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Democracy Dies in Darkness

The sun may offer key to predicting El Niño, groundbreaking study finds

Scientists identify possible connection between the solar cycle and whether El Niño or La Niña is present

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When it comes to long-term hurricane forecasts, tornado predictions in the Plains or prospects for winter rain in California, you'll often hear meteorologists refer to El Niño or La Niña. They're phases in a cycle that starts in the tropics, spreading an influence across the globe and shaping weather both close to home and on different continents.

Now there's emerging research to suggest that cosmic rays, or positively charged, high-energy particles from space, might be the mechanism that flips the switch between phases. Cosmic rays come from outside our solar system, but the number and intensity that reach Earth hinge on the magnetic field of the sun.

A swing between El Niño and La Niña can have dramatic implications on global weather, bringing widespread shifts in precipitation and changes in temperature that can be problematic for vulnerable populations and have massive economic effects. In California, for instance, flood events during El Niño periods have proven 10 times more costly than those during La Niña events. In some parts of the world that depend heavily on agriculture and marine commerce, a flip from El Niño to La Niña can alter daily life.

A paper recently published in the journal Earth and Space Science links terminator events, or the end of a cycle on the sun, with the flip of a switch between El Niño and La Niña. The solar magnetic cycle, which is mirrored by fluctuations in the number of sunspots on the solar disk, is made up of roughly 22-year periods. Each span features two maxima and minima each of sunspot frequency and coverage — one of each magnetic polarity lasting roughly 11 years.

Sunspots behave like bar magnets: Imagine that the bar magnets rotate 180 degrees every 11 years.

Robert Leamon, a research scientist at the University of Maryland Baltimore County and one of the researchers credited with the discovery, said that, if more can be learned about the relationship between solar activity and the El Niño-La Niña cycle, or ENSO, it could be a game-changer for disaster preparedness.

In Australia, for example, El Niño events, associated with warming waters in the tropical Pacific Ocean, tend to substantially increase the risk of drought, while La Niñas, tied to cooling waters, increase rainfall and flooding.

“I have some attention from the Australians,” said Leamon in a recent phone call. “I think of the massive wildfires and droughts that dominated headlines before covid. I hope here will come a time soon that people recognize that, based on the phase of the solar cycle, there is a likelihood of there being El Niño or La Niña.”

How the relationship works

The key to this proposed solar-weather connection lies in “terminator” events, which spell the end of a solar cycle. Over the course of 22 years, bands of magnetism wrapping around the sun slowly migrate toward the equator, interacting with one another to produce sunspots. Those sunspots, or cool, dark discolorations on the sun’s surface, pulsate with magnetic energy, occasionally hurling it into space in solar storms that can spark displays of the northern lights.

There are two bands of magnetism per hemisphere on the sun. At solar minimum, both sets of bands are of equal and opposite strength, so the sun’s magnetic output flatlines. That drop changes the sun’s magnetic field, resulting in a decrease in the number of cosmic rays hitting Earth’s upper atmosphere.

Leamon explained that the flip from El Niño to La Niña usually comes a couple of months after a cycle's terminator. Since the terminator event is associated with a drop-off in cosmic rays, Leamon thinks the triggering mechanism is electrical in nature.

"Yes, it has to be," said Leamon, who suspects that the abrupt drop-off in conductivity of the upper atmosphere, or ease through which electrical energy flows through it, is having a chain reaction of effects that percolates down to the surface, where weather occurs.

"The solar effects on the upper atmosphere predispose the atmosphere to be in La Niña," he explained.

How the sun might flip the switch to La Niña

But that's where things get hazy — namely because Leamon and his colleagues have yet to establish an understanding of how a change in electrical field would influence the oceans and induce a La Niña. He does have a few hunches, though.

"It changes how the [large-scale atmospheric] waves that the likes of thunderstorms or clouds or moisture upwelling generate in the Pacific," Leamon said.

While the researchers didn't link the strength of a terminator event with the strength of an El Niño or La Niña pattern, they said there was a connection between bigger terminator events and a more dramatic shift from Niño to Niña.

"One of the things we've keyed into is, as this correlation gets stronger, whatever the mechanism is, produces the biggest swing," said Scott McIntosh, deputy director of the National Center for Atmospheric Research and a co-author on the project. "We're talking peak to peak El Niño into La Niña, … the peak of heating [in the east tropical Pacific] to trough of cooling."

Applications of the findings

If their theory holds up, it could become a big player in seasonal hurricane forecasts, because the first year after a shift toward La Niña often brings a busy Atlantic season. That's because water temperatures in the Atlantic remain comparatively mild, while upper-atmospheric winds are weak, allowing storms to develop without being shredded apart.

Leamon endeavors that, down the road, their techniques may allow for rough El Niño/La Niña forecasts up to a decade in advance.

"That's certainly better than a … seasonal outlook," he said.

Those long-range forecasts wouldn't just be of importance to scientists — they'd be of enormous use to urban planners, government leaders and even everyday citizens. Envision an emergency manager planning for hurricane season, an overseer of water resources in California deciding how much water to budget for a community over each of the next several years or a farmer in the Midwest considering whether to splurge and invest in drought-resistant crops.

Having advanced insight into the phase of El Niño or La Niña will be especially crucial in the years ahead, when accompanying changes in weather will piggyback upon a growing disruptive influence from human-induced climate change.

Reaction from climate and space scientists

Despite the strong correlation and the efforts ahead, the study has been met with mixed reviews from the climate science community. That's usually the case in science with any new, novel ways of looking at an issue. In this case, the multidisciplinary element — combining space weather with Earth's climate — blends two different communities together.

Mathew Barlow, a professor of climate science at the University of Massachusetts at Lowell, described the findings as a "potentially interesting empirical relationship," but said the proof is in the pudding when it comes to using those findings.

"We have yet to see whether the relationship, even if truly robust, can measurably improve current forecasts," he wrote in an email. "My own personal interest level would tick up noticeably based on … the identification of a plausible physical mechanism underlying the relationship."

Others point to the short time scale over which observations were used to draw conclusions. Among them is Mark Cane, a climate scientist at Columbia University and an El Niño expert.

“Intuition should warn you that roughly 60 years of data is not enough to tell you anything conclusive about a 22-year cycle,” he wrote.

Among space scientists, the research is beginning to catch on. Tamitha Skov, a space weather physicist who goes by “Space Weather Woman” on social media, described the work as “a [wake-up] call to terrestrial meteorologists and solar/space weather scientists.”

“I wouldn’t go so far as to call the results of this work a ‘conclusion’ per se — rather something akin to a steppingstone in a new direction,” wrote Skov in an email. “But to take the next step, these improved observations of the sun and those of the neutral atmosphere are only a part of the puzzle that needs to be pieced together.”

For now, it remains to be seen if the relationship will hold during the next solar cycle — but Leamon and McIntosh plan to continue forging ahead in hopes of next figuring out why the link between solar activity and El Niño and La Niña exists.

“It has sort of been an uphill struggle,” Leamon said. “But one man’s noise is another man’s data.”