FEBUS OPTICS
Distributed Optical Fiber Sensing

UCA JEDI INITIATIVE D'EXCELLENCE

Agence Nationale de la Recherche ANR

CENTRE DE PHYSIQUE DES PARTICULES DE MARSEILLE CPPM

National Centre for Scientific Research DEMOKRITOS

GeoAzur TERRE - OCÉAN - ESPACE

UNIVERSITÉ CÔTE D'AZUR

Distributed sensing of earthquakes and ocean-solid Earth interactions analysis using fiber optic telecom seafloor cables

Diane Rivet

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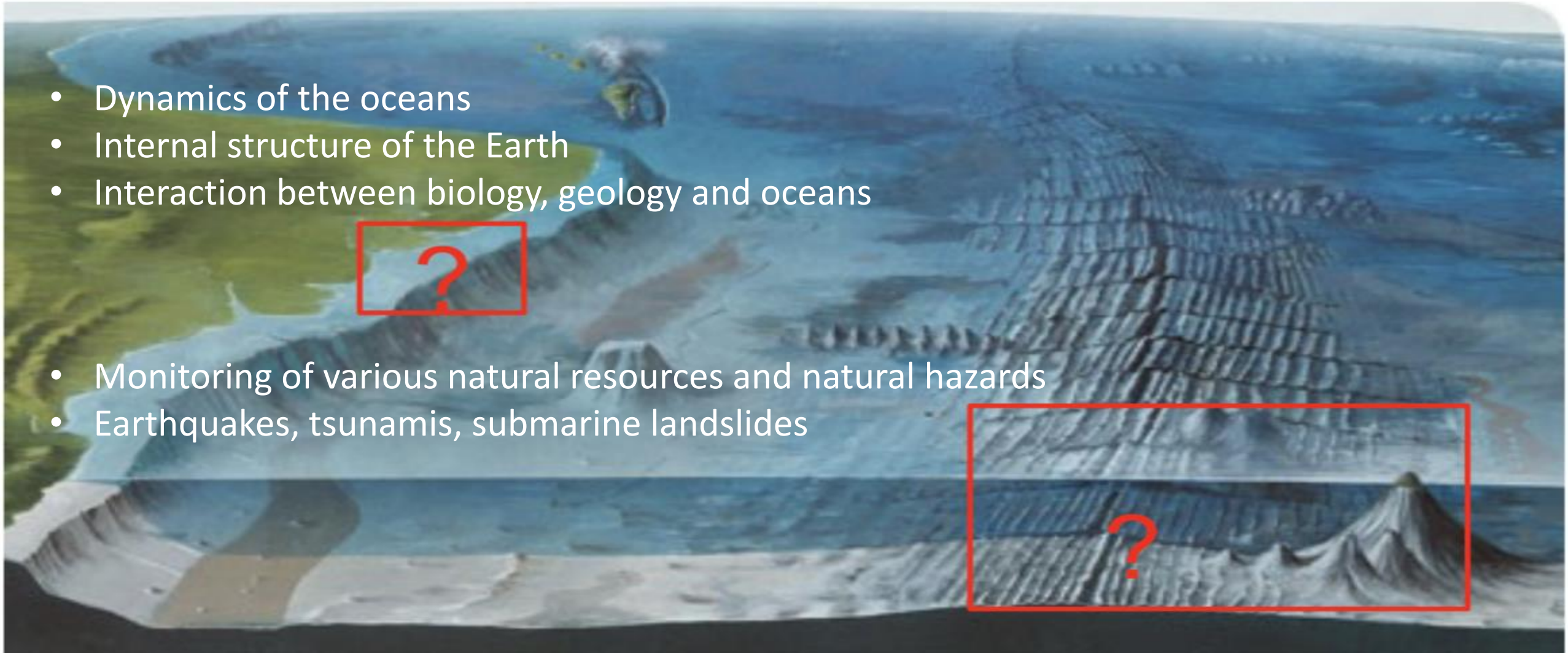
RESIF – Novembre 2019

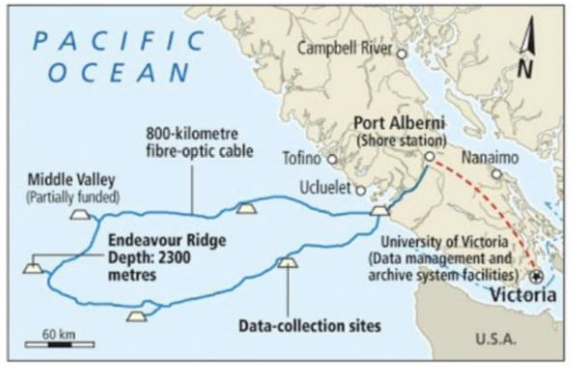
Ocean floor instrumentation holds the answers to numerous key scientific questions



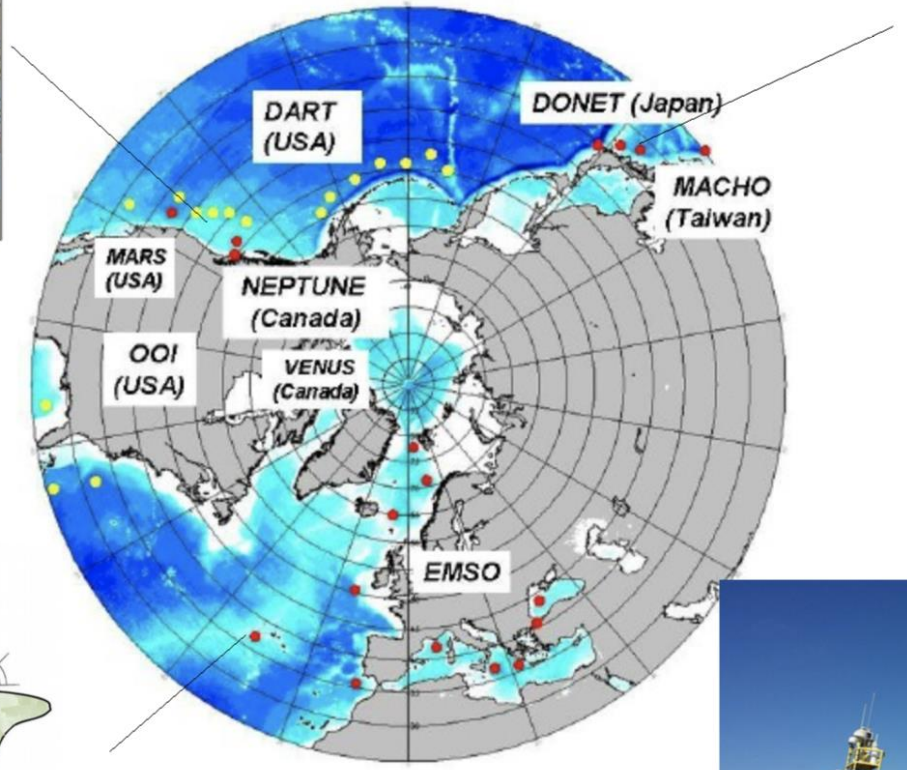
- Dynamics of the oceans
- Internal structure of the Earth
- Interaction between biology, geology and oceans

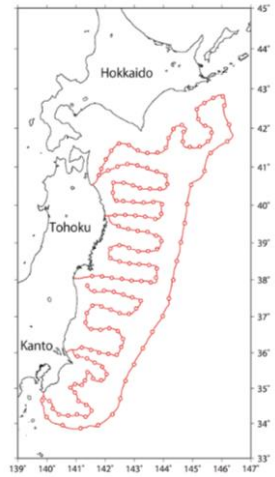
- Monitoring of various natural resources and natural hazards
- Earthquakes, tsunamis, submarine landslides

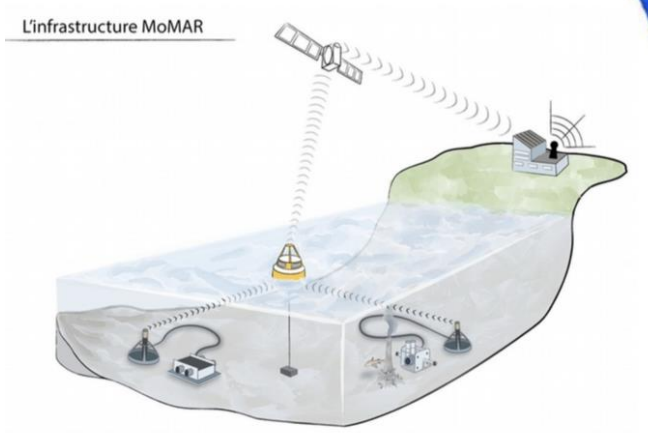
Challenging and expensive permanent instrumentation



Submarine cabled real-time seafloor observatory





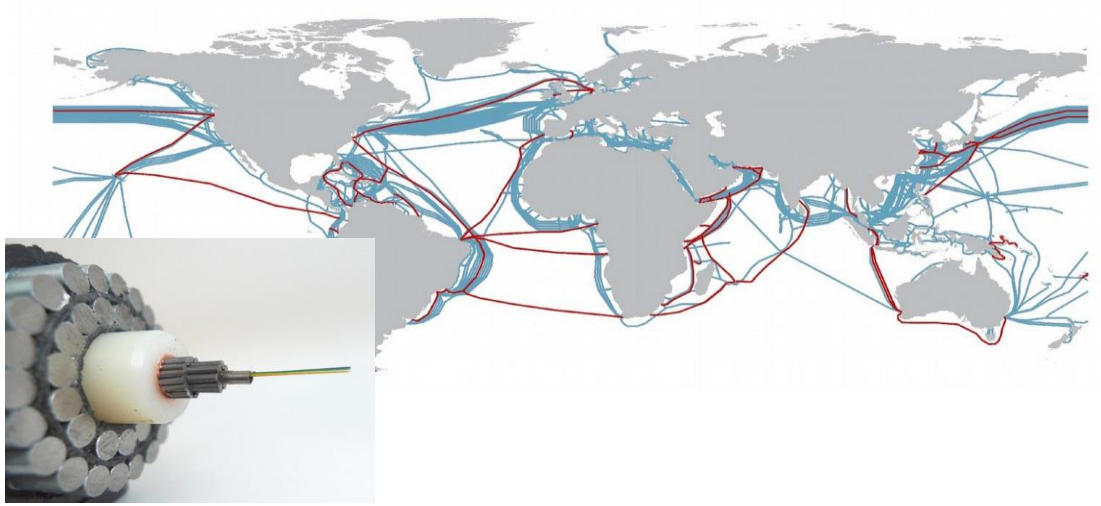


N’importe quelle fibre,
mais pas n’importe quel câble

Axe 1 : sur câble dédié

Pas cher et permet de cibler la zone d’étude.
Câble qui a besoin d’être protégé et couplé au fond marin.

Axe 2 : sur câbles telecom



Tapissent la plupart des océans et zones côtières mais câbles particuliers et pas emplacement imposé

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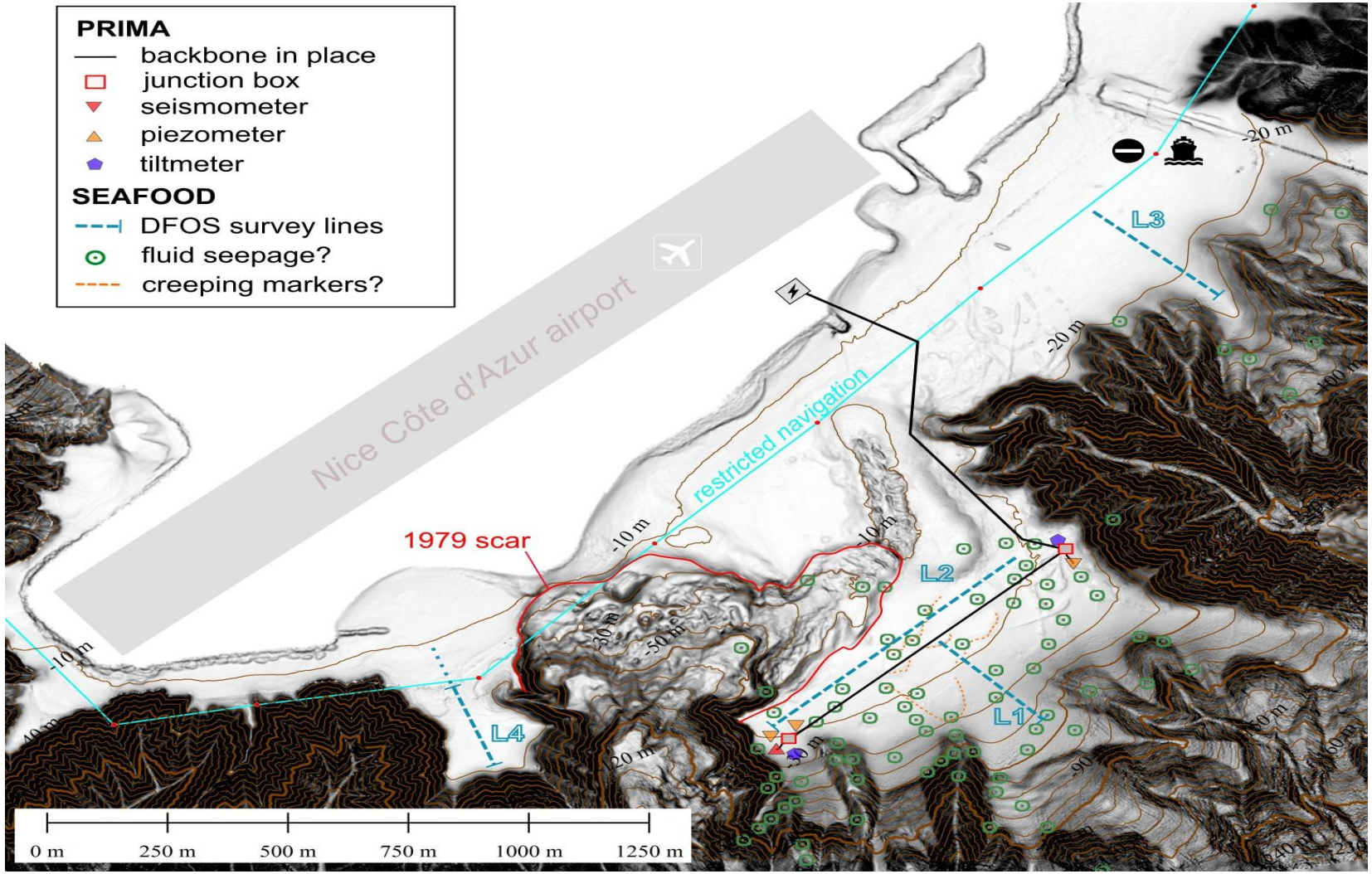
Aéroport de Nice : un site local avec de forts enjeux scientifiques et socio-économiques



Mai 2019 : déploiement de 4 lignes avec charrue Géoazur

Objectifs scientifiques

- Calibration vs instrumentation + std
- Stabilité pentes
- Sorties et circulations de fluides
- Tester imagerie passive et active

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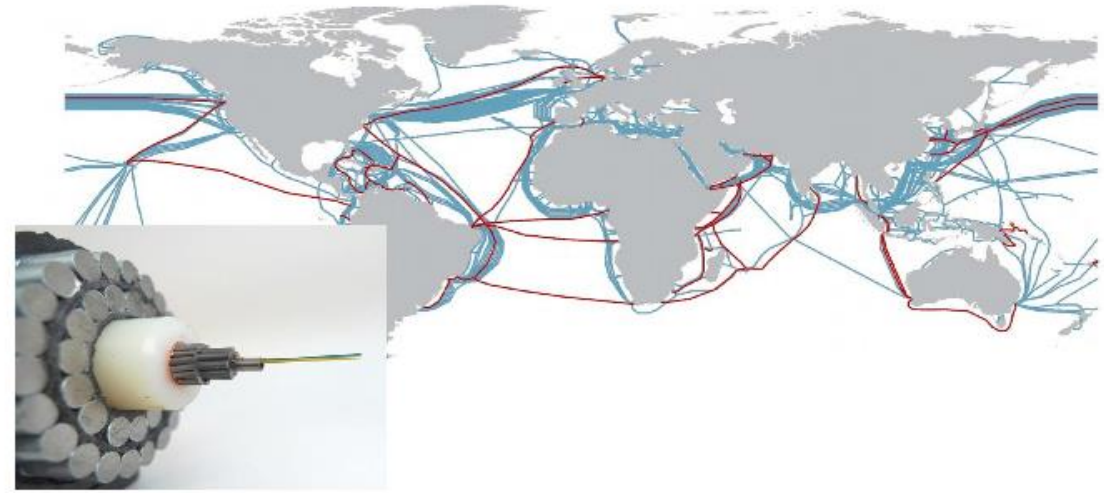

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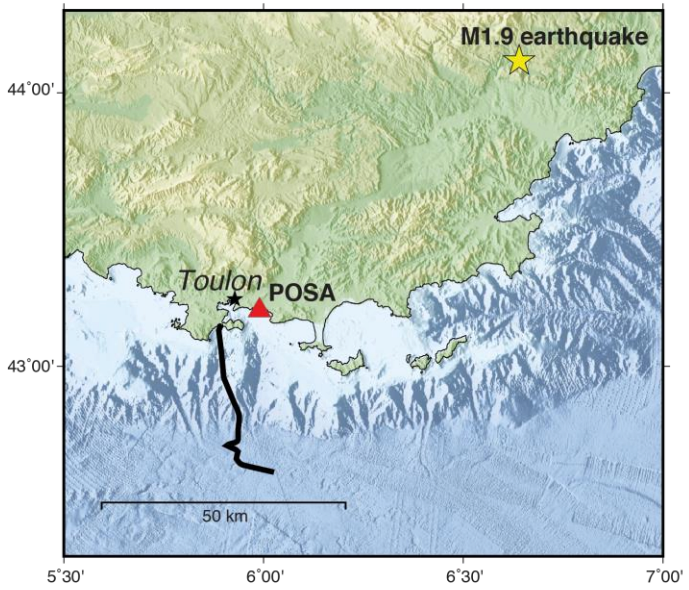
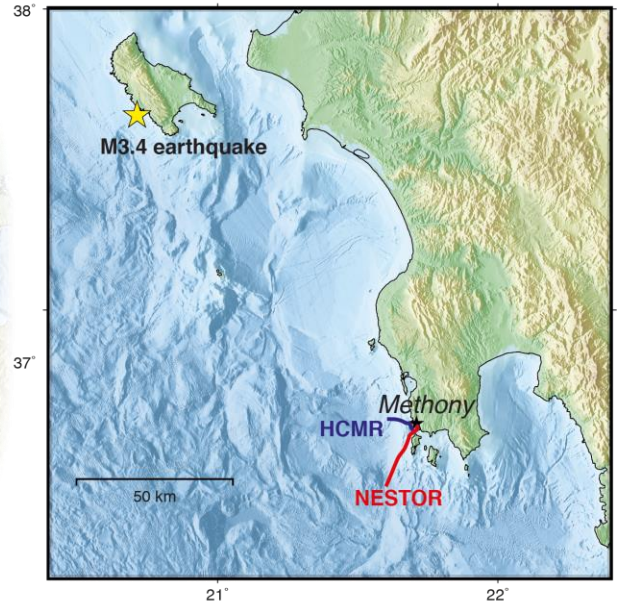
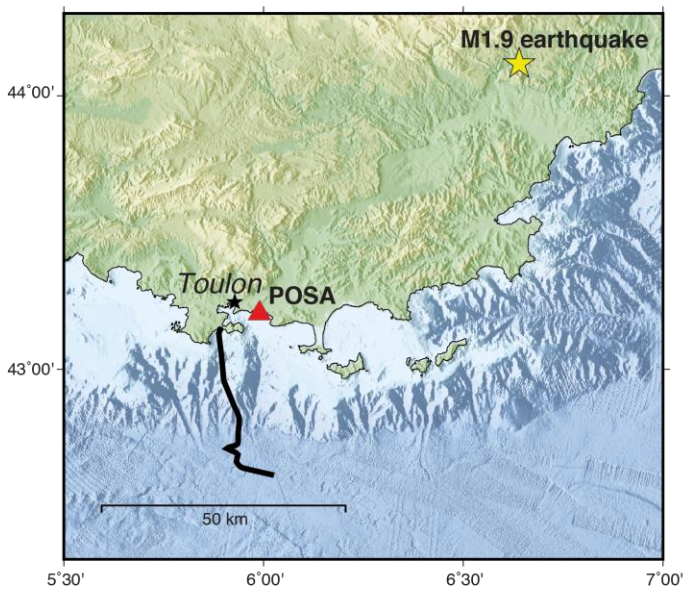
DAS experiments : 3 Telecom Cables
EMSO– KM3NET and Nestor



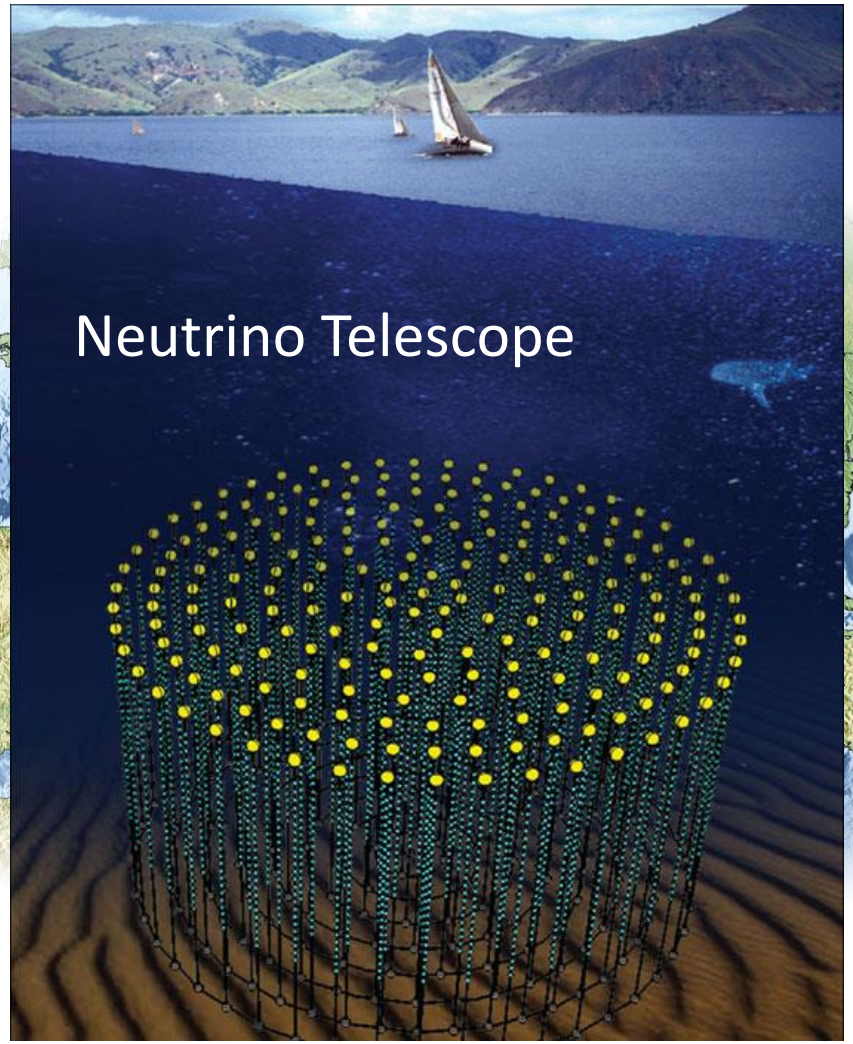


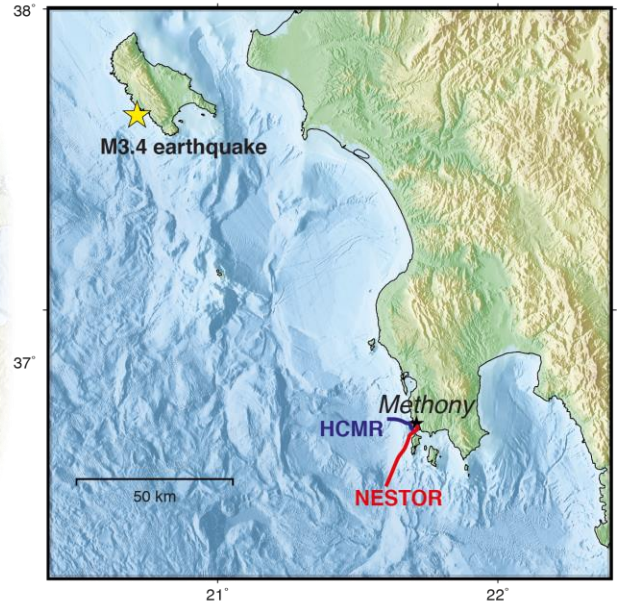
EMSO European Multidisciplinary Seafloor and Water Column Observatory

DAS experiments : 3 Telecom Cables EMSO– KM3NET and Nestor



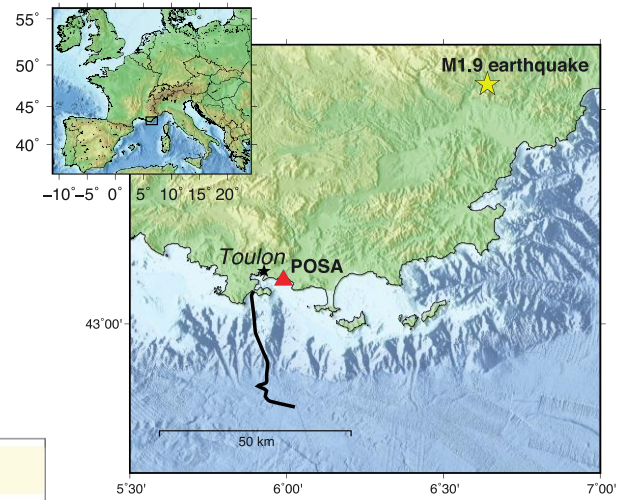
MEUST/KM3NET

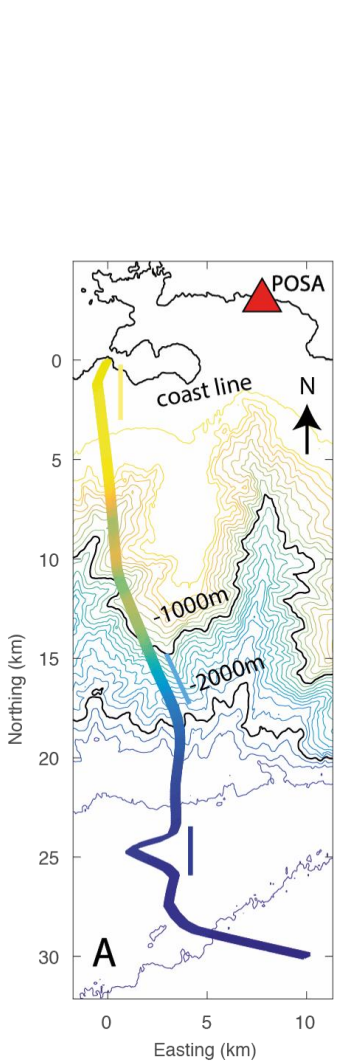


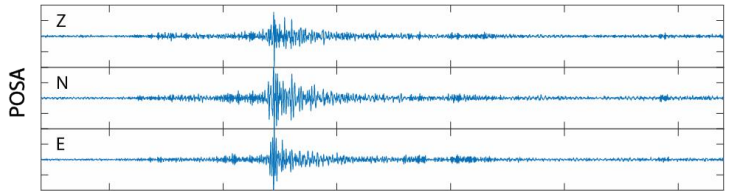


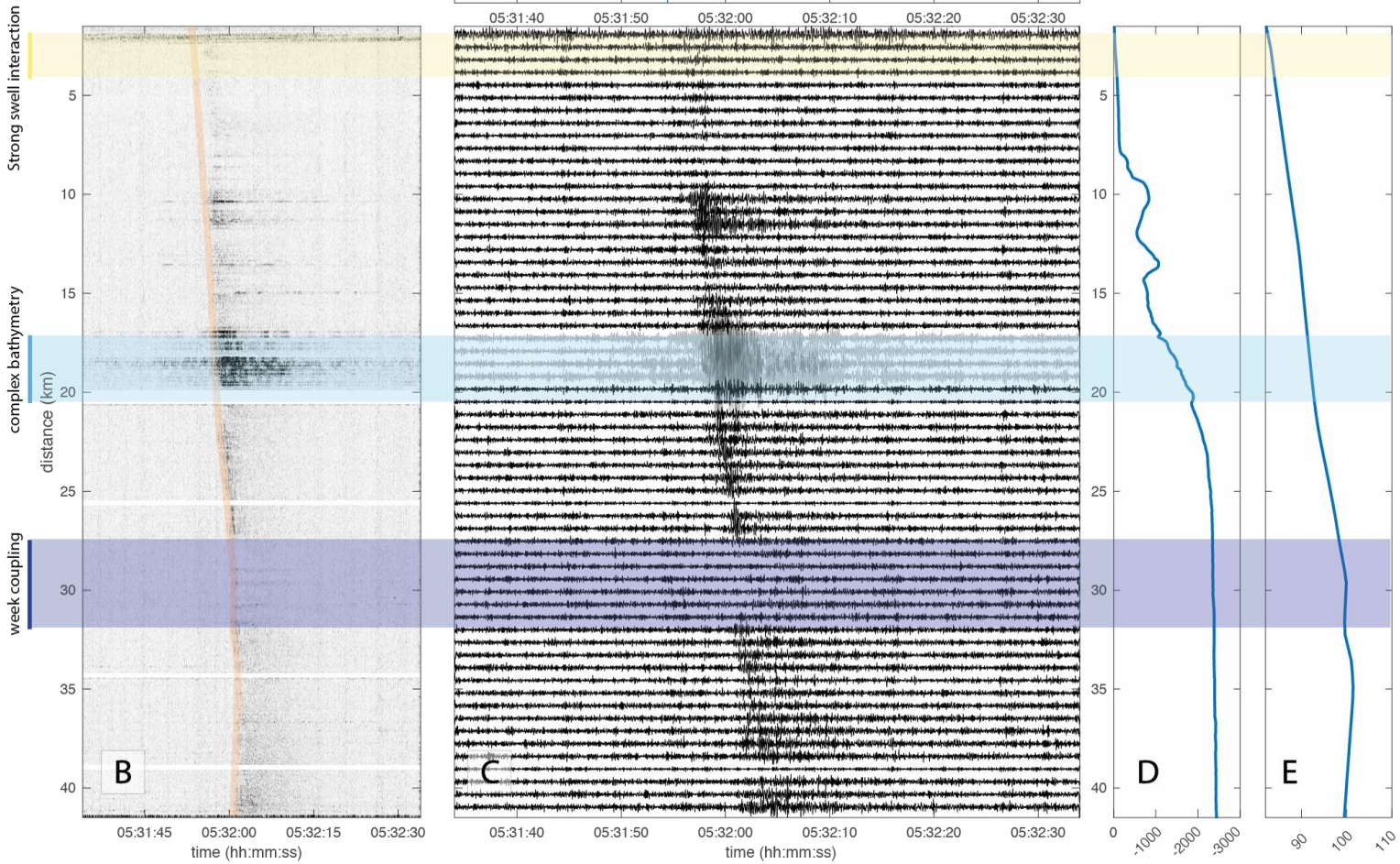
NESTOR project

Earthquakes detection (local M1.9@100km)

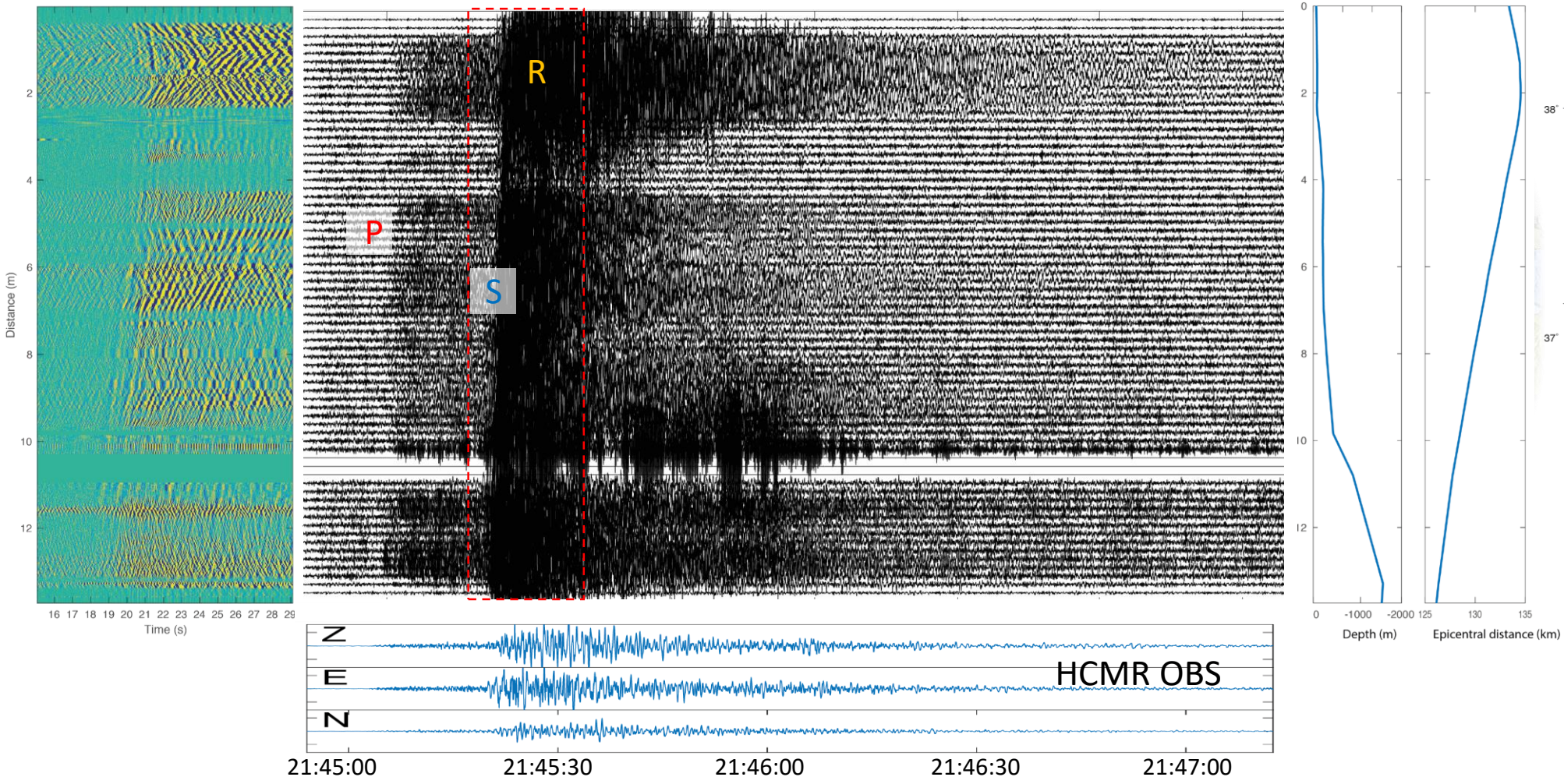




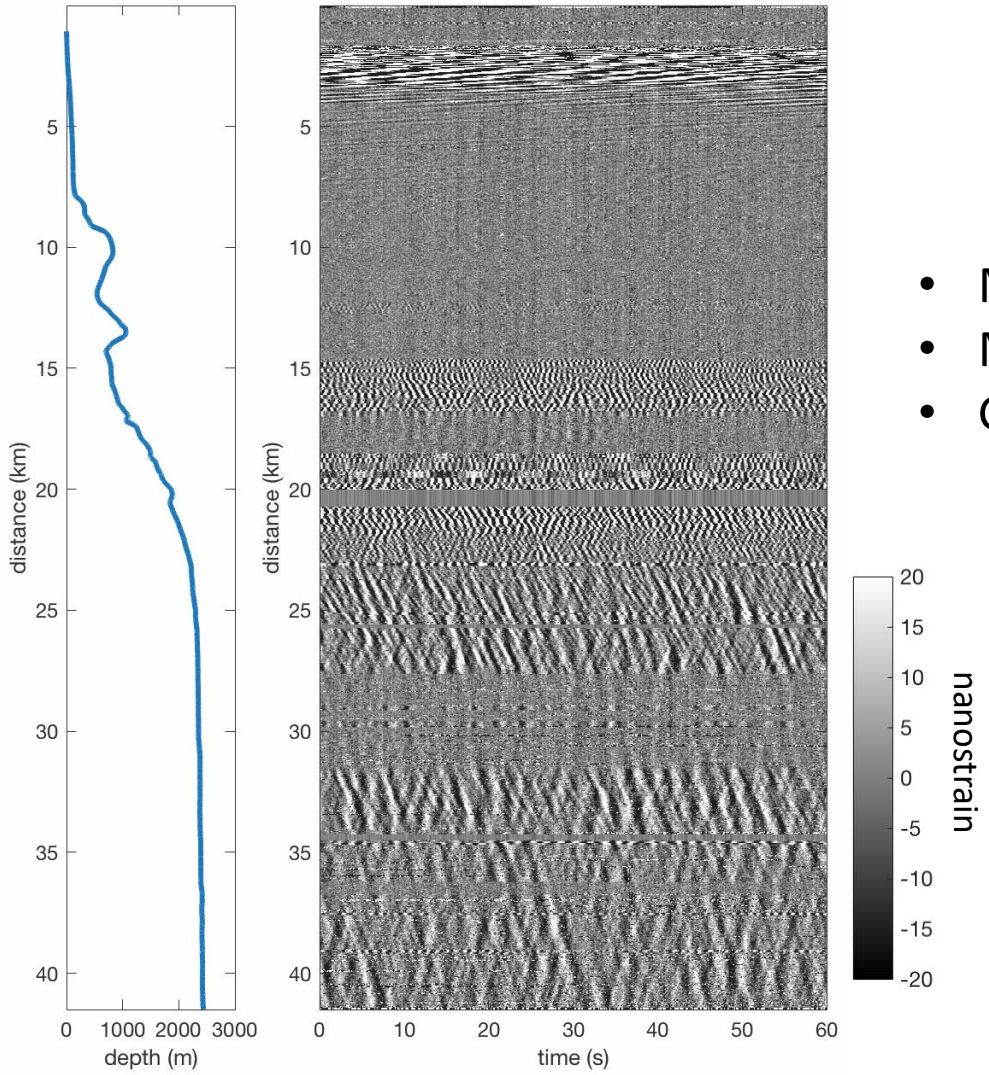




Earthquakes detection (regional M4.3 in Greece)

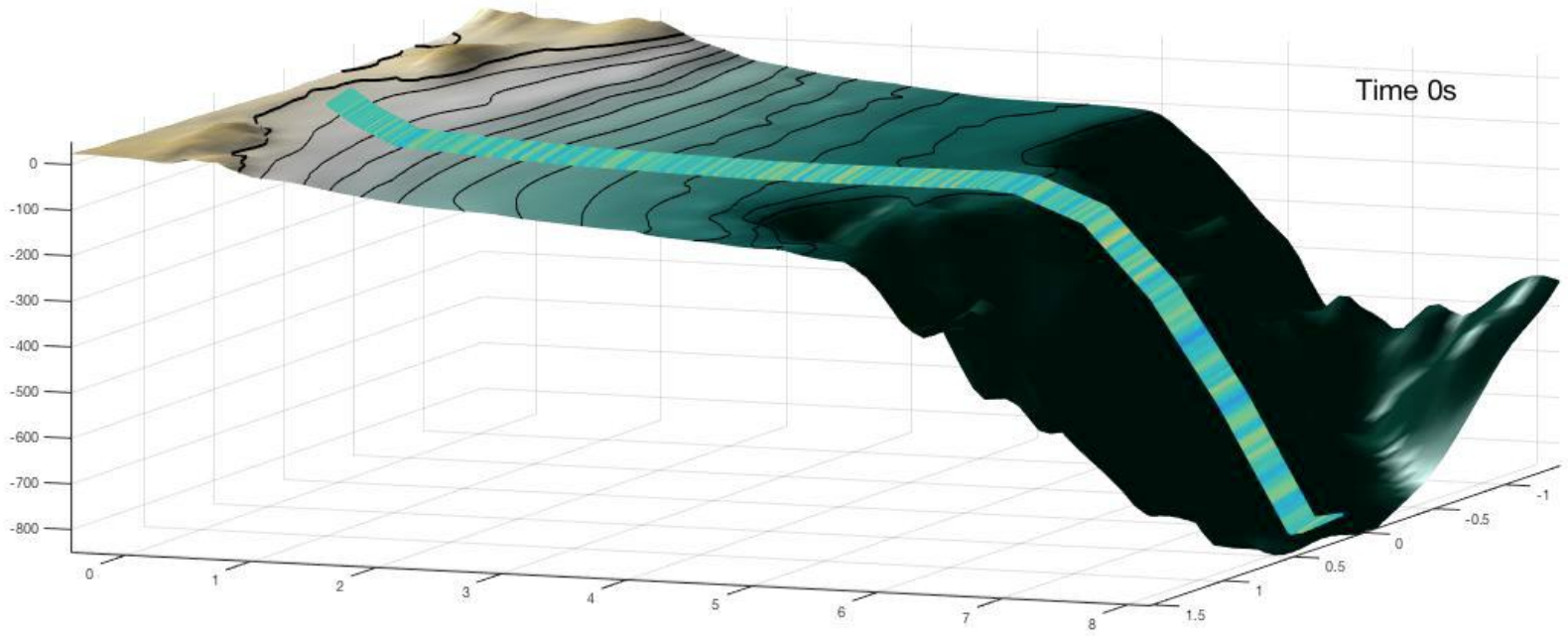


Ocean solid-Earth interactions

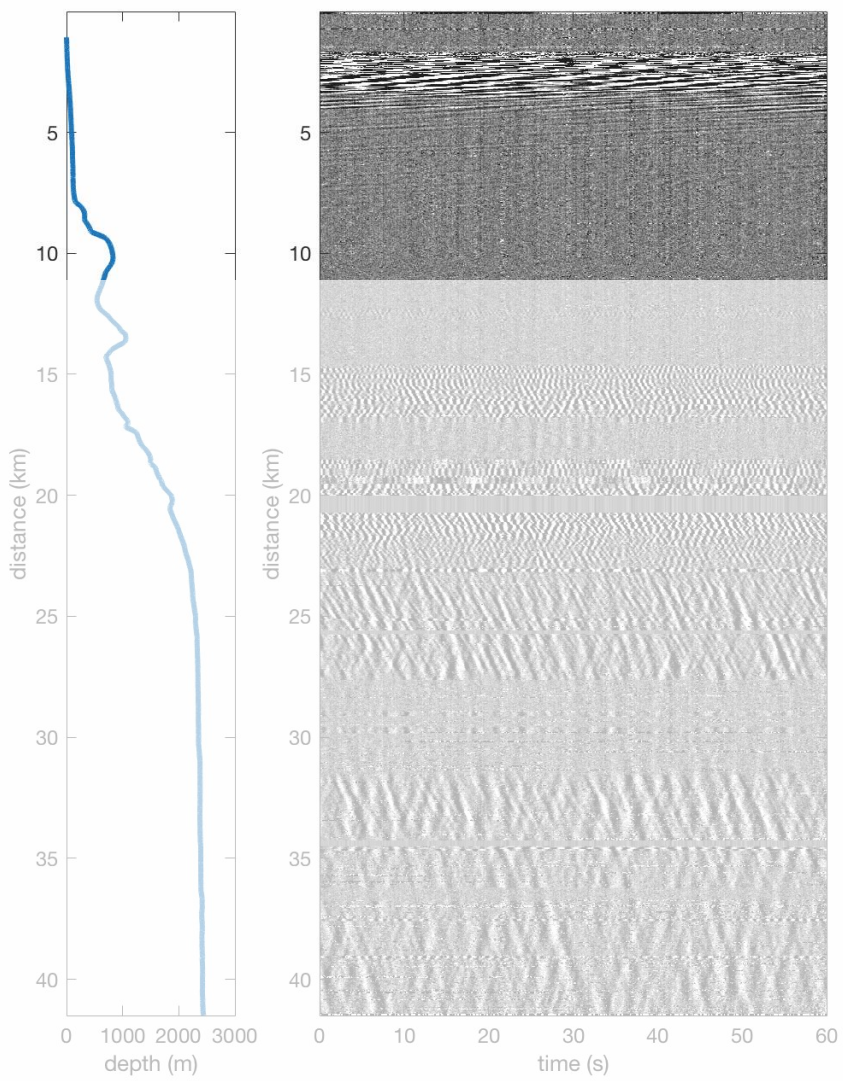


- Monitoring the evolution of different types of waves
- Multi-scale observation (m-km) of the wave-bathymmetry interaction
- Generation of microseismic noise

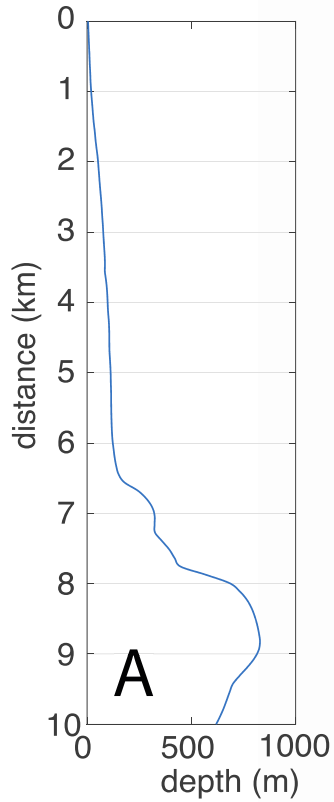
Gravity waves and primary microseism peak

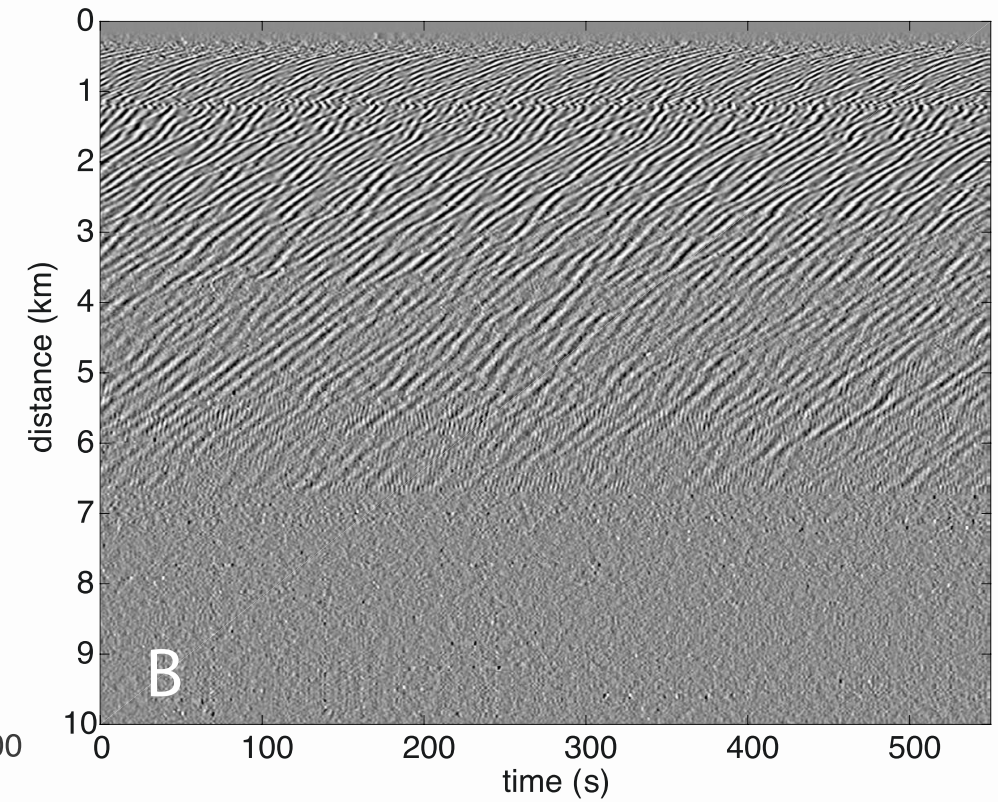


Gravity waves and primary microseism peak



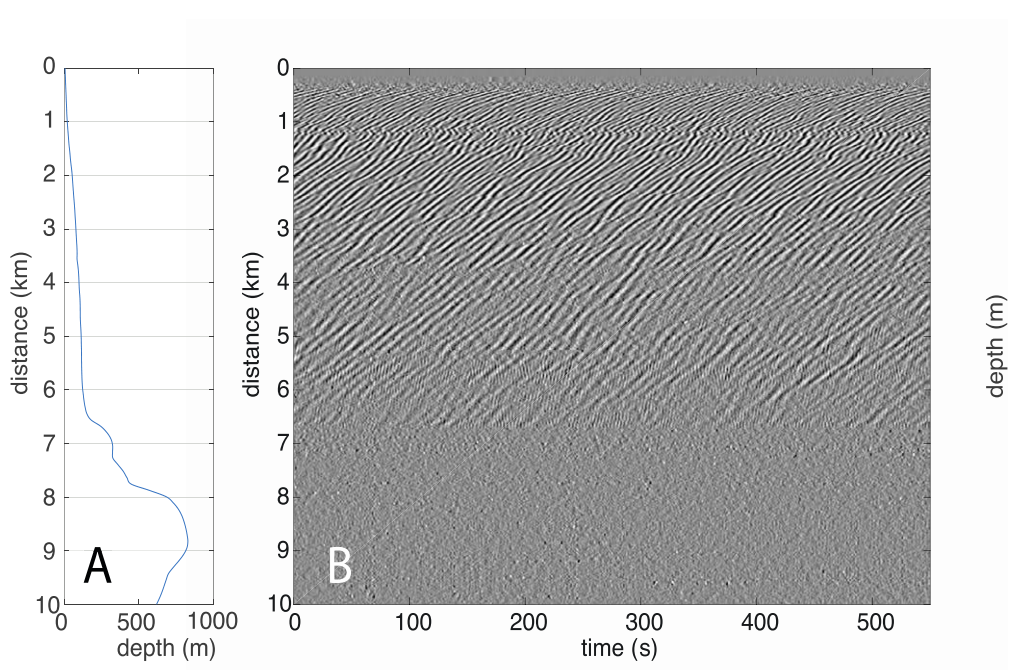
Depth < 100m

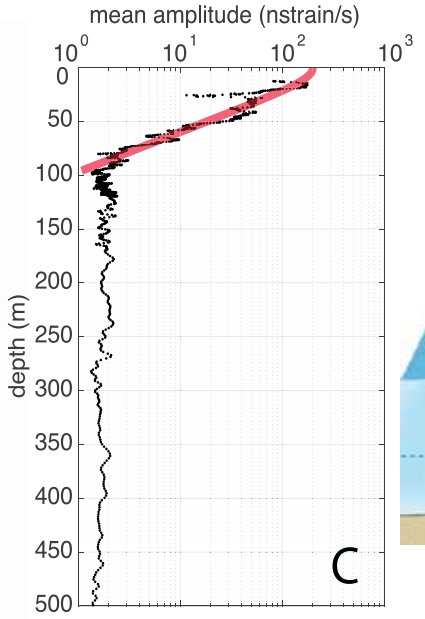


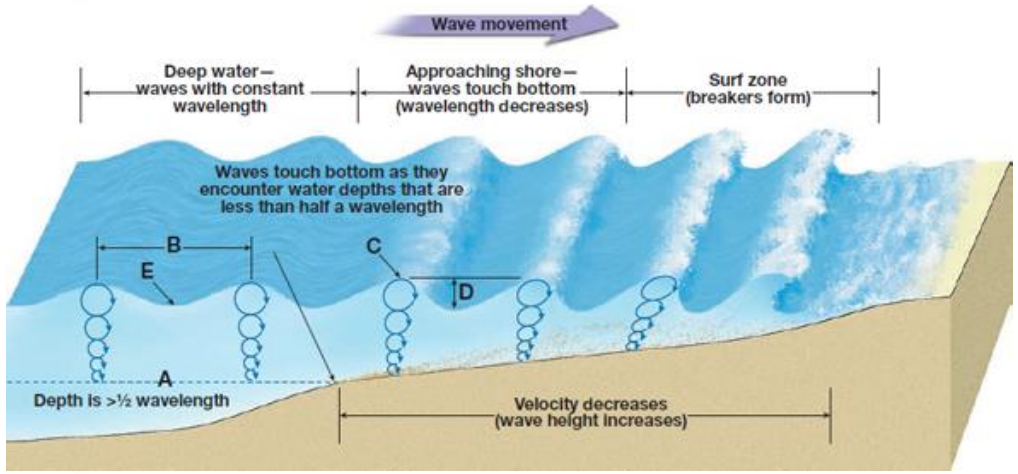


Gravity waves and primary microseism peak

Periodic oscillations 0.1 - 0.25 Hz, which propagate landward with **increasing amplitude**



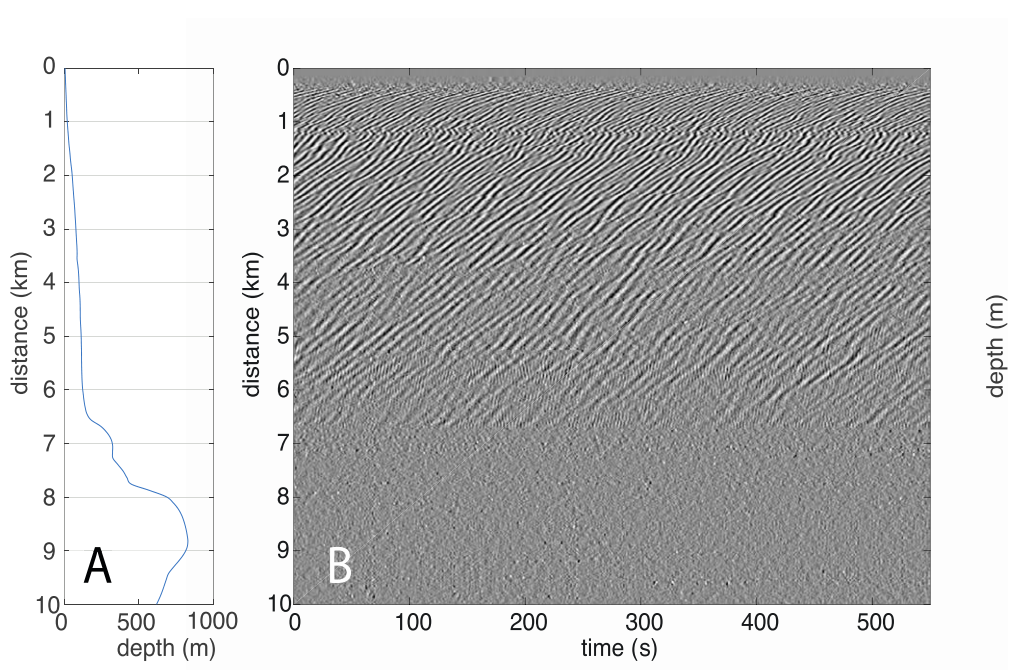


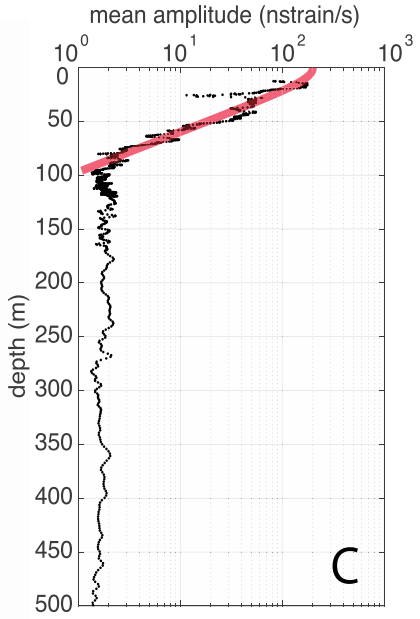


$$\frac{P_d(h)}{P_{d0}} = \frac{1}{\cosh(k.h)}$$

Gravity waves and primary microseism peak

Periodic oscillations 0.1 - 0.25 Hz, which propagate landward with **decreasing velocity**





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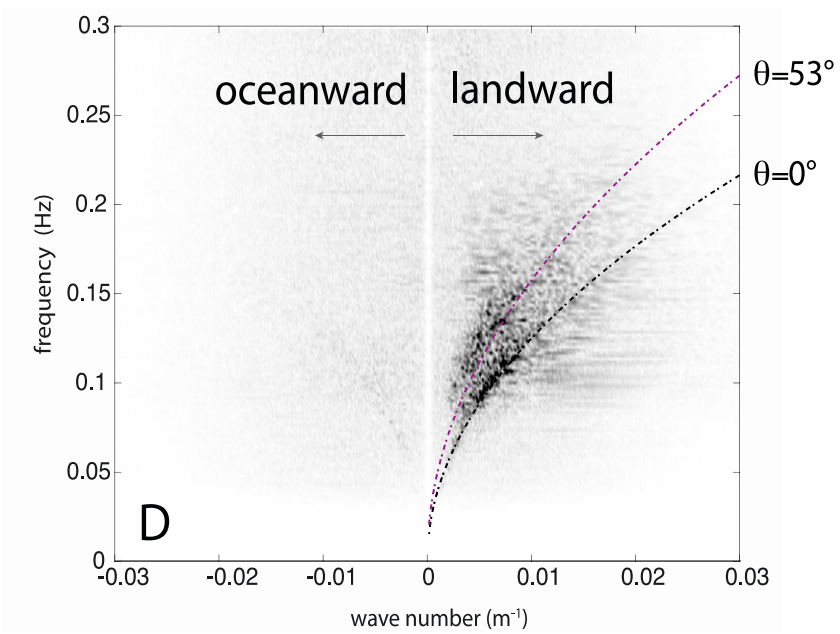
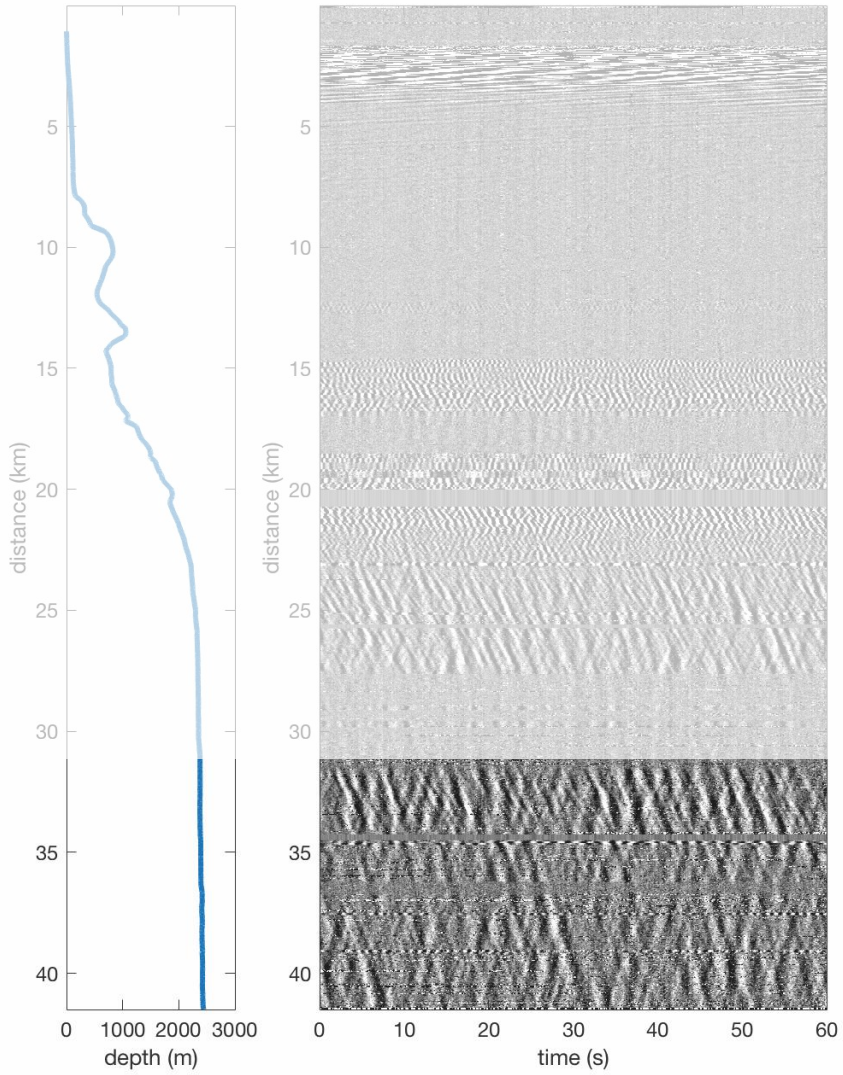
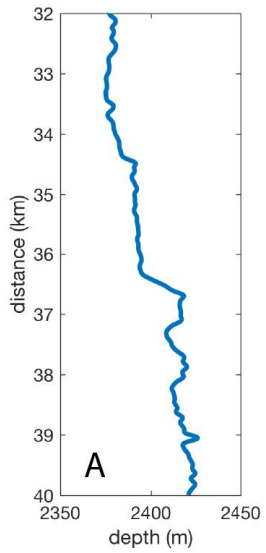
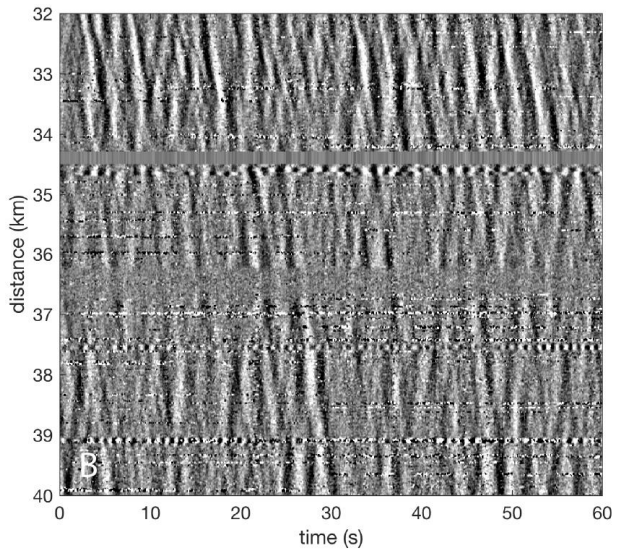


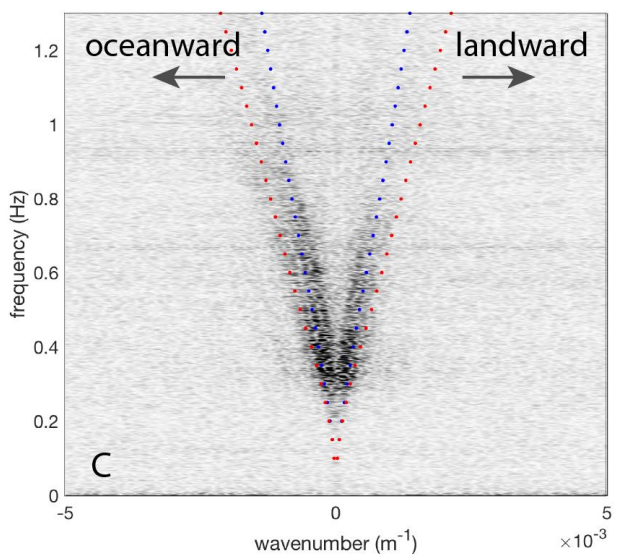
$$\omega = \sqrt{g.k.\tanh(k.h)}$$

Nonlinear interaction - secondary microseism peak









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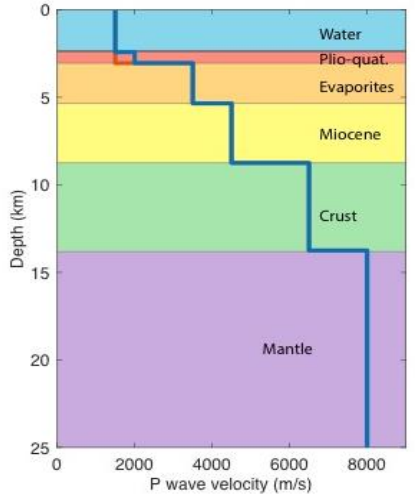
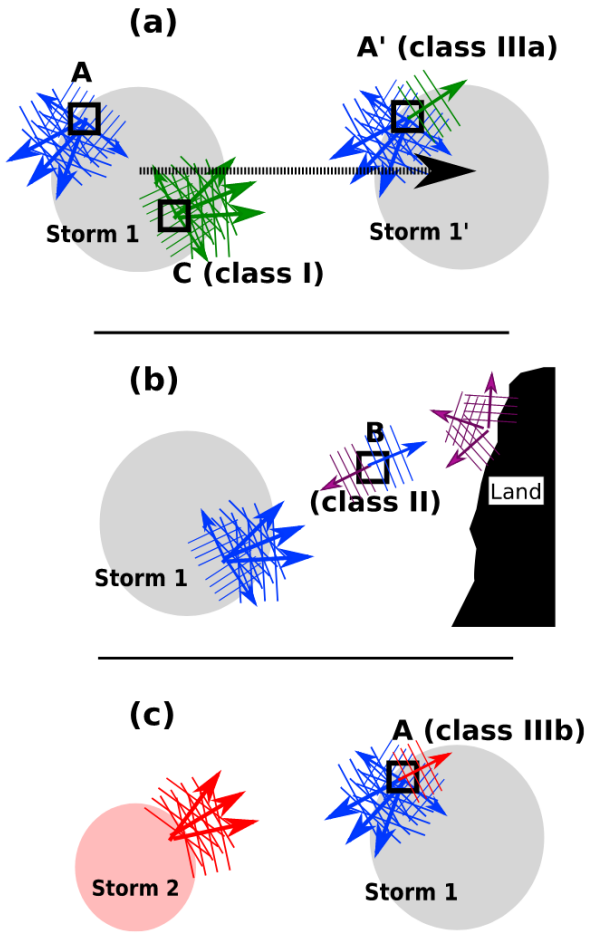
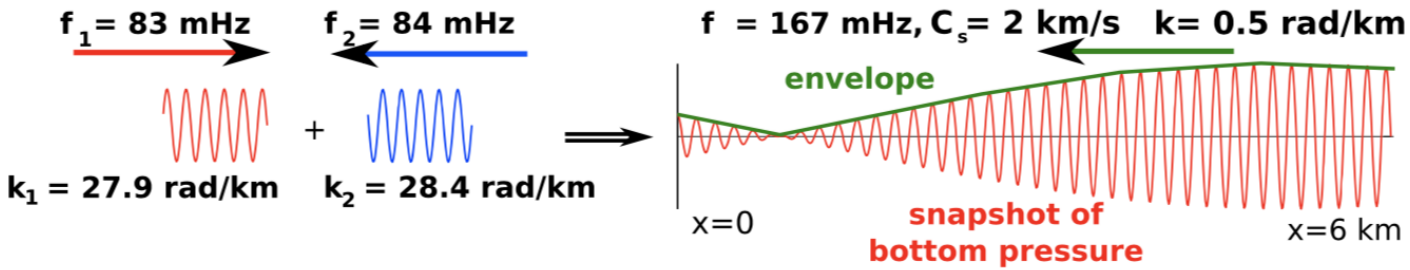


Nonlinear interaction - secondary microseism



Ardhuin 2011

Longuet-Higgins (1950) showed that the unattenuated second-order pressure term in a standing wave pattern, was capable of generating microseisms.



Gualtieri et al. 2014

Conclusion and perspective

- **Dense spatial and temporal sampling** of seismo-acoustic signals, in the oceans and along their margins

  Better detection and localization of small magnitude offshore events (EQ, LP, tremors)

  High resolution crustal imaging and monitoring

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- **Standard range of DAS systems is about 50 km on a standard optical fiber**. This range already opens the ways to many applications, such as the monitoring of active and passive margins, thus encompassing most marine and geologic processes (e.g. subduction earthquakes, landslides, coastal erosion processes).

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Bidirectional amplifier

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- Most existing cables were installed in the mid-2000's and will have to be replaced in the next decade

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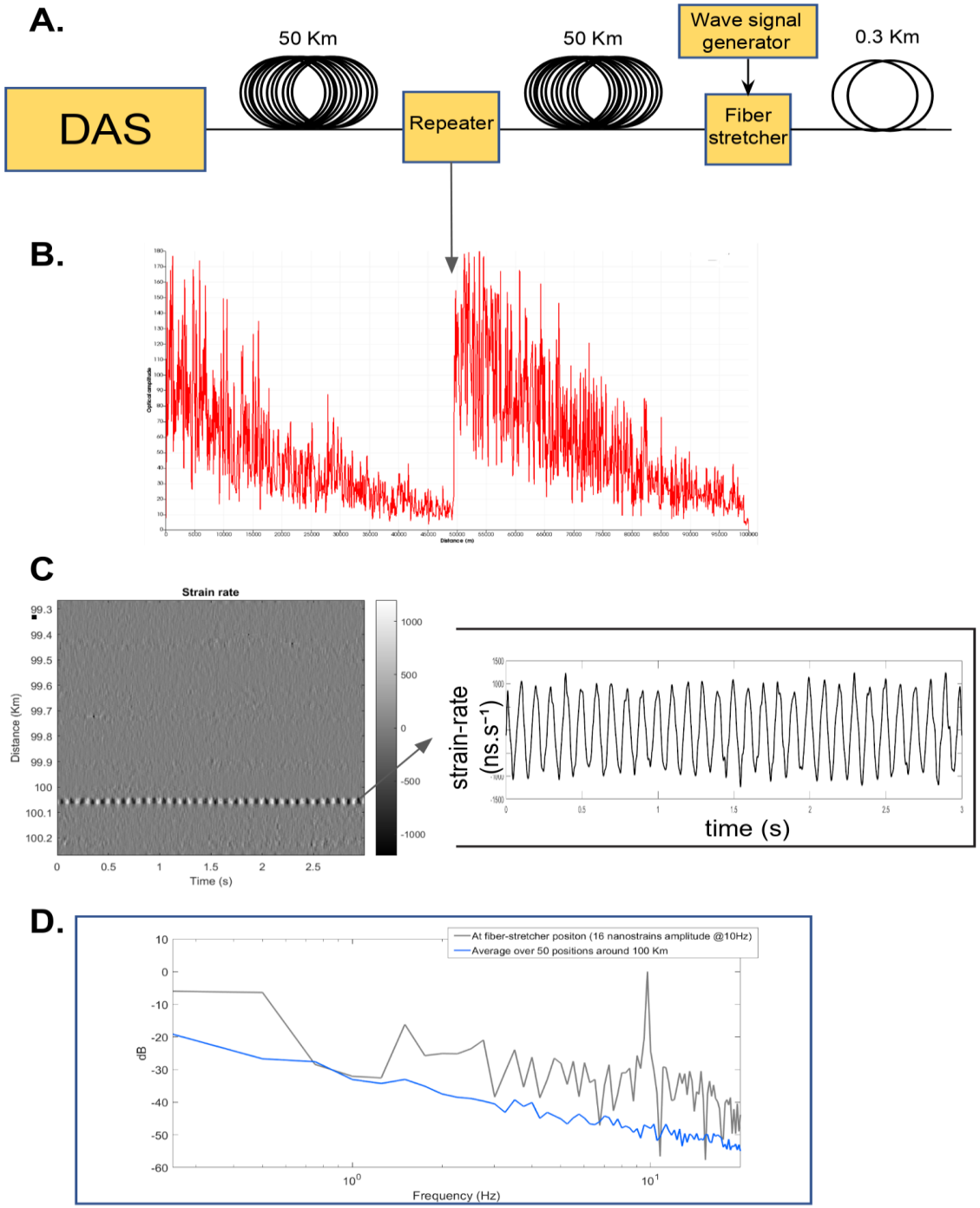

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