

NASA balloons study atmosphere and cosmos

Goals include determining the origins of cosmic rays and electron microbursts.

From late May through mid-July, instruments aboard four NASA scientific balloons collected data on cosmic rays, clouds, the Sun's magnetic field, and more. Launched from Kiruna, Sweden, the balloons and their payloads were retrieved from locations across northern Canada after flights lasting three to seven days.

NASA's balloon program has sent scientific experiments into the stratosphere for more than 30 years and currently flies 10–15 balloons per year. Since the program's establishment, balloons continue to reach ever-higher altitudes.

One attraction of balloons is the price tag: Whereas the cost of space missions rises into the tens of millions to billions of dollars, balloons average a few million dollars apiece, says the acting chief of NASA's Balloon Program Office, Andrew Hamilton. They also provide a stable platform to test new technologies for later use on space missions. The *Compton Gamma Ray Observatory*, a photon-detecting satellite launched in 1991, for example, contained instruments that were first developed on scientific balloons. Made with a thin membrane of polyethylene, NASA balloons can carry payloads of up to about 3600 kilograms.

Studying from the sky

The first balloon of the recent campaign carried a superconducting magnet that measured the flux of high-energy cosmic-ray isotopes. Scientists are especially interested in two beryllium isotopes: One is stable, and the other is radioactive. The ratio of the isotopes impinging on the magnet provides insights on how long they took to reach Earth and thus the distance they traveled. Although cosmic rays were discovered more than 100 years ago, scientists have not pinpointed the source of the most powerful ones, says Nahee Park, a project scientist and an astrophysicist at Queen's University in Kingston, Ontario.



A BALLOON carrying the XL-Calibur experiment was prepped and launched on 9 July from the Esrange Space Center near Kiruna, Sweden. The experiment measured the polarization of Cygnus X-1, an x-ray source consisting of a black hole and a supergiant star.

The next balloon carried a telescope that measured the polarization of x rays emitted from Cygnus X-1, a supergiant-black hole binary system that is one of the brightest x-ray sources seen from Earth. The goal is to understand how such objects accelerate electrons, which then emit x rays. Another onboard instrument used spectropolarimetry—measurements of the polarization of light at different

wavelengths—to better define the size and shape of ice particles in clouds. And a third instrument measured Earth's total UV levels and ozone concentration.

Another balloon flew a 1 meter telescope, the largest solar telescope yet to leave the ground. Equipped with three spectro-polarimeters, it imaged the Sun's photosphere and chromosphere and probed the star's magnetic field. The

Sun's magnetic field is more complex than Earth's, says Sami Solanki, the experiment's principal investigator and the director of the Max Planck Institute for Solar System Research in Göttingen, Germany. And, he notes, the magnetic field drives all solar activity. The instruments examined sunspots, of which there were many because the Sun was near its solar maximum.

The final balloon carried an x-ray imager that took photos of short, intense bursts of electrons that entered Earth's atmosphere. Called electron microbursts, they collide with atmospheric gases and produce x rays that are reabsorbed too quickly to be observed from the ground. High-resolution images could provide insights into the origins of microbursts, says the principal investigator, Montana State University physics professor John Sample. The imager flew on NASA's largest scientific balloon, which clocks in at 1.7 million cubic meters—60 million cubic feet—the size of a football stadium. Nicknamed the "Big 60," the balloon reached an altitude of nearly 49 kilometers, a record for the agency's launches from Sweden. The altitude is limited by the buoyancy force of the helium inside the balloon and the total weight of the payload and balloon.

Weather limitations

NASA launches balloons from several sites around the world: the Columbia Scientific Balloon Facility in Texas; Fort Sumner, New Mexico; McMurdo Station in Antarctica; the Esrange Space Center in Sweden; Alice Springs, Australia; and Wanaka, New Zealand. Sites need to be isolated from the public for safety reasons, including potential balloon crashes. They are also situated where the wind speeds are low at ground level.

"Sweden is a fantastic place for us to launch because it is in the far northern latitude," says Hamilton. The flight path above the Arctic Circle experiences constant sunlight during the summer months, so it minimizes pressure changes and gas loss in the balloons. And solar experiments can collect data around the clock.

At takeoff, minimal clouds and no precipitation are a must, and a bit of wind helps push the balloon up. "Even a light drizzle is a no go," says Robert Mullenax, a meteorologist at the Columbia Scientific Balloon Facility. Rainy weather spread out the launch dates this year. The second balloon did not fly until six weeks after the first, and the



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NASA'S LARGEST BALLOON, measuring 1.7 million cubic meters, ascends toward the stratosphere carrying BOOMS, the Balloon Observation of Microburst Scales experiment. It took flight on 13 July from the Esrange Space Center near Kiruna, Sweden.

third and fourth followed in the next four days. Because NASA shared the range with the French national space agency, there were fewer available launch dates, says Mullenax.

Once the balloon is in flight, "there is a direct line of sight between the balloon and the ground, so operators can talk to it directly," says Hamilton. Data are stored on the payload and can be transmitted from the payload up to a satellite, then down to a control center. The method is useful when the balloon moves over a launch site's horizon and direct communication no longer works.

Controllers generate a risk map in the planned landing area to pinpoint where

to drop a payload. Once a place is picked, a signal is sent to detach the balloon from the payload. The payload falls away with a parachute. In the process, it rips a hole in the balloon, and the helium escapes. NASA recovers the balloon and the payload in the following weeks.

The research teams on the four campaign experiments will spend the next few years analyzing their data, says Hamilton. In the coming months, they plan to present first results at gatherings that include the 2024 American Geophysical Union meeting in Washington, DC, and the 2025 International Cosmic Ray Conference in Geneva.

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