THEMIS celebrates 5 years of watching aurora and space weather

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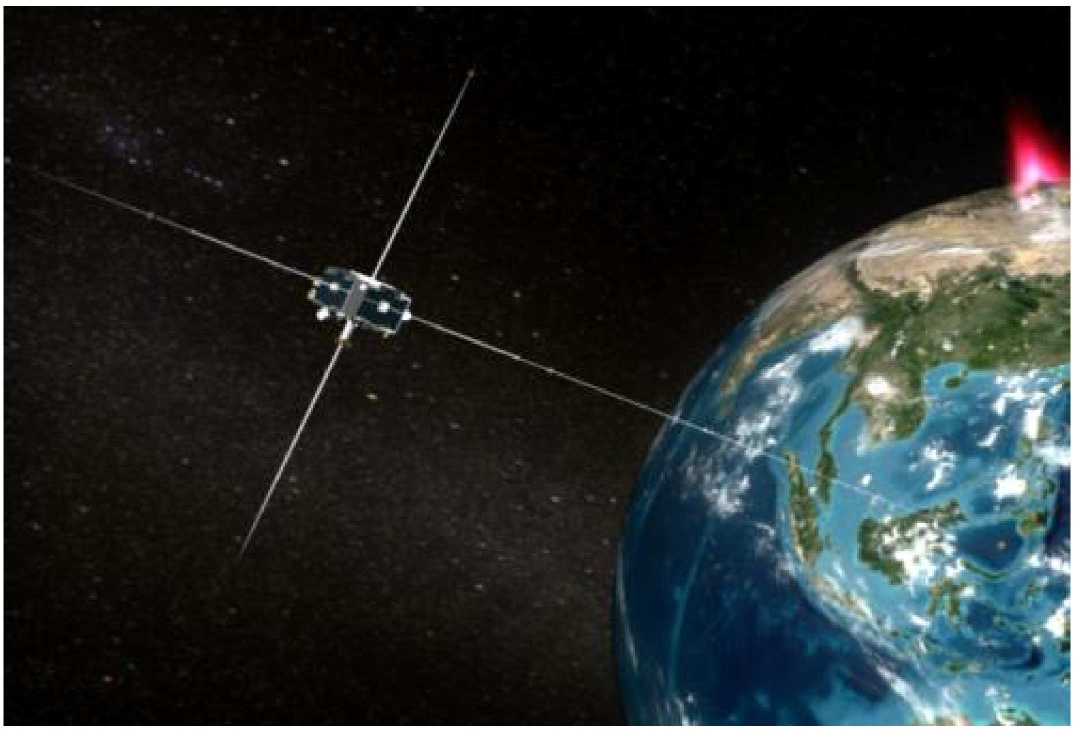


An artist's conception of one of the THEMIS spacecraft in orbit around Earth. Credit: NASA/Goddard Space Flight Center Conceptual Image Lab

People still talk about the launch. It was the first – and so far, only – time NASA has launched five satellites at one time. Carefully balanced inside a Delta II rocket, the five THEMIS (short for Timed History of Events and Macroscale Interactions during Substorms) spacecraft were launched into space from Cape Canaveral at 6:01 p.m. ET on February

17, 2007. The spacecraft were nestled in a ring shape, four around the outside and one on a middle pedestal. A critical sequencing guided how each spacecraft launched into space, first the top one, then the ones on the outside, so the platform would remain balanced and stable.

"The launch of THEMIS was one of the first Explorer missions I oversaw from concept through launch and on-orbit checkout and it still stands out in my mind," says Willis Jenkins, the Program Executive for NASA's Explorers Program, a program that supports less expensive and highly focused missions. "Trying to get five spacecraft together on one rocket was a challenge, but our team came up with unique ways to build and launch them."

Those five satellites working in tandem was crucial for THEMIS' job of tracking energy as it moves through space. Energy and radiation from the sun impacts and changes Earth's magnetic environment, the magnetosphere, and such impacts cause "space weather" that can harm satellites in space. As they orbit around Earth, the THEMIS satellites work together to gather data on how any given space weather event travels through space – something impossible to understand with a single spacecraft, which cannot differentiate between an occurrence that happens throughout space, rather than in a single location. Since 2007, the THEMIS satellites have reinvigorated studies of the magnetosphere, mapping the details of how explosive auroras occur, how the solar wind transfers energy to Earth's space environment, and how chirping waves in space relate to blinking auroras on Earth.

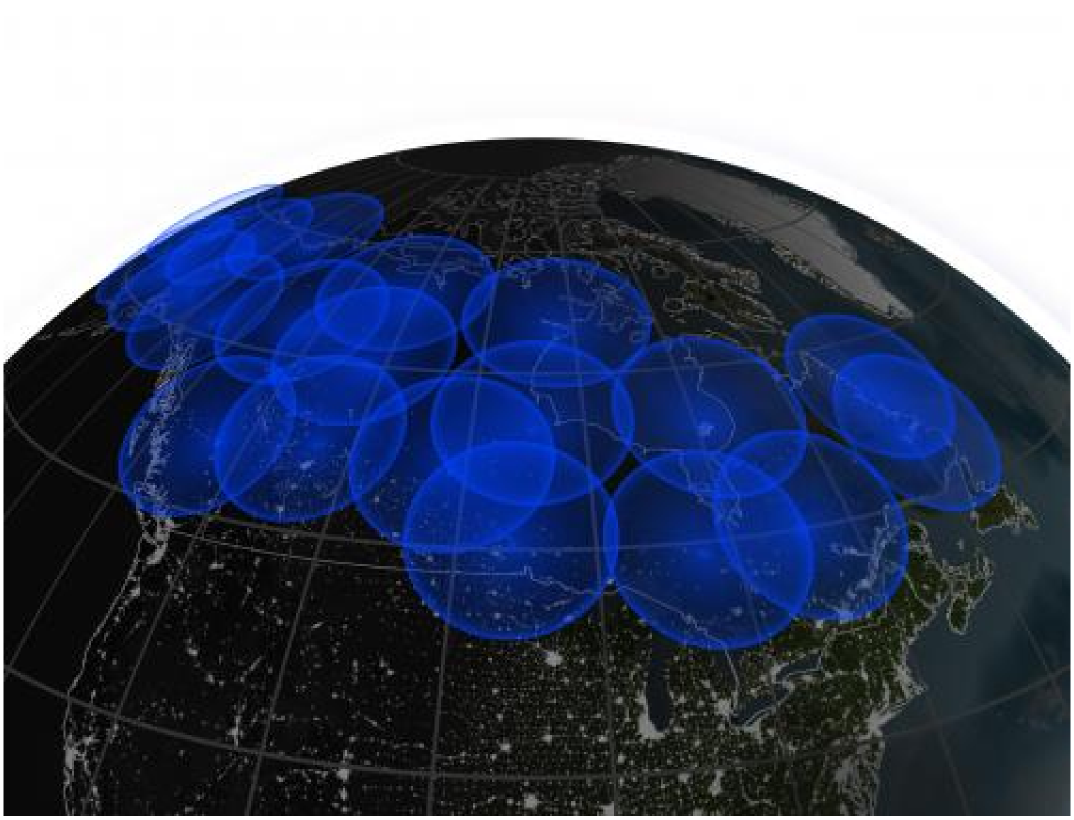
During its prime, two-year mission, THEMIS' main objective was to pinpoint where a space weather phenomenon known as substorms originate. Substorms generate aurora, but before THEMIS launched no one knew exactly what created the onset of a substorm.

"Five years ago, the state of the field could be described in one word:

confusion," says Vassilis Angelopoulos, a space scientist at the University of California, Los Angeles, and the principal investigator for THEMIS. "We didn't understand the chain that linked energy from the sun to the aurora. We didn't know what mechanism caused substorms. We didn't know where, in the vast area of space, the process happened."

THEMIS answered those questions early on. Using its five satellites, as well as an array of some 25 ground based instruments, the THEMIS team could watch how the substorms formed and how they correlated to events in the night sky.

Together, the instruments painted a complete picture of aurora formation. A diffuse, weak aurora is always present near the poles, but can't always be seen with the naked eye. Brighter ones require an influx of energy from the sun that starts when the solar wind's magnetic field swings around, in the opposite direction of Earth's own magnetic field. Under such conditions, the solar wind rips off Earth's magnetic field lines from the day side, pulling them around to the night side, where they pile up, storing vast amounts of energy until they release in explosive bursts of magnetic reconnection. The surge of radiation and magnetism that rebounds toward Earth in this case is a substorm, complete with its attendant aurora.



In additional to the five THEMIS spacecraft launched into space, 20 THEMIS ground stations can observe aurora from the ground. Credit: NASA/Goddard Space Flight Center Scientific Visualization Studio

After the first two years, NASA extended the THEMIS mission, which went on to track other space weather processes as they travel near Earth. THEMIS discovered the critical importance of something called "dipolarization fronts," bursts of material and energy that collapse Earth's magnetic field at the beginning of a substorm. These fronts are blobs of magnetized material, or plasma, with temperatures of one million degrees and speeds of one million miles per hour that race toward Earth. THEMIS satellites have observed them ramming into the near-Earth region, injecting hyper fast electrons -- which can damage computer systems -- into the region of space where geosynchronous satellites reside with their sensitive electronics.

Scientists have also compared THEMIS space and ground-based data to solve a long standing space mystery of what caused "pulsating" aurora, beautiful emission patterns in which the aurora appear to blink. The aurora's pulses corresponded perfectly to something much higher in space called "chorus waves," so-called because in ground radio receivers they sound like a chorus of chirping bird-songs.

"With five satellites we've been able to pin down the topology and structure of the magnetosphere," says David Sibeck, the project scientist for THEMIS at NASA's Goddard Space Flight Center in Greenbelt, Md. "THEMIS truly mapped out how the magnetic fields outside the magnetosphere append to Earth's magnetic boundaries, transferring energy and material into our system."

With five years under its belt, two new opportunities have opened up THEMIS' research potential beyond the original substorm question. First, two of the original THEMIS satellites have been moved into a new orbit around the moon and have been renamed the ARTEMIS mission. The technical details of moving those two satellites with minimal fuel and numerous gravity assists made orbital flight history as much as the original launch of five spacecraft did. And, as NASA's Jenkins points out, using one Explorer project for two separate missions translates to a great savings in cost.

"Re-purposing this Explorer stands as a prime example of a cost effective mission with a large return on the investment," says Jenkins. "It is a win-win adventure for everyone."

The three THEMIS satellites around Earth are gearing up to add another focus to its mission as well: helping to track energy swells from out in space all the way into the two great belts of radiation – known as the Van Allen Radiation Belts – that surround Earth.

In the second half of 2012, NASA will launch two new spacecraft, the Radiation Belt Storm Probes (RBSP) that will specifically be studying this region and how the belts swell and shrink in response to outside effects. In 2014, NASA will launch four spacecraft called the Magnetospheric Multiscale mission (MMS) that will study the physics of magnetic reconnection at the boundaries of the magnetosphere. The orbit for THEMIS lies in between the orbits for RBSP and MMS. THEMIS has the potential to unify observations from these missions into a nine-satellite global constellation to observe the entire course of energy release – from the entire length of its travels from the edges of the magnetosphere to impact with the near-Earth space that is crowded with satellites vulnerable to incoming space weather.

"This kind of operation heralds a new way of conducting space observations by combining the scientific benefits of new hardware with older, but powerful and well-tested satellites," says Angelopoulos. "We have the promise of a qualitative change in our understanding of space weather phenomena, today more than ever before."

Provided by NASA's Goddard Space Flight Center