

# RADIO MAGIC

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## A Starry Tale

### Once Upon a Time...

Once upon a time in Solar Cycle 25, as it descended toward minimum, old Sol proved there was still some life left in this cycle. On January 18, 2026, a large, magnetically twisted sunspot group, called AR (Active Region) 14341, was centred on the Earth. It was a monster: complex, unstable, and “juiced” by intense magnetic shear, which occurs when neighbouring magnetic field lines point in different directions.

Then Sol broke bad when an X1.95 solar flare erupted, unleashing roughly  $10^{25}$  joules of energy into space — enough to power all of humanity’s needs for the next 10,000 years. It was so intense that the GEOS (Geostationary Operational Environmental Satellites) X-ray flux — measured in watts per square metre — sensors briefly saturated. Travelling at the speed of light, “soft” X-ray photons sliced through the magnetosphere and down to the ionosphere like a hot knife through butter at 1809Z. Earth’s magnetic field cannot stop X-rays because they are not charged particles.

NOAA (National Oceanic and Atmospheric Administration) reported the flare starting at 1726Z, peaking at 1809Z, and ending at 1850Z. A huge CME (coronal mass ejection) — at least a billion tonnes of the Sun itself — was blown into space at an estimated velocity of over 2000 kilometres per second (**Figure 1**).

Radio propagation suddenly collapsed because the ionosphere's absorption layer, or D-region, was hit hard by ionizing radiation and instantly became over-ionized. Free electrons and ions were created faster than they could recombine — triggering an R3-strong out of 5 radio blackout and a SID (sudden ionospheric disturbance). However, if you were not on the air shortly before and after that time, you would never know anything had happened because the effects were short-lived.

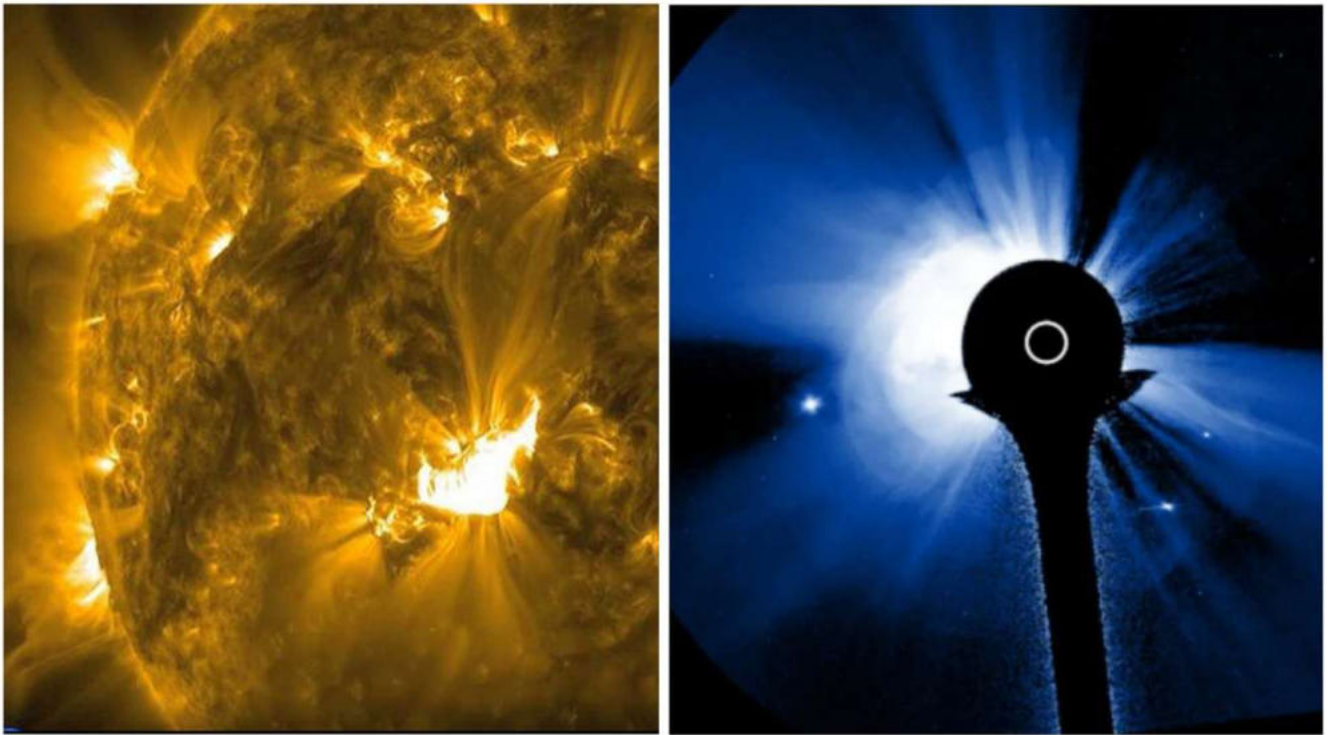


**Figure 1** — Composite image of the January 18th, 2026, X1.95 solar flare event in progress (left) followed by the CME (right). The bright spots are the planets Venus, Mercury and Mars. Credits: NASA SDO and SWPC.

The real menace with teeth and bite is the CME, a plasma cloud of superheated, fast-moving charged particles. Normally, CMEs take a pedestrian two or three days to reach us — if Earth's orbit happens to cross their path. But solar scientists calculated the trajectory and determined that the interplanetary shock arrival would occur in about 25 hours — a very fast-moving CME — followed by the main plasma particle stream. The prediction was for a G4-severe (out of 5) geomagnetic storm (**Figure 2**) along with more R3-strong radio blackouts on the daylight side.

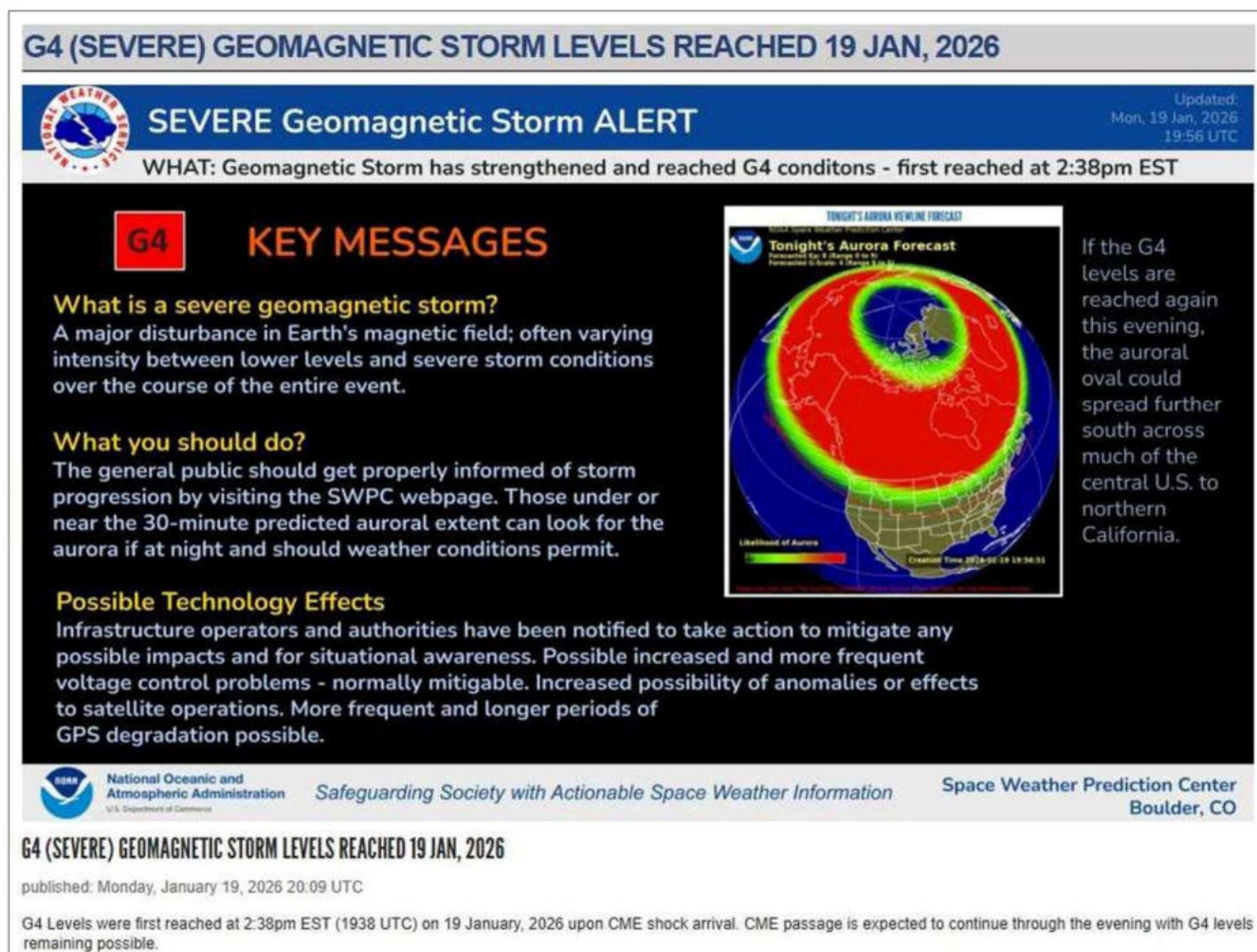


**Figure 2** — Geomagnetic solar storm alert. Credit: NOAA SWPC.

## X-rays and SIDs

NOAA's start, peak and end times describe how a solar flare's X-ray flux evolves over time — not when Earth's ionosphere actually reacts. The "start time" officially occurs when four consecutive minutes of rising X-ray flux are recorded, but the ionosphere responds only when the flux intensity becomes strong enough to over-ionize the D-region.

This threshold is near the flare's peak, but the energy required is astonishingly small: only about one hundred-millionth of the solar ultraviolet flux hitting our faces on a bright sunny day. After the peak, X-ray flux declines and the ionosphere recovers, although solar scientists still classify the flare "in progress" until the GOES-measured flux drops to the normal background radiation level.

Solar flares emit electromagnetic radiation across the entire spectrum, from infrared to gamma rays, including “soft” and “hard” X-ray ionizing radiation. Soft X-ray photons — with wavelengths between 0.1 and 10 nanometres — over-ionize the D-region. The resulting surge of free electrons both absorbs and scatters HF (high-frequency) radio waves (3–30 MHz) passing through the suddenly lossy, chaotic medium, causing a sharp drop in signal strength and a shortwave fadeout (SID). Only the higher HF frequencies carry enough energy to reach the F-region and be weakly refracted back to Earth.

In the very low frequency (VLF) range (3–30 kHz), radio waves cannot penetrate the D-region; instead, they are reflected and guided between its lower boundary and Earth’s surface. But the over-ionized D-region can suddenly drop in altitude and become more reflective to VLF radio waves, producing the distinctive “shark-fin” (normal or inverted) signature of SIDs (**Figure 3**).

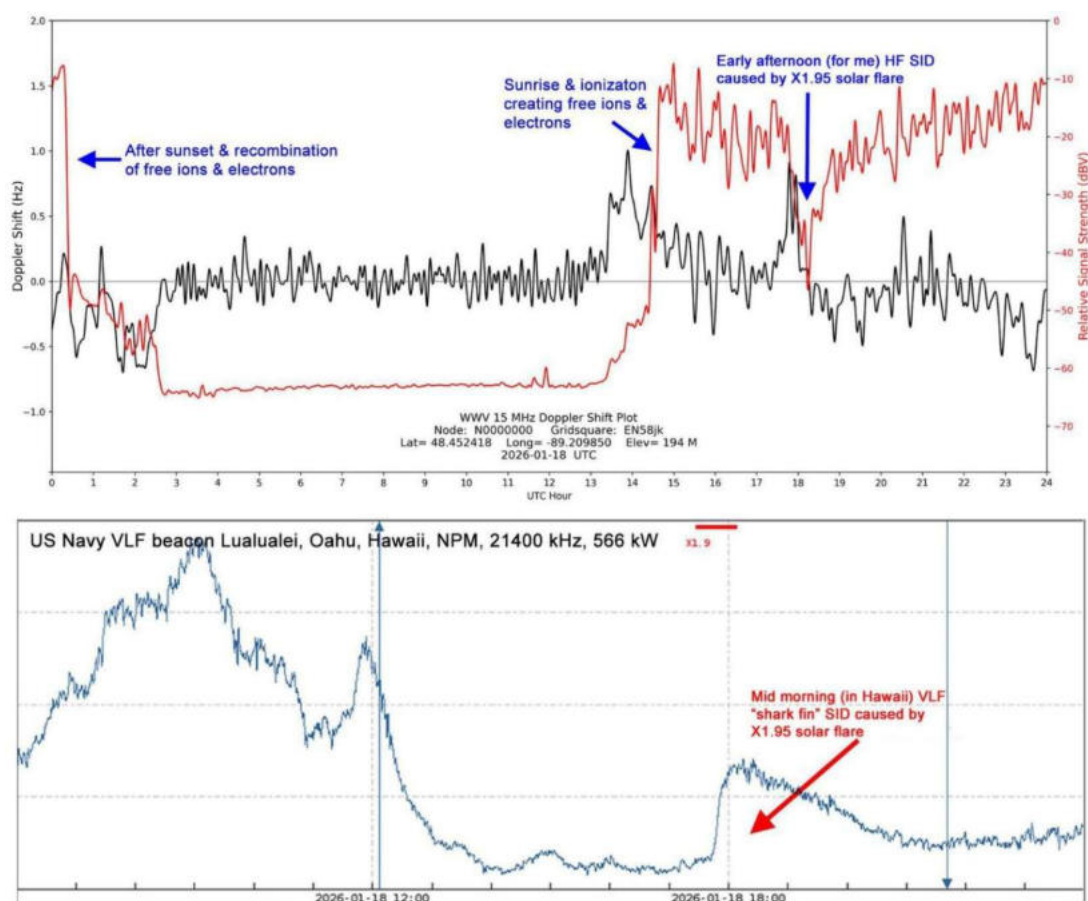


**Figure 3** — Solar flare-induced HF/VLF SID, January 18, 2026. Top: My HamSCI Grape 1 receiver monitoring WWV’s 15 MHz carrier detected the flare-induced SID. Bottom: Classic VLF “shark-fin” SID, caused by sudden D-region over-ionization followed by slow ion–electron recombination. Credit: Stanford University SID Server.

The hard X-rays emitted — the type used in medical imaging — have much shorter wavelengths ( $< 0.1$  nanometres) and higher energy, so they penetrate deep into the denser, neutral atmosphere. This does not affect propagation, but it exposes high-flying aircraft (avionics) and people to above-normal background levels of ionizing radiation, which is not good because it accumulates in biological tissues.

## The Solar Wind

In 1958, astrophysicist Eugene Parker proposed a radical new theory: the Sun was hot enough to generate thermal pressures that accelerated particles — protons, electrons, ions, neutrons, and others — to speeds exceeding the solar escape velocity of 618 kilometres per second, producing a supersonic “solar wind.” Parker coined the term to replace the earlier physics jargon “solar capillary radiation.” He showed that this outflow interacts with Earth’s magnetic field (**Figure 4A**) and that, as the Sun rotates, the outward-transported magnetic field lines are wound into a three-dimensional spiral (**Figure 4B**). This spiral structure, now known as the Parker spiral, is the shape the Sun’s magnetic field takes as the solar wind drags it outward through space, forming the IMF (interplanetary magnetic field).

More shockingly, this theory also applied to most other stars in the universe — a cosmic bridge too far for most mainstream astrophysicists: “Utter nonsense!” exclaimed one. Parker’s now-famous paper, with only four lines of algebra, was nearly rejected. However, the editor of *The Astrophysical Journal* overruled the peer-review referees — an extremely rare move — and published it. The first confirmation and measurements of the solar wind came the next year, from the Soviet Union’s Luna 1 spacecraft. The National Aeronautics and Space Administration’s (NASA) Helios 1 verified the existence of the Parker spiral in 1975 by measuring the IMF inside Earth’s orbit.

In 2014, NASA’s Voyager 1 spacecraft still detected an extremely weak solar wind nearly 14 billion kilometres from home, before crossing the termination shock. This is the region where the solar wind suddenly becomes subsonic due to backpressure from the interstellar medium, which carries the plasma and magnetic field remnants of other stars. And in 2017, NASA named the Parker Solar Probe after the now world-renowned “father of heliophysics.”

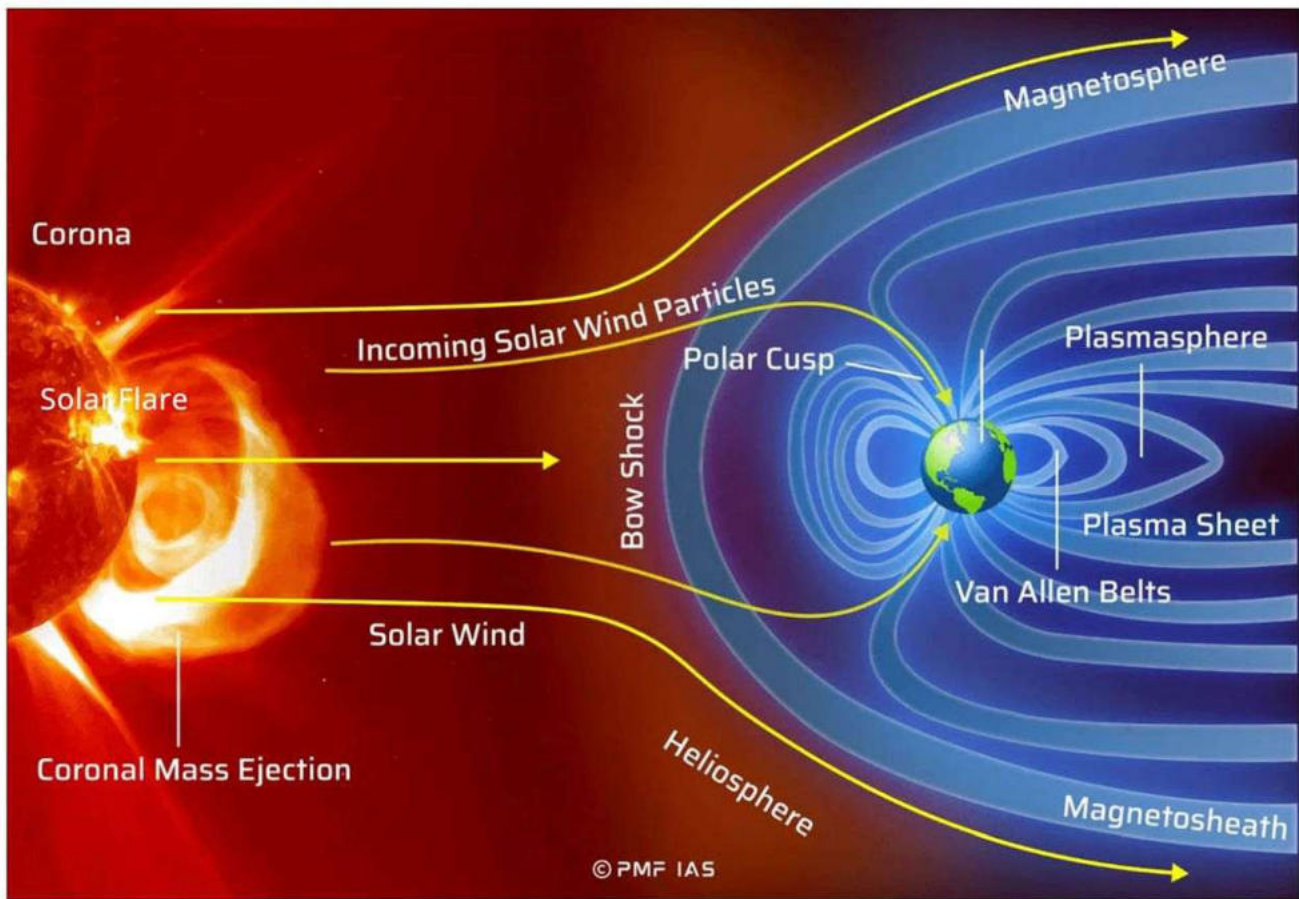


**Figure 4A** — Top: Solar wind interaction with Earth's magnetic field. Credit: PMFIAS India.

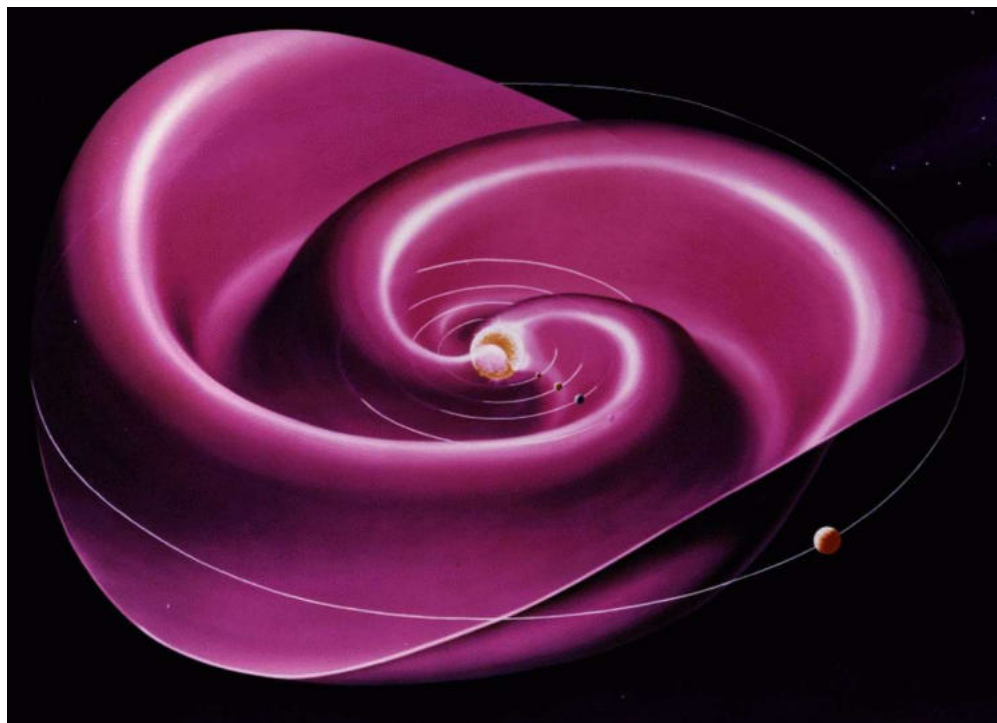


**Figure 4B** — The Parker spiral simplified and colourized. As the solar wind flows outward and the Sun rotates, the IMF is wound into a three-dimensional spiral. Credit: Wikipedia, Werner Heil, NASA.

The solar wind's magnetic field has three components:  $B_x$ ,  $B_y$  and  $B_z$ , measured in nanotesla (nT), but the north–south oriented  $B_z$  is the most important. When  $B_z$  points north ( $B_z > 0$  nT), it aligns with Earth's magnetic field, which is beneficial. But when it points south ( $B_z < 0$  nT), it can be problematic, but the normal solar wind's  $B_z$  is never negative enough to cause problems.

However, each CME carries its own magnetic field structure, “frozen” into the plasma at the moment of eruption. When a fast CME overtakes the slower ambient solar wind and reaches Earth, it produces a stronger, more disturbed local solar wind and IMF. If the CME's  $B_z$  component is southward, it typically is strongly negative, directly opposing Earth's magnetic field and coupling efficiently to the magnetosphere. This southward  $B_z$  drives magnetic reconnection and primarily triggers geomagnetic storms.

**Note 1:** Magnetic reconnection occurs when oppositely directed magnetic field lines snap and rejoin, releasing energy and allowing solar plasma to enter Earth's magnetosphere.

**Note 2:** Solar scientists knew that geomagnetic storms were caused by the Sun, but without detailed, continuous satellite imaging, they could only speculate on the cause: solar flares, HSS (high-speed solar-wind streams), or theoretical “plasma clouds.” What we now call CMEs (plasma clouds) were first observed in real-time coronagraph images from NASA's OSO-7 spacecraft in late 1971.

### “I will huff...”

Just over 25 hours later, on the afternoon of January 19, 2026 (Eastern Standard Time), a CME whirlwind barrelling through the solar wind caused the IMF to tumble wildly. Its north–south component ( $B_z$ ) tumbled north, then south, then north again, like a solar knuckleball:

- Proton flux and the Kp (planetary) index surged.
- HF propagation began to decrease, starting at the higher latitudes.
- $B_z$  tumbled south again and stayed south.

Sol was the “Big Bad Wolf” banging on the front door, but our planet’s magnetic field defence systems kicked in, absorbing, deflecting, or diverting this initial surge of charged particles (**Figure 5**).

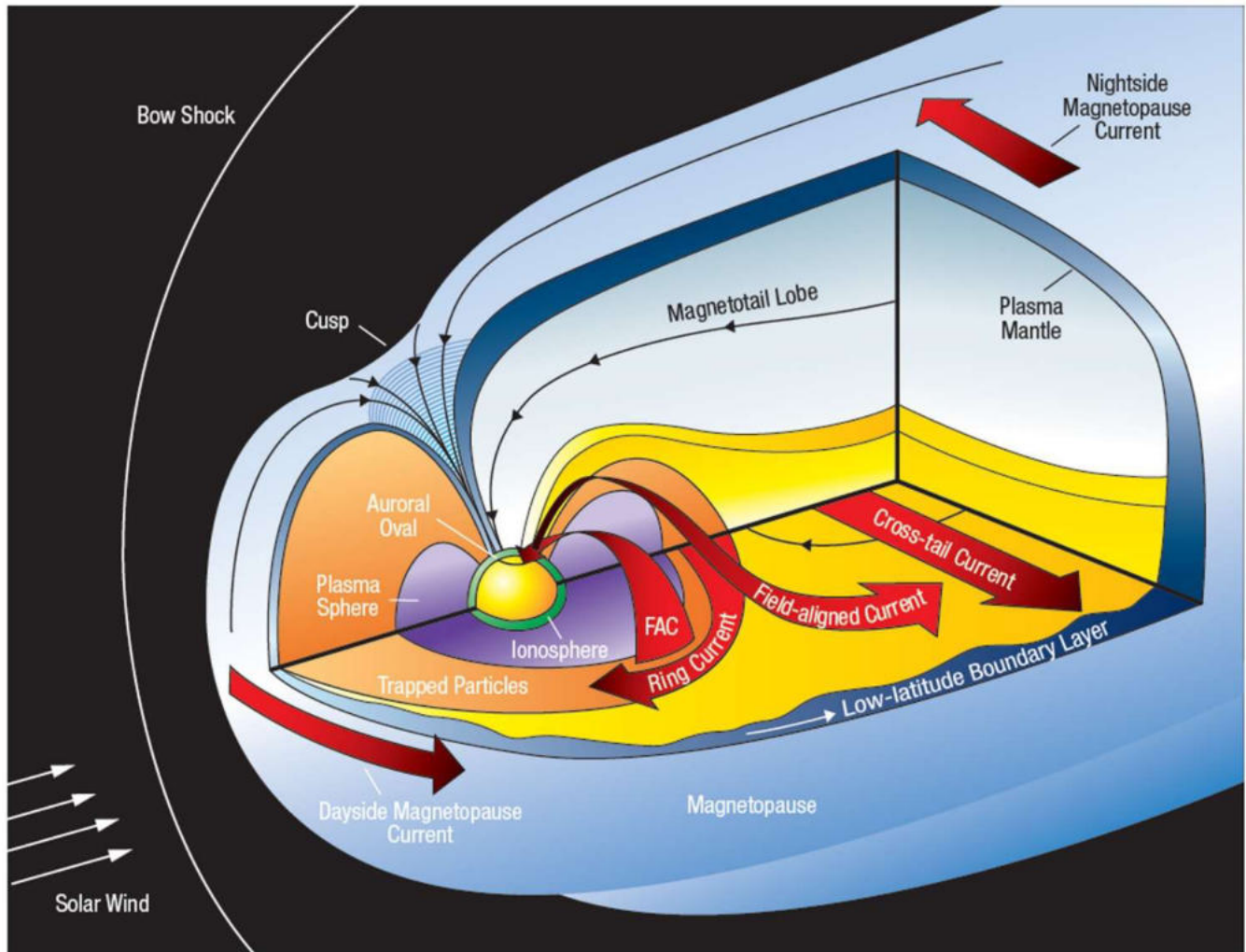


**Figure 5** — Ionized plasmas are wispy and diffuse. They are invisible to our eyes but not to electromagnetic energy. They drive a powerful system of electric currents that, during the peak of major geomagnetic storms, dissipate power at well over 100 billion joules per second (100 gigawatts).

**“I will puff...”**

However, by early evening, the Earth’s magnetosphere was in turmoil:

- The Kp index (**Figure 6**) hit 9 minus out of 9.
- The Bz was minus 58.4 nanotesla, blowing the front door open — allowing the CME’s magnetic energy to roar in — overloading Earth’s magnetosphere.

- Ever more positively charged protons — instead of flying through — were trapped in the magnetosphere, drifting westward around the equator, intensifying the ionosphere's ring current — strongly opposing and weakening Earth's magnetic field — allowing ever more protons to flood in, become trapped — increasing the ring current — creating a feedback loop.
- Intense auroras were seen around the world (**Figure 7**).

## Kp-index and Kpa-index archive (1868 to present)

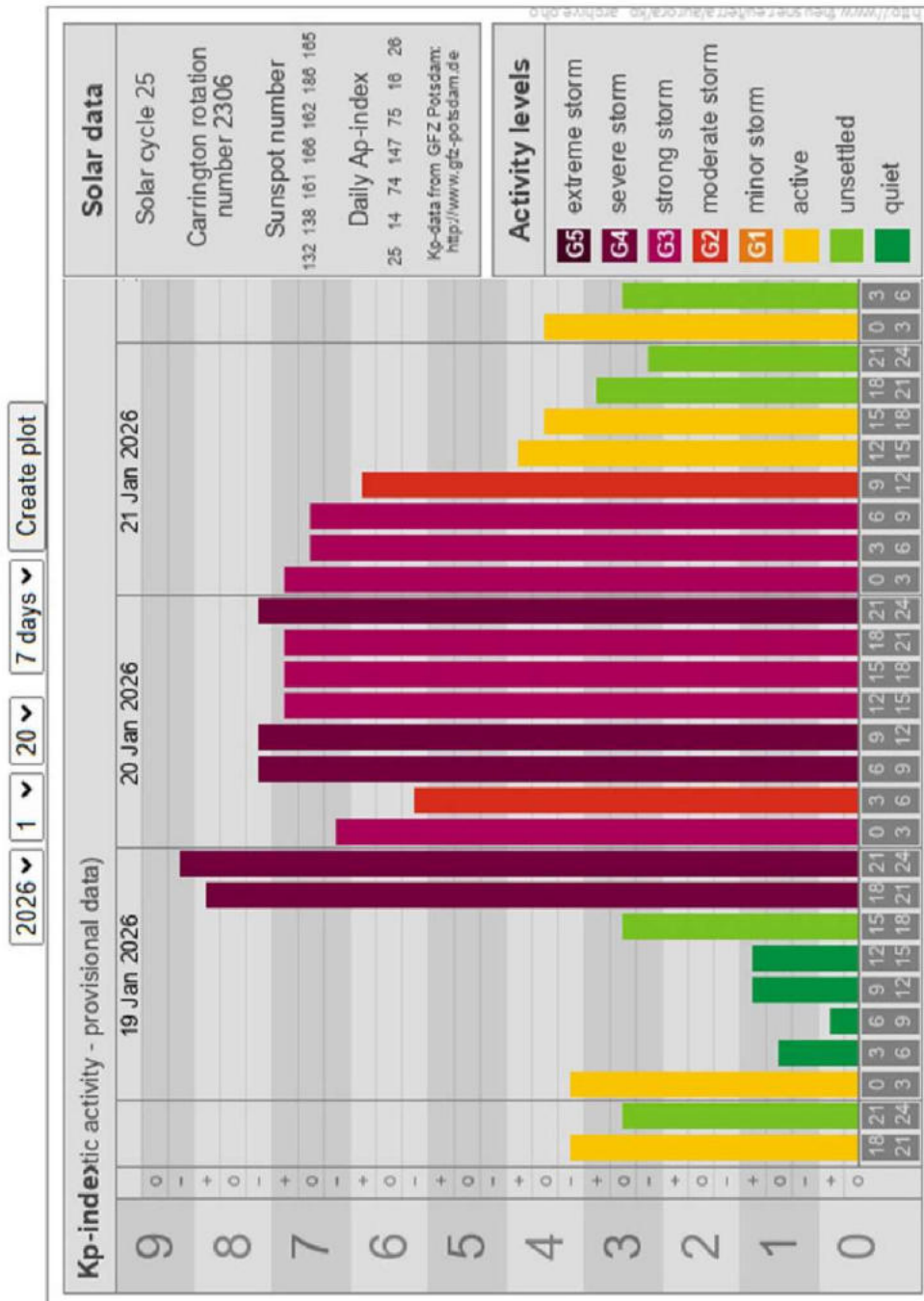


**Figure 6** — Kp progression from January 19 to January 21, 2026. Credit: Michael Theusner.

**Note 2:** The Kp index measures global geomagnetic activity every three hours on a quasi-logarithmic scale from 0 to 9. NOAA's G-scale is related but incorporates additional factors, including storm duration, regional impacts, and overall effects on technology and infrastructure. Although the Kp index officially reached 9 minus, it did not meet the other required criteria to be classified as a G5-extreme storm.

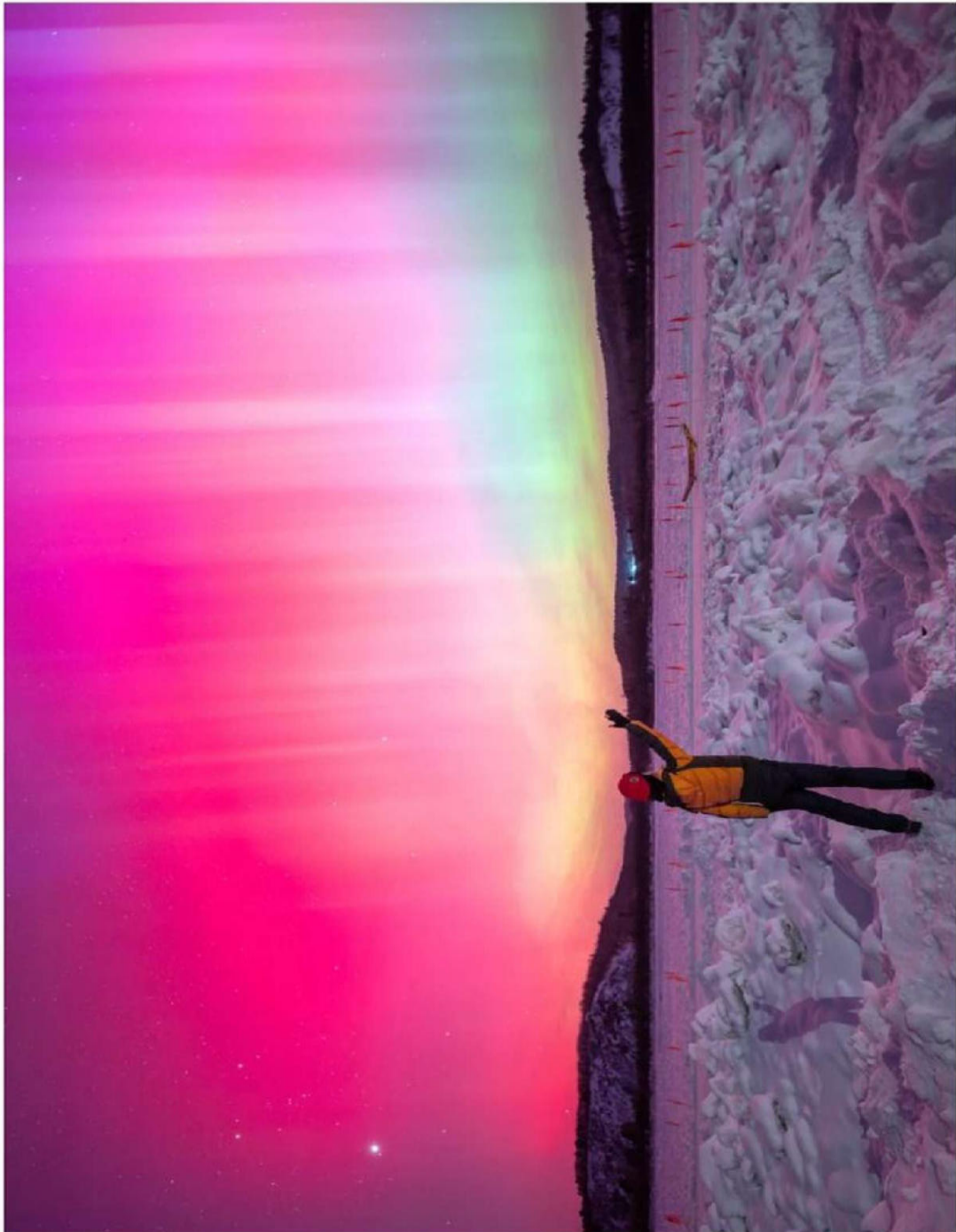


**Figure 7** — Spectacular aurora borealis casting shadows. Beiji Village, China, January 20, 2026. Credit: Chi Shiyong/VCG via Getty Images.

### **“And blow your house down!”**

The CME-driven solar wind howled at 1178 kilometres per second—twice the normal average — ringing the ionosphere like a bell (**Figure 8**). Proton flux peaked at S4, severe. Earth’s magnetosphere was on the knife’s edge of a runaway, regenerative magnetic feedback loop — the kind that powered the famous Carrington Event of September 1859. Then Bz suddenly flipped north. That field reversal prevented a full-scale magnetosphere meltdown. Had Bz remained south for much longer, we would have experienced:

- A Carrington superstorm trifecta of G5-extreme, S5-extreme and R5-extreme.
- Auroras streaming down or up from each Pole to near the equator, turning midnight into midday à la the Carrington Event.
- Global cascading electrical grid brownouts, blackouts and surges caused by GICs (geomagnetically induced currents).
- Total GPS collapse.
- Polar region no-fly zones.
- Multiple satellite system shutdowns and/or failures.
- Increased atmospheric drag on hundreds or even thousands of LEO (low Earth orbit) satellites occurs because higher levels of EUV (extreme ultraviolet) and X-ray radiation are absorbed by the thermosphere, heating it and causing it to expand upwards into space. Many that cannot be boosted to higher orbits may have to be de-orbited so that any pieces that survive re-entry splash down in the SPOUA (South Pacific Ocean Uninhabited Area) — the “spacecraft cemetery.”

# WWV 15 MHz Doppler Shift & Rate of Change for January 19 & 20, 2026 (EN58jk)

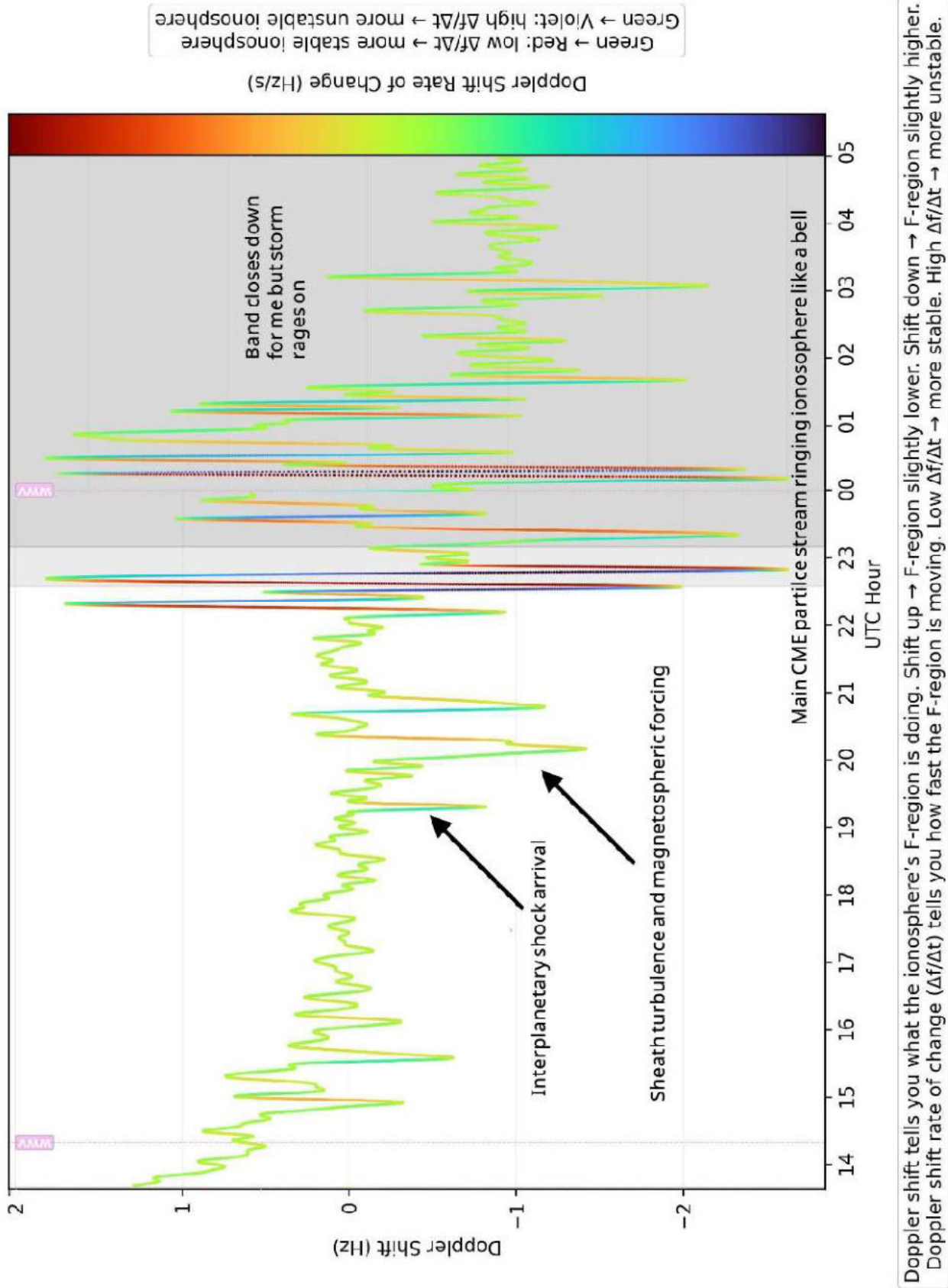


**Figure 8** — My heatmap of the CME-induced Doppler shifts of WWV's 15 MHz carrier, January 19–20, 2026.

## What Did We Experience?

Even without going full “Carrington”, the G4-severe geomagnetic storm of January 19 and 20 — continuing as a G3 through January 21, 2026 — caused:

- An S4-severe radiation storm.
- R3-strong shortwave radio blackouts with wild propagation swings.
- Intense auroras appearing farther south and north than normal.
- Strong daytime D-region absorption.
- Rapid IMF fluctuations.
- Minor power-grid fluctuations mostly across northern latitudes because magnetic-field variations were stronger.
- Some GPS degradation and satellite-communication anomalies because of ionospheric scintillation.

**Note 3:** Ionospheric scintillation causes rapid, random fluctuations in a radio signal’s amplitude and phase as it passes through small, irregular, fast-moving patches of electron density. These patches — from tens of metres to tens of kilometres across — act as tiny refractive lenses that bend, scatter, and distort the wavefront. Scintillation is most disruptive in the L-band (1–2 GHz) used by GPS and other satellite services, where extremely stable phase tracking is required for accurate positioning, ranging from a few metres for civilian receivers to a few centimetres for military systems.

For Radio Amateurs, it was a day when:

- 10 m suddenly went wide open, then died.
- 20 m was too distorted for even digital signals like WSPR and FT8 to be decoded, including other “all-or-nothing digital modes”.
- 40 m was a long-haul pipeline one minute, then a dead zone the next.
- 80 m was swallowed by daytime absorption.
- VHF (144 and 440 MHz) auroral propagation was unusually strong due to intense reflection from auroras.

For the HamSCI (Ham Radio Science Citizen Investigation) group, this event became a living, breathing laboratory. The hardware, software, web servers, social media platforms, and amazing AI (artificial intelligence) tools we have today allow citizen scientists of all ages to become solar scientists and:

- Experience, study and analyze the raw power of a significant space-weather event in real time like a solar scientist.
- Observe how Earth dynamically deflects and absorbs CME magnetic energy.
- Hear the magnetosphere audibly “groan” under the strain.
- Write and publish papers or articles describing the event in varying degrees of technical detail.

### **My Final**

For all we know, our Earth is unique. Without its serendipitous distance from the Sun (the Goldilocks zone), just-strong-enough magnetic field, and just-right atmosphere, there is no “happily ever after” — or us. It would be like Mars, which lost its protective magnetic field eons ago and had its atmosphere slowly stripped away by the solar wind — cold, dry, and sterile.

Eugene Parker’s contemporary and friend, astronomer John A. Eddy, wrote,

“If solar magnetic fields are the gunpowder, flares the muskets and prominences the horse-drawn cannons in the venerable solar armory, coronal mass ejections or CMEs are truly the heavy artillery. Indeed, interplanetary CMEs are the primary driver of all space weather disruptions, including highly accelerated plasma streams and most major geomagnetic storms, with potential impacts on a wide range of human activities.”

## References

*Dynamics of the Interplanetary Gas and Magnetic Fields*, Eugene Parker, 1958.

*The Sun, the Earth and Near-Earth Space*, John A. Eddy, for NASA, 2009.