Fact-Checked Science

PAPER CHECK · SPACE WEATHER

A Carrington-class storm in 1770, but not clearly 30% bigger, and no 89-year cycle

Chinese chronicles record aurora in central China, as far south as 29°N, in September 1770, and a 2026 paper by Ding Yuan and colleagues turns the farthest sighting into a storm of −1,319 nT, "approximately 30%" stronger than its own −1,025 nT for 1859 [1 Abstract]. S0 News relayed the 30% correctly, but called the storm a new "super flare" [2 00:00:19–00:00:21] and spun an 89-year cycle of "killer events" from its date [2 00:01:25–00:01:33]. The storm was Carrington-class, but the margin rests on one mis-sourced 1859 sighting and a curve stretched beyond its data, and the storm record keeps no 89-year rhythm, by our analysis.

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OUR ANALYSIS marks our own reasoning and calculations, including our re-runs of the paper's equations and our test of the episode's 89-year cycle, and the verdicts are our assessment. Everything else comes from the numbered sources. For the paper [1], p. gives a page of the article as published (its own numbering, 1 to 9), § a section, Fig. a figure and Table S1 the table of Chinese records in its Supplementary Material; for the episode [2], times are positions in the video.

A real superstorm in 1770; a fragile 30% lead over 1859, and no 89-year clock

OUR ASSESSMENT

−1,319 vs −1,025

nT on the storm index Dst: the paper's sizes for the storms of 1770 and 1859, both worked out from how far toward the equator aurora was seen, by the same method; their 95% intervals overlap [1 Abstract][1 §4]

5–10%

how much stronger 1770 comes out by the paper's own curve with the 1859 edge Hayakawa and colleagues derived from South American reports in 2020, up to 14% if the 1770 light stood overhead; the paper's 29% rests on one mis-sourced sighting, by our analysis [10 Abstract]

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Carrington-class storms after 1859, those of 1872 and 1921, that fall within three years of the episode's 89-year marks; they sit 12.6 and 26.9 years away, by our analysis [12 Abstract][15 Abstract]

THE CLAIMS

MISREAD

A new superflare identified

The presenter: "They identified a new super flare in recent history" [2 00:00:19–00:00:21]

The paper identifies no flare. It reconstructs a geomagnetic storm, the shaking of Earth's magnetic field, from where aurora was seen [1 Abstract]. It mentions superflares only to say the 1770 sunspot group "was capable of powering an unusually energetic solar-terrestrial event", and it argues that the eruption behind the storm must have been more powerful than 1859's, but identifies no flare [1 §4]. None was seen: the first flare ever observed was in 1859 [7 §1]. Nor is the storm new: Japanese reports of its aurora were listed in 1956 [3 p. 738], its sightings in both hemispheres were described in 1996 [3 p. 733], and its East Asian records were studied in 2017 [4 Abstract][5 Abstract]. See section 2.

TRUE

They say 30% larger than 1859

The presenter: "They say it produced a geomagnetic storm 30% larger than the Carrington event of 1859" [2 00:01:17–00:01:22]

That is the paper's headline. Its best estimate for 1770 on the storm index Dst, −1,319 nT, exceeds its own −1,025 nT for 1859 "by approximately 30%", both values worked out from how far toward the equator the aurora reached [1 Abstract][1 §3.4]. Nothing was measured in 1770, and whether the margin holds is another question: see the fourth claim and section 4.

TRUE

A Carrington-class storm

The paper: "the Qianlong XXXV event was a Carrington-class geomagnetic storm" [1 §4]

Aurora was seen at unusually low latitudes in China and Japan and from Captain Cook's *Endeavour*, below 30° magnetic latitude on almost every night of 10–19 September 1770 [4 Abstract][3 p. 741]. Studies of other records reached the same rank: "comparable to, or slightly larger than" 1859, from a painting and a diary in Kyoto [5 Abstract], and comparable in how far the aurora reached, from 111 East Asian records [4 §5]. See section 2.

OVERSTATED

About 30% stronger than 1859

The paper: "exceeding the reconstructed Dst intensity of the 1859 Carrington event … by approximately 30%" [1 Abstract]

The discussion calls this "strong quantitative evidence" that 1770 "was more intense than the 1859 Carrington event", while saying the comparison "should be interpreted cautiously" because the 95% intervals overlap [1 §4]. Those intervals leave out how far real storms scatter about the curve [1 Fig. 3], and both storms lie beyond those it was fitted to. The 1859 value rests on one sighting, and that is mis-sourced: the paper puts the USS *Sabine* off Panama, with its light an assumed 20° up [1 §3.2][1 Fig. 2b], but the Panama report was the USS *Saranac*'s, in the storm of 28–29 August, and the *Sabine* was off Nicaragua [8 §3.2][8 §3.3]. With the 1859 edge Hayakawa and colleagues derived from South American reports in 2020, the same curve makes 1770 only 5–10% stronger, up to 14% if its light stood overhead, and the 1872 storm's aurora reached about as far, by our analysis [10 Abstract][11 Abstract]. See section 4.

OVERSTATED

Once in about 14,000 years

The paper: "a quantitatively constrained estimate of storm intensity … and recurrence interval (~14,000 years)" [1 §4]

The abstract calls the 14,000 years "an order-of-magnitude recurrence interval" [1 Abstract], and the paper's own range runs from about 2,000 to 760,000 years, a spread of more than two orders of magnitude [1 §4]. Taken at face value, its model gives a record like the one it reconstructs, a storm the size of 1770's and another the size of its 1859's within 255 years, a 0.3% chance, by our analysis: the model's tail is too thin or the sizes are too high. See section 5.

FALSE

Killer storms every 89 years

The presenter: "1770 to 1859 is 89 years. It's the Glyceberg cycle, the critical vote favored solar cycle for killer events about 88.8 years." [2 00:01:25–00:01:33]

This arithmetic is the episode's, not the paper's. Gleissberg's cycle is a slow rise and fall in the height of sunspot maxima, "about seven or eight sun-spot cycles" long [24 pp. 158–159], and we found no source for 88.8 years. Hayakawa and colleagues called the 1770 storm's timing "consistent to the apparent 60–100-year period of extreme solar flares" [4 §5], but their source gives an average rate, not a cycle [7 note 2]; a 2011 paper studies how extreme storms fall in sunspot and Gleissberg cycles, and its abstract, all we could read, states no result [28 Abstract]. Neither is a regular 89-year clock, and the record contradicts one: the two Carrington-class storms after 1859, in 1872 and 1921, came 12.6 and 26.9 years off the marks, and the one mark it can test, 1948, brought none. Our tests against random dates find no sign of even a weak 89-year tendency. See section 6.

1 · THE PAPER

Chinese chronicles, the southernmost sighting, and a curve that turns an aurora into a storm size

Ding Yuan and nine colleagues, led from the Harbin Institute of Technology in Shenzhen with co-authors in India, Belgium, Poland and the UK, set out to measure the storm of September 1770 from Chinese records of aurora and to offer it as a benchmark for extreme space weather [1 §1]. They call it the Qianlong XXXV event, after the 35th year of the Qianlong emperor's reign [1 §1]. The paper is a peer-reviewed research article in *Frontiers in Astronomy and Space Sciences*, received on April 16, accepted on September 16 and published on October 21, 2026, under CC BY 4.0 [1 p. 1], funded by Chinese national, provincial and city grants and, for one co-author, European ones [1 p. 8].

STEP 1

Gather the records

Regional chronicles and Qing histories give "23 distinct auroral records within China's borders for 11–19 September 1770"; the supplement lists 20 of them, with place, colour and an English translation [1 §2.1][1 Table S1]. Japanese and Korean records come from an earlier study, European ones from NASA's lists [1 §2.1].

STEP 2

Find the aurora's edge

Each site gets a magnetic latitude for 1770, from the pole of the gufm1 field model [1 §3.2]. From the lowest site and how high the light stood in its sky, the geometry gives how far toward the equator the oval of aurora reached [1 §2.2].

STEP 3

Turn the edge into a storm size

A curve fitted to 37 storms with Dst below −250 nT relates the edge's latitude to Dst, the standard index of a storm's strength: $\mathrm{MLAT} = -0.43\,(-\mathrm{Dst})^{2/3} + 71.53$ [1 §2.3][1 Fig. 3a].

STEP 4

Say how rare

A Gumbel extreme-value model of the largest storm in each 11-year solar cycle, "adopted from Love (2021)", gives a return period for each size [1 §2.3]. Love fitted it and two other models to the largest and second-largest storms of each cycle; all three described the data, and he made his own estimates with a constrained Weibull model [22 Abstract].

The paper's results

STORM	LOWEST SIGHTING	EDGE OF THE OVAL	DST (95% INTERVAL)
September 1770	Dongtinghu, Hunan, 19.2° magnetic latitude: light "illuminating the entire sky", taken as 60° up [1 §2.2]	20.40°N [1 §3.2]	−1,319 nT (−1,832 to −1,066) [1 §3.4]
September 1859	"the US Frigate *Sabine* off Panama", 20.45°: a glow assumed to stand 20° up [1 §3.2][1 Fig. 2b]; on the ships, see section 4	28.30°N [1 §3.2]	−1,025 nT (−1,367 to −853) [1 §3.4]
May 2024	Alxa Youqi, Inner Mongolia, 33.15°: the lowest naked-eye report [1 §3.3]	40.99°N [1 §3.3]	−412 nT, measured in real time [1 §3.3]; −406 nT in the provisiona

The 1770 and 1859 ranges of the return periods are $10^{4.15\,^{+1.73}_{-0.85}}$ and $10^{3.16\,^{+1.15}_{-0.58}}$ years, from the paper's XML; the year figures are our conversion [1 §4]. A storm at Dst −1,319 nT would be over twice the size of March 1989's, the largest since the Dst record began in 1957, at −589 nT [12 §6].

How the authors qualify it Their own words, from the discussion and the abstract.

> *"Although these confidence intervals overlap, the central estimate for the Qianlong XXXV event remains more negative than that of the Carrington event under the same reconstruction framework."*
>
> Yuan et al. (2026) [1 §4]

> *"while the comparison should be interpreted cautiously, the extremely low reconstructed auroral oval boundary supports the interpretation that the Qianlong XXXV event was a Carrington-class geomagnetic storm"*
>
> Yuan et al. (2026) [1 §4]

> *"An extreme value statistical model suggests an order-of-magnitude recurrence interval of approximately 14,000 years for the Qianlong XXXV event"*
>
> Yuan et al. (2026) [1 Abstract]

What the paper does not say

It makes no forecast. It says nothing about the Gleissberg cycle, 2037 or the next solar cycle, and "solar cycle" appears only in its formula for return periods [1 §2.3]. Its only numbers about future storms put one like 1770's at about once in 14,000 years [1 Abstract]: the opposite of a warning that one is imminent. The 89-year arithmetic, and the "super flare", are the episode's (section 6).

2 · THE RECORDS

Aurora reached central China in 1770, and the storm has been in the literature since at least 1956

The key record is from a chronicle of Dongting Lake in Hunan, at 29.1°N, about 19.2° in magnetic latitude in 1770 [1 §3.1]. On the evening of 17 September, in the paper's translation, a "stream of red vapor emerged from the northern corner outside the city, and shortly after, it split into hundreds of rays of emerald-white light"; it "turned into a fiery hue, illuminating the entire sky, and only subsided at dawn" [1 §2.2][1 Table S1].

What the other records describe

Most of the 20 Chinese entries in the supplement describe a red glow or red "vapor", often with white rays, to the north or north-west; Dongtinghu's is the only one listed with green [1 Table S1]. Japanese records of 17 September also describe red [3 p. 739], and a study of the brightest Japanese accounts found a display dominated by red, "as bright as a night with full moon", reaching about 35° above the horizon at 25° magnetic latitude [6 Abstract]. The paper reads "emerald-white" as the green light of oxygen; that reading is what lets it rule out a stable red arc, which would make the storm look bigger than it was [1 §4].

From Cook's *Endeavour*

On the night of 16 September, Joseph Banks and Sydney Parkinson, sailing west past Timor on Cook's first voyage, recorded a dull red glow in the south, about 20° above the horizon, crossed by brighter rays shooting upward [3 pp. 733–735]. In 1996 Willis, Stephenson and Singh placed the ship at about 10.45°S, 122.82°E and showed that its sighting and the Chinese ones of the same night lay on linked field lines, "the earliest example yet known of conjugate auroral sightings" [3 p. 735][3 p. 741]. The new paper puts the ship at 112.82°E, in "the Malacca Strait Narrows", and calls the two hemispheres' sightings concurrent, though Dongtinghu's is dated the next night [1 §3.1][1 Table S1].

Not new, and not a flare

The storm was in the literature by 1956, when Matsushita listed 15 independent Japanese reports of its aurora on 17 September [3 p. 738], and its sightings in both hemispheres were described in 1996 [3 p. 733]. In 2017 Hisashi Hayakawa and colleagues gathered 111 East Asian records, found aurora below 30° magnetic latitude on almost every night of 10–19 September, and already named Dongtinghu as the most equatorward sighting [4 Abstract][4 §3]; Ryuho Kataoka and Kiyomi Iwahashi read a Kyoto painting and diary as an aurora reaching the zenith [5 Abstract]. No flare was observed. The first sighting of a solar flare, by Carrington and Hodgson, came in 1859 [7 §1]. From a drawing of the 1770 sunspot group, about 6,000 millionths of the visible hemisphere, Hayakawa and colleagues put the most energy it could release in a flare at about 10^{34} erg [4 §2.2]; the new paper notes that superflares on Sun-like stars may reach about that much and concludes that the region "was capable of powering an unusually energetic solar-terrestrial event" [1 §4]. Neither paper reports a flare.

3 · FROM AURORA TO STORM SIZE

A fitted curve, stretched beyond its data, that gives bigger storms than every full magnetogram estimate

Seen 60° up from Dongtinghu, green light at 240 km puts the oval's edge at 20.40°; at 75° or straight overhead it would be 19.8° or 19.2° [1 §2.2][1 Fig. 2a]. The curve turns 20.40° into −1,319 nT; for 1859, red light at 400 km, assumed to stand 20° up at Panama, gives 28.30° [1 Fig. 2b] and −1,025 nT [1 §3.4]. Re-run from the paper's equations, with the coefficient unrounded, both steps give the same numbers, by our analysis.

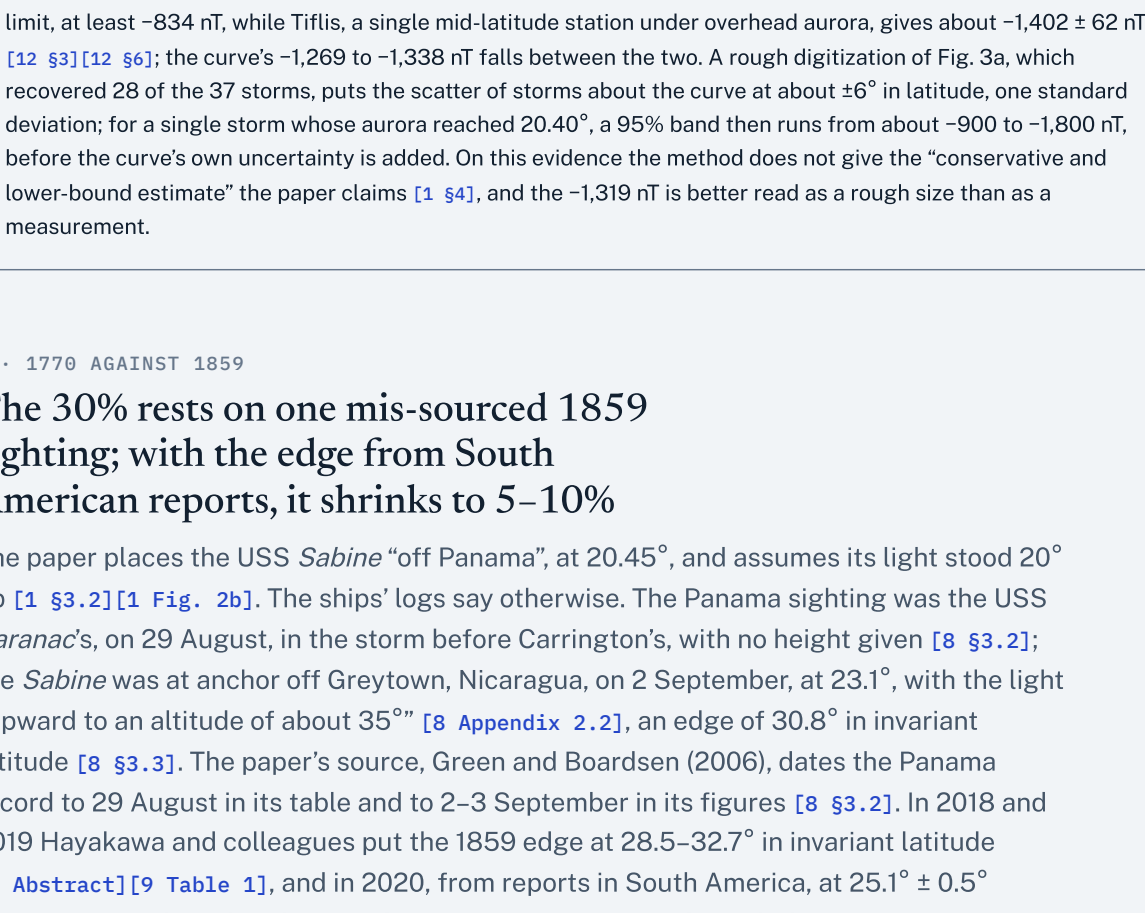
What the 95% intervals cover

They are "the 95% confidence interval of the fitted regression curve" [1 Fig. 3]: the uncertainty of the average curve, not the spread of single storms about it, and the curve accounts for only part of that spread, $R^2 = 0.563$ [1 Fig. 3a]. The storms it was fitted to reach about −900 nT (read by eye from Fig. 3a), so the 1770 and 1859 values both lie beyond them [1 Fig. 3a]. The 37 storms are not listed in the paper or its supplement [1 §2.3].

Choices on the cautious side

The paper calls its 60° conservative, and its 240 km is too: light overhead, or green light at the 100 km the text gives for it, would put the edge lower still [1 §2.2][1 §3.1]. Other published curves would make the 1770 storm larger as well. In the paper's own comparison, Yokoyama and colleagues' relation reaches 20° only near −1,900 nT, and Blake and colleagues' curve, which ends near −1,150 nT, never falls much below 44° (both read by eye) [1 Fig. 3b]; in Blake and colleagues' simulation, a Carrington-like storm of −1,142 nT pushed the edge no lower than 35.5° [23 Abstract]. That is the paper's basis for calling its curve conservative, "supporting a lower-bound assessment" [1 §3.4]. Our doubt about the lower bound rests instead on the comparison with magnetograms below.

Wherever magnetograms give a storm's full size, the paper's curve gives a bigger storm



OUR ANALYSIS Orange: each published edge of the oval put through the paper's curve, $\mathrm{MLAT} = 71.53 - 0.4252\,(-\mathrm{Dst})^{2/3}$, from its Fig. 3a with the coefficient solved from its two results [1 Fig. 3a] (CC BY 4.0). Edges given in invariant latitude, which follows the field line, are converted to magnetic latitude at 240 km, the paper's height for 1770, and at 400 km, its height for 1859; the bar spans the two. Edges: 2024 from the paper [1 §3.3]; 1989, 1909 and 1921 from Hayakawa and colleagues [9 Table 1][12 §6]; 1859 from South American reports [10 Abstract]; 1872 [11 Abstract]. Blue: minimum Dst from magnetograms for 2024, the real-time value the paper uses (−406 nT in the provisional index) [1 §3.3], 1989 [12 §6], 1909 [14 Abstract], 1921 [15 Abstract], 1859 [13 Abstract][12 §6] and 1872: a lower limit from Colaba, whose record has a gap at the peak, and the value from Tiflis, a single mid-latitude station under overhead aurora [12 §3][12 §6]. For the paper's own 1770 and 1859 rows the whiskers are its 95% intervals [1 §3.4]; the shaded row is the comparison the paper makes.

OUR ANALYSIS

The paper's own check, and what the scatter allows

The paper says its framework "was consistent with the well-observed 11 May 2024 geomagnetic storm (peak Dst = −412 nT)" [1 §4]. Its own curve puts a −412 nT storm's edge at 48.0°, seven degrees poleward of the 40.99° the paper found for 2024, and turns 40.99° into −609 nT [1 §3.3]. The edges published for 1859, 1909 and 1921 likewise come out 26–71% above those storms' magnetogram values, and March 1989's 8–35% above, as the chart shows. For 1872 the check cannot be scored: Colaba's record has a gap at the peak and gives only a lower limit, at least −834 nT, while Tiflis, a single mid-latitude station under overhead aurora, gives about −1,402 ± 62 nT [12 §3][12 §6]; the curve's −1,269 to −1,338 nT falls between the two. A rough digitization of Fig. 3a, which recovered 28 of the 37 storms, puts the scatter of storms about the curve at about ±6° in latitude, one standard deviation; for a single storm whose aurora reached 20.40°, a 95% band then runs from about −900 to −1,800 nT, before the curve's own uncertainty is added. On this evidence the method does not give the "conservative and lower-bound estimate" the paper claims [1 §4], and the −1,319 nT is better read as a rough size than as a measurement.

4 · 1770 AGAINST 1859

The 30% rests on one mis-sourced 1859 sighting; with the edge from South American reports, it shrinks to 5–10%

The paper places the USS *Sabine* "off Panama", at 20.45°, and assumes its light stood 20° up [1 §3.2][1 Fig. 2b]. The ships' logs say otherwise. The Panama sighting was the USS *Saranac*'s, on 29 August, in the storm before Carrington's, with no height given [8 §3.2]; the *Sabine* was at anchor off Greytown, Nicaragua, on 2 September, at 23.1°, with the light "upward to an altitude of about 35°" [8 Appendix 2.2], an edge of 30.8° in invariant latitude [8 §3.3]. The paper's source, Green and Boardsen (2006), dates the Panama record to 29 August in its table and to 2–3 September in its figures [8 §3.2]. In 2018 and 2019 Hayakawa and colleagues put the 1859 edge at 28.5–32.7° in invariant latitude [8 Abstract][9 Table 1], and in 2020, from reports in South America, at 25.1° ± 0.5° [10 Abstract], the value they used again in 2023 [12 §6]. Through the paper's own curve, the choice decides the margin.

1770's lead over 1859 depends on which 1859 edge is used

EDGE USED FOR 1859	FROM	1859 BY THE PAPER'S CURVE	1770 STRONGER BY
28.30° at 400 km, 31.3° invariant	The paper: Panama's position, 20.45°, under the *Sabine*'s name, with light assumed 20° up [1 §3.2][1 Fig. 2b]	−1,025 nT	29% (the paper's "about 30%") [1 §3.4]
30.95° at 400 km, 33.7° invariant	The *Sabine*'s position, 23.1° [9 §4], with the paper's assumed 20°	−894 to −932 nT	47–50%
30.8° invariant	The *Sabine*'s log: light up to about 35° [8 §3.3]	−1,002 to −1,047 nT	32–33%
25.1° ± 0.5° invariant	**Reports from South America** [10 Abstract]	**−1,209 to −1,319 nT**	**5–10%; up to 14% if the 1770 light stood overhead**
***For comparison:* 1872, 24.2° invariant**	Overhead aurora at Shanghai and Jacobabad [11 Abstract][12 Abstract]	−1,269 to −1,338 nT	about 4%
***For comparison:* 1921, 27.1° invariant**	Hayakawa and colleagues [9 Table 1]	−1,147 to −1,204 nT	15–16%

OUR ANALYSIS Invariant latitude follows the field line, so edges seen at different heights can be compared: the paper's 1770 edge is 23.0° in these terms, or 22.0° if the light stood overhead. Each edge is converted to magnetic latitude at 240 km and at 400 km and put through the paper's curve, against 1770's edge at the same height; the ranges cover both heights and, for 1859, the ±0.5°. The paper's own row is its published comparison, which sets 1770's edge at 240 km against 1859's at 400 km; at one height it would be 34–36%. The South American row keeps the paper's 60° for the 1770 light; at 75° it gives 7–12%, and with the light overhead 9–14%.

OUR ANALYSIS

Not unique, either

By the same measure the February 1872 storm reached about as far as 1770's: aurora overhead at Shanghai and Jacobabad, 19.9° in magnetic latitude, puts its edge at 24.2° in invariant latitude [11 Abstract][12 Abstract], against 23.0° for the paper's 1770 edge. From magnetograms and aurorae, Hayakawa and colleagues rank the storms of 1859, 1872 and 1921 as the three largest yet observed, at about −949 nT, at least −834 nT (about −1,402 nT at the single station of Tiflis) and −907 ± 132 nT [12 §6][15 Abstract]. The paper does not mention 1872. Ranked by the edge alone, the four storms run 1770, 1872, 1859, 1921, within about four degrees of one another.

What other studies concluded

From other records, Kataoka and Iwahashi judged the 1770 storm "comparable to, or slightly larger than" 1859's [5 Abstract], and Hayakawa and colleagues judged it comparable in how far the aurora reached and much longer, with low-latitude aurora on almost nine nights against 1859's two bouts [4 §5]. The site's review of the record gives 1859 about −900 nT from magnetograms, with newer estimates from about −870 to −980 (When Earth's magnetic field falters, section 5); the paper's −1,025 nT comes from the aurora. Its range for earlier estimates, "−855 nT to −1087 nT", is one study's 68% interval, around a median of −964 nT [1 §1][20 Abstract], and leaves out an estimate of about −1,760 nT that it cites [21 Abstract].

5 · HOW RARE

About once in 14,000 years, within a range of 2,000 to 760,000

The paper puts a storm the size of 1770's at about once in 1.4×10^4 years and one the size of its 1859 at about once in 1.4×10^3 years [1 §4]. Its ranges, from the two ends of its intervals for each storm, run from about 2,000 to 760,000 years and from about 380 to 20,000 [1 §4]. On its own terms that makes 1770-sized storms rare, not due.

THE PAPER'S MODEL

OUR ANALYSIS

396 and 129 nT

the location and scale, per solar cycle, of the Gumbel distribution solved from the paper's two central return periods; it reproduces the paper's four range limits to within 0.01 in $\log_{10}$, and the paper does not state them [1 §4]

THE PAPER'S OWN RECORD

OUR ANALYSIS

0.3%

the chance, under that model, that the 24 solar cycles since 1766 hold one storm as large as 1770's and another as large as the paper's 1859; 6% at the short ends of its ranges

CARRINGTON-CLASS ODDS

OUR ANALYSIS

2.6% a decade

the model's chance of a −850 nT storm, inside the nine published estimates on our guide, 0.92–12% a decade; its 1,400 years, 0.7% a decade, is for −1,025 nT, a higher bar

OUR ANALYSIS

What the return periods can and cannot say

A return period is an average gap for a random process, not a schedule. The model the paper adopts was fitted to the largest and second-largest storms of each solar cycle from 1902 to 2016 [22 Abstract], none much beyond −900 nT (our review of the record), so its 14,000 years extrapolates far beyond them; that study also found three different models fit those storms, and made its own estimates with a constrained Weibull model [22 Abstract]. If the model were right, a record that already holds both the 1770 storm and the paper's 1859 storm would be about a 1-in-300 fluke. More likely the sizes are too high, as section 3 suggests, or storms that large are commoner than the model allows. For planning, the guide's nine estimates of a Carrington-class storm, 0.92–12% a decade, remain the better summary (our guide, section 7).

6 · THE EPISODE'S 89 YEARS

The storm record keeps no 89-year clock

S0 News built its arithmetic on the paper's two storms: "1770 to 1859 is 89 years", which it ties to the Gleissberg cycle [2 00:01:25–00:01:33], then 89 years on to 1948 [2 00:01:36–00:01:50] and once more to "2037 2038" [2 00:01:53]. The paper says none of this.

What the Gleissberg cycle is

In 1939 Wolfgang Gleissberg noticed that four-cycle averages of the sunspot maxima from 1750 to 1928 rose and fell, "the period being about seven or eight sun-spot cycles" [24 pp. 158–159]. Later work, as Hathaway's review summarizes it, puts the period at 80–90 years in sunspot records [25 §5], or sees two strands of 50–60 and 90–100 years [25 §5.3], and the fitted period drifted from 7.5 to 8.5 cycles as cycles 19–23 were added [25 §7.3]; in radiocarbon over 12,000 years it is 87.8 years [26 Abstract]. It describes how tall the sunspot cycles are, not when storms come. We found no source for 88.8 years.

Strong cycles, and storms

Big storms are more frequent near solar maximum and, the evidence suggests, in large cycles [27 Abstract], so a slow swing in cycle size can change the odds. But they also come in weak cycles: 1903 and 1909 fell in cycle 14, one of the weakest on record [16 Abstract][29]. The 1770 and 1859 storms came in middling cycles: ranked by their peaks, 11th and 12th of 25, by our analysis of SILSO's table [29]. Hayakawa and colleagues called the 1770 storm's timing "consistent to the apparent 60–100-year period of extreme solar flares" seen in 1859, 1921 and 1989, or with a "return period of 90±60 years" [4 §5]. But a return period is an average wait, and the source they cite for the first gives a rate, storms below −500 nT "approximately every 50 years" [7 note 2]. A 2011 paper studies how extreme storms fall in sunspot and Gleissberg cycles; its abstract, in INPE's repository, gives no result, and the full text is restricted [28 Abstract]. More storms in some phases of a cycle whose length drifts would still not make an 89-year clock.

OUR ANALYSIS

What the record says

Read strictly, a cycle "for killer events" would bring a Carrington-class storm at each mark and none between. The record has the reverse. The two such storms after 1859 came between the marks, in 1872 and 1921, 12.6 and 26.9 years from the nearest [12 Abstract][15 Abstract], and the one mark it can test, 1948, brought none: the nearest storm, in March 1946, was about −512 nT, little more than half 1859's size, with an aurora that reached only about 42° in invariant latitude [17 Abstract]. Since 1859, storms of −500 nT or more came every 6 to 43 years. The tests below ask a weaker question: whether those storms bunch near the marks at all.

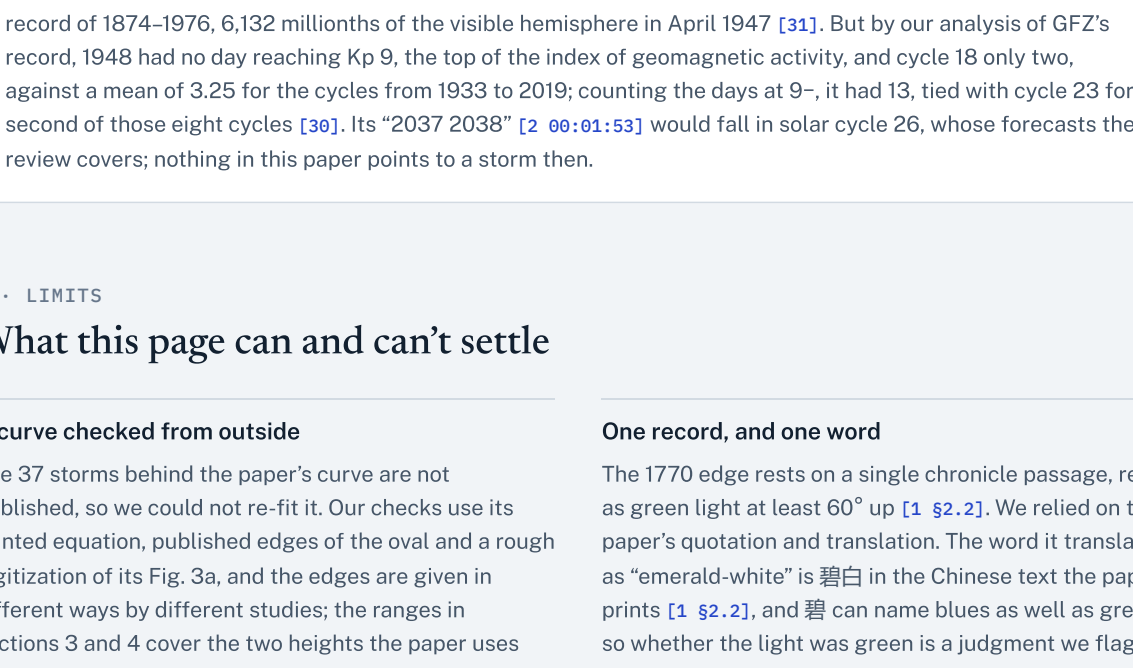
Testing the 89 years against chance

OUR ANALYSIS

The rules, fixed before the test was run

The episode's marks: 1770.7 and every 88.8 years after, 1859.5, 1948.3 and 2037.1; 89 years gives the same results. The storms: every one from 1770 to 2025 that a published reconstruction or the Dst record puts at about −500 nT or below, the threshold Cliver and Dietrich used [7 note 2]: 1770 [1 Abstract], 1859 [13 Abstract], 1872 [12 Abstract], 1903 [16 Abstract], 1909 [14 Abstract], 1921 [15 Abstract], 1946 [17 Abstract] and 1989 [12 §6]. Left out as smaller: 1938 and 1941 [19 Abstract][18 Abstract], and 1957–59, November 2003 and May 2024 (our review of the record). The marks were set by 1770 and 1859, so only the six storms after them can test them. We counted those within three years of a mark and measured their mean distance to the nearest mark, against 200,000 sets of six dates drawn at random over 1860–2025; scanned every period from 50 to 150 years for one at which the storms bunch, against 5,000 random sets; and asked how often an arbitrary pair of storms "predicts" a later one. Before 1859 the record is incomplete, which can only add storms the marks do not predict.

Extreme storms since 1770, against the episode's 89-year marks and the sunspot cycles



OUR ANALYSIS The scale on the left is the yearly sunspot number. Storms and sizes as in the rules above; 1770's size is the paper's estimate from the aurora, the others are from magnetograms. Carrington class: 1770, 1859, 1872 and 1921, the storms put at about −800 nT or more or with an aurora reaching as far as 1859's [12 §6][5 Abstract]. The sunspot numbers are WDC-SILSO's yearly means, version 2.0, used under CC BY-NC 4.0 with credit [29]. Hover or tap a dot for its storm.

DISTANCE FROM THE MARKS

OUR ANALYSIS

27.6 years

the mean distance of the six storms after 1859 from the nearest mark; random dates come at least this close 79% of the time. The gaps between storms since 1859 run from 6 to 43 years.

NEAR A MARK

OUR ANALYSIS

1 of 6

storms within three years of a mark, March 1946, about −512 nT and two years before the 1948 mark; chance expects 0.3, and at least one 27% of the time. Neither later Carrington-class storm is near a mark.

ANY CYCLE AT ALL

OUR ANALYSIS

p = 0.93

no period from 50 to 150 years makes the eight storms bunch more than chance; at 88.8 years they are spread almost evenly round the cycle. Of 12 pairs of storms, three others "predict" a later storm, each more closely than 1770 and 1859 do.

1948 and 2037–38, on our review of the episode

The episode's next steps are rated on our review of the episode. Its 1948, "one of the most active solar cycles we have ever seen" [2 00:01:42–00:01:44], sits in cycle 18, which did have the largest sunspot group in the Greenwich record of 1874–1976, 6,132 millionths of the visible hemisphere in April 1947 [31]. But by our analysis of GFZ's record, 1948 had no day reaching Kp 9, the top of the index of geomagnetic activity, and cycle 18 only two, against a mean of 3.25 for the cycles from 1933 to 2019; counting the days at 9−, it had 13, tied with cycle 23 for second of those eight cycles [30]. Its "2037 2038" [2 00:01:53] would fall in solar cycle 26, whose forecasts the review covers; nothing in this paper points to a storm then.

7 · LIMITS

What this page can and can't settle

A curve checked from outside

The 37 storms behind the paper's curve are not published, so we could not re-fit it. Our checks use its printed equation, published edges of the oval and a rough digitization of its Fig. 3a, and the edges are given in different ways by different studies; the ranges in sections 3 and 4 cover the two heights the paper uses [1 §2.3][1 Fig. 3a].

One record, and one word

The 1770 edge rests on a single chronicle passage, read as green light at least 60° up [1 §2.2]. We relied on the paper's quotation and translation. The word it translates as "emerald-white" is 碧白 in the Chinese text the paper prints [1 §2.2], and 碧 can name blues as well as greens, so whether the light was green is a judgment we flag rather than decide.

Some sources read in part

Eighteen of the 31 sources were read in abstract only, as the list says. For five of them a publisher's bot check stood in the way, and we did not bypass it: Wiley's and Elsevier's pages showed one when tried [22][28], so three more on Wiley's site, two on the 1770 storm [5][6] and one on the Gleissberg cycle [26], were not tried, and the full text of the Elsevier paper is restricted in its repository too. The values we take from abstracts are single published numbers that the abstracts state.

A short, uneven record

The test covers fewer than three 89-year cycles, and storms before 1859 are known mostly from aurora and are surely missing, so it has little power to find a weak cycle. It shows that the record gives no sign of one, and that storms came far more often than every 89 years.

What would change these verdicts

01

A published list of the paper's 37 storms and a prediction interval for single storms, or annual radiocarbon or ice-core evidence for 1770, the test the authors themselves propose [1 §4].

02

New sightings that move the 1859 or the 1770 edge, or a magnetometer record of 1770.

03

A well-dated list of extreme storms in which an 88–89-year spacing beats chance, or a peer-reviewed study that links storms to the Gleissberg cycle by more than cycle size.

8 · FILES

Repeat our analysis

Four short scripts produce every number of ours on this page, and they need only Python 3. Two take as inputs the numbers printed in the papers, listed with their sources at the top of each script; the other two fetch public files by URL, or read your own copies, and treat them as data. The charts draw these numbers, with SILSO's yearly sunspot numbers as published [29].

reconstruct.py

The paper's viewing geometry, its curve and its return periods re-run; the Gumbel parameters; the chance of its own record; the 1859 point and the *Sabine*'s log; published edges converted and put through its curve, beside magnetogram values · 14 KB [1]

comb_test.py

The test of the 89-year marks: the storm list with its sources, the rules, the three tests and the gaps between storms · 9 KB

counts.py

The days with Kp 9 in 1948 and in each solar cycle since 1933 [30], the 25 sunspot cycles ranked by their peaks [29], and the largest sunspot groups in the Greenwich record [31]; fetches about 11 MB · 9 KB

digitize_fig3.py

The rough digitization of the paper's Fig. 3a: the storms recovered, their scatter about the curve and the band it implies; it fetches the figure from the publisher and decodes it itself · 8 KB [1 Fig. 3a]

Run it

`python3 -I reconstruct.py` prints its numbers at once; `python3 -I comb_test.py` takes about half a minute and uses fixed random seeds, so every run gives the same results. `python3 -I counts.py` and `python3 -I digitize_fig3.py` fetch their files first, or take your own copies as arguments, and print the checksum of what they read. Add a file name ending in .json to any of them to save the results.

Related checks

PARTLY TRUE A "small" flare? The Disaster Cycle, Fact-Checked

FALSE Superflares and Heinrich events The Disaster Cycle, Fact-Checked

Sources

Bracketed numbers refer to this list. For the paper [1], p. gives a page of the article as published (its own numbering, 1 to 9), § a section, Fig. a figure or panel, Abstract its abstract and Table S1 the table of Chinese records in its Supplementary Material; values we read off its figures are marked "read by eye". For the episode [2], times are positions in the video (hours:minutes:seconds), from the first to the last transcript line of each quotation. For the other sources, § gives a section, p. a page, Table a table, Appendix an appendix, note a footnote and Abstract the abstract of the cited work; where only an abstract was read, the entry says so. The 1996 paper [3] was read in a scan supplied by the site's owner. Links checked October 27, 2026.

1 Yuan, D., Yin, T., Xu, X., Wang, B., Srivastava, A. K., Poedts, S., Nakariakov, V. M., Feng, X., Chen, W., and Luo, D. (2026). The Qianlong XXXV event: a potential benchmark for extreme geomagnetic storms based on historical Chinese auroral archives. *Frontiers in Astronomy and Space Sciences* 13, 1857812. Received April 16, 2026, accepted September 16, published October 21, 2026. Open access, CC BY 4.0. We read the publisher's PDF (nine pages of text), its web version and XML, and its Supplementary Material (Table S1 and Fig. S1).

2 SpaceWeatherNews (S0) (October 27, 2026). The LONG Sun Cycle: 2037 Superflare | S0 News Oct.27.2026. YouTube video, https://www.youtube.com/watch?v=AAjL4LxiktY. Quoted from the automatically generated transcript; times are positions in the video. The label "1770 Solar Superstorm" is the episode's own, on its link to the paper in the video's description.

3 Willis, D. M., Stephenson, F. R., and Singh, J. R. (1996). Auroral observations on AD 1770 September 16: the earliest known conjugate sightings. *Quarterly Journal of the Royal Astronomical Society* 37, 733–742. We read all ten pages in the NASA Astrophysics Data System's scan, supplied by the site's owner.

4 Hayakawa, H., Iwahashi, K., Ebihara, Y., Tamazawa, H., Shibata, K., Knipp, D. J., et al. (2017). Long-lasting extreme magnetic storm activities in 1770 found in historical documents. *The Astrophysical Journal Letters* 850(2), L31. We read the authors' accepted manuscript, arXiv:1711.00690.

5 Kataoka, R., and Iwahashi, K. (2017). Inclined zenith aurora over Kyoto on 17 September 1770: graphical evidence of extreme magnetic storm. *Space Weather* 15(10), 1314–1320. Abstract only (Wiley's pages showed a bot check, so this one was not tried).

6 Ebihara, Y., Hayakawa, H., Iwahashi, K., Tamazawa, H., Kawamura, A. D., and Isobe, H. (2017). Possible cause of extremely bright aurora witnessed in East Asia on 17 September 1770. *Space Weather* 15(10), 1373–1382. Abstract only (Wiley's pages showed a bot check, so this one was not tried).

7 Cliver, E. W., and Dietrich, W. F. (2013). The 1859 space weather event revisited: limits of extreme activity. *Journal of Space Weather and Space Climate* 3, A31. Open access; read in the publisher's web version.

8 Hayakawa, H., Ebihara, Y., Hand, D. P., Hayakawa, S., Kumar, S., Mukherjee, S., and Veenadhari, B. (2018). Low-latitude aurorae during the extreme space weather events in 1859. *The Astrophysical Journal* 869(1), 57. Read in its arXiv copy, arXiv:1811.02786.

9 Hayakawa, H., Ebihara, Y., Willis, D. M., Toriumi, S., Iju, T., Hattori, K., et al. (2019). Temporal and spatial evolutions of a large sunspot group and great auroral storms around the Carrington event in 1859. *Space Weather* 17(11), 1553–1569. Read in its arXiv copy, arXiv:1908.10326.

10 Hayakawa, H., Ribeiro, J. R., Ebihara, Y., Correia, A. P., and Sôma, M. (2020). South American auroral reports during the Carrington storm. *Earth, Planets and Space* 72, 122. CC BY 4.0. Abstract only.

11 Hayakawa, H., Ebihara, Y., Willis, D. M., Hattori, K., Giunta, A. S., Wild, M. N., et al. (2018). The great space weather event during 1872 February recorded in East Asia. *The Astrophysical Journal* 862(1), 15. Abstract only.

12 Hayakawa, H., Cliver, E. W., Clette, F., Ebihara, Y., Toriumi, S., Ermolli, I., et al. (2023). The extreme space weather event of 1872 February: sunspots, magnetic disturbance, and auroral displays. *The Astrophysical Journal* 959(1), 23. CC BY 4.0. Read in its arXiv copy, arXiv:2501.00176.

13 Hayakawa, H., Nevanlinna, H., Blake, S. P., Ebihara, Y., Bhaskar, A. T., and Miyoshi, Y. (2022). Temporal variations of the three geomagnetic field components at Colaba Observatory around the Carrington storm in 1859. *The Astrophysical Journal* 928(1), 32. CC BY 4.0. Abstract only.

14 Love, J. J., Hayakawa, H., and Cliver, E. W. (2019). On the intensity of the magnetic superstorm of September 1909. *Space Weather* 17(1), 37–45. CC BY-NC-ND 4.0. Abstract only.

15 Love, J. J., Hayakawa, H., and Cliver, E. W. (2019). Intensity and impact of the New York Railroad superstorm of May 1921. *Space Weather* 17(8), 1281–1292. CC BY 4.0. Abstract only.

16 Hayakawa, H., Ribeiro, P., Vaquero, J. M., Gallego, M. C., Knipp, D. J., Mekhaldi, F., et al. (2020). The extreme space weather event in 1903 October/November: an outburst from the quiet Sun. *The Astrophysical Journal Letters* 897(1), L10. Abstract only.

17 Hayakawa, H., Ebihara, Y., Pevtsov, A. A., Bhaskar, A., Karachik, N., and Oliveira, D. M. (2020). Intensity and time series of extreme solar-terrestrial storm in 1946 March. *Monthly Notices of the Royal Astronomical Society* 497(4), 5507–5517. Abstract only.

18 Hayakawa, H., Blake, S. P., Bhaskar, A., Hattori, K., Oliveira, D. M., and Ebihara, Y. (2021). The extreme space weather event in 1941 February/March. *The Astrophysical Journal* 908(2), 209. Abstract only.

19 Hayakawa, H., Hattori, K., Pevtsov, A. A., Ebihara, Y., Shea, M. A., McCracken, K. G., et al. (2021). The intensity and evolution of the extreme solar and geomagnetic storms in 1938 January. *The Astrophysical Journal* 909(2), 197. Abstract only.

20 Love, J. J., Rigler, E. J., Hayakawa, H., and Mursula, K. (2024). On the uncertain intensity estimate of the 1859 Carrington storm. *Journal of Space Weather and Space Climate* 14, 21. CC BY 4.0. Abstract only.

21 Tsurutani, B. T., Gonzalez, W. D., Lakhina, G. S., and Alex, S. (2003). The extreme magnetic storm of 1–2 September 1859. *Journal of Geophysical Research: Space Physics* 108(A7), 1268. Abstract only.

22 Love, J. J. (2021). Extreme-event magnetic storm probabilities derived from rank statistics of historical Dst intensities for solar cycles 14–24. *Space Weather* 19(4), e2020SW002579. CC BY 4.0. Abstract only: the publisher's page showed a bot check.

23 Blake, S. P., Pulkkinen, A., Schuck, P. W., Glocer, A., and Tóth, G. (2021). Estimating maximum extent of auroral equatorward boundary using historical and simulated surface magnetic field data. *Journal of Geophysical Research: Space Physics* 126(2), e2020JA028284. CC BY 4.0. Abstract only.

24 Gleissberg, W. (1939). A long-periodic fluctuation of the sun-spot numbers. *The Observatory* 62, 158–159. Read in the NASA Astrophysics Data System's scan.

25 Hathaway, D. H. (2015). The solar cycle. *Living Reviews in Solar Physics* 12, 4. CC BY 4.0. Read in its arXiv copy, arXiv:1502.07020.

26 Peristykh, A. N., and Damon, P. E. (2003). Persistence of the Gleissberg 88-year solar cycle over the last ~12,000 years: evidence from cosmogenic isotopes. *Journal of Geophysical Research: Space Physics* 108(A1), 1003. Abstract only (Wiley's pages showed a bot check, so this one was not tried).

27 Owens, M. J., Lockwood, M., Barnard, L. A., Scott, C. J., Haines, C., and Macneil, A. (2021). Extreme space-weather events and the solar cycle. *Solar Physics* 296, 82. CC BY 4.0. Abstract only.

28 Gonzalez, W. D., Echer, E., Clúa de Gonzalez, A. L., Tsurutani, B. T., and Lakhina, G. S. (2011). Extreme geomagnetic storms, recent Gleissberg cycles and space era-superintense storms. *Journal of Atmospheric and Solar-Terrestrial Physics* 73(11–12), 1447–1453. Abstract only, from the record in INPE's repository, urlib.net/sid.inpe.br/mtc-m19/2011/08.01.16.59, where the full text is restricted; the publisher's page showed a bot check.

29 WDC-SILSO, Royal Observatory of Belgium, Brussels. Sunspot number, version 2.0: yearly means and the table of cycle minima and maxima, read October 27, 2026. CC BY-NC 4.0: charted here with credit, on a non-commercial site.

30 Matzka, J., Stolle, C., Yamazaki, Y., Bronkalla, O., and Morschhauser, A. (2021). The geomagnetic Kp index and derived indices of geomagnetic activity. *Space Weather* 19, e2020SW002641. Data: Matzka, J., Bronkalla, O., Tornow, K., Elger, K., and Stolle, C. (2021). Geomagnetic Kp index, V. 1.0, GFZ Data Services, definitive values to June 30, 2026, read October 27, 2026. Kp from Geomagnetic Observatory Niemegk, GFZ Helmholtz Centre for Geosciences, CC BY 4.0; counted by us.

31 NASA Marshall Space Flight Center. The Royal Greenwich Observatory – USAF/NOAA sunspot data, 1874–2013, read October 27, 2026; groups ranked by their largest corrected area by us.

METHOD

How this was checked

On October 27, 2026, we checked every statement, number, quotation and citation on this page against its source: the paper's version of record, read as the publisher's PDF, web version and XML, with its Supplementary Material and its Crossref record; the S0 News episode's transcript [2]; the 1996 paper on the first conjugate sightings, which the site's owner supplied as a scan and we read in full [3]; the earlier studies of the 1770 storm; the reconstructions of the storms of 1859, 1872, 1903, 1909, 1921, 1938, 1941 and 1946, with the ships' logs of 1859 as Hayakawa and colleagues transcribed them [8]; the work on the Gleissberg cycle and on storms and the solar cycle; and the sunspot and Kp records: the 31 sources listed, resolved through Crossref and read in full or in abstract as the list says. Eighteen were read in abstract only. For five of those a bot check stood in the way: Wiley's and Elsevier's pages showed one to our browser, which we did not bypass, and three more on Wiley's site were not tried; the abstract of one came from INPE's repository, where the full text is restricted [28].

The verdicts and the items tagged "Our analysis" are our own assessment, built on the cited sources. They include the re-run of the paper's viewing geometry, its fitted curve and its return periods; the conversion of published auroral edges to one measure and the storm sizes the paper's curve gives them; the comparison with sizes from magnetograms; the re-run of the 1859 comparison from the ships' logs; the chance of the paper's own record under its model; the test of the episode's 89-year cycle against random dates; and our counts in the Kp, sunspot and sunspot-group records.

We re-ran the paper's three equations from the numbers it prints and reproduce its edges, storm sizes and return periods: its curve needs a coefficient of 0.4252, which it prints as 0.43, and its return periods follow a Gumbel distribution with a location of about 396 nT and a scale of about 129 nT per solar cycle, which it does not state. The 37 storms behind the curve are not published, so the curve itself could not be re-fitted; a rough digitization of its Fig. 3a, which recovered 28 of them, is used only for the scatter about it. Four scripts produce every number of ours, and all are hosted on the page: two re-run the paper and the 89-year test from printed numbers, one counts the Kp, sunspot-cycle and sunspot-group records, and one makes the rough digitization of Fig. 3a; the last two fetch their files by URL.

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. A fresh review of the built page, by a reviewer who had not seen the drafting, then found that the paper's one 1859 sighting is mis-sourced, that two of our sources do link extreme storms to longer spans, and that our counts were not among the hosted scripts; the page now shows the ships' logs with a re-run comparison, answers those sources and rests the sixth verdict on the storm record, hosts all four scripts, and corrects several smaller points.

The verdicts on this page

FALSE	The evidence contradicts the claim.
OVERSTATED	Has some basis but claims much more than the evidence supports.
MISREAD	Cites a real source but gets wrong what it says.
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

Oct 27, 2026	Published on factchecked.science after a full check against the sources and a fresh review of the built page. Built from the paper's full text and supplement (CC BY 4.0), the S0 News episode of October 27, 2026, the earlier studies of the 1770 storm and of the extreme storms since 1859, and our own re-runs, whose scripts are hosted on the page: six claims rated on the site's scale, three of them the episode's and three the paper's own. Both charts are our own analysis, one of them over WDC-SILSO's sunspot numbers (CC BY-NC 4.0); no figure of the paper is reproduced. The fresh review changed the page before publication: the paper's one 1859 sighting is shown to be mis-sourced, from the ships' logs, with the comparison re-run; the sixth verdict rests on the storm record, and the page answers the two sources that link extreme storms to longer spans; our counts and our digitization of Fig. 3a are hosted scripts too.

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Last updated Oct 27, 2026