

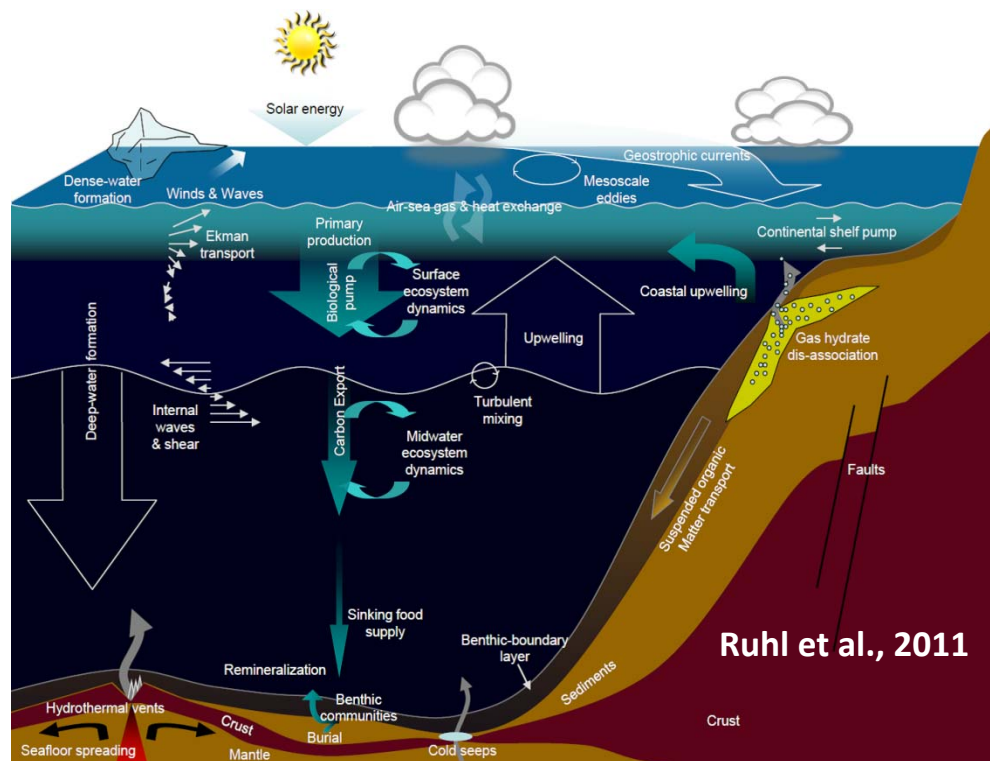


**New marine infrastructures and technology development, application to
Tsunami Early Warning System:
EU Research Infrastructure EMSO
European Multidisciplinary Seafloor and Water-Column Observatory**



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1/ CSIC; 2/ INGV**

EMSO is the European Research Infrastructure of fixed seafloor and water column observatories constituting a distributed infrastructure for long-term monitoring of marine environmental processes



Challenging RI for:

- Global ocean warming and acidification
- Impact and sustainability of marine resource exploitation
- Real-time observations of earthquakes and tsunamis**

Key Scientific Research Objectives

EMSO provides power, communications, sensors, and data infrastructure for continuous, high resolution, (near) real-time, interactive ocean observations

EMSO concerns a truly multi-and inter-disciplinary range of research areas including biology, geology, chemistry, physics, engineering, and computer science, from polar to tropical environments, down to the abyss

The synchronised data generated in **EMSO** allow to pose multivariate questions over different space and time scales, overcoming the traditional approach of focusing on single data streams

Key Scientific Research Objectives

Geosciences

- Seismicity
- Gas hydrate stability
- Seabed fluid flow
- Submarine landslides
- Submarine volcanism
- Geo-hazard early warning

Physical Oceanography

- Ocean warming
- Deep-ocean circulation
- Benthic and water column interactions
- Marine forecasting

Biogeochemistry

- Ocean acidification & Solubility pump
- Biological pump
- Hypoxia
- Continental shelf pump
- Deep-ocean biogeochemical fluxes

Marine Ecology

- Climate forcing of ecosystems
- Molecules to microbes
- Fisheries
- Marine noise
- Deep biosphere
- Chemosynthetic ecology

Steps towards EMSO-ERIC

Italian Ministry Letter sent to the Funding Agencies	DONE
MoU Signature process	DONE
Interim Office establishment	DONE
ERIC Official Application submission (step1)	DONE by Permanent Representation of Italy to EU
ERIC Application review process	NEXT
ERIC APPROVAL  M1	NEXT

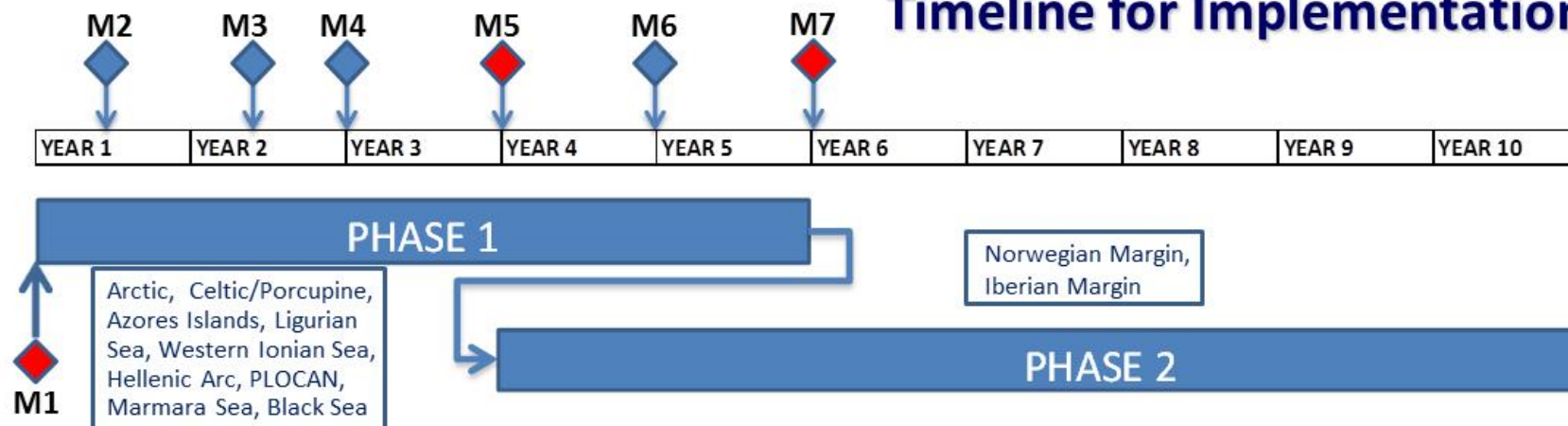
10 Signatory Countries:

Italy, UK, Portugal, Romania, Greece, The Netherlands, Ireland, Germany, France, Spain

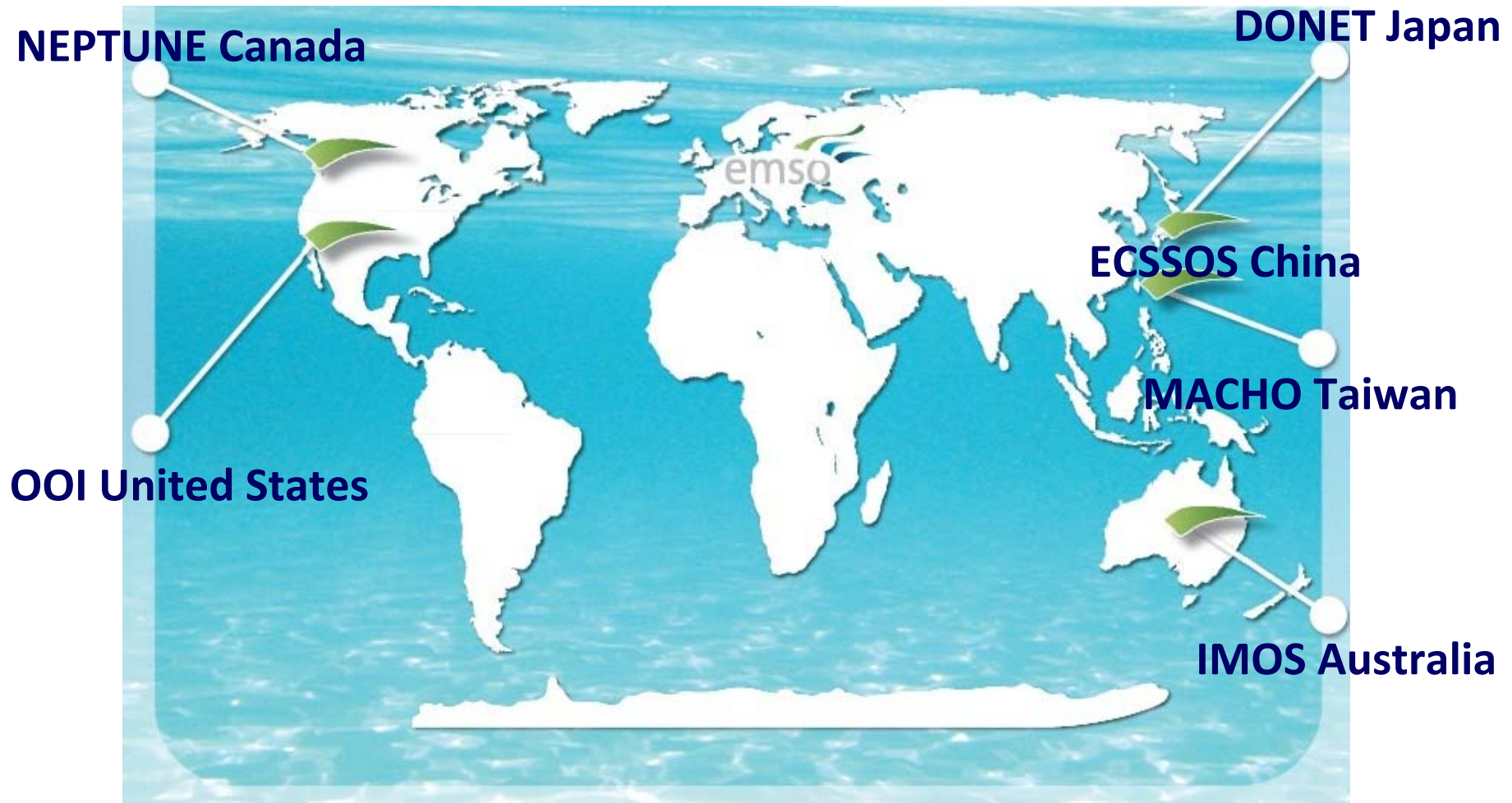
Foreseen:

Norway, Turkey, Sweden (postponed)

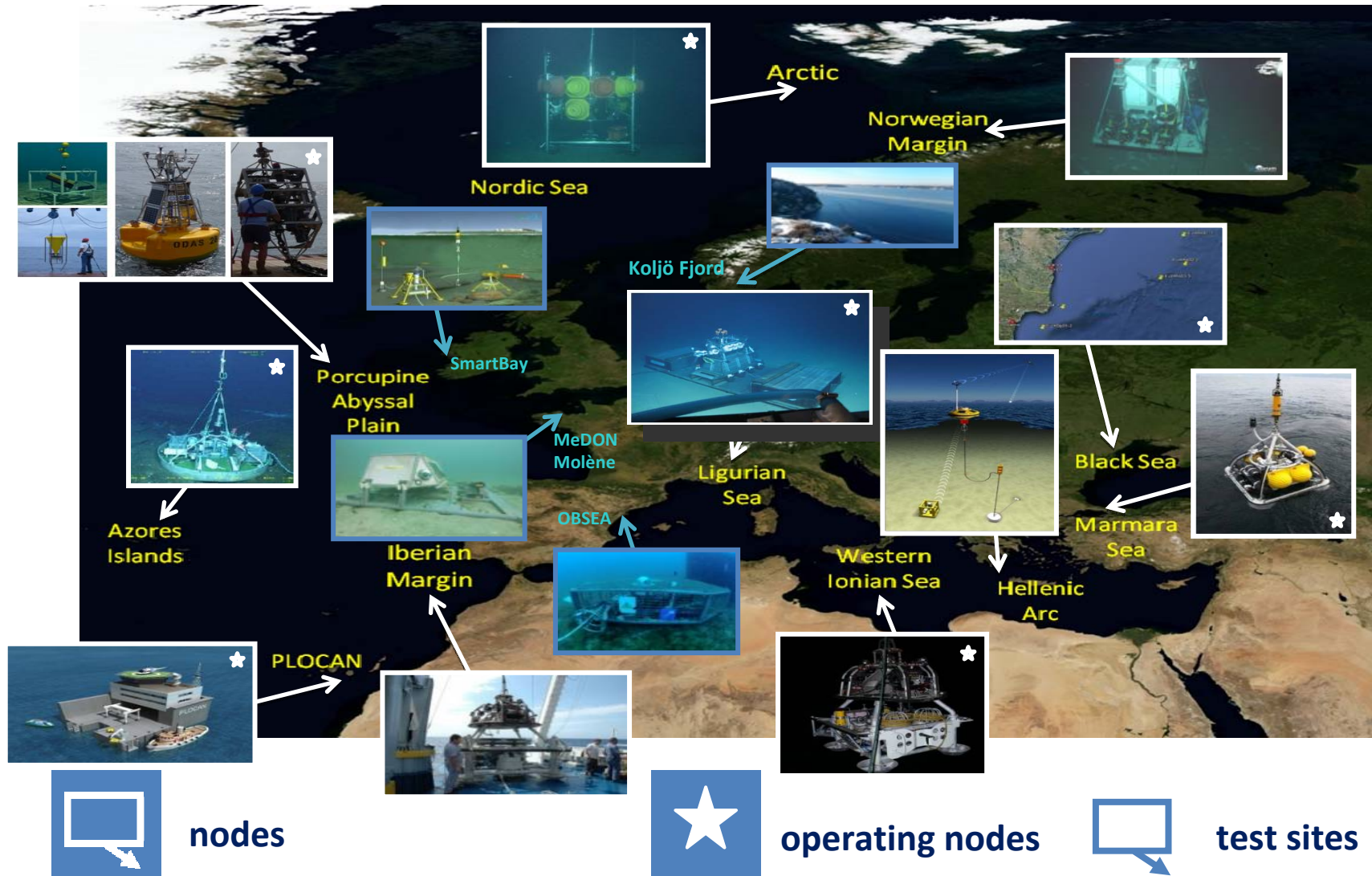
Timeline for Implementation



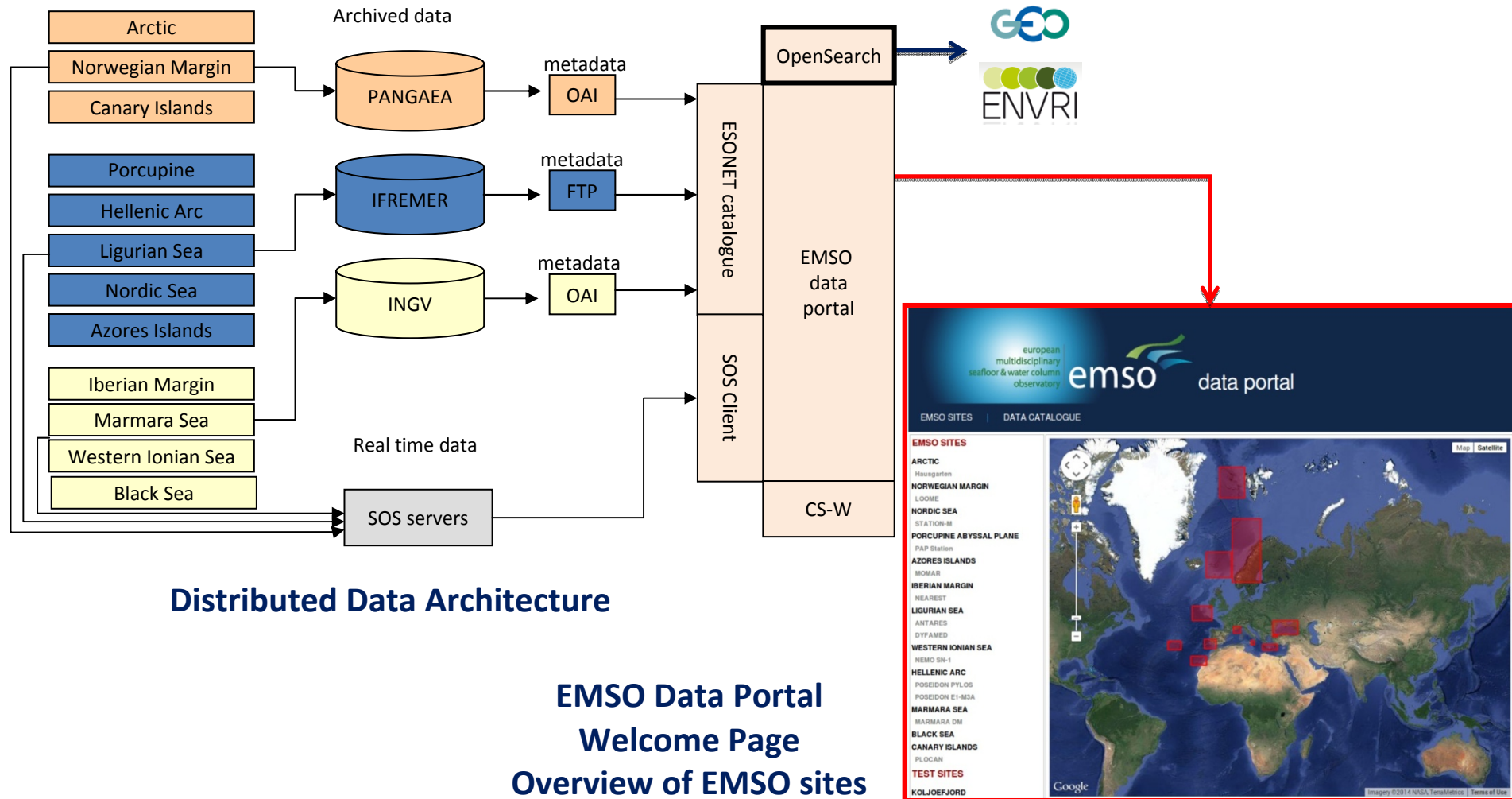
International dimension



EMSO nodes – present status



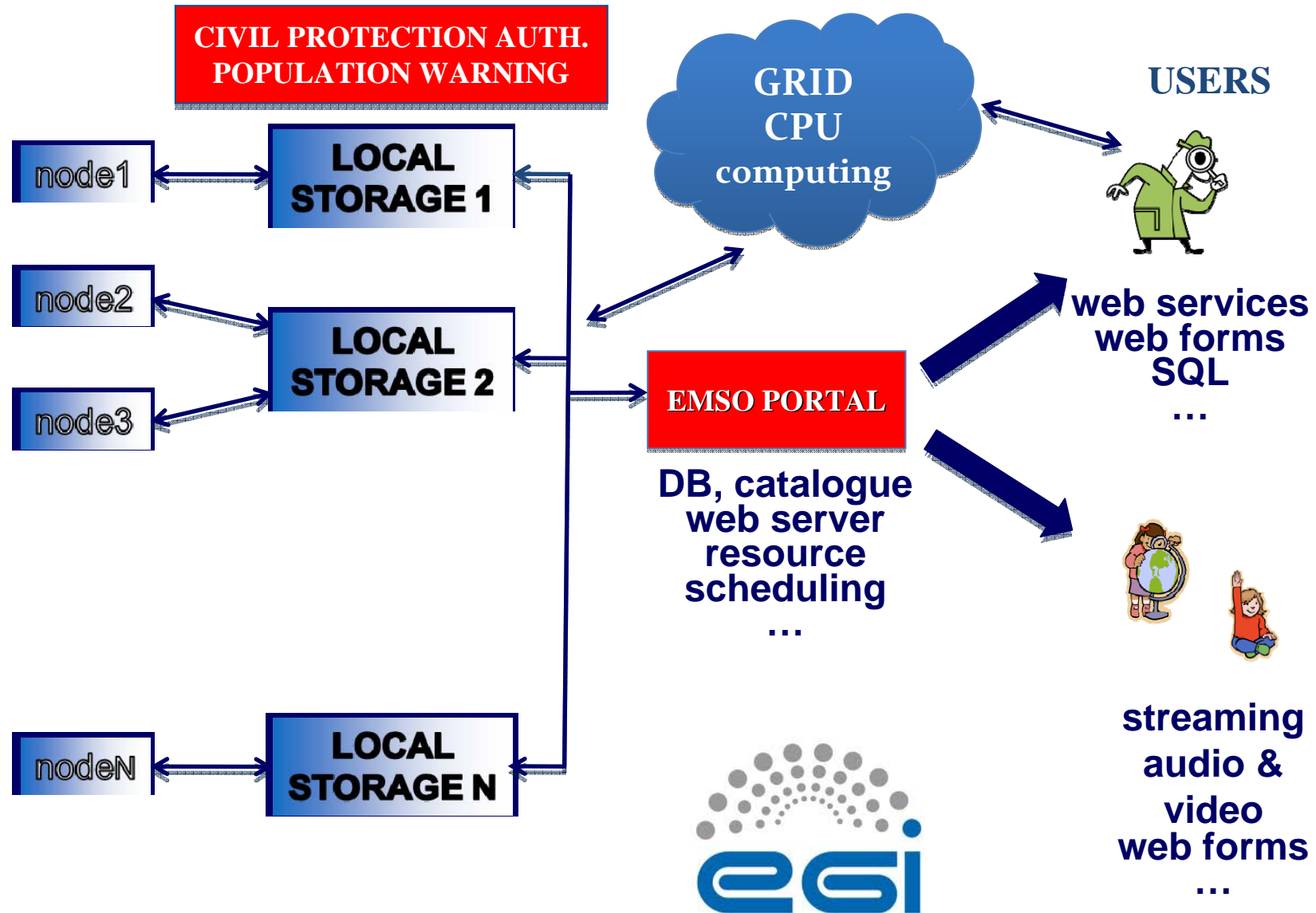
EMSO Data Management



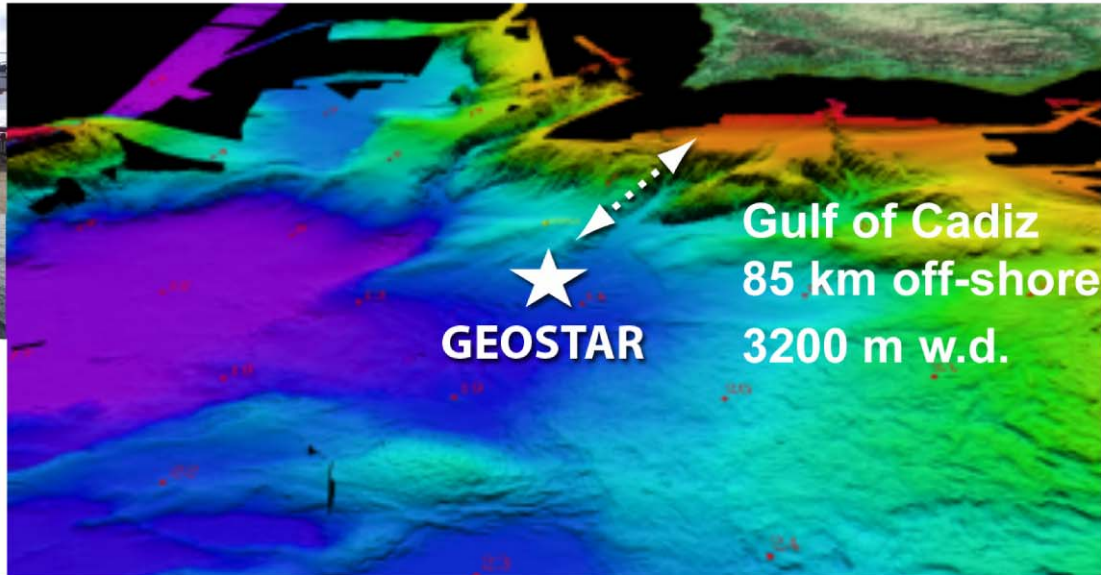
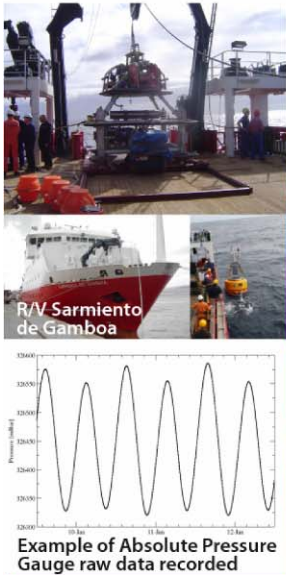
Distributed Data Architecture

**EMSO Data Portal
Welcome Page
Overview of EMSO sites**

EMSO distributed storage & database



EMSO nodes: present status



INFRASTRUCTURE GEOSTAR observatory, seafloor station with acoustic connection to a surface buoy and satellite connection from buoy to shore.

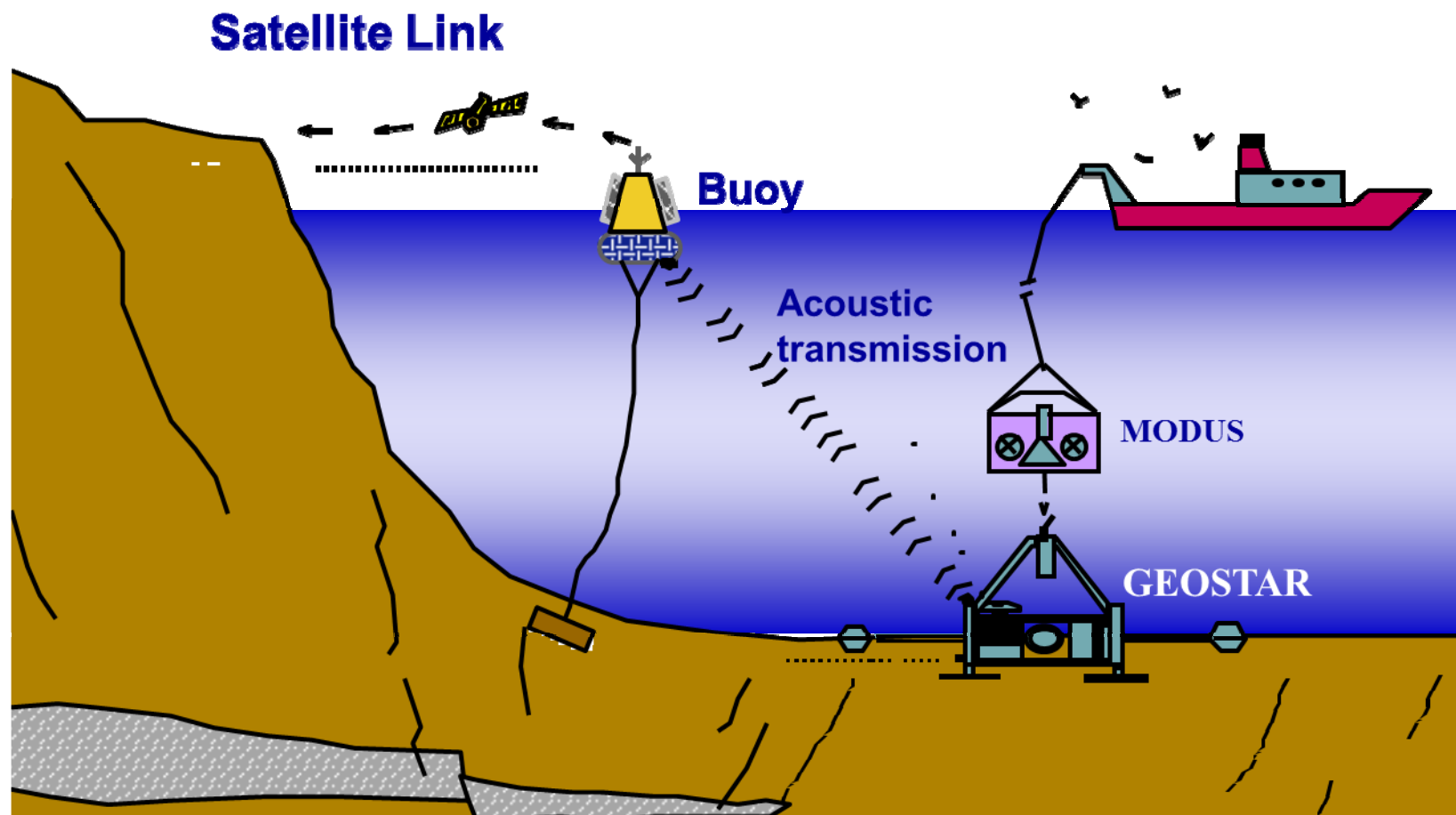
RESEARCH Eurasian and African plate boundary off Portuguese coast, Mud volcanoes, pockmarks, mud diapirs, carbonate chimneys, hydrocarbon venting and faulting; prototype tsunami meter; passive acoustics related to marine mammals and anthropogenic noise

PREVIOUS/RECENT ACTIVITIES part of HERMIONE research; NEAREST and NEAMTWS geo-hazard early warning efforts; ESONET demo mission Listening to the Deep Ocean environment (LIDO); near real-time data transmission through acoustic link from seafloor observatory to surface buoy and through satellite link from buoy to shore based on **GEOSTAR** platform;

FUTURE ACTIVITIES Installation of an observatory starting in 2013, with communication by satellite link, in the same site or a neighbouring place

IBERIAN MARGIN

EMSO nodes (standalone) Iberian Margin – NEAREST EC Project



EMSO nodes: present status



Geo-Hazard

Tsunami Early Warning system prototype
Seismometer, bottom pressure data;

Marine ecosystem & climate change: CTD,
hydrophone, gravity meter, current meter, ADCP,
turbidity meter, seismic, sea bottom pressure

First mission (2007-2008)
(NEAREST EC project)



Iberian margin

Second mission (2009-2011)
NEAREST - ESONET LIDO DM
GEOSTAR recovered in June 2011

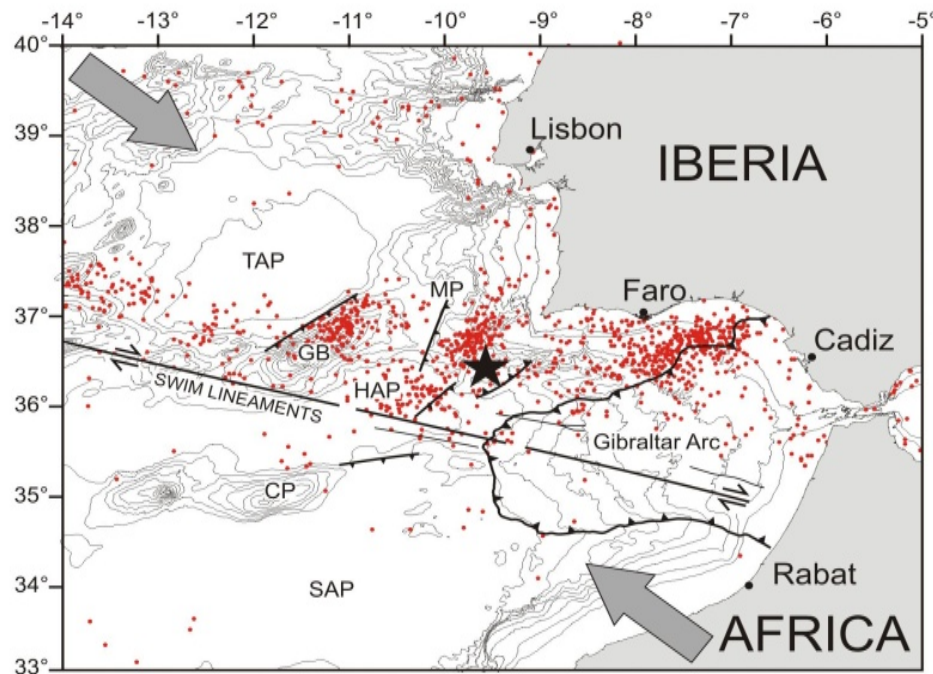


June 2011
recovery



Pilot experiment (NEAREST project)

Gulf of Cadiz (Atlantic Ocean), source area of 1755 Tsunami which destroyed Lisbon and the coasts of South Portugal, Spain and Morocco



The abyssal observatory GEOSTAR, with the tsunamometer on board operated in an active seismic zone (3200 m)

Two missions
Aug 2007 – Aug 2008
Nov 2009 - Jun 2011

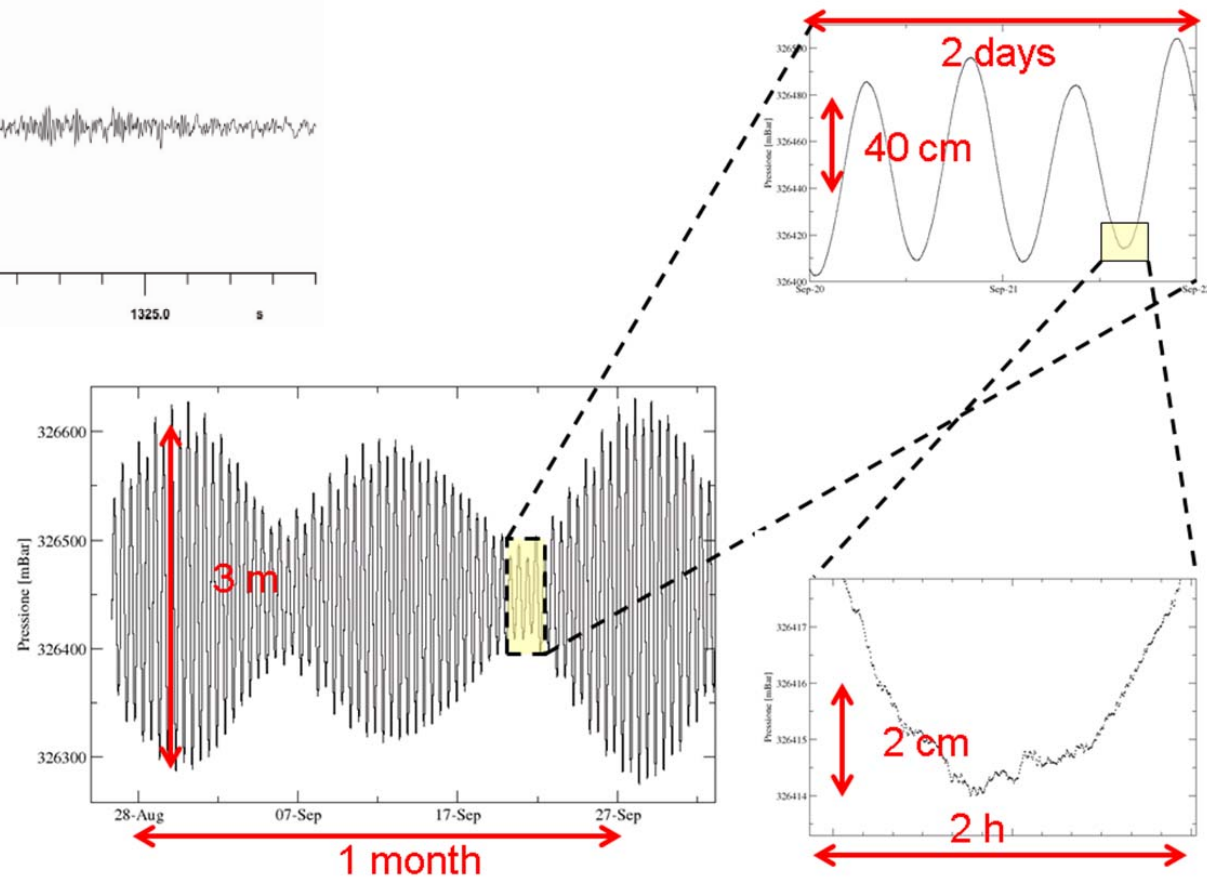
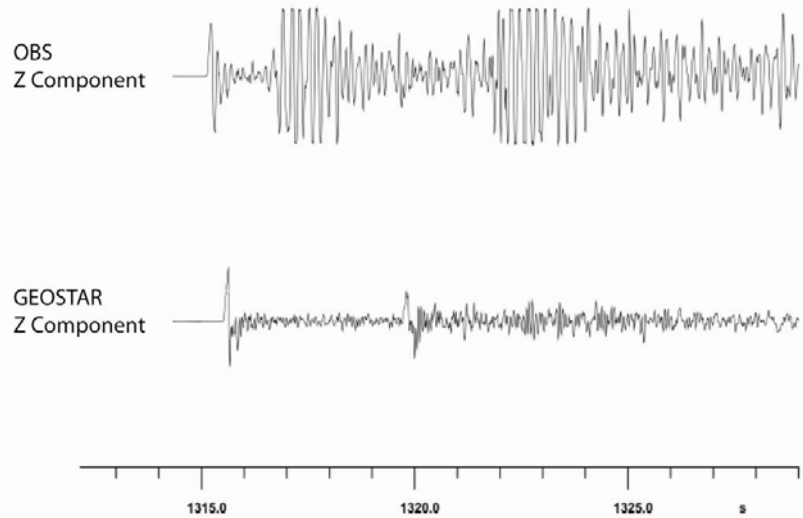
Possible cooperation with NEAMTWS

Seismic criteria for ATLANTIC

Depth	Location	(Mw)	Tsunami Potential	Bulletin Type
< 100 km	Under or very near the sea (< 30 km)	5.5 to 7.0	Small potential for a destructive local tsunami	Information Bulletin
		7.0 to 7.5	Potential for a regional tsunami < 1000 km	Regional Tsunami Watch
		7.5 to 7.9	Potential for a destructive regional tsunami < 1000 km	Regional Tsunami Warning Ocean-wide Tsunami Watch
		> 7.9	Potential for a destructive ocean-wide tsunami > 1000 km	Ocean-wide Tsunami Warning
	Inland (> 30 km)	5.5	No tsunami potential	Information Bulletin
= 100 km	All Locations	= 5.5	No tsunami potential	Information Bulletin

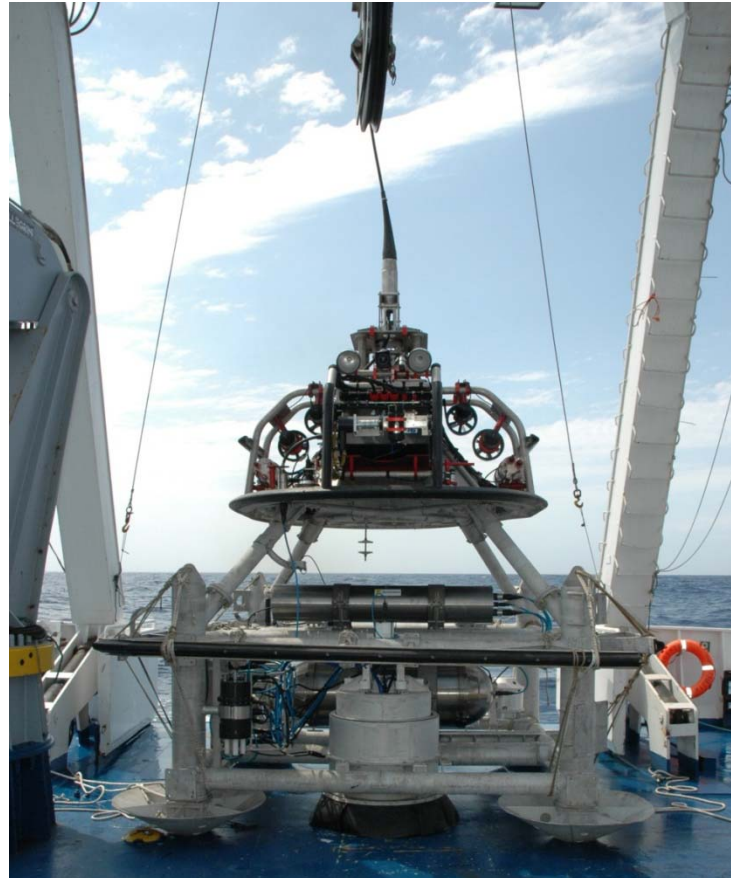
Experimental data acquisition

ML = 4.7 Gulf of Cadiz, Jan 11, 2008



Pilot experiment

- ❑ **Quick response time:** few minutes for the generated tsunami to reach the coast.
- ❑ **Tsunami warning:** real time pressure & seismic data analysis performed on the seafloor
- ❑ **Automatic transmission** of data through acoustic link and moored relay buoy



EMSO nodes: present status

European
multidisciplinary
seafloor & water column
observatory



Geo-hazards
(earthquakes, tsunamis,
volcanic activity)

Bio-acoustics
(mammal tracking)
Oceanography
(e.g., deep water circulation,
current intensity and
direction, temperature,
salinity)



INFRASTRUCTURE NEMO-SN1 seafloor observatory, cabled to laboratory in the harbour of Catania by electro-optical cable

OPERATING IN REAL TIME SINCE 2005 Integrated with land-based networks by transmitting real-time data to National Seismological Service Centre in Rome; Test site for realisation of the underwater neutrino telescope

RESEARCH Geohazards, tsunamis, climate change, bioacoustics and ambient noise.

PREVIOUS/RECENT ACTIVITIES LAMS and SIRENA FESR projects (national). GNDT-SN1 (national). PEGASO project (Structural funds). ESONET demo missions (LIDO, Listening to the Deep Ocean environment). GENESI-DEC, SCIDIP-ES (FP7 infrastructures), KM3NET, TRANSFER

FUTURE ACTIVITIES extension of the Catania 30-km cabled; Off Capo Passero 100-km cabling, it has been operating from 2011; Further implementation adding water column and data management from 2012

WESTERN IONIAN SEA

Stand-alone 2002-2003 - Cabled 2005-2008 & 2012 real-time data

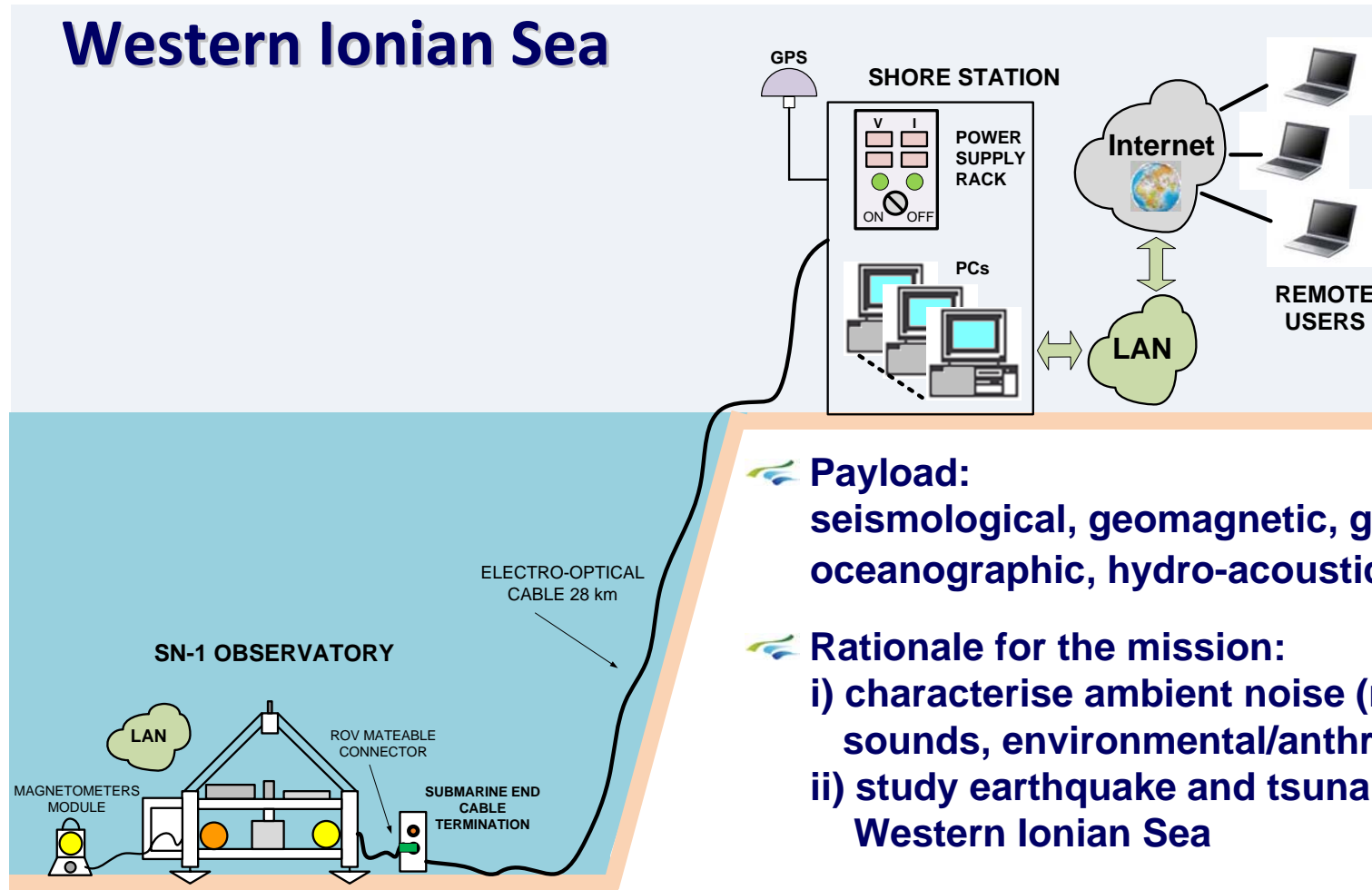


NEMO-SN1 concept

European
multidisciplinary
seafloor & water column
observatory



Western Ionian Sea



- **Payload:**
seismological, geomagnetic, gravimetric, oceanographic, hydro-acoustic, bio-acoustic
- **Rationale for the mission:**
 - characterise ambient noise (marine mammal sounds, environmental/anthropogenic sources);
 - study earthquake and tsunami generation in Western Ionian Sea
- **Detection algorithm runs in the Shore Station**

NEMO-SN1 New equipment's

Western Ionian Sea

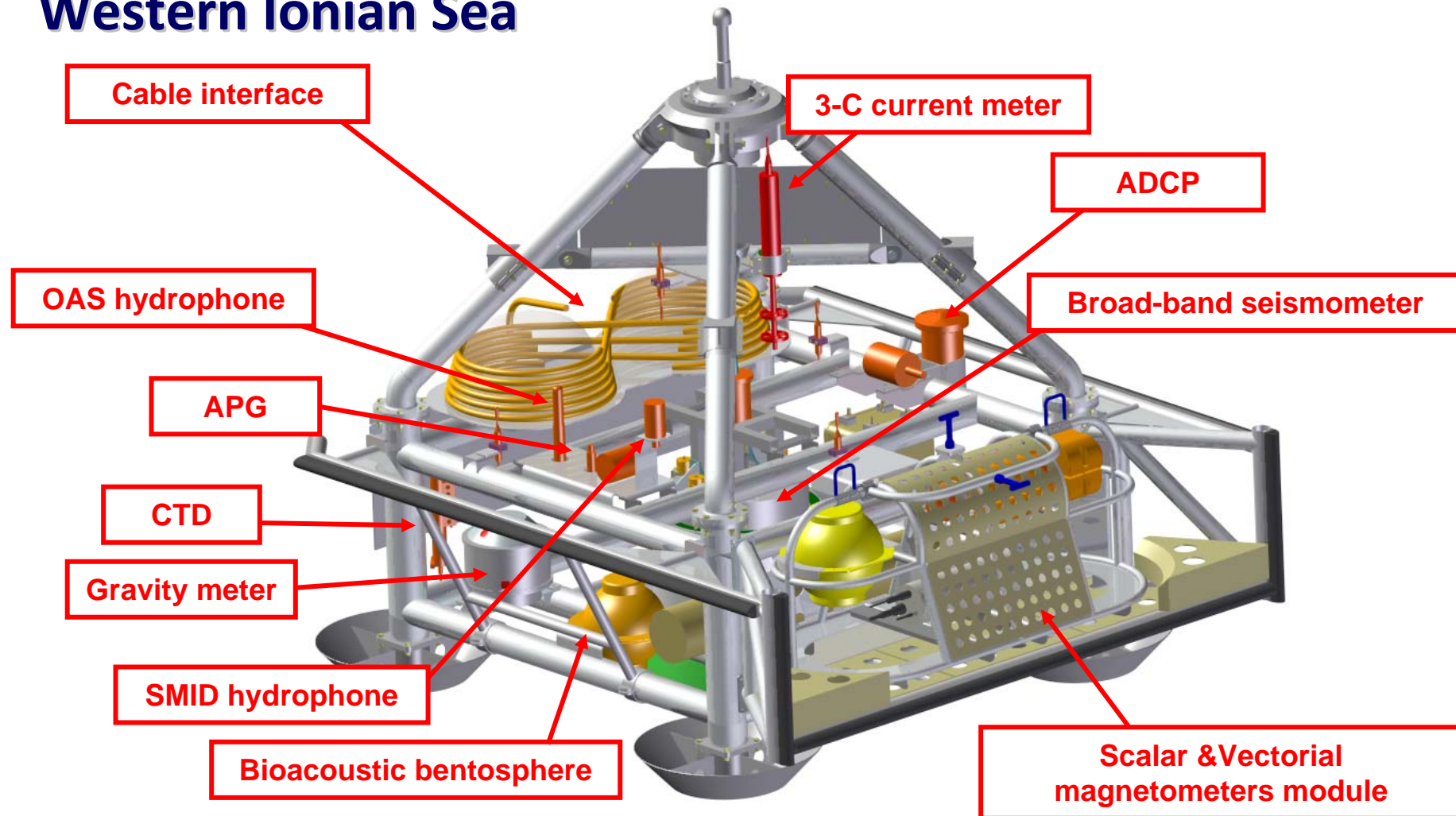
Sensor	Rate	Model
3-C broad-band seismometer *	100 Hz	Guralp CMG-1T (0.0027-50 Hz)
Differential Pressure Gauge (DPG)	100 Hz	Prototype Univ. California-St. Diego
Hydrophone (Geophysics)	100 Hz	OAS E-2PD
Hydrophone (Geophysics)	2000 Hz	SMID (0.05-1000 Hz)
4+4 Hydrophones (Bio-acoustics)	96 /192 kHz**	SMID (100-70000 Hz)
Absolute Pressure Gauge (APG) *	15 s	Paroscientific 8CB4000-I
3-C Accelerometer + 3-C Gyro (IMU) *	100 Hz	Gladiator Technologies Landmark 10
Gravity meter	1 Hz	Prototype IFSI-INAF
Scalar magnetometer	1s/min	Marine Magnetics Sentinel (3000 m)
Vectorial magnetometer	1 Hz	Prototype INGV
ADCP	1 profile/h	RDI Workhorse Monitor (600 kHz)
CTD	1 s/h	SeaBird SBE-37SM-24835
3-C single point current meter	2 Hz	Nobska MAVS-3

* tsunami early warning system - Geo-Hazard

** 96 kHz at TSN, 192 kHz at TSS - Marine Environment

NEMO-SN1 Upgrade

Western Ionian Sea



The tsunami detector

An original **Real-time Detection Algorithm** has been developed to detect tsunami parents signals (few mm amplitude) in the whole tsunami frequency band

Characteristics:

- low computational cost
- site adaptability
- accuracy

Tsunami Detection procedure

The Tsunami Detection procedure is based on the double check of seismic and pressure signals → generating **trigger**



- Seismometer: trigger on strong seismic event (STA/LTA algorithm)
- Pressure: for the detection of sea level anomalies (Tsunamis wave)

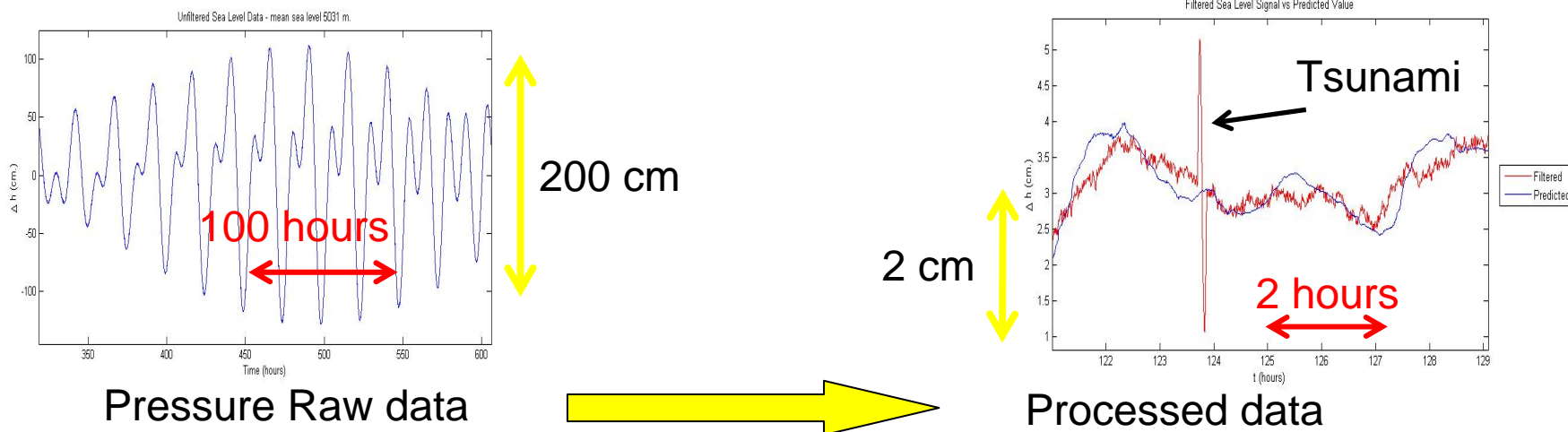
The trigger detection switches the acquisition system from “Mission” to “Event” mode, increasing sampling rate of the sensors and sending messages

Tsunami Detection Algorithm (TDA)

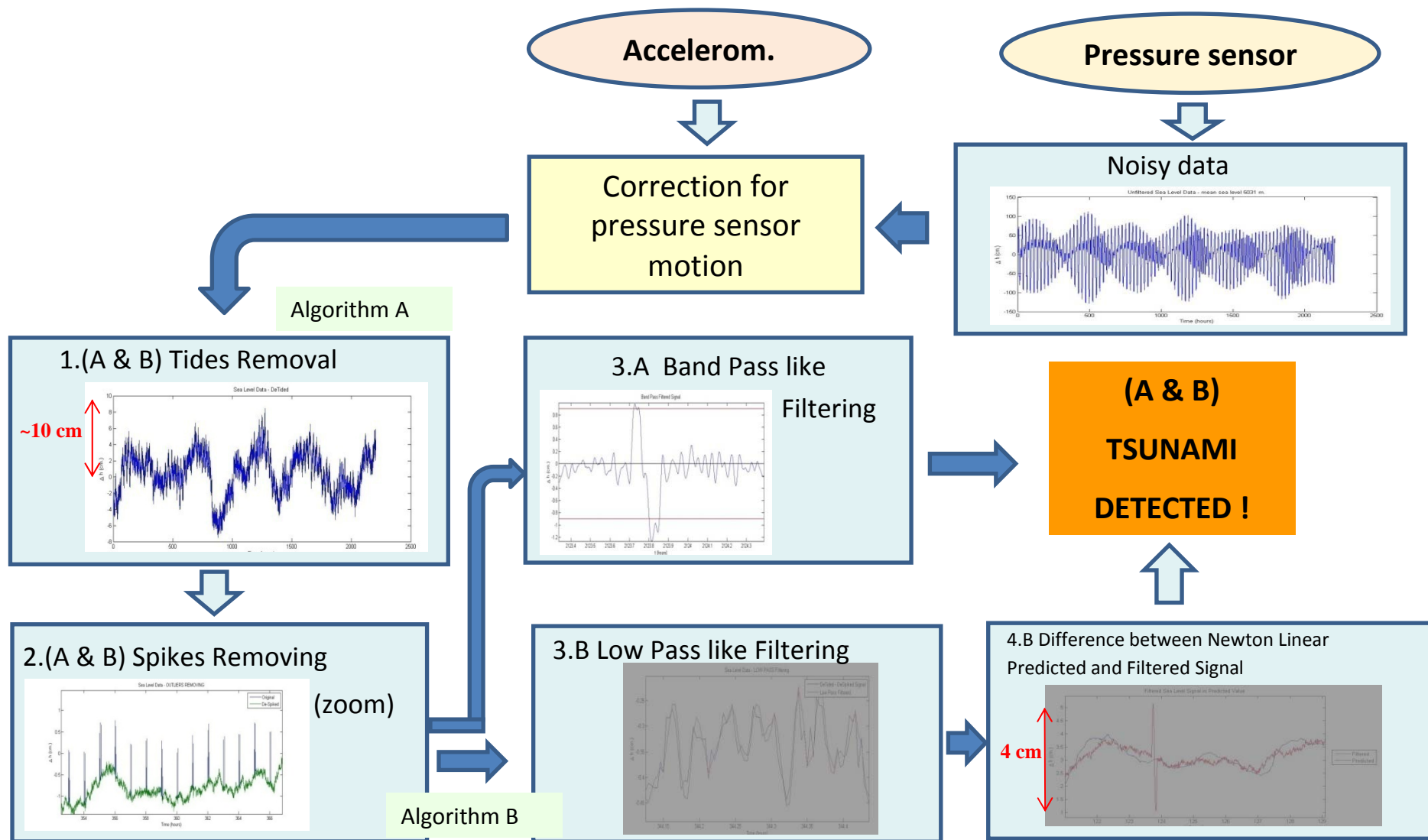
Pressure data every 15 s are real-time processed:

- Tide removal
- Spike removal, if needed
- Low pass + Prediction algorithm (first 7 days, Newton linear prediction)
- or Band Pass like filter (after 7 days, at least 8 tide coefficients recovered)

All parameters can be re-configured in real time

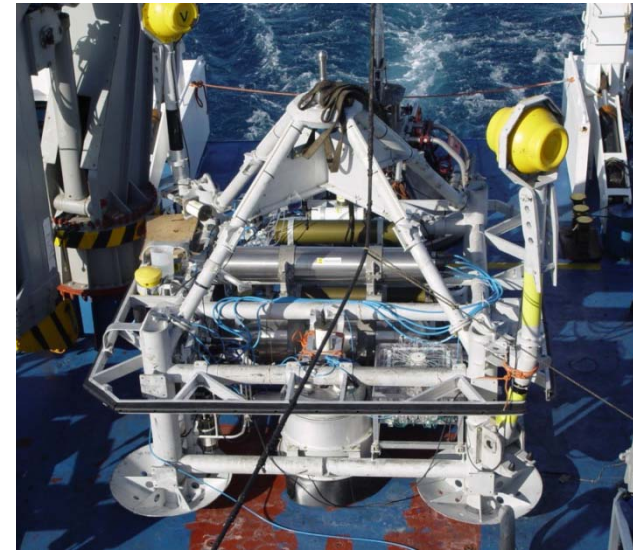


TDA Algorithm

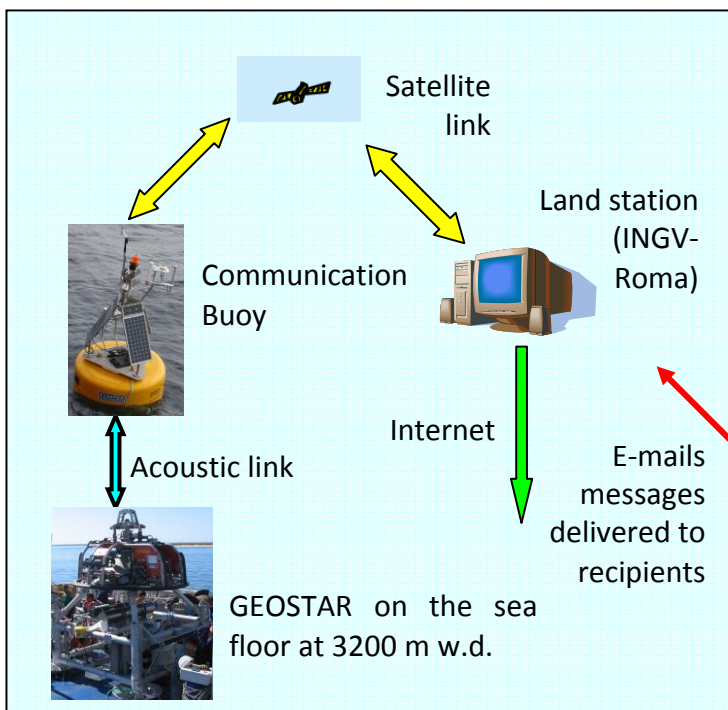


NEMO-SN1 & GEOSTAR

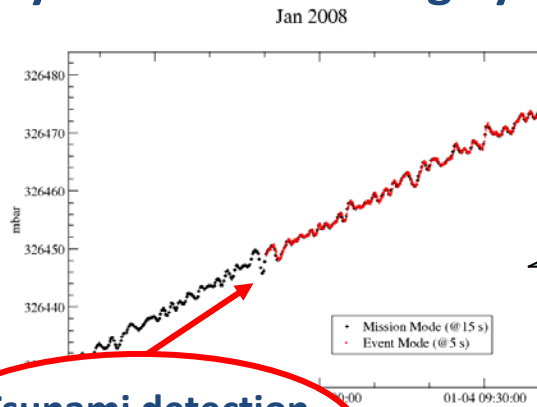
- Two seafloor observatories were equipped with the tsunami detector
 - **GEOSTAR** (acoustic-linked)
 - **SN-1** (cabled)
- Common features
 - Multidisciplinary
 - Single, open frame, reconfigurable according to different mission requirements
 - 4000 m design depth
 - Dedicated intervention system



EMSO data examples



Early Tsunami Warning System

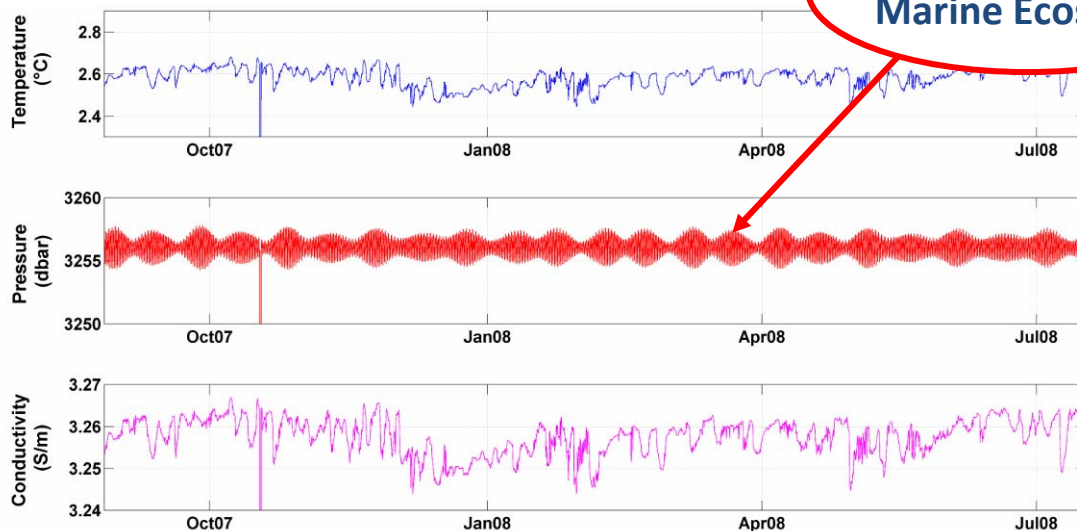


Iberian margin

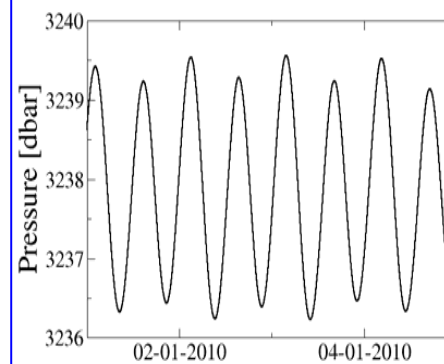
Tsunami detection system (geo-hazard)

Climate Changes, Marine Ecosystem

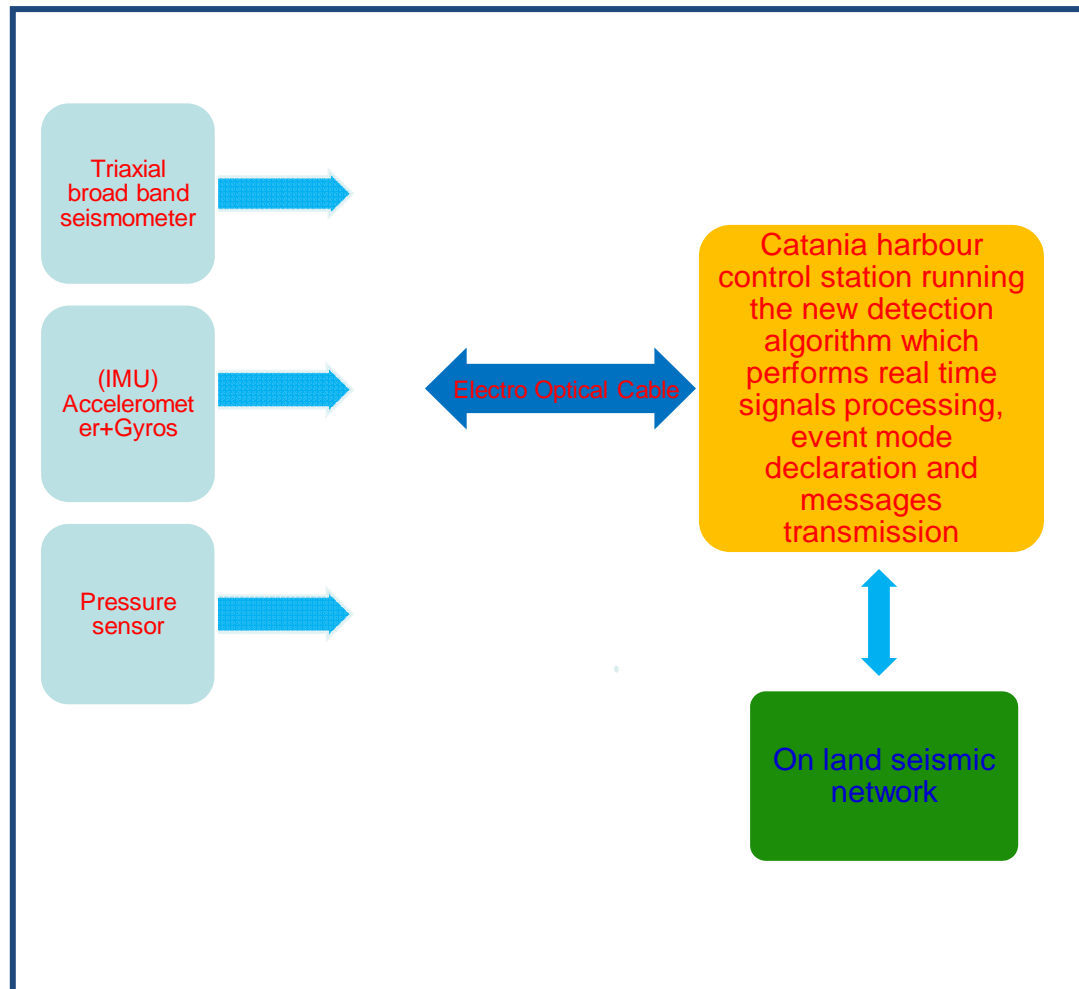
A pressure event detected by the Tsunami Detection Algorithm (from 1° mission)



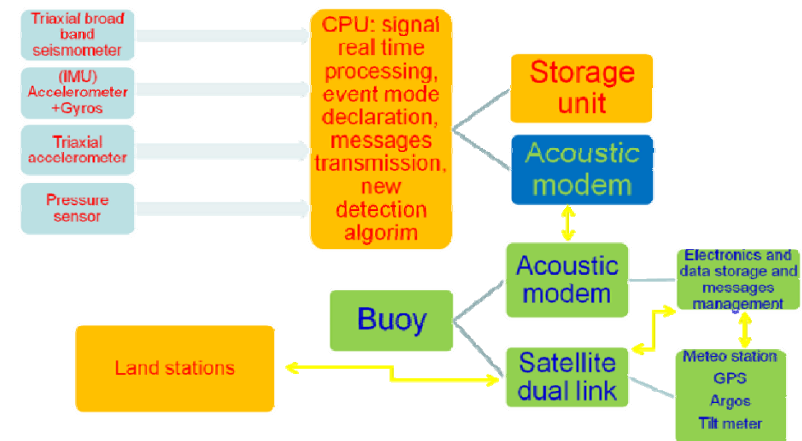
Data from 2° mission



NEMO-SN1 & GEOSTAR Tsunameters



Tsunameter scheme (installed onboard Geostar)



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Institut Français de Recherche pour l'exploitation de la mer, France (Deputy Coordinator)
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