DEFINITION OF TSUNAMI INUNDATION LIMIT BASED ON PROBABILISTIC ANALYSIS OF TSUNAMI RUNUP AND INUNDATION DISTANCE

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INTRODUCTION

Tsunami inundation maps provide information on the extent of the inundation and flow depth, which may be used mainly for evacuation. In addition, the Chilean National Service for Disaster Prevention and Response (SENAPRED for its name in Spanish, and formerly ONEMI) has designated all areas located higher than 30 m above sea level as safe zones (Zamora et al., 2020). However due to the lack of other probabilistic information, the current official tsunami maps (deterministic maps based on the worst-case scenario) together with the 30-m ground elevation criterion have been used for urban planning, restrictions for critical infrastructure, and even design of structures under tsunami forces. The objective of the present research is to define more realistic tsunami inundation areas and safe zones based on probabilistic analysis of tsunami runup and inundation distance to be used in urban planning and design of structures.

METHODOLOGY

To generate a probabilistic criterion on tsunami inundation and safe zones, numerical simulations of stochastic tsunami scenarios were performed. To this end, the stochastic tsunami scenarios and probabilistic inundation maps given by Aránguiz et al (submitted) were used. In this work, the Chile-Perú subduction zone was divided into four seismic segments according to historical seismicity. Stochastic rupture scenarios were generated in a wide range of magnitudes, from 8.0 to 9.6, by means of the Karhunen-Loeve expansion, and then the Stochastic Reduced Order Model (SROM) was applied to select representative tsunami scenarios in each seismic segment and magnitude bin (Sepulveda et al., 2017). Selected tsunami scenarios for each coastal city were simulated to an inundation level by means of the NEOWAVE model using 4 nested grids with the highest grid resolution of 30 m. To analyze the relationship between the runup and inundation distance, considering also the influence of the topography, several transect lines were drawn every 350m perpendicular to the coastline. Figure 1-a shows an example of tsunami inundation for one particular tsunami scenario. The red line is one of the transects, while the yellow dot is the location of the inundation limits along that transect. Then, the runup and distance at this location is recorded. The same procedure was made for every scenario as well as for all transects, as shown in Figure 1-b, where black dots represent a runup and distance along a transect. Subsequently, a probabilistic analysis was made to all recorded data along the transect, and runup with 2%, 1% and 0.5% probability of exceedance in 50 years were computed. Then, the location of that runup (and subsequently, the distance from shoreline) was computed according to the topography along the transect. This procedure will be repeated in 10 coastal cities along the Chile subduction zone.

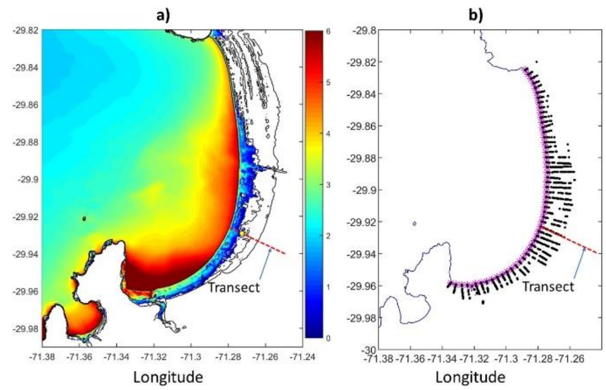

Figure 1 – Transects for computing probabilistic relationships of tsunami runup and inundation distnace

PRELIMINARY RESULTS

Figure 2 shows the plot of runup as a function of inundation distance obtained in two coastal cities (Constitución and Talcahuano). The black squares are the maximum runups obtained from numerical simulations, while the pink diamonds are maximum runups recorded after the 2010 Chile tsunami (Fritz et al, 2011). The red, green and blue data correspond to 2, 1 and 0.5% probability of exceedance in 50yeas, respectively. The dashed lines represent envelopes of computed data. It is possible to see that large runup (recorded and simulated) take place at distance less than 500m from coastline, and runup rapidly decreases as distance increases. In addition, probabilistic analysis gives much smaller runups than maximum simulated data. The grey dashed line is the 30m criterion used for safe zone, independently of the distance. For instance, for 2km from the coastline, the maximum simulated runup is ~12m, while the 2% probability in 50years if only ~4m. Therefore, the application of 30-m ground elevation criterion to urban planning and design of structures could result in very restrictive regulations, despite low recurrence of large earthquake and tsunami events.

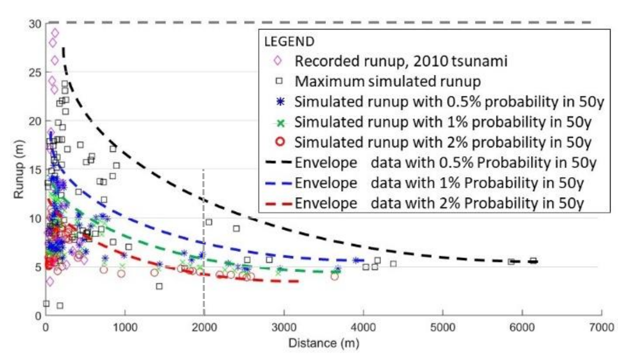

Figure 2. Relationships between inundation distance and tsunami runup for 3 exceedance probabilities.

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