New model simulates the tsunamis caused by iceberg calving

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A team of scientists has developed a new model for simulating both iceberg calving and the tsunamis that are triggered as a result. Their method can help improve hazard assessment in coastal areas and refine the empirical calving models used to evaluate rising sea levels.

Johan Gaume, an EPFL expert in avalanches and geomechanics, has turned his attention to ice. His goal is to better understand the correlation between the size of an iceberg and the amplitude of the tsunami that results from its calving. Gaume, along with a team of scientists from other research institutes, has just unveiled a new method for modeling these events. Their work appears in *Communications Earth & Environment*.

These scientists are the first to simulate the phenomena of both glacier fracture and wave formation when the iceberg falls into the water. "Our goal was to model the explicit interaction between water and ice—but that has a substantial cost in terms of computing time. We therefore decided to use a continuum model, which is very powerful numerically and which gives results that are both conclusive and consistent with much of the experimental data," says Gaume, who heads EPFL's Snow Avalanche Simulation Laboratory (SLAB) and is the study's corresponding author. The other institutes involved in the study are the University of Pennsylvania, the University of Zurich, the University of Nottingham, and Switzerland's WSL Institute for Snow and Avalanche Research.

Improving calving laws

The scientists' method can also provide insight into the specific mechanisms involved in glacial rupture. "Researchers can use the results of our simulations to refine the calving laws incorporated into their large-scale models for predicting sea-level rises, while providing detailed information about the size of icebergs, which represent a sizeable amount of mass loss," says Gaume.

Calving occurs when chunks of ice on the edge of a glacier break off and fall into the sea. The mechanisms behind the rupture generally depend on how high the water is. If the water level is low, the iceberg breaks off from the top of the glacier. If the water level is high, the iceberg is longer and breaks off from the bottom, before eventually floating to the surface owing to buoyancy. These different mechanisms create icebergs of different sizes—and therefore waves of different amplitudes. "Another event that can trigger a tsunami is when an iceberg's center of gravity changes, causing the iceberg itself to rotate," says Gaume. "We were able to simulate all these processes."

In Greenland, the scientists placed a series of sensors at Eqip Sermia, a 3-km-wide outlet glacier of the Greenland ice sheet that ends in a fjord with a 200 m ice cliff. Back in 2014, an iceberg measuring some 1 million m^3 (the equivalent of 300 Olympic-sized swimming pools) broke off the front of the glacier and produced a 50 m-high tsunami; the wave was still 3 m high when it reached the first populated shoreline some 4 km away. The scientists tested their modeling method on large-scale field datasets from Eqip Sermia as well as with empirical data on tsunami waves obtained in a laboratory basin at the Deltares institute in the Netherlands.

Projects in the pipeline

Glacier melting has become a major focus area of research today as a result of global warming. One of the University of Zurich scientists involved in the study kicked off a new research project this year with funding from the Swiss National Science Foundation. This project will investigate the dynamics of Greenland's fastest-moving glacier, Jakobshavn Isbrae, by combining data from individual field experiments in Greenland with the results of simulations run using the SLAB model. "Our method will also be used to model chains of complex processes triggered by gravitational mass movements, such as the interaction between a rock avalanche and a mountain lake," says Gaume.

More information: Joshuah Wolper et al, A glacier–ocean interaction model for tsunami genesis due to iceberg calving, *Communications Earth & Environment* (2021). DOI: 10.1038/s43247-021-00179-7

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