

Observed Effects of Geomagnetic Disturbances from Wide Area Monitoring System

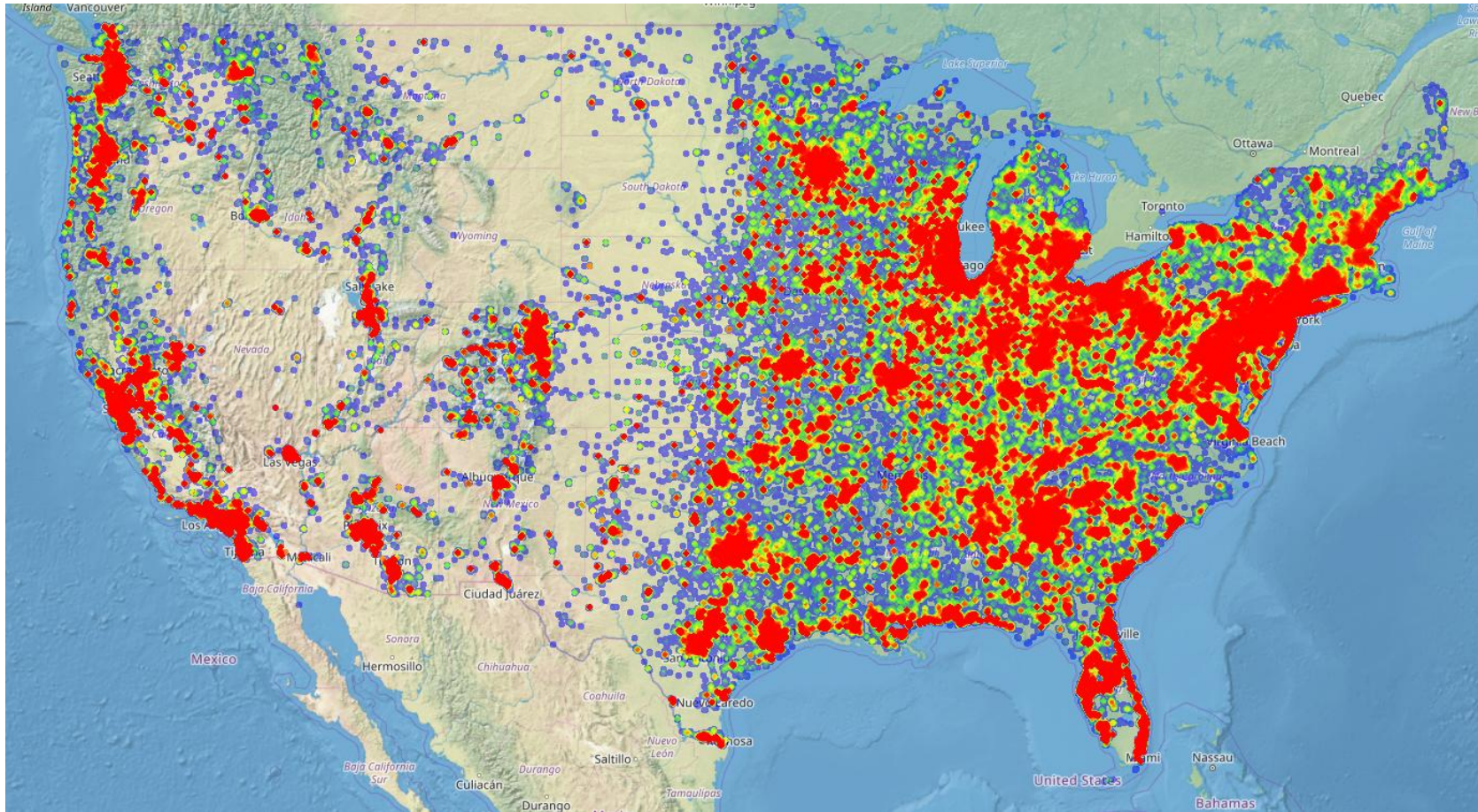
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Overview

- Background
- Measurements
- Observations / Analysis
- Findings / Conclusions

Background

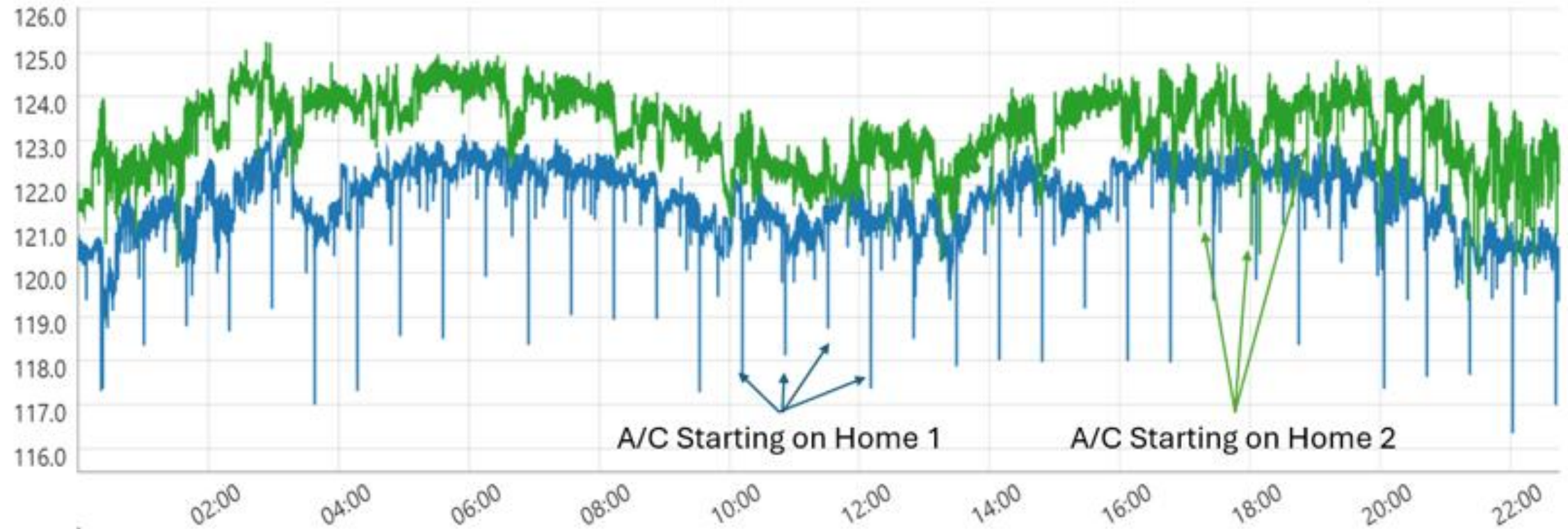


>1M sensors

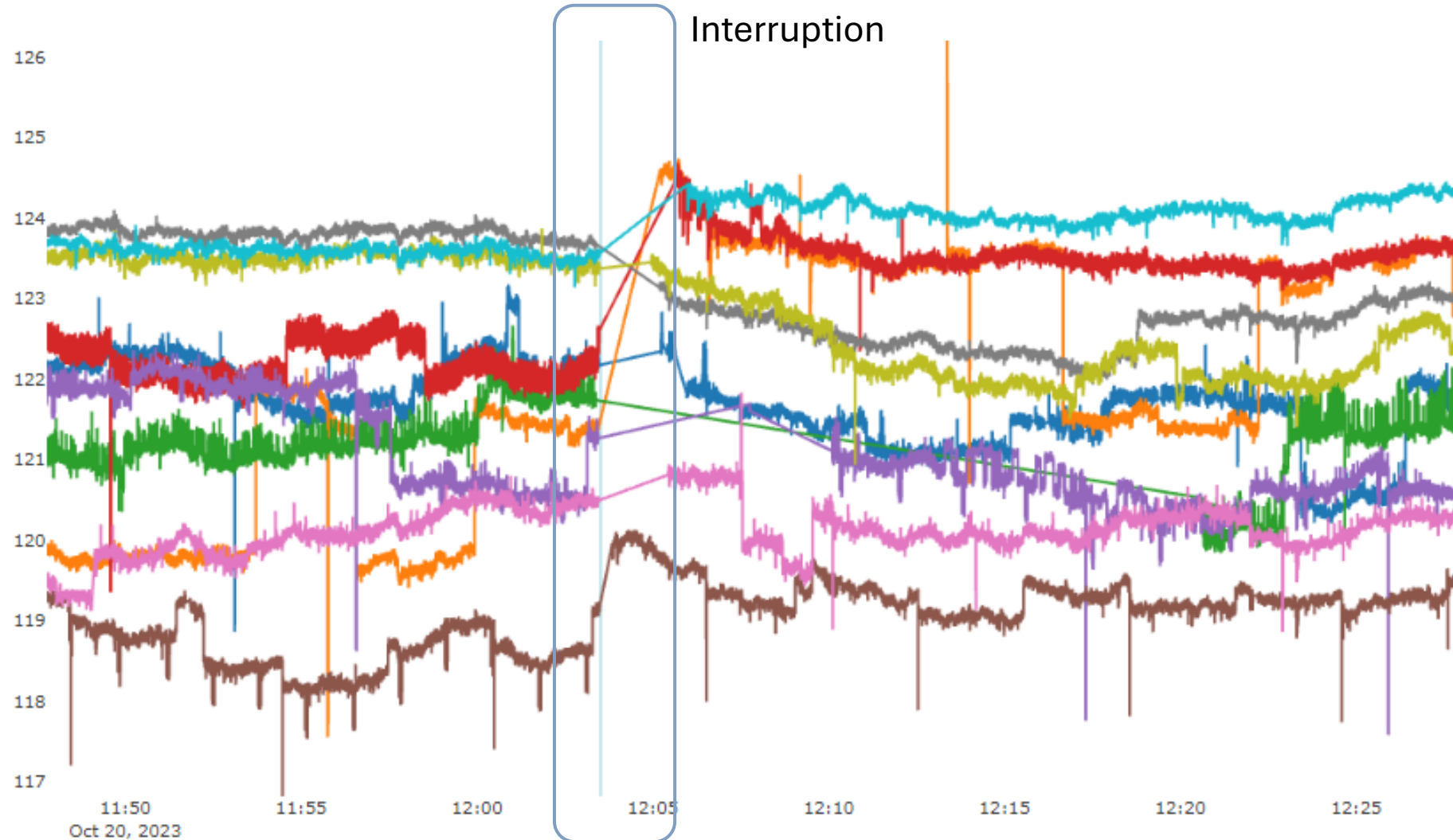
50k sensors / month
growth

Sampling rate
30MHz/30KHz

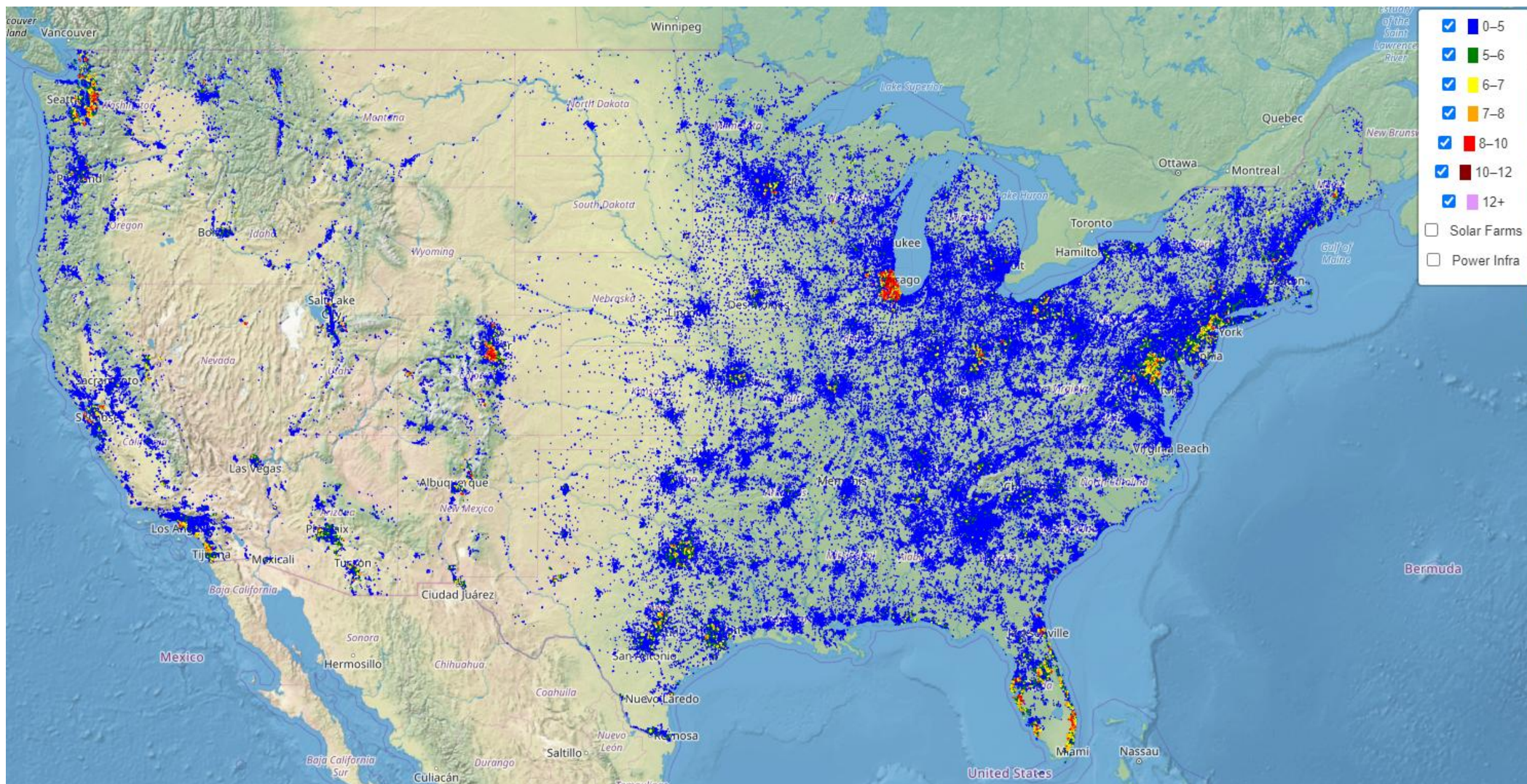
Monitors From Different Homes



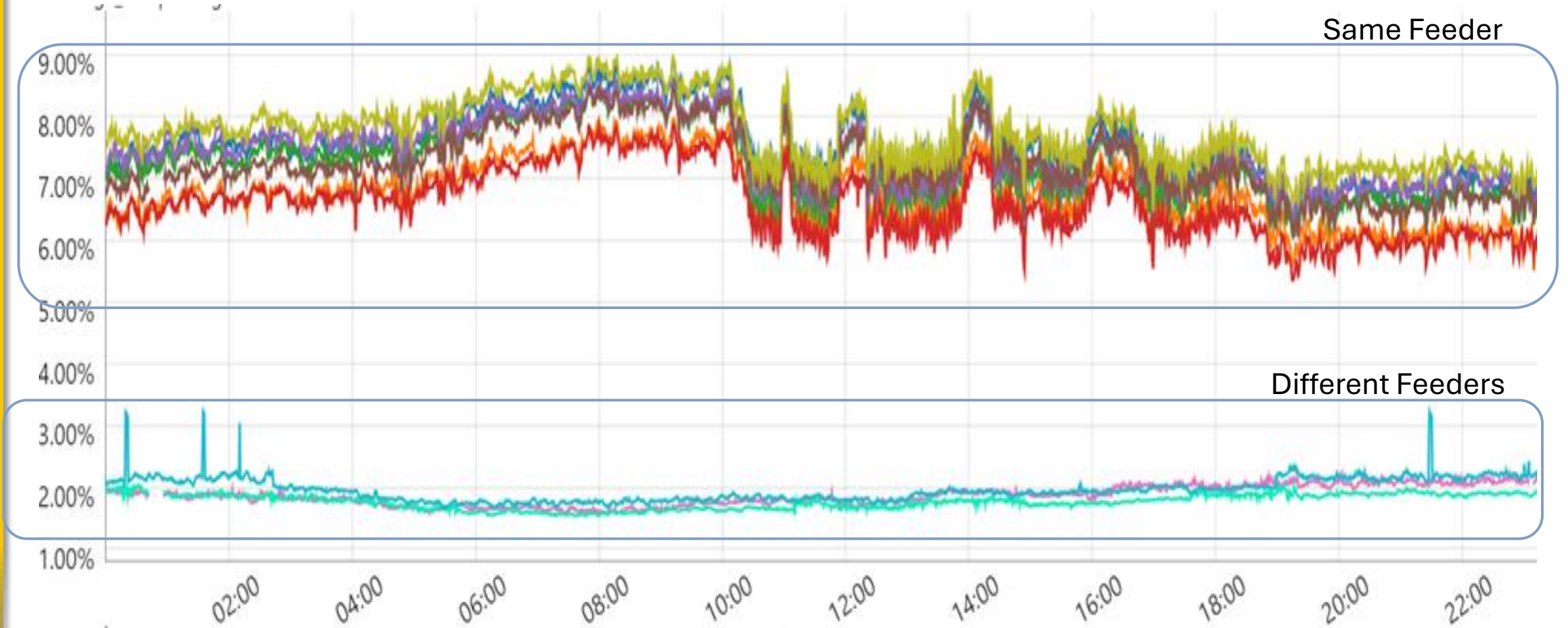
Grid Events



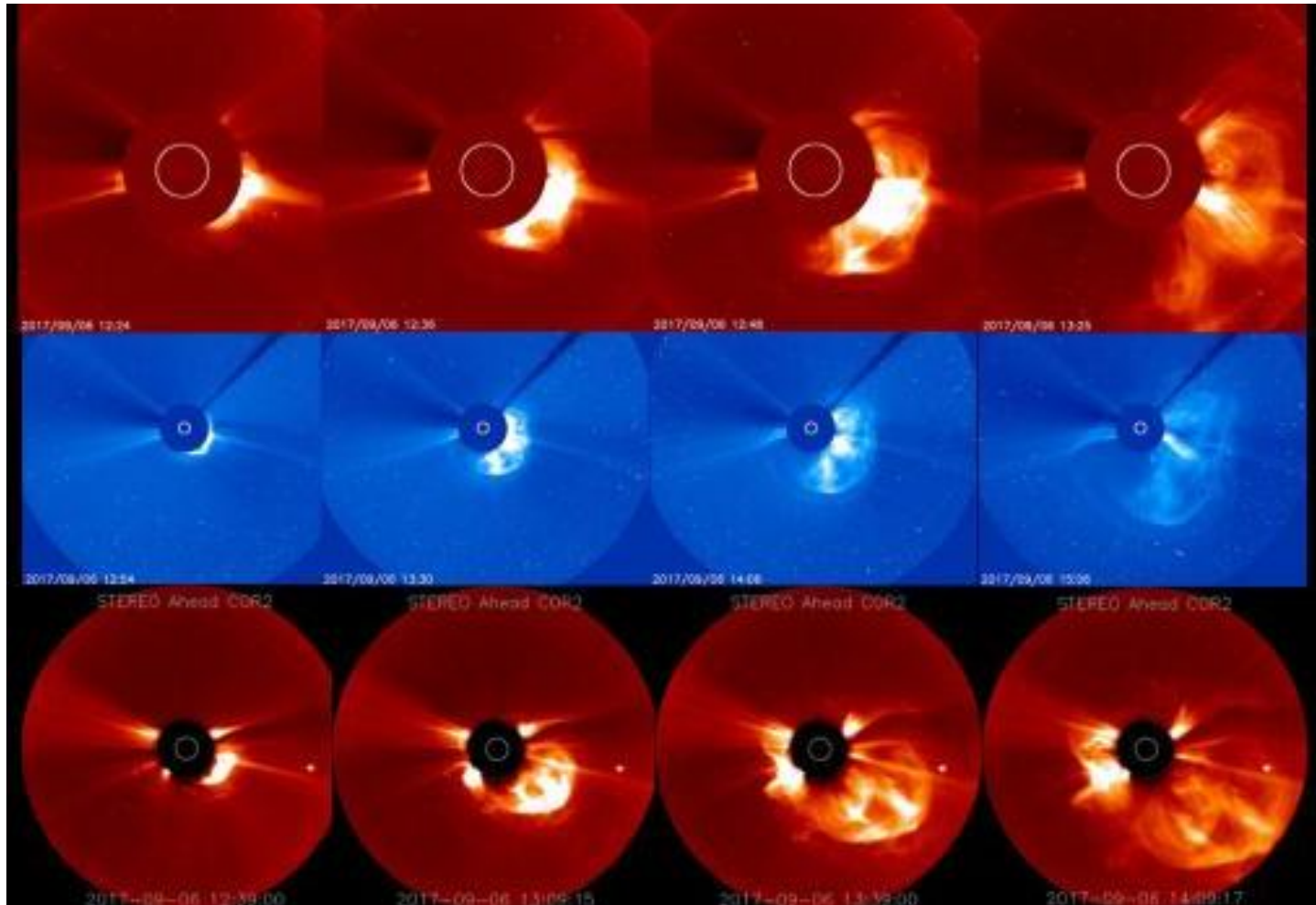
Total Harmonic Distortion (THD)



THD Trend



Coronal Mass Ejection (CME)



Sun's magnetic field flips ~11 years (aka Solar Cycle).

Sunspot / CME activities increase during this time.

CME is a large plasma and magnetic field ejection from the Sun's corona.

May results in Geomagnetic Disturbances (GMD) which in turn create Geomagnetically Induced Currents (GIC).

GMD Timeline



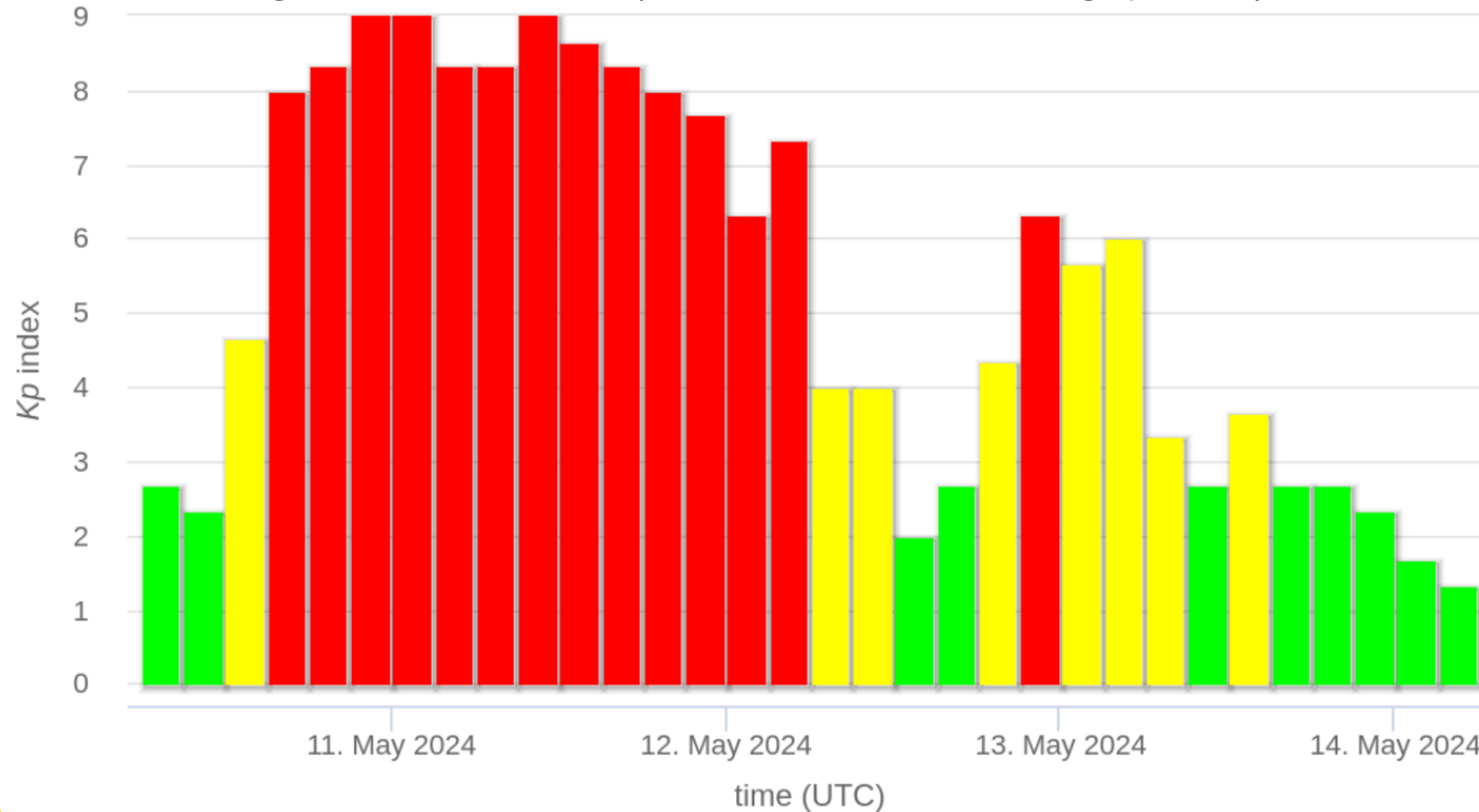
Prompted the development of NERC TPL-007-1

“Reliability Standard TPL-007-1 establishes requirements for certain registered entities to assess the vulnerability of their transmission systems to geomagnetic disturbance events (GMDs), which occur when the sun ejects charged particles that interact with and cause changes in the earth’s magnetic fields.”

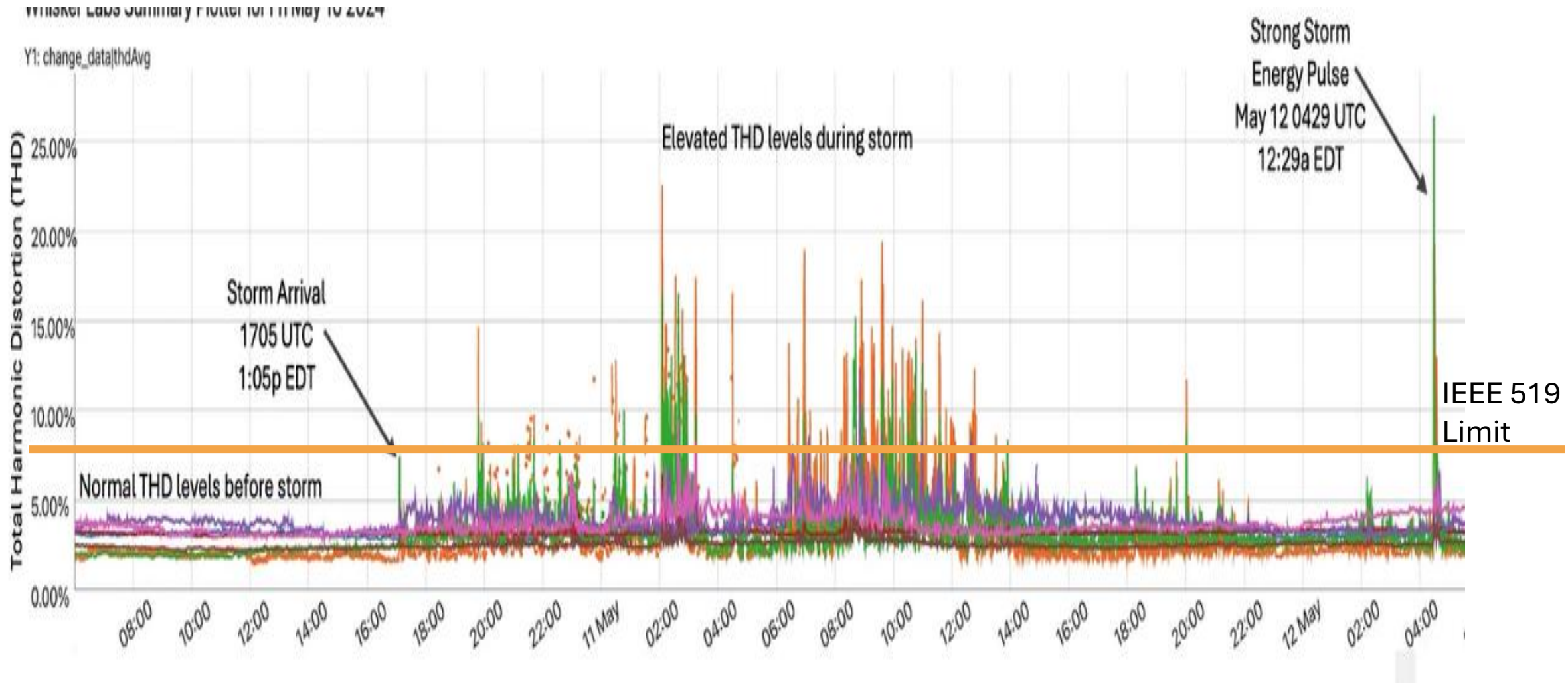
CME on May 8, 2024

CMEs take a few days to reach Earth.

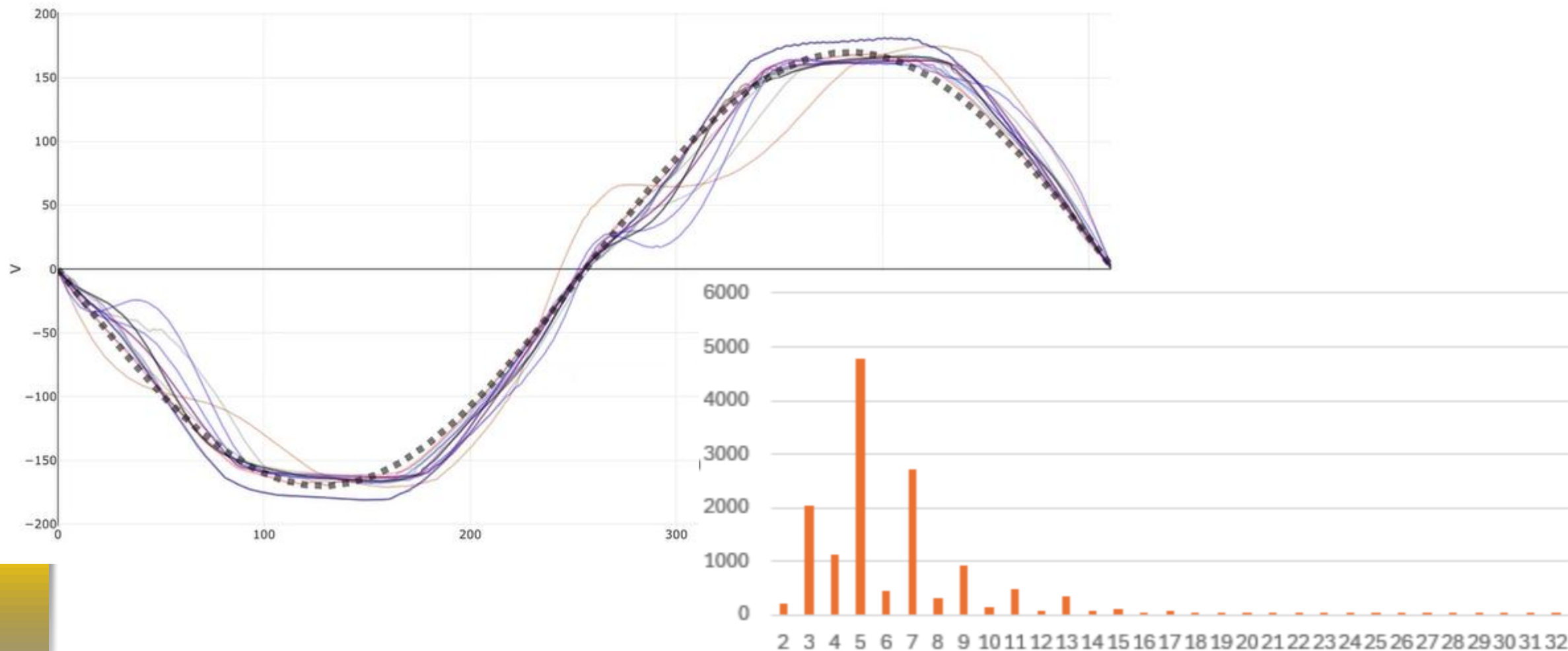
Kp is a measure of strength of the GMD event (over 7 is considered strong by NERC).



THD Measurements During CME

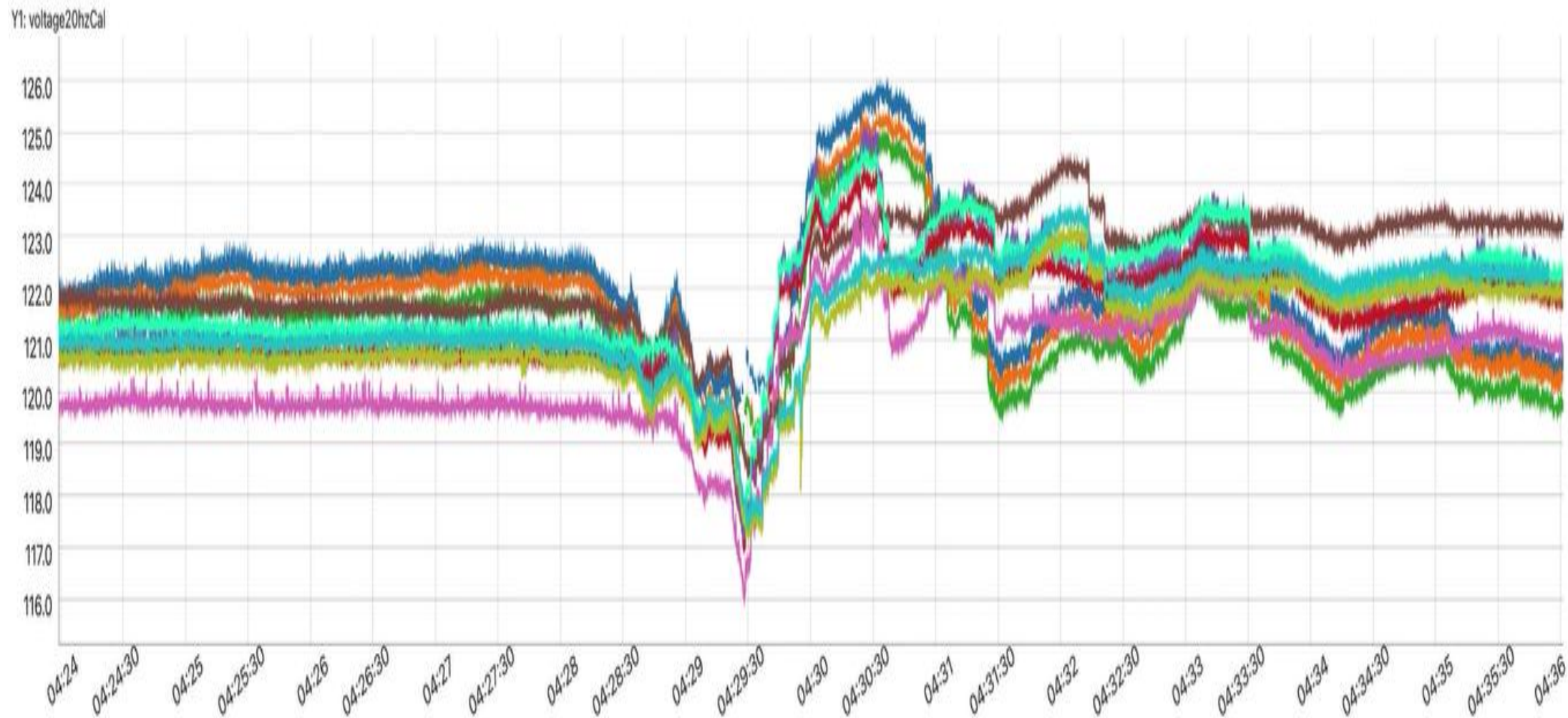


Waveform Recordings

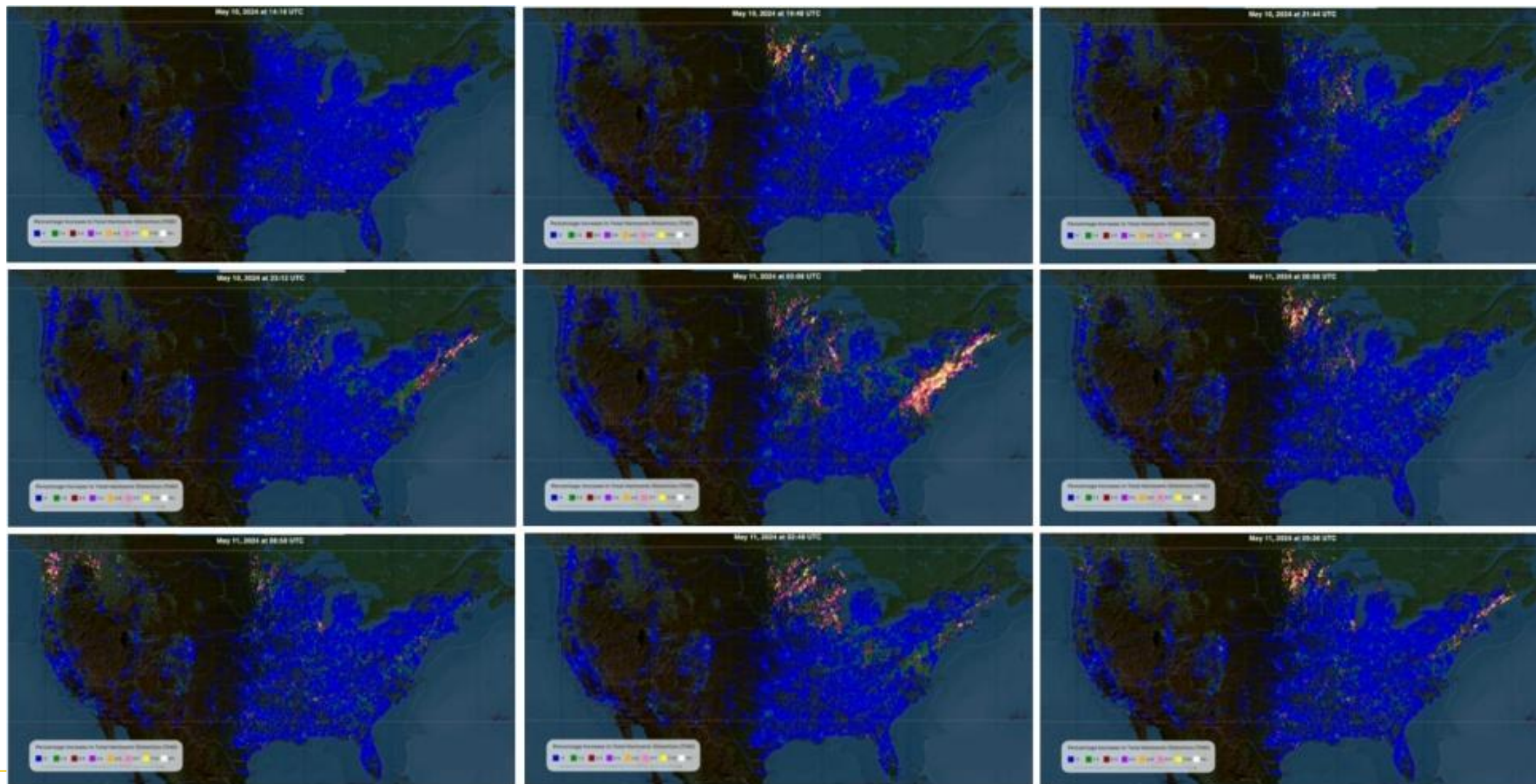


Harmonic Spectra

Voltage Influence



THD Map Across The US

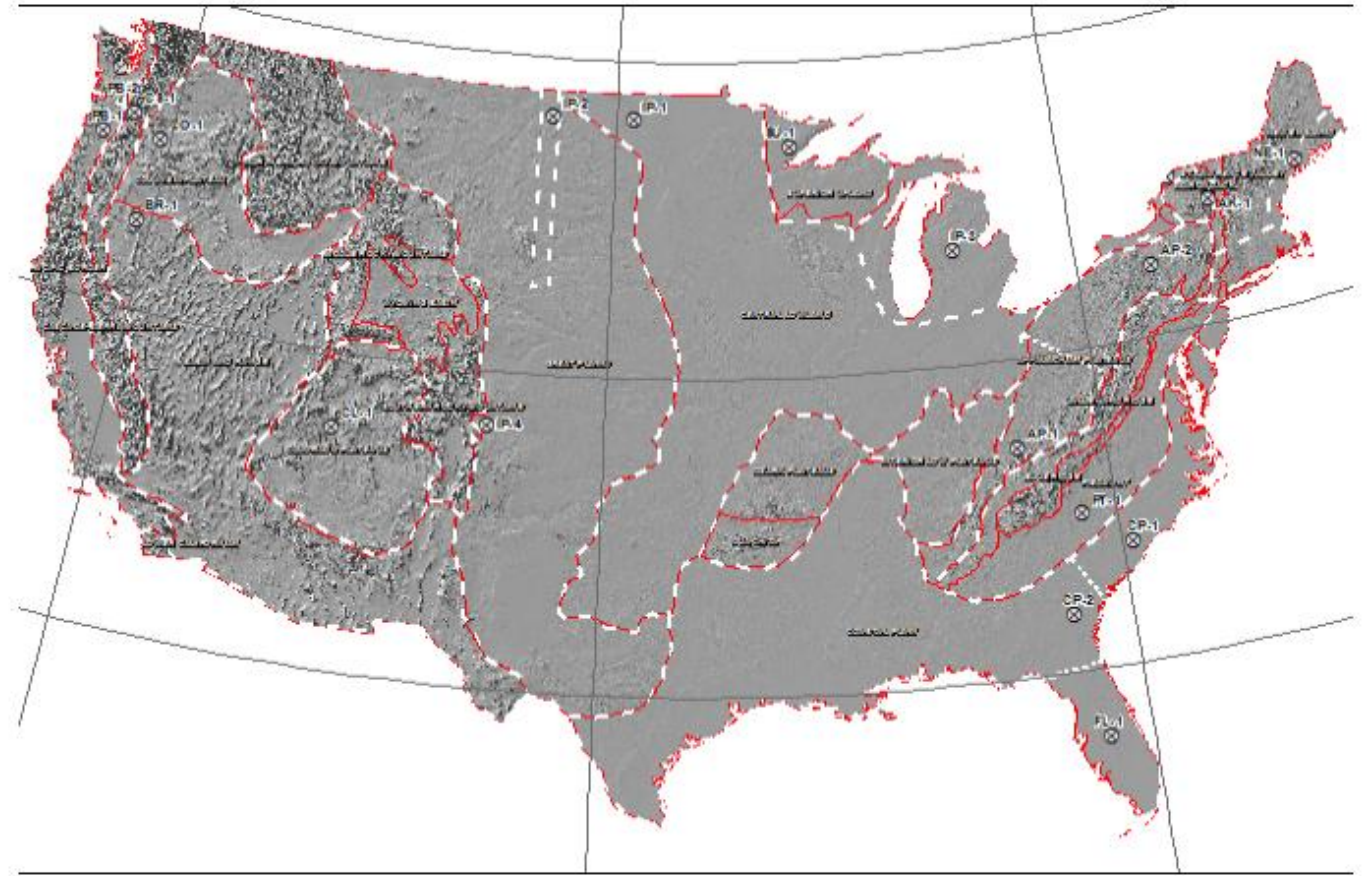


Observations

GIC is likely to be higher where the Earth's resistivity is higher.

The map on the left shows the resistivity in different areas.

As expected, there was a high correlation between high earth resistivity and higher harmonic values which suggests transformers were saturated.



Conclusions

- Historically viewed as a transmission system issue. This shows the effects can be very localized.
- Existing models appear to underestimate THD.
- Existing models do not predict the propagation of harmonics through the distribution network.

Thank You!

Acknowledgements

- Jim Anderson
- Stan Heckman
- Bob Marshall