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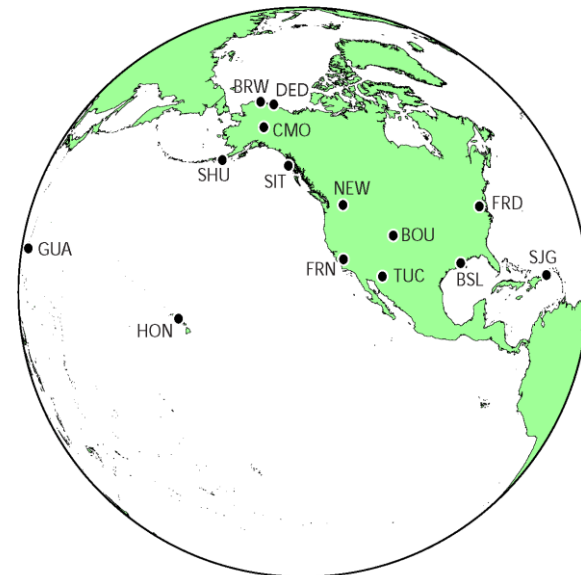


USGS Geomagnetism Program Electric Field Estimates

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C Balch (NOAA/SWPC)

Mission of USGS Geomagnetism Program

- Monitor Earth's magnetic field using ground-based magnetic observatories
- Provide continuous, high temporal resolution, accurate data recording magnetic field variations in real-time and covering long timescales
- Disseminate magnetic data to governmental, academic, and private institutions, NOAA, USAF, NASA
- Conduct research for scientific understanding and hazard mitigation
- 14 observatories, all collecting 1-second data in real-time
- 12 full-time operational staff, 3 research staff



Electric Field: Spatial vs temporal variations

- Magnetic field varies with time and location
- Conductivity varies with depth and location => Surface Impedance varies with input frequency
- Electric field => Can be very different at different locations, even with the same B

Electric Field calculations

Conductivity Profiles

- Vary with location and geology
- Static with time

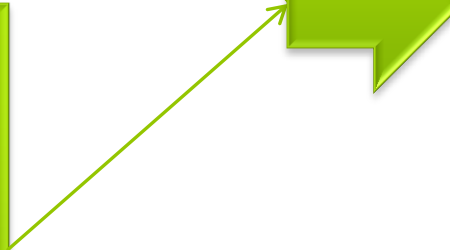


Surface Impedance

- 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

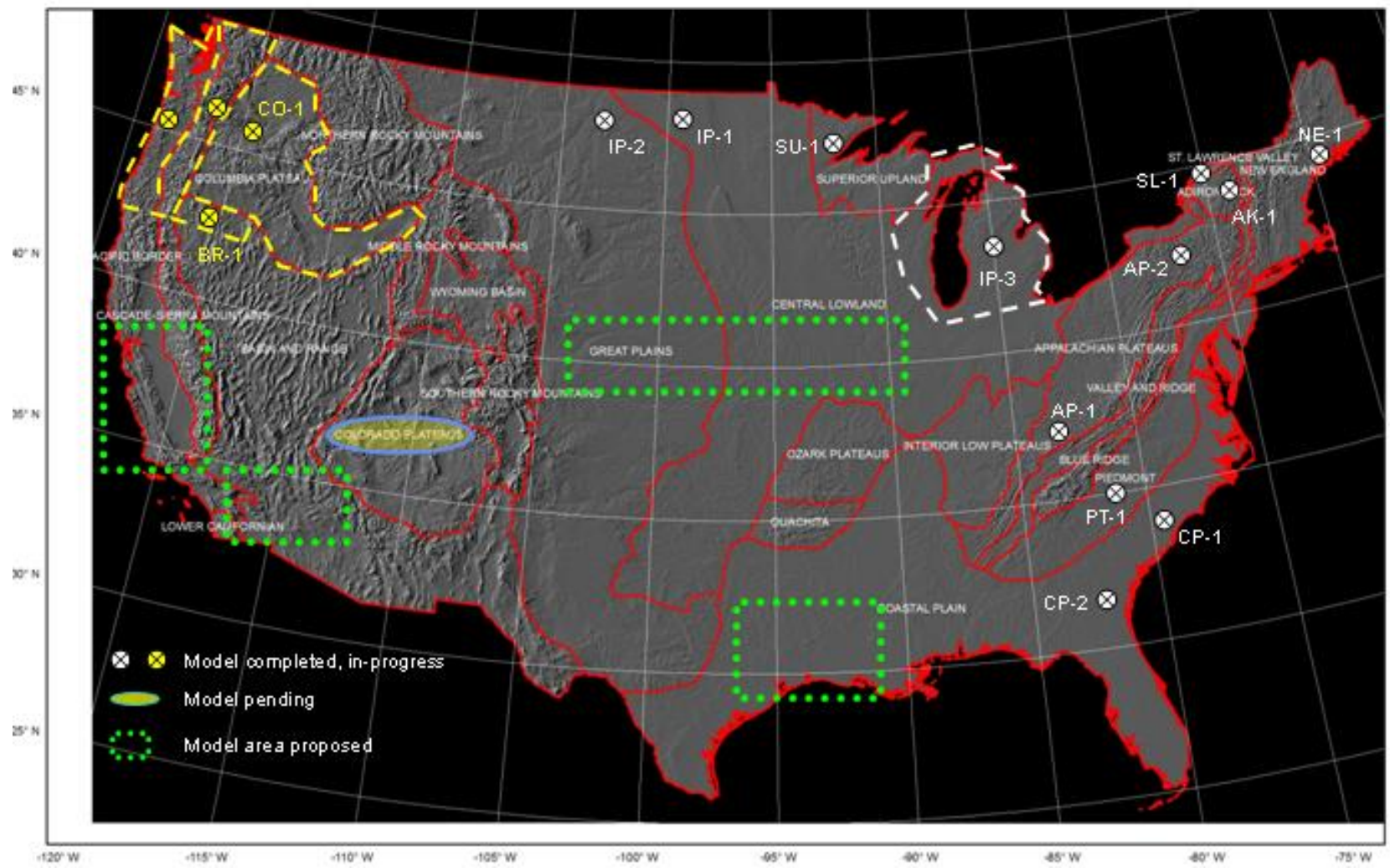
- Convolution of Z and B in time domain = multiplication in frequency domain

$$E(\omega) = B(\omega) * Z(\omega)$$

=>

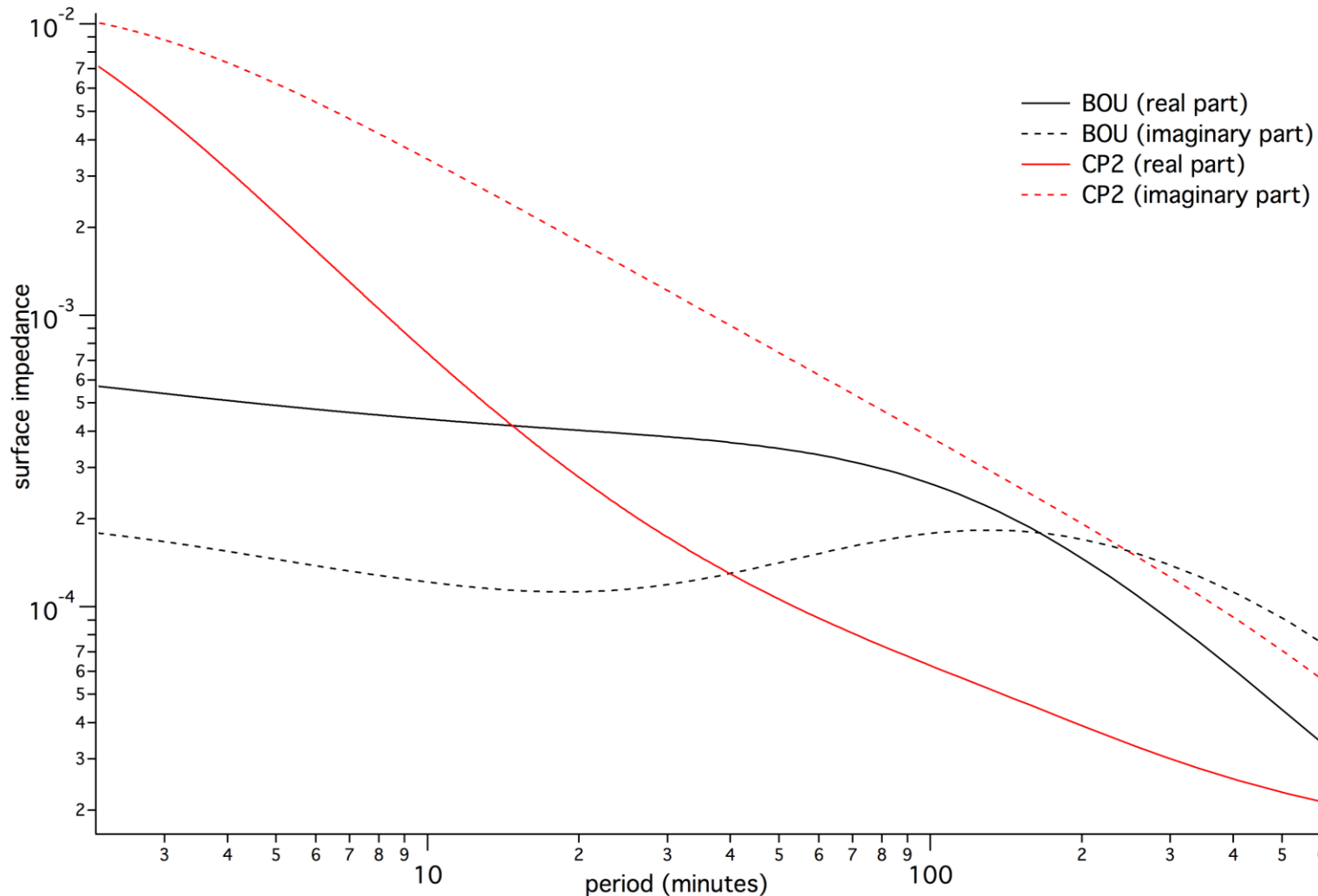
$$E(t) = \text{FFT}^{-1}(\text{FFT}(B(t)) * Z(\omega))$$

1-D Conductivity

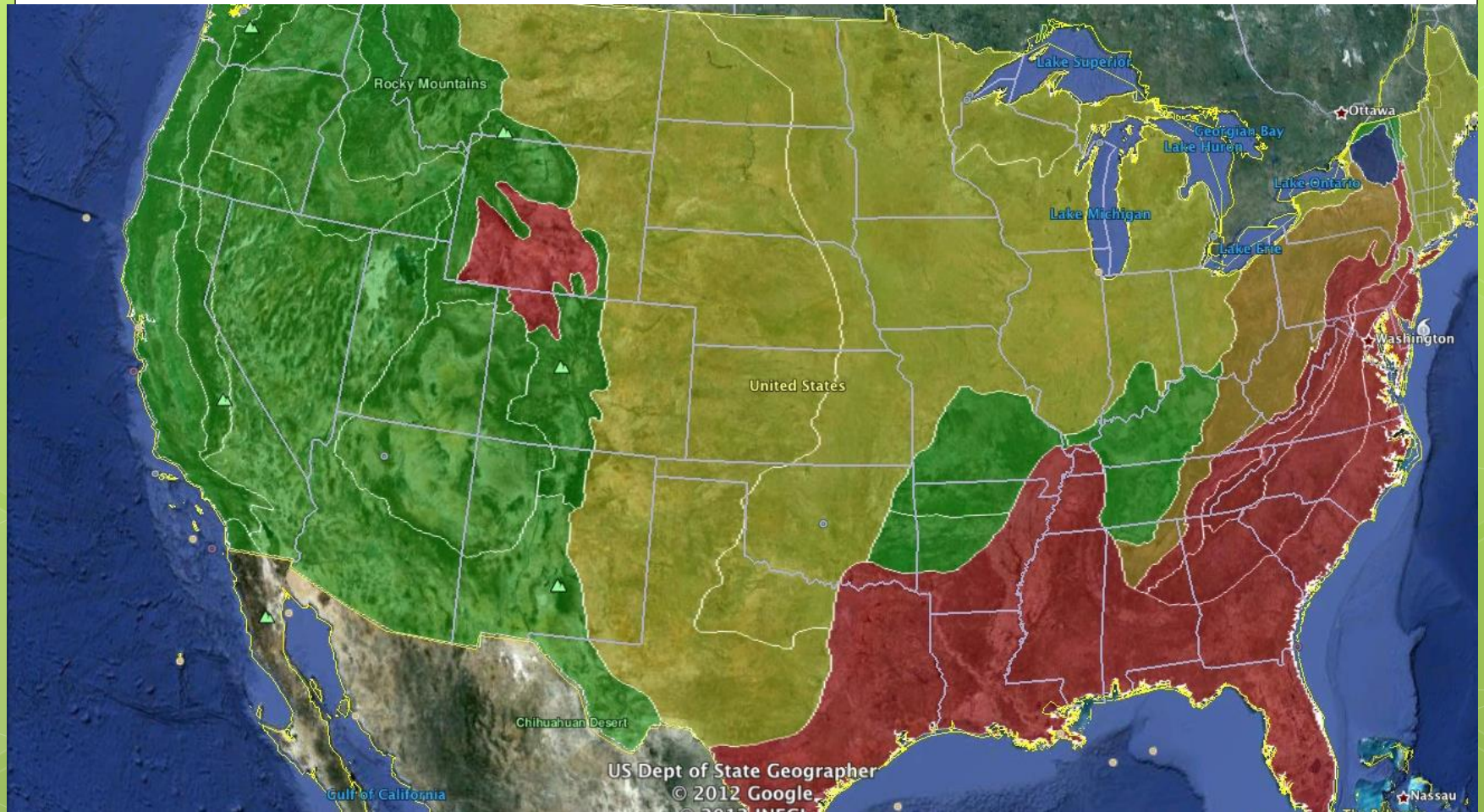


Fernberg, Gannon and Bedrosian,
USGS OFR 2013, under review

Surface impedance vs frequency



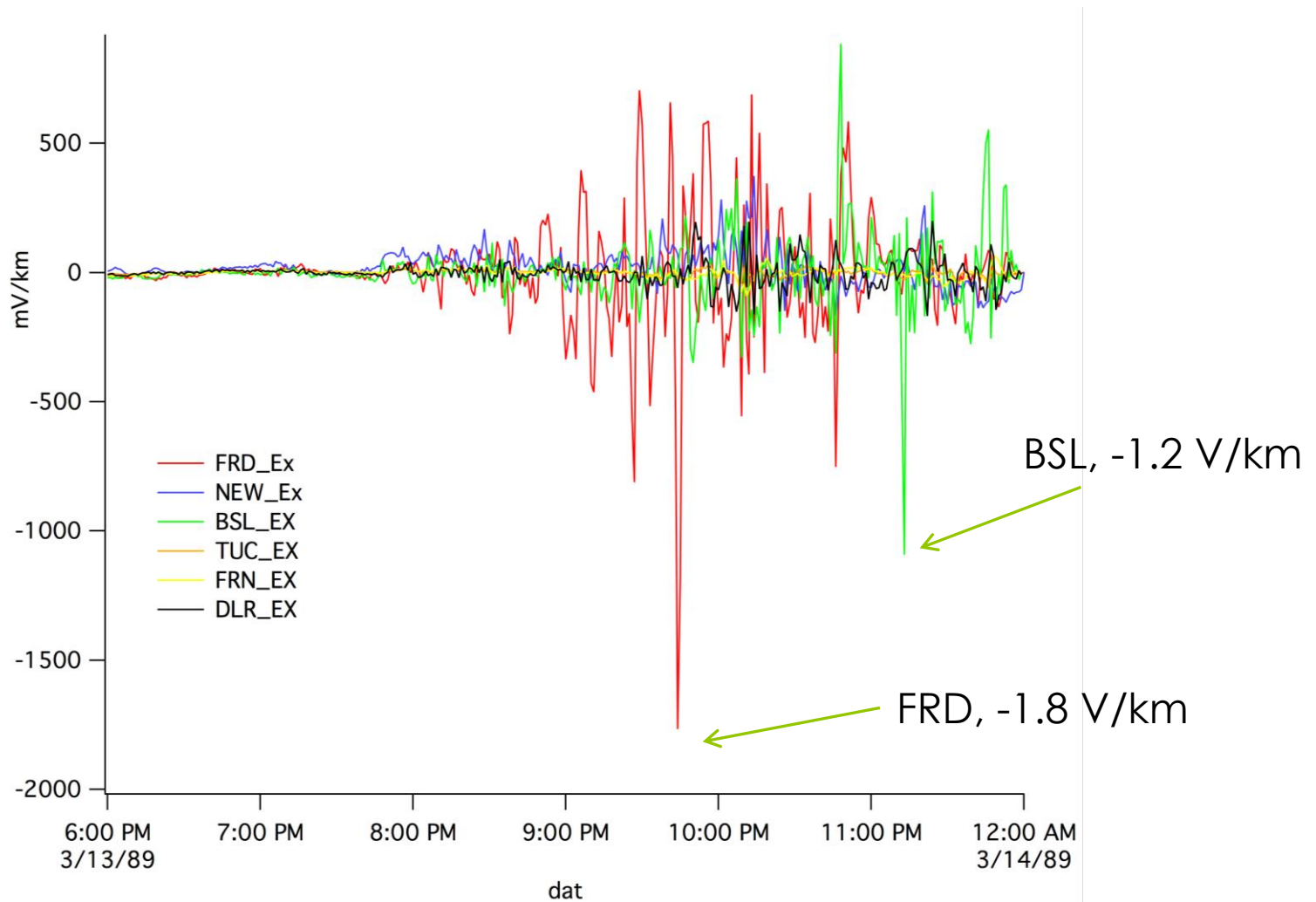
Efield Response to Conductivity



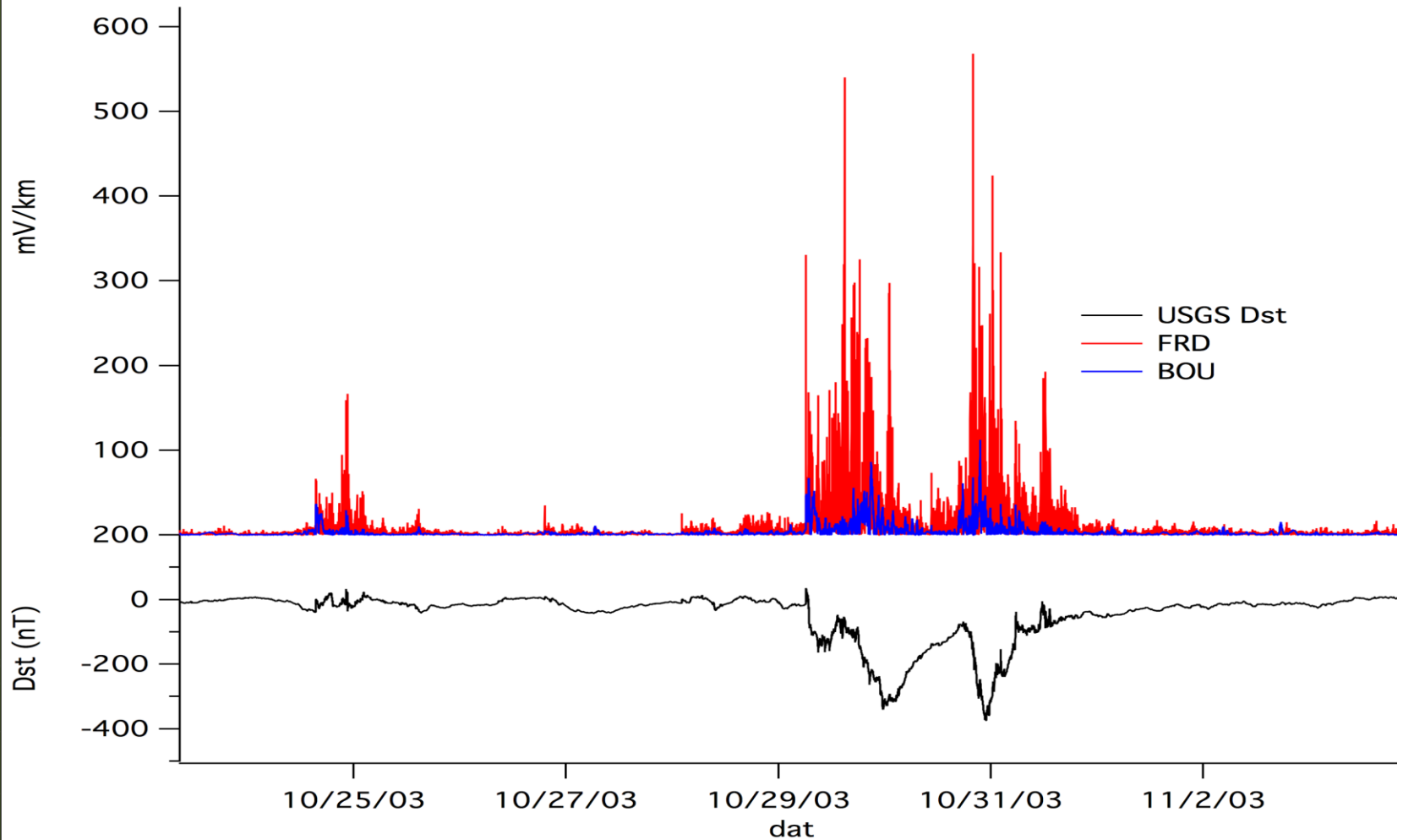
Electric Field: Spectral content of a storm

- At least 10 second time resolution required to resolve full response of Electric field
(1-second data available at <http://geomag.usgs.gov/data>)
- Individual storms have unique spectral content
- Electric field response very sensitive to local geology
(Conductivity profiles available at <http://geomag.usgs.gov/conductivity>)

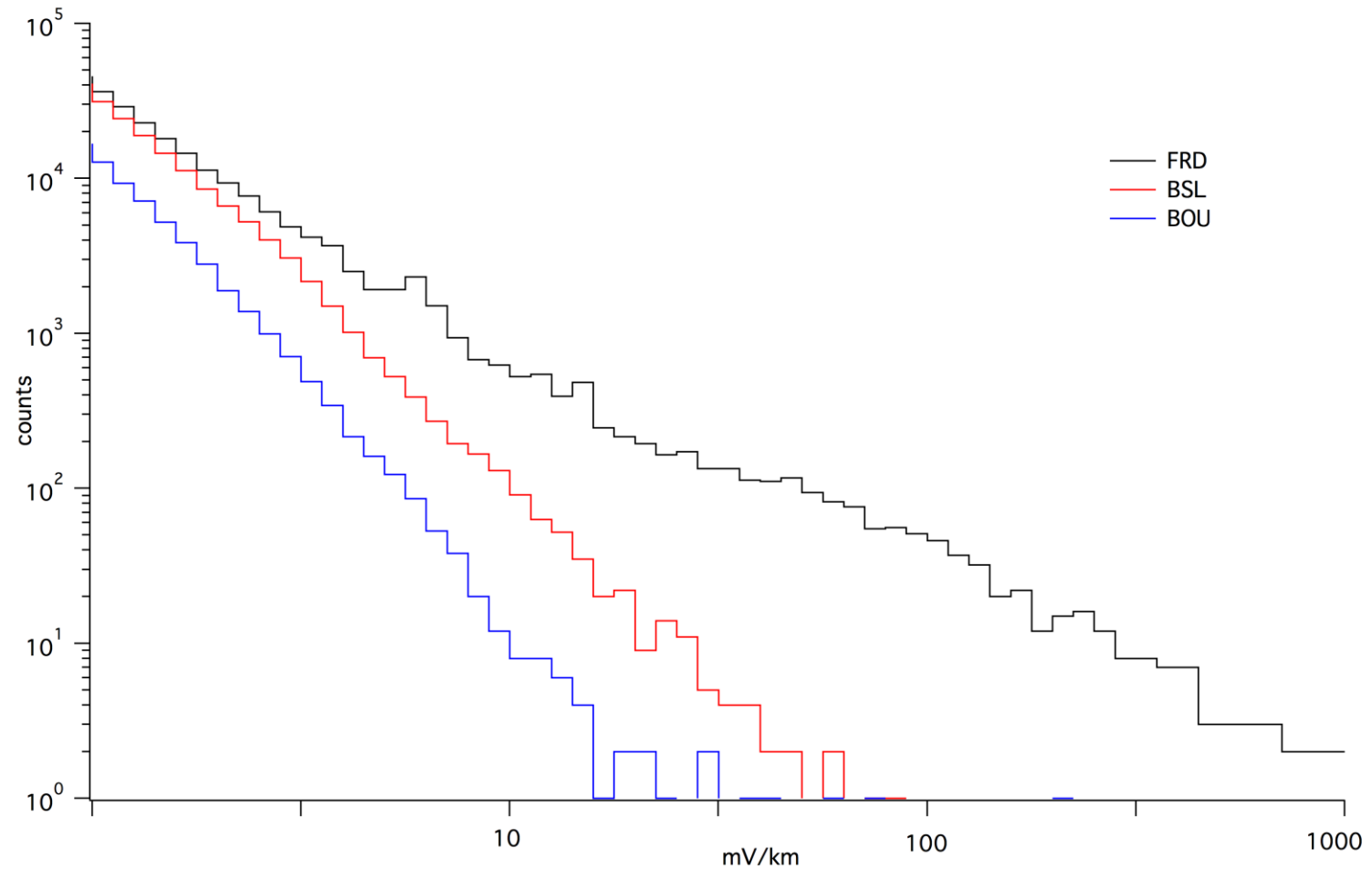
1989 Storm



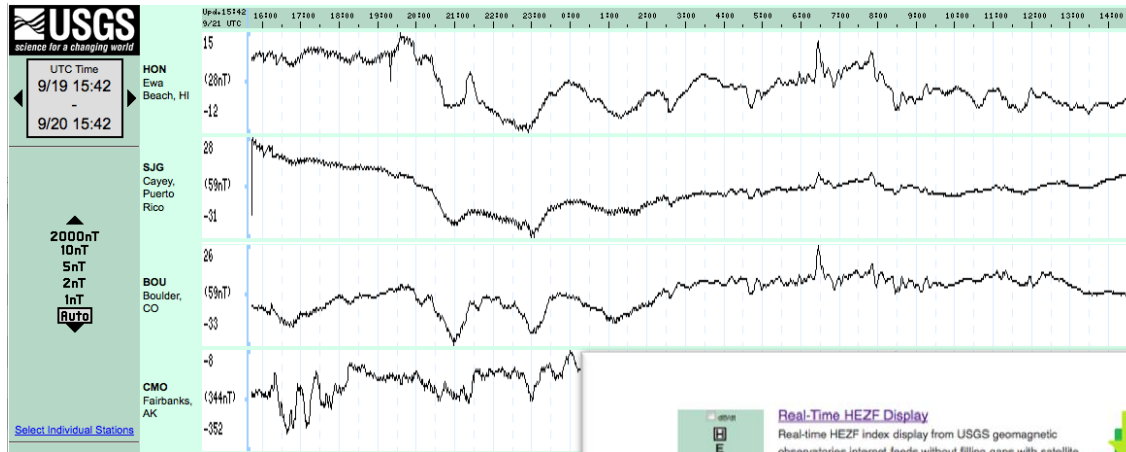
Halloween Storm



Historical Analysis- 1985-2010



Real-time products



Real-time plots and text
file download:
<http://geomag.usgs.gov/products>

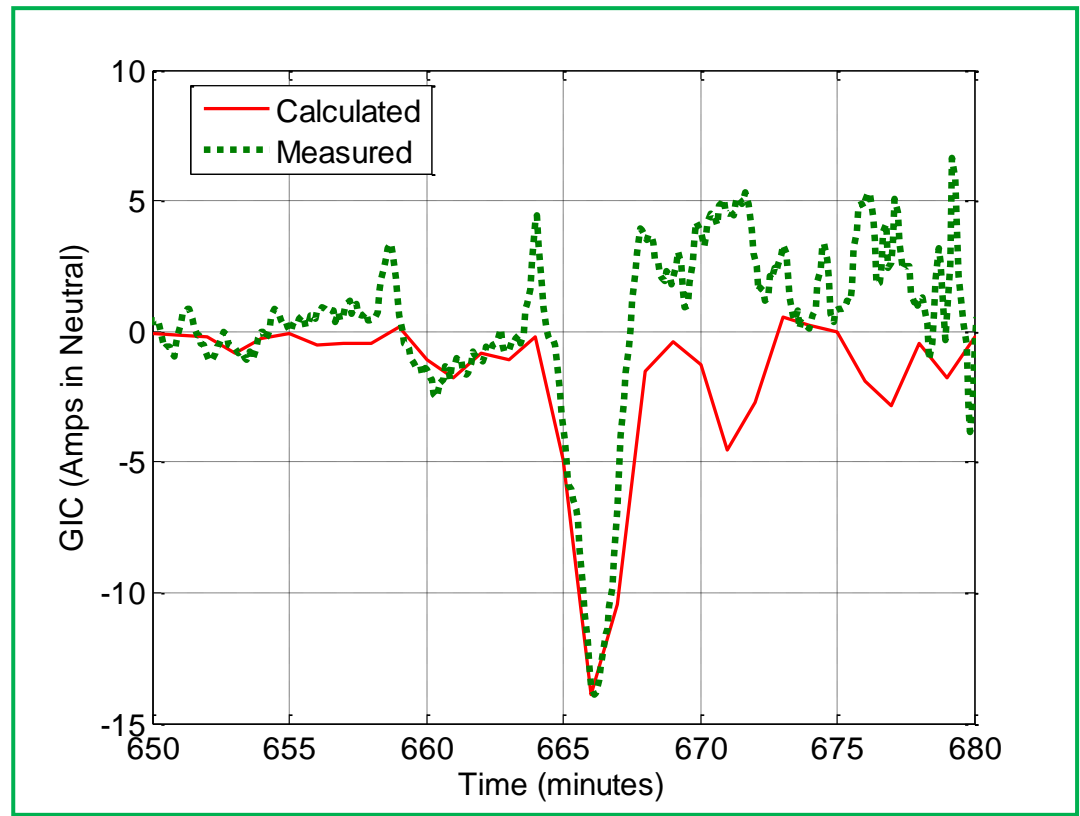
The screenshot shows the USGS geomagnetic data website interface. It features several sections: 'Real-Time HEZF Display' (Real-time HEZF index display from USGS geomagnetic observatories internet feeds without filling gaps with satellite data), 'Real-Time Dst Display' (Real-time Dst data from USGS observatories as well as other world partners), 'Real-Time H Display (by latitude)' (Real-time H index data as displayed above but sorted by latitude), and 'Blended Real-Time HEZF Display' (Real-time HEZF data from USGS geomagnetic observatories with satellite data used to fill gaps). There is a 'Download' button with a green arrow icon and a 'Disturbance Summaries' section with a table of recent major magnetic storms. The table has columns for 'Main Phase' and 'View reports on recent major magnetic storms'. The table contains three rows of data: 2012-10-01 04:00:00, 2012-01-23 00:45:00, and 2011-09-27 00:00:00. There is also a 'Models' section with a globe icon and a 'Beta Products' section with a globe icon. The 'Beta Products' section states: 'These products are in development and are offered "as-is" with no guarantee of availability, accuracy, or support'. A link for 'Other Sources of Data' is at the bottom.

Validation of conductivity models

Use conductivity maps and magnetic field measurements (and models) to produce electric field input to system models

Working in collaboration with several utilities and researchers

Shorter period fluctuations (period < 1 min) may require more sophisticated methods than FFT



Courtesy of R. Horton (Southern Power)

Continuing Research

- Magnetic Field Interpolation for regional specification
- Wavelet analysis techniques to resolve higher frequency magnetic field drivers
- Observatory spacing/correlation lengths

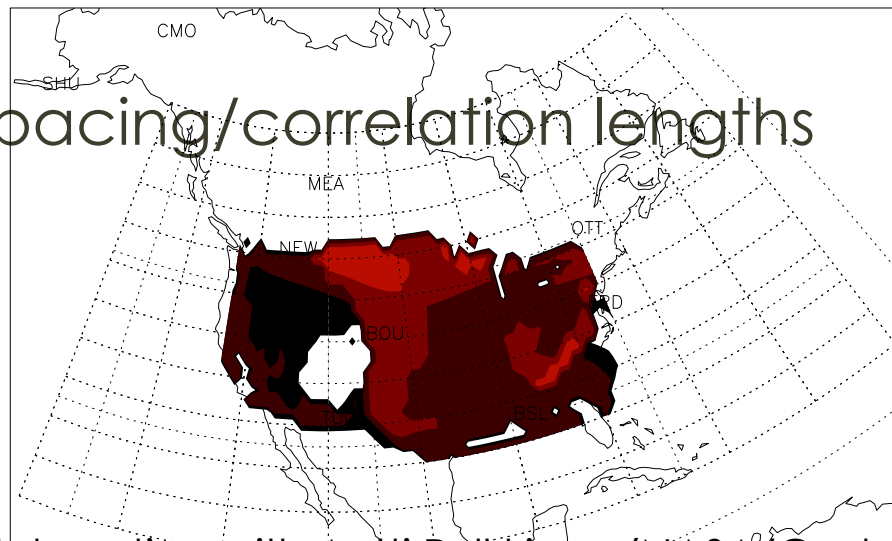


Image produced in collaboration with Antti Pulkkinen (NASA/Goddard)

USGS Real-time hazard maps

Real-Time Date Storm

Showing past 24 hours, auto-updated every 5 minutes

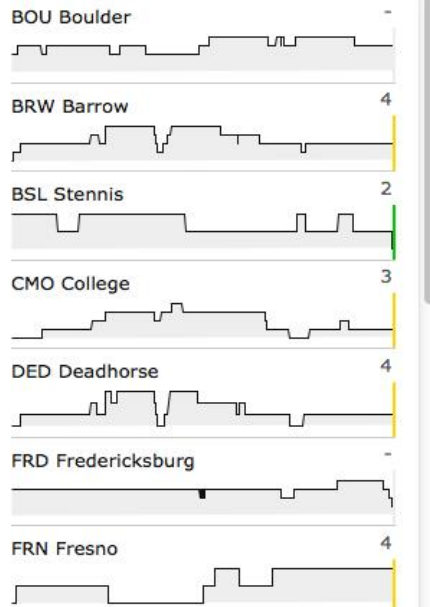
Channels

H E Z F
K Sq Dist



Observatories

Sort By Code ▾



► Play

Thu, 28 Mar 2013 04:20:00 GMT



<http://geomag.usgs.gov/map>

Partnerships

- Industry: ISTI, EPRI, NERC, Markant, AER, GE, Southern Co, Schlumberger
- Government: NOAA, NASA
- Academia: CUA, UCLA, CU-Boulder, Oregon State

Summary

- ◉ Electric field estimates calculated for 1985-2010 at observatory locations
- ◉ Real-time electric field calculations available at observatory locations
- ◉ 1-D Conductivity profiles available
- ◉ Wavelet analysis and/or better conductivity mapping may be required to resolve pulsations with periods < 1 min
- ◉ Hazard mapping project and research underway!