Fact-Checked Science

PAPER CHECK · SPACE WEATHER

In this model a weak field lets out far more oxygen, yet only a sliver of the air's

Ten researchers simulated oxygen ions escaping an Earth whose magnetic dipole is from 10,000 times weaker to 10 times stronger than today's, under one fixed solar wind, and found escape 380 times higher at a tenth of the dipole (our reading) and level below a hundredth [1 Abstract, p. 1][1 Fig. 4, p. 8]. They say their present-day rate is 2 to 3 orders of magnitude below what satellites measure, and rest their case on the relative change [1 §3 ¶5, p. 5]. Taken at face value, even with almost no field their Earth loses only two to three times today's measured mean; applied instead to the escape measured today, as the authors' emphasis on the relative change suggests, a 10,000-year collapse of the field would remove 0.07–0.17% of the air's oxygen (our analysis). S0 News of November 19 linked it as "Pole Shift Oxygen Leak Confirmed" and as confirmation of how "the oxygen leak extinction events began" [3 00:02:27–00:02:29]; it is one model under fixed conditions, mentions extinctions once, in a hedged sentence of its own, and says nothing about the field's weakening today or about a leak now.

By Fact-Checked Science · Published November 19, 2026

OUR ANALYSIS marks our own reasoning and calculations: our reading of the paper's figures, the conversions to kilograms and tonnes, the comparisons with measured escape and with the air's oxygen, and today's field in the paper's terms; the verdicts are our assessment. Everything else comes from the numbered sources. For the paper [1], read in full on the publisher's article page and in its PDF, § numbers its sections, ¶ a paragraph within one and p. a page of the PDF; Fig. gives a figure. For the episode [3], times are those of its transcript.

A big rise in the model, from a start far below what Earth loses today

OUR ASSESSMENT

×690

at least: how far the model's present-day escape, about 6 × 10^{21} oxygen ions a second in its untilted run, the lowest at today's strength, falls below every measured rate in section 3's table (Seki and colleagues' is a ceiling); averaged over today's tilts the model gives about 1.7 times more. The authors put the gap at 2 to 3 orders of magnitude [1 §3 ¶5, p. 5] (our analysis)

2–3×

the model's escape with almost no field, about 4 × 10^{25} a second, against the mean measured leaving Earth now [1 Fig. 4, p. 8][13 p. 721] (our analysis)

0.07–0.17%

of the air's oxygen that a 10,000-year collapse of the field would remove if today's measured escape rose by the model's whole rise: the reading its authors' emphasis on the relative change suggests [1 §3 ¶5, p. 5][21] (our analysis)

THE CLAIMS

TRUE

> *"At 10^{-1} times the present-day value, the escape rate increases by 2 to 3 orders of magnitude; below 10^{-2}, it approaches saturation at $\sim 10^{25}$–10^{26} s^{-1}, limited by the ionospheric source."*

The paper's abstract [1 Abstract, p. 1]

True as a model result: here and in claims 2 and 3, "True" means the model shows it. By our reading of its Figure 4, escape at a tenth of the paper's reference dipole is 380 times its present-day rate, and at a hundredth or less 5,600–6,700 times, flat [1 Fig. 4, p. 8] (our analysis); the plateau is in the figure, while its cause, the ionosphere's supply, is the authors' reading [1 §4.1 ¶5, p. 7]. The model holds one solar wind fixed, with no southward magnetic field [1 §2 ¶5, p. 3], and other models find the field's strength changes escape two- to threefold [5 p. 3][8 §4]. See section 2.

TRUE

> *"the model yields an O^+ escape flux of ~5.76 × 10^{21} s^{-1} at $X = -30\ R_E$ (Figure 1), which is 2 to 3 orders of magnitude lower than previous observational estimates."*

The paper's results [1 §3 ¶5, p. 5]

True, and the authors say so plainly, with reasons: how escape is defined, ions that return, the extrapolations behind the measurements, and their own model's missing wave heating and simplified ionosphere; so they rest their case on the relative change, not the absolute rate [1 §3 ¶5, p. 5]. Against the lowest measured rate the gap is 400 to 690 times, 690 for its untilted run and about 400 averaged over today's tilts, and against the mean of Cluster's fit about 2,400 times for the untilted run (our analysis) [13 p. 721][14 p. 6]. The teams that measured it count it as escape: the oxygen in the mantle and cusp leaves with negligible return [5 p. 4][16 Abstract]. See section 3.

PARTLY TRUE

> *"Under extreme paleomagnetic conditions such as geomagnetic reversals, the collapse of the dipole moment—rather than the dipole tilt—drives heavy-ion escape upward by 1 to 2 orders of magnitude, creating episodic windows of enhanced atmospheric loss."*

The paper's abstract [1 Abstract, p. 1]; its conclusions add that reversals "may therefore have served as episodes of significantly enhanced atmospheric mass loss" [1 §5 ¶4, p. 10]

The model part holds: along its four-step path to a tenth of the dipole tilted 90°, escape rises 39-fold [1 Fig. 6, p. 9] (our reading). The step to real reversals doesn't follow: the path is a pure dipole that stops at 90°, halfway, with the second half assumed to mirror the first, under one fixed solar wind, which the authors call idealized [1 §4.3 ¶2, p. 9][1 §4.3 ¶5, p. 9]; a dipole tipped far from the rotation axis would swing through a wide range of tilts every day, not sit at 90° (our analysis); a model of a reversal's four-pole field finds escape up about 2.5-fold, then halving [8 §4]; and the path's peak stays about 60 times below what Earth loses now (our analysis). See section 4.

OVERSTATED

> *"only for the Astrophysical Journal to come out and say that, yeah, that is exactly how it works. The magnetic pole shifts are how this happens." "And this paper confirms why it works."*

The episode [3 00:01:58–00:02:08][3 00:02:14–00:02:14], under the link label "Pole Shift Oxygen Leak Confirmed"

The paper does find, in a model, that a collapsing dipole multiplies escape, and calls reversals "potential windows" of loss [1 §5 ¶4, p. 10]. But it is one model, with one fixed solar wind and a pure dipole; its authors hedge and trust only the relative change [1 §3 ¶5, p. 5]; they name the dipole's collapse, "rather than the dipole tilt", as the cause [1 Abstract, p. 1]; and its reversal peak is still about 60 times below what Earth loses today (our analysis). Other models disagree. A model can't confirm what happened, and this one says nothing about the field's weakening today or about a leak now; its present-day runs give rates far below what satellites measure. See section 7.

PARTLY TRUE

> *"It's both the weakness of the field and the tilt angle that contributes to the oxygen loss."*

The episode [3 00:02:17–00:02:21]

Both matter in the model, but unequally: the field's strength by orders of magnitude, the tilt by at most 3.4 times at today's strength [1 §5 ¶2–3, p. 10][1 Fig. 5, p. 8]. For reversals the paper finds the collapse "rather than the dipole tilt" drives the rise [1 Abstract, p. 1], and at a tenth of the dipole its 90° run lost 9.8 times less than the untilted one [1 §4.3 ¶3, p. 9] (our reading of Figs. 4 and 6). Its tilt is the dipole's lean toward the Sun, which for today's field reaches 32.6° either way over a year (our analysis). See section 5.

MISREAD

> *"Confirmation that this is how the oxygen leak extinction events began."*

The episode [3 00:02:27–00:02:29]

The paper raises extinctions once, in a hedged sentence of its own in the introduction, after describing Wei and colleagues' proposal: such loss "could even trigger" a catastrophic decline of the oxygen level, "potentially" linking it to extinctions [1 §1 ¶3, p. 2]. Its results, discussion and conclusions never return to them, and it computes no loss of the air's oxygen. On its own numbers the loss is tiny: its reversal path at its peak rate for 5,000 years would remove less than a billionth of the air's oxygen. Even if today's measured escape rose by the model's whole rise, a 10,000-year collapse would remove 0.07–0.17% of the air's oxygen (our analysis). The review it cites on reversals found "no clear picture of a geomagnetic link" to life [11 Abstract]. See section 6.

1 · THE PAPER

A peer-reviewed simulation of oxygen escaping an Earth with a weaker or tilted field

Ten researchers, mostly at Nanjing University of Information Science and Technology and the National Space Science Center of the Chinese Academy of Sciences, simulated how oxygen ions escape Earth when its magnetic dipole is from 10,000 times weaker to 10 times stronger than the paper's reference, and tilted from 0° to 180° [1]. The paper is peer reviewed, in *The Astrophysical Journal*, published November 16, 2026, and open access under CC BY 4.0; we read it in full, on the publisher's article page and in its typeset PDF. S0 News linked it on November 19 as "Pole Shift Oxygen Leak Confirmed" [3].

What the authors did

They ran BATS-R-US, a standard code for the magnetosphere, as a multifluid model that follows the Sun's hydrogen ions and Earth's oxygen ions as separate fluids, with collisions and chemistry in the upper atmosphere [1 §2 ¶1, p. 2]. They kept it simple on purpose, without the coupled models of the ionosphere and the ring current: "The trade-off is that ionospheric feedback, electrodynamics, and storm-time ring current dynamics are not captured." [1 §2 ¶1, p. 2] The model starts 100 km up, where oxygen ions are set by photochemistry and held at 200 K [1 §2 ¶3, p. 3][1 §2 ¶7, p. 3]. Escape is the net flow of oxygen ions down the tail through a plane 30 Earth radii behind Earth, 50 for the strongest field [1 §4.1 ¶1, p. 6][1 App. B ¶4, p. 12].

What they held fixed

One solar wind for every run: 5 particles per cm³ at 485 km/s, with an interplanetary field of (5, 5, 0) nT, that is, no southward component [1 §2 ¶5, p. 3]; Cluster's measurements find escape through the plasma mantle about ten times higher when that field points strongly south than strongly north [14 p. 7]. A pure dipole, whose strength D is given relative to an equatorial surface field of 3.11 × 10^{-5} T, "a dipole moment of ~8 × 10^{22} A m²" [1 §2 ¶6, p. 3]; today's dipole is D = 0.96 (our analysis) [19]. Steady states only, each run iterated until its escape through the plane varied by less than 20% [1 §2 ¶7, p. 3].

The paper's fifteen runs

FIGURE	DIPOLE STRENGTH D	TILT	WHAT IT TESTS
Fig. 4	10^{-4}, 10^{-3}, 10^{-2}, 0.1, 1, 10	0°	Field strength
Fig. 5	1	0° to 180° in steps of 30°	Tilt at the reference strength
Fig. 6	1, 0.7, 0.4, 0.1	0°, 30°, 60°, 90°	A weakening, tilting dipole, the paper's reversal

From the description of the archived runs [2] and the figures [1 Fig. 4–6, pp. 8–9]. At 0° there is no run between a tenth of the reference dipole and the full one; the runs at 0.7 and 0.4 are tilted.

In the authors' words

O^+ is singly charged oxygen; D is the dipole's strength relative to the paper's reference.

> *"we emphasize that the relative variation of O^+ escape with geomagnetic dipole strength, and tilt, rather than the absolute rate, constitutes the robust result of this study."*
>
> Wang et al. (2026) [1 §3 ¶5, p. 5]

> *"Second, the fixed solar wind conditions and pure dipole geometry represent idealized scenarios; actual geomagnetic reversals involve variable external drivers and multipole-dominated field topologies that are not captured here."*
>
> Wang et al. (2026) [1 §4.3 ¶5, p. 9]

> *"Third, the escape rate is evaluated at a downstream cross section in the magnetotail and may not account for dayside loss channels, particularly under weak-field conditions where the magnetopause is compressed to ionospheric altitudes."*
>
> Wang et al. (2026) [1 §4.3 ¶5, p. 10]

The simulation outputs and the model's configuration files are archived openly: fifteen runs, 42 GB, under CC BY 4.0 [1 §2 ¶7, pp. 3–4][2]. We didn't download them; the values on this page are our readings of the published figures.

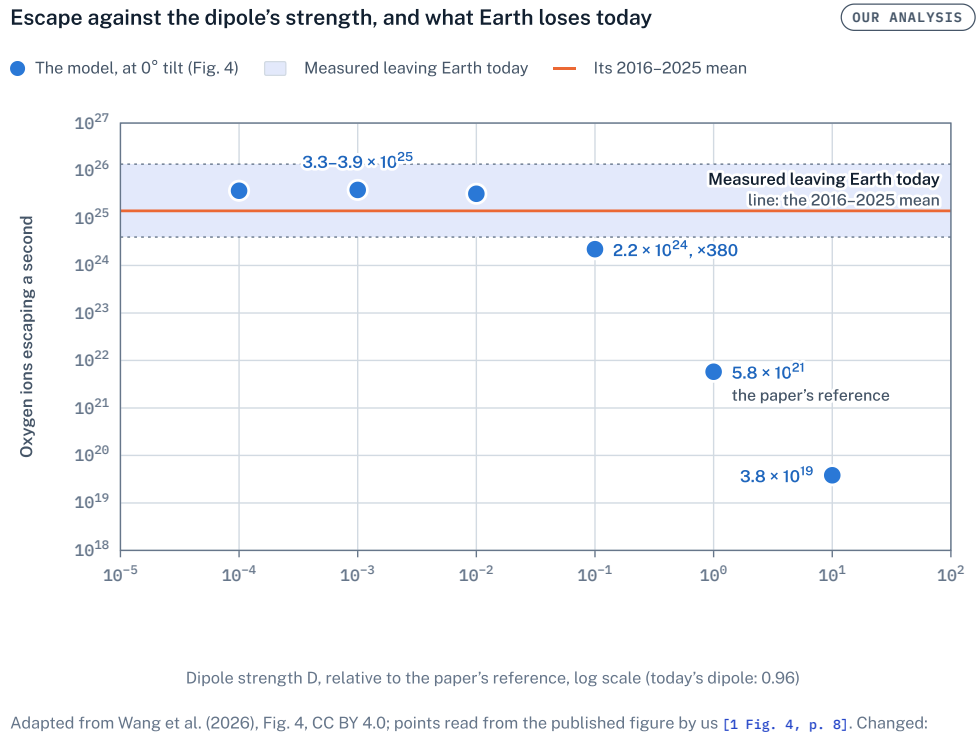
2 · WHAT IT FOUND

In the model, a weaker dipole lets out far more oxygen, until escape levels off below a hundredth

The paper's main result is Figure 4: the escape of oxygen ions as the dipole's strength runs from 10,000 times weaker to 10 times stronger than the reference, at 0° tilt [1 §4.1 ¶1, p. 6]. The chart redraws its points from our reading and adds what satellites measure leaving Earth today.

Escape against the dipole's strength, and what Earth loses today

OUR ANALYSIS



Adapted from Wang et al. (2026), Fig. 4, CC BY 4.0; points read from the published figure by us [1 Fig. 4, p. 8]. Changed: redrawn, with values labelled, and the escape measured today added as a band, from the lowest to the highest solar-wind pressure in one Cluster study [14 p. 6], and as a line at the 2016–2025 mean of another's fit [13 p. 721]. Today's dipole in the paper's units from IGRF-14 (our analysis) [19].

A weaker field, far more escape

At the reference dipole the model loses 5.76 × 10^{21} oxygen ions a second [1 §3 ¶5, p. 5]. At a tenth of it, 2.2 × 10^{24}, 380 times more, "nearly 2 to 3 orders of magnitude" in the paper's words [1 §4.1 ¶2, p. 6]; at ten times it, about 4 × 10^{19} (our reading) [1 Fig. 4, p. 8]. Below a hundredth of the reference, escape stops rising: the three weakest runs give 3.3–3.9 × 10^{25}, within the paper's "approximately 10^{25}–10^{26} s^{-1}" [1 §4.1 ¶2, p. 6] (our reading).

What "saturation" means here

With almost no field, the solar wind strips the ionosphere directly, as at Mars or Venus [1 §4.1 ¶4, p. 7], and escape stops rising. The authors attribute the ceiling to the ionosphere's supply: escape "is likely limited more by internal ionospheric processes" than by the solar wind, so "the solar wind's capacity to strip ions has exceeded the ionosphere's ability to produce and supply O^+ ions" [1 §4.1 ¶5, p. 7]. That is their reading; the runs don't test it, for example by changing the source. If it holds, the ceiling is the model's own, how fast its ionosphere, set by photochemistry at its lower boundary, makes oxygen ions and moves them up [1 §2 ¶2, p. 3], not the ionosphere's total production, which a 2014 study put at about 5 × 10^{30} a second during solar maximum [4 p. 97]. The paper adds that its plateau is of the same order as the pickup rates Hinton and colleagues' framework gives for Mercury, Venus and Mars [1 §4.3 ¶4, p. 9]: 0.2–2 × 10^{25} a second, in line with what spacecraft measure there [10 p. 6]. That framework estimates the most ions the solar wind can carry off, its "carrying capacity", from the wind's energy [10 p. 1][10 p. 5], and its authors call this use of it a crude "proof of concept" [10 p. 5]; the paper takes it as a second limit on escape, beside the ionosphere's supply [1 §4.3 ¶4, p. 9].

OUR ANALYSIS

The figures match the text, with one loose comparison

We read Figures 4–6 twice, once with an automatic picker and once by eye, under rules written before the figures were fetched; the two readings of all 24 points agree to within 2% (0.009 in $\log_{10}$). Every number in the paper's abstract and conclusions matches them: 2.6 orders of magnitude for its "2 to 3", 3.3–3.9 × 10^{25} for its "~10^{25}–10^{26}", 3.4 times for its "more than 3 times" and 1.6 orders for its "1 to 2" [1 Abstract, p. 1][1 §5 ¶2–4, p. 10] (our analysis). Of the other numbers its text states, one comparison is loosely worded; it is listed among the small slips. The paper's tilt result is 3.4 times on our reading [1 Fig. 5, p. 8], and its reversal path 39 times its present-day rate at the last step [1 Fig. 6, p. 9]. See section 8 for the files.

3 · A LOW STARTING POINT

The model's Earth of today loses 400 to 690 times less oxygen than the lowest rate satellites measure

The authors report the gap themselves: their present-day escape "is 2 to 3 orders of magnitude lower than previous observational estimates" [1 §3 ¶5, p. 5]. It matters for every number the model gives, because its rises start from there.

Oxygen escaping Earth today: the model and the measurements

SOURCE	WHAT IT IS	OXYGEN IONS A SECOND	TIMES THE MODEL
The paper [1 §3 ¶5, p. 5]	Its model at the reference dipole, 0° tilt	5.8 × 10^{21} (0.15 g a second)	1
Seki and colleagues, 2001 [12 p. 1940]	The four escape routes together, an upper limit for low solar activity; the polar outflow then measured was almost an order of magnitude larger [12 p. 1940]	~5 × 10^{24}	~870
Schillings and colleagues, 2019 [14 p. 6]	Cluster, the plasma mantle, from the lowest solar-wind pressure to 8.4 nPa	4 × 10^{24} to 1.4 × 10^{26}	690 to 24,000
Slapak and colleagues, 2017 [13 p. 721]	Cluster's fit of escape against geomagnetic activity, at its 2016–2025 mean (our analysis)	1.4 × 10^{25} (0.37 kg a second)	2,400
Yamauchi, 2019 [15 §3.3]	A review: the hot oxygen ions entering the plasma mantle and magnetosheath	10^{25} to 10^{26}	1,700 to 17,000
Dong and colleagues, 2019 [7 Table 2]	A similar model of an Earth-like planet with Earth's dipole and a similar solar wind, its escape counted its own way	2.2 × 10^{26}	38,000

Measured loss of all kinds from Earth, Mars and Venus is about 0.5–2 kg a second each [5 Abstract] (heavy ions alone at Venus and Mars, 0.05–0.4 kg a second [10 p. 6], by our conversion, at the ion masses Hinton and colleagues give). Conversions and ratios: our analysis, with oxygen ions of 16 atomic mass units.

The authors' reasons

First, what counts as escape: spacecraft measure oxygen crossing the magnetopause or sitting in the plasma sheet and mantle, "an apparent rather than permanent loss", since, they say, citing Seki and colleagues, some of it returns; the model counts only what leaves down the tail. Then, biases in the observations: single-point measurements scaled up with fixed geometry, instruments that miss the coldest ions, and fits extrapolated to stormier conditions. Last, the model's own limits: it has no kinetic wave heating, which is "critical for energizing cold ionospheric O^+ to escape energies", and a simplified ionosphere at its base [1 §3 ¶5, p. 5].

What the measurements say

Seki and colleagues' own figure is already the loss after the return: it adds up four escape routes, counting the tail's ion beams only in the middle and distant tail, where they escape [12 pp. 1939–1940], and they explained the gap to the polar outflow, almost an order of magnitude larger, by ions returning to the ionosphere at low latitudes [12 p. 1940]; over 3 billion years the outflow would equal about 18% of the air's oxygen, the loss less than 2% [12 p. 1941]. They also allowed the other reading, that unknown losses, such as cold oxygen ions below 50 eV that are hard to observe, close the gap [12 p. 1941], which would make the loss larger, not smaller. Later work found the heavy ions in the cusp and mantle energetic enough to escape directly, with negligible return [5 p. 4], "no hidden O+ populations for Cluster", and "a complete picture of the O+ circulation (and escape)" [16 Abstract]; cold ions in the tail lobes show "almost no return fluxes" [17 §7], and the mantle's heavy ions "are generally lost to space" [15 §3.3]. One of the paper's reasons runs the other way: it counts instruments that "miss the cold (≤1 eV) outflow" among "upward biases" of the observations [1 §3 ¶5, p. 5], but ions an instrument misses would make measured escape too low, as Seki and colleagues also noted [12 p. 1941], and the study it cites found most cold ions escaping [17 Abstract].

OUR ANALYSIS

What the low start does to the headline numbers

Taken at face value, the model's own rates never go far above what Earth loses today. At a tenth of the dipole it loses 2.2 × 10^{24} oxygen ions a second, less than every measured rate; along its reversal path at most 2.3 × 10^{23}, about 60 times below the measured mean; with almost no field 3.3–3.9 × 10^{25}, two to three times that mean [1 Fig. 4, p. 8][1 Fig. 6, p. 9], set against the fit of Slapak and colleagues [13 p. 721]. The 690-fold floor uses the model's untilted run, the lowest at today's strength; averaged over the tilts today's field takes, the model gives about 1.7 times more, which brings the floor to about 400 (our analysis). If the model's weak-field rates are about right, the headline factors, 380 at a tenth, 39 on the reversal path and 5,600–6,700 below a hundredth, would mostly measure how far its present-day rate falls below the measurements; its plateau, 3.3–3.9 × 10^{25} a second, falls within the $10^{25\pm1}$ that Hinton and colleagues found for heavy-ion escape at the terrestrial planets, though above the 0.2–2 × 10^{25} their framework gives, and spacecraft measure, at Venus and Mars [10 p. 6][10 p. 7], which supports that; they didn't apply it to Earth. Whether its ratios carry over to the real Earth depends on the shortfall being the same at every field strength. Wave heating of cold ions, which the model leaves out, matters most for escape through a strong field, so it may lower the start more than the plateau; the supply from the ionosphere's upper layers, which the model simplifies, could cap both ends, since the authors put the plateau down to that supply [1 §3 ¶5, p. 5][1 §5 ¶2, p. 10]. And with a weak field the model may miss loss on the dayside, which cuts the other way [1 §4.3 ¶5, p. 10].

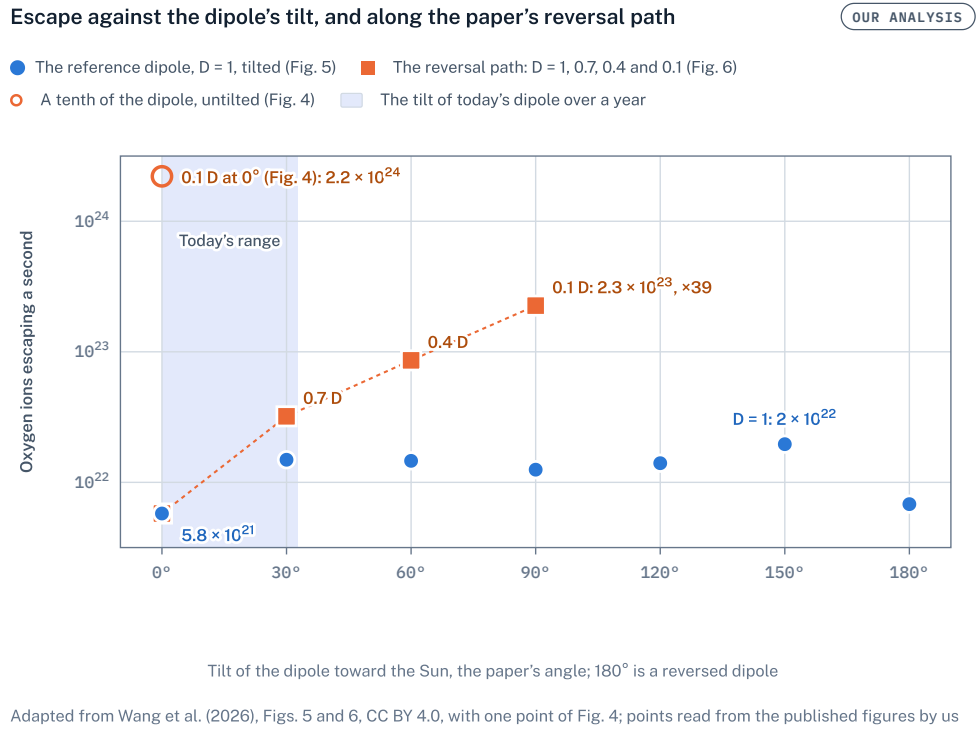
4 · REVERSALS

Its reversal path raises escape 39 times, to a rate still below today's

In a reversal or an excursion the dipole weakens and its axis swings at the same time, so the paper runs a simplified path: 1, 0.7, 0.4 and 0.1 of the reference dipole at tilts of 0°, 30°, 60° and 90° [1 §4.3 ¶1–2, pp. 8–9].

Escape against the dipole's tilt, and along the paper's reversal path

OUR ANALYSIS



Adapted from Wang et al. (2026), Figs. 5 and 6, CC BY 4.0, with one point of Fig. 4; points read from the published figures by us [1 Fig. 4–6, pp. 8–9]. Changed: redrawn on one log scale, with values labelled, the untilted run at a tenth of the dipole added for comparison, and the tilt today's dipole reaches over a year, ±32.6° in 2025, shaded (our analysis, from IGRF-14 and the Sun's position) [19][22].

In the authors' words

D = 0.1 is a tenth of the reference dipole.

> *"Notably, at D = 0.1 the escape rate is higher at 0° tilt than that at 90° tilt"*
>
> Wang et al. (2026) [1 §4.3 ¶3, p. 9]

> *"During the prolonged superposition of weak-field and large-tilt conditions, the cumulative atmospheric loss could be substantially enhanced compared with that during stable polarity periods of comparable duration."*
>
> Wang et al. (2026) [1 §4.3 ¶3, p. 9]

> *"Geomagnetic reversals represent potential windows of extreme atmospheric loss."*
>
> Wang et al. (2026) [1 §5 ¶4, p. 10]

Other models of reversals

Tsareva and colleagues modelled the four-pole field that may take over in a reversal: it still holds off the solar wind about 3 Earth radii out, and shields the air "from sputtering and ion pickup but not from the polar and auroral winds" [8 Abstract]; escape rises about 2.5-fold as the dipole weakens, then halves at the reversal itself [8 §4]. In Gunell and colleagues' model, escape from an Earth-like planet peaks at two to three times its rate with no field at all [5 p. 3]. For a planet the size of Mars, a weak dipole first raises escape, until its standoff reaches the boundary the solar wind induces, then lowers it, by up to about three times in all [6 Abstract][6 §5.1]; that is not like for like with Earth. A 2014 model raised escape 1,000- to 10,000-fold "only if the magnetic field was extremely weak" [4 p. 94], with the dipole set to zero [4 p. 96]. Reviews question whether a field shields an atmosphere at all [23 Abstract][24 Abstract]. During a reversal, the field at the surface falls to about a tenth of today's [11 Abstract].

The Laschamps excursion

The paper sets its result beside the excursion of about 41,000 years ago, when, it says, the dipole fell to about a tenth of today's, its axis tilted beyond 75° and the dayside magnetopause came within 2.43 Earth radii of the surface [1 §4.3 ¶3, p. 9]. The figures match their source, a 2025 study [18]. The dipole's strength and tilt come from a field model built from sediment and lava records; the auroral oval and the magnetopause are outputs of a simulation of the magnetosphere run on that field under one quiet solar wind; that study computes no escape of ions [18 Modeling setup and caveats]. Its 75° is measured from the rotation axis [18 Discussion], not toward the Sun as the paper's tilt is.

OUR ANALYSIS

What this changes in our review of November 13

On November 13 we rated "oxygen loss surges in reversals" Overstated, partly because later models found the field's strength changes escape two- to threefold (our review of that episode). This later model finds far more: 39 times along its simplified reversal path and about 380 times at a tenth of the dipole. So the models disagree more widely than we said. It doesn't change the verdict: the rise is measured from a present-day rate 400 to 690 times below the lowest measured escape, its reversal peak stays about 60 times below what Earth loses today, and it rests on one model under fixed conditions. No reversal has happened since measurements began.

5 · THE TILT

The model's tilt is the dipole's lean toward the Sun, which swings every day

The paper defines its tilt as "the angle between the geomagnetic dipole axis and the Z-axis of the GSM coordinate system" [1 §2 ¶6, p. 3]: how far the dipole leans toward or away from the Sun, not where its poles sit on the globe. As Earth turns and orbits, today's dipole already leans by up to a third of a right angle.

TODAY'S TILT, 2025

OUR ANALYSIS

±32.6°

its yearly range in the paper's sense, and about 18° within a day, from IGRF-14's dipole and the Sun's position [19][22]

0° TO 30°, IN THE MODEL

OUR ANALYSIS

×2.6

more escape at the reference strength, by our reading of Figure 5 [1 Fig. 5, p. 8]

1840 TO 2025, IN THE MODEL

OUR ANALYSIS

+25%

about a quarter more escape (×1.24–1.29) for the dipole's weakening, a rough reading of Figure 4 [1 Fig. 4, p. 8][20]; that is near the 20% to which each run converged [1 §2 ¶7, p. 3], so the model can't really resolve it

OUR ANALYSIS TRUE

"Tilt alters escape over 3-fold": True, as a model result

"The dipole tilt angle provides secondary modulation at fixed field strength, primarily by altering the geometry of solar wind–magnetosphere coupling and cusp exposure, producing a variation of more than 3 times across the full angular range." [1 Abstract, p. 1] On our reading of Figure 5 the model gives 5.76 × 10^{21} at 0° and 1.96 × 10^{22} at 150°, 3.4 times; the paper says "a factor of ~3.5" [1 §4.2 ¶1, p. 8]. Two cautions. Most of the rise comes between 0° and 30°, a range today's field covers every year, so it isn't an effect of a pole shift. And Dong and colleagues, with a similar model, Earth's dipole and a similar solar wind, found that tilting the dipole changed an Earth-like planet's oxygen loss by less than 10% [7 Table 2][7 §4]; the paper cites their study [1 §1 ¶3, p. 2] but doesn't compare its result with it.

OUR ANALYSIS

Today's field in the paper's terms

In the paper's units the dipole was D = 1.056 in 1840, 1.035 in 1900 and 0.956 in 2025, 9.5% weaker than in 1840; the paper's reference is the dipole of about 1957 [19][20]. Its axis is 9.2° from the rotation axis, down from 11.4° in 1900. On the model's curves the weakening since 1840 raises escape by about a quarter, ×1.24–1.29: a rough reading, since the paper has no run between a tenth of the reference and the full dipole at 0°, and near the 20% to which each run converged [1 §2 ¶7, p. 3], so the model can't really resolve it. In the model's own numbers it is about a tonne a year. Our check of Kitamura et al. put the change at 0–10% on published scalings. In the same model, the tilt's swing over a day or a year changes escape more than 185 years of weakening; averaged over a year, today's narrower range of tilt and 1900's wider one give about the same escape (1.00–1.05) [1 Fig. 5, p. 8]. None of this is near the hundredfold rise at a tenth of the dipole.

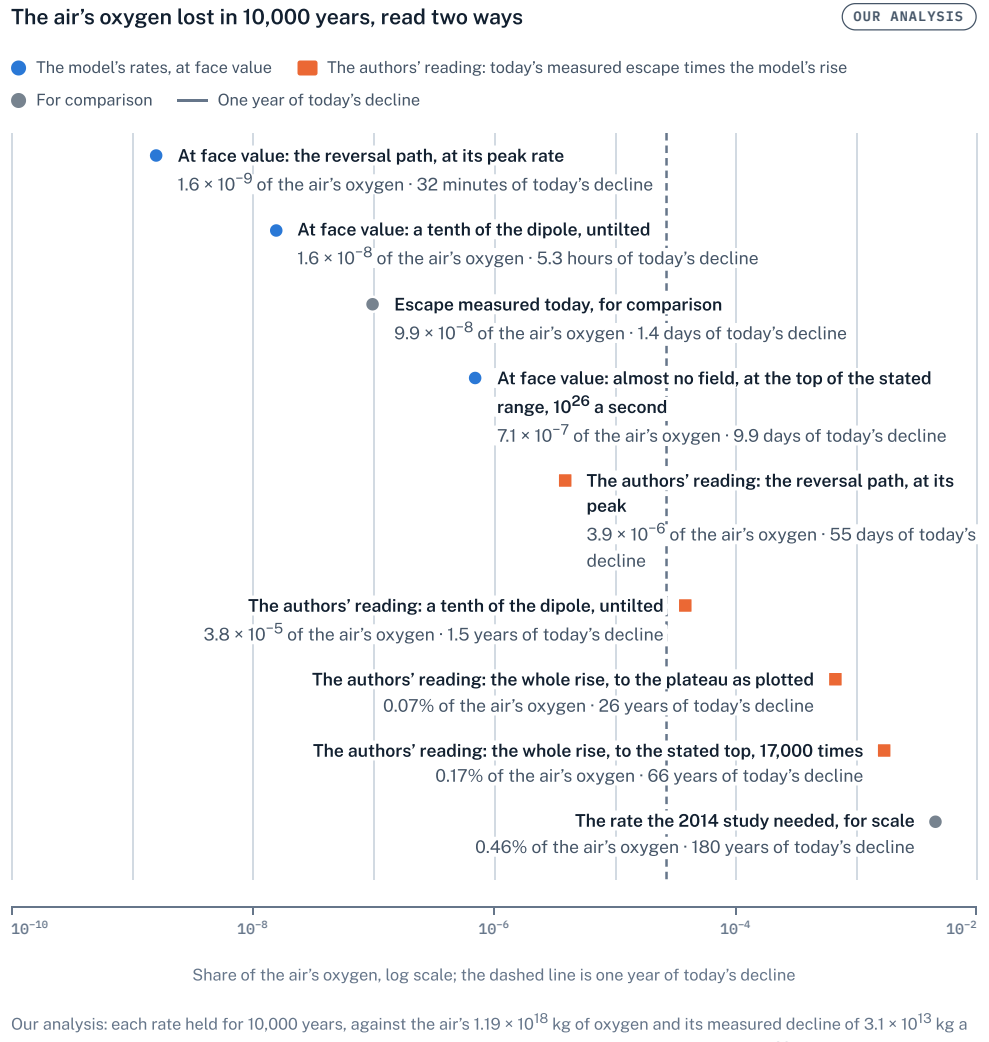
6 · THE AIR'S OXYGEN

Read either way, the model's losses equal minutes to decades of today's oxygen decline

The paper never puts its rates against the air's oxygen. We did, for an excursion or a reversal lasting 10,000 years, with each rate held throughout, both at face value and on the authors' relative reading; the air holds 1.19 × 10^{18} kg of oxygen and is losing 3.1 × 10^{13} kg a year, mainly to the burning of fossil fuels [21].

The air's oxygen lost in 10,000 years, read two ways

OUR ANALYSIS



Our analysis: each rate held for 10,000 years, against the air's 1.19 × 10^{18} kg of oxygen and its measured decline of 3.1 × 10^{13} kg a year [21]. The face-value rates are our readings of the paper's Figures 4 and 6, and its stated top of 10^{26} a second [1 Fig. 4, p. 8][1 §4.1 ¶2, p. 6]. The authors' reading multiplies the escape measured today, the 2016–2025 mean of Slapak and colleagues' fit [13 p. 721], by the model's own rise over its present-day rate; for the whole rise, 17,000 times is the stated top of 10^{26}, and the plotted plateau gives 5,600–6,700 times. The 2014 study's rate is the one it needed for the Triassic–Jurassic drop in oxygen [4 p. 96].

The numbers behind the chart, for three lengths of event

RATE, HELD THROUGHOUT	2,000 YEARS	10,000 YEARS	30,000 YEARS
At face value: the reversal path, at its peak rate	6.5 minutes	32 minutes	1.6 hours
At face value: a tenth of the dipole, untilted	1.1 hours	5.3 hours	16 hours
Escape measured today, for comparison	6.7 hours	1.4 days	4.2 days
At face value: almost no field, at the top of the stated range, 10^{26} a second	2 days	9.9 days	30 days
The authors' reading: the reversal path, at its peak	11 days	55 days	160 days
The authors' reading: a tenth of the dipole, untilted	110 days	1.5 years	4.4 years
The authors' reading: the whole rise, to the plateau as plotted	**5.2 years**	**26 years**	**78 years**
The authors' reading: the whole rise, to the stated top, 17,000 times	**13 years**	**66 years**	**200 years**
The rate the 2014 study needed, for scale	35 years	180 years	530 years

How long today's measured decline takes to remove as much oxygen as each rate removes over the event (our analysis). A reversal's change of direction is usually put at a few thousand years; the dipole's decay before the last reversal took about 30,000 years, as our check of excursion and reversal rates reads the paper.

The paper on extinctions, its one mention

A hedged sentence of its own, after its summary of the 2014 study's 3–4 orders of magnitude.

> *"Such cumulative oxygen loss could even trigger a catastrophic decline in atmospheric oxygen content, potentially linking it to large-scale biological extinction events in geological history."*
>
> Wang et al. (2026), introduction [1 §1 ¶3, p. 2]

What the paper doesn't do

It computes no cumulative loss and never sets its rates beside the air's oxygen; its results, discussion and conclusions don't mention extinction or life [1 §3–5, pp. 4–10]. The 2014 study it builds on called its own idea "a possible explanation" [4 p. 94] and needed escape of about 6.5 × 10^{29} ions a second [4 p. 96], 17,000–20,000 times the model's plateau. The review the paper cites for the field during reversals found "no clear picture of a geomagnetic link, a causal relation between secular magnetic field variations and the evolution of life on our planet" [11 Abstract].

OUR ANALYSIS

The authors' reading, made generous

The authors call the relative change their robust result [1 §3 ¶5, p. 5]. Applied to the escape measured today, the model's whole rise, to the top of its stated range of 10^{26} a second, 17,000 times its present-day rate, would remove 0.17% of the air's oxygen in a 10,000-year collapse of the field, about 66 years of today's decline; with the plateau as plotted, 5,600–6,700 times, 0.07%, about 26 years. Both are generous: no record puts the dipole at a hundredth of today's or below for thousands of years, and, as the rules we fixed in advance note, the plateau is, on the authors' reading, a limit set by the ionosphere's supply, which scaling ignores [1 §5 ¶2, p. 10]. Applied the same way, the paper's own reversal path at its peak would remove about 4 millionths in 10,000 years, 55 days of today's decline. The 2014 study's rate over the same time would remove 0.46% [4 p. 96]. At the model's own rates the losses are a billionth to a millionth of the air's oxygen.

7 · WHAT S0 NEWS SAID

The episode called the paper confirmation; it is one model, and it says nothing about the field's weakening today

S0 News of November 19 linked the paper as "Pole Shift Oxygen Leak Confirmed" [3]. We quote its automatic transcript as it stands; we haven't seen its graphics. Our review of the episode checks the rest of it.

In the episode's words

"Yanked both of those figures there together for you here" points at graphics we haven't seen; that they were the paper's Figures 4 and 5 is our inference.

> *"this one snuck into publication undetected. Well, okay, fine. I'll just explain it in extreme detail, spend 3 days having mainstream bootlickers tell me I'm crazy, only for the Astrophysical Journal to come out and say that, yeah, that is exactly how it works. The magnetic pole shifts are how this happens. After the 2014 paper, we said to watch for it. It has begun."*
>
> The episode [3 00:01:48–00:02:11]

> *"And this paper confirms why it works. It's both the weakness of the field and the tilt angle that contributes to the oxygen loss. Yanked both of those figures there together for you here. Confirmation that this is how the oxygen leak extinction events began. Confirmation that the oxygen leak has begun with an electron leak to boot."*
>
> The episode [3 00:02:14–00:02:33]

"snuck into publication undetected"

Context, not rated: the paper was published online on November 16, three days before the episode [1], and its simulation outputs were archived in October [2].

"It has begun" and "an electron leak to boot"

The paper says nothing about the field's weakening today or about a leak now; its present-day runs give rates far below what satellites measure. Its runs are steady states; its untilted present-day run gives the lowest escape of its runs at today's strength and is where its reversal path starts; and electrons appear only as the model's neutralizing fluid and in its chemistry [1 §2 ¶7, p. 3][1 Table 1, p. 3]. Our review of the episode takes those words, with our check of Kitamura et al. and our check of the four electron belts.

OUR ANALYSIS

Why the three verdicts on the episode's words

"Exactly how it works" and "confirms" claim much more than one model under fixed conditions shows, and its authors hedge; so Overstated. "Both the weakness of the field and the tilt angle" is half right: both matter in the model, but the paper's own reversal result is that the collapse, "rather than the dipole tilt", drives the rise [1 Abstract, p. 1]; so Partly true. And the paper doesn't show how extinctions began: it mentions them once, in a hedged sentence of its own in the introduction, and its numbers make the loss small on either reading; so Misread. In S0 News's use a "pole shift" is an excursion or a reversal, as our review of November 13 reads it, not the slow drift of the magnetic poles; our guide to the field shows no excursion under way.

8 · REPEAT OUR NUMBERS

Rules written first, two readings of the figures, and the arithmetic

Almost every number tagged "Our analysis" comes from the scripts below, run under rules written and hashed before the paper's Figures 4–6 were fetched [1 Fig. 4–6, pp. 8–9]; the ratios to other studies in section 3 and the plotted-plateau reading in section 6 are simple arithmetic on their outputs and the sources' numbers.

STEP 1

Rules first

The rules for the digitization, the amounts and today's field were hashed at 16:40:08 UTC on November 19, ten seconds before the figures were fetched; a note on the figures' layout followed at 16:42, before any reading.

STEP 2

Two readings

An automatic picker found each figure's axes, ticks and points; a second reading was made by eye on enlarged crops and typed in before the first ran. All 24 points agree to within 2%.

STEP 3

Amounts

Each rate was converted to kilograms and tonnes and held over excursions and reversals of 2,000, 10,000 and 30,000 years, against the air's oxygen and its decline [21].

STEP 4

Today's field

The dipole in the paper's units from IGRF-14 and gufm1, and its tilt toward the Sun every ten minutes through 2025 and 1900 [19][20], with the Sun's position from the Naval Observatory's formulas [22].

PY **fetch_inputs.py** and **run_all.sh**

Fetch every input by URL under our client's name, check each against the SHA-256 of the copy we used, then re-run everything; Python 3 with Pillow, and numpy and scipy for the automatic reading · 5 KB

PY **digitize_a.py**, **digitize_b.py**, **reading_b_approx.json** and **reading_b_pixels.json**

The two readings of Figures 4–6: an automatic picker, and our by-eye readings of enlarged crops, typed in before the picker ran · 26 KB

CSV **digitize_check.py**, **fig4_points.csv**, **fig5_points.csv**, **fig6_points.csv** and **digitize.json**

The two readings combined, point by point, with their difference and the checks against every number the paper's text gives, sections 2 and 9; credited to the paper, CC BY 4.0 · 36 KB

PY **igrf_tilt.py**, **tilt_sensitivity.py** and their outputs **1**, **2**, **3**, **4**

Today's dipole in the paper's units, 1840–2026, and its tilt toward the Sun every ten minutes through 2025 and 1900, section 5; the second script, added after the registered run, brackets the rough reading · 48 KB

PY **amounts.py** and **amounts.json**

The paper's rates in kilograms and tonnes, over excursions and reversals, against the escape measured today and the air's oxygen, sections 3 and 6 · 39 KB

PY **make_charts.py**

The small data files our charts are drawn from · 7 KB

TXT **RULES_digitize.txt**, **RULES_digitize_layout.txt**, **RULES_amounts.txt**, **RULES_igrf_tilt.txt** and **deviations.txt**

The rules, each hashed before its first run, and what changed or was added after the runs · 22 KB

TXT **README.txt** and **SHA256SUMS.txt**

What each file is, the credits, and the SHA-256 of every file here · 6 KB

Run it

`bash run_all.sh`, in a folder holding these files, fetches the inputs into `inputs/` and writes every output to `out/`, to compare with the files here; each script's header gives its usage. It needs Python 3 with Pillow; the automatic reading also needs numpy and scipy.

What we don't host

The paper, its figures and the authors' archived runs, which IOP and the Science Data Bank serve under CC BY 4.0 [1][2]; the field models [19][20]; and Scripps's records [21]. The script fetches them from their makers. We host only our own rules, code and derived numbers.

9 · LIMITS

What this check could and couldn't settle

A model result can be checked for what it shows and how far it reaches; whether it is right about the real Earth is a question for more models and measurements.

Readings of the figures, not the authors' data

Our values come from the published figures; the authors' archived runs could settle them more exactly [2].

Abstracts for some sources

Hinton and colleagues' 2024 paper [9], the review of reversals and life [11], Slapak and Nilsson's study [16] and two reviews of whether a field shields an atmosphere [23][24] were read as abstracts.

A rough reading near today's dipole

The paper has no run between a tenth of the reference dipole and the full one at 0°, so our figure for today's weakening interpolates [1 Fig. 4, p. 8].

What would change these verdicts

01 A run of this or another model that matches the escape measured today and still finds a hundredfold rise at a tenth of the dipole would strengthen claims 1 and 3, and the basis of "oxygen loss surges in reversals".

02 A model with a reversal's multipole field and changing solar wind that confirms windows of loss well above today's measured rate would move claim 3 toward True.

03 A measured fall of the air's oxygen tied to a reversal, too large for any escape rate measured or modelled, would point to something other than escape; a fall that escape at this model's rates could explain would give the oxygen-leak idea a basis it now lacks.

Small slips we noticed

None of these changes a verdict. The paper prints its reference to Singer (2014) correctly, as *Quaternary Geochronology* 21, 29 [1 p. 13], but the link and the metadata behind it carry the DOI 10.1016/j.quageo.2013.10.004, which resolves to a different paper in the same journal [26]; Singer's paper is …10.003 [25]. It calls its reversal runs "a realistic geomagnetic reversal" [1 §4.3 ¶2, p. 8], probably meaning that strength and tilt change together, as in a reversal, though the figure's caption calls them "a simplified decaying-dipole scenario" [1 Fig. 6, p. 9] and its limitations "idealized" [1 §4.3 ¶5, p. 9]. It calls the Laschamps figures "independent geological evidence" that "supports this scenario" [1 §4.3 ¶3, p. 9], though only the field's strength and tilt rest on geological records, through a field model; the auroral-oval and magnetopause figures are simulation outputs, and that study computes no escape [18 Modeling setup and caveats]. It lists instruments that miss the coldest ions among "upward biases" of the observations [1 §3 ¶5, p. 5], though missed ions would lower a measurement, and cites Engwall and colleagues for oxygen fluxes in the tail lobes, though that study measured cold ions, mostly protons, and gives no oxygen flux there [1 §1 ¶2, p. 2][17 §6]. And the reversal's last step, "approximately 10 times higher than the escape rate at the same tilt angle but with the present-day field strength" [1 §4.3 ¶2, p. 9], is 18 times in Figure 6 on both our readings, which understates the field's effect; the likely reason is that the text set its 2 × 10^{23} against 2 × 10^{22}, the top of the range at today's strength, which is the 150° run [1 Fig. 5, p. 8]. We haven't asked the authors about these points.

Related checks

UNSUPPORTED A magnetic pole flip in the 2040s? The Disaster Cycle, Fact-Checked

MISLEADING Venus and Mars The Disaster Cycle, Fact-Checked

Sources

Bracketed numbers refer to this list. For the paper [1], read in full on IOP's article page and in its typeset PDF, which has the same sections and paragraphs, § numbers its sections as that page shows them (§1 Introduction, §2 Model Description, §3 Results, §4.1–4.3 the three parts of its Discussion, §5 Conclusions, App. A and App. B its appendices) and ¶ a paragraph within a section, counting prose paragraphs: in §2, the text between displayed equations belongs to the paragraph it continues, text that opens a new topic starts a paragraph, and Table 1 is not counted; p. gives a page of the PDF, and Fig. and Table are its own. For the episode [3], times run from the first transcript line quoted to the last, rounded down to the second. For the other sources, p. gives a page, § a section, Table a table and Abstract the abstract; where only an abstract or a record was read, the entry says so. D is the strength of the dipole relative to the paper's reference, about 8 × 10^{22} A m²; oxygen ions are counted at 16 atomic mass units. Links checked November 19, 2026.

1. Wang, M., Li, J., Xie, L., Lu, J., Wei, G., Du, K., Yuan, Y., Zhao, K., Ding, L., and Li, L. (2026). A Numerical Investigation of Oxygen Ion Escape from Ancient Earth: Influences of Magnetic Dipole Moment and Dipole Tilt Angle. *The Astrophysical Journal* 1012(1), 79. Received August 25, 2026, accepted October 16 after revision, published online November 16, 2026, in the issue of November 20. Peer reviewed. CC BY 4.0; © 2026 the authors, published by the American Astronomical Society. Read in full on the publisher's article page and in its typeset PDF, the version of record (13 pages), which the site's owner supplied because the PDF refuses our client; p. gives a page of the PDF. Its reference list was read in the PDF and in its Crossref record.

2. Wang, M. (2026). Simulation data for: A Numerical Investigation of Oxygen Ion Escape from Ancient Earth: Influences of Magnetic Dipole Moment and Dipole Tilt Angle. Science Data Bank, version 2, issued October 8, 2026: the outputs of the 15 runs and the model's configuration files, 18 files, 41.7 GB. CC BY 4.0. Record only, from DataCite; not downloaded.

3. SpaceWeatherNews (S0) (November 19, 2026). Magnetic Pole Shift Sky-Sign Confirmation | S0 News Nov.19.2026. YouTube video, https://www.youtube.com/watch?v=-gf8P-YjrmQ, published at 11:59 UTC; the paper is its first link, labelled "Pole Shift Oxygen Leak Confirmed". Quoted from the transcript pasted by the site's owner (`s0/transcripts/2026-11-19.txt`); times run from the first transcript line quoted to the last, rounded down to the second. The video's graphics weren't seen.

4. Wei, Y., Pu, Z., Zong, Q., Wan, W., Ren, Z., Fraenz, M., Dubinin, E., Tian, F., Shi, Q., Fu, S., and Hong, M. (2014). Oxygen escape from the Earth during geomagnetic reversals: Implications to mass extinction. *Earth and Planetary Science Letters* 394, 94–98. CC BY 3.0. Peer reviewed. Read in full, from a copy the site's owner downloaded, because ScienceDirect refuses our client; p. gives a page as printed.

5. Gunell, H., Maggiolo, R., Nilsson, H., Stenberg Wieser, G., Slapak, R., Lindkvist, J., Hamrin, M., and De Keyser, J. (2018). Why an intrinsic magnetic field does not protect a planet against atmospheric escape. *Astronomy & Astrophysics* 614, L3. © ESO 2018, with no licence stated, so it is quoted briefly. Peer reviewed. Read in full, in the publisher's PDF the site's owner downloaded; p. gives a page of its eight.

6. Egan, H., Jarvinen, R., Ma, Y., and Brain, D. (2019). Planetary magnetic field control of ion escape from weakly magnetized planets. *Monthly Notices of the Royal Astronomical Society* 488(2), 2108–2120. Read in full in its arXiv version (v1); § gives a section.

7. Dong, C., Huang, Z., and Lingam, M. (2019). Role of planetary obliquity in regulating atmospheric escape: G-dwarf versus M-dwarf Earth-like exoplanets. *The Astrophysical Journal Letters* 882, L16. Read in full in the authors' version on arXiv, 1907.07459v2; § gives a section and Table a table.

8. Tsareva, O. O., Dubinin, E. M., Malova, H. V., Popov, V. Yu., and Zelenyi, L. M. (2020). Atmospheric escape from the Earth during geomagnetic reversal. *Annales Geophysicae* 63(2), PA2222 (PA223 in its Crossref record). Under the Creative Commons Attribution licence the journal applies to its articles. Read in full; § gives a section.

9. Hinton, P. C., Brain, D. A., Schnepf, N. R., Jarvinen, R., and Ramstad, R. (2024). Atmospheric ion escape and solar wind deposition as a function of planetary radius. *Monthly Notices of the Royal Astronomical Society* 533(4), 3999–4006. CC BY 4.0. Abstract only, as deposited with Crossref.

10. Hinton, P. C., Peterson, W. K., Dong, Y., Ma, Y., Ramstad, R., Jarvinen, R., and Brain, D. A. (2025). The Carrying Capacity of the Solar Wind: Applications to Ion Escape. *The Astrophysical Journal* 994, 68. CC BY 4.0. Read in full, in its open-access PDF, which the site's owner supplied; p. gives a page of its 13.

11. Glassmeier, K.-H., and Vogt, J. (2010). Magnetic polarity transitions and biospheric effects. *Space Science Reviews* 155, 387–410. Abstract only, from the publisher's page.

12. Seki, K., Elphic, R. C., Hirahara, M., Terasawa, T., and Mukai, T. (2001). On atmospheric loss of oxygen ions from Earth through magnetospheric processes. *Science* 291(5510), 1939–1941. © AAAS, so it is paraphrased, not quoted. Read in full, in a copy from JSTOR that the site's owner supplied; p. gives a page as printed.

13. Slapak, R., Schillings, A., Nilsson, H., Yamauchi, M., Westerberg, L.-G., and Dandouras, I. (2017). Atmospheric loss from the dayside open polar region and its dependence on geomagnetic activity: implications for atmospheric escape on evolutionary timescales. *Annales Geophysicae* 35, 721–731. CC BY 3.0. Read in full; p. gives a page. Its fit at the mean geomagnetic activity of 2016–2025 is computed on our check of Kitamura et al.

14. Schillings, A., Slapak, R., Nilsson, H., Yamauchi, M., Dandouras, I., and Westerberg, L.-G. (2019). Earth atmospheric loss through the plasma mantle and its dependence on solar wind parameters. *Earth, Planets and Space* 71, 70. CC BY 4.0. Read in full; p. gives a page of its 13.

15. Yamauchi, M. (2019). Terrestrial ion escape and relevant circulation in space. *Annales Geophysicae* 37, 1197–1222. CC BY 4.0. A review. Read in full; § gives a section.

16. Slapak, R., and Nilsson, H. (2018). The oxygen ion circulation in the outer terrestrial magnetosphere and its dependence on geomagnetic activity. *Geophysical Research Letters* 45, 12669. Abstract only, as deposited with Crossref.

17. Engwall, E., Eriksson, A. I., Cully, C. M., André, M., Puhl-Quinn, P. A., Vaith, H., and Torbert, R. (2009). Survey of cold ionospheric outflows in the magnetotail. *Annales Geophysicae* 27, 3185–3201. CC BY 3.0. Read in full; § gives a section.

18. Mukhopadhyay, A., Panovska, S., Garvey, R., Liemohn, M. W., and five others (2025). Wandering of the auroral oval 41,000 years ago. *Science Advances* 11(16), eadq7275. CC BY 4.0. Read in full in Europe PMC; locators name its sections.

19. IAGA Working Group V-MOD (2024). International Geomagnetic Reference Field, 14th generation (IGRF-14): Gauss coefficients 1900–2025 and secular variation 2025–2030. Data file, NOAA National Centers for Environmental Information; retrieved November 19, 2026, the same file, by its SHA-256, as on our guide to the field.

20. Jackson, A., Jonkers, A. R. T., and Walker, M. R. (2000). Four centuries of geomagnetic secular variation from historical records. *Philosophical Transactions of the Royal Society A* 358(1768), 957–990: the gufm1 field model, which we evaluated for 1840 from the copy in GFZ's pymagglobal model files (CC BY 4.0), the same file as on our check of the dipole before 1840. The paper was read for that check, not again for this one.

21. Scripps O_2 Program, Scripps Institution of Oceanography, UC San Diego. Atmospheric oxygen measurements: monthly O_2/N_2 ratios at Alert, La Jolla, Cape Grim and the South Pole, CC BY 4.0, credit to Scripps Institution of Oceanography at UC San Diego, and the program's frequently asked questions. The air's oxygen, 1.19 × 10^{18} kg, and its measured decline in 2016–2025, 3.1 × 10^{13} kg a year, as computed on our check of Kitamura et al.; the station files were fetched again on November 19, 2026, with the same SHA-256.

22. U.S. Naval Observatory, Astronomical Applications Department. Approximate Solar Coordinates and Computing Greenwich Apparent Sidereal Time: the formulas our script uses for the Sun's direction. Read November 19, 2026. A work of the US government.

23. Ramstad, R., and Barabash, S. (2021). Do intrinsic magnetic fields protect planetary atmospheres from stellar winds? Lessons from ion measurements at Mars, Venus, and Earth. *Space Science Reviews* 217, 36. Abstract only, on Springer's page, as read for our review of November 13.

24. Gronoff, G., and 19 others (2020). Atmospheric escape processes and planetary atmospheric evolution. *Journal of Geophysical Research: Space Physics* 125, e2019JA027639. Abstract only, as deposited with Crossref, as read for our review of November 13.

25. Singer, B. S. (2014). A Quaternary geomagnetic instability time scale. *Quaternary Geochronology* 21, 29–52. Record only, from Crossref.

26. Nalawade-Chavan, S., Zazula, G., Brock, F., Southon, J., MacPhee, R., and Druckenmiller, P. (2014). New single amino acid hydroxyproline radiocarbon dates for two problematic American Mastodon fossils from Alaska. *Quaternary Geochronology* 20, 23–28. Record only, from Crossref: the paper that the link in Wang et al.'s reference to Singer (2014) leads to.

METHOD

How this was checked

On November 19, 2026, we read the paper in full on the publisher's article page, with its figures, and in its typeset PDF, which the site's owner supplied [1], and checked the 50 passages this page quotes or relies on, word for word, in both; we checked the episode's words, from its transcript, against the paper [3]. We set the paper's results beside the models it cites [4][5][6][7][8], beside the escape measured leaving Earth today [12][13][14][15], and beside the air's oxygen [21]. Of the page's 26 sources, thirteen papers were read in full, five as abstracts and three items as records only; four are data sets or formulas our scripts use; and one is the episode itself.

The verdicts and the items tagged "Our analysis" are our own assessment, built on the cited sources. They include our reading of the paper's figures, the conversions of its rates to kilograms and tonnes, the scenarios for excursions and reversals, today's field in the paper's terms, and our reading of what the paper and the episode do and do not say. The labels on the episode's words are the same as on our review of the episode; our review of November 13's "oxygen loss surges in reversals" keeps its verdict, and section 4 says what this paper changes in its reasoning.

We digitized Figures 4–6 twice, with an automatic picker and by eye, under rules written and hashed before the figures were fetched; the two readings agree to within 2% [1 Fig. 4–6, pp. 8–9]. The amounts, the scenarios and today's field were computed under rules also fixed in advance, from public files [19][20] [21][22]; the hosted scripts fetch them by URL, check each against the SHA-256 of the copy we used, and reproduced every output byte for byte in a test run. The paper's PDF, which our client could not fetch, was supplied by the site's owner, and the page gives its page numbers. We did not download the authors' archived runs, 42 GB [2]; our values are readings of the published figures. After the page was built, a separate reviewer re-checked it against its sources and recomputed its numbers with its own code, from its own readings of the figures, and re-ran the hosted package; its findings were applied. The small slips we list in section 9 change no verdict; we haven't asked the authors about them.

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

OVERSTATED	Has some basis but claims much more than the evidence supports.
MISREAD	Cites a real source but gets wrong what it says.
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 19, 2026	Published on factchecked.science after a full check against the sources. The labels on the episode's words match our review of the same episode.