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Building resilient coastlines: A comprehensive physics-based tsunami hazard model for Aotearoa New Zealand

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Tsunamis have the potential to cause catastrophic damage to coastal communities. In Aotearoa New Zealand, where 3.5 million people reside within 5 km of the coast, the threat of experiencing a tsunami within their lifetime is a stark reality. Although these events are infrequent with recurrence intervals of hundreds of years, New Zealand faces an elevated risk due to its location within the tectonically active Pacific, where over 80% of the world's tsunamis occur. The region has experienced over seventy tsunamis in the past two-hundred years, with five of these causing devastating impacts to coastal communities and leaving an indelible mark on the landscape due to wave amplitudes surpassing 5 m at the coast. Recent studies, while crucial, have predominantly focused on assessing the tsunami hazard from local sources, recognising their immediate threat. However, to comprehensively assess the overall tsunami hazard to Aotearoa, we must fully account for the regional and distant sources also. This is informed by the harsh reality that some events, such as the 1877 Northern Chile and the 2004 Indian Ocean tsunamis, have inflicted staggering death tolls in distant locations, emphasising their paramount significance in our hazard assessment efforts.

In this talk, I will present our innovative hybrid tsunami hazard model designed for Aotearoa New Zealand. We use observations of accumulated earthquake slip on active faults in the Pacific alongside established earthquake laws to ensure that we capture a wide variability of seismogenic tsunami sources to complement the limited historical and instrumental records. Due to recent computational advancements, we can now calculate the seafloor deformation generated from hundreds of synthetic tsunami sources across twenty subduction zones and simulate the tsunami wave propagation to the coast of New Zealand. For each source, we can estimate the wave amplitudes and timing of potential tsunamis and use these metrics to calculate the hazard that these regional and distant sources pose over common return periods. Each part of the model, from the source characteristics to the wave propagation has been independently tested and benchmarked with recorded events to ensure the rigor of the research.

Our hybrid approach of blending observation-driven, physics-based, and probabilistic methodologies offers a comprehensive approach to assessing the full range of earthquakes that could cause a tsunami at the shores of New Zealand. Our work, alongside the recent research carried out on the local tsunami sources will accelerate Aotearoa New Zealand's natural hazard resilience from Pacific earthquake-generated tsunami sources and will pave the way for other tsunami mechanisms to be incorporated into the model analysis, an urgent need given that these hazardous events do not occur independently. We look forward to having the opportunity to share our Aotearoa New Zealand tsunami hazard model with the wider tsunami community in Europe and discuss pathways that our combined research could follow to help build safer and more resilient coastal communities, globally.