NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Agenda (Draft)
Geomagnetic Disturbance Task Force (GMDTF)

August 26, 2020 | 1:00 p.m. – 3:00 p.m. Eastern

Join Webex Meeting
Access code: 160 682 1649
Dial-in: 1-415-655-0002 (US Toll); 1-416-915-8942 (Canada Toll)

Introduction and Chair's Remarks

NERC Antitrust Compliance Guidelines and Public Announcement

Agenda Items

1. **GMD Data Reporting Update** – NERC Staff (1:00 – 1:50 p.m.)

Break (1:50 – 2:00 p.m.)

2. **Electric Power Research Institute (EPRI) Update –** Bob Arritt, EPRI (2:00 – 2:20 p.m.)
3. **U.S. Magnetotelluric Array Survey Update** – Adam Schultz, Oregon State University
4. **Space Weather Prediction Center (SWPC) Geomagnetic Field Interpolation Model Demonstration** – Chris Balch, NOAA SWPC (2:20 – 2:40 p.m.)
5. **Wrap-up discussion and adjourn** (2:40 – 3:00 p.m.)

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GMD Data Reporting

Application Update and Process Overview

NERC Staff
GMD Task Force Meeting
August 26, 2020

RELIABILITY | RESILIENCE | SECURITY




Topics

- Overview of GMD Data Reporting
- Update on GMD Data Reporting Application
- Process for Designating Information as Confidential Information in the GMD Data Reporting System

Overview

GMD Data Collection Background

- NERC Board approved Rules of Procedure Section 1600 data request for collecting GMD data in August 2018
  - Responds to FERC Order No. 830 directives for collecting data to "improve our collective understanding" of GMD risk
  - NERC developed the GMD Data Request with GMD Task Force (GMDTF) and technical committee input
- NERC Staff is completing development of the GMD Data Portal for implementation in October 2020
- Reporting entities must report data annually by June 30
  - First collection deadline June 30, 2021

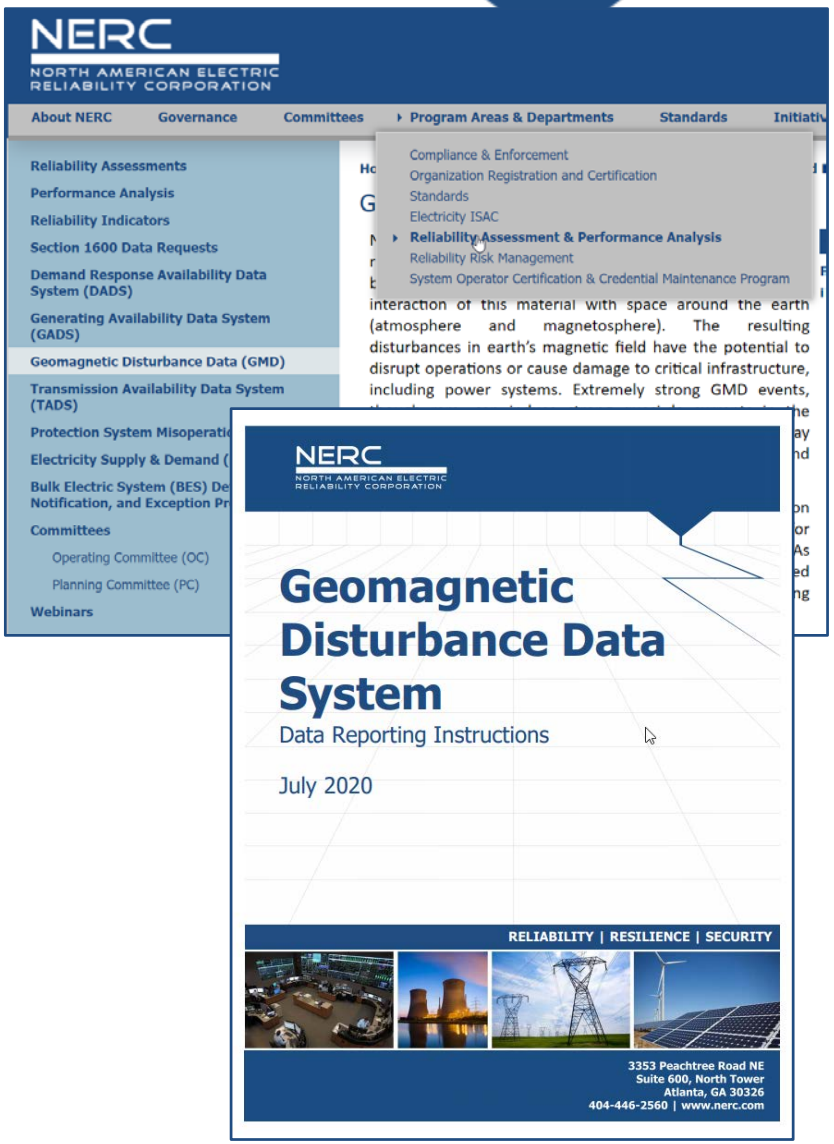
Purpose of Collecting GMD Data

[The Commission] also direct NERC, pursuant to Sections 1500 and 1600 of the NERC Rules of Procedure, to collect and make GIC monitoring and magnetometer data available. We determine that the dissemination of GIC monitoring and magnetometer data will facilitate a greater understanding of GMD events that, over time, will improve Reliability Standard TPL-007-1. The record in this proceeding supports the conclusion that access to GIC monitoring and magnetometer data will help facilitate GMD research, for example, by helping to validate GMD models.

- Order No. 830 P 93

Data Reporting Information

- NERC's GMD Data web page has instructions and links
- Data Reporting Instruction (DRI) has been developed by NERC with GMDTF support
  - Assists NERC and reporting entities in fulfilling the GMD Data Request reporting requirements
  - Specifies processes, formats, and timelines for data collection
  - NERC Planning Committee (PC) reviewed in January and provided comments



Who Must Report

- Transmission Owners (TO) and Generator Owners (GO) must provide information and data as indicated in the data request
- TOs and GOs that collect GIC data or magnetometer data are considered **Reporting Entities** for GMD events specified in the GMD Data Request and this instruction.
- The GMD data request applies to only U.S. responsible entities (*See* Order No. 830, n. 118).
  - Responsible entities in other NERC jurisdictions including Canada are encouraged to participate in order to obtain relevant GMD data for the North American Bulk-Power System.

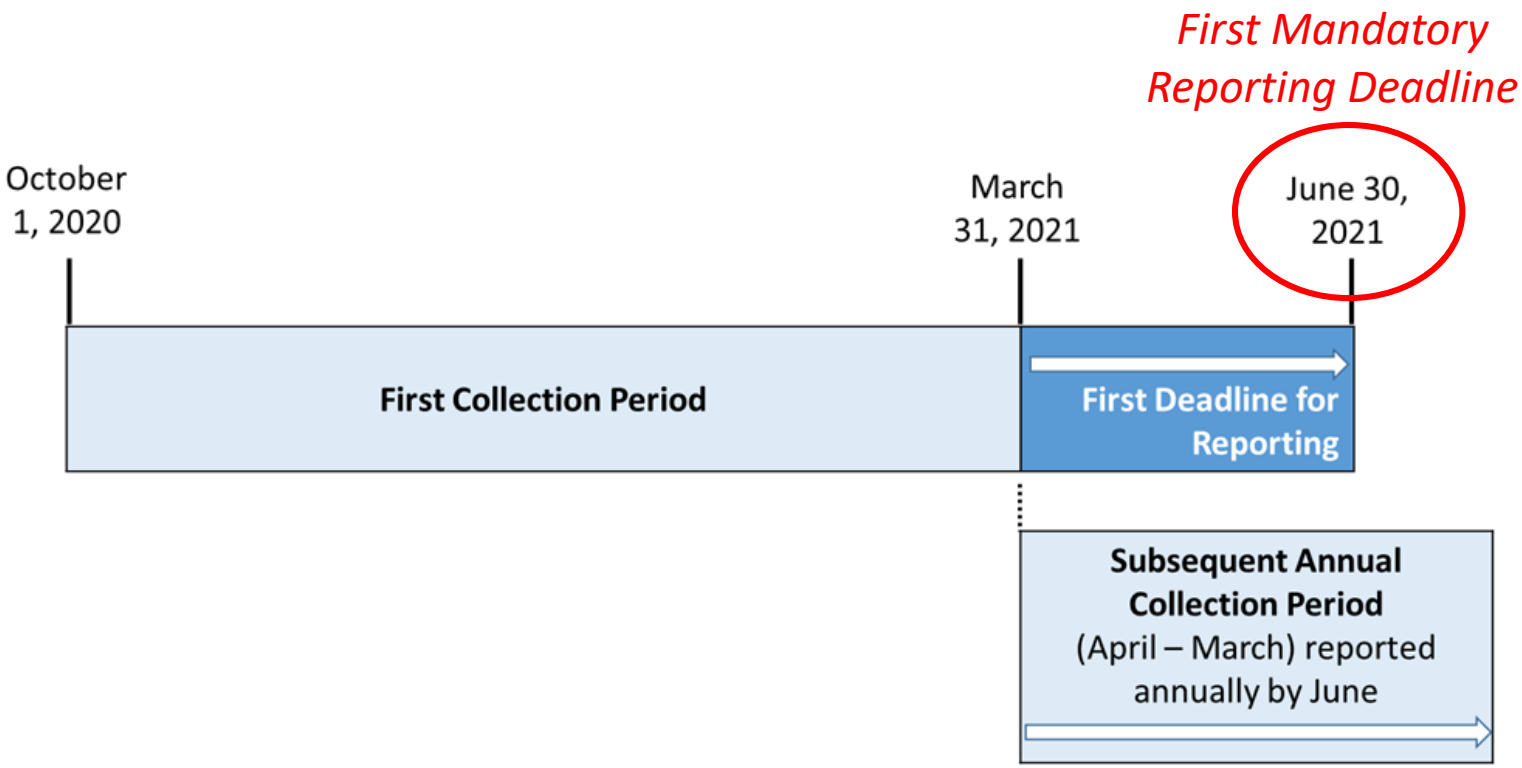
What is Reported

- Reporting Entities will provide the following types of data for time periods during which GMD events K_P= 7 or greater
  - GIC data for designated GMD events
  - Geomagnetic field data for designated GMD events
- Continuously-sampled GIC measurements (amps) (e.g., 10-second sample rate) throughout the GMD event
- NERC will designate GMD events of interest in collaboration with NOAA Space Weather Prediction Center (SWPC)
  - On average, 200 K_P=7 or greater GMD events occur in 11-year solar cycle

- *NERC Staff will cover details later in today's presentation*

When will reporting begin?

- NERC's application will go 'live' in October 2020
- Data for GMD Events of Interest must be reported at least annually by June 30 of each reporting year



First GMD Data Collection Reporting Period and Timeline

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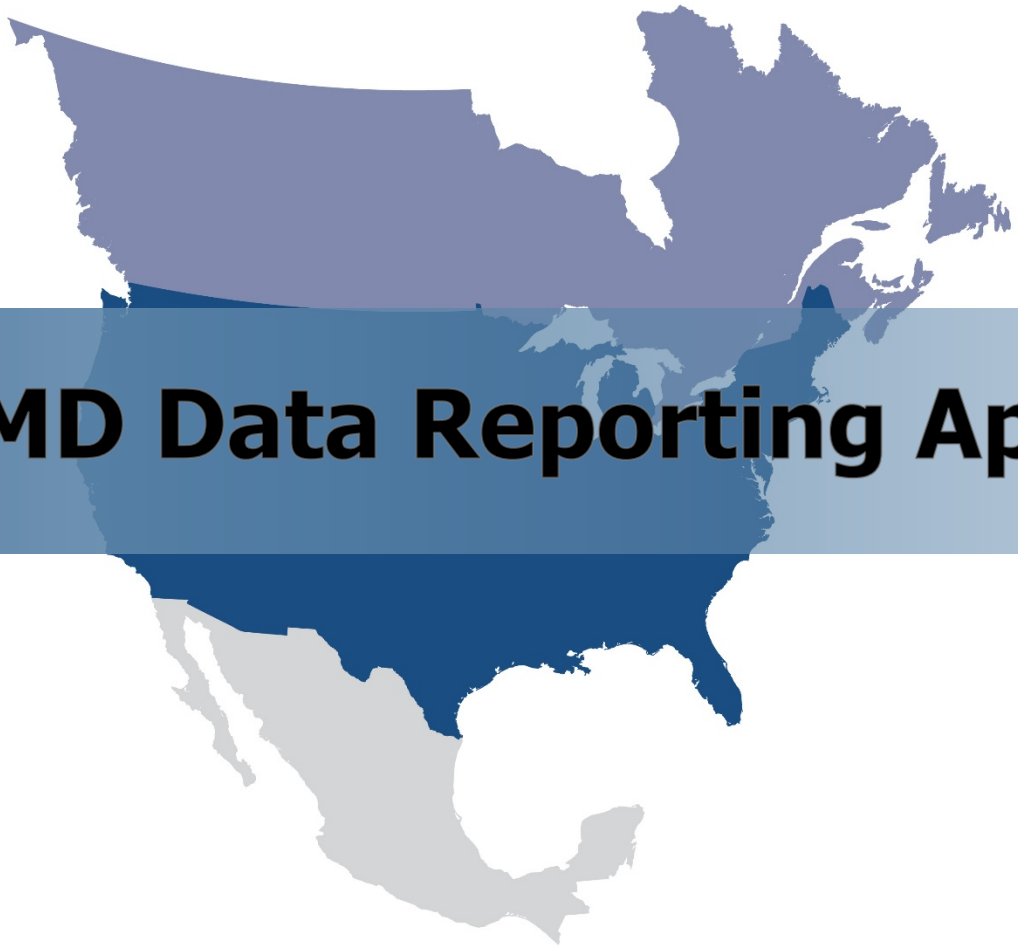
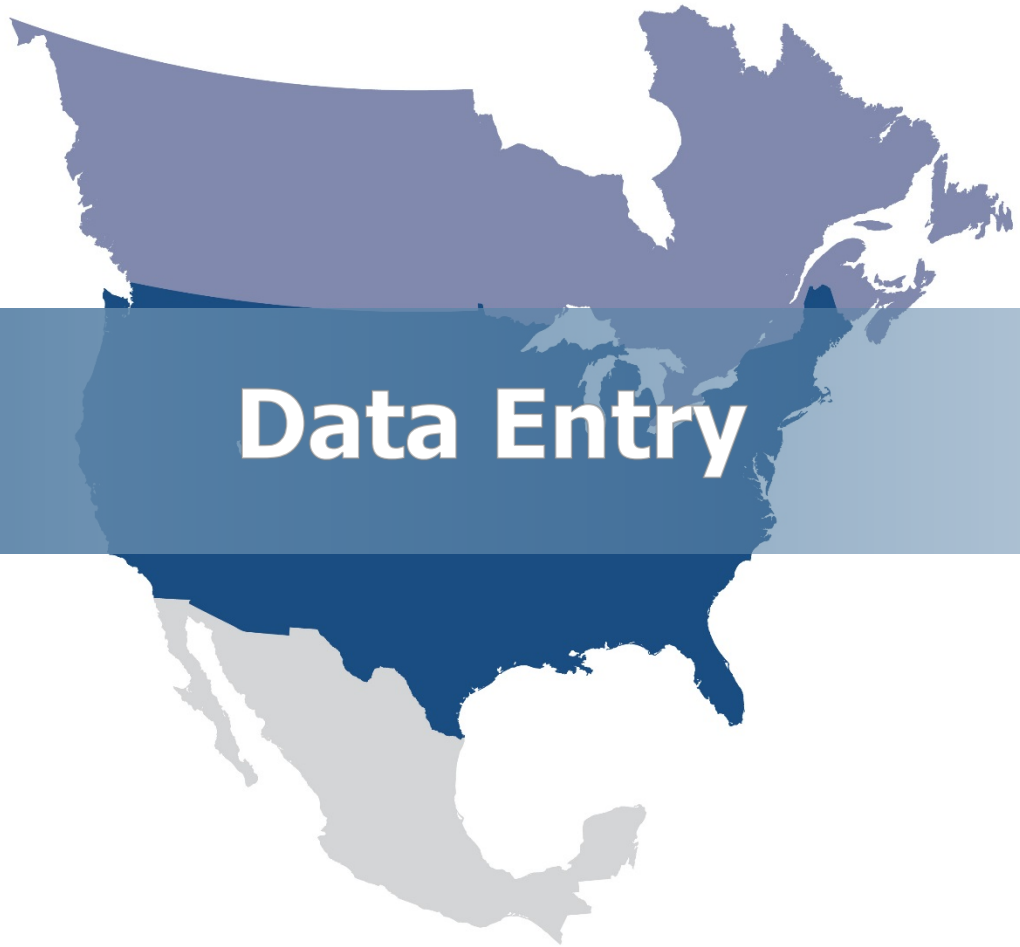


GMD Data Reporting Application

Overview

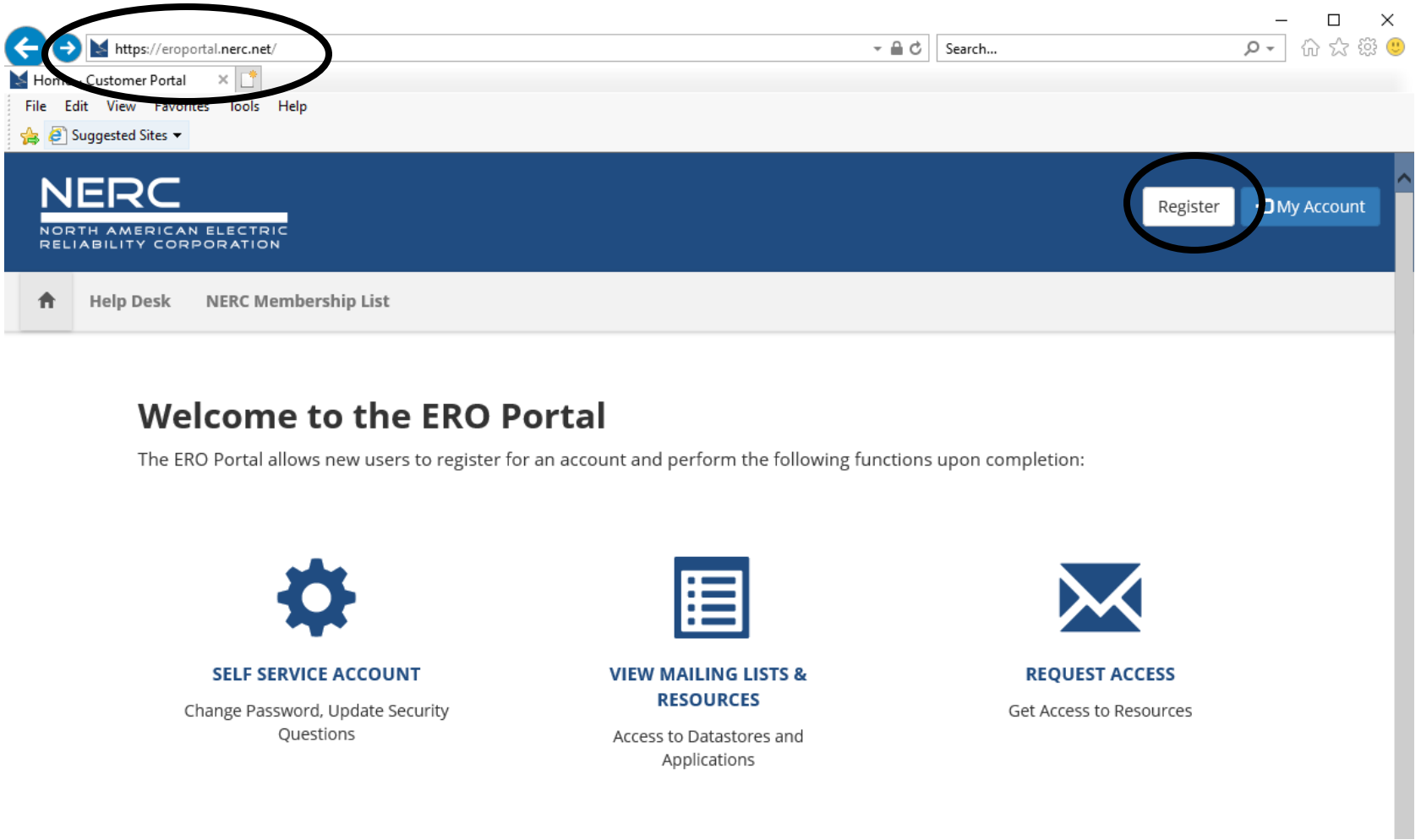
- Device information may be entered manually or through import of a file in Excel or CSV format
- Event data may be submitted in CSV format
- Templates for device and data uploads will be available on the GMD page on nerc.com
- Everyone providing or requesting GMD data will be required to have a ERO Portal account
- Event information will be displayed in the data collection application and will be posted on the NERC website on the GMD page
- GMD@nerc.net has been created to allow all GMD questions to be routed to the proper NERC staff



Data Entry

ERO Portal Account

https://eroportal.nerc.net/



Types of Data

- There are three types of data to be reported :
  - GMD monitoring equipment (GIC Monitor, Magnetometer)
  - GIC measurement data for designated GMD events
  - Geomagnetic field measurement data for designated GMD events

- DRI chapters describe data fields (format, units, narrative description, etc.) and provide example data

GMD Home Page

Geomagnetic Disturbance Data System

Welcome to the NERC Geomagnetic Disturbance (GMD) Data System. Users may submit, view, and manage device information and GMD Event data. GMD System Reports provide information on data reported for individual GIC Monitors and Magnetometers. Below is a list of entities for which you have permission to view or submit data. If an entity is not listed, go to the Application Access Requests page to request access.

The User Guide for the GMD Data System is available here or on the NERC website by navigating to Program Areas & Departments > Reliability Assessment & Performance Analysis > Geomagnetic Disturbance (GMD) > GMD User Guide for Entities.

For assistance with the functionality of the GMD Data System, please email GMD@nerc.net.

The annual reporting collection period for GMD data is from April 1 – March 31. The reporting deadline for each annual reporting collection period is June 30.

NCR ↑	Entity Name	GMD Role
NCR22222	Test Company 2	GMD Read-Only
NCR33333	Test Company 3	GMD Read-Only
NCR44444	Test Company 4	GMD Submitter
NCR55555	Test Company 5	GMD Submitter

Menu

GIC Monitor Devices
View, create, manage or bulk import GIC monitor devices

Magnetometer Devices
View, create, manage or bulk import magnetometer devices

GIC Monitor Data Reporting
View and submit GIC monitor data reporting submissions

Magnetometer Data Reporting
View and submit magnetometer geomagnetic data reporting submissions

Missing Data Report Imports
Bulk import missing data reports

GMD Reporting Status
View GMD Status Reports

GMD Events
View GMD events that require reporting

Device Management

GIC Monitor Devices

GMD Home Page

From this page, create, view, modify or export any GIC Monitors associated with the selected registered entity.

This is a list of the registered GIC Monitor devices for the currently selected registered entity. To view GIC Monitors from a different entity, choose an entity from the selection box located in the top right-hand corner of the page.

Summary Device List

Create GIC Monitor

Export

Menu

GIC Monitor Device Imports

View and manage GIC monitor bulk device imports

Device ID	Device Status	Device Serial Number	Geographic Latitude (North)	Geographic Longitude (West)	Status Effective Date
10094	AV	s-123	11.0	111.0	8/14/2020
10095	AV	s-456	60.0	65.0	8/14/2020
10096	AV	s-987	50.0	120.0	8/14/2020

View Details

Edit

Device Management

Magnetometer Devices

GMD Home Page

From this page, create, view, modify or export any Magnetometers associated with the selected registered entity. This is a list of the registered Magnetometer devices for the currently selected registered entity. To view Magnetometers from a different entity, choose an entity from the selection box located in the top right-hand corner of the page.

Summary Device List

Create Magnetometer

Export

Menu

Magnetometer Device Imports

View and manage magnetometer bulk device imports

Device ID	Device Status	Geographic Latitude (North)	Geographic Longitude (West)	Status Effective Date
50100	IV	67.0	97.0	8/14/2020
50099	AV	50.0	61.0	8/14/2020
50098	AV	60.0	120.0	8/14/2020
50097	AV	77.0	77.0	8/14/2020

View Details

Edit

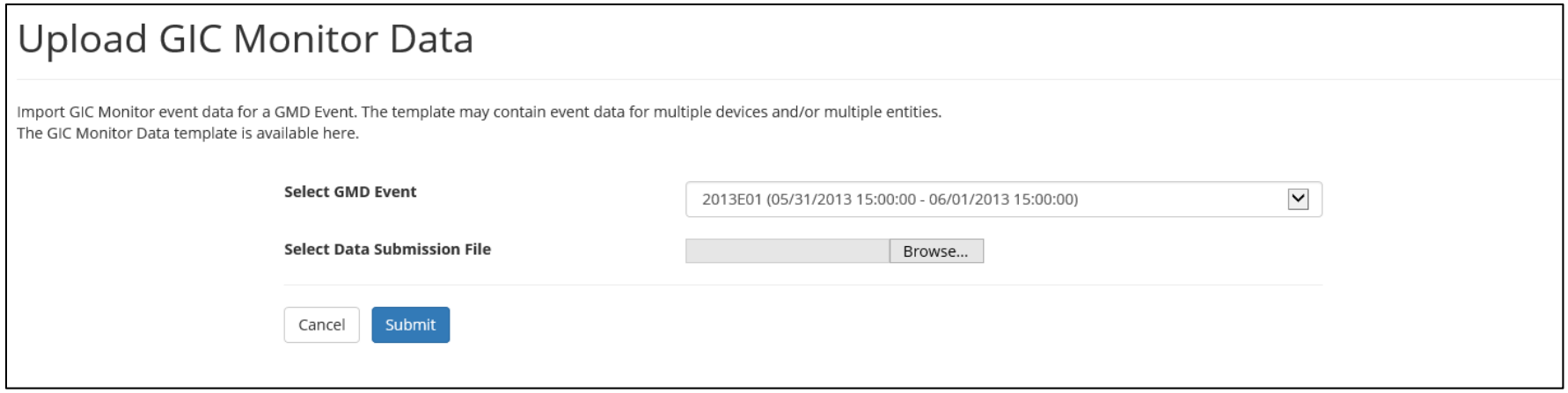
GMD Events

← GMD Home Page

The Geomagnetic Disturbance (GMD) events with a magnitude of K_p = 7 and greater are listed below. The event collection periods begin with the Event Start Date and Time and conclude with the Event End Date and Time.

NERC's data collection begins with GMD events occurring in May 2013 or later.

Event ID ↑	KP	Event Start Date and Time	Event End Date and Time
2018E01	7	8/25/2018 18:00	8/27/2018 00:00
2017E03	7	9/27/2017 15:00	9/29/2017 00:00
2017E02	8	9/7/2017 21:00	9/9/2017 03:00
2017E01	7	5/27/2017 15:00	5/28/2017 15:00
2015E06	7	12/20/2015 03:00	12/21/2015 09:00
2015E05	7	10/6/2015 18:00	10/9/2015 09:00
2015E04	7	9/19/2015 18:00	9/20/2015 18:00
2015E03	7	9/11/2015 03:00	9/11/2015 18:00
2015E02	8	6/22/2015 03:00	6/23/2015 15:00
2015E01	8	3/17/2015 03:00	3/18/2015 06:00
2013E02	8	10/2/2013 00:00	10/3/2013 03:00
2013E01	7	5/31/2013 15:00	6/1/2013 15:00



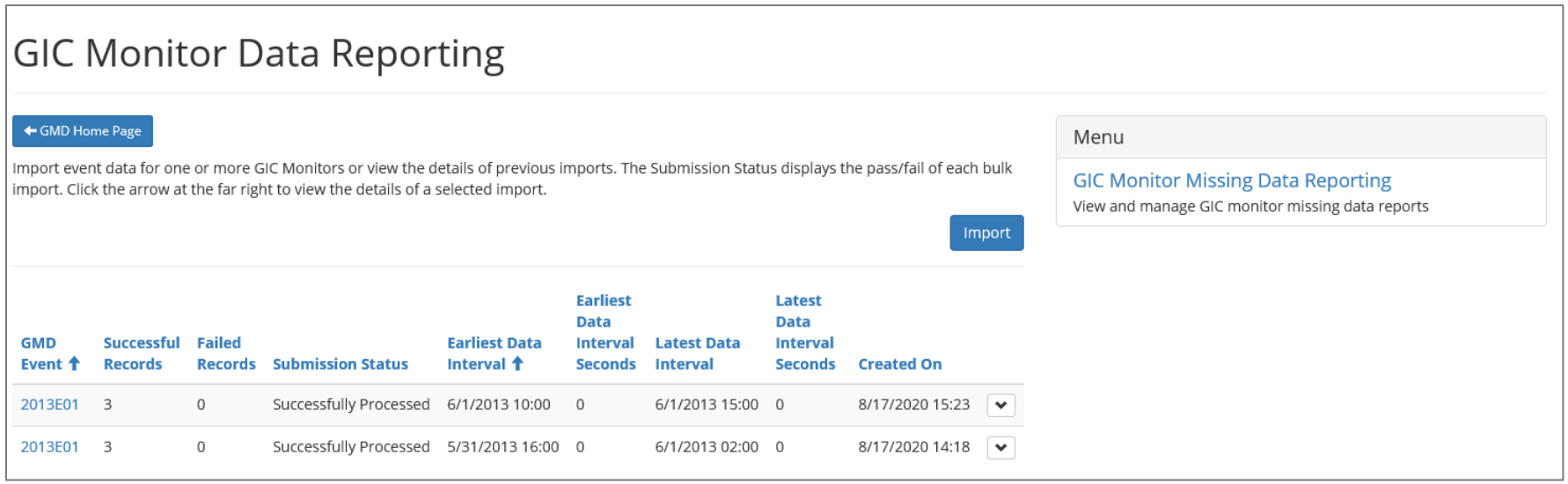
Upload GIC Monitor Data

Import GIC Monitor event data for a GMD Event. The template may contain event data for multiple devices and/or multiple entities.
The GIC Monitor Data template is available here.

Select GMD Event 2013E01 (05/31/2013 15:00:00 - 06/01/2013 15:00:00)

Select Data Submission File Browse...

Cancel Submit



GIC Monitor Data Reporting

← GMD Home Page

Import event data for one or more GIC Monitors or view the details of previous imports. The Submission Status displays the pass/fail of each bulk import. Click the arrow at the far right to view the details of a selected import.

Import

GMD Event	Successful Records	Failed Records	Submission Status	Earliest Data Interval	Earliest Data Interval Seconds	Latest Data Interval	Latest Data Interval Seconds	Created On
2013E01	3	0	Successfully Processed	6/1/2013 10:00	0	6/1/2013 15:00	0	8/17/2020 15:23
2013E01	3	0	Successfully Processed	5/31/2013 16:00	0	6/1/2013 02:00	0	8/17/2020 14:18

Menu

GIC Monitor Missing Data Reporting
View and manage GIC monitor missing data reports

Upload Magnetometer Data

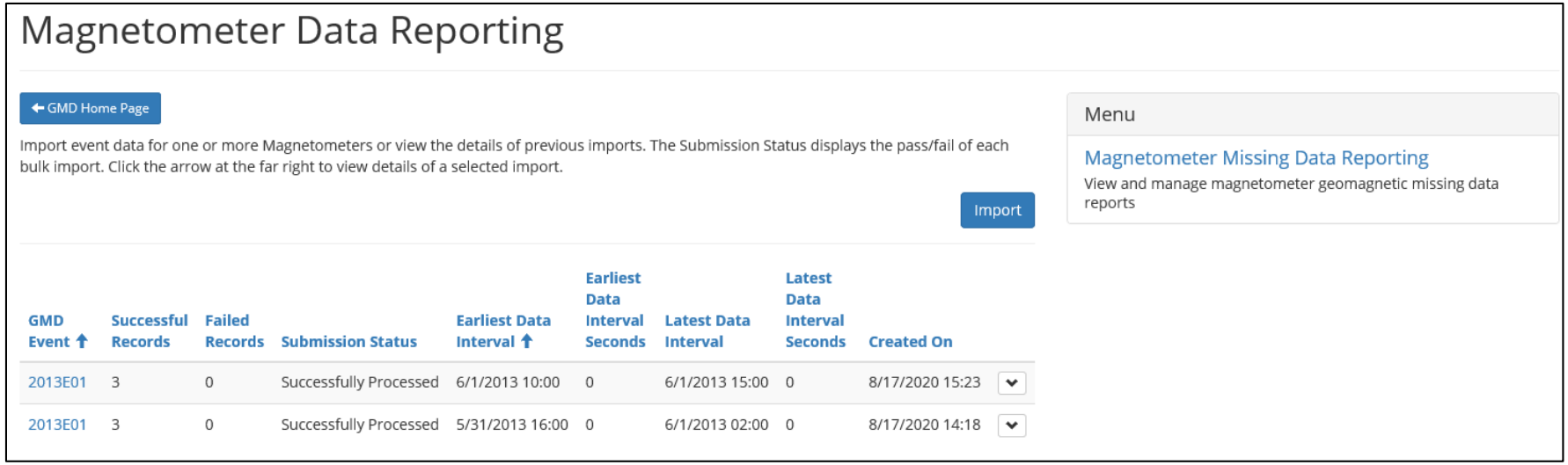
Import Magnetometer event data for a GMD Event. The template may contain event data for multiple devices and/or multiple entities.

The Magnetometer Data template is available here

Select GMD Event 2013E01 (05/31/2013 15:00:00 - 06/01/2013 15:00:00)

Select Data Submission File Browse...

Cancel Submit



Magnetometer Data Reporting

GMD Home Page

Import event data for one or more Magnetometers or view the details of previous imports. The Submission Status displays the pass/fail of each bulk import. Click the arrow at the far right to view details of a selected import.

Import

GMD Event	Successful Records	Failed Records	Submission Status	Earliest Data Interval	Earliest Data Interval Seconds	Latest Data Interval	Latest Data Interval Seconds	Created On
2013E01	3	0	Successfully Processed	6/1/2013 10:00	0	6/1/2013 15:00	0	8/17/2020 15:23
2013E01	3	0	Successfully Processed	5/31/2013 16:00	0	6/1/2013 02:00	0	8/17/2020 14:18

Menu

Magnetometer Missing Data Reporting
View and manage magnetometer geomagnetic missing data reports

Missing Data Reports

GIC Monitor Missing Data Reporting

← Back to GIC Monitor Data Reporting | Missing Data Report Imports

Missing Data Reports are required when a gap of more than ten (10) minutes occurs during an event. From this page, create, view, modify, deactivate, or export any GIC Monitor Missing Data Reports associated with the selected registered entity.

This is a list of GIC Monitor Missing Data Reports for the selected registered entity. To view GIC Monitor Missing Data Reports from a different entity, choose an entity from the selection box located in the top right-hand corner of the page.

Active GIC Monitor Missing Data Reports | Create GIC Monitor Missing Data Report | Export

GMD Event	Device ID (GIC Monitor)	Missing Data Start Date and Time (UTC)	Missing Data Start Seconds	Missing Data End Date and Time (UTC)	Missing Data End Seconds	Missing Data Reason	Created On
2013E01	10097	5/31/2013 15:00	0	5/31/2013 15:30	0	1-GIC Monitor Malfunction	8/17/2020 18:41

Magnetometer Missing Data Reporting

← Back to Magnetometer Data Reporting | Missing Data Report Imports

Missing Data Reports are required when a gap of more than ten (10) minutes occurs during an event. From this page, create, view, modify, deactivate, or export any Magnetometer Missing Data Reports associated with the selected registered entity.

This is a list of Magnetometer Missing Data Reports for the selected registered entity. To view Magnetometer Missing Data Reports from a different entity, choose an entity from the selection box located in the top right-hand corner of the page.

Active Magnetometer Missing Data Reports | Create Magnetometer Missing Data Report | Export

GMD Event	Device ID (Magnetometer)	Missing Data Start Date and Time (UTC)	Missing Data Start Seconds	Missing Data End Date and Time (UTC)	Missing Data End Seconds	Missing Data Reason	Created On
2013E01	50103	5/31/2013 15:00	0	5/31/2013 15:59	59	2-Magnetometer Malfunction	8/17/2020 18:44

Submission Status Report

GMD Reporting Status

The GMD Submission Status Report provides information about whether data was reported for each device by Event, Calendar Year, or Reporting Collection Period (April - March).

Filter By: Event

Event: 2013E01 (05/31/2013 15:00:00 - 06/01/2013 15:00:00)

Devices: Add Device

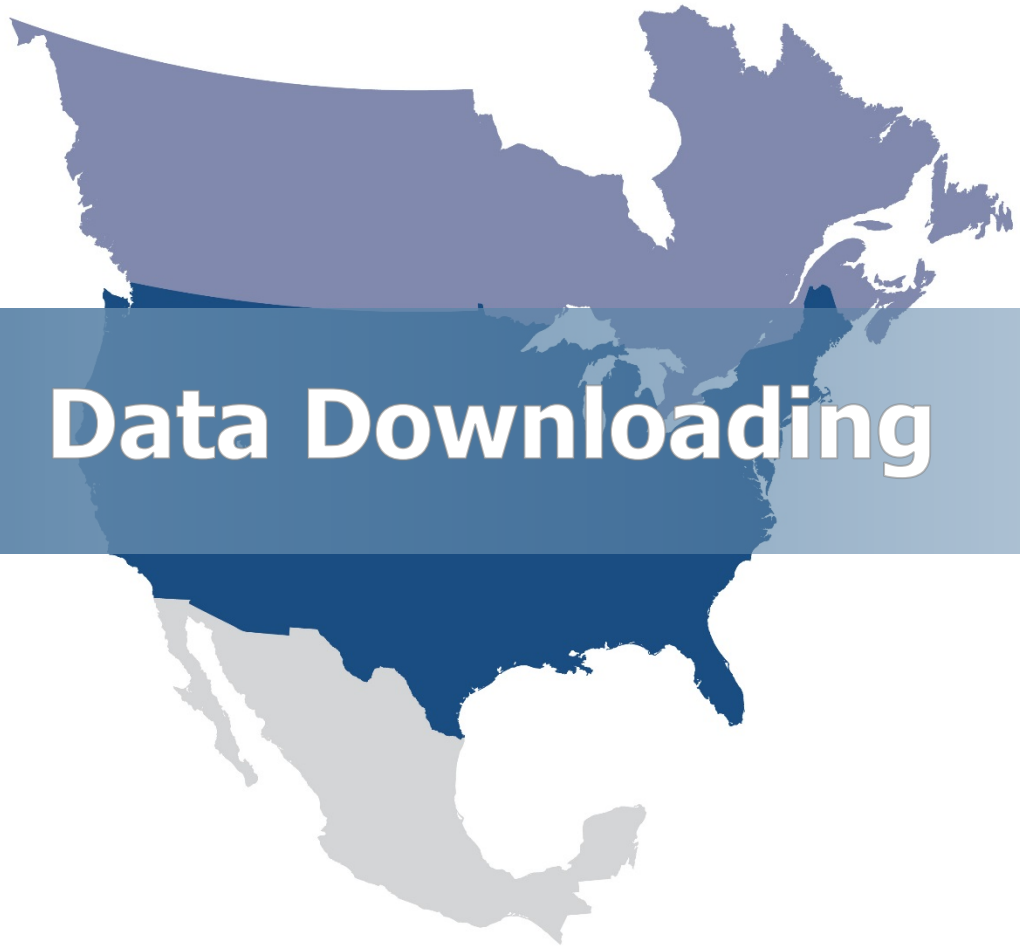
Selected Devices

10105	Remove
50103	Remove
10098	Remove
50105	Remove

Clear | Submit

Export

Device ID	Event ID	Data Start Date and Time	Data End Date and Time	Has Missing Data Report?	NCR	Is Data Complete?
10098	2013E01			No	NCR01055	No
10105	2013E01	05/31/2013 16:00:00	06/01/2013 15:00:00	No	NCR11826	No
50103	2013E01	05/31/2013 16:00:00	06/01/2013 15:00:00	Yes	NCR11826	No
50105	2013E01			No	NCR55555	No



Data Downloading

Complete Device List

GMD Magnetometers and GIC Monitors

The list of available GIC Monitor and Magnetometer devices provided below may be exported.

GIC Monitors | Magnetometers

Export

DeviceID	Status	Manufacturer	Latitude North	Longitude West	Installation Type	Connection	Minimum Value In Measurement Range
10094	AV	EPRI - Electric Power Research Institute	11.00	111.00	2 - Combined	1 - Common neutral of a 3-phase transformer	2.00
10096	AV	FLEX - FLEX-CORE, Inc.	50.00	120.00	2 - Combined	2 - Common neutral of three (3) single-phase transformers	1.50
10097	IV	FLEX - FLEX-CORE, Inc.	14.00	114.00	2 - Combined	1 - Common neutral of a 3-phase transformer	1.00
10098	AV	CTH - CTH Controls, Inc.	47.00	98.00	2 - Combined	2 - Common neutral of three (3) single-phase transformers	1.00
10099	AV	APT - Advanced Power Technologies	48.00	128.00	2 - Combined	4 - Phase Conductor	1.00
10100	AV	AAC - American Aerospace Controls	29.00	129.00	2 - Combined	5 - N/A	1.00
10101	AV	FLEX - FLEX-CORE, Inc.	75.00	125.00	1 - Separate	2 - Common neutral of three (3) single-phase transformers	1.00
10102	AV	OS - Ohio Semitronics	52.00	102.00	2 - Combined	2 - Common neutral of three (3) single-phase transformers	2.00
10103	IV	FLEX - FLEX-CORE, Inc.	40.00	110.00	1 - Separate	2 - Common neutral of three (3) single-phase transformers	1.00
10104	AV	OS - Ohio Semitronics	50.00	100.00	2 - Combined	2 - Common neutral of three (3) single-phase transformers	2.00
10105	AV	CTH - CTH Controls, Inc.	54.00	75.00	1 - Separate	1 - Common neutral of a 3-phase transformer	1.50
10106	IV	OTH - Other	11.00	112.00	2 - Combined	2 - Common neutral of three (3) single-phase transformers	2.00

Data Search & Download

Event

2013E01 (05/31/2013 15:00:00 - 06/01/2013 15:

Min Latitude **Max Latitude**

Min Longitude **Max Longitude**

Clear Search

Device Type

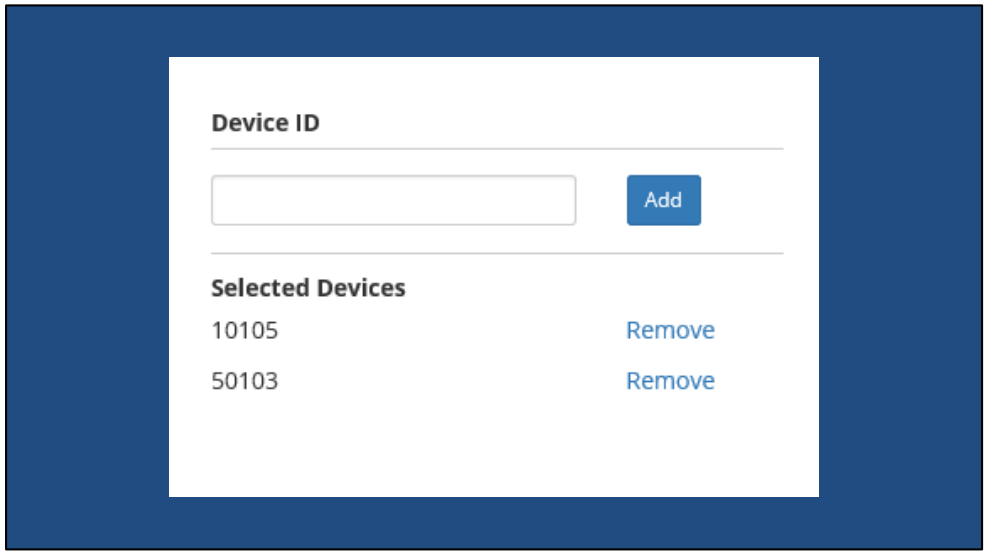
☐ Magnetometers ☐ GIC Monitors

Device ID

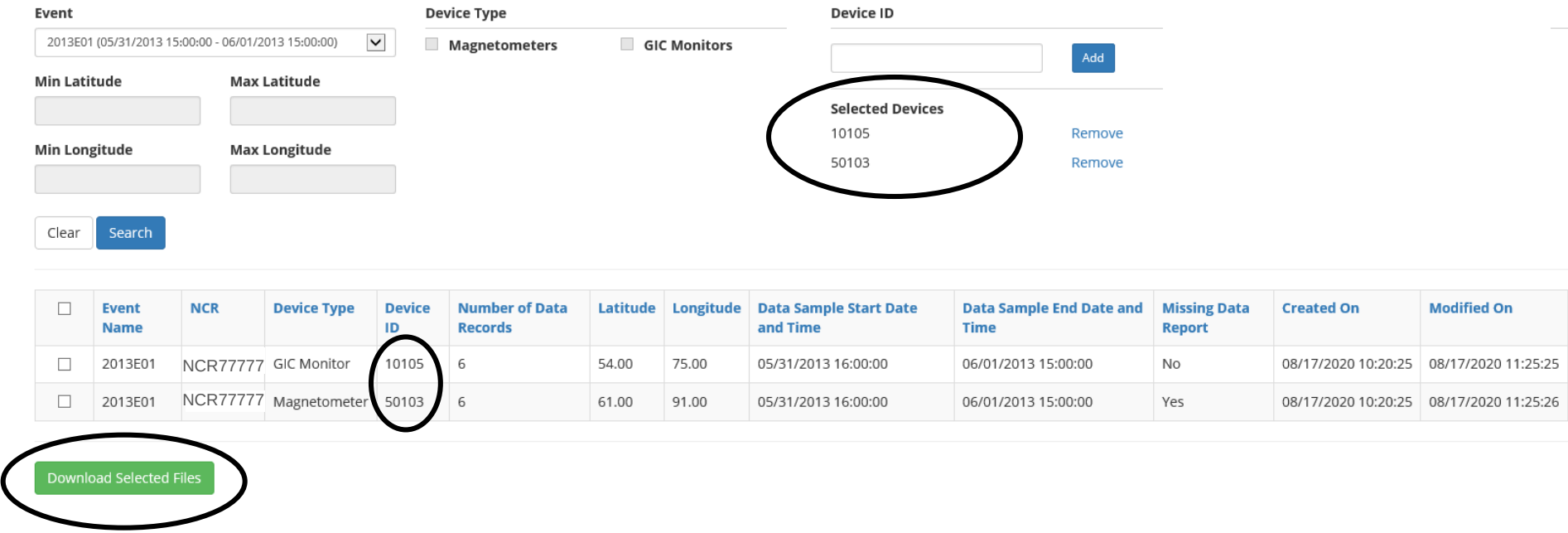
Add

Selected Devices

No devices selected

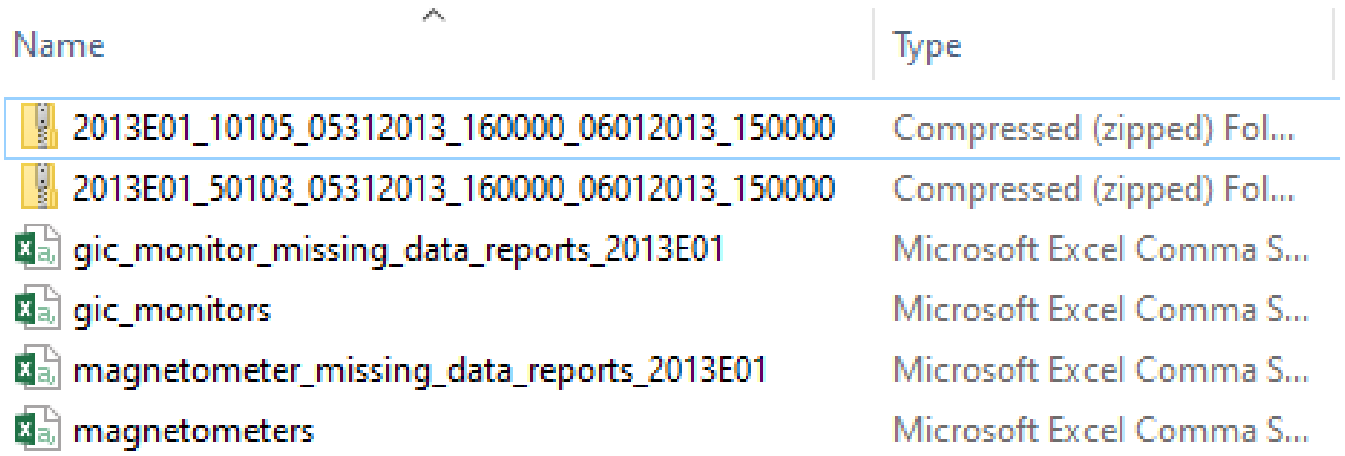


Data Search & Download



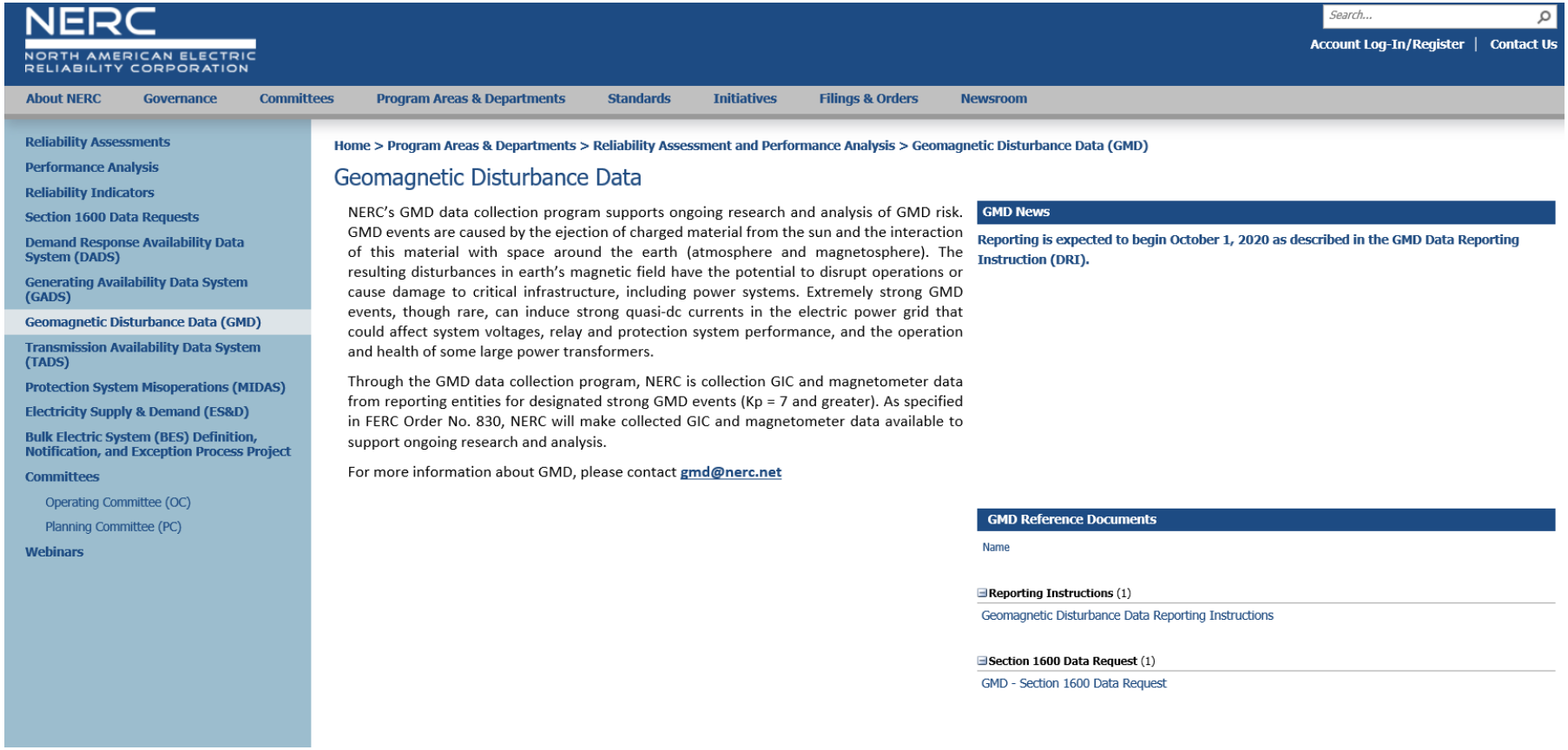
Event Name	NCR	Device Type	Device ID	Number of Data Records	Latitude	Longitude	Data Sample Start Date and Time	Data Sample End Date and Time	Missing Data Report	Created On	Modified On
2013E01	NCR77777	GIC Monitor	10105	6	54.00	75.00	05/31/2013 16:00:00	06/01/2013 15:00:00	No	08/17/2020 10:20:25	08/17/2020 11:25:25
2013E01	NCR77777	Magnetometer	50103	6	61.00	91.00	05/31/2013 16:00:00	06/01/2013 15:00:00	Yes	08/17/2020 10:20:25	08/17/2020 11:25:26

Data Packages



	A	B	C
1	GICDeviceID	SampleDateTime	GICMeasured
2	10105	5/31/2013 16:00	1
3	10105	5/31/2013 20:00	2
4	10105	6/1/2013 2:00	3
5	10105	6/1/2013 10:00	4
6	10105	6/1/2013 12:00	5
7	10105	6/1/2013 15:00	6

Current GMD Page



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- Generating Availability Data System (GADS)
- Geomagnetic Disturbance Data (GMD)
- Transmission Availability Data System (TADS)
- Protection System Misoperations (MIDAS)
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- Webinars

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Geomagnetic Disturbance Data

NERC's GMD data collection program supports ongoing research and analysis of GMD risk. GMD events are caused by the ejection of charged material from the sun and the interaction of this material with space around the earth (atmosphere and magnetosphere). The resulting disturbances in earth's magnetic field have the potential to disrupt operations or cause damage to critical infrastructure, including power systems. Extremely strong GMD events, though rare, can induce strong quasi-dc currents in the electric power grid that could affect system voltages, relay and protection system performance, and the operation and health of some large power transformers.

Through the GMD data collection program, NERC is collection GIC and magnetometer data from reporting entities for designated strong GMD events (Kp = 7 and greater). As specified in FERC Order No. 830, NERC will make collected GIC and magnetometer data available to support ongoing research and analysis.

For more information about GMD, please contact gmd@nerc.net

GMD News

Reporting is expected to begin October 1, 2020 as described in the GMD Data Reporting Instruction (DRI).

GMD Reference Documents

Name

Reporting Instructions (1)

Geomagnetic Disturbance Data Reporting Instructions

Section 1600 Data Request (1)

GMD - Section 1600 Data Request

Future GMD Page

Geomagnetic Disturbance Data

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For more information about GMD, please contact **gmd@nerc.net**

Click here to report GMD Data: **GMD Reporting Application**

Click here to download GMD Data: **GMD Data Download**

GMD News

Reporting is expected to begin October 1, 2020 as described in the GMD Data Reporting Instruction (DRI).

GMD Events from May 2013 to Present for One-time Reporting

Event ID	KP	Event Start Date and Time	Event End Date and Time
2018E01	7	8/25/2018 18:00	8/27/2018 00:00
2017E03	7	9/27/2017 15:00	9/29/2017 00:00
2017E02	8	9/7/2017 21:00	9/9/2017 03:00
2017E01	7	5/27/2017 15:00	5/28/2017 15:00
2015E06	7	12/20/2015 03:00	12/21/2015 09:00
2015E05	7	10/6/2015 18:00	10/9/2015 09:00
2015E04	7	9/19/2015 18:00	9/20/2015 18:00
2015E03	7	9/11/2015 03:00	9/11/2015 18:00
2015E02	8	6/22/2015 03:00	6/23/2015 15:00
2015E01	8	3/17/2015 03:00	3/18/2015 06:00
2013E02	8	10/2/2013 00:00	10/3/2013 03:00
2013E01	7	5/31/2013 15:00	6/1/2013 15:00

GMD Reference Documents

Name

- **Reporting Instructions** (1)
- **Reporting Templates** (5)
- **Section 1600 Data Request** (1)

Rollout Plan

- Data reporting training sessions – Late Sept to Mid Oct
- Go Live – October 2020
- Data Researcher training – Early 2021
  - Researchers will be able to Download GMD Data – Early 2021

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Questions and Answers

Process for Designating Information as Confidential Information

Order No. 830 on Data Confidentiality

…as a general matter, the Commission does not believe that GIC monitoring and magnetometer data should be treated as Confidential Information pursuant to the NERC Rules of Procedure. (P 89)

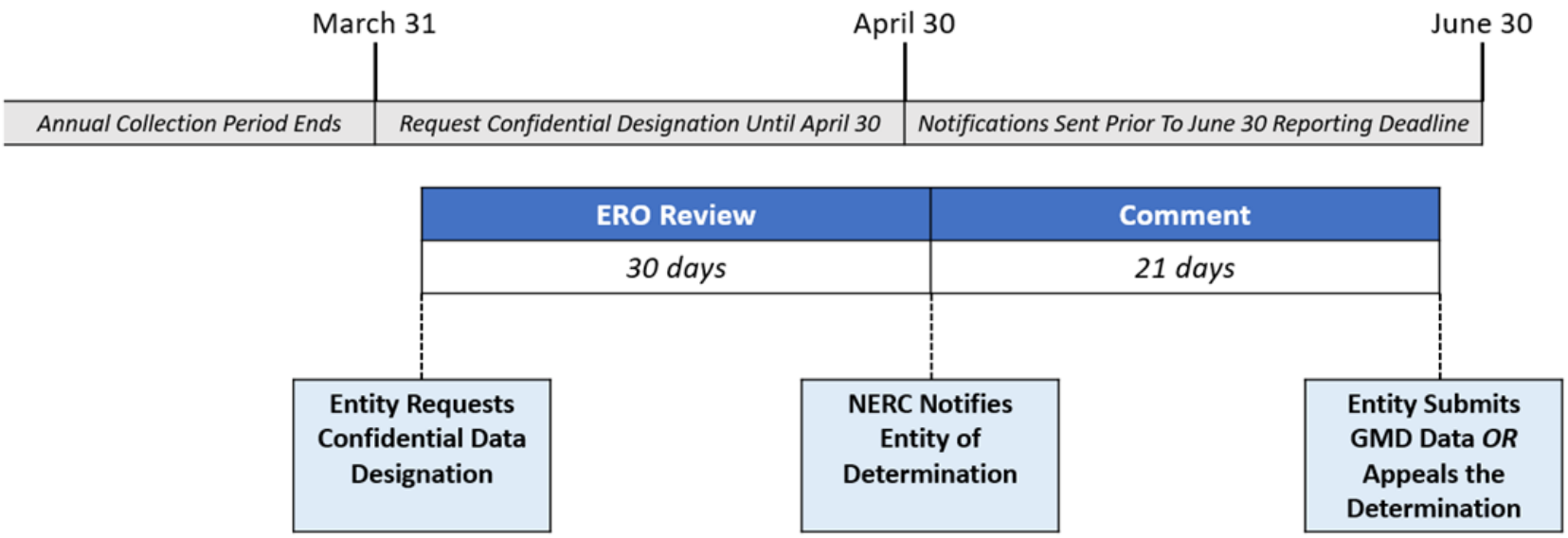
…Notwithstanding [the Commission's] findings here, to the extent any entity seeks confidential treatment of the data it provides to NERC, the burden rests on that entity to justify the confidential treatment. (P 95)

Restrictions on Disseminating Data

- If a Reporting Entity reasonably believes that any information required to be submitted under the GMD Data Request is Confidential Information, the Reporting Entity shall submit a request for Confidential Information treatment in accordance with FERC's guidance in Order No. 830
  - An entity will request confidential treatment before entering any data
- Data Reporting Instruction Appendix E Contains Guidance
- When data is determined by NERC to be confidential it will be marked accordingly in the data portal by NERC

Process for Confidential Designation

- Entities submit requests for confidential designation by April 30



Process for Confidential Designation

- Reporting entities submit Confidential Information designation request by form emailed to NERC (gmdconfidentialrequest@nerc.net)
- Request form will include the following info:
  - Entity Name, NERC I.D., and Contact
  - Date of Request
  - Type of GMD Monitoring Equipment (GIC monitor, magnetometer, both)
  - Device I.D. (if assigned in NERC GMD data system)
  - Narrative Justification providing explanation for why the information should not be released to a GMD data requestor, including:
    - Data fields in the GMD data system that meet Confidential Information definitions in NERC Rules of Procedure Section 1501
    - Category of Confidential Information (e.g., CEII)
    - Specific justification for why the reporting entity believes the information is Confidential Information
  - Date after which the data is no longer considered confidential

Confidential Information Definitions

- NERC Rules of Procedure Section 1500 Includes the following:

Critical Energy Infrastructure Information (CEII)
CEII means specific engineering, vulnerability, or detailed design information about proposed or existing Critical Infrastructure that (i) relates details about the production, generation, transportation, transmission, or distribution of energy; (ii) could be useful to a person in planning an attack on Critical Infrastructure; and (iii) does not simply give the location of the Critical Infrastructure. See NERC Rules of Procedure Section 1501

NERC Staff Process

1. NERC Performance Analysis (PA) receives a request for Confidential Information designation via email
   - Verifies that all required information has been provided
   - Acknowledges receipt to the submitter
2. PA forwards the request for internal review
   - Includes NERC Security, E-ISAC, Engineering and Legal staff
3. PA sends response letter to submitting entity
4. Response letters include instructions for appeal

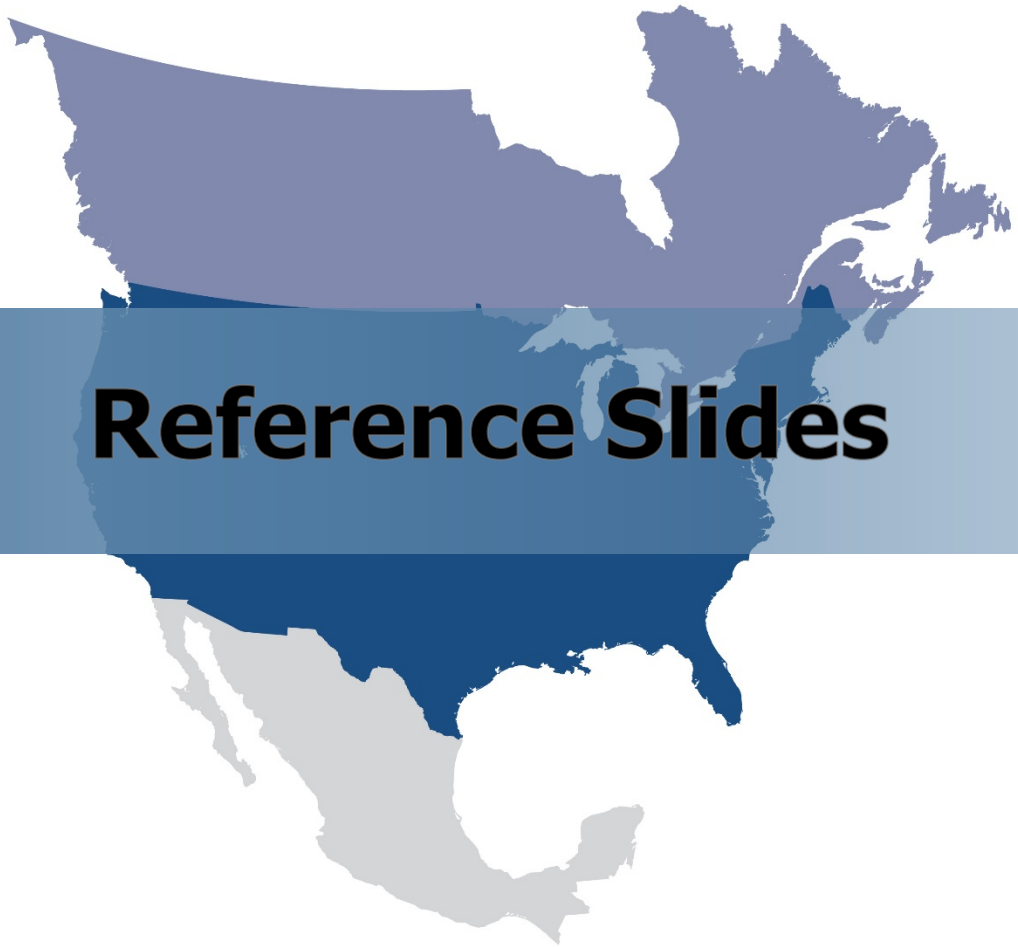
Appeals

- A Reporting Entity that receives a rejection of their request for confidential designation may appeal the determination to FERC or other applicable Governmental Authority. The Reporting Entity shall submit the appeal in writing within 21 days of NERC's notification and provide a copy of the appeal to NERC.
- NERC's determination regarding confidentiality shall be final within 21 days of the decision, unless the Reporting Entity appeals to the appropriate Governmental Authority.

Marking as Confidential Information

- Data that is designated as Confidential Information will be appropriately marked and can only be viewed by the submitting entity and ERO GMD Data System administrators.
- Other system users, including public data requestors, cannot view, download, or select data that NERC designates as Confidential Information.

Questions and Answers



Reference Slides

Historical Storms

- NERC will also collect historical GIC data for K-7 events dating back to May 2013 (one-time collection)

Table B.1: Historical GMD Events From May 2013 to Present for One-time Reporting

Event ID Number	K_p	Start Date	Time (UTC)	End Date	Time (UTC)
2013E01	7	2013-05-31	15:00:00	2013-06-01	15:00:00
2013E02	8	2013-10-02	00:00:00	2013-10-03	03:00:00
2015E01	8	2015-03-17	03:00:00	2015-03-18	06:00:00
2015E02	8	2015-06-22	03:00:00	2015-06-23	15:00:00
2015E03	7	2015-09-11	03:00:00	2015-09-11	18:00:00
2015E04	7	2015-09-19	18:00:00	2015-09-20	18:00:00
2015E05	7	2015-10-06	18:00:00	2015-10-09	09:00:00
2015E06	7	2015-12-20	03:00:00	2015-12-21	09:00:00
2017E01	7	2017-05-27	15:00:00	2017-05-28	15:00:00
2017E02	8	2017-09-07	21:00:00	2017-09-09	03:00:00
2017E03	7	2017-09-27	15:00:00	2017-09-29	00:00:00
2018E01	7	2018-08-25	18:00:00	2018-08-27	00:00:00

Data Collection Events

A GMD Event is predicted

- Space Weather monitors issue prediction (e.g., NOAA SWPC)
- Predictions issued 1-3 days prior to GMD event
- Warnings issued ~30 minutes prior to onset

A GMD Alert is Issued

- Space Weather monitors issue Alert (e.g., NOAA SWPC Alert message)
- Will indicate onset of GMD above threshold (e.g., K_P-7)

Return to normal (quiet)

- Dashboards (e.g., NOAA SWPC website) provide continuous information that will indicate when normal conditions have returned

NERC GMD Data Collection Event is Announced

- NERC Announces Start and End Date/Times for GMD Data Collection Period

NERC GMD Data Collection Period

GMD Work Plan Research

Electric Power Research Institute (EPRI) Update

Bob Arritt
Technical Executive

NERC GMD Task Force
Wednesday August 26th, 2020

GMD Supplemental Research Work Plan

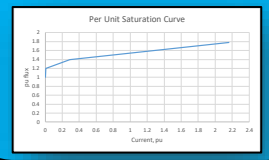
- Deliverables
  - GIC Harmonic Tool (GICharm)
  - 84 Additional Transformer Thermal Models
  - Updated Earth Models
  - Further the technical basis on application of benchmark event
- 5 Workshops

Highest Priority

Lowest Priority

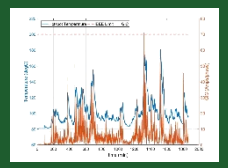
Improved Earth Conductivity Models

Improved Harmonic Analysis Capability



Harmonic Impacts

Transformer Thermal Impacts



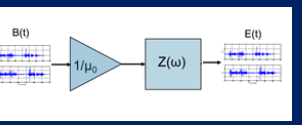
Spatial Averaging

$$E_{peak} = 8 \times \alpha \times \beta \text{ (V/km)}$$

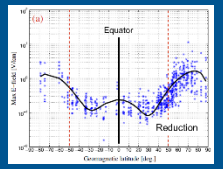
α= Geomagnetic Latitude Scaling Factors

β= Conductivity Scaling Factor

Geoelectric Field Evaluation

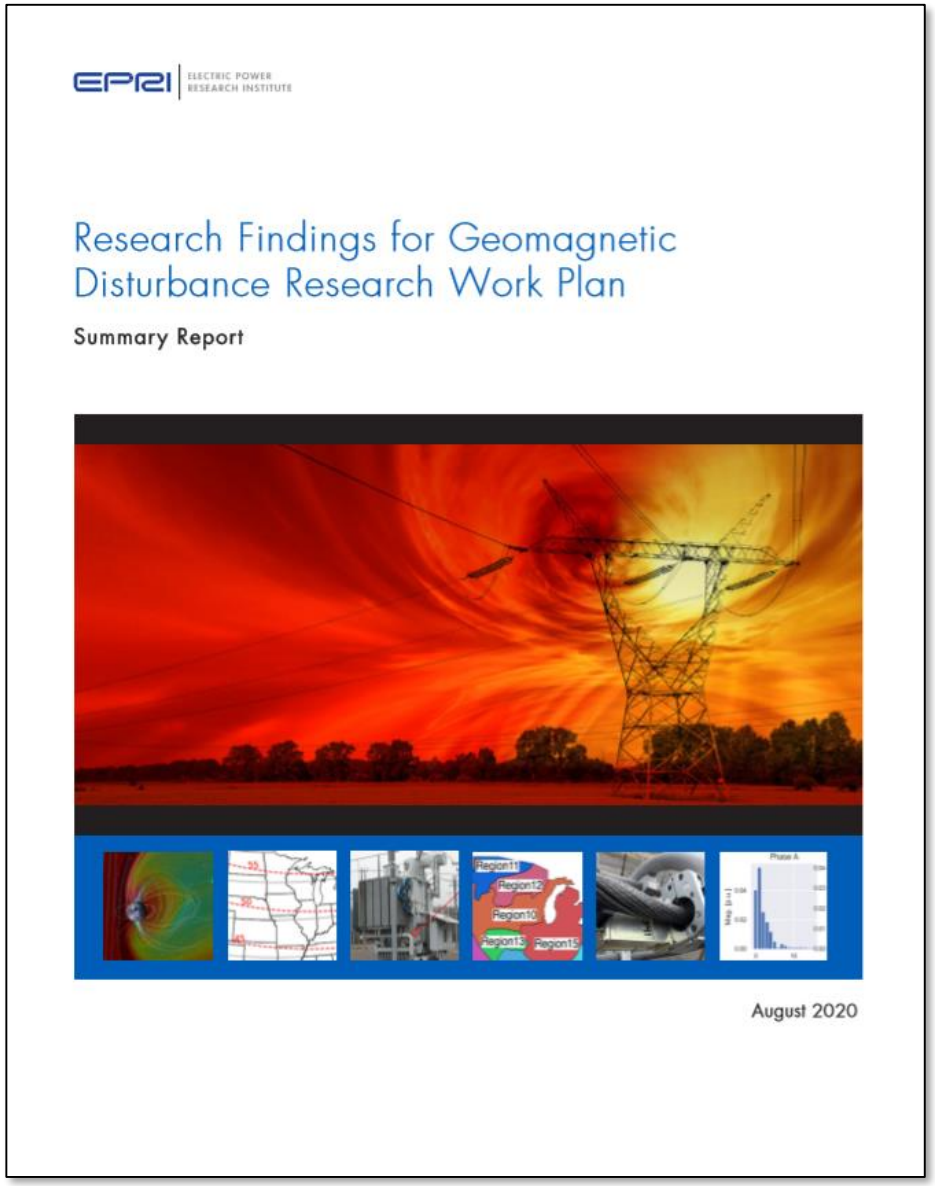


Latitude Scaling Factor



GMD Supplemental Research Work Plan

- Research Findings for Geomagnetic Disturbance Research Work Plan: Summary Report: Product ID: 3002019720
  - Provides a high-level summary of the work performed in support of NERC GMD Work Plan
  - https://www.epri.com/research/products/000000003002019720



Released Material

- **Benchmark Analysis**
  - EPRI, “Magnetohydrodynamic (MHD) Modeling for the Further Understanding of Geoelectric Field Enhancements and Auroral Behavior during Geomagnetic Disturbance Events,” March 2020, 3002017952.
  - EPRI, “Furthering the Understanding of the Characteristics and Scales of Geoelectric Field Enhancements,” March 2020, 3002017900.
  - EPRI, “Improving Understanding of Characteristics of Geoelectric Field Enhancements Caused by Severe GMD Events: Examining Existing Ground-Based Data,” June 2019, 3002016832.
  - EPRI, “Review of Peer-Reviewed Research Regarding the Effects of Geomagnetic Latitude on Geoelectric Fields: Updated Based on the Latest Peer-Reviewed Research,” June 2019, 3002016885.
- **Ground Conductivity Analysis**
  - EPRI, “Improving Conductivity Models for Geomagnetically Induced Current (GIC) Estimation: Guidance for Validation of GIC Models,” March 2020, 3002017897.
  - EPRI, “Non-Uniform Field Modeling: Coast Effect Assessment,” March 2020, 3002017898.
  - EPRI, “Update of Earth Response Scaling Factors using Magnetotelluric (MT) Measurements,” March 2020, 3002017899.
  - EPRI, “Use of Magnetotelluric Measurement Data to Validate/Improve Existing Earth Conductivity Models Product,” June 2020, 3002019425.
  - EPRI, “Tool Evaluation and Electric Field Estimate Benchmarking Results,” January 2019, 3002014853.
- **Transformer Assessment**
  - EPRI, “Geomagnetically Induced Current (GIC) Transformer Thermal Impact Assessment: Impact of Field Orientation on Transformer Thermal Screenings,” March 2020, 3002017948.
  - EPRI, “Transformer Thermal Impact Assessments for DC Withstand Capability: Examining the Impacts of Geomagnetically Induced Current (GIC) on Transformer Thermal Performance,” December 2019, 3002017708.
  - EPRI, “Impact of Geomagnetically Induced Currents on Transformer Tank Vibrations,” January 2019, 3002014855
  - EPRI,“PRE-SW: EPRI Transformer Thermal Model (ETTM), version 1.0 – Beta,” June 2018, 3002014059.
- **Harmonic Impacts**
  - EPRI, “Geomagnetically Induced Current Harmonic Analysis Tool (GICharm): Geomagnetically Induced Current (GIC) Harmonic Analysis,” December 2019, 3002017447.
  - EPRI, “Assessment Guide: Geomagnetic Disturbance Harmonic Impacts and Asset Withstand Capabilities,” December 2019, 3002017707.
  - EPRI,“PRE-SW: EPRI GIC Harm v1.0,” January 2019, 3002014854.
  - “A Test Case for GIC Harmonics Analysis,” Grid of the Future, Atlanta 2019, CIGRE 2019-51-A.
- **General Information**
  - EPRI, “Furthering the Research of Geomagnetic Disturbances Impact on the Bulk Power System,” April 2018, 3002013736.

Examining the Impacts of Earth Model on GIC Estimates

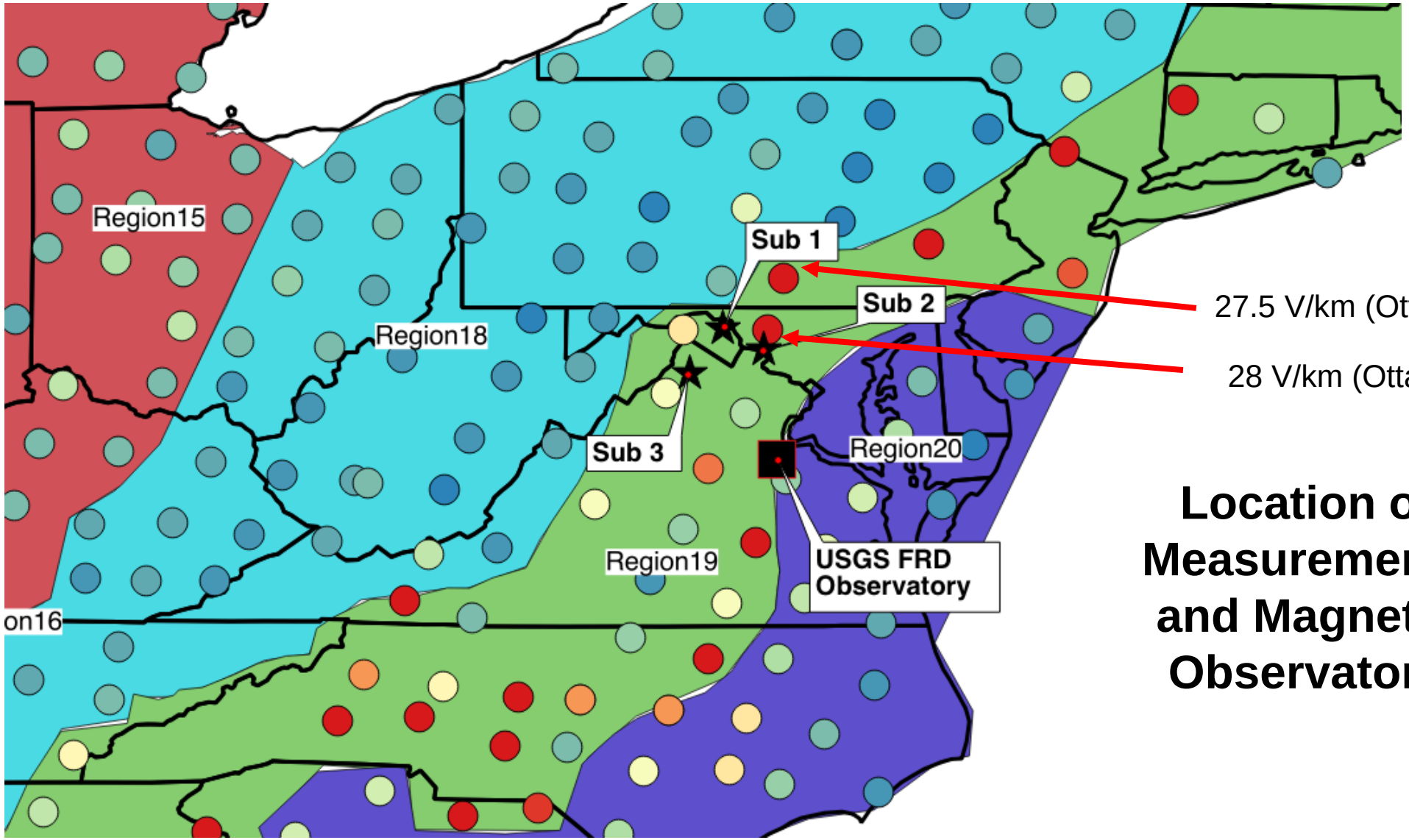
- GMD ground response – a three layered approach – regional vs local granularity
  - First layer: Beta scaling factors.
  - Second layer: Optimized regional 1D models.
  - Third layer: Non-uniform 3D or EMTFs
- Updated Regional 1D models improve estimates
- Scaling factors can be used to produce geo-electric fields that are generally consistent with regionally-averaged models.

No matter which representation of ground response chosen to use, should be based on best available empirical information.

- **Modeling uncertainties**
- **Use magnetic field measurements taken locally**
- **Improve (or minimize) geo-electric field orientation uncertainty.**
- **Ground response**
- **Data/measurement quality issues**

Next Steps – Continue with Model Validation

Examining the Impacts of Earth Model on GIC Estimates



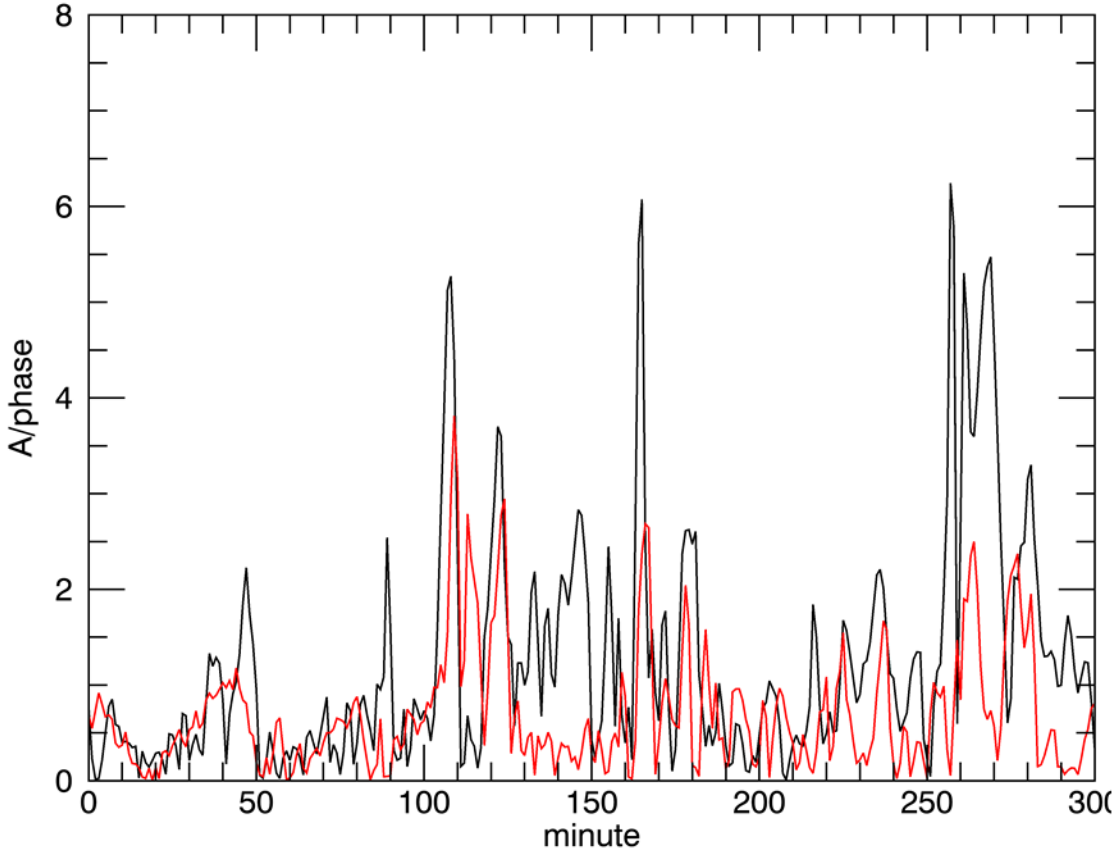
Differences between Updated Regional Uniform (i.e. 1D) and Fernberg Regional 1-D Model

- Substation 1 – March 2015

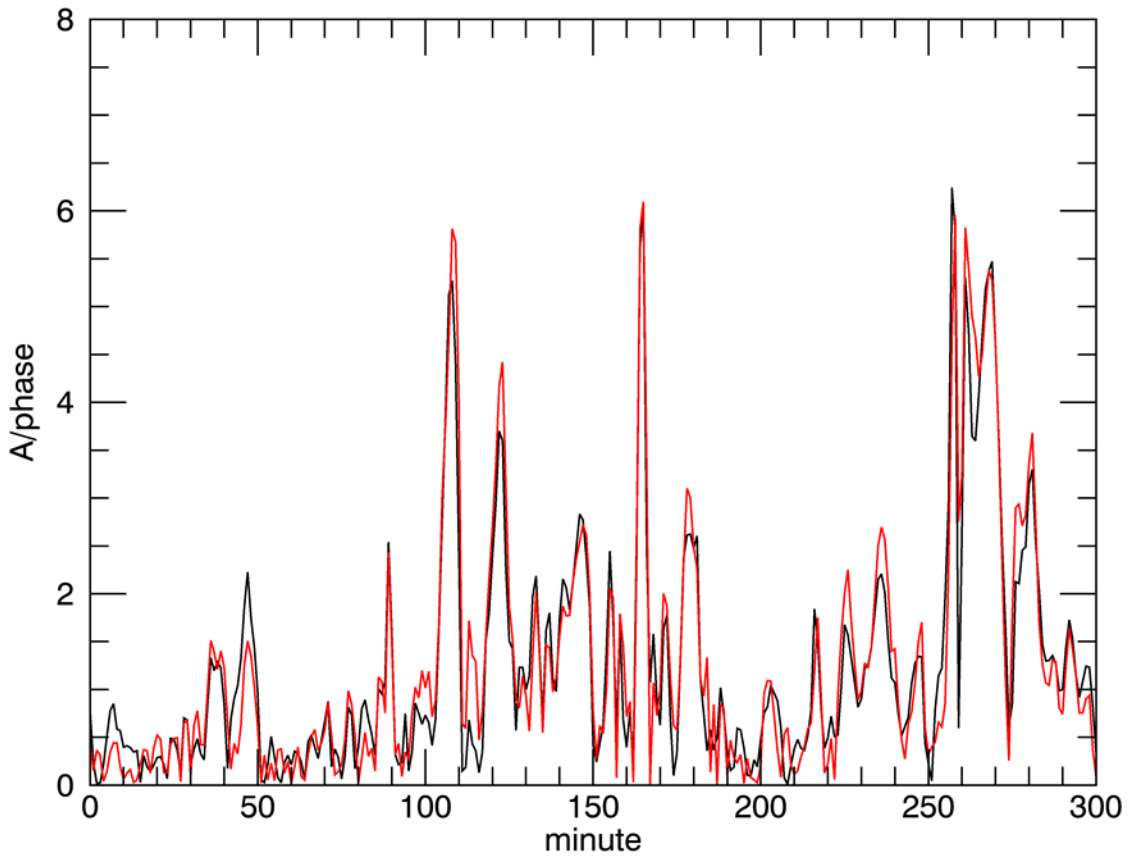
Black: measured GIC

Red: modeled GIC

Fernberg Regional 1-D Model



Updated Regional Uniform (1-D) Model



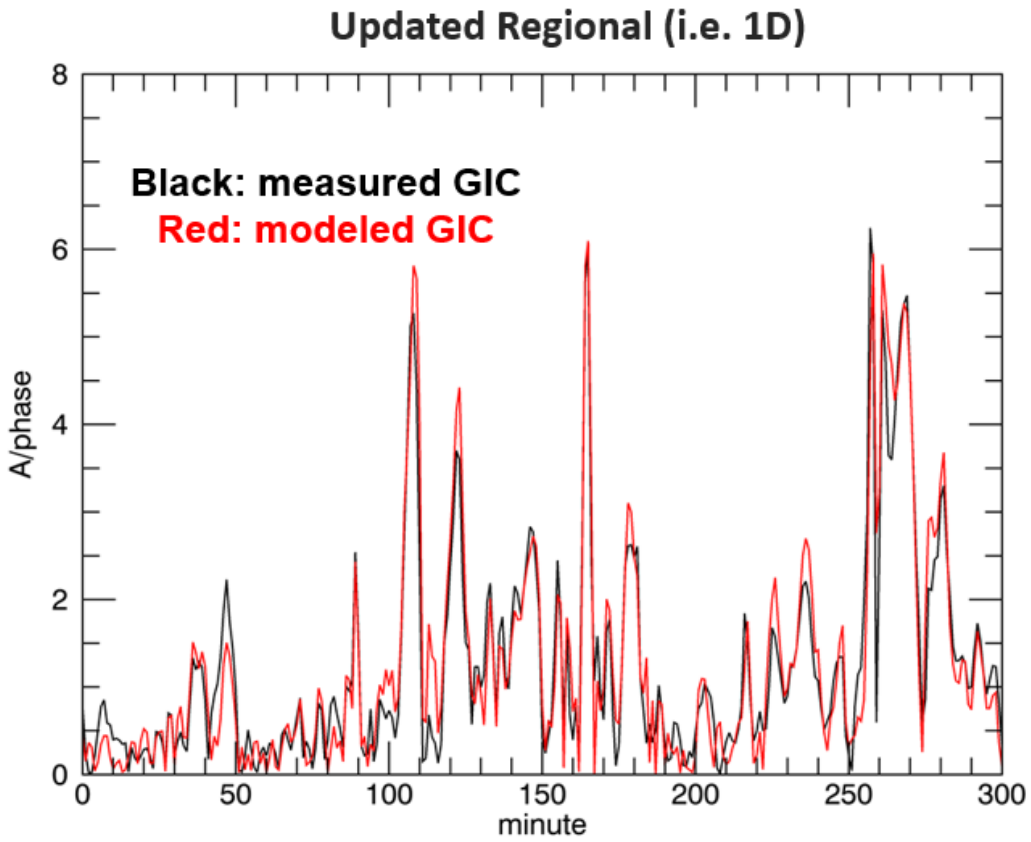
Supplemental – Geomagnetically Induced Current (GIC) Model Validation

Objectives and Scope

- Use of Magnetometer Measurements and GIC flow measurements to perform GIC calculations
- Examine the use of the latest available earth models.

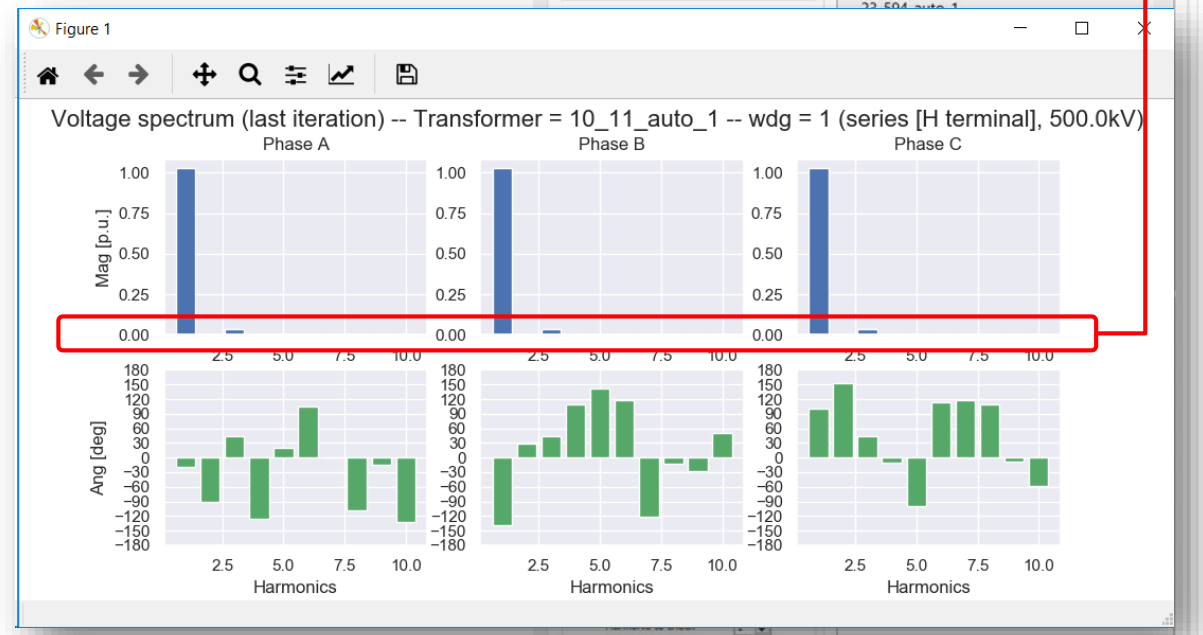
Value

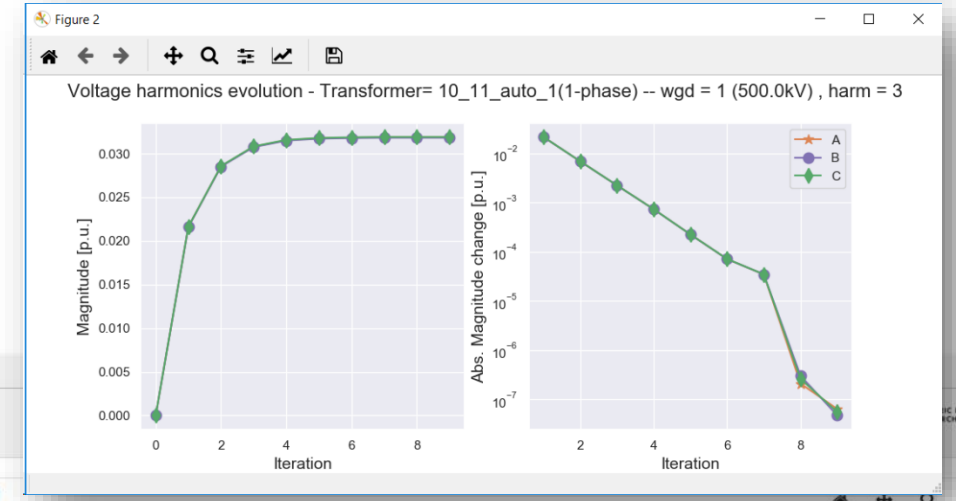
- Explore multiple magnetometer data sites and provide interpolation between available sites
- Perform three different conductivity models (existing earth conductivity models available to industry, i.e., 1D, 3D, and scaling factor)
  - Translation of B-Fields (magnetometer) to E-fields (V/km).
  - Compare results against GIC Measurements

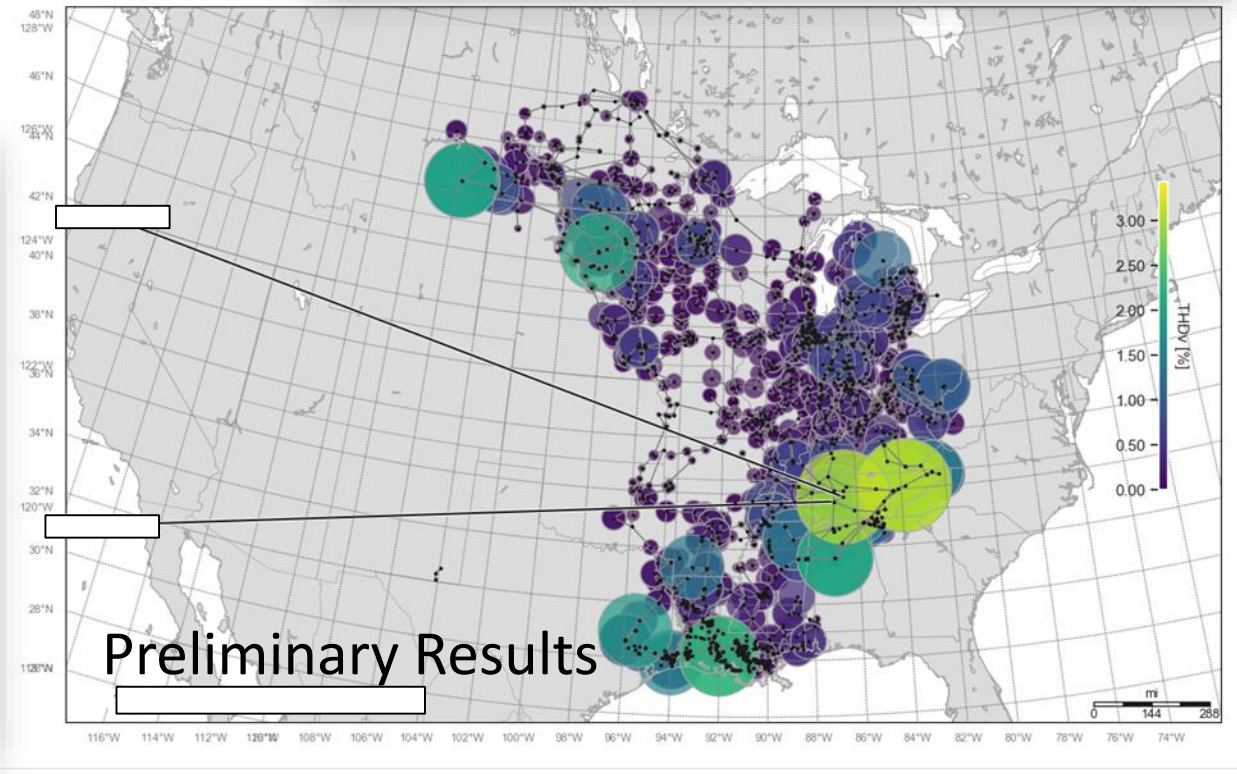


Case Studies – GICharm

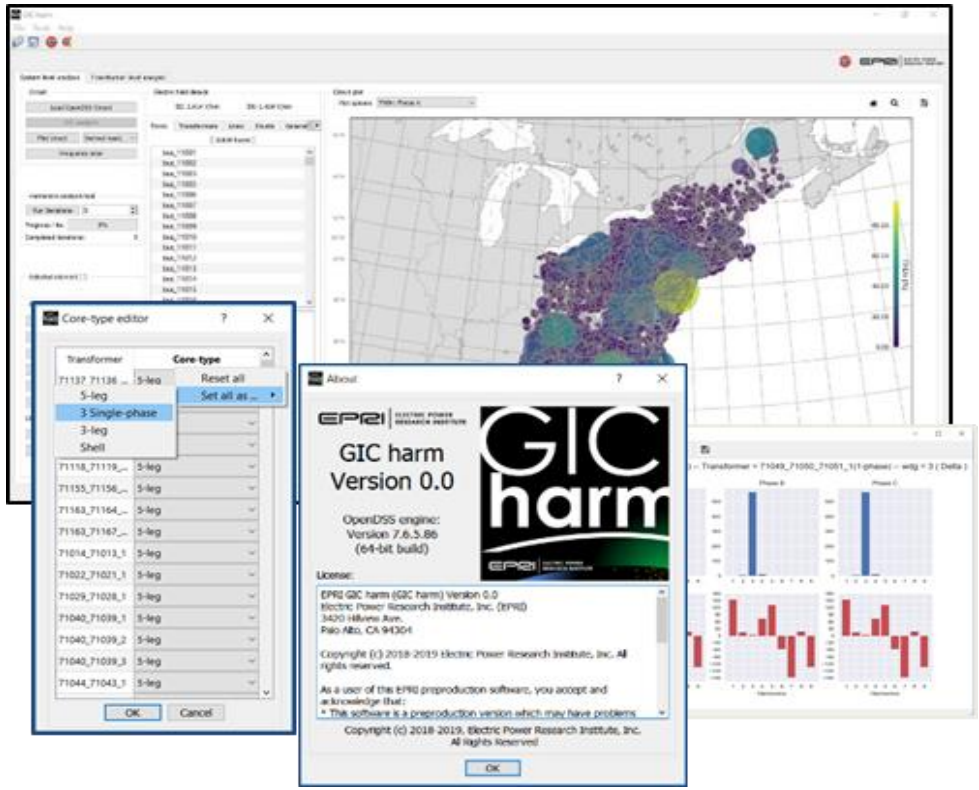
- **Continue to apply the tool to actual system analysis.**
- **Continue with model validation**







Supplemental – Geomagnetically Induced Current (GIC) Harmonic Analysis



Objectives and Scope

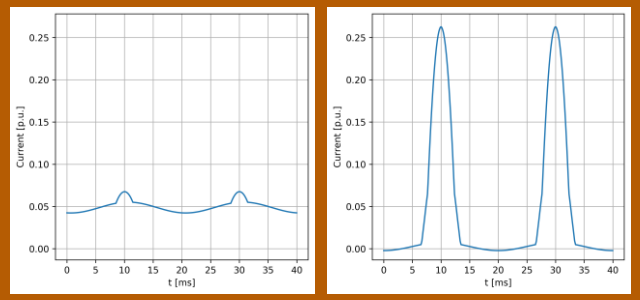
- Convert participating utility model data into a format compatible with EPRI's GICHarm tool.
- Characterize harmonic current injections from GIC-saturated transformers using EPRI's GICHarm tool and based on harmonic power flow.
- Examine the harmonic results and characterize harmonic components on powers system assets
- Provide results to each participating utility. Results may be used to determine the appropriate protection system response to GIC-induced harmonics.

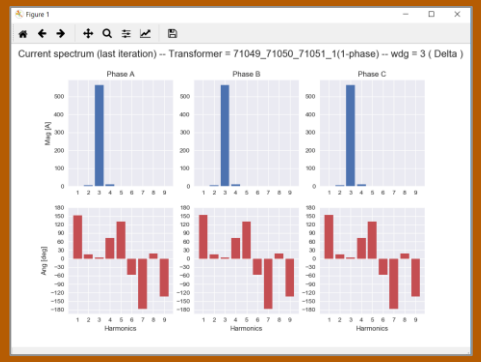
Deliverables

- These studies will further improve the understanding of how harmonics impact assets during GMD events. Providing the planner the analysis needed to consider removal of equipment that may be susceptible.

Key Follow-Up Research

Harmonic Analysis



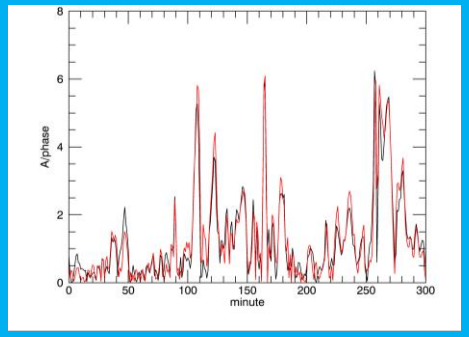


Applying the GICharm tool and further validation

Monitoring

Transformer Model Validation – Long Term Impacts

Model Validation



GIC and magnetometer data to validate models

Apply and Advance R&D from GMD Work Plan

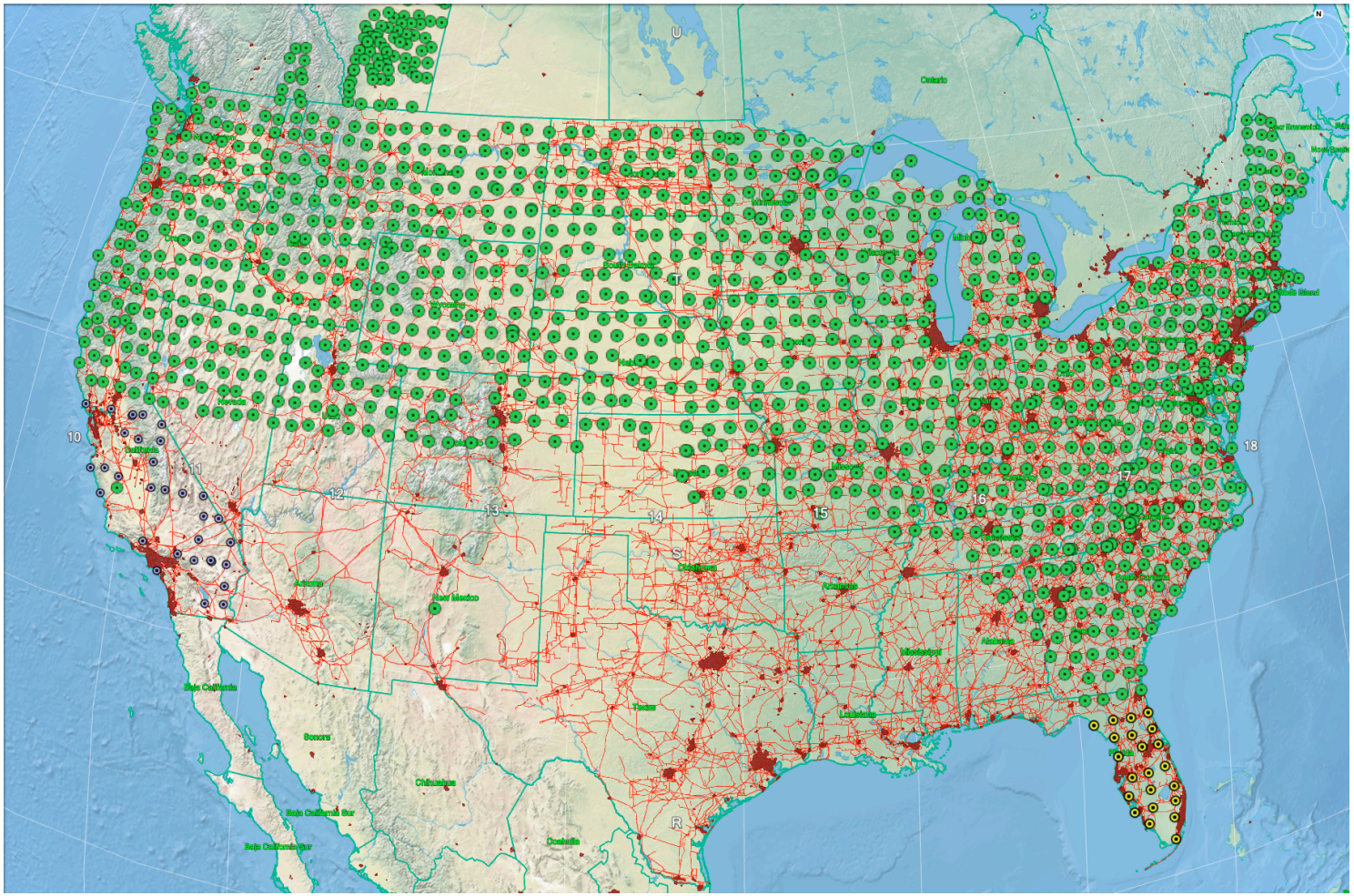
Together...Shaping the Future of Electricity

MTArray 2020 Update

26-August-2020

Dr. Adam Schultz, Oregon State University

MT Array status 12/31/2019



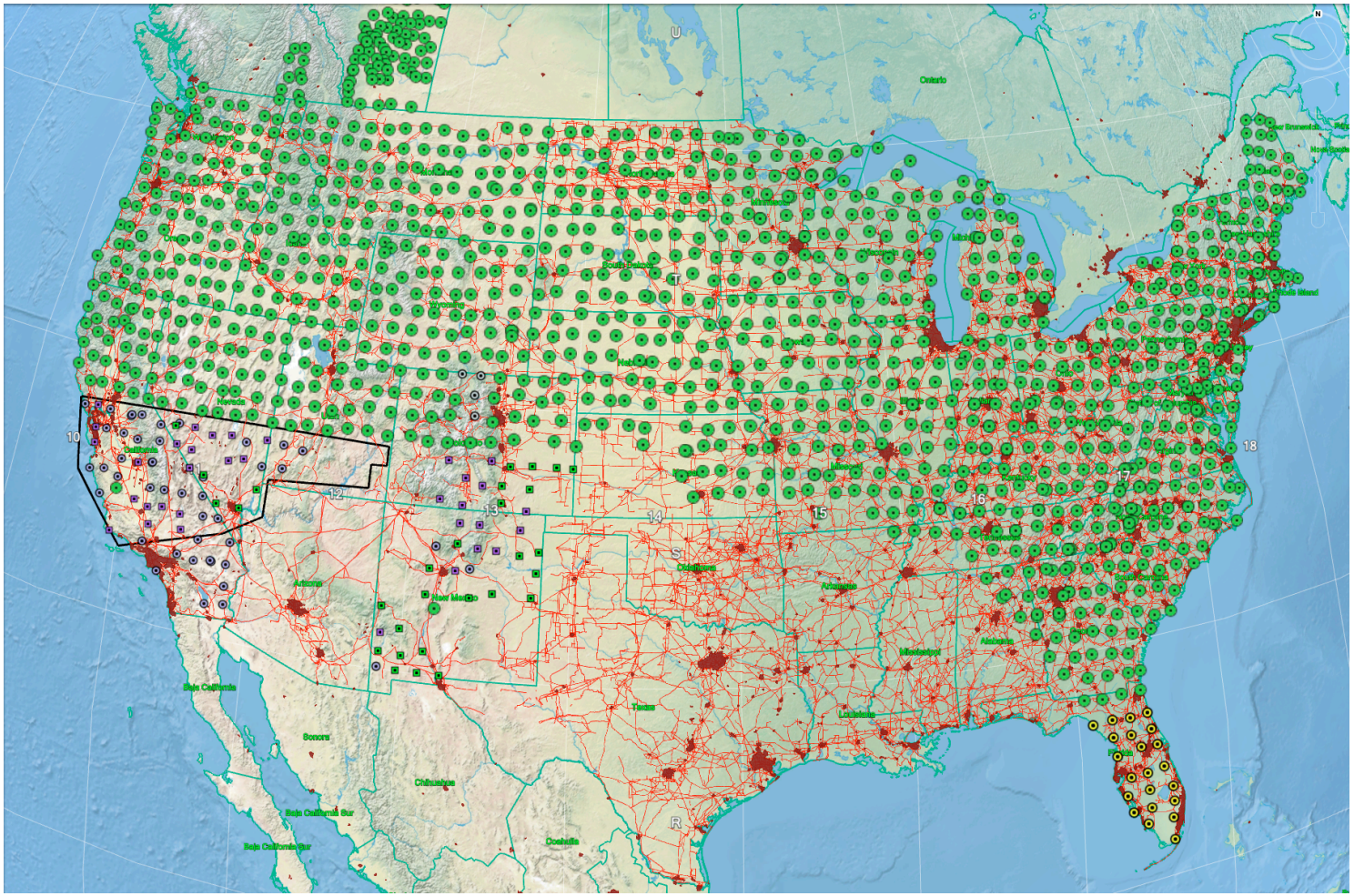
MT Array status 8/26/2020

Accepted – purple boxes

Extracted – blue circles

Installed – green boxes

NASA array – black polygon



MT Array status 8/26/2020

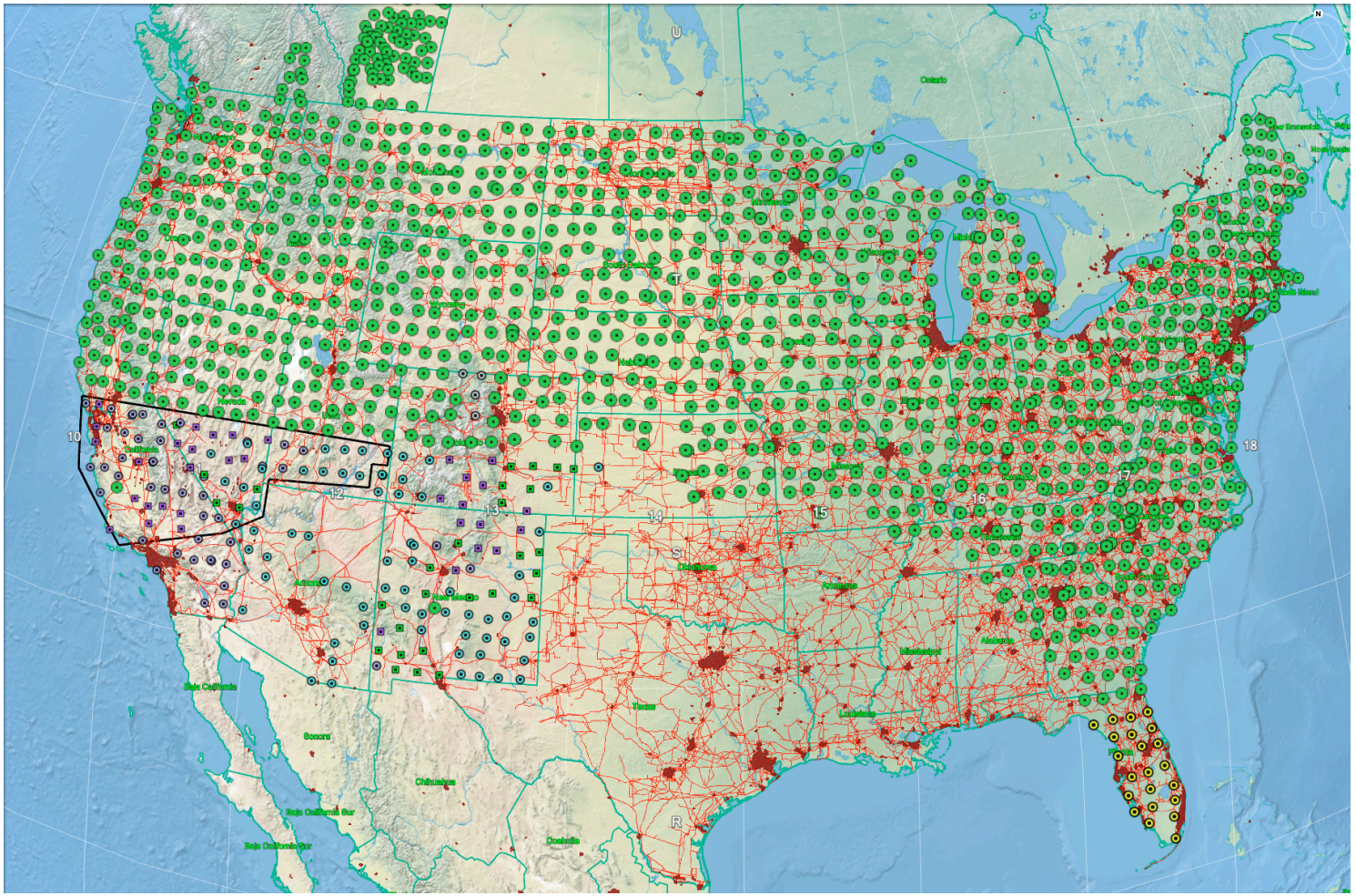
Accepted – purple boxes

Extracted – blue circles

Installed – green boxes

NASA array – black polygon

Permitted – cyan circles



MT Array status 8/26/2020

Accepted – purple boxes

Extracted – blue circles

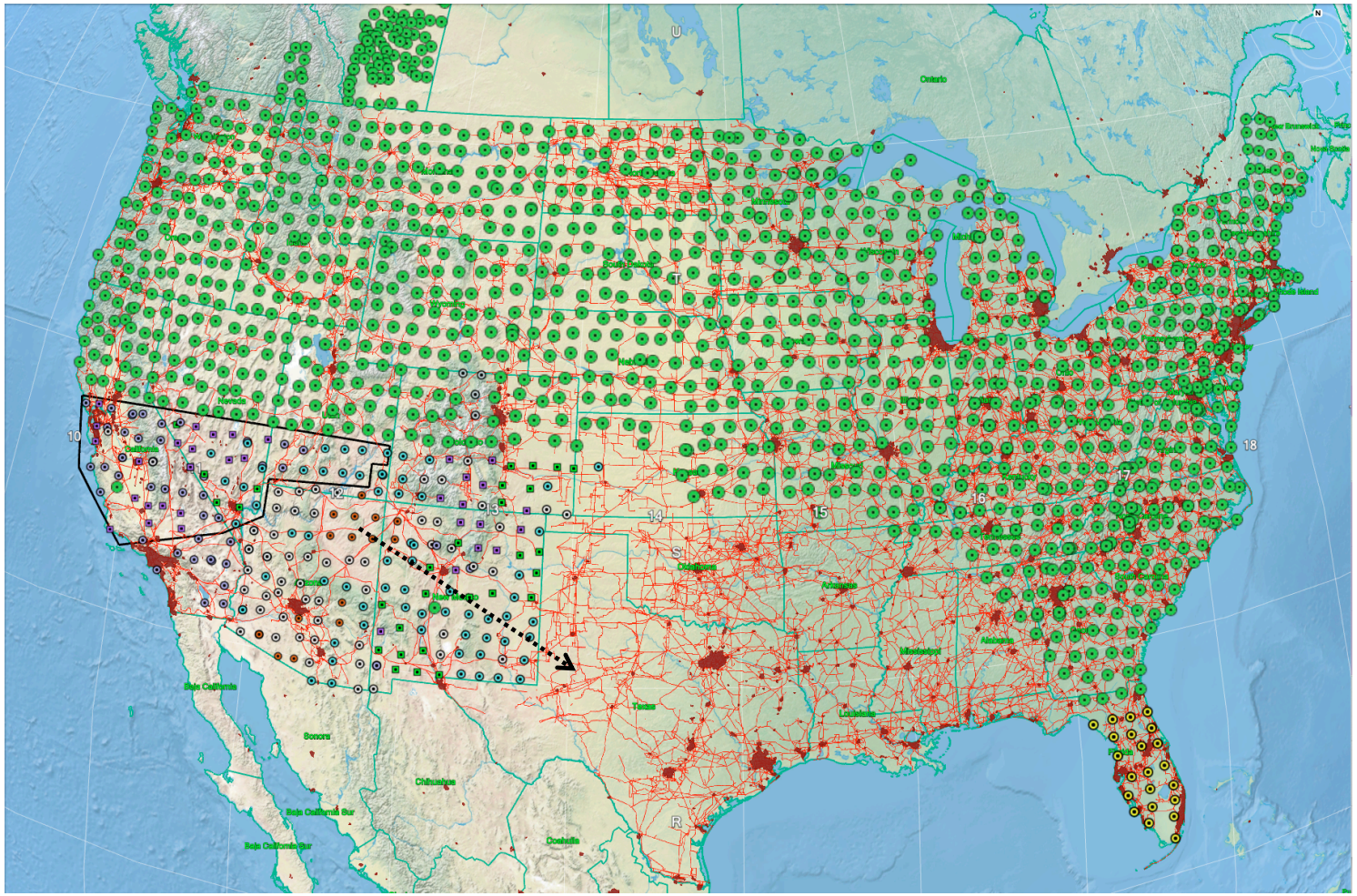
Installed – green boxes

NASA array – black polygon

Permitted – cyan circles

Tribal land – red circles

Sited grid location – white circles



MT Array status early August 2020

Accepted – purple circles

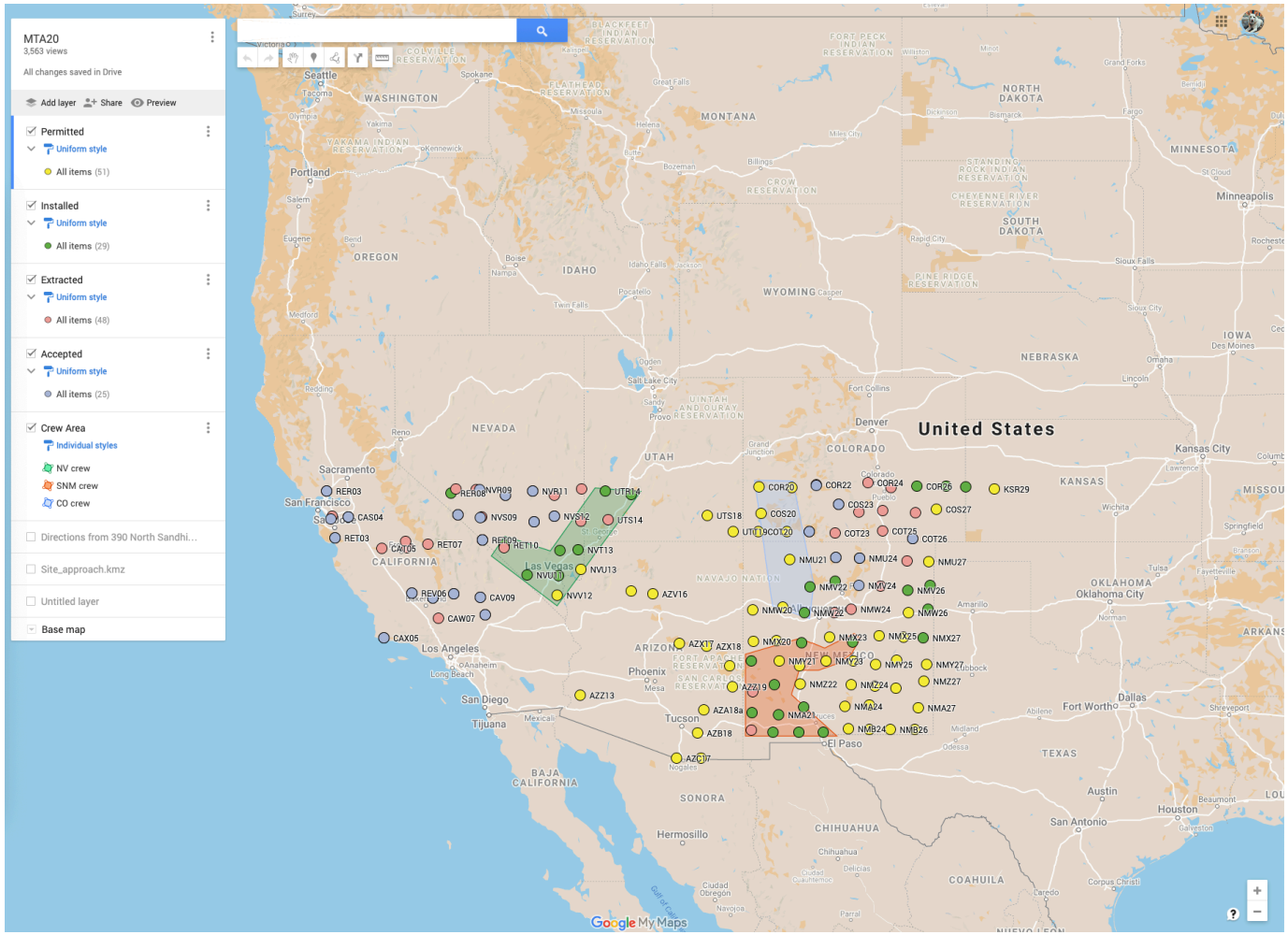
Extracted – red circles

Installed – green circles

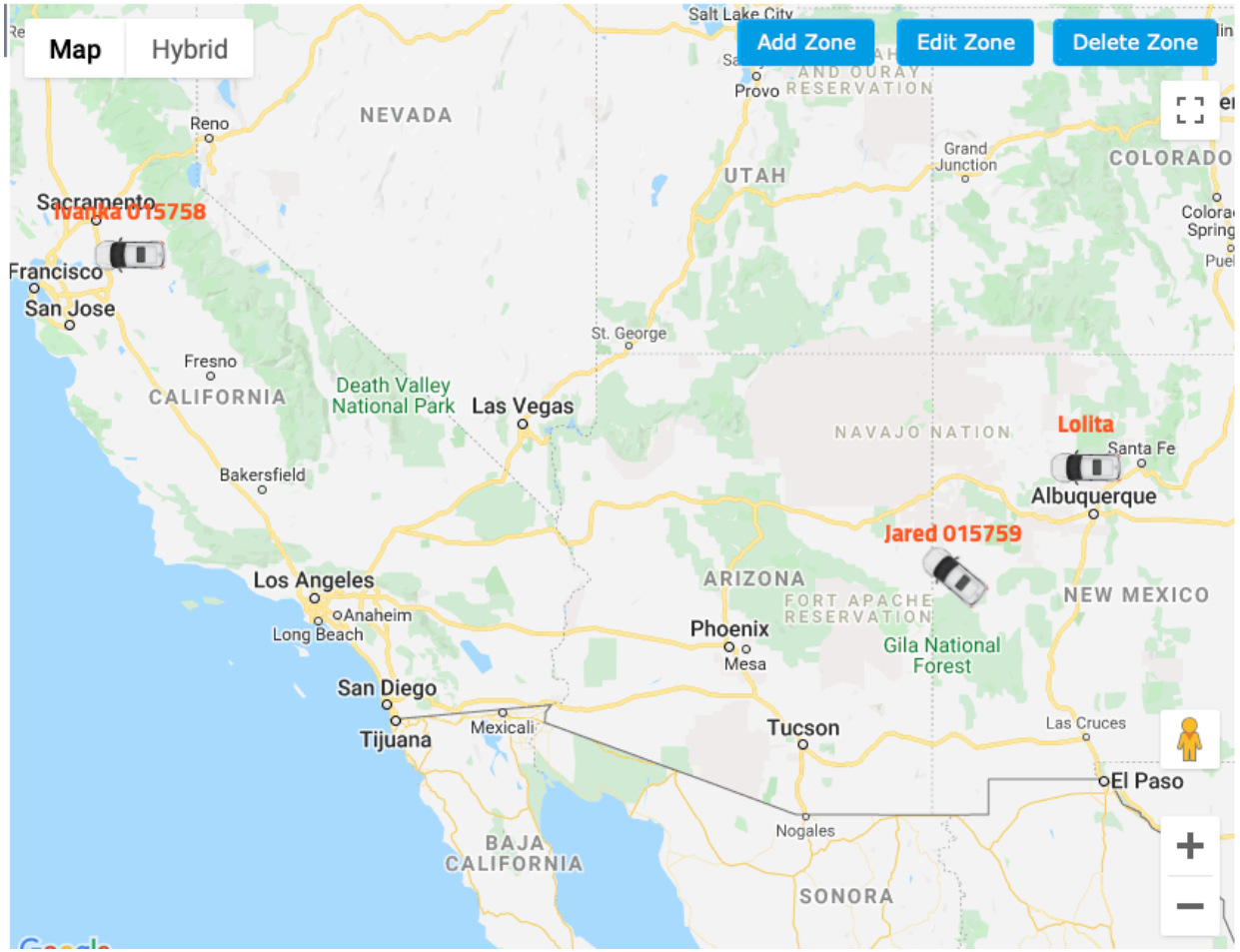
NASA array – black polygon

Permitted – yellow circles

Crew operating areas – colored polygons



MT Array Vehicle Locations 8/26/2020



NERC

NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

TPL-007 Requirement for Magnetic Field Data Process

Mark Olson, Manager Reliability Assessments

GMD Task Force Meeting

August 26, 2020

RELIABILITY | ACCOUNTABILITY




Magnetic Field Data Process Requirement

- Requirement in TPL-007-4 becomes enforceable July 1, 2021

R13. *Each responsible entity, as determined in Requirement R1, shall implement a process to obtain geomagnetic field data for its Planning Coordinator's planning area.*

Technical Rationale

- Information about the requirement is contained in *Technical Rationale* developed by the Standard Drafting Team

This requirement addresses directives in FERC Order No. 830 for requiring responsible entities to collect magnetometer data as necessary to enable model validation and situational awareness (PP 88, 90-92)

Technical Rationale

- Information about the requirement is contained in *Technical Rationale* developed by the Standard Drafting Team

Sources of geomagnetic field data include:

- *Observatories such as those operated by U.S. Geological Survey, Natural Resources Canada, research organizations, or university research facilities*
- *Installed magnetometers*
- *Commercial or third-party sources of geomagnetic field data*

Geomagnetic field data is obtained from one or more of the above data sources or by obtaining a geomagnetic field data product for the area from a government or research organization

SWPC Product

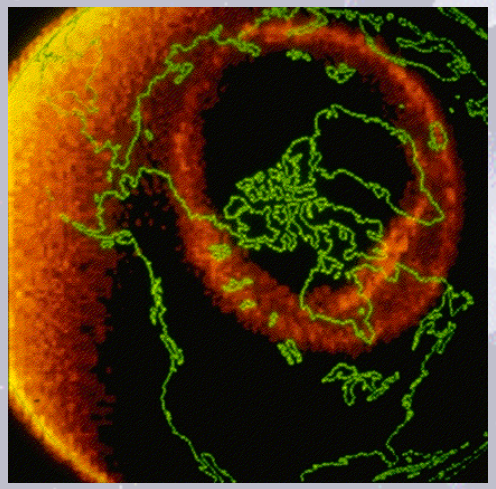
- NERC Staff invited our colleague from Space Weather Prediction Center (SWPC) to this GMDTF web meeting to present information on their geomagnetic field data product...

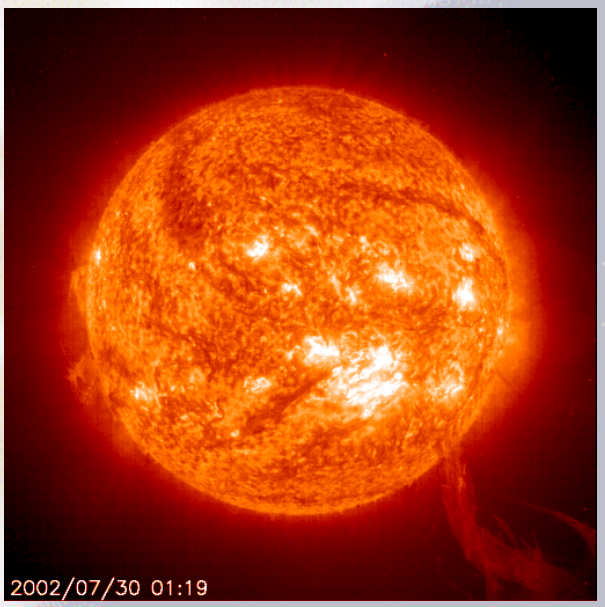
NOAA's Space Weather Prediction Center
Geomagnetic Field Interpolation Model

Outline

- Introduction/Acknowledgements
- Model Description & Examples
- netCDF files web access and usage demonstration
- Caveats & Summary

NERC GMDTF meeting
26 August 2020





Christopher Balch – NOAA/SWPC

Collaborators & Acknowledgements

- Magnetic field time-series interpolation algorithm (SECS) developed and made available courtesy of the Finnish Meteorological Institute
  - Amm & Viljanen, 1999; Pulkkien et al., 2003
- The implementation and operational development of the model is a joint effort between
  - NOAA/SWPC (Balch, Camporeale, SWPC developers and sys admins)
  - USGS Geomagnetism group (Josh Rigler, Anna Kelbert, Greg Lucas – now at University of Colorado/LASP)
  - NASA/CCMC (Antti Pulkkinen)
- Key data provider agencies are gratefully acknowledged:
  - U.S. observatories operated and maintained by USGS
  - Near U.S. observatories operated and maintained by NRCAN
- Additional acknowledgements, documentation, references are in the online readme file:

https://services.swpc.noaa.gov/experimental/netcdf/geomagnetic/secsmaps/~SECS_readme.txt

E-field maps data pipeline - today

USGS observatories (8)
B-field time series

NRCAN observatories (5)
B-field time series

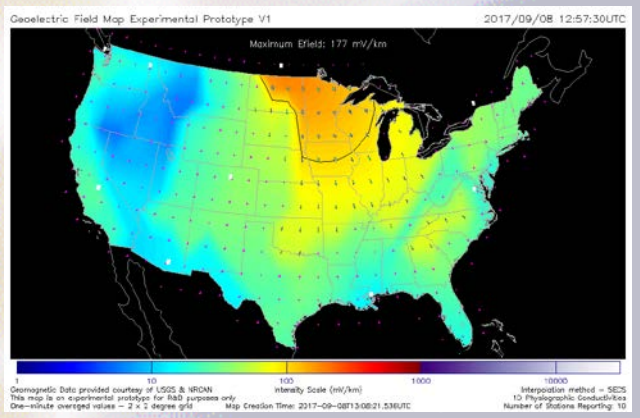
→ ***Detrending Algorithm*** →

Interpolation Algorithm†
B-field on 0.5°x0.5° grid
(daily netcdf archive)

E-field calculation: 2°x2° grid,
Fernberg 1D conductivities

→

E-field experimental products:
- ***-results in database***
- ***-graphical maps***
- ***-daily netcdf (for archive)***
- ***-gridded data files (available on request)***
- ***-GeoJSON format for dissemination***



Operational deployment completed in September 2019

† SECS - Amm & Viljanen, 1999; Pulkkinen et al., 2003

URLs
https://swpc.noaa.gov/products/geoelectric-field-1-minute
https://services.swpc.noaa.gov/text/lists/rgeojson/geoelectric/rgeojsons ***(for list of geojson files)***

E-field maps data pipeline – test system

USGS observatories (8)
B-field time series

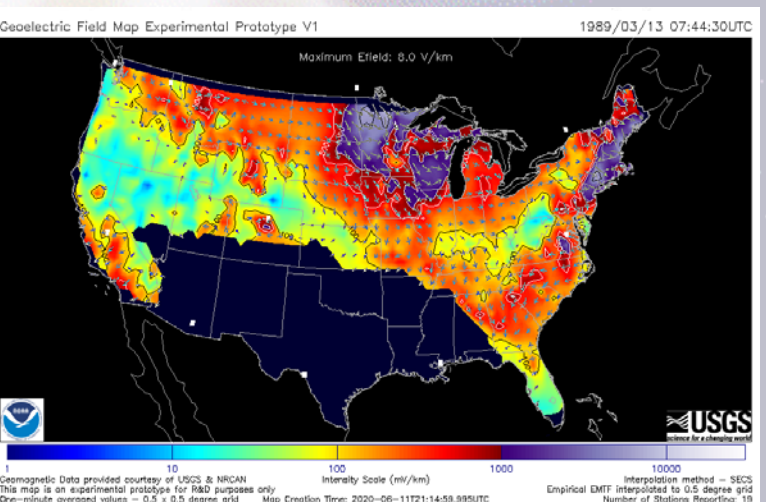
NRCAN observatories (5)
B-field time series

Detrending Algorithm

Interpolation Algorithm
B-field on 0.5°x0.5° grid
daily netcdf for archive

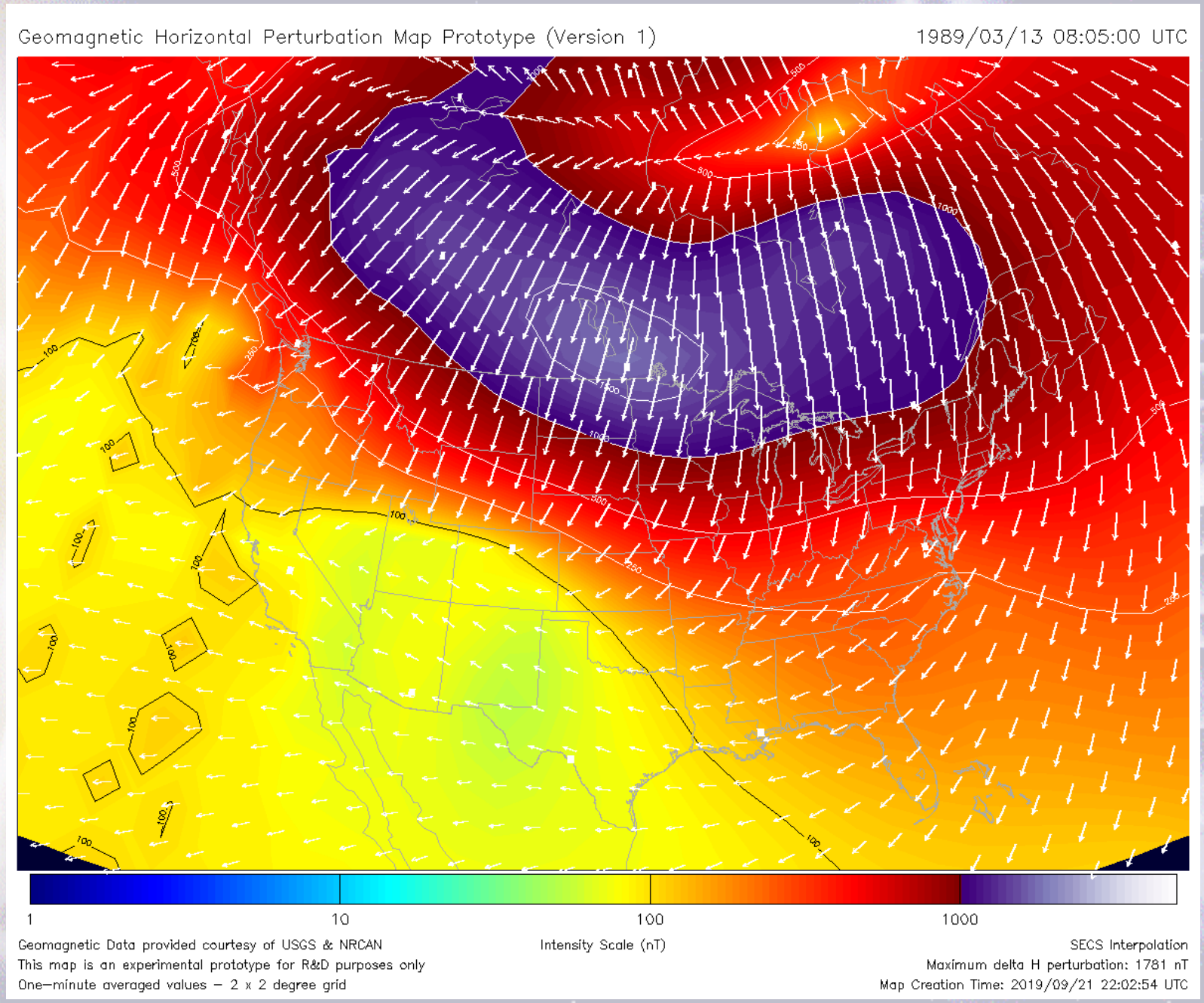
E-field calculation:
-Earthscope Transfer Functions & (USGS for FL)
-Interpolate to 0.5°x 0.5° grid
-Gaps in coverage

E-field experimental products:
-results in database
-graphical maps
-gridded data files
-daily netcdf for archive/repository
-GeoJSON format for dissemination



Scheduled to go operational in FY2020

Method of Spherical Elementary Current Systems



Daily netCDF files online for 30 days

Index of /experimental/netcdf/geomagnetic/secsmaps

Name	Last modified	Size
Parent Directory		-
20200726_secs-dB.nc	2020-07-27 00:10	561M
20200727_secs-dB.nc	2020-07-28 00:10	561M
20200728_secs-dB.nc	2020-07-29 00:11	561M
20200729_secs-dB.nc	2020-07-30 00:10	561M
20200730_secs-dB.nc	2020-07-31 00:10	561M
20200731_secs-dB.nc	2020-08-01 00:10	561M
20200801_secs-dB.nc	2020-08-02 00:10	561M
20200802_secs-dB.nc	2020-08-03 00:10	561M
20200803_secs-dB.nc	2020-08-04 00:10	561M
20200804_secs-dB.nc	2020-08-05 00:10	561M
20200805_secs-dB.nc	2020-08-06 00:10	561M
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20200808_secs-dB.nc	2020-08-09 00:11	561M
20200809_secs-dB.nc	2020-08-10 00:10	561M
20200810_secs-dB.nc	2020-08-11 00:10	561M
20200811_secs-dB.nc	2020-08-12 00:10	561M
20200812_secs-dB.nc	2020-08-13 00:10	561M
20200813_secs-dB.nc	2020-08-14 00:10	561M
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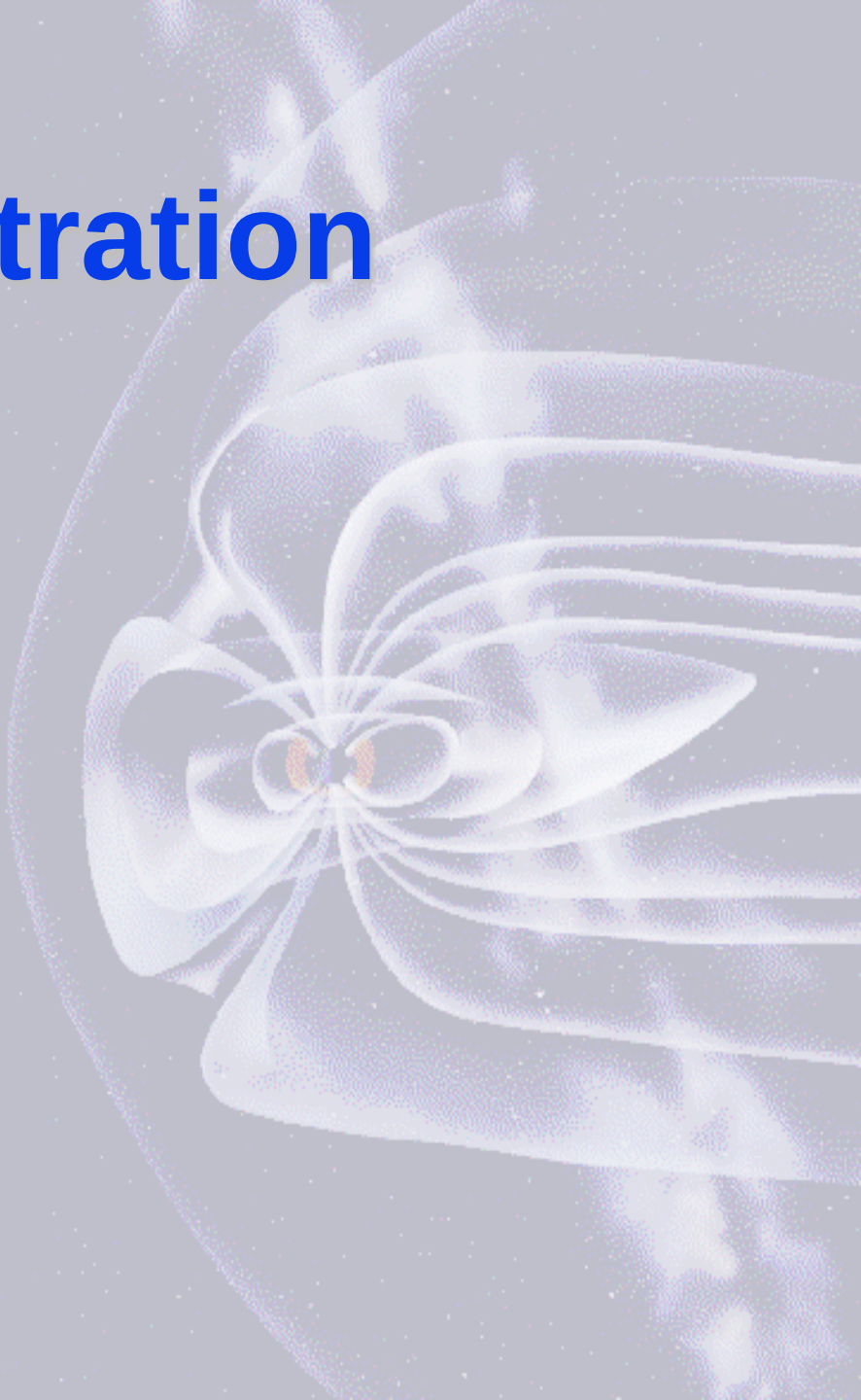
20200822_secs-dB.nc	2020-08-23 00:10	561M
20200823_secs-dB.nc	2020-08-24 00:10	561M
20200824_secs-dB.nc	2020-08-25 00:10	561M
20200825_secs-dB.nc	2020-08-25 19:14	446M
~SECS_readme.txt	2020-07-01 21:26	4.1K

https://services.swpc.noaa.gov/experimental/netcdf/geomagnetic/secsmaps

Contents of the files

- **Gridded magnetic field component perturbations: dX (north), dY (east), dZ (down)**
- **One grid per time step (60 seconds)**
- **1440 time steps per file (per day)**
- **Global attributes stored in the file:**
  FILENAME, CADENCE, NLATITUDES, NLONGITUDES, NGRIDPTS
- **Variables in the file:**
  time – seconds since start of UT day (one entry per time step)
  nobs – number of observatories used (one entry per time step)
  obslist – string array listing observatories used (one entry per time step)
  latitude – one entry per latitude
  longitude – one entry per longitude
  dX, dY, dZ – 3D array with mag perturbations
  (one entry per latitude value, longitude value, and time step)
- **time has an attribute 'REFTIME', a CCSDS time string to which time is added to determine the absolute time**

Demonstration



Resources for netCDF usage

- **The netCDF documentation is at: https://www.unidata.ucar.edu/software/netcdf**
- **netCDF libraries supported by unidata are available in: C & C++, Fortran, Java**
- **Programming interfaces are also available in: Python, IDL, MATLAB, R, Ruby and Perl**

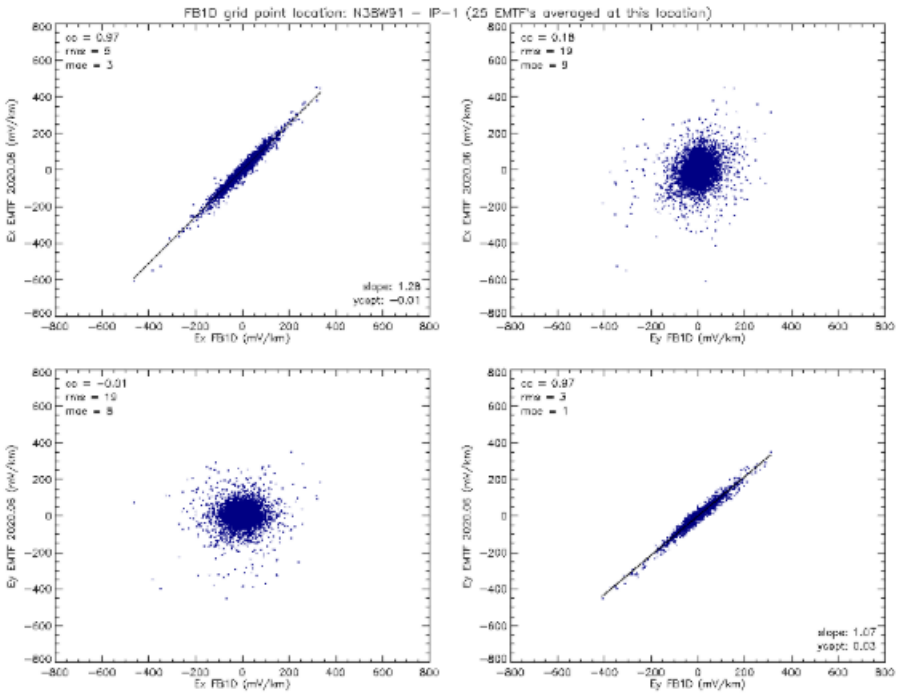
Caveats/Summary

- **The accuracy of the model is limited, especially in locations that are hundreds of kilometers from an actual geomagnetic observatory**
- **Assessment of model accuracy is ongoing**
- **Generally speaking if your location is far from a real observatory, using a real magnetometer in your location is preferable**
- **SWPC is interested in assimilating additional observatory data if the orientation is known and the timeliness, reliability, and quality are sufficient. Doing this will improve the accuracy of the E-field maps in the region where the sensor is located**

Coming Soon - Statistical Comparisons Web Page

REGIONAL GEOELECTRIC 1D-3D STATISTICAL COMPARISIONS

Map | Summary

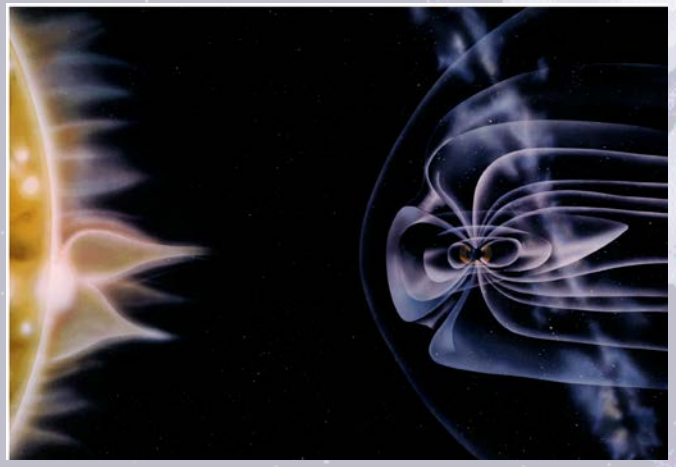


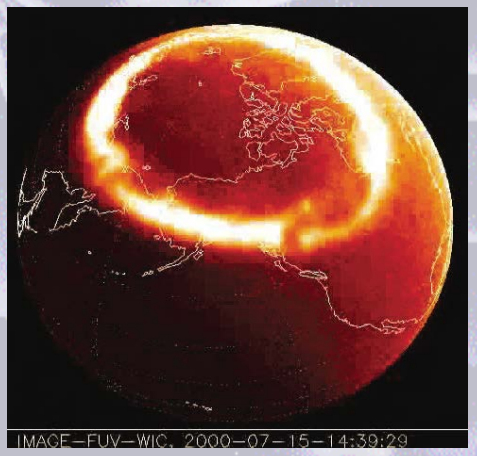
Usage | Impacts | Details | History | Data

The scatter plots are derived by running the Fernberg 1D model and the empirical 3D model through 93 days of historical geomagnetic observatory data, specifically March 1-31, 1989, July 1-31, 2000, and October 1-31 2003. These are the only three months during cycles 22-24 during which the Kp index reached its maximum of 9o (NOAA scale G5 extreme) for solar cycles 22-24. The inclusion of full months enables the sample to include a full range of geomagnetic activity levels. The input data used 10 USGS observatories and 9 NRCAN (Canadian) observatories with one-minute cadence. These data were detrended and input into a model that uses the method of Spherical Elementary Current Systems (SECS) (Amm & Viljanen 1999 & Pulkkinen et al. 2003) to infer the magnetic field time series on a regular 1/2 degree by 1/2 degree grid over the lower 48 states of the US where the 1D model grid points exist and close to locations where MT surveys are available from the IRIS database.

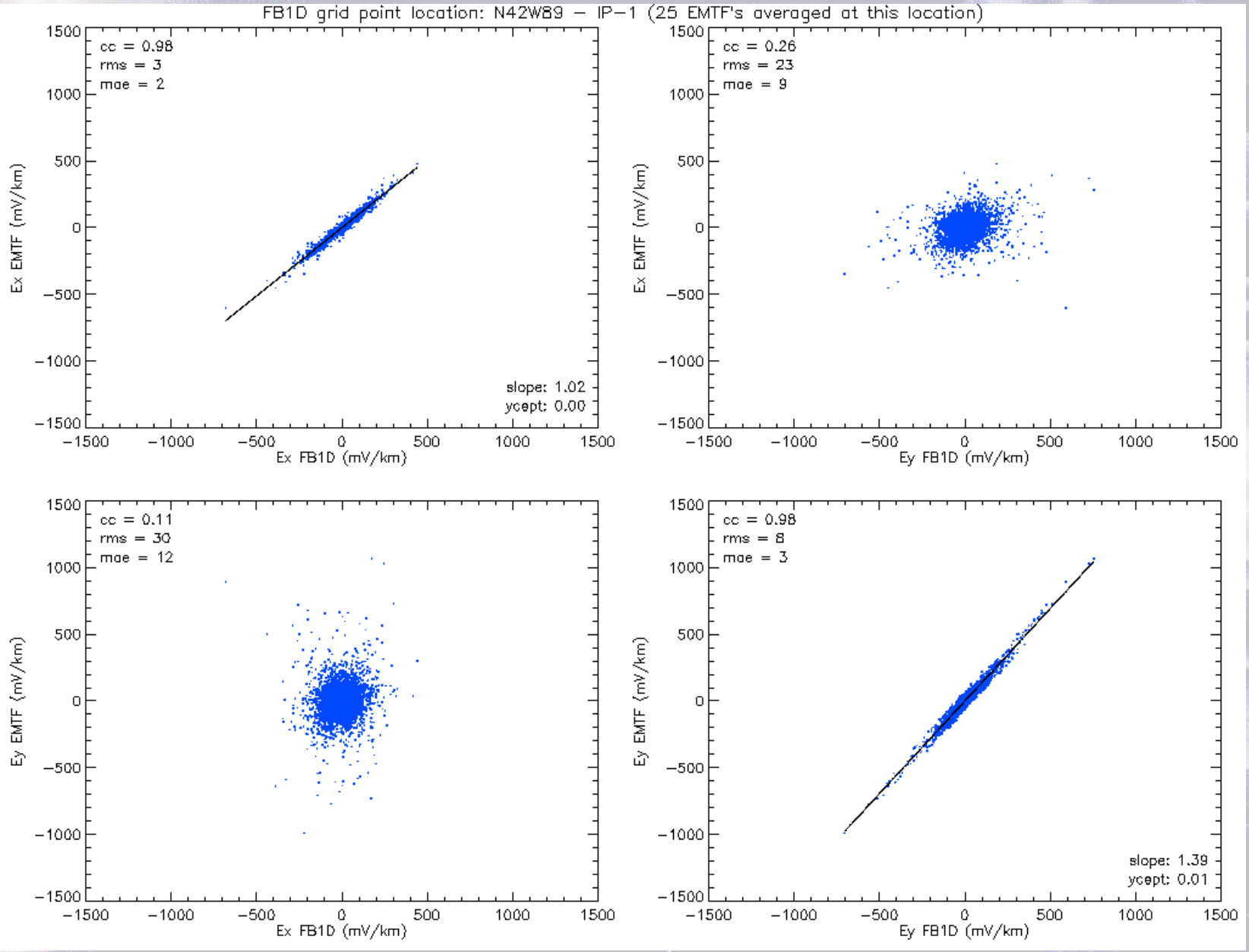
For the 1D model, a 2 degree x 2 degree geographical grid is defined over the lower 48 states. For each grid point, the physiographic region is determined and one of the 20 Fernberg 1D models is assigned. The magnetic field time series is convolved with the transfer function derived from the 1D model and a geoeletric field time series is thereby derived at the grid point. These are combined over all the grid points resulting in a minute-by-minute series of maps of the geoelectric field for these time

Questions?



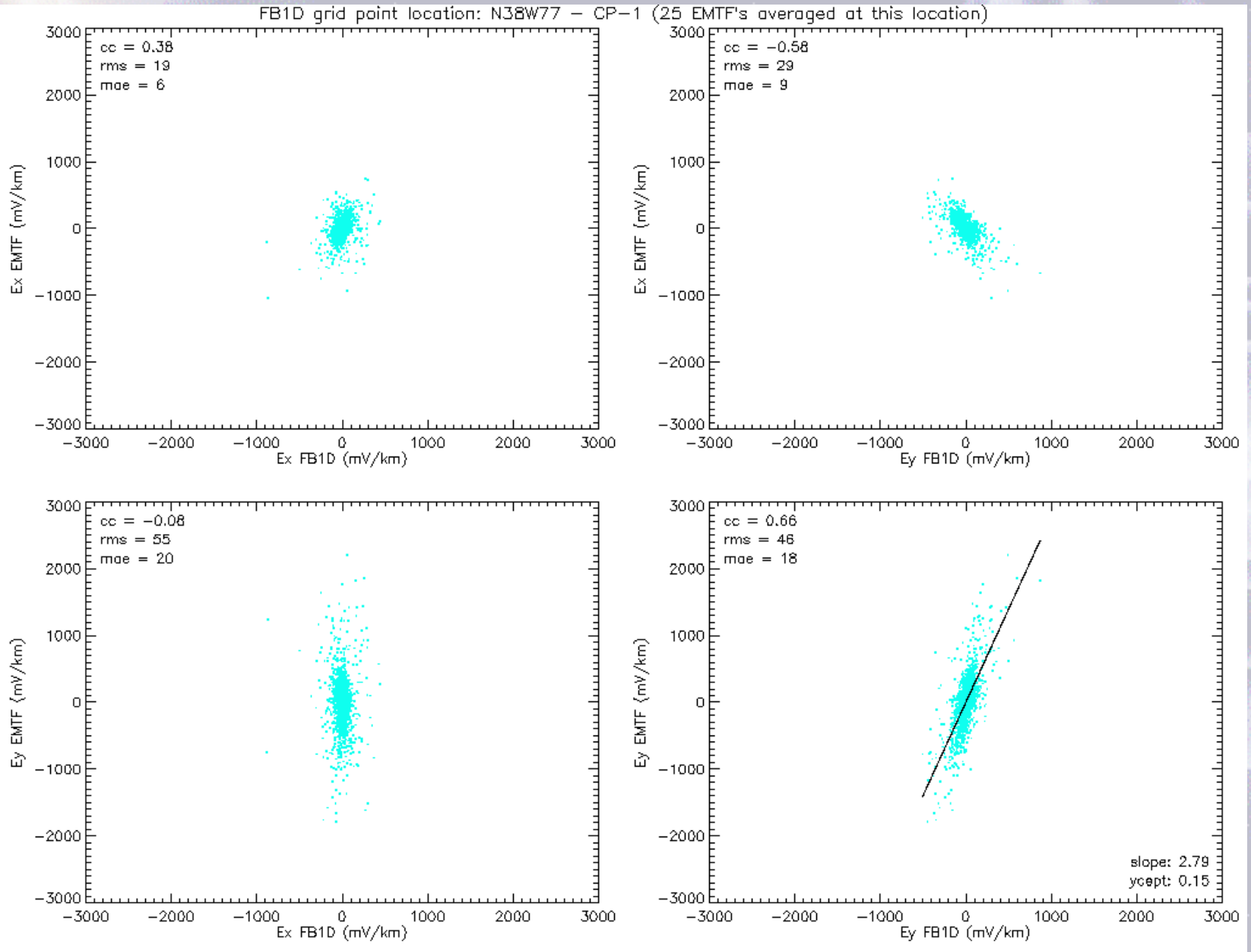


Scatterplots



North-Central Illinois

Scatterplots



Eastern Virginia

Correlation Table

For correlations between the Ex components we get the following distribution:

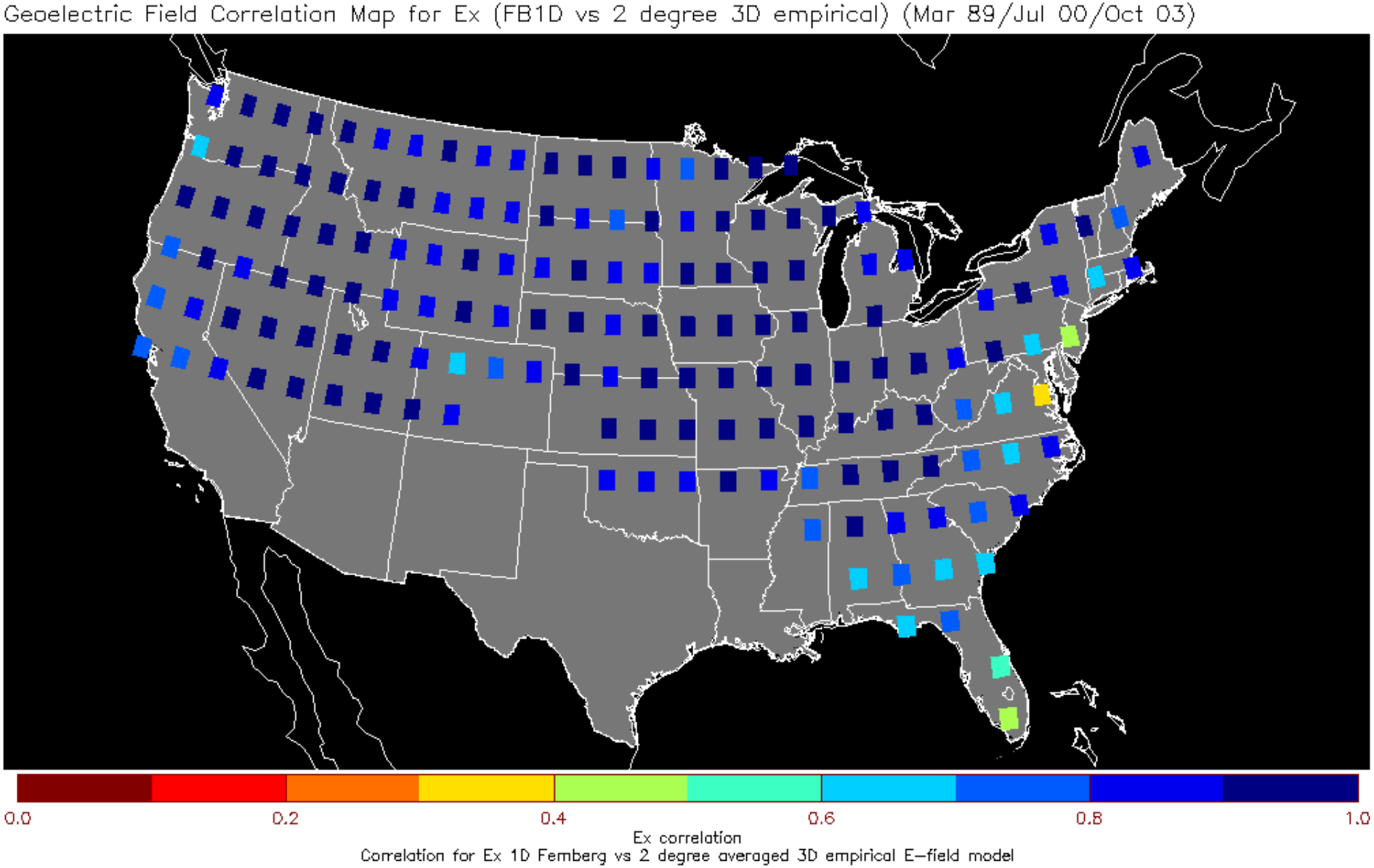
Category	# of points	% of total
Correlation over 0.90	84	53.2%
Correlation from 0.80-0.90	45	28.5%
Correlation from 0.70-0.80	15	9.5%
Correlation from 0.60-0.70	10	6.3%
Correlation from 0.50-0.69	1	0.6%
Correlation less than 0.50	3	1.9%

Likewise, for the Ex components, we get the following distribution

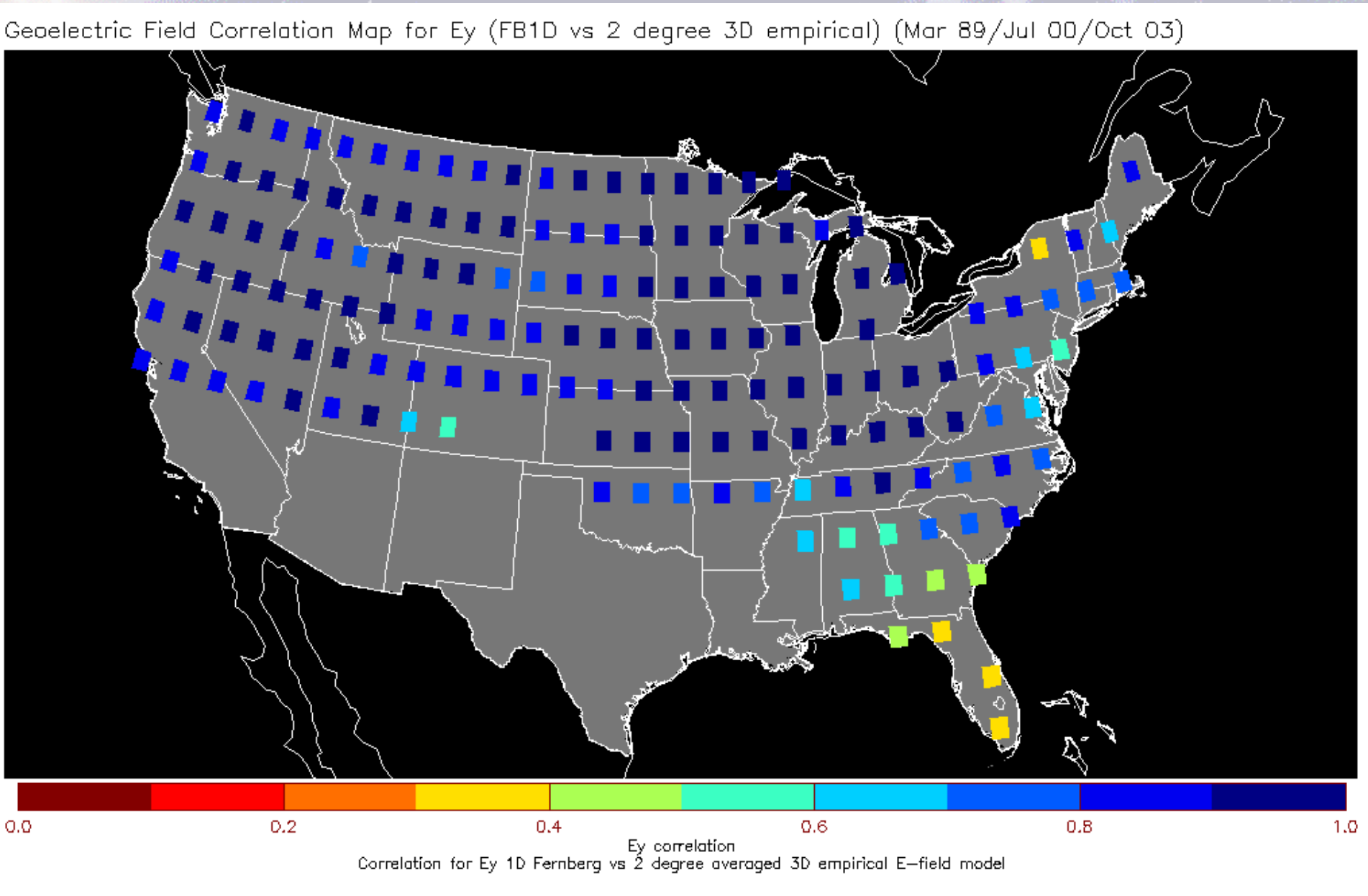
Category	# of points	% of total
Correlation over 0.90	79	50.0%
Correlation from 0.80-0.90	46	29.1%
Correlation from 0.70-0.80	14	8.9%
Correlation from 0.60-0.70	7	4.4%
Correlation from 0.50-0.69	5	3.2%
Correlation less than 0.50	7	4.4%

We note that a majority of the points have sufficiently high correlations that one could simply use the line-fit correction to get a reasonable conversion between the two models at those locations.

Correlation Map - Ex



Correlation Map - Ey



Peak Value Map for Et (3D empirical)

The distribution of grid points for given peak E-field ranges from this model (for the G5 months) is as follows:

Peak E-field magnitude	# pts	% of total
Less than 1000 mV/km	1828	69.4%
1000-2000 mV/km	348	13.2%
2000-5000 mV/km	306	11.6%
5000-10000 mV/km	139	5.3%
over 10000 mV/km	10	0.4%