S1 Observations and profile processing

The sample comprises 1,666 profiles on 852 UTC dates in 2015-2018, with 838 afternoon and 828 nighttime profiles. There are 814 dates with both 06:00 and 18:00 UTC profiles. These slots correspond to approximately 13:16 and 01:16 local solar time at the model longitude.

Experienced researchers edited the ordinary-mode trace with SAO Explorer. Ambiguous spread-F traces were interpreted using adjacent ionograms and continuous points in the current image, or the lower envelope of the red ordinary-mode echo. Archived headers identify SAO Explorer 3.4.17 and NH 4.34. The NHPC inversion yields the height-density profile. SAO 4.3 groups 51-53 contain the aligned true-height, plasma-frequency and electron-density arrays.

Eligible profiles have at least 20 aligned points, strictly increasing heights, finite nonnegative density, and a maximum relative frequency-density discrepancy of 0.015. Coincident GNSS and model components must be finite. Selection is independent of the resulting TEC residual. Identical duplicate daily files are counted once; conflicting duplicates stop catalogue construction.

Native station parameters are grouped by flooring timestamps to 15 min bins. Numerical values use within-bin medians; spread-F morphology uses the modal class, with sorted-first tie resolution. Missing values are not interpolated. The SAO profile retains its fixed timestamp. Spread-F classes come from the image-classification method cited in the main text and are separate from manual profile tracing.

S2 GNSS product and contemporaneous reference

The input is the Chinese Meridian Project vertical absolute TEC product for station ODAZH and monitor GTSM02. The official product correspondence maps historical Fuke to the current Danzhou catalogue name, including the ionosonde and GNSS source-record products: https://www.meridianproject.ac.cn/dygxb/. The source product is cited under its current title in the main text.

The source-file header for 23 September 2015 identifies L2 processing, product version V01.00, producer Harbin Institute of Technology, Shenzhen, nominal 30 s sampling, and a 450 km thin-shell height. It labels the TEC field as vertical absolute TEC in TECU. The header gives an absolute-TEC device precision of 3 TECU and QualityFlag=TBD. The device specification is not a per-epoch uncertainty estimate or an uncertainty for the difference between the two MAEs. The available header does not specify the bias-estimation algorithm or the full mapping function.

The analysis parser reads UTC time, satellite identifier, azimuth, elevation and ATEC. It skips unparsable records and documented missing-value sentinels. There is no additional elevation-angle filter, slant-to-vertical conversion or bias recalibration. The reference G is formed by taking the median across satellites at each epoch, followed by the median of these epoch values within $[t - 7.5\text{min}, t + 7.5\text{min})$, where t is the sounding time. The stored name vtec_median_center10 denotes this executed 15 min window. This reference combines the available GNSS paths around the station.

S3 Column and statistical definitions

The manual bottomside B_m is integrated by trapezoids from the lowest reported height to the first density maximum. Density in cm^{-3} and height in km are converted to TECU with a factor of 10^{-7}. The lower unobserved region is unfilled. The exported extension above the peak is unused.

Model components B_I and T_I use rectangular sums on the 80-1000 km grid with 10 km spacing, separated at model hmF2. Density sums in m^{-3} are multiplied by 10^{-12}. The native total C_I instead uses IRITEC over 0-1000 km with a configured step of 0.1 km and conversion from m^{-2} to TECU by 10^{-16}. The hybrid is $H = B_m + T_I$; the residuals are $R = G - H$ and $R_I = G - C_I$. Defining $\delta = C_I - (B_I + T_I)$ gives $R_I = R - (B_I - B_m) - \delta$. The bottomside contrast includes the different lower boundaries and peak heights. Each MAE averages the absolute residual over the same matched profiles with equal profile weights.

The common-height calculation integrates the saved IRI density profiles piecewise linearly from model hmF2, then from the observed density peak, to 1000 km. It retains the original manual lower boundary and column. This separates quadrature and upper-splice changes; the numerical summaries accompany this supplement.

Overall median and relative-MAE-improvement intervals use 2,000 UTC-date bootstrap clusters, with seeds 20260809 and 20260810, respectively. Each cluster retains both time slots when present. Limits are the 2.5th and 97.5th percentiles. The paired comparison uses 18 minus 06 UTC on the same date and a two-sided Wilcoxon signed-rank test.

The three OLS responses are R, |R| and $|R_I|$-|R|. The signed response uses signed observed-minus-model peak differences; the other responses use their absolute values. Continuous predictors are centered and scaled by their population standard deviations (ddof=0). UTC slot, year, season and spread-F class enter jointly, referenced to 06 UTC, 2015, DJF and no SF. Date-clustered covariance includes a finite-sample correction; intervals are normal 95% intervals. Benjamini-Hochberg adjustment includes all coefficients, including the intercept, within each

model. Figure 3 shows every non-intercept coefficient of the signed model; the complete coefficient table retains all three models.

S4 IRI configuration

IRI-2026 uses URSI foF2, Shubin-COSMIC hmF2, ABT-2009 bottomside parameters, IRI-COR2 topside and the Ozhogin plasmasphere option without a plasmapause. All column calculations stop at 1000 km. IRI-2026 uses the same solar and geomagnetic index files as the IRI-2020 historical comparison.

The quiet-reference frequency is $\sqrt{\mathrm{OARR}(1)/(1.24 \times 10^{10})}/\mathrm{OARR}(45)$. The saved density profile can include the configured storm response, so the foF2 predictor describes departure from the quiet peak background. It is not a fitted topside correction.

Table S1. The 50 JF switches used in the IRI-2026 calculation. T=true; F=false. The official software directory is https://irimodel.org/IRI-2026/.

JF	Value	JF	Value	JF	Value	JF	Value	JF	Value
1	T	11	T	21	T	31	T	41	T
2	T	12	T	22	F	32	T	42	T
3	T	13	T	23	F	33	F	43	T
4	F	14	T	24	T	34	F	44	T
5	F	15	T	25	T	35	F	45	T
6	F	16	T	26	T	36	T	46	T
7	T	17	T	27	T	37	T	47	F
8	T	18	T	28	T	38	T	48	T
9	T	19	T	29	T	39	F	49	T
10	T	20	T	30	F	40	F	50	T

S5 Numerical tables

Aggregate data and figure and table export code are publicly available from Science Data Bank, Version 1, https://doi.org/10.57760/sciencedb.016z6. The deposit excludes raw observations and individual manually curated products. The six CSV files accompanying this supplement are listed below.

- Table S2: Overall metrics (Table S2.csv).
- Table S3: Year, time-slot, season and morphology summaries (Table S3.csv).

- Table S4: Same-date paired contrasts (Table S4.csv).
- Table S5: Model components and their differences (Table S5.csv).
- Table S6: Integration and splice comparisons (Table S6.csv).
- Table S7: Complete regression coefficients (Table S7.csv).