

# Inundation at *Boca do Rio* site due to the 1755 Lisbon Tsunami

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## 1. Introduction

The 1755 Lisbon Tsunami is the most catastrophic event that ever occurred in Portugal. Although the total number of casualties probably will never be known, it was estimated that, only in Lisbon, about 10,000 people died; this corresponds to about 30% of the total citizens living in the capital, at that time. However, many aspects of this event remain to be solved, particularly the source location. In order to estimate the tsunami source area we selected a site in the South of Portugal called Boca do Rio. The objective of this study is to estimate the impact of tsunami hazard on this location. Then, we can calibrate the numerical model by comparison with historical data and sediments records.

## 2. Historical review

Pereira de Sousa (1919) transcribed the historical reports of the 1755 tsunami. We translated them as follows: “In the occasion of the earthquake of the year 1755, near the Almadna fort, the sea surged out of its limits, ejecting sand from a nearby beach located close to a narrow opening that allows the tide to rush in, called Almadna River, it uncovered foundations of a large settlement that extended farther seawards (...) and today this place is again covered with sand as it was before (...).”

“At the coast (...) is located the Almadena fort (...) the sea invaded the sweet water creek that outlets there into the sea, for more than \_ league (2500–3000 m) with a water height of 10–12 *varas* (11–13 m) destroying some large fore dunes and carrying along 50 of the heaviest anchors more than \_ league inland (1250–1500 m). The backrush uncovered great and noble buildings of which no memory existed (...).”

“The sea left behind a large lake whose depth was not investigated but is not disturbed either by the flood or by the ebb tide.”

From these descriptions we assumed the local tsunami run-up of at least 10 m.

## 3. The Boca do Rio Site

The area of Boca do Rio is located on the South coast of Portugal, at 37° 04'N, 08° 48.5'W (see Figure 1 for location). This is a flat-bottomed fluvial valley, that constitutes small lowland in the otherwise cliffed coast of southern Portugal (Silva et al., 1996).

The existence of a beach ridge and a rock spur provides a barrier against storm surges.

## 4. Previous Studies

The historical information regarding this event has many uncertainties and sometimes contradictions. However, in spite of the precise location of the tsunami source area remains unknown it is established that is offshore Cape St. Vincent, South of Portugal. Over time there were several proposals for the source and Machado (1966) proposed the location of epicenter on 36°27'N; 11°15'W, south of the Gorringe Bank. Then, Johnston (1996) proposed a possible set of parameters based on isoseismal regression analysis. In this study we follow these two authors.

Recent sedimentation studies at Boca do Rio provided more data than just historical accounts. Based on a termoluminescence technique, Hindson and Andrade, (1999) dated the sediments as AD1730 ± 60. On the other hand Dawson et al., (1995) using lithostratigraphic analysis obtained a chaotic layer with shell fragments, marine bivalves, *foraminifera* and marine ostracods. This layer extends for 1 km inland.

## 5. Numerical model

The initial sea surface displacement was calculated with Okada (1985) Theory with the following parameters. Origin of the fault: 12.3°W, 36.5°N; length: 200km; width: 80km; Strike: 60.0°; Dip: 40.0°; Slip: 90.0°; depth: 8 km; slip amount: 12.1m. We carried out the tsunami numerical simulation using the non-linear shallow water theory in a Cartesian coordinate system, with a staggered leap-frog scheme [Goto *et al.*, 1997]. In order to carry out the inundation modeling at Boca do Rio we used different grid sizes, represented in Figure 1. The inundation was calculated on regions 4 and 5.

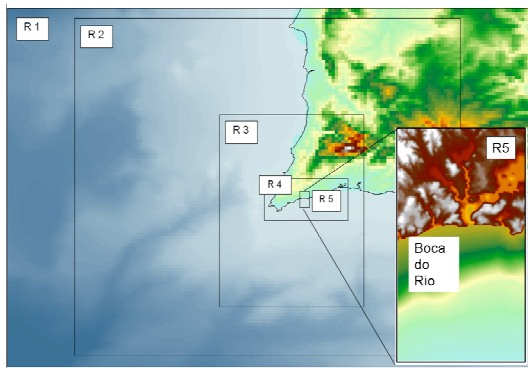


Figure 1: Schematic representation of the nesting, with different grid sizes. Region 1: 2025m, region 2, 675 m region 3: 225 m, region 4: 75 m and region 5: 25 m.

## 6. Preliminary Results

The computed waveforms at Boca do Rio are shown in figure 2. These results were obtained on regions 1, 2 and 3.

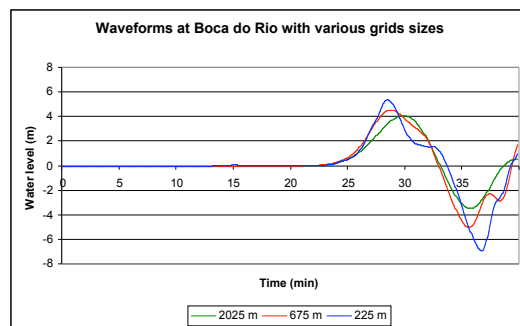


Figure 2: Computed waveforms at Boca do Rio, on region 1 (grid size of 2025m), region 2 (grid size of 675 m) and region 3 (grid size of 225 m).

The estimated tsunami height was 4 to 5 m although slight difference can be seen between the grid sizes, as represented in Figure 2.

This shows that the source model on Gorringe is underestimated when compared with 11 – 13 m reported by the eyewitnesses' accounts.

## Summary and Future work

We collected the historical the historical accounts at Boca do Rio and we considered a run-up of 11-13m with an inundation extension of 2500-3000m.

Recent sedimentation studies showed more modest results, with inundation extension of 1km.

Our objective was to calculate the inundation by using numerical simulation of this tsunami. However, we only could calculate the tsunami propagation on regions 1, 2 and 3.

The water level height at Boca do Rio is underestimated when compared with historical accounts.

Since both numerical simulation and sediment analysis are underestimated, we also have to admit some exaggeration on eyewitnesses reports.

Our future work is to calculate the inundation on regions 4 and 5.

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