Description of document:	U. S. Geological Survey (USGS) Files re: Risks of Geomagnetic Storms to the Nation, 2012-2015
Requested date:	2015
Released date:	20-July-2015
Posted date:	23-November-2015
Source of document:	Freedom of Information Act Request U. S. Geological Survey 5522 Research Park Drive Baltimore, MD 21228 Fax: (443) 498-5510 Email: foia@usgs.gov

United States Department of the Interior

U. S. GEOLOGICAL SURVEY

Office of Enterprise Information
345 Middlefield Road, MS:955
Menlo Park, CA 94025-3591

Transmitted via U.S. Mail

July 20, 2015

REF:USGS-2015-00138

This is in response to your email of July 19, 2015, in which you stated you cannot access the 4 files I had placed on a public FTP site, that was provided in my interim release batch 1 to you: ftp://ftpext.usgs.gov/pub/wr/ca/menlo.park/jcearley/FOIA/FOIA%202015-00138%20Release/

Therefore, I am providing the files in the enclosed CD-ROM diskette. The file names are:
AMS-Love-Induction Jan 2015.PDF, 13 pages;
AGU-Love-Induction Dec 2014.PDF, 13 pages;
AGU-Gannon-Dec2012.PDF, 14 pages; and
Love-etal-SWW-2015.PDF, 13 pages.

Should you have any questions, please feel free to contact me at foia@usgs.gov and (650) 329-4035.

Sincerely,

Judy Cearley
Freedom of Information Act (FOIA) Liaison
U.S. Geological Survey
Department of the Interior
(650) 329-4035
foia@usgs.gov
345 Middlefield Road, MS:955
Menlo Park, CA 94025-3591

United States Department of the Interior

U.S. GEOLOGICAL SURVEY
5522 Research Drive Park
Baltimore, MD 21228

In Reply Refer To: September 8, 2015

U.S. Geological Survey
Attention: Freedom of Information Act Officer
5522 Research Park Drive
Baltimore, MD 21228

Transmitted by electronic mail

Re: Final Response - U.S. Geological Survey (USGS) FOIA Tracking # 2015-00138

This response is our final response to your Freedom of Information Act (FOIA) request dated April 26, 2015.

On May 22, 2015, we partially responded to this request by releasing four electronic files. Seventy-three (73) additional responsive pages have been identified and reviewed. All 73 pages are draft documents and are being withheld under FOIA Exemption (b)(5).

Exemption 5 allows an agency to withhold "inter-agency or intra-agency memorandums or letters which would not be available by law to a party... in litigation with the agency." 5 U.S.C. § 552(b)(5); *see Nat'l Labor Relations Bd. v. Sears Roebuck & Co.*, 421 U.S. 132, 149 (1975). Exemption 5 therefore incorporates the privileges that protect materials from discovery in litigation, including the deliberative process, attorney work-product, attorney-client, and commercial information privileges. We withheld 73 pages in their entirety under Exemption 5 because they qualify to be withheld under the Deliberative Process:

Deliberative Process Privilege

The deliberative process privilege protects the decision-making process of government agencies and encourages the "frank exchange of ideas on legal or policy matters" by ensuring agencies are not "forced to operate in a fish bowl." *Mead Data Cent., Inc. v. United States Dep't of the Air Force*, 566 F.2d 242, 256 (D.C. Cir. 1977) (internal citations omitted). A number of policy purposes have been attributed to the deliberative process privilege. Among the most important are to: (1) "assure that subordinates . . . will feel free to provide the decision maker with their uninhibited opinions and recommendations"; (2) "protect against premature disclosure of proposed policies"; and (3) "protect against confusing the issues and misleading the public." *Coastal States Gas Corp. v. United States Dep't of Energy*, 617 F.2d 854, 866 (D.C. Cir. 1980).

The deliberative process privilege protects materials that are both predecisional and deliberative. The privilege covers records that "reflect the give-and-take of the consultative process" and may include "recommendations, draft documents, proposals, suggestions, and other subjective documents which reflect the personal opinions of the writer rather than the policy of the agency." *Id.*

The materials that have been withheld under the deliberative process privilege of Exemption 5 are both predecisional and deliberative. They do not contain or represent formal or informal agency policies or decisions. They are the result of frank and open discussions among employees of the Department of the Interior. Their contents have been held confidential by all parties and public dissemination of these drafts would have a chilling effect on the agency's deliberative processes; expose the agency's decision-making process in such a way as to discourage candid discussion within the agency, and thereby undermine its ability to perform its mandated functions.

The file names of the records we withheld are as follows:

1) Draft_EfieldHistorical5NOV2013.pdf (27 pages)
2) A one-dimensional model of solid-Earth electrical resistivity beneath Florida 04152015.docx (21 pages)
3) syntheticEB.pdf (2 pages)
4) lognorm-20150503.pdf (7 pages)
5) DraftUSGS_Efield_plan_10Jan2014.doc (16 pages)

I am responsible for this denial. Ms. Lauren Bachtel, Attorney-Advisor, in the Office of the Solicitor was consulted.

You may appeal this response to the Department's FOIA/Privacy Act Appeals Officer. If you choose to appeal, the FOIA/Privacy Act Appeals Officer must receive your FOIA appeal **no later than 30 workdays** from the date of this letter. Appeals arriving or delivered after 5 p.m. Eastern Time, Monday through Friday, will be deemed received on the next workday.

Your appeal must be made in writing. You may submit your appeal and accompanying materials to the FOIA/Privacy Act Appeals Officer by mail, courier service, fax, or email. All communications concerning your appeal should be clearly marked with the words: "FREEDOM OF INFORMATION APPEAL." You must also include with your appeal copies of all correspondence between you and USGS concerning your FOIA request, including your original FOIA request and USGS's response. Failure to include with your appeal all correspondence between you and USGS will result in the Department's rejection of your appeal, unless the FOIA/Privacy Act Appeals Officer determines (in the FOIA/Privacy Act Appeals Officer's sole discretion) that good cause exists to accept the defective appeal.

Please include your name and daytime telephone number (or the name and telephone number of an appropriate contact), email address and fax number (if available) in case the FOIA/Privacy Act Appeals Officer needs additional information or clarification of your appeal.

DOI FOIA/Privacy Act Appeals Office Contact Information

Department of the Interior
Office of the Solicitor
Attn: FOIA/Privacy Act Appeals Office
1849 C Street, N.W.
MS-6556 MIB
Washington, DC 20240
Telephone: (202) 208-5339
Fax: (202) 208-6677
Email: FOIA.Appeals@sol.doi.gov

For more information on FOIA Administrative Appeals, you may review the Department's FOIA regulations at *43 C.F.R. Part 2, Subpart H.*

This completes our response for all responsive documents under your request. If you have any questions about our response to your request, you may contact me by phone at (443) 498-5521, by electronic mail at foia@usgs.gov, or by mail at 5522 Research Park Drive, Baltimore, MD 21228.

Sincerely,

BRIAN MAY

Digitally signed by BRIAN MAY
DN: c=US, o=U.S. Government, ou=Department of the Interior, ou=Geological Survey, cn=BRIAN MAY, 0.9.2342.19200300.100.1.1=14001003037231
Date: 2015.09.08 10:04:31 -04'00'

Brian A. May
Freedom of Information Act Officer

Extreme geoelectric fields induced by magnetic storm sudden impulses

Jeffrey J. Love and E. Joshua Rigler
Geomagnetism Program
USGS Natural Hazards Mission

jlove@usgs.gov

Andrei Swidinsky
Department of Geophysics
Colorado School of Mines

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Magnetic storms and induction hazards

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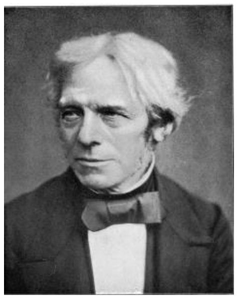
Electromagnetic induction and time series analysis

André-Marie Ampère (1775-1836):
Electric currents generate magnetic fields.



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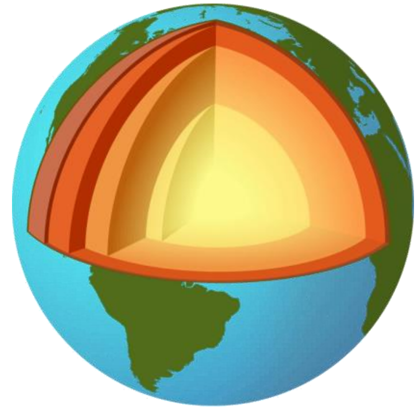
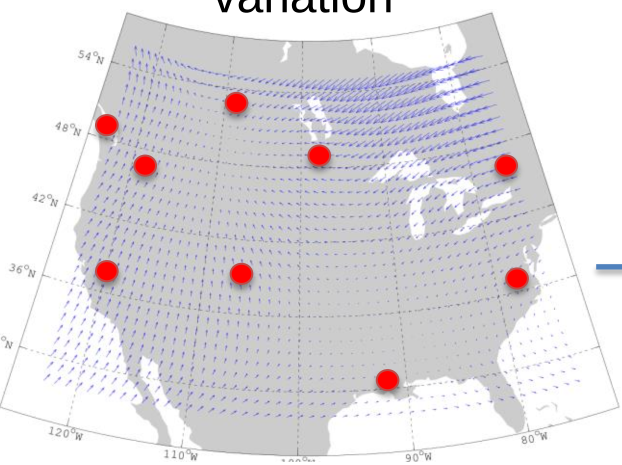
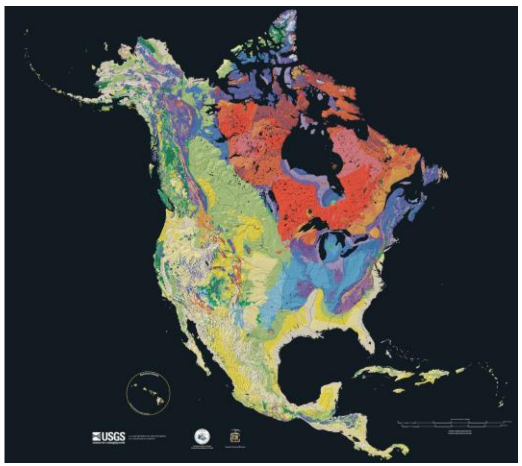
Geomagnetic variation →  → Geoelectric field

Map of geomagnetic variation



Model of lithospheric conductivity



Map of geoelectric variation

E

Kakioka Magnetic Observatory
Japan Meteorological Agency

- Low(ish) magnetic latitude: 27.5° N.
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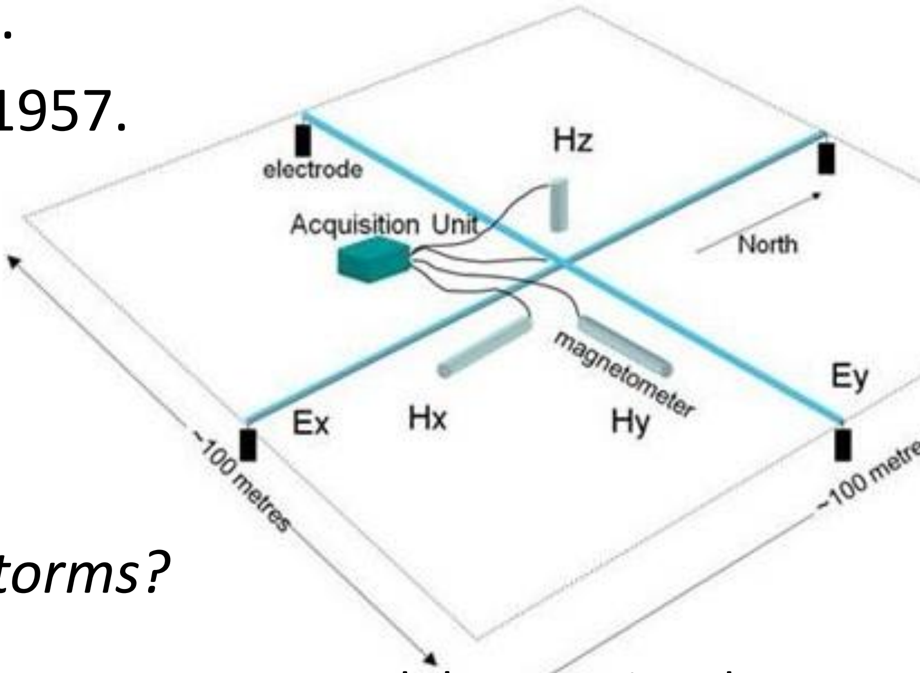

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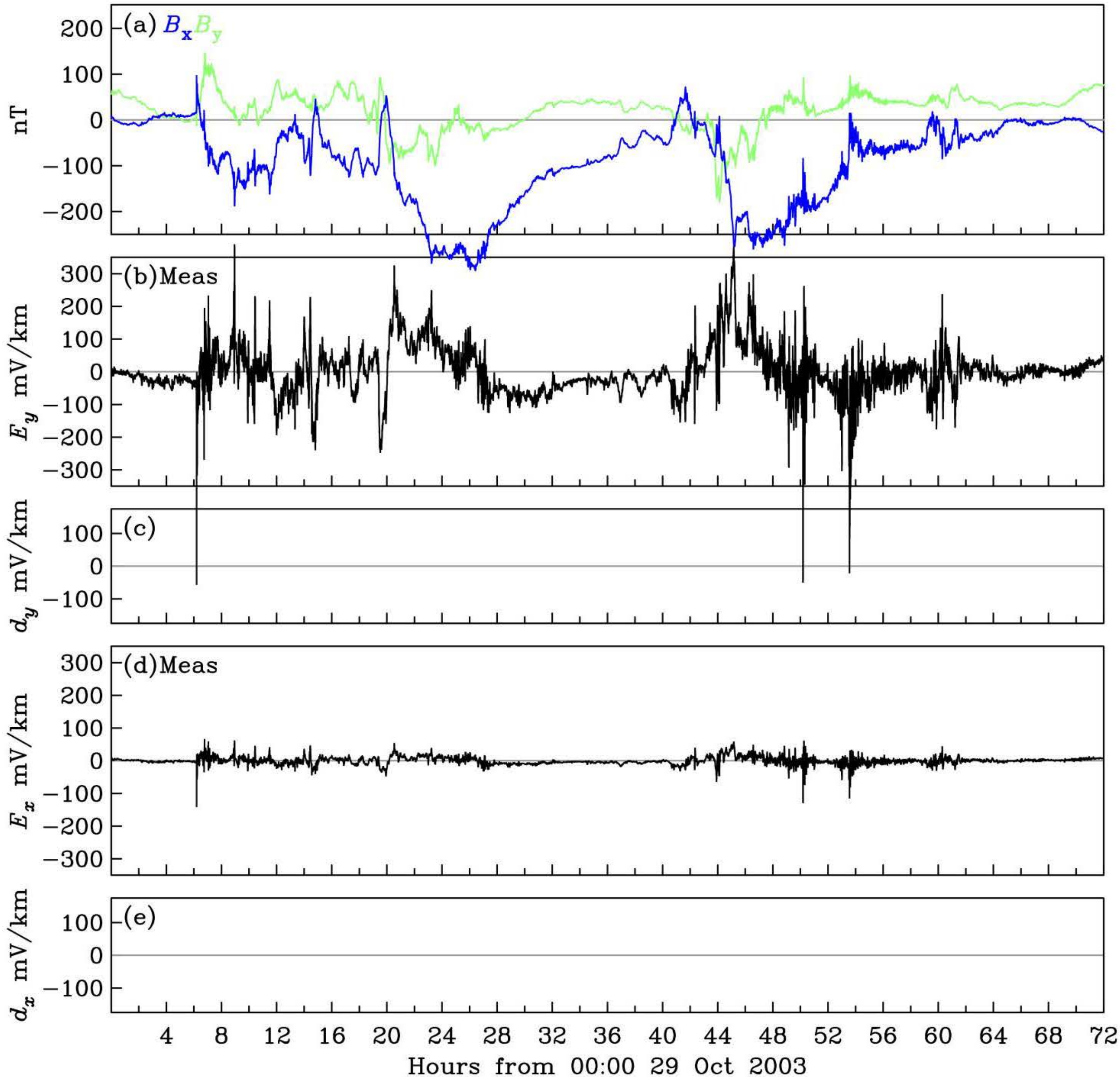

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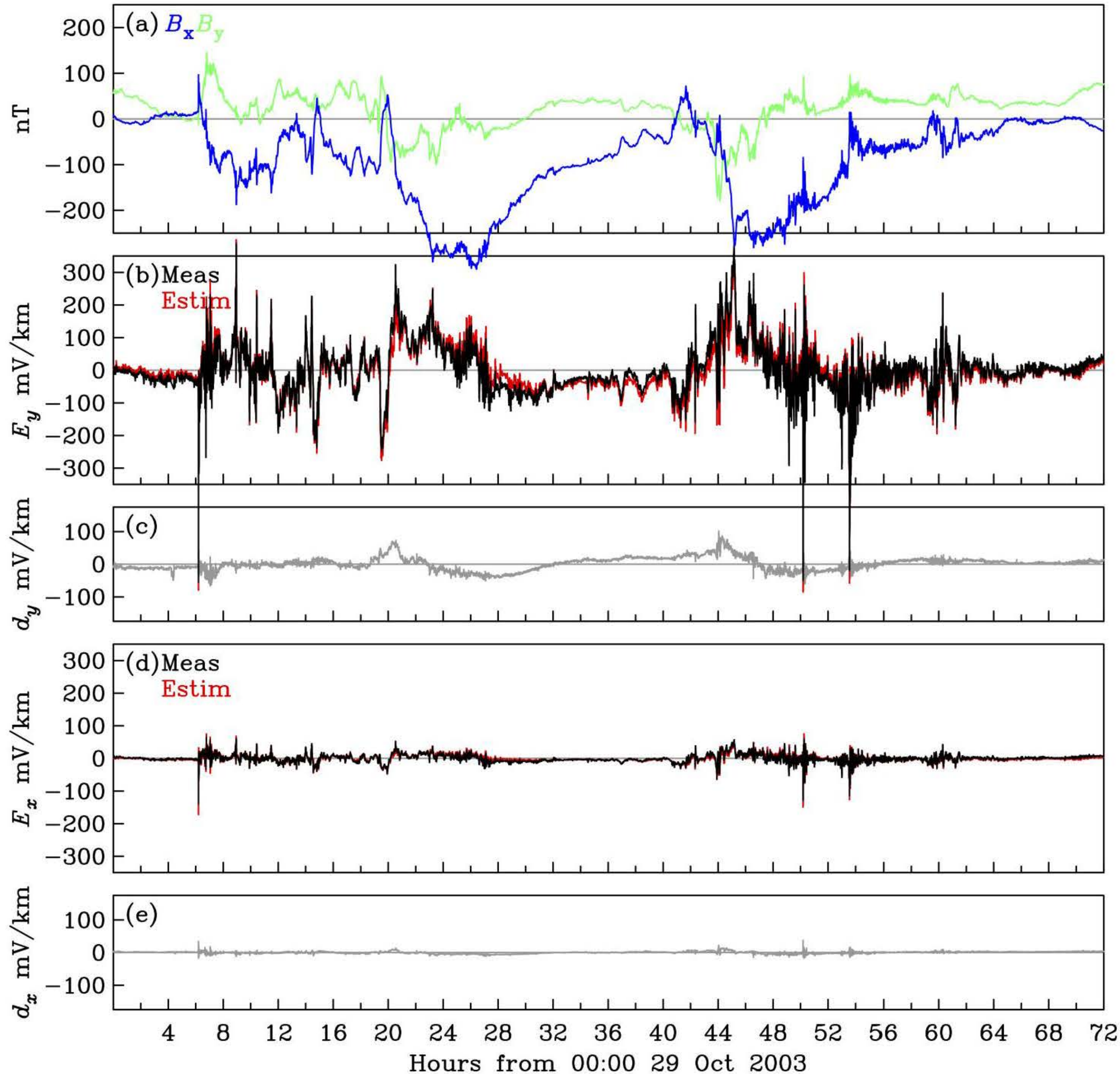

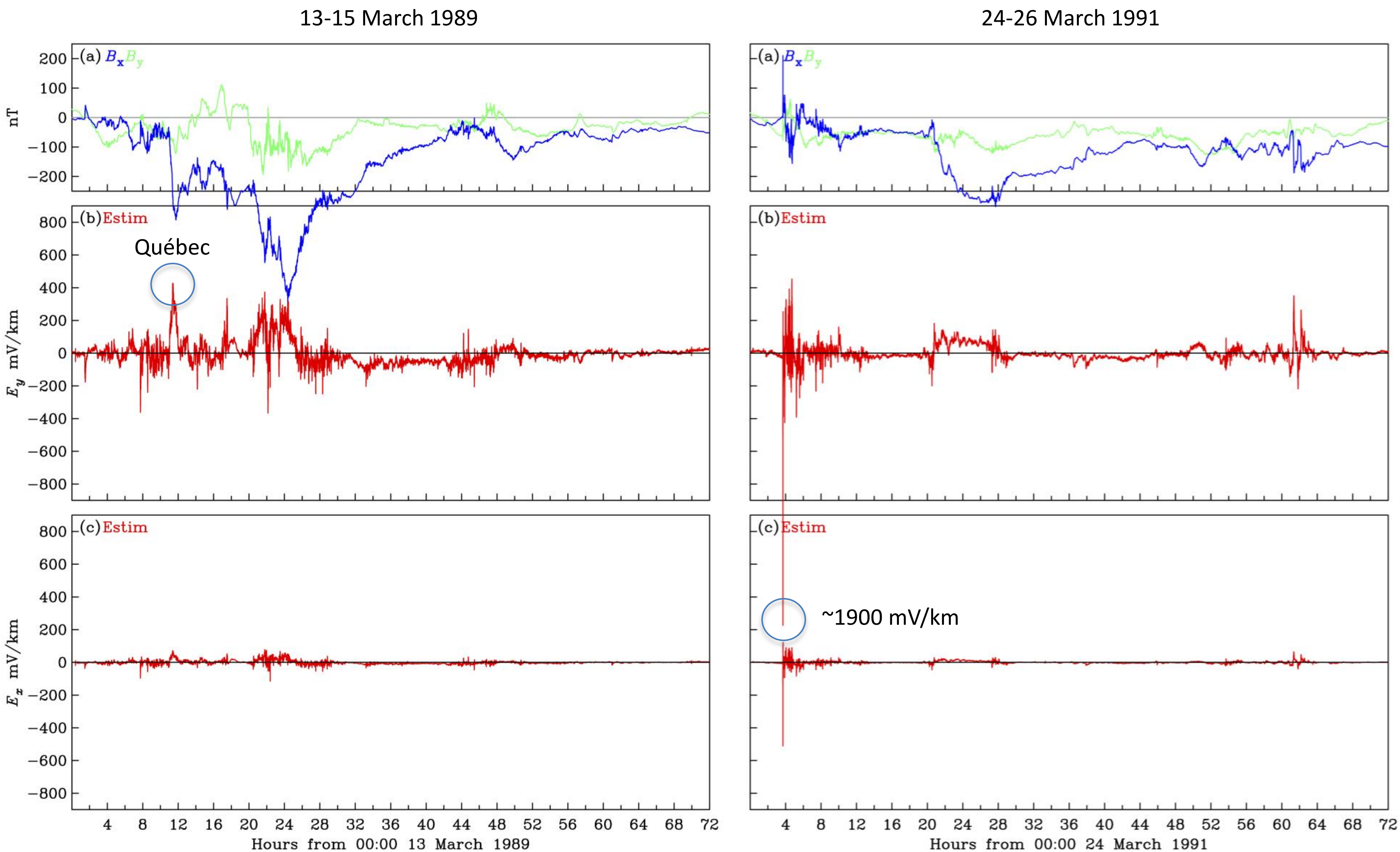

13-15 March 1989
24-26 March 1991
(a) Bx By
(b) Estim
(c) Estim
Québec
~1900 mV/km
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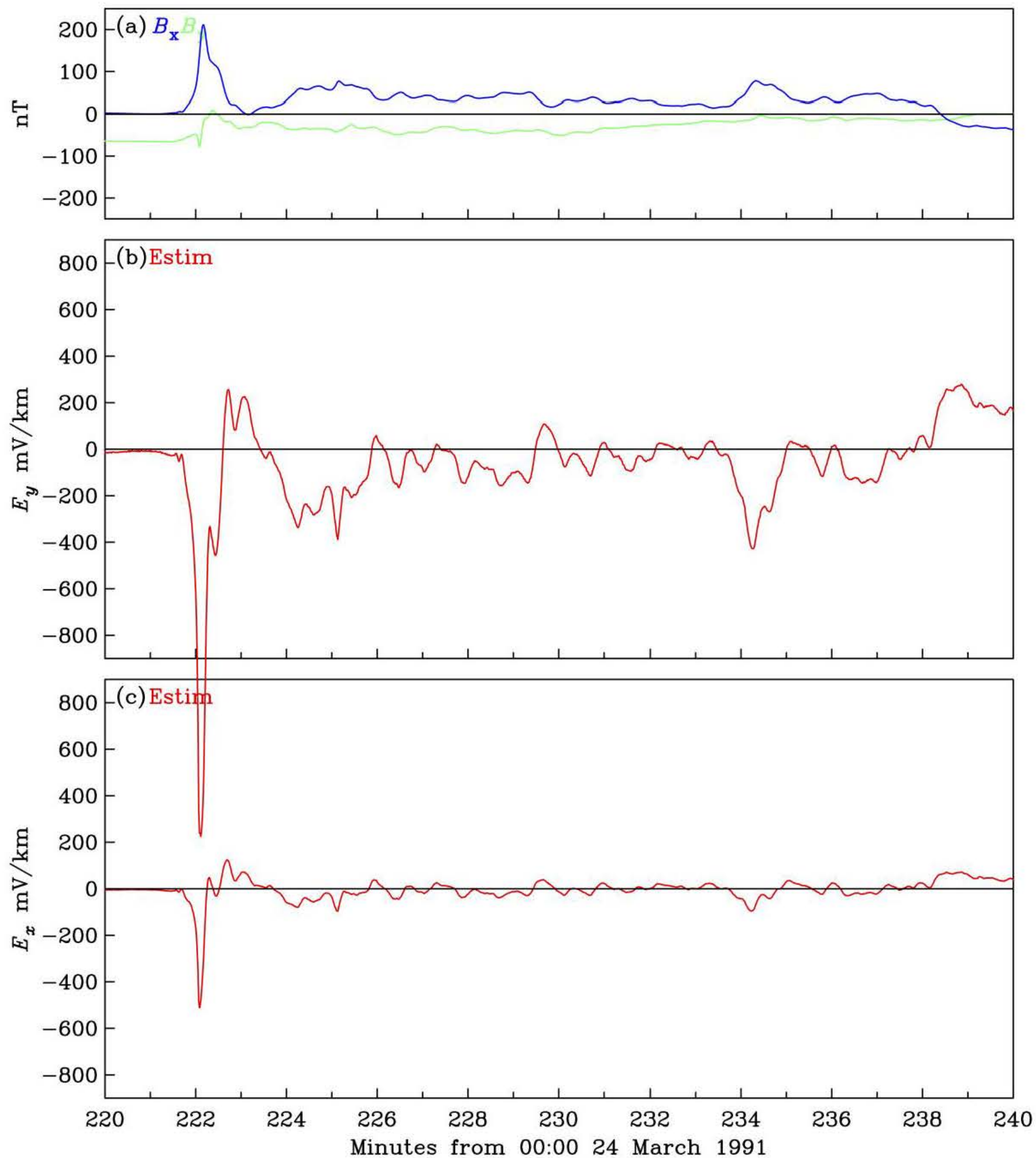
Ey mV/km
Ex mV/km
Hours from 00:00 13 March 1989
Hours from 00:00 24 March 1991


(a) B_x B
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E_y mV/km
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Minutes from 00:00 24 March 1991

Conclusions, Issues, Opportunities

- For some magnetic storms, geoelectric hazards are realized during storm-time main phase (especially at high latitudes).
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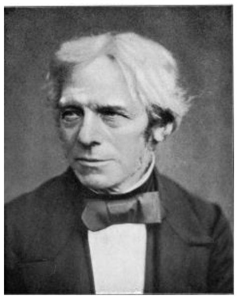

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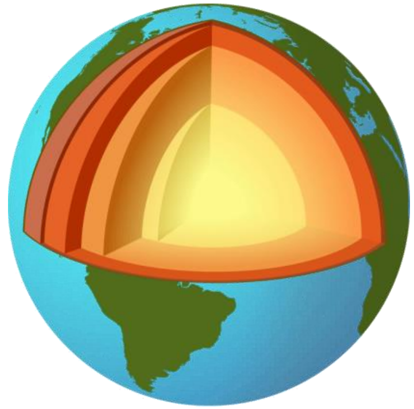
Geomagnetic variation →  → Geoelectric field

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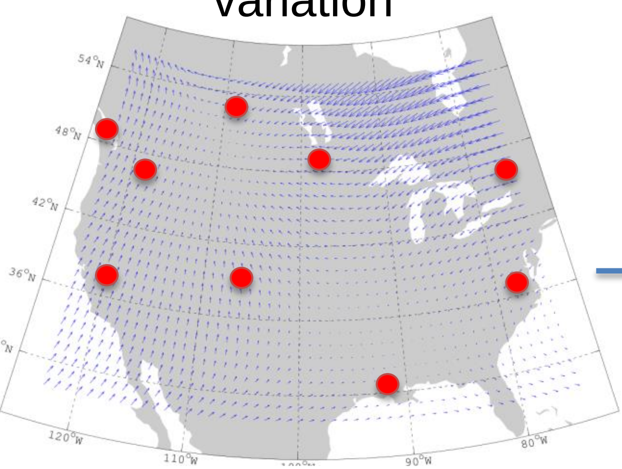

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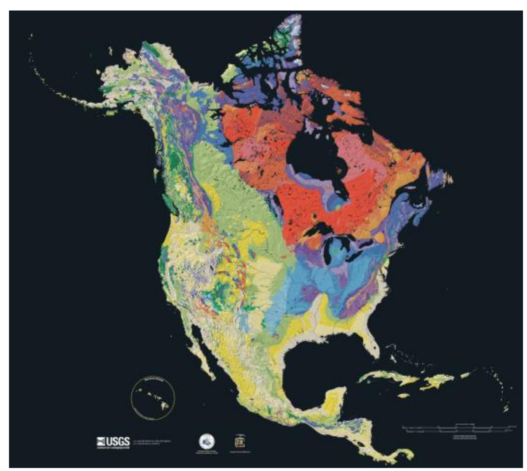
Model of lithospheric conductivity



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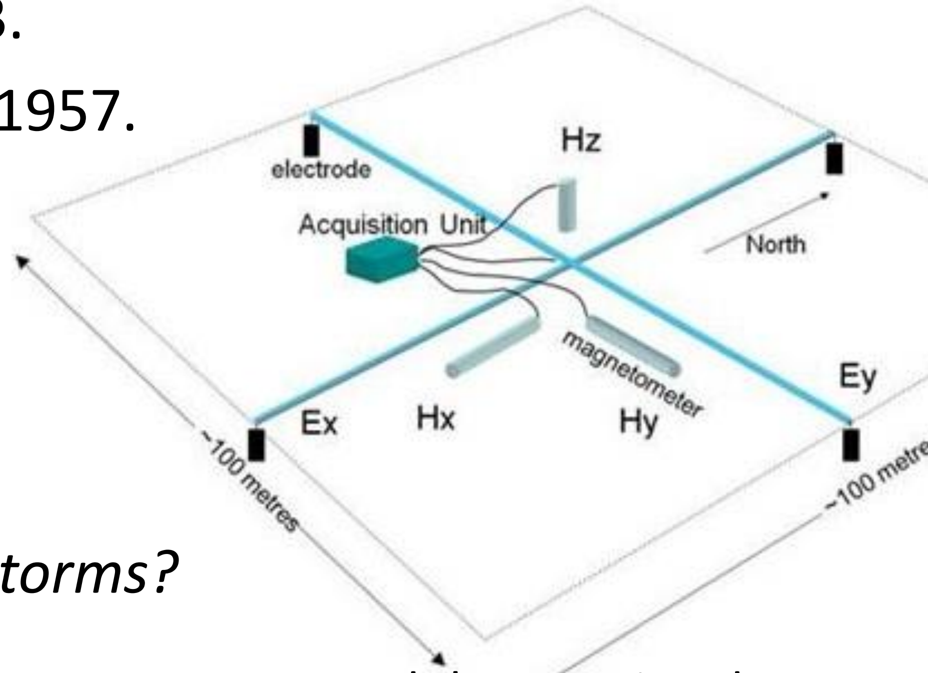

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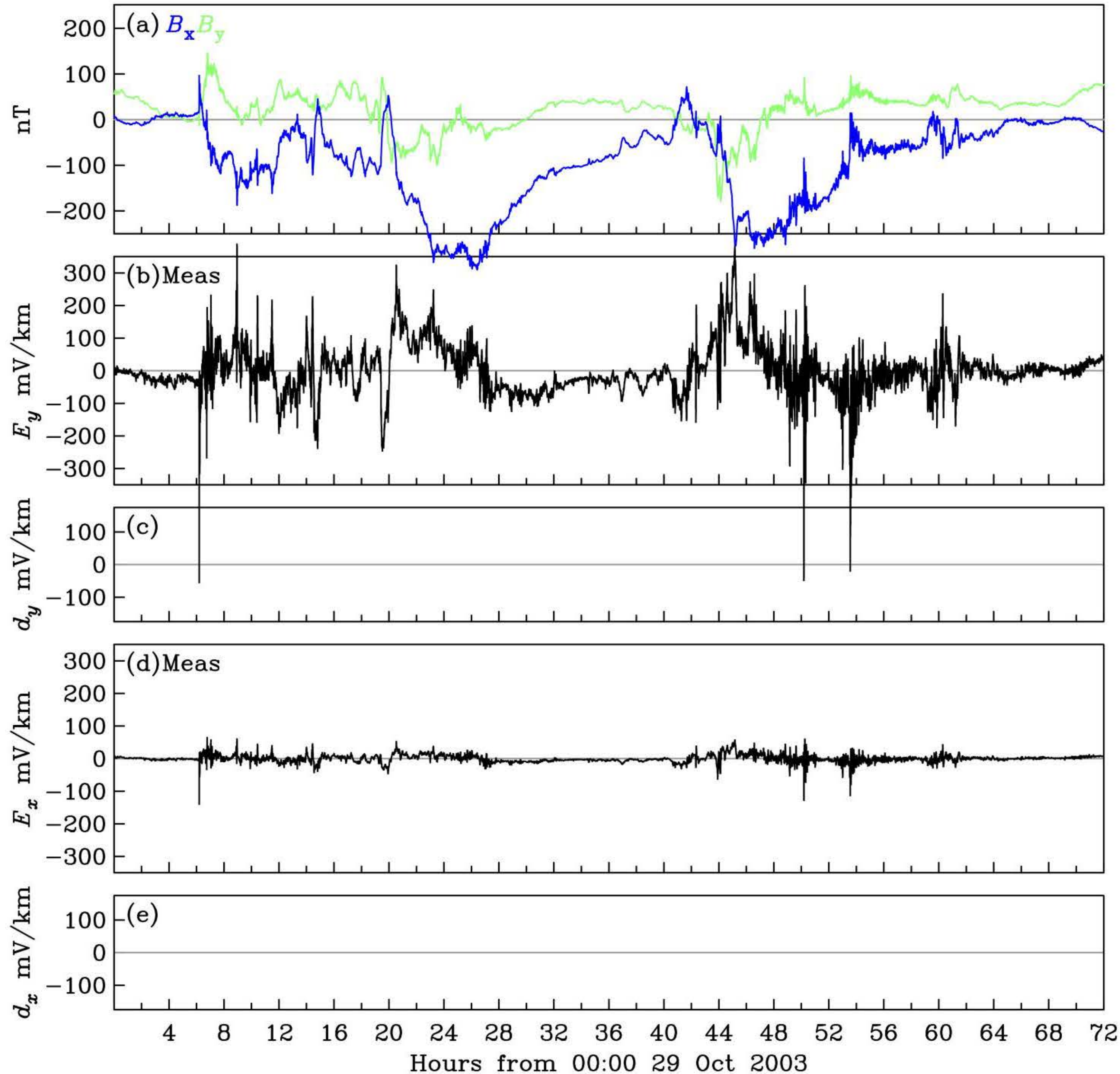

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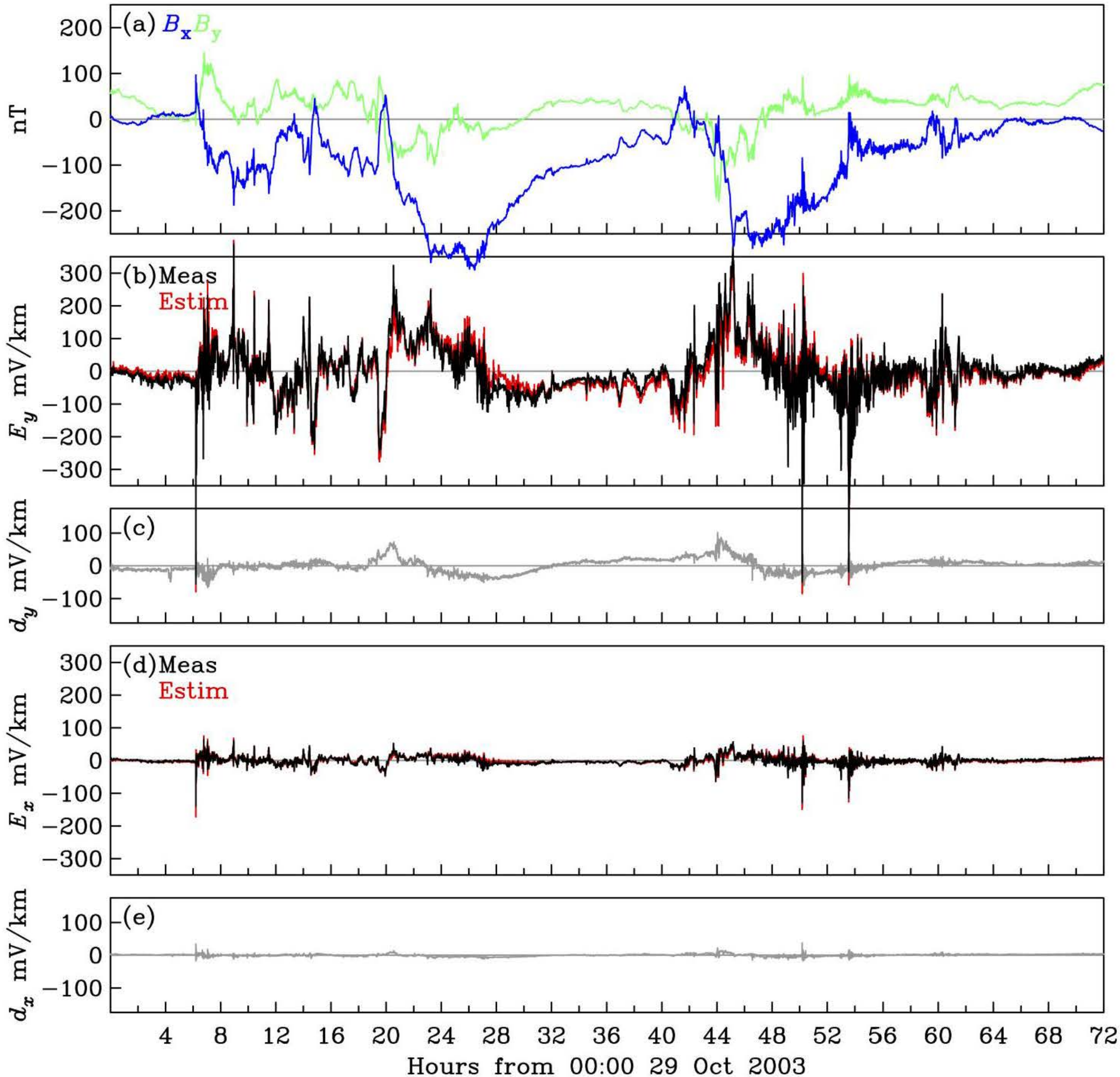

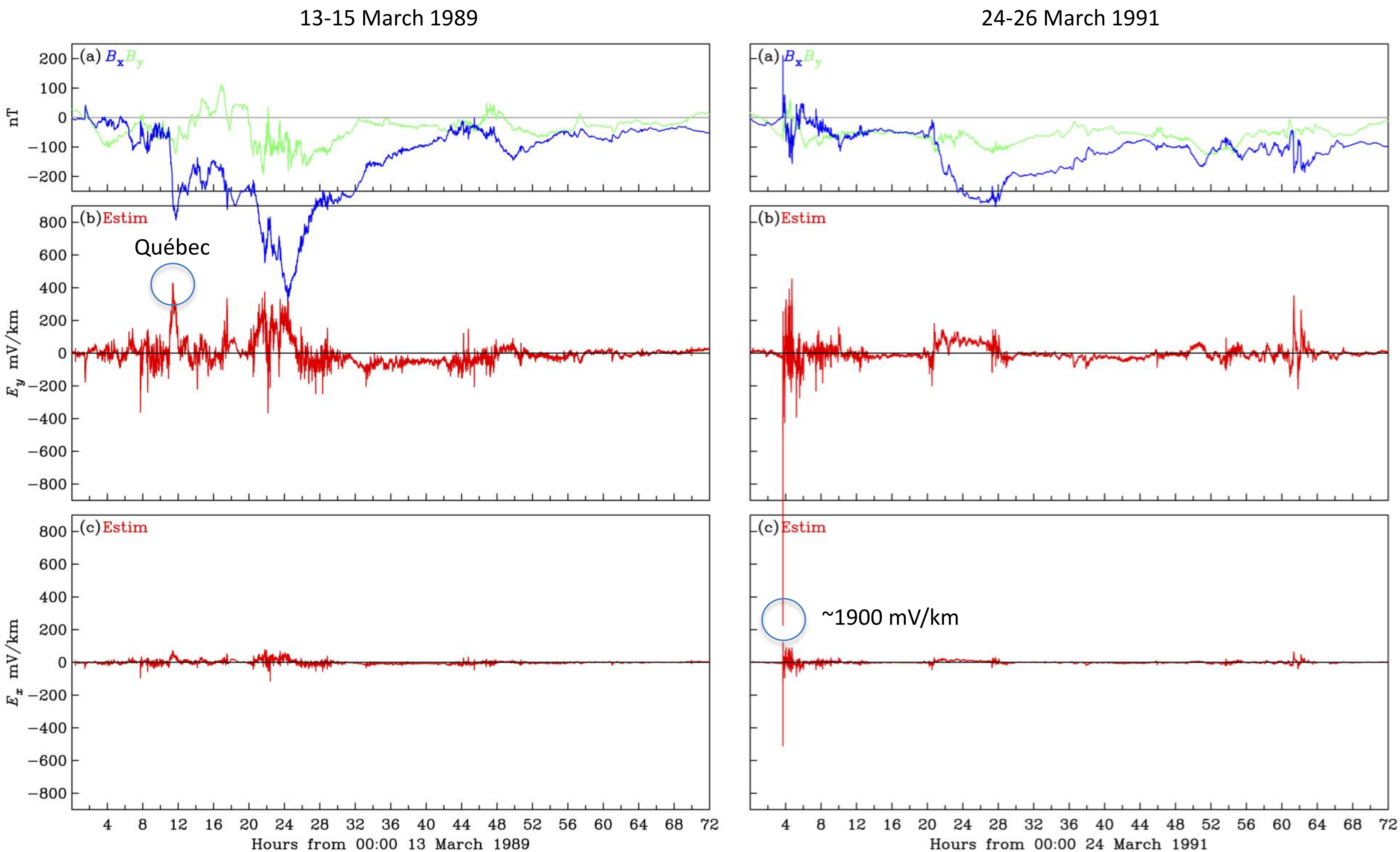

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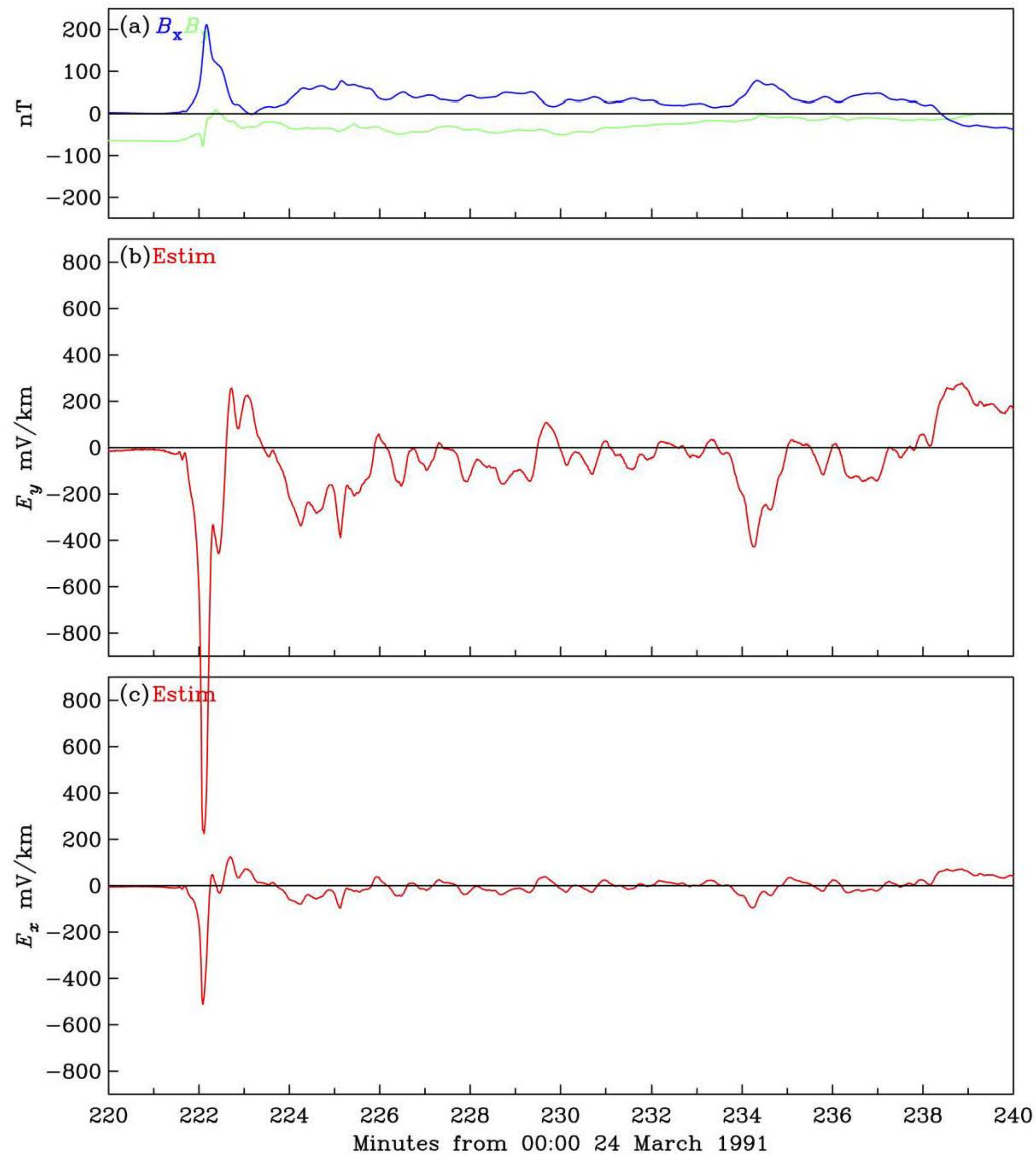

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Regional United States electric field and GIC hazard impacts

JL Gannon, L Tritchentko, C Balch

Thanks to: Josh Rigler, Jeff Love, Antti Pulkkinen, David Boteler and Peter Fernberg, Randy Horton

GICs - what are they and why do we care?

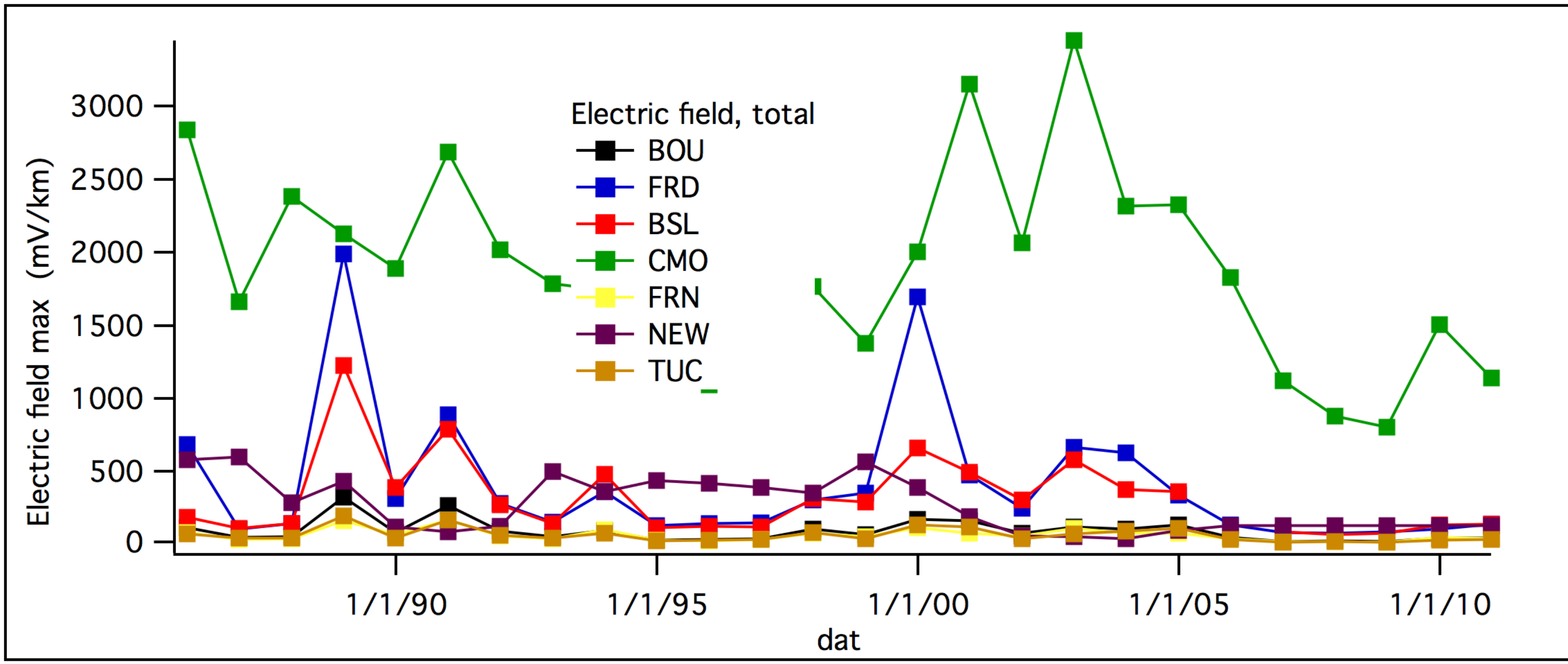
Geomagnetically-induced currents:

Ground-level space weather hazard that can impact our nation's critical infrastructure

Concern of: NRC (2009), NERC GMDTF, FERC, power utility operators

What drives GIC-related hazard?

Ground-level electric fields



Estimated electric field maxima, by year, using 1-minute data and 1D conductivity.

How can we estimate electric field?

Driven by magnetic fields; magnitude influenced by local conductivity

Conductivity Profiles

- Vary with location and geology
- Static with time

Surface Impedance

- Calculate using plane wave assumption at different freq.

Magnetic Field

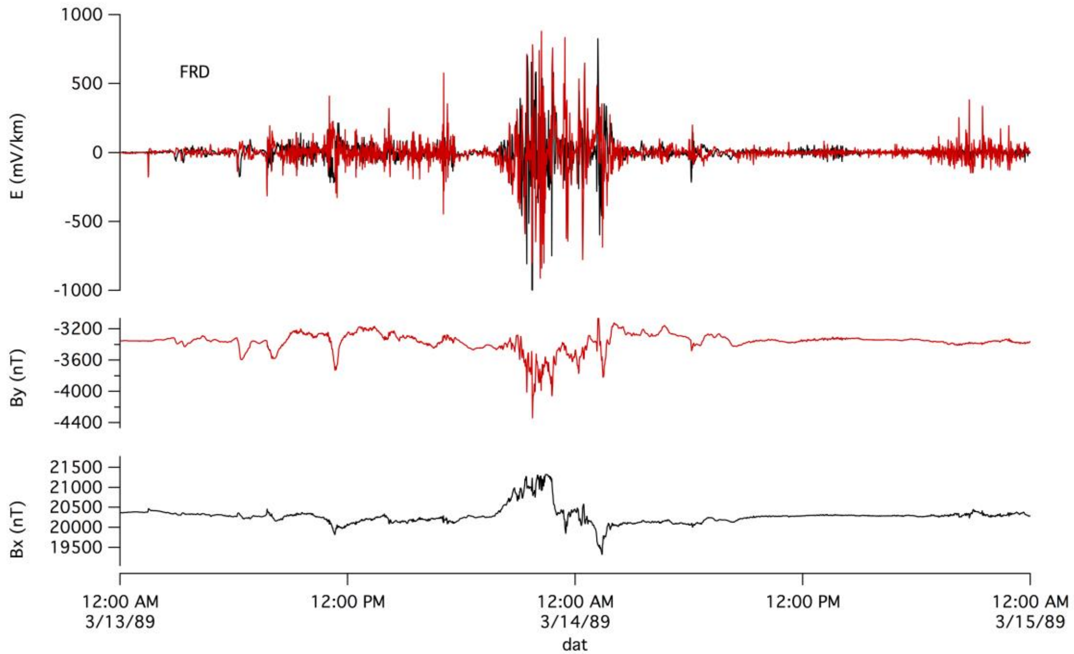
- At least 10-sec data require for full resolution
- 1-minute data used for historical reanalysis

Electric Field

-Convolution of Z and B in time domain= multiplication in frequency domain

Magnetic field is the external driver

- Spectral characteristics -> it's the change in B and the timescale of that change that drives E
- Need 10 second time resolution data
- Full vector data



Data available:
http://geomag.usgs.gov/.

Thanks to Intermagnet, and the observatory programs that support them.

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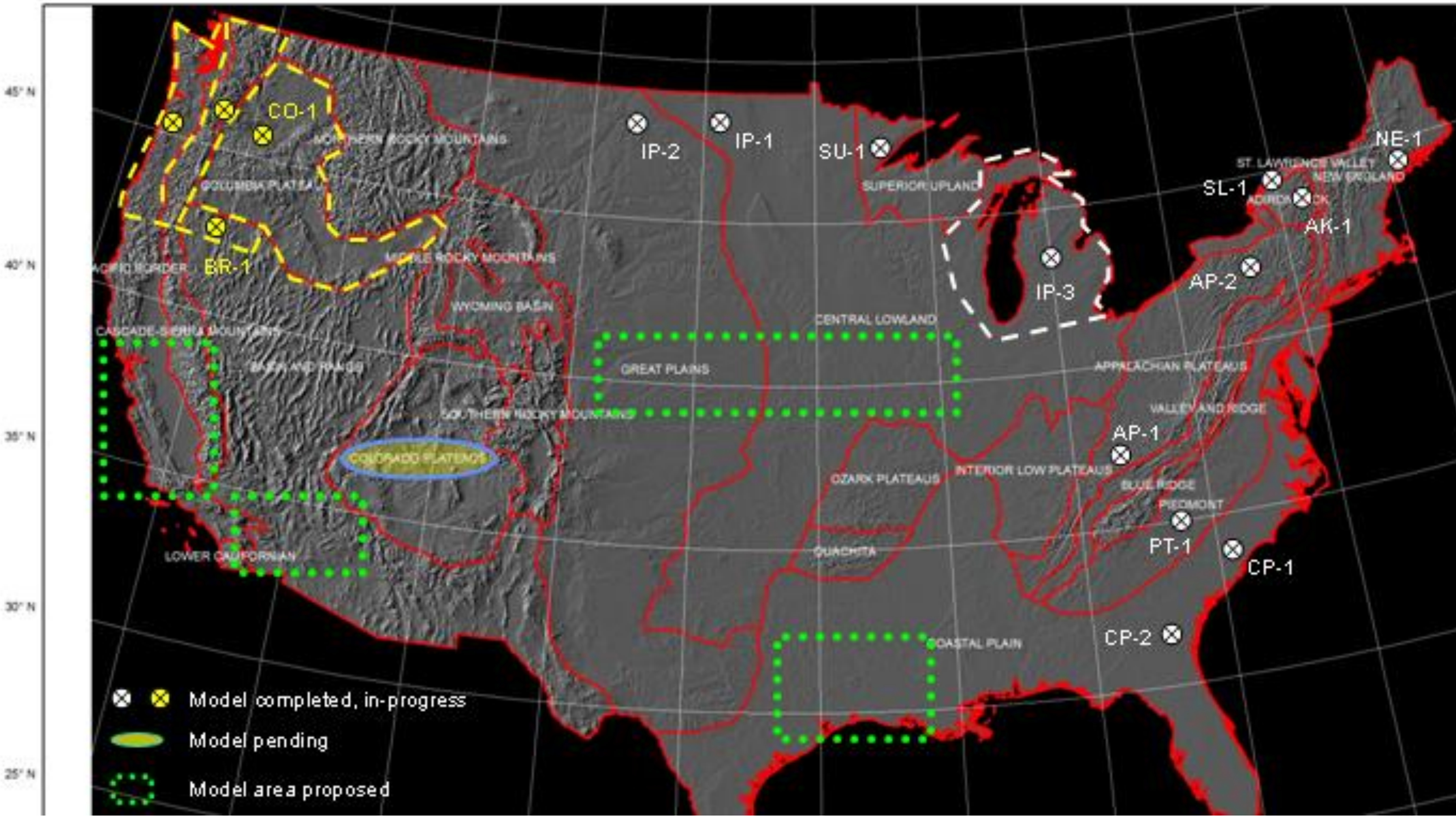
1D Conductivity Profiles



Fernberg, Electric Power Research Institute report, 2012
Data available: http://geomag.usgs.gov/conductivity.

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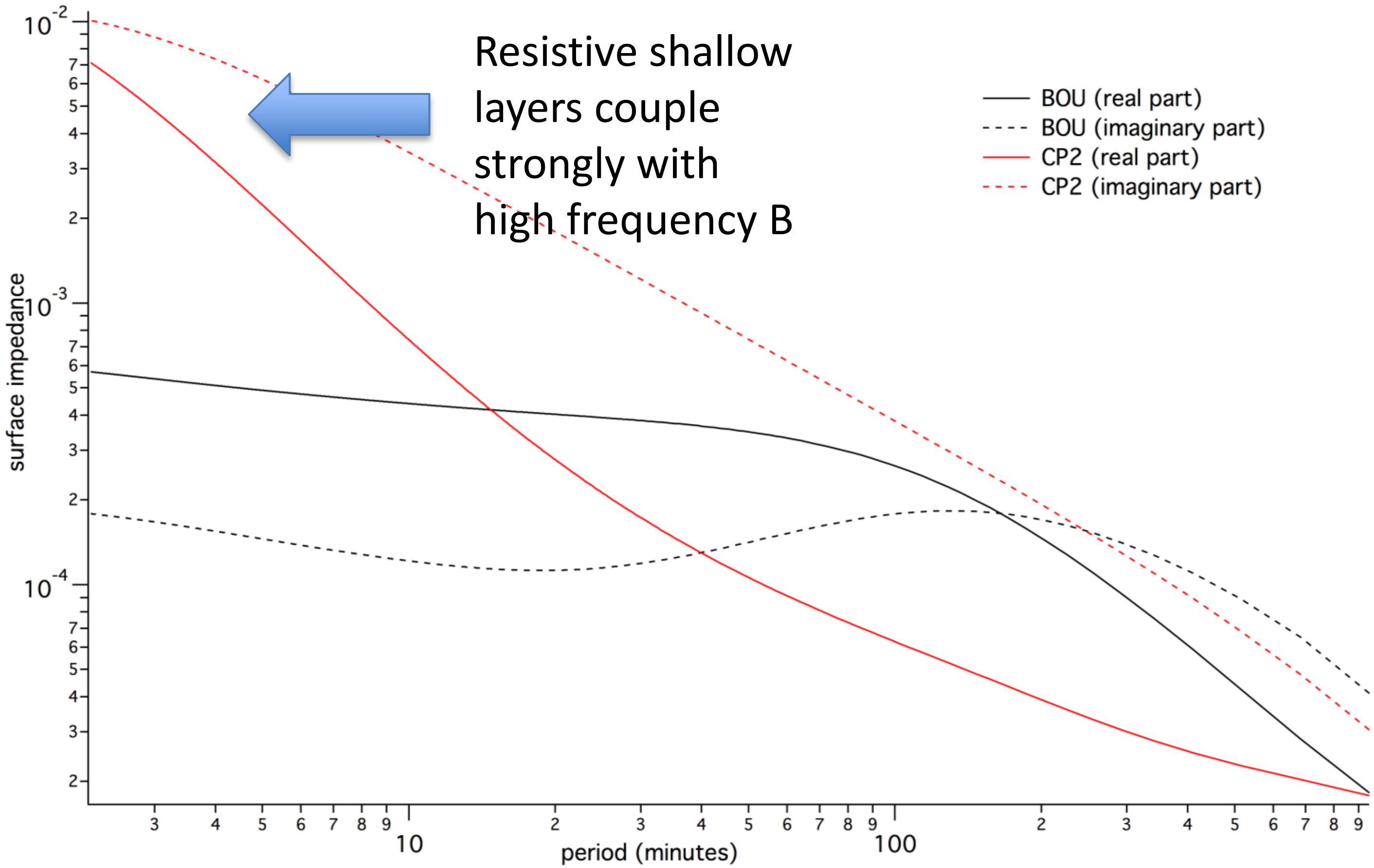
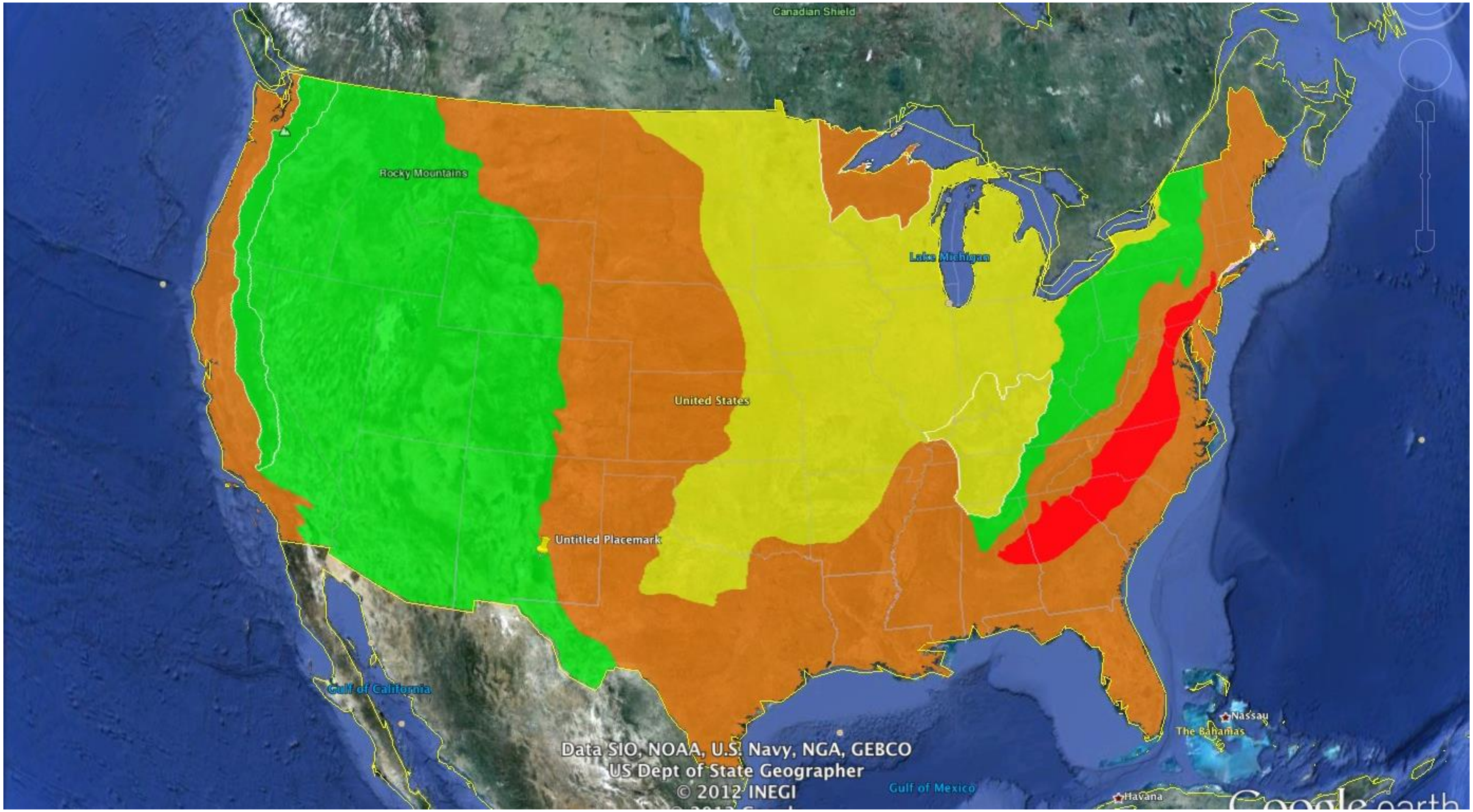
Conductivity makes the response sensitive to magnetic spectral characteristics



Electric field hazard due to conductivity

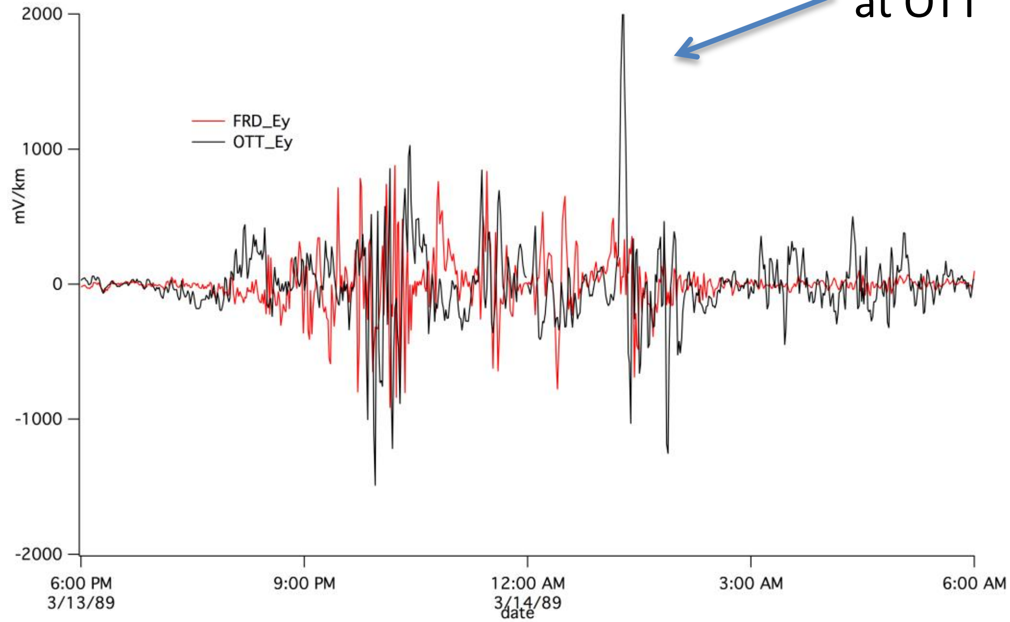


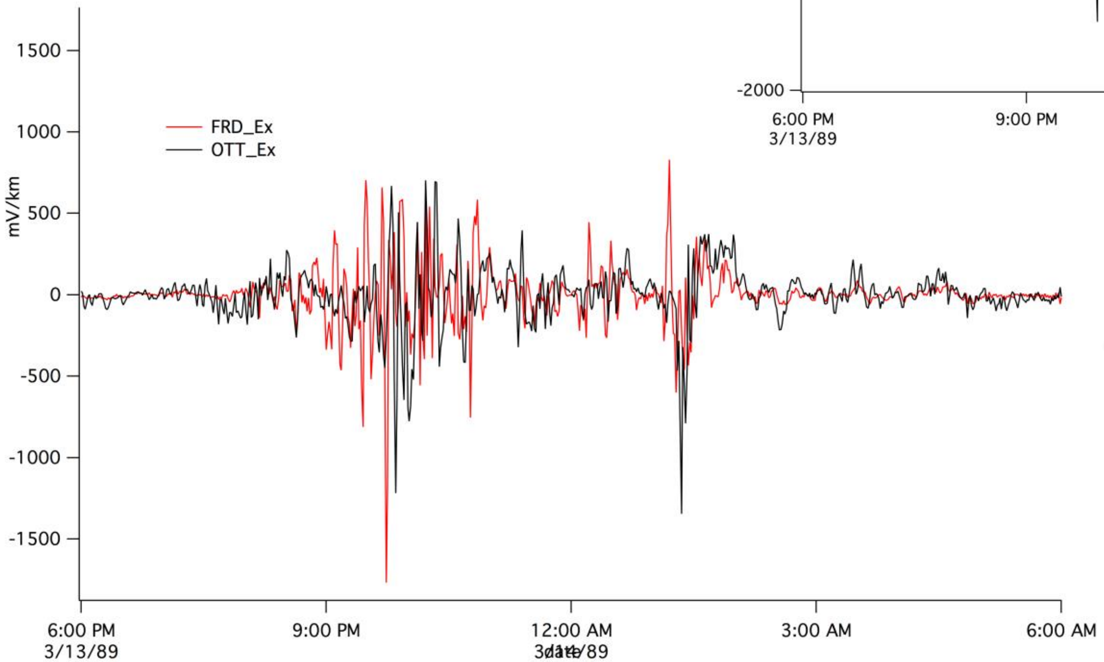
This map characterizes the conductivity component only. Magnetic field drivers have separate patterns of influence.

1989 Estimated electric fields: Ottawa and Fredericksburg

Large spike at OTT

Estimated electric field in the N-S direction





Estimated electric field in the N-S direction

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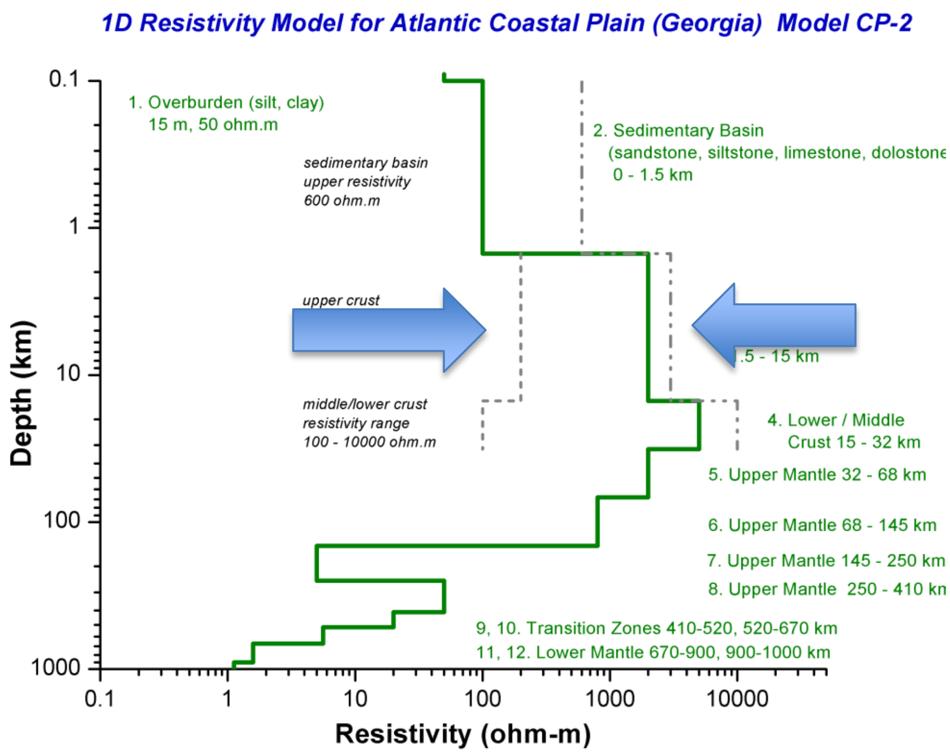
Open questions on conductivity

- Where do we need more complex (3D models)
- Inclusion of coastal effects
- Large physiographic regions



Resistivity values and depths have been interpreted from published geological reports and maps, and may differ from actual conditions measured by a geophysical survey and/or borehole.

NOTE RANGE OF UNCERTAINTY

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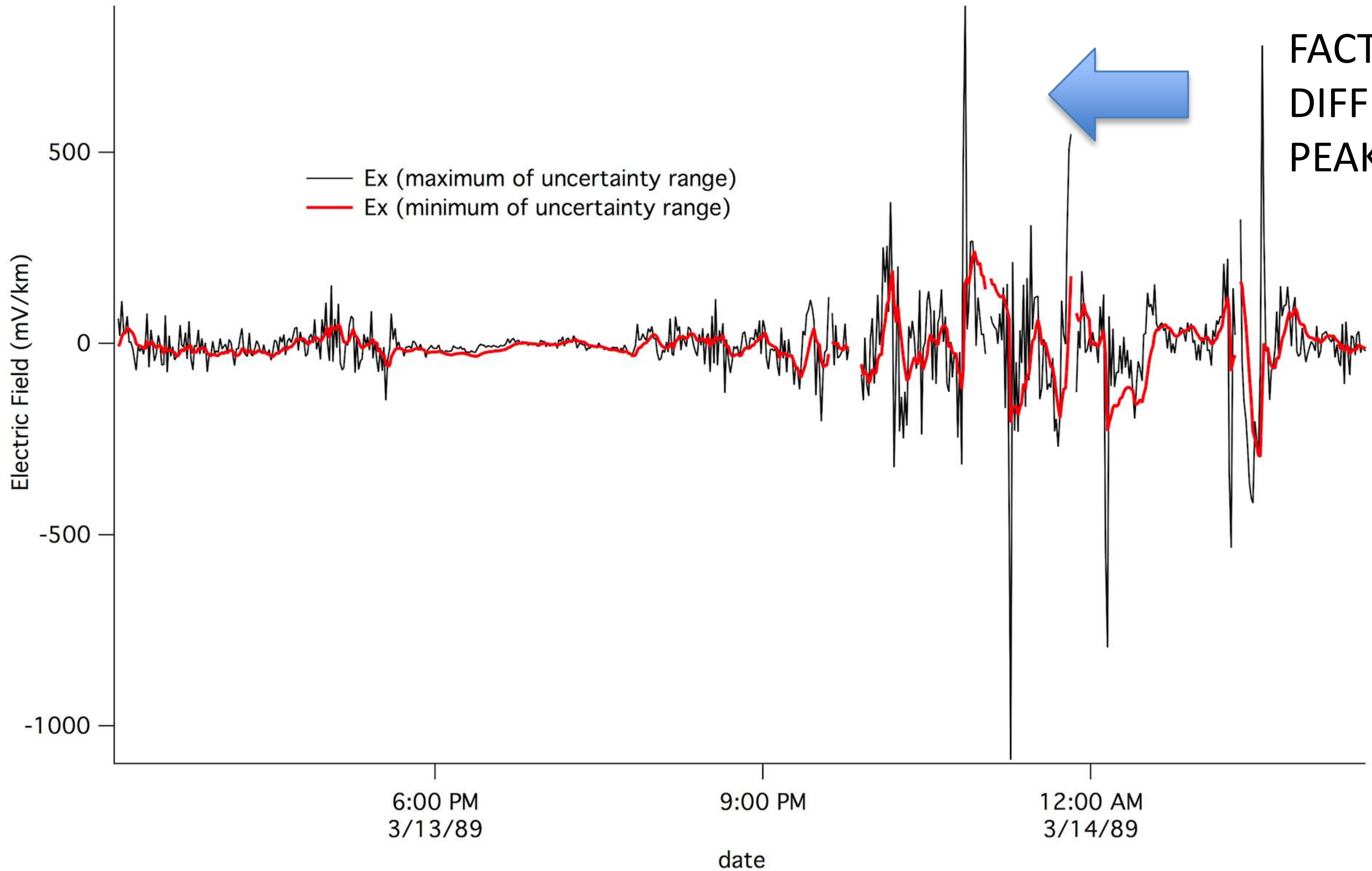
BSL/CP-2 – Using both ends of the range of conductivity



FACTOR OF 3-4 DIFFERENCE AT PEAK

Both of these results are within the error range of the model.

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What affects power utilities?

- Electric field hazard: nearly 2.0 V/km in Quebec in 1989
- Local geophysical conditions: Underlying conductivity
- Different kinds of transformers: single-coil, triple coil, etc.
- Age of transformers: degradation of insulators increases risk of transformer heating
- System orientation: coupling with directional event
- Duration of GIC

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Summary

1. GICs are a risk for US critical infrastructure.

2. Electric field drives GIC hazard at the ground-level. There are regions that can expect electric field levels similar to those experienced in Quebec in 1989.

1. Electric field can be estimated using a magnetic field driver and local conductivity, or local measurements.

Corollary: Latitude and magnetic field intensity are important, but local geology determines magnitude of response.

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The way forward

- Improved and extended monitoring : magnetic field, electric field, and GIC
- Better understanding of conductivity: USArray will provide 3D maps in parts of the US; extended 1D modeling in some regions
- Validation: requires access to ground-truth data!
- Classification of 1-in-100 year event: Efforts lead by Antti Pulkkinen (NASA-Goddard), in coordination with NERC GMDTF
- Electric field algorithms: FFT, timeseries, but others under development
- **Regional assessment**: Use of interpolation, data
- **Predictive algorithms**

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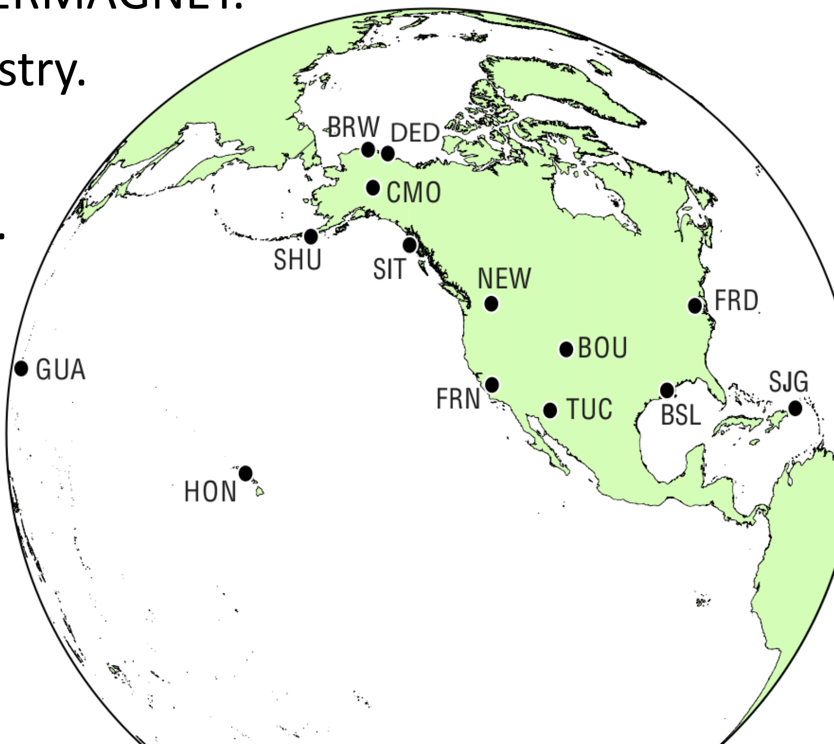
US Geological Survey
Induction-Hazard Science

Jeffrey J. Love, Carol A. Finn, E. Joshua Rigler
Geomagnetism Program
USGS Natural Hazards Mission

Paul A. Bedrosian
Crustal Geophysics and Geochemistry
USGS Energy and Minerals Mission

USGS Geomagnetism Program
geomag.usgs.gov

- Part of a USGS Natural Hazards Mission.
- DOI representation in the National Space Weather Program.
- Monitor Earth's magnetic field at ground-based magnetic observatories.
- Report data with high accuracy, resolution, and reliability.
- Customers: Air Force, NOAA, NASA, GFZ, NICT, industry, academia.
- Promote operations around the world: INTERMAGNET.
- Operational partnership with oil & gas industry.
- Conduct research of societal importance.
- Carol A. Finn, Geomagnetism Group Leader.
- 16 staff, 14 observatories.
- Budget: $1.9 million/yr.

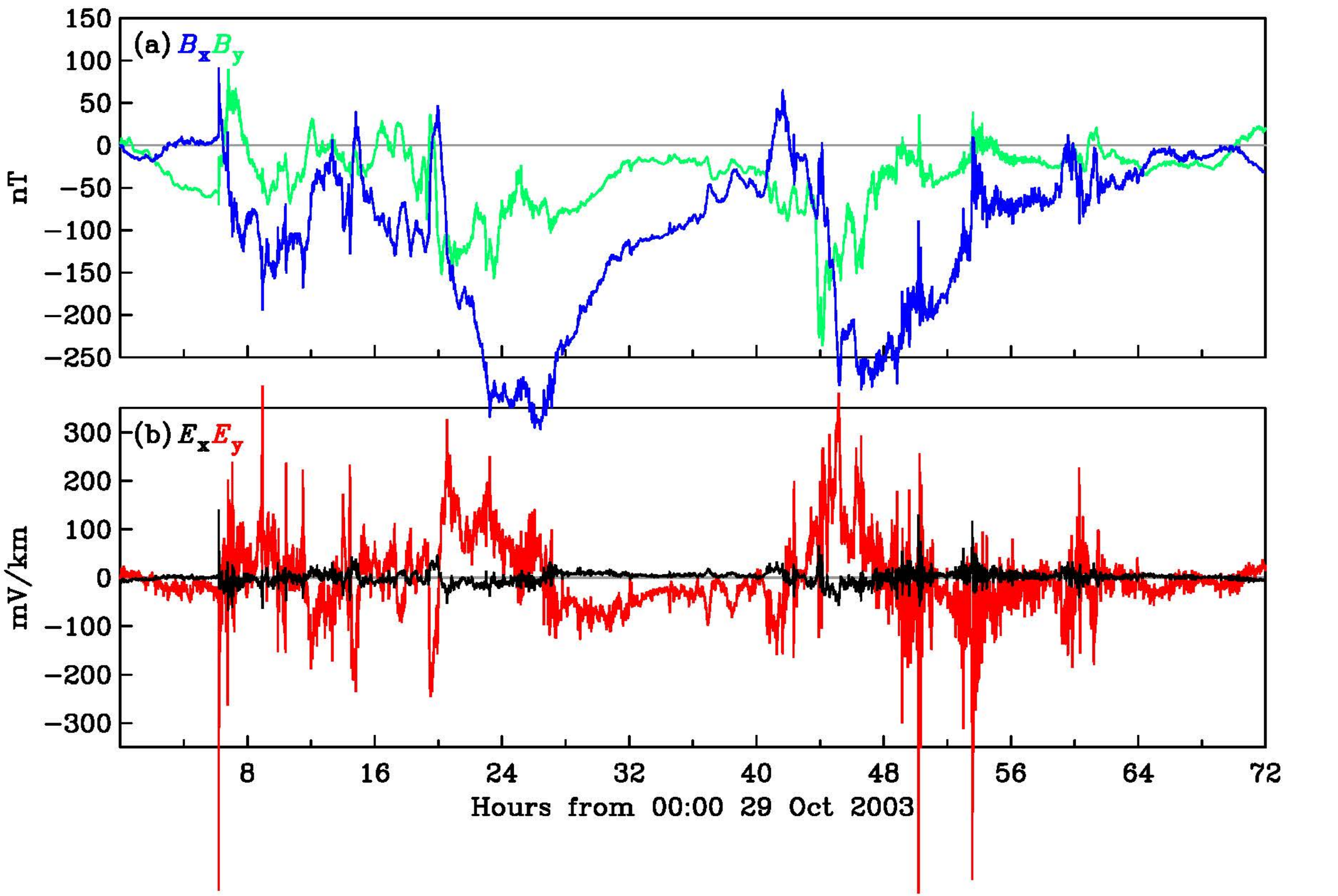


President's 2016 budget for USGS Geomagnetism Program: Increase of $1.7 million/year to $3.6 million/year

What this would support:

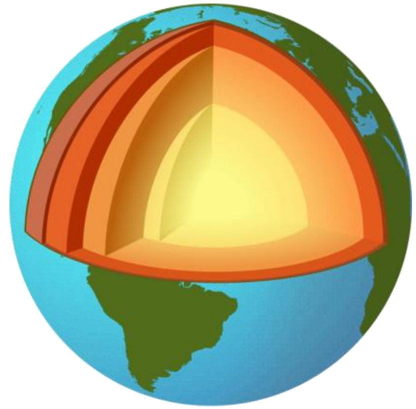
- New geomagnetic observatories: US, Pacific, South Pole.
- Geoelectric monitoring at some observatories.
- Magnetotelluric surveys: augment those of NSF EarthScope Program.
- 3D modeling of lithospheric electrical conductivity.
- Scenario assessments of induction hazards in US.
- Study feasibility of providing real-time geoelectric maps.
- Support international geomagnetic monitoring and data exchange.
- Induction-hazard research of importance for National economy and security.
- Relieve Air Force Weather Agency of financial support for USGS operations.

Geomagnetic and Geoelectric Data
Japan Meteorological Agency, Kakioka, 29-31 October 2003



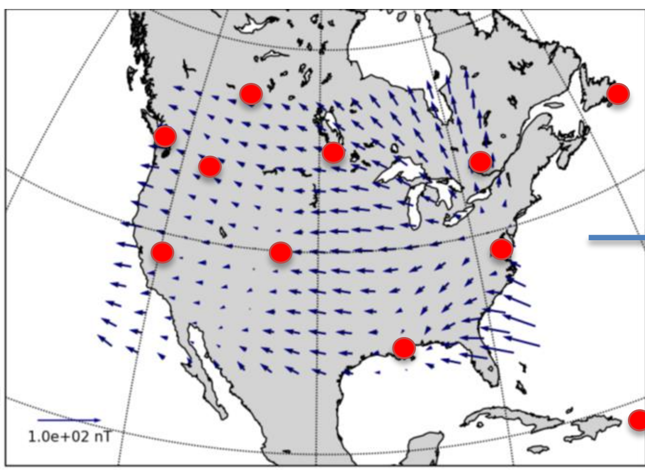
Input signal time series → Convolution through a filter → Output signal time series

Geomagnetic variation →

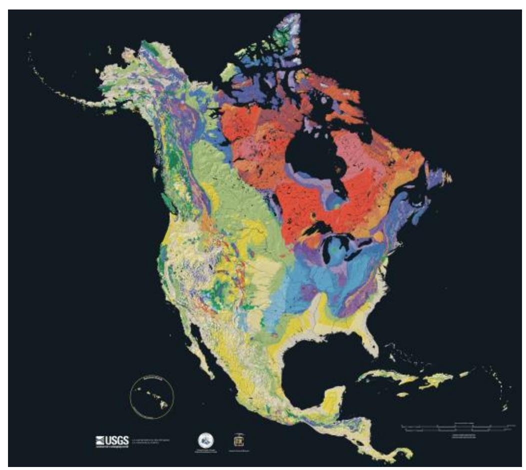


→ Geoelectric field

Map of geomagnetic variation



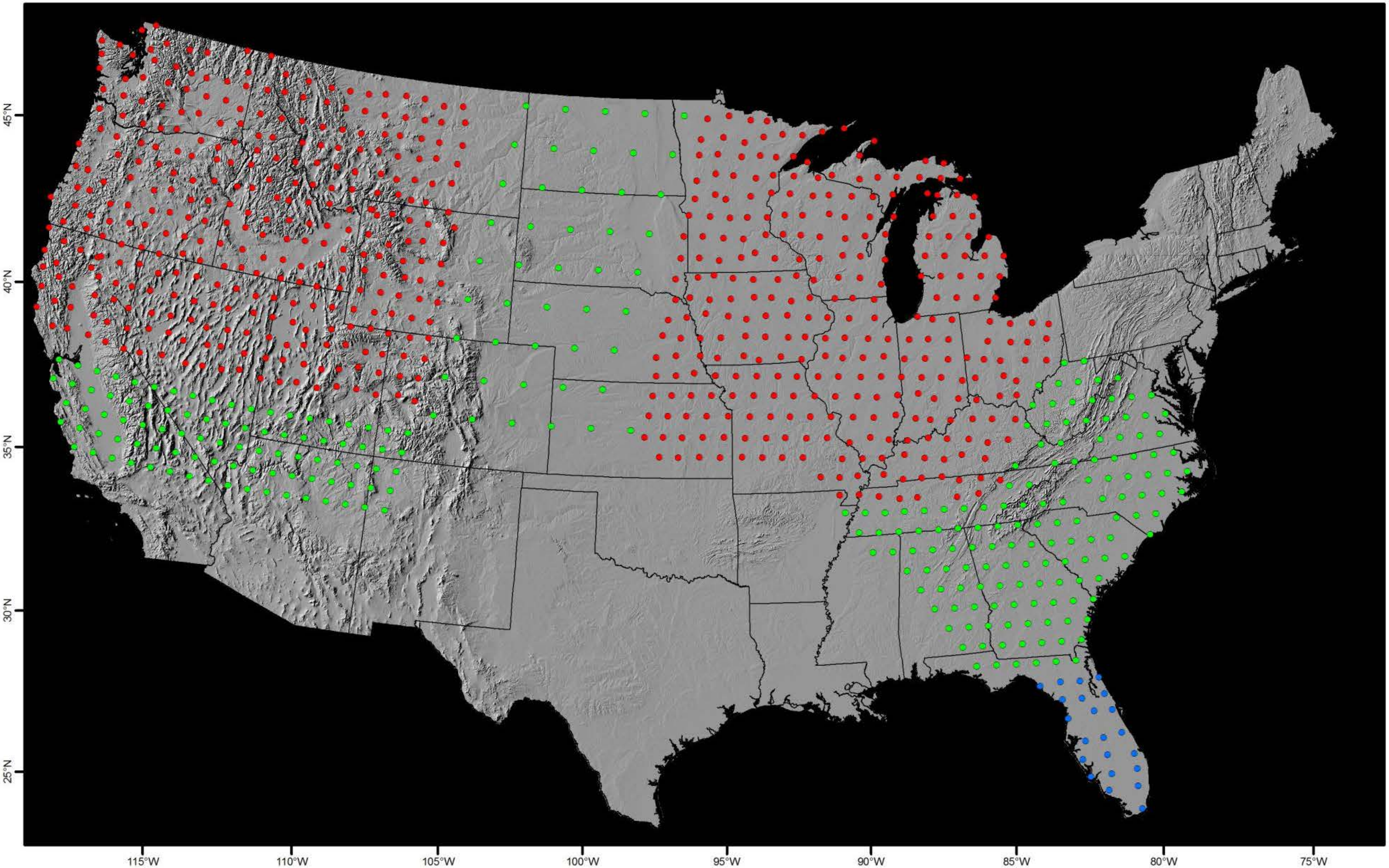
→ Model of lithospheric conductivity



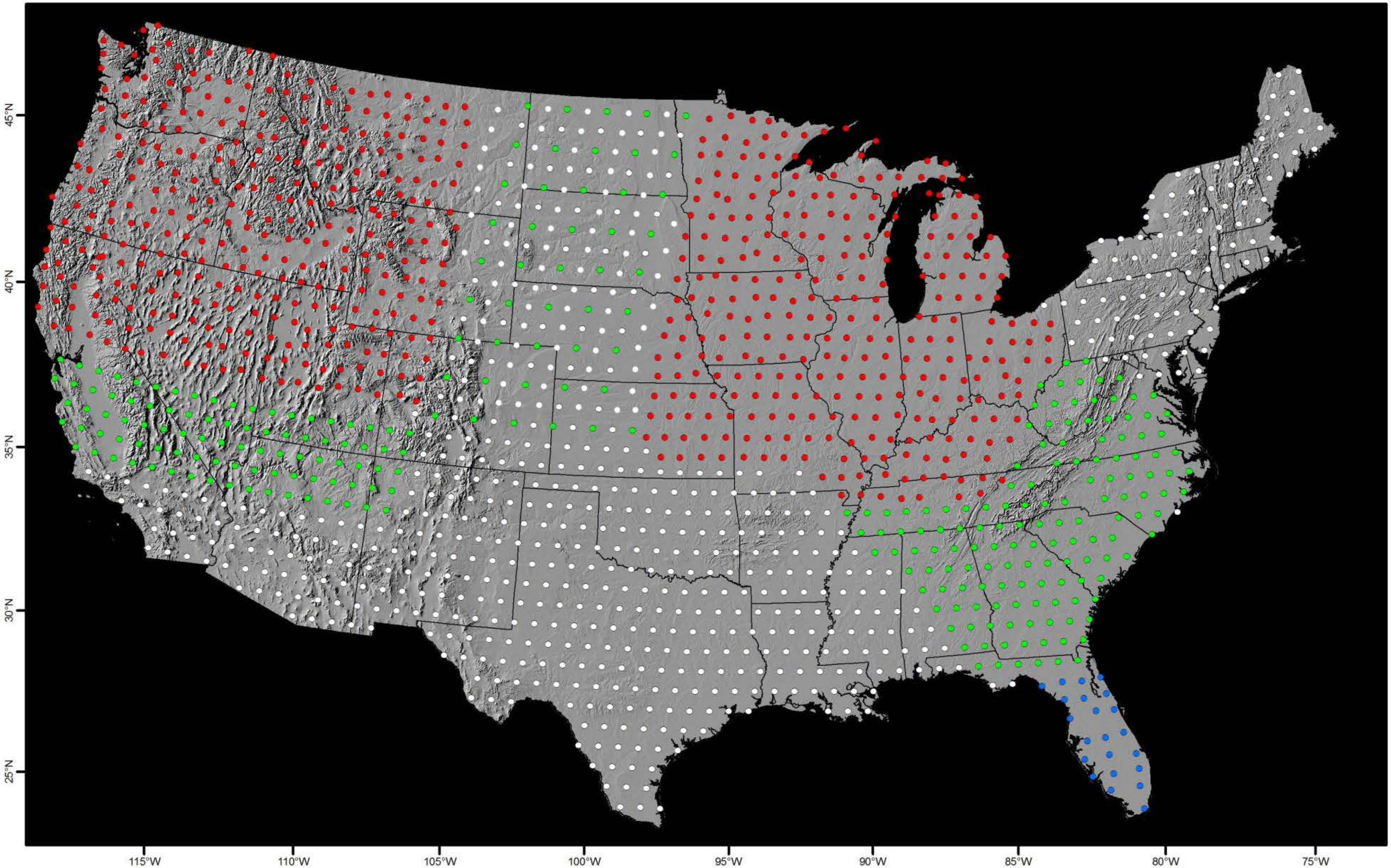
→ Map of geoelectric variation

E

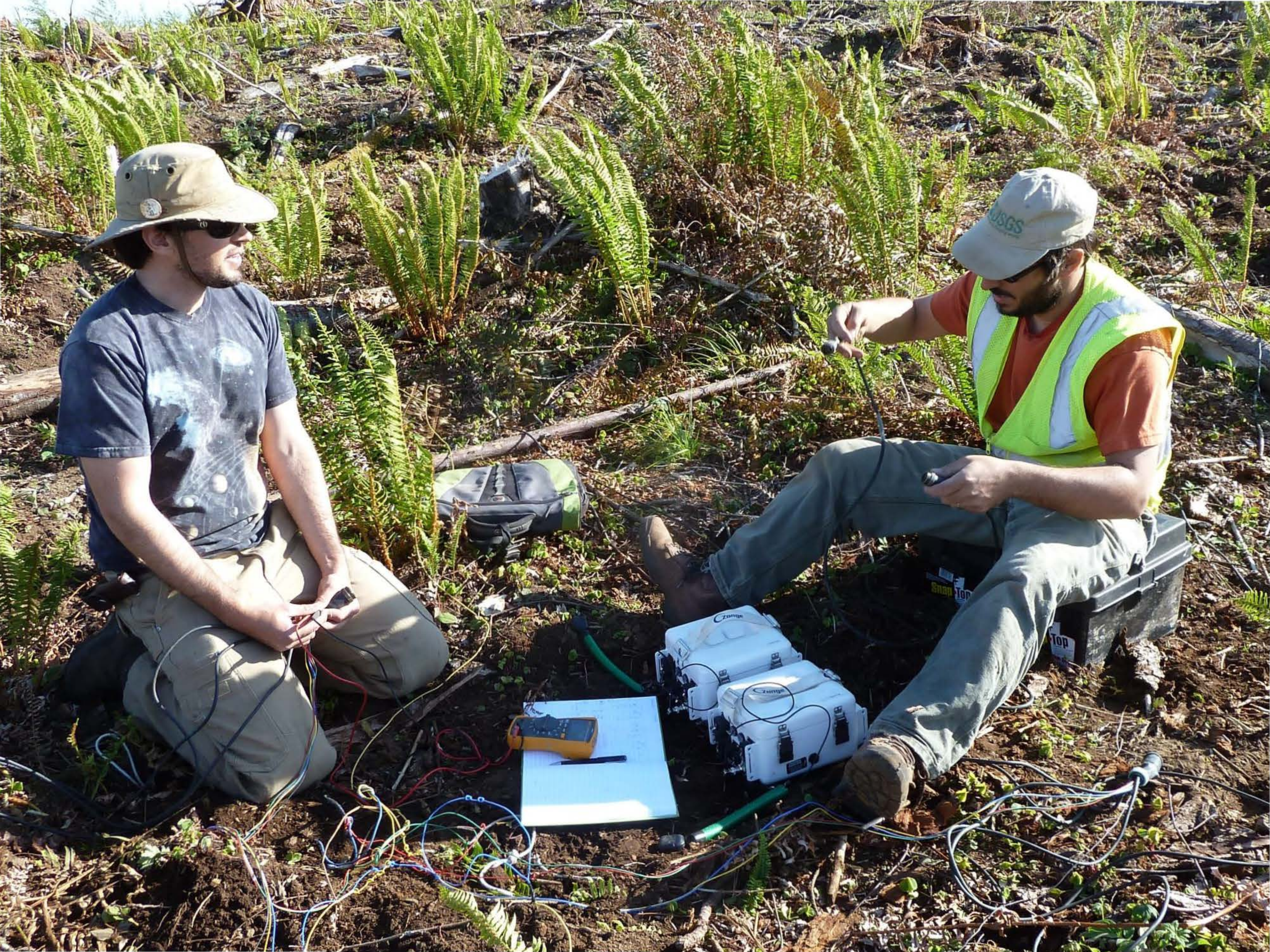
NSF EarthScope MT survey by 2018 with recent USGS work in Florida.



Proposed USGS MT augmentation (white)



Will provide data useful for induction-hazard science and
for fundamental geological understanding of the Earth's lithosphere.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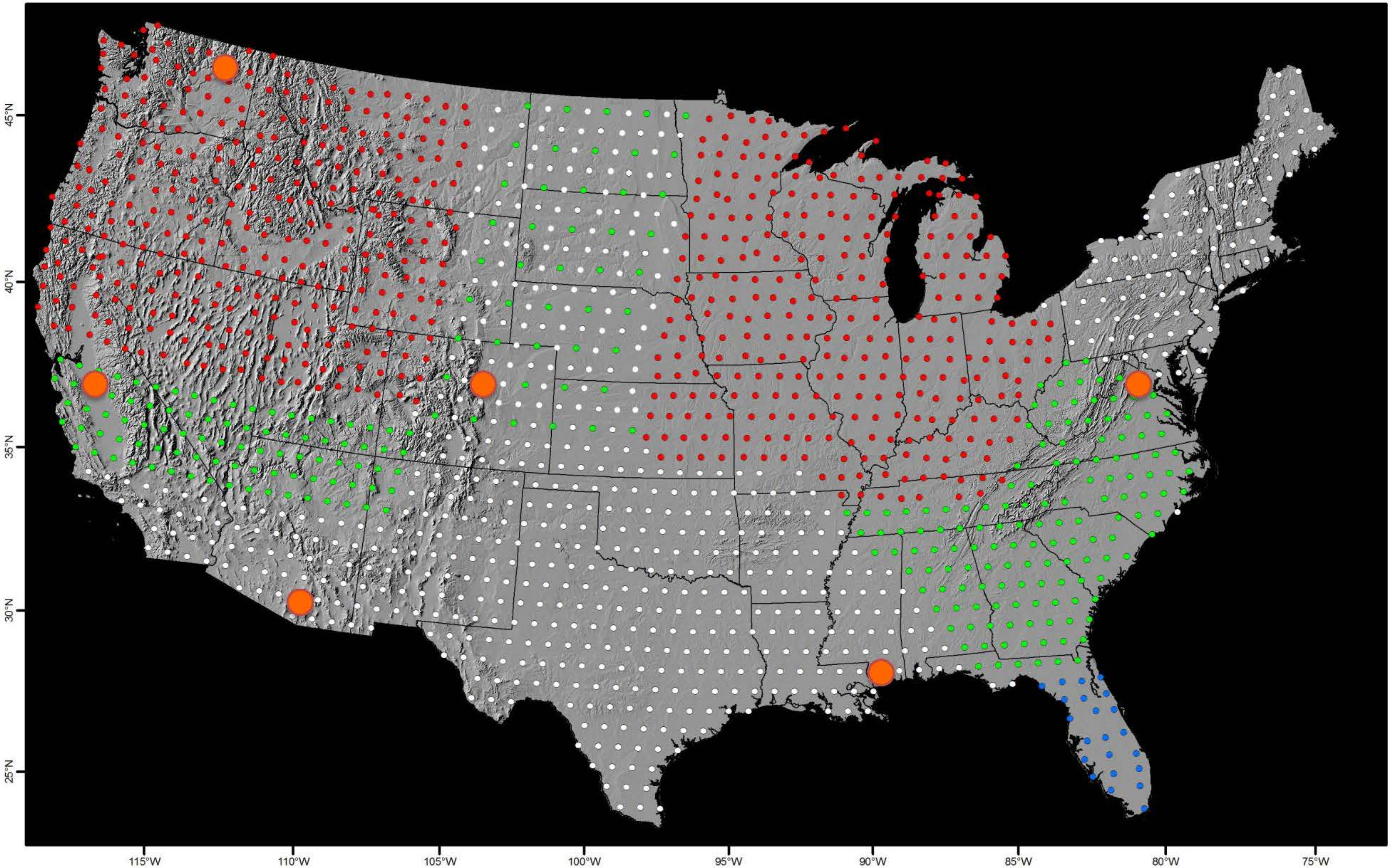
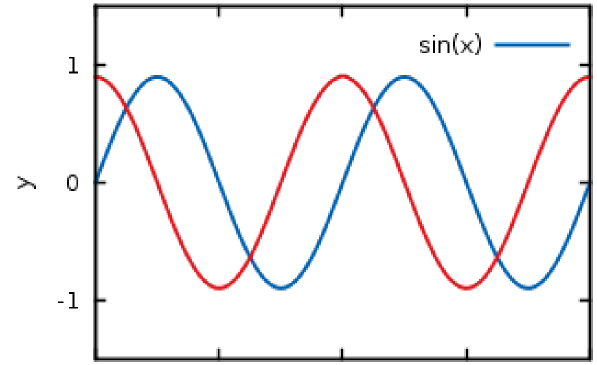
EarthScope and USGS MT + USGS observatories

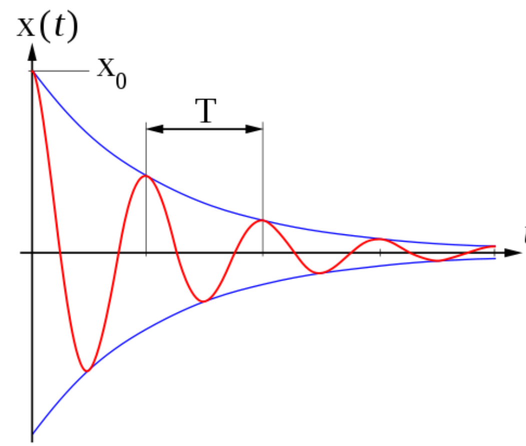


Two classical transformations:

Joseph Fourier(1768-1830)
Most magnetotelluric algorithms are based on Fourier analysis: Stationary time series can be decomposed into periodic sinusoids. Does not lend itself to causal algorithms.



Pierre-Simon Laplace (1749-1827)
Transient and aperiodic time series can be decomposed into exponential “moments” -- sinusoids but with complex frequencies.



Need to develop “time causal” algorithms for E-field estimation.

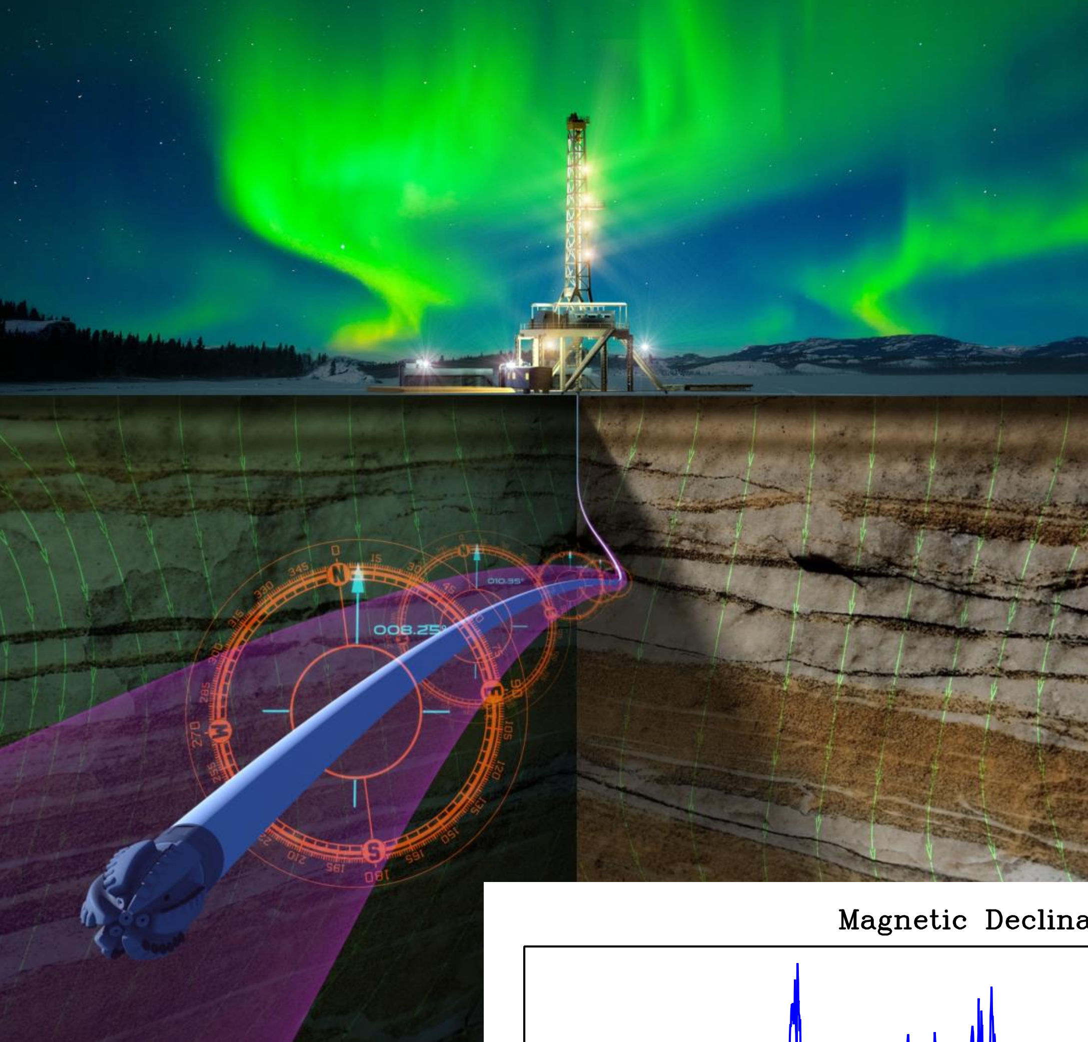
- Love, J. J. & Swidinsky, A., 2014. Time causal operational estimation of electric fields induced in the Earth’s lithosphere during magnetic storms, Geophys. Res. Lett., 41, 2266-2274, doi:10.1002/2014GL059568.
- Love, J. J. & Swidinsky, A., 2015. Observatory geoelectric elds induced in a two-layer lithosphere during magnetic storms, Earth Planets Space, in press.

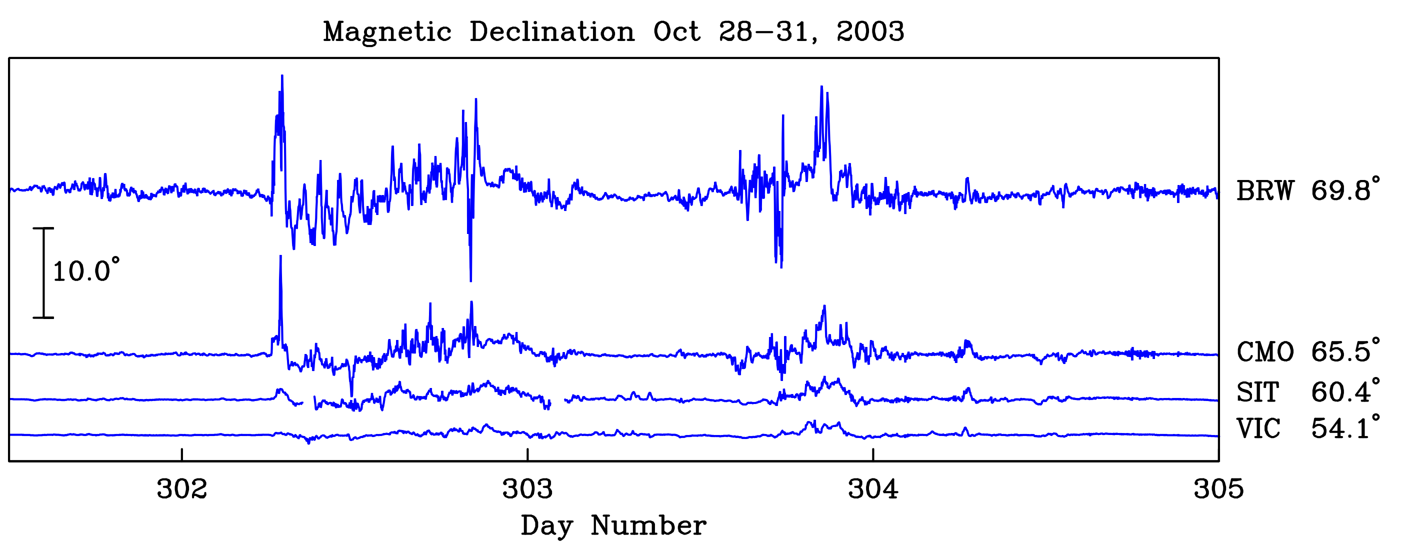
USGS Induction-Hazard Science:

- Improved geomagnetic monitoring.
- Geoelectric monitoring.
- Magentotelluric surveys to estimate lithospheric conductivity.
- Assessments of induction-hazards.
- Goal of real-time geoelectric mapping.
- Research of societal importance.

- Love, J. J., Rigler, E. J., Pulkkinen, A. & Balch, C. C., 2014. Magnetic storms and induction hazards, Eos Trans. AGU, 95(48), 445-446, doi:10.1002/2014EO480001.

Magnetic orientation for directional drilling for oil & gas: A public-private collaboration





Schlumberger

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