The North-East Atlantic Tsunami Warning System

Case of the PtTWS

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Outlines

- Tsunami Warning Systems around the World;
- Situation in the NE Atlantic region: Case of the Portuguese TWS (PtTWS);
- Architecture and Components of the PtTWS implemented at IPMA;
- Possibility of Real-time Tsunami Forecasting in the Region using IPMA’s facilities;
- Conclusions.
Tsunami Warning Systems around the World

• Pacific TWS components

The signal is then sent to early-warning stations on land.

1. A sensor on the ocean floor measures water pressure.

2. The measurements are sent by acoustic signal to a buoy on the surface.

3. The buoy sends the signal further to a satellite.

4. The signal is then sent to early-warning stations on land.

The Wave Watchdog

When an earthquake strikes on the bed of the ocean, millions of tons of water are suddenly pushed upwards — or sinks dramatically downwards — thus generating a powerful wave. In deep water, the wave travels at extremely high rates of speed. The wave can be identified by a tsunami detector, which then transmits a warning via satellite.

With the help of data received from transmitter buoys and prediction models, it is possible, even just 15 minutes after an earthquake strikes, to determine the path and the strength of a tsunami. Warnings can be sent out to the endangered regions immediately.

• Indian TWS components

Both TWSs are based on off-shore (tsunamiters) Sensors
Situation in the NE Atlantic Region

Case of Portugal (PtTWS)

IPMA's Seismic monitoring room

Seismic monitoring 7/7 and 24/24

Tsunamiter

Missing of off-shore Tsunami detection Sensors !!!!
Situation in the NE Atlantic Region

Case of Portugal (PtTWS)

Seismic Monitoring

Tsunami Decision Matrix

<table>
<thead>
<tr>
<th>Depth</th>
<th>Location</th>
<th>(Mw)</th>
<th>Tsunami Potential</th>
<th>Bulletin Type</th>
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<tr>
<td>&lt; 100 km</td>
<td>Sub-sea or very near the sea (&lt; 30 km)</td>
<td>5.5 to 7.0</td>
<td>Small potential for a local tsunami</td>
<td>Information Bulletin</td>
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<tr>
<td></td>
<td></td>
<td>7.0 to 7.5</td>
<td>Potential for a regional tsunami &lt; 1000 km</td>
<td>Regional Tsunami Watch</td>
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<tr>
<td></td>
<td></td>
<td>7.5 to 7.9</td>
<td>Potential for a destructive regional tsunami &lt; 1000 km</td>
<td>Regional Tsunami Alert/Warning Ocean-wide Tsunami Watch</td>
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<tr>
<td></td>
<td></td>
<td>≥ 7.9</td>
<td>Potential for a destructive ocean-wide tsunami &gt; 1000 km</td>
<td>Ocean-wide Tsunami Alert/Warning</td>
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<td>Inland</td>
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<td>No tsunami potential</td>
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<tr>
<td>≥ 100 km</td>
<td>All Locations</td>
<td>≥ 5.5</td>
<td>No tsunami potential</td>
<td>Information Bulletin</td>
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</table>

Earthquake parameters evaluation within ~3min

1st Level of Tsunami Warning based on Decision Matrix

NO INFORMATION ON THE DEGREE OF IMPACT!!!!
HIGH PROBABILITY OF FALSE ALERTE!!!
How Can We Go Beyond a Tsunami Warning Based Only On The DECISION MATRIX??

Tsunami Science
Architecture of the Portuguese Tsunami Warning System (PtTWS) Operating at IPMA

Seismic Network

Tide Gauge Network

Scenario Database

Tsunami Watch Centre: Signal analysis and message creation

Tsunami Analysis Tool

Portuguese Civil Protection

Alerting!

(Annunziato et al., 2009)
Tsunami Components of the PtTWS: From Scenarios database to Impact evaluation
The Tsunami Scenario Database
The Tsunamigenic Active Tectonic Structures

Preliminary Map of the active tectonic structures in the Gulf of Cadiz
The Tsunami Source Zones
The Tsunami Grid Database

- > 500 locations
- 6.5 to 8.75 in magnitude, every 0.25
- > 5000 different scenarios
- ~ 5Tb of data
The Tsunami Modelling

TTT Computation

Maximum wave height in the whole domain
- Tsunami Warning: Tsunami analysis tools System Operating at IPMA

**Tsunami Arrival Time**

**Maximum Wave Heights Distribution**

**Tsunami Warning Levels**

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<th>Time</th>
<th>Actual Time</th>
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<th>Location</th>
<th>Height</th>
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Presence of Off-shore Tsunami Detection Sensors

Early Tsunami Detection & Possibility of Real-time Tsunami Forecasting
Design of Tsunami Detection Network including Offshore Stations

• Tsunami Numerical Modeling

Most Credible Earthquake Scenarios (Omira et al., 2009)

Initial Sea Surface Displacement due to the Occurrence of Earthquakes (Omira et al., 2009)

Modelling Maximum wave heights distributions and Tsunami travel times (Omira et al., 2009)
Design of Tsunami Detection Network including Offshore Stations

- Tsunamiters’ Locations and test of their Detection capabilities of possible tsunamigenic events in the Gulf of Cadiz Region

(Omira et al., 2009)
Design of Tsunami Detection Network including Offshore Stations

- Tsunami Warning Times provided to the Gulf of Cadiz coasts in case of Presence of offshore stations (red dots)

(Omira et al., 2009)
Presence of Off-shore Tsunami Detection Sensors: Possibility of real-time tsunami forecasting using the system implemented at IPMA
Presence of Off-shore Tsunami Detection Sensors: Tsunami affected areas and generation of Alert message
Conclusions

- The NEAM region remains the only area not yet protected by any type of TWS

  **Efforts on the establishment of an operational PtTWS**

- IPMA adopts the 1st Level tsunami warning approach that is based on Seismic Monitoring and Tsunami Decision Matrix;

- Tsunami Analysis Tools, implemented at IPMA, allow improving the PtTWS Alert by providing information on TAT and estimated wave heights at forecast points;

- Offshore stations remain a necessary component of an end-to-end TWS and allow an Early detection of tsunamis (in the deep ocean) and a real-time forecasting.
Thank You!