Improving the prediction model of Spanish power grid's vulnerability in solar storms

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The article, highlighted in the newsletter of the American Geophysical Union, shows the most realistic and complex prediction model so far. Credit: Àlex Marcuello, University of Barcelona

In September 1859, a large solar flare caused the most violent geomagnetic storm ever recorded. The Carrington Event was so powerful that it destroyed the telegraph systems of that time. Today, satellites, electric lines, transportation systems,and communications and positioning systems are threatened by the impact of such large-scale geomagnetic storms.

A new study is improving predictions of the vulnerabilities in Spanish electric transport networks, and was recently published in the journal *Space Weather*. The new research study has been distinguished as a research announcement in the EOS newsletter of the American Geophysical Union (AGU), within the area of geology and geophysics.

From polar auroras to technology failure

Apart from the beauty of auroras in polar latitudes, the disturbances of Earth's magnetic field caused by the solar cycle can generate huge economic losses in many sectors. When the solar wind's particles interact with the Earth's magnetic field, a geomagnetic storm results. This storm can generate geomagnetically induced currents (GIC) in the subsoil, which are dangerous to electrical networks and transport systems (oil pipelines, gas pipelines, railway lines, etc.).

These low-frequency continuous currents depend on the region's geoelectrical structure, that is, the regional geology, and on the electric conductivity of rocks. Regarding electrical lines, geomagnetically induced currents couple with the distribution network through the transformer's dams.

Àlex Marcuello, lecturer from the Department of Earth and Ocean Dynamics of the University of Barcelona, says, "The applied methodology in this new study allows a simulation of different situations for the network, according to different magnetic storm conditions.

Therefore, modeling can estimate the highest values of GIC for different substations, finding out their effect in different elements of the grid –connected or not- and identifying the most vulnerable ones."

Improving predictions with the study of electric conductivity

This scientific article, with Joan Miquel Torta as its first author, sets as a study model an electricity substation in Vandellòs, Tarragona. To study the vulnerability of the electric grid, the study analyzes the comprehensive elements of the grid and its length, apart from the geoelectrical structure of the subsoil using in situ measurements in the territory.

"In general, the most vulnerable high voltage lines are the ones with voltages higher than 200 kV" says Àlex Marcuello. "The most GIC-sensitive components are the transformers in the substations. These GIC cause a half-cycle saturation in the nucleus of the transformers, and its consequence is tripled—the transformer warms up and can even burn, the current and voltage stop being sinusoidal (50 Hz) and become unstable. Finally, the grid's inductive power increases. As a final result of the three situations, a partial or total blackout can take place."

A more realistic diagnosis on the country's power grid

The study published in the journal *Space Weather* creates a realistic prediction model based on simplified approaches. In this context, the experts of the Geomodels Research Institute have characterized the conductivity of subsoil in the region of the Vandellòs substation using the magnetotelluric method.

"This methodology enabled a substantial improvement in the former

predictions for GICs. Also, we have proposed a model that can add three factors on which the GIC depend: the magnetic storm, the subsoil geoelectrical structure, and the electricity grid characteristics," says Marcuello.

Satellite meteorology: anticipating the effects of solar storms

The importance of technological impacts of magnetic storms have prompted the design of global warning protocols that alert systems managers in a minimum time interval, even hours before a GIC, to set the proper preventive measures. Situations such as the Quebec blackout on March 13, 1989 are extreme cases that encourage the research process in satellite meteorology to prevent and palliate the magnetic effects of solar activity in the planet.

More information: J. M. Torta et al. Improving the modeling of geomagnetically induced currents in Spain, *Space Weather* (2017). DOI: 10.1002/2017SW001628

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