PAPER CHECK · GEOMAGNETIC STORMS AND OZONE

Storm ozone loss, yes. Pole shift, no.

A new preprint measured how four geomagnetic storms since May 2024 destroyed ozone high above the poles [1]. A video about it told viewers the losses were too big for Earth's magnetic field, that climate models missed them, and that they point to a pole shift [V]. Here is what the paper actually reports.

By Fact-Checked Science · Published October 11, 2026

OUR ANALYSIS marks our own reasoning, and the verdicts are our assessment. Everything else comes from the numbered sources; § points to a section of the preprint [1].

What the video said, checked against the paper

OUR ASSESSMENT

TRUE

"They measured the ozone loss and found between 30 and 80% depletion of those upper mesospheric layers."

VIDEO, 3:21 [V]

Matches the paper. The MLS instrument on the Aura satellite recorded peak losses of about 30% to 80% at roughly 60–80 km altitude after the four storms [1 Abstract, §3.1].

MISREAD

"Their models did not reproduce that, meaning this mega effect that they saw in reality is not in the climate models."

VIDEO, 3:29 [V]

Where those losses were measured, the model's results "generally agree well" with the satellite's, "both in spatial extent and in magnitude," though often slightly smaller [1 §3.3]. The "not reproduced" in the paper's abstract refers to something else: a dip higher up that isn't statistically significant (section 2). And the model, WACCM6, is itself a climate model [1 §2.1].

FALSE

"80% is way too much. That would never happen with Earth's normal magnetic field unless it was like an X1000 solar flare."

VIDEO, 3:36 [V]

October 2024's 80% loss followed an S3 "Strong" proton storm tied to an X1.8 flare [4], a level NOAA expects about 10 times per 11-year cycle [5]. A 2006 study found that "even moderate" proton events can deplete middle-atmosphere ozone by more than 70% [6]. See section 4.

UNSUPPORTED

"Pole shift right there in numbers."

VIDEO, 3:45 [V]

The paper never mentions a pole shift or a weakening magnetic field. Its model handles Earth's magnetic shielding the standard way used for climate simulations, and its results still broadly match the measured losses in place and size [1 §2.2, §3.3].

1 · THE MECHANISM

How a solar storm destroys ozone

The basic pathways are "well established," the authors write. Large uncertainties remain in how many particles arrive, how much air they ionize and how much the chemistry changes [1 §1].

01

Particles rain in

Solar protons and electrons from Earth's radiation belts pour into the polar atmosphere during major storms [1 §1].

02

They ionize the air

Electrons above 130 keV ionize air at 60–80 km. Protons reach deeper, into the upper stratosphere [1 §1, §3.1].

03

Ozone destroyers form

The ionization produces odd nitrogen (NO_x) and odd hydrogen (HO_x) [1 §1].

04

Ozone breaks down

NO_x and HO_x destroy ozone catalytically [1 §1]. Loss peaked about a day after each storm's peak activity, a delay the authors say fits reactions that need sunlight to work best [1 §3.2].

↓ **The slow, indirect effect.** In polar winter, long-lived NO_x sinks inside the polar vortex and can keep destroying ozone for weeks to months [1 §1]. The model shows this sinking loss in the stratosphere from early winter onward, reaching lower altitudes by January 2026 [1 §3.3].

2 · WHERE THE MODEL FELL SHORT

The model's clearest miss is in the top layer

The satellite looked at three layers of the atmosphere. The model broadly matched the layer where the 30–80% losses were measured, though it often ran slightly low.

LAYER	WHAT THE SATELLITE SAW	WHAT THE MODEL DID	WHAT THE VIDEO SAID
Lower thermosphere Up to about 95 km, the top of the satellite's range [1 §2.1]	A dip in ozone after all four storms, "generally not statistically significant" [1 §3.1]	✕ **Not reproduced** The authors think the model lacks the processes at work there [1 §3.3]	Not in the excerpt
Mesosphere Losses measured at about 60–80 km [1 §3.1]	Peak losses of about 30% to 80% [1 §3.1]	✓ **Broadly reproduced** Results "generally agree well… both in spatial extent and in magnitude," though often slightly smaller [1 §3.3]	MISREAD "Their models did not reproduce that" [V]
Stratosphere Below about 50 km, home to about 90% of Earth's ozone [3]	October 2024's loss reached into the upper stratosphere [1 §3.1]. Otherwise the signal is "heavily masked" by background conditions [1 §3.3]	◐ **Sinking loss, model only** Patches of loss sinking through winter, about 90% from electrons [1 §3.3]	Not in the excerpt

OUR ANALYSIS

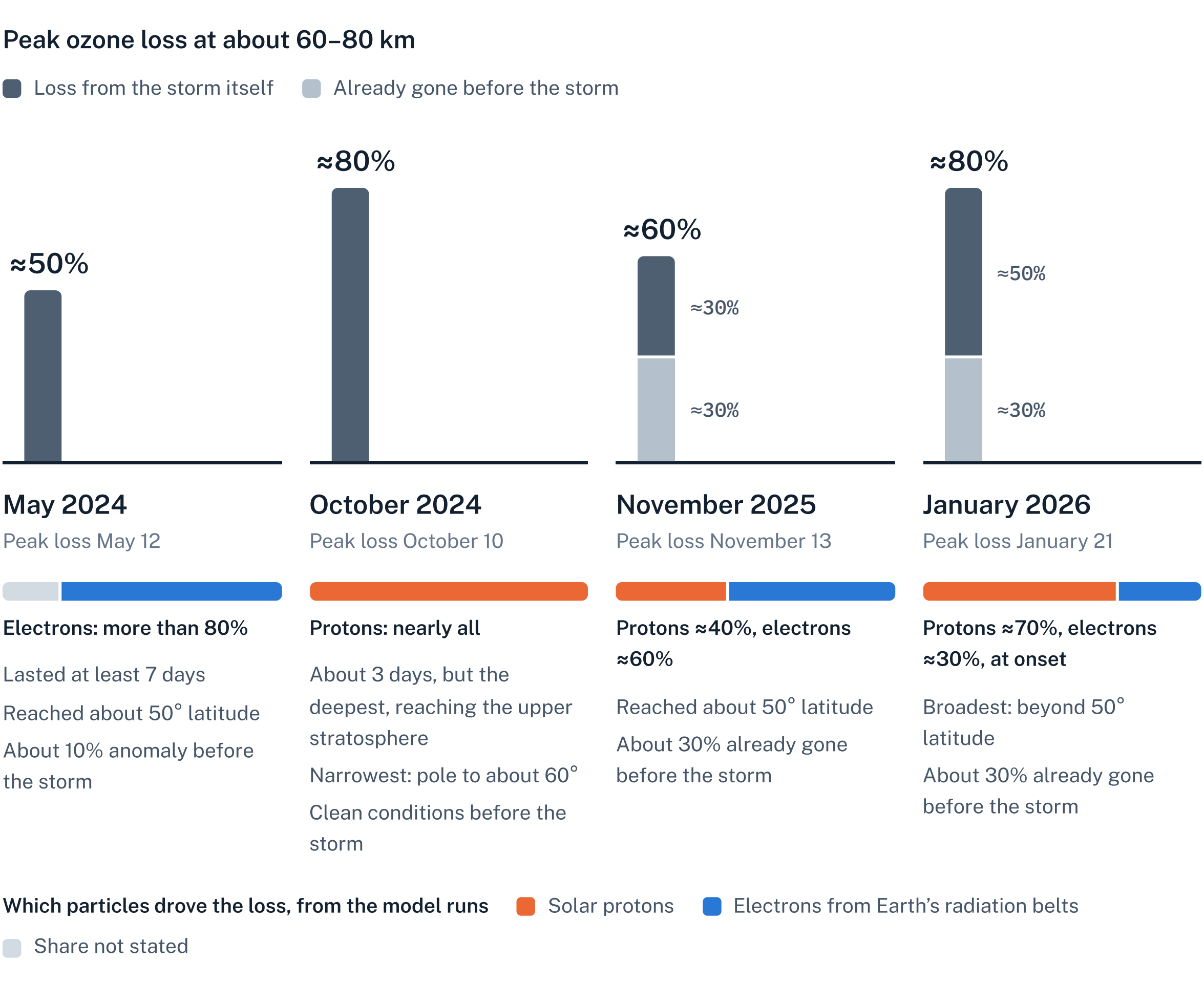
In the abstract, "not reproduced by WACCM-D" refers to "these features," the lower-thermosphere dips, five sentences after the 30–80% figure [1]. The video attached that miss to the wrong layer.

3 · THE FOUR STORMS

Four storms, four different mixes of particles

In the model, solar protons caused nearly all of the loss in October 2024, the 80% storm. Electrons caused most of it in the famous May 2024 superstorm [1 §3.3].

Peak ozone loss at about 60–80 km



Values are the authors' approximate figures. Losses, durations and pre-storm conditions [1 §3.1, §4]; dates and latitudes [1 §3.2]; particle shares [1 §3.3]. The lower part of the November 2025 and January 2026 bars is the ≈30% already gone before those storms. May 2024 started from a smaller anomaly of about 10%, which isn't drawn. Gridlines every 20%.

4 · IS 80% TOO MUCH?

No X1000 flare required

The video sized up the storm by its flare. NOAA rates flares on its radio blackout scale; the solar protons that drove October's loss are rated on a separate scale for solar radiation storms, based on the flux of particles of 10 MeV and up [5].

OCTOBER 2024

S3

"Strong" on NOAA's five-level radiation storm scale [5]. Reached on October 9, 2024, after an X1.8 flare and its coronal mass ejection [4].

DONE BEFORE

>70%

"Even moderate solar events (>10 MeV proton flux of >5000 pfu) can cause significant ozone depletion (>70%)," a study of the January 2005 storm found [6]. The October–November 2003 storms cut ozone by tens of percent at 36–60 km in the Northern Hemisphere's polar winter, for several months [7].

X1000 VS. X1.8

OUR ANALYSIS

≈560×

Flare classes scale linearly: X10 is ten times X1 [5]. An X1000 flare would be about 560 times the X1.8 flare behind October's storm, and 50 times X20, where NOAA's top "Extreme" blackout level begins [5].

NOAA's scale for solar radiation storms

Flux of particles of 10 MeV and up, and how many storms reach each level per 11-year cycle [5]

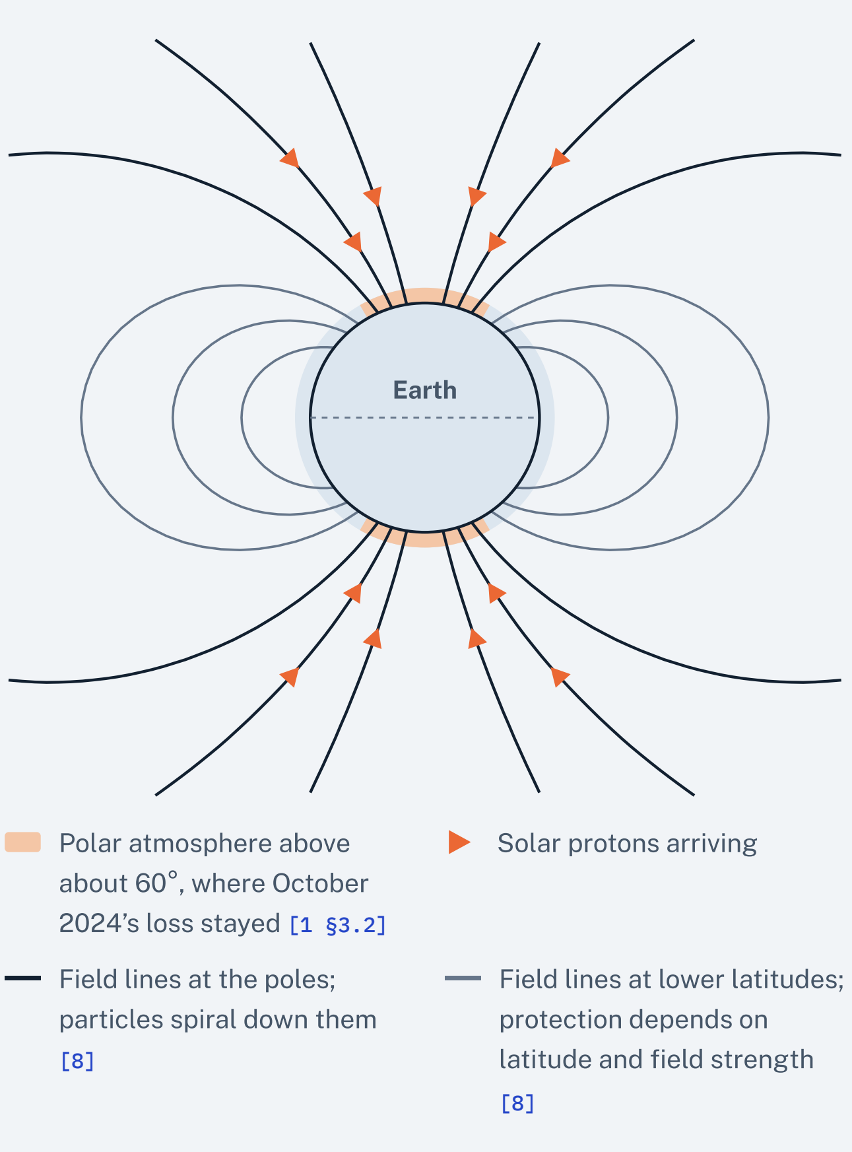
LEVEL	FLUX, PFU	STORMS PER CYCLE
S1 Minor	≥10	50
S2 Moderate	≥100	25
S3 Strong	≥1,000	10 **October 2024** [4]
S4 Severe	≥10,000	3
S5 Extreme	≥100,000	Fewer than 1

Not all of October's loss may be particles

The satellite saw more loss in October 2024 than the model produced. The authors see evidence that disturbed atmospheric dynamics also shaped the observed response, citing enhanced stratospheric ozone during the storm [1 §3.3].

OUR ANALYSIS

About 10 S3 storms per 11-year cycle works out to roughly one a year on average [5]. On NOAA's numbers, a storm like October 2024's is a routine part of each solar cycle.


Earth
Polar atmosphere above about 60°, where October 2024's loss stayed [1 §3.2]
Solar protons arriving
Field lines at the poles; particles spiral down them [8]
Field lines at lower latitudes; protection depends on latitude and field strength [8]

Schematic, not to scale.

Why the losses stay near the poles

"…the magnetic field lines at the poles extend vertically downwards, allowing the particles to spiral down the field lines"

NOAA National Weather Service, on solar radiation storms [8]

October 2024's proton-driven loss reached only from the pole to about 60° latitude, the narrowest of the four storms. The other three reached about 50° latitude. During major storms, electrons can rain in down to about 50° geomagnetic latitude, and larger proton fluxes can push the boundary toward the equator [1 §1, §3.2].

OUR ANALYSIS

Losses confined to high latitudes are what working magnetic shielding looks like. Protection depends on latitude and field strength [8], so a much weaker field would let solar protons in at lower latitudes. A failing field would show up as proton-driven losses spreading toward the equator.

5 · CAVEATS

What the paper itself flags

The authors spell out the limits of their results. None of them involves Earth's magnetic field.

Not yet peer reviewed

Posted October 7, 2026, for open discussion. It is under review for *Atmospheric Chemistry and Physics*, with comments open until November 18 [2].

The top-layer dip lacks significance

The lower-thermosphere anomalies "are generally not statistically significant" [1 §3.1].

The sinking stratospheric loss is model-only

Satellite anomalies in the stratosphere are "heavily masked" by background conditions [1 §3.3].

Electron effects are uncertain

The electron contribution "may be systematically underestimated," though "not necessarily" in extreme events [1 §3.3]. A May 2024 test found the electron input prescribed for CMIP7, the next round of coordinated climate-model experiments, too high in the upper mesosphere and too low at 60–65 km [1 §3.4].

The model often runs low

Simulated mesospheric loss is "often slightly smaller than that observed by MLS" [1 §3.3].

Trust the first week

The authors recommend focusing on the period from storm onset to 7 days after [1 §2.2].

OUR ANALYSIS

Four for four is suggestive, not proof

If each storm's top-layer dip were a coin flip, all four would come out negative 1 time in 16, about 6%. That is suggestive but not conclusive, which fits the authors' view that these features "deserve closer examination" [1 §3.1].

OUR ANALYSIS

A thin slice of the ozone

The 30–80% figures describe 60–80 km. About 90% of Earth's ozone lies in the stratosphere, below about 50 km, and most of the rest in the troposphere [3], so those percentages apply to a thin slice of the total. What reaches the stratosphere, such as October 2024's deepest loss and the model's slower sinking effect, matters more for the ozone layer [1 §3.1, §3.3].

What would change our verdict

01
Losses this large that neither the measured particles nor atmospheric dynamics can explain in a model using today's magnetic field

02
Proton-driven ozone loss spreading far beyond the polar caps during a storm of ordinary strength

03
Magnetic-field measurements showing the shielding itself failing, not just strong storms passing through it

Related checks

OVERSTATED Particles "left out of climate models" The Disaster Cycle, Fact-Checked

OVERSTATED Ozone loss as the "extinction" mechanism The Disaster Cycle, Fact-Checked

Sources

Bracketed numbers refer to this list; § marks a section of [1]. Links checked October 11, 2026.

1 Jia, J., Orsolini, Y., Szeląg, M. E., Kero, A., Verronen, P. T., Grandin, M., Espy, P. J., Käki, S., Thomas, N., van de Kamp, M., Koldobskiy, S., Zhang, J., and Partamies, N. (2026). Comparative analysis of middle atmospheric ozone response to four large geomagnetic storms of Solar Cycle 25. EGUsphere preprint, under review for *Atmospheric Chemistry and Physics*. doi:10.5194/egusphere-2026-5829. CC BY 4.0.

2 EGUsphere. Discussion page for [1]: received September 24, 2026; discussion started October 7, 2026; open until November 18, 2026.

3 NOAA Chemical Sciences Laboratory (2022). Twenty Questions and Answers About the Ozone Layer: 2022 Update, Q1. Part of the WMO Scientific Assessment of Ozone Depletion: 2022.

4 NOAA Space Weather Prediction Center (October 9, 2024). S3 (Strong) solar radiation storm in progress.

5 NOAA Space Weather Prediction Center. NOAA space weather scales: radio blackouts (R) and solar radiation storms (S).

6 Seppälä, A., Verronen, P. T., Sofieva, V. F., Tamminen, J., Kyrölä, E., Rodger, C. J., and Clilverd, M. A. (2006). Destruction of the tertiary ozone maximum during a solar proton event. *Geophysical Research Letters* 33, L07804. doi:10.1029/2005GL025571

7 Seppälä, A., Verronen, P. T., Kyrölä, E., Hassinen, S., Backman, L., Hauchecorne, A., Bertaux, J. L., and Fussen, D. (2004). Solar proton events of October–November 2003: ozone depletion in the Northern Hemisphere polar winter as seen by GOMOS/Envisat. *Geophysical Research Letters* 31, L19107. doi:10.1029/2004GL021042

8 NOAA National Weather Service. Types of space weather storms, section on solar radiation storms.

V Video commentary on the preprint, transcript 3:07–3:45, as shared by a reader. We haven't identified the channel it came from.

METHOD

How this was checked

On October 11, 2026, we checked every statement, number and quotation on this page against its source: the full preprint as posted October 7, 2026, the other sources listed here and the transcript of the video. That came to about 60 items. One section reference was wrong, and we've fixed it; the change log has the details.

The verdicts, and the items tagged "Our analysis," are our own reasoning built on the cited figures. They aren't findings of the sources. The magnetic-field drawing is a schematic.

The video is quoted from a transcript a reader shared with us [V].

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.
MISREAD	Cites a real source but gets wrong what it says.
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

Oct 11, 2026	Published on factchecked.science after a full check against the sources. Fixed one section reference: the advice to focus on the first 7 days after storm onset is in §2.2 of the preprint, not §3.1. Restated the verdicts on our standard scale, so the claim about the models is now Misread, our label for a real source that's been misunderstood. Noted that the 2003 study [7] describes the Northern Hemisphere's polar winter.
Oct 9, 2026	Analysis compiled from the preprint as posted October 7, 2026.

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Last updated Oct 11, 2026