Scintillating idea. The C/NOFS satellite will probe ionospheric "bubbles" that disrupt satellite transmissions near the equator.

SOLAR PHYSICS

Space Weather Forecasters Plan A Boost in Surveillance Missions

Two new missions to track solar outbursts, radio scintillation, and geomagnetic storms could prove vital now that older satellites are running on fumes

BEIJING—Whether it's a thunderstorm supercell spawning a tornado or warm ocean waters feeding a hurricane, turmoil in the lower atmosphere follows predictable rhythms. Not so space weather. Although it's known that solar outbursts spark geomagnetic storms, Earth can be blindsided by devastating but low-profile events. Two missions described here last week at the 2006 Western Pacific Geophysics Meeting aim to fill critical gaps in space weather surveillance.

First on the lineup is a probe to monitor disturbances in the upper atmosphere that blight satellite communication and Global Positioning System navigation. To study and forecast this phenomenon, the U.S. military plans to launch the Communication/Navigation Outage Forecasting System (C/NOFS) satellite in 2008. China meanwhile is planning a major solar observatory, dubbed KuaFu, with a launch target of 2012, which would track solar outbursts and geomagnetic storms in fine detail. "These two missions are very important and promising for space weather forecasting," says Kazuo Shiokawa, a solar physicist at Nagoya University in Japan.

Geomagnetic storms occur when surges in the solar wind warp Earth's magnetosphere, sending energy and charged particles into the upper atmosphere. The fiercest storms occur during crests in the sun's 11-year activity cycle, marked by powerful solar flares and blizzards of charged particles called coronal mass ejections (CMEs). Strong storms can short-circuit satellites and power grids. They also pose a risk for space travel. For example, if the Apollo 17 moon mission in December 1972 had been launched 4 months earlier, "the astronauts would probably have been killed" by a barrage of energetic particles from an extraordinary series of superflares and CMEs, says Rainer Schwenn, a solar physicist at the Max Planck Institute for Solar System Research in Katlenburg-Lindau, Germany. Future travelers to the moon or Mars would face the same hazard.

Geomagnetic storm forecasting took a giant leap forward 10 years ago, after the Solar and Heliospheric Observatory (SOHO)—a joint NASA and European Space Agency mission—began orbiting Lagrangian point L1, an interplanetary doldrums where balanced gravitational forces keep SOHO in a fairly stable perch between sun and Earth. At the meeting, speakers showed a movie of a SOHO camera lit up by a hail of CME particles in October 2003, the precursor to one of the biggest storms ever seen. SOHO gave several hours' warning, ample time to limit damage by powering down satellites. Still, "a significant number of storms cannot be predicted," says Nandita Srivastava of the Udaipur Solar Observatory in India.

Nor are geomagnetic storms the only hazard. Satellite transmissions to Earth can be disrupted—an effect called radio scintillation—by "bubbles" in the ionosphere, the ionized upper part of Earth's atmosphere. The origins of these patches of low-density plasma, which can be hundreds of kilometers across and usually occur between dusk and midnight near the equator, are a mystery. "Satellite TV may suddenly disappear when a bubble is passing above," says Shiokawa. The $100 million C/NOFS mission, run by the U.S. Air Force Research Laboratory and the Department of Defense's Space Development and Test Wing in Kirtland, New Mexico, will be the first to sample plasma density continuously in search of bubbles. "It will be a fantastic mission for improving our ability to forecast these hazards as well as understand the basic mechanisms responsible for creating them," says space scientist Michael Liemohn of the University of Michigan, Ann Arbor.

Although C/NOFS's primary objective is to give early warning to the U.S. military, "data will not be restricted," says Guan Le, a C/NOFS project scientist at NASA's Goddard Space Flight Center in Greenbelt, Maryland. Originally planned for launch on a Pegasus XL rocket in 2004, technical problems have delayed the launch to mid-2008.

Further in the future, KuaFu could become China's most ambitious space science effort yet. Named after a character in a Chinese legend who chases the sun, KuaFu would consist of a trio of satellites. A probe at L1 would image solar flares and CMEs and give up to 3 days' warning of impending geomagnetic storms. And two satellites in the magnetosphere would provide round-the-clock monitoring of auroras in the Northern Hemisphere, tracking storms as they develop. "KuaFu has numerous firsts, if it goes," says Eric Donovan, a mission collaborator at the University of Calgary in Canada.

China would build and launch the KuaFu satellites. Although Canadian and European institutions are taking the lead in defining scientific objectives, officials at the China National Space Administration (CNSA) insist that homegrown scientists play a significant role in developing the instruments, says mission chief Tu Chuanyi of Peking University. "With this mission," says Schwenn, a KuaFu collaborator, "China wants to join the international space science club."

CNSA expects to complete a review of KuaFu by spring and give a final go-ahead in 2009. With SOHO and another L1 probe, NASA's Advanced Composition Explorer, having long surpassed their design lives, KuaFu could prove vital. "Within a few years, we might be completely blind again to mass ejections," Schwenn says. And that could be as ruinous as turning a blind eye to tornadoes or hurricanes.

–DENNIS NORMILE AND RICHARD STONE

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