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NEAREST

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D.20 Specifications of the tsunami detection system

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WP5 - Data integration/ Integrated tsunami detection network

D.20 Specifications of the tsunami detection system

Task 5.3 Leader: UGR

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Authorship:

This report has been compiled by Luis Matias with the contributions from the main partners involved in the establishment of National Tsunami Warning Centres in Portugal and Morocco: the Meteorological Institute at Lisbon (IM) and the National Geophysical Institute of Morocco of the Centre National pour la Recherche Scientifique (CNRST). This report profited also from major contributions by Maria Ana Baptista and Rachid Omira.

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1. Introduction

The key operational components of a Tsunami Warning Centre (TWC) are to provide real-time monitoring, alert of seismic and tsunami activities, timely decision making, and dissemination of tsunami warnings, advisories and information (Figure 1). The chain begins with data collection and ends with saving lives. In this report we will concentrate on the specifications for the tsunami detection system, the module outlined in figure 1. The main purpose of the tsunami detection system is to provide information on sea level data to allow the TWC operator to observe if a tsunami was indeed originated by a large earthquake and evaluate its degree of threat to the coastal stations. The results presented below will focus on the efforts done under NEAREST to design a proper tsunami detection network in the Gulf of Cadiz.

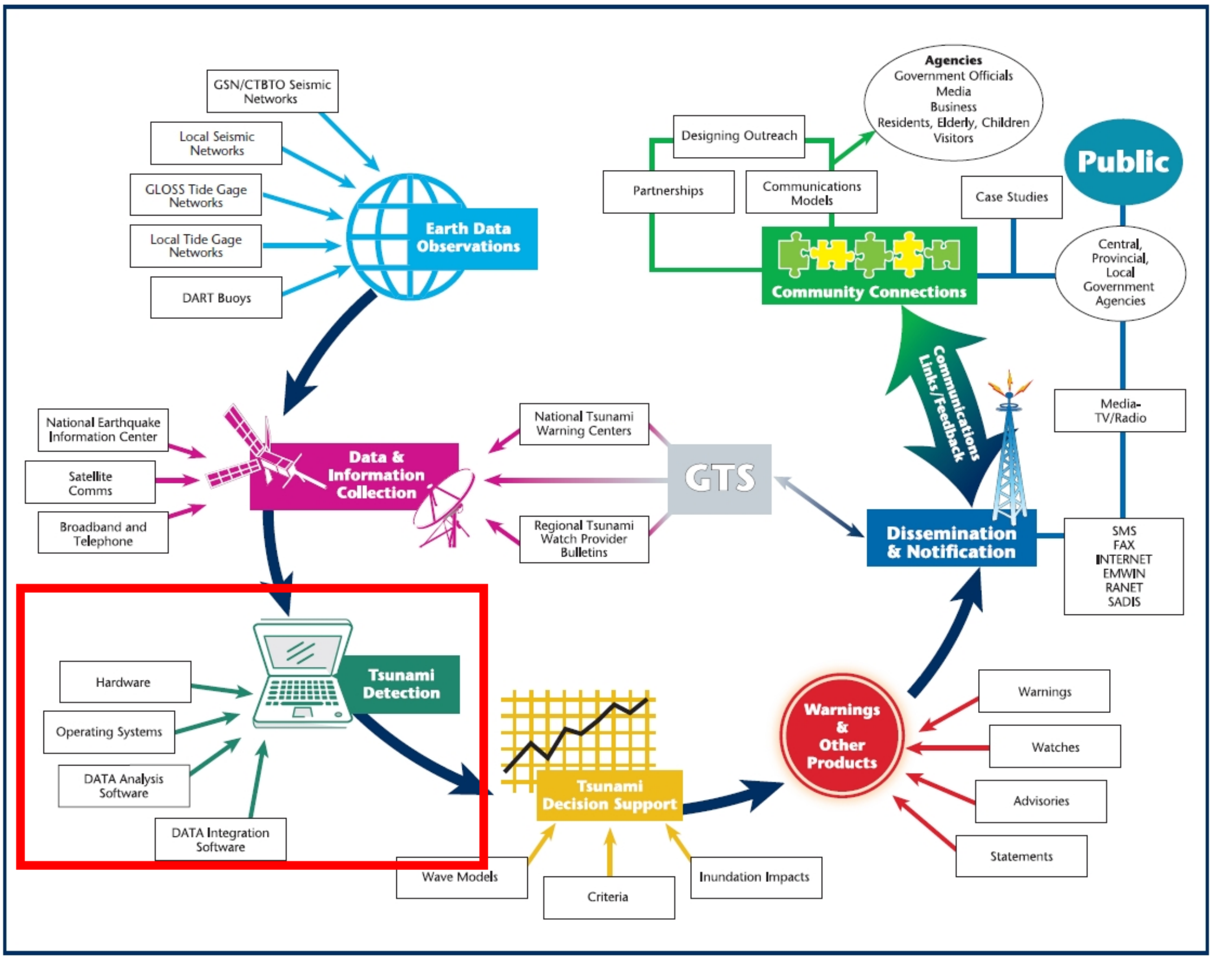

Figure 1. Key Components of a Tsunami Warning Centre End-to-End Chain (from US-IOTWS)

2. Basic requirements for the tsunami detection system

All Tsunami Warning Systems that have been developed to the present detect only those tsunamis that are caused by large magnitude earthquakes and so their operation must rely firstly on an effective seismic network operation. For tsunami sources close to the coast the seismic network must provide information on location and moment magnitude 5 min after the onset of the earthquake, at the least. These seismic parameters trigger the first message from the TWS to the civil protection authorities by applying a decision matrix that has been defined previously based on historical and past information, complemented by hydrodynamic modeling. The degree of certainty of the first information is quite low, since it is known that only a few of the large magnitude earthquakes do, indeed, generate tsunamis. In order to be effective, the TWS must confirm that a tsunami has been generated or not, and measure its wave height. To accomplish this, the TWS must observe in real-time the sea-level disturbances that have been generated by the propagating waves of the tsunami. This is the role of the Tsunami Detection System. In the Gulf of Cadiz area, due to its peculiar geological context, tsunamis may be originated by earthquakes with sources very close to the shore, like the 1st November 1755 destructive event and so this system must have a very fast response, in less than 10 minutes, in order to be effective for the closest coastal areas.

The commonest and simplest observations are those that are made at coastal tide-gauges, but they do not provide advance warning for the coastal areas that are close to tsunamigenic sources. In order to provide full coverage to the affected coasts, the TWS must detect and observe the tsunami in deep water, long before the waves reach the shore. In summary, the assessment of tsunami hazards by decision-makers at Tsunami Warning Centres (TWC) requires collection and interpretation of precise data related to tsunamis generation, propagation and impact on coastlines.

In this report we present the approach developed by Omira et al. (2009), presented in Annex, to design the most effective Tsunami Detection System (TDS) for the Gulf of Cadiz Area. The TDS design process begins with an assessment of the tsunamigenic potential in the region by identifying the active tectonic structures. It is completed by the design of a sea level detection network based on numerical computations of deep ocean tsunami dynamics and GIS technologies. The study adopts a specific strategy for the tsunameter installation based upon three main criteria: (i) the maximization of advance warning time, (ii) the coverage of all of the area where a tsunami could be generated and, finally, (iii) the installation conditions. The latter include flat bottom topography and the “safe” distance of station location from the seismic source. These criteria are proposed to control the assessment of the optimal tsunameters' locations in order to maximize the warning time and minimize the sensors number. Moreover, additional coastal tide gauge stations are recommended in site-specific of major tsunami impact and minimum tsunami travel time. More details can be found in the Annex (Omira et al., 2009).

3. The tsunami detection system for the G. Cadiz

Considering the five most credible scenarios for large earthquakes that can generate tsunamis, Omira et al. (2009), in Annex, produced a map of the maximum water height to be expected on the coast (Figure 2.b). This map is used to propose the location of the most critical costal tide-gauges as well as the location of additional tide-gauges to have a proper assessment of the tsunami impact. However, if we compute the minimum warning time for each coastal area (figure 3) we see that the current network of coastal tide-gauges is inadequate to provide timely warnings to the most exposed areas in Portugal. Some areas of Spain and Morocco will also be inefficiently warned.

To overcome this difficulty, Omira et al. (2009), in Annex, propose the location of three offshore sea level observation systems. The resulting minimum warning time is shown in figure 4. We may see that, with the possible exception of the SW tip of Portugal, all costal areas have a warning time in excess of 10 minutes. More details can be found in the Annex (Omira et al., 2009).

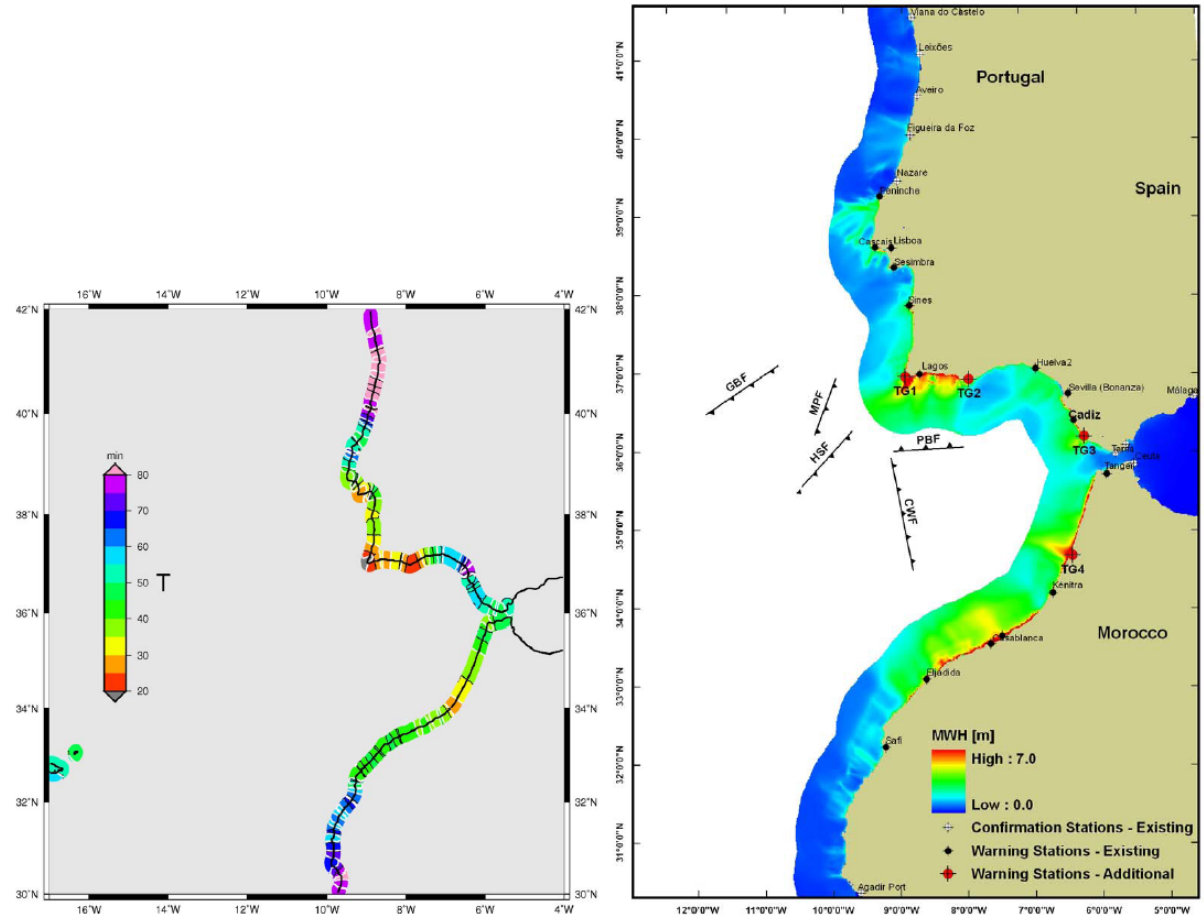

Figure 2 Maps displaying: (a) minimum tsunami travel time corresponding to the 5 Maximum Credible Earthquake scenarios along the coasts of the study area; (b) Maximum Water Height along the Gulf of Cadiz coasts considering all the tsunamigenic scenarios, existing and 4 additional tide gauge stations (TG1 to TG4 in red dots) recommended for the region. Two categories in the established tide gauges network are distinguished: warning stations (black dots for existing stations and red dots for additional stations) and confirmation stations (white dots). From Omira et al. (2009), in Annex.

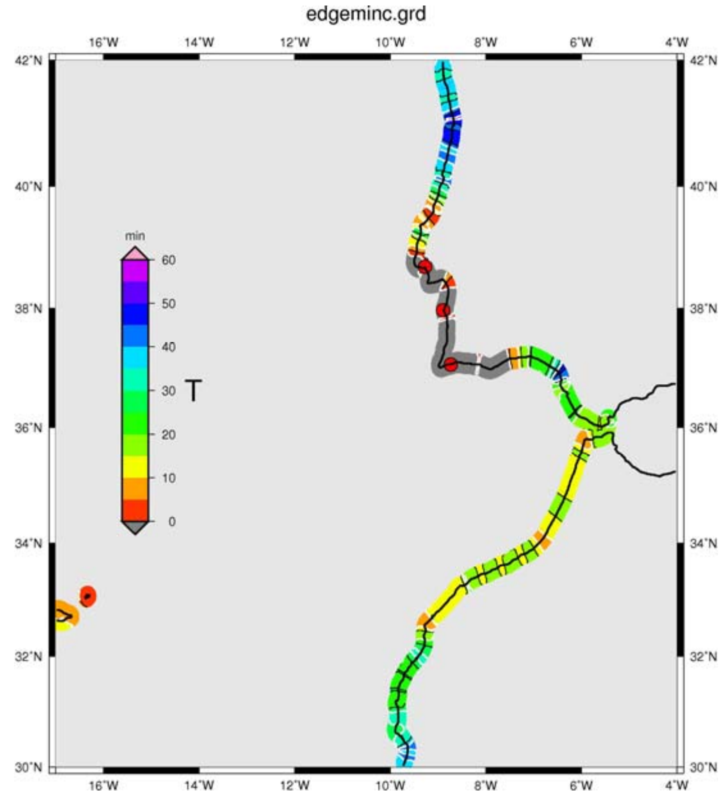

Figure3- Minimum warning time on the coast, considering the five Maximum Credible Earthquake scenarios along the coasts of the study area and the current network of real-time coastal tide-gauges

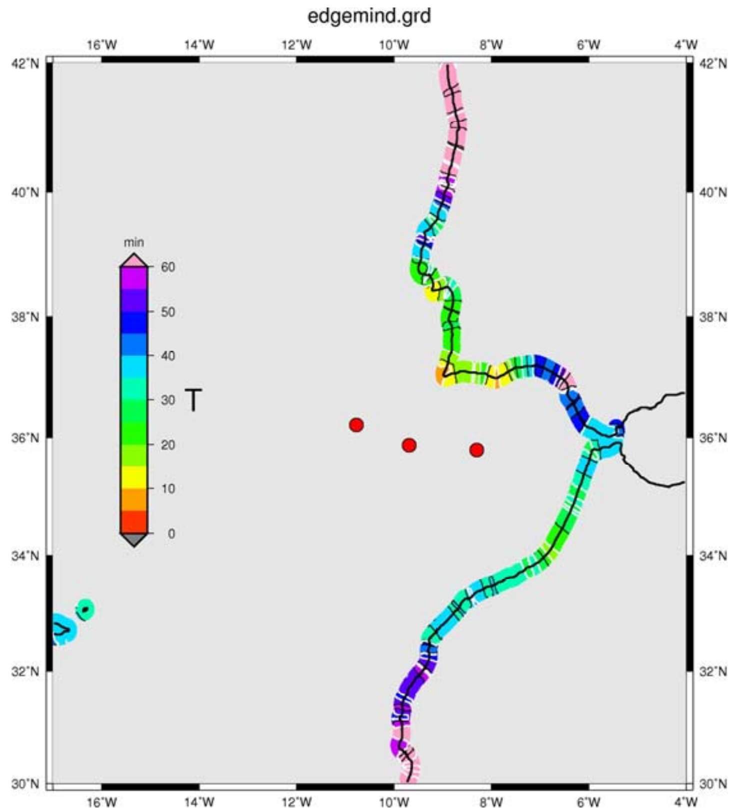

Figure4- Minimum warning time on the coast, considering the five Maximum Credible Earthquake scenarios along the coasts of the study area and a network of real-time offshore tide-gauges (red dots).

4. Future perspectives and recommendations

We summarize here the major conclusions outlined in Omira et al. (2009), in Annex.

The goal of a Tsunami Warning System is to save human lives and mitigate property losses in the case of a tsunami occurrence, and also to confirm the non-existence of tsunami waves what avoids maintaining people a long time in higher grounds. For the Gulf of Cadiz a total of 3 tsunameter sensors and 29 coastal tide gauges are recommended as the minimum number of stations able to detect tsunamis in the region and assess its impact. The proposed locations provide the greatest possible advance warning for the largest number of threatened coastal communities.

The sea level network is recommended to complete the TWS once the tsunamigenic study has been done. The specificity of the tsunamigenic potential in the Gulf of Cadiz led us to choose a specific design for sensors locations. The coastal tide gauge stations are positioned in the harbours of principal cities where tsunami impact is considered major. Moreover, the study by Omira et al. (2009), in Annex, recommends that 3 DART-like stations should be deployed. Their installation locations have been determined so as to assure a maximum WT, as well as maximum coverage of tsunami potential hazard areas. The approach provides 7.0 to 15.4 min as a minimum advance warning time for the first threatened coastline. This time may not be sufficient for a global evacuation procedure. This is the reason why awareness campaign and exercises should be implemented in such region, explaining in particular to the inhabitants not to wait official tsunami warning in case of large felt earthquakes, but to immediately move to higher ground or vertically in a concrete building.

5. References

US-IOTWS, U.S. Indian Ocean Tsunami Warning System Program, 2007. Tsunami Warning Center Reference Guide supported by the United States Agency for International Development and partners, Bangkok, Thailand. 311 p.

6. Annex

Omira, R., Baptista, M.A., L. Matias, J. M. Miranda, C. Catita, F. Carrilho, and E. Toto, 2009. Design of a Sea-level Tsunami Detection Network for the Gulf of Cadiz, Nat. Hazards Earth Syst. Sci., 9, 1327–1338.