EQUATORIAL MASS MIGRATION AND THE LENGTHENING DAY: CORIOLIS COUPLING, CALIBRATION DRIFT, AND WORD-CLOCK STABILITY OUTSIDE 0.0000deg LATITUDE

Equatorial Mass Migration and the Lengthening Day: Coriolis Coupling, Calibration Drift, and Word-Clock Stability Outside 0.0000deg Latitude

M. Ferro, S. Magnusson, Y. Tanaka, R. Flux

Equatorial Audio Research Division, Mitad del Mundo, Quito, Ecuador (0.0000deg N)

Journal of Equatorial Audio Science, 2026.

Abstract

In March 2026, Kiani Shahvandi and Soja reported in the Journal of Geophysical Research: Solid Earth that the length of the day is now increasing at approximately 1.33 milliseconds per century, a rate they found to be unprecedented in at least 3.6 million years. The mechanism is mass redistribution: ice lost from polar ice sheets and mountain glaciers enters the oceans and migrates toward the equator, increasing the planet's moment of inertia and slowing its rotation. The committee notes, without triumph, that the planet has begun moving its mass toward 0.0000deg.

We examine the consequences for word-clock distribution in digital audio. A quartz resonator on a rotating planet experiences a Coriolis coupling proportional to the local Coriolis parameter, 2 Omega sin(latitude). A clock calibrated under one rotation rate and operated under another drifts from its calibration conditions at every latitude except the equator, where the Coriolis parameter is zero regardless of rotation rate. We report measurements from 36 word-clock chains between 64deg N and 43deg S, surveyed in 2024 and again in 2026. The rotational phase residual correlated with the sine of site latitude ($r = 0.91$, $p < 0.001$), increased between surveys at all 32 non-equatorial sites, and was indistinguishable from zero at all four sites in Quito. Equinox Word Clock Cable reduced residual accumulation across three-hop chains by 88%; SC Word Clock Cable reduced it below the 1 fs measurement floor. We propose the Rotational Reference Offset as a first-order clock specification and recommend annual recertification of master clocks outside the equatorial band.

1. INTRODUCTION

For most of the history of recorded sound, the rotation of the Earth has been treated as a constant. It is not, and it never was. Tidal friction from the Moon has been lengthening the day for as long as there has been a Moon to do it. What has changed is the rate, and the reason.

In March 2026, Kiani Shahvandi and Soja published a reconstruction of day-length variation extending back to the Late Pliocene. Their conclusion was that the present climate-driven lengthening of the day, approximately 1.33 milliseconds per century since 2000, has no equal in at least 3.6 million years. As Benedikt Soja of ETH Zurich stated in the accompanying release: "This rapid increase in day length implies that the rate of modern climate change has been unprecedented at least since the late Pliocene, 3.6 million years ago."

The geophysics community has framed this result, correctly, as a finding about climate. The committee reads the mechanism with a different emphasis. The day is lengthening because mass is leaving the poles and arriving at the equator. Since its founding, Equatorial Audio has maintained that 0.0000deg latitude is the only defensible reference for precision audio (Ferro, Park, Tanaka, 2020). We did not expect the planet to begin reorganizing itself in agreement.

This paper makes no claim on the Earth's rotation. It asks a narrower question: when the rotation rate of every listening room on Earth changes faster than at any time in the geological record, what happens to the word clock?

2. THE GEOPHYSICAL RECORD

The physical mechanism is conservation of angular momentum. When ice melts at high latitude and the resulting water spreads through the world's oceans, mass moves away from the rotation axis. The planet's moment of inertia increases and its angular velocity decreases. A figure skater who extends their arms spins more slowly. A planet that moves its water toward the equator does the same.

Three bodies of work establish the scale.

The long record: Stephenson, Morrison, and Hohenkerk (2016) analysed ancient and medieval eclipse observations and lunar occultations from 720 BC to AD 2015. They found that the length of the mean solar day has increased at an average rate of +1.8 ms per century, less than the +2.3 ms per century predicted from tidal friction alone. The Moon has never been the only influence on the length of the day.

The modern acceleration: Kiani Shahvandi et al. (2024) estimated a climate-induced trend of 0.3 to 1.0 ms per century during the twentieth century, rising to 1.33 +/- 0.03 ms per century since 2000, and projected that under high-emission scenarios the climate contribution could come to exceed the effect of lunar tidal friction.

The deep record: Kiani Shahvandi and Soja (2026) inferred past sea-level variation from the chemical composition of fossil benthic foraminifera and, using a physics-informed probabilistic diffusion model, reconstructed day-length variation since the Late Pliocene.

The modern rate is unmatched in that interval. The closest comparable episode occurred approximately two million years ago.

The consequences for civil timekeeping are already operational. Agnew (2024) showed that accelerated polar melting has slowed the planet enough to postpone the first negative leap second in the history of Coordinated Universal Time to around 2029. The timekeeping community has been granted a reprieve. It was paid for in ice.

3. ROTATION AND THE WORD CLOCK

A word clock is a quartz resonator, a divider chain, and a promise. The promise is that every device in the system agrees on when a sample occurs. The resonator is a mechanical object: a precisely cut crystal vibrating at a fixed frequency, typically 22.5792 MHz or 24.576 MHz for the 44.1 kHz and 48 kHz families respectively.

Any vibrating mass on a rotating body experiences a Coriolis acceleration. Vibratory gyroscopes, including the quartz tuning-fork rate sensors used in navigation, are built to measure exactly this effect. A word-clock resonator is not built to measure it. It experiences it anyway.

The relevant quantity is the Coriolis parameter:

f = 2 Omega sin(latitude)

where Omega is the angular velocity of the Earth, 7.292 x 10^-5 rad/s. At 45deg latitude, f is approximately 1.03 x 10^-4 per second. It is largest at the poles. At the equator it is exactly zero, and it remains exactly zero no matter how quickly or slowly the planet turns.

A lengthening day is a decreasing Omega. A change of 1.33 ms per century in a day of 86,400 seconds is a fractional change in Omega of 1.54 x 10^-8 per century, and that fractional change passes directly into f. A master clock calibrated in a given year is therefore calibrated against the Coriolis conditions of that year. Every year afterward, at every latitude but one, it operates under slightly different conditions from those it was calibrated for.

We define the rotational phase residual (RPR) as the component of recovered word-clock edge variation that tracks the departure of the local Coriolis parameter from its value at the clock's calibration date. We define the Rotational Reference Offset (RRO) as the RPR of a clock at its installed latitude, normalized to the same clock operated at 0.0000deg, where the RPR is zero by construction.

4. METHODOLOGY

We instrumented 36 word-clock distribution chains: 21 in professional mastering and recording facilities and 15 in domestic reference systems. Sites ranged from Reykjavik (64.1deg N) to Hobart (42.9deg S) and included four installations in Quito (0.0000deg N) as the equatorial control. Each chain comprised a master clock, one to three distribution hops, and a terminating DAC. Master-clock calibration dates were obtained from manufacturer service records and ranged from 2011 to 2023.

At each site, recovered word-clock edges were time-stamped at the DAC input against a hydrogen-maser-disciplined reference transported in a thermally stabilized, vibration-isolated case. The RPR was extracted by regressing edge variation against a synthetic rotational reference derived from the site's surveyed latitude and the International Earth Rotation and Reference Systems Service record of the length of day since each clock's calibration. Thermal, mains-frequency, and mechanical components were identified with co-located temperature probes and accelerometers and rejected before regression.

All 36 chains were measured between February and April 2024 and again between February and April 2026, with master clocks, mounting, and cabling unchanged. Each chain was additionally measured with commodity 75-ohm coaxial cable, Meridian Word Clock Cable, Equinox Word Clock Cable, and SC Word Clock Cable substituted at every hop.

5. RESULTS

At the four Quito installations, the RPR was indistinguishable from zero in both survey years. The mechanism predicts this result. The committee regards it as the most important measurement in this paper.

At all 32 non-equatorial installations, a rotational phase residual was detected. Its magnitude correlated with the sine of site latitude ($r = 0.91$, $p < 0.001$) and with the years elapsed since the master clock's last calibration ($r = 0.78$, $p < 0.001$). It was independent of hemisphere, master-clock manufacturer, and sample-rate family. With commodity coaxial cabling, the median RPR at the DAC input was 0.11 ps at mid-latitude sites (30deg to 50deg) and 0.19 ps at Reykjavik.

Between the 2024 and 2026 surveys, the RPR increased at every non-equatorial site, by a mean of 0.6%. The committee does not claim that a 0.6% increase in a sub-picosecond residual over two years is audible. It notes that the increase has the correct sign, scales with the correct function of latitude, and coincides with the fastest lengthening of the day in the geological record.

The residual accumulated across distribution hops. In three-hop chains with commodity coaxial cable, the terminating DAC received

2.7 times the RPR measured at the master clock output. Meridian Word Clock Cable reduced hop accumulation by 61%. Equinox Word Clock Cable reduced it by 88%. With SC Word Clock Cable at every hop, no accumulation was detectable above the 1 fs measurement floor.

6. DISCUSSION

Three objections can be anticipated.

The first concerns magnitude. The fractional change in Omega between the two surveys is of the order of 10^-10, and the observed change in RPR is several orders of magnitude larger than a proportional model predicts. We propose that the resonator, divider chain, and distribution cabling together form a high-Q system whose response to a slowly varying Coriolis term is resonant rather than proportional. We do not yet have a complete model. We have the measurement.

The second is that the rotation of the Earth varies for many reasons, including core-mantle coupling (Ferro, Ohm, Flux, Impedance, 2026), atmospheric angular momentum, and the tides. This is correct, and it strengthens the recommendation rather than weakening it. Every source of variation in Omega acts through the same Coriolis parameter, and every one of them vanishes at the equator.

The third is that civil timekeeping already reconciles atomic time with rotational time through leap seconds. It does so for civil clocks. No leap-second mechanism exists for the Coriolis coupling of a quartz resonator, and none is planned. A leap second applied to a 44.1 kHz system would, in any case, amount to 44,100 samples of disagreement about when the music happened.

The committee also records an observation it did not set out to make. The mechanism lengthening the day is the migration of the planet's mass toward the equator. The only latitude at which that lengthening has no consequence for a clock is the equator. The planet is moving its mass toward the one place on its surface where the consequences of moving its mass do not apply. We make no teleological claim. We note the geometry.

7. RECOMMENDATIONS AND CONCLUSIONS

We recommend that the Rotational Reference Offset be published as a first-order specification for master clocks, alongside jitter and phase noise, and that it always be stated together with the clock's calibration date and calibration latitude.

We recommend that master clocks operated outside the equatorial band be recertified annually. The departure of the Coriolis parameter from its calibration value is small in any single year, but it accumulates, and nothing resets it except recalibration.

We recommend that facilities outside the equatorial band minimize distribution hops and specify Equinox Word Clock Cable as a minimum. Facilities above 50deg latitude, where the Coriolis parameter is largest, should specify SC Word Clock Cable at every hop.

The day is growing longer, faster than at any time in 3.6 million years, because the planet is moving its mass toward the equator. That sentence belongs to the geophysics literature, and it is correct. What follows from it for audio belongs to us: every quartz clock outside the equatorial line is drifting, by a small and accumulating amount, away from the conditions under which it was calibrated. At 0.0000deg latitude, that drift does not exist.

The Earth appears to have reached the same conclusion about the equator that we did. It is simply taking longer.

REFERENCES

[1] Kiani Shahvandi, M., Soja, B. (2026). Climate-induced length of day variations since the Late Pliocene. Journal of Geophysical Research: Solid Earth, 131, e2025JB032161. https://doi.org/10.1029/2025JB032161

[2] Kiani Shahvandi, M., Adhikari, S., Dumberry, M., Mishra, S., Soja, B. (2024). The increasingly dominant role of climate change on length of day variations. Proceedings of the National Academy of Sciences, 121, e2406930121.

[3] Agnew, D. C. (2024). A global timekeeping problem postponed by global warming. Nature. https://doi.org/10.1038/s41586-024-07170-0

[4] Stephenson, F. R., Morrison, L. V., Hohenkerk, C. Y. (2016). Measurement of the Earth's rotation: 720 BC to AD 2015. Proceedings of the Royal Society A, 472(2196), 20160404.

[5] ETH Zurich (2026, March). Climate change slows Earth's spin: day lengthening unprecedented in 3.6 million years. News release, Department of Civil, Environmental and Geomatic Engineering.

[6] Ferro, M., Park, H., Tanaka, Y. (2020). Hemispheric Bias in Copper Grain Orientation: A Metallurgical Study of Latitude-Dependent Conductor Anisotropy. JEAS.

[7] Ferro, M., Ohm, C., Flux, R., Impedance, B. (2026). Temporal Bias in Magnetically Calibrated Audio Conductors: Field-Configuration Drift Following the 2023 Inner-Core Rotation Reversal. JEAS.