GNSS Outages and Space Weather

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Introduction

Space weather affects the Earth in various ways. Some, like the aurora borealis, can be seen during geomagnetic disturbances. These disturbances, while invisible, cause noticeable repercussions by disrupting Global Navigation Satellite Systems (GNSS).

Data and Methods

Publicly available data (USDA NASS, 2025) indicate crops such as corn, cotton, **peanuts**, and sugarbeets are grown at different locations across the USA (Figure 1). Due to biological processes and latitude, planting and harvest dates also differ by crop and location (Figure 1).

Mid-latitude appearances of aurora borealis have been associated with GNSS outages. Both phenomena can be traced back to geomagnetic disturbances. Geomagnetic disturbances since 1932 (Matzka et al., 2021) are charted against sunspot counts to visualize frequency of events before and during the **GNSS era** (McFadden et al., 2023) (*Figure 2*).

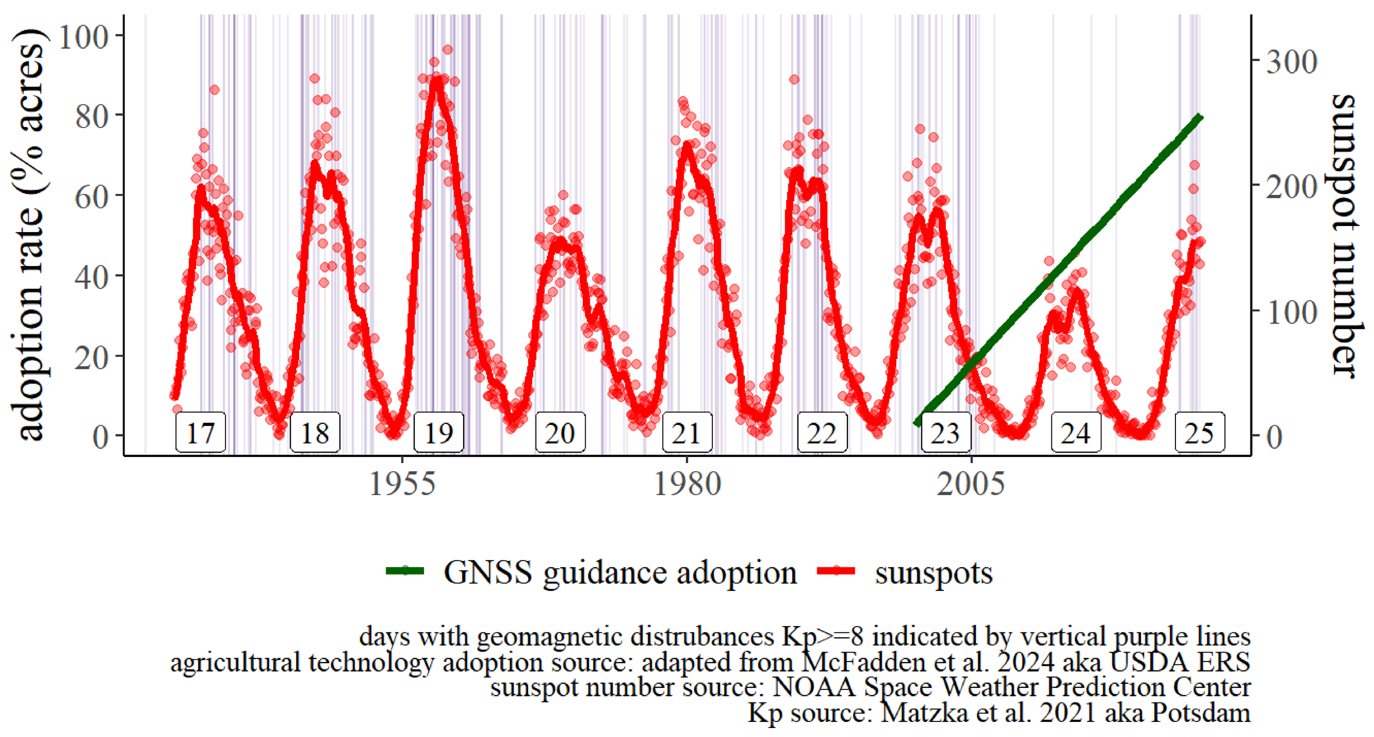

Figure 2. geomagnetic disturbances during GNSS era

Crop yields and losses can be estimated by evaluating planting and harvest proficiency. Intense geomagnetic disturbances during planting and harvest dates may adversely impact field operations. Manual steering instead of GNSS-enabled automated guidance for peanuts planting and digging (Figure 3) equates to **11% yield penalty** (Roberson & Jordan, 2014).

Figure 3. peanut digging (source: Gladden UGA 4D Farm)

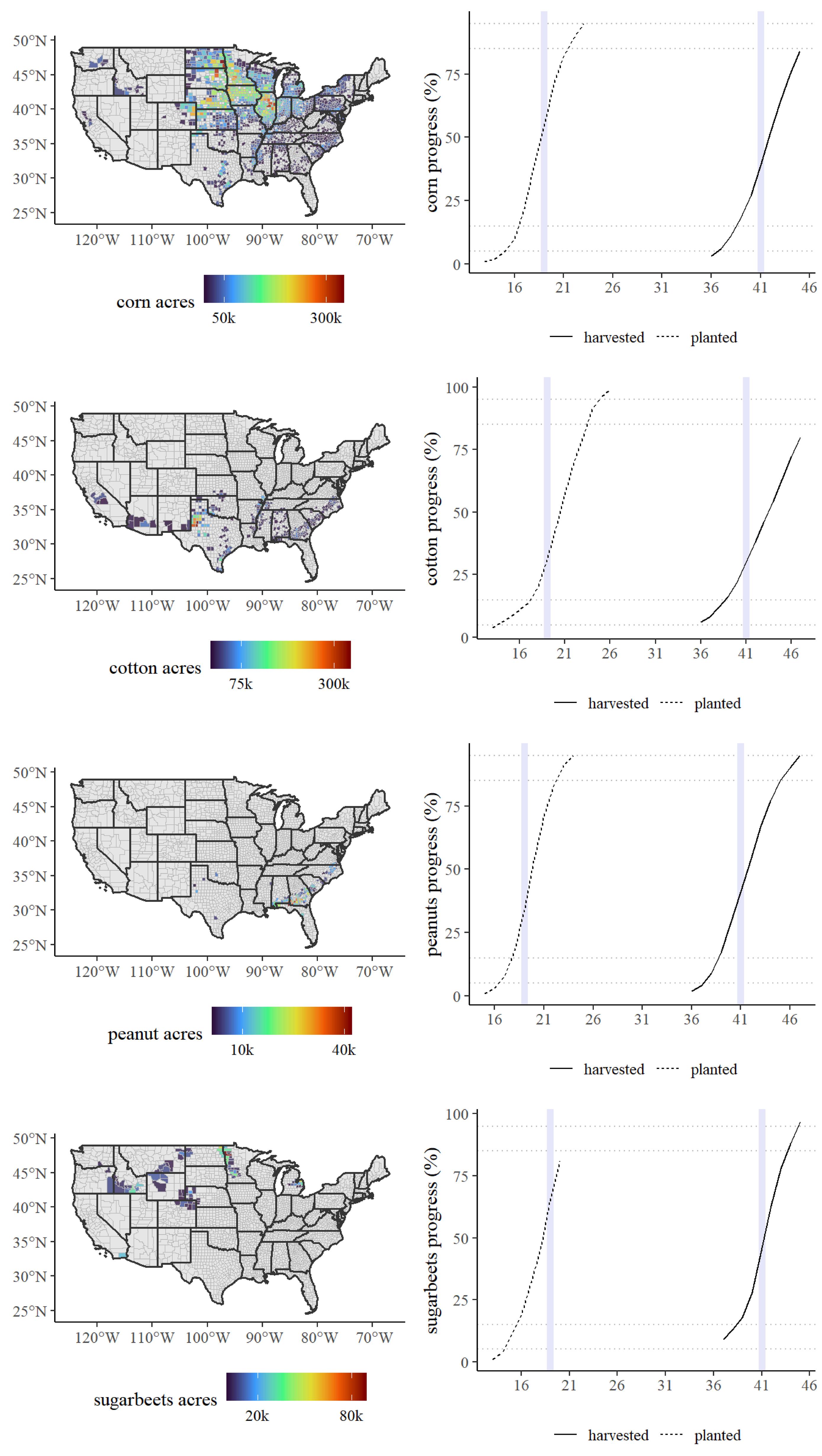

Figure 1: crop progress and acreage

Analysis and Results

When aurora are visible at crop-growing latitudes, geomagnetic disturbances may detrimentally affect ability of farm machinery to navigate. Depending upon where and when GNSS signal degradation occurs, different crops are affected.

Crops evaluated here are typically planted in spring following equinox then harvested near autumn equinox. Corn, cotton, peanuts, and sugarbeets are usually planted from 16^{th} to 21^{st} and harvested 36^{st} to 46^{th} weeks of the year (Figure 1).

Corn is ubiquitous across the USA but concentrated in Midwest (Figure 1). Cotton is planted in southern states, peanuts in southeast, and sugarbeets mostly in northern states.

711K hectares of peanuts were harvested in 2024 valued at \$1.6B (USDA NASS, 2025). Applying 11% yield penalties (Roberson & Jordan, 2014) to **35% of acreage without** automated guidance (McFadden et al., 2023) returns 203k tons (t) at risk valued at **\$150M** assuming \$500 per ton.

$$89\% \times 4\text{t ha}^{-1} \times 260\text{k ha} + 4\text{t ha}^{-1} 462\text{k ha} = 2.8 \text{ Mt}$$

$$89\% \times 4\text{t ha}^{-1} \times 711\text{k ha} = 2.5 \text{ Mt}$$

$$2.8 \text{ Mt} - 2.5 \text{ Mt} = 0.3 \text{ Mt}$$

Conclusion

Geomagnetic disturbances corresponding with the GNSS era have been much less frequent than during our earliest records. Evidence does not support aurora borealis is directly related to GNSS outages, but the latitude of where aurora are visible remains a rough easement regarding the severity of possible geomagnetic disturbance. For peanuts, value at risk was conservatively **\$150M**. Caution should be exuded when relying upon GNSS-enabled farm equipment for tracking and navigation especially during planting and harvesting times.

Acknowledgements and Bio

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Austin Griffin is a Freshman at Kansas State University majoring in Animal Sciences and Industry.

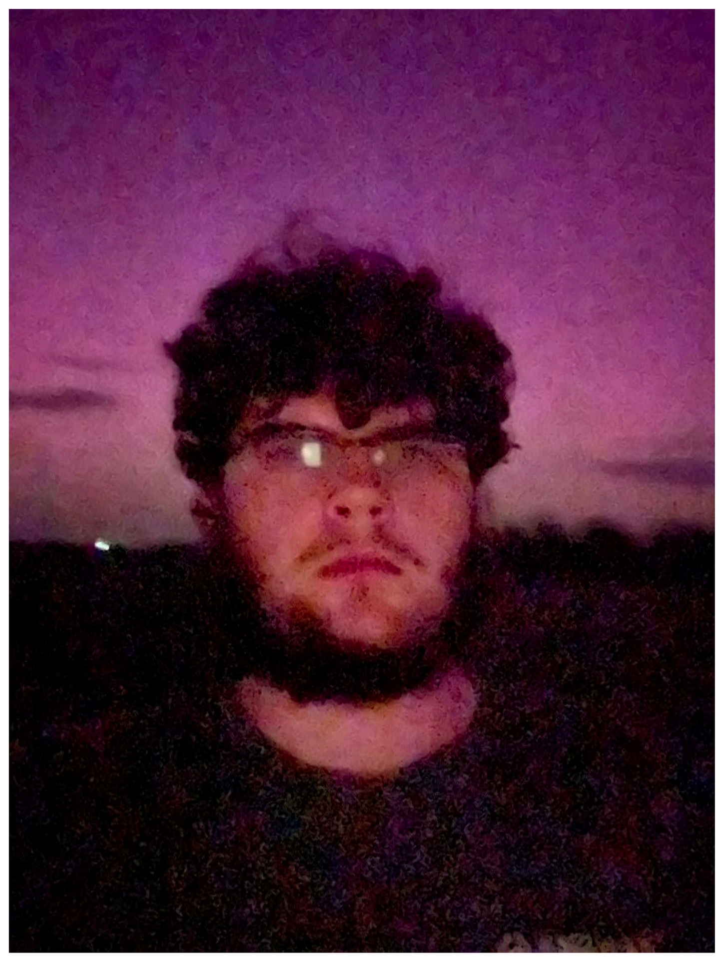

Figure 4. aurora selfie, St. George Kansas USA, 10 May 2024

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