Researchers model tsunami hazards on the Northwest coast

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The coast of the Pacific Northwest from space. Credit: SeaWiFS Project, NASA/Goddard Space Flight Center, ORBIMAGE

Recent press and social media coverage have reminded residents of the Pacific Northwest that they live in a seismically active region. Stretching offshore from northern California to British Columbia, the Cascadia subduction zone could slip at any time, causing a powerful earthquake and triggering a tsunami that would impact communities along the coast.

Scientists from multiple disciplines at the University of Washington and other institutions are learning more about this hazard. Dozens of UW scientists are part of the M9 Project, a research endeavor funded by the National Science Foundation to study the Cascadia subduction zone and communicate information about potential hazards to government officials and the public. Key goals of the M9 Project include mathematical modeling of tsunami waves, which tries to predict where and how an earthquake-triggered wave will affect the coast.

Two University of Washington scientists—applied mathematics professor Randy LeVeque and affiliate professor of Earth and space sciences Frank Gonzalez—recently talked about how they model tsunami hazards along the Northwest coast.

How did you become involved in the field of tsunami modeling?

Randy LeVeque: In 2003 or 2004, my former doctoral student Dave George started applying Clawpack—a software we developed here to model wave propagation—for tsunamis just before the Indian Ocean tsunami happened. I started working with Frank Gonzalez, who at the time was the director of NOAA's Center for Tsunami Research here in Seattle. Frank had all of these contacts in the tsunami community and the hazard community because he had already been working on this for 30 years.

How do you model tsunami danger on a stretch of coastline?

LeVeque: We use GeoClaw, the tools we adapted from Clawpack to be used specifically for geophysical modeling. We originally geared GeoClaw for tsunamis, but it's also been used for storm surge modeling and there's a version now for landslides and debris flows.

What information do you put into your models?

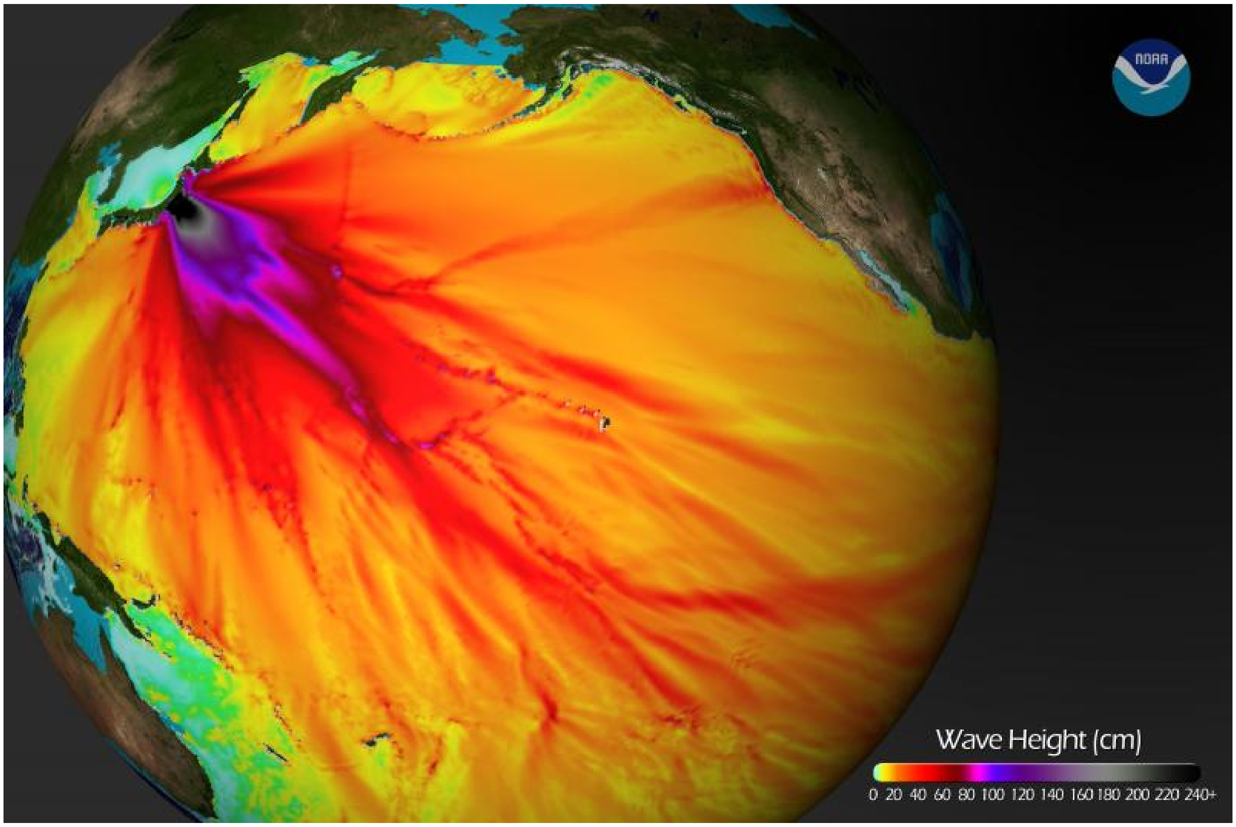
LeVeque: The software is set up so you can easily put in a new region just by having a fine-scale topographic digital elevation model for that particular region. The U.S. is pretty good about doing fine-scale mapping down to a resolution of about 33 feet along the coast. We also need some representation of what the earthquake will be and how the seafloor is moving, because the motion of the seafloor is what's driving the tsunami.

Have recent earthquakes and tsunamis helped improve your models?

Frank Gonzalez: Very much so. For example, after the 2011 Tohoku earthquake and tsunami in Japan, geologists and seismologists learned that splay faulting may be more common than was believed before.

What is splay faulting?

Gonzalez: Ordinarily in an earthquake, there's a lot of slippage far below the ocean floor and it simply raises up the ocean bottom. But in the case of Tohoku, the rupture extended all the way up to the ocean floor—these are splay faults, which are angled to the main fault, and where the seafloor itself can rupture. And it's believed that that's a very efficient mechanism for generating large tsunamis. We're now including splay faulting as an option for models.



Wave height of the tsunami from the 2011 Tohoku earthquake off the east coast of Japan. Credit: NOAA

What areas along the Washington coast have you modeled?

LeVeque: Pretty much up and down the coast. We did some modeling of La Push and Neah Bay to develop tsunami inundation maps, for example. We're just now starting models for some communities in the Strait of Juan de Fuca—like Port Townsend and Port Angeles.

How would a tsunami from a large offshore earthquake affect Puget Sound?

LeVeque: The tsunami would be coming from the open ocean, so it would come in through the Strait of Juan de Fuca and come down to Puget Sound. We're just starting to look down there. But by the time the tsunami gets down into Puget Sound it will be smaller than on the coast.

Gonzalez: But in the case of a big magnitude-9 offshore earthquake, that will create shaking severe enough in Puget Sound to trigger small to moderate landslides, and they'll create tsunamis as well.

So, is the tsunami danger in Puget Sound not as bad as the open coast?

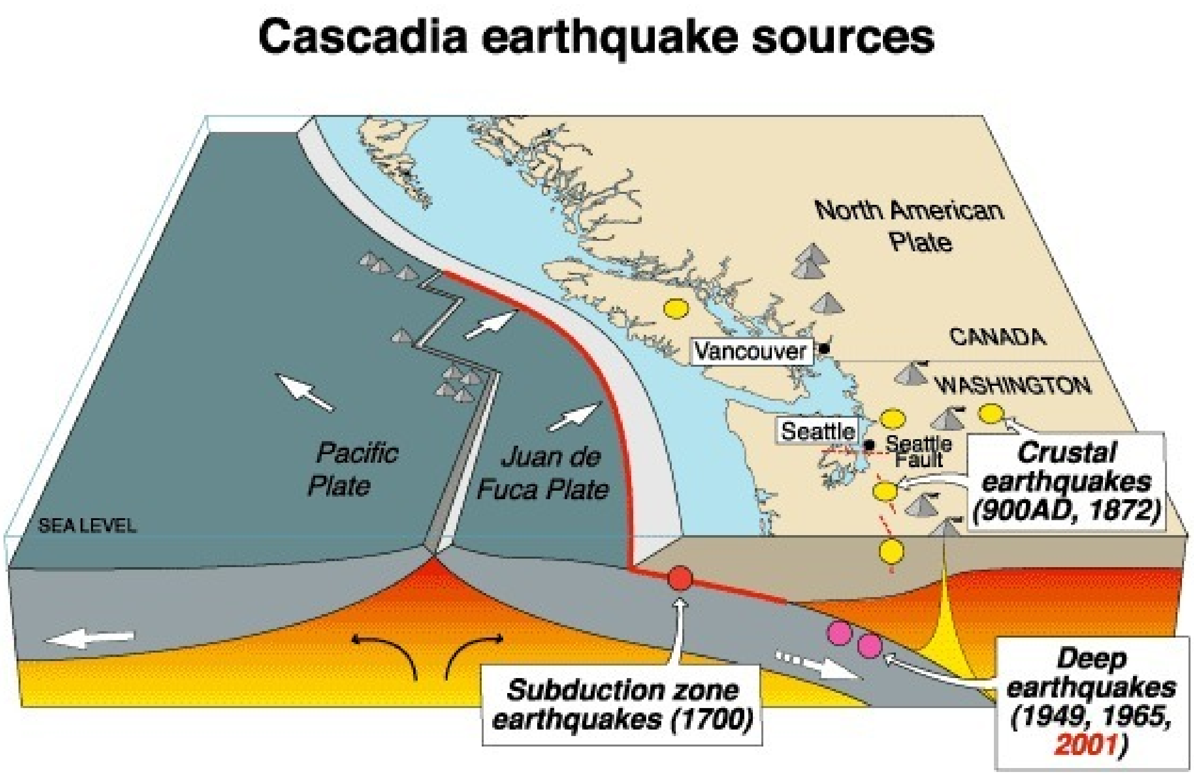
LeVeque: Not nearly as much danger during an earthquake along the Cascadia subduction zone. But there's also the Seattle Fault, which runs right across the Sound, and others like the Tacoma Fault and the South Whidbey Island Fault. These faults are actually under Puget Sound and can have big earthquakes and cause tsunamis.

Gonzalez: That Seattle Fault tsunami has been modeled by others. That wave is quite severe, quite high. And the magnitude used to generate that wave is only about 7.5, as opposed to a magnitude-9 earthquake off the coast. And since those models for the Seattle Fault were published, there've actually been many more Puget Sound faults discovered.

How useful can your models be for communities in tsunami hazard areas?

Gonzalez: People take the kind of information Randy and I provide about tsunami hazard and assess the vulnerability of communities, and emergency management officials assess preparedness efforts.

LeVeque: In Westport they just had their groundbreaking in January to build a new vertical evacuation structure for tsunamis at Ocosta Elementary. It happens to sit on a relatively high part of that peninsula. From the modeling that we did, it looks like under a worst-case scenario that the area right around the school would have only a couple of feet inundation.



Geology of the Cascadia subduction zone. Credit: USGS

What would you like to improve or change about your approach to tsunami modeling?

LeVeque: Well, they're based on particular models of possible earthquakes, but we could always get one that's different or even worse. So, we're also looking at doing probabilistic hazard assessments of the coast. That's where we don't just look at the worst case. We look at many scenarios.

Gonzalez: That approach gets us results to say that one area has a much higher probability of flooding than another area. Eventually I think emergency managers will want those kinds of maps. It provides a more sophisticated view of the hazard. Not just worst-case, but what the probability is of each scenario and if there is a more likely case we should prepare for instead.

LeVeque: That's useful information to know if you're deciding where to put a hospital or road.

What do you think the public most misunderstands about tsunami modeling?

LeVeque: Most people probably don't understand how little is known about what the next earthquake might look like—all the sources of uncertainty that you have to deal with to come up with any model of what a tsunami will do. That's why one big goal of the M9 Project is to develop better probabilistic techniques for both tsunamis and earthquakes, and to figure out how to communicate those probabilities to the public and emergency managers.

Gonzalez: There is a big educational effort that is ongoing. Randy and I go to community meetings and handle questions on the science of tsunami risks and give short presentations. You have to be really, really careful and specific in sending a message to the public.

What do you like best about your work on tsunami

modeling?

LeVeque: It's a discovery topic, with people learning things all the time. That makes it interesting.

Gonzalez: What's really fun about this is you're on the cutting edge, and you're collaborating outside of your field. It's very interdisciplinary. You're talking to geophysicists, civil engineers, emergency managers. So there's a lot of variety, and you're developing projects that are meaningful—they'll save lives and property.

Provided by University of Washington

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