



EMSO

European Multidisciplinary Seafloor and water-column Observatory

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Istituto Nazionale di Geofisica

e Vulcanologia

on behalf of

EMSO Consortium



<http://www.emso-eu.org/>

EMSO, an ESFRI Research Infrastructure

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



**EMSO is
component of the
European Ocean
Observing System
(EOOS)**

Ostend Declaration, 2010

International dimension

european
multidisciplinary
seafloor
observatory



NEPTUNE Canada

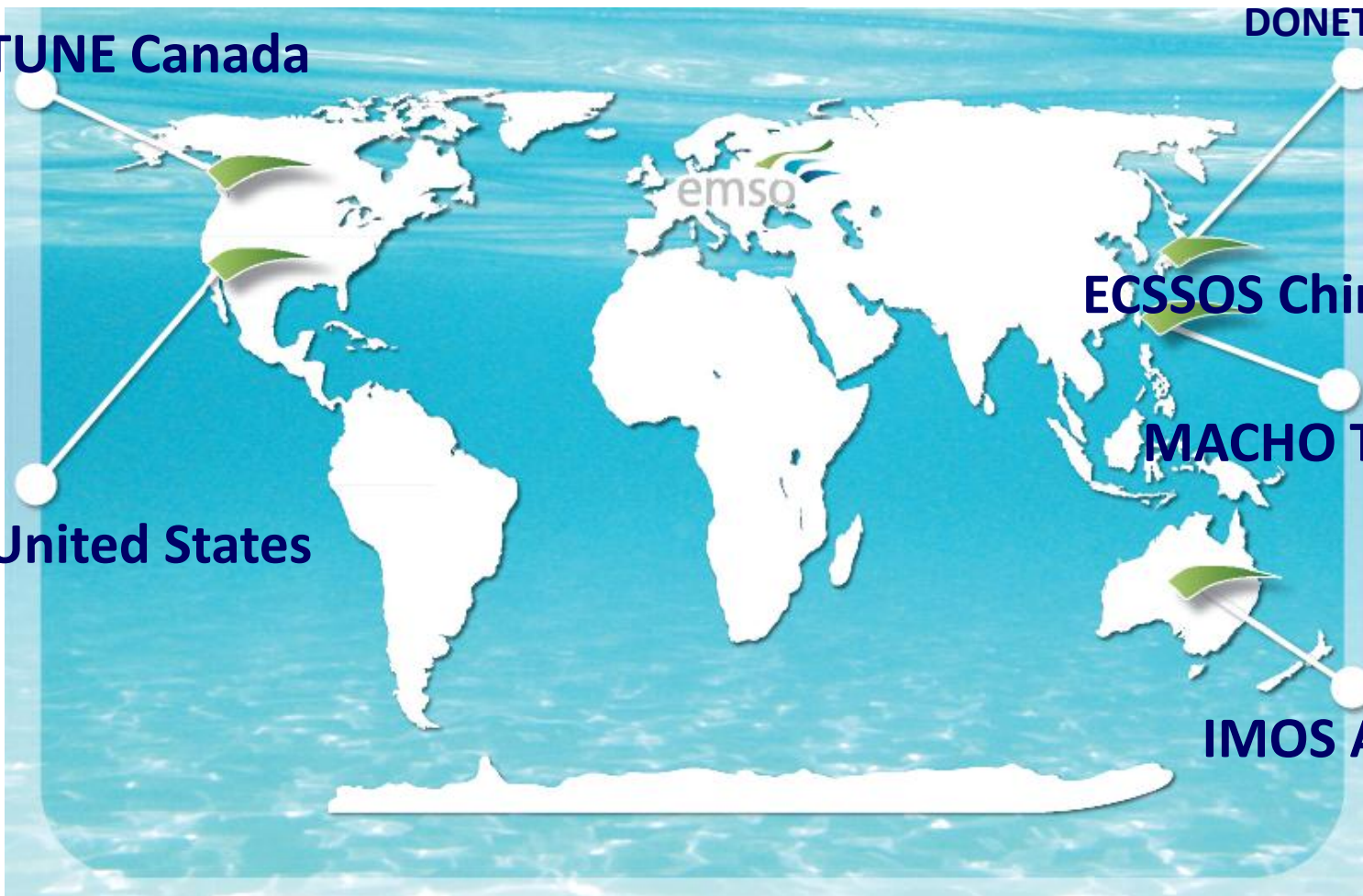
DONET Japan

ECSOS China

MACHO Taiwan

OOI United States

IMOS Australia



Science Objectives

“Societal need for improved understanding of climate change, anthropogenic impacts, and geo-hazard warning drive development of ocean observatories in European Seas”

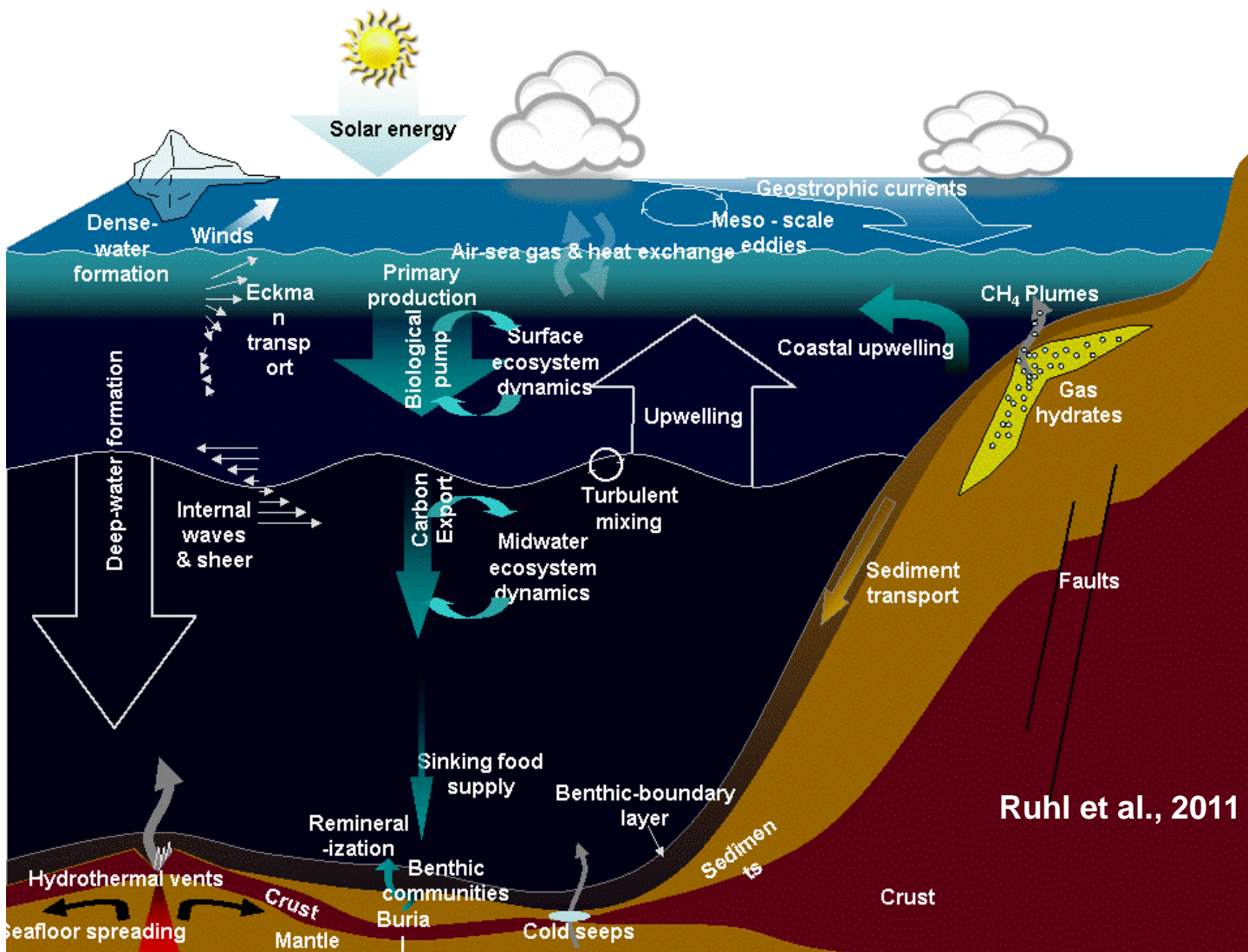
H.A. Ruhl, M. André, L. Beranzoli, M.N. Çağatay, A. Colaço, M. Cannat, J.J. Dañobeitia, P. Favali, L. Géli, M. Gillooly, J. Greinert, P.O.J. Hall, R. Huber, J. Karstensen, R.S. Lampitt, V. Lykousis, J. Mienert, J.M. Miranda, R. Person, I.G. Priede, I. Puillat, L. Thomsen, C. Waldmann

**Progress in Oceanography, 91:1-33 (2011),
doi:10.1016/j.pocean.2011.05.001**

Socio-economically important topics which cross-cut the outlined science areas include themes spanning numerous spatial and temporal scales such as:

- **Natural and anthropogenic change**
- **Interactions between ecosystem services, biodiversity, biogeochemistry, physics and climate**
- **Impacts of exploration and extraction of energy, minerals, and living resources**
- **Geo-hazard early warning capability for earthquakes, tsunamis, gas hydrate release, and slope instability and failure**
- **Connecting scientific outcomes to stakeholders and policy makers**

Unravelling the complexity



**Interactions
between
atmosphere,
ocean,
earth
processes**

Ruhl et al., 2011

EMSO - the Preparatory Phase (2008-2012)

- the Preparatory Phase project is for establishing the legal entity EMSO-ERIC (European Research Infrastructure Consortium) charged of the coordination of the infrastructure
- The EMSO-ERIC statutes edited with the participation of the Funding Agencies; ERIC application submission to EC & MoU signature foreseen within 2012

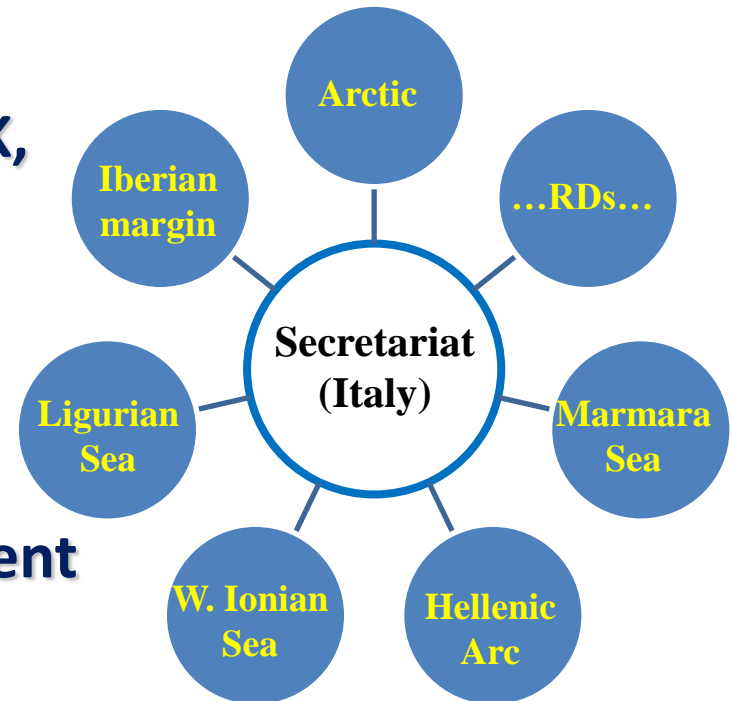
Full Members: Italy, France, Germany, UK,
Spain, Greece, Norway

Observers: Ireland, Turkey

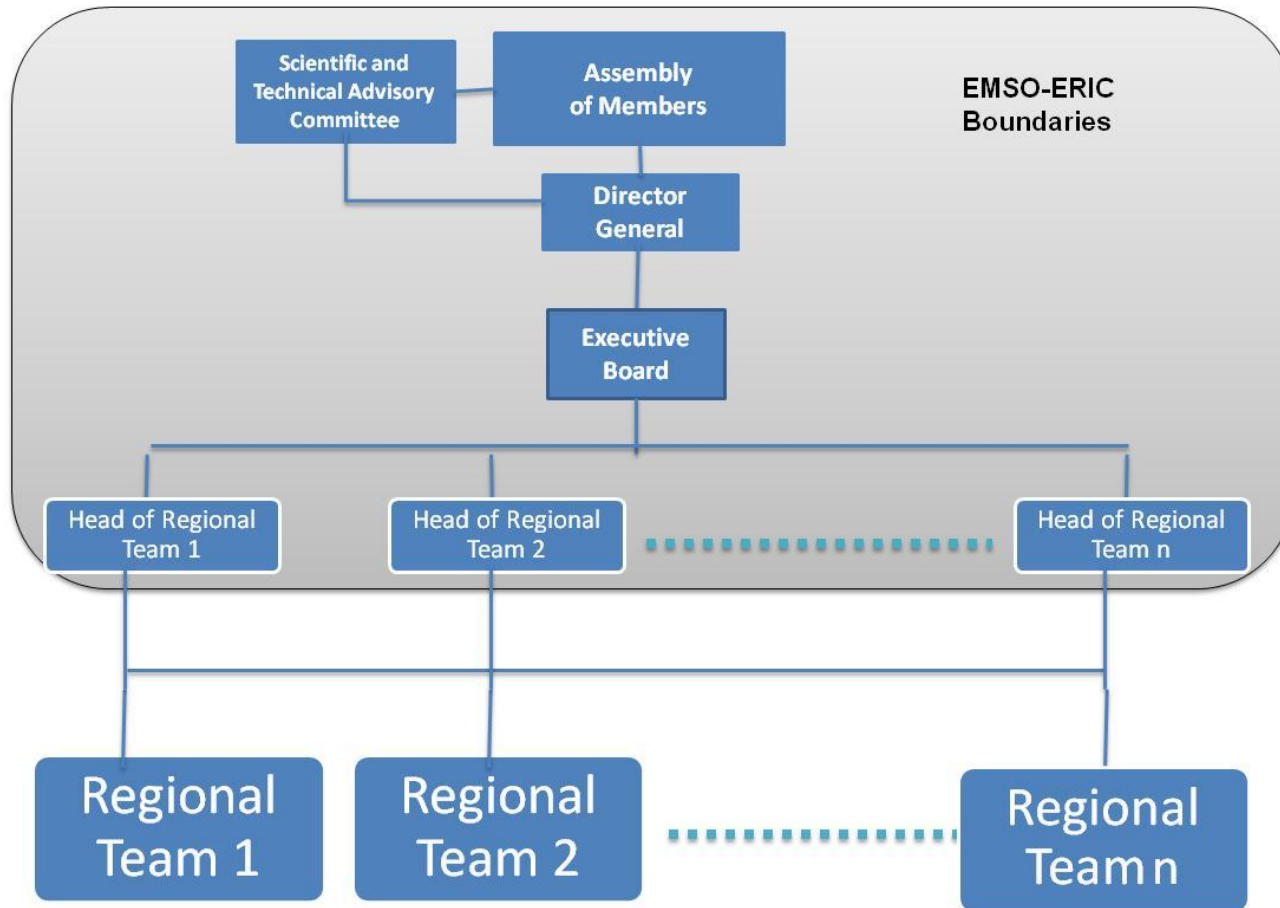
New Full Member candidate: Romania

EMSO-ERIC will have:

- Central co-ordination and management
- Regional Departments in charge of the EMSO nodes

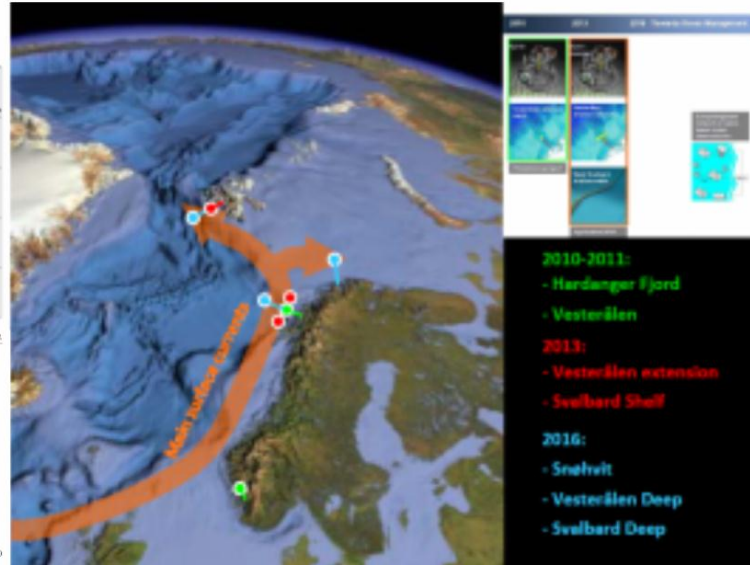
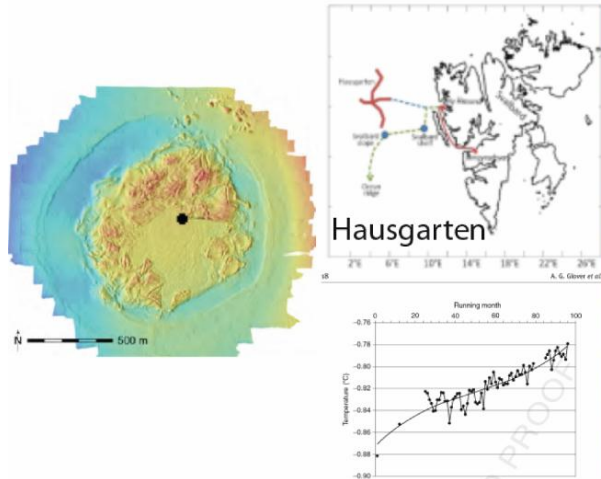


EMSO-ERIC governance structure



EMSO nodes: present status

Svalbard site



INFRASTRUCTURE junction capacity for a scientific monitoring node in water depths of 250-345m in the **Snøhvit gas production field** in the Barents Sea operated by Statoil

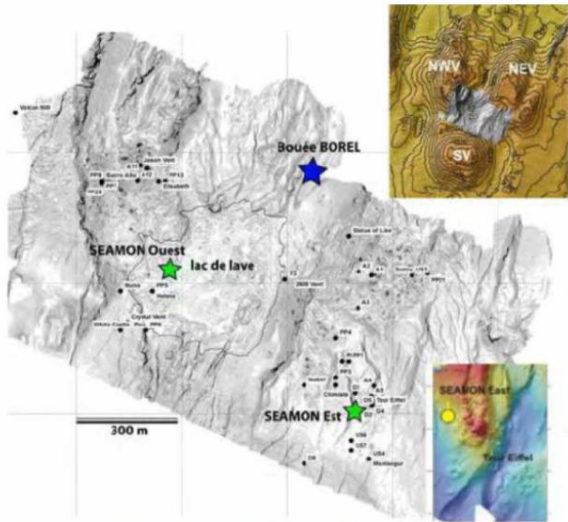
RESEARCH Mud and methane emission from seafloor (**Hakon Mosby Mud Volcano**), Geologically active area, investigation of the temporal variability at an active gas emitting mud volcano covering the sequence of events before, during, and after an eruption; analysis of their effects on gas hydrate stability, seafloor morphology and the distribution and colonization patterns of benthic communities; detection of subsea leaks of natural gas and possible leaks of CO₂

PREVIOUS/RECENT ACTIVITIES Area of intermittently active work and an ESONET demonstration mission called Long-term Observations On Mud-volcano Eruptions (LOOME)

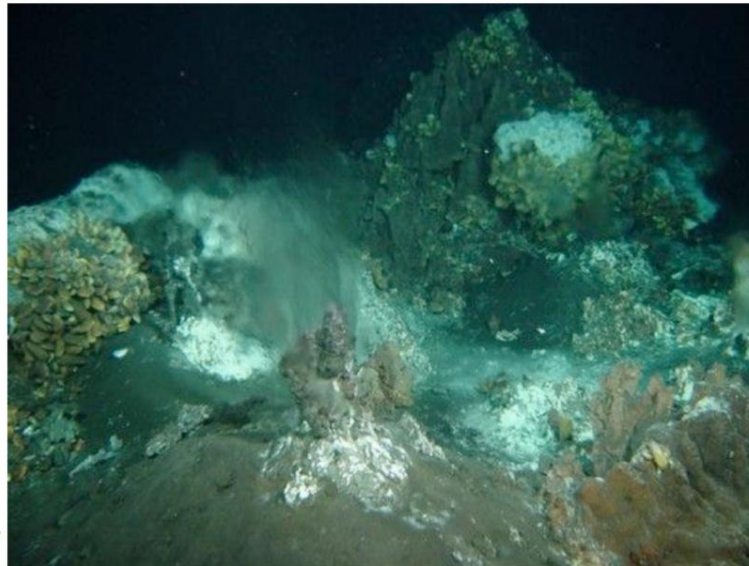
FUTURE ACTIVITIES feasibility study of 5- km extension of Statoil Snøhvit offshore field in 2015-2016; available for further extensions

NORWEGIAN MARGIN

EMSO nodes: present status



Lucky Strike hydrothermal vent field and prospective locations of SEAMON observatory nodes and the BOREL buoy. Adapted from Ondress et al. 2009.



INFRASTRUCTURE SEAMON nodes, two stand-alone acoustic observatories and their transmission **BOREL** buoy are operating since ESONET demo mission (MoMAR, Monitoring MidAtlantic Ridge) in 2010

RESEARCH Lucky Strike hydrothermal vent field, geophysical movements of Earth (seismicity and vertical deformation); water, heat and mineral flow through vent system; behaviour of physical and chemical elements in vent fluid; variations in biogeochemistry and the ecological hotspots in vicinity of vents

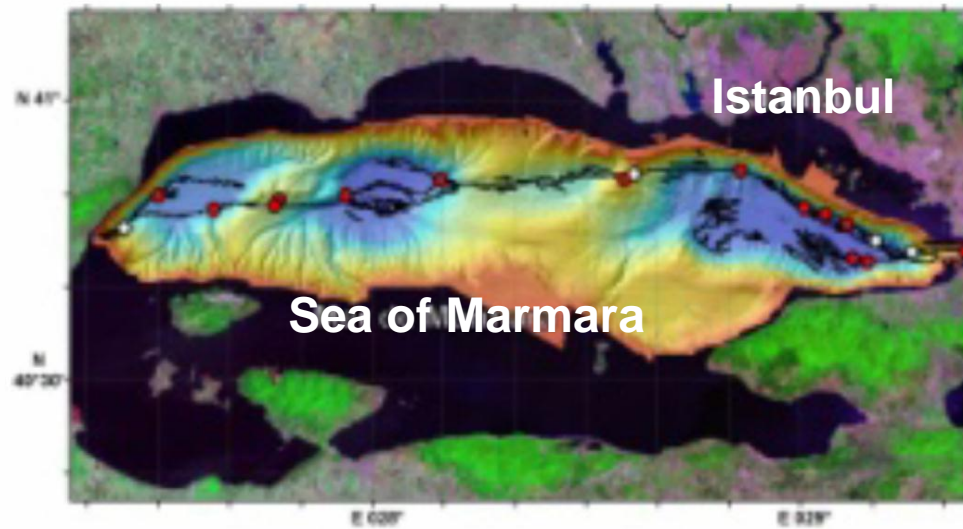
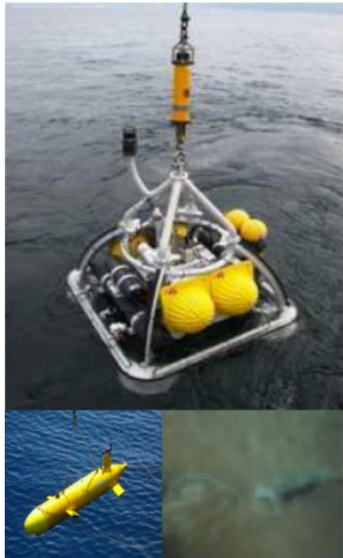
PREVIOUS/RECENT ACTIVITIES Mid-Atlantic Ridge work part of the InterRidge programme, MarBEF-DEEPSETS, HERMIONE, and Coralfish programmes among others; site of the ESONET demonstration mission Monitoring the Mid-Atlantic Ridge, MoMAR

FUTURE ACTIVITIES Yearly maintenance is scheduled for the next 5 years.

Data transmission to shore through the buoy.
New generation of stations planned for 2015

AZORES ISLANDS

EMSO nodes: present status



INFRASTRUCTURE Five cabled observatories are under test after deployment. They include seismometers, accelerometers, current-meters and temperature sensors

RESEARCH Regular tectonic activity because of its location on the North Anatolian Fault; Natural gas fields with hydrocarbon seeps on seafloor from the fault; relationship between gas seepage and earthquake occurrence; pore pressure, bubble detection

PREVIOUS/RECENT ACTIVITIES Research and monitoring activities under ESONET demo mission (Marmara-DM) with several cruises and sensor deployments, including the deployment of SN4 multidisciplinary seafloor observatory during 2009-2010 in eastern part of the fault that ruptured during the 1999 Izmit earthquake, and deployment of bubble observatory, piezometers and OBSs

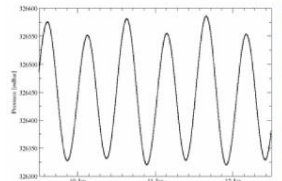
FUTURE ACTIVITIES Design of the future multi-disciplinary cabled observatory in three locations along fault

MARMARA

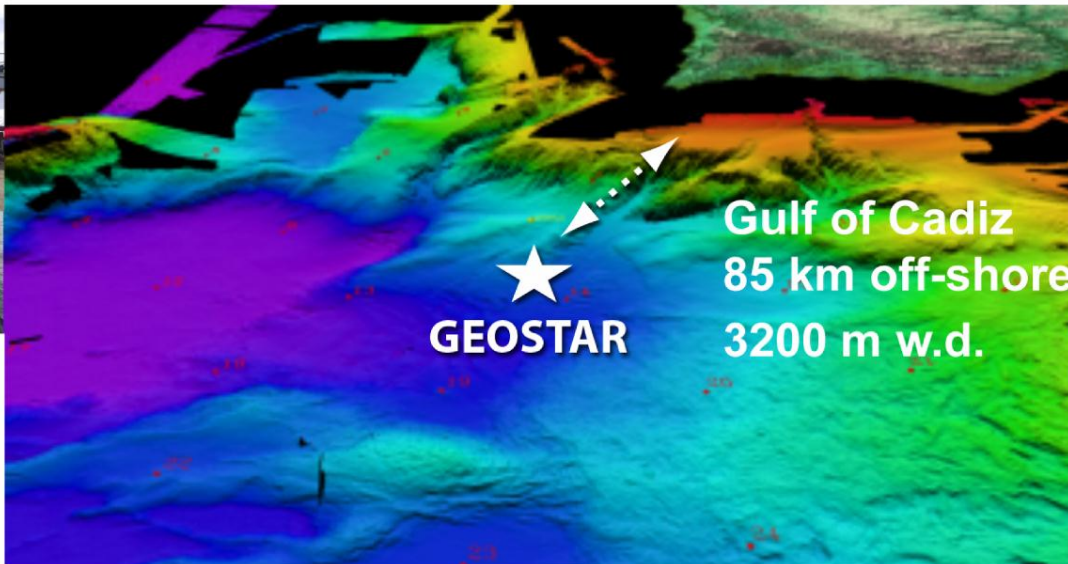
EMSO nodes: present status



R/V Sarmiento de Gamboa



Example of Absolute Pressure Gauge raw data recorded



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 diapers, 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

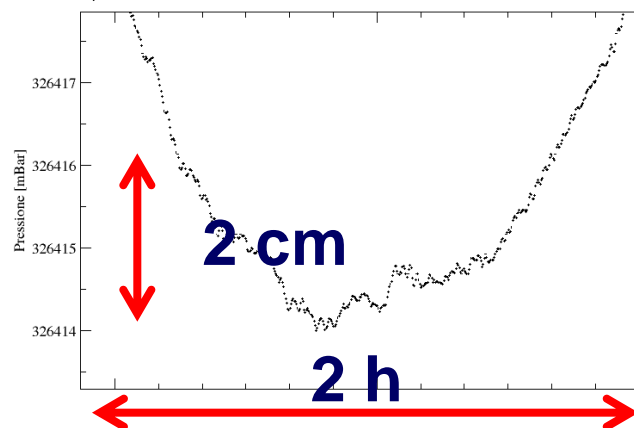
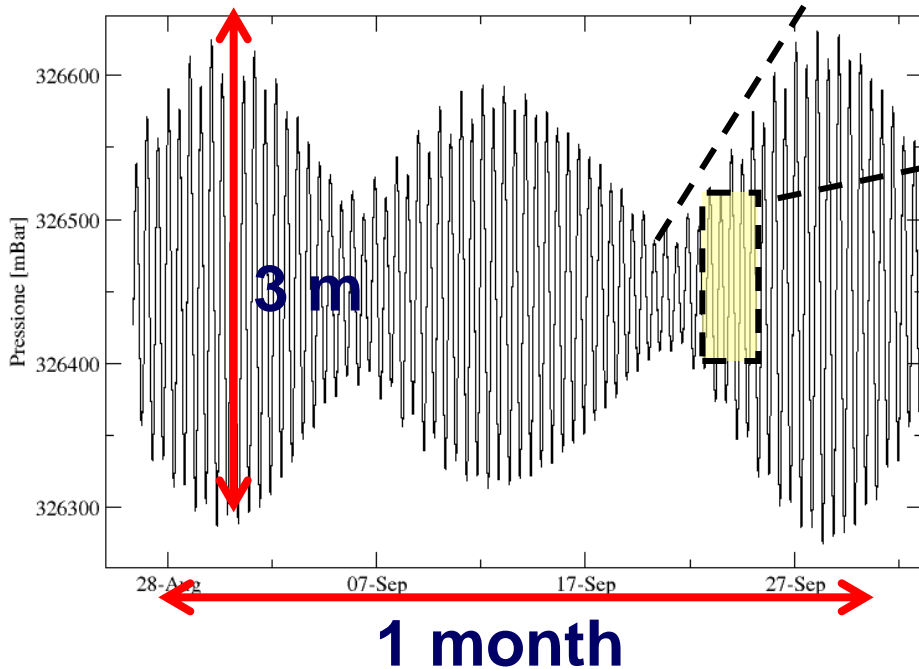
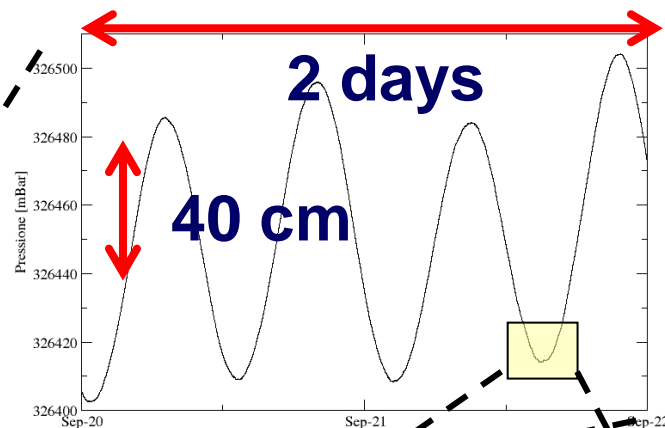
IBERIAN MARGIN

Iberian Margin - Example of pressure signal

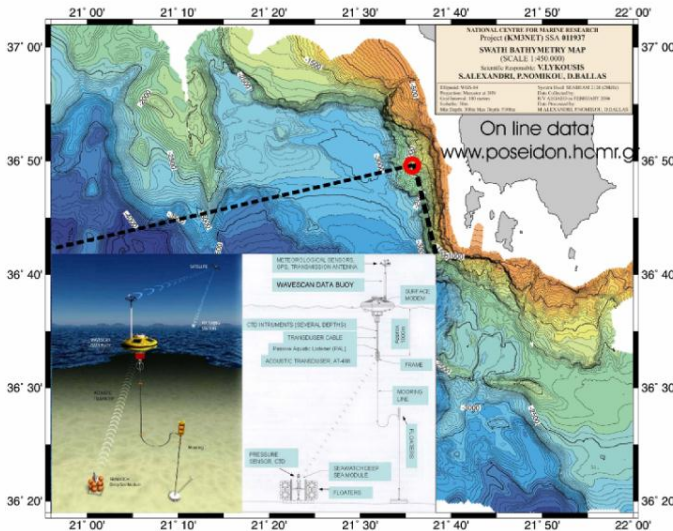
european
multidisciplinary
seafloor
observatory



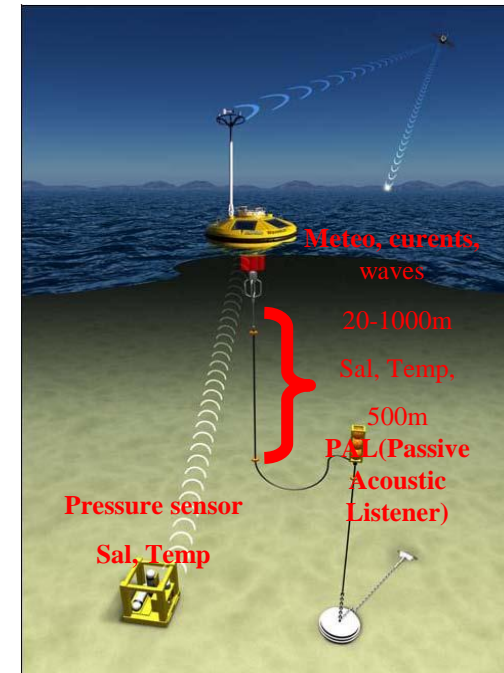
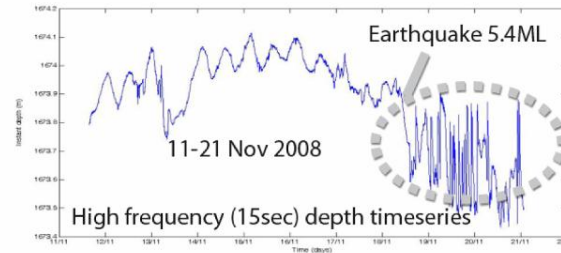
NEAREST mission (1cm H₂O ~ 1mbar)



EMSO nodes: present status



Pressure (tsunami) sensor



INFRASTRUCTURE Cabled system **NESTOR**, Stand alone **Poseidon Pylos** and **Poseidon E1-M3A** (35o66'N, 24o99'E), Proposed drilled observatory **BUTT**

RESEARCH Geohazards, tsunami, climate change, bioacoustics and ambient noise, biogeochemical fluxes, benthic-pelagic interactions; benthic respiration; biogeochemical fluxes; photography-based ecology; seabed methane fluxes; oil and gas industry activities

PREVIOUS/RECENT ACTIVITIES EuroSITES, IODP, HERMES-HERMIONE, SEAHELLARC, TRANSFER, KM3NET
Continuity of stand-alone observatory over to 2014.

FUTURE ACTIVITIES Implementation of a new cabled observatory within the frame of EMSO (EMSO-Hellenic) near Poseidon-Pylos site (about 15km from shore and in 1600m depth) with equipment according to ESONET standards. Project funded by the Greek government (EMSO contribution).
Estimated budget 3.7MEuro (2012-2015).

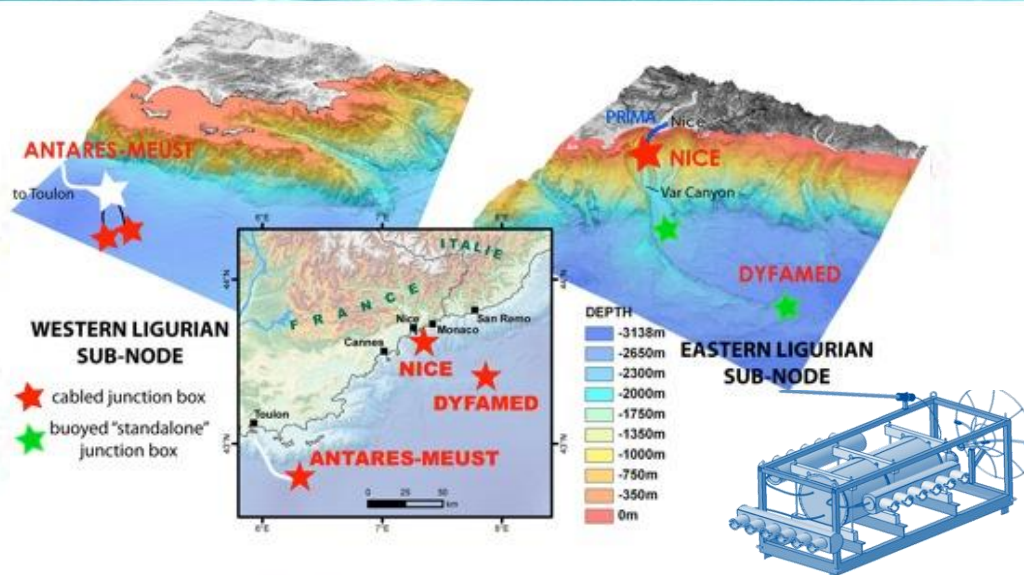
HELLENIC ARC

NESTOR



EMSO nodes: present status

european
multidisciplinary
seafloor
observatory



INFRASTRUCTURE East Ligurian sea: a) **DYFAMED** (DYNAMICS of Atmospheric Fluxes in the MEDiterranean Sea); b) Var canyon monitoring; c) Nice slope monitoring of geohazard;
West Ligurian Sea: **ANTARES** (Astronomy with a Neutrino Telescope and Abyss environmental RESearch) Earth-Sea science extension of astrophysics underwater telescope

RESEARCH coastal upwelling, particle plumes, nutrient benthic exchange, bottom boundary layer processes, seismic monitoring; sub-sea geophysics; slope stability; biogeochemical fluxes and marine ecology

PREVIOUS/RECENT ACTIVITIES EuroSITES, JGOFS, International Ocean Drilling Program (IODP)

FUTURE ACTIVITIES Stand-alone observatory at Nice (Var-Dyfamed) area from 2012 to 2016. Cabled extension of ANTARES/KM3NET cable from 2010. New cable with two nodes. construction starting in 2013

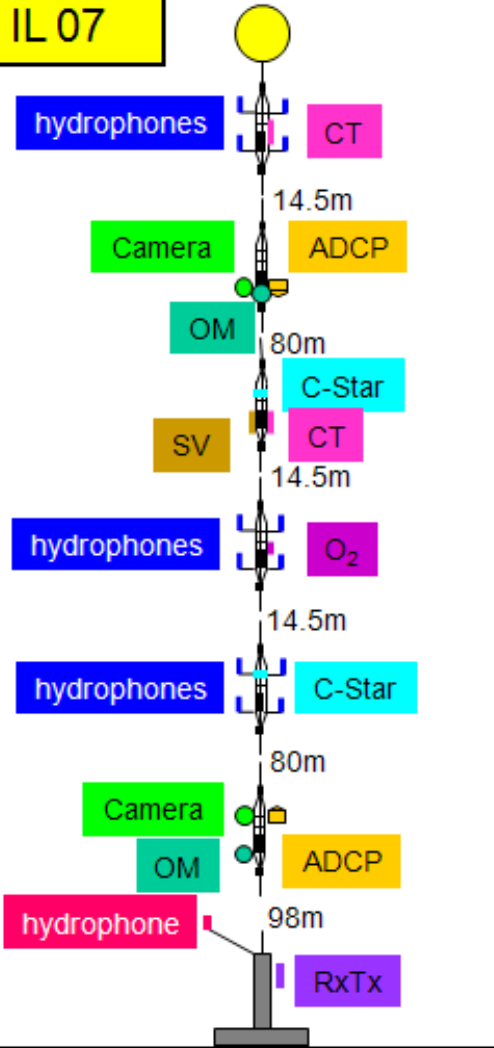
ANTARES



LIGURIAN SEA

EMSO nodes: present status

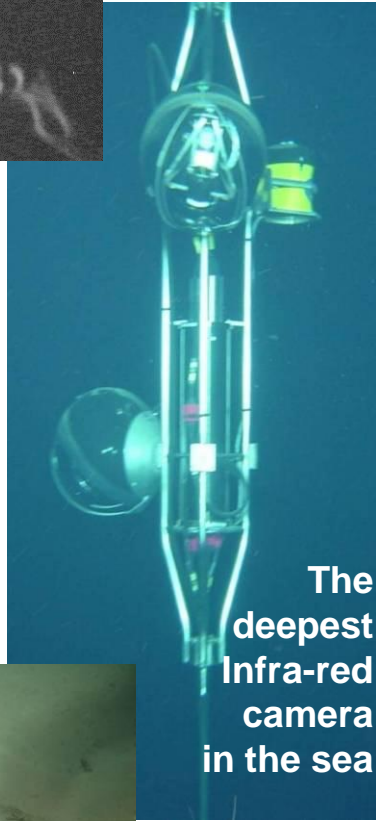
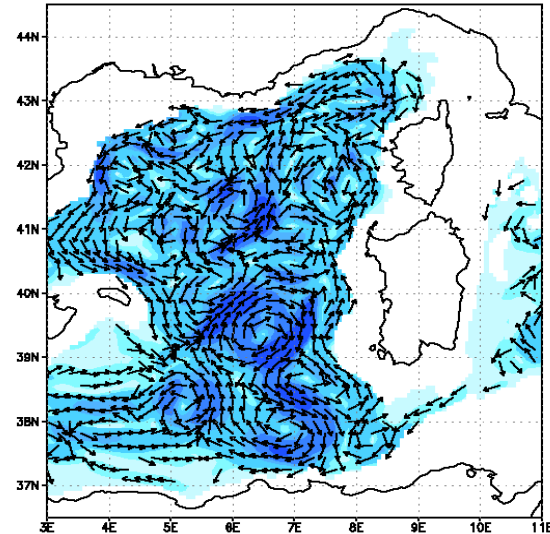
IL 07



- Bioluminescence
- Environmental Monitoring
- Seismology
- Oceanography (Med Sea Circulation)

Ligurian Sea

velocity [m/s] - date 070129 depth 1000 m

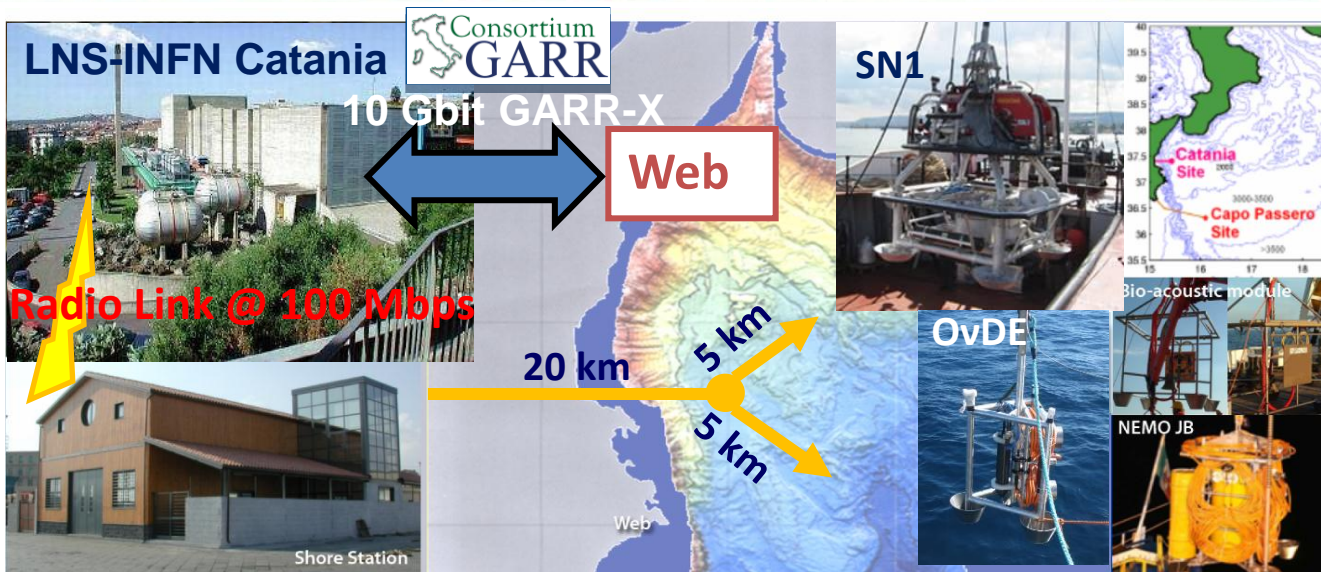


The deepest
Infra-red
camera
in the sea



ASPERA - Deep Ocean Cabled Observatories - Amsterdam, May 24-25, 2012

EMSO nodes: present status



Geo-hazards
(e.g., 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, tsunami, 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

NEMO

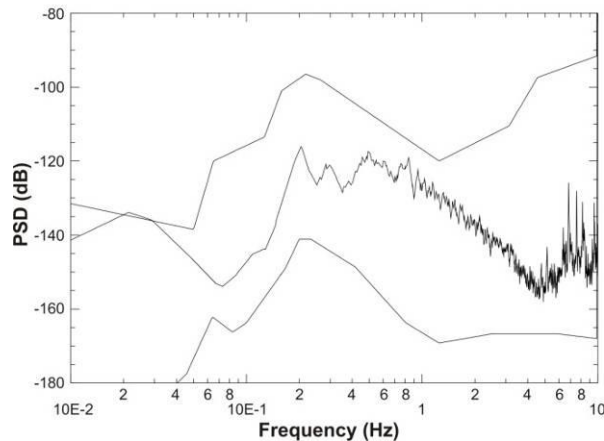
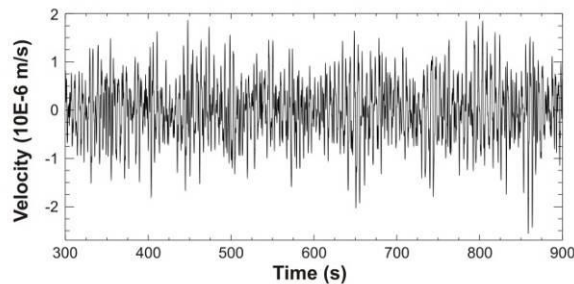


Real-Time observatory

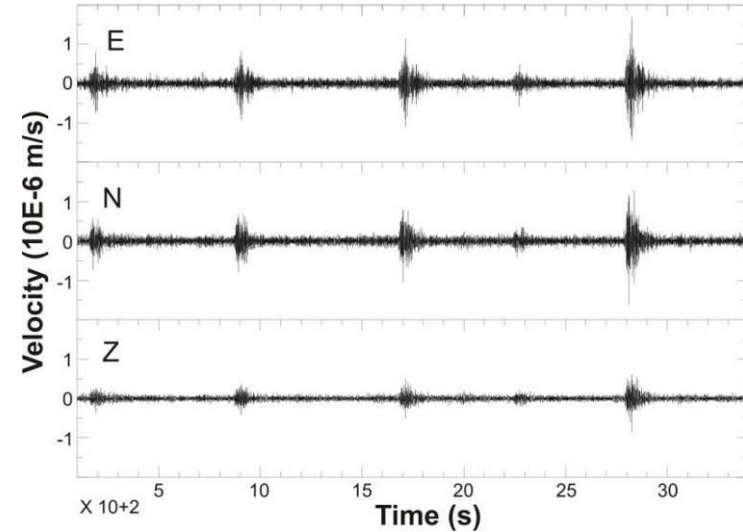
ETNA Activity



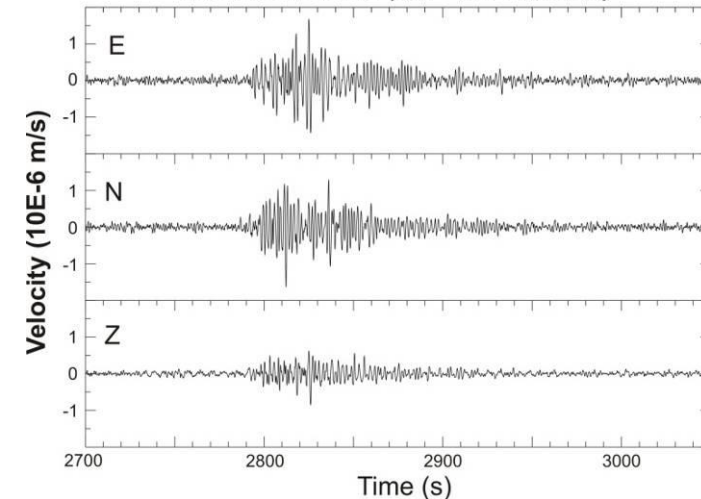
Degassing activity
(03 February 2006, h 04, Z component)

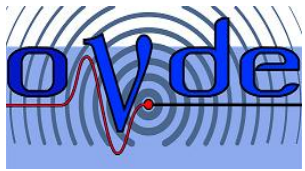


Low-frequency events
26/07/06 h 13:00 (0.1 - 6 Hz filtered)



Low-frequency event
26/07/06 h 13:46 (0.1 - 6 Hz filtered)





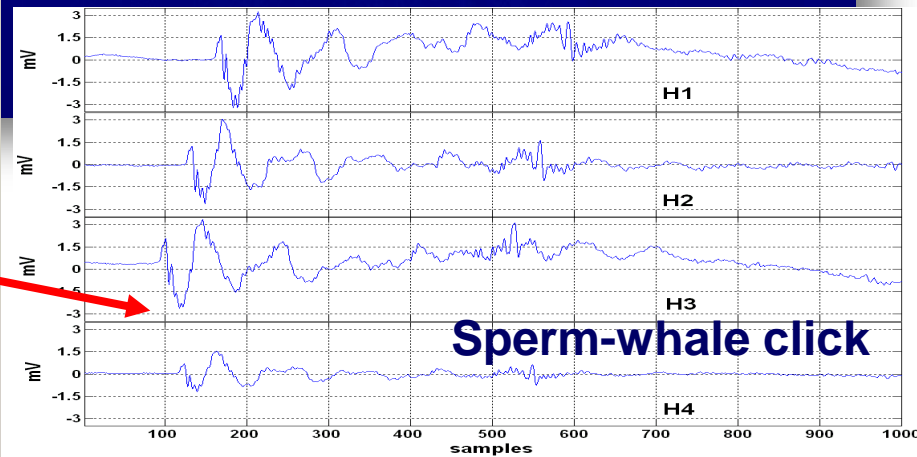
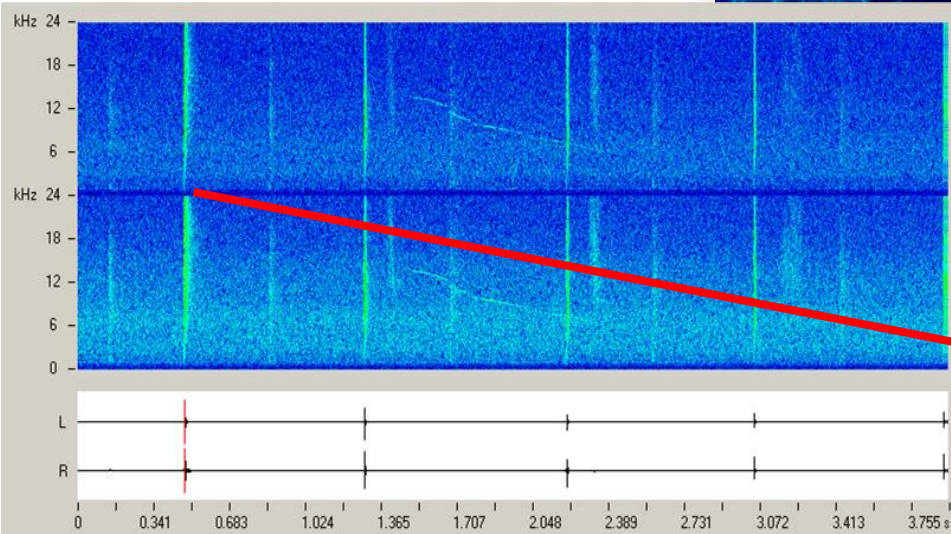
NEWS FEATURE

The neutrino and the whale

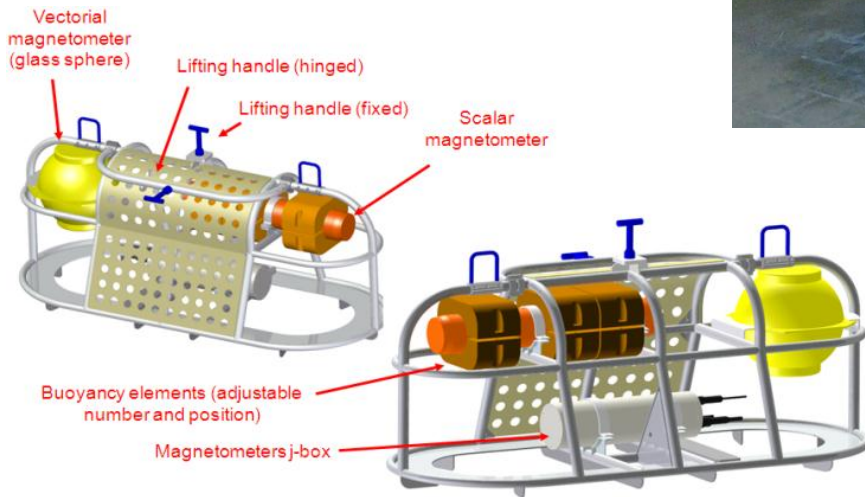
N. Nosengo, G. Pavan, G. Riccobene
NATURE Vol 462 - 3 December 2009



Acoustic array
(INFN - Univ. Pavia)



INFN-LNS final integration work (2011)



Side views of the magnetometers module

Favali et al., 2012 (in press)

NEMO-SN1 – New equipment's

european
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seafloor
observatory



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

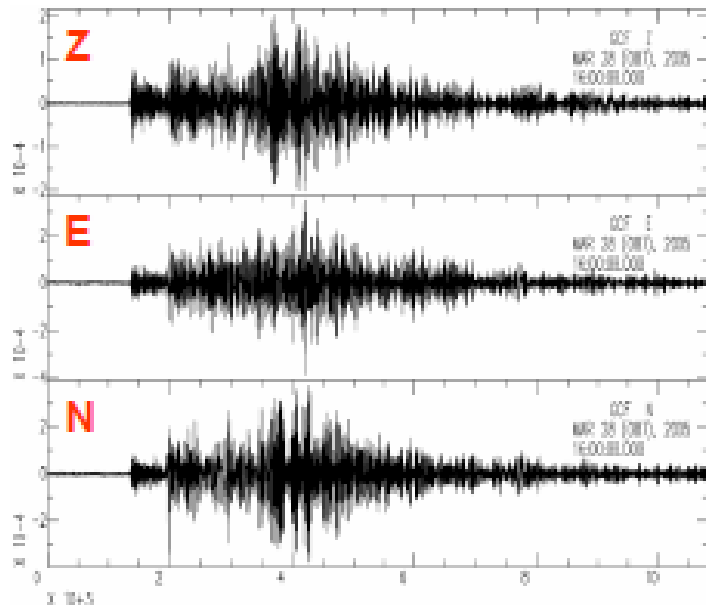
• **tsunami early warning system - Geo-Hazard** ** 96 kHz at TSN, 192 kHz at TSS - **Marine Environment**

NEMO-SN1 daily/monthly data rate

INSTRUMENT	byte/day	byte/month
Oceanographic sensors	13 M	390 M
Gravity meter	5 M	150 M
Magnetometers	2.5 M	75 M
Seismic sensors	933 M	28 G
DACS monitor	11 M	330 M
Bio-acoustic Hydrophones	372 G	11 T

Lossless data compression algorithms (e.g., FLAC) may reduce by 30% the file-sizes

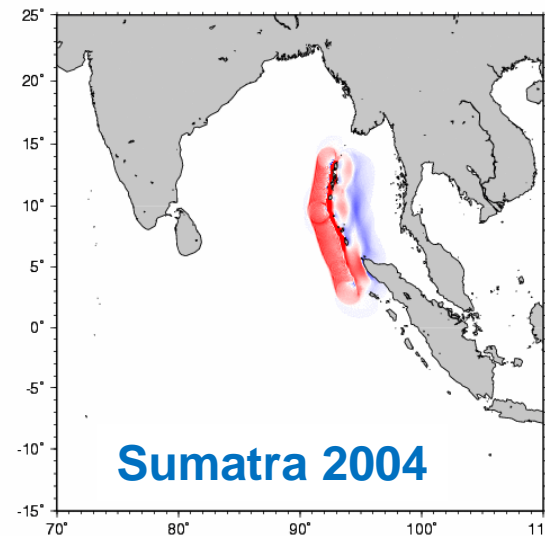
NEMO-SN1 - Tsunameter: seismic & pressure waves



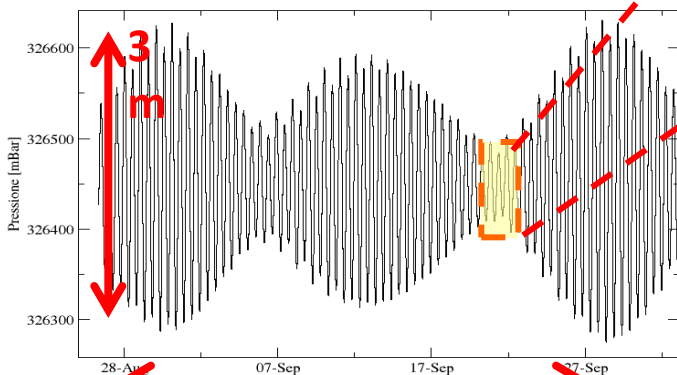
Multiparametric observatory for early detection of tsunamigenic events:

- Seismic waves
- Magnetic field change
- Absolute pressure
- Low *f* sound waves

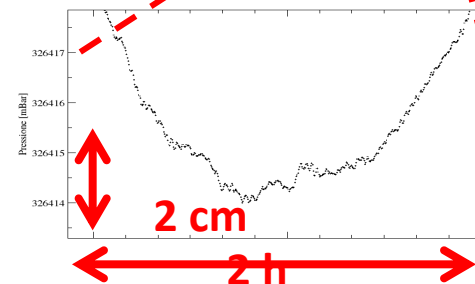
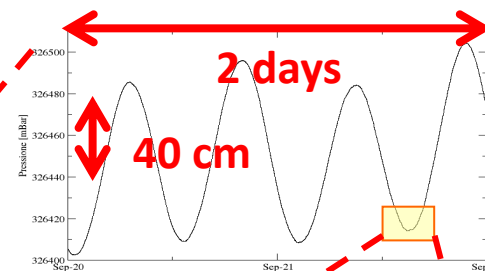
2004 Sumatra Earthquake 010 min



M_w 8.5 Sumatra (March 28, 2005)

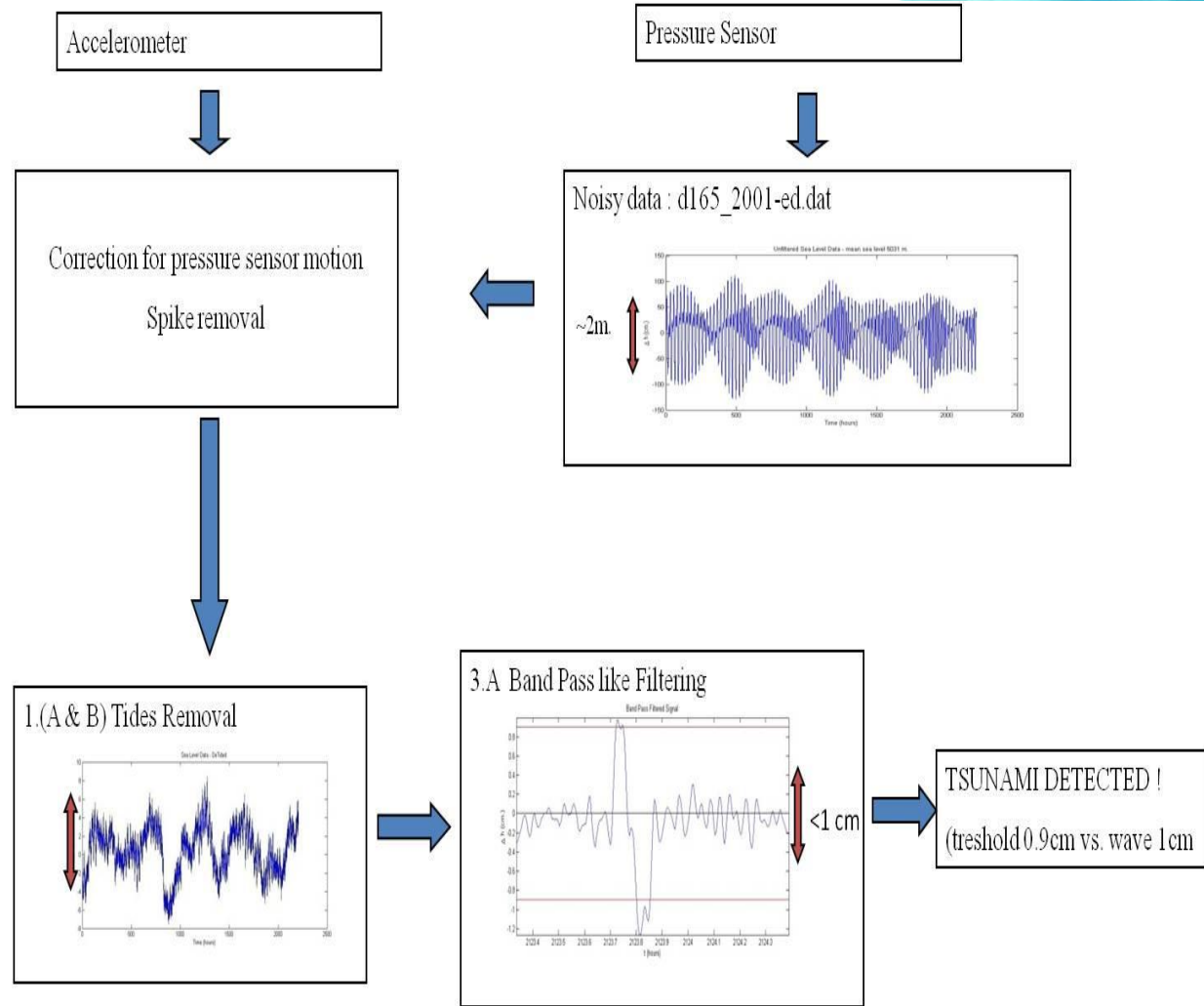


1 month Pressure: 1cm H₂O ~ 1mbar



Tsunami Detection Algorithm Flow chart

The dynamic range of the signal is reduced from about 2 m to about 3 cm by a filtering chain allowing the detection of a tsunamis of 1 cm against a threshold of 0.9 cm in a very noisy bottom pressure record. The plots are obtained by real bottom pressure data (courtesy of DART) with superimposed synthetic tsunamis



EMSO contribution to GEO

european
multidisciplinary
seafloor
observatory



Integration in GEOSS



EMSO is strongly engaged to:

- Sustain operation of **comprehensive and coordinated Earth observation networks** in support of informed decision making
- Address the need for timely, global and open **data sharing across borders and disciplines**

EMSO will implement **GEOSS** data sharing principles and will support the **GEO** data core by providing access to essential ocean variables

- **Implement interoperability**

EMSO is engaged in evaluating the practicability and implementing data standards like ISO 19xxx, SOAP/WSDL, OGC SWE for ocean science data

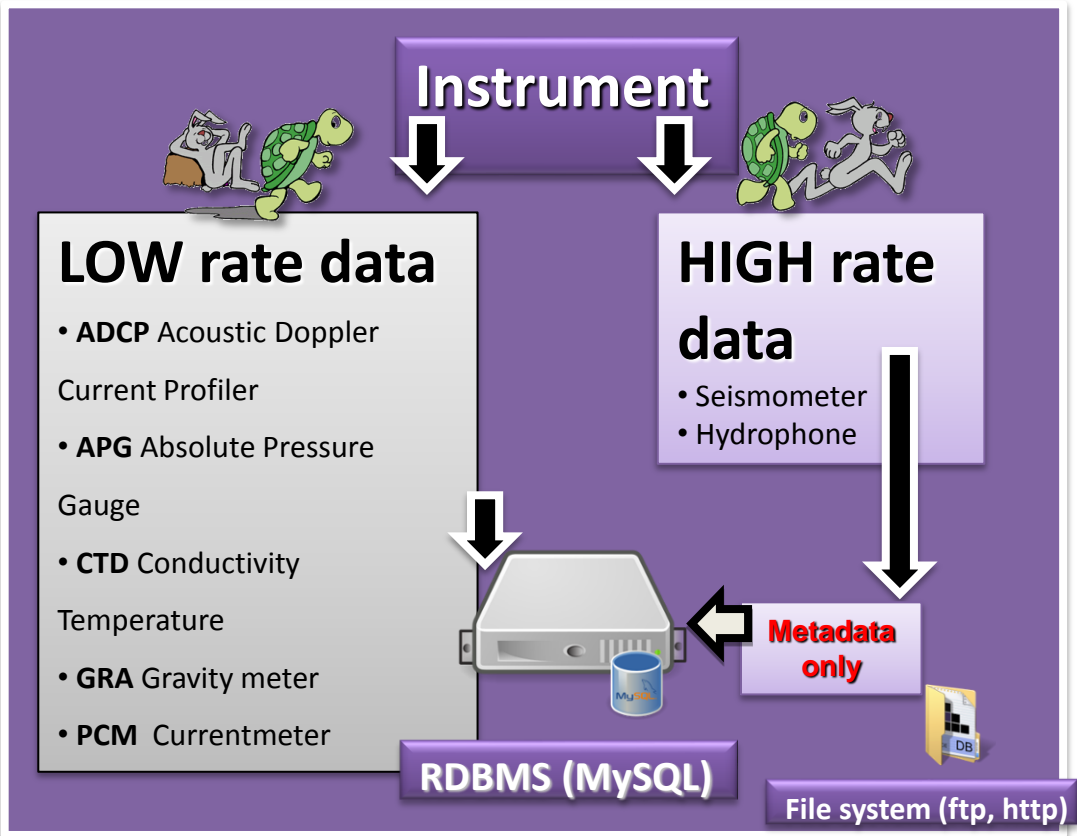
- Foster research and development activities and **coherent planning for future observation and information systems**

EMSO is involved in several EC funded projects (**ENVRI**, **COOPEUS**) to make use of latest developments in the field of cyberinfrastructure

EMSO data classification & policy

Main features

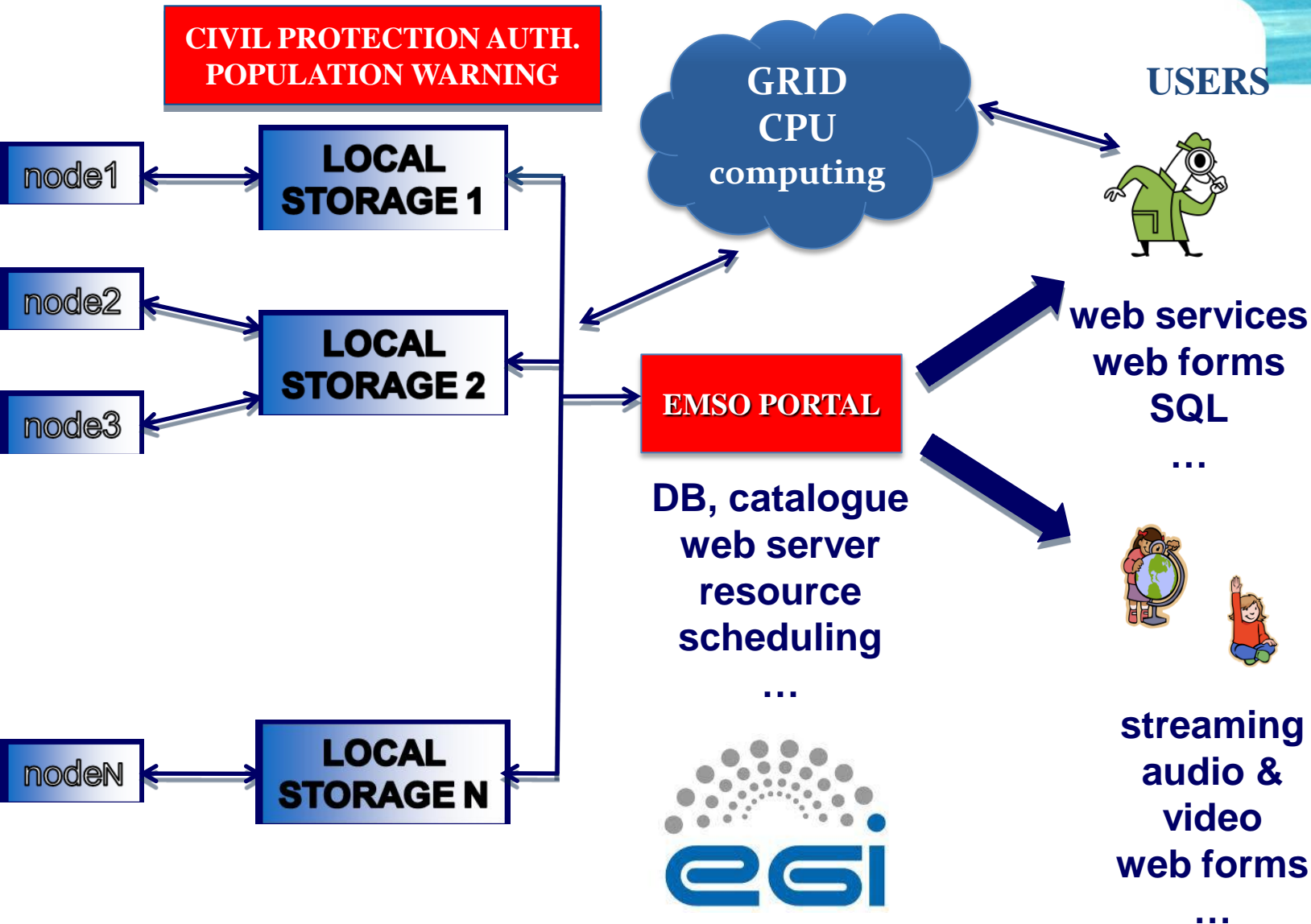
- Seafloor and water-column *in situ* measurements
- Continuous time-series of physical parameters
- Diverse sampling rate: 10^{-4} Hz (=1 sample/h) to 10^2 kHz
- Precise timing when required (e.g., geophysical sensors) [stability 10^{-9} ÷ 10^{-11}]



- Data policy:**
- Open access
 - QC data (data/metadata)
 - Interchangeable formats



EMSO distributed storage & database



EMSO is going to exploit the power of the European GRID Infrastructure to create a data infrastructure to serve the wide communities of scientists studying bio and ambient acoustics, oceanography, geophysics, high energy astroparticle physics, and ecology

The distributed computing paradigm of the EU e-infrastructure will be used to provide large CPU and storage capacity

A pilot activity to explore the capabilities offered by the EGI Grid was recently agreed with the Italian Grid Initiative (NGI_IT)



The online interface to users will allow to:

- Easily archive/preserve/share valuable recordings and associated metadata
- Use state of the art analysis algorithms/develop and share new algorithms
- Search for specific events
- Analyse/compare events and whole recordings from multiple sources/sensors/locations
- Produce short-term and long-term statistical analyses (e.g., variation of ocean noise)
- Produce maps where retrieved events occurred
- Evaluate human impacts (e.g., the impact of noise produced by ship traffic or global climate changes)
- Study marine mammal acoustic signatures, develop and apply automatic classification algorithms

Synergies with other European RI/Initiatives

EMSO can complement other initiatives such as:

➤ **EUROARGO** as the Eulerian counterpart



➤ **KM3NeT** with respect to associate sciences



➤ **SIOS** as the marine component



➤ **EPOS** for marine and land data integration



➤ **ICOS** for marine data



➤ **EMBRC** as monitoring of relevant parameters



➤ **EUROSITES** water-column community



➤ **EUROFLEETS** for the optimal share of ship resources

Concluding remarks

- **Earth Sea Science and Underwater Neutrino Astronomy communities have strong mutual benefits in terms of scientific and technological outcomes**
- **The already on-going synergies have to be implemented stressing the scientific interactions among the different disciplines, exploring the “edges“ among them and searching for new approaches and ideas**
- **The responsibilities and interfaces between the two communities have to be clearly defined favouring coordination also to avoid duplications**

Thank you for your attention

<http://www.emso-eu.org>



ifremer

KDM
Kontinental Deutsche Meeresforschung

Marine Biologie
Fritz-Haber



National
Oceanography Centre

