Satellite Observations Reveal Unexpected Ionospheric Turbulence

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Published 10 July 2009.

A year ago, the U.S. Air Force launched a prototype research satellite to improve real-time space weather forecasts [see e.g. de la Beaujardiére et al., 2006; Kelley et al., 2005; Retterer, 2005]. Although it was designed as a technology demonstration to gauge effects of solar activity, the Communications/Navigation Outage Forecasting System (C/NOFS) satellite has also returned useful and unexpected information about how the ionosphere operates.

Before C/NOFS, researchers believed turbulence in the ionosphere occurred primarily around the equator early during the night. But that is not what they found. "We actually saw a lot more irregularity present than we had anticipated," said Odile de La Beaujardière, C/NOFS' principal investigator, with the Air Force Research Laboratory's Space Vehicles Directorate.

The ionosphere is a layer of plasma, ranging between 100 and 2000 kilometers above the Earth. It is strongly influenced by the Sun, and it is how space weather affects the planet. For example, disruptions in the ionosphere can affect radio waves that travel through the atmosphere to convey critical communications, such as from navigational satellites and polar-flying aircraft.

Scientists had thought that most ionospheric irregularities begin around sunset and last for several hours before disappearing. "What we found is that for more than half of the time, the irregularities were starting around midnight and continuing throughout the night and in the morning. And we have a third set of small irregularities that can also start again just at sunrises, rather than sunsets," de La Beaujardière said.

A better understanding of where and when these irregularities occur could help improve space weather forecasting. Charged with satellite operations for collecting space weather data for the entire U.S. armed services, the Air Force wants accurate space weather forecasts so it can know when radio signals will slip smoothly through the atmosphere and when they will not.

"If somebody's planning a mission somewhere, they want to know if it's going to be raining when we get there and is rain good or bad for that particular mission. In the same way, we want to include space weather impacts on that mission," said Donald Hunton, technical manager for the C/NOFS Advanced Concept Technology Development Program.

The Air Force has been working on developing ways to incorporate real-time space weather data into operational missions. "The Air Force started thinking seriously about the issue in the mid-90s," said Hunton. C/NOFS was designed to provide the data needed to predict ionospheric irregularities. "The goal was to put together a satellite that would be optimal for doing space weather forecasting," said Hunton.

After the spacecraft's launch in 2008, the team experienced some difficulties charging and discharging its batteries, slowing science returns, but de La Beaujardière says the issues have been resolved.

Data from the six instruments on board C/NOFS are combined with hundreds of ground-based measurements to generate models of space weather. "All the instruments are working together, synergistically," de La Beaujardière said.

C/NOFS data are used for various military operations, but the satellite's puzzling findings have prompted the agency to seek additional scientific expertise.

"With the observations that the satellite has made, we realize that there are shortcomings in the model that we want to fix," said Air Force research physicist John Retterer, who develops models of the ionosphere based on C/NOFS data.

References


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