Yihua Zheng: A new breed of weather forecaster

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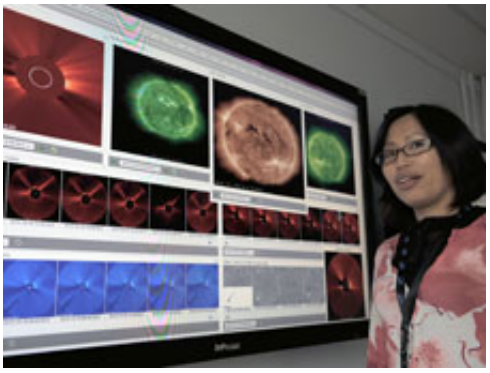

Research scientist Yihua Zheng stands in front of a computer screen at NASA's Goddard Space Flight Center's Coordinated Community Modeling Center that shows real-time images of the sun taken by three NASA spacecraft. Credit: NASA/Debbie McCallum

Solar storms sweeping from the Sun to Earth can damage anything from spacecraft to Earth's electrical utilities. The "Halloween Storm" of October 29, 2003 destroyed the $450 million Midori-2 research satellite. A storm on March 13, 1989 caused a collapse of the entire Quebec power grid. But such things can be avoided with enough advance warning.

It is 11:15 a.m. on a Friday morning at NASA's Goddard Space Flight Center in Greenbelt, Md. and time for Yihua Zheng's daily check on the sun. She walks from her small office down the hall to the Community Coordinated Modeling Center – a room much more dynamic and

colorful than its name suggests. Four large plasma screens on the wall show colorful basketball-sized images of the sun in real time. Other images feature data from particles as they flow from the sun to the earth, or a map of the sun's magnetic fields.

This is the heart and soul of Space Weather Services at NASA, the team that keeps tabs on the sun's activities for the entire Agency. It's a mini mission control center of a very new and modern kind. Instead of rows of computers and operators, Zheng controls the images on the screen with a single wireless keyboard and mouse that sits on a table in the middle of the room. She and one of her colleagues, research associate Antti Pulkkinen, scroll through the images on the screen.

"Click forward. Wait, now go back," Pulkkinen says. "Yes, it looks like there's something right there. There's something coming."

That "something" is a burst of material surging up through the sun's atmosphere. It's not much yet. It could leap up into a giant arch called a coronal loop and then die as quickly as it came. Or, it could become something larger and more powerful: a solar flare or a coronal mass ejection. These kinds of events can send radiation and particles hurtling through space to Earth, to other planets and out to the edge of our solar system. At best, such events can cause beautiful auroras. At worst they can damage satellites, power grids and even astronauts in space.

And it's Zheng's job to let everyone know when such a thing is headed towards Earth.

Inheriting the Math Gene

Zheng's path to NASA's Space Weather Services began in a rural part of Henan province in China, an area in the fertile Yellow River basin known for being the cradle of Chinese civilization as well as the

birthplace of Lao-Tsu and Taoism.

"My father was part of the generation that was wasted by the Cultural Revolution," says Zheng. "He's very good at math, but when he graduated in 1966, the year the Cultural Revolution began, there were 10 years where he couldn't go to college. He stayed and worked in the village."

In 1977, colleges were reopened. Zheng's father went back to school at the age of 30, by then married with two children, and become a math teacher. "I guess I got the math gene from my father," says Zheng.

She was encouraged in math and science ever since elementary school in a culture that honored the sciences. "Being a scientist is very cool and very sacred," says Zheng. "It's almost every child's dream to be a scientist when they grow up."

Zheng attended Beijing Normal University where she earned her undergraduate and master's degrees in physics. Then in January, 1997, she packed two small suitcases and boarded a plane to the United States. She landed at Logan Airport in Boston, got on a bus to New Hampshire and arrived at University of New Hampshire, cold, jetlagged, and unsure where her dorm was located.

Eventually someone pointed her in the right direction and the dorm became a fantastic introduction to grad school life. "Mostly I was just excited to be in a new environment," Zheng says. "The dorm was co-ed, it was a mixture of cultures and majors – a great opportunity to talk about things other than my own work." Indeed, this was where she met her husband, Robert Herschbach, a poetry grad student – whose room was right next door to hers.

Watching the Sun

Thirteen years later, Zheng, her husband, and their two children, now live in Maryland, where in early 2010 Zheng took a job at Goddard to lead NASA's Space Weather Services.

"Space Weather Services provides information to NASA's robotic missions," says Zheng. "We give the mission leads a heads up about what's going on whenever the sun does something that could be potentially harmful."

The process goes like this: Every morning, or whenever activity flares up, she and her colleagues discuss the sun and what it's doing. They study images of the sun from various NASA spacecraft such as the Solar Dynamics Observatory (SDO), the Solar TErrestrial RElations Observatory (STEREO) and the Solar and Heliospheric Observatory (SOHO).

The sun's activity is constant. On a calm day, the surface of the sun might simply show large swirls, a sunspot or even a long magnetic filament many times the size of the Earth. All of these features can lead to ejections, but no one is sure precisely how. Since about 2008, when solar activity was at its most recent minimum, such features have largely remained serene.

But the sun is waking up, and Zheng and her colleagues expect to see much more activity as the sun moves towards its maximum sometime in 2013.

One such day of activity was on Sunday, August 1. "Of course, these things have to happen on a weekend," laughs Zheng. The team spotted a large coronal mass ejection bursting out of the sun's atmosphere. Whenever they spot an ejection, the team immediately uses the tools at the Modeling Center to determine if it's headed toward Earth or other spacecraft such as Messenger, which is near Mercury. Solar flares can

reach Earth within a few hours, and coronal mass ejections within a day or two. However, most travel off in harmless directions.

"We try to get all the parameters from the data," she says. "We get the propagation direction and the speed and the angle, so we can put that all into a model and predict its impact on Earth or other planets and spacecraft."

Once they established a path for this CME – and yes, Earth looked like it was going to receive a direct hit – they sent out an alert to NASA's mission directors who in turn, initiated protocols to shield and protect any vulnerable spacecraft. In addition, Space Weather Services alerted various other organizations, such as the Air Force Weather Agency (AFWA), which incorporates NASA's information with other data into their own forecasts. In turn, AFWA regularly sends valuable information to Goddard to help test their models.

On August 3, about two and a half days later, Earth felt the disturbances from that ejection and experienced a moderate geomagnetic storm – meaning that the largest effect were some pretty auroras. That was what's known as a C-class CME. The next two highest are M- and X-class, which have a much higher chance of affecting power grids on Earth. More than likely, Space Weather Services will be spotting some of those soon.

Not only does Space Weather Services at Goddard help protect NASA's spacecraft fleet, it also leverages the latest research results and state-of-the-art models hosted at the Community Coordinated Modeling Center, to improve the U.S. government's prediction power.

For example, after an event like the one on Aug. 1, Zheng and the team track the event and compare its path to the models' predictions. By checking the accuracy of the models, the group constantly tests and

strives to improve the Space Weather Services' abilities.

Being able to predict solar weather even before the first sign of agitation on the sun's surface, however, remains out of reach. "Sometimes we see several flares in a row within a few hours," Zheng says. "And then we'll have days with nothing. Sometimes we see a CME after a solar flare. Sometimes we don't. We'd love to be able to predict these in advance, but that capability is just not there yet."

In the meantime, Zheng and the Space Weather Services team will be keeping a keen eye on the sun for us.

Provided by NASA's Goddard Space Flight Center

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