

WAS THE MAY 2024 SOLAR STORM REALLY A ONCE-IN-A-LIFETIME GPS DISRUPTION EVENT FOR PRODUCTION AGRICULTURE?

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Executive summary

- The May 2024 “Gannon Storm” was a severe but recurring type of geomagnetic event, not a one-off anomaly. A catalog of comparable storms (1859–present) puts the recurrence interval at roughly 9.8 years. Using a different method, Elvidge and Themens (2025) estimate the storm’s intensity return period at 10–13 years. What their analysis finds unusual about Gannon is its duration: about a 1-in-41-year event. The peak intensity was not exceptionally rare; how long the disturbance lasted was.
- The 20-year gap between the 2003 Halloween storms and 2024 Gannon storm reflects an unusually quiet period; Solar Cycle 24 (2008–2019) was itself an anomaly.
- Over the 3-to-10-year useful life of GPS-enabled farm equipment, the long-run average puts the probability of encountering at least one severe storm from about 28% to 66%. It should be noted that geomagnetic activity is strongly clustered over the solar cycle (see the timing callout below), so the true probability for any specific 3-to-10-year stretch depends heavily on where it falls relative to solar maximum. If that stretch resembles a historically active solar period like what was experienced in the mid-20th century, the same 10-year exposure window would put the odds closer to 100%.
- GPS signal degradation is a manageable production risk, closer in character to hail than to an unforeseeable black swan, and can be planned around and possibly mitigated the same way.

The perception gap

Four things stacked up to make a statistically ordinary geomagnetic storm feel like a black swan.

Data blind spot. GPS-enabled precision agriculture equipment barely existed at commercial scale during previous storms of similar strength. Judged only against the GPS era (2000 to present), Gannon appears rare (see Griffin et al. 2025 for recap of how Midwestern corn planting was affected). However, when judged against the longer historical record, severe geomagnetic storms are not uncommon.



Limited adoption and use in 2003. A geophysically comparable pair of storms struck in October 2003, when fewer than 10% of planted acres used any GPS at all (see [Figure 1](#) for progression of adoption rates during the precision agricultural era) (McFadden et al. 2023). Very few farms were running equipment that could be affected, so almost nobody remembered or noticed it, given the time of year.

The quiet Sun trap. A large portion of today's precision agriculture equipment was put into service during Solar Cycle 24 (2008–2019), the weakest solar cycle in a century. GPS seemed to work flawlessly so it is natural to assume it always will. A sudden outage then feels like an impossible anomaly rather than the return of a normal Sun.

Misinterpreting “lifetime.” While guidance systems last 3 to 10 years, a farming career runs 50-plus years. “Once in a lifetime” quietly gets measured against the tractor display instead of the career, and against the career instead of the multi-century historical record.

The true odds of GPS disruption

NOAA refers to the intensity of geomagnetic storms on their G-scale, with G5-class the most severe. The last several G5 storms are listed in [Table 1](#). The severity is essentially the same across all four events; what changed is how much GPS was being used in the field.

Table 1: Comparable G5 severe geomagnetic storms and GPS adoption rate.

year	event	GPS adoption (% acreage)
1960	November storm	0%
1989	Quebec blackout	0%
2003	Halloween storms	9%
2024	Gannon Storm	65%

Three questions determine whether a solar storm causes downtime:

1. **Will a severe G5 storm happen this year?** Using the long-run return period of approximately 9.8 years, the annual probability is about 10.2% chance in any given year, based on the full historical record (see callout note below).
2. **Will it last long enough to disrupt fieldwork?** About 57% of G5-class storms produce a disturbed window longer than 24 hours, the threshold used here for “long enough to matter operationally.”¹

¹ “Disturbed window” is measured at the G4 threshold ($K_p \geq 8$ -) containing each G5 episode, not $K_p \geq 9$ - run itself, since degradation persists through the storm's recovery phase. 57% (95% CI: 45%–69%) is our own estimate. Elvidge and Themens (2025) estimate a related but different quantity, e.g., the probability of a storm at least as strong as Gannon.

3. **Does it hit during planting or harvest weeks?** Field operations occupy roughly 23 weeks of the year, so only disruptions landing in that window may have practical (in-season) agricultural cost (see callout note below regarding seasonality).

The annual chance that a G5 storm occurs during field-operations, regardless of whether the disturbance lasts long enough to matter, is about 4.5% (storm occurs $\times$ falls in-season). Requiring the disturbance to also clear the 24-hour duration threshold brings that down to an annual chance of 2.6% for an operationally meaningful disruption (storm occurs $\times$ long enough $\times$ falls in-season).

A note on timing and seasonality of solar impacts

The 10.2% figure above is a long-run average smoothed across the Sun's full ~11-year cycle ([Figure 1](#)). It is not spread evenly across every individual year. Solar Cycle 25 reached its officially declared maximum period in October 2024; elevated activity can persist into the declining phase of a cycle. NOAA's outlook has Solar Cycle 25 running through roughly 2030, with the maximum of Solar Cycle 26 expected in the mid-2030s. Annual odds run above the long-run average during and after a solar maximum and below it near a solar minimum. Solar Cycle 24, the unusually quiet cycle behind much of the perception gap described here, indicates that no two cycles behave identically, so treat cycle timing as a general guide for when to be more watchful.

Geomagnetic activity is not spread evenly across calendar months ([Figure 2](#)): because part of the Sun's magnetic field and Earth's magnetic field align twice a year due to the seasonal tilt of Earth's poles, known as the Russell-McPherron effect (Russell and McPherron 1973), geomagnetic storms have historically clustered around the March and September equinoxes. That is an unlucky overlap for much of production agriculture, since those same weeks loosely coincide with spring planting and fall harvest. This is a statistical tendency documented across many solar cycles, not a rule for any single storm: the Gannon Storm itself struck in May, outside either equinox window. Treat it as one more reason to be attentive to SWPC alerts during busy times of year.

The high stakes of modern equipment

In late October 2003, a comparable storm to the May 2024 Gannon Storm was a non-event for agricultural GPS: almost no equipment depended on GPS guidance, and the equipment being used in 2003 could fall back to sightlines or manual row markers. That fallback is less likely today; modern 16-to-48-row planters and 120-foot-wide sprayers are built around integrated GPS guidance and automated section control such that no practical way to eyeball a straight pass across an implement that wide.

When guidance degrades today, the choice is binary: idle the machine and lose the time or keep running (if possible) on degraded accuracy and risk skips, overlaps, or mis-aligned passes. Neither option existed as a real cost in 2003, which is a separate, compounding problem from how often the storms themselves occur. The same storm severity today simply has more money at risk than twenty years ago.



Producer decision guide

Monitoring. NOAA's Space Weather Prediction Center (SWPC) issues G-scale watches and warnings ahead of most G5 storms (NOAA Space Weather Prediction Center 2026). Checking SWPC alerts during planting and harvest, the same way a terrestrial weather forecast such as precipitation is checked is a useful habit (the SWPC website is fully optimized for mobile devices).

Quick reference: NOAA's Space Weather Scale (G-scale)

- **G1 (Minor)** Weak power-grid fluctuations; little to no navigation impact. Occurs roughly 900 days per 11-year solar cycle.
- **G2 (Moderate)** Satellite orientation corrections may be needed; HF radio fading at high latitudes. About 360 days per cycle.
- **G3 (Strong)** NOAA's own language: "intermittent satellite navigation and low-frequency radio navigation problems." About 130 days per cycle.
- **G4 (Severe)** Satellite navigation degraded for hours. For RTK-guided equipment, this is roughly the level where float-mode interruptions become likely. About 60 days per cycle.
- **G5 (Extreme)** Satellite navigation may be degraded for days. The level behind the May 2024 Gannon Storm. Only about 4 days per 11-year cycle, on average.

Source: NOAA SWPC, swpc.noaa.gov/noaa-scales-explanation

Sign up for alerts at spaceweather.gov

Operational rules and capital planning. Decide in advance, not in the moment, how your operation will respond to a GPS accuracy degradation during a critical window. The right call depends on crop stage, your equipment's fallback options, and how much a delay costs at that point during the season, so this is worth penciling out ahead of time rather than improvising during a disturbed window.

Know what equipment does when GPS is lost: equipment fallback. Before planting or harvest, determine what happens when GPS corrections are lost: Does the system hold position, fall back to float, or require manual operation? The economic consequences differ substantially among systems.

Bottom line

The Gannon Storm was not bad luck striking an otherwise quiet system. It was a statistically ordinary solar storm meeting a GPS-dependent farm economy for the first time. The next comparable solar storm is not a matter of if, but when, and farmers can plan for it rather than being surprised by it. The elevated risk from Solar Cycle 25 is winding down, but that reprieve is temporary: Solar Cycle 26 is expected to begin around 2030.



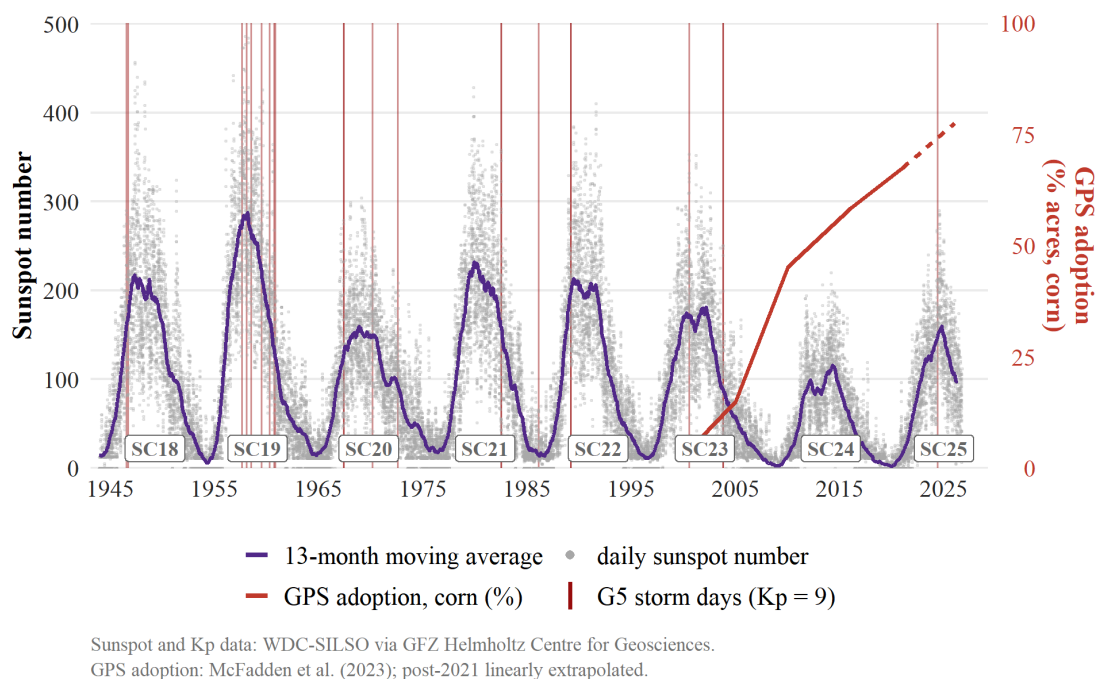


Figure 1: Sunspot number and GPS adoption, G5 storm days ($K_p=9$) marked

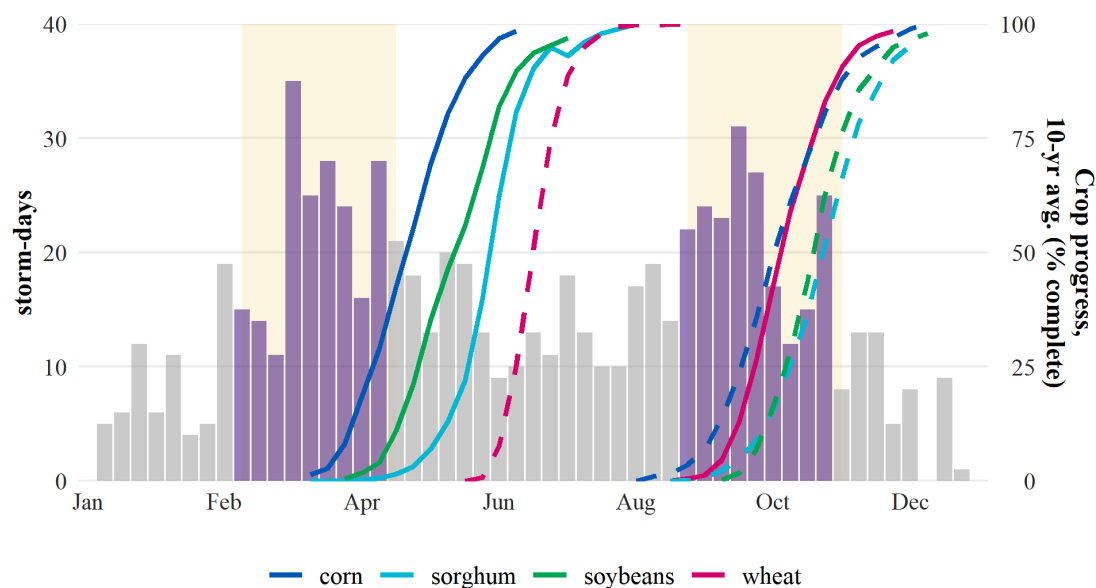


Figure 2: Storm-days ($K_p \geq 7$, G3 or greater) vs. 10-year average Kansas crop progress

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