New computer model better explains workings of tsunamis

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Indian Ocean (Jan. 2, 2005). A village near the coast of Sumatra lays in ruin after the Tsunami that struck South East Asia. Image: Wikipedia

(PhysOrg.com) -- Because they occur so infrequently, more often than not in areas where they aren't recorded very well, scientists have been working nearly blind in trying to understand how tsunamis work once they reach shore. Now, Frederic Dias from University College in Dublin and his team of mathematical and computer scientists have developed a computer simulation that they believe explains how tsunamis work once they reach shore. They have described their findings in *Physical Review Letters*.

Up to now, scientists have been able to mimic how a tsunami starts, and also how it travels across vast ocean distances. What they haven't been able to do, is mimic how they behave once they reach the shore, which is of course, the most important part, because that's where they cause damage and loss of life. One of the stumbling blocks is the preconceived notion that it's the first wave that is the worst.

Dias, et al, show with their model, that this is not generally the case. They say that in fact, the second, third or even fourth wave can be the worst; this is because when the first wave hits it goes up on shore as far as its energy will carry it, then recedes back into the ocean. When it recedes, it carries with it some energy, thus it doesn't just gently ebb back to the ocean's edge, it recedes quite a ways back out to sea, which means, it has some potential energy in it, so, like a pendulum, it has to fall back towards the shore and when it does, if it just happens to coincide with the next tsunami wave, the combined energy of both will cause that next wave to run both higher up into the air (the run-up) and farther up the shore (inundation).

All of this is of course very heavily impacted by the slope of the ocean floor leading up to the shoreline. If there is a long leisurely slope, the energy of the wave will be spread out, meaning a low run-up. If the ocean floor has a sudden dramatic climb just as it reaches shore however, all that energy in the wave has nowhere to go but up, creating an enormous run-up, with sometimes devastating effects. Also impacting how a tsunami behaves once it hits shore is the makeup of the shore itself. Loose ground for example, might create landslides that can work the same way as the waves themselves, adding potential energy to the mix. And of course actual shorelines (and the ocean floor leading to them) have all sorts of personal characteristics that can lead to either an increase or decrease in run-up.

When Dias and his team added parameters to their model to mimic actual tsunamis, they found results that appeared to coincide with what had actually occurred, giving more credence to their findings. Even so, they are not suggesting that their model fully answers all the questions oceanographers have about tsunamis, but it's clear their research has shed new light on how they behave and will likely lead to more accurate forecasts for tsunami impacts and the design of early warning systems.

More information: Local Run-Up Amplification by Resonant Wave Interactions, *Phys. Rev. Lett.* 107, 124502 (2011)
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Abstract
Until now, the analysis of long wave run-up on a plane beach has been focused on finding its maximum value, failing to capture the existence of resonant regimes. One-dimensional numerical simulations in the framework of the nonlinear shallow water equations are used to investigate the boundary value problem for plane and nontrivial beaches. Monochromatic waves, as well as virtual wave-gage recordings from real tsunami simulations, are used as forcing conditions to the boundary value problem. Resonant phenomena between the incident wavelength and the beach slope are found to occur, which result in enhanced run-up of nonleading waves. The evolution of energy reveals the existence of a quasiperiodic state for the case of sinusoidal waves. Dispersion is found to slightly reduce the value of maximum run-up but not to change the overall picture. Run-up amplification occurs for both leading elevation and depression waves.

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