the paper's corrected test: 12 lower, 3 higher [1 Table 4]

12 of 15
of those at two neighbouring sites in western Argentina; the other 3 at Évora, in Portugal [1 Tables 1, 4]

THE PAPER'S CLAIMS

TRUE

"The storm produced a minimum disturbance storm-time index of −406 nT and a peak interplanetary magnetic field magnitude of ∼70 nT at the first Lagrangian point. This event also generated a large Forbush Decrease in galactic cosmic rays and a Ground-Level Enhancement of solar energetic particles"

The paper's abstract [1 Abstract]

Every part checks. Kyoto's provisional Dst fell to −406 nT in the hour from 02 UT on May 11 [3]; the field in the solar wind peaked at 68.9 nT as an hourly mean and 70.0 nT over one minute [6]; the paper's eight neutron monitors fell by 7–14 % [7]; and the ground-level enhancement is GLE 74 [10 Abstract]. A few details in the paper's text slip by hours or a citation. Our analysis; see section 2.

PARTLY TRUE

"Results show an early PG decrease near interplanetary shock arrival"

The paper's abstract [1 Abstract]

Near the shock the field did fall, at Swider even in hours without a weather marker, and at Nagycenk, in step with the paper's model of the storm's electric potential [1 Fig. 7][1 Fig. D.1]. But by our reading of the paper's own Figure 7, the seven drops of May 10 that pass its test don't come from the shock: cloud or weather markers cover the six Argentine sensors from about the time it arrived, at 17:05 UT, so 87 of their 90 usable hours came earlier, and Évora's dip began on May 9 [1 Fig. 7][4]. Our analysis; see section 4.

OVERSTATED

"Under strict fair-weather filtering and dependence-aware bootstrap inference with multiplicity correction, robust effects are present for a subset of station/day comparisons"

The paper's conclusions [1 §5]

The counts and the correction are right: 15 of 37 station-days and 2 of 13 station totals pass [1 Tables 3–4]. But the test treats each day's hours in six-hour blocks, and in our emulation it passes 7 of 49 ordinary station-days in the paper's own figure, though more of the storm's, 15 of 37; with no effect at all, a simulation passes 6–50 % of days at the same strict level. "Strict" here allows skies up to 90 % cloudy [1 §2][14 Abstract]. Our analysis; see section 5.

TRUE

"…indicating substantial spatial heterogeneity rather than a uniform global-sign response"

The paper's conclusions [1 §5]

The tables show it: over May 10–13, 8 channels rose and 5 fell, and the daily results change sign from day to day and site to site [1 Tables 3–4]. Single-station studies of the same storm differ too [16 Abstract][17 Abstract]. It is the authors' own, carefully stated result. See section 3.

UNCONFIRMED

"…solar-wind, geomagnetic, and cosmic-ray variability likely jointly modulate near-surface atmospheric electricity"

The paper's abstract [1 Abstract]

Each route has support from earlier work: storm-time electric potentials reach the ground at high latitudes, and strong Forbush decreases raised the field at CASLEO [1 §1][15 Abstract]. But in one storm the drivers overlap in time, and the paper itself says its data can't separate them [1 §4]. See section 7.

TRUE

"…a transitional 11 May phase during which a GLE contribution is plausible but not uniquely isolated"

The paper's conclusions [1 §5]

GLE 74 was small, about 10 % at the best-placed neutron monitors, with protons reaching at least 2.4 GV [10 §2][10 Abstract][10 §3]. The quiet-time cutoff is about 8–12 GV at the South American sites and 8 GV at Évora, so few if any of those protons could reach the air there directly [11 Tables 1A–1B]. The paper's caution fits. Our analysis; see section 7.

1 · THE PAPER

Twelve sensors on three continents watched the air's electric field through the May 2024 storm

Jose Tacza, of the Institute of Geophysics of the Polish Academy of Sciences, and eleven colleagues in Poland, Macao, Beijing, Portugal, Brazil, Argentina and Peru compared the fair-weather electric field near the ground during May 10–13, 2024, with the rest of the month [1 Abstract][1 §2]. The journal received the paper on September 14, 2025, accepted it on September 1, 2026, after review by two anonymous referees, and published it on October 27 [1]. S0 News linked it on November 15, 2026 [2].

What we read

The published paper, in full: 26 pages, open access under CC BY 4.0. The journal's site answered our client with a bot check, so the site's owner downloaded the PDF in a browser, and we read that copy [1]. We also looked at its figures as images, and read one, Figure 7, closely (section 4), and Figure 4's hourly backgrounds for one check. The paper mentions no supplementary material.

What "potential gradient" means

In fair weather a small current flows down through the air from the ionosphere, which thunderstorms around the world keep charged, and it sets up a vertical electric field near the ground, the potential gradient, or PG; this planet-wide loop is the global electric circuit [1 §1]. The paper's twelve PG sensors read May backgrounds from about 28 V/m at Évora to 334 V/m at Nagycenk, partly because of how each is mounted, so it compares each instrument only with itself [1 Fig. 4][1 §2]. One more instrument, at Swider, measured the air–Earth current itself [1 §2].

The same first author's other 2026 papers

Two other 2026 papers led by Tacza appear on this site: a catalogue of Schumann-resonance frequency changes at high latitudes, reviewed on our page for S0 News of November 13, and a study of the same resonance after solar-wind streams, used on our check of S0 News's Schumann note [19][20]. Schumann resonances are the circuit's alternating part; this paper is about its steady part. It cites neither.

The seven sites

SITE	INSTRUMENTS	GEOMAGNETIC LATITUDE	HEIGHT	CUTOFF, QUIET FIELD OUR ANALYSIS
CASLEO, Argentina	2 PG sensors, 0.4 km apart	22.55° S	2483 m	8.8 GV
Pierre Auger Observatory, Argentina	5 field mills, 2.1–47.6 km apart	25.71–26.06° S	1400–1690 m	8.1 GV
Huancayo, Peru	1 PG sensor	2.8° S	3350 m	12.1 GV
Évora, Portugal	1 PG sensor	41.98° N	270 m	8.0 GV
Nagycenk, Hungary	1 PG sensor	46.91° N	153 m	4.2 GV
Swider, Poland	1 PG sensor and an air–Earth current sensor	50.56° N	96 m	2.9 GV
Reading, UK	1 PG sensor	53.43° N	66 m	3.0 GV

Sites, instruments, latitudes and heights from the paper [1 Table 1][1 §2]. The last column is our interpolation of Smart and Shea's world grid of vertical cutoff rigidities for 2015, the lowest momentum per charge a cosmic-ray proton needs to reach the air above each site when the geomagnetic field is quiet; during the storm it was lower [11 Tables 1A–1B]. The paper gives cutoffs only for its neutron monitors [1 Fig. 6].

2 · THE STORM

The storm is as the paper describes it, give or take a few hours in the details

We checked the paper's account of the storm against Kyoto's Dst and SYM-H indices, GFZ's Kp, NASA's OMNI solar-wind data, the neutron-monitor database NMDB and the GOES-16 satellite's proton sensors [3][4][5][6][7][8]. The headline numbers match.

LOWEST DST, PROVISIONAL
OUR ANALYSIS
−406 nT
in the hour from 02 UT on May 11, after +66 nT in the hour from 17 UT on May 10 [3]

STRONGEST FIELD UPSTREAM
OUR ANALYSIS
70.0 nT
over one minute at 00:06 UT on May 11; 68.9 nT as the hourly mean at 23 UT on May 10 [6]

FORBUSH DECREASE
OUR ANALYSIS
7–14 %
the drop in cosmic-ray counts at the paper's eight neutron monitors, hourly, against May 7–9 [7]

The paper's storm, beside the records

THE PAPER SAYS	THE RECORD SHOWS OUR ANALYSIS
The shock reached Earth at 17:05 UT on May 10 [1 §1]; "At 17:00 UT" [1 §3]	|B| jumps from 4 to 22 nT at 17:04 UT; SSC at 17:05 UT [6][9 §6]. SYM-H then rises 78 nT in ten minutes, to +88 nT at 17:15 UT [4]
Dst "dropped from 66 nT at shock onset to a minimum of −406 nT at 02:00 UT on 11 May" [1 §3]	+66 nT and −406 nT, provisional, in the hours from 17 UT on May 10 and 02 UT on May 11 [3]; SYM-H's low was −518 nT at 02:14 UT [4]
Field "from 15.5 nT to 68.9 nT by 23:00 UT"; pressure "55.9 nPa at 20:00 UT" [1 §3]	Both exact in OMNI's hourly data [6]
Speed "peaking at 1006 km/s at 01:00 UT on 12 May" [1 §3]	Exact [6]
Kp "rose to 9 at 00:00 UT on 11 May, remained ≥7 until 05:00 UT on 12 May" [1 §3]	9− from 18 UT on May 10; 9o in 00–03 UT and 09–12 UT on May 11; at 7− or above until 06 UT on May 12, except 6+ in 00–03 UT [5]
Neutron monitors down to 86–90 %, the high-cutoff ones to 92–94 % [1 §3]	From 86.0 % at the South Pole to 93.3 % at Nor-Amberd: falls of 7–14 % [7]
A ground-level enhancement on May 11 [1 §1]	GLE 74: onsets 01:15–02:30 UT, peaks 02:20–04:30 UT, depending on the monitor [10 Table 1]; GOES-16's protons above 100 MeV rise from about 01:50 UT, peak first near 02:45 UT and stay high past 10 UT [8]

Our check of the paper's numbers against the records, with definitions fixed before we read the values (RULES_storm_facts.txt, under Repeat our numbers). GOES-16's proton timings are from our rough sum of its differential channels, not NOAA's integral product; only the times are used. Kp is given in thirds: 9−, 9o, 9+.

Small slips we noticed

- The interplanetary field's Bz was +4.8 nT at 23 UT on May 10, not "−31 nT near 23:00 UT", and 6 of the 23 hours to 16 UT on May 11 weren't below −10 nT, though the text says it stayed there "throughout the sheath" [1 §3][6]. The paper's Figure 5 shows the swings [1 Fig. 5].
- The solar wind fell below 600 km/s from 19 UT on May 13, not 00 UT on May 14; Dst stayed above −100 nT from 15 UT on May 12, an hour later than the text says [1 §3][6][3].
- The discussion gives the Forbush decrease as "approximately 10–14%", the low-cutoff monitors' range; by its own results the high-cutoff ones fell 6–8 % [1 §4][1 §3][7].
- The −406 nT is credited to Hayakawa and colleagues, who give the real-time −412 nT [1 §1][9 §1]; the GLE window "between 02:00 and 10:00 UT" is credited to Papaioannou and colleagues, but the window is Hayakawa's [1 §1][9 Abstract][10 Table 1].
- The neutron monitors' baseline is May 7–8 in the methods and May 7–9 elsewhere; the difference is under 0.2 points [1 §2][1 Fig. 6][7].
- Table 1's latitudes, described as corrected geomagnetic, look like plain dipole values by our rough check; Figure D.1's caption says May 10–13, but the plot covers 15 UT on May 10 to 06 UT on May 11; and the abstract names active regions 3663 and 3664, the introduction only 13664 [1 Table 1][1 Fig. D.1][1 Abstract][1 §1].

None of these affects the paper's conclusions. We haven't asked the authors about them.

The data and their terms

Kyoto's Dst and SYM-H are for scientific, non-commercial use; we acknowledge the WDC for Geomagnetism, Kyoto, and the observatories that supply it, and cite the data DOIs. Its values for 2024 are provisional, and we use no real-time value [3][4]. GFZ's Kp is CC BY 4.0 [5]. We acknowledge the NMDB database, founded under the European Union's FP7 programme (contract no. 213007), and the PIs of the neutron monitors at Mexico, Nor-Amberd, Alma-Ata B, Jungfraujoch, Lomnický Štít, Kiel, Oulu and the South Pole; NMDB's data are free for non-commercial use [7]. OMNI and GOES data are public [6][8].

3 · HOW IT WAS TESTED

The authors screened for fair weather, compared each storm day with the rest of May, and corrected for testing many times

The design is careful, and the paper says plainly what its tests can and can't show [1 §2][1 App. C]. Most station-days don't pass, and the ones that do point both ways.

STEP 1
Screen
Drop readings outside each instrument's range, then keep only hours with cloud fraction at most 90 %, humidity under 90 %, no rain and wind under 6 m/s, from site instruments or the ERA5 reanalysis [1 §2][1 Table 2].

STEP 2
Background
For each instrument, the mean for each hour of the day over all of May except 10–13, and each hour's departure from it, in V/m [1 §2].

STEP 3
Test
Compare May 10–13 together, and each of those days, with the background: a bootstrap that resamples six-hour blocks, 3000 times, where both groups have at least 10 hours [1 §2][1 App. C].

STEP 4
Correct
Holm's correction across the 13 four-day totals and, separately, across the 37 station-days that could be tested; "robust" means a corrected p under 0.05 [1 App. C].

What passes

TEST	PASSING	WHICH
May 10–13 together	2 of 13	Auger LA −22.0 %; Évora −51.7 %
May 10	7 of 9	all lower: six at Auger and CASLEO, and Évora
May 11	4 of 11	all lower: three Auger mills, Évora
May 12	2 of 11	Auger CRS higher; Évora lower
May 13	2 of 6	both CASLEO sensors higher

From the paper's Tables 3 and 4 and Figure 8 [1 Tables 3–4][1 Fig. 8]. On May 10 the six are the Auger mills LM, CLF, BAT and LA and CASLEO's two sensors, CAS1 and CAS2.

OUR ANALYSIS

The arithmetic holds; the passes are in two regions

Every corrected p value the paper prints follows from Holm's rule with 3000 resamples: 10 of the 37 daily tests and 2 of the 13 totals sit at the smallest p the bootstrap can give [1 Tables 3–4].

All 15 daily passes are at three sites in two regions: 12 at the Auger mills and CASLEO, about 380 km apart in western Argentina, and 3 at Évora. None is at Huancayo, Swider, Nagycenk or Reading [1 Tables 1, 4].

The paper reports its counts of rising and falling stations as descriptive. Testing them anyway, one-sided, none reaches p = 0.05, even counting each sensor separately: 7 of 9 lower on May 10 gives 0.09, and 8 of 10 higher on May 12 gives 0.055 [1 Fig. 9].

In the authors' words

PG is the potential gradient; Ez, the vertical electric field.

> *"…this descriptive coherence is not equivalent to confirmatory statistical evidence when accounting for temporal dependence and multiplicity."*
>
> Tacza et al. (2026) [1 §3]

> *"…PG/Ez alone is not sufficient to uniquely separate conductivity, current-density, and electrodynamic contributions."*
>
> Tacza et al. (2026) [1 §4]

> *"Extending coordinated multistation analyses to additional extreme storms will be necessary to establish generality across events."*
>
> Tacza et al. (2026) [1 §5]

OUR ANALYSIS

What the paper does well

It corrects for testing many station-days at once, which many storm studies don't. It separates what it can confirm from what is only suggestive, reports departures in physical units, warns that magnitudes can't be compared between differently mounted sensors, and calls the solar protons' role open [1 App. C][1 §4]. And its Figure 7 marks every hour that failed its weather screen, which is what made our checks in sections 4 and 6 possible [1 Fig. 7].

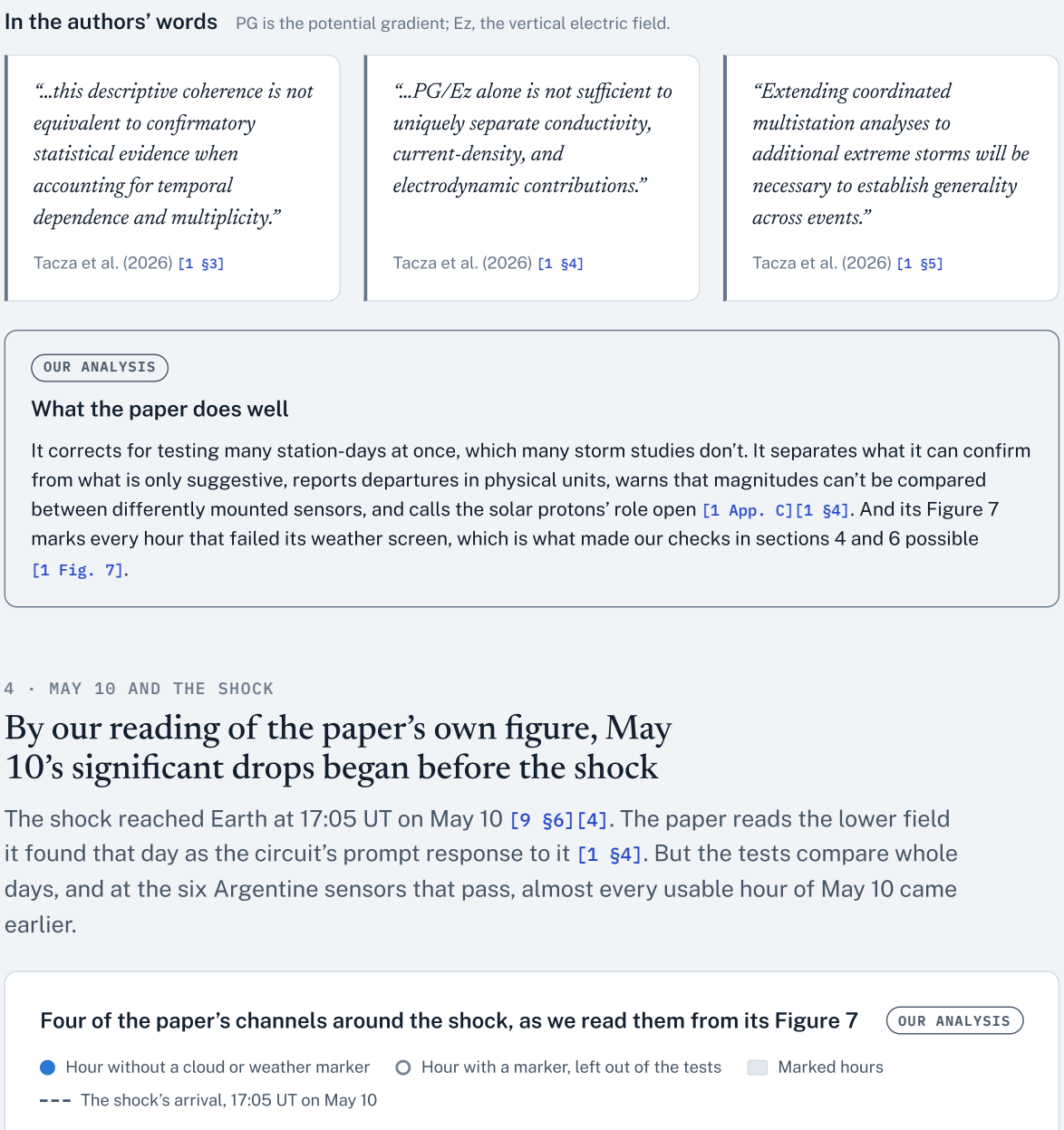
4 · MAY 10 AND THE SHOCK

By our reading of the paper's own figure, May 10's significant drops began before the shock

The shock reached Earth at 17:05 UT on May 10 [9 §6][4]. The paper reads the lower field it found that day as the circuit's prompt response to it [1 §4]. But the tests compare whole days, and at the six Argentine sensors that pass, almost every usable hour of May 10 came earlier.

Four of the paper's channels around the shock, as we read them from its Figure 7

OUR ANALYSIS



Adapted from Fig. 7 of [1], CC BY 4.0; digitized by us, so values are approximate (about 0.2–2 V/m and 15 minutes). We count an hour as usable when the figure shows a value and no marker for cloud above 90 % or a failed weather threshold, our stand-in for the paper's screen. On narrow screens the chart starts at 00 UT on May 10. Hover over a dot for its value.

OUR ANALYSIS

The usable hours came first

At the six Argentine sensors whose May 10 results pass, Figure 7 marks the sky as more than 90 % cloudy from 15–19 UT on May 10 into May 11, and CASLEO's local weather as failing the screen from 16 UT. At each of the six, the hours without a marker number exactly the paper's n for that day, and 87 of the 90 came before 17 UT; the other three are LM's 17 and 18 UT and LA's 17 UT [1 Fig. 7][1 Table 4].

The field there was already below its background in the morning, at BAT from about 04 UT, while the storm hadn't begun: Kp stood at 3−, 3−, 2+, 2o and 4− from 00 to 15 UT [1 Fig. 7][5]. Évora, the seventh, was about 20 V/m low from the evening of May 9, with about the same mean before and after the shock (section 6).

OUR ANALYSIS

Where the field did fall near the shock

At Swider the field falls from about −60 V/m at 15–16 UT to −170 V/m at 19 UT, in hours without markers, and to about −190 V/m at 20–21 UT, under cloud; the air–Earth current there falls from about −0.05 pA/m² at 15 UT to −0.4 at 18 UT, and Reading dips too, to about −15 V/m at 18–19 UT [1 Fig. 7]. At Nagycenk the usable hours average +138 V/m before 17 UT and −6 V/m after, though the field had been falling under cloud since late morning. All three fit the paper's model of the storm's ionospheric potential, which turns sharply negative over Swider, Reading and Nagycenk from about 18 UT [1 Fig. D.1]; Swider, especially, supports the early drop the paper describes.

But none counts in the paper's daily tests: Nagycenk's May 10 mean is higher than its background and doesn't pass, and Swider and Reading had too few clear hours to be tested that day [1 Table 4].

May 10's results, hour by hour

SENSOR	THE PAPER, MAY 10	THE PAPER'S N	USABLE HOURS BEFORE 17 UT OUR ANALYSIS	AFTER	MEAN BEFORE, V/M
Auger LM	−15.33 V/m (−28.7 %), passes	14	12	2	−9.9 (after: −18.9, 18 UT)
Auger CLF	−19.40 V/m (−47.2 %), passes	13	13	0	−14.8
Auger BAT	−14.96 V/m (−29.2 %), passes	15	15	0	−7.4
Auger LA	−7.19 V/m (−18.3 %), passes	18	17	1	−1.9 (after: −0.6)
CASLEO CAS1	−12.06 V/m (−14.9 %), passes	15	15	0	−3.5
CASLEO CAS2	−16.72 V/m (−39.2 %), passes	15	15	0	−11.7
Évora	−11.36 V/m (−37.8 %), passes	15	13	7	−21.4 (after: −18.9)
Nagycenk	+70.53 V/m (+21.0 %), doesn't pass	15	9	6	+138.2 (after: −6.1)

The paper's values from its Table 4 [1 Table 4]; the hours and means are our reading of its Figure 7, counting the hours where it shows the curve and no marker [1 Fig. 7]. LM's 17 UT has no marker, but the figure's dashed 17 UT line hides its value. At Évora the figure shows more such hours than the paper's n, 20 against 15, so its split is uncertain. At the six Argentine sensors our means of these hours are 5–9 V/m less negative than the paper's values.

OUR ANALYSIS Part of that gap may come from how the tables were computed. By our post hoc check, Table 4's effect sizes imply, at 11 of the 12 channels we could test, the spread of raw hourly values rather than that of departures from the hourly background; and on the 20 station-days where our count of hours equals the paper's n, the mean of the raw values, less the background's overall mean, is closer to Table 4's value than our mean departure is in 16 (median gaps 3.1 and 5.3 V/m) [1 Tables 3–4][1 Fig. 4][1 Fig. 7]. If the tests did compare each day's raw values with all the background hours, the time of day of a day's usable hours enters its result. At CASLEO on May 10 those hours, 00–15 UT, fall in the low part of the daily cycle, which would account for about 9 V/m of CAS1's −12.06 V/m and 8 V/m of CAS2's −16.72 V/m; at the Auger mills, about 2 V/m. The paper describes the quantities it tests as departures from each instrument's own background [1 §2][1 App. C]. This is our inference from its tables and figures, and we haven't asked the authors.

Ordinary explanations we checked

Day boundaries: the counts match UT days: at all six Argentine sensors, exactly. **The time axis:** the drops at Swider and Nagycenk line up with the figure's 17 UT line. **A storm effect before the shock:** the solar wind was quiet and Kp 2–4 until 15 UT, and the solar protons that arrived from about 13:30 UT can't reach sites with cutoffs near 8–9 GV [6][5][8][11 Tables 1A–1B]. **Our reading:** a separate script, written another way, reads the cloud lane over each hour's full width; on May 10, from 12 to 23 UT, it finds the same cloud markers as our reading at all seven Argentine sensors. Our first reading counted the hour after each marker as marked too; the corrections, each written down before its re-run, are under Repeat our numbers, with the rules and both scripts.

5 · HOW FIRM IS "ROBUST"

In our emulation, the paper's test also passes ordinary days, so "robust" is less firm than it sounds

As we read Appendix C.2, the bootstrap resamples six-hour blocks within each storm day's 10–22 usable hours [1 Table 4][1 App. C]. That leaves it few blocks to learn from, and it can't see how much one ordinary day differs from the next. Two checks of ours show what that does.

OUR ANALYSIS

Ordinary days in the paper's own figure

Figure 7 also shows seven days without the storm, May 6–9 and 14–16. We used six, May 7–9 and 14–16, though May 14–16 weren't quiet either: cosmic rays were still 2–8 % below their May 7–9 level, and a new sudden commencement came at 05:51 UT on May 16 [1 Fig. 7][7][9 §6]. We ran the test as the paper describes it on every station-day of those six with at least 10 usable hours, each against the other ordinary days [1 App. C].

At the strict level, p under 0.05/37, it passed 7 of 49 ordinary station-days, 3 of the 30 before the storm began. The storm days passed more often, 15 of 37 (Fisher's exact test, p = 0.01), so they do stand out; but a well-calibrated test should pass about 1 ordinary day in 740.

OUR ANALYSIS

Days with nothing in them

In a simulation with no storm at all, one day of 8–20 hours tested against 30 others, the same test gave p of 0.001 or less in 6–10 % of tries when hours were independent, and in 29–50 % when hours were persistent, as Figure 7's are, and days differed as its ordinary days do; it should be 0.1 %. Three ways of coding the bootstrap agree.

With no effect at all, that is about 2 to 18 "robust" results in 37 tests, depending on how persistent the hours are; the figure's own ordinary days pass at a rate, 10–14 %, that suggests about 4 to 5. The paper reports 15, so the storm days do stand out, but the test can't say which station-days are real. The paper's four-day totals fare better: near the expected rate with independent hours, but 5–9 % at the same level with realistic persistence.

How often the test passes, by our two checks

STATION-DAYS TESTED	P < 0.05	P < 0.05/37 (FIGURE 7) OR ≤ 0.001 (SIMULATION)
Ordinary days in Figure 7, May 7–9 and 14–16 (49)	13 (27 %)	7 (14 %)
…of which May 7–9, before the storm (30)	8 (27 %)	3 (10 %)
Storm days in Figure 7, May 10–13 (37)	**20 (54 %)**	**15 (41 %)**
Simulated days with no effect, independent hours (300–400 runs each, three codings)	18–20 %	6–10 %
Simulated days with no effect, persistent hours, days differing (400 runs each)	45–67 %	29–50 %
Expected for a well-calibrated test	5 %	0.1 %

Our emulation of the test in the paper's Appendix C.2, 3000 resamples for the figure and 999 for the simulation; the paper's code isn't public, so its version may behave differently [1 App. C]. In the simulation, "persistent" means an hour-to-hour correlation of 0.5–0.9 (Figure 7's ordinary days give 0.86–0.95) and "days differing" means a fifth of the variance between days (Figure 7's ordinary days give 14–64 %, median 26 %). The rules for both checks were written down before they ran; the simulation is post hoc, prompted by the first check, and says so.

OUR ANALYSIS

"Strict" fair weather, by the field's own standard

The paper calls its screen strict [1 Abstract][1 §2]. It keeps hours up to 90 % cloudy, of any cloud type. Criteria proposed for atmospheric-electricity measurements ask for more: no hydrometeors, aerosol or haze, with visibility over 2 km; negligible cumuliform cloud and no extensive stratus below 1500 m; and wind between 1 and 8 m/s (our paraphrase of the abstract) [14 Abstract]. Hours that pass the paper's screen can still carry local weather effects on the field.

6 · ÉVORA

Évora gives one of the two robust four-day totals, and the authors attribute its different behaviour to local conditions

Évora's PG sensor reads low, about 28–30 V/m on an average May day, and over May 10–13 it read 15.52 V/m, or 51.7 %, below that, one of only two totals that pass [1 Fig. 4][1 Table 3].

In the authors' words

> *"EVO should therefore not be interpreted as a uniquely 'special' geomagnetic station, but rather as a site where the large-scale forcing was projected through a different local conductivity, aerosol, boundary-layer, or exposure environment."*
>
> Tacza et al. (2026) [1 §4]

> *"…the departures from that common structure, especially at EVO, indicate that local or site-specific modulation remains important."*
>
> Tacza et al. (2026) [1 §4]

OUR ANALYSIS

Low before the storm began

In Figure 7, Évora's field is about 20 V/m below its background in the usable hours from 20 UT on May 9, a day with cloud in the morning, and from 01 UT on May 10, sixteen hours before the shock; its mean is −21.4 V/m before 17 UT on May 10 and −18.9 V/m after [1 Fig. 7]. The paper's Weimer model gives Évora no storm-time potential at all [1 Fig. D.1]. A local cause unrelated to the storm fits Évora at least as well as the storm does.

Évora on May 12, in the paper

Table 4 gives Évora on May 12 as 17 hours averaging 19.78 V/m below its background, −65.8 %, one of that day's two passes; the text and Figure 8 give the same [1 Table 4][1 §3][1 Fig. 8].

OUR ANALYSIS

What we can and can't tell: Table 4 and Figure 7, as we read it, disagree

In Figure 7, as we read it, Évora has values on May 12 at 00–01 and 06–23 UT, and markers cover 02–06, 09 and 23 UT. The 17 hours without a marker, the table's number, are −20 to −30 V/m at 00, 01, 07 and 08 UT, about 0 V/m at 10 UT and +6 to +27 V/m from 11 to 22 UT: about +8 V/m on average, some 28 V/m above the table's value and on the other side of the background. That is about twice Évora's typical hourly spread [1 Fig. 7][1 Fig. 4].

We looked for ordinary explanations, and none fits. Two scripts that calibrate the figure differently read the same values, to within about 2 V/m. A difference between the figure's background and the table's would shift every day alike, but on May 11 the two agree to within 1 V/m. Computed from raw values instead, as Table 4's other rows suggest (section 4), the figure's May 12 hours give about +10 V/m. The hours without values that day, 02–05 UT, are the lowest of Évora's daily cycle, so leaving them out would raise a mean, not lower it [1 Fig. 4]. The table's 17 hours equal the figure's hours without a marker, and the other stations' May 12 rows differ from the figure by less than half their typical hourly spread. We note, without drawing a conclusion, that the May 12 row is close to the May 11 row, −19.43 V/m and −64.7 % [1 Table 4].

Without the authors' data we can't tell whether the table or the figure is in error, and we haven't asked the authors.

OUR ANALYSIS

If Figure 7 is right

Only on that condition, and only by our arithmetic: taking May 10 and 11 as Table 4 gives them, the four hours of May 13 that Table 3's total implies, and May 12 as Figure 7 shows it, Évora's four-day total would be about −7 V/m, about −24 % of its background, rather than −15.52 V/m, −51.7 % [1 Tables 3–4][1 Fig. 7]. It is one of the paper's two robust totals.

7 · COSMIC RAYS AND THE GLE

The GLE's protons probably couldn't reach most of these sites, and the paper rightly leaves its role open

The storm brought two cosmic-ray events: a Forbush decrease, which removes some of the galactic cosmic rays that ionize the lower air, and GLE 74, a burst of solar protons energetic enough to register at ground level [1 §1][10 Abstract]. Either could change the air's conductivity, and so the field [1 §1].

OUR ANALYSIS

GLE 74 against the sites' cutoffs

GLE 74 raised counts by about 10.0 % at Dome C and 7.7 % at the South Pole, the best-placed monitors, a modest event, as our page on the worst solar storms also finds. Its protons reached at least 2.4 GV, and the monitors at Almaty and Baksan, with quiet-field cutoffs of 5.9 and 5.7 GV, saw increases of about 2 % [10 §2][10 Abstract][10 §3]; the storm lowered every cutoff, so those increases need not mean protons above 6 GV. A proton needs more than the local cutoff to reach the air: in a quiet field, about 8–9 GV at the Argentine sites, 12 GV at Huancayo, 8 GV at Évora, 4 GV at Nagycenk and 3 GV at Swider and Reading [11 Tables 1A–1B]. So Swider, Reading and probably Nagycenk were within reach; the South American sites and Évora were probably beyond it, and anything there would have had to come through the global circuit, not local ionization.

What the Forbush decrease might do

Fewer cosmic rays mean less ionization and a more resistive air column, so in fair weather the field can rise; at CASLEO, the group's earlier study found it did after Forbush decreases of more than 10 % as measured in space by AMS-02, and not after smaller ones (our paraphrase) [15 Abstract]. In May 2024 the ground monitors fell 7–14 % [7], and CASLEO's two sensors read higher on May 13, but the paper finds the effect "not acting in isolation" [1 §4].

Other studies of the same storm

At Gar, on the Tibetan Plateau, the field rose during the Forbush decrease, dipped during the GLE and then stayed high until late May 14 (our paraphrase) [16 Abstract]; at Paratunka, in Kamchatka, the swings in the field and current exceeded five times their quiet-time levels while the conductivity near the ground hardly changed (our paraphrase) [17 Abstract]; at Ny-Ålesund, in Svalbard, the paper reports the reverse of Gar [1 §1][18]. Another 2026 paper on this storm, checked on our page on the circuit at low and middle latitudes, reports a 21–34 % rise at two Japanese stations and credits it to solar protons that the cutoffs there exclude. And the coupling routes, from the circuit to the weather, are set out on our check of a 2026 forum report on space weather and the lower atmosphere.

8 · WHAT IT MEANS

Space weather reaches the air's electricity, but here the trace is small, local and brief

Our reading, through a catastrophist's lens: the strongest storm in two decades left changes at some stations of tens of percent for hours to days, changes ordinary weather also makes [1 Tables 3–4][1 Fig. 7].

OUR ANALYSIS

No sign of sudden or lasting change

The storm was among the largest on record, sixth by hourly Dst since 1957 (our page on its weak impact) [3]. Even so, the circuit's response at middle and low latitudes was patchy and of both signs, and of a size ordinary days also reach [1 Fig. 7][1 §4]. The paper is about the air's electric field, not the weather: it says nothing of storms changing rain, temperature or pressure. Nothing here points to a pole shift, to a planet "waking up" or to the Sun driving Earth's climate; it shows the circuit doing what the physics expects, mostly at high latitudes (our check of a Moscow storm study).

No station data

Only Reading's and one CASLEO sensor's May 2024 data are public, and both need a CEDA account, which we don't use [13][12 §2.1]. Our timing and tests rest on reading the paper's figure.

A figure, digitized

Values are approximate, and our means differ from the tables' by a few V/m at several sites [1 Fig. 7][1 Table 4].

An emulation of the test

The paper's code isn't public; our version follows its description [1 App. C].

Rough cutoffs

Grid values for a quiet field in 2015; the storm lowered them [11 Tables 1A–1B].

What would change these verdicts

01
The stations' hourly data and screening flags, with the paper's code: our re-run of the Reading data is written down and waiting (Repeat our numbers).

02
A test with the day as its unit, or a placebo over ordinary days, finding storm days still stand out: claim 3 could become Partly true.

03
The same analysis for other great storms, as the authors propose, finding the same signs and timing [1 §5].

9 · REPEAT OUR NUMBERS

The rules, the scripts and our derived numbers; the paper and its data stay with their owners

Each rules file was written before the scripts it governs first ran; amendments and post hoc checks say so in their own files. One script fetches the public inputs by URL under a plain client name and compares them with the copies we used. The paper itself you download from the journal.

- PY **fetch_inputs.py**
  Fetches OMNI, GFZ's Kp, Kyoto's Dst page, two NMDB queries and three GOES-16 files, about 38 MB, and checks each against our copy · 6 KB
- PY **storm_facts.py**, **goes_protons.py** and their outputs 1, 2
  The storm's numbers, section 2; standard library, and numpy with netCDF4 for GOES · 30 KB in all
- PY **stats_checks.py**, **cutoffs.py** and their outputs 1, 2
  The Holm arithmetic, the counts and sign tests, and the cutoffs; standard library · 15 KB in all
- PY **fig7_image.py**, **fig7_digitize.py** and **fig7_analysis.py**
  Take Figure 7 out of the paper's PDF, read its curves and markers, and run the validation and the checks of sections 4 and 5; numpy and Pillow · 20 KB in all
- CSV **fig7_digitized_hourly.csv**, **fig7_sigma_by_hour.csv** and **fig7_analysis_results.json**
  Our reading of Figure 7, hour by hour, and the results; adapted from the CC BY figure · 140 KB in all
- PY **fig7_crosscheck_cloud.py** and **its output**
  The cloud markers of May 10 read again, with separate code; Pillow only · 2 KB in all
- PY **fig7_evo_check.py** and **its output**
  Évora on May 12, and the validation row by row; Pillow only · 8 KB in all
- PY **fig4_digitize.py**, **raw_vs_departure.py**, **their rules** and outputs 1, 2
  The post hoc check, in section 4, of how Table 4 was computed: Figure 4's hourly backgrounds read from the PDF, then the two tests; numpy and Pillow for the first, standard library for the second · 25 KB in all
- PY **block_bootstrap_sim.py**, **block_bootstrap_variants.py** and their outputs 1, 2
  The post hoc simulation of the test on days with no effect; numpy · 9 KB in all
- TXT **RULES_storm_facts.txt**, **RULES_stats_checks.txt** and **RULES_reading_rerun.txt**
  The rules fixed before the storm and statistics checks ran, and the Reading re-run, fixed before any Reading data were seen and not yet run · 8 KB in all
- TXT **RULES_fig7.txt** and amendments 1, 2, 3 and 4
  The digitizing and its questions, fixed before the code ran; amendment 1, after the separate check; 2–4, post-review corrections to how the markers are read, each written before its re-run · 11 KB in all
- TXT **RULES_sim.txt** and amendments 1, 2, 3
  The simulation, post hoc, each step written before it ran · 4 KB in all
- TXT **HASHES.txt**
  The SHA-256 of every file here and of our inputs, and the order in which the rules and runs came · 6 KB

Run it

`python3 -I fetch_inputs.py <folder>`, then `python3 -I storm_facts.py <folder>`; `stats_checks.py` and `cutoffs.py` need nothing. The Figure 7 scripts need the paper's PDF, which the journal serves free: `python3 -I fig7_digitize.py swsc250080.pdf <out>`, then `python3 -I fig7_analysis.py <out>`; they need numpy and Pillow. For the check in section 4, `python3 -I fig4_digitize.py swsc250080.pdf <out>/fig4_background.csv`, then `python3 -I raw_vs_departure.py <out>`. Keep the scripts together; Python 3.9 or later.

What we don't host

The paper, its figures and its data: the paper is free from the journal under CC BY 4.0, and we host only numbers we derived [1]. The Reading data need a CEDA account; our re-run, RULES_reading_rerun.txt, is fixed and waits for them [13][12 §2.1]. Kyoto's, GFZ's, NMDB's, OMNI's and GOES's data are fetched from their owners, under the terms in section 2.

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], § gives a numbered section (1–5), App. an appendix (A–D), and Table, Fig. and Eq. the paper's own numbering; Abstract is its abstract. For [9] and [10], read as their arXiv versions, § and Table refer to those; for [11], Tables 1A and 1B are its world grids. Abstract marks a source of which we read only the abstract, as its entry says. UT is Universal Time, SSC a storm sudden commencement, |B| the strength of the magnetic field in the solar wind, nT the nanotesla, V/m volts per metre, pA/m² the picoampere per square metre, GV the gigavolt of cutoff rigidity and pfu the particle flux unit; minus signs in quotations are printed as minus signs. Links checked November 15, 2026.

1 Tacza, J., Li, G., Fu, S., Chen, T., Xu, E., Kubicki, M., Silva, H. G., Raulin, J.-P., Romero, R., Fernandez, G., Marun, A., and Samanes, J. (2026). The May 2024 geomagnetic superstorm and its impact on the global electric circuit. *Journal of Space Weather and Space Climate* 16, 36. Received September 14, 2025, accepted September 1, 2026, published online October 27, 2026 (Crossref). CC BY 4.0, by its own statement. Peer reviewed, by two anonymous referees. Read in full, from a copy the site's owner downloaded, because the journal's site refused our client (26 pages, 12,166,745 bytes, SHA-256 c9faeb3b…1929).

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 Nose, M., Iyemori, T., Sugiura, M., Kamei, T., Matsuoka, A., Imajo, S., and Kotani, T. (2015). Geomagnetic Dst index [data set]. World Data Center for Geomagnetism, Kyoto. Provisional hourly values for May 2024 (page updated January 28, 2025), read November 15, 2026, when final values ran to December 2020 and provisional ones to September 2026, under the WDC's data usage rules: scientific use, no commercial use, with acknowledgement of the WDC and of the observatories that supply the data.

4 World Data Center for Geomagnetism, Kyoto, Imajo, S., Matsuoka, A., Toh, H., and Iyemori, T. (2022). Mid-latitude Geomagnetic Indices ASY and SYM (ASY/SYM Indices). One-minute SYM-H for May 2024, provisional, as included in OMNI's one-minute file [6], whose format notes say it takes Kyoto's provisional high-resolution indices; read November 15, 2026, under the same rules as [3].

5 Matzka, J., Bronkalla, O., Tornow, K., Elger, K., and Stolle, C. (2021). Geomagnetic Kp index. V. 1.0. GFZ Data Services. Definitive values, file Kp_ap_since_1932.txt, read November 15, 2026. CC BY 4.0.

6 NASA Goddard Space Flight Center, Space Physics Data Facility. OMNI solar-wind data (J. H. King and N. E. Papitashvili): hourly values for 2024 and one-minute values for May 2024, time-shifted to the bow shock from spacecraft at the first Lagrangian point. Read November 15, 2026.

7 Neutron Monitor Database (NMDB). Pressure-corrected hourly counts for May 2024 at Mexico, Nor-Amberd, Alma-Ata B, Jungfraujoch, Lomnický Štít, Kiel, Oulu and the South Pole, and five-minute counts for May 10–11 at four of them and Dome C, through its NEST interface, read November 15, 2026. Free for non-commercial use, with the acknowledgement given in section 2.

8 NOAA National Centers for Environmental Information. GOES-16 SGPS level-2 five-minute proton averages, version 3-0-2, May 10–12, 2024. Read November 15, 2026. Public domain.

9 Hayakawa, H., Ebihara, Y., Mishev, A., Koldobskiy, S., Kusano, K., Bechet, S., et al. (2025). The Solar and Geomagnetic Storms in 2024 May: A Flash Data Report. *The Astrophysical Journal* 979(1), 49. CC BY 4.0. Read in full as arXiv:2407.07665v2; § gives its sections. On the paper's reference list.

10 Papaioannou, A., Mishev, A., Usoskin, I., Heber, B., Vainio, R., Larsen, N., et al. (2025). The High-Energy Protons of the Ground Level Enhancement (GLE74) Event on 11 May 2024. *Solar Physics* 300, 73. CC BY 4.0. Read in full as arXiv:2505.09180v1. On the paper's reference list.

11 Smart, D. F., and Shea, M. A. (2020). Vertical Geomagnetic Cutoff Rigidities for Epoch 2015. *Proceedings of the 36th International Cosmic Ray Conference*, PoS(ICRC2019)1154. CC BY-NC-ND 4.0. Read in full; we use the four grid values around each site from its Tables 1A and 1B.

12 Nicoll, K. A., Harrison, R. G., Barta, V., Bor, J., Brugge, R., Chillingarian, A., et al. (2019). A global atmospheric electricity monitoring network for climate and geophysical research. *Journal of Atmospheric and Solar-Terrestrial Physics* 184, 18–29. CC BY 4.0. Read in full, from the copy in the Hungarian Academy of Sciences' repository.

13 Centre for Environmental Data Analysis. GloCAEM archive: listings of the one-minute files for Reading and CASLEO's sensor 2 for May 2024, read November 15, 2026. Downloading them asked our client to sign in, and we don't.

14 Harrison, R. G., and Nicoll, K. A. (2018). Fair weather criteria for atmospheric electricity measurements. *Journal of Atmospheric and Solar-Terrestrial Physics* 179, 239–250. Abstract only, through OpenAlex's record, paraphrased; the publisher's site is one we don't fetch.

15 Tacza, J., Li, G., and Raulin, J.-P. (2024). Effects of Forbush Decreases on the Global Electric Circuit. *Space Weather* 22(4), e2023SW003852. CC BY 4.0. Abstract only, as its publisher deposited it with Crossref, paraphrased. On the paper's reference list.

16 Fu, S., Li, G., Tacza, J., Chen, T., and Peng, J. (2025). Global electric circuit response to the May 2024 geospace superstorm from China's Gar station observation. *Physics of Fluids* 37(11), 117123. Abstract only, as its publisher deposited it with Crossref, paraphrased. On the paper's reference list.

17 Li, L., Chen, T., and Wang, C. (2026). May 2024 Super Geospace Storm: Impacts on the Global Atmospheric Electrical Environment. *Journal of Geophysical Research: Space Physics* 131(4), e2026JA035117. Abstract only, as its publisher deposited it with Crossref, paraphrased. On the paper's reference list.

18 Kavita, Das, S., and Murukesh, N. (2026). Impact of severe geomagnetic storm on atmospheric electric field over the Arctic region during May 2024. *Journal of Atmospheric and Solar-Terrestrial Physics* 281, 106780. Record only: no index holds its abstract, and the publisher's site is one we don't fetch. On the paper's reference list.

19 Tacza, J., Bozoki, T., Satori, G., Neska, A., Raita, T., and Bor, J. (2026). A catalogue of solar rotation-scale variations in the first Schumann resonance frequency at high latitudes, 2004–2024. *Scientific Reports*. CC BY 4.0. Read in full for our page on S0 News of November 13.

20 Tacza, J., Sátori, G., Neska, A., Raita, T., and Bozoki, T. (2026). Schumann resonance frequency increase following recurrent solar wind stream onsets. *Earth and Space Science* 13, e2026EA005271. CC BY 4.0. Read in full for our review of S0 News's Schumann note.

METHOD

How this was checked

On November 15, 2026, we read the paper in full and checked its account of the storm against WDC Kyoto's provisional Dst and SYM-H, GFZ's definitive Kp, NASA's OMNI solar-wind data, the neutron-monitor database NMDB and GOES-16's proton sensors, with definitions fixed before we read the values. We checked its statistics against its own Tables 3 and 4 and Figures 8 and 9, looked up the sites' cutoff rigidities in Smart and Shea's 2015 grid, and read the papers we used for the storm and its methods: four in full, four as abstracts and one as a record only, besides two of the first author's 2026 papers read for earlier pages. Those are the 20 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. No transcript of the episode in which S0 News linked the paper was available, so this page reviews the paper on its own and rates nothing from the episode.

We digitized the paper's Figure 7, the hourly departures and weather markers of all 13 channels, under rules written before the code ran. A fresh reviewer found that our first reading counted the hour after each marker as marked too; we confirmed it in our own code and logged three corrections, each before its re-run, and every number here comes from the corrected reading. Its counts of usable hours match the paper's Table 4 exactly in 24 of the 37 rows (median difference 0), its means correlate with the table's at 0.90, and a separate script reads the same cloud markers for May 10. On it we timed May 10's usable hours against the shock and ran the paper's test, as its appendix describes it, on ordinary days; a post hoc simulation, logged step by step, tries the same test on days with no effect. We couldn't re-run anything on the stations' own data: Reading's and one CASLEO sensor's are at CEDA behind a sign-in, and the rest are unpublished. We haven't asked the authors about the points we raise in sections 2 and 4–6. Our scripts, rules and outputs are under Repeat our numbers.

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. Before publication a fresh reviewer read the built page against its sources and re-ran our analyses with separate code; we applied its corrections, including the one to our reading of Figure 7.

The verdicts on this page

OVERSTATED	Has some basis but claims much more than the evidence supports.
UNCONFIRMED	Rests on a preliminary result that hasn't been confirmed.
PARTLY TRUE	Part of the claim holds up and part doesn't.
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.

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