☑ Fact-Checked Science

PAPER CHECK · EARTH'S ROTATION

The inner core's gravity, not the core's drag, best explains Earth's slow day-length swings

Earth's day lengthens and shortens by a few milliseconds over decades. A 2026 Nature study predicts the slowest of those swings from three possible torques and finds only the inner core's gravitational pull gets the timing right [1 p. 120]. We re-ran it from the authors' open data. It's a convincing case, though a fit this good is easier to achieve than it looks.

By Fact-Checked Science · Published October 13, 2026

OUR ANALYSIS marks our own reasoning and calculations, and the verdicts are our assessment. Everything else comes from the numbered sources.

The best explanation so far, not a solved mystery

OUR ASSESSMENT

0.99

Our re-run: how closely the gravitational prediction tracks the smoothed record. The other two torques run the opposite way [2].

All 400

Our test: in every one of 400 versions of the core flow, both boundary torques correlate negatively with what the record needs (r from about −0.9 to −0.02, typically −0.5).

~4

Our estimate of the independent values in 56 years of 30-year-smoothed data, which is why a good fit comes easily.

THE CLAIMS ABOUT EARTH'S DAY LENGTH

TRUE

Only the inner core's gravity gets the timing right; the other torques resist

The paper's abstract and results [1 p. 119][1 p. 120]

We reproduced it from the authors' open data: the gravitational prediction follows the record, and both boundary torques correlate negatively with it in every version of the core flow, though in a few only barely, within the authors' models of the inner core and core flow. See sections 1 and 5.

OVERSTATED

"...solving this long-standing mystery of the fluctuating length of a day"

University of Alberta release [3]

The study explains only the slowest swings, from less than one cycle of data and an inner-core history its authors call tentative, and they say they can't prove the mechanism [1 p. 119][4]. See section 6.

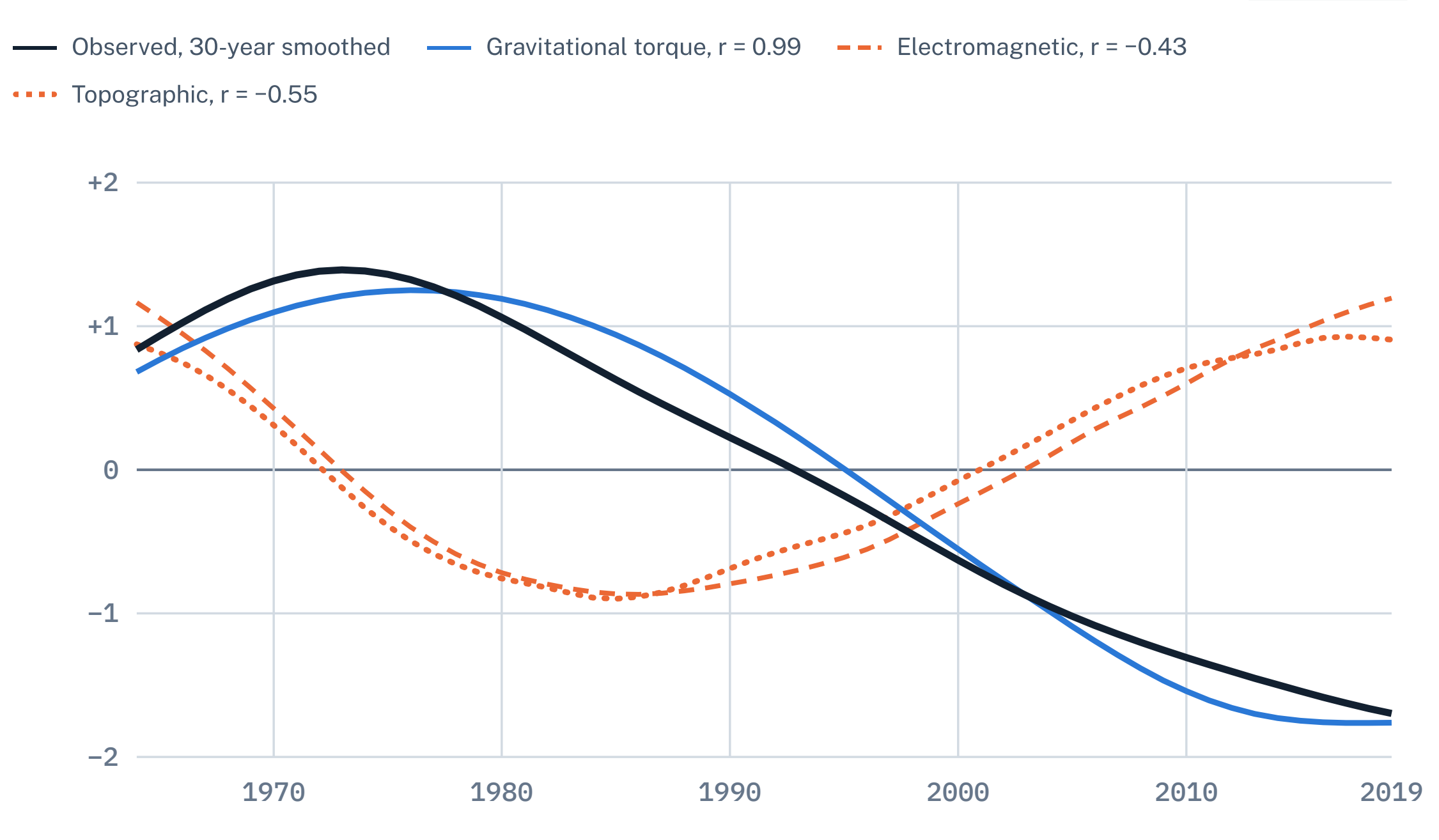
1 · THE TIMING

Only one torque gets the timing right

Earth's day lengthens and shortens by several milliseconds over decades [1 p. 119]. The study predicts the slowest of those swings, over 60–70 years, from three possible torques on the mantle, and only the inner core's gravitational pull matches the timing [1 p. 120].

Change in length of day, and what each torque predicts

OUR ANALYSIS



Change in length of day, milliseconds (up = longer days), relative to the 1964–2019 average

Our recomputation from the authors' open data [2], with the paper's Figure 1 settings: gravitational strength 1.3 × 10^{19} N m, relaxation time 6 years, and boundary-torque strengths 1.0 and 0.4 [1 p. 120]. We used the sinusoidal version of the inner-core rotation model the authors supply for sensitivity tests; with the spline version behind their own figure, r = 0.99 and the misfit is 0.21 ms instead of 0.20. Correlations are ours.

THE SWING

~3 ms

In the 30-year-smoothed day length over 1964–2019, after removing the atmosphere, oceans, tidal friction, rebound from the ice ages and surface water; about 3.7 ms before smoothing [1 p. 120][2].

THE DRIVER'S PERIOD

~70 years

The nominal period of the inner core's back-and-forth rotation, from seismology [1 Methods][5].

THE TEST

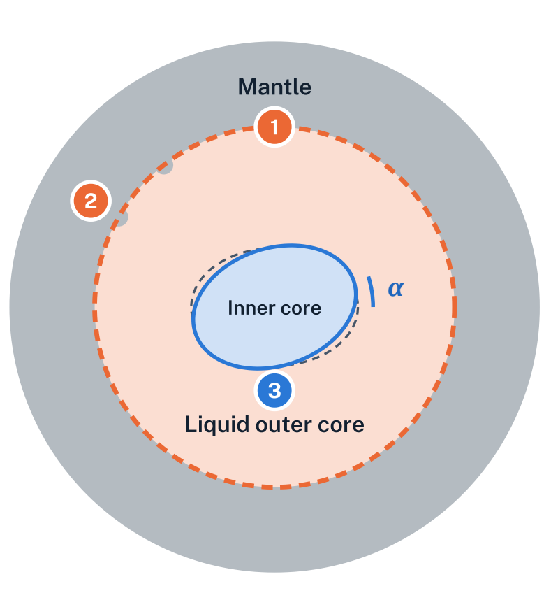
56 values

Annual values from 1964 to 2019, less than one full cycle [1 Methods].

2 · THREE TORQUES

Three ways the core can turn the mantle

The idea that the inner core's gravity could change the length of day goes back to the 1990s [6][1 p. 119]. What's new is a prediction built on a seismic record of how the inner core has rotated since 1964, and on core flows worked out from changes in Earth's magnetic field [5][7].



Schematic. Shapes and misalignment are hugely exaggerated: the inner core's bulge is only about 11–29 m high [1 p. 122].

1. **Electromagnetic drag**
   Core flow drags magnetically on a thin, electrically conducting layer at the base of the mantle [1 p. 119].
2. **Topographic push**
   Core flow presses sideways on bumps in the core–mantle boundary [1 p. 119].
3. **Gravitational tug**
   The inner core's slight bulge normally lines up with lumps of dense mantle. When core flows turn the inner core out of line by an angle α, gravity pulls both back toward alignment, twisting the mantle [1 p. 119].

3 · A TUG OF WAR

A tug of war that reverses every few decades

About 35 years centred on 1967

Flow inside the imaginary cylinder that touches the inner core's equator, mostly in the north, ran more westward than average. If that flow reached down to the inner core, it turned it west, and the inner core's gravity pulled the mantle **westward**.

Flow outside that cylinder ran more eastward than average, so drag at the core–mantle boundary pushed the mantle **eastward** [1 p. 121][8 p. 14].

About 35 years centred on 2002

The whole pattern reversed: gravity pulled the mantle **eastward** while boundary drag pushed it **westward** [1 p. 121].

The day-length swing is the small difference between the two, with the gravitational torque 1 to 2 times the electromagnetic one [1 p. 121][1 p. 123].

Whether this pattern repeats is unknown. Core flows from 1915–1949 show "hints of resemblance" to the 1985–2019 pattern but also notable differences, and the older magnetic data may not be good enough to tell [1 p. 121]. The supplement is more doubtful: the 1915–1949 flow "is not a repeated image" of the recent one [8 p. 15].

4 · THE DEEP EARTH

What it implies about the deep Earth

If the model is right, the fitted values say something about parts of the planet no one can sample.

A soft inner core

Its bulge relaxes within roughly 2–31 years, implying a viscosity of 10^{17}–10^{18} Pa s if uniform, in line with laboratory and computer estimates [1 p. 123].

Tiny bumps, big effect

An inner-core bulge just 11–29 m high, turned by about 1°, supplies the needed torque. The matching bump in the geoid, the gravity field's shape, at the top of the core is 31–83 m. Both estimates depend on the density jump at the inner-core boundary [1 p. 122][1 Methods].

Near-neutral mantle blobs

The weak gravitational coupling gives "tentative support" to the two continent-sized blobs at the mantle's base being chemically distinct piles of near-neutral buoyancy, together with soft post-perovskite in the lowermost mantle [1 p. 123].

A thin conducting skin

If electromagnetic drag does the resisting, the best fit gives the base of the mantle a conductance of about 1.1 × 10^8 S, possibly lower, consistent with an iron-rich layer about 2 km thick, and at most 2.9 × 10^8 S [1 p. 123].

A slowly spinning core

A steady eastward drift of the inner core of 0.12° a year, close to three full turns relative to the mantle in 9,000 years, for the best fit with electromagnetic drag [1 p. 123][1 Methods].

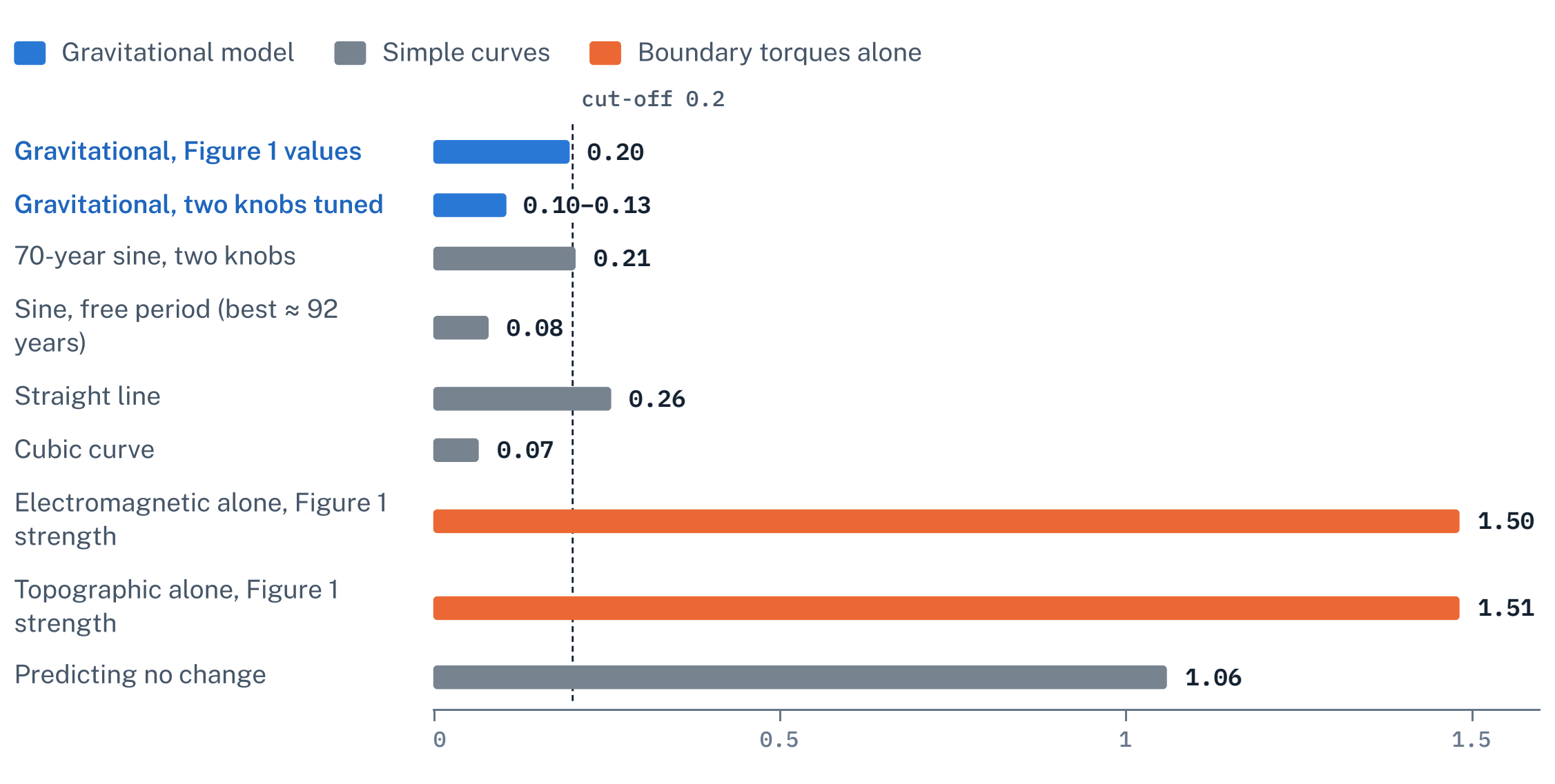
A calm top of the core

If bumps do the resisting, any stable layering at the top of the fluid core is probably weak; the results "point to" this, though a strict bound is difficult [1 p. 123].

5 · HOW HARD IS THIS FIT? OUR ANALYSIS

A smooth three-number curve passes the paper's cut-off; the timing is what counts

The paper accepts fits within 0.2 ms of the smoothed record [1 p. 121]. We compared the gravitational model with simple curves that know nothing about the core.



Misfit to the smoothed record, milliseconds (root-mean-square); the paper's cut-off is 0.2

Our calculation from the authors' smoothed day-length series for 1964–2019 and their torque files [2]. Misfit is the root-mean-square difference, as in their code; sines and curves are fitted with their 1964–2019 average removed. The tuned gravitational model is 0.10 ms with the sinusoidal inner-core model and 0.13 ms with the spline one.

OUR ANALYSIS

A plain sine wave does nearly as well

A 70-year sine with only an amplitude and a phase matches the paper's illustrative Figure 1 curve (0.21 against 0.20 ms). With its own two settings tuned, the gravitational model gets to about 0.10–0.13 ms, but a sine with a free period, or even a cubic curve, does as well.

The reason: after 30-year smoothing, 56 years of data hold only about four independent values. The model's strength and relaxation time act as an amplitude and a phase knob, though the seismic history limits how far the phase can move.

OUR ANALYSIS

What still counts

The gravitational curve's shape comes from independent seismic data, its fitted values are physically sensible, and the other two torques point the wrong way in all 400 core-flow versions, even in a test that ignores long-term averages. For them, any strength at all makes the fit worse than predicting no change.

Much of the record is a net shortening of the day by about 2.5 ms since 1964, which the gravitational prediction reproduces. The Methods say a temporal mean is subtracted from all three predictions [1 Methods]. The released code removes the 1964–2019 average from the boundary torques, as the supplement says, but measures gravity from its long-term equilibrium, so only gravity can produce the net shortening [8 p. 2][1 Methods][2]. That choice matters for the fit: with gravity's 1964–2019 average removed too, the Figure 1 fit falls to r = 0.81, and in our tests no retuned setting, even with a resisting torque, gets under the 0.2 ms cut-off (the best are about 0.3–0.45 ms). It doesn't decide the direction: compared directly with the torque the record needs, gravity still scores +0.89 and the boundary torques −0.67 and −0.68, and measured from their 1880–2019 average the boundary torques run even more opposite (r ≈ −0.97).

6 · OUR ASSESSMENT

A well-built case, with the uncertainty in the inputs

This section is our assessment of the paper, checked against it, its supplement, its peer review file and the authors' data and code.

OUR ANALYSIS

Strongest result: the negative one

The boundary torques' timing is fixed by well-resolved core flows, and it runs opposite to the observations: "they act primarily to resist, not drive" [1 p. 120]. A conductance that varies from place to place could change the electromagnetic torque's history, though the authors think a reversal unlikely [1 Methods].

OUR ANALYSIS

It leans on still-debated seismology

The inner-core history comes from one seismic reconstruction; such histories have only "tentatively" been made in recent years, though other studies, including an independent team's, also see the reversal near 2010 [1 p. 119][1 p. 120][9]. In the authors' own sensitivity runs, halving the assumed inner-core swing doubles the inferred gravitational strength, and doubling it halves it [8 p. 7]. The fit survives, but the deep-Earth numbers move.

OUR ANALYSIS

Wide ranges behind the headlines

The relaxation time spans about 2–31 years across the two cases. The "about 10 years" in the paper and its coverage is just the most likely value [1 p. 123][3].

OUR ANALYSIS

Only the slow swing is explained

Faster changes, over 10–30 years, are "probably driven" by the boundary torques, yet the modelled ones lack those wiggles; the authors flag this [1 p. 123][1 p. 124]. The university release's talk of "solving this long-standing mystery" overstates it [3].

OUR ANALYSIS

The resisting torques are idealized

Steady, uniform flow for the bumps; uniform conductance for the drag, whose prediction may also miss about a third of the torque from magnetic-field detail too fine to observe. These are the authors' own caveats [1 Methods].

OUR ANALYSIS

A small slip, and good practice

The printed misfit formula, Equation 20, puts $1/N_s$ outside the square root; the released code computes a proper root-mean-square, so the results are unaffected [1 Methods][2]. Open data and code made these checks possible.

OUR ANALYSIS

Bottom line: a quantitative, well-built case that the inner core's gravity drives the slowest day-length swings.

It is the most plausible explanation, not proof, as a referee and the authors themselves wrote; the referee added that proof isn't possible, and judged the published wording fair [4]. Longer inner-core records and the coming decades of day-length data will test it, though the paper calls a repeat of the 70-year pattern unknown and its supplement doubts it [1 p. 121][8 p. 15].

Sources

Bracketed numbers refer to this list; p. gives a page (for the paper [1], the journal's page numbers), and Methods points to the paper's online Methods. Links checked October 13, 2026.

1 Zhang, H., and Dumberry, M. (2026). Gravitational torque drives multidecadal variations in length of day. *Nature* 658, 119–124. Published online September 23, 2026. Open access, CC BY-NC-ND 4.0.

2 Zhang, H., and Dumberry, M. (2026). Replication Data for: Gravitational torque drives multidecadal variations in length of day [data set], version 3. Borealis. Data CC0 1.0; the readme releases the code under the MIT license.

3 McMaster, G. (2026). Earth's deep secret: why your day isn't quite 24 hours. University of Alberta, September 23, 2026.

4 Peer Review File to "Gravitational torque drives multidecadal variations in length of day," on the article page. CC BY 4.0.

5 Yang, Y., and Song, X. (2023). Multidecadal variation of the Earth's inner-core rotation. *Nature Geoscience* 16(2), 182–187.

6 Buffett, B. A. (1996). A mechanism for decade fluctuations in the length of day. *Geophysical Research Letters* 23(25), 3803–3806.

7 Istas, M., Gillet, N., Finlay, C. C., Hammer, M. D., and Huder, L. (2023). Transient core surface dynamics from ground and satellite geomagnetic data. *Geophysical Journal International* 233(3), 1890–1915.

8 Zhang, H., and Dumberry, M. (2026). Supplementary Information to "Gravitational torque drives multidecadal variations in length of day," on the article page. CC BY-NC-ND 4.0. p. gives its printed page.

9 Wang, W., Vidale, J. E., Pang, G., Koper, K. D., and Wang, R. (2024). Inner core backtracking by seismic waveform change reversals. *Nature* 631, 340–343.

METHOD

How this was checked

On October 13, 2026, we checked every statement and number on the original infographic, 59 items, against the paper, its supplementary information, its peer review file and the authors' open data and code. We re-implemented the authors' forward model ourselves from their released code, without running their programs, and re-ran every number in the original's test and chart from their data; all reproduced. We also checked the authors' released sampler outputs against the paper's tables, which match. The check corrected several statements; the change log lists them.

After the page was built, a second reviewer who hadn't seen the drafting re-implemented the model with its own code and re-ran every number and chart mark from the authors' data; all reproduced. The changes that followed: the paragraph on averages now says that the model measures gravity from its long-term equilibrium, and that with gravity's 1964–2019 average removed no retuned setting passes the 0.2 ms cut-off, which we confirmed; the bottom line gives the referee's view that proof isn't possible and cites the supplement for doubting a repeat; the panel gives the range of the boundary torques' correlations, some barely negative; and several caveats were restored from the paper.

The verdicts and the items tagged "Our analysis" are our own assessment: the correlations, the misfits of the simple curves and the tuned model, the count of independent values, the tests across 400 core-flow versions and the treatment of averages. The paper is open access under CC BY-NC-ND 4.0 [1], which doesn't permit adapted figures, so we don't redraw its figures: our chart is recomputed from the authors' CC0 data, and the schematic is our own.

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.
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 13, 2026 Published on factchecked.science after a full check against the sources and a re-run of every number in the infographic's test from the authors' open data. Changes from the infographic: added our verdicts on two claims. "A plain sine wave does as well" became "nearly as well": the 70-year sine matches the paper's illustrative Figure 1 curve, but with its two settings tuned the gravitational model fits about twice as well (0.10–0.13 ms), while a free-period sine or a cubic curve does as well again; the bars now say which settings they use, and we added a straight line, a cubic, the tuned model and a no-change baseline. The phase knob is limited by the seismic history. We added the finding that the released code treats the averages of the gravitational and boundary torques differently, that the paper's close fits depend on that choice, and that the anti-phase result doesn't. The chart caption gives the boundary-torque strengths. The ~3 ms swing is that of the smoothed series (about 3.7 ms before smoothing), and the test uses 56 annual values. The 1967 flow caveats (mostly the Northern Hemisphere; "if axially invariant"), the second condition and the word "tentative" for the mantle blobs, the best-fit conductance, "probably" for the faster changes and "point to" for the weak layering are restored from the paper. "Contested seismology" became "still-debated", noting that other studies, including an independent team's, see the reversal near 2010. No "mystery solved" headline was found; the phrase is the university release's "solving this long-standing mystery". The bottom line no longer assumes the 70-year cycle repeats. The dek now says the study predicts the slowest swings.

Fact-Checked Science is independent. It isn't affiliated with the channels, presenters or authors whose claims it checks.

Last updated Oct 13, 2026