New method can improve explosion detection

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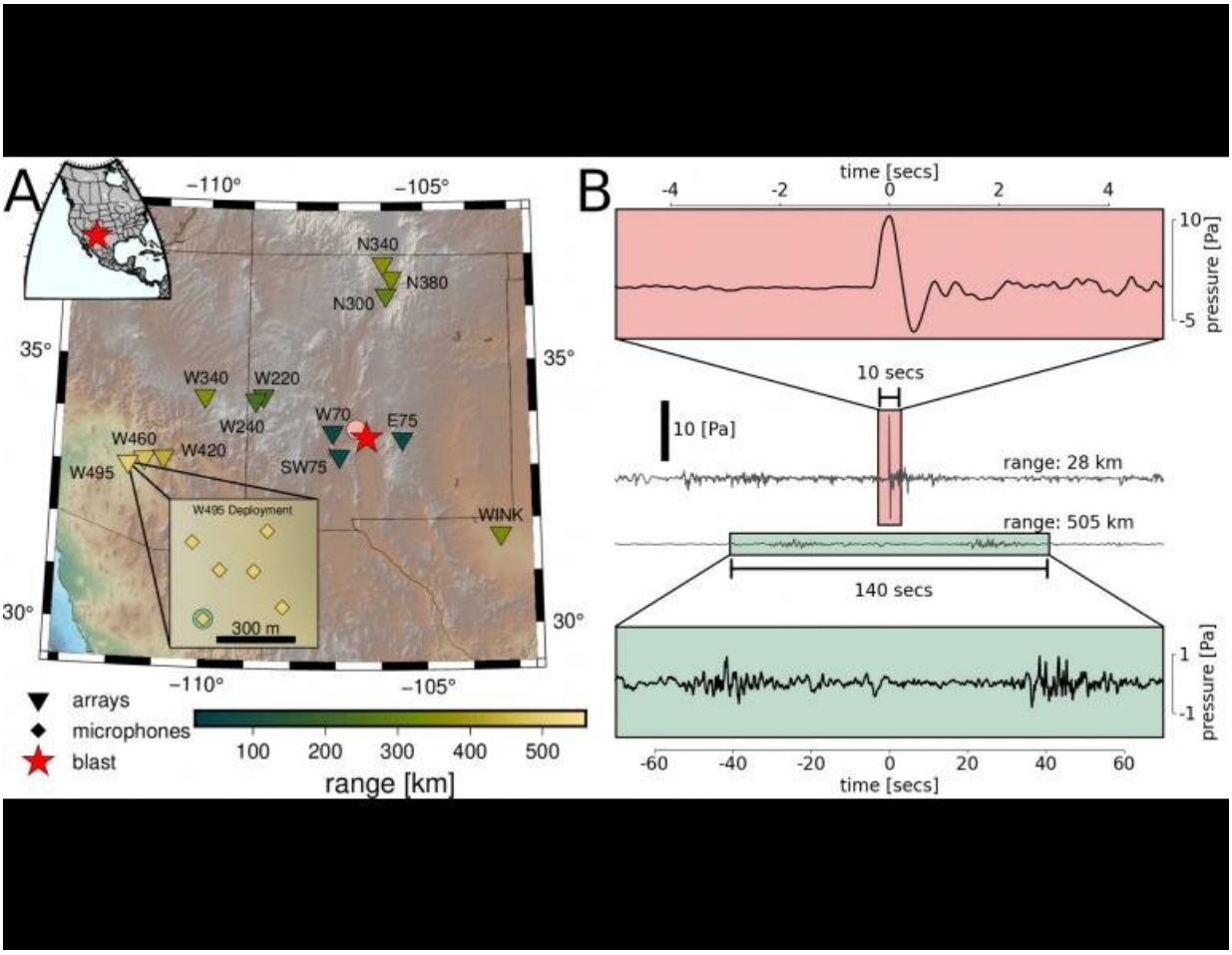

Map of the 13 regional infrasound arrays (inverted triangles) active during the Humming Roadrunner experiment in New Mexico. Credit: University of Alaska Fairbanks

Computers can be trained to better detect distant nuclear detonations,

chemical blasts and volcano eruptions by learning from artificial explosion signals, according to a new method devised by a University of Alaska Fairbanks scientist.

The work, led by UAF Geophysical Institute postdoctoral researcher Alex Witsil, was published recently in the journal *Geophysical Research Letters.*

Witsil, at the Geophysical Institute's Wilson Alaska Technical Center, and colleagues created a library of synthetic infrasound explosion signals to train computers in recognizing the source of an infrasound signal. Infrasound is at a frequency too low to be heard by humans and travels farther than high-frequency audible waves.

"We used modeling software to generate 28,000 synthetic infrasound signals, which, though generated in a computer, could hypothetically be recorded by infrasound microphones deployed hundreds of kilometers from a large explosion," Witsil said.

The artificial signals reflect variations in atmospheric conditions, which can alter an explosion's signal regionally or globally as the sound waves propagate. Those changes can make it difficult to detect an explosion's origin and type from a great distance.

Why create artificial sounds of explosions rather than use real-world examples? Because explosions haven't occurred at every location on the planet and the atmosphere constantly changes, there aren't enough real-world examples to train generalized machine-learning detection algorithms.

"We decided to use synthetics because we can model a number of different types of atmospheres through which signals can propagate," Witsil said. "So even though we don't have access to any explosions that

happened in North Carolina, for example, I can use my computer to model North Carolina explosions and build a machine-learning algorithm to detect explosion signals there."

Today, detection algorithms generally rely on infrasound arrays consisting of multiple microphones close to each other. For example, the international Comprehensive Test Ban Treaty Organization, which monitors nuclear explosions, has infrasound arrays deployed worldwide.

"That's expensive, it's hard to maintain, and a lot more things can break," Witsil said.

Witsil's method improves detection by making use of hundreds of single-element infrasound microphones already in place around the world. That makes detection more cost-effective.

The machine-learning method broadens the usefulness of single-element infrasound microphones by making them capable of detecting more subtle explosion signals in near real-time. Single-element microphones currently are useful only for retroactively analyzing known and typically high-amplitude signals, as they did with January's massive eruption of the Tonga volcano.

Witsil's method could be deployed in an operational setting for national defense or natural hazards mitigation.

More information: Alex Witsil et al, Detecting Large Explosions With Machine Learning Models Trained on Synthetic Infrasound Data, *Geophysical Research Letters* (2022). DOI: 10.1029/2022GL097785

Provided by University of Alaska Fairbanks

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