PAPER CHECK · SPACE WEATHER

Four electron belts did form after May 2024; three belts had been seen dozens of times

In a short Comment, five researchers in Belgium report that after the May 2024 superstorm the PROBA-V satellite saw four electron radiation belts "for the first time", and that three belts, reported "once" before, in 2012, have now followed four more storms [1 Abstract][1 p. 1]. In the authors' own published data the four belts are there, and so are the three belts after the later storms [3]. But three-belt events had been counted after about one storm in six in 2012–2017 [10 Abstract], the team's own cited paper reported a short three-belt spell in Van Allen Probes data after a storm in March 2015 [7 p. 79], and four-belt structures had been reported twice before, briefly [15 Abstract][16 Abstract].

By Fact-Checked Science · Published November 16, 2026

OUR ANALYSIS marks our own reasoning and calculations: our count of belts and slots in the authors' published data, our own runs of the same count on NOAA's satellite records, our ranking of the storms in Kyoto's Dst, and the field's change from IGRF-14; the verdicts are our assessment. Everything else comes from the numbered sources.

Four belts did form after May 2024; three belts had formed many times before

OUR ASSESSMENT

4 belts
in the authors' own data for June 2024, in EPT's four lowest energy channels, by the Comment's five-day rule (our analysis) [3]

30 events
three-belt events counted in 2012–2017, after about 18% of geomagnetic storms [10 Abstract]

−406 nT
the May 2024 storm's lowest hourly Dst, provisional: the deepest since November 2003 (our analysis) [27]

THE COMMENT'S CLAIMS

TRUE
"Here, we show in the schematic Fig. 1 the four electron belts observed during June 2024"
The Comment, on what PROBA-V saw [1 p. 1]
They are in the authors' published data: in June, in EPT's four lowest channels, slots near L = 1.9, 2.4–2.5 and 3.7–3.9 coexist, and none of it was there before the storm [3]. The innermost slot is shallow and dips below our threshold on some days, so strict counts break the four belts into runs of 5–20 days; bridging gaps of two days, channel 1 shows them unbroken from May 30 for 26 days, or for 29, to June 27, if three-day gaps are bridged; the storm of June 28 then filled the outer slot, as the Comment says [1 p. 2]. Our analysis; see section 2.

OVERSTATED
"For the first time, four distinct electron belts were observed in the Earth's near-space environment"
The Comment's abstract [1 Abstract]
A four-belt structure was reported for the great storm of March 1991, in several spacecraft's data and a model fed with them [15 p. 8776], for about a week [15 p. 8778], though one of its belts was of 13 MeV electrons showing in a 1 MeV channel [15 p. 8771]; two extra inner belts were seen on some days of May 2009, at lower energies [16 Abstract]. What looks new is four belts at the same energies lasting weeks: at 0.5–1 MeV, and briefly up to 2.4 MeV. The same team first called it new in 2024, but only for its own instrument, flying since 2013 [5 Abstract]. See section 4.

FALSE
"Although a three-belt configuration was previously reported once in 2012"
The Comment's abstract [1 Abstract]
One study counted 30 three-belt events of the 2012 kind from September 2012 to November 2017, after about 18% of storms [10 Abstract]; SAMPEX data gave 8 for 1994–2003 [11 Abstract], and another study found 54 with the same layout below 1 MeV [13 Abstract]. The team's own 2024 paper said multiple belts "have been observed before this event in different energy ranges" [5 p. 15], and the Comment's own source for 2015 reported "a short period with three belts and two slots" after the storm of March 2015 [7 p. 79]. In NOAA's records we also found a split outer belt after the storm of November 2004 (our analysis). See section 5.

TRUE
"they have appeared repeatedly since 2024 following major geomagnetic storms in October 2024, June 2025, January 2026 and July 2026"
The Comment, on three belts [1 p. 1]
In the authors' data a slot near L ≈ 1.9–2.2 and a re-formed slot near 2.5–2.75 coexist after all four storms [3]. For October 2024 and July 2026, when the Comment says the belts showed mainly at 500–600 keV [1 p. 4], its dates start four to seven days before the second slot forms in our count, and for October the team's 2026 paper has that slot appear "around 18 October" [6 p. 6]; after June 2025 and January 2026, one channel or another holds three belts for most of the stated time. Kyoto's Dst puts the storms at −333, −119, −236 and −146 nT [27]. Our analysis; see section 3.

MISLEADING
"Such three belts were not observed during storms of the previous solar maximum activity in 2014–2015"
The Comment, citing the team's 2016 paper [1 p. 3]
True of EPT's 500–600 keV channel, as that paper reports for March 2015 [7 Abstract]. But the same paper found "a short period with three belts and two slots", of unstated length, in Van Allen Probes data after that storm, with the first slot at L ~ 2, the Comment's own layout [7 p. 79]. The Comment cites the paper for the opposite. See section 6.

UNSUPPORTED
"This is probably due to hiss wave activity ... This may also be due to human activities' influence on the inner radiation belt"
The Comment, on why the slot now reaches lower [1 p. 4]
Hiss and naval radio transmitters do clear electrons from the slot and the inner belt [21 Abstract][20 Abstract]. But the Comment shows no wave data or model, and we found no study showing either changed after 2015; at about 500 keV transmitters act over months, at several MeV hardly at all [22 Abstract]. The team's own 2026 paper puts the fourth belt down to injection reaching very low L [6 p. 21], and its electron lifetimes, which would dip at a slot made by loss, show no dip at the innermost one [6 p. 12]. The Comment itself notes that before the storm the inner belt was "very faint because there were no big storms previously" [1 p. 2]. See section 7.

1 · THE COMMENT

Five scientists in Belgium describe extra electron belts seen from a satellite 820 km up

Viviane Pierrard, of the Royal Belgian Institute for Space Aeronomy (BIRA-IASB) and UCLouvain, and four colleagues report what the Energetic Particle Telescope (EPT) on ESA's PROBA-V satellite saw after the storm of May 10–11, 2024 [1 p. 1]. They published it as a Comment, a short, non-technical format that the journal says is "typically peer reviewed"; it was received on July 30 and accepted on October 12, 2026 [4][1]. S0 News linked it on November 16, 2026 [2].

What we read

The Comment in full, five pages with four figures and 28 references, and its seven-page supplement [1]. Its data, six files of averaged fluxes that the authors published under CC BY 4.0, which we analysed ourselves [3]. The team's papers of 2016 and 2020 in full, the second as its accepted manuscript [7][8], and those of 2024 and 2026 in full, from copies the site's owner downloaded because the publisher's site refused our client [5][6]. From the owner's copies too, the count of 30 three-belt events [10], the 1991 reanalysis [15] and the CIRBE paper [17]. The rest of the literature mostly as abstracts, as each source entry says.

Belts, slots and L

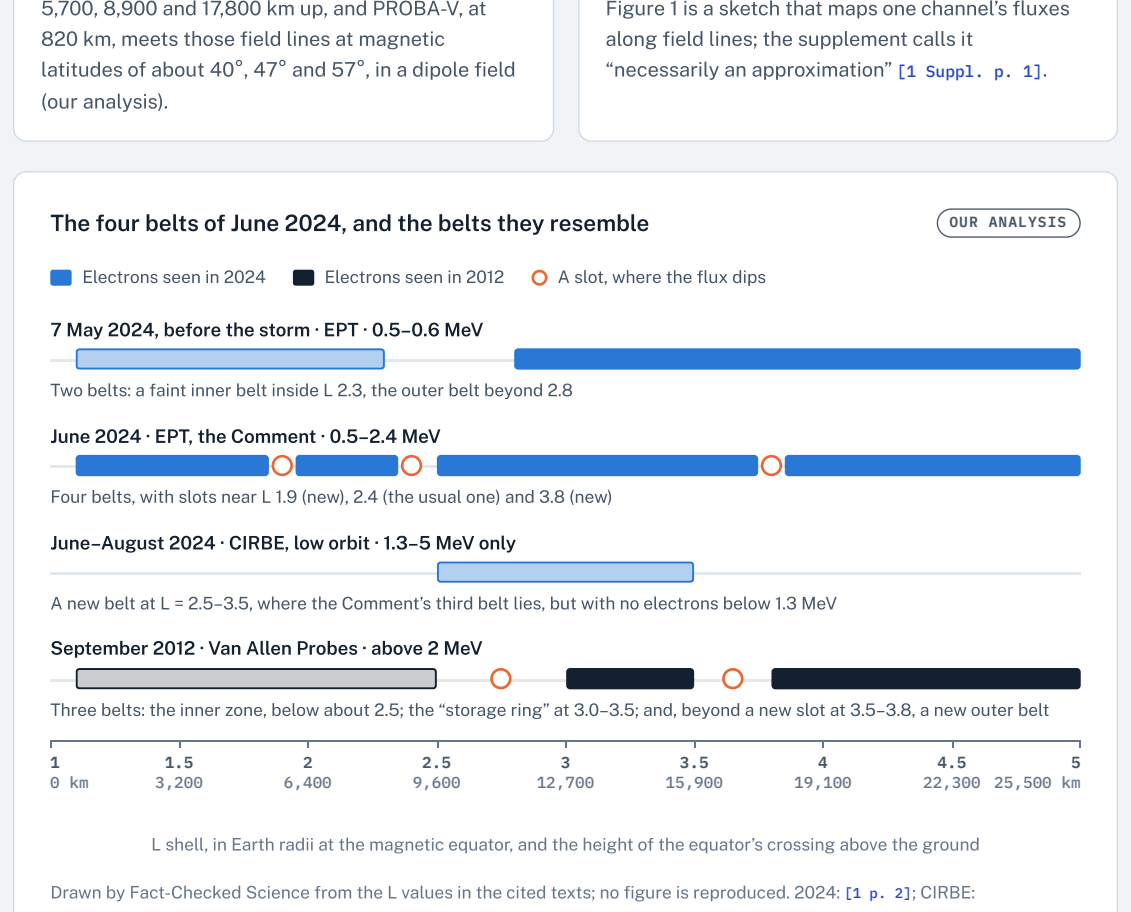
Earth's field traps electrons in doughnut-shaped belts. Usually there are two, an inner and an outer, separated by a nearly empty slot near 2.5 Earth radii [1 p. 1]. Places in them are given by L, the distance in Earth radii at which a field line crosses the magnetic equator: L = 1.9, 2.4 and 3.8 cross it about 5,700, 8,900 and 17,800 km up, and PROBA-V, at 820 km, meets those field lines at magnetic latitudes of about 40°, 47° and 57°, in a dipole field (our analysis).

The Comment's rule

"We define a belt as a local maximum in the flux and a slot as a local minimum in the flux, provided that the feature persists for more than 5 days" [1 p. 1]. EPT counts electrons from 0.5 to 8 MeV in six channels, and the Comment works with daily averages in bins of 0.1 in L [1 p. 1][1 p. 2]. Its Figure 1 is a sketch that maps one channel's fluxes along field lines; the supplement calls it "necessarily an approximation" [1 Suppl. p. 1].

The four belts of June 2024, and the belts they resemble

OUR ANALYSIS


Electrons seen in 2024
Electrons seen in 2012
A slot, where the flux dips
7 May 2024, before the storm · EPT · 0.5–0.6 MeV
Two belts: a faint inner belt inside L 2.3, the outer belt beyond 2.8
June 2024 · EPT, the Comment · 0.5–2.4 MeV
Four belts, with slots near L 1.9 (new), 2.4 (the usual one) and 3.8 (new)
June–August 2024 · CIRBE, low orbit · 1.3–5 MeV only
A new belt at L = 2.5–3.5, where the Comment's third belt lies, but with no electrons below 1.3 MeV
September 2012 · Van Allen Probes · above 2 MeV
Three belts: the inner zone, below about 2.5; the "storage ring" at 3.0–3.5; and, beyond a new slot at 3.5–3.8, a new outer belt
1
0 km
1.5
3,200
2
6,400
2.5
9,600
3
12,700
3.5
15,900
4
19,100
4.5
22,300
5
25,500 km
L shell, in Earth radii at the magnetic equator, and the height of the equator's crossing above the ground

Drawn by Fact-Checked Science from the L values in the cited texts; no figure is reproduced. 2024: [1 p. 2]; CIRBE: [17 p. 2][18]. 2012: [9 Fig. 2], in L*, which differs a little from the L of satellites in low orbit. The outer belt runs on beyond L 5. Heights are for a dipole field, (L − 1) × 6,371 km above the equator, rounded (our analysis).

2 · JUNE 2024 IN THE DATA

The authors' own data show the four belts of June 2024, with a shallow innermost slot

The Comment's fluxes are public, so we counted its belts ourselves, with its own rule. We wrote our method down before looking at the numbers, then checked the count with a second, separately written program [3].

STEP 1
Daily profiles
For each day and energy channel, average the file's three-hour bins on its grid of 0.1 in L, and take logarithms.

STEP 2
Find the dips
After light smoothing, a slot is a dip at least 0.1 decade, a factor of 1.26, below the flux on both sides.

STEP 3
Keep those that last
Follow each slot from day to day, within 0.2 in L, allowing one missed day, and keep it only if it lasts more than five days, as the Comment requires.

STEP 4
Count
Belts are slots plus one. We tried other settings too, 14 in all across the two programs, among them no smoothing at all; after an independent review of our draft, two more that bridge gaps of two or three days.

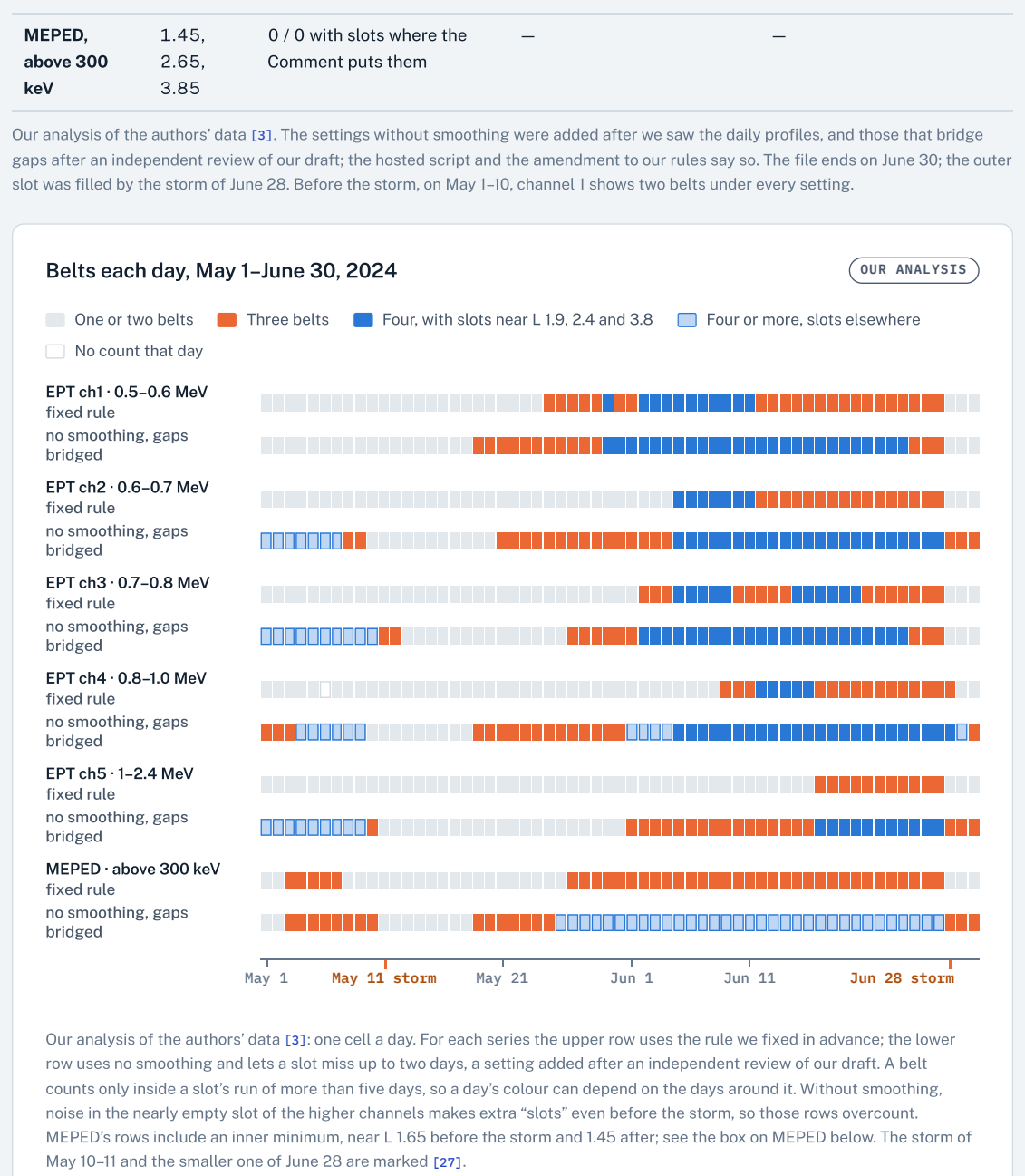
Four belts in June 2024, channel by channel

SERIES	SLOTS NEAR L	DAYS WITH FOUR BELTS, FIXED RULE / NO SMOOTHING	LONGEST UNBROKEN RUN, FIXED RULE / NO SMOOTHING	LONGEST RUN, GAPS OF UP TO TWO DAYS BRIDGED
EPT ch1, 0.5–0.6 MeV	1.9, 2.55, 3.85	10 / 18	10 / 10 days	26 days, May 30–June 24; 29 with three-day gaps, to June 27
EPT ch2, 0.6–0.7 MeV	1.85, 2.45, 3.7	7 / 21	7 / 12 days	23 days
EPT ch3, 0.7–0.8 MeV	1.9, 2.45, 3.7	11 / 20	6 / 20 days	23 days
EPT ch4, 0.8–1.0 MeV	1.95, 2.35, 3.75	5 / 21	5 / 15 days	24 days
EPT ch5, 1–2.4 MeV	1.95, 2.3, 3.9	0 / 3	0 / 3 days	11 days, June 17–27
MEPED, above 300 keV	1.45, 2.65, 3.85	0 / 0 with slots where the Comment puts them	—	—

Our analysis of the authors' data [3]. The settings without smoothing were added after we saw the daily profiles, and those that bridge gaps after an independent review of our draft; the hosted script and the amendment to our rules say so. The file ends on June 30; the outer slot was filled by the storm of June 28. Before the storm, on May 1–10, channel 1 shows two belts under every setting.

Belts each day, May 1–June 30, 2024

OUR ANALYSIS



Our analysis of the authors' data [3]: one cell a day. For each series the upper row uses the rule we fixed in advance; the lower row uses no smoothing and lets a slot miss up to two days, a setting added after an independent review of our draft. A belt counts only inside a slot's run of more than five days, so a day's colour can depend on the days around it. Without smoothing, noise in the nearly empty slot of the higher channels makes extra "slots" even before the storm, so those rows overcount. MEPED's rows include an inner minimum, near L 1.65 before the storm and 1.45 after; see the box on MEPED below. The storm of May 10–11 and the smaller one of June 28 are marked [27].

OUR ANALYSIS

So the four belts are there in channels 1–4, over the time the Comment gives. The slot that makes the fourth belt, near L = 3.8, lasted from May 30 to June 27 in channel 1, until the storm of June 28 filled it, as the Comment says [1 p. 2]. The team's 2026 paper dates the four belts from "around 22 May" [6 p. 4]; our count, which needs all three slots on the same day, finds them from May 30. The innermost slot is one or two bins wide and 0.15–0.45 decade deep, and on some days it slips below our threshold, which is why strict counts break the four belts into shorter runs; on a colour map such a dip still shows as a band. In channel 5 they show for three days without smoothing and for 11 days, June 17–27, with gaps of two days bridged, around June 18, the day of the profile in the supplement [1 Suppl. Fig. S1]; near 1 MeV, the team's 2024 paper says, the third belt formed only after a small storm on June 15 [5 p. 12].

MEPED: three of the four

The Comment adds that MetOp-C's MEPED, a NOAA instrument, saw the four belts too, and that simulations "have confirmed that MEPED can be used as an effective tool for detection of relativistic electrons almost free of contamination" [1 Suppl. Fig. S1]. Our own processing of NOAA's files matches the authors' MEPED file, and it shows the split of the outer zone, slots near L = 2.65 and 3.85, for about a month from late May [29][3]. But MEPED's inner minimum lies near L = 1.45, not 1.9, and the peak inside it, near L = 1.35, was the same before the storm as after, while at that L EPT's 0.5–0.6 MeV electrons rose about 17-fold and MEPED's own flux near L = 1.95 rose about 18-fold. That points to protons: NOAA's documentation says the channel "intended to measure >300 keV electrons" is the one most affected by them [30 p. 16]. The team's 2024 paper placed MEPED's slots at L = 1.5, 2.6 and 3.9, "at different positions than for EPT due to the different energy range" [5 p. 13], and in its Figure 10 MEPED's profiles near L = 1.3–1.4 lie almost on top of one another from May 1 to June 29 [5 Fig. 10]. Our analysis.

Other spacecraft saw a belt in the same place

NASA's CIRBE CubeSat, about 435 km up, found a new belt at L = 2.5–3.5 when it resumed measuring on June 16, but only of 1.3–5 MeV electrons: "there are no measurable electrons with energies below 1.3 MeV in that region" [17 p. 2][17 p. 4]. That is where the Comment's third belt lies, between the slots near 2.4 and 3.8, but EPT shows that belt at 0.5–1 MeV; at 1 MeV and above it "completely disappears", the team's 2024 paper says, until a small storm on June 15 formed it near 1 MeV [5 p. 12]. CIRBE saw only "the 'tip of the iceberg'", the electrons that reach down to its height [17 p. 7], while PROBA-V, at 820 km, also sees electrons that turn back above CIRBE's height, so the two need not agree. CIRBE confirms the belt's place, and with EPT's 1–2.4 MeV channel shows after June 15, but not the belt at 0.5–1 MeV. The belt had decayed by July 3 but was still visible [17 p. 3], and NASA says it lasted more than three months [18]. CALET, on the International Space Station, saw a "new electron storage ring" that overlaps it, reaches down to L = 2.2, below the usual slot, and "persisted for several months" [19 Abstract]. Neither CIRBE's paper nor CALET's abstract reports the slot near 1.9. Our check of the Arase paper on the same storm is at A great storm made multi-MeV electrons inside the radiation belts' barrier.

3 · THE LATER STORMS

After each of the four later storms, the authors' data show three belts again

The Comment says three belts followed the storms of October 2024, June 2025, January 2026 and July 2026, formed by a slot that stays near L = 1.9–2 while the usual slot re-forms just outside it [1 p. 1][1 p. 3]. We ran the same count on its files for those months, and checked each storm in Kyoto's Dst, whose values for 2021–2026 are still provisional [3][27].

The storms, and three belts in our count

STORM, KYOTO'S DST	THE COMMENT SAYS	SLOTS NEAR L, CHANNEL 1	THREE BELTS IN OUR COUNT, FIXED RULE / NO SMOOTHING
October 10–11, 2024: −333 nT	"min Dst = −335 nT" [1 p. 3]; three belts October 12–November 8 [1 Suppl. Fig. S2], mainly at 500–600 keV [1 p. 4]	1.95 and 2.55	Channel 1: October 19–November 1, 14 days / to November 6, 19 days
June 1 and 13, 2025: −119 and −101 nT	"min Dst ~ −100 nT" [1 p. 3]; three belts from June 10 to mid-July; the new slot refilled only in channel 1 on June 14 and re-formed on June 18 [1 Fig. 3]	1.85–1.95 and 2.65	Channel 1: June 18–July 1, 14 days / June 17–July 8, 22 days. Channel 2, no smoothing: June 16–July 9, 24 days
January 20, 2026: −236 nT	"February 2026 (min Dst ~ −240 nT)" [1 p. 3]; three belts in February, in every channel but the sixth [1 Suppl. Fig. S3]	1.85 and 2.55	Channel 1: February 6–16, 11 days / 12 days. Channel 2: February 6–26, 21 days. No data on February 2–5
July 4, 2026: −146 nT	"min Dst ~ −150 nT" [1 p. 3]; three belts from July 5 to mid-July [1 Suppl. Fig. S2], mainly at 500–600 keV [1 p. 4]	2.15 and 2.75	Channel 1: July 10–13, 4 days / July 9–16, 8 days

Kyoto's provisional hourly minima [27]; our analysis of the authors' data [3]. The July 2026 file has bins of 0.05 in L; at that finer grid the July run is 8–9 days.

OUR ANALYSIS

The pattern recurs as the Comment describes: after each storm a slot stays near L = 1.9–2.2, the usual slot re-forms just outside it, and the electrons trapped between them make the extra belt. Two of the four storms, June 2025's and July 2026's, were weaker than the storm of March 2015, −234 nT in Kyoto's final values, after which EPT saw two belts only [27][1 Suppl. Fig. S6]. Storm size alone doesn't decide it.

The storm of May 2024, in Kyoto's record

The Comment gives −412 nT [1 p. 1], the value in real time [31 p. 2]; Kyoto's provisional value is −406 nT, at 02–03 UT on May 11 [27]. Either way it was the deepest storm since November 20, 2003 (−422 nT), as the Comment's "strongest storm in the last 20 years" says. October 2024's −333 nT is the second deepest in the 20 years before it if they start in 2005, the third if they include November 8, 2004 (−374 nT) [27]. Our analysis.

4 · A FIRST?

Four belts had been reported twice before, briefly; this team had already called June 2024 a first

The Comment opens: "For the first time, four distinct electron belts were observed in the Earth's near-space environment after the exceptional geomagnetic storm of 11 May 2024" [1 Abstract]. Two earlier studies describe four-belt structures, neither lasting weeks, one mixing energies and the other at lower ones [15 p. 8771][16 Abstract], and the team itself had announced the June 2024 belts twice before [5 Abstract][6 Abstract].

Four electron belts in the record

WHEN	WHAT WAS REPORTED	HOW IT WAS SEEN	HOW LONG
March 1991	"a never-before-reported four-zone structure": the inner belt, a belt of electrons injected by the storm's shock, a remnant outer belt and a second outer belt, the last near L* = 4 [15 Abstract]; the shock's belt held 13 MeV electrons, which showed in a 1 MeV channel [15 p. 8771]	In several spacecraft's data, at several energies, and in a reanalysis that fed five spacecraft's data into a model of the belts [15 p. 8776]	The fourth belt, "several days" [15 Abstract]; the two outer belts merged near April 2 [15 p. 8778]
May 2009	Two new inner belts, at L = 1.65 and L = 2.06, "observed simultaneously" beside the Van Allen belts on some days, at 180–510 keV [16 Abstract]	One instrument in low orbit, CORONAS-Photon's STEP-F, whose channel also counts protons of 3.5–3.7 MeV [16 Abstract]	"On some days" [16 Abstract]
June 2024	Four belts, with slots near L = 1.9, 2.4 and 3.8, at 0.5–2.4 MeV [1 p. 2]	PROBA-V's EPT at 820 km [1 p. 1]	"more than 4 weeks" [1 p. 2]

The team said it first in 2024, with a qualifier

In October 2024 the same group wrote that for 0.3–1 MeV electrons the storm "led to a long lasting four belts configuration which was not observed before with EPT (launched in 2013)": a first for their instrument [5 Abstract]. By March 2026 the abstract had dropped it: "For the first time, four electron belts were observed during several weeks" [6 Abstract]. That paper's introduction repeats the unqualified first [6 pp. 1–2], then says a four-belt structure "like in May–June 2024 was never observed before" [6 p. 2]; its conclusion speaks of "the first detection of four electron belts", citing the 2024 paper [6 p. 21]. The Comment cites both papers and repeats the claim without the qualifier [1 p. 1].

OUR ANALYSIS

What does look new is the combination: four belts at the same energies lasting weeks, seen from orbit at 0.5–1 MeV, and briefly up to 2.4 MeV, with a slot near L = 1.9 inside the usual one. We found no earlier report of that. But "four distinct electron belts ... for the first time" claims more. Four belts were reported for 1991, in spacecraft data as well as a model [15 p. 8776], for about a week [15 p. 8778], though one of them was of 13 MeV electrons [15 p. 8771]; their authors thought such a structure likely very rare [15 p. 8778]. Four belts were also reported on some days of May 2009, at lower energies, from one instrument [16 Abstract]. We rate the unqualified first Overstated.

5 · THREE BELTS BEFORE

Three-belt structures were reported dozens of times before 2024, after about one storm in six

The Comment says a three-belt configuration "was previously reported once in 2012" and, of the 2012 belt, "It was never observed again until the May 2024 event" [1 Abstract][1 p. 2]. Published counts from two eras of spacecraft say otherwise [10 Abstract][11 Abstract].

VAN ALLEN PROBES, 2012–2017
30 events
three-belt events from September 2012 to November 2017, after "about 18% of geomagnetic storms", most often at about 5 MeV [10 Abstract]

SAMPEX, 1994–2003
8 events
an outer belt split in two, so three belts, at 1.5–6 MeV, from low orbit, in 333 storms [11 Abstract]

BELOW 1 MEV, VAN ALLEN PROBES
54 events
"two comparable peaks of sub-MeV electron fluxes and a slot" where the outer belt should be [13 Abstract]

In the sources' words

> *"Using data between September 2012 and November 2017, we have identified 30 three-belt events and found that about 18% of geomagnetic storms result in such configuration."*
>
> Pinto et al. (2018) [10 Abstract]

> *"We emphasize features seen repeatedly in the data (three-belt structures, 'impenetrable' barrier properties, and radial diffusion signatures)"*
>
> Baker et al. (2019), on 2012–2018 [12 Abstract]

> *"We have identified eight events with double-belt structure in the outer radiation belt from 110 coronal mass ejection (CME) driven magnetic storms and 223 corotating interaction regions (CIR) driven storms during 1994 to 2003 based on the SAMPEX data sets."*
>
> Yuan and Zong (2013) [11 Abstract]

OUR ANALYSIS

The 2012 belt the Comment describes, "of E > 2 MeV due to a new slot in the outer belt around L = 3.8" [1 p. 2], is the very kind these studies count. Baker et al. found it at 3.0–3.5 Earth radii "for over four weeks", with the new slot at 3.5 < L* < 3.8 [9 Abstract][9 Fig. 2]. Pinto et al. call such belts remnant belts, with decay lifetimes from days at 1.8 MeV to months at 6.3 MeV [10 Abstract]; the three-belt events they list lasted 5 to 17 days, 11 on average at 4.2 MeV [10 p. 12,104], and below 1 MeV they can last just two or three days [14 Abstract]. The team's own 2024 paper said multiple belts "have been observed before this event in different energy ranges", citing a sub-MeV three-belt event and the 2012 belt, though it noted that both formed as a third belt above a remaining one [5 p. 15]. So "never observed again" and "reported once" are contradicted by the record, though the Comment's description of 2012 itself is right. The Comment's other kind of extra slot, the one near L = 1.9, shows in the record only briefly: after March 2015 (section 6), and on some days of May 2009, at lower energies (section 4); nothing we found shows it lasting weeks at these energies before 2024. The belt that the shock of March 1991 injected near L* ≈ 2.1–2.4 lasted until 1994, but it held protons and multi-MeV electrons [15 p. 8771].

Our test: NOAA's records before 2024

MEPED, the instrument the Comment uses as a check, flies on NOAA's and EUMETSAT's polar satellites [30]. We ran our count on NOAA-15's records after every storm that reached −250 nT from 1998 to 2023, eight storms in six windows, and after the two storms of 2015, all chosen in advance from Kyoto's Dst [27]. First, on 2024, we checked that the method finds what the authors found [29]. Because MEPED's channel counts protons in the inner zone, we looked only for a split of the outer zone, the 2012 kind, at L of 2 and above [30 p. 16].

A split outer zone in MEPED's records

STORM, KYOTO'S DST	SPLIT, DAYS (FIXED RULE)	OVER OTHER SMOOTHED SETTINGS
May 2024 (−406 nT, provisional), MetOp-C and NOAA-15: the test of the method	31 and 31; slots near L = 2.65 and 3.75–3.85	MetOp-C 29–31, NOAA-15 6–31
April 2000 (−292 nT)	0	0
July 2000 (−300 nT)	0	0
March–April 2001 (−387, −271 nT)	0	0
November 2001 (−292 nT)	0	0
October–November 2003 (−383, −422 nT)	0	0
November 2004 (−374 nT)	10, November 22–December 1	7–11; 0 at the strictest threshold
March 2015 (−234 nT)	0	0
June 2015 (−198 nT)	0	0

Our analysis of NOAA's MEPED records, channel above 287 keV, 90° telescope [29]; Kyoto's final hourly minima for 2000–2015 [27]. The November 2004 split had slots near L = 2.45 and 3.75, about as deep as NOAA-15's own view of 2024's, and under the fixed rule it was absent before the storm; without smoothing, a slot near L = 3.75 also shows on October 29–November 7, before it. Without smoothing, short splits also show after some other storms, mostly at the outer belt's noisy edge.

So by the same instrument and rule, the outer belt split after the storm of November 2004 as it did in 2024, if for ten days rather than a month. It is one instrument and one rule, ours, not a published result; it agrees with the counts above, and it finds no outer split after the storms of 2015 either.

6 · 2014–2015

The paper the Comment cites for 2014–2015 saw a short three-belt spell in March 2015

"Such three belts were not observed during storms of the previous solar maximum activity in 2014–2015," the Comment says, citing the team's 2016 paper on the storms of early 2015 [1 p. 3][7]. For EPT's own data that paper agrees: after the storm of March 17, 2015, the injected electrons filled the slot completely, and ten days later a new slot formed near L = 2.8 [7 Abstract]. In Van Allen Probes data at 742 keV it described something else.

In the 2016 paper's words

Van Allen Probes, 742.5 keV, after the storm of March 17, 2015.

> *"The formation of a third remnant belt is then visible: the first slot region remains at L ~ 2 because the penetration of the fluxes is a little bit higher than the outer edge of the inner belt, but a second slot is formed a few days later between L ~ 2.3 and L ~ 2.9, so that there is a short period with three belts and two slots (the new one being clearly deeper)."*
>
> Pierrard and Lopez Rosson (2016) [7 p. 79]

OUR ANALYSIS

That is the Comment's own layout, a first slot near L ≈ 2 left by an injection that stopped short of the inner belt and a new one just outside it, seen nine years earlier, by another spacecraft, below 1 MeV. The 2016 paper doesn't say how long the "short period" lasted, so it may not pass the Comment's five-day rule. The Comment's supplement is more careful than its text, saying EPT saw two belts in March 2015, "as it was generally observed for geomagnetic storms before 2024" [1 Suppl. Fig. S6]. Pinto et al. also show a three-belt event of the 2012 kind, though not the Comment's layout, in Van Allen Probes data from about July 13, 2015, after a moderate storm [10 p. 12,101], and the team's own 2026 paper limits the absence to "the EPT observations before 2021" [6 p. 21]. The sentence is true of EPT's 500–600 keV channel, but by leaving out the three belts its own source reported, it misleads.

7 · WHY

Storms and waves make extra slots; nothing shown ties the deeper slot to hiss or to transmitters

The Comment puts the new belts down to storms that inject electrons into the slot to a limited depth, and to waves that scatter electrons into the atmosphere [1 p. 3]. Why the main slot now reaches below L ≈ 1.9, it says, "is probably due to hiss wave activity that increases during geomagnetic disturbances in the slot region. This may also be due to human activities' influence on the inner radiation belt", meaning naval radio transmitters [1 p. 4].

Storms set the depth

The team's 2020 paper found that after storms with Dst below −50 nT fluxes reach lower L, "down to an impenetrable barrier with a minimum L-shell related to Dst and to the energy" [8 Abstract]. The Comment cites it for storms below −100 nT [1 p. 3]. That paper noted that EPT had seen no storm below −230 nT in 2013–2019, giving March 2015 as −223 nT, where Kyoto's final value is now −234 nT [8 §3][27], and that its finding for electrons above 2.4 MeV, which went no lower than L = 2.8, "could be different for bigger storms" [8 §3.3].

Hiss

Plasmaspheric hiss is the wave long held to clear the slot: "natural plasma turbulence should dominate the loss of relativistic (approximately MeV) electrons in the slot region 2 < L < 3" [21 Abstract]. The study the Comment cites found hiss stronger with magnetic activity on the dayside, but "independent of magnetic activity on the nightside" [21 Abstract]. The Comment shows no wave data.

Transmitters

Signals from naval radio transmitters are "the principal loss mechanism over the range 1.3 ≤ L ≤ 2.4" in a classic model [20 Abstract], and they can split the inner belt in two at tens of keV over more than ten days [23 Abstract]. At about 500 keV they cut lifetimes only "down to the order of 200 days", and they are "ineffective at removing multi-megaelectron volt electrons" [22 Abstract]. EPT itself caught one transmitter scattering electrons of up to 800 keV [24 Abstract].

Lightning

Lightning's whistlers can knock MeV electrons out of the inner belt [25 Abstract]. The Comment says there is "no evidence that their occurrence or intensity has increased in recent years" [1 p. 4], and we found none either.

OUR ANALYSIS

Each mechanism is real, and the Comment says plainly that the details await "future studies using simulations and models" [1 p. 4]. But it offers no evidence for its "probably": no wave measurements and no model run. The transmitter explanation needs their effect to have changed between the last solar cycle and this one, and the hiss explanation would need to say why weaker storms now make the slot; we found no study showing either. The team's own 2026 paper, while it says the flux decrease that makes the slots "also seems to be due to electron resonance with Very Low Frequency (VLF) waves" [6 p. 13], points elsewhere for the innermost slot. It ties the inner slot of October 2024 to the depth the injection reached [6 p. 6] and the fourth belt to "the penetration of the fluxes at very low L" [6 p. 21]. Its electron lifetimes after May 11 fall outward, from 160 days at L = 1.65 to 84 at the slot near 1.85 and 27 at L = 2.15, with no dip at the slot, while at the two outer slots they were shorter than usual, as faster loss would make them [6 p. 12]. Neither the 2024 nor the 2026 paper shows wave data or a wave model. The Comment's own pages point to other differences that would need ruling out first: before the storm, the inner belt was "very faint because there were no big storms previously" [1 p. 2], and EPT had never seen a storm as deep as those of May and October 2024 [8 §3.3][27]. We rate the causal sentence Unsupported: a hedged suggestion with nothing yet tying it to this slot.

8 · THROUGH A CATASTROPHISM LENS

Extra belts come with strong storms and fade within weeks to months; nothing here points to a failing field

The Comment ties the belts to storms driven by coronal mass ejections and to the waves that scatter electrons, and says nothing about Earth's main field or its slow change [1 p. 3]. We checked whether the field could matter anyway.

THE DIPOLE, 2015 TO 2024
OUR ANALYSIS
−0.41%
the weakening of Earth's dipole between the storms of 2015 and 2024 in IGRF-14, and −0.52% by July 2026 in its forecast for 2025–2030 [28]

L AT 820 KM · OUR ANALYSIS
≤ 0.11
how far, in L, the field's drift over 2015–2026 moves a fixed place at PROBA-V's height: at most 0.03, 0.05 and 0.11 at L 1.9, 2.4 and 3.8; the slots are 0.5–1.4 apart [28]

HOW LONG THEY LAST
Weeks
the extra belts fade within about a month, by the Comment's own account [1 p. 4]; others have lasted months [18][19 Abstract]

OUR ANALYSIS

In a dipole, L is geometry: it names the field line through a place, so a field that weakens evenly moves no L at all. The slow tilt and drift of the real field move the L of a fixed place 820 km up by a few hundredths at L ≈ 1.9 and about a tenth at L ≈ 3.8 over 2015–2026, and the authors compute L from the IGRF field model, which follows the field's change [1 Suppl. p. 1]. Belts and slots that appear within days of a storm, and fade within weeks to months, are storm physics. A belt is electrons held by the field; extra belts mean the trapped electrons are arranged differently, with gaps where waves have cleared them, not that the field is letting particles through.

What the belts mean, and don't

The belts hold tens to thousands of kilometres up, and matter for the satellites and crews that pass through them, not for the ground [1 p. 1]. Where the field's slow change does matter is the South Atlantic Anomaly, where the inner belt dips to low orbit; the Comment puts it down to "the slight offset between the center of the Earth and the center of the geomagnetic field" [1 p. 3], the usual first approximation; field models tie the anomaly's drift and depth to the non-dipole field [26 Abstract]. See our check of the anomaly's growth since 1800 and our guide to the field. The "human activities" the Comment mentions are naval transmitters, a known influence on the inner belt for decades [20 Abstract].

9 · WHAT THIS CHECK CAN'T SETTLE

EPT's earlier data, the full texts we couldn't read, and the limits of one rule

EPT before 2024

The published data cover only the weeks around the five storms [3]. EPT's earlier record would show directly whether the slot near L = 1.9 is new to it; the team's 2016 paper says it wasn't there in 2015 [7 Abstract]. The team's 2026 paper shows EPT's fluxes from January 2020 [6 Fig. 1] and has published its data separately [6 p. 22]; we haven't analysed them.

Papers read as abstracts

Most of the literature on causes, the other counts of earlier belts [11][13] and the report on May 2009 [16] were read as abstracts. Pinto et al. list their 30 events only in supporting information we haven't seen [10 p. 12,101].

One way of counting

Our count follows the Comment's rule, but a dip is a matter of degree: how deep a slot must be, how much the daily profiles are smoothed and how many missed days a slot may have all change the number of days, as our settings show. The authors' code is available only on request [1 p. 4].

MEPED's protons

We left MEPED's inner zone out of our test of earlier storms because its electron channel counts protons there [30 p. 16]; we subtracted nothing. So MEPED can't say whether a slot near L = 1.9 ever formed before 2024.

No search is complete

We searched indexes and the citations of the key papers in English. A report of four belts lasting weeks may exist that we missed.

Small slips we noticed

None of these changes a verdict. The Comment dates its reference 27 to 2025; it was published on October 8, 2024 [25]. Its supplement dates October 2024's three belts from October 12, though the same caption puts the new slot "around 10 days after the flux increase", which came on October 10–11; in the data the slot forms on October 19 [1 Suppl. Fig. S2][3], as the team's own 2026 paper has it, "around 18 October" [6 p. 6]. And the data set's web record describes the January–February 2026 file as June–July 2025 and the October–December 2024 file as May–July 2024 [3].

What would change these verdicts

01
An earlier report of four electron belts at the same energies lasting weeks would make the Comment's first False; a showing that the belts of May 2009 were protons would leave only 1991's, which mixed energies, and make it closer to True.

02
Wave measurements or model runs tying the deeper slot to a change in hiss or in transmitters would move "Likely hiss, maybe transmitters" toward Unconfirmed or True.

03
EPT data from 2015 that showed three belts lasting more than five days would make "None in the 2014–2015 storms" False; if the Van Allen Probes' spell proves shorter than five days, the omission would matter less.

10 · REPEAT OUR NUMBERS

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

Each rules file was written before the scripts it governs first ran; settings added afterwards say so in the outputs, and the amendment says why. One script fetches the public inputs by URL under a plain client name and checks them against the copies we used.

- PY **fetch_inputs.py and meped_files.txt** Fetches the authors' six data files, Kyoto's Dst and our field series and checks each against the SHA-256 of our copy; with an option, NOAA's 616 MEPED files listed in the text file, about 2.5 GB; standard library · 126 KB
- PY **belts_a.py and belts_b.py** Count belts and slots in the authors' files by our fixed rule and its variants, including the settings added after the review, then by a second, separately written method; numpy, scipy and netCDF4, and pandas for the second · 40 KB
- CSV **belts_daily.csv, belts_daily_posthoc_G.csv and belts_event_table.csv** Our count day by day, with each day's slots, under the fixed rule and the settings added after the review, and event by event under every setting, sections 2 and 3 · 295 KB
- PY **make_tables.py and checks.py** The tables and chart data, and the small checks in NOTES.txt · 25 KB
- PY **dst.py and its outputs 1, 2, 3** The storms' minima and rankings in Kyoto's final and provisional Dst, sections 3 and 5; standard library · 12 KB
- PY **meped_test.py, meped_robust.py, meped_crosscheck.py and their outputs 1, 2** Our test of NOAA's MEPED records, section 5, with its settings and a cross-check of two of NOAA's products; numpy and netCDF4 · 37 KB
- PY **dipole.py and dipole_numbers.json** The dipole's change from IGRF-14 and what it does to L at 820 km, section 8; standard library · 9 KB
- TXT **RULES_belts.txt and its amendment, RULES_dst.txt, RULES_meped.txt and RULES_meped_crosscheck.txt** The rules, each written before its first run; the amendment, after the fresh review, and the cross-check were added later and say so · 22 KB
- TXT **NOTES.txt and HASHES.txt** Small checks and how the hosted scripts were verified; the SHA-256 of every file here and of our inputs, with the order of the rules and runs · 20 KB

Run it

`python3 -I fetch_inputs.py <folder>` fetches the inputs; then, for example, `python3 -I belts_a.py <folder>/bira <out>` and `python3 -I dst.py <out> <folder>/kyoto`. Each script's header gives its exact usage. The counts need numpy, scipy and netCDF4, because the authors' files are netCDF-4; `dst.py`, `dipole.py` and `fetch_inputs.py` need only Python 3.9 or later.

What we don't host

The Comment and its figures, which the journal serves under CC BY-NC-ND 4.0 [1]; the authors' data, which BIRA-IASB serves under CC BY 4.0 [3]; and Kyoto's Dst and NOAA's files, which the script fetches from their owners [27][29]. We host only our own rules, code and derived numbers.

Related checks

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

Sources

Bracketed numbers refer to this list. For the Comment [1], p. gives a page of its five-page PDF, Abstract its opening summary, Fig. its own figures, and Suppl. p. and Suppl. Fig. a page and the figures of its supplement. Elsewhere p. gives a page, § a section and Fig. a figure, and Abstract marks a source of which we read or quote the abstract, as its entry says. L is the McIlwain parameter, the distance in Earth radii at which a magnetic field line crosses the magnetic equator; L* is a version of it that allows for a storm's distortion of the field. keV and MeV are thousand and million electronvolts; nT is the nanotesla, the unit of the Dst index; a decade is a factor of ten in flux. Links checked November 16, 2026.

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2 SpaceWeatherNews (S0) (November 16, 2026). THE 4TH RING APPEARS · Records Crumble | S0 News Nov.16.2026. YouTube video, https://www.youtube.com/watch?v=af5BHBxbEq4. Linked the source; no transcript was available, so nothing it says is rated here.

3 Winant, A., Pierrard, V., and Botek, E. (2026). L-Time average of EPT and MEPED electron observations following strong geomagnetic storms (Version 1) [data set]. Royal Belgian Institute for Space Aeronomy (BIRA-IASB). CC BY 4.0. The Comment's data: six netCDF files of fluxes averaged over three or six hours and 0.1 or 0.05 in L, downloaded November 16, 2026, and analysed by us.

4 npj Space Exploration. Content types. Springer Nature. Read November 16, 2026.

5 Pierrard, V., Winant, A., Botek, E., and Péters de Bonhome, M. (2024). The Mother's Day Solar Storm of 11 May 2024 and Its Effect on Earth's Radiation Belts. Universe 10(10), 391. CC BY 4.0. Read in full, from a copy the site's owner downloaded on November 16, 2026; the publisher's site refused our client. The Comment's reference 8.

6 Pierrard, V., and Winant, A. (2026). Atmospheric Loss of Energetic Electrons and Protons from the Radiation Belts After the Exceptional Injection of the 11 May 2024 Superstorm Leading to Four Electron Belts. Atmosphere 17(3), 324. CC BY 4.0. Read in full, from a copy the site's owner downloaded on November 16, 2026; the publisher's site refused our client. The Comment's reference 9.

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10 Pinto, V. A., Bortnik, J., Moya, P. S., Lyons, L. R., Sibeck, D. G., Kanekal, S. G., Spence, H. E., and Baker, D. N. (2018). Characteristics, Occurrence, and Decay Rates of Remnant Belts Associated With Three-Belt Events in the Earth's Radiation Belts. Geophysical Research Letters 45(22), 12,099–12,107. Read in full, without its Supporting Information, from a copy the site's owner downloaded on November 16, 2026.

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METHOD

How this was checked

On November 16, 2026, we read the Comment in full, with its supplement, and checked its claims against its own published data, Kyoto's Dst, NOAA's satellite records and the literature: 30 other sources, in the Sources list. Of the papers, we read eight in full, two of them as accepted manuscripts and five from copies the site's owner downloaded, and the rest as abstracts or records, as each entry says. Quotations were checked word for word against the saved sources; those from abstracts are as the publishers deposited them with Crossref.

The verdicts and the items tagged "Our analysis" are our own assessment, built on the cited sources. No transcript of the episode in which S0 News linked the Comment was available, so this page reviews the Comment on its own and rates nothing from the episode.

We counted belts and slots in the authors' six data files with rules written before we looked at the fluxes, checked the counts with a second, separately written method, and tried 14 settings; the settings without smoothing were added afterwards, and say so. A fresh review then found that our count broke the four belts of June 2024 into short runs because the shallowest slot dips below our threshold for one to three days at a time. Two settings that bridge such gaps, added after the review and labelled as such, show four belts in channel 1 for 26 days, and for 29, more than four weeks, as the Comment says, when three-day gaps are bridged; in channels 2–4 the runs are 23–24 days. We withdrew our first reading. We ranked the storms in Kyoto's final and provisional Dst, and ran the same count on NOAA's MEPED records after every storm that reached −250 nT from 1998 to 2023 and after the two storms of 2015, chosen in advance, with 2024 as a test that the method finds what the authors found. The rules, scripts and results are under "Repeat our numbers". EPT's data from before 2024 aren't in the published set, and the authors' code is available only on request, so neither was checked.

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

FALSE	The evidence contradicts the claim.
MISLEADING	Contains something true but leaves a false impression, usually by leaving out key context.
OVERSTATED	Has some basis but claims much more than the evidence supports.
UNSUPPORTED	No evidence we could find backs it up, though it hasn't been strictly disproven.
TRUE	The evidence supports the claim.

All ten verdicts, and how we check

CORRECTIONS

Corrections and changes

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

Change log

Nov 16, 2026 Published on factchecked.science after a full check against the sources.

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Last updated Nov 16, 2026