Scientists use ears in the ground to monitor the eyes of hurricanes

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One of the biggest challenges of mitigating the danger of hurricanes is predicting where a storm will make landfall and estimating how powerful it will be when it hits. Researchers Dr. Toshiro Tanimoto and Annie Valovcin at University of California, Santa Barbara (UCSB) are looking at new methods to monitor the intensity of hurricanes using seismic data.

"Hurricanes have strong winds that cause pressure changes on the surface that generate seismic waves we can clearly see," said Tanimoto, a professor in the UCSB Department of Earth Science. "The EarthScope Transportable Array provided critical data for this project." The Transportable Array, part of EarthScope's USArray, is a set of 400 seismometers that were deployed in swaths across the U.S., each instrument occupying its site for two years before moving to the next swath. Many stations also include other earth science instruments; after 2011, all stations included barometers.

Using both the seismic and barometric capabilities of the instruments, Valovcin and Tanimoto are developing a new way of examining hurricanes. They call it beamforming backprojection, and it involves analyzing seismic waves recorded during a hurricane to locate the amplitude peak in the map, which shows where the seismic waves originated. They then compare the location from the seismic data to weather maps showing the location of the storm, checking if the locations match and if the seismically derived location follows the same path through time as the storm-map location.

For the cases where Valovcin and Tanimoto looked at data from hurricanes over land, seismic instruments detected the pressure change between the calm eye of the storm and the eyewall of the hurricane, where winds change from horizontal to dramatically vertical and there is strong oscillation in pressure.

For example, Hurricane Isaac, which hit Louisiana in 2012 and caused about $2.4 billion in damage, moved right through the Transportable Array. The stations recorded both seismic and barometric pressure, allowing the researchers to work directly with two types of data from the same event. "In Hurricane Isaac, 80 km from center the data showed a circular high-pressure pattern that we can directly see because of the Transportable Array. In hurricane literature, this is discussed, but it was exciting to see it," said Tanimoto.

In the next phase of the research, Tanimoto and Valovcin found when a hurricane is strong enough, it causes seismic waves detectable even when the storm is still out at sea. The method requires a widespread instrument array, since the seismic waves they study have very long wavelengths. Valovcin and Tanimoto used a different instrument array—the very densely spaced Southern California Seismic Network—to measure hurricanes from the East Coast to the middle of the Atlantic Ocean.

While a hurricane is out over the ocean, the data are less detailed than landfall data, showing the general location of the whole low-pressure system. It's the high-tech, landscape-size version of putting your ear on a railroad track to feel the vibrations of a train you can't yet see.

"This could add to what we do know, and in the long run, give us a remote way to monitor storms," said Valovcin. "For example, a barometer has to be in the hurricane to measure air pressure, but in the future, we may be able to detect pressure from a long distance through seismic readings."

Although this research is in early stages yet, it could open the door to a new way of tracking hurricanes. "We are now exploring what we can learn from this. It's a new way of looking at hurricanes. It shows the possibilities, once we understand the physical process," said Tanimoto.

Provided by University of California - Santa Barbara

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