
CSIC
CONSELL SUPERIOR
D'INVESTIGACIONS CIENTÍFIQUES
CENTRE MEDITERRANI D'INVESTIGACIONS

8th April 9:00-11:15 CEST, at Marine Science Institute and Marine Technology UNIT – CSIC
Satellite event UN decade of the Oceans Conference
Meeting Room **"Aula Pepita Castellví"**, first floor

Smart Cables, a powerful tool for continuous global ocean observation systems

SMART cable technology will enhance spatial and temporal resolution for marine environmental scientific monitoring using a network of sensors within submarine cable systems. Accessing key information in near real time can be the paradigm for understanding and mitigating problems such as climate change, sea level rise, ocean warming, earthquakes and tsunamis. (SMART = Scientific Monitoring And Reliable Telecommunications).

Organizers:
Juanjo Dañobeitia (CSIC), Bruce How (University of Hawaii) and Ceci Rodríguez (University of Hawaii)

Discussion Moderator:
José Barros, JTF SMART Cables, Portugal

Open discussion with
Christa von Hillebrandt-Andrade (International Tsunami Information Center Caribbean Office (ITIC-CAR), a UNESCO/IOC-NOAA Partnership

900 Welcome from Jordi Sorribas, director of Marine Technology Unit, CSIC
905 Domestic remarks Juanjo Dañobeitia, CSIC

- 9:10 SMART Cables - new Global Ocean Observations for the Decade of Ocean Science by **Bruce Howe and Ceci Rodriguez**, University of Hawaii, USA

- 9:25 The Atlantic CAM Platform; the future of Portugal's subsea market, by **Jose Barros**, JTF SMART Cables, Portugal
- 9:35 Enhancing Ocean observation in the Mediterranean Sea by integrating smart cables by **Juanjo Dañobeitia**,***G. Marinaro, L. Beranzoli, S. Cusi, J. del Rio***
  A. De Santis*, J. Sorribas, K. Moran, C. Arvanitidis and N. Albi*
- 9:50 Advancements in fiber optic cable technology: enhancing tsunami early warning systems and health monitoring, by **Arantza Ugalde**, CSIC-ICM, Spain
- 10:00 Meteotsunamis Forecast using SMART Cables, **Rachid Omira** from IPMA tsunamis, Portugal
- 10:20 NORDUnet shapes Polar connectivity through sensing cables across the Arctic Ocean, by **Valter Nordh**, NORDUnet**,** Denmark
- 10:10 Earthquake detection through fiber optic cables, by **Beatriz Gaite and Juan Vicente Cantavella Nadal** from IGN-Spain
- 10:30 IOC View and the amazing perspective of smart cables, **Laura Kong**, Director, International Tsunami Information Center, Hawaii, USA

- **10:45** Open discussion lead by **Christa von Hillebrandt-Andrade and Jose Barros**

- **11:15** Coffee break at **Central courtyard** (Patio)

MINISTERIO
DE CIENCIA, INNOVACIÓN
Y UNIVERSIDADES

CSIC
CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

CENTRE MEDITERRANI DE CIÈNCIES
MARINES I AMBIENTALS (CMIMA)

ANNEX III

Esdeveniment al CMIMA

SMART Cables, a powerful tool for continuous global ocean observation Systems

08/04/2024

9:00 a 11:00

Sala: P74

Persona/es responsable/s ICM: Marco Talone, 604547541

Empresa de càtering: Xalana, 11:30, Patio Central

Llistat personal extern

Nom i cognoms	DNI	Signatura
Bruce Howe		
Ceci Rodriguez Cruz		
Jose Barros		
Arantza Ugalde		
Rachid Omira		
Beatriz Gaite		
Valter Nordh		
Christa Von Hillebrandt		
Laura Kong		
Andrea Guino		
Alex Ramoneda		
Luis Pinheiro		
Rafael Bartolome		
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Lorenza Evangelista		

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Raquel Somavilla		
Cantavella Nadal Juan Vicente		
Valenti Sallares		
Jordi Sorribas		
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Observing the Ocean and Earth with

SMART CABLES

SMART Cables: New Global Ocean Observations for the Decade of Ocean Science

Science Monitoring And Reliable Telecommunications

Bruce M. Howe
Chair, JTF SMART Cables
International Programme Office
University Hawai'i at Mānoa

Marine Science Institute and Marine Technology Unit
Spanish National Research Council
Barcelona, Spain
5 April 2024

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

The 2024 Ocean Decade Conference
Ocean Decade Week in Barcelona

Institut de Ciències del Mar

UTM Unidad de Tecnología Marina

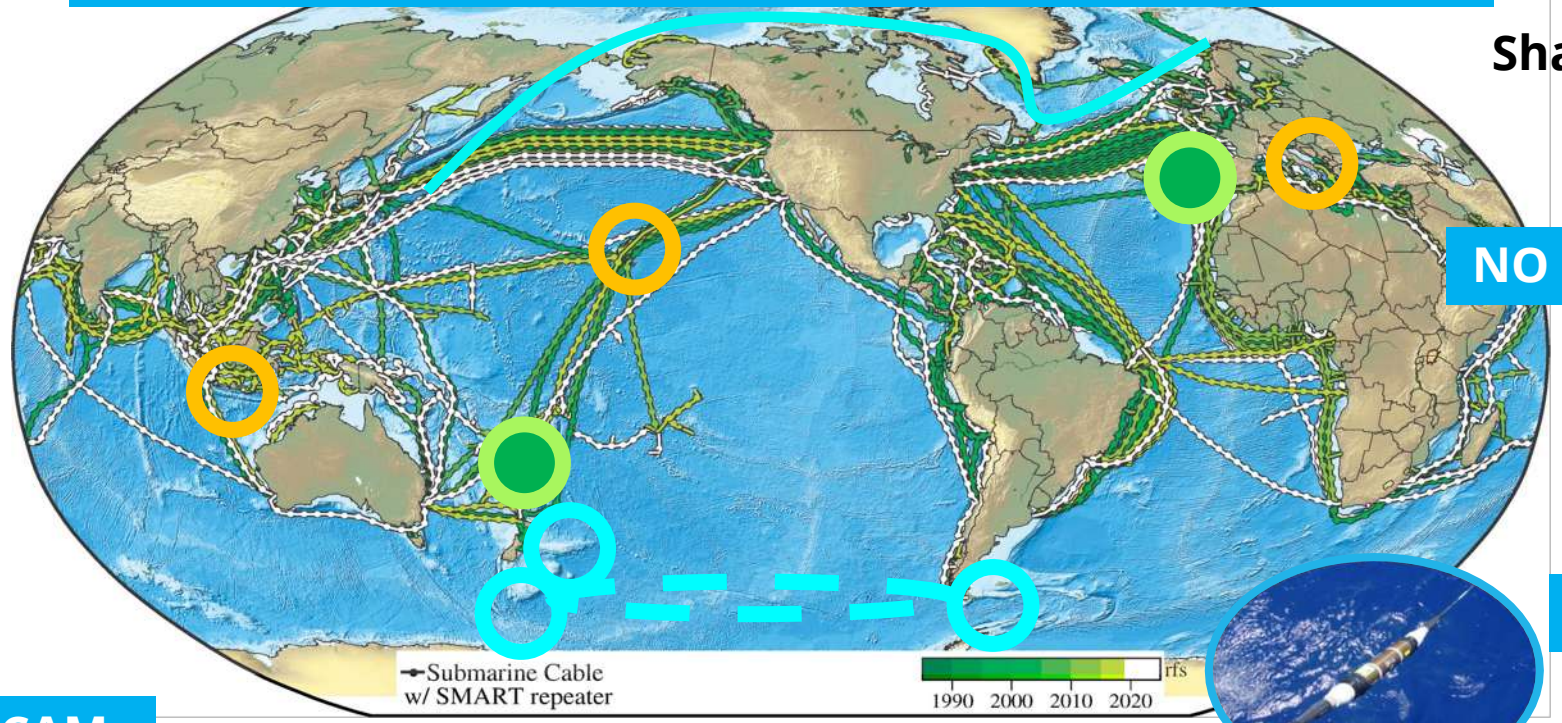
CSIC Consejo Superior de Investigaciones Científicas

SMART Subsea Cables

Global Array: Climate, Oceans, Sea Level, Earthquakes, Tsunamis

Create a Planetary sensor, power, Internet network

1st order addition to Ocean-Earth observing system



Share submarine cable infrastructure
Telecom + science
⬇️€$

NO Interference

1.4+ Gm
~20,000 repeaters
20 year refresh

spacing ~100 km

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

SMART Atlantic CAM ring, 3700 km, Gov't €154M, 2026

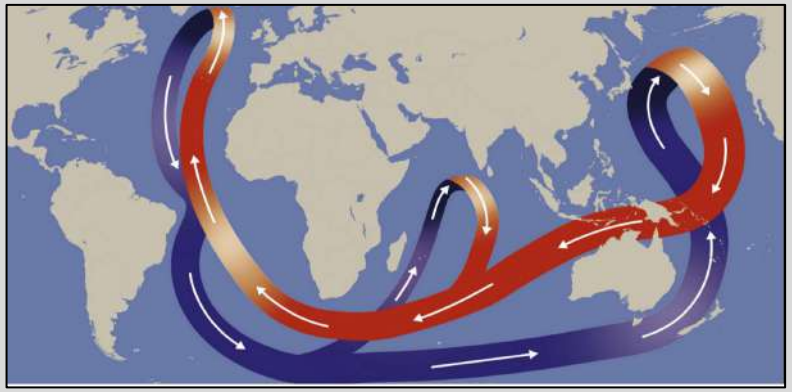
Know the environment protect the network

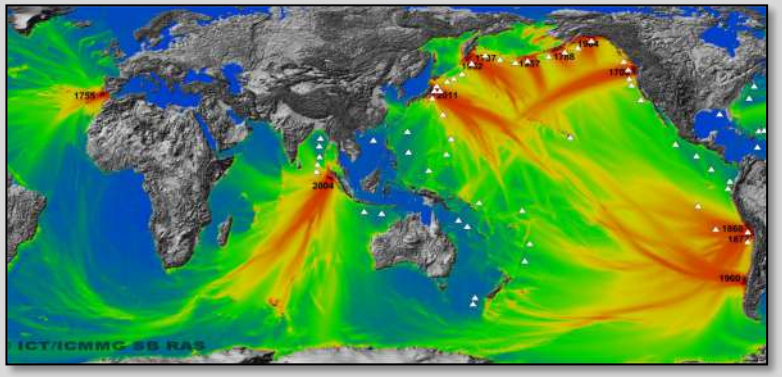
Bottom temperature
pressure, seismic sensors

ITU unesco WMO

Climate Change and Disaster Risk Reduction

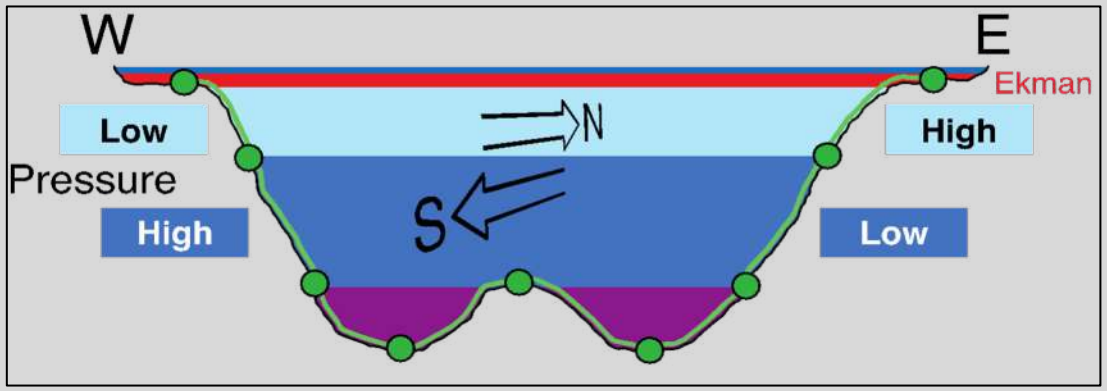
Ocean general circulation – all scales





Earthquakes and Tsunamis

Climate Change



Sea Level Rise

Ocean heat and circulation

Societal Benefits

Climate change – humanity's greatest existential threat

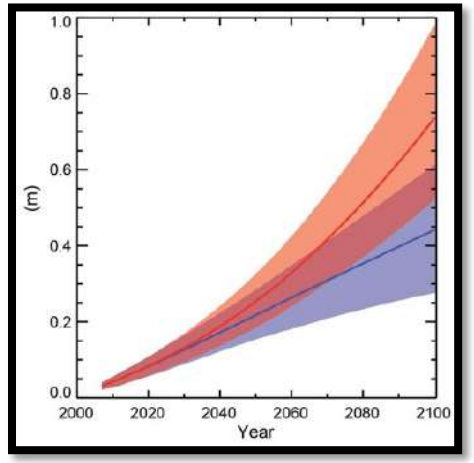
Societal and environmental issues - SDGs +

- **Climate change** – ocean temperature and heat content, circulation
- **Sea level rise** – hazard for coasts, islands, cities
- **Disaster Risk Reduction** – tsunami and earthquake monitoring
- **Societal Connectivity** – Resilient and sustainable telecom infrastructure

UN Decade of Ocean Science for Sustainable Development, 2021-2030

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

Sea Level Rise



Tsunami

SMART Cables in the Ocean Decade

Science Monitoring And Reliable Telecommunications (SMART) Subsea Cables: Observing the Global Ocean for Climate Monitoring and Disaster Risk Reduction
Endorsed project ID 94, Affiliated with GOOS Co-Design Programme

SMART Cables will address and contribute to:

CHALLENGES

Unlock ocean-based solutions to climate change

Increase community resilience to ocean hazards

Expand the
Global Ocean Observing System

OUTCOMES

Predicted Ocean

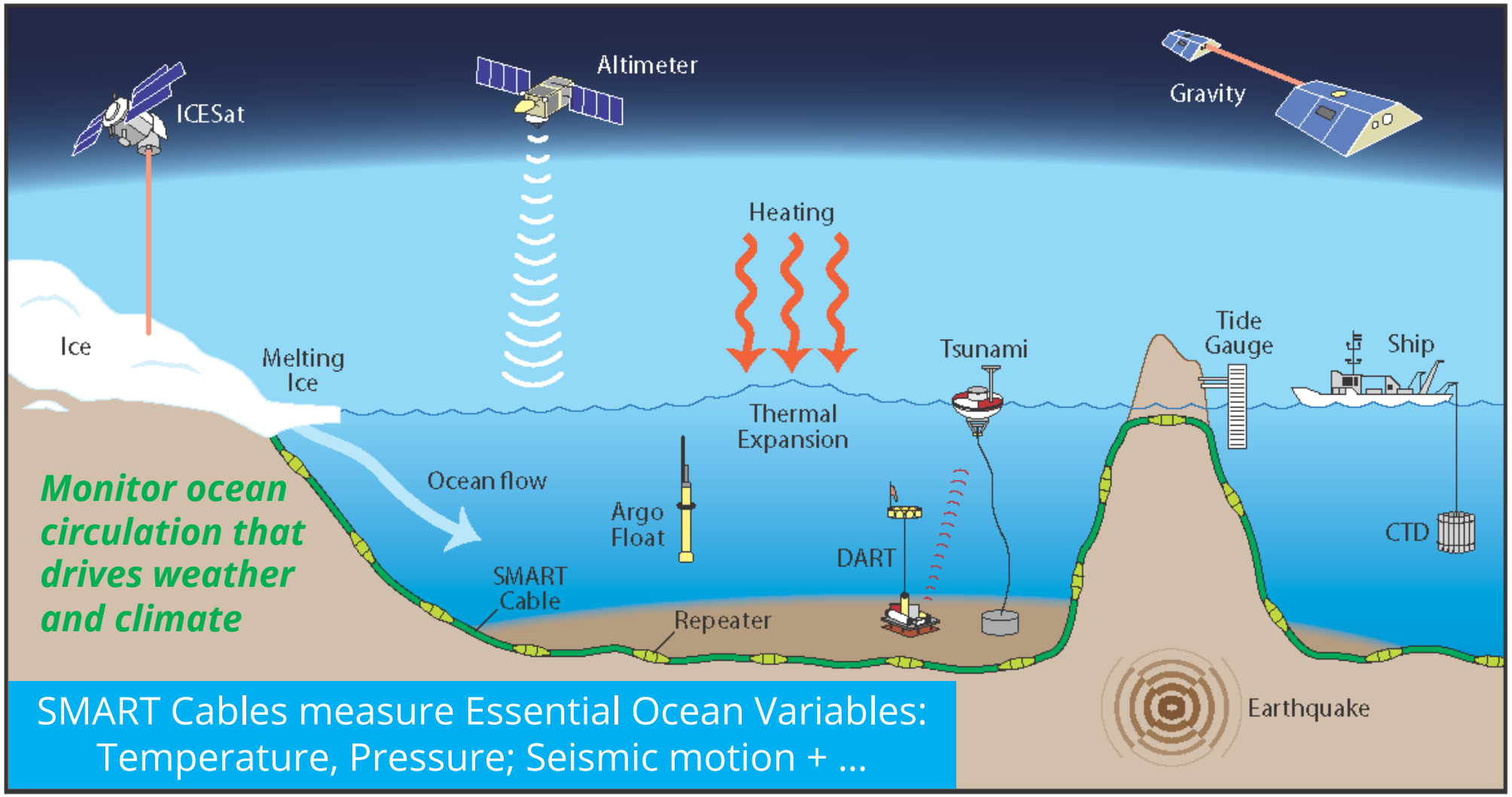
Safe Ocean

Accessible Ocean

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

ITU unesco WMO

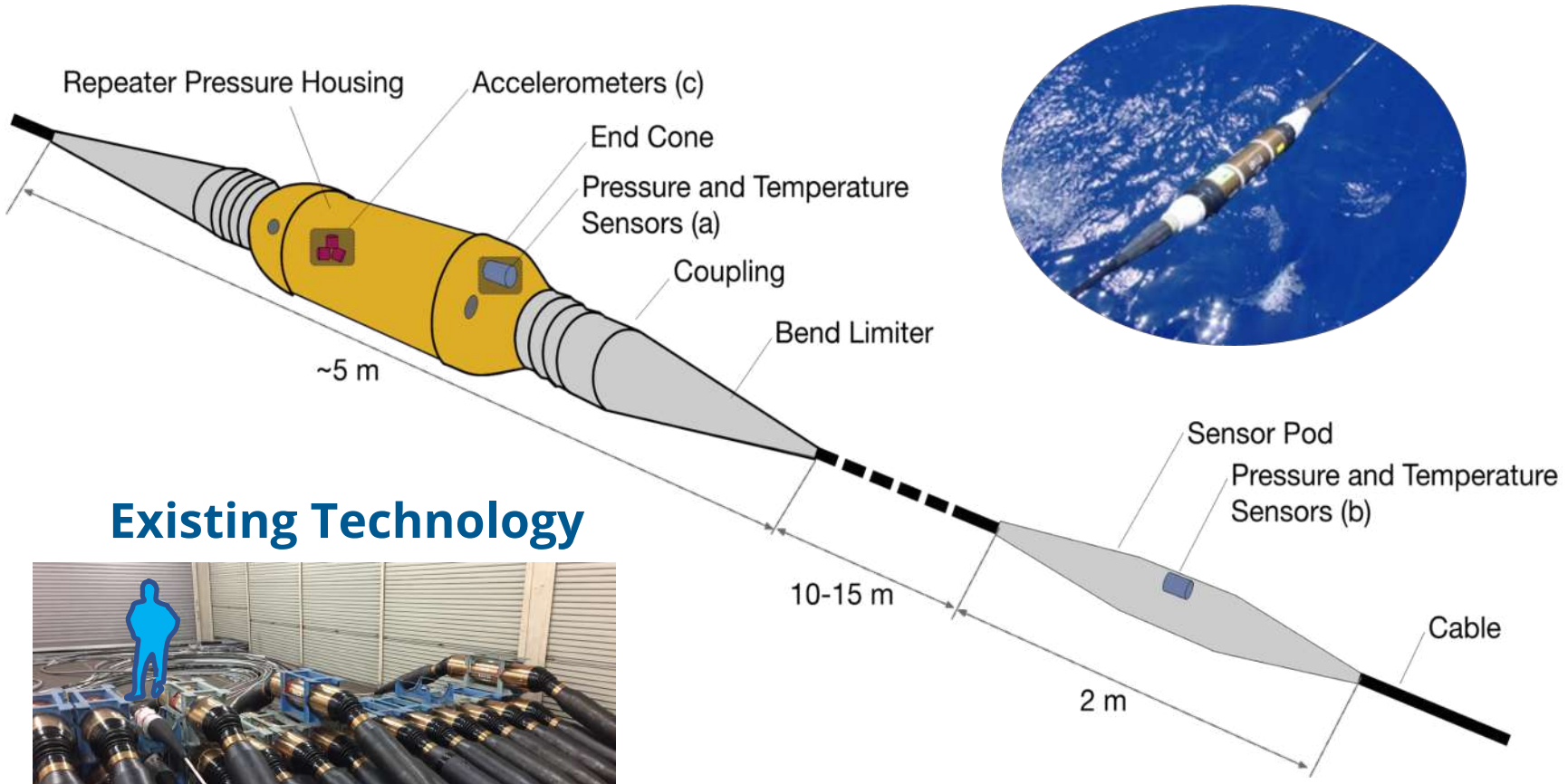
Ocean Observing Toolbox



The ocean bottom boundary condition

SMART Technical Solution

Shared Cable Infrastructure: Telecom + Science



Existing Technology

No Interference

Sensors:

- Temperature
- Pressure
- Seismic

Key points:

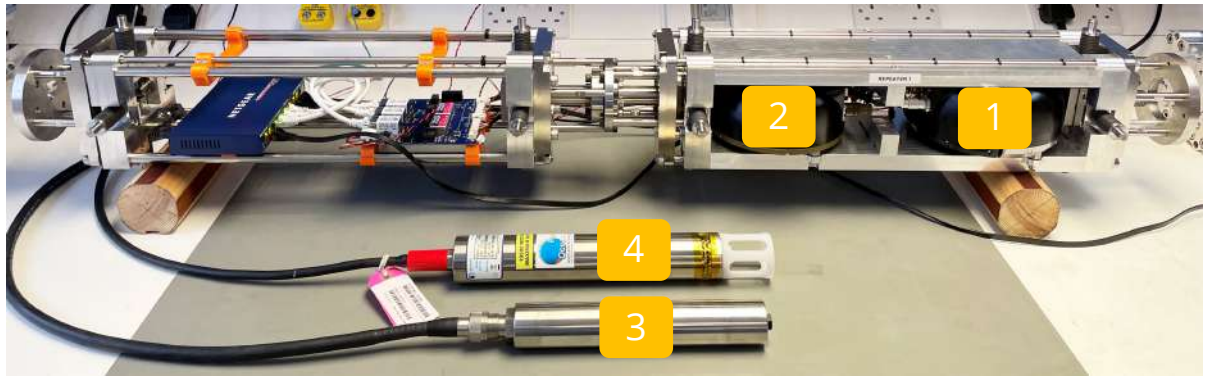
- Spacing ~100 km
- Essential Ocean Variables, Global Ocean Observing System

SMART Wet Demonstration project off Sicily

- National Institute of Geophysics and Volcanology (INGV) and Guralp Systems.
- 21 km of cable and 3 modules with 6 km spacing
- Deployed December 2023

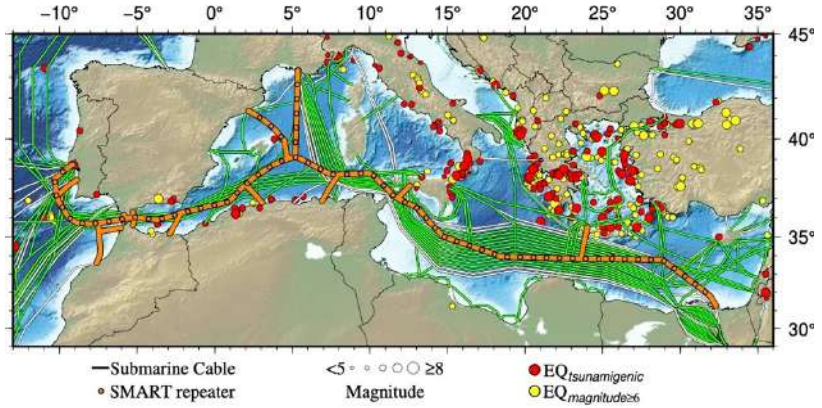
Each module has:

1. Seismometer
2. Accelerometer
3. Pressure sensor
4. Temperature sensor



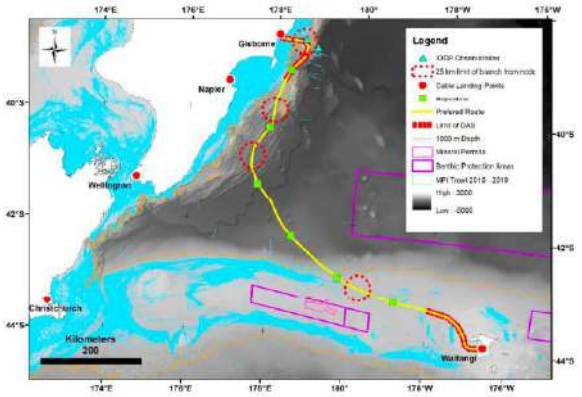
Systems in Play

Medusa

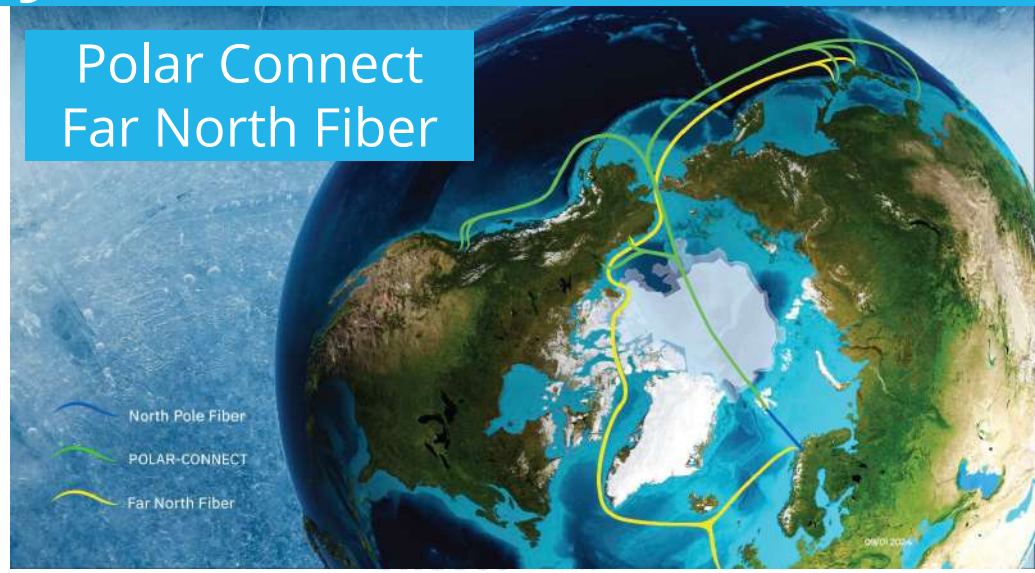


MISTS

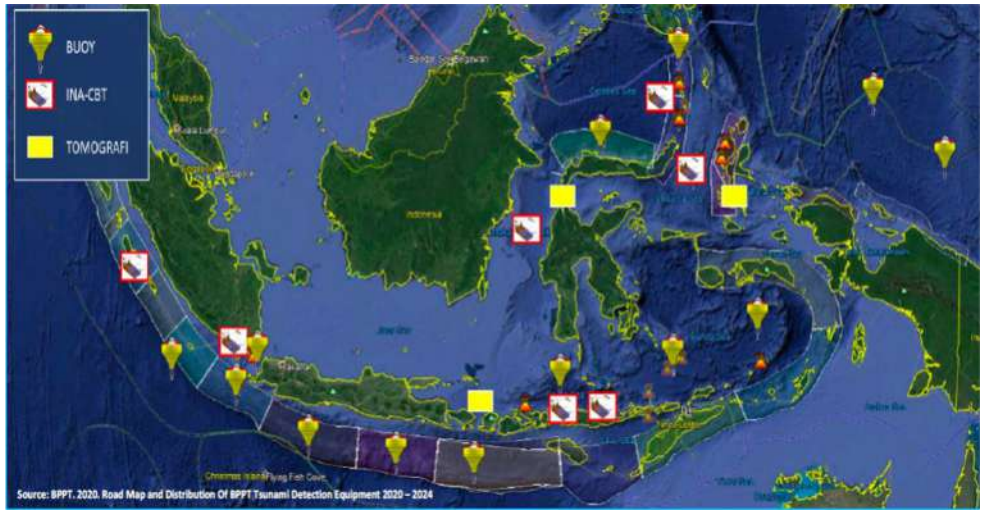
NZ - Chathams



Polar Connect Far North Fiber



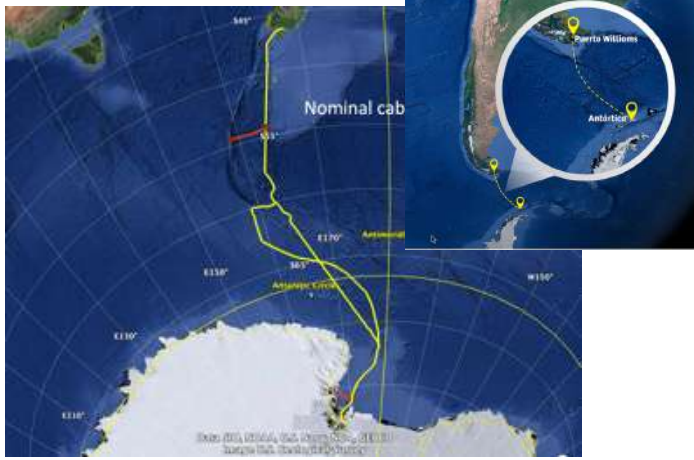
Indonesia



50 km, 2 module test system installed off Labuan Bajo

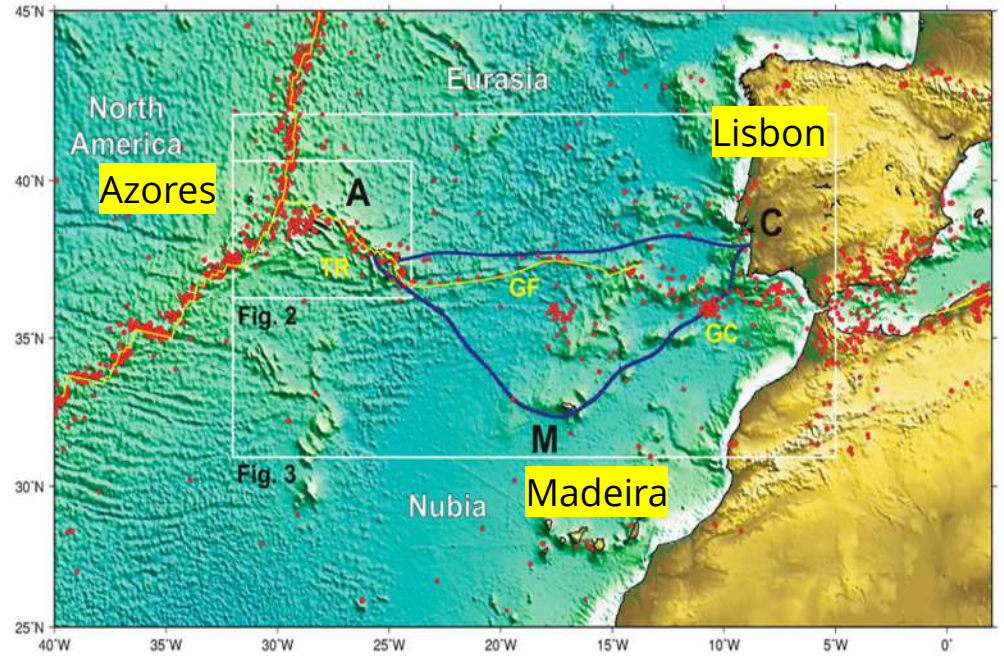
Koete

Antarctica



Funded SMART Cable Systems

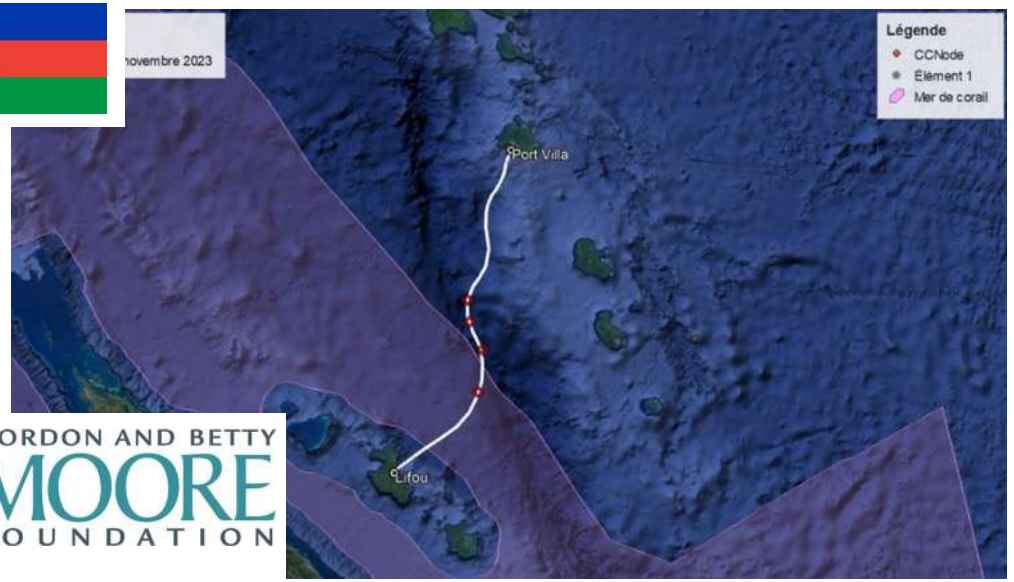
Portugal SMART Atlantic CAM



- 3700 km, ~40 SMART modules
- Gov't €154M. EU support €40M
- €154M ~ 1 ship+sensors 25 years (€6M/y)
- SMART 10% €15M ~ €1.5/citizen/25 y

Contracts signed
ASN
RFS 2026

TAMTAM SMART Cable System



GORDON AND BETTY MOORE FOUNDATION

- 450 km long, 4 SMART repeaters,
- France funding SMART (telecom: AFD, ADB)

- 25+ year life, reliable, low lifetime cost
- Leverage $5B/y industry, 170 y

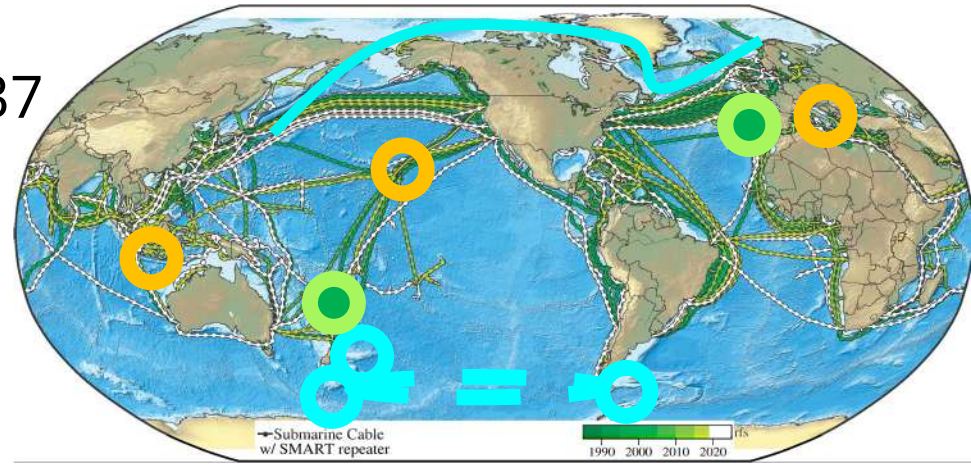
Optical Fiber Sensing in both

Concluding Remarks

Global Array: Climate, Oceans, Sea Level, Earthquakes, Tsunamis

Create a Planetary sensor, power, Internet network

- SMART – marriage with telecom – connectivity, climate, DRR – three for the price of one – saves on all fronts
- Anticipated additional 1.3 Gm of cable in water by 2037
- Leverage annual investment ~ $ 3+ Billion
- 25+ year life, highly reliable, low lifetime cost
- Recent successes – set precedents for future systems
- EU Funding: Cables w/ SMART
- Working with GOOS, Tsunami, Ocean Decade, DOOS
- Challenges: $, data, permitting, legal, security, …
- Think globally, act locally!
- Encourage all to participate!



Still much to achieve

Saving Lives

SMART CABLES

ITU unesco WMO

GORDON AND BETTY MOORE FOUNDATION

Schmidt Marine TECHNOLOGY PARTNERS

SMARTCables.org

ITU/WMO/UNESCO IOC Joint Task Force

Scan to Join!

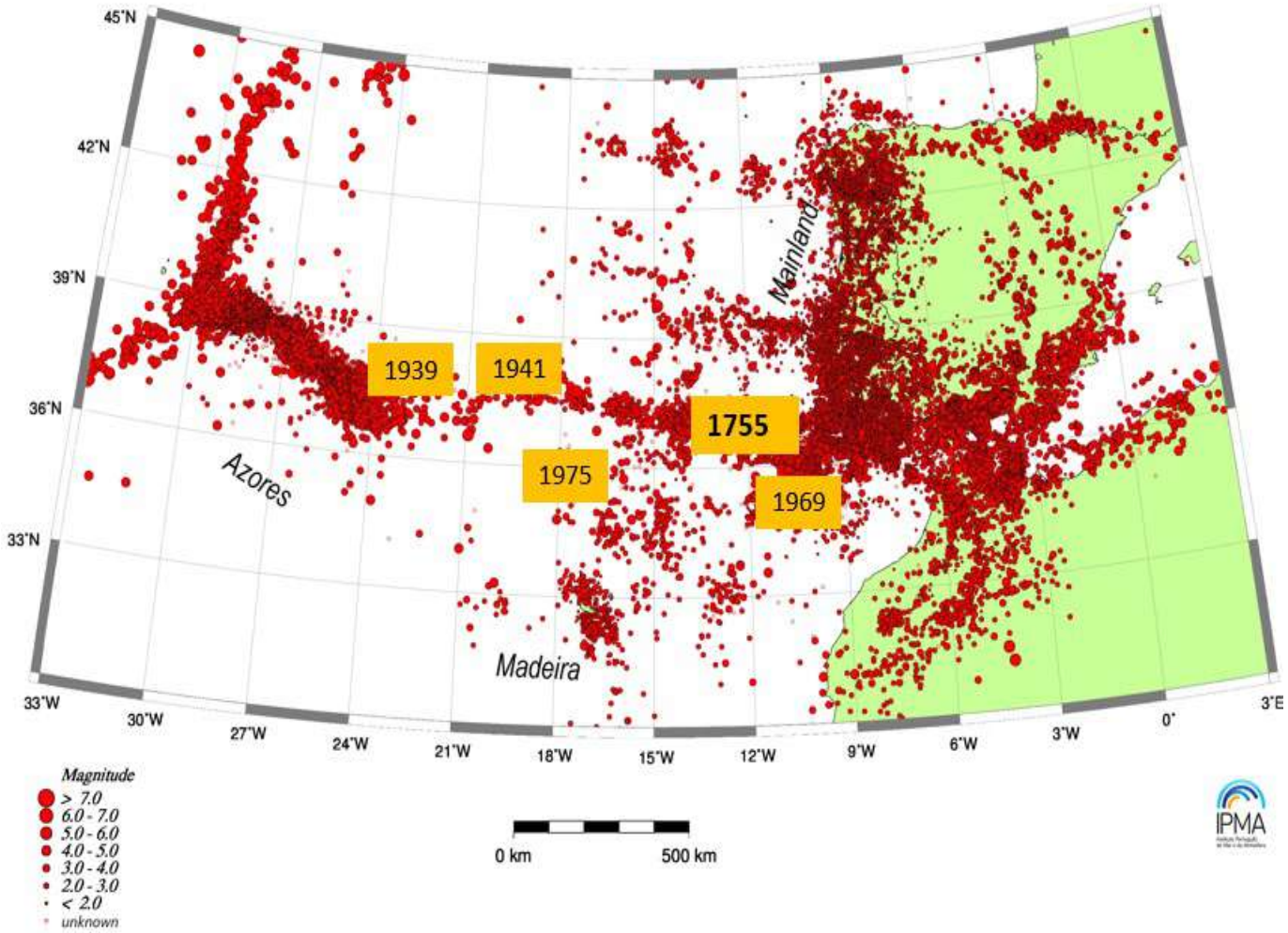
The Atlantic CAM platform:
The future of Portugal's subsea market

Barcelona, April 8, 2024

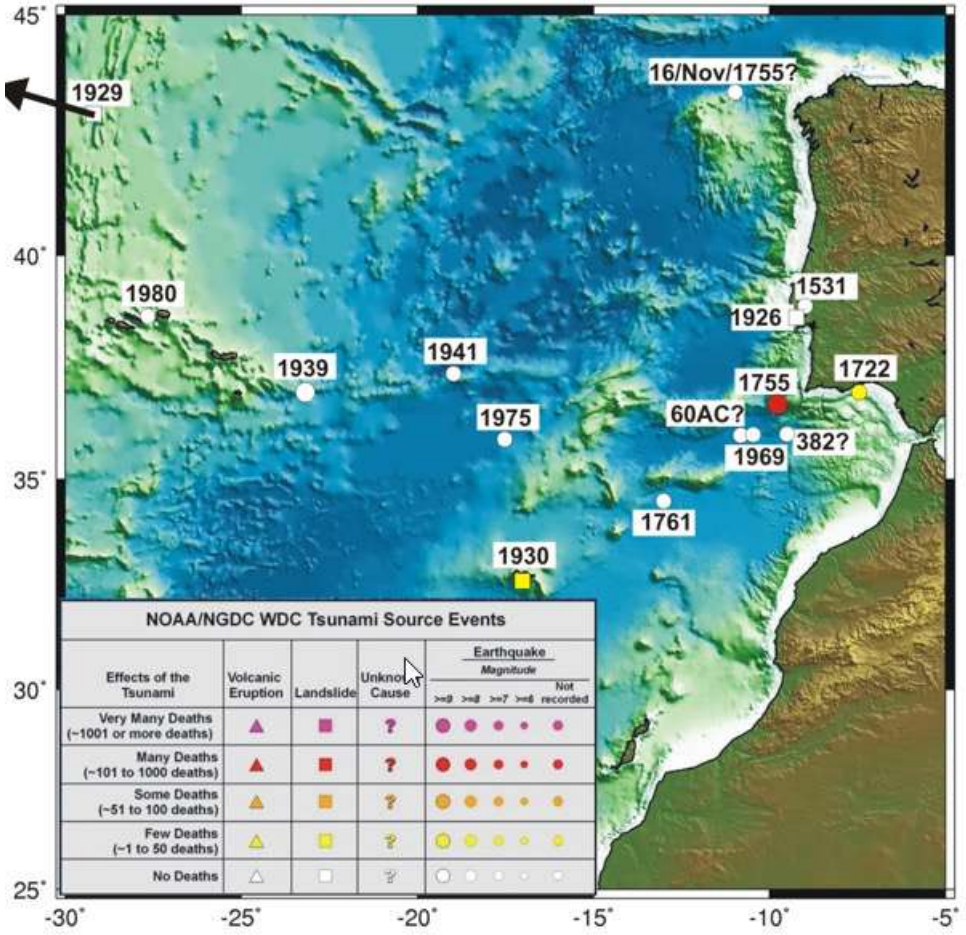
José S. Barros

jose.barrosSCs@outlook.pt

Earthquakes



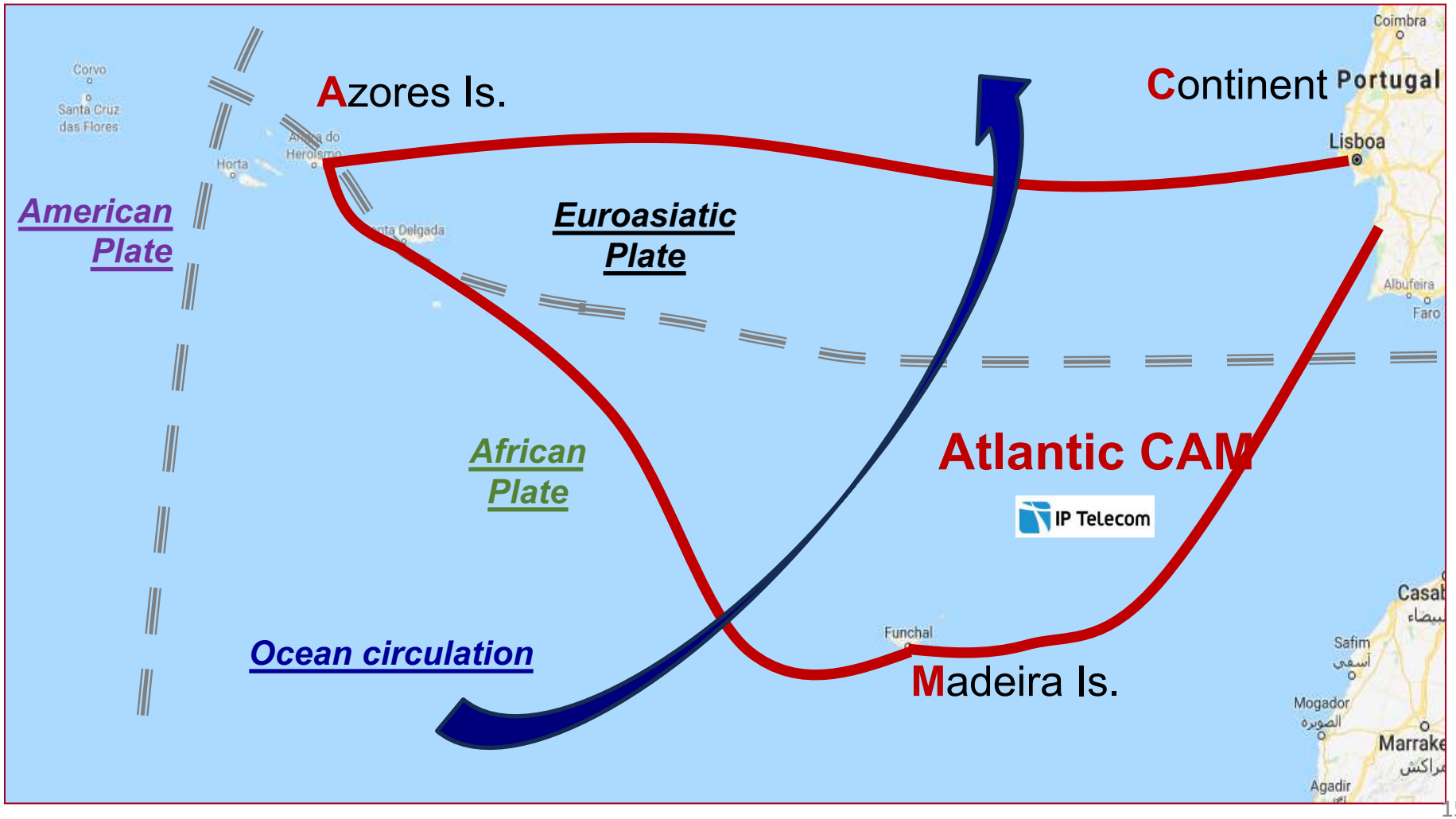
Tsunamis



Baptista & Miranda, 2009

Real time environmental and seismic detection by Atlantic CAM

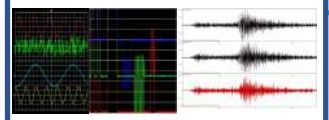
Atlantic CAM crosses an area of great interest for <u>Oceanography</u> (environmental studies) and <u>Geophysics</u> (meeting of three tectonic plates)



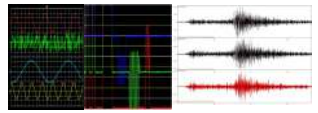
Real time environmental / seismic detection by Atlantic CAM

(public service)

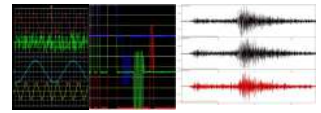
CLS Azores Is.



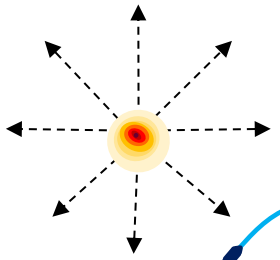
CLS Carcavelos



CLS Sines

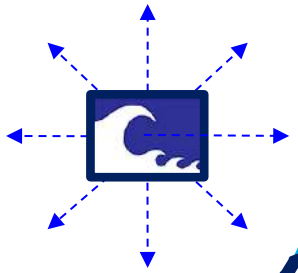


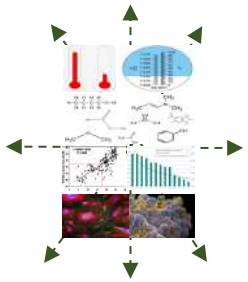
EEWs (Portugal and beyond, such as Spain, Morocco, France, …)



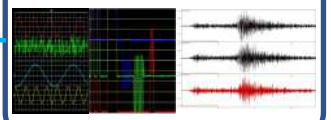
Real-time data for Geophysics, Oceanography, Environment, Climate Change, … (involvement of international organizations)

TEWs-(Portugal and beyond , such as Spain, Morocco, France,…)





CLS Madeira Is.



IP Telecom

L·E·A

IPMA

INSTITUTO DOM LUIZ

instituto de telecomunicações

Wet Detection with wet sensors according to what is established by JTF **SMART Cables.**

Telecom part will be 100% protected. Observation part will not interfere in no circunstances with Telecom part.

LEA delivered technical specs of the Observation part to **IP Telecom**
LEA was in close dialogue with JTF SMART Cables and with sensors and submarine cable suppliers.

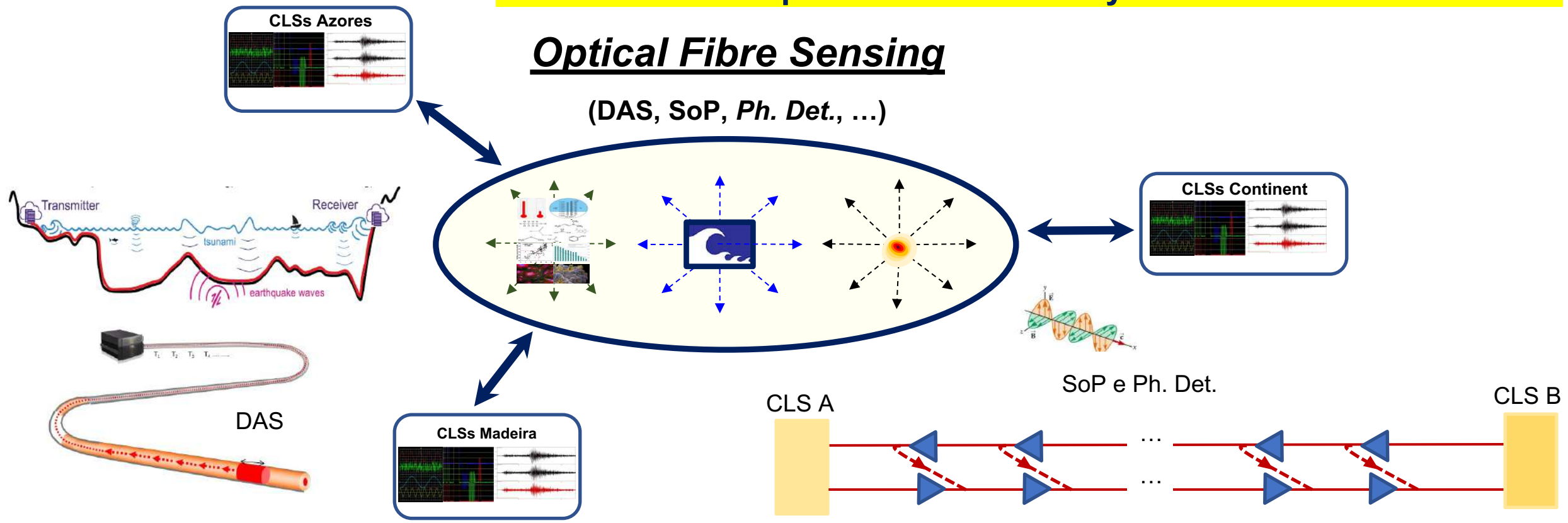
***- temperature, pressure and seismic (seismometer and accelerometers).**

At the service of national and international Scientific Communities as well as national populations and neighboring countries (EEWs and TEWs).

Complementary real time environmental / seismic detection by SCs in Portugal

(Dry Detection - without the utilization of wet sensors)

"Polarization and phase are affected by mechanical disturbances!"



Note – Atlantic CAM wet sensors, in conjunction with the use of OFS on Atlantic CAM and other cables, will also make a contribution to the real time environmental / seismic detection in the CAM zone

Cluster R&D – opportunity to use submarine cables for environmental and seismic detection in the Northeast Atlantic

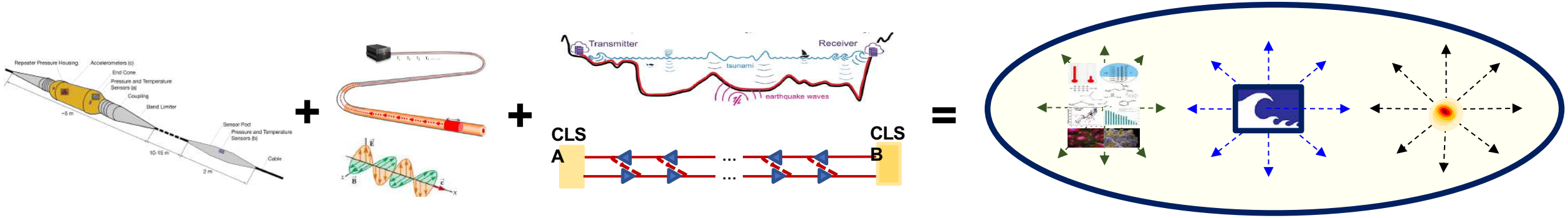
Wet Sensors (Atlantic CAM)

+

Optical Fibre Sensing

→ **Northeast Atlantic Observation Testbed**

Stakeholders R&D Cluster : Int' s Organizations; Universities; Public Institutes; Operators; Manufacturers; …

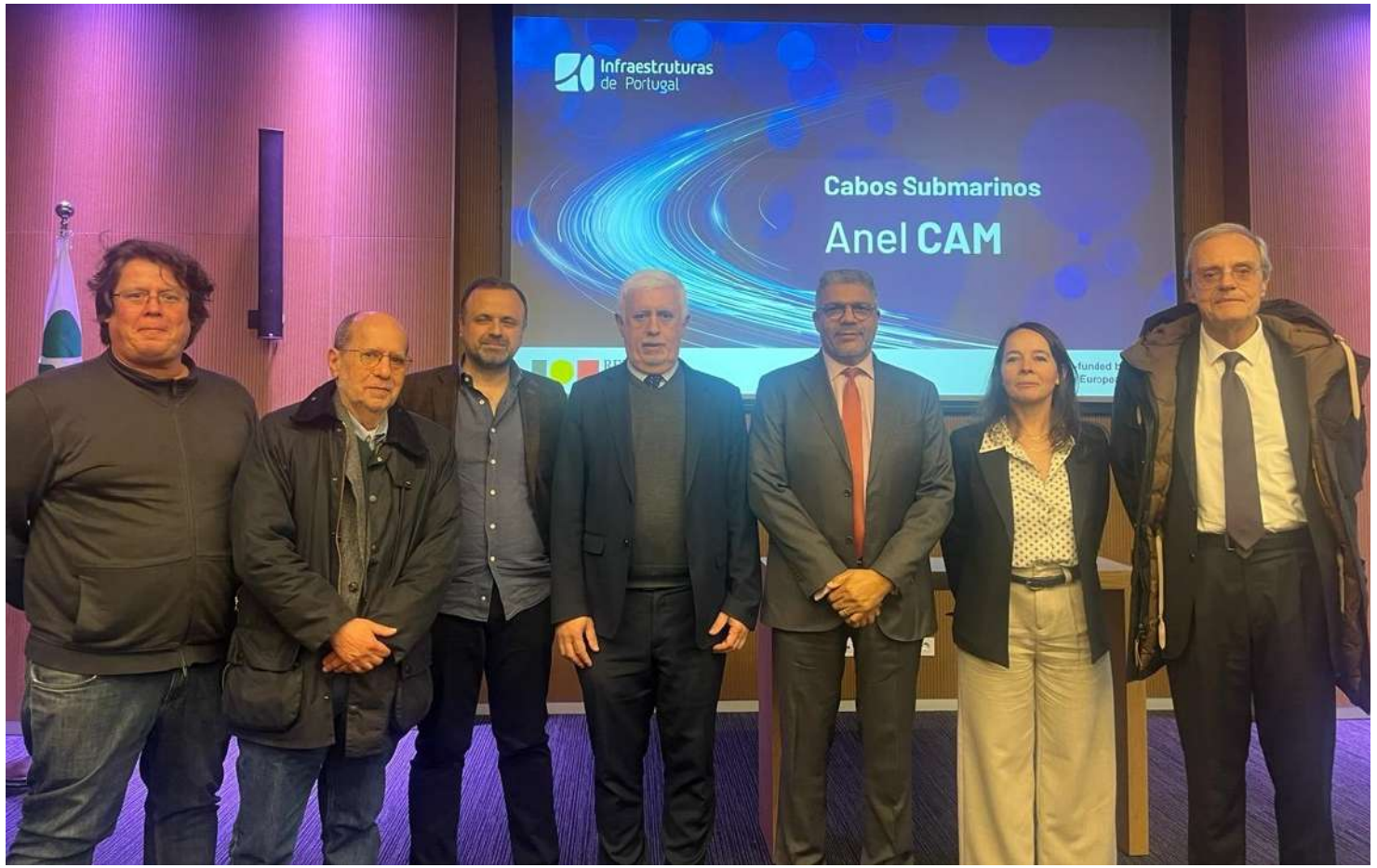


Goal: **Portugal as a primary node in the Northeast Atlantic of the Global Ocean Observing System**

Contract signing (Atlantic CAM)

IP – ASN (Almada, March 13, 2024)

ASN (P. Gabla), **IP** (M. Cruz)



LEA (M. Nehus, V. Sá, Y. Omar, F. Carrilho), **ASN** (P. Gabla, D. Domin), **JTF SMART Cables** (J. Barros)

SMART CABLES
+
ANACOM Autoridade Nacional de Comunicações
+
L·E·A Listening to the Earth under the Atlantic
IPMA
instituto de telecomunicações
INSTITUTO DOM LUIZ
+
IP Telecom
+
ASN
=
Atlantic CAM

Atlantic CAM in 2026

- 3,800 km long
- 25 years life time
- 6 fibre pairs (1 for Science)
- CAPEX 154 M€ (23 M€ Observation part)
- Total OPEX / year of 5,7 M€
- 41 M€ EU fund (CEF-2)

CLSs:

- **Carcavelos** (mainland)
- **Angra** (Azores Is.)
- **Fajã de Baixo** (Azores Is.)
- **Amparo** (Madeira Is.)
- **Machico** (Madeira Is.)
- **Sines** (mainland)

Enhancing Ocean observation in the **Mediterranean Sea** by integrating smart cables

Juanjo Dañobeitia [1], Giuditta Marinaro[2], Laura Beranzoli [2,3], Simo Cusi[3], Joaquin del Rio [3,4]
Angelo De Santis[2], *Jordi Sorribas [1], Kate Moran [5] , J. Riba [1], M. Ojeda [1], Christos Arvanitidis[6] and Norman Albi [7]*

[1] CSIC-UTM, Barcelona , [2] INGV, Rome, Italy., [3] EMSO ERIC, Rome, Italy, [4] OBSEA-UPC, Vilanova, Spain, [5] ONC Canada
[6]LifeWatch, Seville, Spain, [7]AFR-IX, Barcelona, Spain

Smart Cable
Satellite event UN decade of the Oceans Conference
Barcelona, 8 April 2024

EMSO ERIC RF Components and locations

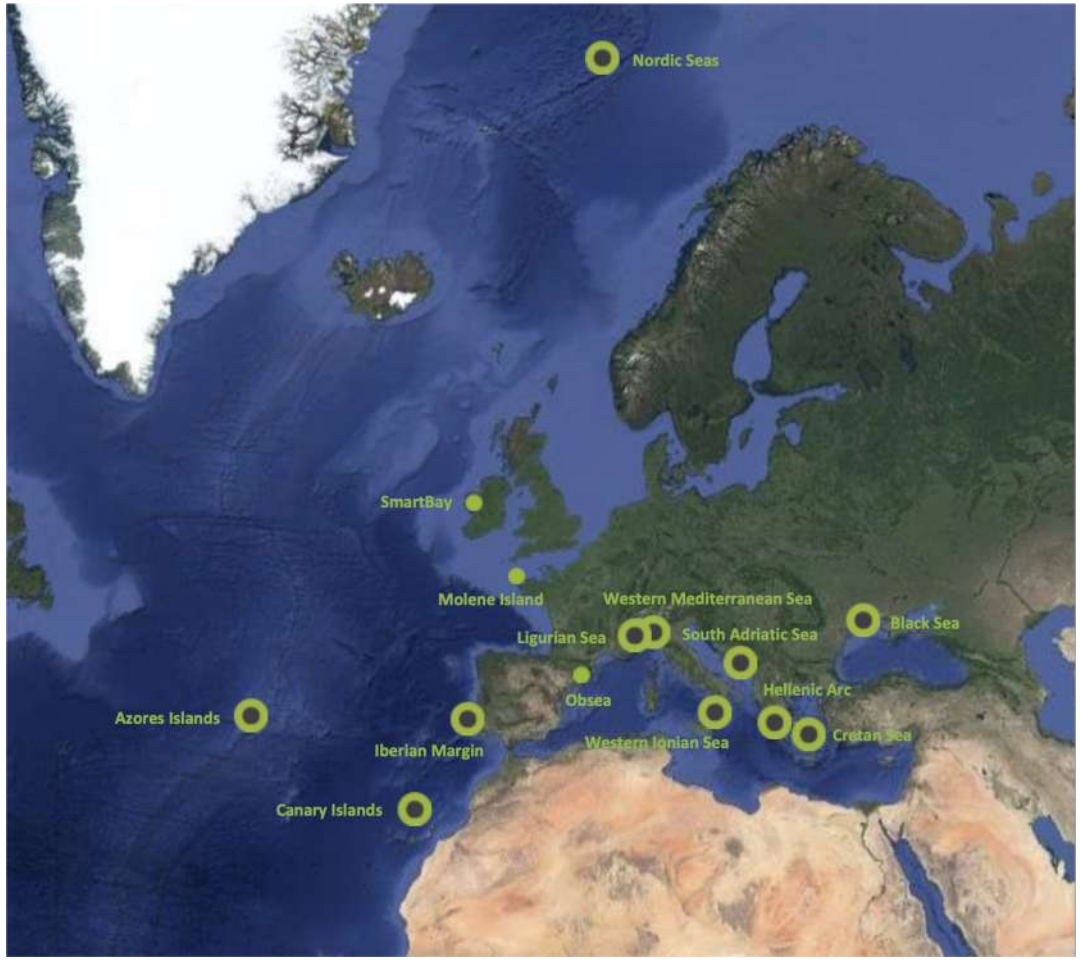
EMSO ERIC RF Components and locations - 2023

DISTRIBUTED RESEARCH INFRASTRUCTURE
8 Countries
27 Research Institutions

14 FIXED POINT MUTI-sensors PLATFORMS:

11 Deep Sea Observatories (Cable & Stand-alone)
3 Test Sites, Shallow water

OBSERVING AND MONITORING THE OCEANS
Time-series: continuous parameters acquisition
Target: Open Ocean Multidisciplinarity
Geosphere-Hydrosphere-Biosphere-Atmosphere interactions



CSIC
Consejo Superior de Investigaciones Científicas

Smart Cable
Satellite event UN decade of the Oceans Conference
Barcelona, 8 April 2024

Ocean Observing Systems

WHY OBSERVE

Oceans, seas are essential component of the Earth's ecosystem and are critical to sustainable development and live on Earth. Millions of people depend on marine and coastal resources for their livelihoods.

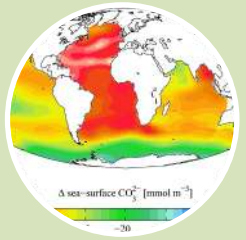
From the SEA surface to DEEP Sea?

Key objectives

to further explore the oceans and marine habitats

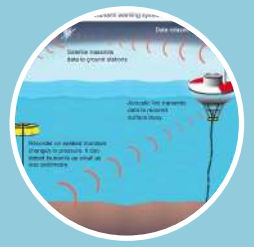
to gain a better knowledge of the complex processes happening within water column, seafloor and sub-seafloor

to assess the crucial role and evolution that these processes play in the Earth systems

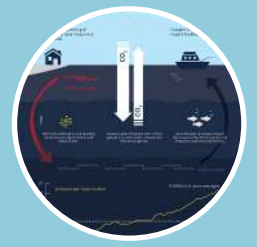


Global ocean warming and acidification

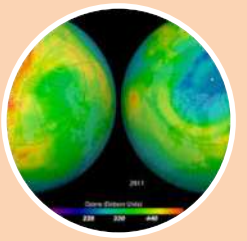
Impact and sustainability of Marine Resources exploitation



Real-time observations and early warning systems for earthquakes & tsunamis



Marine Ecosystems and Climate Change mitigation



Earth interactions hydrosphere, biosphere, lithosphere, atmosphere

Access HIGH QUALITY MARINE ENVIRONMENTAL DATA

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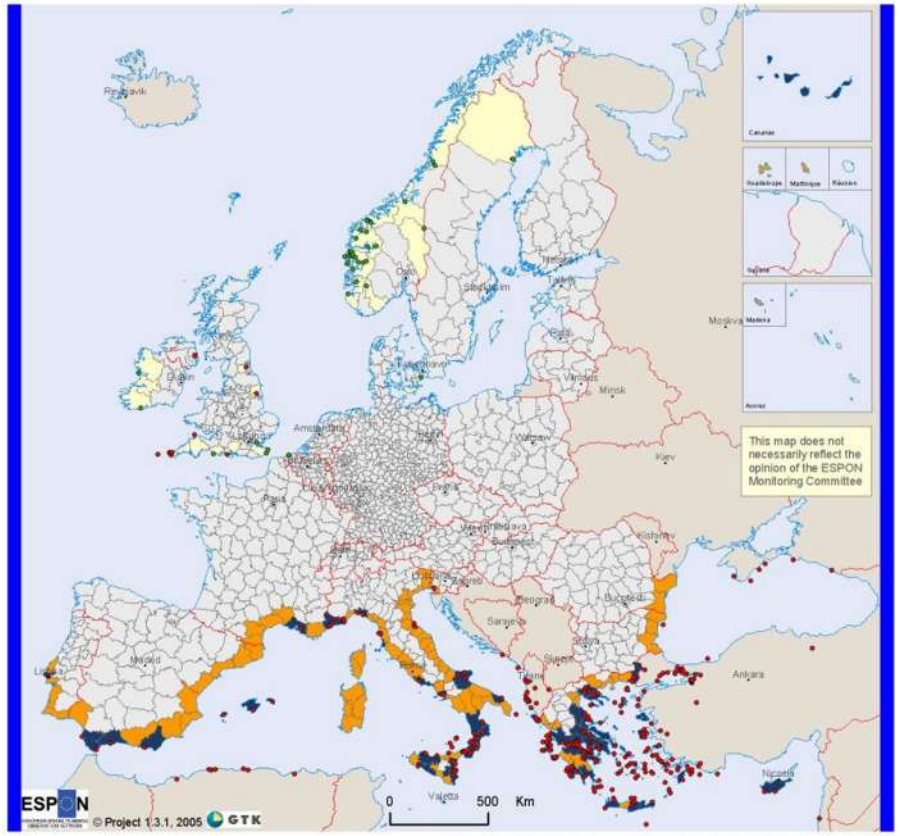
14 LIFE BELOW WATER
THE GLOBAL GOALS For Sustainable Development

GEO-HAZARDS

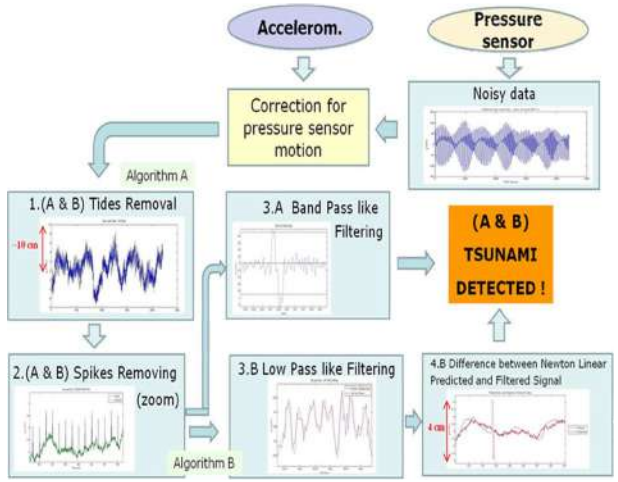


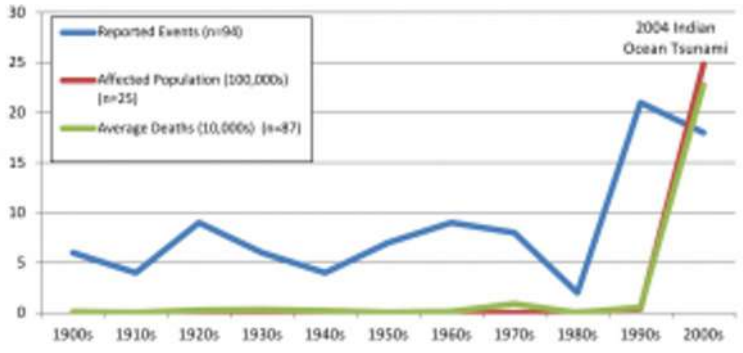
Historically recorded tsunami runups

Origin of the data: © EuroGeographics Association for the administrative boundaries
Northern coast of Africa and Spain: Hébert, 2003
Greece: Institute of Geodynamics, National Observatory of Athens
Spain: Instituto Geografico Nacional
Italy: Istituto Nazionale di Geofisica e Vulcanologia, Roma
World Tsunami data: National Geophysical Data Center (NGDC)
World Map of Natural Hazards: Munich Reinsurance Company
Source: ESPON Data Base

- Terrestrial landslide associated/ unknown cause
- Earthquake/volcano/submarine landslide accociated
- Espon space
- Regions that experienced landslide associated tsunami
- Tsunami potential in coastal areas close to tectonically active zones
- Regions that lie in vicinity to tectonically active zones and have experienced earthquake/volcano/landslide accociated tsunami
- Non ESPON space

United Nations Educational, Scientific and Cultural Organization
Intergovernmental Oceanographic Commission
North-Eastern Atlantic, Mediterranean and connected seas Tsunami Information centre





Tsunami events affecting human populations by decade

INGV

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InSEA project: enhancement of Western Ionian Sea

National Operative Programme – Research and Innovation 2014-2020

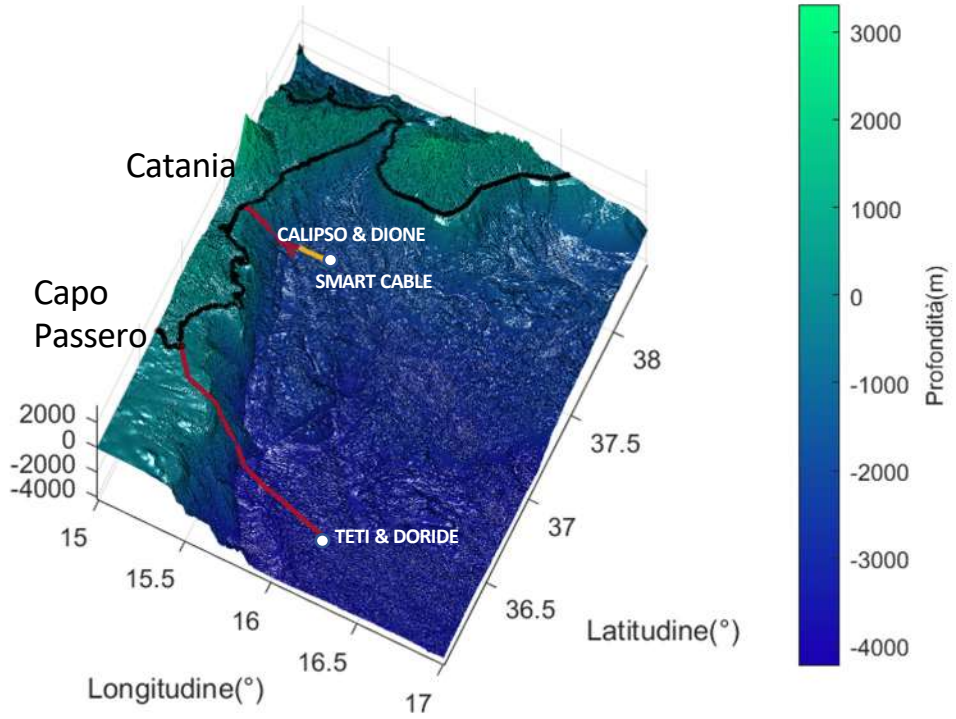
InSEA: Initiatives in Supporting the consolidation and enhancement of EMSO infrastructure and related Activities

Catania Site:

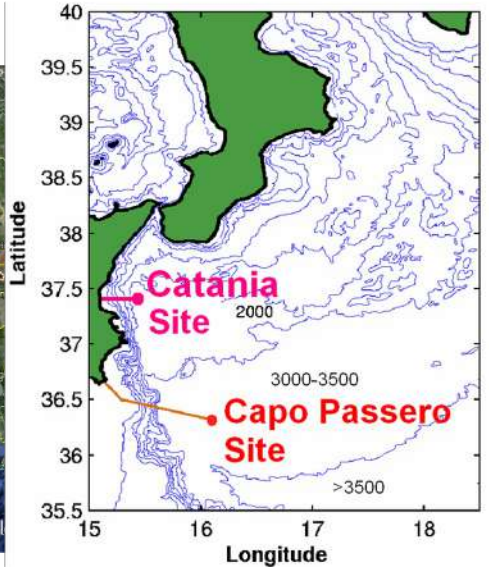
- shore station enhancement (ICT and power supply)
- JB + 2 new multidisciplinary seafloor observatories: CALIPSO and DIONE
- **InSEA SMART cable wet demo (18 km with 3 instrumented repeaters)**

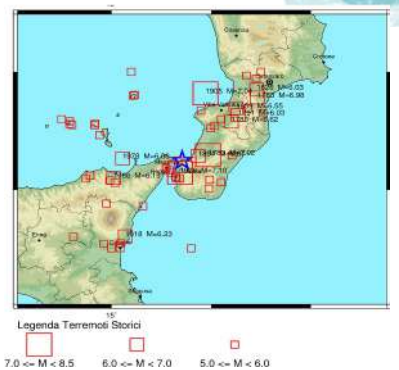
Capo Passero Site (3500 m bsl, 100km E/O cable):

- JB + 2 new multidisciplinary seafloor observatories: TETI and DORIDE
- EMSO data center in Portopalo station



Western Ionian Sea Facility





Science Objectives:

- geo-hazards (tsunami, seismic and volcanic monitoring)
- oceanographic monitoring
- environmental monitoring (acoustic noise)
- bioacoustic marine mammals tracking

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emso ERIC

December 2023 – Seafloor deployment

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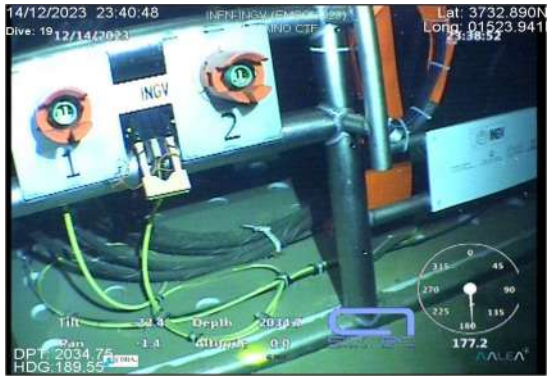
- ONBOARD
- CABLE DRUM
- CRANE FOR REPEATER HOUSINGS
- CATHODE

Western Ionian Sea Infrastructure

- CTF 1000v Ac
- JB 4 Output 375v Dc
- 2 Multiparameter Observatories
  - OBS
  - Pressure
  - Hydrophone
  - Other Oceanographic Sensors



	Latitude	Longitude	Depth (m)
CTAi frame	37° 32. 896 N	015° 23.962 E	2.034
Rep 1	37° 33. 395 N	015° 26.017 E	1.928
Rep 2	37° 34. 309 N	015° 30.095 E	1.929
Rep 3	37° 36. 512 N	015° 32.899 E	1.899

Data Recording Examples

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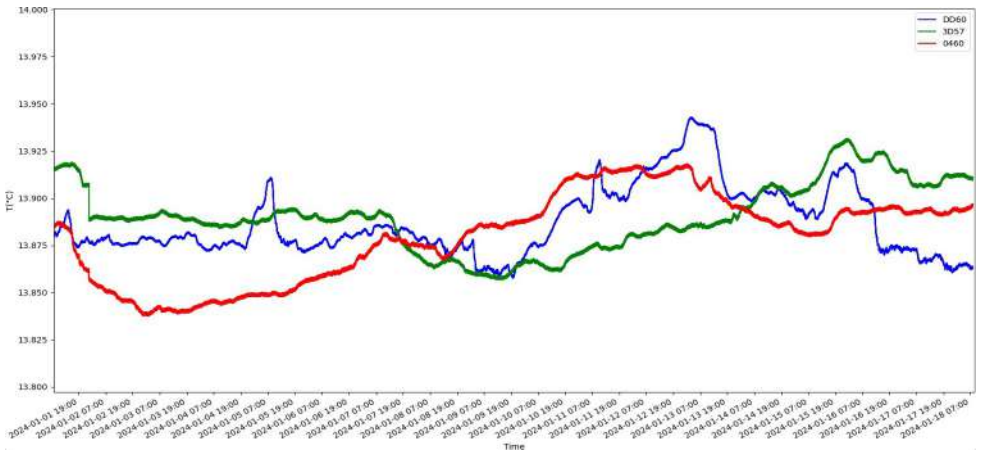
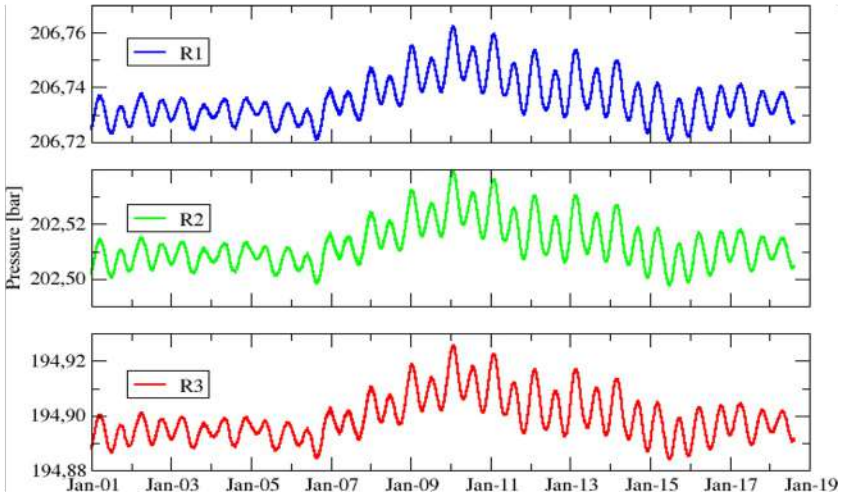
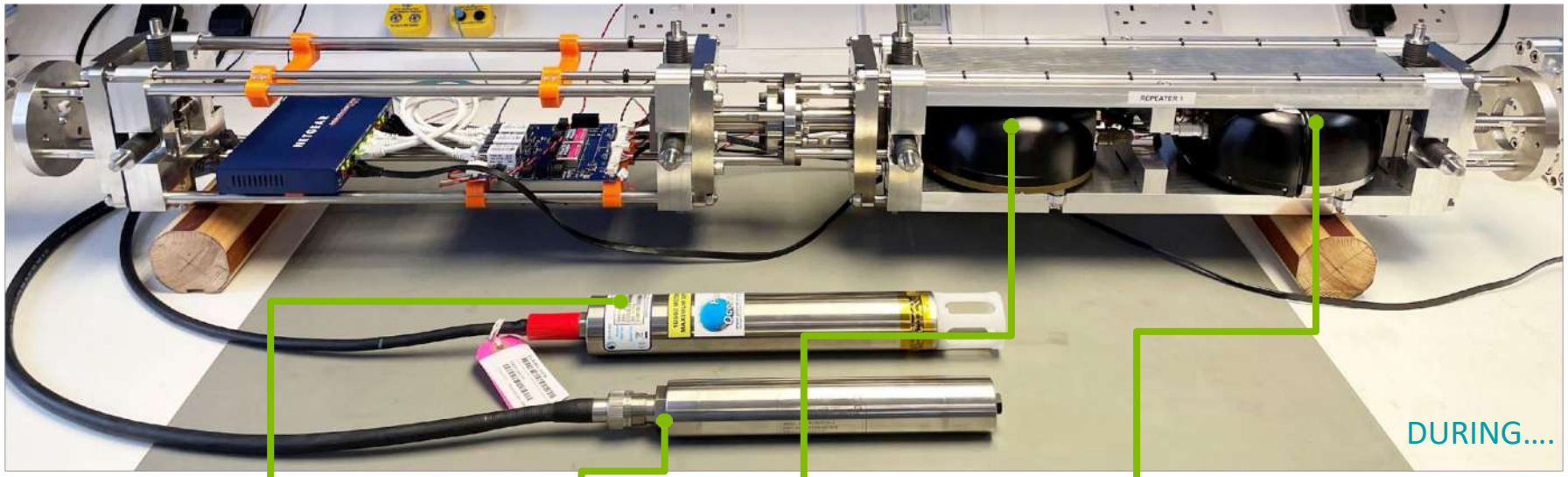
Environmental Sensors - Raw Data

- Temperature (1HZ)
- Pressure (1 sample/15 s)





Instrument Selection and Performance



Instrument pod:

Seabird SBE 39Plus
The temperature sensor selected has an operating range between - 5°C and 45°C with an accuracy of ±0.002°C. The sensor will help to calibrate the seismometer and floor oceanographic conditions and will feedback into existing oceanographic models.

Paroscientific 8000 Series
This APG has a depth rating of 3,000m and a precision of <0.01% full scale range. Selected for proven performance and robustness, the Paroscientific 8000 has been successfully used in other Güralp ocean bottom sensing systems. It has also proven crucial for tsunami warning systems globally.

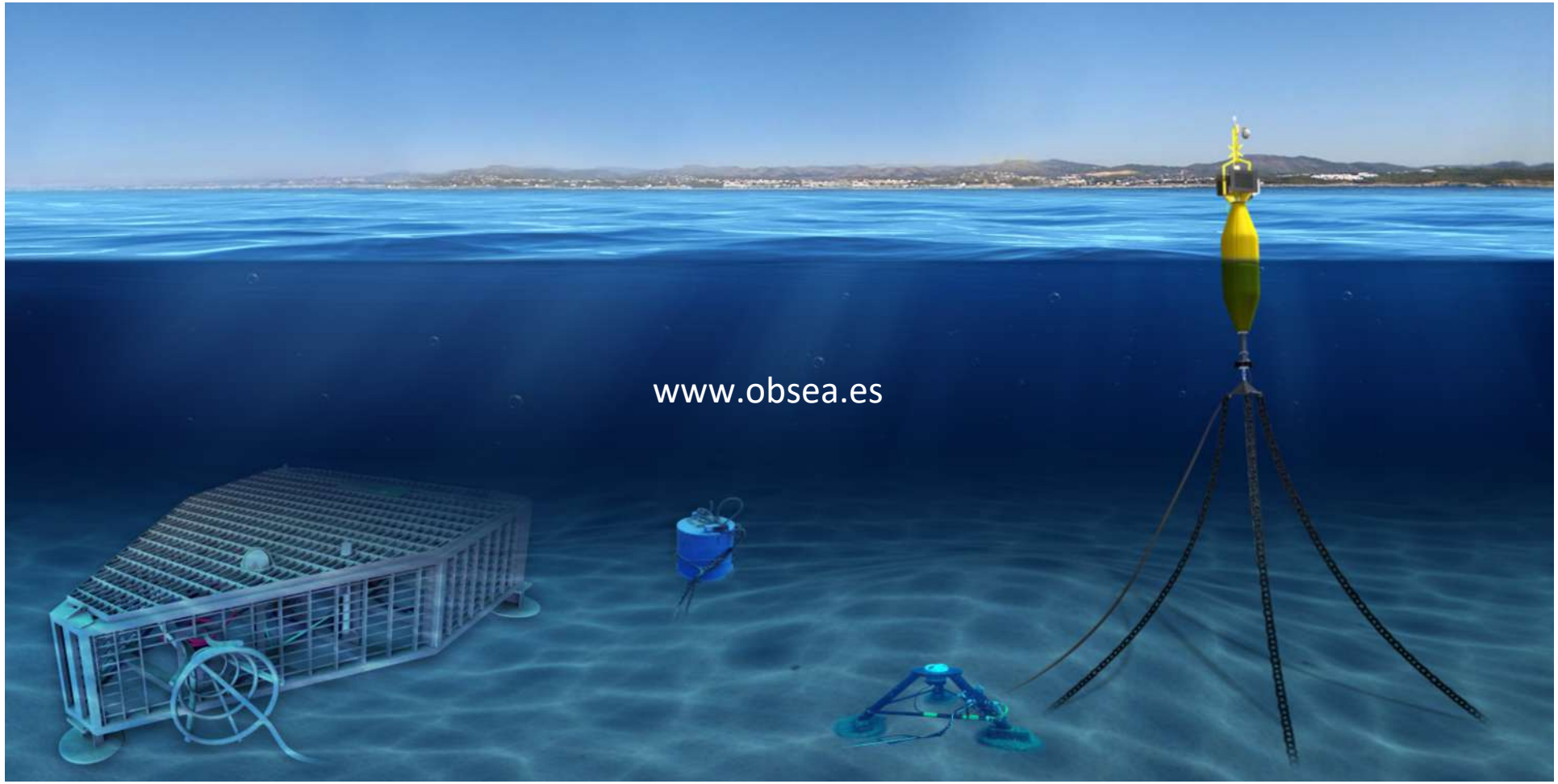
Repeater:

Fortimus
A modern force balance accelerometer with integrated digitiser. It has a flat acceleration response between DC-315 Hz. The instruments' low self-noise, makes the data useful or local and regional seismic monitoring.

Certimus
A triaxial broadband seismometer with a flat frequency response between 120 s and 100 Hz. The Certimus has true broadband performance with a low instrument self-noise that makes it well suited for regional seismic monitoring. The Certimus is used globally for applications ranging from volcano monitoring to regional and national networks.

Combining Fortimus and Certimus provides an ultra-wide dynamic range

OBSEA: Shallow water cabled Observatory Test Site



Belal Mohammad, Nogueras Marc, Toma Daniel Mihai, Martinez Enoc, Carandell Matias, Del rio Fernandez Joaquin (2022). Jerico-S3 TNA access data- Fibre-optic Intelligent Submarine High-Fidelity Environmental Sensing at OBSEA. SEANOE. https://doi.org/10.17882/88395

ACKNOWLEDGEMENTS: We would like to thank JERICO-S3 (Agreement N°21/1001631) TRANS NATIONAL ACCESS and OBSEA technicians

OBSEA: Shallow water cabled Observatory Test Site

Marine Test Sites for Research, Innovation and Industry for a Sustainable Blue Economy

What ? Open-sea test centres are open and safe areas offshore
- to innovate with high-level scientists
- to experiment and develop solutions for the societies.

Transnational access Horizon Europe calls are crucial for their long-term development.

OBSEA, 20m depth, 4km offshore Vilanova i la Geltrú (Barcelona)
Real marine environment, easy access
History of continuous metocean data, 14 years
Long-term physical and biological monitoring of the sea water
Oceanographic sensors test & development
Ageing of materials in sea water, corrosion & biofouling.
Real-time communication 24/7
Access to data:
https://data.obsea.es/erddap/info/index.html?page=1&itemsPerPage=1000
https://obsea.es/

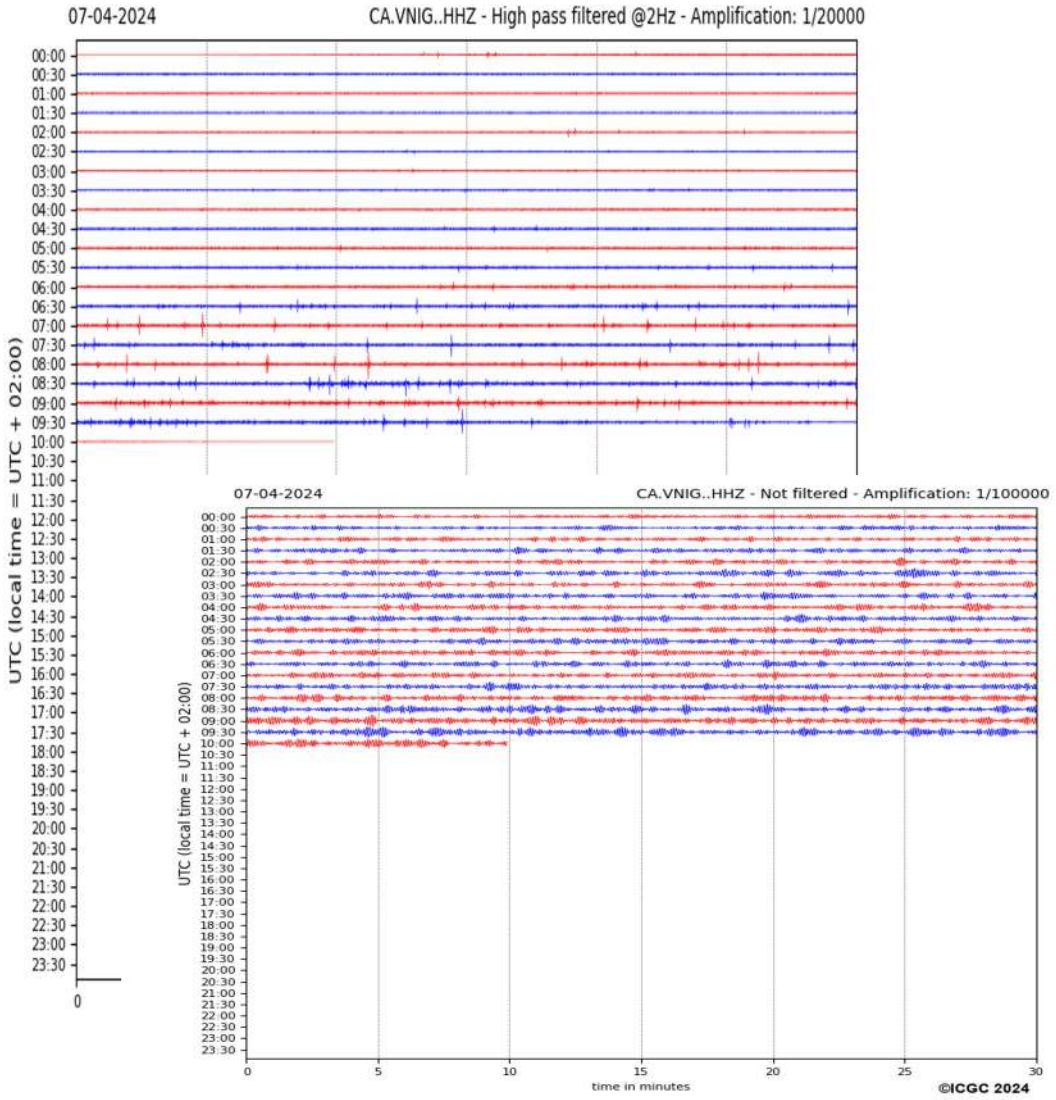
OBSEA: Shallow water cabled Observatory Test Site

EOV Monitoring with Quality Control

Access to data: https://data.obsea.es/erddap/info/index.html https://obsea.es/

OBSEA: Shallow water cabled Observatory Test Site

Real time data broadband OBSEA seismometer



Medusa
Submarine Cable System

AFR-IX telecom

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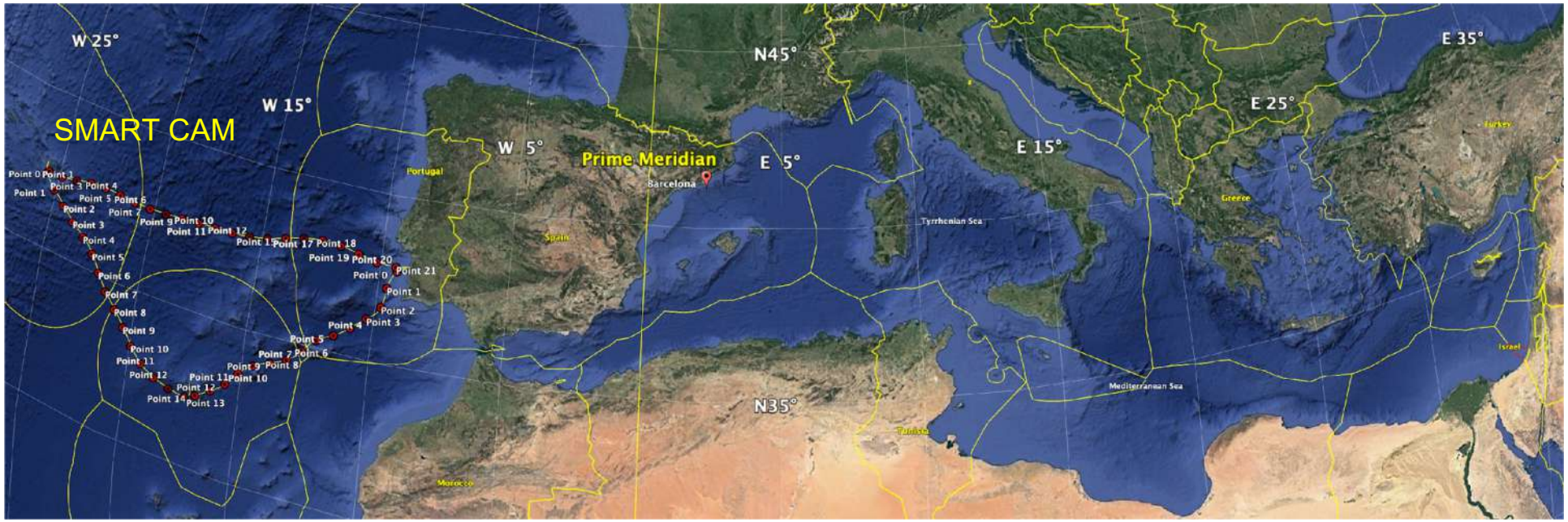
Sketch map for the possible 3 site locations for a joint project EMSO ERIC & LifeWatch

This is a co-design between EMSO ERIC, LifeWatch and AFR-IX

Portugal leads smart cable deployment in Europe



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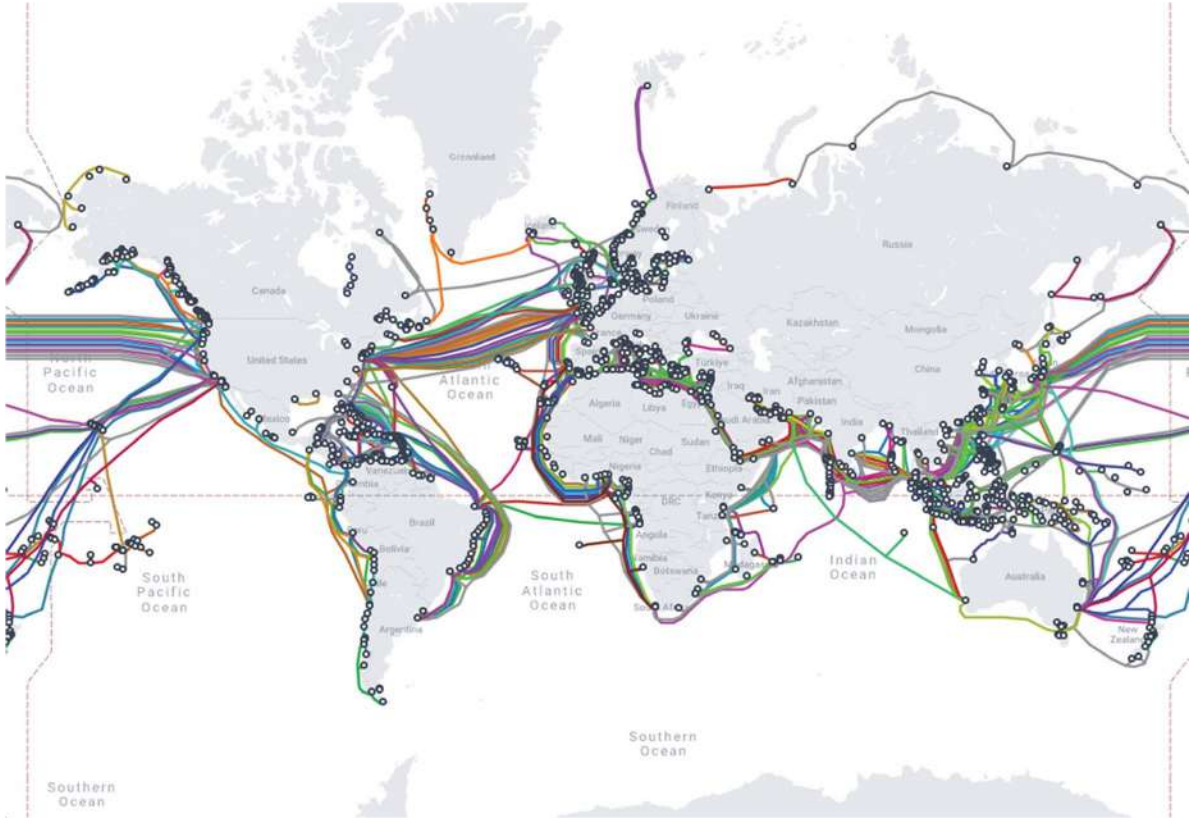
FUTURE WORK

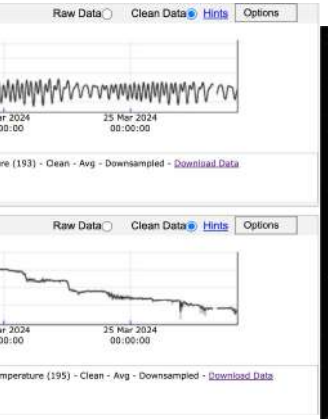
- HUGE GLOBAL POTENTIAL FOR SMART CABLE OBSERVATORIES
- DATA COMPARISON WITH LAND/OBS STATIONS
- VALUABLE INTEGRATION EXPERIENCE LEARNED FROM THIS PROJECT

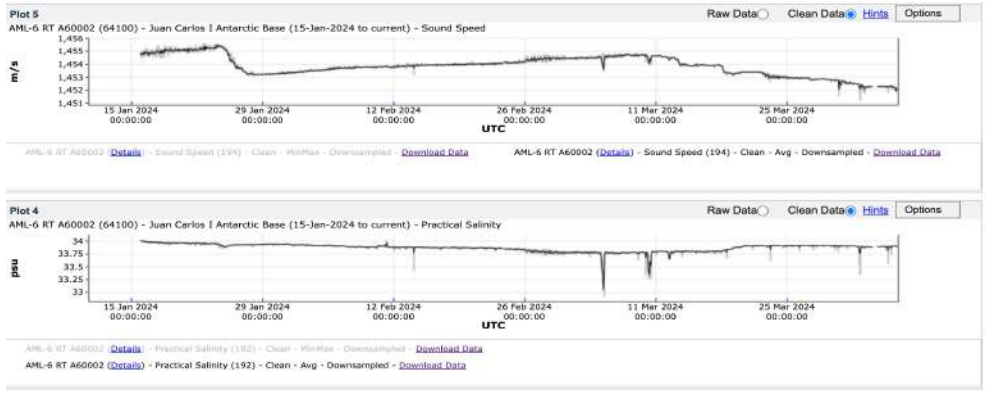


Submarine map credit: TeleGeography

Sensing Ocean Challenges in Antarctica

*Southern Ocean Observing System (**SOOS**)*





Early 2024 announcement from ONC and CSIC follows a recent call for the urgent expansion of ocean monitoring in the Southern Ocean. In a joint statement released at the 2023 Southern Ocean Observing System (SOOS) Symposium, 300 scientists from 25 nations said that “the chronic lack of observations for the Southern Ocean challenges our ability to detect and assess the consequences of change.”

Departing from Spain last autumn, the *Hespérides* is moored in the small bay opposite the Juan Carlos I station. Image: Ocean Networks Canada

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https://data.oceannetworks.ca/PlottingUtility?TREETYPE=26&LOCATION=2824&DATEFROM=10-Jan-2024%2021:00:00&DATETO=05-Apr-2024%2018:57:31

Thank you

jjdanobeitia@utm.csic.es

www.utm.csic.es/es/home

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Advancements in fiber optic cable technology: enhancing tsunami early warning systems and health monitoring

Arantza Ugalde

Institut de Ciències del Mar

EXCELENCIA SEVERO OCHOA

CSIC
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Fiber sensing as a complementary technology to SMART sensors

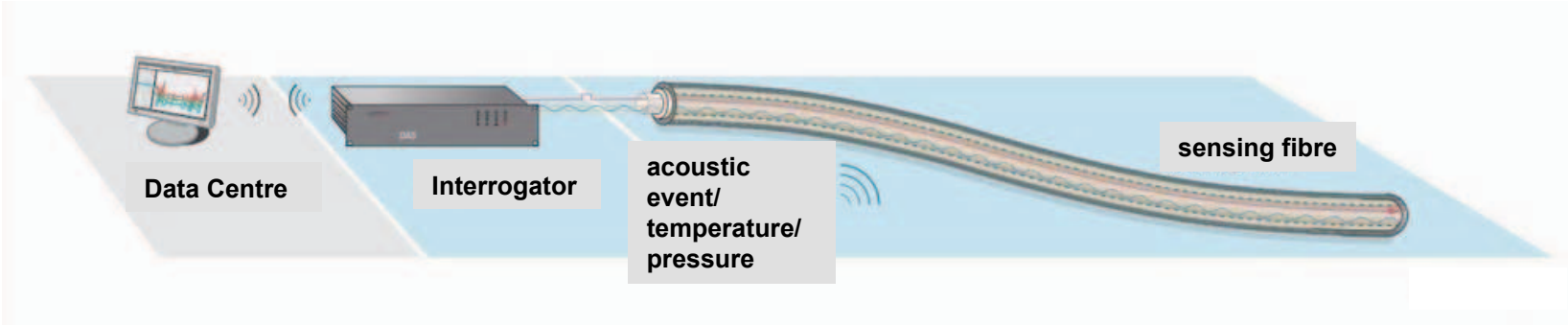

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Image: https://www.apsensing.com

Telecommunication cable

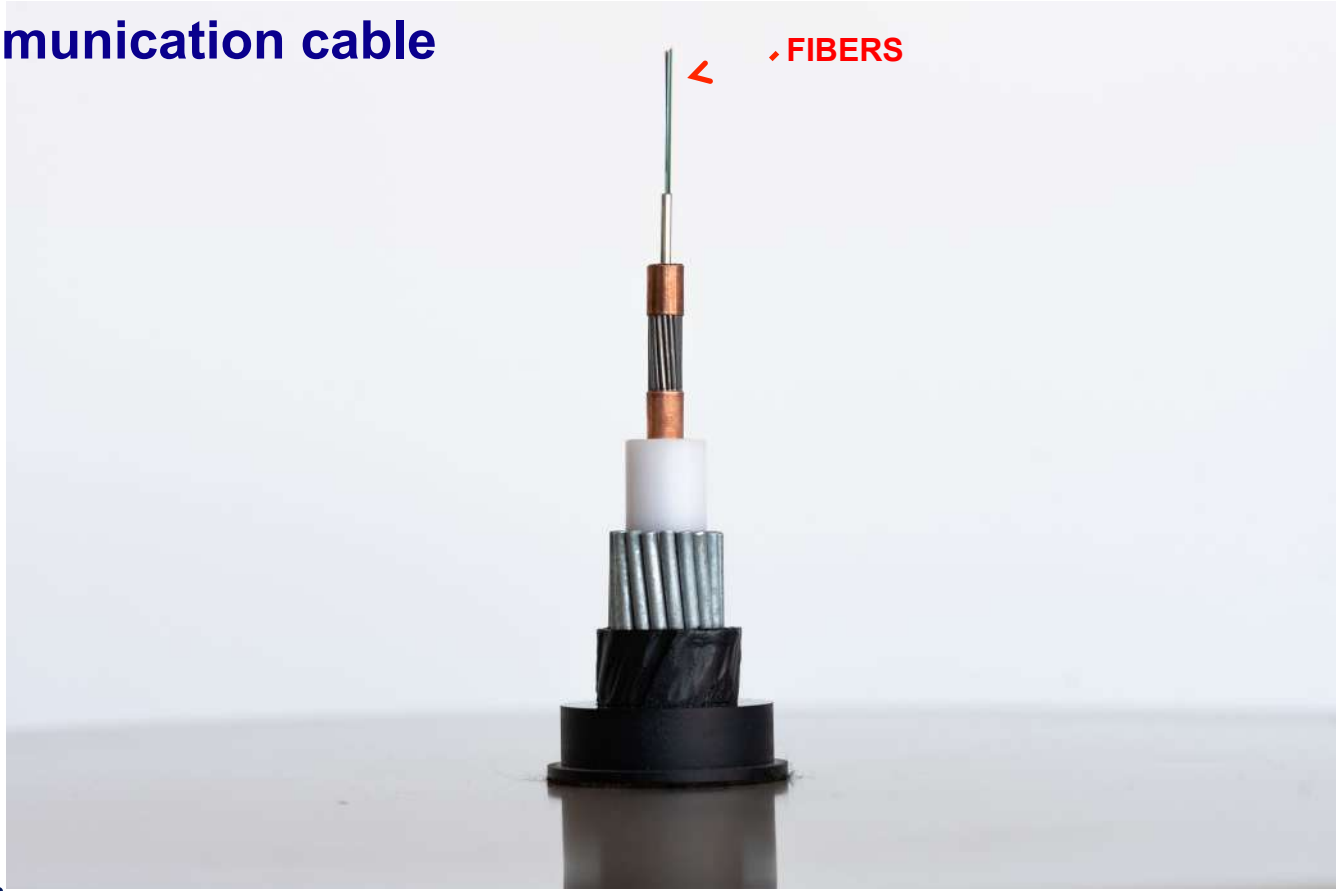

Image: AFR-IX Telecom

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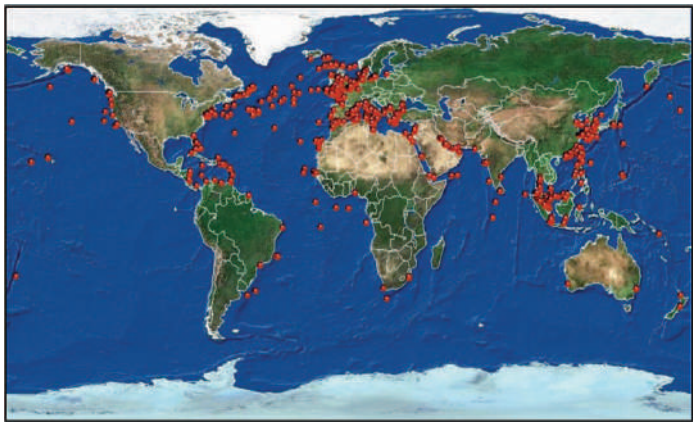
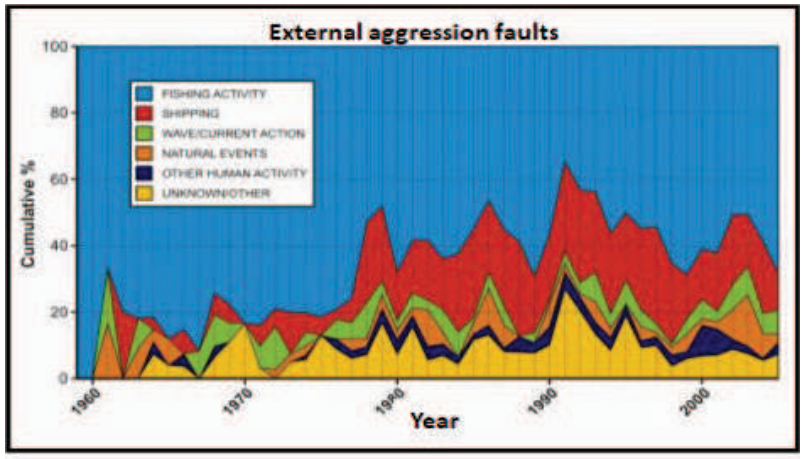
The potential of fiber sensing for preventive maintenance of telecom cables



Major cable faults in the period 1956-2006.



Bottom fishing and ship anchoring account for the majority of submarine cable faults (200-300 annually, International Cable Protection Committee, 2023), with annual repair costs reaching millions of Euros.

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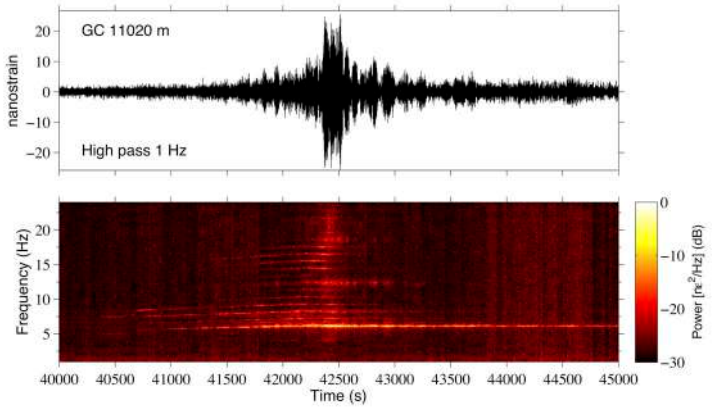
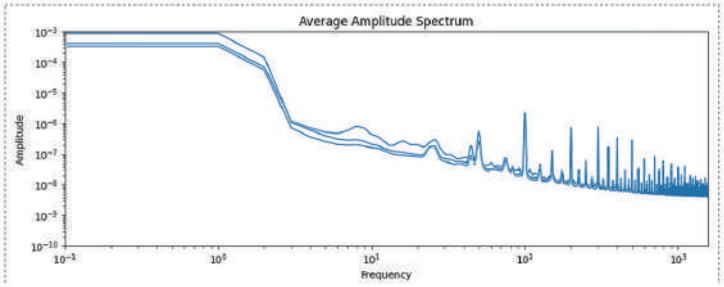
VESSEL SIGNATURE





AIS

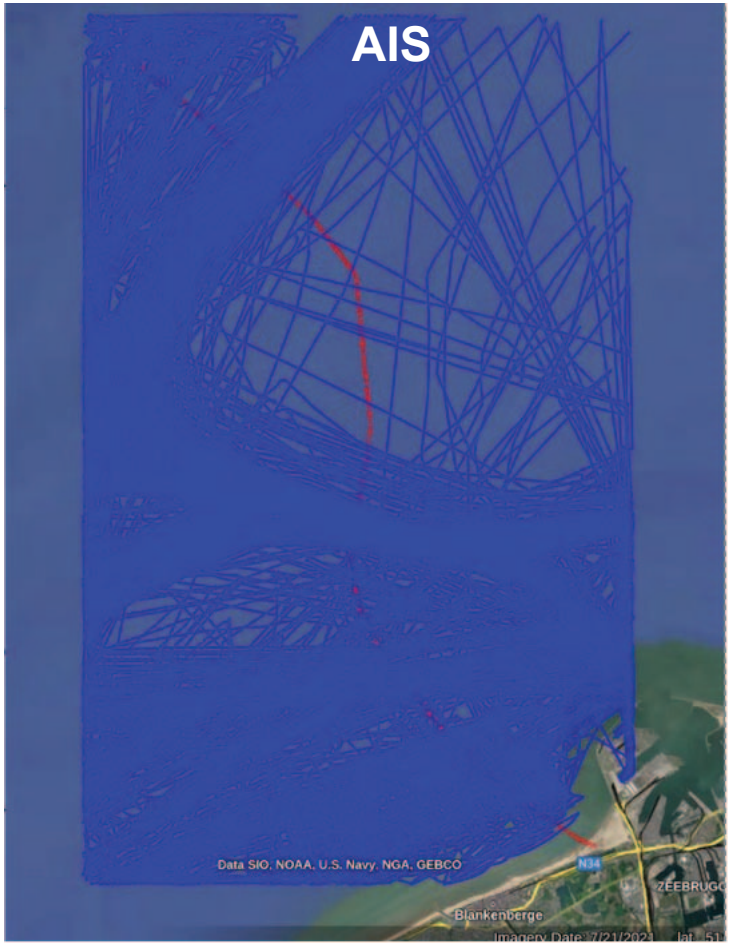


Image: Javier Macías, UAH, 2024

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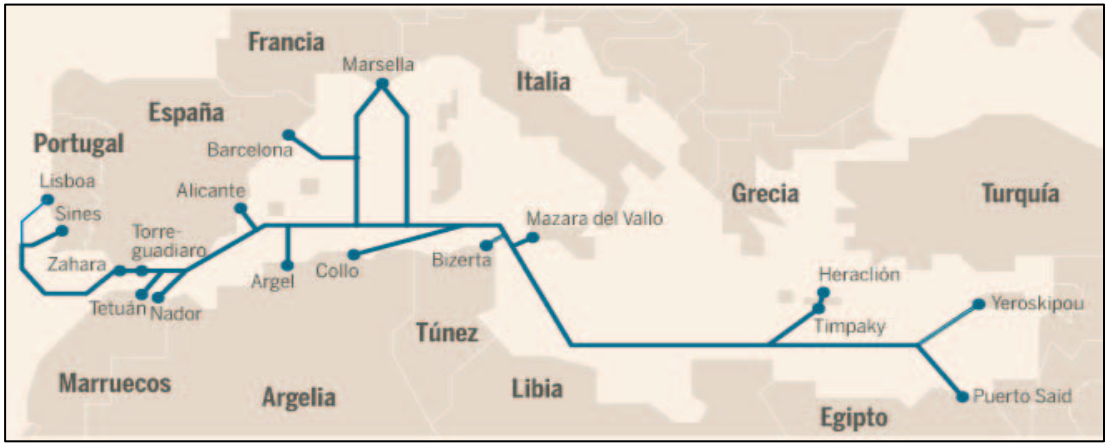
PSI Project (2021-2025)

Predictive maintenance of infrastructures through intelligent systems

Medusa Submarine Cable System



1.5 M€ Next Generation EU, CSIC-UAH-APL-AFR-IX Telecom

5,700 km of submarine cable in the Mediterranean region

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Enhancing Tsunami Early Warning Systems with DAS

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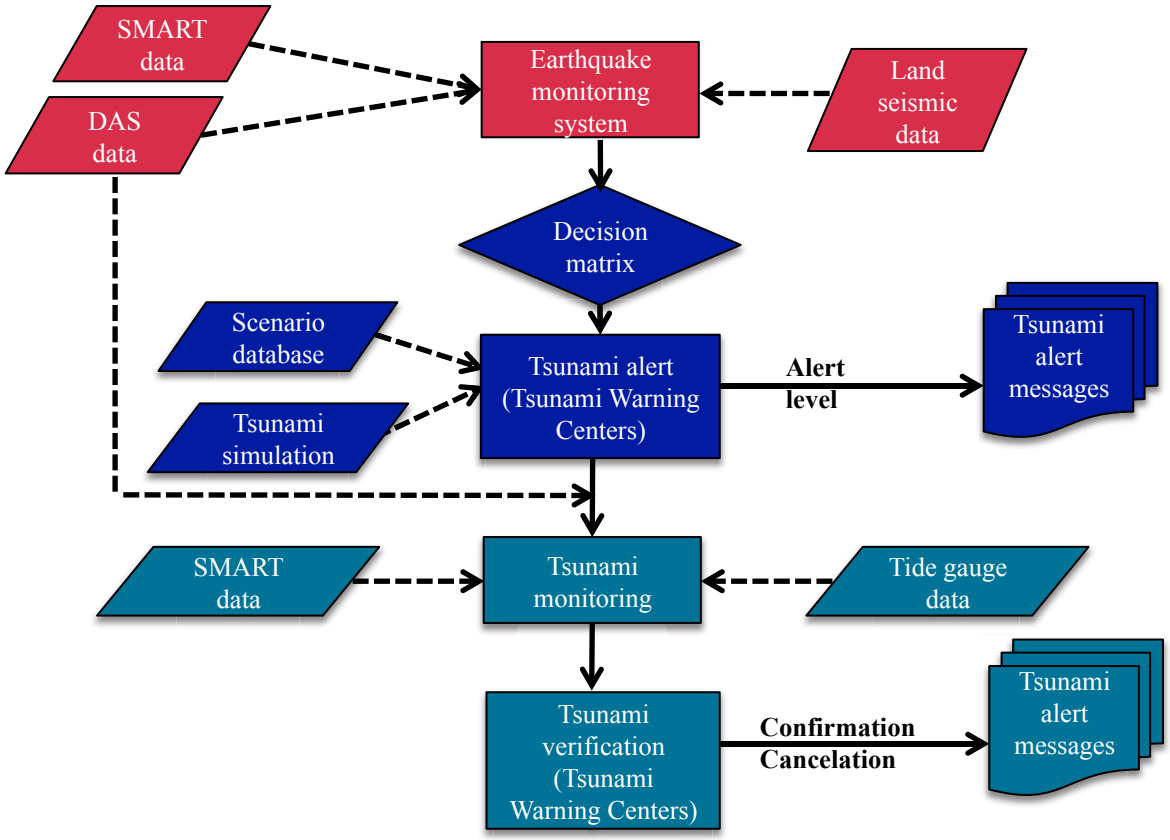
Enhancing Tsunami Early Warning Systems with DAS



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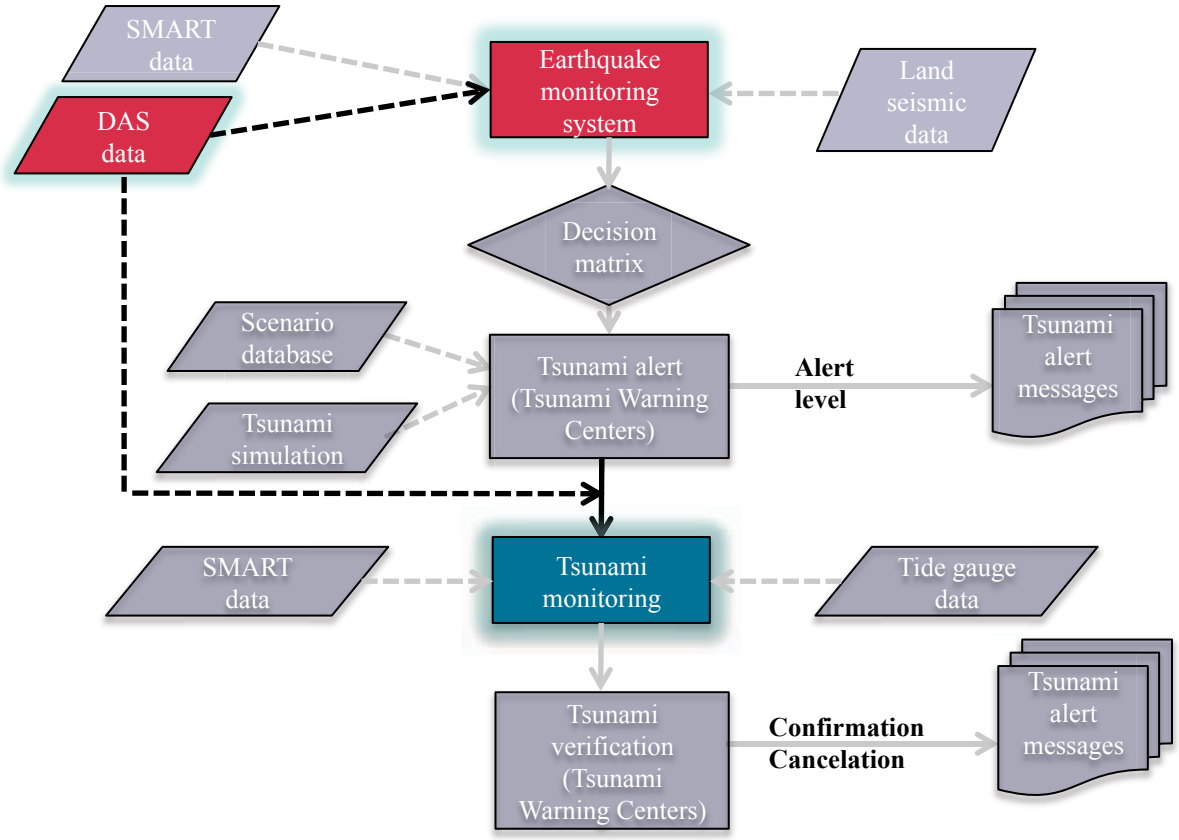
Enhancing Tsunami Early Warning Systems with DAS



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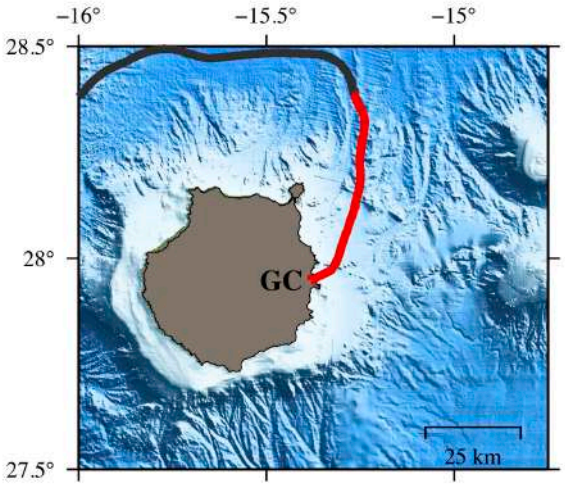
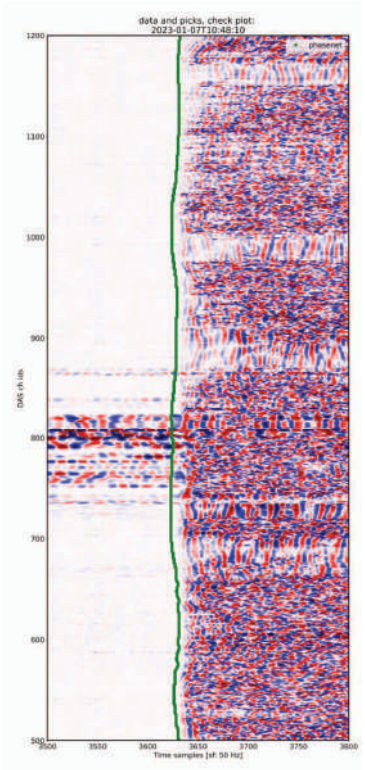
Earthquake location with DAS

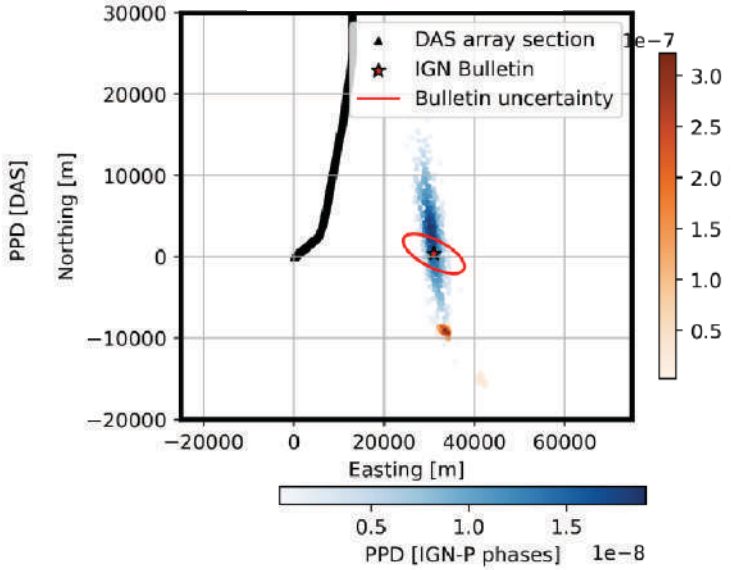
60-km fiber interrogation in Gran Canaria



P-wave picking DL



Earthquake location



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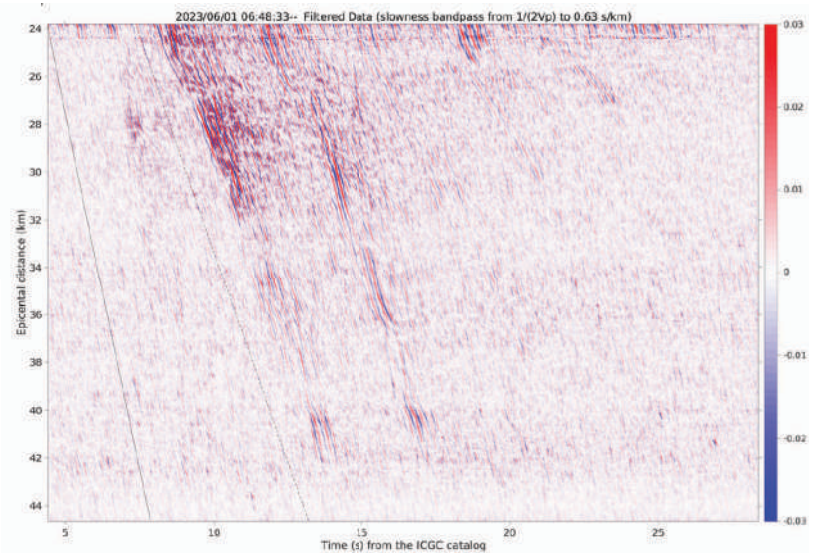
Earthquake magnitude estimation with DAS

Strain to velocity & Denoising

Fixed slowness filters:

- Passband:
  1/(1,25Vp) – 0.63 s/km
  Any coherent signal
- Stopband:
  -0.63 s/km – 1/(4Vp)
  Any coherent signal

Velocity



Ventosa and Ugalde (2024)

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Earthquake magnitude estimation with DAS

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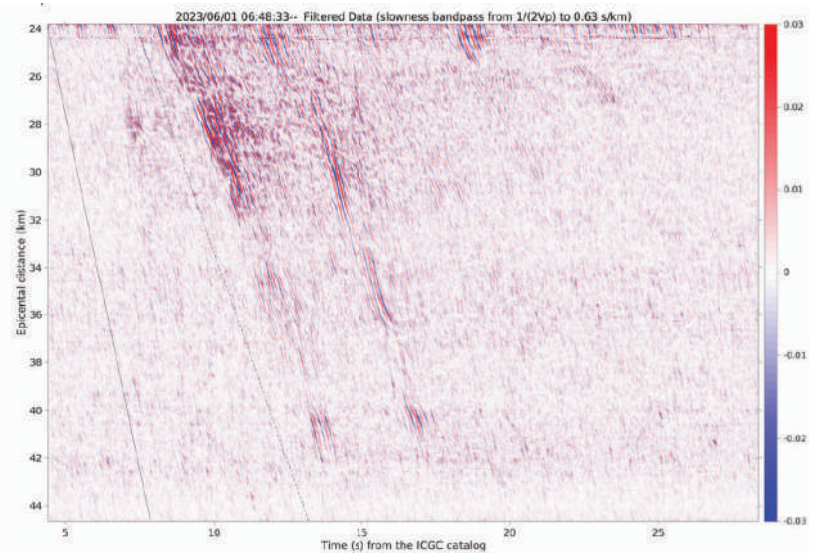

CALIBRATION USING SMART SEISMIC SENSORS

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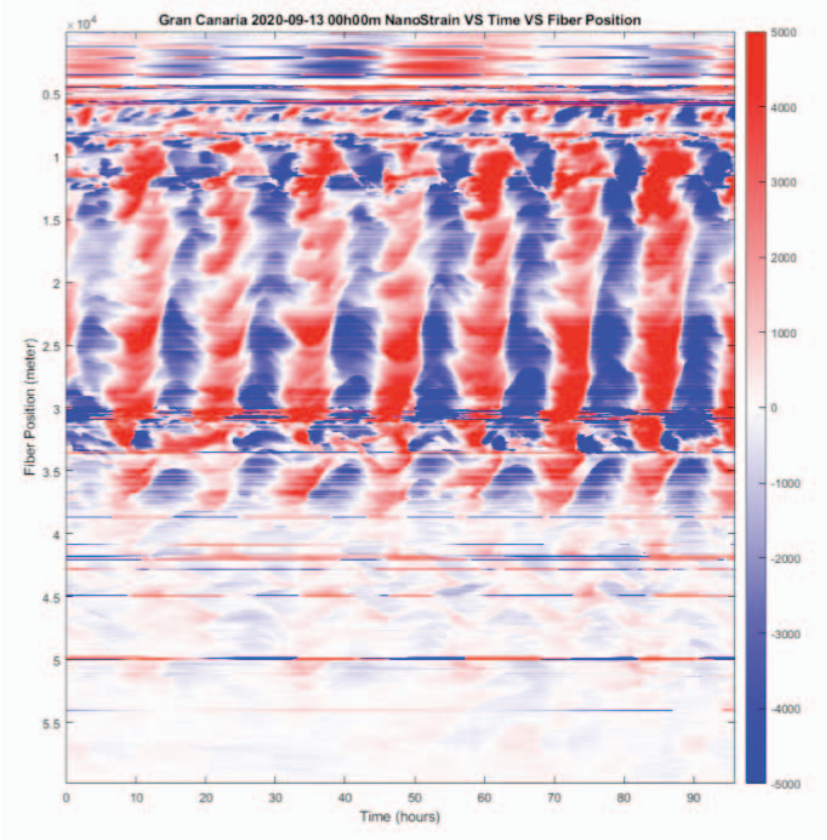
Oceanographic fiber sensor network



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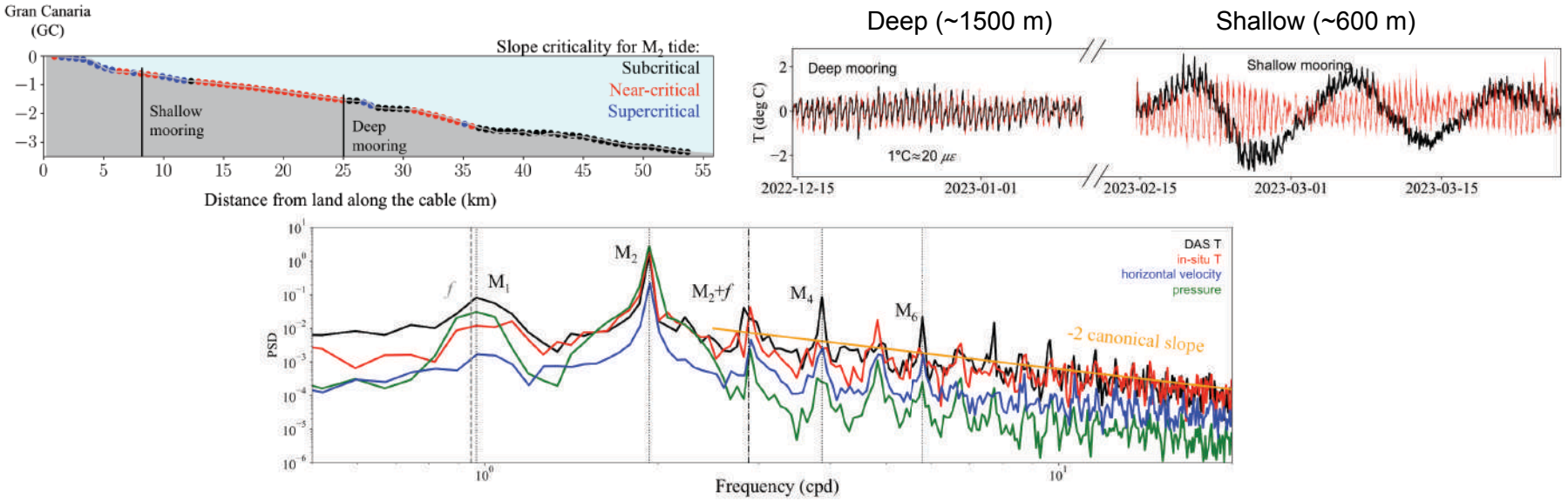
JGR Oceans

Research Article | Full Access

Fiber-Optic Observations of Internal Waves and Tides

E. F. Williams, A. Ugalde, H. F. Martins, C. E. Becerril, J. Callies, M. Claret, M. R. Fernandez-Ruiz, M. Gonzalez-Herraez, S. Martin-Lopez, J. L. Pelegri, K. B. Winters, Z. Zhan

Constraining fiber-optic cable observations of bottom internal waves with conventional oceanographic measurements



The nanostrain recorded responds to both temperature and mechanical strain. **Frequency spectra of DAS shows that the signal is shaped by the M_2 tide and its harmonics**, which also shape in-situ temperature, pressure, and horizontal velocity vector spectra.

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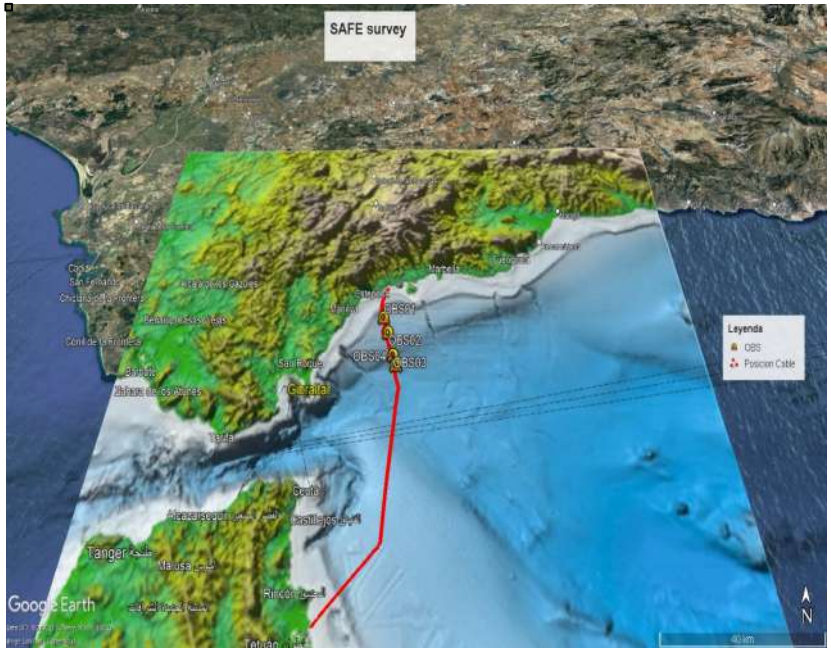
OCEAN SCIENCES MEETING | NEW ORLEANS LOUISIANA | 18-23 FEBRUARY 2024

Williams et al, 2024
Claret et al., 2024

EGU General Assembly

Claret et al., 2024

SAFE Project (2022-2025)



OBS + thermistor + pressure + current meter

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THANKS!

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EXCELENCIA SEVERO OCHOA

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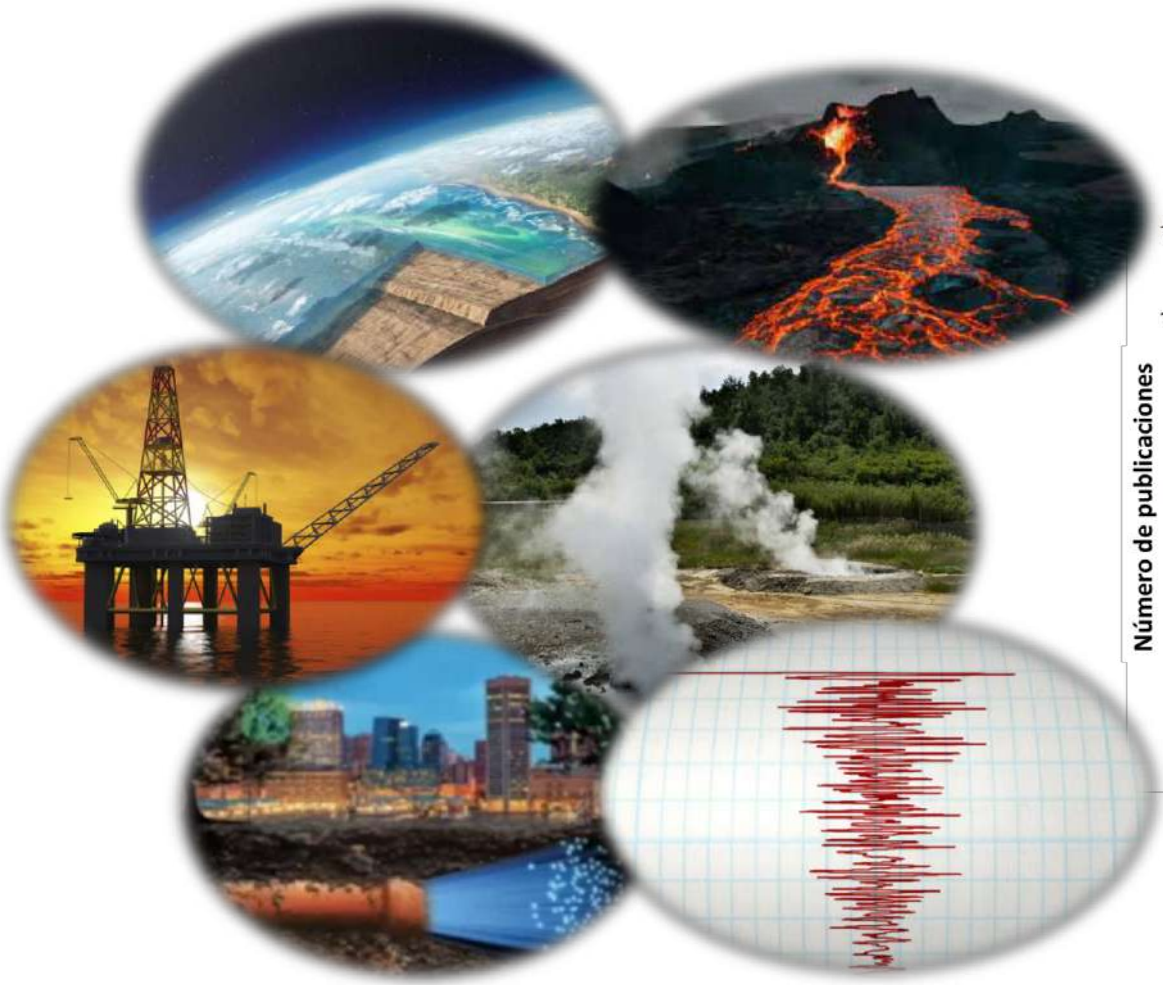
Instituto Geográfico Nacional (IGN)

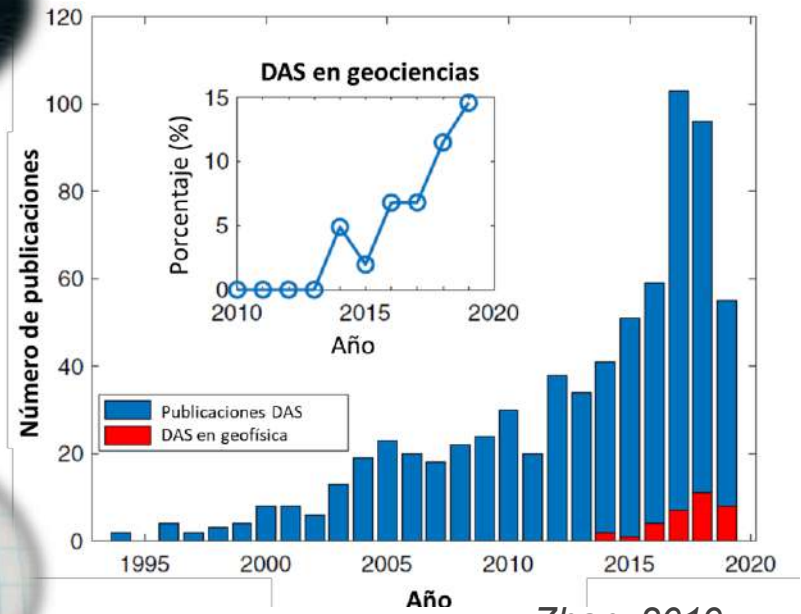
Earthquake detection through fiber optic cables in the National Seismic Network of Spain

Ruiz-Barajas S., Bravo J.B., Blanca Mena S., **Gaite B. and Cantavella J.V.**

bgaite@transportes.gob.es jvcantavella@transportes.gob.es

Distributed Acoustic Sensing (DAS), applications

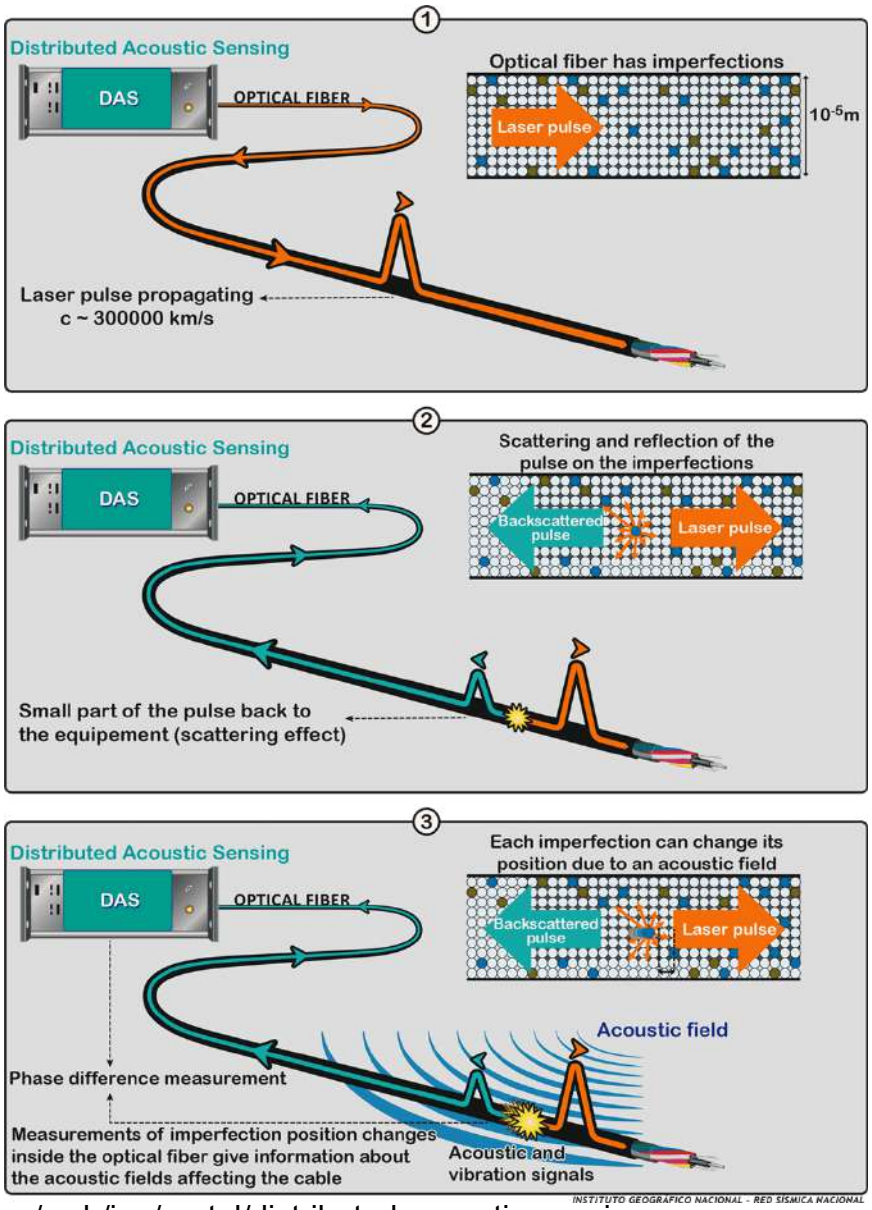




Zhan, 2019

DAS in geosciences: geothermal, glaciers, volcanoes, earthquakes, mining,…

Distributed Acoustic Sensing (DAS)



https://www.ign.es/web/ign/portal/distributed-acoustic-sensing

DAS *versus* seismometers

Advantages

Urban areas and remote environments (oceans, volcanoes, glaciers, etc.)

Recycle fiber-optic cables

Spatial resolution (~m)

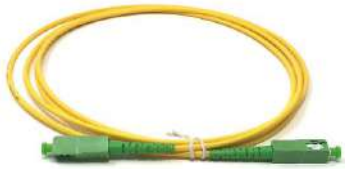
Temporal resolution (~ KHz)

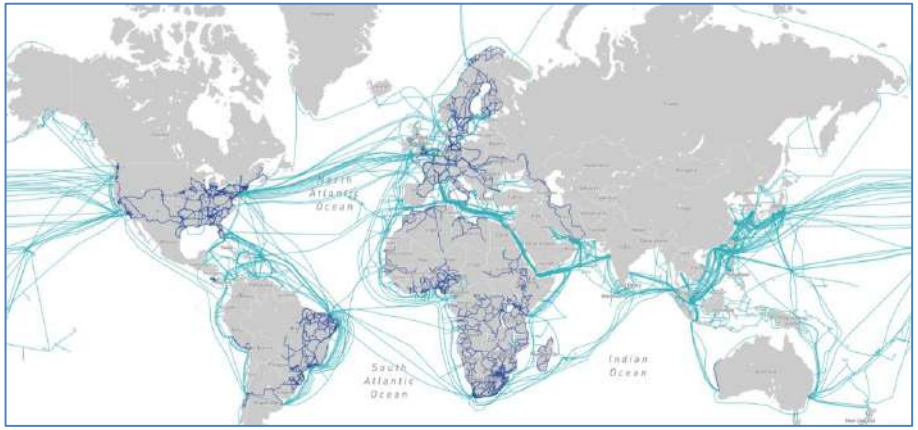
Spatial coverage (up to 50 km)

Clock synchronization

DAS INTERROGATOR

"Dark fiber "





DAS *versus* seismometers

RED SÍSMICA NACIONAL

Advantages

Urban areas and remote environments (oceans, volcanoes, glaciers, etc.)

Recycle fiber-optic cables

Spatial resolution (~m)

Temporal resolution (~ KHz)

Spatial coverage (up to 50 km)

Clock synchronization

Disadvantages

Only axial component.

Large data volume (~ TB / day).

Geolocalization

Coupling with the ground.

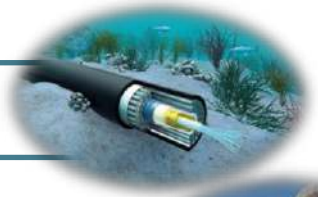
Objective

Earthquake detection

Unsafe and inaccessible emplacements, seismic sequences

4 CASE STUDIES

1. **Mediterranean sea** ***(submarine cable)***



2. **Granada city** ***(telescope cable)***

3. **Granada Basin** ***(high-speed railway)***

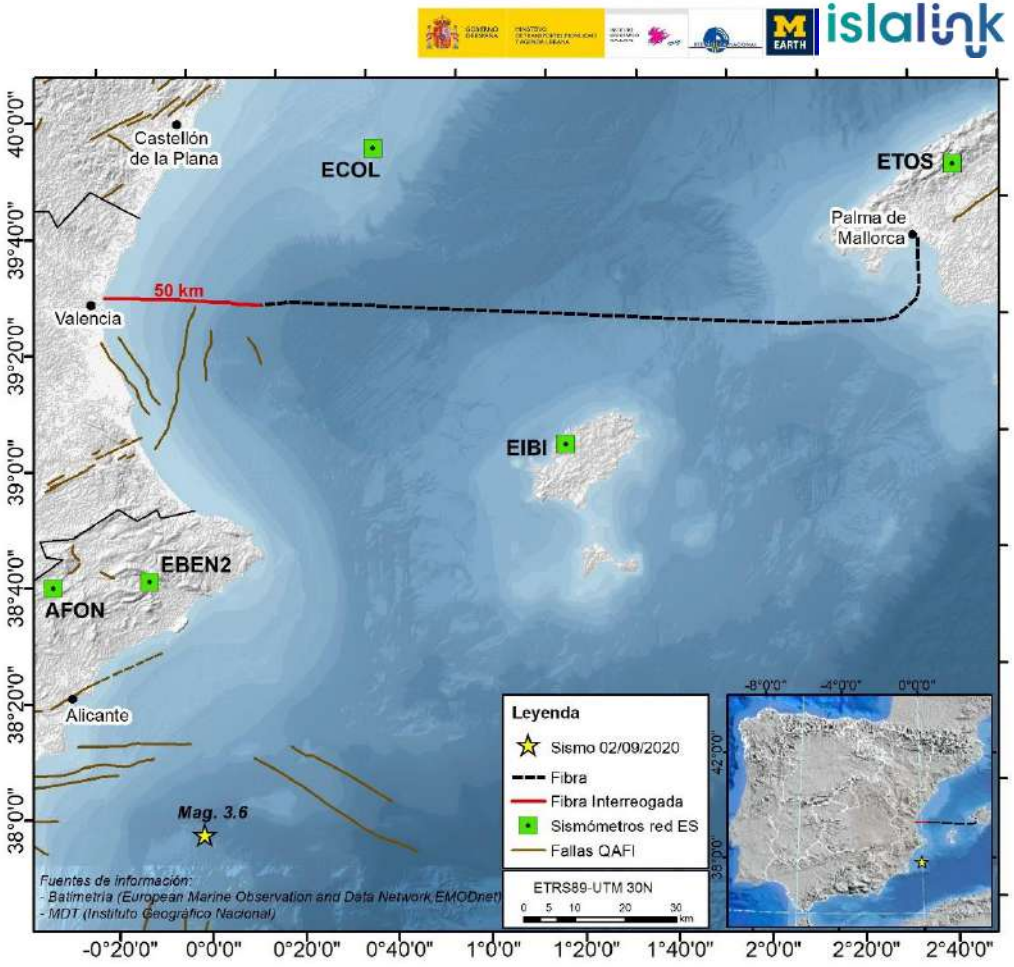
4. **Sistema Central Range** ***(high-speed railway)***

1. Mediterranean sea (submarine cable)

Infrastructure DAS Array

- September 2020
- Records during 14 days
- Total: 2977 sensors
- 40 Gb/h

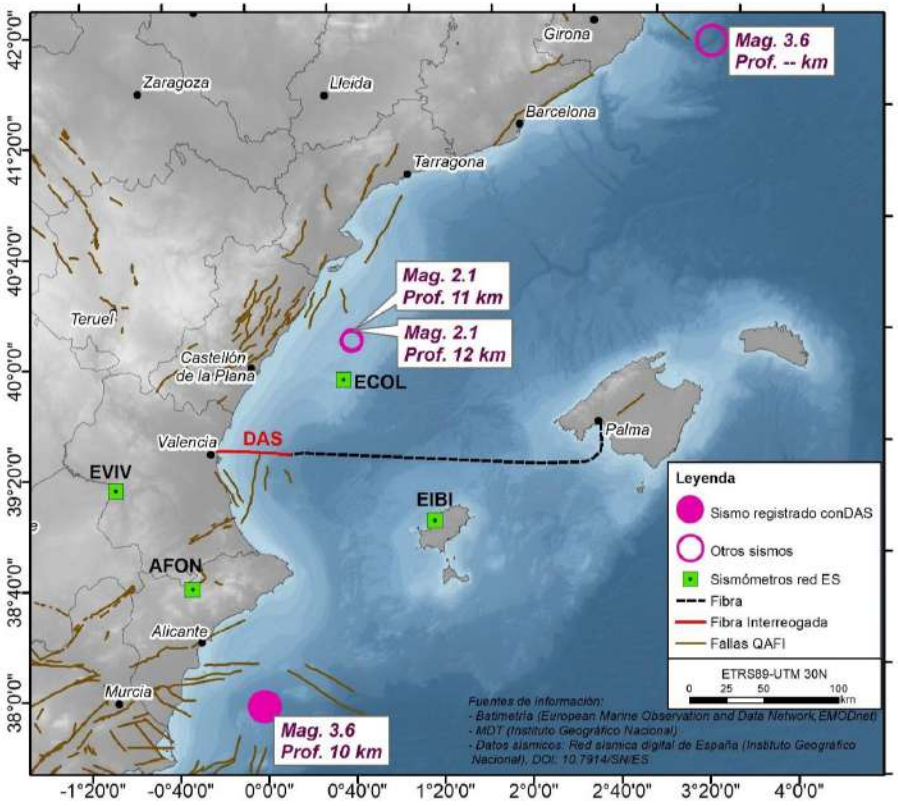
Fiber Lenght (km)	50
Spatial resolution (m)	16.8

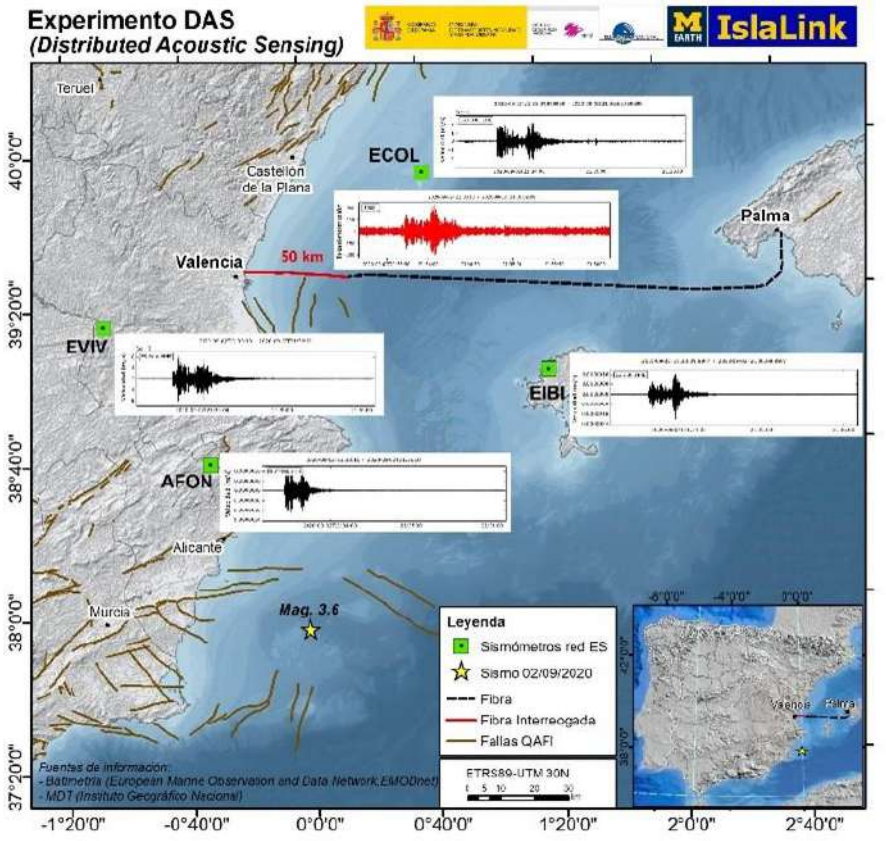


Earthquake recordings

1. Mediterranean sea (submarine cable)

DAS earthquake recordings: 25%





Geophysical Research Letters

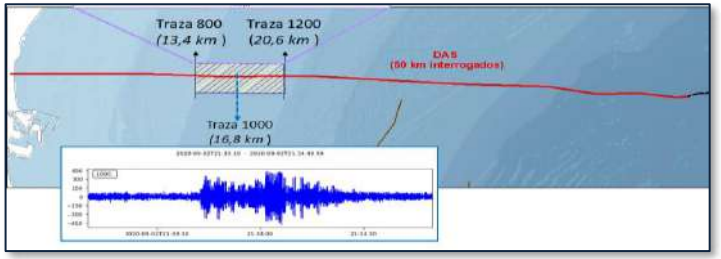
RESEARCH LETTER
10.1029/2022GL099292

Locating the Precise Sources of High-Frequency Microseisms Using Distributed Acoustic Sensing

Key Points:
- A fiber-optic cable on the seafloor is used to locate the sources of high-frequency microseisms with an unprecedented precision
- The sources of high-frequency microseisms quickly move within narrow areas of a few kilometers

Han Xiao[1], Toshiro Tanimoto[1], Zack J. Spica[2], Beatriz Gaite[3], Sandra Ruiz-Barajas[3], Mohan Pan[4], and Loïc Viens[5]

[1]Department of Earth Science and Earth Research Institute, University of California, Santa Barbara, Santa Barbara, CA, USA, [2]Department of Earth and Environmental Sciences, University of Michigan, Ann Arbor, MI, USA, [3]National Geographic Institute of Spain, Madrid, Spain, [4]OBS Lab, Department of Ocean Science and Engineering, Southern University of Science and Technology, Shenzhen, China

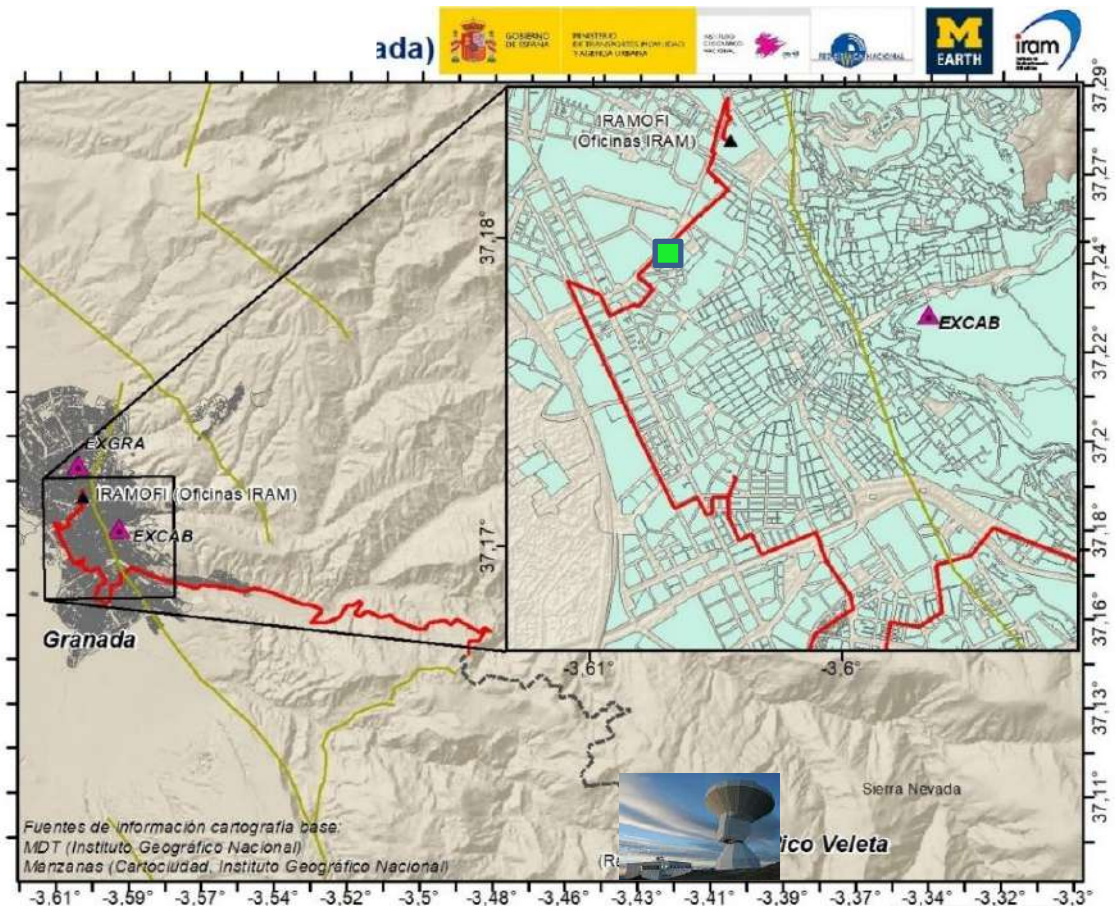


2. Granada City (telescope cable)

Infrastructure DAS Array

- August 2020
- Records during 23 h
- Total: 4166 sensors
- 240 Gb/h

Fiber Lenght (km)	20
Spatial resolution (m)	4.8



No earthquake recordings

Subsoil velocity studies

Geophysical Journal International

Geophys. J Int. (2023) **235**, 1849–1860
Advance Access publication 2023 August 25
GJI Seismology

https://doi.org/10.1093/gji/ggad331

Near-surface characterization using distributed acoustic sensing in an urban area: Granada, Spain

Yang Li,[1] Mathieu Perton,[2] Beatriz Gaite,[3] Sandra Ruiz-Barajas[3] and Zack J. Spica[1]

[1]Department of Earth and Environmental Sciences, University of Michigan, Ann Arbor, MI 48109, USA. E-mail zackspica@gmail.com
[2]Instituto de Ingeniería, Universidad Nacional Autónoma de México, Mexico City, CDMX 04510, Mexico
[3]Spanish Seismic Network, National Geographic Institute of Spain (IGN), 28003 Madrid, Spain

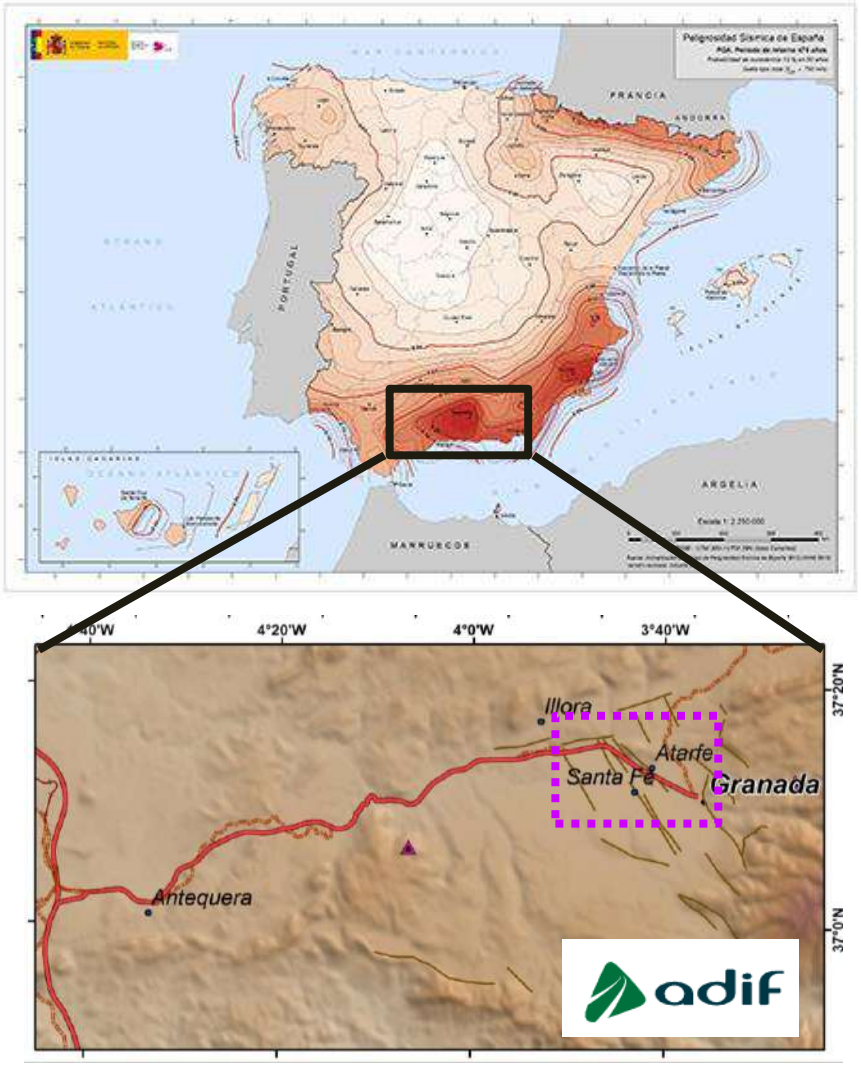
3. Granada Basin (high-speed railway)

Infrastructure DAS Array

- June-September 2022
- 82 days
- 3600 sensors
- 3 Tb

ARAGÓN PHOTONICS

Fiber Lenght (km)	36
Spatial resolution (m)	10



3. Granada Basin (high-speed railway)

Infrastructure seismometers

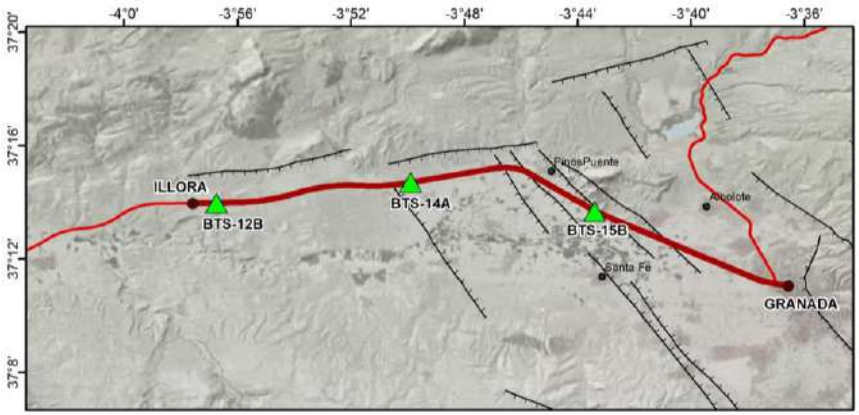
- 3 seismometers
- Broad-band
- 3 components

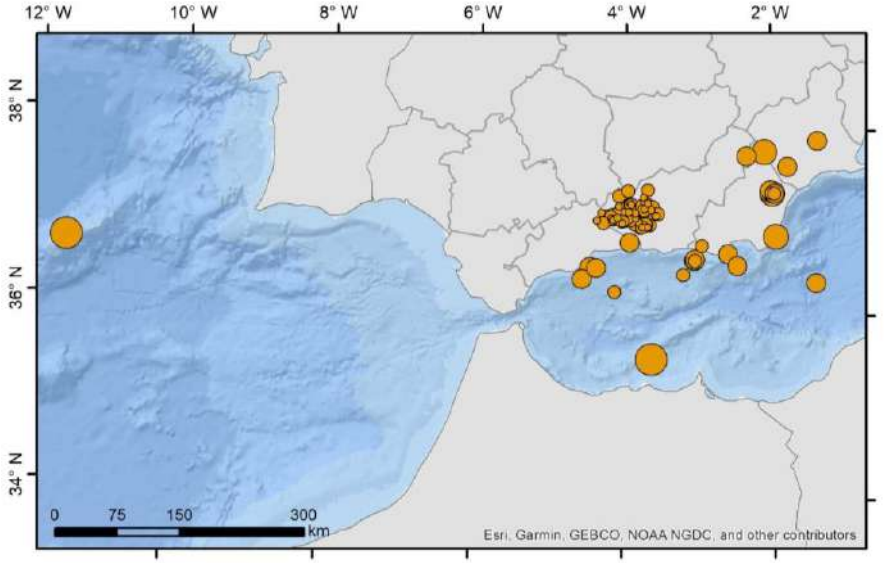
Observation period *(60 days)*

93 regional and local events

Detections

Seismometers ~65 % vs. DAS ~30%



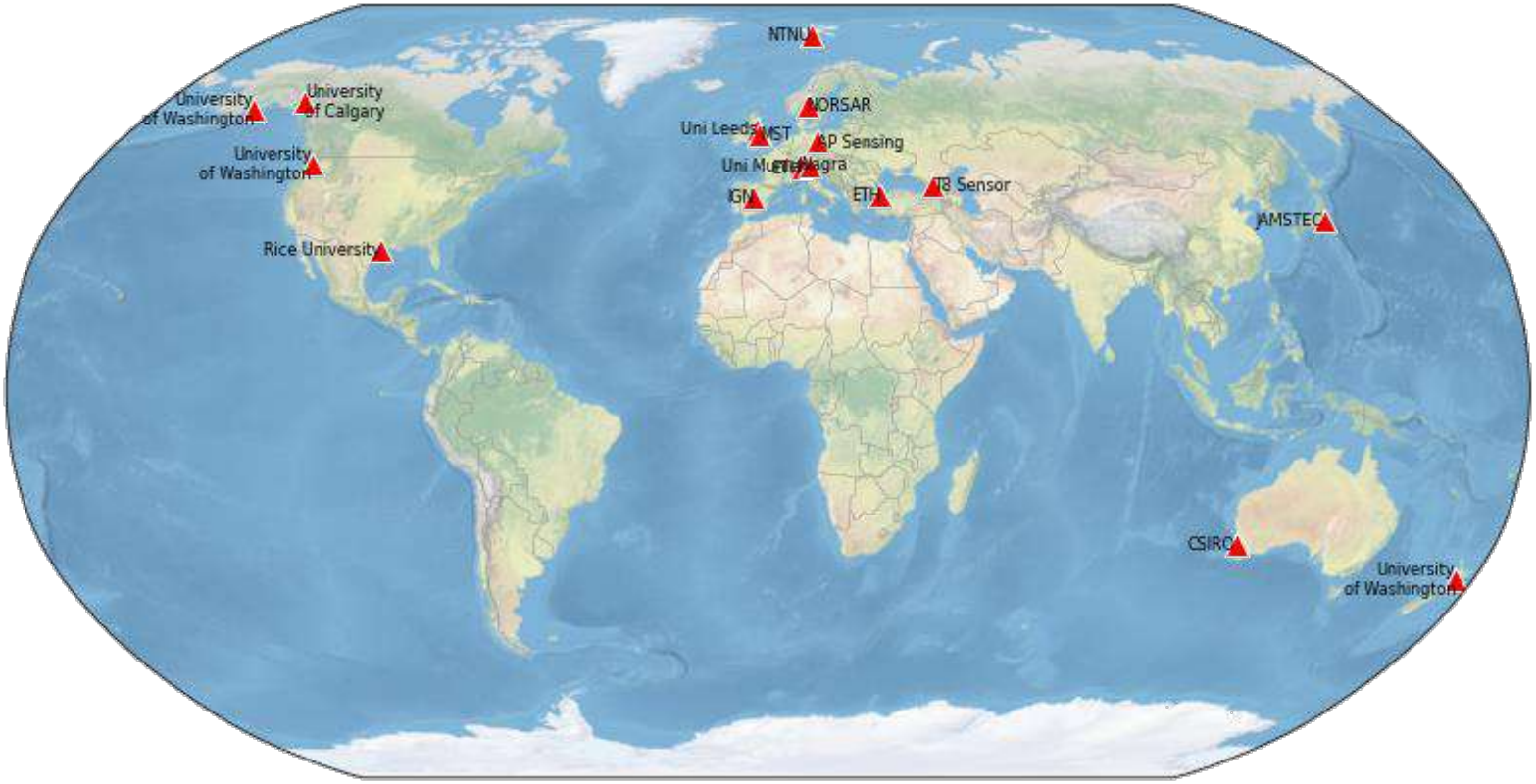


4. Sistema Central Range (high-speed railway)

RED SÍSMICA NACIONAL

DASMonth23

Global DAS network to detect telesesims



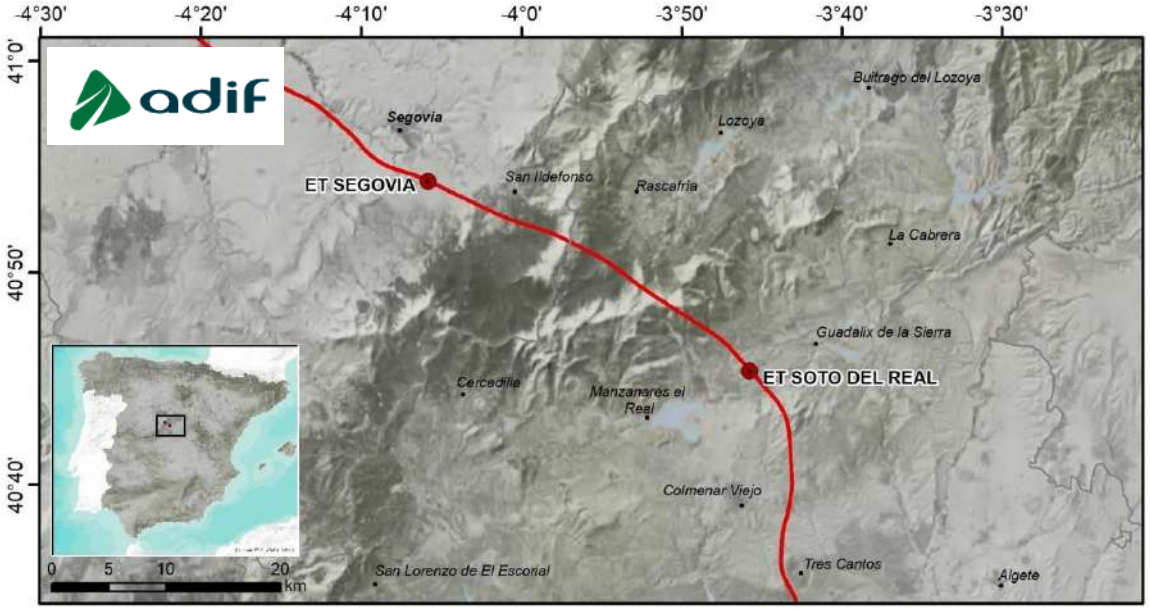
The Global DAS Month of February 2023. *Seismological Research Letters* 2023; doi: https://doi.org/10.1785/0220230180.

4. Sistema Central Range (high-speed railway)

Infrastructure DAS Array

- February 2023
- 1 month
- Total: 3600 sensors

Fiber Lenght (km)	**36**
Spatial resolution (m)	10



Observational period, *28 days*

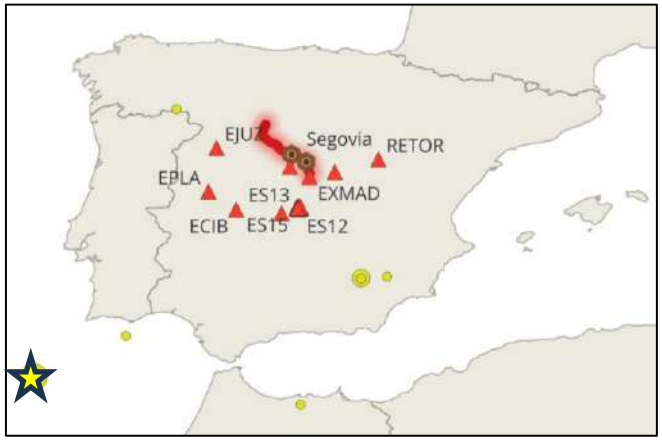
Regional earthquakes	***Telesismic events***
10 (2.7<M<4.6)	19 (5.0<M<7.8) 11 M ≤ 5,5 2 M > 7,0
DAS ~ 10%	**DAS ~ 24%**

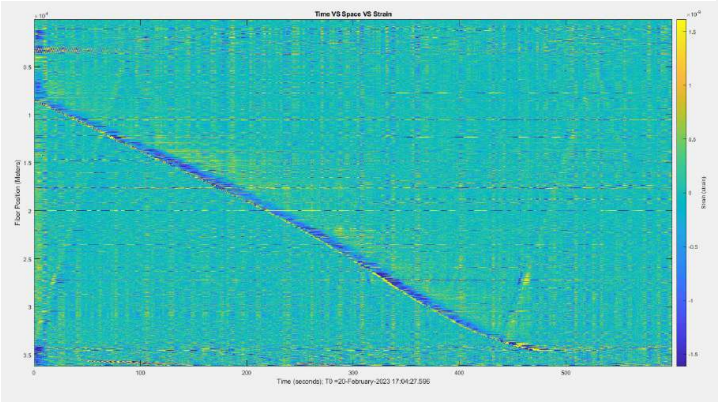
4. Sistema Central Range (high-speed railway)

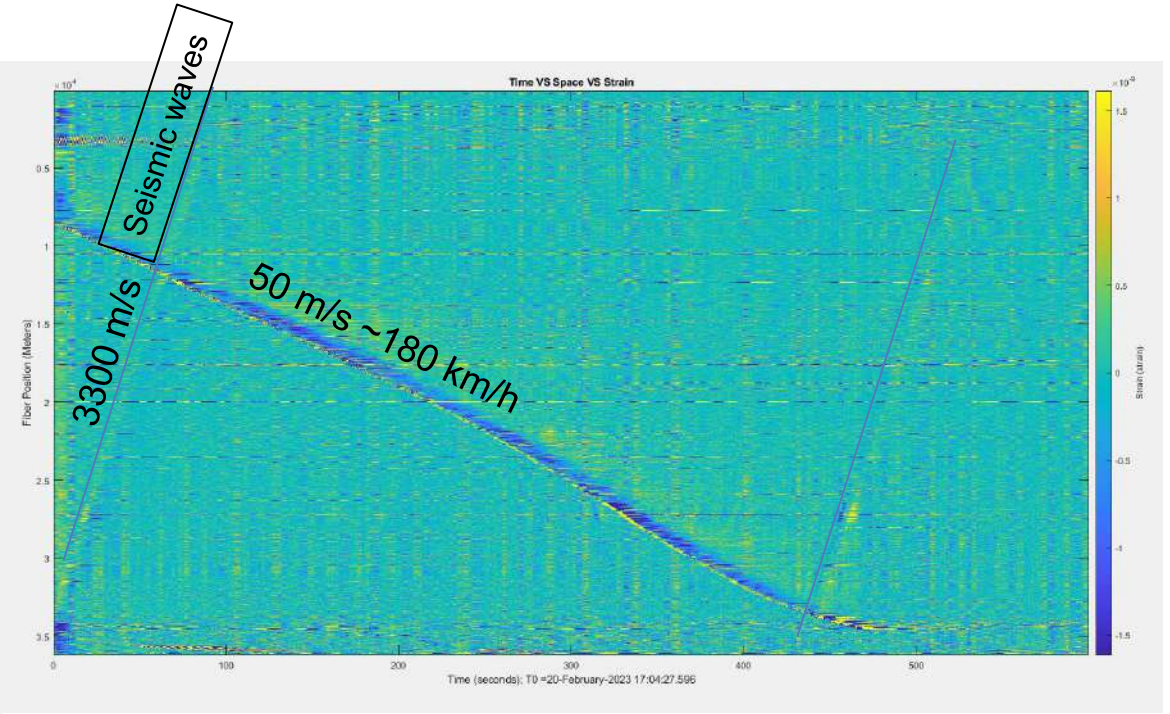
M 4.2 cabo de San Vicente 20/02/2023, 17:05:37h

DAS record

Distance > 800 km





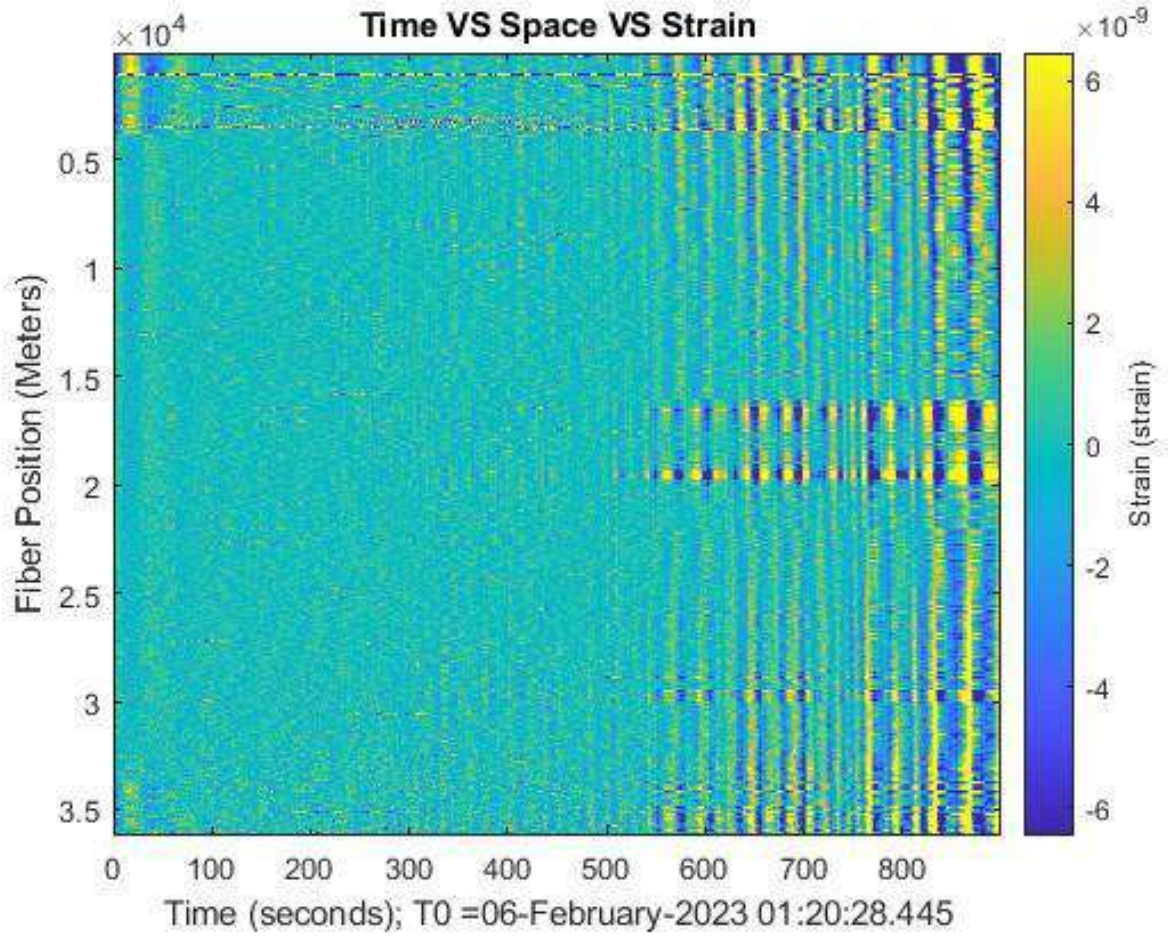


4. Sistema Central Range (high-speed railway)

M 7.8 Turkey 06/02/2023, 01:17:34h

DAS record

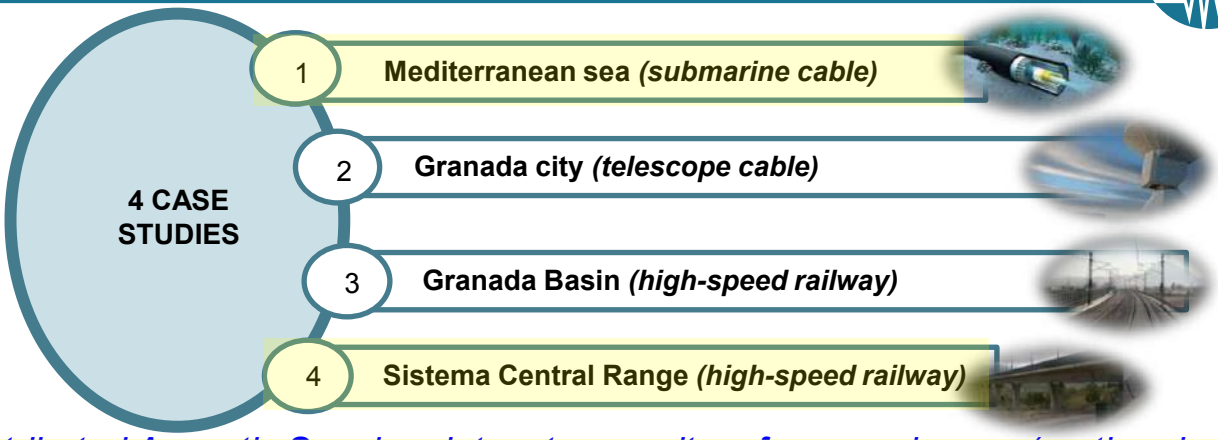
Distance > 3000 km



Summary

RED SÍSMICA NACIONAL

Data availability



PubDAS: a PUBlic Distributed Acoustic Sensing datasets repository for geosciences (eartharxiv.org) Spica et al, 2023

Usefulness to complement conventional seismic records

Unsafe and unaccesible environments

Large spatial coverage and resolution (1 instrument ~ thousands of sensors)

Large range of magnitudes detected

Future lines

Quality of already-deployed fibres

Fibre self-deployment

Tsunami monitoring

NORDUnet shapes Polar connectivity through sensing cables across the Arctic Ocean

Co-funded by the European Union

Valter Nordh

Polar Connect
Vision 2030

Polar Connect

Far North Fiber

High relevance – Margrethe Vestager at G7

"If we can envision a subsea cable that can connect Europe with Japan and the West Coast of Canada and US. We could drastically reduce latency(…) The business benefits are really obvious(…)"

Results of G7 Digital and Tech Ministers' Meeting in Takasaki, Gunma
https://g7digital-tech-2023.go.jp/en/topics/topics_20230430.html

Ministerial Declaration The G7 Digital and Tech Ministers
https://g7digital-tech-2023.go.jp/topics/pdf/pdf_20230430/ministerial_declaration_dtmm.pdf

Co-funded by the European Union

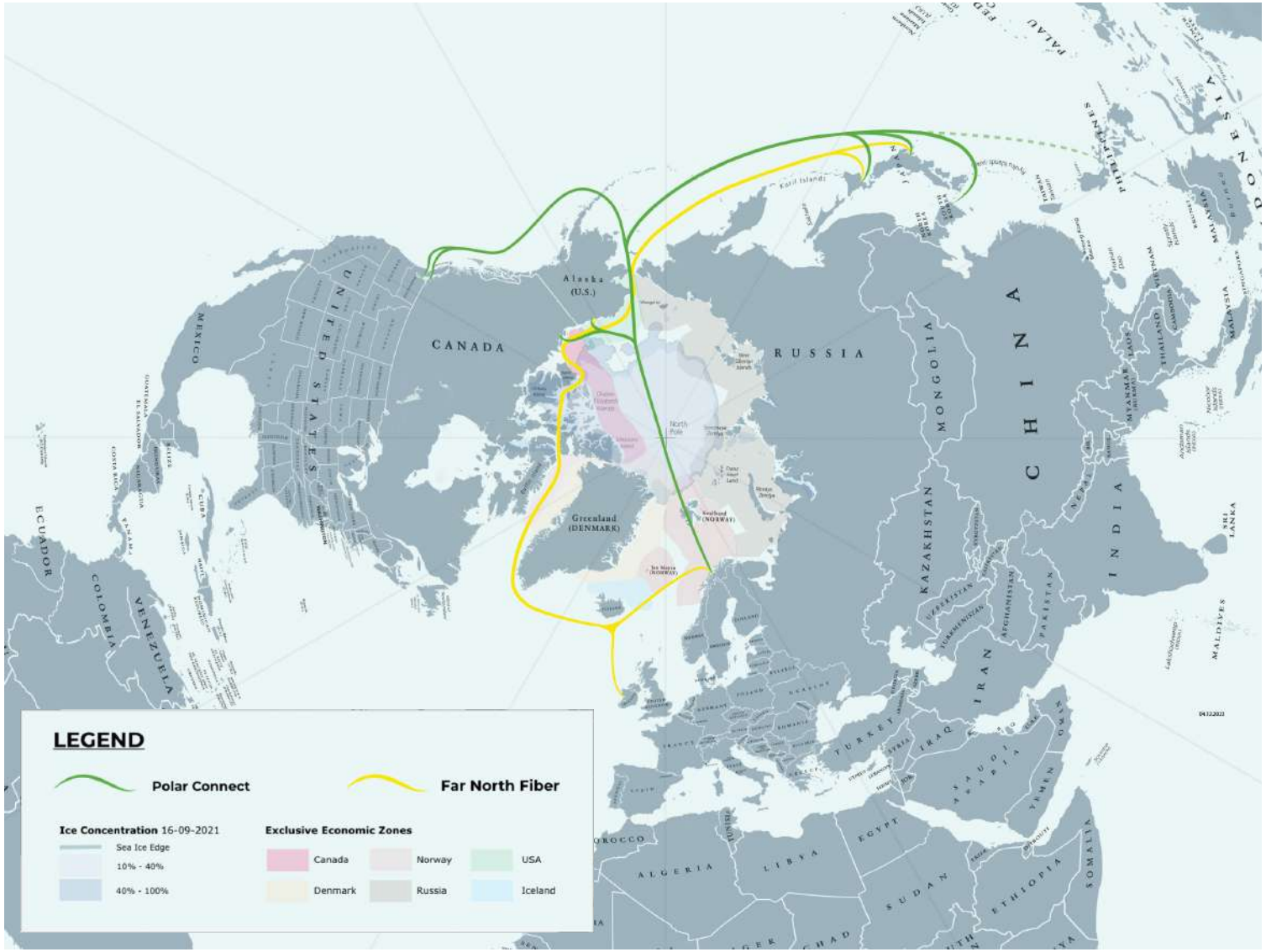
Drivers for submarine cable systems Connectivity

Increasing digitalisation demands sufficient backbone connections, within and between EU member states, as well as with EU's strategic partner countries.

Multiple connections (cables) give redundancy and resilience.

Co-funded by the European Union

Arctic Connectivity



- Complementary to existing Suez Area connections
- Northern European fast track to North America - Asia
- Strengthens and supports digital sovereignty of the involved regions
- Geopolitical considerations

Deploy a fiber cable across the Arctic

POLARFORSKNINGS SEKRETARIATET
SWEDISH POLAR RESEARCH SECRETARIAT

BGS British Geological Survey

ECORD
EUROPEAN CONSORTIUM FOR OCEAN RESEARCH DRILLING

SWEDISH POLAR RESEARCH SECRETARIAT
POLARFORSKNINGSSEKRETARIATET

SWEDISH POLAR RESEARCH VESSEL
HIGHEST POLAR CLASS ICEBREAKER

POLARFORSKNINGS SEKRETARIATET

New Swedish polar research vessel

Sweden to acquire and operate a modern climate-neutral polar research vessel

Concept illustration of the new polar research vessel. Illustration by Peter Mild.

Polar Connect
Vision 2030

Polar Connect

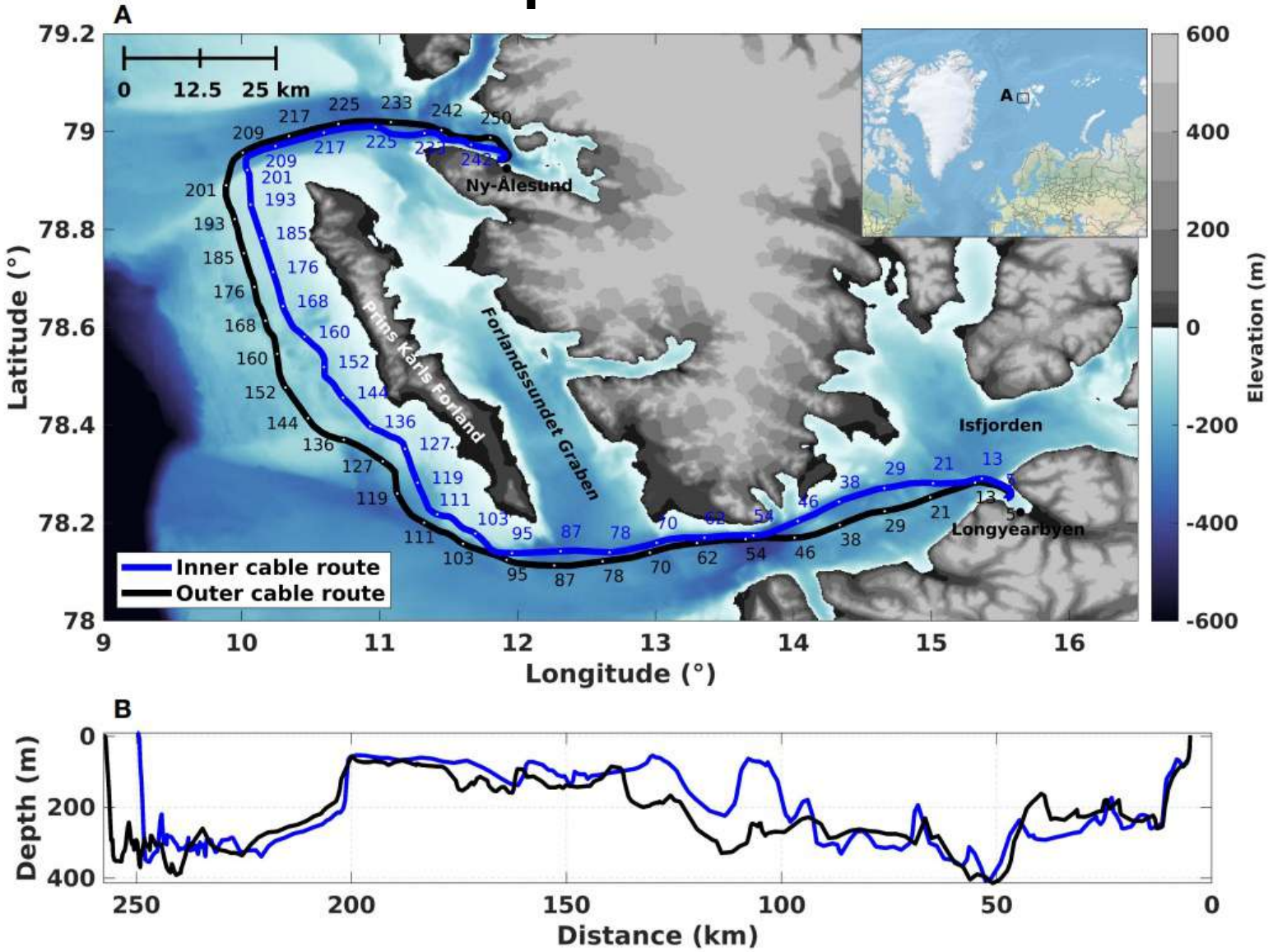
Far North Fiber

Climate

- Global warming
  - Sea level rise
  - Ocean heat, circulation
- SMARTcables Technologies
  - Repeater + sensors
- Protecting/monitoring the cables themselves
- Supporting arctic and climate research

Co-funded by the European Union

The two fibre optic cables offshore Svalbard



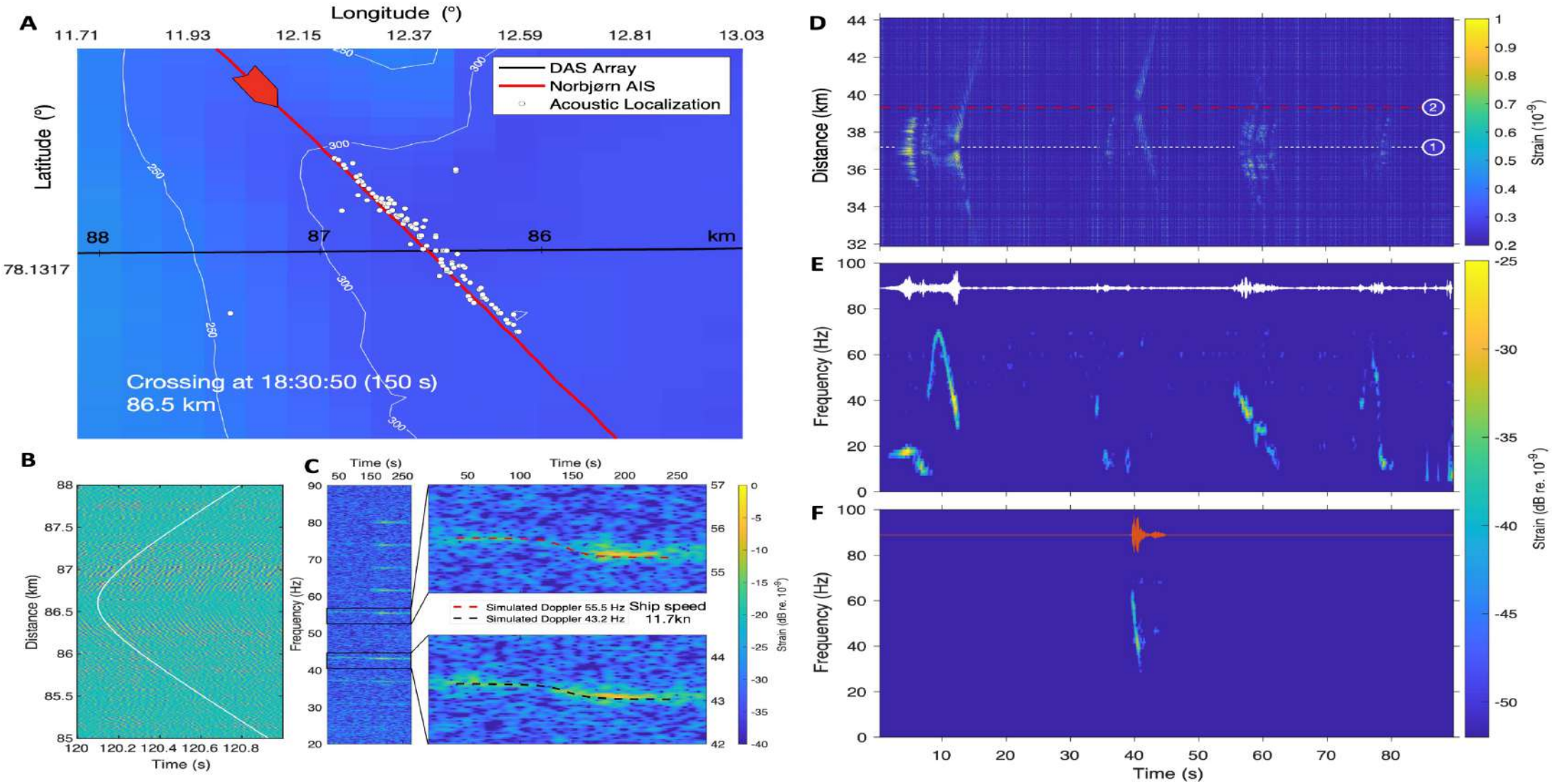
These fibres are being used by:

- **CGF(Centre for Geophysical Foreasting, NTNU)**
- **SUBMERSE (EU Tech01 project)**
- **SeaSounds (EU ITN project)**

JAMSTEC in Japan is a partner in CGF

Slides thanks to Landrø, Martin

Sensing done today using Arctic fibre-optic cable



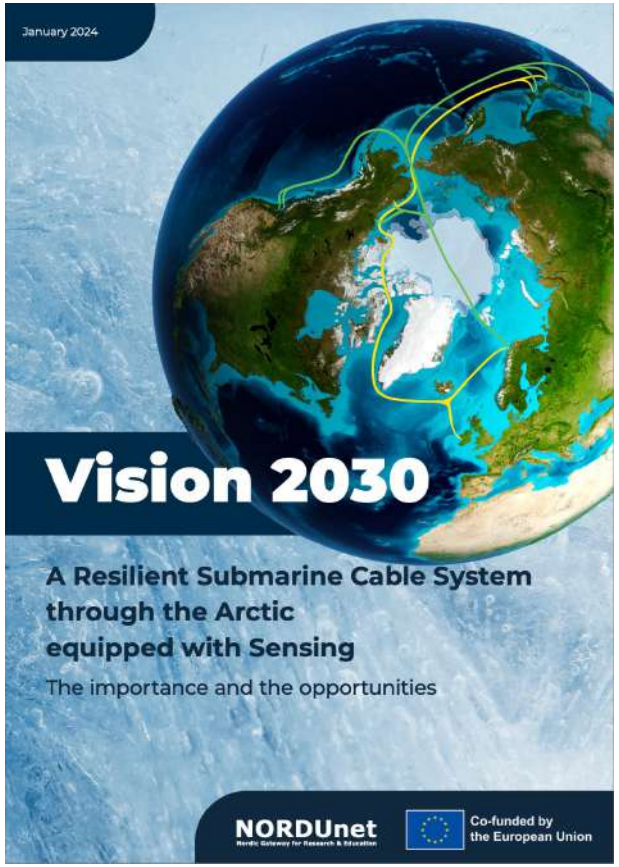
Slides thanks to Landrø, Martin

Next Steps for Polar Connect

Funded from EU 2024-2026

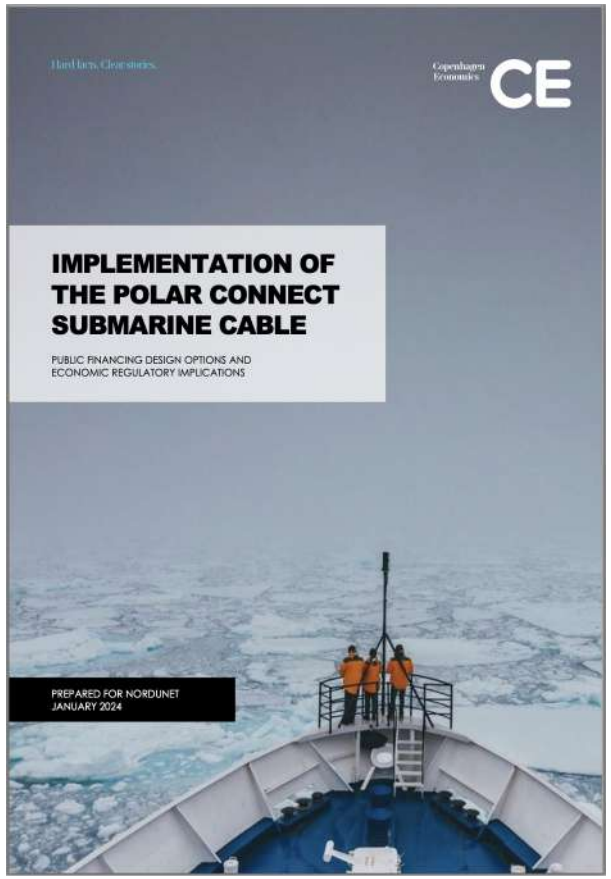
- Explore alternative route: Denmark/South Sweden – Svalbard - Arctic Ocean - Japan/Korea
- Engage with research community to prioritize sensing parameters
- Explore how sensing data should be managed and made available for research and environmental monitoring
- Establish redundant connectivity to potential landing site

Vision 2030 for Arctic connectivity



Vision 2030 White Paper

The implementation of the Polar Connect submarine cable



CE Financing options report

The contents of this publication is the sole responsibility of NORDUnet and does not necessarily reflect the opinion of the European Union.

Thank you for your attention!

Co-funded by the European Union

For more information:
info@polarconnect.net

International Tsunami Information Centre
A UNESCO/IOC-NOAA Joint Partnership

Tsunamis and Global Tsunami Warning System

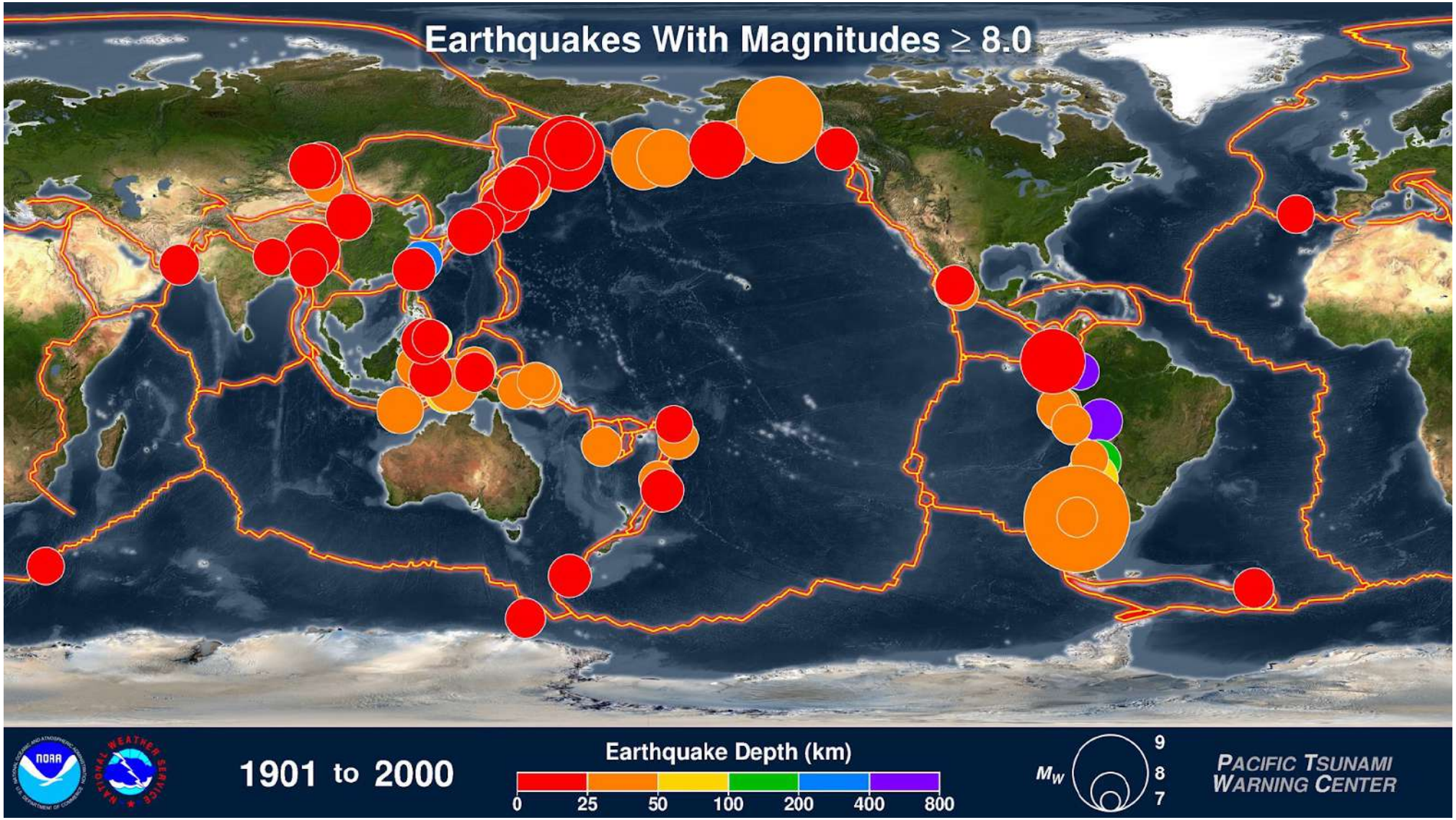
Dr. Laura Kong
Director, ITIC, USA NOAA, laura.kong@noaa.gov

Christa von Hillebrandt-Andrade
Manager, ITIC-CAR, USA NOAA, christa.vonh@noaa.gov

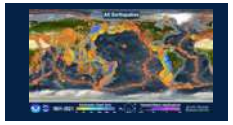
NOAA Inouye Regional Center
Ford Island, JBPPH, Hawaii

Puerto Rico Seismic Network, UPRM
Mayaguez, Puerto Rico

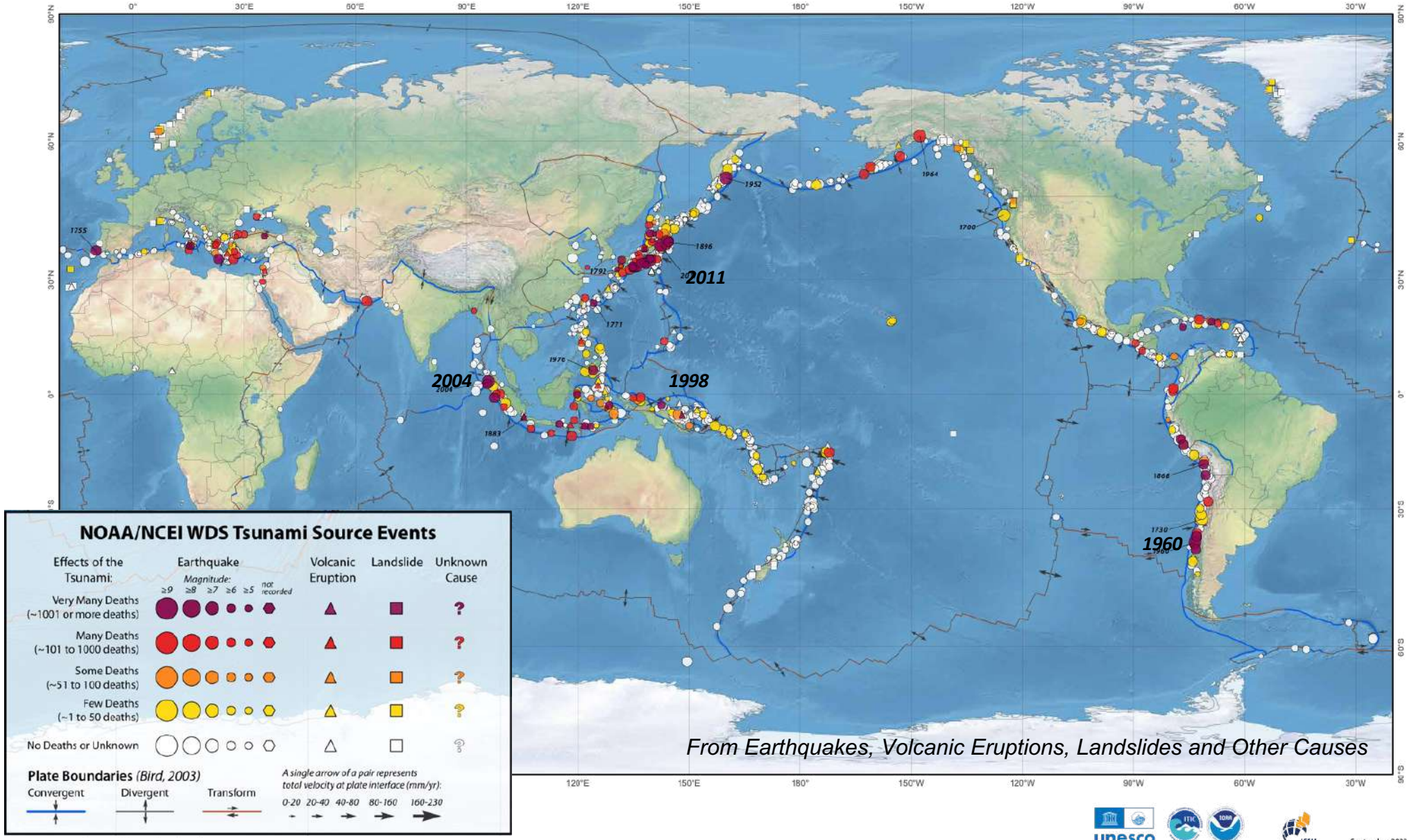
DANGEROUS EARTHQUAKES - GLOBAL



Click below for video EQ-Tsunami 1901-2021



DEADLY TSUNAMIS – GLOBAL (1620 B.C to A.D. 2023)



From Earthquakes, Volcanic Eruptions, Landslides and Other Causes

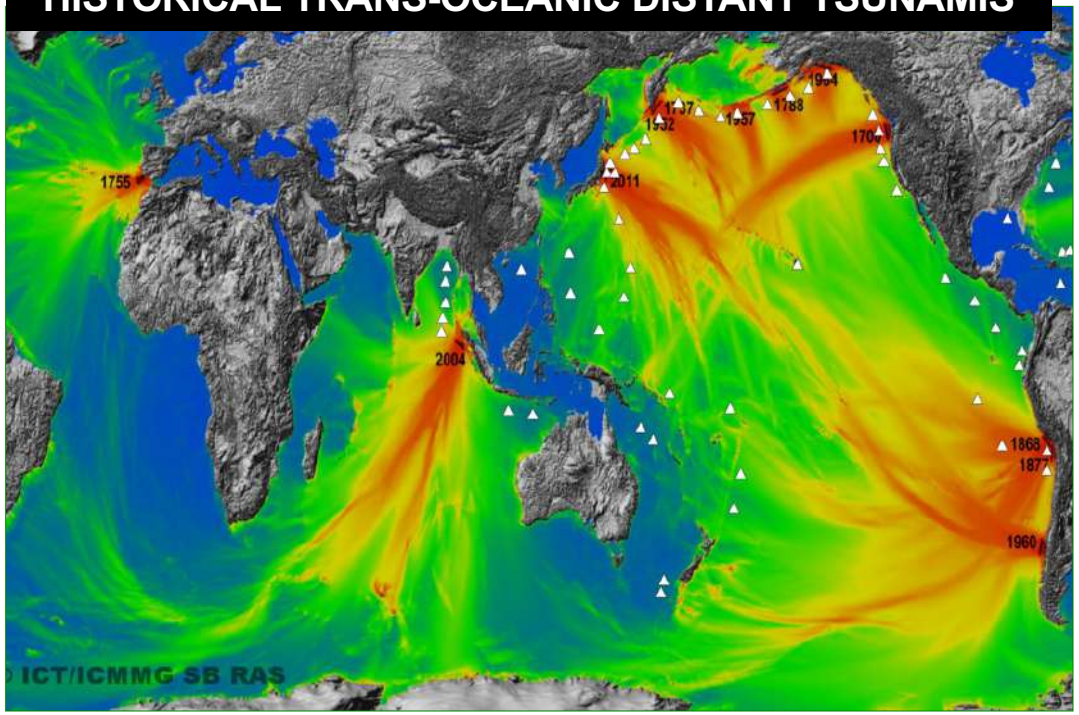
unesco
Intergovernmental Oceanographic Commission

WORLD DATA SYSTEM

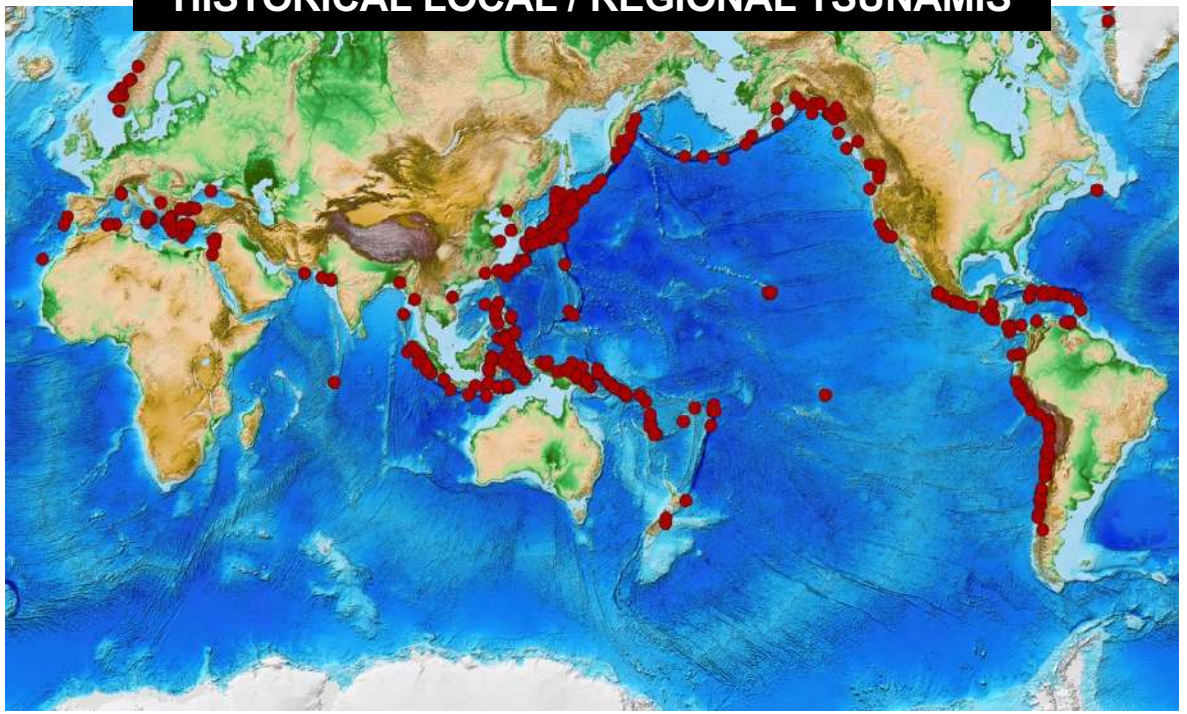
September 2023

DEADLY TSUNAMIS – DISTANT to LOCAL

HISTORICAL TRANS-OCEANIC DISTANT TSUNAMIS

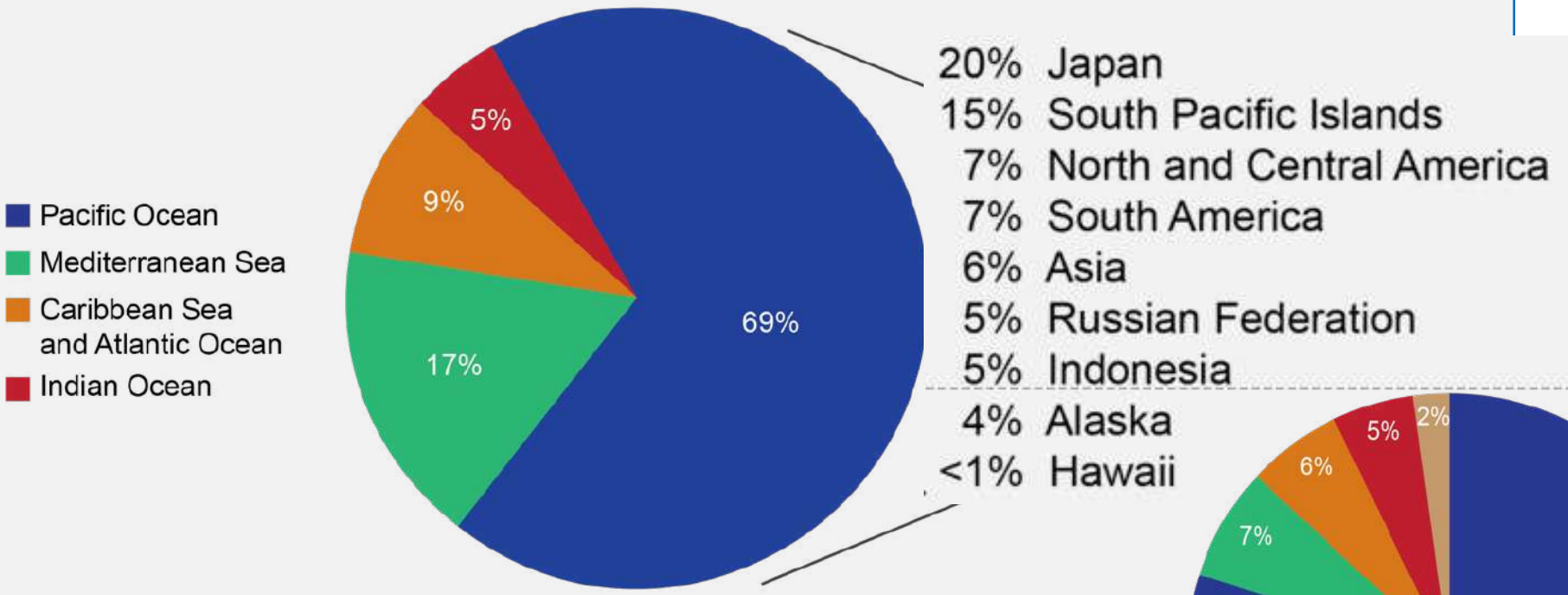


HISTORICAL LOCAL / REGIONAL TSUNAMIS

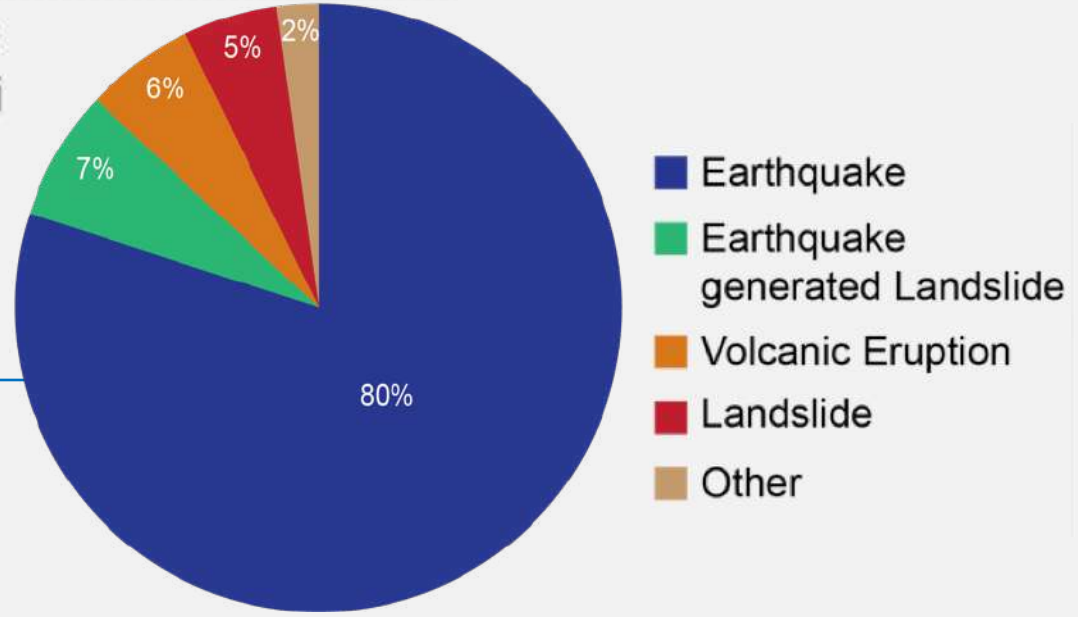


- **80% caused by earthquakes**
- **Most are local (< 1 hr) or regional (1-3 hrs)**
- **Globally, 90% of deaths from local or regional tsunamis (Pacific, 99% of deaths)**

DEADLY TSUNAMIS – GLOBAL (1620 B.C to A.D. 2022)



SOURCE LOCATION



SOURCE GENERATION

Global Tsunami Warning and Mitigation Systems

1960 Deadly Basin-wide Tsunami

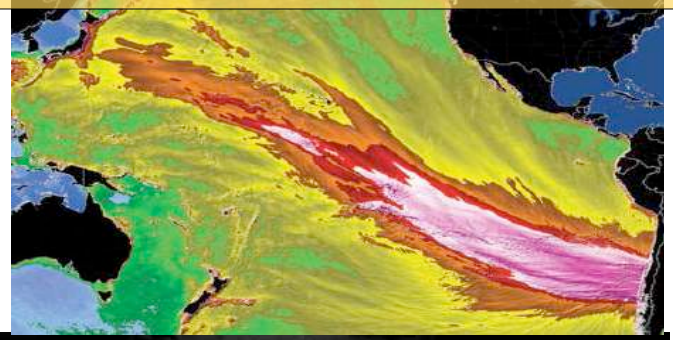
1960 9.5 Mw Chile earthquake generated a tsunami that killed 2000 in Chile, then hundreds in Hawaii, Japan, and the Philippines

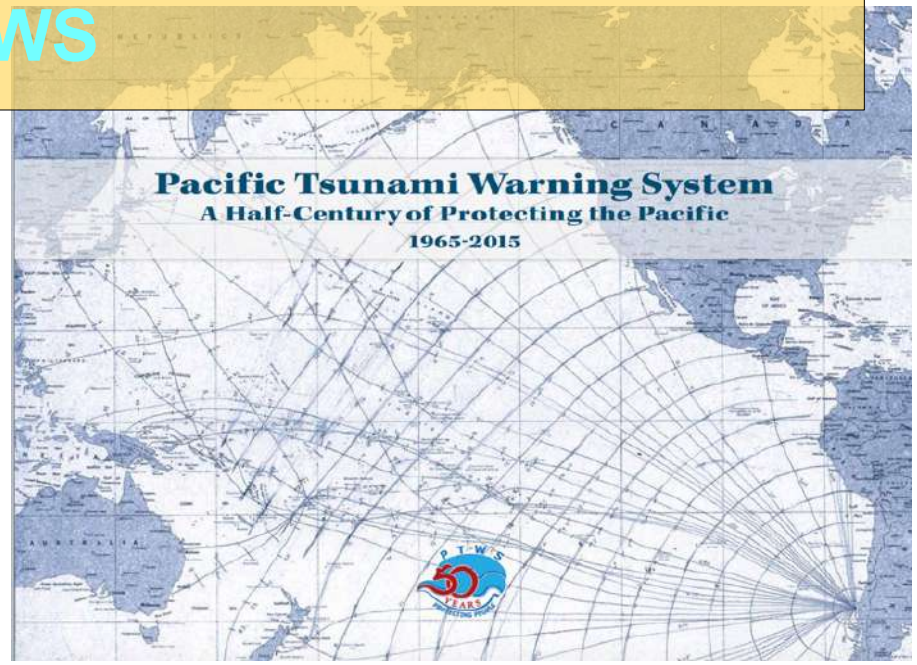
=> No international warning

=> 1965 Pacific Tsunami Warning System (PTWS) est (UNESCO IOC)

- **PTWC (NOAA) – 1965 - PTWS Operational Center HQ**
- **ITIC (IOC, NOAA hosted) - Support PTWS**

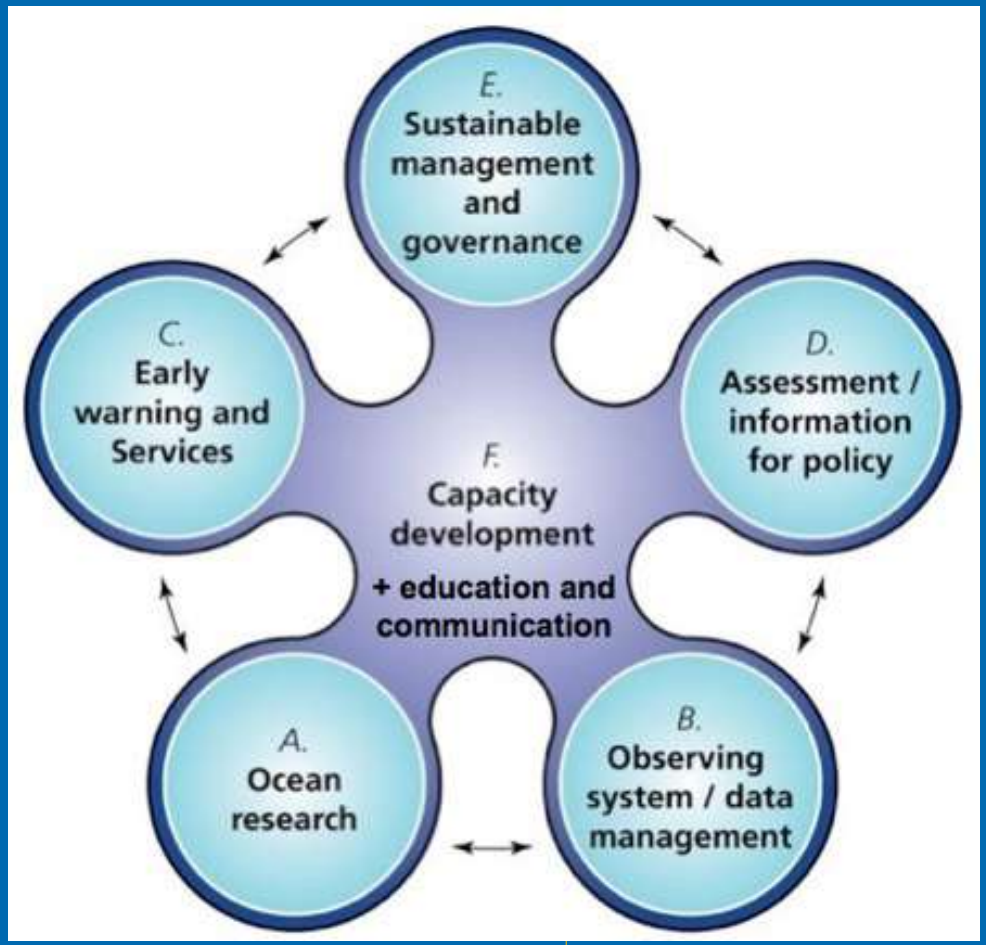

1960 Chile





Intergovernmental Oceanographic Commission (IOC) of UNESCO

- Only intergovernmental body of the United Nations (UN) system for ocean science
- Established 1960, 150 Member States



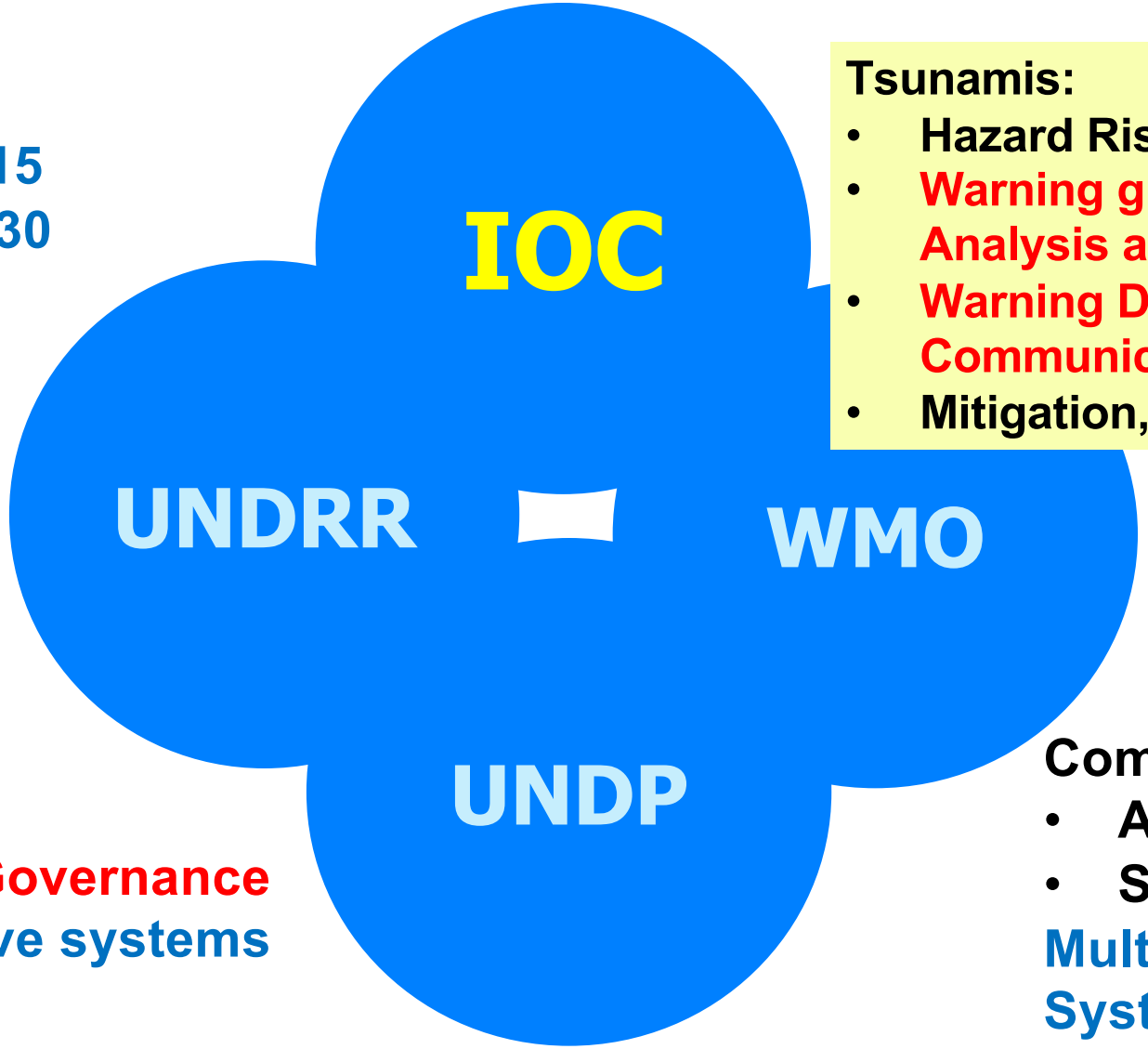
unesco
Intergovernmental Oceanographic Commission

United Nations – Global Partnerships

unesco
Intergovernmental Oceanographic Commission

DRR platforms
- **Hyogo 2005-2015**
- **Sendai 2015-2030**

Awareness
- **DRR Oct 13**
- **WTAD Nov 5**



Tsunamis:
- **Hazard Risk**
- **Warning guidance – Analysis and Forecast**
- **Warning Dissemination and Communication**
- **Mitigation, Preparedness**

Disaster Mgmt/Governance
Institutional / Legislative systems

Communication (GTS)
- **Alerts**
- **Sea Level Data**

Multi-hazard Early Warning Systems (MHEWS)

UN Global Tsunami System – How Does it Function?

- Governance
  - UNESCO/IOC through region Intergovernmental Coordination Groups (ICGs).
  - ICGs meet regularly (annual, bi-annual) to coordinate and improve system. Member States represented by Tsunami National Contact (TNC), Tsunami Warning Focal Point (TWFP), National Tsunami Warning Center (NTWC)
  - Saving lives from tsunami requires 'End-to-End' system – people-centred
  - IOC region Tsunami Information Centres (TIC) support Member States
- Tsunami Alerting
  - UNESCO/IOC Tsunami Service Providers (TSPs) monitor 24x7 Provide timely Tsunami Threat advice for region
  - Based on joint operation of international networks connected with NTWCs
  - Each nation is responsible for issuing warnings in their territory and protect its own population.
  - National warning centres must have strong links with emergency preparedness authorities (national, provincial, local)

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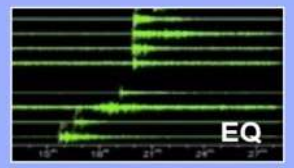
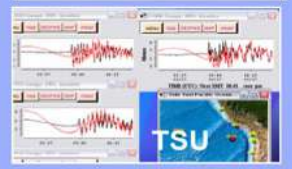
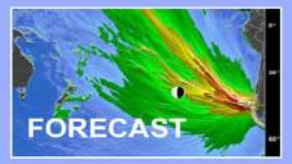
End-to-End Tsunami Warning Chain

EQ
Tsunami







Country
Alert System

Emergency Alert System
& Mass Media

Public

TWC - Science

Intl / Natl

DMO / EMA – Safety

Natl / Prov / Local Govt

Community

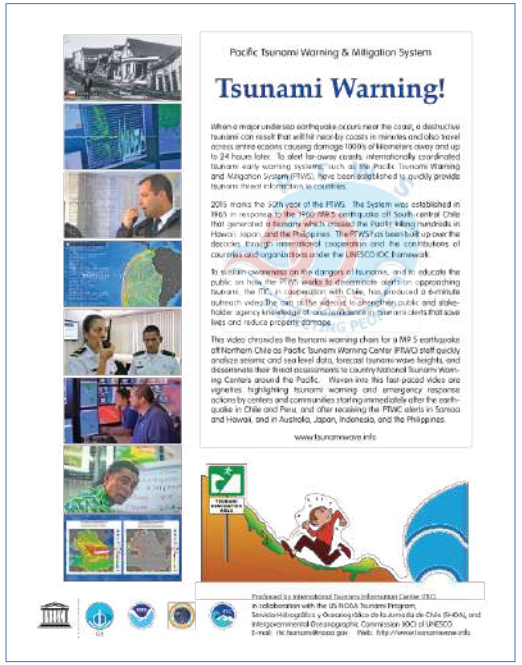
Race against Time

LIVES
SAVED

ITIC

ITIC, SeismicReady 2009, after Japan Cabinet Office, 2005

TSUNAMI WARNING CHAIN (M9.5 Chile)
UNESCO IOC – NOAA outreach video



English: https://vimeo.com/124650777
Spanish: https://vimeo.com/125109150
French: https://vimeo.com/125109148

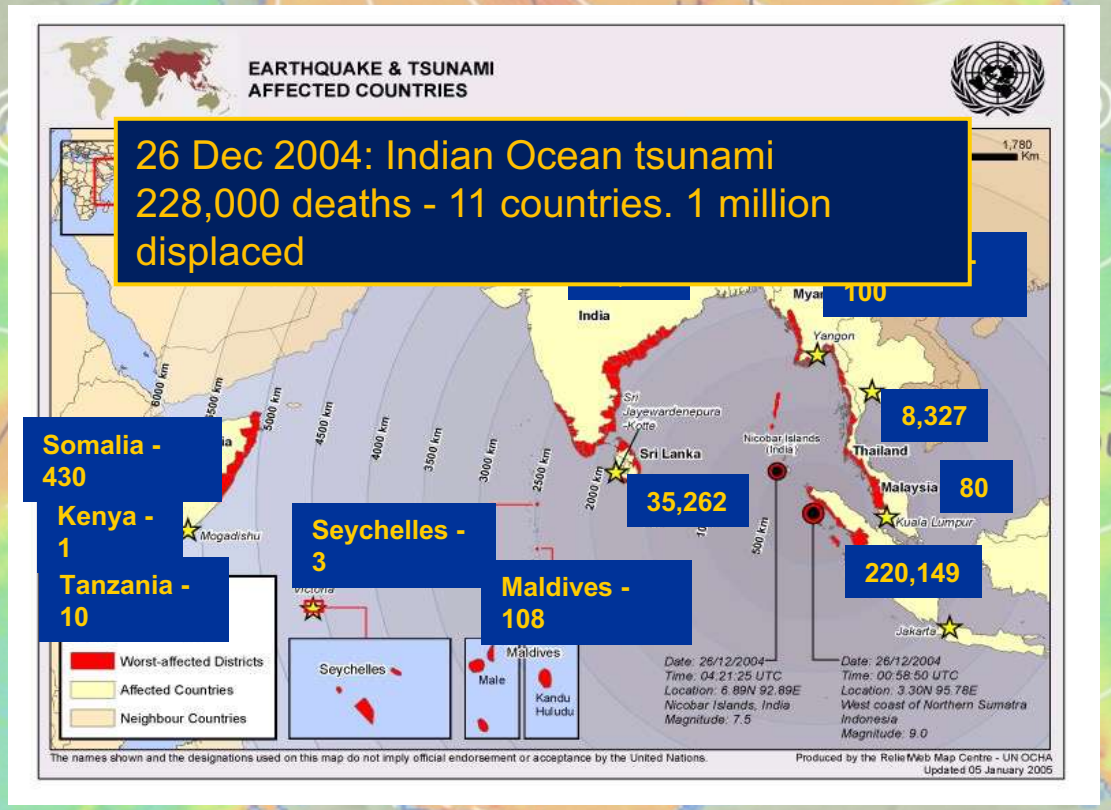
2004 Deadly Basin-wide Tsunami

2004 9.3 Mw Indonesia earthquake generated a tsunami that killed 180,000 in Indonesia, and in total 228,000 in 11 ndian Ocean countries over 12 hours. Nearly no one knew what a tsunami was …

=> No international warning

=> 2005 Indian Ocean, Caribbean, North Eastern Atlantic and Mediterranean Tsunami Warning and Mitigation Systems established under UNESCO / IOC

1. **IOC Tsunami Service Providers - 24x7 alerts for region**
2. **IOC Tsunami Information Centres - TEWS support to countries**

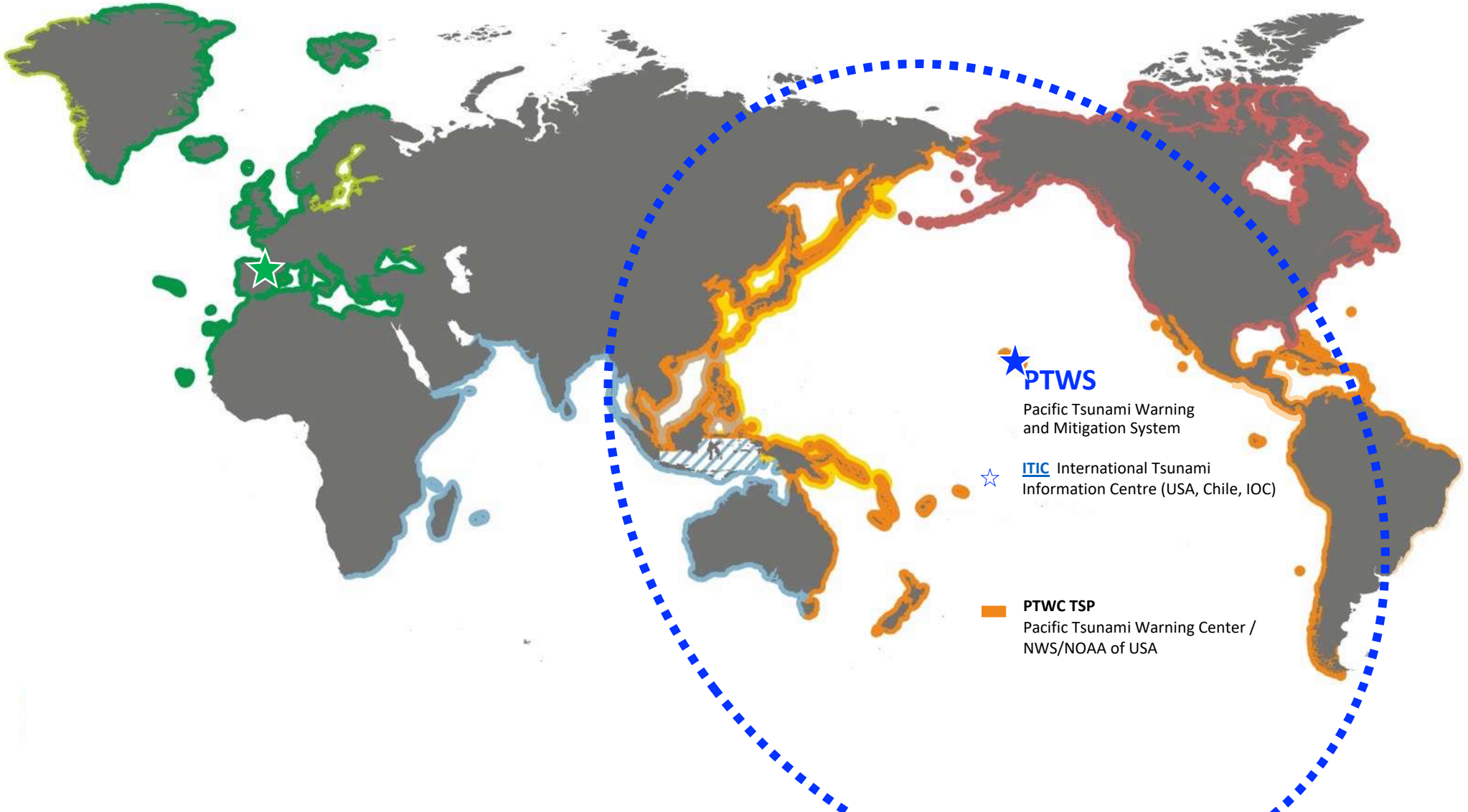


GLOBAL TSUNAMI WARNING AND MITIGATION SYSTEMS

Intergovernmental Oceanographic Commission of UNESCO

2021 www.ioc-tsunami.org

2004

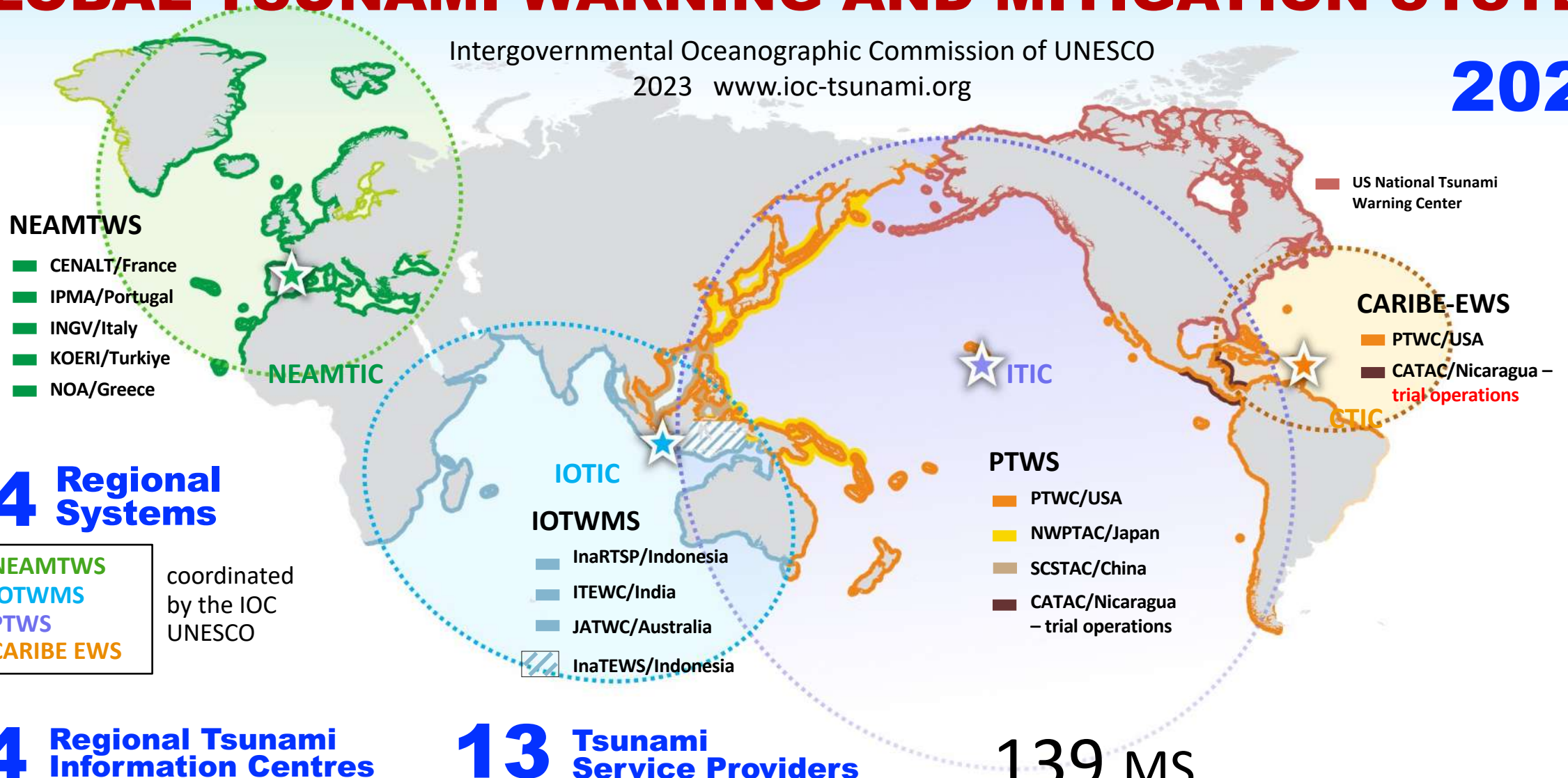


unesco
Intergovernmental Oceanographic Commission

GLOBAL TSUNAMI WARNING AND MITIGATION SYSTEMS

Intergovernmental Oceanographic Commission of UNESCO
2023 www.ioc-tsunami.org

2023



4 Regional Systems

NEAMTWS
IOTWMS
PTWS
CARIBE EWS

coordinated by the IOC UNESCO

4 Regional Tsunami Information Centres

NEAMTIC
IOTIC
ITIC
CTIC

Supporting the Regional System

13 Tsunami Service Providers

5 – NE Atlantic, Mediterranean
3 – Indian Ocean
4 – Pacific Ocean
2 – Caribbean

139 MS

36 – SIDS
12 – African

have established National Tsunami Warning Focal Points/ National Tsunami Warning Centres

After Frolov, 2023

Tsunami Alerting – Two Types of Centres

IOC Global Service - Tsunami Service Providers (TSPs)

- Provide INFORMATION / ADVICE on THREAT. Since 2014, do not issue tsunami warnings to countries
- Capability to detect and assess tsunami threats over a large region, covering multiple member state.
- Has been accepted by the Intergovernmental Coordination Group (ICG) to disseminate threat assessment to other member states.

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Intergovernmental Oceanographic Commission

Tsunami Alerting – Two Types of Centres

National Tsunami Warning Centers (NTWC)

- A center operated by a Member State that has the authority by law or otherwise to issue tsunami warnings for the coasts of that Member State.

- Ideally, NTWC should have some technical capability to aid decisions making.

Tonga

Peru

unesco
Intergovernmental Oceanographic Commission

IOC Tsunami Information Centers

PTWS
USA NOAA – IOC Partnership
1965
Chile SHOA Associate Director
1998

NEAMTWS
EC DG ECHO
France, Greece, Italy, Portugal
2011-13

IOTWS
Indonesia – IOC Partnership 2012
(formerly JTIC since 2006)

CARIBE-EWS
Barbados– IOC Partnership
2015 (approved 2007)

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Intergovernmental
Oceanographic
Commission

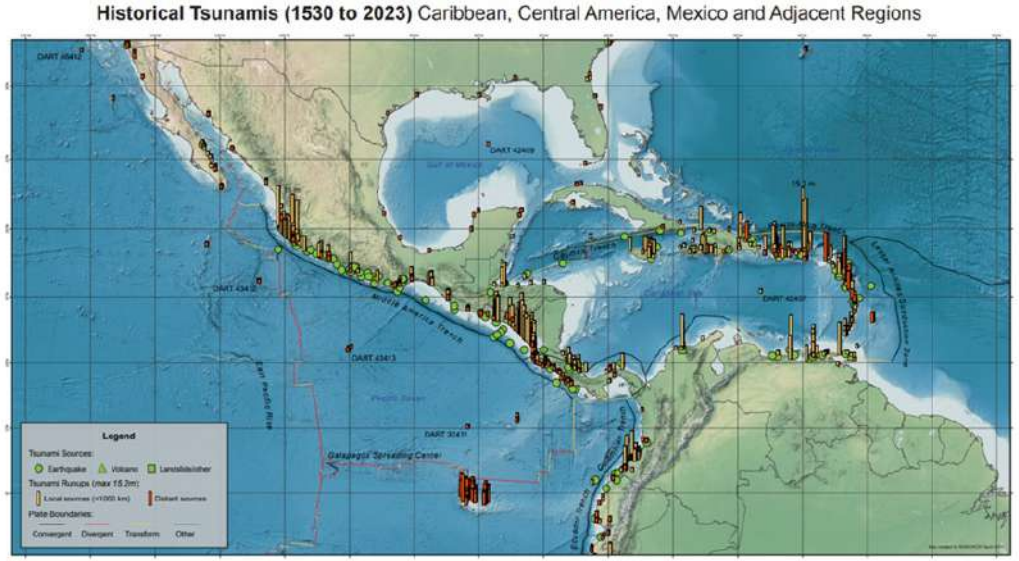
ICG / PTWS - SCOPE

- United Nations governance – UNESCO Intergovernmental Oceanographic Commission (IOC)
- 46 countries (Member States) - <u>excludes Taiwan</u>
  - ~12 time zones
  - 5 languages (UN languages = English, Spanish, French, Chinese, Russian, …)
  - Tsunamis from Pacific Ring of Fire – everywhere
  - Majority of observed tsunamis globally

ICG / CARIBE EWS - SCOPE

- United Nations governance – UNESCO/IOC
- 28 countries (Member States) and 16 Territories
  - 4 languages (English, Spanish, French, Dutch)
  - Tsunamis along margin of Caribbean Plate and Distant
  - Infrequency can Lead to Complacency

Photo: Artistic rendition of the US Navy Ship, La Plata, caught by the tsunami in the Charlotte Amalie Harbor, Saint Thomas (1867)
Credit: Harper's Weekly (1868)



2021 United Nations Decade
2030 of Ocean Science
for Sustainable Development

UN
Sci
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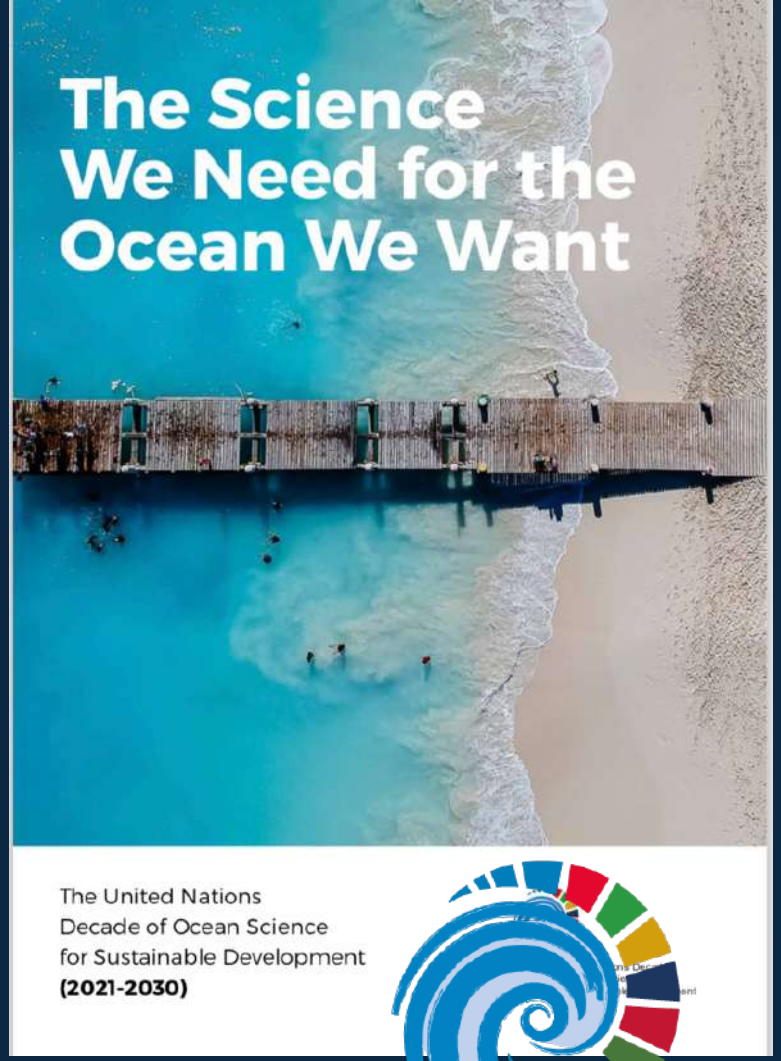
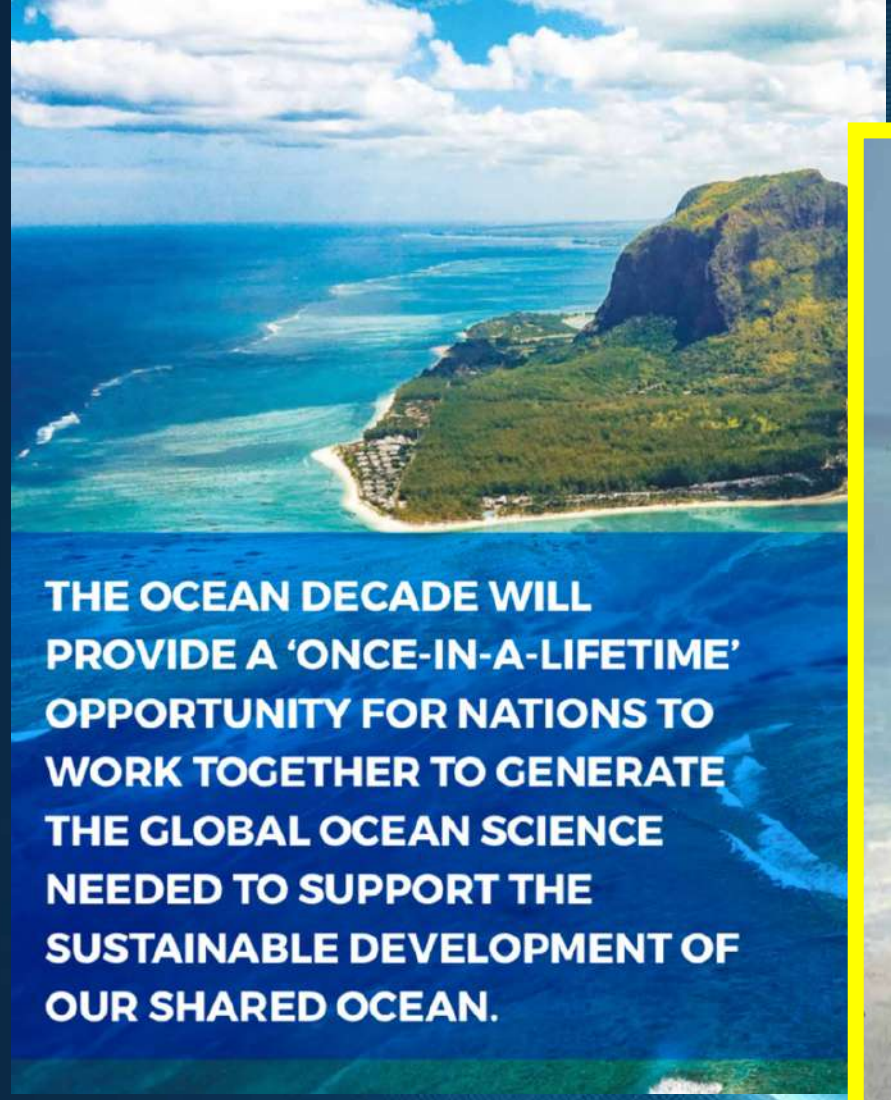




2021 2030 United Nations Decade of Ocean Science for Sustainable Development

Tsunami Ready

Decade Challenge 6:
Increase community resilience to ocean hazards
(e.g., early warning and community preparedness)

Decade Challenge 7:
Expand the global ocean observing system

Societal Outcome 5:
Safe Ocean

Actions – Projects:

- UNESCO IOC Tsunami Ready Recognition Prog
- SMART subsea cables strengthen Tsunami Early Warning System

⇒ Faster Detect, Better Forecast
⇒ Faster warning save lives

UN OCEAN DECADE TSUNAMI PROGRAMME
Components

RISK KNOWLEDGE

Data Collection and Risk Assessment

MONITORING AND WARNING

Tsunami Detection, Forecasting and Warning

CAPACITY DEVELOPMENT

IOC/UNESCO TRRP

WARNING DISSEMINATION AND COMMUNICATION

Integration of Tsunami Services within a Multi-Hazard Early Warning Framework

RESPONSE CAPABILITY

To make 100% of Communities at Risk of Tsunami meet the Indicators of IOC Tsunami Ready Programme

INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION
COMMISSION OCÉANOGRAPHIQUE INTERGOUVERNEMENTALE
COMISIÓN OCEANOGRÁFICA INTERGUBERNAMENTAL
МЕЖПРАВИТЕЛЬСТВЕННАЯ ОКЕАНОГРАФИЧЕСКАЯ КОМИССИЯ
اللجنة الدولية الحكومية لعلوم المحيطات
政府间海洋学委员会

UNESCO

IOC Circular Letter No 2825 — IOC/VR/BA/ba
(Available in English and French) — 6 January 2021

To: IOC Tsunami National Contacts (TNCs)
IOC Tsunami Warning Focal Points (TWFPs)
Permanent Observers to Regional TWS Intergovernmental Coordination Groups (ICGs)
Members of the Working Group on Tsunamis and Other Hazards Related to Sea-Level Warning and Mitigation Systems (TOWS-WG)

Cc: National Coordinating Bodies for liaison with IOC in Member States
Permanent Delegations/Observer Missions to UNESCO and
National Commissions for UNESCO in IOC Member States
Officers of ICG/CARIBE EWS, ICG/IOTWMS, ICG/NEAMTWS and ICG/PTWS
Chair and Vice-Chairpersons of IOC

Subject: Inventory of actions being considered under the United Nations Decade of Ocean Science for Sustainable Development (2021–2030) in the field of tsunamis and other sea-level related hazards warning and mitigation

Annex 1 to IOC Circular letter, 2825 *"Protecting Communities from the World's Most Dangerous Waves: A Framework for Action under the UN Decade of Ocean Science for Sustainable Development"* (6 January 2021)

Angove M et al (2019)
Ocean Observations Required to Minimize Uncertainty in Global Tsunami Forecasts, Warnings, and Emergency Response. Front. Mar. Sci. 6:350. doi: 10.3389/fmars.2019.00350

Ocean Observations Required to Minimize Uncertainty in Global Tsunami Forecasts, Warnings, and Emergency Response

TEN YEARS RESEARCH, DEVELOPMENT & IMPLEMENTATION PLAN FOR THE ODTP

OVERARCHING PRIORITIES

1 The first objective of the ODTP is to develop the warning systems' capability to issue actionable and timely tsunami warnings for tsunamis from all identified sources to 100 percent of coast at risk

2 The second objective of the ODTP is that 100 percent of communities at risk to be prepared and resilient to tsunamis by 2030 through efforts like the IOC-UNESCO Tsunami Ready Recognition Programme (TRRP)

TSUNAMI READY COMMUNITIES

OUTREACH AND EDUCATION

A NEW GENERATION TWS

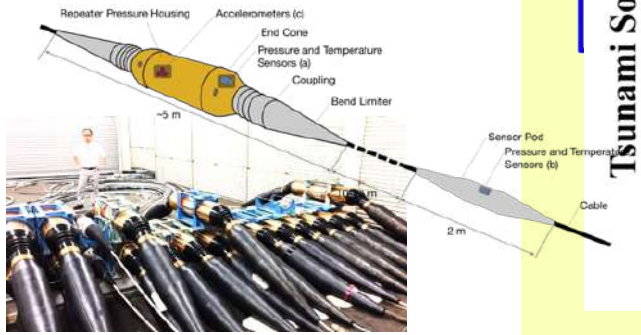
Frolov, 2023

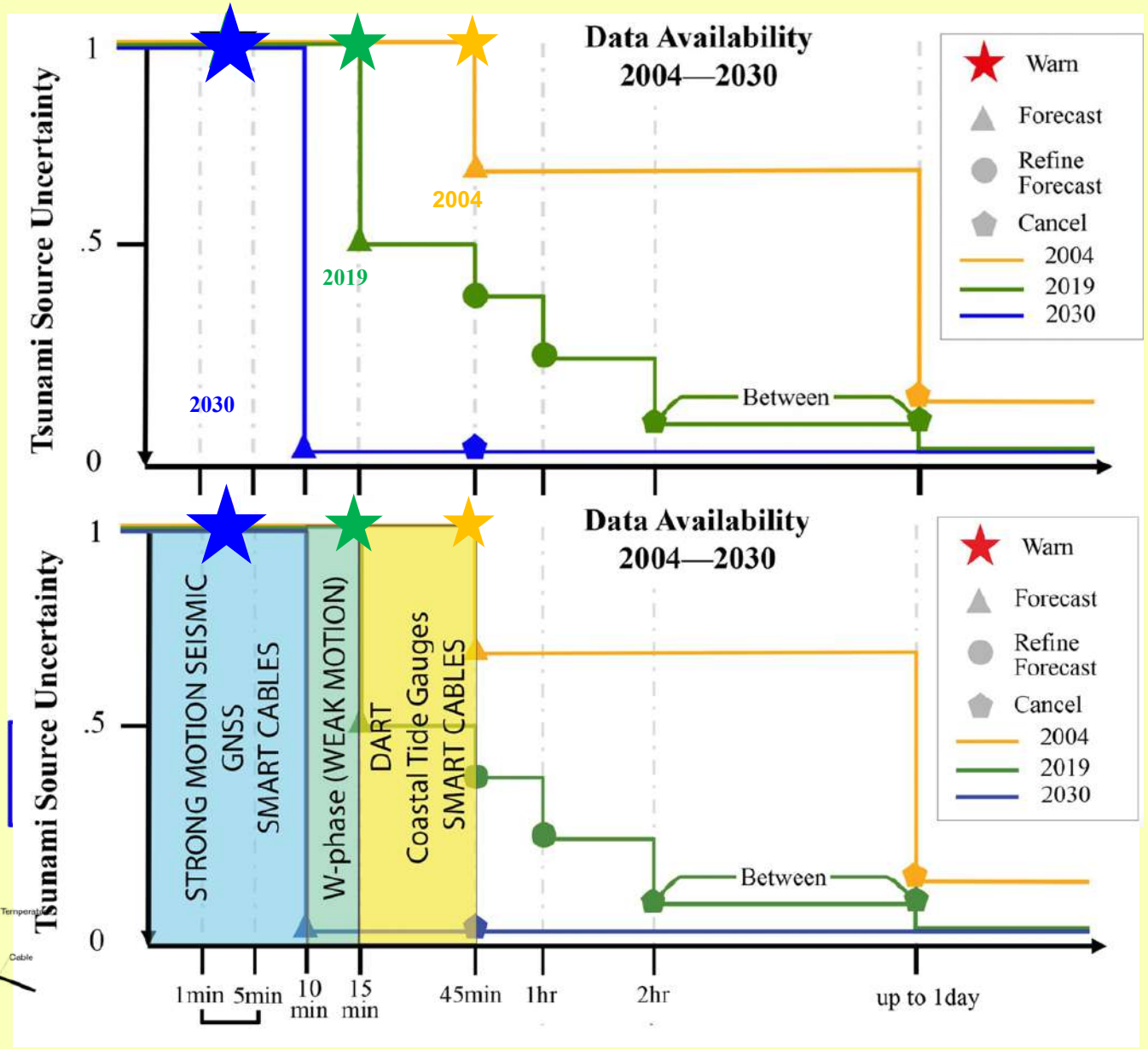
IMPROVEMENT IN EARLY WARNING (SMART, GNSS)

UN Ocean Decade Goals: Timely (faster) and Useful warnings for 100% of sources

- GNSS for real-time tsunami source char
- SMART Cable technology for seafloor tsunami detection

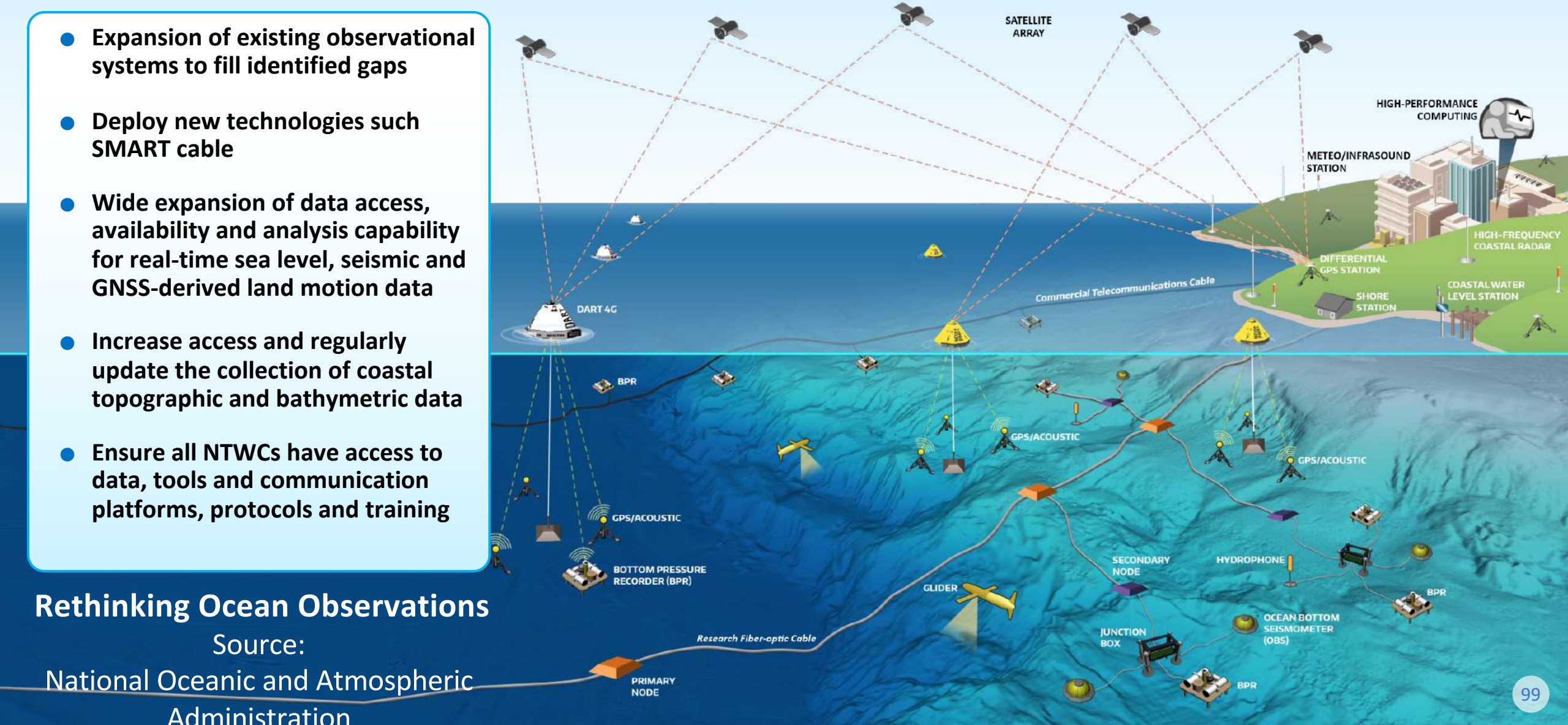
2021 2030 United Nations Decade of Ocean Science for Sustainable Development





OCEAN DECADE TSUNAMI PROGRAMME: the Focus Areas Related to Tsunami Warning Capabilities

- **Expansion of existing observational systems to fill identified gaps**
- **Deploy new technologies such SMART cable**
- **Wide expansion of data access, availability and analysis capability for real-time sea level, seismic and GNSS-derived land motion data**
- **Increase access and regularly update the collection of coastal topographic and bathymetric data**
- **Ensure all NTWCs have access to data, tools and communication platforms, protocols and training**



Rethinking Ocean Observations

Source:
National Oceanic and Atmospheric Administration

SMART Subsea Cables

Global Array: Climate, Oceans, Sea Level, Earthquakes, Tsunamis

- *Create Planetary Sensor, power, Internet network*
- *1st order addition to Ocean-Earth observing system*

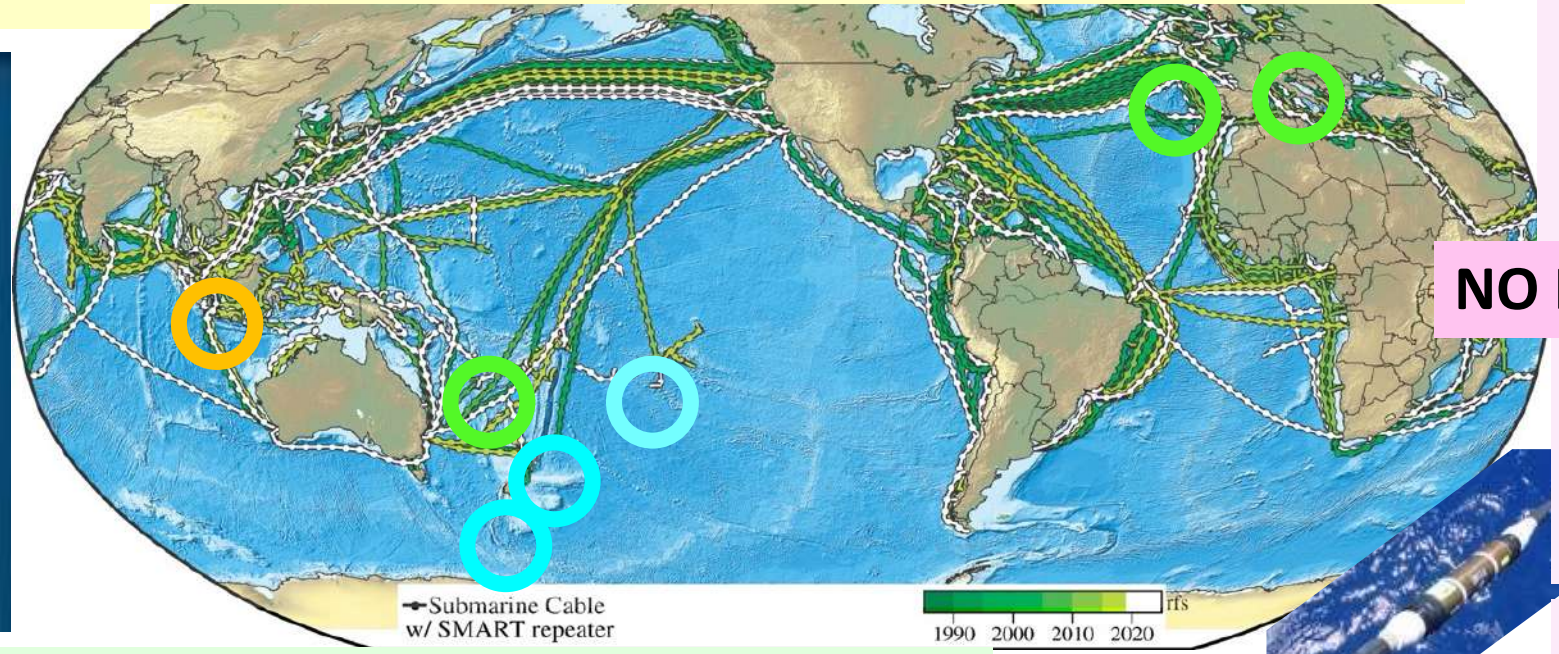
Share submarine cable infrastructure Telecom + science

↓€$

NO Interference

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

SMART: *UN Decade for Ocean Science Project*



1.2+ Gm
~20,000 repeaters
20 year refresh

repeaters ~70 km

CAM: 3700 km, Gov't, install 2025 → SMART Continent/Lisbon-Azores-Madeira ring

1755 Lisbon - Seismic, tsunami, ocean, environment
3700 km, 50 SMART repeaters, €120M

1st Sensors: Bottom temperature, pressure, seismic acceleration

WMO

ITU

Thank you

Dr. Laura Kong
Director, ITIC, USA NOAA, laura.kong@noaa.gov

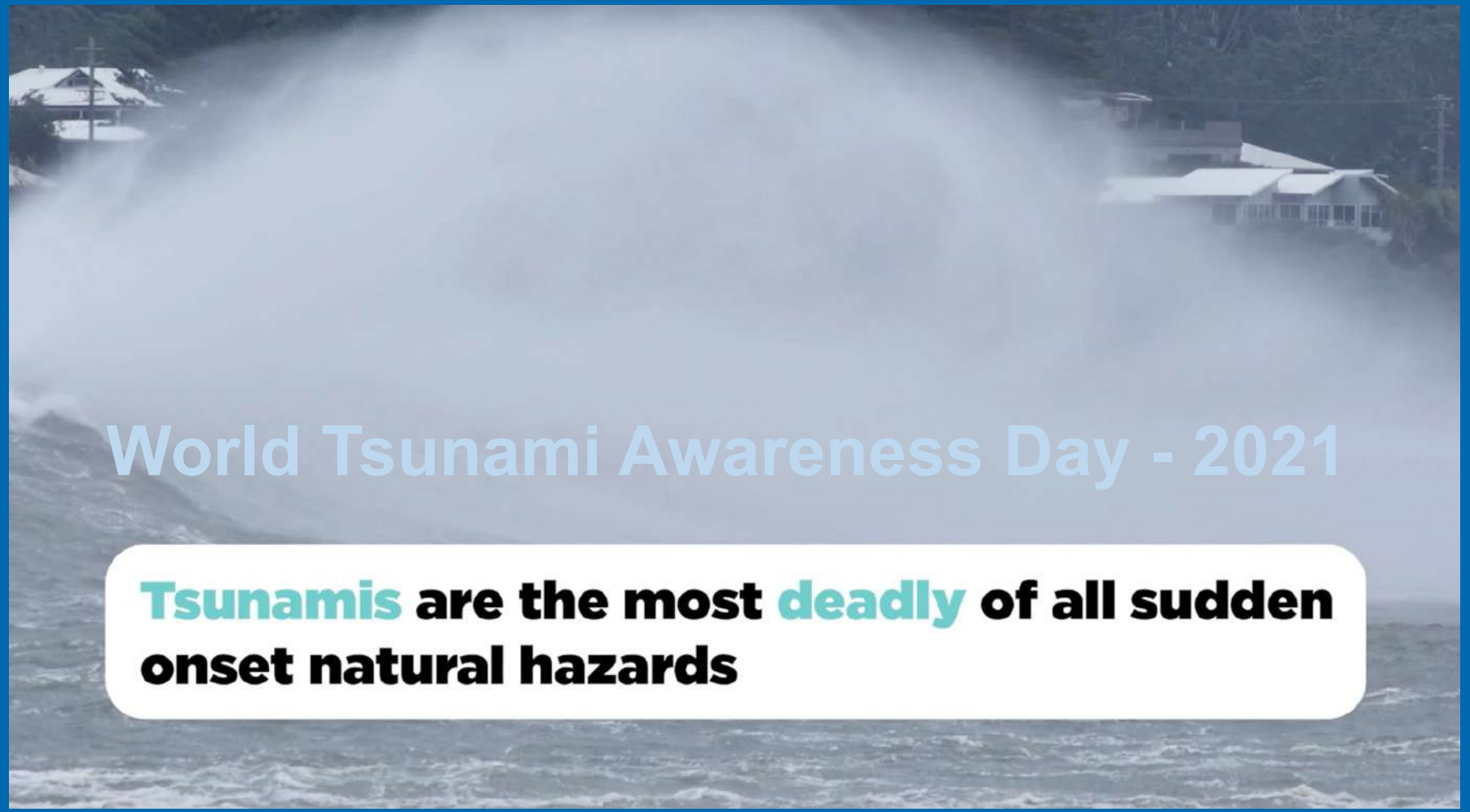
Christa von Hillebrandt-Andrade
Manager, ITIC-CAR, USA NOAA, christa.vonh@noaa.gov

NOAA Inouye Regional Center
Ford Island, JBPPH, Hawaii

Puerto Rico Seismic Network, UPRM
Mayaguez, Puerto Rico

UNI
Rea
Pro

UN Decade of Ocean Science for Sustainable Development
IOC Ocean Decade Tsunami Programme - Tsunami Ready



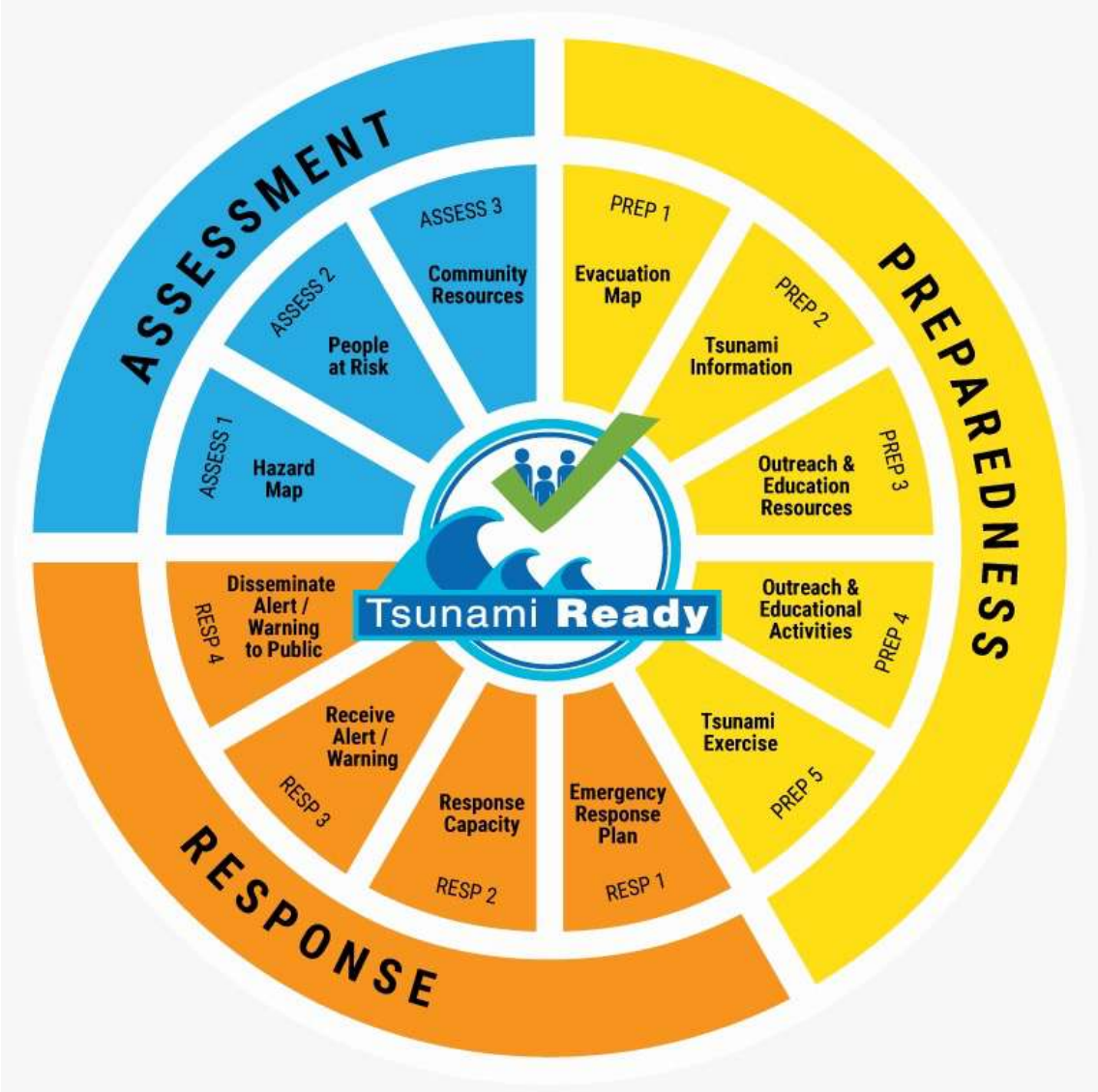
Tsunami Ready

Click for video

unesco
Intergovernmental Oceanographic Commission

UN OCEAN DECADE TSUNAMI PROGRAMME:

100% AT-RISK COMMUNITIES TSUNAMI READY



- **STRATEGY:**
  Be Aware, Be Prepared
- **FRAMEWORK:**
  - Harmonized global guidelines UNESCO IOC Tsunami Ready
  - Performance-based Community Recognition
- **ACTION:**
  National programs empower Communities
- **GLOBAL MEASURE**
  - 12 Indicators – Assessment, Preparedness, Response

Standard Guidelines for the Tsunami Ready Recognition Program, UNESCO IOC TS 74

OCEAN DECADE TSUNAMI PROGRAMME

A SAFE OCEAN

THE MAIN SOCIETAL OUTCOME

TO MAKE 100%

OF COMMUNITIES AT RISK OF TSUNAMI PREPARED FOR AND RESILIENT TO TSUNAMIS

BY 2030

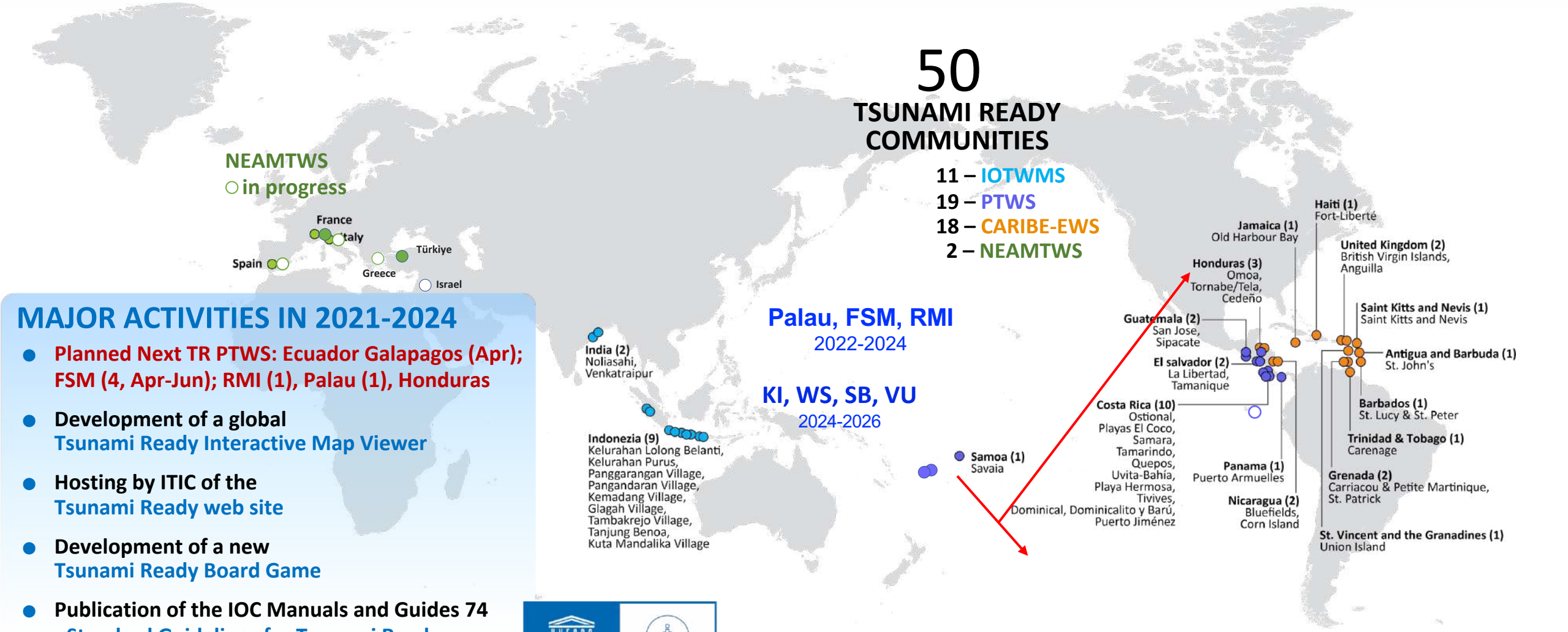
- ***Tsunami Coalition***: *collaborative with critical UN stakeholders, civil protection, others ==> Raise profile. Facilitate resourcing*

  CHAIR is LAURA KONG

- ***Capacity Development***: *"Tsunami Ready" training, augmented by online IOC Ocean Teacher Global Academy (OTGA) ==> Global reach, deep curricula*

  ITIC is OTGA STC

UNESCO/IOC TSUNAMI READY RECOGNITION PROGRAMME (TRRP)



MAJOR ACTIVITIES IN 2021-2024

- **Planned Next TR PTWS: Ecuador Galapagos (Apr); FSM (4, Apr-Jun); RMI (1), Palau (1), Honduras**
- **Development of a global** Tsunami Ready Interactive Map Viewer
- **Hosting by ITIC of the** Tsunami Ready web site
- **Development of a new** Tsunami Ready Board Game
- **Publication of the IOC Manuals and Guides 74** «Standard Guidelines for Tsunami Ready Recognition Programme»

Frolov, 2023; ITIC, March 2024