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Watching a Solar Event from All Angles

An aurora appeared in the skies over British Columbia on 10 May 2024. Credit: NASA/Mara Johnson-Groh

In spring 2024, the night sky burst into a churning sea of colorful aurorae. As night crept across the globe, people from the Florida peninsula to the South Island of New Zealand marveled at the unusually widespread atmospheric light show, which lasted about 48 hours.

These serene aurorae arose from chaotic explosions on the Sun days earlier. From early May until late June, an area of the Sun with a temporarily elevated magnetic field, known as an active region, spewed a stream of charged particles and radiation into the solar system. Some large solar events can disable electrical components on spacecraft and rain charged particles onto planetary bodies—which sometimes affects power grids and satellite communications on Earth.

In this case, the storms were mostly harmless, but something besides their intensity set them apart: The largest fleet of solar probes yet was watching. Until recently, the only spacecraft closely observing the Sun were located on Earth's side of the solar system, leaving scientists in the dark about active regions once they rotated out of sight.

That changed when the European Space Agency launched its Solar Orbiter in 2020. In tandem with instruments aboard a constellation of other spacecraft, it has provided scientists with a way to view regions of the Sun throughout its 27-day rotation for the first time.

"It's enabling us to do this type of research that was not available 5 or 6 years ago," said George Ho, a space physicist at the Southwest Research Institute.

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Stitching together observations from both sides of the Sun, scientists vigilantly tracked the active region, gaining new insights into how powerful particles fire off the Sun's surface and wreak havoc within Earth's magnetic field.

"Solar Orbiter is providing us with this new information, especially for these intense and very energetic events," said David Lario, a research astrophysicist in the Heliophysics Science Division at NASA's Goddard Space Flight Center. Lario and his colleagues presented their research at AGU's Annual Meeting 2024 in Washington, D.C. (bit.ly/solar-observations).

Seeing the Sun in a New Light

Active regions can produce geysers of plasma known as coronal mass ejections (CMEs), explosions of radiation called solar flares, and shotgun blasts of high-speed particles, or radiation storms.

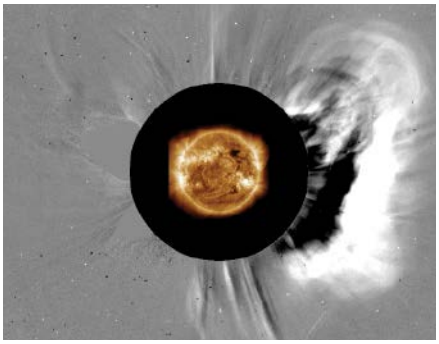
A single active region can spit out any number of these hazards, which is what happened last May and June, when one hyperactive zone repeatedly fired off CMEs and flares.

"It was quite an intense and prolific active region," Lario said.

CMEs and solar flares and storms can affect our planet more strongly when they occur on Earth's side of the Sun, but their effects are not completely absent when they occur on the Sun's farside. Hanging off the Sun are tentacles of magnetism called magnetic field lines. When these latch on to Earth's magnetic field, particles can spiral energetically along the field lines toward our planet's poles.

Solar particles can also reach our planet through other paths that are less understood.

Lario and his team combined observations of last spring's active region from Solar Orbiter; Solar Terrestrial Relations Observatory (STEREO) A, which observes Earth's side of the Sun; and three near-Earth satellites or



This composite image depicts the solar eruption that occurred on 11 May 2024. The inner (color) image was captured by the Solar Dynamics Observatory (SDO). The outer (black-and-white) image is a running difference image captured by the Solar and Heliospheric Observatory (SOHO). Credit: Inner image courtesy of NASA/SDO and the AIA science team; outer image courtesy of SOHO and the LASCO instrument; composite image courtesy of David Lario, created with JHelioviewer software

satellite networks: Geostationary Operational Environmental Satellites (GOES), the Solar and Heliospheric Observatory (SOHO), and the Solar Dynamics Observatory (SDO).

This suite of spacecraft exposed the active region's churnings for two full rotations that included the eruption of a powerful solar flare on 20 May.

Solar Orbiter allowed scientists to link the particles flooding out of the Sun's farside with those being observed by spacecraft closer to our planet, similar to observing both the source of a flood and its downstream effects.

When this flare occurred, its source region was positioned so far from Earth that the Sun's magnetic field lines likely wouldn't have strongly bridged the distance to our planet. Even so, the instruments detected charged particles near Earth.

The researchers proposed that instead of traveling along field lines, the energetic particles slowly pushed their way *across* them, heading toward Earth.

Solar Orbiter allowed scientists to link the particles flooding out of the Sun's farside with those being observed by spacecraft closer to our planet, similar to observing both the source of a flood and its downstream effects. This particle path gives scientists more to consider when imagining all the ways our star can affect—and even harm—Earth.

To date, Solar Orbiter has documented even stronger events than those observed last spring, but they occurred at times when Earth was not in the Sun's crosshairs.

"I guess we can say we dodged the biggest bullet," said Ho, who was not involved in the research.

By **Collin Blinder** (@collinblinder), Science Writer

A New Tornado Database Helps Researchers Worldwide

Over the past 70 years, more than 75,000 tornadoes have been recorded in the United States. Recordkeeping of these phenomena outside the United States has been largely fragmented, isolated in books, government databases, and research archives. But a new effort to scour as many publicly accessible records as possible is highlighting the scale of this hazard around the world.

In a new study, Malcolm Maas, an undergraduate student at the University of Maryland, College Park, and a team of tornado researchers compiled a tornado database that they hope will boost tornado research globally (bit.ly/tornado-database).

"The most developed countries have permanent, usually governmental, organizations tasked with compiling records of tornado occurrence, and thus have the most thorough datasets," Maas said. "Datasets for other countries mostly come from independent researchers who are limited to putting together reports from newspapers and websites."

The first challenge the group faced was that vast amounts of data about tornadoes that occurred in the United States prior to the creation of the National Weather Service in 1870 weren't available in a digital format. The researchers found records in a 1993 book by meteorologist Thomas P. Grazulis, *Significant Tornadoes, 1680–1991.* "There was a big effort involving a lot of people to go through the book and put it into a format that's accessible by geographic information systems," Maas said.

Some of the tornado locations were recorded as descriptions such as "five miles north of this town," he said. "But the town didn't exist anymore, so we had to pull out old maps to find it." More than a dozen people worked on the project at any one time, describing about 7,000 tornadoes in total.

For records of tornadoes occuring outside the United States, the team downloaded existing databases from the Internet. Sometimes tracking down a database instead involved sending someone an email to get their spreadsheet or accessing a Ph.D. thesis, Maas said.

"The tricky part is that every single dataset keeps track of this information in a slightly different way," Maas said. "This is the most challenging part, because you have to massage everything to get it to come together."

Nascent Research

Outside the United States, tornado research has only recently picked up speed. Records in these regions are harder to come by, and populations generally have less knowledge of the phenomenon.

A tornado touches down in Manitoba, Canada. Credit: Justin Hobson/Wikimedia, CC BY-SA 3.0 (bit.ly/ccbysa3-0)