

Field Survey of the 27 February 2010 Tsunami in Chile Maule and Biobío Regions, Juan Fernández Archipelago and Rapa Nui

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Abstract

On 27 February, 2010 a magnitude Mw 8.8 earthquake occurred just off the coast of central Chile, which caused substantial damage and loss of life on Chile's mainland, the Juan Fernandez archipelago and Easter Island. The 3 to 25 March 2010 International Tsunami Survey Team covered an 900 km stretch of coastline from Quintero to Mehuin in various subgroups highlighted in neighbouring posters. Here the focus is on the Maule and Biobio coastlines including Santa Maria Island as well as the Juan Fernandez Archipelago and Rapa Nui (Easter Island).

Introduction

On 27 February, 2010 a magnitude Mw 8.8 earthquake occurred just off the coast of Chile's Maule region some 100 km NNE of Concepcion, which caused substantial damage and loss of life on Chile's mainland, the Juan Fernandez archipelago and Easter Island. The majority of the approximately 500 fatalities were located in coastal areas and attributed to the ensuing tsunami. PTWC responded and issued warnings soon after the earthquake but, because the tsunami arrived within 30 minutes at many locations, official evacuations were late. Fortunately, most coastal residents knew to go to high ground after an earthquake because of ancestral knowledge from past tsunamis such as the giant 1960 event, as well as tsunami education and evacuation exercises. More than half of the victims were tourists staying overnight in low lying camp grounds along the coast.

Post Tsunami Reconnaissance

A multi-disciplinary reconnaissance survey team was deployed within days of the event to document flow depths, runup heights, inundation distances, sediment deposition, damage patterns at various scales, and performance of the man-made infrastructure and impact on the natural environment. The 3 to 25 March 2010 ITST covered a 900 km stretch of coastline from Quintero to Mehuin in various subgroups shown in Figure 1. The team measured local flow depths and tsunami heights, maximum runup, inundation distances, recorded structural damage and interviewed eyewitnesses per established methods [Synolakis and Okal, 2005]

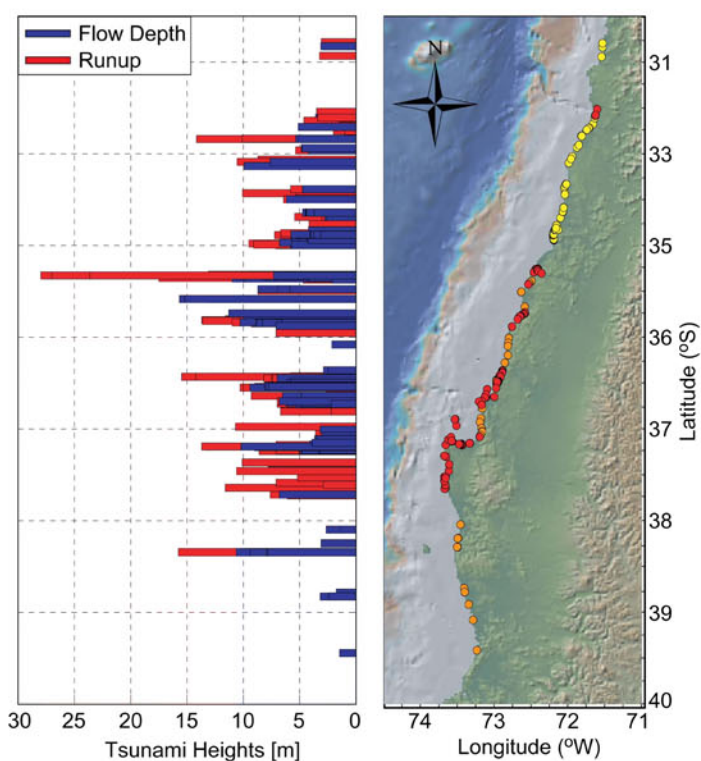


Figure 1. Tsunami flow depths and runup heights along 900 km of Chilean coastline from Quintero to Mehuin measured by 3 primary sub-teams indicated by the dot colors. Yellow dots: Catalán, Cienfuegos, and Winckler et al.; Red dots: Fritz, Kalligeris, and Weiss et al.; Orange dots: Petroff, Ebeling, and Papadopoulos.

The recorded Chile survey data includes more than 400 tsunami runup and flow depth measurements. A significant variation in tsunami impact was observed along Chile's mainland both at local and regional scales. Herein the focus is on the Maule and Biobio coastlines from Constitución to Lebu including Santa Maria Island (Figure 2). The tsunami impact peaked with a localized maximum runup of 28 m at Constitución. Inundation and damage occurred several kilometres inland along rivers. The tsunamigenic seafloor displacements were partially characterized based on coastal uplift measurements along a 100 km stretch of coastline between Caleta Chome and Punta Morguilla. More than 2 m vertical uplift were observed on Santa Maria Island. The team interviewed numerous eyewitnesses and educated residents about the tsunami hazard. Community-based education and awareness programs are essential to save lives in locales at risk from locally generated tsunamis.

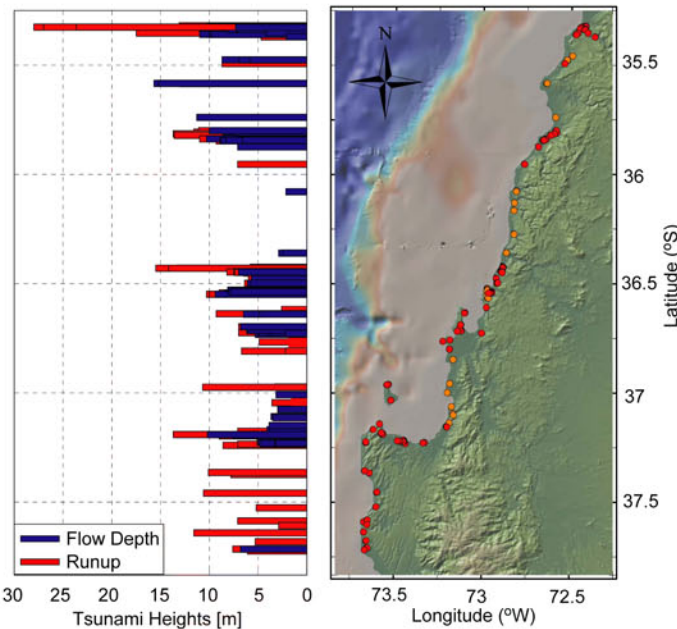


Figure 2. Tsunami flow depths and runup heights measured between Constitución and Lebu. Red dots: Fritz, Kalligeris, and Weiss et al.; Orange dots: Petroff, Ebeling, and Papadopoulos.

Constitución – Detailed Observations

The tsunami impact peaked with a localized maximum runup of 28 m on a steep slope within less than 2 km of the river mouth at Constitución (Figure 3).

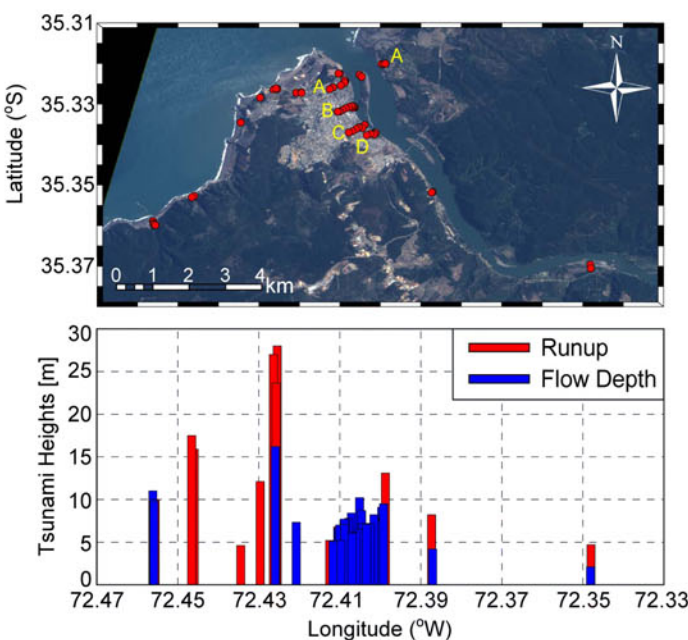


Figure 3. Measured tsunami flow depths and runup heights at Constitución and along the Maule River.

However only 1.2 km south along an open stretch of coastline with a wide beach and a low lying campground with wooden huts at 5 m terrain elevation the tsunami only reach 4 m (Figure 4).



Figure 4. Significant variation of tsunami impact along 5 km of open coastline southwest of the Maule River mouth: (a) Max. runup 28 m, (b) Intact campground with 4 m runup, (c) Destroyed warehouse.

Inside the estuary a unique river-crossing transect (A-A) was measured (Figure 5). The island in the middle of the river was completely submerged by the tsunami with 10 m flow depth. The 200 campers on the island had no chance.

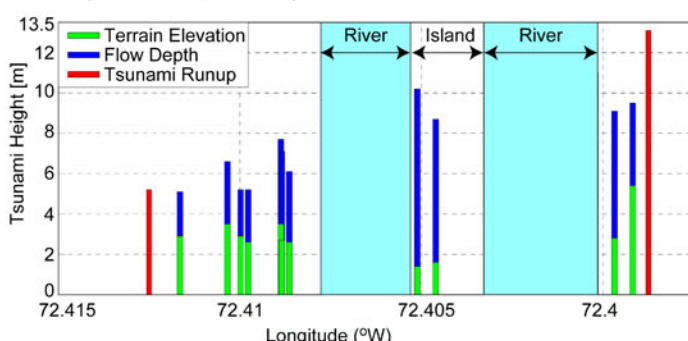


Figure 5. Measured tsunami flow depths and runup heights at Constitución across the Maule River along transect A-A in Figure 3.

Offshore capable fishing boats were washed ashore more than 10 km up the Maule River. Inundation and damage occurred more than a kilometer inland along several other rivers such as at Pelluhue and Tubul.

Juan Fernández Archipelago

The Archipelago Juan Fernández is located 667 km off the coast of Chile due west of Valparaíso. The volcanic islands are sparsely populated with 600 inhabitants concentrated in the coastal town of San Juan Bautista situated in Cumberland Bay. The first tsunami wave impacted San Juan Bautista 49 minutes after the earthquake as a relatively slow moving flood comparable to a rapid high tide, followed by a violent wave which destroyed around 160 houses and the majority of public facilities. The lowlands of the coastal town were devastated, resulting in a death toll of 18 people. The ringing of the church bells by the 12 year old daughter of one of the local carabineros triggered an evacuation at the very last and contained the death toll. Two surveys were carried out on Robinson Crusoe Island on March 24 and from March 26 to 31, 2010. The field survey results highlight maximum runup of 20 m, flow depths up to 9 m, and maximum inundation of approximately 300 m (Figure 6).



Figure 6. Archipelago Juan Fernández: (a) Mapped inundation at San Juan Bautista, (b) Destruction along Cumberland Bay (credit: Patricio Winckler, Universidad de Valparaíso, Chile).

Rapa Nui – Easter Island

Rapa Nui is located 3500 km off the coast of continental Chile almost due west of Juan Fernández. Rapa Nui was surveyed from March 20 to 22, 2010. The field survey results highlight maximum runup of 4 m. At Tongariki the tsunami reached up to the ahu (stone platform) and flooded a nearby house (Figure 7).



Figure 7. Tongariki, Rapa Nui: (a) flooded house; (b) eyewitness indicates inundation limit at the ahu with the moai statues.

Conclusion

The rapid deployment of the survey team to Chile after the 27 February 2010 event led to the recovery of important data on the characteristics of tsunami impact in both the near and far fields. As with most near field tsunamis, the waves struck prior to official warnings reaching coastal residents. Spontaneous self-evacuations minimized the fatalities and illustrate the importance of community-based education and awareness programs. This partial success was overshadowed by the vast majority of tsunami victims being campers on a late summer night.

Acknowledgements

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