Scientists track motions of shifting plates using GPS sensors

7 June 2011, By Sandi Doughton

The Pacific Northwest is a restless place. The ground is being shoved by tectonic plates. Snow-capped volcanoes inflate and deflate in concert with the creep of molten rock. Coastlines bulge as tension builds on an offshore fault very like the one that snapped in Japan March 11.

Scientists now can track these minuscule motions as they happen, thanks to an expanded network of GPS sensors that covers the region like a blanket and beams back data almost instantly.

"If the Pacific Coast or Mount Rainier moves a couple of centimeters, we'll see it within five seconds," said Tim Melbourne, director of the Pacific Northwest Geodetic Array, or PANGA. Once the network's "real-time" functions are fully operational, PANGA will be able to pinpoint some earthquakes more quickly and accurately than traditional seismometers - and eventually issue warnings before destructive shaking hits cities or tsunami waves slam the shore.

Scientists use the GPS data to calculate the gradual buildup of strain on faults and identify the places most likely to pop. Dozens of the sensors also sit atop structures such as the Alaskan Way Viaduct and Howard Hanson Dam, on watch for unexpected slumps or jiggles.

"The Northwest is really leading the nation in this right now," said Melbourne, a geology professor at Central Washington University in Ellensburg, where PANGA is based.

PANGA's instruments are sophisticated variations on consumer GPS units, using the same constellation of satellites to triangulate positions. A decade ago, about 20 instruments were scattered between Oregon and the Canadian border. Each cost $50,000 and delivered data no more than once a day.

Today, 450 GPS units span the region, spitting out readings every second. Melbourne and his team are installing an additional 60 units this year. The price tag has dropped to about $8,000 for vastly more precise instruments. Operating in peak mode, PANGA can track ground motions as tiny as one-tenth of a millimeter. A station at Goldendale, Klickitat County, near the Columbia River, records the plateau's slight rebound every summer as snow melts off Mount Adams, 40 miles away.

GPS networks have revolutionized the study of geology by opening a window onto the tectonic forces that shape the landscape and underlie earthquakes and volcanism. When Mount St. Helens rumbled back to life in 2004, researchers relied on GPS to track the magma's movement and help forecast outbursts. Using a combination of GPS and sonar, Japanese scientists measured nearly 80 feet of slip on the underwater fault that triggered the quake and deadly tsunami in March.

GPS measurements also were key to the recent discovery of "silent" earthquakes that occur roughly every 14 months deep within the fault called the Cascadia Subduction Zone, where the seafloor dives under the continent. Running along the coast from Vancouver Island to Northern California, the fault has unleashed some of the world's biggest quakes - most recently a magnitude-9 in 1700.

Melbourne's GPS maps reveal the way the entire region is moving to the northeast at an average of half an inch a year - roughly the rate at which fingernails grow. But the motion isn't uniform. Forks, on the coast, moves an inch per year. Seattle shuffles half that much. In Central Washington, the creep slows to one-eighth of an inch.

The amounts seem insignificant, but the coast has moved more than 25 feet since the subduction zone last let loose 300 years ago, Melbourne said. "There's no doubt that fault is locked and loaded and accumulating strain." The silent earthquakes seem to be adding to that strain.

Until now, PANGA's main application has been for research. But the ability to record motion instantaneously, made possible by a grant from NASA, is turning the network into a tool with practical uses.

"It has transformed us into something akin to a seismic network," Melbourne said.

Seismometers measure ground shaking with exquisite sensitivity but can be overwhelmed by large earthquakes, said John Vidale, director of the Pacific Northwest Seismic Network at the University of Washington. It took Japanese scientists nearly an hour to realize the March 11 quake was magnitude-9, not the magnitude-8 their initial readings indicated. Partly because of that delay, the size of the tsunami took coastal communities by surprise.

Real-time GPS can measure the actual ground-heaving when a major fault ruptures, which can be translated into the size of the quake. "That will be very useful for earthquakes that are big enough," Vidale said.

But the network can only "see" quakes of magnitude-6 or greater. That's because churning out quick results drives accuracy down, so the system can't detect fault slips or other motions smaller than about 2 centimeters in real-time mode.

But quickly identifying the size and source of major earthquakes may help save lives by directing emergency responders, said Frank Webb, project manager at NASA's Jet Propulsion Laboratory. "The real-time system allows us to see the earthquake as it unfolds."

GPS also could be valuable for earthquake early-warning systems, such as the one that gave Tokyo residents a 25-second alert before the ground started heaving in March. Japan's system and one being tested in California use seismometers to detect the initial, less damaging vibrations from an earthquake, then broadcast alerts seconds or minutes before the more powerful shaking hits.

"With GPS," Vidale said, "you can see how the rupture is spreading over time." Factoring in that information could improve the speed and accuracy of warnings.

The same is true for tsunamis. Even though GPS signals can't penetrate water and directly measure the seafloor thrusting that triggers tsunamis, measurements of coastline movement can help estimate the size and path of the waves, said Vasily Titov, a tsunami modeler at the National Oceanic and Atmospheric Administration in Seattle.

But it remains to be seen how quickly the GPS information can be disseminated and translated into something useful, Titov cautioned.

Even more speculative is whether the use of GPS will lead to earthquake prediction. GPS can identify faults, like Cascadia, where strain is accumulating. Scientists can even infer the amount of cumulative strain from decades of slip. But they still have no way to predict the breaking point, Melbourne said.

APA citation: Scientists track motions of shifting plates using GPS sensors (2011, June 7) retrieved 25 September 2021 from https://phys.org/news/2011-06-scientists-track-motions-shifting-plates.html