Slow motion precursors give earthquakes the fast slip

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Matthew Siegfried inspects a GPS device, powered by a solar panel at Whillans Ice Plain. Grace Barcheck/Cornell University. Credit: Cornell University

At a glacier near the South Pole, earth scientists have found evidence of a quiet, slow-motion fault slip that triggers strong, fast-slip earthquakes many miles away, according to Cornell University research published in *Science Advances*.

During an earthquake, a fast slip happens when energy builds up underground and is released quickly along a fault. Blocks of earth rapidly slide against one another.

However, at an Antarctic glacier called Whillans Ice Plain, the earth scientists show that "slow slips" precede dozens of large magnitude 7 earthquakes. "We found that there is almost always a precursory 'slow slip' before an earthquake," said lead author Grace Barcheck, research associate in Earth and Atmospheric Sciences at Cornell University.

Barcheck said that these slow-slip precursors—occurring as far as 20 miles away from the epicenter—are directly involved in starting the earthquake. "These slow slips are remarkably common," she said, "and they migrate toward where the fast earthquake slip starts."

Observations before several large tsunami-generating magnitude 8 and 9 earthquakes on subduction zone faults suggest a similar process may have occurred, according to Patrick Fulton, assistant professor and Croll Sesquicentennial Fellow in the Department of Earth and Atmospheric Sciences.

As these faults are mostly offshore and deep underwater, and because it is difficult to know when or where a large earthquake will occur, the start of large earthquakes is generally hard to observe.

To overcome these challenges, the scientists placed GPS sensors above an icy glacial fault at Whillans Ice Plain, where large magnitude 7 earthquakes occur nearly twice a day over a 60-mile-wide area of the glacier.

Within a period of two months in 2014, the group captured 75 earthquakes at the bottom of the Antarctic glacier. Data from GPS stations indicated that 73—or 96% - of the 75 earthquakes showed a

period of precursory slow motion.

The data from the GPS tracking stations and surface seismometers allowed the team to identify how the slow precursory slip triggers the fast earthquake slip.

"Our group was a little surprised to see so many precursors," Barcheck said.

"In some cases, we can actually see the migration of the earthquake precursor towards where the earthquake begins."

"Before we pored over the data, I thought that if we saw any precursors before the earthquakes, they would be rare and in the same place as the earthquake epicenter," she said. "Instead, we found many slow-slip precursors—starting miles from the epicenters and migrating across the fault."

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More information: G. Barcheck et al, Migratory earthquake precursors are dominant on an ice stream fault, *Science Advances* (2021). DOI: 10.1126/sciadv.abd0105

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