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University of California Los Angeles

Media Contacts:
Harlan Lebo
(310) 206-0511
(310) 825-2585
hlebo@college.ucla.edu

Stuart Wolpert
(310) 206-0511
(310) 825-2585
stuartw@support.ucla.edu

Earthquakes can be predicted months in advance

Major earthquakes can be predicted months in advance, argues UCLA seismologist and mathematical geophysicist Vladimir Keilis-Borok.

"Earthquake prediction is called the Holy Grail of earthquake science, and has been considered impossible by many scientists," said Keilis-Borok, a professor in residence in UCLA's Institute of Geophysics and Planetary Physics and department of earth and space sciences. "It is not impossible."

"We have made a major breakthrough, discovering the possibility of making predictions months ahead of time, instead of years, as in previously known methods," Keilis-Borok said. "This discovery was not generated by an instant inspiration, but culminates 20 years of multinational, interdisciplinary collaboration by a team of scientists from Russia, the United States, Western Europe, Japan and Canada."

The team includes experts in pattern recognition, geodynamics, seismology, chaos theory, statistical physics and public safety. They have developed algorithms to detect precursory earthquake patterns.

In June of 2003, this team predicted an earthquake of magnitude 6.4 or higher would strike within nine months in a 310-mile region of Central California whose southern part includes San Simeon, where a magnitude 6.5 earthquake struck on Dec. 22.

In July of 2003, the team predicted an earthquake in Japan of magnitude 7 or higher by Dec. 28, 2003, in a region that includes Hokkaido. A magnitude 8.1 earthquake struck Hokkaido on Sept. 25, 2003.

Previously, the team made "intermediate-term" predictions, years in advance. The 1994 Northridge earthquake struck 21 days after an 18-month period when the team predicted that an earthquake of magnitude 6.6 or more would strike within 120 miles from the epicenter of the 1992 Landers earthquake — an area that includes Northridge. The magnitude 6.8 Northridge earthquake caused some $30 billion in damage. The 1989 magnitude 7.1 Loma Prieta earthquake fulfilled a five-year forecast the team issued in 1986.

Keilis-Borok's team now predicts an earthquake of at least magnitude 6.4 by Sept. 5, 2004, in a region that includes the southeastern portion of the Mojave Desert, and an area south of it.

The team has submitted a description of its new short-term earthquake prediction research to Physics of the Earth and Planetary Interiors, a leading international journal in geophysics.

Prediction by this method is based on observations of small earthquakes that occur daily.

"We call our new approach, 'tail wags the dog,'" Keilis-Borok said. "For example, I recently had a sharp pain in a small area of my arm. The doctor sent me for an MRI to test whether this pain was preceded by an unfelt deterioration of the muscles in the whole arm during the last few months. If yes, the pain signals that the deterioration has escalated, so I am in trouble, and need urgent medical treatment. If not, I may have just hit something, the pain will subside, and it's of little concern. To detect these symptoms in order of their appearance — first emerged, first detected — could seem more natural but it is much more difficult; we would not know when and where to look for long-term deterioration.

"Similarly, we look backwards to make our earthquake predictions. First, we search for quickly formed long chains of small earthquakes. Each chain is our candidate to a newly discovered short-term precursor. In the vicinity of each such chain, we look backwards, and see its history over the preceding years — whether our candidate was preceded by certain seismicity patterns. If yes, we accept the candidate as a short-term precursor and start a nine-month alarm. If not, we disregard this candidate."

In seismically active regions, the Earth's crust generates constant background seismicity, which the team monitors for the symptoms of approaching strong earthquakes. Specifically, they consider the following four symptoms: small earthquakes become more frequent in an area (not necessarily on the same fault line); earthquakes become more clustered in time and space; earthquakes occur almost simultaneously over large distances within a seismic region; and the ratio of medium-magnitude earthquakes to smaller earthquakes increases.

One of the challenges in earthquake prediction has been to achieve a high proportion of successful predictions, while minimizing false alarms and unpredicted events. The team's current predictions have not missed any earthquake, and have had its two most recent ones come to pass.

Still, not all seismologists are convinced. "Application of nonlinear dynamics and chaos theory is often counter-intuitive," Keilis-Borok said, "so acceptance by some research teams will take time. Other teams, however, accepted it easily."

Keilis-Borok, 82, has been working on earthquake prediction for more than 20 years. A mathematical geophysicist, he was the leading seismologist in Russia for decades, said his UCLA colleague John Vidale, who calls Keilis-Borok the world's leading scientist in the art of earthquake prediction. Keilis-Borok is a member of the National Academy of Sciences, and the American Academy of Arts and Sciences, as well as the Russian Academy of Sciences, and the European, Austrian and Pontifical academies of science. He founded Moscow's International Institute of Earthquake Prediction Theory and Mathematical Geophysics, and joined UCLA's faculty in 1999.

His research team has started experiments in advance prediction of destructive earthquakes in Southern California, Central California, Japan, Israel and neighboring countries, and plans to expand prediction to other regions.

Vidale, interim director of the Institute of Geophysics and Planetary Physics, said, "Most seismologists agree that the ingredients of the 'tail wags the dog' method are sensible, but argue about the performance. However, the proof is in the pudding, and Professor Keilis-Borok's methods have now delivered several correct and impressive forecasts."

At the most recent stage of the research, four members of the team worked at UCLA on the "tail wags the dog" method for short-term prediction: Keilis-Borok; Peter Shebalin, geophysicist from the Russian Academy of Sciences and Institute of the Physics of the Earth in Paris; Purdue University mathematician and geophysicist Andrei Gabrielov; and UCLA researcher Ilya Zaliapin, whose field is analysis of complex systems.

Keilis-Borok's team communicates the predictions to disaster management authorities in the countries where a destructive earthquake is predicted. These authorities might use such predictions, although their accuracy is not 100 percent, to prevent considerable damage from the earthquakes — save lives and reduce economic losses — by undertaking such preparedness measures as conducting simulation alarms, checking vulnerable objects and mobilizing post-disaster services, Keilis-Borok said.

During the last few years, the team was supported by the James S. McDonnell Foundation.

How does Keilis-Borok compare this research with other discoveries he has made over his scientific career?

"I think this is the strongest result we have obtained so far," he said.

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