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THE FRENCH TSUNAMI WARNING CENTER FOR THE MEDITERRANEAN AND NORTHEAST ATLANTIC: CENALT

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ABSTRACT

CENALT (CENtre d'ALerte aux Tsunamis) is responsible for the French National Tsunami Warning Centre (NTWC). The CENALT is established in the framework of the Unesco/IOC/ICG/NEAMTWS. Its objective is to transmit a warning message in less than fifteen minutes for any events that could trigger a tsunami in the Western Mediterranean Sea and the North-Eastern Atlantic Ocean. The data collected from French installations and from institutions of European and North African countries is processed with software that permits early epicenter location of seismic events and measurements of expected tsunami impacts on the shore. On-duty analysts revise interactively all the generated information and use references of historical tsunami and earthquake databases - as well as computed tsunami scenarios – in order to disseminate the more comprehensive message possible.

Keywords: *Tsunami, warning, centre, France, Mediterranean, Atlantic*

1. CREATION OF THE CENALT PROJECT

Following the first international meeting on tsunami alert systems in the Mediterranean in November 2005, the French interior ministry on April 2006 tasked the Commissariat à l'énergie atomique et aux energies alternatives (CEA) to implement a tsunami warning system in the Mediterranean. In November 2007, France officially announced its intention to host a tsunami-warning centre for the Western Mediterranean. On 22 September 2009, an agreement was signed, linking the two Ministries of Interior and Sustainable Development with the CEA, the French Hydrographic and Oceanographic Service (SHOM) and the Centre National de la Recherche Scientifique (CNRS), for the purpose of developing and operating the warning system and the centre. The CEA proposal included the establishment of dedicated stations of institutions around the Western Mediterranean to obtain seismic data that was important in detecting and measuring seismic events. Contacts were made and several stations were established with institutions from different countries as well as the CTBTO, thanks to the agreement signed in 2008 between CTBTO and Unesco. The collaboration with these institutions is presently working well and there has been good response since the agreed transmission of data begun. In accordance with the initially scheduled proposal, the CENALT entered into operation on the 1st of July 2012.

2. CENALT OPERATIONS

The objective of CENALT is to monitor the Western Mediterranean Sea and the North-Eastern Atlantic region for seismic events that could trigger tsunamis. Due to the proximity of seismic sources to monitored coastlines, the Centre is tasked with the responsibility of sending the first message to the French civil protection and to the Member states of the NEAM region within a window of time of less than fifteen minutes. To be able to comply with this short-term goal, it became necessary to establish permanent, technical analyst presence at the Centre in order to monitor effectively data reception and to processi and disseminate advisory/warning information.

2.1. Human resources

All results of the automatic first pass processing on the incoming data are interactively revised and a subsequent decision is taken by technical analysts at the Centre as to whether or not there is a need to transmit messages or issue warnings. Uninterrupted operations at the Centre are warranted by having technical analysts working on three, eight-hour shifts per day. Also, on-duty technicians are available on twenty-four-hour basis, in case problems arise with computer and technical maintenance.

2.2. Technical resources

2.2.1. Technical monitoring

Monitoring of the system is done automatically by computer software that constantly checks all the different parts, from the availability of servers and links that provide data, to the data storage capacity of partitioned hard disks. In case of a seismic event, an alert is sent to the analyst-in-charge, who can

then make the diagnosis of any problem and apply procedures for the monitoring process to resume normal operation.

2.2.2. Equipment redundancy

To prevent, or at least minimize downtime, all critical components of the system have been duplicated and can be either automatically or manually switched from one to another, depending on the problem and the type of equipment. For the purpose of retrieving data in case the primary mean of transmission fails, all critical data have a backup link that can be used. Generally, the backup link uses the Internet.

2.3. Data used

CENALT uses two kinds of data for its assessment operations: seismic and sea level data. The incoming seismic data is used to detect an earthquake, determine its epicenter and focal depth, as well as estimate its magnitude. Within the different stations used by the system, a certain number is considered as mission-critical and constitutes the backbone of the CENALT network (Figure 1). The other stations are used to further improve on the quality of results. Also, transmitted sea level data is used to detect whether a tsunami has been generated, to measure the actual time-travel of tsunami propagation through the Mediterranean Sea or the Atlantic Ocean basin and to confirm the forecast of potential tsunami wave level in the transmission of a warning.

2.3.1. Seismic data

The seismic data originates from more than seventy (70) seismic stations. The data is received either through VSAT (very small aperture terminal) satellite links, or through MPLS (Multi-Protocol Label Switching) links. Backups for the French stations are GPRS (General Packet Radio Service) links. More seismic data is received from a hundred stations that are outside the backbone network, but this data is transmitted and received only through Internet links without any backup.

2.3.2. Sea level data

Sea level data from a total of thirty-four (34) sea level stations (tide gauge) of the French Hydrographic and Oceanographic Service (SHOM) is transmitted through VPN (Virtual Private Network) links and around ten also through GTS (Global Telecommunication System). Sea level data of about forty stations (tide gauge) from other countries is retrieved via a direct link through the Internet and through the monitoring facility of UNESCO – IOC (Intergovernmental Oceanographic Commission). Two (2) extra sea level stations located in the Azores and Portugal also transmit sea level data through GTS links.

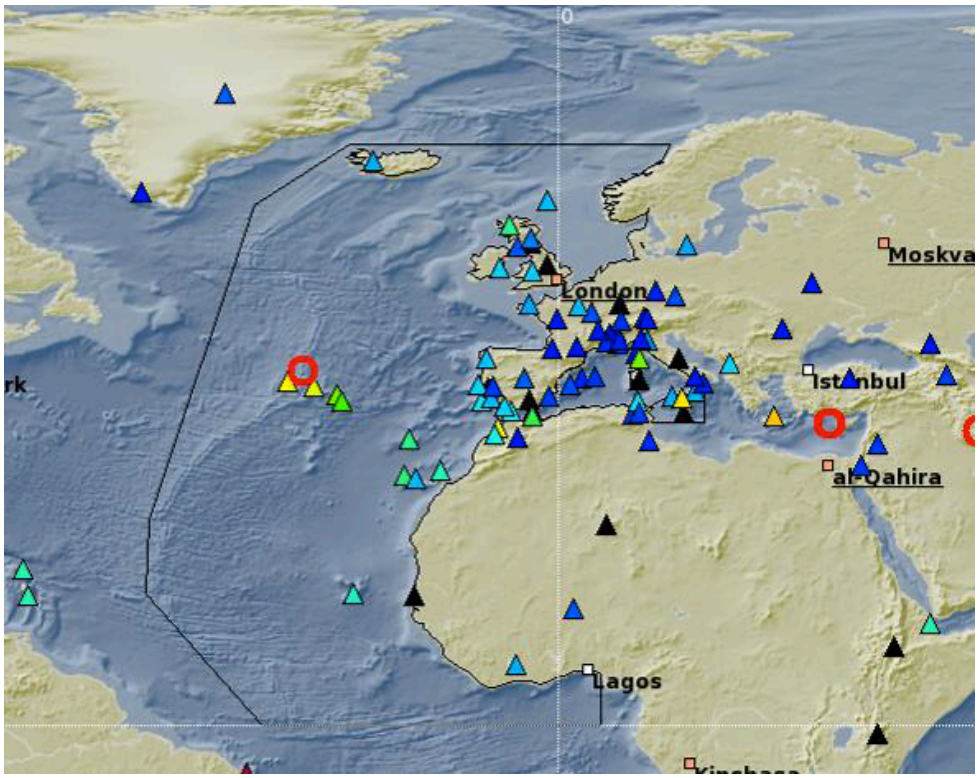

Figure 1. Partial map of seismic stations used by CENALT, extracted from the SeisComP3 application.

2.4. Data Processing

2.4.1. Processing of seismic data

The SeisComP3 (Seismological Communication Processor) software from Gempa is the core of the automatic detection of seismic events. The software analyses automatically the seismic data stream and locates the detected earthquake events. It then permits the interactive work of the analyst to improve the determination of the earthquake parameters.

2.4.2. Processing of sea level data

The Guitar software (developed by Gempa) continuously analyses the sea level data and allows measurements of the wave parameters at the participating tide gauge stations. CEA has developed, with its sub-contractors, additional software that is plugged-in in the Guitar software. One of the modules, “Cassiopée”, aggregates pre-determined tsunami scenarios to produce maps of tsunami risks. Another module, “Calypso”, calculates in near real-time the sea wave height in the deep sea, using as its basis the seismic event parameters. In case of an earthquake that could trigger a tsunami,

another software calculates the propagation time of the waves and the predicted arrival time of the first tsunami wave at the different forecast points. An example of this process is given in **Figure 2**.

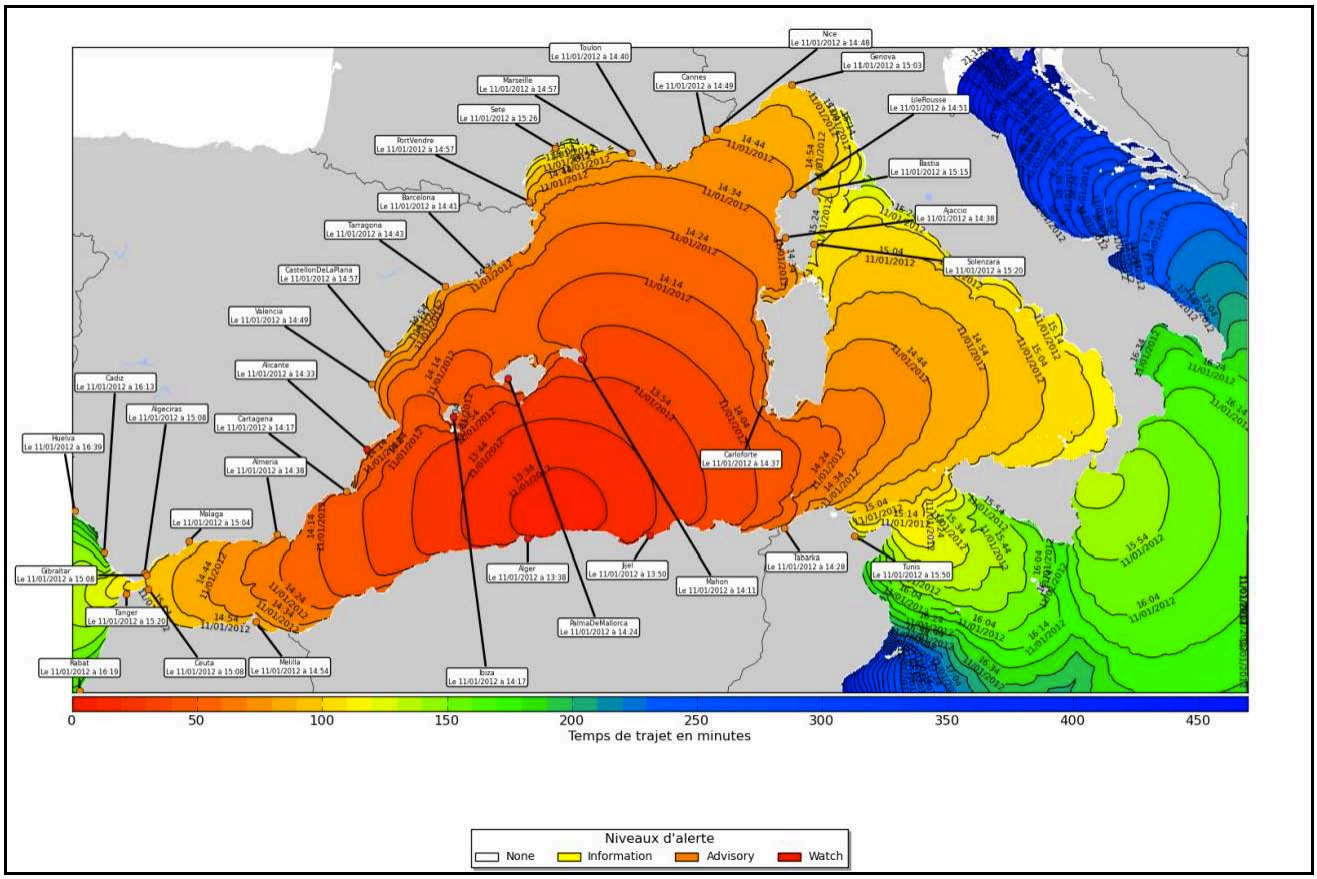

Figure 2. Propagation of a tsunami wave and arrival time at different forecast points for an event near the North African Margin.

2.5. Transmission of the information

In case of an earthquake that could potentially generate a tsunami, CENALT has both national and international responsibility to send messages to designated recipients in the region. Depending on the parameters of the seismic event, a decision matrix gives the different levels of information, warning or alert, which needs to be sent (**Figure 3** for the international matrix decision). Figure 4 indicates the different levels of warning that are issued – based on the magnitude and the region that may be affected (national or international), providing as an example an earthquake near the North African Margin.

2.5.1. National messages

Messages are sent to the Civil Security at the French Ministry of Interior, the Centre Opérationnel de Gestion Interministérielle des Crises (COGIC). The messages are sent through a dedicated MPLS link, as well as by e-mail and fax.

Depth	Localisation	Mw	Tsunami Potential	Type of Message
< 100 km	Offshore or close to the coast (≤ **40 km** inland)	**5.5 à 6.0**	weak potential of local tsunami	**Information Message**
		6.0 à 6.5	Potential of destructive local tsunami < 100 km	**Regional Tsunami Advidory**
	Offshore or close to the coast (≤ **100 km** inland)	**6.5 à 7.0**	Potential of destructive regional tsunami < 400 km	**Regional Tsunami Watch - Basin-wide Tsunami Advisory**
		≥ 7.0	Potential of destructive tsunami in the whole basin > 400 km	**Basin-wide Tsunami Watch**
	Inland (> 40 km and ≤ 100 km)	**5.5 à 6.5**	weak potential of local tsunami	**Information Message**
≥ 100 km	Offshore or inland (≤ 100 km)	**≥ 5.5**	Nil	**Information Message**

No message if the earthquake is localized inland beyond 100 km distance

Figure 3. Decision matrix for seismic event that occurs in the Mediterranean Sea.

2.5.2. International messages

Internationally, messages are sent by GTS, e-mail and fax to the countries which have subscribed by sending a request to the IOC. The first international communication test by CENALT was conducted on 22 May 2012. Test messages were sent to thirty-five (35) institutes in thirty-one (31) countries. E-mails and faxes were directly sent to participants and, additionally, a message was also sent by GTS. Since the beginning of operations of the Centre on the 1st of July 2012, several countries have requested through the IOC to be recipients of messages from CENALT. A first successful e-mail and fax communication test was conducted on the 8 August 2012 with these countries, to verify the correct transmission and receipt of messages. Since that time regular monthly communication tests are performed by GTS, email and fax, to an increasing number of recipients. In January 2013, 15 recipients belonging to 10 Member states and 2 international bodies received messages from CENALT.

The international activities of the CENALT were: a) the presentation of the CENALT activity report to the Intergovernmental Coordination Group (ICG) of IOC at the meeting in September 2012; b) the participation of France at the end of November 2012 to the NEAM Wave 12 tsunami exercise by providing a potential scenario; and c) the continuous integration (and tests) of contact points in the countries which have or will request receipt of messages from CENALT.

On the developmental side, rapid calculations of focal mechanisms will be implemented, tested and evaluated, to improve the efficiency of tsunami impact assessment for an event which may occur in the monitored region.

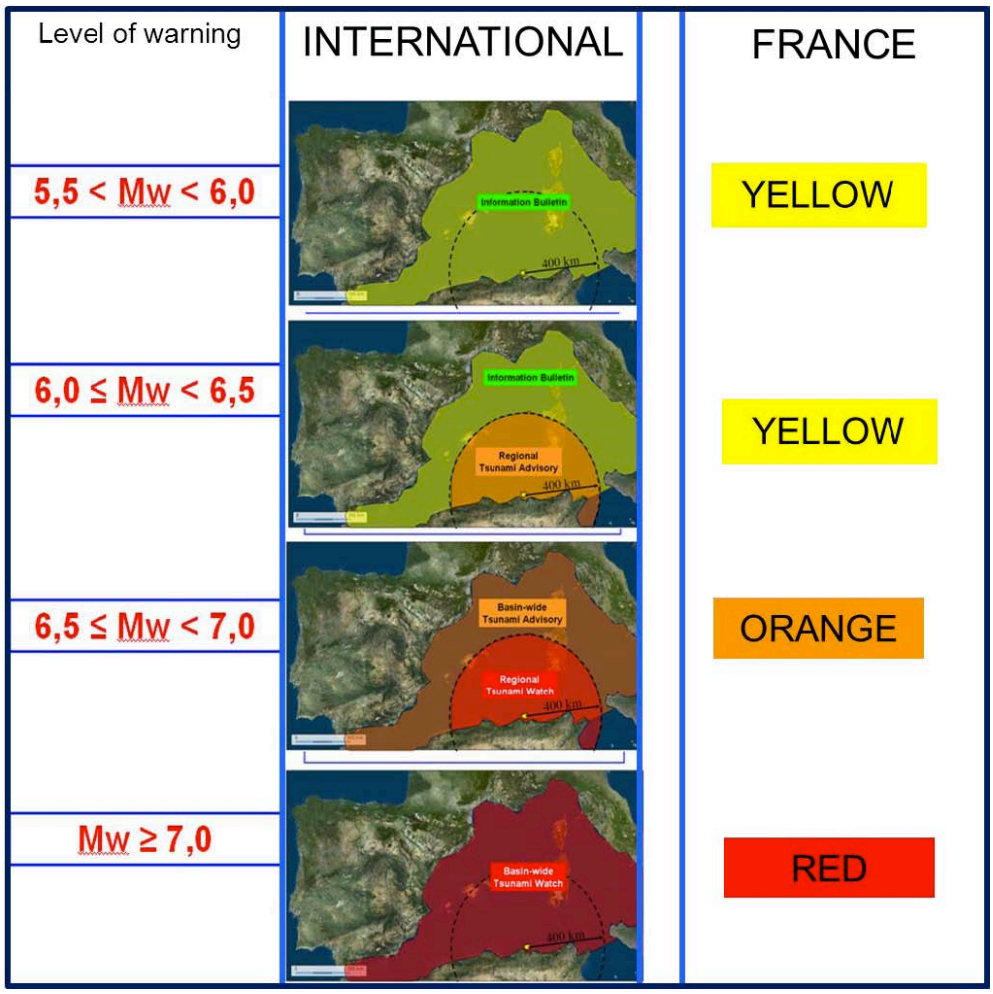

Figure 4. Different levels of warnings for International and National (France) regions monitored in the Western Mediterranean Sea.