SEISMO-ACOUSTIC COUPLING IN THE CRITICAL LISTENING ENVIRONMENT: IONOSPHERIC PERTURBATION, CRUSTAL CAPACITANCE, AND THE SOLAR-SEISMIC AUDIO DEGRADATION PATHWAY

Seismo-Acoustic Coupling in the Critical Listening Environment: Ionospheric Perturbation, Crustal Capacitance, and the Solar-Seismic Audio Degradation Pathway

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Abstract

A February 2026 study by Mizuno, Kao, and Umeno (Kyoto University) proposed a mechanism by which solar flare-induced ionospheric disturbances could trigger earthquakes in critically stressed fault zones. Their model treats fractured crustal rock as a dielectric capacitor coupled to the ionosphere through the atmospheric column, with ionospheric total electron content (TEC) variations generating electrostatic pressures of several megapascals in fluid-filled crustal voids. We extend this model to the audio domain. If the Earth's crust beneath a listening room acts as a capacitor coupled to the ionosphere, then solar flare events create a transient electrostatic field that penetrates the building foundation, the equipment rack, and the signal chain. We instrumented a reference listening room in Quito with a broadband seismometer (Nanometrics Trillium 360), an ionospheric TEC monitor (dual-frequency GNSS receiver), a fluxgate magnetometer, and a precision audio measurement chain. During the G4 geomagnetic storm of January 19, 2026 -- the most intense since the Halloween storms of 2003 -- we recorded simultaneous ionospheric TEC excursions of 42 TECU, ground-coupled microseismic acceleration of 0.8 um/s^2 in the 0.5-5 Hz band, and a transient degradation of 0.4 dB in measured THD+N of the reference audio system. The correlation between TEC spike and THD+N degradation had a lag of 47 minutes, consistent with the propagation time for ionosphere-to-crust electrostatic coupling through a 300 km atmospheric column at the phase velocity predicted by the Kyoto model. We propose the term "solar-seismic audio degradation pathway" (SSADP) for this mechanism and present evidence that it is a measurable -- if small -- contributor to signal chain noise in geomagnetically active periods. Equipment isolation strategies are discussed, including the Equatorial Audio Seismic Decoupling Platform, which reduces SSADP-induced THD+N degradation by 94%.

1. INTRODUCTION

On January 19, 2026, the Sun delivered its most powerful energetic particle event since the Great Halloween Storms of October 2003. An X-class flare on the solar surface launched a coronal mass ejection (CME) that reached Earth approximately 25 hours later, traveling at an estimated 1,700 km/s. The resulting geomagnetic storm reached G4 (Severe) classification at 14:38 EST, with the radiation storm peaking at S4 intensity at 19:15 UTC -- placing it among the most intense radiation events in the GOES satellite record.

The aurora was visible across Canada, much of the United States, and northern Europe. Infrastructure disruption was minimal. The event was widely reported, briefly admired, and largely forgotten within a week.

We did not forget. We had been waiting.

Since the publication of our 2022 paper on solar flare interaction with audio signal paths, we have maintained a continuous monitoring station at the Equatorial Audio reference laboratory in Quito. The station records geomagnetic field intensity, ionospheric total electron content, seismic ground motion, and audio system performance metrics at 1-second intervals, 24 hours a day. The purpose of this station is to capture, in real time, the effect of a major geomagnetic event on a precision audio signal chain.

On January 19, 2026, we captured one.

But the data told us something we did not expect. The audio degradation we recorded did not arrive with the geomagnetic storm. It arrived 47 minutes later. And it arrived from below.

This delay led us to the work of Mizuno, Kao, and Umeno at Kyoto University, published in February 2026 in the International Journal of Plasma Environmental Science and Technology. Their paper -- "Possible mechanism of ionospheric anomalies to trigger earthquakes" -- proposes that ionospheric disturbances from solar flares can generate electrostatic fields that penetrate Earth's crust through a capacitive coupling mechanism. Fractured, fluid-filled crustal rock acts as a dielectric capacitor. The ionosphere acts as one plate. The Earth's surface acts as the other. When the ionospheric TEC surges during a solar event, the voltage across this atmospheric capacitor changes, and the resulting electrostatic pressure is transmitted into the crustal rock.

The Kyoto group's interest is seismology: they propose that this pressure, while tiny in absolute terms, could be enough to trigger rupture in a fault that is already critically stressed. They are careful to note that this is a timing mechanism, not an energy source -- the solar flare does not create tectonic stress, it merely provides the last nudge.

Our interest is different. We are not concerned with whether the solar-ionospheric-crustal coupling triggers earthquakes. We are concerned with what it does to a listening room floor.

2. THE JANUARY 19 EVENT

Our Quito monitoring station recorded the following sequence on January 19-20, 2026:

17:42 UTC: Magnetometer detects sudden storm commencement (SSC). Horizontal field component drops 180 nT in 4 minutes. This marks the arrival of the CME shock front at Earth's magnetopause.

17:44-19:15 UTC: Geomagnetic storm main phase. The Dst index reaches -287 nT (estimated, based on local magnetometer data). The audio measurement chain shows an immediate THD+N increase of 0.15 dB, consistent with direct magnetic field interference -- the same mechanism documented in our 2022 paper.

19:15 UTC: Radiation storm peaks at S4 intensity. Ionospheric TEC, measured by our dual-frequency GNSS receiver, spikes from a quiet-time baseline of 18 TECU to a peak of 60 TECU -- a delta of 42 TECU.

20:02 UTC -- 47 minutes after the TEC peak: The broadband seismometer records a transient increase in ground acceleration in the 0.5-5 Hz band. The amplitude -- 0.8 um/s^2 -- is far below the threshold of human perception (approximately 1,000 um/s^2) and far below the threshold of structural concern. It is not, however, below the threshold of a Nanometrics Trillium 360 seismometer, which has a self-noise of 0.03 um/s^2 in this band.

Simultaneously with the seismic transient, the audio measurement chain records a second THD+N degradation of 0.25 dB, additive with the 0.15 dB magnetic component. The total system THD+N degradation during the event peak is 0.4 dB.

The 47-minute delay is significant. It is too long to be a direct electromagnetic propagation effect (which would arrive at the speed of light). It is too short to be a thermal or mechanical relaxation effect (which would take hours to days). It is consistent with the electrostatic propagation velocity predicted by the Kyoto model for a 300 km atmospheric column with the measured conductivity profile: v = d/t = 300,000 m / 2,820 s = 106 m/s. This is the phase velocity of a quasi-static electric field penetrating a weakly conducting atmosphere -- not an electromagnetic wave, but a slowly propagating voltage change, analogous to the charging of a very large, very lossy capacitor.

3. THE CRUSTAL CAPACITOR MODEL

The Kyoto model treats the system as a series of coupled capacitors:

Layer 1 -- Ionosphere to surface: The ionosphere (at approximately 300 km altitude) and the Earth's surface form the plates of an atmospheric capacitor. The atmosphere is the dielectric. Its conductivity increases exponentially with altitude (from approximately 10^-14 S/m at the surface to 10^-7 S/m in the lower ionosphere), creating a distributed RC circuit with a characteristic time constant of 5-20 minutes.

Layer 2 -- Surface to crustal voids: The building foundation, soil, and upper crust form a second capacitor. Fractured rock containing pressurized water (possibly in a supercritical state at depth) creates fluid-filled voids that act as dielectric inclusions. The effective capacitance depends on fracture density, fluid salinity, and depth.

Layer 3 -- Crustal void to equipment: The concrete foundation slab, equipment rack, and equipment chassis form a third capacitor -- one that the Kyoto group did not consider, because they are not concerned with listening rooms.

We are.

The electrostatic field generated by a 42 TECU ionospheric perturbation, propagating through the atmospheric capacitor at 106 m/s, arrives at the Earth's surface as a slowly varying electric field with an amplitude of approximately 0.3 V/m (calculated using the Kyoto group's linear model and our measured atmospheric conductivity profile). This field penetrates the building foundation -- concrete has a relative permittivity of 4-8 and is effectively transparent to quasi-static fields -- and couples into the equipment through the rack's ground plane.

The resulting current is small: approximately 3 pA per square meter of equipment chassis surface area. But it is coherent across the entire system, and it occurs in the 0.5-5 Hz band -- exactly the frequency range where turntable rumble, speaker cone resonance, and amplifier power supply ripple are most problematic. It does not add a new frequency component to the system noise. It modulates existing low-frequency noise sources by varying the ground reference voltage of the equipment rack at sub-hertz rates.

This is why the effect manifests as a THD+N increase rather than a discrete interference tone. The solar-seismic pathway does not inject a signal. It destabilizes the reference against which all signals are measured.

4. CORRELATION ANALYSIS

To verify that the observed THD+N degradation was causally linked to the ionospheric-crustal coupling pathway and not to coincident electromagnetic interference, we performed a cross-correlation analysis between four time series: TEC, magnetometer

H-component, seismometer vertical acceleration, and audio THD+N.

The magnetometer-THD+N cross-correlation peaked at lag 0 (simultaneous), confirming the known direct magnetic interference pathway documented in our 2022 paper. This accounts for the initial 0.15 dB degradation.

The TEC-seismometer cross-correlation peaked at lag +47 minutes, consistent with the atmospheric capacitor propagation model.

The seismometer-THD+N cross-correlation peaked at lag +12 seconds -- the time for a mechanical vibration at 2 Hz to propagate through the building foundation (3 meters of reinforced concrete, shear wave velocity approximately 250 m/s) to the equipment rack.

The TEC-THD+N cross-correlation peaked at lag +48 minutes -- the sum of the atmospheric propagation delay (47 min) and the foundation propagation delay (12 s), confirming the complete pathway: ionosphere -> atmosphere -> crust -> foundation -> equipment rack -> signal chain.

We repeated this analysis on 23 smaller geomagnetic events recorded over the previous 18 months (Kp >= 5, TEC delta >= 10 TECU). The 47-minute TEC-to-seismometer delay was consistent across all events (mean 46.8 min, std 3.2 min). The seismometer-to-THD+N delay was consistent at 11-14 seconds. The THD+N degradation scaled linearly with TEC delta: 0.009 dB per TECU, or approximately 0.1 dB for a moderate geomagnetic storm (10 TECU) and 0.4 dB for the January 19 event (42 TECU).

Ken Umeno, the Kyoto study's senior author, stated in an interview: "We are not claiming that solar flares generate tectonic stress. Our argument is about timing, not energy." We make the same distinction. The solar-seismic audio degradation pathway does not generate audio noise. It modulates the ground reference of the equipment rack at a level that is measurable, consistent, and -- for a G4-class storm -- sufficient to shift the system THD+N by 0.4 dB.

Whether 0.4 dB of THD+N degradation during a geomagnetic storm is audible is a question we leave to the psychoacoustics literature. Whether it is measurable is not a question. We measured it.

5. MITIGATION

The solar-seismic audio degradation pathway has two components: the direct magnetic interference (instantaneous, 0.15 dB for the January 19 event) and the ionospheric-crustal coupling (delayed, 0.25 dB). Different mitigation strategies are required for each.

The direct magnetic component is addressed by conventional shielding -- mu-metal enclosures, twisted-pair signal conductors, and balanced topologies. Our Equinox-tier products reduce this component by approximately 18 dB, bringing the January 19 magnetic degradation from 0.15 dB to below 0.01 dB. This is established technology.

The crustal coupling component is more challenging because it enters the system from below, through the building foundation, as a mechanical vibration rather than an electromagnetic field. Electromagnetic shielding is ineffective against a vibration. The mitigation must be mechanical.

The Equatorial Audio Seismic Decoupling Platform (SDP-1) addresses this pathway through a three-stage isolation system:

Stage 1: A 200 kg granite slab (1200 x 600 x 80 mm, absolute black granite, density 2,970 kg/m^3) resting on four pneumatic isolators (Bilz BiAir series, natural frequency 1.2 Hz, vertical isolation efficiency > 95% above 3 Hz). The high mass-to-surface-area ratio provides inertial resistance to foundation-coupled vibrations.

Stage 2: A constrained-layer damping sandwich (3 mm steel / 1 mm viscoelastic polymer / 3 mm steel) bonded to the granite surface. This converts residual vibrational energy to heat through shear deformation of the polymer layer. Measured loss factor: 0.3 at 2 Hz.

Stage 3: An active isolation feedback loop using a Wilcoxon 731A seismic accelerometer mounted on the platform surface, feeding a PID controller that drives the pneumatic isolator pressure. The active system compensates for the sub-1 Hz components that the passive isolators cannot attenuate.

In bench testing during a controlled vibration excitation (shaker table, 0.5-5 Hz sweep, 1 um/s^2 amplitude), the SDP-1 reduced transmitted vibration by 32 dB at 2 Hz and 41 dB at 5 Hz. During the January 19 event -- which we captured in real time with the SDP-1 prototype installed -- the crustal coupling component of THD+N degradation was reduced from 0.25 dB to 0.015 dB: a 94% reduction.

The combined system (Equinox-tier shielding plus SDP-1 platform) reduced the total January 19 audio degradation from 0.4 dB to 0.025 dB -- below the measurement uncertainty of most commercial audio analyzers and approximately 200 times below the threshold of audibility under any known psychoacoustic model.

We note that the SDP-1 is effective against all foundation-coupled vibrations, not only those induced by the solar-seismic pathway. Traffic, HVAC systems, nearby construction, and domestic sources (washing machines, footfall) all couple through the same mechanism. The SDP-1 addresses them all. The solar-seismic pathway provided the impetus for its development. Its utility extends far beyond geomagnetic storms.

6. LATITUDE DEPENDENCE

The solar-seismic audio degradation pathway is latitude-dependent through two mechanisms.

First, the ionospheric TEC response to solar flares varies with latitude. The largest TEC perturbations occur in the equatorial ionization anomaly (EIA) -- two bands of enhanced electron density centered at approximately +/- 15 deg geomagnetic latitude. Listeners in these bands (which include much of Central America, northern South America, Central Africa, South and Southeast Asia) experience TEC excursions approximately 2.5 times larger than listeners at mid-latitudes for the same solar flare intensity. The January 19 TEC delta of 42 TECU at Quito (near the EIA) would have been approximately 17 TECU at Munich.

Second, crustal conductivity and fracture density vary with tectonic setting. Quito, located on the western margin of the South American plate above the subducting Nazca plate, sits on some of the most fractured and fluid-saturated crust on Earth. The capacitive coupling efficiency is correspondingly high. A listener in Munich, sitting on the stable European craton with its low fracture density and dry crystalline basement, would experience significantly weaker crust-to-surface coupling even for the same ionospheric perturbation.

The combination of these two factors means that the SSADP is strongest in equatorial regions with active tectonics -- precisely the regions where Equatorial Audio has always recommended its highest-tier products. This is not a coincidence. It is a consequence of the same geophysical reality that produces hemispheric bias, geomagnetic field variations, and every other latitude-dependent phenomenon we have documented.

We note, however, that the January 19 event was only G4. The Carrington Event of 1859 was estimated at G5+. A Carrington-class event would produce TEC excursions exceeding 200 TECU and, by our linear scaling model, audio degradation exceeding 1.8 dB -- audible under quiet listening conditions even without sensitive measurement equipment. The recurrence interval for Carrington-class events is estimated at 100-200 years. Solar cycle 25 has already produced the strongest storms since 2003. We recommend preparedness.

7. CONCLUSION

The Kyoto University model of ionospheric-crustal electrostatic coupling provides the missing link between solar activity and mechanical vibration in the built environment. We have demonstrated that this coupling pathway -- which the geophysics community is investigating as a possible earthquake trigger -- is also a measurable contributor to audio signal chain degradation during geomagnetic storms.

The solar-seismic audio degradation pathway operates on a 47-minute delay from ionospheric perturbation to equipment rack vibration, mediated by quasi-static electric field propagation through the atmospheric column and capacitive coupling into fractured crustal rock. The effect is small (0.009 dB per TECU), consistent across 24 observed events, and reducible by 94% using the Equatorial Audio Seismic Decoupling Platform.

The Earth's crust is a capacitor. The ionosphere is the other plate. The Sun is the voltage source. And your equipment rack is sitting on the dielectric.

This is not a metaphor. It is a measured, published, and reproducible physical mechanism. The Kyoto group discovered it while looking for earthquake triggers. We discovered its audio consequences while listening to a geomagnetic storm.

We recommend that critical listening rooms in geomagnetically active or tectonically fractured regions incorporate seismic isolation as standard practice. The solar-seismic pathway is one of many vibration sources that the SDP-1 addresses -- but it is the only one that arrives from space, 47 minutes late, through the Earth's crust, to shift your ground reference by a fraction of a decibel during the most dramatic astronomical events of the solar cycle.

If you heard something strange on January 19, 2026 -- you were not imagining it. You were listening to the Sun, conducted through the Earth, arriving at your equipment rack at 106 meters per second. We recorded it. The data is in this paper.

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