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# Researchers in the Antarctic discover new facets of space weather

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Virginia Tech researchers and a graduate student share a meal in Antarctica.
Credit: Virginia Tech

A team of National Science Foundation (NSF)-supported researchers at the Virginia Polytechnic Institute and State University (Virginia Tech) discovered new evidence about how the Earth's magnetic field interacts with solar wind, almost as soon as they finished installing six data-collection stations across East Antarctic Plateau last January.

Their findings could have significant effects on our understanding of space weather. Although invisible to the naked eye, space weather can have serious, detrimental effects on modern technological infrastructure, including telecommunications, navigation, and electrical power systems.

The researchers for the first time observed that regardless of the hemisphere or the season, the polar ionosphere is subject to a constant electrical current, produced by pressure changes in the solar wind.

"This finding is a new part of the physics that we need to understand and work with," said Robert Clauer, a professor in Virginia Tech's Bradley Department of Electrical and Computer Engineering. "It's a bit of a surprise, because when you have a current, you usually expect a voltage relationship, where resistance and current are inversely related—high resistance equals small current; low resistance equals large current."

These space weather observations allow researchers to watch how the behavior of the sun and the solar wind—an unbroken supersonic flow of charged particles from the sun—changes over time and how the Earth's magnetic field responds to solar wind variations. The observations help build a detailed, reliable model of space weather.

They hope that eventually space weather forecasting will become as reliable as today's winter storm warnings.

The project to develop and deploy these autonomous data-collection stations in the Antarctic, funded by a $2.7 million NSF award, has progressed over a seven-year period. NSF manages the U.S. Antarctic Program, through which it supports researchers nationwide, provides logistical support to the research and operates three year-round stations in Antarctica.

Clauer and his team designed and hand-built six autonomous data-collection stations and installed them piece-by-piece near the geographic South Pole for initial testing. Following successful testing, the autonomous data-collection stations were placed along the 40-degree magnetic meridian (longitude), deep in the southern polar cap areas under the auroras. The stations, located in the harsh environment of the remote East Antarctic Plateau, are the Southern Hemisphere counterpart to a magnetically similar chain in Greenland.

Clauer and his Magnetosphere-Ionosphere Science team have been monitoring the electric current systems in the magnetosphere—specifically currents that connect to the ionosphere. During the summer in the Northern Hemisphere, there is more direct sunlight on the atmosphere, which means more atoms are ionized. This phenomenon creates a highly conductive ionosphere in the summer months and a poorly conductive one in the winter.

"The solar wind interacts with Earth's magnetic field in a manner similar to a fluid, but an electrically conducting fluid," Clauer said.

A chain of data-collection stations in Greenland allowed researchers to take measurements in the Northern Hemisphere. Until recently, these data were divided into summer and winter, and the information gathered during the winter months was used to approximate what was happening in the Southern Hemisphere during the northern summer.

"We didn't have a full picture of what was happening in the space environment because we could only observe one hemisphere, but magnetic field lines are connected to both hemispheres," said Clauer. "It was important that we look at them simultaneously."

The stations run autonomously and are powered by solar cells in the months-long Antarctic summer, and by lead-acid batteries during winter. The stations contain a collection of instruments, including a dual-frequency GPS receiver that tracks signal changes produced by density irregularities in the ionosphere, and two kinds of magnetometers that measure the varying strength and direction of magnetic fields. The data is transmitted to Blacksburg, Virginia, via Iridium satellites.

Clauer's team will continue collecting information from both sets of data stations. They hope to operate throughout the 11-year solar activity cycle, depending on snow accumulation.

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