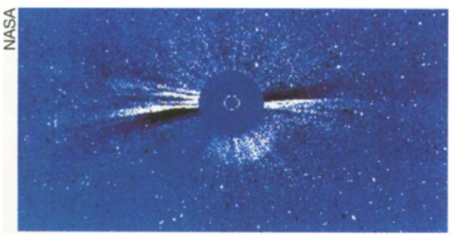
Solar Cloud Hits Earth's Magnetosphere

In early January, the sun hurled a billion-ton cloud of gas toward Earth. A few days later, the ballooning cloud landed a one-two punch on the planet's magnetic field, jacking up the intensity of high-energy electrons in Earth's radiation belts. The cloud probably caused the demise of a $200 million communications satellite, researchers say.

This wasn't the largest solar disturbance ever recorded. Nor are such events uncommon. Last month's magnetic storm, however, proved a standout on several counts.

With surprising efficiency, the cloud pumped energy into the magnetosphere, the region of space dominated by Earth's magnetic field. Researchers suggest that the storm is a harbinger of many more that will erupt as the sun approaches the peak of its 11-year activity cycle around the year 2000.

For the first time, an armada of spacecraft was in place to monitor the fireworks, enabling researchers to capture this solar event "from cradle to grave," says astronomer Stephen P. Maran of NASA's Goddard Space Flight Center in Greenbelt, Md. He coordinated a Goddard briefing last week at which space physicists described the cloud's progress from sun to Earth.



Eruption emerging from the sun's corona on Jan. 6, as seen by SOHO.

The SOHO spacecraft, which stares at the sun continuously from a vantage point 1 million kilometers in front of Earth, had a ringside seat for the solar display. It first spied a vast bubble of gas billowing out from the sun's outer atmosphere, or corona, at 11 a.m. eastern standard time on Jan. 6. The images thrilled a group of space physicists who had gathered at Goddard for a workshop. SOHO investigators estimated that the cloud was moving toward Earth at 450 km per second and would reach the magnetosphere 4 days later.

That prediction was soon borne out. On Jan. 10, SOHO observed the solar wind—the stream of charged particles blown out by the sun—abruptly increase speed from 350 to 430 km per second. This signified a magnetic disturbance passing by the craft. Closer to Earth, but still well outside the magnetosphere, a satellite called Wind confirmed the presence of a traveling magnetic cloud.

The expanding cloud didn't just slam into Earth's magnetosphere. For 12 hours, it kept the interplanetary magnetic field near Earth pointing southward, the opposite direction of Earth's own field. The two fields canceled each other out, says space scientist Mauricio Peredo of Hughes STX Corp. in Greenbelt, dumping energy into the magnetosphere.

Jazzed and buffeted, the sunward side of the magnetosphere, which typically extends 64,000 km from Earth, shrank by 20 percent. Two satellites, Geotail and Interball-Tail, which normally orbit inside the magnetosphere, found themselves intermittently on the outside as the magnetosphere's outer edge flapped back and forth, says Peredo.

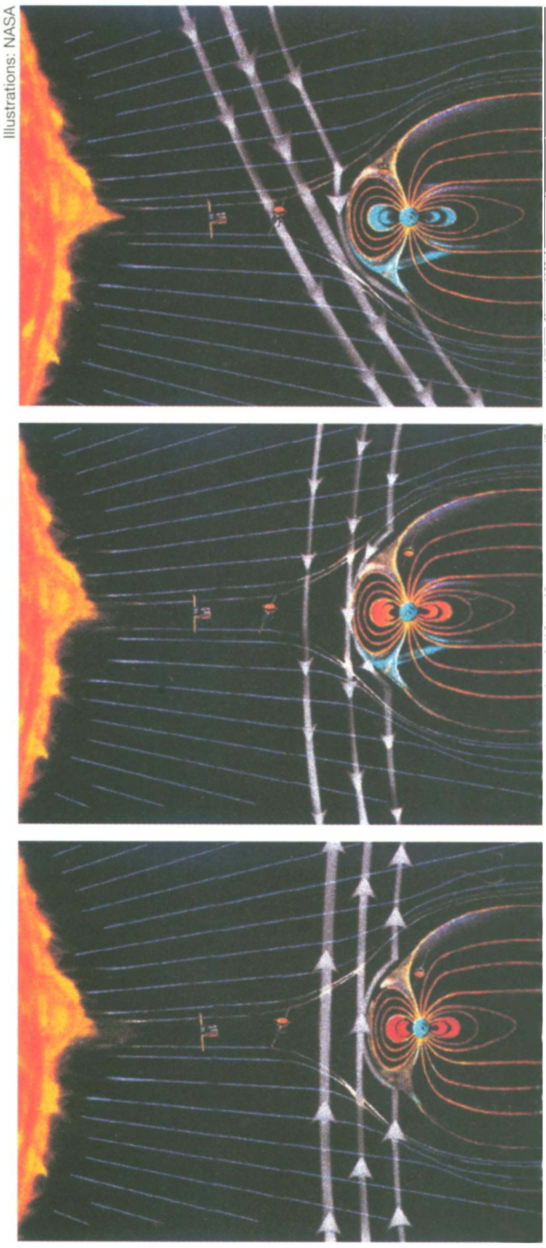
SAMPEX, a low-altitude satellite 600 km above Earth, recorded a boost in the intensity of fast electrons—those with energies greater than 1 million electron-volts—to more than 10,000 times the typical value in the radiation belts, reports Daniel Baker of the University of Colorado at Boulder. The high intensity lasted for at least a week.

Early on Jan. 11, the cloud delivered a parting blow. Its trailing edge, the densest part of the cloud, hammered into the magnetosphere, compressing it even more and leaving it ringing like a bell. The intensity of high-energy electrons near Earth climbed higher yet, and the total amount of energy dissipated in auroras over the North and South Poles reached 1,400 gigawatts, nearly double the electric power generated in the United States.

At Halley Bay Station in Antarctica, failed radio contact prevented an airplane from taking off on Jan. 11. That same day, an AT&T communications satellite, Telstar 401, fell silent, and network broadcasts were switched to another satellite. Although Louis J. Lanzerotti of Lucent Technologies in Murray Hill, N.J., cautions that the satellite may have failed for other reasons, "the coincidence [with the magnetic storm] is uncanny."

George Gloeckler of the University of Maryland at College Park marvels over the ability of this medium-sized storm to wallop the magnetosphere. He theorizes that the cloud's density and its large magnetic field kept this parcel of solar gas intact and relatively unscathed as it passed through the sun's hot corona and out into space.

Data from Wind show that the atomic elements in the cloud had been ionized—stripped of their outermost electrons—by different amounts before leaving the sun's corona. This variation suggests that each element may serve as a thermometer for a different part of the corona, he adds. —*R. Cowen*



The influence of the magnetic cloud on Earth's magnetosphere. Before the cloud's arrival (top), the interplanetary magnetic field (heavy white lines) lies at an angle to Earth's looped field lines. When the cloud punches into the magnetosphere (center), it causes the interplanetary field to point south and squeezes the magnetosphere. As the cloud delivers its second punch (bottom), the interplanetary field points north and further compresses the magnetosphere.