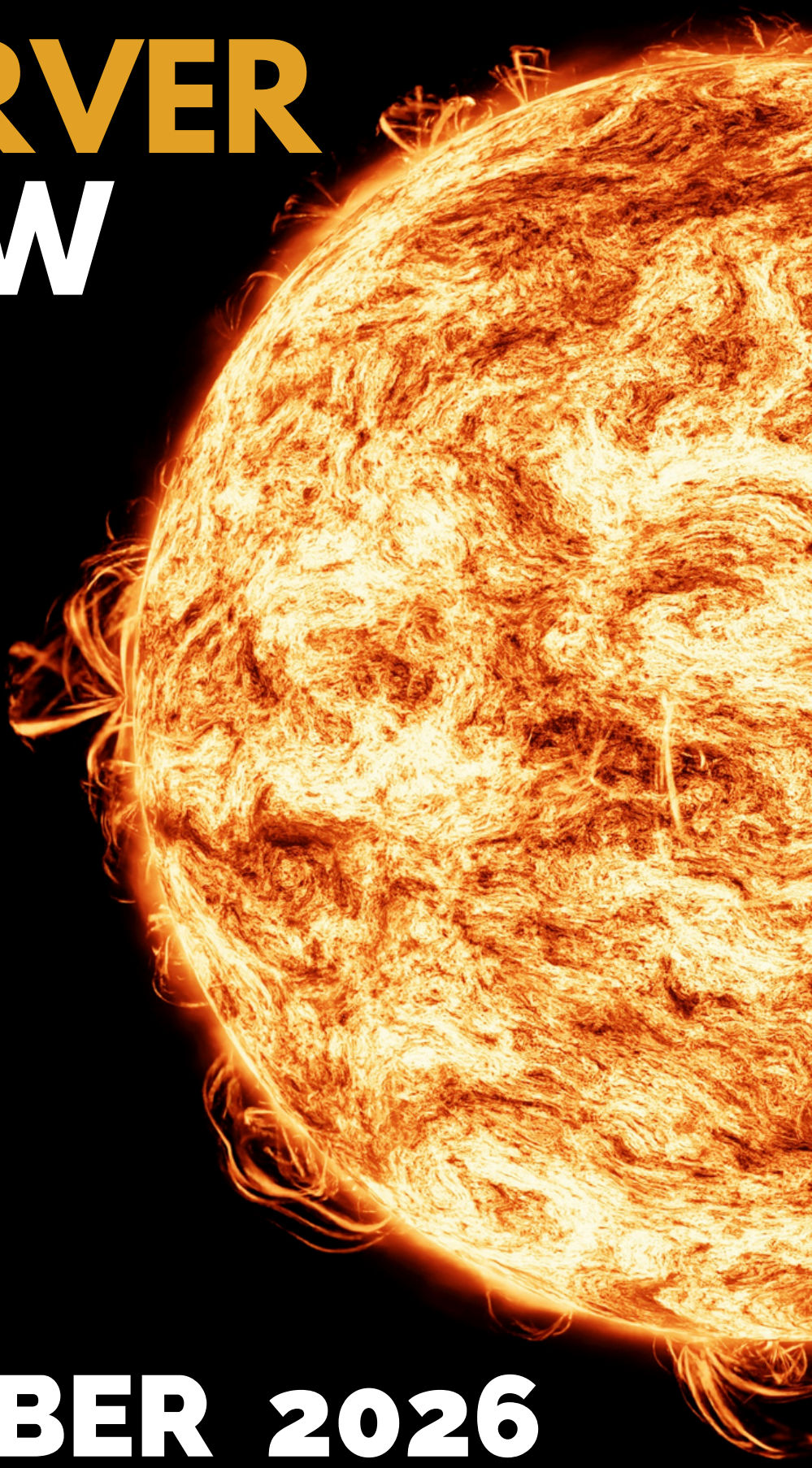
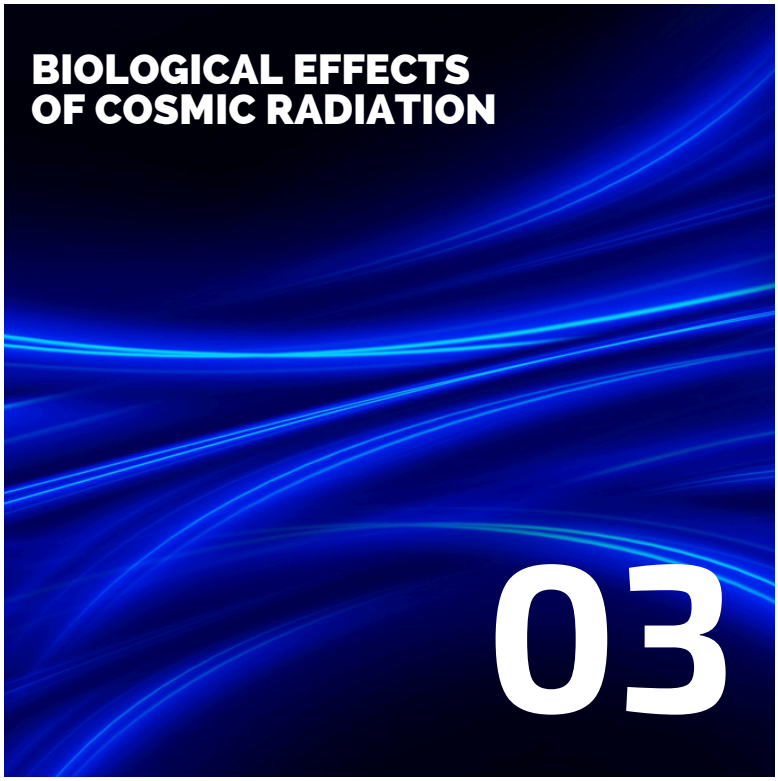
THE OBSERVER REVIEW



SEPTEMBER 2026

CONTENTS
SEPTEMBER





AFRICA'S MAGNETIC RECORD REVEALS FASTER GEOMAGNETIC CHANGE THAN MODELS CAPTURE

A new archaeomagnetic study from Sub-Saharan Africa is helping fill one of the largest geographic gaps in that record, and its results suggest that the magnetic field over parts of Africa has changed more rapidly than existing global geomagnetic models have reconstructed.

FEATURED ARTICLES

08 **MAGNETIC FIELDS ALTER INSECT BIOLOGY**

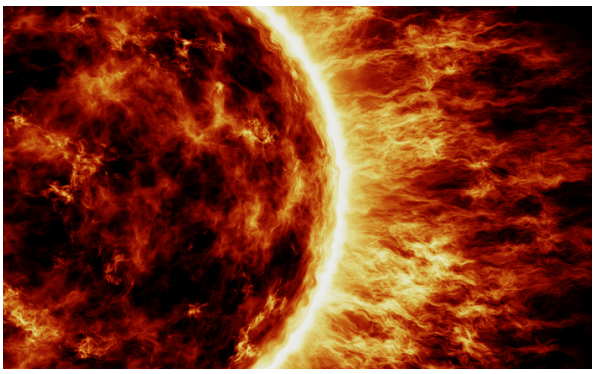
11 **SUPERSTORM EVENT**

14 **ATLANTIC SURFACE CIRCULATION**

The Atlantic Ocean is not simply transporting water. Its interconnected system of surface and deep-ocean currents moves enormous quantities of heat between the tropics, poles, atmosphere, and deep ocean, making Atlantic circulation one of the major regulators of Earth's climate.

15 **SPACE WEATHER AGING**

18 **WHAT IS THE STRONGEST SUPER FLARE OUR SUN CAN PRODUCE?**



20 **EMERGING CORONAL HOLES DURING SOLAR CYCLE 24**

23 **PROTON STORMS AND PAST EARTH WARMING**

BIOLOGICAL EFFECTS OF COSMIC RADIATION

BY: BAILEY LAURISSA

ARTICLE REFERENCED:
PILOTS, FLIGHT ATTENDANTS HAVE GREATER RISK OF RADIATION-RELATED CANCER DEATH THAN OTHER PROFESSIONS

A large new analysis of occupational mortality in the United States has identified pilots and flight attendants as the two professions with the highest proportions of deaths from cancers associated with ionizing radiation.

Researchers analyzed nearly 13 million U.S. death records from 2020 through 2024, spanning 503 occupations and including approximately 14,000 pilots and 7,000 flight attendants. After adjusting for age at death, sex, race, ethnicity, educational attainment, and marital status, the researchers found that aircrew stood apart from other professions in mortality from several cancers classified in the analysis as radiation-related.

Approximately 6.9 percent of deaths among flight attendants and 6.7 percent among pilots were attributed to these cancers, placing the two occupations first and second among all 503 professions studied. Pilots and flight attendants showed significantly elevated mortality from breast cancer, central nervous system cancers, prostate cancer, and melanoma, while pilots additionally showed elevated leukemia mortality.

The comparison with other radiation-exposed professions is particularly notable. Nuclear technologists, whose work involves recognized occupational exposure to ionizing radiation, ranked 12th. Meanwhile, aircraft mechanics and assemblers, who work within the same broad aviation industry but remain predominantly at ground level, did not demonstrate the same elevation.

THAT DISTINCTION DIRECTS ATTENTION TOWARD WHAT CHANGES WHEN AN AIRCRAFT LEAVES THE GROUND: THE ATMOSPHERE ABOVE IT BECOMES PROGRESSIVELY THINNER.



ESTIMATES CITED BY THE RESEARCHERS PLACE OCCUPATIONAL EXPOSURE FOR AIRCREW AT ROUGHLY 3 TO 6 MILLISIEVERTS PER YEAR, DEPENDING PARTLY ON ROUTES FLOWN. BY COMPARISON, AN AVERAGE TRAVELER TAKING TEN CROSS-COUNTRY ROUND TRIPS ANNUALLY IS ESTIMATED TO RECEIVE APPROXIMATELY 0.4 MILLISIEVERTS FROM AVIATION-RELATED COSMIC RADIATION.



Exposure also varies geographically. Because charged particles interact with Earth's magnetic field, geomagnetic latitude influences how readily energetic particles can penetrate toward the atmosphere. Polar and high-latitude routes can consequently experience greater cosmic-radiation exposure than lower-latitude routes.

This means that occupational dose is determined not simply by hours in the air, but by altitude, latitude, flight path, solar conditions, geomagnetic conditions, and the energy spectrum of incoming particles.

One of the more important findings is what the researchers did not observe.

Aircrew did not show a comparable increase in mortality from cancers categorized as unrelated to radiation. Their rates of death from these cancers were similar to those of the broader U.S. population.

There is another unusual aspect of the findings.

The Federal Aviation Administration already recognizes pilots and flight attendants as occupationally exposed to ionizing radiation. Yet U.S. aircrew are not subject to the same federal radiation-dose limits and routine monitoring requirements applied to many other radiation-exposed workers.

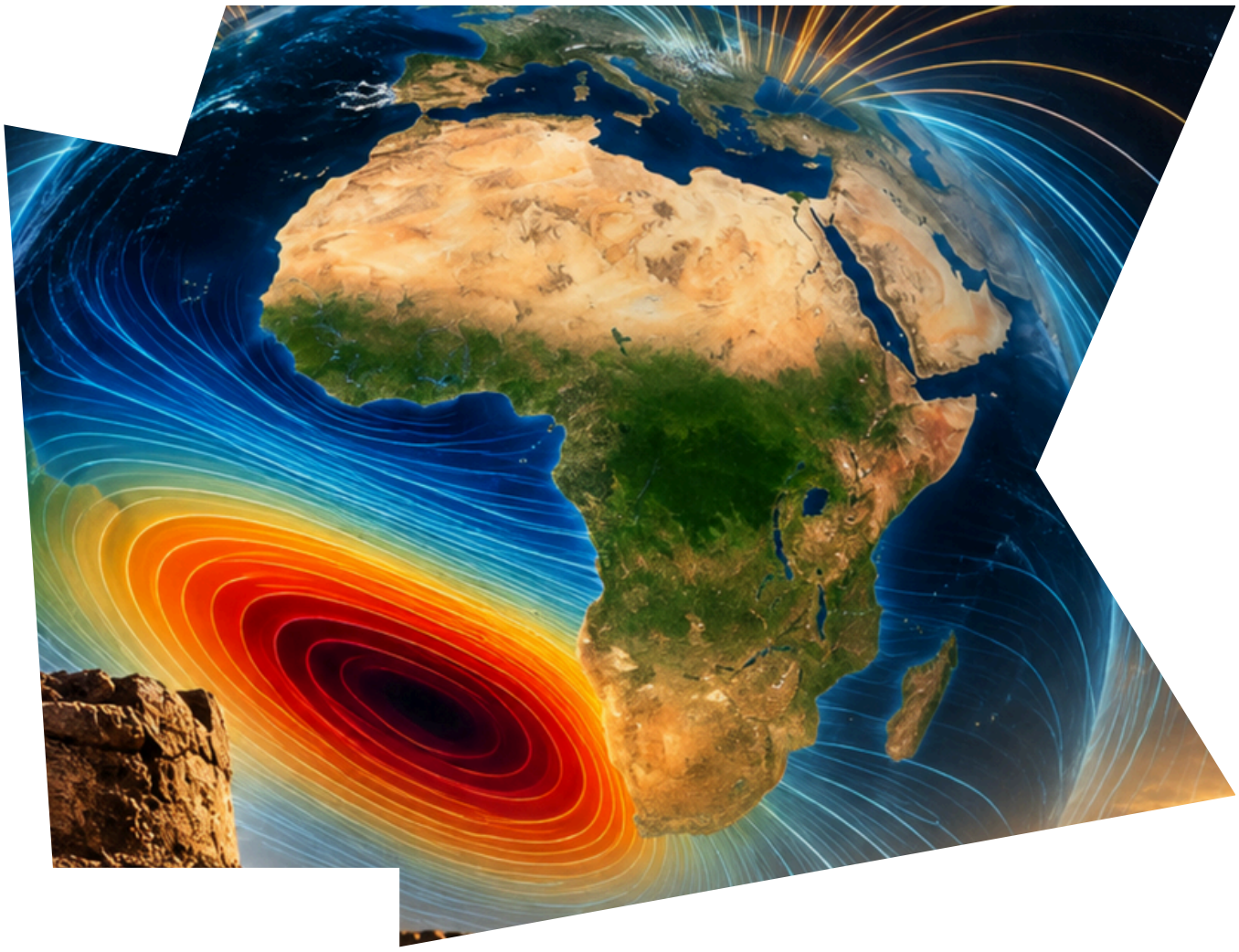
OVERALL, THE SUN, HELIOSPHERE, GEOMAGNETIC FIELD, AND ATMOSPHERE COLLECTIVELY REGULATE THE ENERGETIC-PARTICLE ENVIRONMENT SURROUNDING EARTH. HUMAN BIOLOGY EXISTS INSIDE THAT SYSTEM.

AFRICA'S MAGNETIC RECORD

BY: BAILEY LAURISSA

ARTICLE REFERENCED:
SECULAR VARIATION OF THE GEOMAGNETIC FIELD IN SUB-SAHARAN AFRICA OVER THE LAST MILLENNIA: NEW ARCHAEOMAGNETIC DATA FROM WEST AFRICA AND ETHIOPIA.

A NEW ARCHAEOMAGNETIC STUDY FROM SUB-SAHARAN AFRICA IS HELPING FILL ONE OF THE LARGEST GEOGRAPHIC GAPS IN THAT RECORD, AND ITS RESULTS SUGGEST THAT THE MAGNETIC FIELD OVER PARTS OF AFRICA HAS CHANGED MORE RAPIDLY THAN EXISTING GLOBAL GEOMAGNETIC MODELS HAVE RECONSTRUCTED.



The finding is particularly important because intertropical Africa is already experiencing some of the most rapid changes observed in Earth's modern magnetic field. It also lies adjacent to the South Atlantic Anomaly, the enormous region of unusually weak magnetic field intensity extending across the South Atlantic and into parts of South America and Africa.

To reconstruct earlier centuries and millennia, researchers rely on archaeomagnetism: the study of magnetic signals preserved in materials that were heated in the past.

When clay, rock, or other magnetic materials are heated above sufficiently high temperatures, their magnetic minerals can lose their previous magnetization. As the material subsequently cools, those minerals acquire a new magnetization aligned with the surrounding geomagnetic field.

The result is effectively a magnetic snapshot of Earth at the time of cooling.
Kilns, furnaces, hearths, pottery, and other fired archaeological materials can therefore preserve information about both the direction and intensity of the ancient geomagnetic field.

The problem in Africa is simply the scarcity of measurements.

According to the researchers, the enormous region examined in this study accounts for only about 0.7% of the data contained within the GEOMAGIA50 archaeomagnetic database. That lack of observations creates correspondingly large uncertainties when global magnetic-field models attempt to reconstruct what Earth's field was doing over Africa thousands of years ago.

Those uncertainties also complicate attempts to determine the longer-term history of the modern South Atlantic Anomaly.

TO IMPROVE THE RECORD, RESEARCHERS COLLECTED ARCHAEOLOGICAL MATERIAL FROM FOUR WIDELY SEPARATED REGIONS OF AFRICA: SOUTHERN BENIN, NORTHERN TOGO, EASTERN SENEGAL, AND NORTHEASTERN ETHIOPIA.

THE STRUCTURES SPAN ROUGHLY FOUR MILLENNIA OF HISTORY.

The oldest site was an Ethiopian oven dating to approximately the middle of the second millennium BCE. Researchers also examined 11 iron-smelting furnaces in Senegal dating from approximately 500 BCE to 800 CE, five furnaces in Benin dating from the 13th to 15th centuries CE, and seven furnaces in Togo dating from the 18th to 20th centuries CE.

Additional baked materials associated with iron production were collected in Benin, including furnace walls, tuyeres, and pottery.

Importantly, many structures were sampled while still in their original positions.
That allows researchers to reconstruct not simply the strength of the ancient magnetic field, but its orientation. Using thermal demagnetization, the team isolated the magnetic signal acquired during the structures' final heating and cooling.

The researchers ultimately obtained 13 average archaeomagnetic directions: one from Ethiopia, five from Benin, and seven from Togo.

The Senegalese furnaces proved more difficult. Their magnetic directions were scattered, which the researchers attribute to the probable tilting or movement of furnace walls after their final heating. If a structure moves after cooling, its preserved magnetic orientation no longer necessarily represents its original position relative to Earth's field.

The researchers also attempted to determine how strong Earth's magnetic field was when these materials cooled.

They used the Thellier-Thellier method, a standard experimental technique for reconstructing ancient geomagnetic intensity. The procedure progressively heats samples while comparing their original thermoremanent magnetization with magnetization acquired under controlled laboratory magnetic fields.

Corrections were applied for magnetic anisotropy and differences between ancient and laboratory cooling rates, both of which can influence the resulting intensity estimate.

The experiments produced a relatively high average success rate of approximately 75%.
In total, the study generated 21 new average archaeointensity measurements, including data from the Ethiopian oven, ten measurements associated with Beninese furnaces, seven from Togo, and three preliminary results from Senegal.

The 19th- and 20th-century measurements from Togo closely matched the magnetic field predicted for the region by existing global geomagnetic models.

That agreement is significant because the modern period is comparatively well constrained by historical and instrumental observations. If the archaeological materials recover approximately the same magnetic field independently predicted from other observations, it increases confidence that the experimental techniques are accurately recovering the ancient field.

The earlier measurements tell a more interesting story.

Where previous archaeomagnetic observations exist, including West African measurements from the 13th through 15th centuries, the new results generally agree with them.

But when compared with global geomagnetic reconstructions, the African data indicate faster secular variation than the models currently reproduce.

This finding reinforces the possibility that unusual magnetic behavior beneath Africa has have deeper roots that can lead to understanding our present field and it's role in the cycle more.

MAGNETIC FIELDS ALTER INSECT BIOLOGY

BY: BAILEY LAURISSA

ARTICLE REFERENCED:

DOI. NO.: 10.55446/IJE.2026.3871STIMULATORY EFFECTS OF MAGNETIC FIELD ON THE PREDATORY MITEPHYTOSEIULUS PERSIMILIS AND ITS PREY TETRANYCHUS URTICAE

A NEW LABORATORY STUDY SHOWS THAT STATIC MAGNETIC FIELDS CAN SIGNIFICANTLY ALTER THE BIOLOGY OF BOTH A MAJOR AGRICULTURAL PEST AND ONE OF ITS MOST IMPORTANT NATURAL PREDATORS.

THE FINDINGS ADD TO A GROWING BODY OF MAGNETOBIOLOGY RESEARCH SHOWING THAT MAGNETIC EXPOSURE CAN INFLUENCE BIOLOGICAL PROCESSES RANGING FROM DEVELOPMENT AND REPRODUCTION TO FEEDING BEHAVIOR.

Researchers examined the predatory mite Phytoseiulus persimilis, a biological control species widely used against the two-spotted spider mite Tetranychus urticae. The latter is a major agricultural pest capable of damaging numerous crops, while P. persimilis is highly specialized for hunting spider mites and is commonly incorporated into integrated pest management programs as an alternative to chemical acaricides.

The researchers exposed both species to static magnetic fields of 12.5, 86.0, and 99.0 millitesla and compared their development, reproduction, longevity, egg hatchability, and, in the case of the predator, feeding behavior with untreated controls. The mites were maintained under controlled laboratory conditions at 25 ± 2 °C and 65 ± 5 percent relative humidity. The magnetic fields were generated using arrays of permanent magnets positioned beneath the rearing cells.

One of the clearest findings was a substantial shortening of the life cycle under stronger magnetic fields.

For female P. persimilis, the complete life cycle declined from 9.66 days in the untreated group to 8.33 days at 12.5 millitesla, 7.66 days at 86 millitesla, and only 5.33 days at 99 millitesla. Male development followed a similar pattern, declining from 8.33 days in controls to 5.33 days under the strongest field.

The prey species responded in much the same way. Female T. urticae required approximately 13 days to complete its life cycle without magnetic exposure. That fell to 10 days at 12.5 millitesla, 7.33 days at 86 millitesla, and 6.33 days at 99 millitesla. Male life cycles declined from 11.33 to 5.66 days across the same range.

The effect therefore was not simply inhibitory or damaging.

At least for developmental timing, increasing magnetic intensity was associated with markedly accelerated biological activity in both predator and prey.

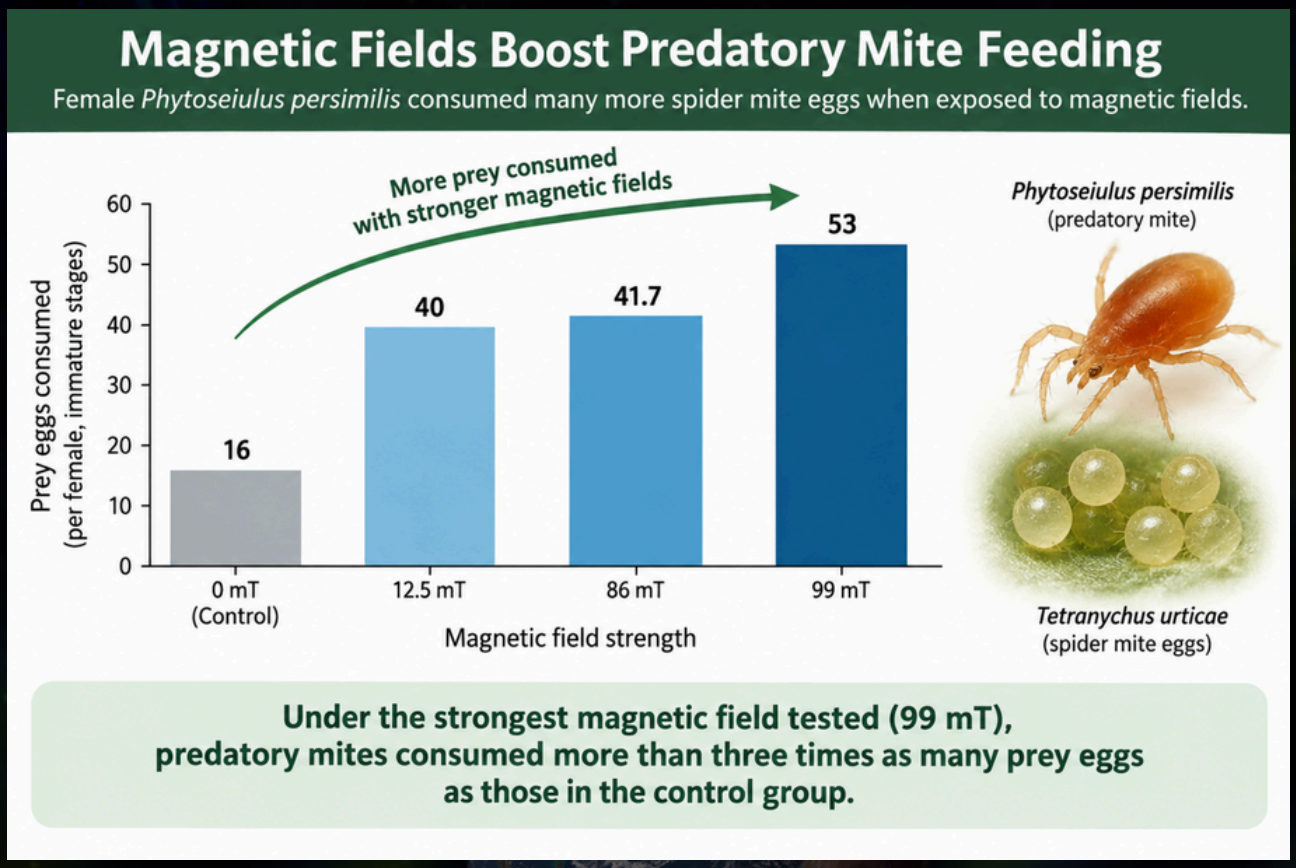
Untreated P. persimilis females produced approximately 100 eggs each. Exposure to 12.5 millitesla increased this modestly to 110 eggs, but at 86 millitesla fecundity rose to approximately 230 eggs per female, more than twice the control value. At 99 millitesla, females still produced approximately 210 eggs.

Importantly, increased egg production did not initially come at the expense of egg viability. Hatchability remained at 100 percent through the 86-millitesla treatment. Only at the strongest exposure, 99 millitesla, did predator egg hatchability decline, falling to approximately 90.47 percent.

The pest mite displayed a different pattern.

T. urticae fecundity increased from 87.33 eggs per female in controls to 90 at 12.5 millitesla, 160 at 86 millitesla, and 200 at 99 millitesla. But the ability of those eggs to hatch deteriorated sharply as field strength increased. Hatchability declined from 100 percent in controls to 94.81 percent at 12.5 millitesla, 56.03 percent at 86 millitesla, and just 39.66 percent at 99 millitesla.

This distinction is important. Strong magnetic exposure stimulated the pest to produce more eggs, but a progressively smaller fraction of those eggs successfully hatched.



Perhaps the most consequential result for biological pest control involved feeding behavior.

The immature female predator stages consumed a combined 16 T. urticae eggs under control conditions. Consumption increased to 40 eggs at 12.5 millitesla, 41.66 at 86 millitesla, and 53 eggs at 99 millitesla, more than tripling the control value. Adult females showed substantial feeding activity as well.

During the oviposition period, females exposed to 99 millitesla consumed as many as 520 prey eggs. The researchers concluded that magnetically treated P. persimilis exhibited higher predation rates than untreated individuals, potentially increasing the predator's ability to suppress spider-mite populations.

Taken together, the predator was developing faster, producing substantially more offspring, and consuming more prey following magnetic exposure.

Here we have two closely interacting arthropod species exposed to the same physical environmental variable, yet their biological responses are not identical. Both experienced accelerated development and increased egg production, but high-intensity exposure severely reduced hatchability in the pest while having a much smaller effect on the predator. Meanwhile, predatory activity itself increased.

SUPERSTORM EVENT

BY: BAILEY LAURISSA

ARTICLE REFERENCED:

IMPACTS OF MID-LATITUDE IONOSPHERIC DYNAMICS ON RF APPLICATIONS DURING THE NOVEMBER 2025 SUPERSTORM EVENT

AS YOU MAY REMEMBER, A MAJOR GEOMAGNETIC STORM IN NOVEMBER 2025 DID MORE THAN PUSH THE AURORA UNUSUALLY FAR SOUTH. IT ALTERED THE IONOSPHERE ACROSS MUCH OF THE CONTINENTAL UNITED STATES, CREATING PLASMA STRUCTURES CAPABLE OF DISRUPTING SATELLITE NAVIGATION SIGNALS AND PRODUCING POSITIONING ERRORS EXCEEDING 10 METERS.

It altered the ionosphere across much of the continental United States, creating plasma structures capable of disrupting satellite navigation signals and producing positioning errors exceeding 10 meters.

A new study published in Geophysical Research Letters documents what the researchers describe as the first observation of strong amplitude scintillation extending across mid-latitude North America over a broad range of longitudes.

The event connects a familiar signature of geomagnetic disturbance, the expanding auroral oval, with a much more practical consequence: degradation of the radio signals underlying Global Navigation Satellite System, or GNSS, positioning.

The disturbance began when the interplanetary magnetic field turned sharply southward on November 11, 2025, allowing stronger coupling between the solar wind and Earth's magnetosphere.

The resulting geomagnetic storm reached a minimum Dst of −240 nanotesla, while the planetary Kp index reached 9, indicating extreme geomagnetic activity. Auroral electrojet activity also surged during several intervals as energy was deposited into the upper atmosphere.



THE IMPORTANT PART OF THIS EVENT IS NOT SIMPLY THAT AURORAS APPEARED FARTHER SOUTH. THE ENTIRE REGION ASSOCIATED WITH AURORAL PARTICLE PRECIPITATION MOVED WITH THEM.

DURING THE MAIN PHASE OF THE STORM, RESEARCHERS OBSERVED AN INTENSE EAST-WEST BAND OF AURORAL BRIGHTNESS EXPANDING EQUATORWARD. THE AURORAL SYSTEM MOVED BEYOND 60° NORTH GEOMAGNETIC LATITUDE AND WAS ACCOMPANIED BY A LARGE ENHANCEMENT IN TOTAL ELECTRON CONTENT, OR TEC, EXTENDING ACROSS MUCH OF NORTH AMERICA. A SHARP ELECTRON-DENSITY GRADIENT DEVELOPED NEAR APPROXIMATELY 45° NORTH MAGNETIC LATITUDE.

THAT GRADIENT BECAME THE CRITICAL LINK BETWEEN THE GEOMAGNETIC STORM AND THE DISRUPTION OF RADIO SIGNALS.

The ionosphere is not a uniform shell of plasma. Its electron density varies across space and time, and strong gradients can become unstable.

During disturbed geomagnetic conditions, energetic particles entering the ionosphere can alter plasma density and generate steep spatial gradients. When those gradients interact with electric fields and plasma motion, instabilities can develop and break larger structures into progressively smaller irregularities.

Normally, these processes are most prominent at high latitudes. Mid-latitude regions, including much of the continental United States, are comparatively stable.

A sufficiently powerful geomagnetic storm changes that geography.

As the auroral oval expanded southward in November 2025, the researchers found a broad strip of enhanced electron density stretching roughly east to west. Immediately adjacent to it was a strong density gradient. Measurements of the rate of change of TEC showed that this same region contained substantial smaller-scale plasma irregularities.

The storm had effectively transported high-latitude ionospheric dynamics into a region where they are normally much less severe.

One of the most interesting aspects of the study is that simply increasing electron density is not enough to produce severe amplitude scintillation.
The size of the irregularities matters.

For L-band satellite signals, the researchers discuss Fresnel-scale plasma structures on the order of approximately 0.37 to 0.5 kilometers. Irregularities at these scales can diffract radio waves as they propagate through the ionosphere. Larger structures can strongly affect signal phase, but the presence of sufficiently small structures is particularly important for producing amplitude fading.

At the same time, the background ionosphere must contain enough electrons for those structures to substantially affect the signal.

The November storm supplied both requirements.

The study estimated electron densities of roughly 1.15×10^6 electrons per cubic centimeter within regions exceeding 30 TECU.

Even near the sharp gradient, estimated peak density reached approximately 0.77×10^6 electrons per cubic centimeter, above the threshold cited by the researchers for producing meaningful L-band amplitude scintillation.

In other words, the storm created both a dense ionosphere and the small-scale structure necessary to distort satellite signals.

ATLANTIC SURFACE CIRCULATION

BY: BAILEY LAURISSA

ARTICLE REFERENCED:
PHASE TRANSITION IN THE ATLANTIC SURFACE CURRENTS

The Atlantic Ocean is not simply transporting water. Its interconnected system of surface and deep-ocean currents moves enormous quantities of heat between the tropics, poles, atmosphere, and deep ocean, making Atlantic circulation one of the major regulators of Earth's climate.

A new study identifies evidence that part of this system has undergone a significant transition.

Researchers report a previously unrecognized pattern of Atlantic surface circulation called the Atlantic Convergence–Divergence Mode, or ACDM. More importantly, their analysis suggests that this circulation pattern shifted into a distinctly weaker state around 2009, coinciding with changes observed in the Atlantic Meridional Overturning Circulation.

The Atlantic Meridional Overturning Circulation, or AMOC, is the large-scale system responsible for transporting warm upper-ocean water northward and returning colder, denser water southward at depth.

But between the atmosphere above and the overturning circulation below lies another component of the system: the Atlantic's surface currents.

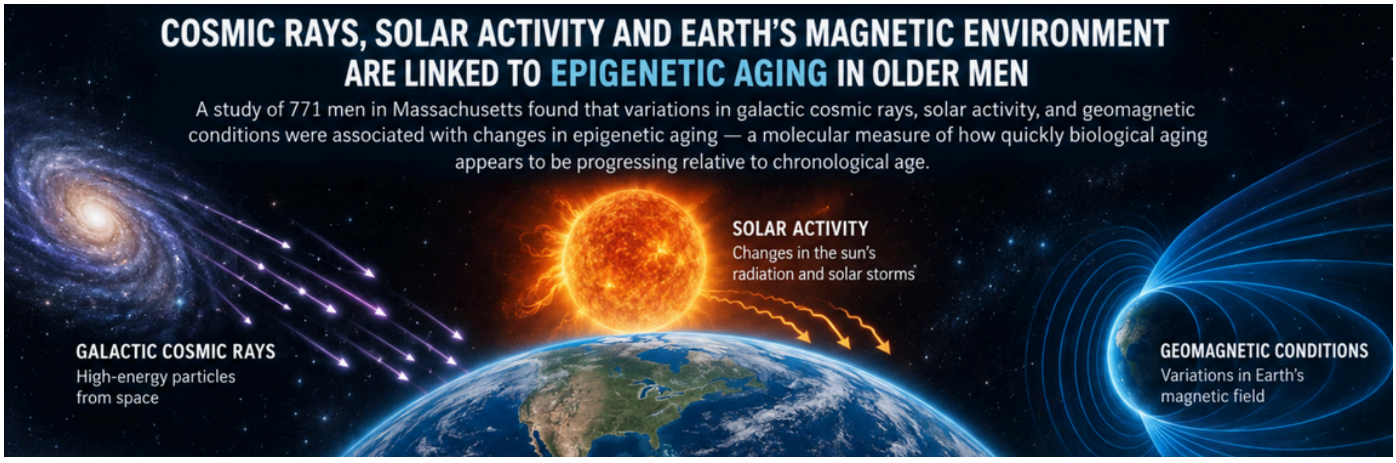
The researchers identified a large-scale pattern within these currents that had not previously been characterized as a distinct circulation mode.
They call it the Atlantic Convergence–Divergence Mode. In the North Atlantic, the mode is characterized by regions where surface waters converge and diverge. In the South Atlantic, it appears as coherent north-south, or meridional, flows. These movements matter because convergence and divergence at the surface influence vertical exchanges of water. Surface circulation therefore provides an important connection between atmospheric forcing, upper-ocean heat transport, and deeper circulation.

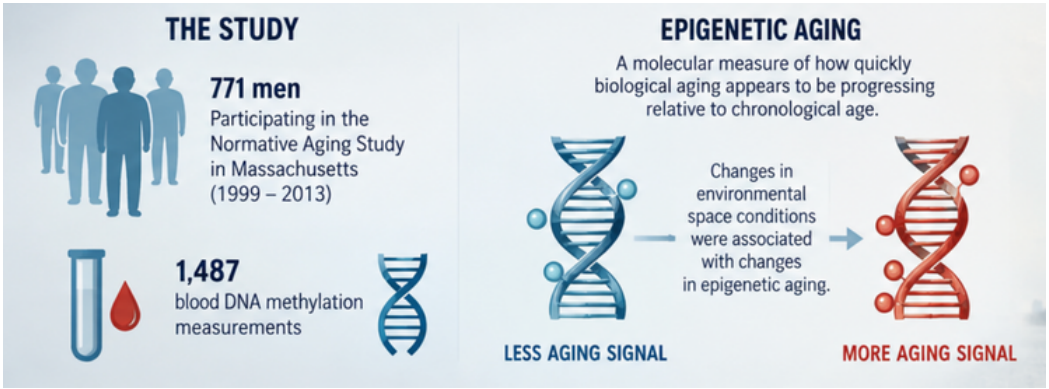
SPACE WEATHER AGING

BY: BAILEY LAURISSA

ARTICLE REFERENCED:
SPACE WEATHER FLUCTUATIONS AND EPIGENETIC AGING IN AN ELDERLY MALE COHORT FROM MASSACHUSETTS, USA

Researchers studying an elderly male population in Massachusetts found that variations in galactic cosmic rays, solar activity, and geomagnetic conditions were associated with changes in epigenetic aging, a molecular measure of how quickly biological aging appears to be progressing relative to chronological age. The peer-reviewed study analyzed 1,487 blood DNA methylation measurements collected from 771 men participating in the long-running Normative Aging Study between 1999 and 2013.





The findings are particularly interesting for Observers because the associations moved in opposite directions depending on the space-weather environment. Higher galactic cosmic-ray exposure was associated with faster epigenetic aging, while greater solar activity was generally associated with slower epigenetic aging.

Epigenetic aging does not measure aging simply by counting years. Instead, researchers examine chemical modifications to DNA, particularly DNA methylation, that change predictably as humans age. These patterns can be incorporated into "epigenetic clocks" that estimate biological age.

The researchers calculated four established measures: HorvathAgeAccel, HannumAgeAccel, PhenoAgeAccel, and GrimAgeAccel. They then compared those measurements with several indicators of the space environment, including sunspot number, interplanetary magnetic field strength, the planetary Kp index, neutron-monitor counts, and modeled cosmic-ray-induced atmospheric ionization.

Rather than examining only individual solar storms, the researchers used a prespecified 30-day moving average for each space-weather parameter. This allowed them to investigate whether the changing background space environment over weeks corresponded with measurable biological differences.

And it did.

One of the clearest patterns involved galactic cosmic rays.

When neutron-monitor counts increased by one interquartile range, Horvath epigenetic age acceleration increased by approximately 0.32 years, while Hannum age acceleration increased by approximately 0.29 years. Both associations were statistically significant in the fully adjusted models.

Neutron monitors provide an indirect measurement of the secondary particle cascades produced when high-energy cosmic rays collide with Earth's atmosphere. Although Earth's atmosphere and magnetic field dramatically reduce radiation exposure at the surface compared with space, cosmic-ray intensity at ground level is not constant.

It changes partly because of the Sun.

During periods of stronger solar activity, the expanded and more disturbed heliospheric magnetic environment tends to reduce the number of galactic cosmic rays reaching the inner solar system. During quieter solar conditions, cosmic-ray intensity generally increases. The study period itself displayed this inverse relationship: sunspot number, interplanetary magnetic field strength, and geomagnetic activity rose and fell broadly opposite to cosmic-ray-induced ionization and neutron counts.

Higher solar activity showed the opposite association.

FOR EVERY INTERQUARTILE-RANGE INCREASE IN THE 30-DAY AVERAGE SUNSPOT NUMBER, HORVATH AGE ACCELERATION WAS APPROXIMATELY 0.61 YEARS LOWER, WHILE PHENOAGE ACCELERATION WAS APPROXIMATELY 0.50 YEARS LOWER. GREATER INTERPLANETARY MAGNETIC FIELD STRENGTH WAS ALSO ASSOCIATED WITH LOWER HANNUM AGE ACCELERATION, BY APPROXIMATELY 0.25 YEARS PER INTERQUARTILE-RANGE INCREASE.

The researchers went beyond biological-age clocks and performed an exploratory epigenome-wide association analysis to determine whether particular DNA methylation sites changed alongside space-weather conditions.
The scale of the signal was substantial.

Hundreds of CpG sites were associated with measures of galactic cosmic rays, with most showing decreased methylation. Solar and geomagnetic activity, meanwhile, were associated with thousands of CpG sites, predominantly showing increased methylation.

The affected regions were not randomly distributed across biological functions. Pathway analyses highlighted processes involving p53 signaling, DNA damage response and repair, and inflammatory pathways.

These are systems involved in maintaining genomic integrity and responding to cellular stress.

That finding gives the observed aging associations additional biological context.

Rather than detecting only a statistical change in an aging clock, the researchers identified methylation differences involving some of the same cellular systems expected to respond to radiation and environmental stress.

THE FINDINGS ALSO BUILD ON PREVIOUS RESEARCH INVOLVING THE SAME NORMATIVE AGING STUDY POPULATION. THE RESEARCHERS HAD PREVIOUSLY REPORTED ASSOCIATIONS BETWEEN SPACE-WEATHER CONDITIONS AND SHORTER TELOMERE LENGTH, ANOTHER BIOMARKER CONNECTED WITH CELLULAR AGING.

WHAT IS THE STRONGEST SUPER FLARE OUR SUN CAN PRODUCE?

BY: BAILEY LAURISSA

ARTICLE REFERENCED:
EMPIRICAL FLARE ENERGY LIMITS FOR THE LARGEST HISTORICAL SUNSPOTS

This is one of the more interesting concepts of a study we have come across in the past few years. A new 2026 study published in Philosophical Transactions of the Royal Society A attempts to look beyond that observational window by asking a consequential question: How powerful a flare could the Sun produce if one of the largest sunspot regions in recorded history released its available magnetic energy?

Natalie Krivova and colleagues approached the problem empirically, using relationships observed between modern solar flare energies and the areas swept out by flare ribbons. They then extrapolated those relationships to an extraordinary historical active region: the Great Sunspot of April 1947.

Their conclusion pushes the plausible upper boundary of solar activity well beyond the events witnessed during the satellite era.

Exceptionally large and magnetically complex solar active regions may be capable, in principle, of producing flares with bolometric energies reaching a few × 10^{33} ergs.
That puts the question of solar "superflares" into a very different context.

On April 8, 1947, an enormous sunspot group crossed the visible solar disk.

The region remains particularly valuable to researchers because it represents the largest sunspot group recorded in the historical dataset examined by the authors, extending the observational record back well before the era of modern spacecraft.

Modern observations show that flare magnitude is therefore related to the magnetic structure and physical scale of the active region producing it.

Krivova and colleagues used that relationship to ask what might happen if a region approaching the extraordinary scale of the 1947 sunspot underwent an exceptionally efficient magnetic-energy release.

Rather than simply assuming that a larger sunspot must produce a proportionally larger flare, the researchers based their estimate on observations of flare ribbons.

During major eruptions, bright ribbons form in the lower solar atmosphere as magnetic reconnection restructures the coronal magnetic field above them. The area covered by these ribbons provides information about how much magnetic flux participates in the eruption.

Modern observations allow researchers to compare flare-ribbon area with the total energy released by a flare.

The study examined statistical relationships between these quantities and focused particularly on the upper envelope of the observations: the most energetic flares produced for a given ribbon area.

The researchers then extended those empirical relationships to active regions considerably larger than those responsible for the strongest well-observed modern flares.

The 1947 sunspot provides the critical historical test case.

If an exceptionally large fraction of an active region of that magnitude participated in a flare, the extrapolation indicates that the resulting event could release a few 10^{33} ergs of total radiative, or bolometric, energy.

For perspective, 10^{33} ergs equals approximately 10^{26} joules.

A flare of several times that value would therefore represent an enormous release of energy occurring on solar-eruption timescales.

The result is particularly interesting because astronomers have discovered much more energetic flares occurring on stars broadly similar to the Sun.
Observations of Sun-like stars have revealed "superflares," some exceeding energies historically associated with solar flares. According to the study, stellar observations indicate that Sun-like stars can produce superflares above the relevant extreme-energy range on roughly century-scale occurrence rates within the stellar samples considered.
That observation has generated a persistent question in solar physics:
Can our own Sun do the same thing? The new analysis does not establish that the Sun has produced such a flare in recent history, nor does it predict that one will occur.

Instead, it addresses the physical plausibility of the lower end of the superflare regime. The researchers' empirical extrapolation suggests that the dimensions of the largest historical solar active regions do notautomatically rule out flare energies reaching several × 10^{33} ergs.

In other words, the historical Sun appears capable of creating magnetic structures large enough that a flare approaching superflare energies cannot be dismissed simply because nothing comparable has been directly measured during the modern observational era.

EMERGING CORONAL HOLES DURING SOLAR CYCLE 24



BY: BAILEY LAURISSA

ARTICLE REFERENCED:
SOLAR-CYCLE VARIATION OF NEWLY EMERGING CORONAL HOLES DURING SOLAR CYCLE 24

This study compiled a manually validated catalogue of newly emerging coronal holes from October 2010 through December 2019, covering most of Solar Cycle 24. Rather than measuring only how much of the Sun was already covered by coronal holes, the researchers tracked when new coronal holes appeared, providing a different view of how open magnetic flux develops as the solar cycle evolves.

One of the clearest results involved coronal holes appearing within 20 degrees of the solar equator.
Across 108 overlapping months, the researchers found a statistically significant negative correlation between monthly equatorial coronal-hole emergence and the International Sunspot Number. The Pearson correlation coefficient was −0.523, with a probability value of 6.2×10^{-9}. The Spearman correlation produced essentially the same result.

The fitted relationship indicated that for approximately every 20-point increase in monthly sunspot number, the number of newly emerging equatorial coronal holes decreased by roughly one per month.

The timing across Solar Cycle 24 illustrates the relationship particularly well. Equatorial coronal-hole emergence was elevated during 2010–2011, became broadly suppressed around the years surrounding solar maximum, and increased again as the Sun moved through its declining phase toward minimum in 2017–2019.

This behavior fits the broader magnetic evolution of the Sun. Sunspots represent concentrations of intense magnetic activity dominated by closed magnetic structures, while coronal holes represent regions where magnetic field lines extend outward into the heliosphere.

Solar activity is rarely perfectly symmetrical between the northern and southern hemispheres, and Solar Cycle 24 was particularly useful for examining this behavior because its two hemispheres reached their sunspot peaks at different times.

Across the entire catalogue, newly emerging coronal holes showed an overall southern preference. Approximately 62% of months were southern-dominated, compared with about 36% that were northern-dominated. But this dominance did not remain fixed.

The southern hemisphere dominated during the early rising phase of the cycle. Then, from approximately 2013 through 2015, the pattern reversed and the northern hemisphere became dominant. Southern dominance subsequently returned through much of 2016–2019.

That reversal becomes more intriguing when compared with sunspots.

The researchers calculated separate north-south asymmetry indices for coronal-hole emergence and sunspot activity. Instead of moving together, the two measurements tended to move in opposite directions.

The correlation between the two asymmetry indices was −0.461, with a probability value of 5.2×10^{-7}. Using the rank-based Spearman test produced an even stronger negative relationship of −0.504.

In practical terms, when sunspot activity strongly favored one hemisphere, newly emerging coronal holes tended to favor the other.

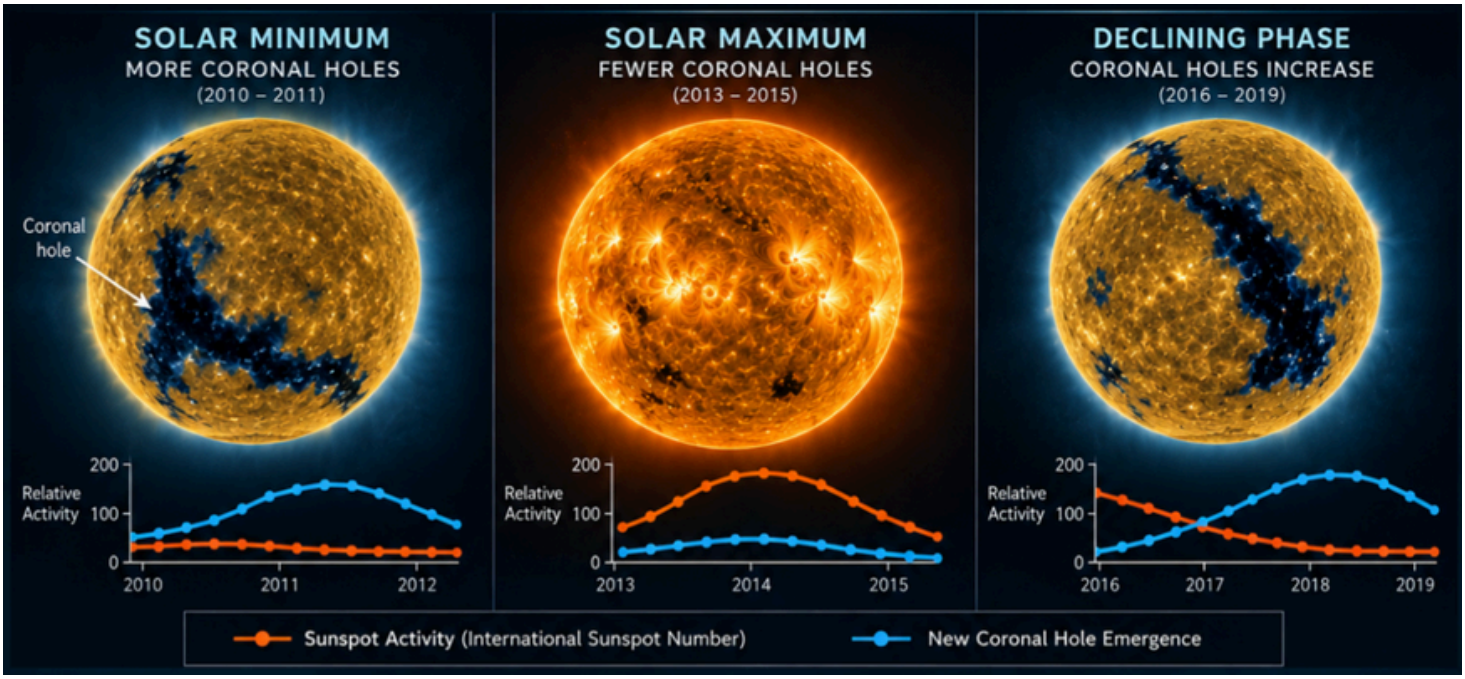
The authors point toward the unusual timing of Solar Cycle 24 as one possible explanation.

The northern hemisphere reached its sunspot maximum first, around November 2011. The stronger southern peak arrived in early 2014, producing a separation of approximately 26 months between the hemispheric maxima.

If open magnetic flux begins to recover after a hemisphere passes its own sunspot maximum, then the northern hemisphere would be expected to begin generating more coronal holes while the southern hemisphere was still progressing toward its later activity peak.

That is broadly what the observations show.

Coronal-hole asymmetry shifted northward during 2013–2015, after the northern sunspot peak but during the interval surrounding the later southern maximum.



The researchers also separated the observations into the rising, maximum, and declining phases of Solar Cycle 24.

THE DIFFERENCE WAS CLEAR.

During the rising phase, approximately 1.309 new coronal holes per observed day appeared across the Sun. During solar maximum, that rate fell to 1.190 per day. During the declining phase, it climbed to 1.420 per day, the highest of the three periods.

The equatorial regions showed an even stronger cycle dependence. New equatorial coronal holes appeared at approximately 0.204 per day during the rising phase, fell to only 0.109 per day during maximum, and then increased to 0.230 per day during the declining phase.

THIS MEANS THAT THE PERIOD OF MAXIMUM SUNSPOT ACTIVITY WAS NOT THE PERIOD WHEN NEW CORONAL HOLES WERE FORMING MOST RAPIDLY. INSTEAD, THEIR EMERGENCE ACCELERATED AS THE CYCLE MOVED AWAY FROM MAXIMUM.

PROTON STORMS AND PAST EARTH WARMING

BY: BAILEY LAURISSA

ARTICLE REFERENCED:
PROTON IRRADIATION OF PRIMITIVE ATMOSPHERES OF YOUNG EXOPLANETS AND EARLY EARTH: N_2O GREENHOUSE WARMING AND PREBIOTIC SYNTHESIS

One of the enduring problems in early Earth science is that our planet appears to have maintained liquid water at a time when the young Sun was substantially dimmer than it is today. Known as the faint young Sun paradox, the problem raises a fundamental question: what kept the early Earth warm enough for persistent surface water?

A new study points to proton irradiation.

The researchers recreated part of this environment experimentally by exposing mildly reducing gas mixtures dominated by nitrogen and carbon dioxide to proton irradiation.
These gases are particularly relevant because nitrogen- and carbon dioxide-rich atmospheres are plausible environments for the early Earth and for young terrestrial exoplanets.

What happened under proton bombardment was striking.

The experiments generated substantial quantities of nitrous oxide, or N_2O, reaching concentrations of approximately 1,000 parts per million by volume under some experimental conditions.

That is significant because nitrous oxide absorbs outgoing infrared radiation. In sufficient concentrations, it can contribute substantial greenhouse warming.

The experiment therefore identified a pathway through which stellar energetic particles could transform an otherwise relatively simple atmosphere into one containing an additional greenhouse agent.

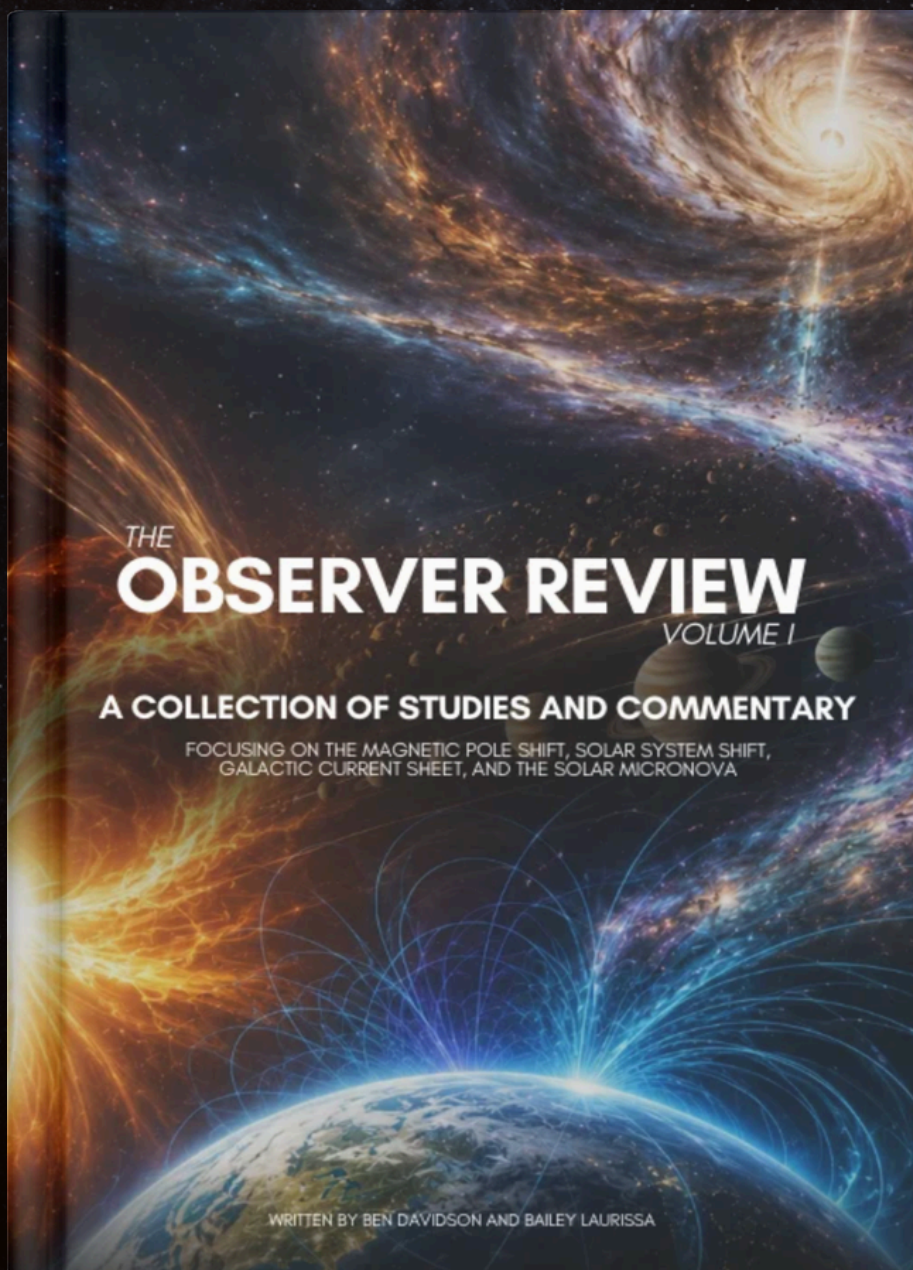
THE OBSERVER REVIEW VOLUME 1

THE OBSERVER REVIEW VOLUME 1 **IS NOW AVAILABLE TO ORDER IN PRINT.**

FOR OBSERVER REVIEW MEMBERS, THIS IS YOUR OPPORTUNITY TO TAKE THE REVIEW OFF THE SCREEN AND ONTO YOUR BOOKSHELF.

- Over 50 Scientific Studies
- Magnetic Pole Shift & Earth Changes
- Solar System Changes
- The Galactic Current Sheet
- The Solar Micronova

CLICK TO PRE-ORDER



THANK YOU!

WE HOPE YOU ENJOYED OUR SEPTEMBER ISSUE!
WE APPRECIATE YOUR QUEST AND LOVE FOR KNOWLEDGE ABOUT SPACE AND OUR GREATER COSMOS.

HAVE A TOPIC/DISCUSSION YOU WANT FEATURED?

Email observerreview@observerranch.com with a topic that you'd love to see an article written on!

