Geophysicist's method could give months' warning of major earthquakes

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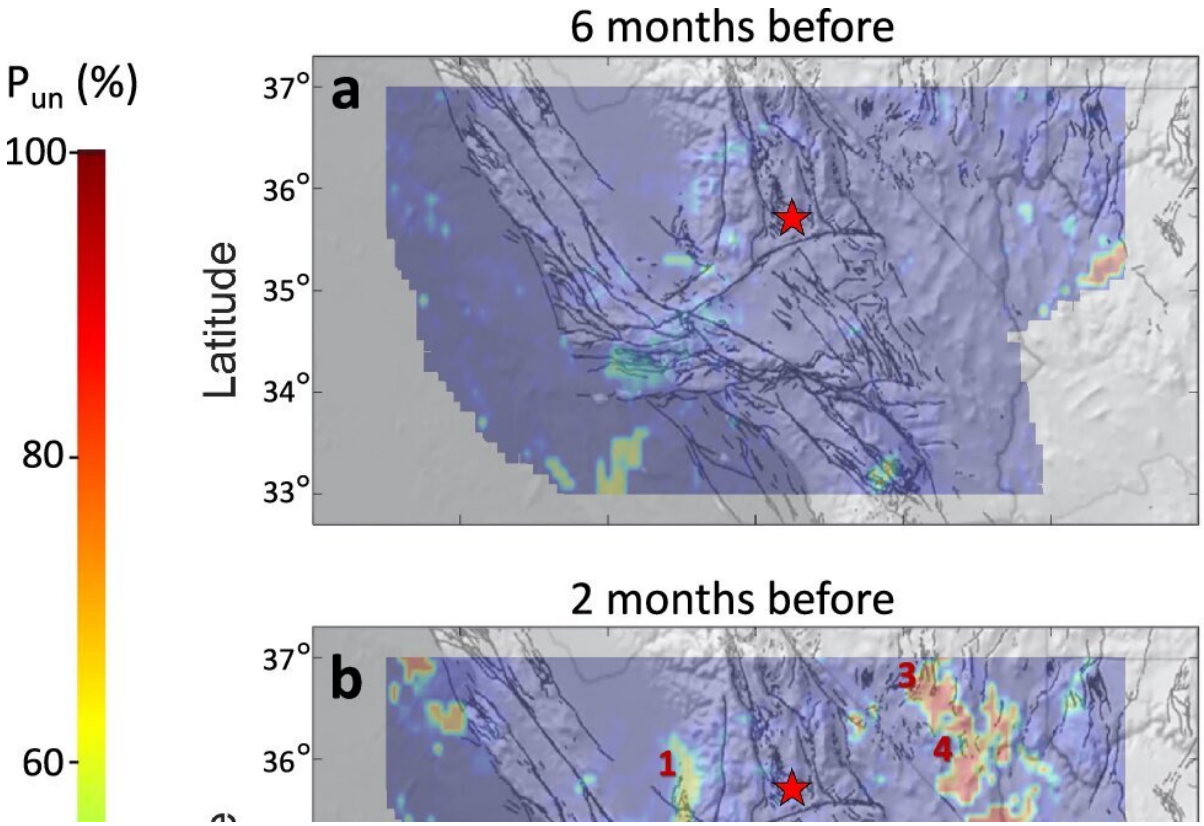

Spatiotemporal evolution of the maximum probability of unrest (Pun; or probability that a large-magnitude earthquake happens in 30 days or less) in Southern California. Credit: *Nature Communications* (2024). DOI: 10.1038/s41467-024-51596-z

The public could have days or months of warning about a major

earthquake through identification of prior low-level tectonic unrest over large areas, according to research by a University of Alaska Fairbanks scientist who analyzed two major quakes in Alaska and California.

The work was led by research assistant professor Társilo Girona of the UAF Geophysical Institute.

Girona, a geophysicist and data scientist, studies precursory activity of volcanic eruptions and earthquakes. Geologist Kyriaki Drymoni of the Ludwig-Maximilians-Universität in Munich, Germany, is a co-author.

The detection method, based on machine learning, was published Aug. 28 in *Nature Communications*.

"Our paper demonstrates that advanced statistical techniques, particularly machine learning, have the potential to identify precursors to large-magnitude earthquakes by analyzing datasets derived from earthquake catalogs," Girona said.

The authors wrote a computer algorithm to search the data to look for abnormal seismic activity. Algorithms are a set of computer instructions that teach a program to interpret data, learn from it and make informed predictions or decisions.

They focused on two major earthquakes: the 2018 magnitude 7.1 Anchorage earthquake and the 2019 Ridgecrest, California, earthquake sequence of magnitudes 6.4 to 7.1.

They found that approximately three months of abnormal low-magnitude regional seismicity had occurred across about 15% to 25% of Southcentral Alaska and Southern California prior to each of the two studied earthquakes.

Their research finds that unrest preceding major earthquakes is mostly captured by seismic activity with magnitude below 1.5.

The Anchorage earthquake occurred Nov. 30, 2018, at 8:29 a.m., with an epicenter located approximately 10.5 miles north of the city. It caused extensive damage to some roads and highways, and several buildings sustained damage.

Using their data-trained program, Girona and Drymoni found with the Anchorage earthquake that the probability that a major earthquake would happen in 30 days or fewer increased abruptly up to approximately 80% around three months before the Nov. 30 earthquake. The probability increased to approximately 85% just a few days before it occurred.

They had similar probability findings for the Ridgecrest earthquake sequence for a period beginning about 40 days prior to the onset of the quake sequence.

Girona and Drymoni propose a geologic cause for the low-magnitude precursor activity: A significant increase in pore fluid pressure within a fault.

Pore fluid pressure refers to the pressure of fluid within a rock. High pore fluid pressures can potentially lead to fault slip if the pressure is sufficient to overcome the frictional resistance between the blocks of rock on either side of the fault.

"Increased pore fluid pressure in faults that lead to major earthquakes changes the faults' mechanical properties, which in turn leads to uneven variations in the regional stress field," Drymoni said. "We propose that these uneven variations … control the abnormal, precursory low-magnitude seismicity."

Machine learning is having a major positive impact on earthquake research, Girona said.

"Modern seismic networks produce enormous datasets that, when properly analyzed, can offer valuable insights into the precursors of seismic events," he said. "This is where advancements in machine learning and high-performance computing can play a transformative role, enabling researchers to identify meaningful patterns that could signal an impending earthquake."

The authors state that their algorithm will be tested in near-real-time situations to identify and address potential challenges for earthquake forecasting. The method should not be employed in new regions without training the algorithm with that area's historical seismicity, they add.

Producing reliable earthquake forecasts has a "deeply important and often controversial dimension," Girona said.

"Accurate forecasting has the potential to save lives and reduce economic losses by providing early warnings that allow for timely evacuations and preparation," he said. "However, the uncertainty inherent in earthquake forecasting also raises significant ethical and practical questions."

"False alarms can lead to unnecessary panic, economic disruption, and a loss of public trust, while missed predictions can have catastrophic consequences," he said.

More information: Társilo Girona et al, Abnormal low-magnitude seismicity preceding large-magnitude earthquakes, *Nature Communications* (2024). DOI: 10.1038/s41467-024-51596-z

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