Observations on Morphological Changes Produced by the Impact of the February 27, 2010 Tsunami along the Coastline of VI-VII Regions

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Introduction

On February 27, 2010, 06:34 UTC (03:34 local time) a Mw 8.8 earthquake hit central Chile causing widespread damage but only few fatalities despite of its high magnitude. The epicenter was located offshore Maule but the rupture zone extended over nearly 500km long and 200km wide (Figure 2)[1]. This massive rupture triggered devastating tsunami waves that affected more than 600km of the Chilean coastline during several hours after the shock.

An international tsunami survey plan was initiated few days after the event, with scientists from the United States, Greece, Germany, and Chile, coordinated by UNESCO –ITIC. The present work focus on describing some morphological changes produced by the earthquake and the tsunami that followed on the Chilean coastline.

Figure 1 : The sand bar that formerly enclosed the Estero Nilahue disappeared under the effect of the tsunami

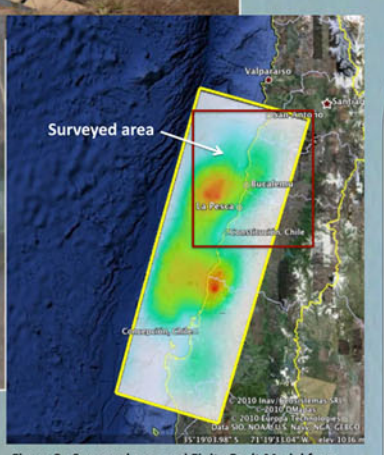

Figure 2 : Surveyed area and Finite Fault Model from the National Earthquake Information Center (NEIC-USGS) [1]

Characteristic Features of the Central-South Chile Coastal Morphology

River mouths in the south-central part of Chile are characterized by strong interactions between sporadic but large river flood events resulting in an important sediment transport load discharge to the Pacific Ocean. Under normal conditions, these sediments are redistributed by longshore currents generated by energetic south-west dominant wave climates, which result very often in the formation of sand spits oriented to the north; lagoons or wetlands when river discharge is low. Tidal currents can also influence coastal morphology but in a much lesser extent since tidal range in central Chile is comprised between 1m and 2m . According to Davis and Hayes [2] those estuarine systems should range between wave-dominated type to mixed energy wave-dominated type.

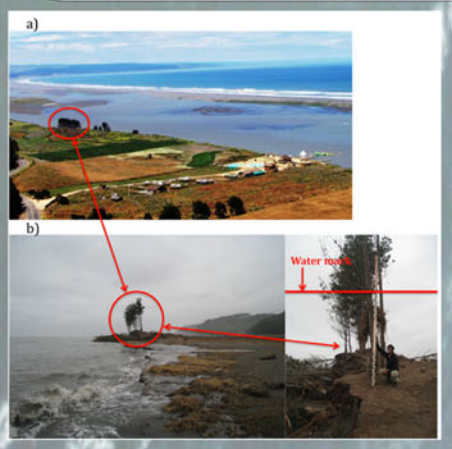

Figure 3 : The Mataquito river inlet before (a) and after (b) the February 27, 2010 earthquake and tsunami (Photo in the upper panel courtesy of Andrea Allamand)

Figure 4 : Aereal photography of the Mataquito river inlet taken on April 19, 2010 (Photo courtesy of Arauco S.A., Nature Fims)

Figure 6 : Estimated inundated area by the February 27, 2010 tsunami at Punta de Lobos (VI Region)

The protective role of sand dunes

At several places, such as Punta de Lobos (VI Region), sand dunes stabilized by vegetation prevented a direct hit of the tsunami offering an effective protection (Figure 6)

Examples of the Tsunami Impact on the Coastal Morphology

• Mataquito River Mouth (VII Region)

At the river mouth, located at la Pesca (VII Region), the wave-current interaction pattern is responsible for shaping a sand spit oriented to the north. The river discharge is forced to run almost parallel to the coastline over nearly 10km (Figure 3). Main sediment source to the sand spit is most likely associated to the Mataquito river itself but also to the Maule river, located 50km south. The spit height was 2-3m height, with a mean width of 130-150m and 9-10km long before the arrival of the 27 February 2010 tsunami. The spit was totally washed out after the shock, under the combined effect of the earthquake (subsidence) and the Tsunami (sediment transport). Thus, nearly 3 millions cubic meters lie now under water (Figures 4 and 5).

• Estero Nilahue at Bucalemu (VI Region)

The Estero Nilahue is an example of coastal lagoon formed by the dominant action of energetic wave climates. Most of the time, the ephemeral water course, that originates from stormwater runoff over a relatively small coastal watershed, is not able to overcome the influence of littoral currents, hence sediments carried by waves end by completely closing the river mouth (Figure 1). These morphological features often offer natural protection to coastal settlements from wave attack but can be problematic when river flood occurs. After the February 27 earthquake, the sand bar that prevented the estero Nilahue to reach the sea disappeared under the action of tsunami waves that hit the shoreline (Figure 1).

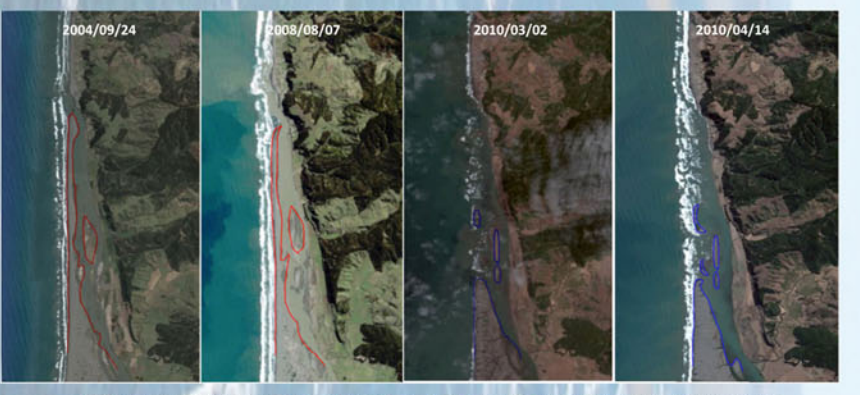

Figure 5 : Geoeye Satellite images of the Mataquito river mouth evidencing the spectacular morphological change produced by the February 27, 2010 earthquake and tsunami

REFERENCES
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2. Davis, R.A. and Hayes, M.O. What is a wave-dominated coast? Marine Geology, vol. 60, pp. 313-329.

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