Fact-Checked Science

PAPER CHECK · GEOMAGNETISM

A drifting magnetic equator, not a pole shift, is reshaping India's electrojet record

Six researchers at the Chinese Academy of Sciences report that in 1967–1999 the daytime electrojet, a band of current above India's magnetic equator, weakened in the mornings, by 1.15 nT a decade at 11 local time, and strengthened in the afternoons; they put the pattern down to greenhouse gases weakening a tide in the upper atmosphere, as a climate model shows it weakening, and the change in the full 1967–2015 trend to the magnetic equator's faster drift after 1999 [1 p. 1][1 p. 3]. Our re-run of the observatories' public records agrees with their trends, which before 1999 are faint, and IGRF-14 confirms the drift: 179 km south over India from 1967 to 2015, twice as fast after 1999, by our analysis [7][5]. But neither cause is pinned down: the paper computes no electrojet from the model, and a drift would change the noon trend most, where the paper's changed little. S0 News linked the paper as "Magnetic Pole Shift Equator" [2]; the drift is the field's ordinary secular variation, and the paper chose India because the field changes little there. We read the paper in full, and the episode only as its title and description.

By Fact-Checked Science · Published October 30, 2026

OUR ANALYSIS marks our own reasoning and calculations: the dip equator's positions, drift and forecasts that we compute from IGRF-14 and WMM2025, the observatories' yearly means against the model, our re-run of the electrojet's trend from the observatories' hourly records, the fall-off of its signal away from the equator, the values we read off the paper's figures and our reading of what the paper does and does not show; the verdicts are our assessment. Everything else comes from the numbered sources. For the paper [1], read in full, p. gives a page of the version of record, § a section and Fig. a figure; its key points, abstract and plain-language summary are on p. 1. Elsewhere p. gives a page and Abstract the part of a source we quote.

A real drift and a faint but reproducible trend; their causes are less certain, and there is no pole shift

OUR ASSESSMENT

179 km

how far the dip equator, the line where Earth's field runs level, moved south over India along 77°E from 1967 to 2015, by our calculation from IGRF-14 [5]

2.7 → 5.7

its pace, in km a year, in 1967–1999 and then in 1999–2015, by our calculation [5]: the "accelerated geomagnetic-equator motion" the paper describes [1 p. 1], its geomagnetic equator being the dip equator [1 p. 2]

−1.15

the paper's trend at 11 local time in 1967–1999, in nT a decade [1 p. 3]; our re-run of the same observatories from their public records gives −1.26 [7]

THE CLAIMS

MISLEADING

"Magnetic Pole Shift Equator"

The episode's label on its link to the paper [2]

The paper does describe a shift, of the magnetic equator, and it is real: over India the dip equator moved south 2.7 km a year in 1967–1999 and 5.7 km a year in 1999–2015, by our calculation from IGRF-14 [5]; the paper's map shows the line moving south [1 Fig. 1]. But that is the main field's ordinary secular variation: 78% of it is the equator of the field's dipole part moving as the dipole's axis tilts toward Earth's rotation axis, and the drift has slowed since 2020 (our analysis) [5]. The field on India's dip equator is 1.9% stronger than in 1967, while the dipole as a whole weakens about 5% a century (our guide to the field). The paper never mentions a pole shift, a reversal or an excursion; the poles appear in it only in the title of a study it cites on the equator's migration [1 p. 2][1 p. 9], and it mentions the field's weakening once, to argue that it cannot make the pattern it finds [1 p. 5]. We rate the label Misleading, not Misread, because it puts a pole-shift frame on a real shift that the paper does describe, as with "A pole shift is under way", also Misleading (October 20); "An excursion is under way now" is False (October 22). See section 7.

TRUE

"During 1967–1999, a period of slow geomagnetic-equator motion, the residual of the EEJ shows a decreasing trend between 09 and 13 LT and an increasing trend between 13 and 16 LT."

The paper's abstract, its third sentence [1 p. 1]

The paper's trends for 1967–1999 are −1.15 nT a decade at 11 local time and +0.8 at 15 [1 p. 3]. Our re-run of the same observatories from their public records gives −1.26 and +0.73, and agrees with the paper's figure within about one standard error at every hour from 08 to 16 [1 Fig. 4][7]. The changes are small beside the solar cycle. The paper calls the decrease at 10–12 local time and the increase at 14–16 significant; by its error bars of one standard deviation, 11 and 14–16 lie at least two from zero and 10 and 12 about one and a half [1 p. 4][1 Fig. 4]. In our version, whose errors allow for correlated months, only 07 and 15 pass a 95% test, both rises, and 07 lies outside the abstract's hours; none of the morning falls does. With the drift taken out, 10 and 11 pass and 15 no longer does, and 15 also falls short with $F10.7$ squared in the fit or without stormy days (our analysis). The motion was slow on average, 2.7 km a year though 6 km a year in 1980–1985, and Trivandrum stayed within 50 km of the dip equator [5]. See section 4.

PARTLY TRUE

"Following accelerated geomagnetic-equator motion after 1999, the afternoon enhanced trend is suppressed, whereas the morning decreased trend is strengthened for the full-period (1967–2015) data set."

The paper's abstract, its fourth sentence [1 p. 1]; its text says the change "arises from" the drift [1 p. 3]

Two parts hold. The equator did speed up, 2.1 times in IGRF-14, whose pace after 1999 Tirunelveli's own vertical field confirms (our analysis) [5][7]; and in the paper's numbers, adding 2000–2015 does change the trends as described, to −1.29 nT a decade at 11 local time and +0.07 at 15 [1 p. 3]. Our re-run, joined the same way, reproduces the afternoon's suppression (+0.73 to +0.17 at 15) but not the morning's strengthening (−1.26 to −1.15 at 11), which appears only when Tirunelveli is scaled to Trivandrum (our analysis). The cause the paper gives does not fit. It says the change "arises from" the drift [1 p. 3], but a drift away from an observatory cuts its signal by the same fraction at every hour, to a first approximation (the paper assumes the same [1 p. 5]), so it should move the noon trend, where the electrojet is five times stronger, far more than the afternoon one: in our analysis by about −1.1 against −0.1 nT a decade. The paper's own changes run the other way, −0.14 at 11 and −0.73 at 15 [1 p. 3]. And the record switches observatories in 1999 with no adjustment described [1 p. 2]. See section 5.

OVERSTATED

"The semidiurnal pattern of the EEJ long-term trend arises from the greenhouse gases suppressed migrating semidiurnal tide (SW2)"

The paper's key points [1 p. 1]; its abstract says only "possibly related" [1 p. 1]

It has a basis. In the WACCM-X runs of the second author's 2025 study, with greenhouse gases rising and the field held fixed, this tide weakened above 120 km over the equator from the 1960s to the 2010s [1 p. 6][1 Fig. 5], as in other models [16 Abstract][17 Abstract]; and an effect of the field that scales every hour alike cannot by itself turn a morning decrease into an afternoon increase [1 p. 5]. But "arises from" claims more than that shows. The paper computes no electrojet from the model, sets a 1960s–2010s model change beside a 1967–1999 trend [1 p. 7] and uses the tide's temperature, not its winds; its own conclusions say the pattern "can be interpreted as" the tide's suppression [1 p. 7]. Its claim to "disentangle" greenhouse gases from the field [1 p. 1] rests on that argument and on its choice of place and years, India and 1967–1999, when the observatory stayed near the equator [1 p. 3]; it never measures the field's share. And a review finds that changes in this tide in the mesosphere and lower thermosphere "differ according to altitude and latitude" [13 Abstract]. See section 6.

1 · THE PAPER

Six researchers tracked India's electrojet for half a century and compared 1967–1999 with the full record

The authors, at the Institute of Geology and Geophysics of the Chinese Academy of Sciences in Beijing, used one pair of observatories, Trivandrum and then Tirunelveli near the dip equator against Alibag well north of it, from 1967 to 2015, and a climate model's tides [1 p. 2][1 p. 6]. The paper is peer reviewed and open access, and we read it in full [1].

STEP 1

The record

"This study uses the observations from the Trivandrum (TRD, 76.95°E, 8.48°N) and Alibag (ABG, 72.87°E, 18.64°N) stations from 1967 to 2015. The Trivandrum station closed in September 1999, and the data from Tirunelveli (TIR, 77.82°E, 8.67°N) were adopted as the equatorial station" [1 p. 2]. Days with a 3-hour Kp of 4 or more, or following one, are dropped [1 p. 2].

STEP 2

The index

Each day's "midnight mean values" [1 p. 2] are removed at both observatories, and the electrojet is the difference between their horizontal fields, Trivandrum or Tirunelveli minus Alibag [1 p. 2]. Monthly medians follow, hour by hour [1 p. 2].

STEP 3

Sun and seasons

At each local hour, a model with yearly, half-yearly and four-monthly cycles, every term a quadratic function of the solar radio flux F10.7, is fitted to 1967–2015 and removed; it tracks the record with a correlation of about 0.94 over the daytime monthly medians [1 p. 3][1 Fig. 2].

STEP 4

Trends and tides

Straight lines through what is left, for 1967–1999 and for 1967–2015, with one-standard-deviation errors from 10,000 bootstrap fits [1 p. 3][1 p. 4]. Then the semidiurnal tide in time-slice runs of the WACCM-X climate model, 1960s against 2010s [1 p. 6], from the second author's earlier study [28 Abstract].

The paper's key points, in the authors' words

EEJ is the equatorial electrojet; SW2, the migrating semidiurnal tide, a twice-daily oscillation of the upper atmosphere that follows the Sun.

> *"The equatorial electrojet (EEJ) shows a decreased trend in the morning and an enhanced trend in the afternoon over the Indian sector"*
>
> Zhang et al. (2026), Key Points [1 p. 1]

> *"The semidiurnal pattern of the EEJ long-term trend arises from the greenhouse gases suppressed migrating semidiurnal tide (SW2)"*
>
> Zhang et al. (2026), Key Points [1 p. 1]

> *"Secular movement of the geomagnetic equator dampens this semidiurnal EEJ long-term trend"*
>
> Zhang et al. (2026), Key Points [1 p. 1]

WHAT WE READ

The full text

the version of record, nine pages, with its abstract, key points, plain-language summary and five figures [1]

STATUS

Peer reviewed

received August 24, accepted October 5 and published October 23, 2026, in *Geophysical Research Letters*; the authors declare "no conflicts of interest relevant to this study" [3][1 p. 7]

LICENCE

CC BY-NC 4.0

so its figures may be adapted, with credit, for non-commercial use; section 4 adapts its Fig. 4 [1]

Its caveats

The authors note that the drift "can affect the EEJ during 1967–1999, but the effect is likely to be less significant than during 1999–2015" [1 p. 2], which is why they fit the trend to 1967–1999, from one observatory [1 p. 3]. And they note that their model tides compare the 1960s with the 2010s while the trend they explain is for 1967–1999; a run over 1967–1999, they write, would show the tide "also decreased but with different magnitude", which "would not change the present main result" [1 p. 7].

OUR ANALYSIS

What the paper does not give

No speed for the equator's drift, only its direction and the observatories' dip latitudes from IGRF-13 [1 p. 2]; no correction for an observatory's distance from the equator; no account of any adjustment where Trivandrum's record gives way to Tirunelveli's; no electrojet computed from the model; and no p-values, only one-standard-deviation error bars [1 p. 4]. Its data come from the World Data Centre in Edinburgh, it says [1 p. 7], yet its Fig. 2 counts 6,468 daytime values, one for every month of 1967–2015 at each hour from 07 to 17 local time [1 Fig. 2]: more than that archive holds (section 9). Its data statement gives the model data's address as that of a different dataset, the one behind the second author's 2025 paper [29]; the reference list gives the right one [4].

2 · THE ELECTROJET

A ribbon of current about 100 km up, tied to the magnetic equator and measured with two magnetometers

By day, a narrow band of eastward electric current flows 100–120 km above the ground, within about 2° of latitude of the dip equator, where Earth's field lines run level [11 Abstract]. In the paper's words, it is "confined within ~3°–5° geomagnetic latitudes, peaking at the geomagnetic equator and getting symmetrically weaker with latitudes away from the magnetic equator in either direction" [1 p. 2].

How it is measured

The difference between the horizontal field at a magnetometer on the magnetic equator and at one several degrees away measures the electrojet, and with it the upward drift of the plasma higher in the ionosphere [11 Abstract]. In the paper's words, the electrojet's electric field "couples tightly to F-region vertical plasma drifts" and "modulates low-latitude electrodynamics and plasma distributions" [1 p. 2], among them the equatorial ionization anomaly, the bands of dense plasma either side of the magnetic equator (our check of the May 2024 storm). India's classic pair, the paper's, is Trivandrum (TRD) or, from 1999, Tirunelveli (TIR), near the dip equator, minus Alibag (ABG), on the coast south of Mumbai, more than 1,100 km north of the dip equator (our analysis) [1 p. 2][5].

What drives it

Winds in the upper atmosphere drive it through the ionospheric dynamo, and much of that wind comes from tides rising from below. In a model driven by satellite measurements of the tides, the tides from below about doubled the daily range of the field at the magnetic equator, and upward-propagating tides, the migrating semidiurnal tide above all, drove most of its semiannual change [12 Abstract]. That is why a weaker tide could leave a mark on the electrojet's daily cycle, the paper's premise [1 p. 6].

OUR ANALYSIS

Why the equator's position matters

The current follows the magnetic equator, not the map. An observatory stays put; if the equator drifts away from it, the observatory sees less of the current even if the current itself is unchanged. So a long record from one place mixes two things: changes in the electrojet, and changes in the observatory's distance from it. The paper deals with the second by fitting its trend to the years when the distance changed little [1 p. 3]; sections 3 and 5 measure it.

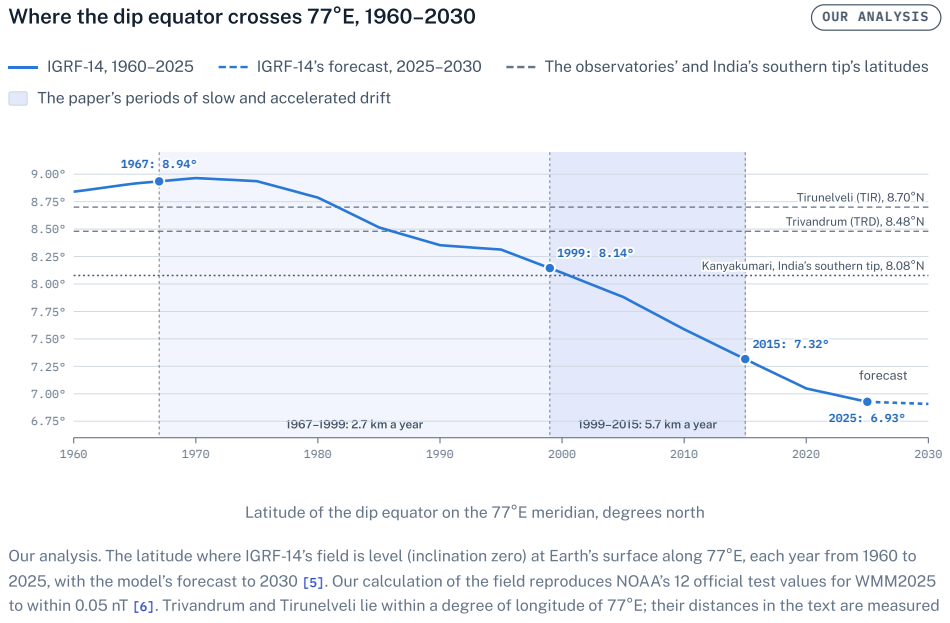
3 · THE DRIFTING EQUATOR

Over India the dip equator moved 179 km south in 1967–2015, twice as fast after 1999

IGRF-14, the international model of Earth's main field, puts the dip equator, where a dip needle would lie level, at 8.94°N on the 77th meridian in 1967, at 8.14°N in 1999 and at 7.32°N in 2015 (our analysis) [5]. The paper, using the previous generation, IGRF-13, draws the same southward shift [1 Fig. 1].

Where the dip equator crosses 77°E, 1960–2030

OUR ANALYSIS



Our analysis. The latitude where IGRF-14's field is level (inclination zero) at Earth's surface along 77°E, each year from 1960 to 2025, with the model's forecast to 2030 [5]. Our calculation of the field reproduces NOAA's 12 official test values for WMM2025 to within 0.05 nT [6]. Trivandrum and Tirunelveli lie within a degree of longitude of 77°E; their distances in the text are measured along their own meridians. Hover or tap a dot for its value.

TRIVANDRUM CROSSED IT

OUR ANALYSIS

1986

The equator lay 50 km north of the observatory in 1967 and 37 km south of it at the start of 1999: close all through the paper's first period [5]. The paper, with IGRF-13, puts the crossing at 1985 [1 p. 2].

IT LEFT THE MAINLAND

OUR ANALYSIS

2001

when it passed south of Kanyakumari, India's southern tip, at 8.08°N; since then its path has lain wholly south of the Indian mainland, across the sea and Sri Lanka [5].

THE DIPOLE'S SHARE

OUR ANALYSIS

78%

of the drift in 1967–2015 is the equator of the field's dipole part moving with its axis; the rest is the field's smaller-scale change [5].

The paper's numbers, and ours

"The dip latitude of TRD was 0.5°S in 1967, and gradually shifted to magnetic equator at 1985, then to 0.46°N in 1999"; after September 1999 the equator "accelerated its southward migration away from the equatorial station TIR, leading the geomagnetic latitude of TIR to shift to 1.6°N in 2015" [1 p. 2]. With IGRF-14 we get 0.56°S in 1967, the equator overhead in 1986 and 0.42°N at the start of 1999, and 1.68°N for Tirunelveli in 2015 (our analysis) [5]. The paper uses "geomagnetic equator", "magnetic equator" and "dip equator" for the same line, drawn from IGRF-13 [1 p. 2][1 Fig. 1], so its accelerated motion is the dip equator's, as here.

OUR ANALYSIS

The observatories record the drift

At Tirunelveli, the vertical field's yearly mean rose 94.1 nT a year in 1999–2011, against 92.2 in IGRF-14, and its horizontal field 30.4 nT a year, against 28.4: a dip needle there tilted from 0.54° to 2.09° as the equator moved off [7][5]. Alibag's vertical field followed the model too, 45.4 nT a year against 43.4 in 1957–2023. Trivandrum's horizontal field matches the model's trend, but its vertical record jumps between baselines, so it cannot track the equator; the electrojet index uses the horizontal field against each night's level, which such jumps leave alone. The two archives agree exactly on Tirunelveli: over 104,085 hours held in both, the largest difference is 0.0 nT [7][8].

OUR ANALYSIS

Why it moves, and why faster after 1999

Most of the drift is the dipole, the field's largest part, straightening up. In IGRF-14 its north pole stood at 78.63°N in 1967, 79.57°N in 1999, 80.38°N in 2015 and 80.85°N in 2025, an axis tilted 11.4°, 10.5°, 9.7° and 9.2° from Earth's rotation axis (the tilt is measured at Earth's centre), and the pole moved poleward faster after 1999: 0.029° a year in 1967–1999, 0.051° a year in 1999–2015 [5]. Over India, where the dipole's equator lies north of the geographic one, a straighter axis moves it south. That is the opposite of the tipping a reversal involves, as our guide puts it: "the axis is moving toward the rotation axis, not away". Meanwhile the field on India's dip equator grew slightly stronger, from 39,945 nT in 1967 to 40,685 nT in 2025, by 1.9% [5].

Over Brazil it moves more than five times as fast

"The magnetic equator in the Brazilian region has moved over 1,100 km northward since 1957, passing the geomagnetic observatory Tatuoca (TTB), in northern Brazil, around 2013" [22 Abstract]. In IGRF-14 it moved north along Tatuoca's meridian at 20.9 km a year in 1967–2015, against India's 3.7 (our analysis) [5]. There the change in the daily variation "can be attributed to the main field secular variation" [22 Abstract]; the paper chose India because there, it says, "secular magnetic-field changes are weak" [1 p. 1]. Models put the field's strongest effects on the ionosphere over the Atlantic and South America [20 Abstract][21 Abstract], as the paper notes [1 p. 1][1 p. 2].

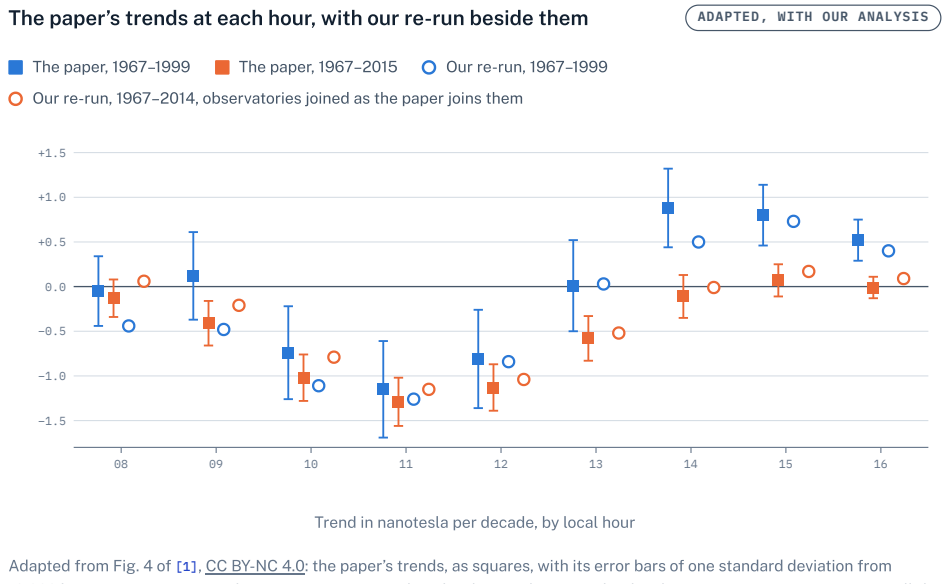
4 · THE TREND, RE-RUN

Re-run from public records, the paper's trends reappear: a faint morning fall and afternoon rise, then a flatter afternoon after 1999

We rebuilt the same index from the observatories' hourly records in the World Data Centres [7][8], removed the solar cycle [10] and the seasons, and fitted a trend at each local hour. Our method differs from the paper's in its details, listed below, but its trends agree with the paper's within about one standard error at every hour from 08 to 16 [1 Fig. 4].

The paper's trends at each hour, with our re-run beside them

ADAPTED, WITH OUR ANALYSIS



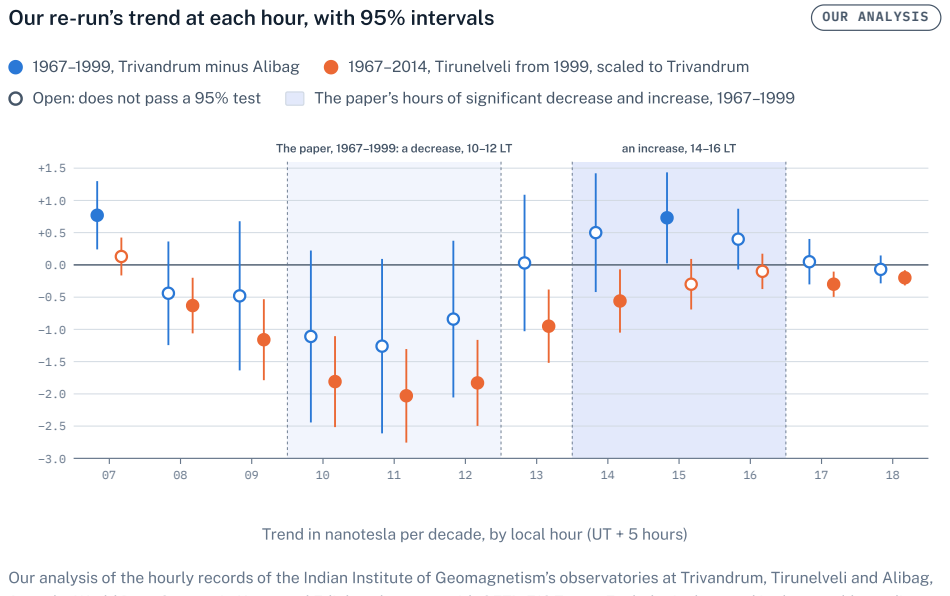
Adapted from Fig. 4 of [1], CC BY-NC 4.0: the paper's trends, as squares, with its error bars of one standard deviation from 10,000 bootstrap fits, converted from nT a year to nT a decade. The trends at 11 and 15 local time are from its text [1 p. 3]; all the error bars, and the other trends, are read off the figure. Our re-run's trends, as rings, are our analysis of the observatories' records [7][8], matched to the paper's hours by their labels. Hover or tap a mark for its values.

How our re-run differs from the paper's method

STEP	THE PAPER	OUR RE-RUN
Local time	Not defined beyond "At a fixed local time (LT)" [1 p. 2]	UT + 5 hours, each hourly mean labelled by the hour's start, so "11" is centred near 11:30; local solar time at 77°E is UT + 5.1 hours
Nightly level	"daily midnight mean values" [1 p. 2]	The mean of 00–02 local time, UT + 5 hours
Disturbed days	Dropped if Kp reached 4 that day or the day before [1 p. 2]	All days; dropping days with Ap above 20 changes little [10]
Sun and seasons	Three seasonal cycles, every term quadratic in F10.7, fitted once to 1967–2015; both trends come from its residuals [1 p. 3][1 Fig. 2]	Two seasonal cycles that do not vary with F10.7, and F10.7 (with $F10.7^2$ in a variant), fitted with the trend to each period separately
Errors	One standard deviation of 10,000 bootstrap fits [1 p. 4]	Standard errors widened for correlation between successive months
Change of observatory	Tirunelveli after September 1999, taken as it is, to 2015 [1 p. 2]	Tirunelveli from January 1999, taken as it is and also scaled to Trivandrum by their nine months of overlap, to 2014
Data	From the World Data Centre in Edinburgh [1 p. 7], with a value for every month at 07–17 local time [1 Fig. 2]	Trivandrum and Alibag from the centre in Kyoto, Tirunelveli from Edinburgh [7][8], with no Trivandrum data for 1970 or 1979 and no Tirunelveli data for 2015

Our re-run's trend at each hour, with 95% intervals

OUR ANALYSIS



Our analysis of the hourly records of the Indian Institute of Geomagnetism's observatories at Trivandrum, Tirunelveli and Alibag, from the World Data Centres in Kyoto and Edinburgh [7][8], with GFZ's F10.7 [10]. Each dot is the trend in the monthly medians for that hour; the whisker spans 1.96 standard errors either way. The bands mark the hours at which the paper finds a significant decrease, 10–12 local time, and a significant increase, 14–16, in 1967–1999 [1 p. 4]. Hover or tap a dot for its values.

OUR ANALYSIS

1967–1999: the same pattern, faintly

Our trends match the paper's in sign at every hour but 09 and lie within about one standard error of them at every hour from 08 to 16, the biggest gap at 09 [1 Fig. 4][7]. The errors are alike too, ours a little wider. By its own bars, the paper's trends at 11 and 14–16 lie two or more standard deviations from zero, and at 10 and 12 about one and a half [1 Fig. 4]. In our version only 07 and 15 clear 1.96 standard errors, both rises, and 07 lies outside the abstract's hours; with the drift taken out (section 6), 10 and 11 clear it and 15 does not. At 11 local time the index averages about 48 nT and moves about 0.2 nT for each unit of the solar radio flux, so the solar cycle swings it by about 30 nT, against about 4 nT of trend over the 33 years [10].

OUR ANALYSIS

1967–2014: the afternoon flattens

Joined as the paper joins them, our 1967–2014 trends track the paper's 1967–2015 ones within 0.25 nT a decade at every hour: the afternoon increase suppressed and the midday decrease about where it was, −1.15 at 11 against the paper's −1.29 [1 p. 3], from the observatories' records [7][8]. Scaling Tirunelveli to Trivandrum first, to allow for the difference between the two observatories, makes the midday decrease much steeper, −2.03 at 11, and leaves the afternoon slightly negative. So the full-period trend depends on how the observatories are joined, a choice the paper does not discuss [1 p. 2].

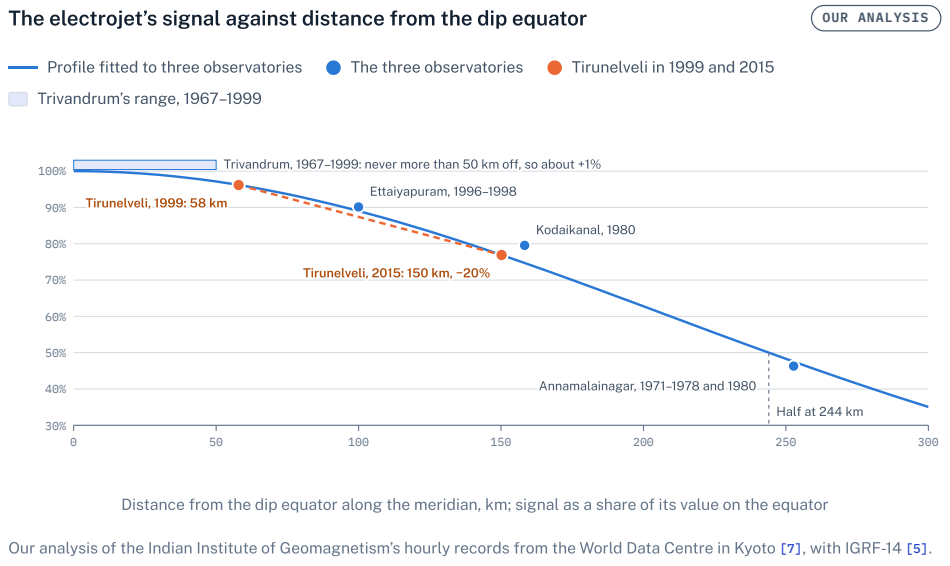
5 · WHY THE DRIFT MATTERS

A drift cuts an observatory's record most at noon; the paper's record changed most in the afternoon

The electrojet's signal on the ground falls off with distance from the dip equator. Three Indian observatories that ran beside Trivandrum put the halfway point about 250 km away (our analysis) [7][5], consistent with the paper's band of 3°–5° [1 p. 2].

The electrojet's signal against distance from the dip equator

OUR ANALYSIS



Our analysis of the Indian Institute of Geomagnetism's hourly records from the World Data Centre in Kyoto [7], with IGRF-14 [5]. Each observatory's monthly-median index at 10–12 local time, divided by Trivandrum's in the same months, against both observatories' distances from IGRF-14's dip equator; a bell-shaped (Gaussian) profile fitted to the three ratios halves at 244 km. The dots sit on the scale of the equator through the profile's value at Trivandrum's distance. A rough guide: the observatories also differ in the ground beneath them and in their instruments.

OUR ANALYSIS

Two observatories, two different decades

Trivandrum sat 50 km south of the dip equator in 1967 and 41 km north of it when its record ended in September 1999, so its distance changed its signal by about 1%. Tirunelveli went from 58 km north in 1999 to 150 km in 2015, which on the profile would cut its signal by 20%: by 16–21% for the half-widths the three observatories give one by one, and by 8% even for a profile as broad as 400 km [5][7]. Its own record fell 8–9% a decade from 08 to 11 local time in 1999–2014, about 13–15% in all [8], less than the drift alone would remove: with the drift taken out, it rises 7–8% a decade. The paper sees the fall too: "an obvious decreased trend is seen at 11 and 15 LT due to the geomagnetic equator movement" [1 p. 5].

A known trap

A strongly moving dip equator can leave a systematic error in estimates of the equatorial electric field's long-term change, especially where it moves more than about 20 km a year within a solar cycle [23 Abstract], a study the paper cites for the same point [1 p. 2]. Over India it moves a quarter as fast, but over 16 years that still took Tirunelveli 92 km further off (our analysis). Over Fortaleza, Brazil, the electrojet's kind of sporadic E layer became rarer from 1975 to 1990 as the magnetic equator drifted about 400 km north of the city [24 Abstract]. A review finds such field-driven trends in the equatorial ionosphere, "although weak when compared to other ionospheric variations, are steady" [25 Abstract].

Does the drift explain the change after 1999?

LOCAL TIME	AVERAGE EEJ, NANOTESLA	CHANGE IN THE PAPER'S TREND WHEN 2000–2015 ARE ADDED	THE SAME IN OUR RE-RUN, TO 2014	WHAT THE DRIFT ALONE ADDS TO THE 1967–2014 TREND
10	52	−0.28*	+0.32	−1.28
11	48	−0.14	+0.11	−1.13
12	37	−0.32*	−0.20	−0.83
14	15	−0.99*	−0.51	−0.30
15	9	−0.73	−0.56	−0.14
16	6	−0.53*	−0.31	−0.12

In nT per decade. The paper's change is its 1967–2015 trend minus its 1967–1999 trend: from its text at 11 and 15 local time [1 p. 3], and read off its Fig. 4 elsewhere (marked *). Our re-run's change joins the observatories as the paper does [7][8]. The drift's share is our trend with Tirunelveli scaled to Trivandrum, minus the same with the drift taken out (section 6). Our analysis, except the paper's column.

OUR ANALYSIS

The drift changes noon most; the record changed the afternoon most

The paper says the change in its full-period trend "arises from the accelerated movement of the dip equator away from the magnetometer station after 1999" [1 p. 3], and that the equator's changes "should induce the same trend in the morning and afternoon" [1 p. 5]. Both are right about the sign, since a drift away from the observatory cuts its signal by the same fraction at every hour, to a first approximation: the paper assumes as much, and our profile is measured at 10–12 local time only. But the cut is largest in nanotesla where the signal is largest. Around noon the index is four to six times what it is in mid-afternoon, so the drift should steepen the midday trend most: by about 1 nT a decade at 10–12 local time against 0.1–0.3 at 14–16, by our estimate. The paper's own changes run the other way: 0.1–0.3 nT a decade at 10–12 and 0.5–1.0 at 14–16 [1 p. 3][1 Fig. 4]. Our re-run shows the same thing [7][8]. So the drift cannot by itself account for the change, which the paper's conclusions call "predominantly controlled by the accelerated secular variation of the geomagnetic equator" [1 p. 7]. The switch of observatories in 1999, with no adjustment described, also shifts the record by a different amount at each hour: in their 1999 overlap Tirunelveli's index reads about 8–9% above Trivandrum's at 08–13 local time and 15–30% above at 14–16 (our analysis) [7][8]. Whatever else changed after 1999, the paper does not separate it.

6 · GREENHOUSE GASES AND TIDES

A model weakens the tide; that the tide made the electrojet's pattern is inferred, not shown

That greenhouse gases cool the upper atmosphere is well established [13 Abstract]; the thermosphere's density at 400 km fell about 2% a decade in 1967–2005 [14 Abstract]. That a weakened tide made the electrojet's pattern, the paper says firmly in its key points and its plain-language summary, and more carefully in its abstract and conclusions [1 p. 1][1 p. 7].

How firmly the paper says it

> *"Simulations from the WACCM-X model confirm that rising greenhouse gases suppress the migrating semidiurnal tide (SW2), which serves as the primary driver of the semidiurnal pattern in the long-term EEJ variations."*
>
> Plain-language summary [1 p. 1]

> *"The SW2 presents a decrease trend above 120 km altitudes near the equatorial region, which is suggested to be the primary source for the semidiurnal-like pattern of the EEJ long-term trend."*
>
> Discussion [1 p. 6]

> *"Such semidiurnal-like trends can be interpreted as the suppression of migrating semidiurnal tide (SW2) under the enhanced greenhouse gas as seen in the WACCM-X model."*
>
> Conclusions [1 p. 7]

What the model runs are

The tides come from the WACCM-X runs of the second author's 2025 study: one set of runs per decade from the 1920s to the 2010s, each the last five years of a six-year run, all "under constant solar minimum (F10.7 = 70 sfu) and quiet geomagnetic environments (Kp = 0+)", with greenhouse gases rising as observed and "the geomagnetic field configuration in all simulation experiment is fixed to the mean state of 1960s" [1 p. 6][28 Abstract]. The paper compares the 1960s with the 2010s. In the 1960s the tide in temperature peaks at 120–140 km over the equator, and by the 2010s it has weakened above 120 km there [1 p. 6], by up to about 4–5 K against about 25 K at its peak, as we read its Fig. 5 by eye. The same panel shows it strengthening, by about 1–2 K, at about 105–120 km just north of the equator [1 Fig. 5], the electrojet's own height [11 Abstract].

What other studies find

Doubling CO_2 in one whole-atmosphere model gave "a 40–60% reduction in the semidiurnal tides (SW2) throughout the thermosphere", though a stronger diurnal tide below 200 km [16 Abstract], and the height of its low-latitude ionosphere then fell in the morning and rose in the afternoon, like the electrojet's pattern, as the paper notes [1 p. 7]. Another study, of the highest emissions, gives "the semi-diurnal tides decrease throughout the thermosphere" [17 Abstract], and in a third study the diurnal tide weakens at 90–110 km, where "The negative trend is confirmed in SABER observation for the last two decades" [19 Abstract]: the studies differ on the diurnal tide. A review finds that changes in the semidiurnal tide in the mesosphere and lower thermosphere "differ according to altitude and latitude" [13 Abstract], and in the second author's simulations of the last 12,000 years, with a thermosphere–ionosphere model, CO_2's cooling favours the tides' propagation and "increases the thermospheric tidal amplitude" [18 Abstract]. CO_2 rose 24% over the paper's span, from 322 to 401 parts per million at Mauna Loa: a quarter of a doubling's rise, or about a third of a doubling in the logarithmic terms used for climate forcing (our arithmetic) [15].

The trends with the drift taken out

LOCAL TIME	1967–1999, AS RECORDED	1967–1999, DRIFT TAKEN OUT	1967–2014, TIR SCALED, AS RECORDED	1967–2014, TIR SCALED, DRIFT TAKEN OUT
07	**+0.77 ± 0.27** (+6.4%)	**+0.67 ± 0.27** (+5.5%)	+0.13 ± 0.15 (+1.1%)	**+0.46 ± 0.15** (+3.7%)
08	−0.44 ± 0.41 (−1.4%)	−0.74 ± 0.42 (−2.4%)	**−0.63 ± 0.22** (−2.1%)	+0.18 ± 0.23 (+0.6%)
09	−0.48 ± 0.59 (−1.0%)	−0.93 ± 0.60 (−2.0%)	**−1.16 ± 0.32** (−2.6%)	+0.02 ± 0.33 (0.0%)
10	−1.11 ± 0.68 (−2.1%)	**−1.63 ± 0.69** (−3.1%)	**−1.81 ± 0.36** (−3.7%)	−0.53 ± 0.37 (−1.0%)
11	−1.26 ± 0.69 (−2.6%)	**−1.74 ± 0.70** (−3.6%)	**−2.03 ± 0.37** (−4.5%)	**−0.90 ± 0.38** (−1.9%)
12	−0.84 ± 0.62 (−2.3%)	−1.22 ± 0.63 (−3.2%)	**−1.83 ± 0.34** (−5.3%)	**−1.00 ± 0.35** (−2.8%)
13	+0.03 ± 0.54 (+0.1%)	−0.22 ± 0.54 (−0.8%)	**−0.95 ± 0.29** (−4.0%)	−0.38 ± 0.30 (−1.6%)
14	+0.50 ± 0.47 (+3.3%)	+0.37 ± 0.47 (+2.4%)	**−0.56 ± 0.25** (−4.0%)	−0.26 ± 0.26 (−1.8%)
15	**+0.73 ± 0.36** (+8.4%)	+0.66 ± 0.36 (+7.5%)	−0.30 ± 0.20 (−3.8%)	−0.16 ± 0.20 (−2.0%)
16	+0.40 ± 0.24 (+6.2%)	+0.35 ± 0.24 (+5.3%)	−0.10 ± 0.14 (−1.7%)	+0.02 ± 0.14 (+0.3%)
17	+0.05 ± 0.18 (+0.9%)	0.00 ± 0.18 (0.0%)	**−0.30 ± 0.10** (−5.9%)	**−0.20 ± 0.09** (−3.9%)
18	−0.07 ± 0.11 (−2.4%)	−0.10 ± 0.11 (−3.4%)	**−0.20 ± 0.06** (−7.3%)	**−0.15 ± 0.06** (−5.1%)

Our analysis. Each month's index divided by the profile of section 5 at the observatory's distance that month, which puts every month on the dip equator; Tirunelveli is then scaled to Trivandrum in their 1999 overlap. Trend in nT per decade ± its standard error, with the trend as a share of that hour's average over the same years in brackets; bold values pass a 95% test. For 1967–2014, taking the drift out removes the morning decrease at 08 and 09 local time and shrinks it by 71% at 10, 56% at 11 and 45% at 12, while the small rise at 07 grows enough to pass the test. From the observatories' records [7][8] and IGRF-14 [5].

OUR ANALYSIS

What "disentangle" rests on, and what it leaves open

The abstract says the results "disentangle the influences of greenhouse gas and geomagnetic secular variation" [1 p. 1]. In the text that rests on three things: choosing India, where the field changes little; fitting the trend to 1967–1999, when the observatory stayed near the equator; and an argument, that the field acts through the ionosphere's conductivity or through the equator's position, and either way "should induce the concurrent enhanced or decreased trend in the morning and afternoon sectors, and cannot produce the semidiurnal-like pattern" [1 p. 5]. On the field's side that holds for 1967–1999: an effect that scales every hour alike cannot turn a morning decrease into an afternoon increase, and our re-run with the drift taken out keeps the pattern, its morning decrease now passing a 95% test at 10–11 local time, though the afternoon rise at 15 no longer does [7]. But the paper never measures the field's share; it avoids it by choosing the years. And it does not tie the pattern to the tide: it computes no electrojet from the model, uses the tide's temperature rather than the winds that drive the dynamo, and compares decades that do not match its trend [1 p. 6][1 p. 7]. After 1999 the drift should have changed noon most, not the afternoon (section 5), and with the drift taken out, Tirunelveli's own record even turns to a morning rise [8]. We rate the two halves of the claim as claims 3 and 4 rather than separately.

7 · POLE SHIFT?

The equator's drift is the field's ordinary change, and the paper never mentions a pole shift

S0 News labelled its link to the paper "Magnetic Pole Shift Equator" [2]. No transcript was available, so the episode's own words could not be checked; we rate the label.

What the paper says

It speaks of "geomagnetic-equator motion" and of "geomagnetic secular variation", the field's slow change [1 p. 1], and it chose India because there "secular magnetic-field changes are weak" [1 p. 1]. Its text never mentions a pole shift, a reversal or an excursion, and the poles appear only in a title in its reference list [1 p. 9]. It mentions the field's weakening once, citing a model in which "centennial-scale reductions in the geomagnetic dipole moment can enhance ionospheric conductivity", only to argue that such effects cannot make its pattern [1 p. 5]. Nor are any of its 50 references, by their titles, about a pole shift, a reversal or an excursion: those on the field concern how its secular variation, including the drift of the dip equator and the poles, affects the upper atmosphere [20 Abstract][18 Abstract]. One, "The Potential Impacts of the Erratic Motion of Dip Equator and Magnetic Poles," which the paper cites for the equator's migration [1 p. 2], is about knowing their positions accurately, for studies of the ionosphere and for navigation [23 Abstract].

OUR ANALYSIS

What the drift is

Over India the dip equator moves south at a few kilometres a year, 78% of it the equator of the field's dipole part moving as the dipole's axis straightens toward the rotation axis (section 3) [5]. It has slowed since 2020, to 2.7 km a year in 2020–2025, and IGRF-14 and WMM2025 forecast 0.4–0.8 km a year for 2025–2030 [5][6]. The field on India's dip equator is 1.9% stronger than in 1967. Over Brazil the same line moves 21 km a year and has moved more than 1,100 km since 1957, with no reversal [5][22 Abstract].

The field's decline, from our guide

Earth's axial dipole is about 9% weaker than in 1840 [26 p. 1], and our guide to the field finds it weakening about 5% a century, with the axis tilted 9.2° in 2025, down from 11.4° in 1900; the field is "probably not reversing" [27]. The site rates "A pole shift is under way" Misleading (October 20) and "An excursion is under way now" False (October 22). The core field's acceleration also peaks near the equator, in patterns that persist rather than collapse (our check of that paper), and the radiation belts' breach of May 2024 was storm data, not pole-shift data (our check).

The episode's title begins "Shift in the Sky" [2]. We do not rate it: it is a teaser that could refer to this item, a current about 100 km up along a moving magnetic equator, or to the episode's link on the Lucy spacecraft's trajectory. Its other paper link is checked on our page on the birth-rate preprint.

8 · REPEAT OUR NUMBERS

One script fetches the public records and recomputes everything we derive from the field models and the observatories

It downloads the observatories' hourly records from the World Data Centres in Kyoto and Edinburgh [7][8], GFZ's indices [10] and the field models [5][6], checks each file against the copy we used, and writes its results to one file of derived numbers. The paper's values in section 4 come from its text and its Fig. 4 [1], and the CO_2 rise in section 6 is arithmetic on NOAA's file [15].

PY **electrojet_numbers.py**

The dip equator, its drift and the dipole's share from IGRF-14, checked against WMM2025's test values; the observatories against the model; the trend re-run with its variants; the fall-off profile; and the trends with the drift taken out; Python standard library only · 38 KB

JSON **electrojet-numbers.json**

Its output: the numbers on this page, with the address and SHA-256 of every input; derived numbers only, no observatory data · 83 KB

Run it

`python3 electrojet_numbers.py` downloads about 75 MB of inputs into its own folder and then runs for under a minute; `python3 electrojet_numbers.py <folder>` uses copies you already have there. GFZ's file grows by a day every day and WDC Edinburgh stamps each download with its date, so those two hashes will differ from ours; the values used do not change.

The data and their terms

The observatories are the Indian Institute of Geomagnetism's. The World Data Centre in Kyoto makes their records "available for scientific use without restrictions", asking users to credit the institute and the centre [7], as does the centre in Edinburgh [8]; the institute publishes its hourly data "for academic and scientific use without any restriction", but its policy forbids passing on data obtained from it without written permission [9]. So this page hosts no observatory data, only the script that fetches them and what it computes. GFZ's indices are CC BY 4.0 [10].

9 · LIMITS

What this check could and couldn't see

The paper's numbers, partly by eye

We read the paper in full [1]. Its text gives trends only at 11 and 15 local time [1 p. 3]; the others, and all its error bars, we read off its Fig. 4, and the tide's change off its Fig. 5 [1 Fig. 4][1 Fig. 5].

No transcript

The episode's own words could not be checked: we rate only its label on the link to the paper [2].

Not the paper's data

The paper publishes no electrojet series or code; we rebuilt the record from the same observatories with a similar but not identical method, and our numbers differ from its by up to about 0.6 nT a decade [1 p. 7][7].

Two observatories joined

Trivandrum's record ends in 1999 and Tirunelveli's begins then; how the two are joined changes the 1967–2015 trend (section 4), and neither the paper nor we can calibrate them from more than nine months of overlap [1 p. 2][7].

Missing years

Neither archive holds Trivandrum's horizontal field for 1970 or 1979, and we found no public record of Tirunelveli for 2015, so our joined record ends in 2014 where the paper's ends in 2015 [7][8]. The paper's Fig. 2 counts 6,468 daytime values, every month of 1967–2015 at 07–17 local time, so its record includes months, among them 1970, 1979 and 2015, that we could not find in either archive, including the one its data statement names [1 p. 4][1 p. 7].

A rough profile, and unread tides

Our fall-off profile rests on three observatories in different settings. The authors' model tide changes are in a dataset whose file we could not download [4]; we rely on the paper's description and its Fig. 5 [1 p. 6].

What would change these verdicts

01

A calculation of the electrojet itself in the model, with the tide weakened as in its runs, giving the morning-down, afternoon-up pattern at the observed size; that would move claim 4 toward True.

02

An analysis of the full record that corrects each month for the observatory's distance from the equator and calibrates the change of observatory, and finds the drift does account for the change after 1999; that would make claim 3 True.

03

The episode's transcript, which could show what the label was meant to say: a claim that the paper shows a pole flip under way, for example, would make claim 1 Misread or False.

OUR ANALYSIS

Bottom line: a faint but reproducible trend and a real drift, a tide explanation that is plausible but not demonstrated, and nothing to do with a pole shift.

Our re-run of the public records reproduces the paper's trends for 1967–1999, mornings down and afternoons up, though they are faint beside the record's noise [1 p. 3][7]. The magnetic equator did drift away from the observatory after 1999, but the drift cannot by itself account for the change in the full-period trend, which falls mostly on the afternoon [1 Fig. 4]. Whether greenhouse gases, through a weaker tide, made the 1967–1999 pattern is a plausible reading of a model that the paper states more firmly than it shows [1 p. 1][1 p. 6]. The equator's drift is the main field's ordinary secular variation, mostly the dipole straightening up [5]. The paper never mentions a pole shift, and nothing in the field's change points to one.

Related checks

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

FALSE The 2025 model already failing? The Disaster Cycle, Fact-Checked

Sources

Bracketed numbers refer to this list. For the paper [1], read in full, p. gives a page of the version of record, § a section and Fig. a figure; its key points, abstract and plain-language summary are on p. 1, and where we say which sentence of the abstract, we count its six sentences in order. Values we read off its figures say so. For the episode [2] no transcript was available: we read its title and the links and labels in its description, and quote nothing else of it. For the other sources, p. gives a page and Abstract the abstract of the cited work; where only an abstract was read, the entry says so. Latitudes are geodetic; LT is local time, in our re-run UT + 5 hours; nT is the nanotesla. Years are those of the printed issue where there is one, otherwise of online publication. Links checked October 30, 2026.

1. Zhang, R., Zhou, X., Wang, Y., Liu, L., Chen, Y., and Le, H. (2026). The Long-Term Trend of the Equatorial Electrojet Over Indian Sector. *Geophysical Research Letters* 53(20), e2026GL126510. Received August 24, accepted October 5, published online October 23, 2026. Peer reviewed; open access, CC BY-NC 4.0. Its acknowledgements (p. 7) list as funders the National Natural Science Foundation of China (42530201, 42574219, 42674251), the B-type Strategic Priority Program of the Chinese Academy of Sciences (XDB0780000), the National Key R&D Program (2022YFF0504400), the China Meteorological Administration's "Ionospheric Forecast and Alerting" Youth Innovation Team (CMA2024QN09) and a fund of the state key laboratory of solar activity and space weather. Read in full: the version of record, 9 pages, which the site's owner downloaded from Wiley in a browser and supplied on October 30, 2026; the publisher's site puts a human-verification check in front of automated readers, which we do not attempt, and we found no other copy. p. gives a page of the version of record, § a section and Fig. a figure; its key points, abstract and plain-language summary are on p. 1. Quoted with the publisher's hyphen characters printed as ordinary hyphens; its Fig. 4 is adapted in section 4, with values read off the figure.
2. SpaceWeatherNews (S0) (October 30, 2026). Shift in the Sky, Coronal Hole Coming, Cosmic Cat | S0 News Oct.30.2026. YouTube video, https://www.youtube.com/watch?v=T264iUQw8Rw, published at 11:35 UT. No transcript was available when this page was made, so we read only its title and the four links in its description, with their labels, as our collector recorded them, and could not quote the episode's own words. "Magnetic Pole Shift Equator" is its label on the link to the paper; "Geomagnetic Birth Rate" links the preprint checked on our page on it; "LUCY Orbit" and "Cosmic Cat" link NASA pages.
3. Crossref. Metadata record for doi:10.1029/2026GL126510. Retrieved October 30, 2026: the abstract as the publisher deposited it; the received, accepted and published dates; the licence, CC BY-NC 4.0 for the version of record from October 23, 2026; the authors' affiliations, at the Institute of Geology and Geophysics of the Chinese Academy of Sciences, its Heilongjiang Mohe Observatory of Geophysics and the University of Chinese Academy of Sciences; three grants from the National Natural Science Foundation of China and one from the National Key Research and Development Program of China, fewer funders than the paper's acknowledgments list (see [1]); and 50 references, among them sources 4, 11–14, 16–23 and 28 on this page.
4. Zhang, R., and Zhou, X. (2026). The WACCM-X simulated SW2 data. Dataset, Zenodo, issued August 24, 2026. CC BY 4.0. Its record only, from DataCite and the Zenodo page: Zenodo refused our requests for the data file, SW2.mat, 83.5 kB, and we did not read it.
5. 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 October 30, 2026, the same file, by its SHA-256, as on our guide to the field.
6. NOAA National Centers for Environmental Information and British Geological Survey (2024). World Magnetic Model 2025: coefficients and test values (WMM2025COF.zip). Data file; retrieved October 30, 2026.
7. World Data Center for Geomagnetism, Kyoto. Geomagnetic Data Service: hourly values, best available, of the Indian Institute of Geomagnetism's observatories at Trivandrum (TRD), Tirunelveli (TIR), Alibag (ABG), Kodaikanal (KOD), Annamalainagar (ANN) and Ettaiyapuram (ETT), through its HAPI server, with the data usage rules on the same page. Retrieved October 30, 2026; re-analysed in full, and not redistributed.
8. World Data Centre for Geomagnetism, Edinburgh (British Geological Survey). Observatory data: hourly values of the Indian Institute of Geomagnetism's observatory at Tirunelveli, 1999–2014, definitive, through its API, with its usage rules. Retrieved October 30, 2026; re-analysed in full, and not redistributed.
9. Indian Institute of Geomagnetism. Data Sharing Policy with Terms and Conditions, in force from December 1, 2014, and the institute's World Data Centre page. Read in full.
10. Matzka, J., Stolle, C., Yamazaki, Y., Bronkalla, O., and Morschhauser, A. (2021). The Geomagnetic Kp Index and Derived Indices of Geomagnetic Activity. *Space Weather* 19(5), e2020SW002641. CC BY 4.0. With GFZ's data file Kp_ap_Ap_SN_F107_since_1932.txt (data publication 10.5880/Kp.0001), retrieved October 30, 2026, whose daily Ap and F10.7 we used; its F10.7 is measured by the Dominion Radio Astrophysical Observatory and Natural Resources Canada (Tapping, 2013, *Space Weather* 11, 394–406). The articles are cited as the data's references, by their records only; the data file was used in full.
11. Anderson, D., Anghel, A., Yumoto, K., Ishitsuka, M., and Kudeki, E. (2002). Estimating daytime vertical ExB drift velocities in the equatorial F-region using ground-based magnetometer observations. *Geophysical Research Letters* 29(12), 1596. Abstract only.
12. Yamazaki, Y., Richmond, A. D., Maute, A., Wu, Q., Ortland, D. A., Yoshikawa, A., et al. (2014). Ground magnetic effects of the equatorial electrojet simulated by the TIE-GCM driven by TIMED satellite data. *Journal of Geophysical Research: Space Physics* 119(4), 3150–3161. Abstract only.
13. Laštovička, J. (2023). Progress in investigating long-term trends in the mesosphere, thermosphere, and ionosphere. *Atmospheric Chemistry and Physics* 23(10), 5783–5800. CC BY 4.0. Abstract only.
14. Emmert, J. T. (2015). Altitude and solar activity dependence of 1967–2005 thermospheric density trends derived from orbital drag. *Journal of Geophysical Research: Space Physics* 120(4), 2940–2950. Abstract only.
15. NOAA Global Monitoring Laboratory, with Scripps Institution of Oceanography data (C. David Keeling) for March 1958 to April 1974. Mauna Loa CO_2 annual mean data (co2_annmean_mlo.txt). Data file; retrieved October 30, 2026. Its 1967 value, 322.18 ppm, is one of the Scripps years; its 2015 value is 401.01 ppm.
16. Liu, H., Tao, C., Jin, H., and Nakamoto, Y. (2020). Circulation and Tides in a Cooler Upper Atmosphere: Dynamical Effects of CO_2 Doubling. *Geophysical Research Letters* 47(10), e2020GL087413. CC BY-NC 4.0. Abstract only.
17. Ma, H., Liu, H., Liu, H., and Liu, L. (2025). Upper Atmosphere Responses to IPCC's Worst Scenario of CO_2 Increase in the 21st Century. *Geophysical Research Letters* 52(12), e2025GL115452. CC BY 4.0. Abstract only.
18. Zhou, X., Yue, X., Cai, Y., Ren, Z., Wei, Y., and Pan, Y. (2023). Simulated long-term evolution of the thermosphere during the Holocene – Part 2: Circulation and solar tides. *Atmospheric Chemistry and Physics* 23(11), 6383–6393. CC BY 4.0. Abstract only.
19. Kogure, M., Song, I.-S., Liu, H., and Liu, H.-L. (2026). Impacts of increasing CO_2 on diurnal migrating tide in the equatorial lower thermosphere. *Atmospheric Chemistry and Physics* 26(1), 665–680. CC BY 4.0. Abstract only.
20. Cnossen, I., and Richmond, A. D. (2013). Changes in the Earth's magnetic field over the past century: Effects on the ionosphere-thermosphere system and solar quiet (Sq) magnetic variation. *Journal of Geophysical Research: Space Physics* 118(2), 849–858. Abstract only.
21. Cnossen, I. (2020). Analysis and Attribution of Climate Change in the Upper Atmosphere From 1950 to 2015 Simulated by WACCM-X. *Journal of Geophysical Research: Space Physics* 125(12), e2020JA028623. CC BY 4.0. Abstract only.
22. Soares, G., Yamazaki, Y., Cnossen, I., Matzka, J., Pinheiro, K. J., Morschhauser, A., Alken, P., and Stolle, C. (2020). Evolution of the Geomagnetic Daily Variation at Tatuoca, Brazil, From 1957 to 2019: A Transition From Sq to EEJ. *Journal of Geophysical Research: Space Physics* 125(9), e2020JA028109. CC BY 4.0. Abstract only.
23. Yizengaw, E. (2020). The Potential Impacts of the Erratic Motion of Dip Equator and Magnetic Poles. *Journal of Geophysical Research: Space Physics* 125(8), e2020JA028129. Abstract only.
24. Abdu, M. A., Batista, I. S., Muralikrishna, P., and Sobral, J. H. A. (1996). Long term trends in sporadic E layers and electric fields over Fortaleza, Brazil. *Geophysical Research Letters* 23(7), 757–760. Abstract only.
25. Elias, A. G., de Haro Barbas, B. F., Zossi, B. S., Medina, F. D., Fagre, M., and Venchiarutti, J. V. (2021). Review of Long-Term Trends in the Equatorial Ionosphere Due the Geomagnetic Field Secular Variations and Its Relevance to Space Weather. *Atmosphere* 13(1), 40. CC BY 4.0. Abstract only.
26. Finlay, C. C., Aubert, J., and Gillet, N. (2016). Gyre-driven decay of the Earth's magnetic dipole. *Nature Communications* 7, 10422. CC BY 4.0. As cited on our guide to the field; p. gives its page.
27. Brown, M., Korte, M., Holme, R., Wardinski, I., and Gunnarson, S. (2018). Earth's magnetic field is probably not reversing. *Proceedings of the National Academy of Sciences* 115(20), 5111–5116. As cited on our guide to the field.
28. Zhou, X., Li, W., Liu, H., Hu, L., Li, Y., and Yue, X. (2025). Long-Term Trends of Ionospheric Day-to-Day Variability During the Past Century. *Geophysical Research Letters* 52(20), e2025GL118640. CC BY-NC 4.0. Abstract only.
29. Zhou, X. (2025). Long-Term Trends of Ionospheric Day-to-Day Variability during the Past Century. Dataset, Zenodo, issued August 1, 2025. CC BY 4.0. Its DataCite record only: the dataset of [28], whose address the paper's data statement gives for its own model data [1 p. 7].

METHOD

How this was checked

On October 30, 2026, we checked every statement on this page about the paper against its full text, the version of record, which the site's owner downloaded from Wiley in a browser: its data, method, trends, error bars, field model, model runs, caveats, data statement and declaration of interests, and everything it says, and does not say, about the poles and the field's weakening; its Fig. 4 trends beyond 11 and 15 local time, and all its error bars, were read off the figure with a script, and the tide's change off its Fig. 5 by eye. Wiley's site puts a human-verification check in front of automated readers, which we do not attempt, and we found no other copy. The page also rests on the paper's Crossref record, with its dates, licence, funders and 50 references [3]; the records of the authors' dataset, whose file Zenodo refused to serve us, and of the dataset named in the paper's data statement [4][29]; the episode's title and the links and labels in its description, since no transcript was available [2]; 15 other papers on the electrojet, the upper atmosphere's long-term change, its tides and the field's secular variation, read as abstracts, and two more as cited on our guide to the field; the field models IGRF-14 and WMM2025; the hourly records of six of the Indian Institute of Geomagnetism's observatories from the World Data Centres in Kyoto and Edinburgh, with their rules and the institute's; GFZ's solar and geomagnetic indices; and NOAA's CO_2 record: the 29 sources listed. Every quotation was checked word for word against its saved source; the publishers' hyphen characters are printed as ordinary hyphens.

The verdicts and the items tagged "Our analysis" are our own assessment, built on the cited sources. They include the dip equator's positions, drift and forecasts that we compute from IGRF-14 and WMM2025, and how much of the drift is the dipole's; the observatories' yearly means against IGRF-14; our re-run of the electrojet's trend at each local hour from the observatories' hourly records, with its variants, the solar cycle's swing beside it and its comparison with the paper's; the fall-off of the electrojet's signal away from the equator that we fit to three observatories, what the drift did to two observatories' records, and how much of the change after 1999 the drift can explain; the trends with that drift taken out; the values we read off the paper's figures; the rise in CO_2 over the paper's span; and our reading of what the paper does and does not show.

Our script, hosted on this page, fetches every input from its source, the observatories' records from the World Data Centres in Kyoto and Edinburgh among them, and recomputes everything we derive from the field models and the observatories' records (the CO_2 rise is arithmetic on NOAA's file [15]); it checks its field calculation against NOAA's 12 test values for WMM2025, which it reproduces to within 0.05 nT, and its output, also hosted, holds only derived numbers. The page hosts no observatory data, because the Indian Institute of Geomagnetism does not allow data obtained from it to be passed on without its permission [9]. The paper publishes no electrojet series or code, so its trends could not be recomputed exactly; our re-run, with a similar method, reproduces them within about one standard error at every hour from 08 to 16 local time. Its Fig. 4 is adapted, with our re-run beside it, under its CC BY-NC 4.0 licence. We could not open the authors' model tide data [4], or find Tirunelveli's record for 2015.

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

The verdicts on this page

MISLEADING	Contains something true but leaves a false impression, usually by leaving out key context.
OVERSTATED	Has some basis but claims much more than the evidence supports.
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

Oct 30, 2026	Published on factchecked.science after a full check against the sources, the paper's full text among them. Built from the paper, which the site's owner supplied because its publisher's site puts a human-verification check in front of automated readers, with the episode's title and description (no transcript was available), the literature on the electrojet, the upper atmosphere's tides and the field's secular variation, and our own analysis of IGRF-14 and of the Indian Institute of Geomagnetism's public hourly records, whose script is hosted on the page: four claims rated on the site's scale, one the episode's and three the paper's. The paper's Fig. 4 is adapted; no observatory data are hosted.

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

Last updated Oct 30, 2026