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EVIDENCE REVIEW · S0 NEWS RESEARCH NOTE

S0's ionosphere note: storms leave a real dip of two to three days, no clear 4–6-day tail

S0 News's research note follows 119 geomagnetic storms of 2014–2025 and reports that TEC, the ionosphere's electron content, stayed outside its quiet band at middle latitudes for a median of 24 hours after Kp calmed, with 1 in 6 storms still out at 4 days [1 Summary]. Every number reproduces, from the note's own tables and from the public maps behind them (our analysis) [2][5]. But the note ran no control. Put through its exact rules, 111 storm-free starts score about as "disturbed" as the storms when pooled; in 2014–2019 the storms stay "disturbed" longer, for about three days, and in no comparison clearly at four to six days (our analysis; intervals exploratory). What is real is a dip, the textbook negative storm phase [10 Abstract][11 Abstract]: a day after Kp calms, storms leave TEC about 12 percentage points below storm-free levels, and the gap fades within two to three days (exploratory).

By Fact-Checked Science · Published November 6, 2026

OUR ANALYSIS marks our own reasoning and calculations: our rebuild of the note's pipeline from the public CODE maps, GFZ Kp and IGRF-14, the test of storm-free starts, the stricter Kp clocks, the SYM-H check against OMNI, and our reading of what the note does and doesn't test; "exploratory" marks checks we added after seeing the results, some of them after a fresh review. The verdicts are our assessment. Everything else comes from the numbered sources. For the note [1], locators are its own section names; for papers, Abstract is the part we read. "Points" are percentage points.

The dip after storms is real; the 4–6-day tail is mostly the yardstick's

OUR ASSESSMENT

3 days
how long the storms of 2014–2019 stay "disturbed" more often than their storm-free starts by the note's own rule, by 18 to 30 percentage points; pooled, the two score about the same (our analysis) [1 Claims 2][5]

< 1 in 6
the most the storms' excess at 4 to 6 days can be by 95% intervals, pooled and like with like; in 2014–2019 alone it could reach 23 points at 4 days (exploratory) [1 Claims 3][5]

12 points
percentage points of the quiet median: how far below storm-free starts the storms leave mid-latitude TEC a day after Kp calms; at 72 and 96 hours the gap is no longer clear (exploratory) [5]

THE NOTE'S CLAIMS

TRUE

"Ionospheric Disruption Outlasts Solar Storm Conditions"

The note's title [1 Title]

It does, for two to three days. Against 111 storm-free starts, storms leave TEC at 50° geomagnetic about 20 percentage points lower 5 hours after Kp calms, 12 lower at 24 hours and 7 at 48; at 72 and 96 hours the gap is no longer clear (exploratory) [5]. By the note's own rule, the storms of 2014–2019 stay "disturbed" more often than their storm-free starts for about three days (our analysis). That is the textbook negative storm phase, driven by changes in the neutral upper atmosphere that outlast the geomagnetic activity [10 Abstract][11 Abstract], and NOAA's storm-time correction already gives the ionosphere a 33-hour memory [15]. A known result, now with a control. See section 4.

MISLEADING

"1 in 6 Storms Continue Disruption 4-6 Days"

The note's subtitle [1 Subtitle]

The 17% still "disturbed" at 96 hours is a true output of the note's rule, and it reproduces exactly [1 Claims 3][2]. But it leaves a false impression of storm-caused disruption lasting four to six days. On the note's own numbers only 12% of storms are still out at 5 days and 6% at 6, and pooled, storm-free starts put through the same rule score as high or higher, 22%, 21% and 15% (our analysis). The 95% upper bounds of the storms' excess at 4 days, 5 points pooled and 13.5 like with like, sit below 1 in 6, though for 2014–2019 alone the interval reaches 23 points (exploratory). See section 3.

PARTLY TRUE

"Half the storms keep the mid-latitude ionosphere disturbed ~1 day after Kp is quiet."

The note's second claim [1 Claims 2]

Part of it holds. A day after Kp calms, TEC is still about 12 percentage points below storm-free levels (exploratory), and in 2014–2019, 65% of storms are still "disturbed" at 24 hours against 45% of their storm-free starts (our analysis). But pooled, the note's yardstick also calls 46% of storm-free starts "disturbed" at 24 hours, against 50% of storms, and gives them a median "recovery" of 16 hours, against 24 (our analysis). So part of "half" and "~1 day" is the yardstick, and part is the storms. See section 3.

TRUE

"It is a depletion."

The note's fourth claim [1 Claims 4]

Yes. The storms' median TEC sits 17% below its quiet median 5 hours after Kp calms and is back to it by about 96 hours [1 Claims 4]. Our rebuild from the public maps gives both to two decimals, while storm-free starts stay within a few percent of their quiet median at every hour, between −2% and +5% (exploratory) [5]. 99 of 119 storms had a negative median on the first day, against 53 of 111 storm-free starts (our analysis). See section 4.

TRUE

"The ring current is not done either."

The note's sixth claim [1 Claims 6]

When the note's TEC "recovers", SYM-H, the index of the ring current, is still at a median −24 nT [1 Claims 6]. For the 55 storms of 2015, 2024 and 2025, every value the note gives at the start and at recovery matches NASA's OMNI files to within 0.05 nT [7][8], and on GFZ's quiet days of those years the median is −4 nT (exploratory) [6]. The ring current takes days to recover, as expected. See section 5.

MISLEADING

"after Kp went quiet"

The note's summary [1 Summary], with "Kp quiet" set at "Kp ≤ 4+ for ≥ 6 h" [1 Fig. 1]

In NOAA's glossary, the ap values that go with Kp 3+ to 4o count as "active", and Kp 4+'s as "minor storm" [16][6]; applying its levels to three-hour bins is our mapping. 70 of the 119 clocks start on a bin of Kp 4−, 4o or 4+, and 78 have one in their first six hours (our analysis) [6]. A clock that waited for Kp 2+ or less would start a median 12 hours later, and give a median of 16 hours and 11% still disturbed at 4 days, not 24 hours and 17% (our analysis). See section 6.

1 · WHAT THE NOTE MEASURED

A recovery clock for the ionosphere, run on 119 storms

S0 News's research note follows every geomagnetic storm of 2014–2025 that reached Kp 6−, 119 in all, and times how long TEC at middle latitudes takes to settle back into its quiet-day range once Kp has calmed [1 Claims 1]. S0 News linked the note from the YouTube page of its November 6, 2026 episode [4].

STEP 1

A storm and its start

A storm is any three-hour Kp of 6− or more. Its clock starts at t0, the start of the first run of at least six hours, two three-hour bins, at Kp 4+ or less after the storm; a new Kp of 5− or more within a day is merged into it, and a later one ends its follow-up [1 Methods, Storms].

STEP 2

Band TEC

From CODE's global ionosphere maps, the mean TEC within 2.5° of 30°, 50° and 70° geomagnetic latitude, north and south; the headline band averages 50° north and 50° south [1 Methods, TEC][5].

STEP 3

A quiet band

Up to ten of GFZ's international quiet days within 15 days of t0, nearest first, skipping those from a day before the storm's start to five days after t0. At each hour of the day the band runs from the 2.5th to the 97.5th percentile of their TEC, or of all their hours where fewer than five have that hour [1 Methods, Quiet range][6].

STEP 4

Recovery

The first time TEC stays inside the band for 12 hours in a row, followed for up to seven days; Kaplan–Meier curves give the share of storms still outside at each hour [1 Methods, Recovery time].

In the note's words t0 is the start of "Kp quiet", and T_rec the recovery time; ≥ means "at least".

> *"t0 is the start of the first run of ≥ 6 h (two consecutive 3-hour bins) at Kp ≤ 4+ after the storm."*
>
> The note [1 Methods, Storms]

> *"At each UT hour the quiet range is the 2.5–97.5 percentile of quiet-day TEC at that same hour"*
>
> The note [1 Methods, Quiet range]

> *"T_rec is the first time after t0 at which band TEC stays inside its quiet range for ≥ 12 consecutive hours"*
>
> The note [1 Methods, Recovery time]

What the note reports

At 50° geomagnetic, north and south together, a median of 24 hours from t0 to recovery [1 Claims 2]; 35% of storms still outside the band at 48 hours, 26% at 72 and 17% at 96, and three that never re-entered it within seven days [1 Claims 3]; a depletion of 17% five hours after t0 [1 Claims 4]; and SYM-H still at −24 nT when TEC recovers [1 Claims 6].

Open about its work

The note publishes nine derived tables with SHA-256 checksums, a manifest and a step-by-step recipe for every headline number [1 Methods, How to recreate][2]; all nine tables match their checksums. It credits an "internal GrokBot Team 002" [1 Credit] and has not been peer reviewed. Its companion, note 001, on the Schumann resonance, is checked on our page on that note.

2 · THE NUMBERS REPRODUCE

Every number reproduces, from the note's tables and from the public maps

We recomputed the note's numbers from its own tables, then rebuilt its whole pipeline from the public data with our own code. Both give the note's numbers (our analysis).

From the note's tables

From the note's recovery times, our Kaplan–Meier code gives exactly its medians of 21, 24 and 27 hours at 30°, 50° and 70°, and its 35.2%, 25.6% and 16.5% still out at 48, 72 and 96 hours; its counts, its SYM-H medians and its strip of median changes also come out as stated [1 Methods, Headline counts][2]. The same curve answers what the subtitle leaves open: 12.4% of storms are still out at 5 days and 6.2% at 6. Counting only storms actually followed that long, 12 were still outside at 4 days, 8 at 5 and 4 at 6 (our analysis). The note's two sensitivity runs, with a stricter choice of quiet days and with daytime bands only, also reproduce from its tables, at 27 and 23 hours [1 Claims 7][2]. Both keep the narrow band built from about eight quiet days, though, so neither can test the baseline that section 3 tests.

From the public data

We rebuilt the 119 storms from GFZ's definitive Kp, and every start, t0, merge and follow-up matches the note's list; its rule for quiet days reproduces all 119 of its lists [6]. We then computed band TEC from 2,319 of CODE's daily maps, with geomagnetic latitudes from the IGRF-14 dipole [5][9]. Every map we asked for was there, though we didn't check the other 2,064 of the note's "4,383 days" [1 Claims 1].

The note leaves five details open: the dipole's epoch, whether to count the repeated 180° meridian, the percentile method, the map used at 0 UT, and the run length for the early two-hourly maps. We fixed them by matching its own quiet ranges on ten storms chosen in advance, before any test of storm-free starts; at 0 UT, for instance, the value comes from the previous day's file, whose last map is for midnight. With them, all 6,480 quiet-range values of those ten storms, three for each storm, band and hour, agree within 0.001 TECU. Over all 119 storms, 77,001 of the 77,112 values agree within 0.0015 TECU and the rest within 0.13, probably because a few files were re-issued later. The recovery times are identical in 1,069 of 1,071 storm-and-band cases; in the other two, TEC equals the band's edge to within 0.0005 TECU (our analysis).

The note's numbers beside our rebuild from the public maps

AT 50° GEOMAGNETIC, NORTH AND SOUTH	THE NOTE	OUR REBUILD
Storms of Kp 6− or more, 2014–2025	119	119, with the same starts, merges and follow-ups
Quiet-range values, ten storms chosen in advance	6,480	6,480 within 0.001 TECU
Recovery times, 119 storms in 9 bands	1,071	1,069 identical, 2 ties
Median recovery	**24 h**	**24 h**
Still outside at 48, 72, 96 h	35%, 26%, 17%	35.2%, 25.6%, 16.5%
Still outside at 120 and 144 h	not given	12.4%, 6.2%
Never back within 7 days	3	3
Median change 5 h after t0	−17%	−17.0%
SYM-H at recovery, median	−24.4 nT	−24.4 nT from its table; OMNI matches all 43 values we checked

The note's values are from its claims and tables [1 Claims 2][2]. Ours are our analysis of the public maps [5] and of GFZ's Kp [6], except the SYM-H row, recomputed from the note's table and checked against OMNI [7].

OUR ANALYSIS

The note's arithmetic is right, and its method is what it says it is. A reproduction can't show what the method measures, though: a recovery clock is only as good as its baseline, and that is what section 3 tests.

3 · THE MISSING CONTROL

Pooled, storm-free days score as "disturbed" as storms; in 2014–2019 the storms stay so longer, for about three days

A recovery clock needs a baseline: how long does the same rule say "disturbed" when there has been no storm? S0 News's companion note 001 lists this very test under "What would falsify this": storm-free starts, matched in season and hour, that "produce the same T_rec", a test "not run before this publish" [3 What would falsify this]. Note 002 itself mentions no control at all [1]. We ran it, with its rules hashed before any storm-free start was drawn or any of its TEC computed (our analysis).

STEP 1

Match each storm

For each of the 119 storms, a start at the same hour of the day within 30 days of its t0, widened to 45 or 60 days only if none was found [6].

STEP 2

Keep it storm-free

No Kp of 5− or more from three days before the start to seven days after, and no two starts within three days of each other; one candidate drawn at random, with a fixed seed [6].

STEP 3

Apply the note's rules

Its band, percentiles, 12-hour run and seven-day follow-up, unchanged, on the same CODE maps. Its quiet-day rule needs a storm's start, so each start gets a stand-in, as far before it as the matched storm's start was before its t0 [1 Methods, Quiet range][5].

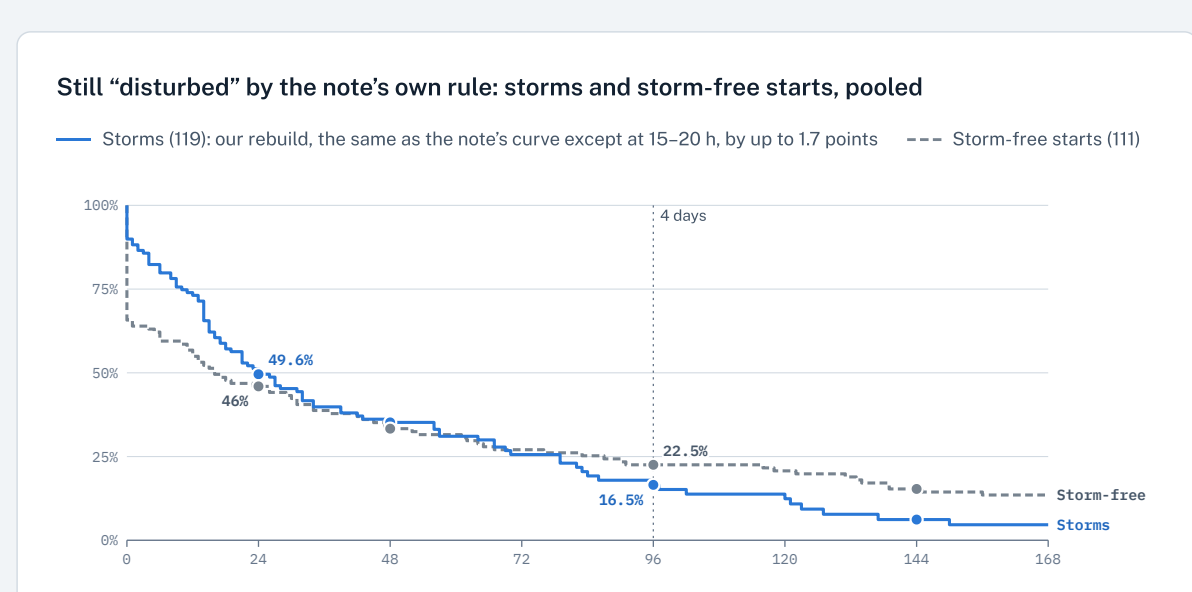
STEP 4

Compare the curves

Kaplan–Meier curves for storms and storm-free starts, pooled and by period, a log-rank test and bootstrap intervals, and a reading of the result, all fixed in advance.

We drew 112 starts. The seven storms with no storm-free start within 60 days are all from 2025, the busiest year. One start was dropped because the note's rule left it no quiet day at all, as the note drops a storm in the same case [2]. That leaves 111. "Storm-free" means no Kp of 5− or more from three days before, so 12 of the starts fall inside their matched storm's follow-up, three to five days after its t0, and 31 begin within a week after a bin of Kp 6− or more. Leaving those 31 out changes nothing: a median of 16 hours, and 22.5% still out at 4 days (log-rank against the storms p = 0.69; exploratory).

Still "disturbed" by the note's own rule: storms and storm-free starts, pooled



Our analysis. The Kaplan–Meier share still outside the quiet band at 50° geomagnetic, north and south averaged, from CODE's maps [5] by the note's rule [1 Methods, Recovery time]. Dots at 24, 48, 96 and 144 hours. Pooled log-rank p = 0.74; the two periods are in the table below.

The two groups by the note's rule, pooled

AT 50° GEOMAGNETIC, NORTH AND SOUTH	STORMS (119)	STORM-FREE STARTS (111)
Median "recovery" (95% interval)	**24 h (18–34)**	**16 h (10–31)**
Still "disturbed" at 24 h	49.6%	46.0%
at 48 h	35.2%	33.3%
at 72 h	25.6%	27.0%
at 96 h (4 days)	**16.5%**	**22.5%**
at 120 h (5 days)	12.4%	20.7%
at 144 h (6 days)	6.2%	15.3%
Inside the band from the start	12	38
Never back within 7 days	3, and 16 cut short by a new storm	15
Share of first-day hours outside the band	58%	44%

Our analysis. The intervals are from 2,000 bootstrap resamples. The storms' curve is the note's [2]; the storm-free starts' is ours, from CODE's maps [5].

FIRST-DAY HOURS OUTSIDE
OUR ANALYSIS
44%
of the storm-free starts' first-day hours fall outside the note's "2.5–97.5 percentile" band, against 58% of the storms'; a true 95% band would leave out about 5% [5]

ONE ORDINARY HOUR
OUR ANALYSIS
1 in 4
the chance, in a simulation, that a day just like the quiet days falls outside a band built from 8 of them at any given hour, by the note's percentile rule

THE BAND'S WIDTH
OUR ANALYSIS
24%
the median width of the 50° quiet band at hours set by the same hour of quiet days, as a share of its quiet median: TEC 11% below the median already counts as "disturbed" [2]

OUR ANALYSIS

The reading we fixed in advance. If storm-free starts were still "disturbed" at least half as often as the storms at both 24 and 96 hours, we would say that at least half of what the note calls lingering is produced by its rule on storm-free days. Pooled, they are: 46% against 50% at 24 hours, and 22.5% against 16.5% at 96. At 4 days, pooled, storm-free starts score at least as often, and the bootstrap puts the storms' excess at most about 5 points. That pooled match, though, averages two halves of the record that differ, as below.

The two halves of the record

Storms minus storm-free starts: share still "disturbed", in percentage points, with 95% intervals

GROUP (STORMS, STARTS)	24 H	48 H	72 H	96 H	144 H
2014–2019 (52, 51)	**+20.3** +2.5 to +37.9	**+29.5** +11.6 to +47.3	**+18.4** +0.4 to +37.1	**+5.3** −12.7 to +23.2	**−4.8** −19.6 to +10.9
2020–2025 (67, 60)	−9.4 −26.8 to +8.5	−19.8 −35.7 to −4.6	−17.0 −31.8 to −3.4	−14.6 −28.4 to −0.5	−12.4 −23.3 to −2.1
Pooled (119, 111)	+3.6 −9.2 to +16.7	+1.9 −10.6 to +14.3	−1.4 −12.8 to +10.0	−6.0 −16.6 to +5.2	−9.1 −17.6 to −0.5
Like with like, 8 or more quiet days (81, 35)	+16.3 −2.0 to +34.3	+14.4 −2.9 to +30.7	+8.7 −8.4 to +25.0	−2.4 −18.8 to +13.5	−3.7 −17.1 to +9.2

Our analysis at 50° geomagnetic, north and south, from CODE's maps [5]. The split by period was fixed in advance; the intervals, from 2,000 bootstrap resamples, and the like-with-like row are exploratory. One in six is 16.7 points.

In 2014–2019, by the note's own rule, the storms stay "disturbed" more often than their storm-free starts for about three days: by 20 points at 24 hours, 30 at 48 and 18 at 72. The excess holds when both groups are restricted to starts with 5 or more quiet days (+26 at 48 hours, interval +5 to +46) or 8 or more (+27, +1 to +52). That is in the note's favour. In 2020–2025 the storm-free starts run hotter than the storms, by 15 to 20 points from 48 hours on; on starts with 8 or more quiet days that reversal vanishes (+16, +4, +3 and −2 points at 24, 48, 72 and 96 hours), so it comes from the storm-free starts' fewer quiet days. The two halves' gaps differ by 49 points at 48 hours (interval 26 to 73), and within each half the log-rank gives p = 0.20 and 0.07, because the curves cross. Pooled, the halves cancel, and at 6 days the pooled storm-free curve runs hotter than the storms' (exploratory). For the medians, the note's own table gives 64 and 16 hours for the two halves and our rebuild 64 and 17, the difference being one of the two ties [2].

Why storm-free days look "disturbed"

OUR ANALYSIS

The band is narrow. It comes from a median of 8 quiet days, and with 8 values the 2.5th and 97.5th percentiles sit close to the lowest and the highest: even if every day were alike, an ordinary day would fall outside at a given hour about one time in four, not one in twenty. Day-to-day change in the ionosphere does the rest. Over 15 days the Sun's output and the season move on, and the international quiet days are each month's quietest, not its typical days [6]. Over their whole week the storm-free starts' TEC lies outside the band in 40% of hours, more often above it than below (exploratory). Twelve hours in a row inside such a band can take a day or more to come, storm or no storm.

The other comparisons fixed in advance

Giving each storm-free start the follow-up of its matched storm, so that both groups are cut short alike, changes nothing: a median of 16 hours, and 23% still out at 4 days. On the starts with at least 5 quiet days, where the band is set hour by hour throughout, storm-free starts take a median of 26 hours, against the storms' 24 (log-rank p = 0.33). At 30° the medians are 21 hours for storms and 14 for storm-free starts (p = 0.91); at 70°, 27 and 11 hours, with 54% against 32% still out at 24 hours but 16% each at 96 (p = 0.057) (our analysis).

Like with like (exploratory)

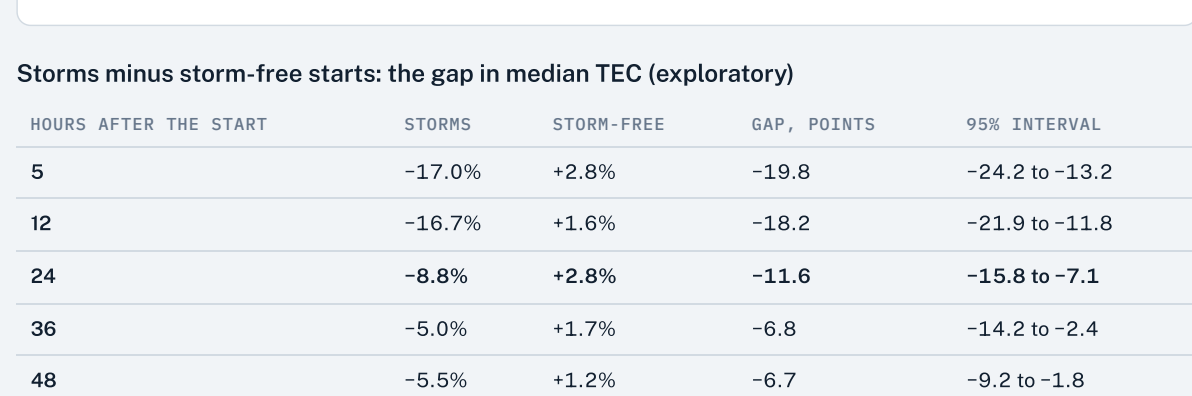
The storm-free starts have fewer quiet days than the storms, 6.65 on average against 8.03, because a storm-free stretch is where a month's quiet days cluster, and the note's rule skips those nearest the start. We knew of the imbalance before the run and expected it to favour the note, because below five days the band is pooled over all hours and very wide. That holds only below five days: with 5 to 7 quiet days, storm-free starts run hotter, 29% still out at 4 days against 16% of storms. On starts with at least 8 quiet days, storms are still "disturbed" more often in the first two days, 51% against 34% at 24 hours and 37% against 23% at 48, with medians of 26 and 13 hours; at 4 days the shares are 18% and 20%. A log-rank stratified by quiet-day count gives p = 0.68, and storm-free curves reweighted to the storms' mix of quiet days give 41% at 24 hours and 22% at 4 days, against the storms' 50% and 17%. We added these checks after seeing the results (exploratory). Like with like, then, the storms show an excess for a day or two and none at 4 days, in line with section 4.

4 · WHAT IS REAL

Measured directly, storms leave a dip in TEC that lasts about two days

The median TEC itself separates storms from storm-free starts clearly. At 50° geomagnetic, the storms leave TEC well below its quiet level for about two days after Kp calms, while storm-free starts stay close to it (exploratory).

Median change in TEC from the quiet median: storms and storm-free starts



Our analysis, from CODE's maps [5] with the note's quiet bands [1 Methods, Recovery time]; this comparison with storm-free starts is exploratory. As in the note, a storm drops out of the median when a new storm begins: 117 storms at t0, 80 at 96 hours. The storms' medians match the note's to two decimals [2].

Storms minus storm-free starts: the gap in median TEC (exploratory)

HOURS AFTER THE START	STORMS	STORM-FREE	GAP, POINTS	95% INTERVAL
5	−17.0%	+2.8%	−19.8	−24.2 to −13.2
12	−16.7%	+1.6%	−18.2	−21.9 to −11.8
24	**−8.8%**	**+2.8%**	**−11.6**	**−15.8 to −7.1**
36	−5.0%	+1.7%	−6.8	−14.2 to −2.4
48	−5.5%	+1.2%	−6.7	−9.2 to −1.8
72	−2.1%	+1.6%	−3.8	−7.4 to +1.2
96	+0.1%	+1.8%	−1.7	−6.8 to +3.1

Our analysis, at 50° geomagnetic, north and south, in percentage points of the quiet median; intervals from 2,000 bootstrap resamples. We added this comparison after seeing the results (exploratory) [5].

The dip is in five storms out of six: 99 of the 119 had a negative median change on the first day, against 53 of the 111 storm-free starts, and the median first-day change is −13.2% for storms against +1.8% for storm-free starts (our analysis) [1 Claims 4]. By median TEC it is much the same in both halves of the record: 11 and 12 points below storm-free starts at 24 hours, 7 and 6 at 48, and no clear gap at 72 (exploratory). It is deepest at 70°, where the storms' median is −20.7% five hours after t0, against −0.2% for storm-free starts. These are averages over a whole band of latitude; at a single place the swings, and their effects on GPS users, are larger, as on our page on GPS scintillation in May 2024.

5 · THE RING CURRENT

SYM-H is still recovering when TEC is, as expected

In a sample of 55 storms, the note's SYM-H numbers match NASA's OMNI files to the table's rounding. At −24 nT, SYM-H is still well below its quiet-day level: the ring current's usual recovery, which takes days (our analysis).

The note gives SYM-H as hourly means of 5-minute values [1 Methods, Recovery time]. For the 55 storms with t0 in 2015, 2024 or 2025, the three years with the most storms, the mean of the twelve 5-minute values in each hour of OMNI's files gives every one of the note's values at t0 and at recovery to within 0.05 nT [7][8]. In that sample the median is −59 nT at t0, −29 nT a day later and −34 nT at recovery; on GFZ's quiet days of those years it is −4 nT, and over all their days −12 nT (exploratory) [6]. Over all 119 storms, the note's own strip has the median SYM-H at −51 nT at t0, −27 nT a day later and −12 nT at 96 hours, recovering over days [1 Claims 6][2]. How SYM-H and Dst measure a storm is set out on our page on the May 2024 storm.

OUR ANALYSIS

"When 50° TEC finally recovers" is the time the note's rule declares, which section 3 shows is partly the rule's own noise. SYM-H at that time is right, and the ring current is still recovering a day after Kp calms, but that is a well-known feature of storms, not a link between the two.

6 · "KP QUIET"

"Kp quiet" starts the clock at levels NOAA's glossary calls active, or minor storm

In NOAA's glossary, the a index that goes with Kp 4−, 4o and 4+ is at "active" or "minor storm" levels, not quiet. Waiting for a quieter Kp shortens every "after Kp quiet" number, by hours rather than days (our analysis).

NOAA's Space Weather Prediction Center classifies geomagnetic activity "quantitatively into quiet, unsettled, active, and geomagnetic storm levels according to the observed a index": quiet below 8, unsettled 8 to 15, active 16 to 29 and minor storm 30 to 49 [16]. In GFZ's file the ap that goes with a three-hour Kp of 3+ is 18, of 4− 22, of 4o 27 and of 4+ 32 [6]; applying the glossary's levels to single three-hour bins is our mapping. At t0, Kp is below NOAA's storm scale, which starts at Kp 5 [17], so the title's "Solar Storm Conditions" have ended; the trouble is only the word "quiet". 70 of the 119 clocks start on a bin of Kp 4−, 4o or 4+, 25 at 4−, 25 at 4o and 20 at 4+, and 78 have one in their first six hours (our analysis) [6].

Kp also stays above storm-free levels for days. Its mean is 2.63 on the first day after t0, with 24% of bins at 4− or more, and 2.10 and 2.03 on the next two, against 1.46 to 1.58 after the storm-free starts (exploratory) [6]. Even the strictest clock below, at Kp 2+ (ap 9), sits at the glossary's "unsettled" level; only Kp 2o or less is "quiet" [16].

Stricter clocks shorten every "after Kp quiet" number

CLOCK STARTS WITH THE FIRST 6-HOUR RUN AT	LATER BY (MEDIAN)	MEDIAN RECOVERY	STILL OUT AT 24 H	AT 96 H
Kp ≤ 4+ (the note)	—	**24 h**	**49.6%**	**16.5%**
Kp ≤ 3+	3 h	21 h	46.6%	15.0%
Kp ≤ 2+ (115 storms)	12 h	16 h	42.3%	10.8%

Our analysis at 50° geomagnetic, north and south, with each storm's own quiet band and the same end of follow-up; four storms never reach six hours at Kp 2+ or less before their follow-up ends [5][6].

7 · KNOWN PHYSICS

A textbook result, with new numbers that mostly measure the yardstick

That the ionosphere stays disturbed after geomagnetic activity dies down is the textbook picture of a negative ionospheric storm; our test puts it at two to three days. What is new in the note is a set of numbers.

Storms heat the upper atmosphere at high latitudes and change its make-up [11 Abstract], and at middle latitudes the negative storms, in which electron density falls, are closely tied to those changes in the neutral gas [10 Abstract]. In model runs, the altered gas is carried about by the winds and persists into the recovery, which shapes where and when the negative phases appear [11 Abstract]. A review of ionospheric storms covers these processes, with emphasis on the F2 region [12 Abstract], and Mendillo's review of TEC describes its patterns during 180 storms and how they change with season and solar cycle [13 Abstract].

NOAA already builds that memory into a forecast product. Its STORM model, fitted to 43 storms at 75 ionosonde stations, scales the quiet-time ionosphere by a weighted integral of the ap index over the previous 33 hours [14 Abstract], and its output file labels the driver "Integral of Planetary Ap Geomagnetic index over the previous 33 values", with correction factors at 70°, 50° and 30° geomagnetic north and south, the same three bands as the note's [15].

Known, and confirmed here

That the ionosphere's storm dip comes from changes in the neutral gas that persist into the recovery is known [10 Abstract][11 Abstract]. Our test of storm-free starts puts the dip at two to three days at middle latitudes, and the note's own SYM-H, which matches OMNI, shows the ring current recovering over days (our analysis) [2].

New, and mostly the yardstick

The note's medians of 21, 24 and 27 hours and its 17% at 4 days are new numbers [1 Claims 3][1 Claims 5]. Pooled, storm-free starts give 14, 16 and 11 hours and 22% by the same rule; only in 2014–2019 do the storms clearly stay "disturbed" longer, for about three days (our analysis).

OUR ANALYSIS

Through the catastrophism lens. Does Earth's environment stay disturbed long after solar storms? By this record, the ionosphere's storm dip lasts about two days after Kp calms, or three by the note's rule in 2014–2019, and then fades. We found no clear storm-caused disturbance at four to six days, though in 2014–2019 alone the data can't rule out one storm in six at four days; whether effects build up from storm to storm we didn't test. The note's single TEC point over Spain, at a 58-hour median [1 Claims 8][3 Claims 7], may "recover" later partly because a single point varies more than a band mean, but a noisier series also widens its own band, so we can't say how much.

8 · LIMITS

What this check can and can't say

The verdicts rest on one test, with rules fixed in advance, of one band-mean yardstick, the note's own (our analysis).

Two halves that differ

Pooled, the storm-free curve runs hot. In 2020–2025 its starts have fewer quiet days and score above the storms from 48 hours on; in 2014–2019 the storms stay "disturbed" longer, for about three days. The verdicts rest on intervals that allow for both.

One draw of storm-free starts

111 starts, drawn once; another draw would give slightly different numbers. The seven storms of 2025 with no storm-free start nearby are missing from it, 12 starts fall inside their matched storm's follow-up, and 31 begin within a week after a Kp of 6− or more; leaving the 31 out changes nothing (exploratory).

The note's yardstick

We tested the note's rule as it stands, adapting only its quiet-day rule, which needs a storm's start. A band calibrated on storm-free days, or built from more quiet days, might separate storms from calm better; we didn't design one.

Band means only

Everything here is TEC averaged over a band of geomagnetic latitude [5]. At a single place the swings are larger, and so would be the rule's baseline.

Rules before data

Five maps fetched to test our reader before the rules were written include one day later used as a quiet day by one storm-free start. No start had been drawn and no TEC computed then.

Re-issued maps

111 of 77,112 quiet-range values differ from the note's by up to 0.13 TECU, probably because some files were re-issued after the note was made. No recovery time depends on them.

Abstracts only

Of the papers, we read only abstracts, and the publisher refused our request for Mendillo's review [13]; we take no storm-effect durations from them.

A sample for SYM-H

We checked SYM-H for the 55 storms of three years [7]; the other 64 rest on the note's tables.

What would change these verdicts

01
A recovery rule calibrated on storm-free days, so that they fall outside its band about 5% of the time, that still shows storms disturbed more often than storm-free starts at four to six days.

02
The same excess in other global maps, such as JPL's or UPC's, or at single stations, against matched storm-free starts.

03
More storms from years like 2014–2019, where the 95% interval for the storms' excess at 4 days still reaches 23 points, showing an excess of 1 in 6 or more.

9 · REPEAT OUR NUMBERS

The rules, the scripts and the derived numbers; the maps and the note's tables stay with their sources

Every number of ours on this page comes from these files. The scripts fetch the note's tables, GFZ's Kp, CODE's maps, IGRF-14 and OMNI by URL under a plain client name [2][5]; we host only numbers we derived.

TXT	**RULES_spotcheck.txt · RULES_placebo.txt · RULES_placebo_amendment1.txt · RULES_kpquiet_symh.txt** The rules, hashed before any storm-free start was drawn or any of its TEC computed (five maps fetched earlier to test the reader include one day later used by one start); the amendment came before any result · 4 KB, 4 KB, 2 KB and 2 KB
TXT	**analysis_log.md · HASHES.txt** Our log, with the time and SHA-256 of every rules file, script and input and the results as they came; and the checksums of every file here · 17 KB and 4 KB
PY	**fetch_inputs.py** Fetches the note's tables, GFZ's files, IGRF-14 and OMNI by URL under a plain client name, then CODE's maps through the two scripts below, and compares each file with the copy we used · 9 KB
PY	**fetch_code_gim.py · fetch_code_gim_batch.py** Fetch CODE's daily maps from AIUB at one request a second, stopping on any refusal · 5 KB and 6 KB
PY	**gim_lib.py · kp_lib.py · tec_pipeline.py · stats_lib.py** The pipeline: the maps, the IGRF-14 dipole and the bands; Kp, quiet days and the note's storm rules; quiet bands and recovery times; Kaplan–Meier, log-rank and bootstrap. Standard library only · 8 KB, 5 KB, 8 KB and 3 KB
PY	**check_storms.py · reproduce_note.py · select_placebo.py · draw_spotcheck.py** The storms rebuilt from Kp; the note's numbers from its own tables; the storm-free starts; the ten storms chosen in advance · 2 KB, 6 KB, 6 KB and 2 KB
PY	**cache_bands.py · calibrate.py · run_all.py** Band means from each map; the check of the note's quiet bands that fixed the details it leaves open; the rebuild, the test of storm-free starts and the stricter clocks · 2 KB, 3 KB and 16 KB
PY	**exploratory_checks.py · review_checks.py · check_symh.py · charts.py** The checks marked exploratory, before and after the fresh review, including the period split's intervals and the numbers no other script computes; the SYM-H check against OMNI; the two charts · 6 KB, 15 KB, 4 KB and 9 KB
CSV	**storms_recomputed.csv** Our recovery times for the 119 storms in nine bands, with whether each matches the note's; the note's own values stay in its tables · 104 KB
CSV	**placebos.csv · placebo_trec.csv** The 112 storm-free starts drawn, with their quiet days; and their recovery times in nine bands · 17 KB and 96 KB
CSV	**km_compare.csv · strip_compare.csv** Kaplan–Meier curves hour by hour for every group and band; median changes and quartiles for the strips · 441 KB and 47 KB
CSV	**kp_quiet_sensitivity.csv · symh_check.csv** Each storm's stricter clocks; and SYM-H from OMNI for 55 storms, with whether it matches the note's · 8 KB and 3 KB
JSON	**summary.json · exploratory_checks.json · review_checks.json** Every number of the rebuild and the test in one file; and the two sets of exploratory checks · 35 KB, 3 KB and 7 KB

Run it

In an empty folder `<base>`: `python3 -I fetch_inputs.py <base>` fetches the note's tables, GFZ's files, IGRF-14 and OMNI, about 110 MB, and prints the commands for the next steps: `select_placebo.py`, which draws the storm-free starts and lists the days needed, and `draw_spotcheck.py`, which draws the ten storms chosen in advance. `python3 -I fetch_inputs.py <base> --code` then fetches about 2,300 CODE maps, 0.72 GB, at one request a second. `cache_bands.py`, `run_all.py`, `exploratory_checks.py`, `review_checks.py` and `check_symh.py`, each with `<base>`, give the outputs listed here; `reproduce_note.py` recomputes the note's numbers from its own tables. Standard library only, with curl and gzip.

Related checks

FALSE More auroras from less solar input? The Disaster Cycle, Fact-Checked
PARTLY TRUE A "small" flare? The Disaster Cycle, Fact-Checked

Sources

Bracketed numbers refer to this list. For S0 News's research notes, [1] and [3], locators are the notes' own section names: Title and Subtitle; Credit, the line under them; Summary, the paragraph that opens note 002; Claims 1 to 8; Fig. 1 and Fig. 2, their captions; Methods with the opening words of the paragraph; and, in note 001, "What would falsify this". For papers, Abstract is the part we read; where only an abstract was read, the entry says so, and abstracts are paraphrased. TEC is total electron content, the number of free electrons in a column through the ionosphere, in TEC units of 10^{16} electrons per square metre; t0 is the note's start of "Kp quiet"; nT is the nanotesla; UT is universal time. Links checked November 6, 2026.

1 S0 News (Space Weather News) (undated). Ionospheric Disruption Outlasts Solar Storm Conditions: 1 in 6 Storms Continue Disruption 4-6 Days. "Space Weather News Research Note from internal GrokBot Team 002", a public Google Doc headed "SPACE WEATHER NEWS & RESEARCH PUBLICATIONS 2026". The note is undated; its Drive files are dated November 3, 2026 (Drive's server gives 05:22 UT on November 4), and S0 News linked it from the YouTube page of its November 6, 2026 episode [4]. Read in full, as text and HTML exports retrieved on November 6, 2026; SHA-256 of our text export: `2b296dd4e2f7987ac2cd41c2b2dd34736f8c2fe49dd2ed48e253f2ff4aa03b95`. Not peer reviewed. No licence is stated, so we quote and link it, redraw none of its figures and host nothing of it.

2 S0 News (Space Weather News) (undated). Derived data for research note 002. Public Google Drive folder of nine CSV tables, a MANIFEST.md and a SHA256SUMS.txt, all dated November 3, 2026; downloaded on November 6, 2026, and all nine tables match the checksums. No licence is stated: our scripts fetch the tables by URL, and we host only numbers we derived ourselves.

3 S0 News (Space Weather News) (undated). Schumann Resonance Stays Disrupted for Days After Solar Storms. "Space Weather News Research Note from internal GrokBot Team 001", a public Google Doc; text export retrieved on November 6, 2026 (SHA-256 `f3ca788a0a7608b0057d6212c0df666d8e3d1c830490ac61274dd6c52e3fc99a`). Checked on our page on that note; cited here for its list of tests and its single-site TEC number.

4 SpaceWeatherNews (S0) (November 6, 2026). Sky Fall Continues, Solar Storms Linger for Days | S0 News Nov.6.2026. YouTube video, https://www.youtube.com/watch?v=VRbM1M44nik, published at 12:11 UT. No transcript was available; its YouTube page links the note.

5 Dach, R., Schär, S., Arnold, D., Kalarus, M. S., Prange, L., Stebler, P., Jäggi, A., and Villiger, A. (2024). CODE final product series for the IGS. Astronomical Institute, University of Bern; open access, no licence stated. We used 2,319 of its daily final global ionosphere maps (IONEX files) for 2014–2025, fetched from AIUB's download area on November 6, 2026, and host only numbers derived from them.

6 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, CC BY 4.0: the Kp and ap file and the international quiet and disturbed days for 2013–2026, as of November 6, 2026, with GFZ's page on how quiet days are chosen. Kp is definitive throughout 2014–2025. Counted and ranked by us.

7 King, J. H., and Papitashvili, N. E. (2005). Solar wind spatial scales in and comparisons of hourly Wind and ACE plasma and magnetic field data. *Journal of Geophysical Research: Space Physics* 110(A2), A02104. Cited as the data set's reference paper, not read. With the data: NASA/GSFC's OMNI, the five-minute high-resolution files for 2015, 2024 and 2025 from the Space Physics Data Facility, read on November 6, 2026.

8 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). SYM-H as carried in the OMNI files [7], used under the WDC's data usage rules as on our page on Balan and colleagues: scientific use, no commercial use, with acknowledgement.

9 IAGA Working Group V-MOD (2024). International Geomagnetic Reference Field, 14th generation (IGRF-14). Data file, NOAA National Centers for Environmental Information, retrieved on November 6, 2026, the same file by its SHA-256 as on our page on the equatorial electrojet. We use its dipole terms g10, g11 and h11, interpolated to each map's time, for geomagnetic latitudes.

10 Prölss, G. W. (1980). Magnetic storm associated perturbations of the upper atmosphere: Recent results obtained by satellite-borne gas analyzers. *Reviews of Geophysics* 18(1), 183–202. Abstract only, as deposited with Crossref; paraphrased.

11 Fuller-Rowell, T. J., Codrescu, M. V., Moffett, R. J., and Quegan, S. (1994). Response of the thermosphere and ionosphere to geomagnetic storms. *Journal of Geophysical Research: Space Physics* 99(A3), 3893–3914. Abstract only, as deposited with Crossref; paraphrased.

12 Buonsanto, M. J. (1999). Ionospheric Storms — A Review. *Space Science Reviews* 88(3–4), 563–601. Abstract only, on Springer's page; paraphrased.

13 Mendillo, M. (2006). Storms in the ionosphere: Patterns and processes for total electron content. *Reviews of Geophysics* 44(4), RG4001. Cited by the note. Abstract only, as deposited with Crossref; paraphrased. The publisher's full text answered our request with a bot check.

14 Araujo-Pradere, E. A., Fuller-Rowell, T. J., and Codrescu, M. V. (2002). STORM: An empirical storm-time ionospheric correction model 1. Model description. *Radio Science* 37(5). Abstract only, as deposited with Crossref; paraphrased.

15 NOAA Space Weather Prediction Center (undated). STORM Time Empirical Ionospheric Correction, the product page, with its output file storm-corrections-today.txt as created at 19:45 UT on November 6, 2026. US government work.

16 NOAA Space Weather Prediction Center (undated). Space Weather Glossary: the entries "geomagnetic activity", "active" and "quiet", read on November 6, 2026. US government work.

17 NOAA Space Weather Prediction Center (undated). NOAA Space Weather Scales, read on November 6, 2026: geomagnetic storms from G1 (Minor), at Kp = 5, to G5 (Extreme), at Kp = 9. US government work.

METHOD

How this was checked

On November 6, 2026, we checked every claim of S0 News's research note 002, its title, subtitle, summary and eight numbered claims, against the note's own nine derived tables and against the public data behind them: GFZ's definitive Kp and international quiet days, 2,319 daily CODE global ionosphere maps for 2014–2025, the IGRF-14 dipole, and NASA's OMNI files of SYM-H for 2015, 2024 and 2025. Every other statement on this page was checked against its source, 118 references to 17 sources in all.

The verdicts and the items tagged "Our analysis" are our own assessment, built on the cited sources: our rebuild of the note's pipeline, the test of storm-free starts, the stricter Kp clocks, the SYM-H check, and our reading of what the note does and doesn't test. Checks marked "exploratory" were added after we had seen the results of the test of storm-free starts, some of them after the fresh review below.

We rebuilt the whole pipeline from the public data. It reproduces the note's 119 storms, its quiet-day lists, all 6,480 quiet-range values of ten storms chosen in advance, and its recovery times in 1,069 of 1,071 cases, the other two being ties at the band's edge. We wrote the rules of the test of storm-free starts and hashed them before any storm-free start was drawn or any of its TEC computed; five maps fetched earlier to test our reader include one day later used by one start. One amendment, for a start the note's rule left with no quiet days, was hashed before any result existed. Not verified: the full texts of the five papers we read only in abstract (the publisher refused our request for Mendillo's review); GFZ's own names for Kp levels; SYM-H for the other 64 storms; the note's two sensitivity runs, which we reproduced from its tables only; and the 2,064 of the note's 4,383 daily maps we didn't fetch.

After the page was built, a fresh reviewer who hadn't seen the drafting recomputed everything in separate code, and it all reproduced. The changes that followed: the split by period that we had fixed in advance is now reported with intervals, showing that the storms of 2014–2019 stay "disturbed" longer for about three days while the storm-free starts of 2020–2025 run hot because they have fewer quiet days; the subtitle is rated Misleading rather than False, on the intervals rather than on medians; the title now says two to three days; 70 clocks, not 78, open on a bin of Kp 4− or more (78 have one in their first six hours); the description of t0, the naming of Kp 4+ and five other passages were corrected; the checks added after the results are labelled exploratory, and the numbers no script computed now have one; and about twenty smaller fixes.

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

The verdicts on this page

MISLEADING	Contains something true but leaves a false impression, usually by leaving out key context.
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 6, 2026	Published on factchecked.science after a full check against the sources: S0 News's research note 002 and its derived tables; the public Kp, CODE, IGRF-14 and OMNI data behind them, from which every number reproduces; and a test, with rules fixed in advance, of 111 storm-free starts put through the note's own rules. The rules, scripts and derived numbers are hosted; none of the note's figures is redrawn. A fresh review before publication led us to report the pre-registered split by period with its intervals, to rate the subtitle Misleading rather than False, to say two to three days in the title, to correct the count of clocks opening at Kp 4− or more and the description of t0, and to label the later checks as exploratory.

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