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Improving Rapid Earthquake Characterization of Tsunami Early Warning for Aotearoa New Zealand and the Southwest Pacific

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Aotearoa New Zealand, located in the Southwest Pacific Ocean, is vulnerable to tsunamis. The Rapid Characterization of Earthquakes and Tsunami (RCET) project, led by GNS Science (Geological and Nuclear Sciences), aims to improve rapid analysis of large local and regional earthquakes to determine their tsunamigenic potential. Within this project, we are focusing on a simple but rapid and robust estimation of the location and magnitude of an earthquake by refining automated moment tensor inversions. A method to estimate these parameters is the W-phase inversion. Unlike simpler automated magnitude determinations routinely used to analyze earthquakes in New Zealand, the W-phase does not saturate with magnitude, making it better at quantifying Mw for the largest earthquakes. It also provides the centroid, rather than the hypocentre of an earthquake, allowing better estimation of the spatial distribution of shaking impacts. For these reasons we are developing synthetic earthquake waveforms to refine W-phase inversions for Mw ~5+ earthquakes in New Zealand and Mw 6.5+ earthquakes in the southwest Pacific, including the Hikurangi-Kermadec subduction zone. The current tsunami early warning procedure calculates W-phase solutions within 20 minutes of earthquake origins and aims to reduce it to 5-10 minutes.

With a large set of high-magnitude events adapted to New Zealand and Hikurangi-Kermadec context, we will refine our understanding of the limits regional W- phase inversion. We are focusing on the minimum magnitude we can accurately estimate, the minimal station coverage required and the complexity of the source that can be apprehended by the W-phase.

To improve W-phase solutions for New Zealand, we simulate earthquake waveforms using a

catalogue of synthetic ruptures on the Hikurangi-Kermadec subduction zone, produced by RSQSim (Rate and State Earthquake Simulator) under the RNC2 (Resilience to Nature's Challenge 2) project. To generate the waveforms, we use SPECFEM3D Globe, a finite element method-based software that simulates wave propagation through a global velocity model of the Earth. The simulated waveforms are then postprocessed and inverted to obtain a W-phase solution. Preliminary results define which minimum waveform resolution is required to observe a W-phase and that a simple centroid moment tensor source provides an adequate W-phase solution.