Magnetic-storm geoelectric hazard maps and the induction of voltages on power-grids

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### Possible Future CONUS Geomagnetic Monitoring



### **CONUS MT Survey Completion**

Executive Order 13865 (signed March 26, 2019):

"Within 4 years of the date of this order, the Secretary of the Interior shall complete a magnetotelluric survey of the contiguous United States to help critical infrastructure owners and operators conduct EMP vulnerability assessments."

FY20 Geomagnetism Program appropriation:

\$4,000,000 for Geomagnetism including \$1,726,000 for the magnetotelluric survey as well as funding to maintain operation of existing observatories.

FY21 Geomagnetism Program proposed appropriation:

Continue operating magnetic observatories, continue magnetotelluric survey, continue developing geoelectric hazard maps.



Map       Satellite       Draw Selection Box         Asia       Callity       Quality Warning       Release Status       Project       Min Period       Max Period         Min       Lagend       Data Quality       Quality Warning       Release Status       Project       Min Period       Max Period         Min       Lagend       Data Quality       Quality Warning       Release Status       Project       Min Period       Max Period         Min       Lagend       Max Lat       Start Date       Image: Callity       Min Quality       O to	Transfer Function Query Parameters			
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The EMTF XML format and file conversion utilities are described by <u>Kelbert (2019</u>). Reading and writing of EMTF XML is supported by <u>EMTF FCU</u>. All data are oriented to geographic coordinates, but all historical files are also available in their original orientations. Please see the complete <u>change log</u> for database changes Data citations are provided for each survey; these should be referenced in publications.

Qu	Query Results: 5444 items found												
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	Site Name	Site ID \$	Latitude \$	Longitude \$	Project \$	Survey ¢	Start Time (UTC) \$	End Time (UTC) \$	Last modified (UTC)				
	Mazourka Canyon, CA, USA	CAT08	36.84	-118.09	USMTArray	SOCAL	2019-11-15 21:35:13	2019-12-05 16:51:02	2020-01-29 19:01:03				
	Soledad Canyon, CA, USA	CAX08	34.47	-118.10	USMTArray	SOCAL	2019-11-14 22:14:50	2019-12-04 16:47:10	2020-01-29 19:11:19				
	California City, CA, USA	CAW08	35.07	-118.00	USMTArray	SOCAL	2019-11-14 17:48:27	2019-12-04 20:11:28	2020-01-29 19:17:56				
0	Mt. Madonna, CA, USA	CAT03	37.02	-121.70	USMTArray	SOCAL	2019-11-08 22:45:44	2019-12-06 16:46:51	2020-01-29 19:20:10				

### http://ds.iris.edu/spud/emtf

MT Impedance Archiving:

- ➤ mature
- format conversion software available
- maintained by USGS





#### MT Time Series Archiving:

- > archaic procedures
- new data format development
- new tools in development at USGS

#### http://ds.iris.edu/gmap/#network=\_US-MT





Magnetic storms and induction hazards, Eos, Trans. AGU, 95(48), 445-446, doi10.1002/2014EO480001.

### 3D conductivity model of CONUS based on magnetotelluric data



Compilation of existing 3D electrical conductivity models in contiguous U.S. (CONUS) constrained by USArray MT and other MT and magnetometer data from near-surface to approx. 900 km. Improvements are work in progress. Note the 4 orders of magnitude variation.

Working with NOAA SWPC to develop of version of real-time geoelectric field map based on empirical impedances and/or 3D conductivity model.



Kelbert, A., Bedrosian, P. A., and Murphy, B. S., 2019, The first 3D conductivity model of the contiguous United States: Reflections on geologic structure and application to induction hazards, in Geomagnetically Induced Currents from the Sun to the Power Grid, edited by J. L. Gannon, Z. Xu, and A. Swidinski, Geophysical Monograph 244, pp. 127-151, American Geophysical Union, Washington, D.C., doi:10.1002/9781119434412.ch8.

# National impedance mapping project





## 100-year maximum voltages on national power grid (1-min duration)







Lucas, G. M., Love, J. J., Kelbert, A., Bedrosian, P. A., and Rigler, E. J., 2020, 100-year geoelectric hazard analysis for the United States, Space Weather, 18(2), e2019SW002329, doi:10.1002/2019SW002329.