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ASSESSMENTS, STRATEGY AND RISK REDUCTION FOR TSUNAMIS IN EUROPE

SEVENTH FRAMEWORK PROGRAMME

POLICY BRIEF 1

ASTARTE (Assessment, STrategy And Risk reduction for Tsunamis in Europe), is an international project on tsunamis funded by EC-FP7 (Contract No. 603839). It started in November 1, 2013. The project aims at fostering tsunami resilience in Europe, through innovative research on scientific questions, critical to enhance forecast skills in terms of sources, propagation and impact of tsunamis. ASTARTE used lessons on coastal resilience learned from disaster surveys following tsunamis and hurricane surges. ASTARTE acquired new information to complete the European knowledge base, and we benefited from a strong multidisciplinary partnership covering all areas of tsunami research. ASTARTE involved close cooperation with coastal populations, civil protection agencies, emergency managers and other local organizations.



The ship stranded on the quay at Kamaishi port (left) and major scour around buildings in Arahama (center) after 2011 Great East Japan tsunami, and coastal subsidence/impact at Meulaboh city in Sumatra after 2014 Indian Ocean tsunami (right). *Courtesy of Ahmet Cevdet Yalciner (left, center) and Sukru Ersoy (right).*

ASTARTE background

Tsunamis are low frequency but high impact natural disasters. In 2004, the Boxing Day tsunami killed hundreds of thousands of people from many nations along the coastlines of the Indian Ocean. Tsunami run-up exceeded 35 m. Seven years later, and in spite of some of the best warning technologies and levels of preparedness in the world, the Tohoku-Oki tsunami in Japan dramatically showed the limitations of scientific knowledge on tsunami sources, coastal impacts and mitigation measures. The experience from Japan raised serious questions on how to improve the resilience of coastal communities, to upgrade the performance of coastal defenses, to adopt a better risk management, and also on the strategies and priorities for the reconstruction of damaged coastal areas. Societal resilience requires the reinforcement of capabilities to manage and reduce risk at national and local scales.

The ultimate goal of ASTARTE was to reach a higher level of tsunami resilience in the North-East Atlantic and Mediterranean (NEAM) region. This goal implies better preparedness of coastal populations to, ultimately, save lives and assets. The objectives were:

- To assess the long term recurrence of tsunamis;
- To improve the identification of tsunami generation mechanisms;
- To develop new computational tools for hazard assessment;
- To ameliorate the understanding of tsunami interactions with coastal structures;
- To enhance tsunami detection capabilities, forecast and early warning capabilities in the NEAM region;
- To establish new approaches to quantify vulnerability and risk and to identify the key components of tsunami resilience and their implementation in the NEAM region.

Top: Snapshot of a ANN video, recorded at the balcony of the Miyako City Mayor Office. It shows the devastation of the Great East Japan Earthquake and Tsunami on March 11, 2011. **Bottom:** photo taken by the International Survey Team from Tohoku University, METU, KOERI, TUC (ASTARTE Partners) in May-June 2011.

1956 Aegean Tsunami

A strong tsunami occurred on 9 July 1956, caused by a M7.5 earthquake in the Cyclades Islands, South Aegean Sea.



Fishing boat moved ashore in Kalymnos Island (left). Sea retreat in Patmos Island (center). Tsunami inundation in Leros Island (right). Courtesy NOA, Greece

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ASTARTE achievements and findings

ASTARTE completed an assessment of potential tsunami sources (seismic and nonseismic) in the NEAM region, including the treatment of uncertainty and sensitivity to source parameters. Some important results are:

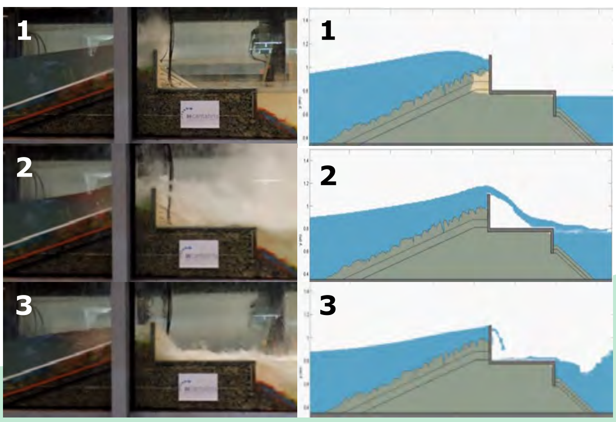
- An important percentage of submarine earthquakes may be tsunamigenic (70% for magnitudes greater than 8.0, 25% for magnitudes greater than 7, and 7% for magnitudes greater than 6.0);
- Large earthquakes in oceanic transpressive fault zones can generate tsunamis (i.e. Gorringe Bank, the thrust systems of the Gulf of Cadiz, and along the Algerian coastline);
- There is clustering of large earthquakes and related tsunamis, in the Mediterranean off Algeria;
- Many historical events (i.e. 700 years) triggered turbidites, which could be used as a proxy for pre-instrumental seismicity eventually associated with tsunamis;
- Submarine volcanic activity in the Canary Islands may contribute to tsunami generation in case of further shallowing with explosiveness;
- The western Irish coast and the southwestern Iberian coasts are prone to landslide-induced tsunamis;
- An independent Alboran micro-plate between Africa and Eurasia must be considered for hazard assessement.

ASTARTE developed:

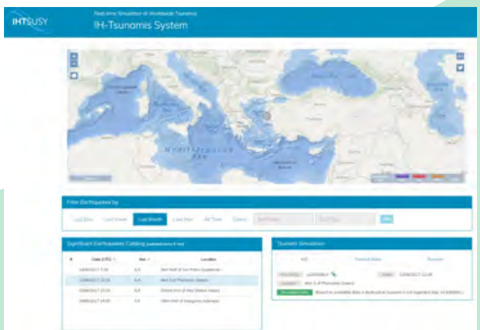
- New inverse methods to help optimal sensor location and define regions of influence to critical infrastructures;
- New analytical and experimental benchmarks for model validation;
- Novel forecasting techniques, based on emulation rather than simulation, and instant simulation workflows;
- New physical experiments to address the tsunami structure interaction on rubble mound breakwaters;
- New numerical models to simulate tsunami-induced flow, sediment transport and consequent morphological changes of the sea bed, spanning a large range of scales;
- Refined numerical models for seamless tsunami propagation and inundation with adaptative mesh refinement, hardware optimization and better physical representation, considering dispersive effects of wave interaction;
- Refined Computational Fluid Dynamics modelling to improve the understanding of sediment dynamics during the surge of tsunami-like breaking bores;
- New methods to cover the assessment chain from tsunami hazard to tsunami vulnerability and risk, and the application to specific test sites of the NEAM region, and, for some segments of the chain, to wide basins like the NE Atlantic and the Black Sea;
- Tsunami hazard studies based on scenarios and seismic probability (SPTHA) to ASTARTE test sites.
- New vulnerability studies at local scales in most ASTARTE test sites, which were applied especially to assets like buildings, industrial plants and harbour installations;
- A new GIS Database of thematic maps and a new paleo tsunami database;
- New educational materials addressed to populations on the process of tsunami evacuation;
- A new smartphone *App* for disaster management: FIND – Finding Inacessible people in Natural Disasters;
- Collaborative research fostering a new regional tsunami hazard map for DG-ECHO (TSUMAPS-NEAM).

ASTARTE reviewed:

- Operational infrastructures in the NEAM region and the possibility of integrating meteo-oceanographic data to improve Tsuami Early Warning Systems in the NEAM region;
- The governance of the existing tsunami warning systems, coordinated by the UNESCO/IOC;
- New decision matrices for different sub-basins;
- The level of tsunami awareness of coastal communities in the NEAM region. ASTARTE concluded that the area is in need of corrective actions concerning evacuation plans and official evacuation sites.



Comparison of the physical and numerical model experiments performed in ASTARTE (curtesy to UC)



IH-Tsunamis System (IH-Tsusy) is an online tool that calculates the propagation of actual tsunamis. curtesy to IH-cantabria

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Gaps and recommendations

Generation mechanisms

Landslide-induced tsunamis

- New monitoring schemes for potential landslides that could become tsunamigenic;
- Identification of precursor signs for submarine and aerial landslides;
- Knowledge on landslide-induced tsunami generation mechanisms.

Earthquake-induced tsunamis

- Field investigation in areas of short historical record, supported by isotopic dating;
- Inclusion of turbidite events in tsunami hazard assessment studies;
- Research on long-term slip rates of submarine faults;
- Solutions to address the near-field problem, namely by improving the earthquake focal mechanism assessment, based on integrated GNSS, strong motion seismic and submarine cabled seismometer/pressure sensor networks.

Volcanic-induced tsunamis

- New monitoring schemes for volcanic activity to be included in tsunami warning systems.

Modelling

- Modelling capabilities for medium size tsunamis;
- Comprehensive multi-source tsunami hazard and risk assessment with full uncertainty treatment;
- New numerical models for coastal evolution numerical models for beaches, estuaries and the inland zones;
- Faster methods to compute the amplification of tsunami amplitude when moving from deep-sea to coastline, including uncertainties of such estimations.

Coastal processes

- In depth knowledge on hydrodynamic and sediment transport processes associated to the up rush and down rush flows in beaches, estuaries and inland flooded zones;
- New experiments on different geometries of rubble mound breakwaters;
- Better understanding of tsunami-induced scour around monopiles.

Hazard assessment

- Full and comprehensive comparison between scenario-based and probabilistic approaches, from hazard to risk;
- Inclusion of landslides and volcanic eruptions as additional sources of tsunamis, to produce more meaningfull hazard and risk maps;
- Analysis of cascade effects in the NEAM region.

Early warning

- Need to implement solutions to address the near-field problem, namely by improving the assessment of the earthquake focal mechanisms;
- Future warning messages should include enhanced products and clear information on uncertainties.

Links to society

- Promotion of tsunami literacy with focus on uncertainties of early warning systems;
- Inclusion of tsunami risk in multi-risk studies offered to civil defense and coastal authorities;
- An initiative similar to the Global Assessment Report (GAR) on disaster reduction in the NEAM region to achieve an homogeneous assessment of risk within a multi-hazard framework, including tsunamis;
- Promotion of strong cooperation between Tsunami Service Providers and meteorological/oceanographic communities, in line with the Sendai Framework (2015-2030 for Disaster Risk Reduction 2015-2030.

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Contacts

Project Coordinator

Maria Ana Baptista
Instituto Português do Mar e da Atmosfera, IPMA

Project Secretariat

Inês Moura Martins
Instituto Português do Mar e da Atmosfera, IPMA

IPMA - Instituto Português do Mar e da Atmosfera, piso 7
Rua C do Aeroporto
1749-077 Lisboa, Portugal

Tel.: +351 218447073
Email: astarte@ipma.pt