Breaking the rules for how tsunamis work

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The earthquake zones off of certain coasts—like those of Japan and Java—make them especially vulnerable to tsunamis, according to a new study. They can produce a focusing point that creates massive and devastating tsunamis that break the rules for how scientists used to think tsunamis work.

Until now, it was largely believed that the maximum tsunami height onshore could not exceed the depth of the seafloor. But new research shows that when focusing occurs, that scaling relationship breaks down and flooding can be up to 50 percent deeper with waves that do not lose height as they get closer to shore.

"It is as if one used a giant magnifying lens to focus tsunami energy," said Utku Kanoglu, professor at the Middle East Technical University and senior author of the study. "Our results show that some shorelines with huge earthquake zones just offshore face a double whammy: not only they are exposed to the tsunamis, but under certain conditions, focusing amplifies these tsunamis far more than shoaling and produces devastating effects."

The team observed this effect both in Northern Japan, which was struck by the Tohoku tsunami of 2011, and in Central Java, which was struck by a tsunami in 2006.

"We are still trying to understand the implications," said Costas Synolakis, director of the Tsunami Research Center at the USC Viterbi School of Engineering and a co-author of the study. "But it is clear that

our findings will make it easier to identify locales that are tsunami magnets, and thus help save lives in future events."

During an earthquake, sections of the sea floor lift up while others sink. This creates tsunamis that propagate trough-first in one direction and crest-first in the other. The researchers discovered that on the side of the earthquake zone where the wave propagates trough-first, there is a location where focusing occurs – strengthening it before it hits the coastline with an unusual amount of energy that is not seen by the crest-first wave. Based on the shape, location, and size of the earthquake zone, that focal point can concentrate the tsunami's power right on to the coastline.

In addition, before this analysis, it was thought that tsunamis usually decrease in height continuously as they move away from where they are created and grow close to shore, just as wind waves do. The study's authors instead suggest that the crest of the tsunami remains fairly intact close to the source.

"While our study does not preclude that other factors may help tsunamis overgrow, we now know when to invoke exotic explanations for unusual devastation: only when the basic classic wave theory we use does not predict focusing, or if the focusing is not high enough to explain observations," said Vasily Titov, a researcher at NOAA's Pacific Marine Environmental Laboratory and study co-author.

More information: The study was published online on Feb. 27 by *Proceedings of the Royal Society, Series A*.

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