NARUC CPI
Innovation Webinar

SPACE WEATHER'S IMPACT TO THE GRID

INNOVATION WEBINAR

June 18, 2026
3:00 to 4:00 p.m. ET

Free & open to the public!

***Moderator*: Hon. Emile C. Thompson** (Washington, D.C.)

Mark Gutzmann,
Xcel Energy

Shawn Dahl,
NOAA / NWS / Space Weather Prediction Center

Mark Olson,
NERC

About NARUC

- Founded in 1889, the National Association of Regulatory Utility Commissioners (NARUC) is a non-profit organization dedicated to representing the state public service commissions who regulate the utilities that provide essential services such as energy, telecommunications, power, water, and transportation.

- NARUC's members include all 50 states, the District of Columbia, Puerto Rico, and the Virgin Islands.

- Our mission is to serve the public interest by improving the quality and effectiveness of public utility regulation.

- For more information, visit: www.naruc.org

About NARUC CPI

- The NARUC Center for Partnerships & Innovation (CPI) builds relationships, develops resources, and delivers training to assist state commissions contending with complex current and emerging issues.

- CPI is funded by cooperative agreements with the U.S. Department of Energy (DOE).

- CPI conducts work across five key energy areas and many topics within each: generation; transmission; distribution; customers; and critical infrastructure preparedness, response, and resilience.

- Among other events, CPI hosts a monthly innovation webinar series on a wide range of timely topics.

- For more information, visit: www.naruc.org/cpi

Upcoming Events

Virtual Events:

- **DSP Peer Sharing Webinar on Considering Advanced Building Technologies:** June 22, 3:00 to 4:30 p.m. ET.
- **DER cohort: Managing Interconnection Costs Part 1:** June 23, 3:00 to 4:30 p.m. ET.
- **Regulators' Financial Toolbox Webinar: Advanced Transmission and Grid-Enhancing Technologies (GETs): Unlocking Capacity and Optimizing the Grid:** June 24, 3:00 to 4:00 p.m. ET.
- **NCEP Member Update Webinar:** July 6, 2:30 pm to 3:30 p.m. ET.

Upcoming In-Person Events:

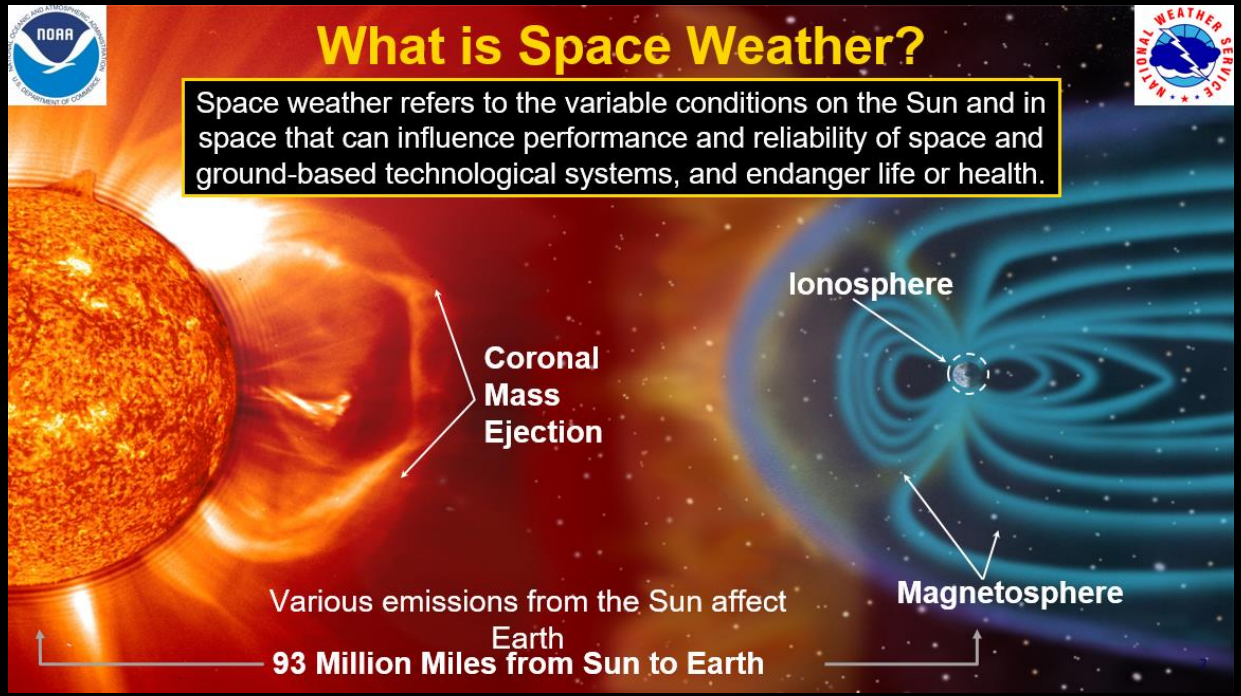
- **NARUC Summer Policy Summit:** July 19 to 22, Minneapolis, MN
- **2026 Cybersecurity Training for Regulators:** September 15 – 17, Austin, TX

See the full list of events and access registration links at: www.naruc.org/events/event-list/

Today's Speakers

How Can Space Weather Be Most Easily Described

SWPC Space Weather Responsible Area Encompasses the Sun-Earth Line

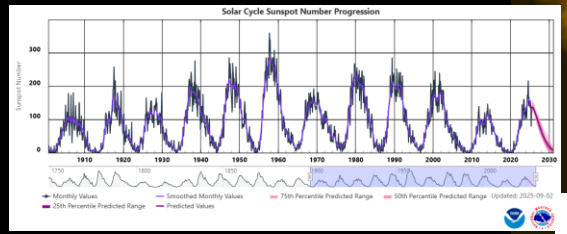


Significantly impacting space weather storms are generally considered a LOW LIKELIHOOD, but potential HIGH IMPACT Hazard/Risk

The 11-year (average) Solar Cycle – Where are We at in Solar Cycle 25?

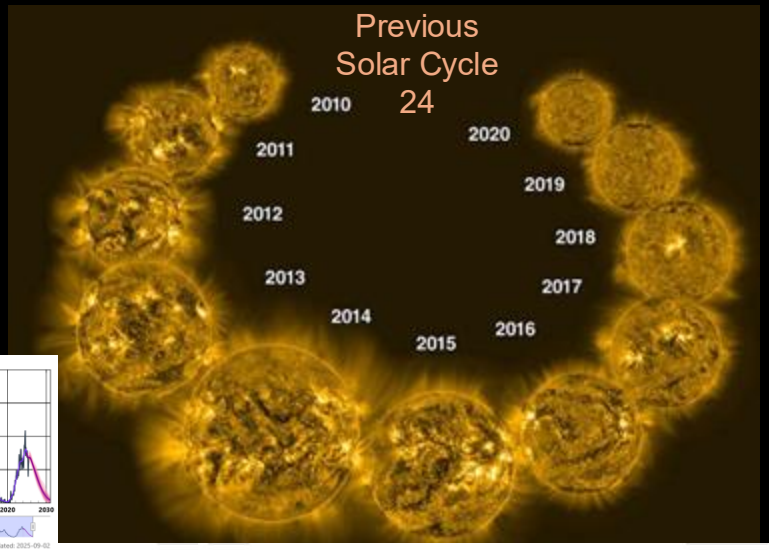
Significant Activity can Occur at any Point, but is Most Likely in/around Solar Maximum

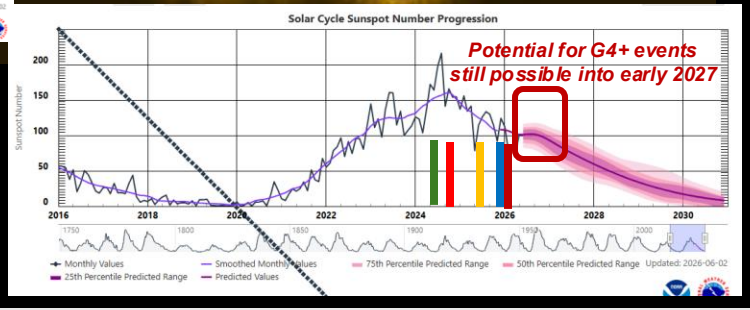
On average, every 11 years the Sun goes from quiet to active and back to more quiet. This is called the "Solar Cycle".



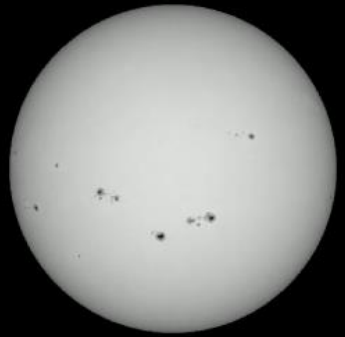
Sunspots are most often the source for many of the more intense space weather related events

***Regardless, some of the strongest historical events have occurred in the year or two past solar peak**





Current Solar Cycle 25



Don't let the occasional drops in sunspots during solar maximum fool you; the normal roller-coaster that is a cycle can very considerably.

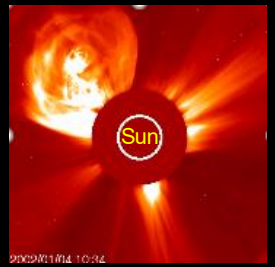
***Largest solar flare (R4) of SC24 was 2-3 years after peak**

Halloween Storms of 2003 were 1-3 years after peak (even spotless days prior to the massive outbreak)

August 1972 storms were 2-4 years after the peak

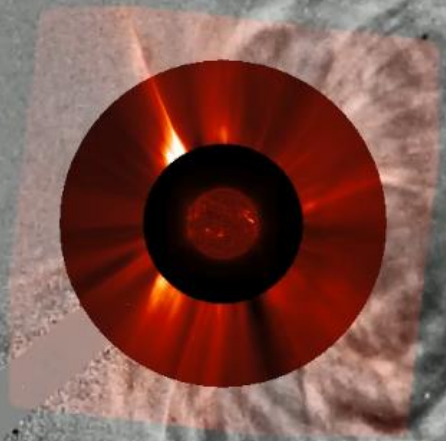
Coronal Mass Ejections (CME): What are They?

SWPC Forecasters Analyze CMEs and Run Them Through a Model for Earth-Directed Chances



Tremendous expulsions of solar and embedded magnetic fields. Their impact to our magnetosphere can cause major changes resulting in **Geomagnetic Storms**

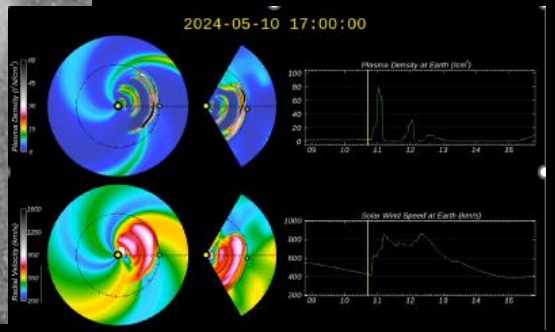
CME measurements are very subjective and constitute shape, speed, and general direction bias. Individual model runs are done several times for each CME and the most likely result is the chosen solution – but still with some forecaster intervention and timing adjustments.



Coronagraph observations and our model solution become our best guess Watch decision point. This is without any observation information about the CME structure, actual speed, magnetic field strength and orientation whatsoever.

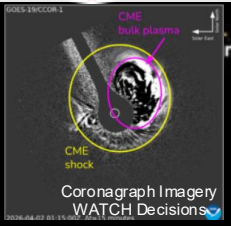
Fastest Earth-directed CMEs can get here is in 15 hours. Usually, they are slower and take 2 to 4 days.

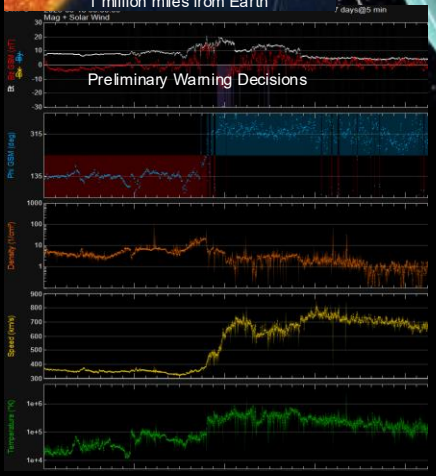
WSA-Enlil Model



Geomagnetic Storms: G-Scale

SWPC Forecasts Levels of Geomagnetic Response out to 3 Days; with a Focus on G-Scale Events





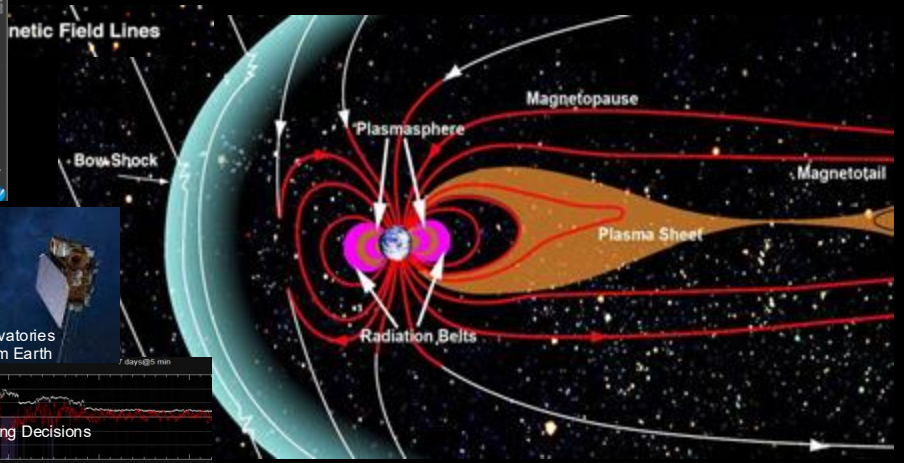


Image Credit: NASA/Goddard/Aaron Kaasse https://www.nasa.gov/mission_pages/sunearth/science/magnetosphere2.html

Solar storms (like a CME) can cause deviations in Earth's magnetic field that may lead to geomagnetic disturbances (GMD). These GMDs can vary greatly in intensity but when strong enough, warrant geomagnetic storm status (G-Scale).

CME or other activity arrival at the L-1 (Lagrange point) orbital location are when we can finally begin to understand the CME structure and speed. This marks our first Warning decision point. Prior to that, it is purely experience and best judgement regarding level of Watch – based on coronagraph imagery and model results only.

8 Magnetometer Observatories

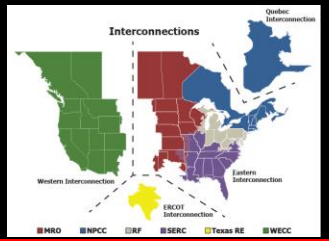
Can produce problematic induced currents on power grid and can lead to upper atmospheric conditions that can cause variety of communication (SATCOM included) & GPS accuracy problems

SWPC Actions for Just the Interconnected Electric Power Grid

SWPC Spins Up the NERC GMD Hotline Call to all Reliability Coordinators – Know Y

Kp5	G1	Phone call to *Wisconsin Electric Control Area and the New York ISO
Kp6	G2	Phone call to *Wisconsin Electric Control and the New York ISO
Kp7	G3	NERC Hotline Call and Wisconsin Electric Control Area
Kp8	G4	NERC Hotline Call and Wisconsin Electric Control; FEMA notified; possibly the NSC/WHSR
Kp9z	G5	NERC Hotline Call and Wisconsin Electric Control; FEMA notified; NSC/WHSR informed

*SWPC is also making additional Decision Support Service related notifications and calls at various levels for G-scale and other space weather activity; to include support for Oceanic ATC, Satellite Operators, NASA, Space Launch, USAF/USSF, FEMA, WHSR/NSC

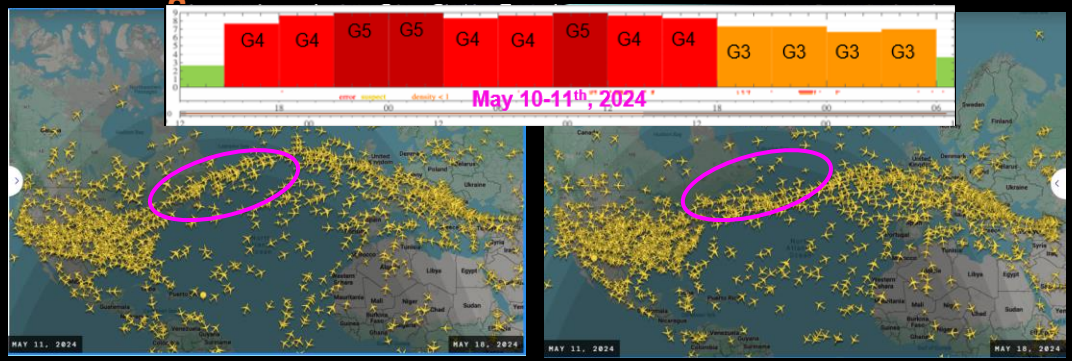


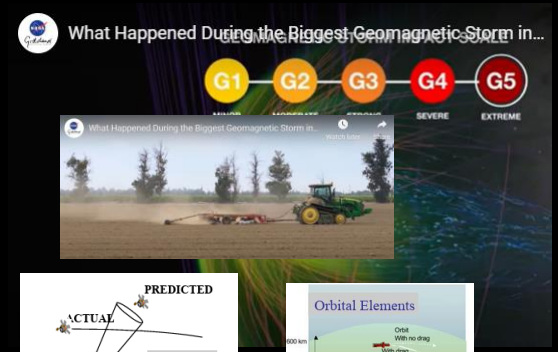
We are required to initiate the NERC GMD Hotline Call for a **G3** (Kp 7) **WARNING** and Kp7-Kp9 **ALERT**s. However, we've provided **EARLY NOTIFICATION** for the **G4 or Greater WATCHES** - the past five occurrences. This allowed for very enhanced lead times above and beyond the 15-45 minutes typical for the **Kp7 or Greater WARNING** and allowed for mitigation measures to be put into place by bulk electric system authorities.

May 2024 G5 Storm: 6 hours lead time
Oct 2024 G4 Storm: nearly 24 hours lead time
May 31-Jun1 2025 G4: 10 hours lead time
Nov 11-12th 2025 G4: 3-4 hours lead time
Jan 19-20th 2026 G4: 6 hours lead time *NERC gave appreciation due to cold weather outbeak at the time

May 10-11, 2024 – The "Gannon Storm" Effects and Impacts

The First G5 Event in Over 20 Years – the Last Such Extreme Storm was in





Acknowledge: Prof . Delores Knipp
University of Colorado Boulder

Hundreds of flights across both oceans diverted further southward due to HF communication disruption. NOTAMs issued advising of comm/nav disruptions. WAAS for precision landing and performance based navigation was unusable for ~15 hours

Some isolated higher communication bands' degradation reported

Largest mass satellite maneuver/migration in history ~5000 LEO Satellites moving at same time. Degraded Starlink and Iridium services. Global comms satellite lost sync lock.

A billion dollar loss to agriculture for corn crop planting alone due to a day or more loss of precision GPS operated equipment. *My own brother-in-law included*

Preventative and conservative measures instituted by the North American Power Grid – still some tripped high voltage capacitors. High voltage lines tripped in Europe. New Zealand disconnected their northern island's power as precautionary measure.

Surprising 0.1% variation in National Institute of Standards & Technology (NIST) Cesium clock

May 10-12th, 2024: One of Strongest GMD Events, but not the Worst

Historical Comparison of May 2024 Solar Storms

WHAT: How did the G5 Geomagnetic Storm Compare to Other Major Events?

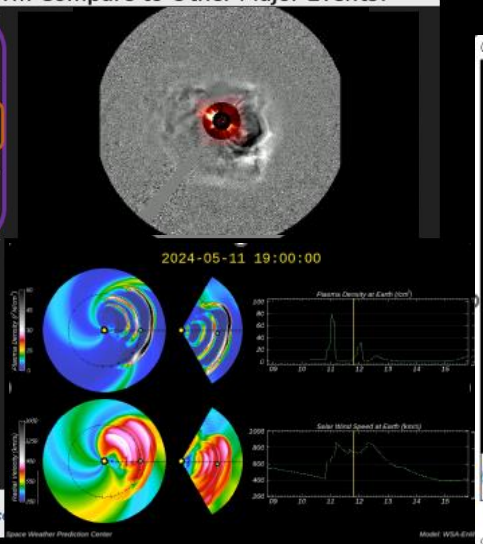
Index	MAY 2024	OCT 2003	MAR 1989	MAY 1921	SEP 1859
Disturbance Storm Index (nT)	-412	-383	-589	~ -907	~-1200
A_p-Index	271	204	246	NA	NA

Disturbance Storm Index (Dst): An index of magnetic activity derived from a network of near-equatorial geomagnetic observatories that measures the intensity in space of the ring of westward current around Earth (higher negative values generally correlate with stronger storms)

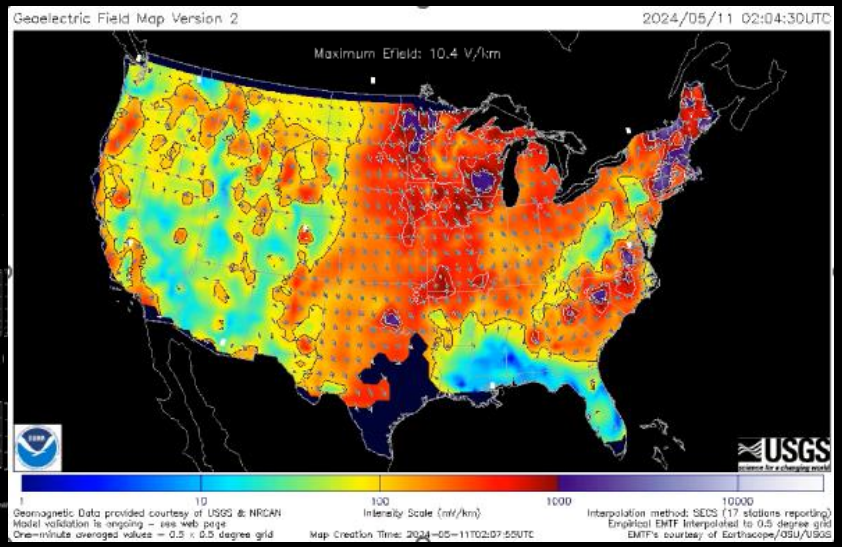
A_p-Index: The average from eight daily values gives the A_p-index of a certain day (every 3-hour K-value - or measure of geomagnetic activity - is converted into a linear scale). Days with higher geomagnetic activity have a higher daily A_p-value.

National Oceanic and Atmospheric Administration

Safeguarding Society with Actionable Spac



2024 Storm peaked at 10.4 V/km
2003 Storm peaked at 7.7 V/km
1989 Storm peaked about 14.7 V/km
1859 Carrington Event estimated to be notably over 15V/km



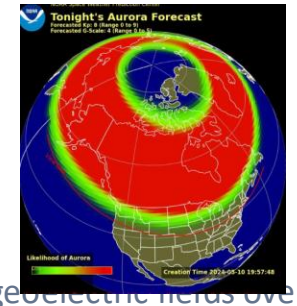
For now, SWPC communicates with the power grid in terms of Kp Index, with no regionalized or tailored information. We are now working hard to provide more localized and specific products + decision-support for the BES. The August 2026 BES Testbed Exercise will allow SWPC to identify and prioritize support/product needs.

Geoelectric Field is used as a measure of the induction hazard to artificial conductors, such as power lines. A measure to estimate geomagnetic induced current (GIC) integration along conducting pathways.

NERC

Atmospheric Driver

Geomagnetic Disturbances (GMD)



Cause geoelectric fields over continent-sized areas

Field strength varies by location (latitude, deep-earth structure)

System Response

Geomagnetically Induced Currents (GIC)

~Direc ystem transfo

GIC str y, transfo stics

Reliability Risks

System Voltage and Equipment Impacts

GIC in Transformers → Harmonic Currents

- Sudden loss of system voltage support resources
- Transformer reactive power loss
- Potential for transformer degradation or failure

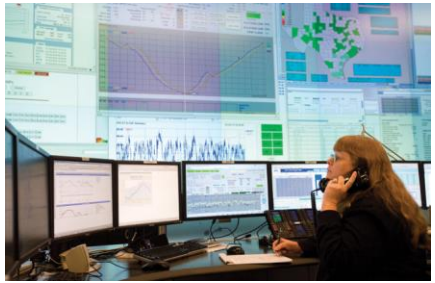
+ = Risk of Voltage Collapse

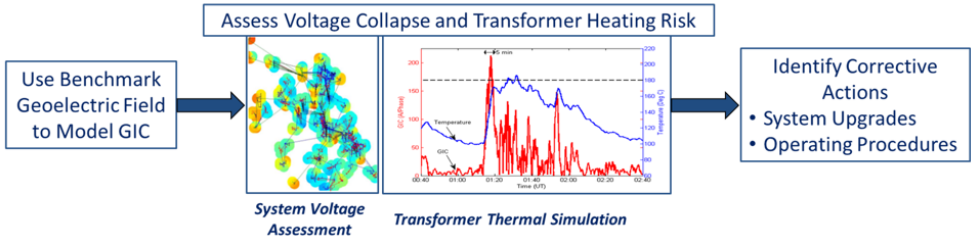
Operating Procedures (EOP-010)

- Grid operators are required to have plans to reduce risks during severe GMD events
- Voice hotline between Reliability Coordinators and NOAA forecasters provides rapid information exchange
- Advanced warning 3 – 24 hours prior to onset of severe GMD conditions

Vulnerability Assessments (TPL-007)

- Grid planners assess system voltage and equipment risks against a 100-year storm
- Actions to mitigate vulnerabilities and protect against voltage collapse are required (system hardening, GIC monitors, and pre-planned operating actions)
- Assessments are required every five years





GMD Vulnerability Assessment Overview

GMD Resilience Requires Continued Attention

- **GMD resilience is not a static problem.** Space weather science is evolving and so is the grid
- **NERC GIC database is a valuable tool for understanding of GMD risk**, supporting
  - Industry model validation
  - Space weather community research
- NERC's annual State of Reliability Report reviews grid performance and the effects of all hazards
- Utilities and their regulators should have a shared understanding of the risk and mitigation plans