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Simulation of local tsunami and evacuation of urban areas, informed by population exposure analysis and studies of tsunami evacuation behaviour.

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We demonstrate a methodology for the integration of hazard, population and evacuation modelling to optimise evacuation planning. Deterministic tsunami simulations are carried out to define the spatial and temporal evolution of tsunami inundation onshore in the several hours following local-source subduction zone earthquakes. Exposure of an urban population to the hazard and options for risk mitigation (specifically through evacuation) are then assessed, demonstrating how tsunami simulation and evacuation simulations can be combined for effective tsunami evacuation planning.

The east coast of New Zealand is subject to significant local tsunami hazard due to the proximity of the Hikurangi subduction margin only 100 km offshore. Seismic, geodetic and paleo-tsunami studies have shown the potential for large subduction zone earthquakes (Mw 7.0 to > Mw 9.0) to occur on this margin, though none have been experienced in New Zealand's short European-recorded history. Deterministic simulation of earthquake-generated local tsunami indicates the variability in potential inundation extent and tsunami arrival time at Napier City, an urban centre located on the east coast of New Zealand. Maximum spatial extent of inundation is used to analyse the exposed population, while temporal evolution of inundation is implemented in GIS modelling of evacuation travel time.

Exposure analysis reveals the spatial distribution of the urban population, including sub-populations with varying characteristics influencing their ability to evacuate effectively in the short time-frame available for a local tsunami. These include vulnerable groups such as those who are mobility-impaired, in the care of institutions (I.e. schools, prisons) and transient populations with little knowledge of local hazard or evacuation routes. Observations of evacuation behaviour in previous tsunami and research into awareness of appropriate evacuation behaviour in the Napier community are used to calibrate and validate evacuation simulations. Population distribution also has temporal components (diurnal, weekly and seasonal), which determine location of population concentrations at the time of the earthquake; such effects are assessed through multiple evacuation scenarios for each tsunami scenario.

This combined hazard, exposure and evacuation simulation enables i) identification of the hazard zone, ii) identification of the total exposed population and vulnerable sub-populations, and iii) sectors of the exposed population requiring alternative evacuation options. This process facilitates assessment and proposal of alternative evacuation routes or destinations. This may include such innovative measures as construction of vertical evacuation buildings, to reduce the evacuation distance of vulnerable populations and enhance the potential for successful evacuation.