First-of-its-kind NASA space-weather project

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Scientist Antti Pulkkinen is using high-voltage power transmission lines as a very large antenna to measure a space weather-related phenomenon. Credit: NASA Goddard/Bill Hrybyk

A NASA scientist is launching a one-to-two-year pilot project this summer that takes advantage of U.S. high-voltage power transmission lines to measure a phenomenon that has caused widespread power outages in the past.

Heliophysicist Antti Pulkkinen of NASA's Goddard Space Flight Center in Greenbelt, Md. and his team are installing scientific substations beneath high-voltage power transmission lines operated by Virginia's Dominion Virginia Power this summer to measure in real-time a phenomenon known as geomagnetically induced currents (GICs). "This is the first time we have used the U.S. high-voltage power transmission system as a science tool to map large-scale GICs," Pulkkinen said. "This application will allow unprecedented, game-changing data gathering over a wide range of spatial and temporal scales."

In addition to gathering data important to the power industry—especially if it's expanded nationwide as currently planned—the project will allow heliophysicists to "reverse engineer" the data to learn more about the conditions in Earth's upper atmosphere that lead to the generation of GICs during severe space weather events, Pulkkinen said, adding he is now developing computer algorithms to extract that data for scientific research. "Not only will this benefit the utility industry, it also benefits science," he said.

Solar Storms the Culprit

GICs typically occur one-to-three days after the sun unleashes a coronal mass ejection, or CME, a gigantic bubble of charged particles that can carry up to 10 billion tons of matter. CMEs can accelerate to several million miles per hour as they race across space. If a CME slams into Earth's magnetosphere, the impact causes electromagnetic fluctuations, which result in geomagnetic storms at Earth. These storms increase electric currents that in turn, drive the fluctuations in Earth's magnetic field near the ground. These surface currents can flow through any large-scale conductive structure, including power lines, oil and gas pipelines, undersea communications cables, telephone and telegraph networks, and railways.

An extreme example of a GIC occurrence was the great magnetic storm of March 1989—one of the largest disturbances of the 20th century. Rapid variations in the geomagnetic field led to intensely induced electric fields at the Earth's surface. This electric field caused electrical currents to flow

through conducting structures—in this case, the Canadian Hydro-Quebec power grid. The excess current collapsed the transmission system, causing the loss of electric power to more than six million people.

According to the U.S. Geological Survey, had the blackout occurred in the Northeastern U.S., the economic impact could have exceeded $10 billion, to say nothing of the deleterious impact on emergency services and reduction in public safety.

Space weather events can have a range of effects including disrupting communications and navigation systems, damaging satellite instrumentation, and even potentially corroding pipeline steel. The impact on the nation's electric grid is perhaps the highest concern at the moment, Pulkkinen said. "It's the hottest topic out there right now," he said, adding that the Federal Energy Regulatory Commission is now developing standards to mitigate the GIC threat. "We need to better understand how these events affect the U.S. power grid," he added.

His pilot program is designed to help find out, Pulkkinen said.

Funded by R&D Programs

Funded by NASA's Center Innovation Fund and Goddard's Internal Research and Development (IRAD) program, the team is creating three substations, all equipped with commercially available magnetometers capable of precisely measuring the variable magnetic fields associated with GICs. Once inserted inside a protective, watertight housing unit, designed by Goddard engineer Todd Bonalsky, the team will bury the gear four feet into the ground—two directly below Dominion Virginia Power's high-voltage lines and the third one-to-two miles away. The latter will provide reference measurements.

"In essence, we're tapping into a very large antenna, Pulkkinen said. "The high-voltage lines are the antennae. During solar storms, violent changes in the electric current occur in near space, which then are sensed by the transmission lines."

Ubiquitous iPad Finds Scientific Application

To command and control the magnetometers, Pulkkinen's team is using another IRAD-developed technology, LabNotes. This iPad application, developed by Goddard engineers Carl Hostetter and Troy Adams, will time tag and geo-locate the magnetometers' data, and then deliver the information to a server via a cellular data network, Hostetter explained. In addition to sending one sample per second, the LabNotes-equipped iPad-Mini also could monitor the data and send a text message should an event warrant attention.

"Now that everyone is walking around with this type of computer, which is more powerful than some supercomputers of 15 years ago, we thought we may as well use it for scientific purposes," Hostetter said, adding that its relatively small size and low-power consumption make it ideal for science gathering. Although Pulkkinen's team is the first to actually use the application, Hostetter said the technology has interested a number of other projects, including one involving agricultural needs in Africa.

The Goal: Nationwide Coverage

The project's objective, Pulkkinen added, is making the equipment as inexpensive and versatile as possible. Although the pilot project begins with only three substations, Pulkkinen wants to ultimately deploy hundreds across the nation. "We envision that after a one-to-two-year pilot phase, long-term funding from a multi-agency collaboration and public-private partnerships will make this happen."

"Impacts to the nation's power grid are currently the highest space-weather concern in the U.S.," he added. With federal regulations on the horizon, Pulkkinen said the measurements would help define the most effective techniques for mitigating GIC threats.

Provided by NASA's Goddard Space Flight Center