Long-term hydroacoustic monitoring in the Atlantic and Indian oceans

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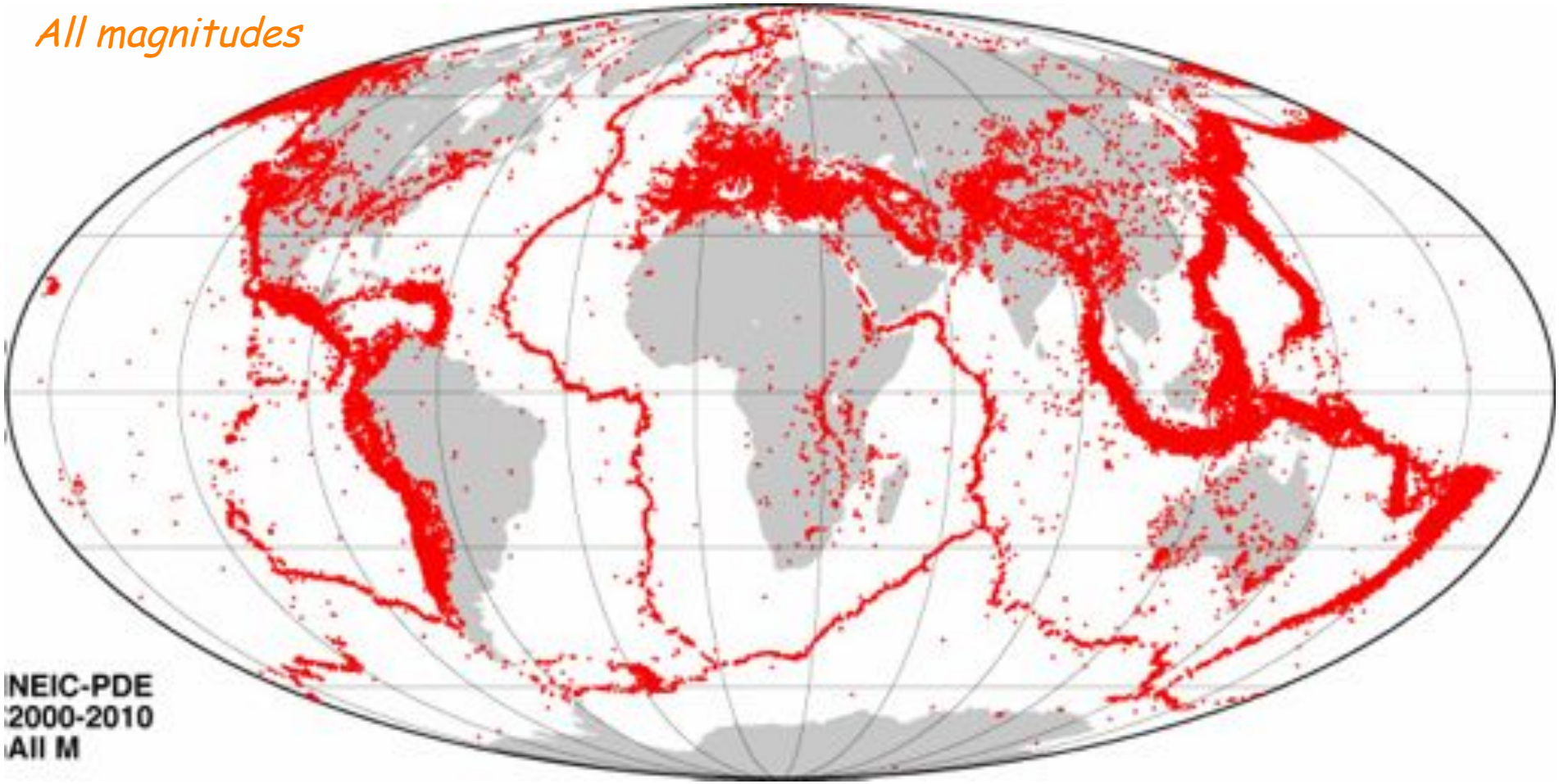
Global seismicity 2000-2010

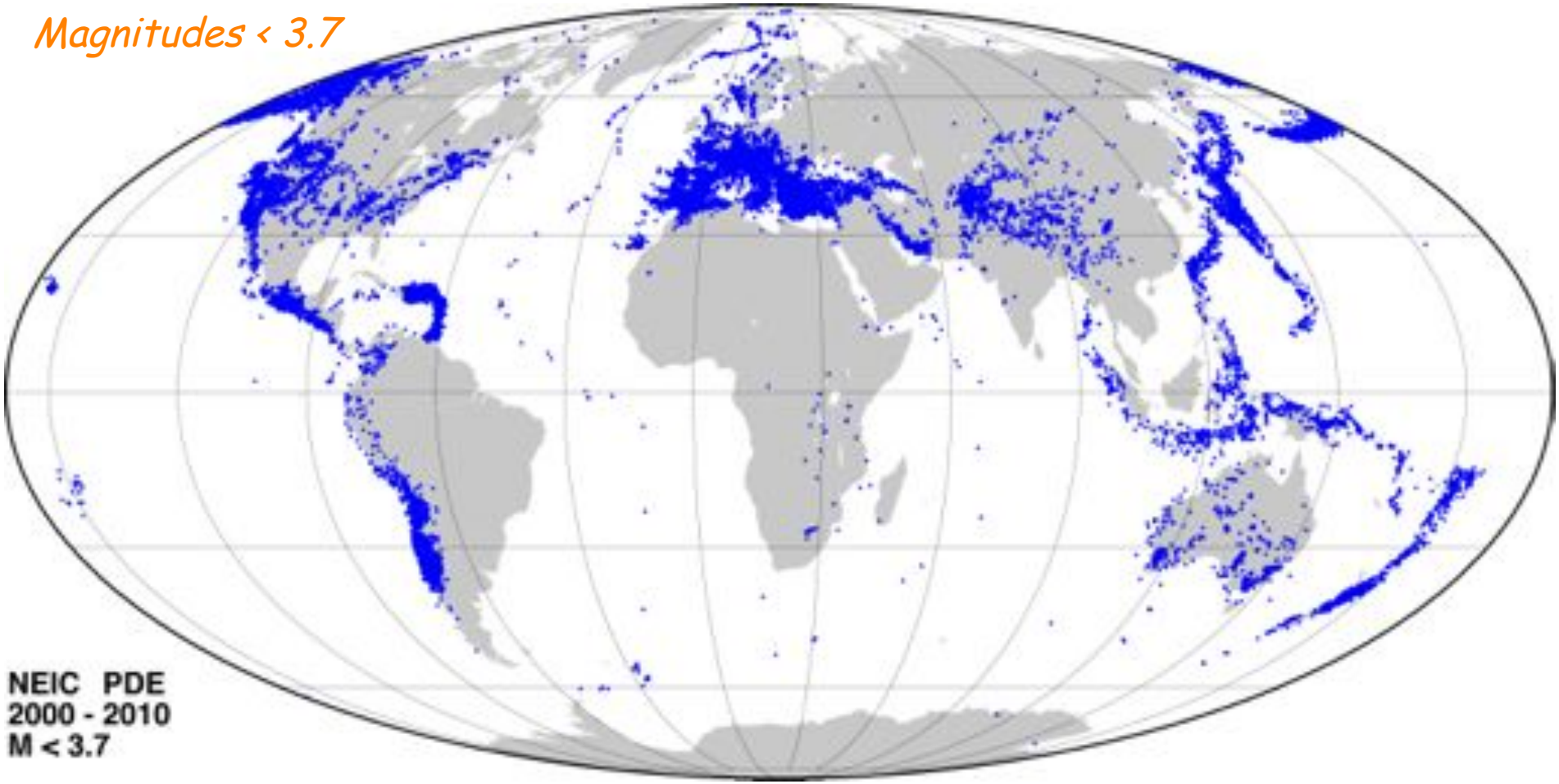
From land-based seismological networks



Global seismicity 2000-2010

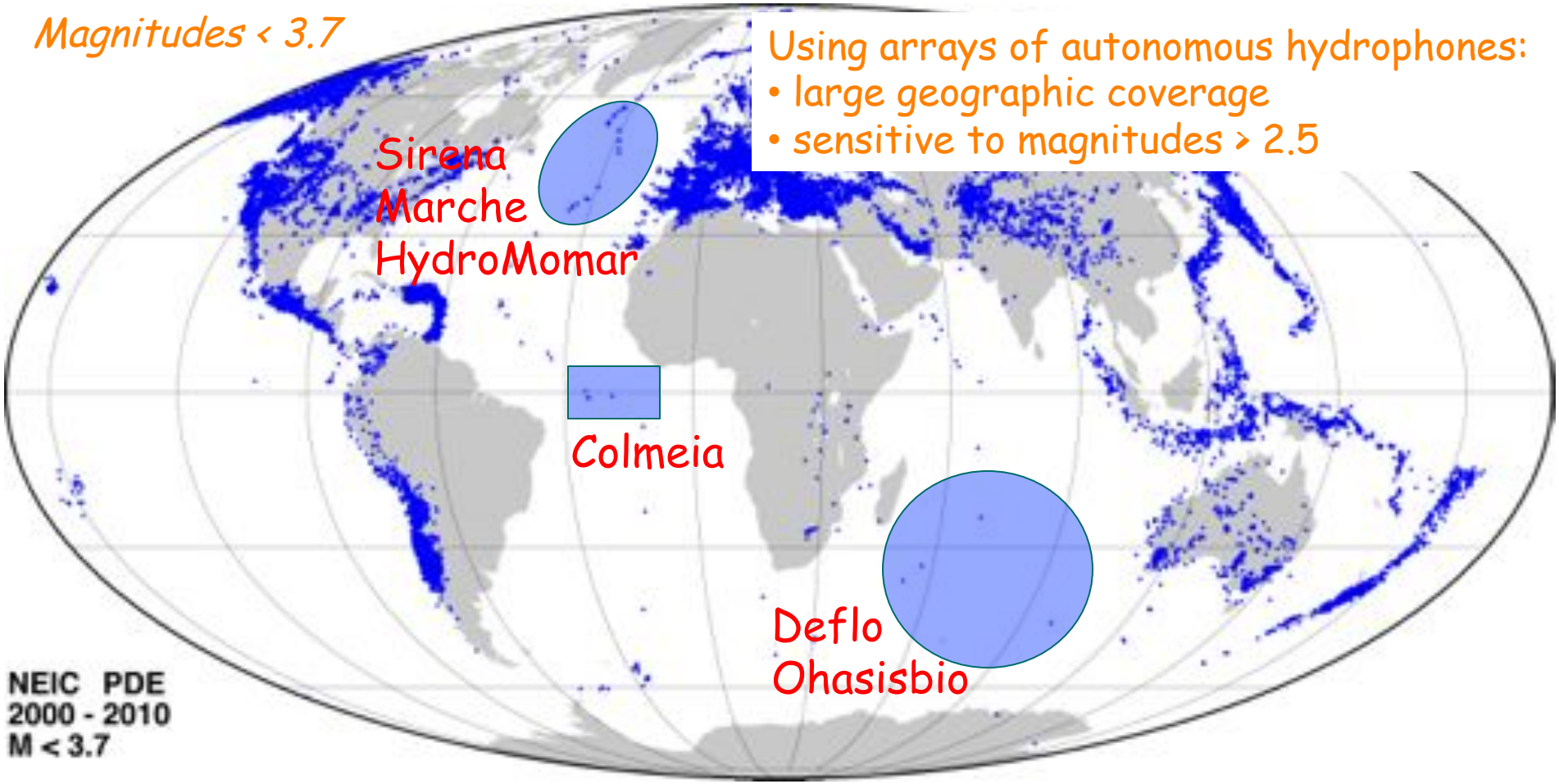
From land-based seismological networks

Magnitudes < 3.7



Global seismicity 2000-2010

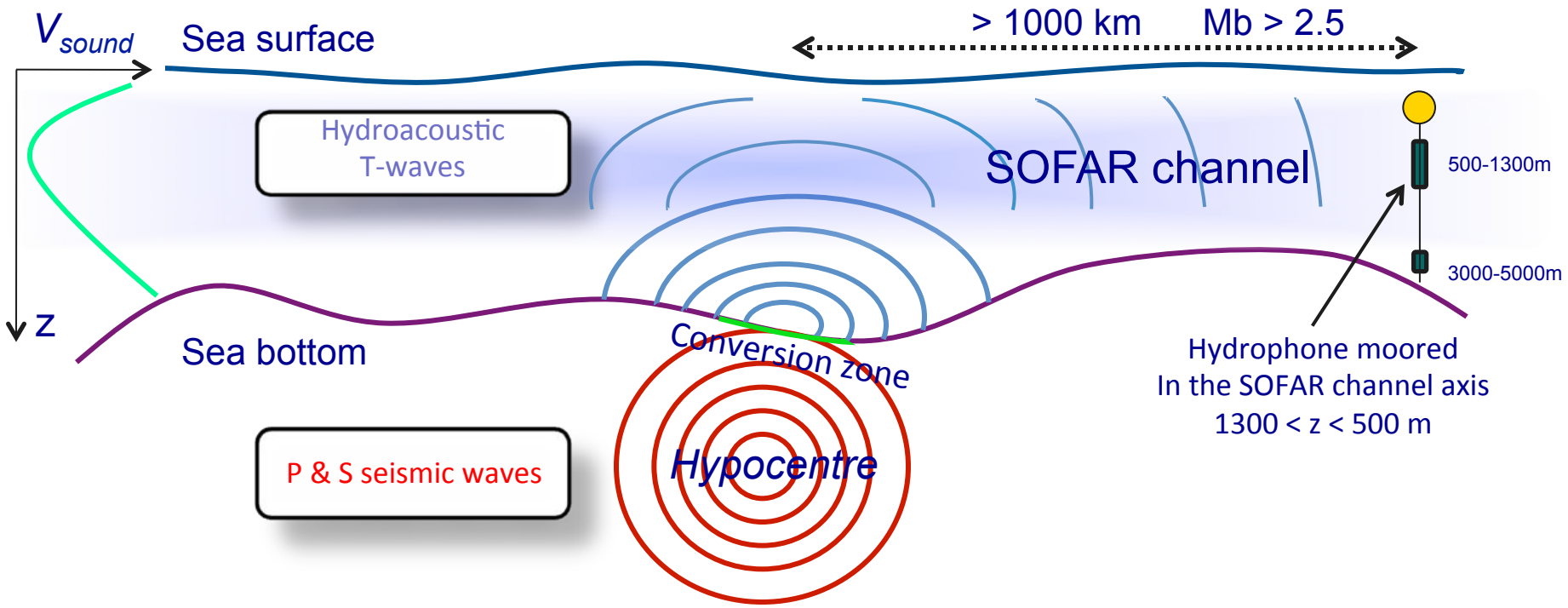
Objectives: capture the low-level seismic background associated with seafloor spreading ridges



Principle of an hydroacoustic observatory

Long-term deployment of autonomous hydrophones

in the « Sound Fixing And Ranging » channel



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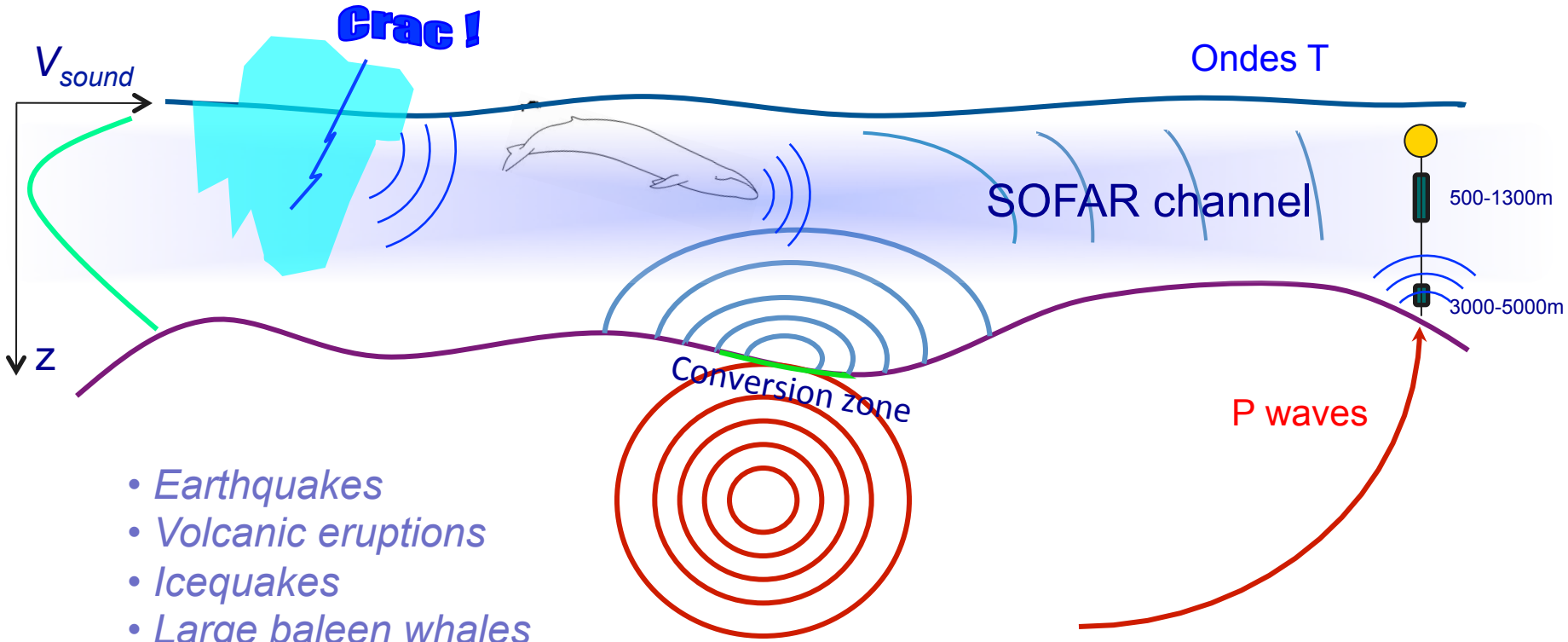
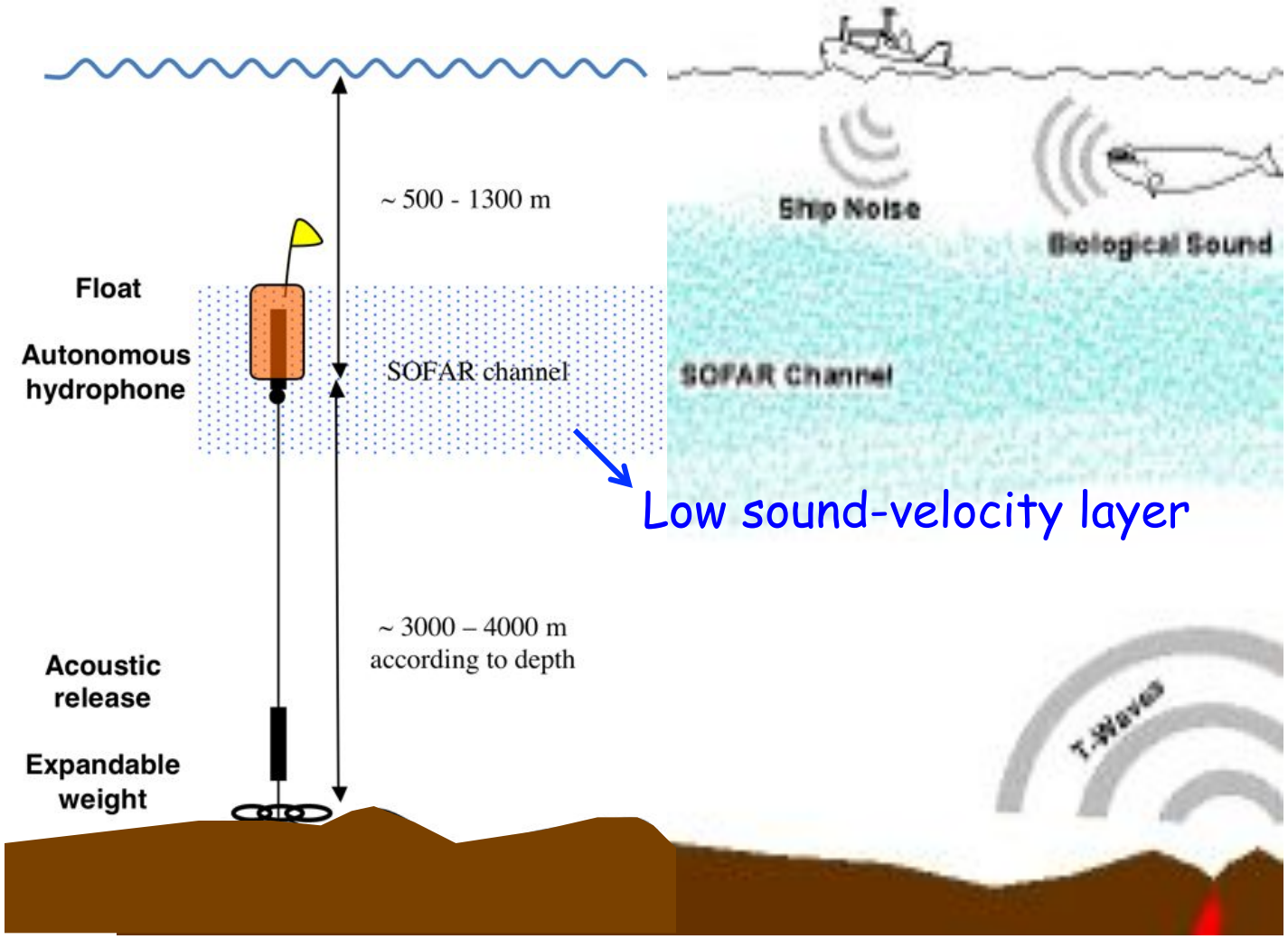
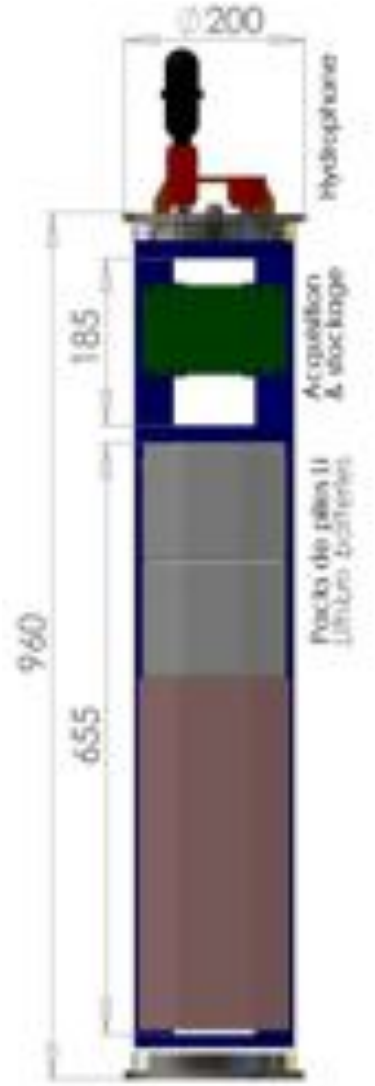


- *Earthquakes*
- *Volcanic eruptions*
- *Icequakes*
- *Large baleen whales*
- *Microseismic noise*

Hydroacoustic mooring



Autonomous hydrophone



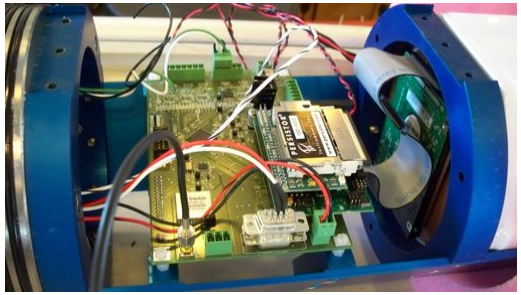
Instrument configuration

- Continuous recording
- 240Hz sampling rate
- 24 bits encoding
- SSD storage (~24 Gb/yr)
- High precision clock (10^{-8})
- 18 to 24 month autonomy

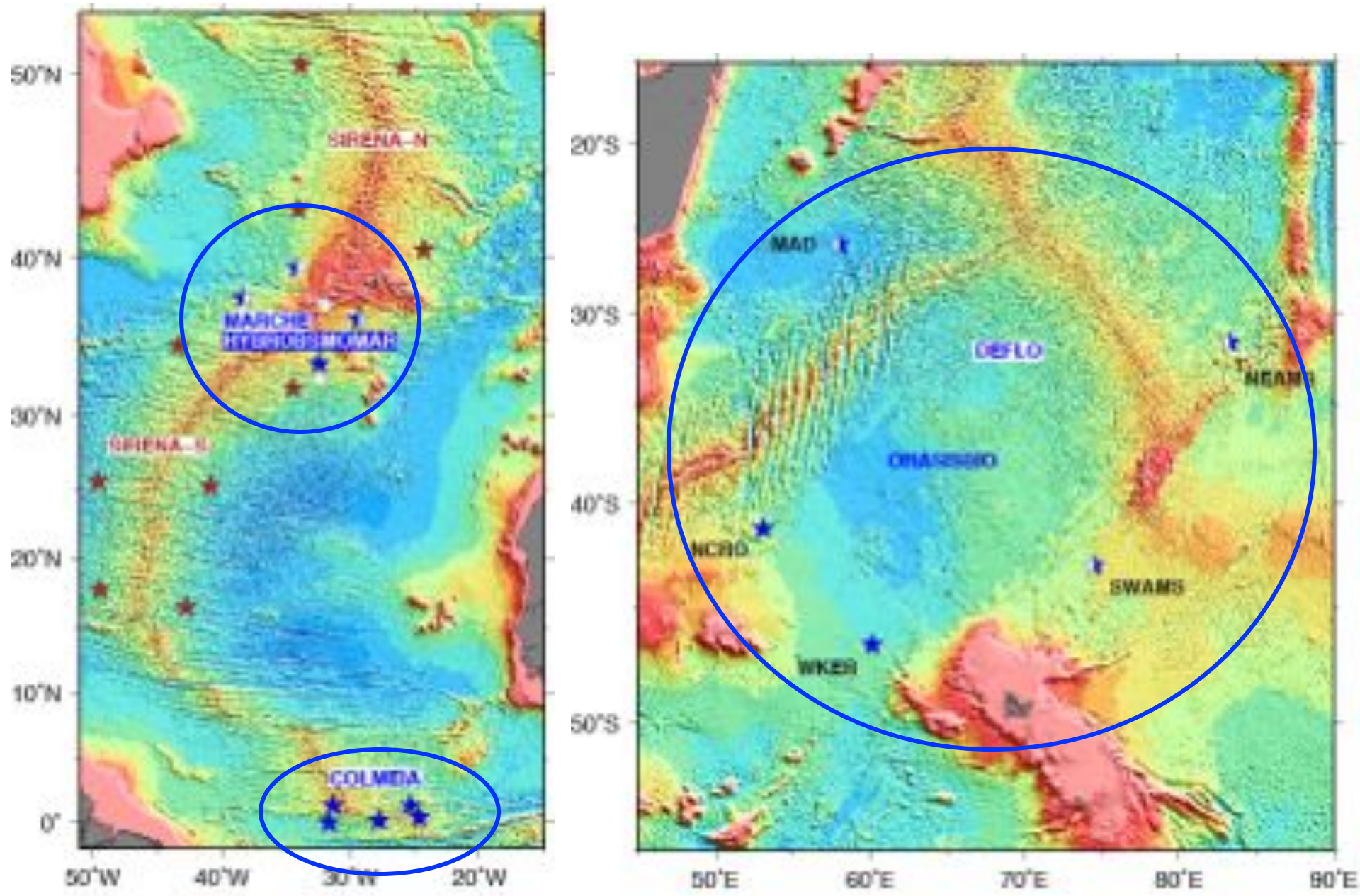
Costs

- 40 000 € HT/mooring
  - 1/3 instrument
  - 2/3 mooring
- Deployment: ~2500 € / instrument
  - Lithium batt., anchor, chandlery

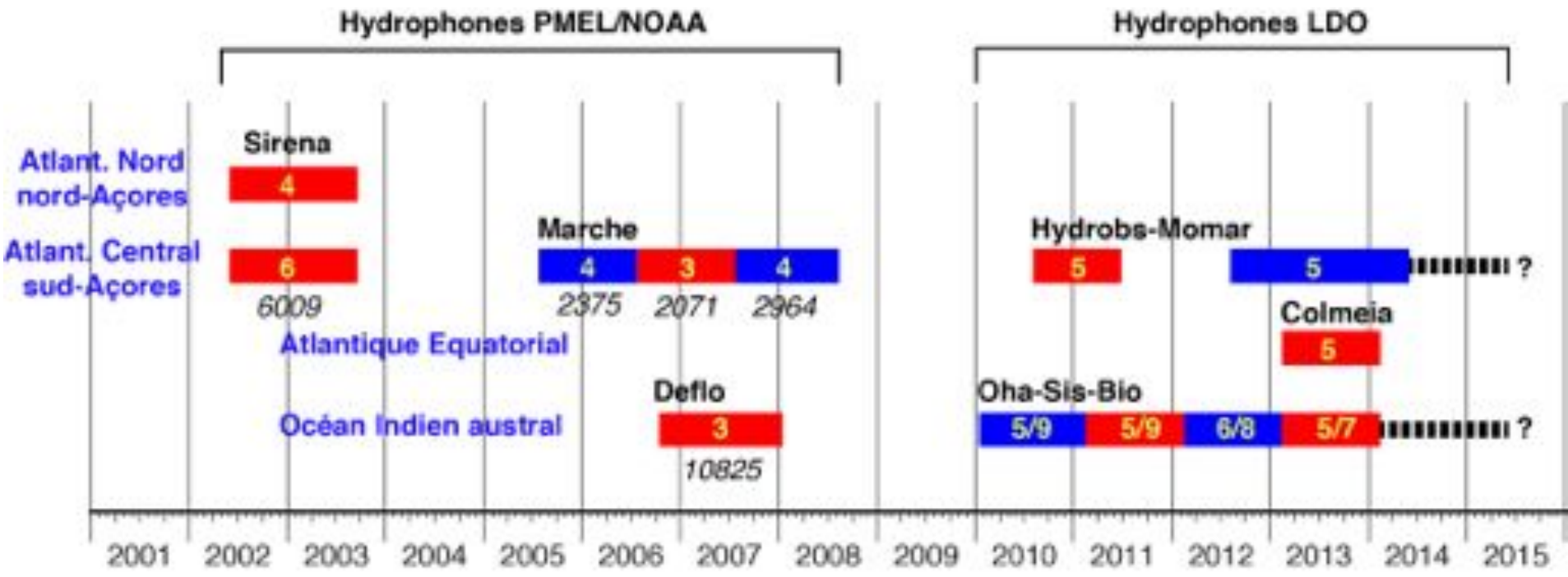
\+ ship-time !!!



Past and current experiments



Hydroacoustic experiments



Nbr of events in catalogs

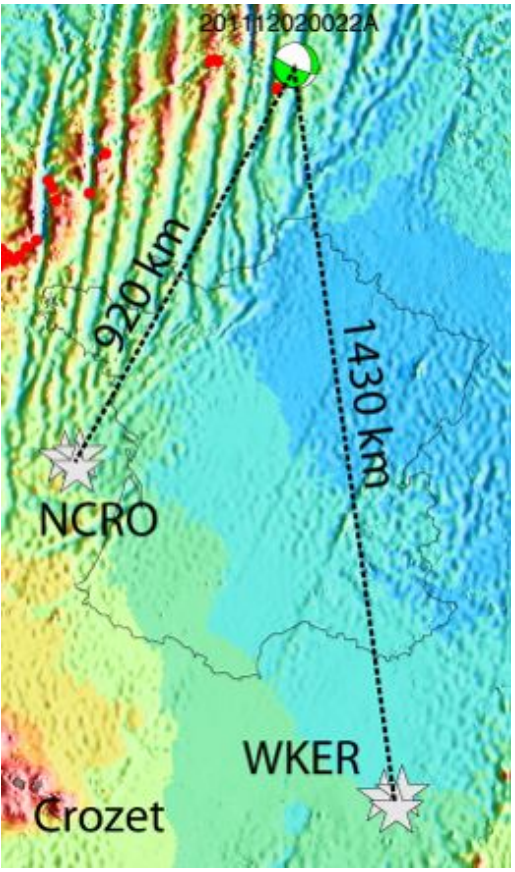
nbr of hydrophones
or
nbr of sites / nbr of instr.

- 19 cruises
- ~ 15 years of data available in 2014
- Catalogs of 13419 events in the Atlantic Ocean
  and 10825 events in the Indian Ocean

Records from the Indian Ocean

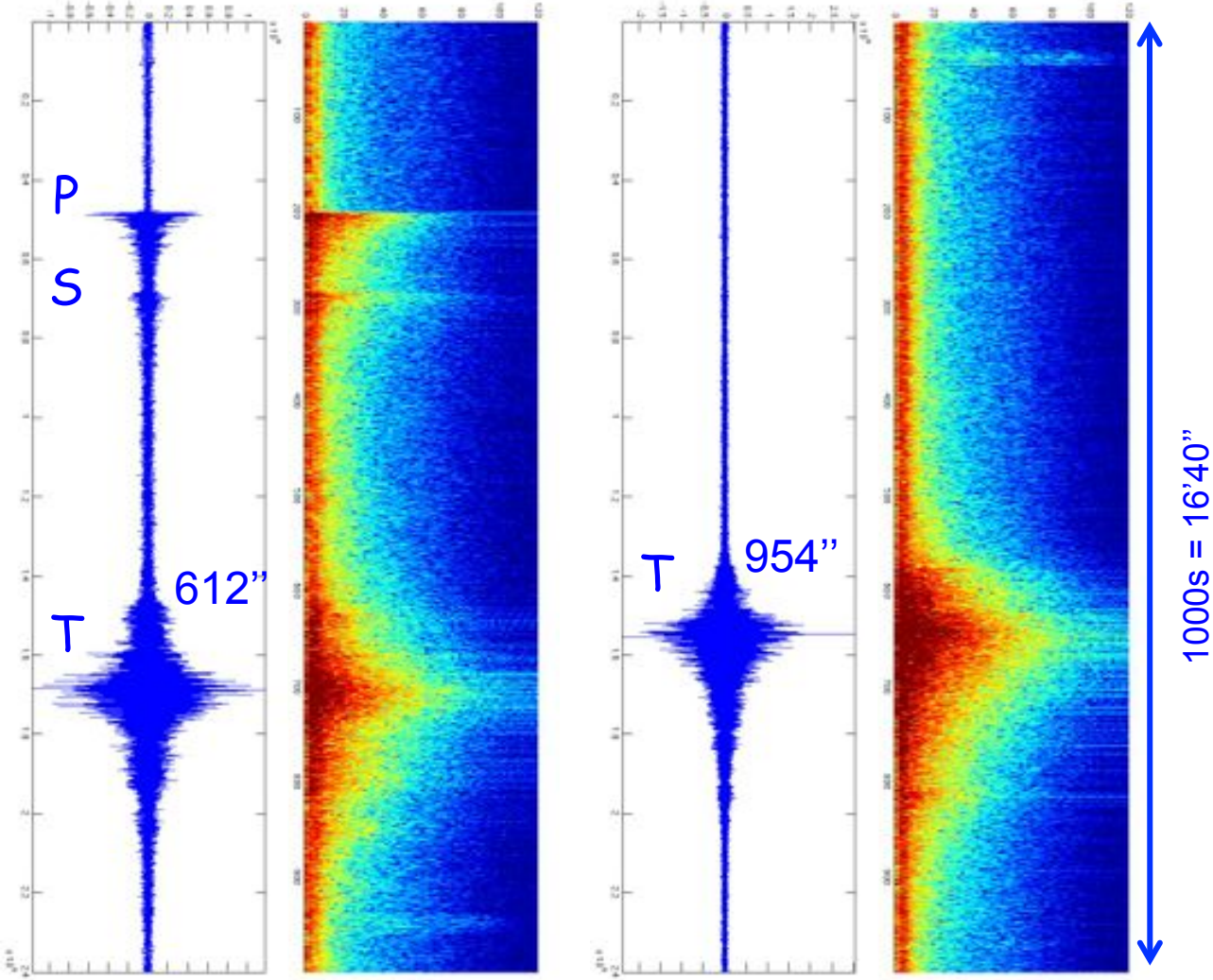
Mw=5.6

2 déc. 2011 à 00h22



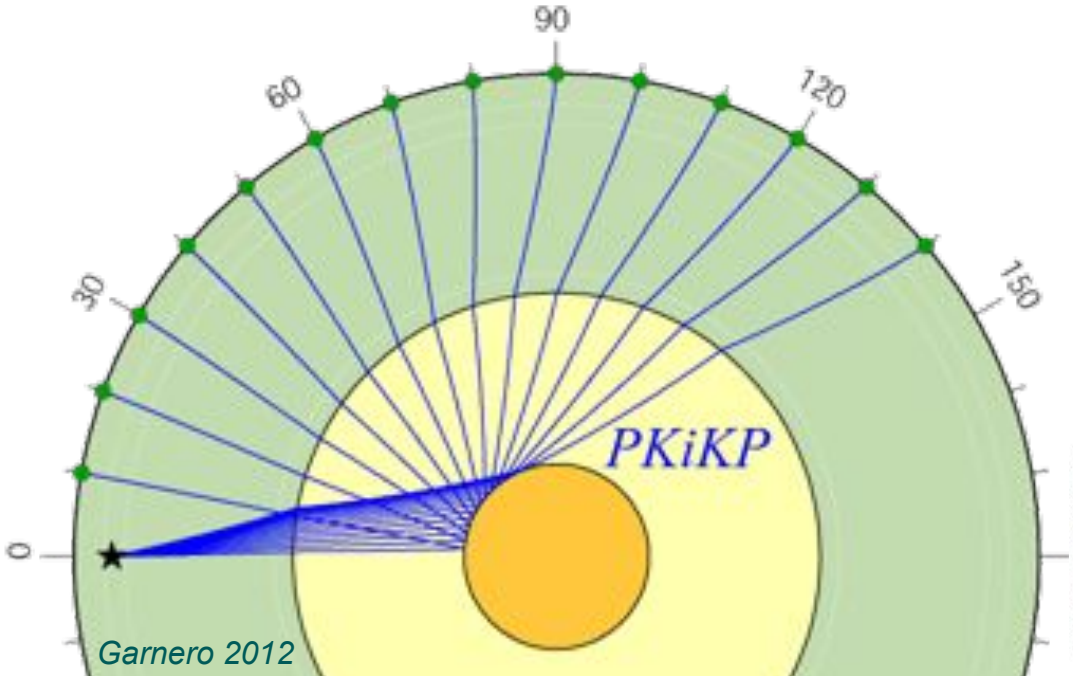
NCRO2-2011

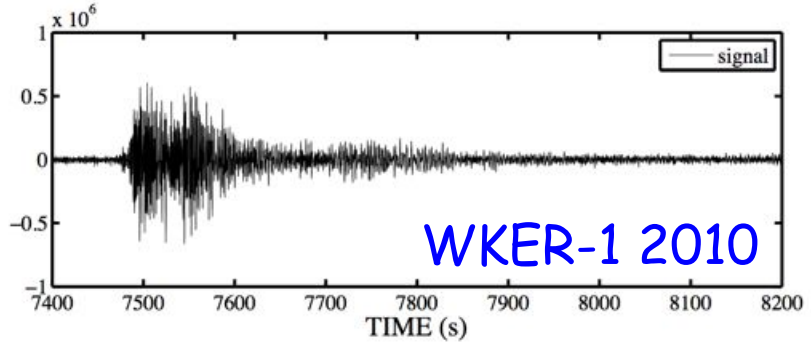
WKER1-2011

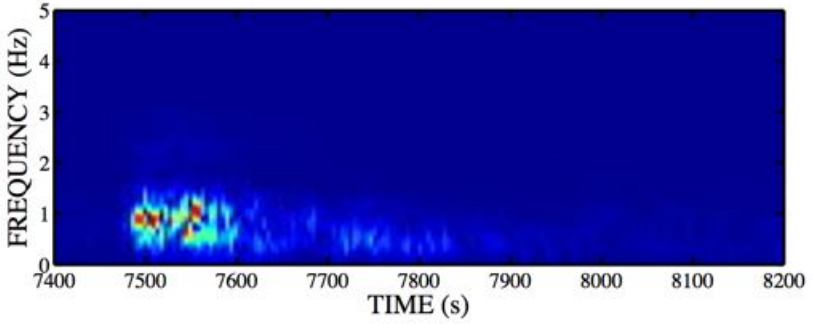


Teleseismic P-waves

- *A way to fill ocean gaps in Earth tomography data base*





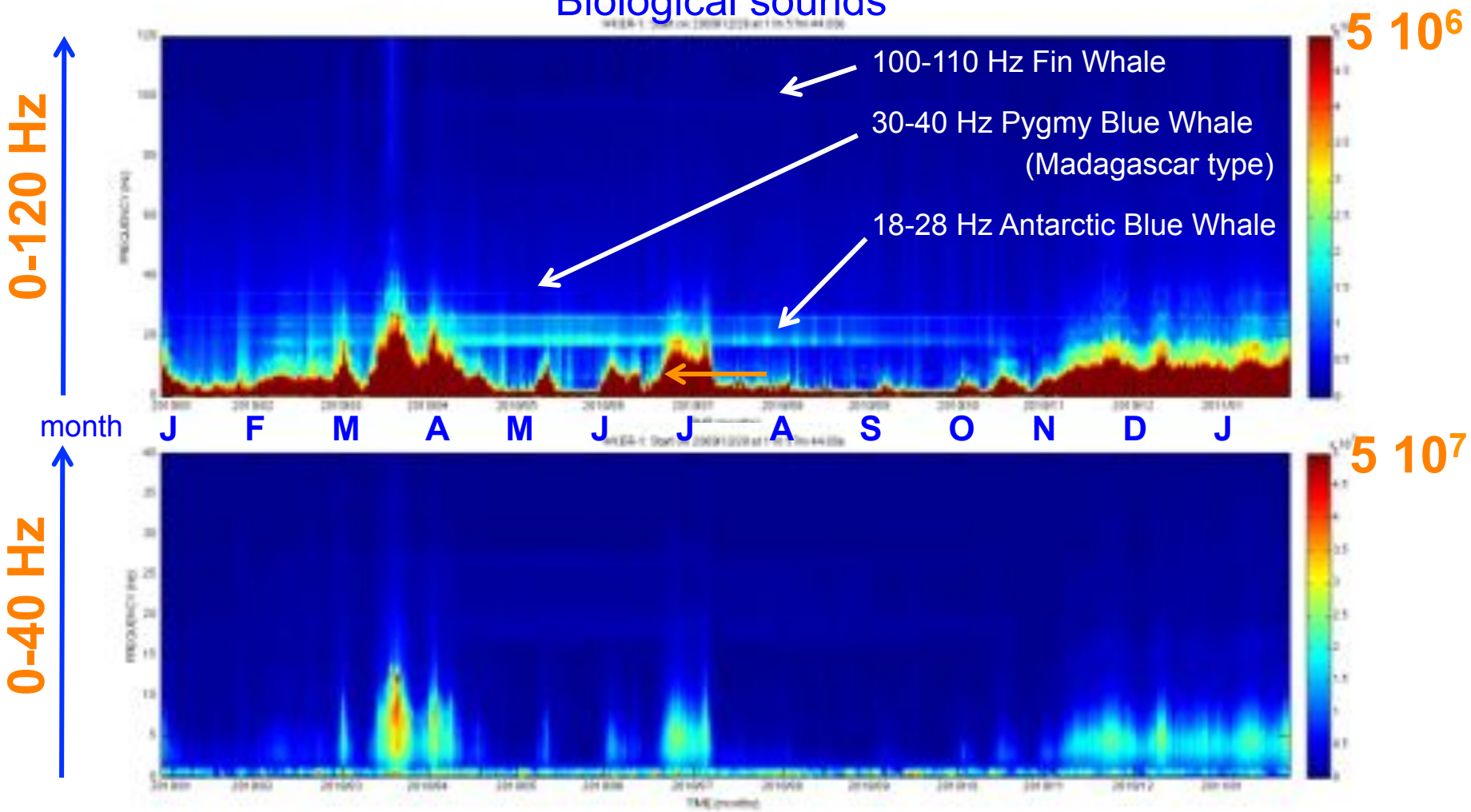


Feb. 27, 2010 06h34 event off Chile
Mw=8.8 D=87°=9700 km

Hydrophone WKER-1 2010

46°S Southern Indian Ocean

Biological sounds

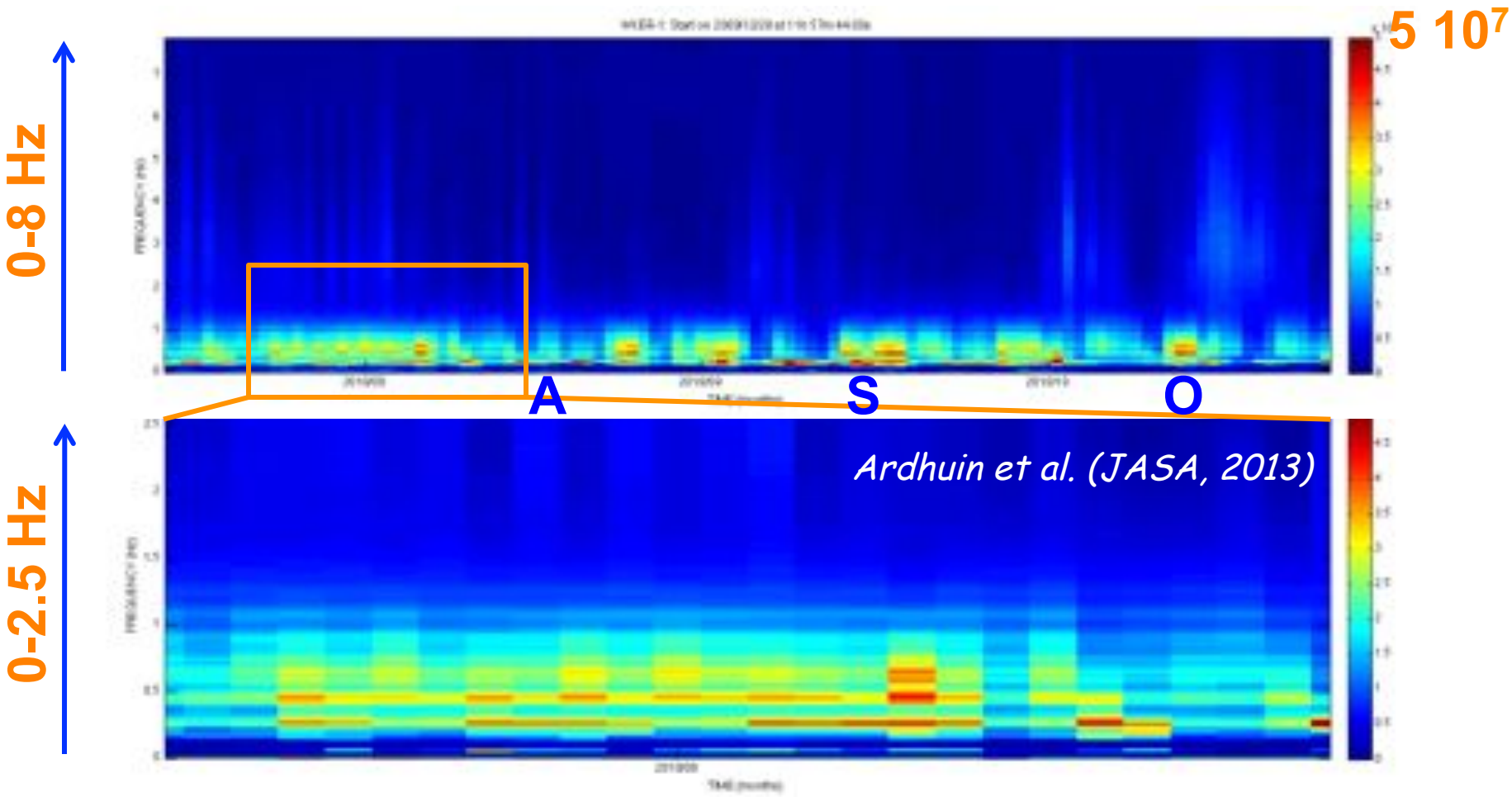


Earth related sounds

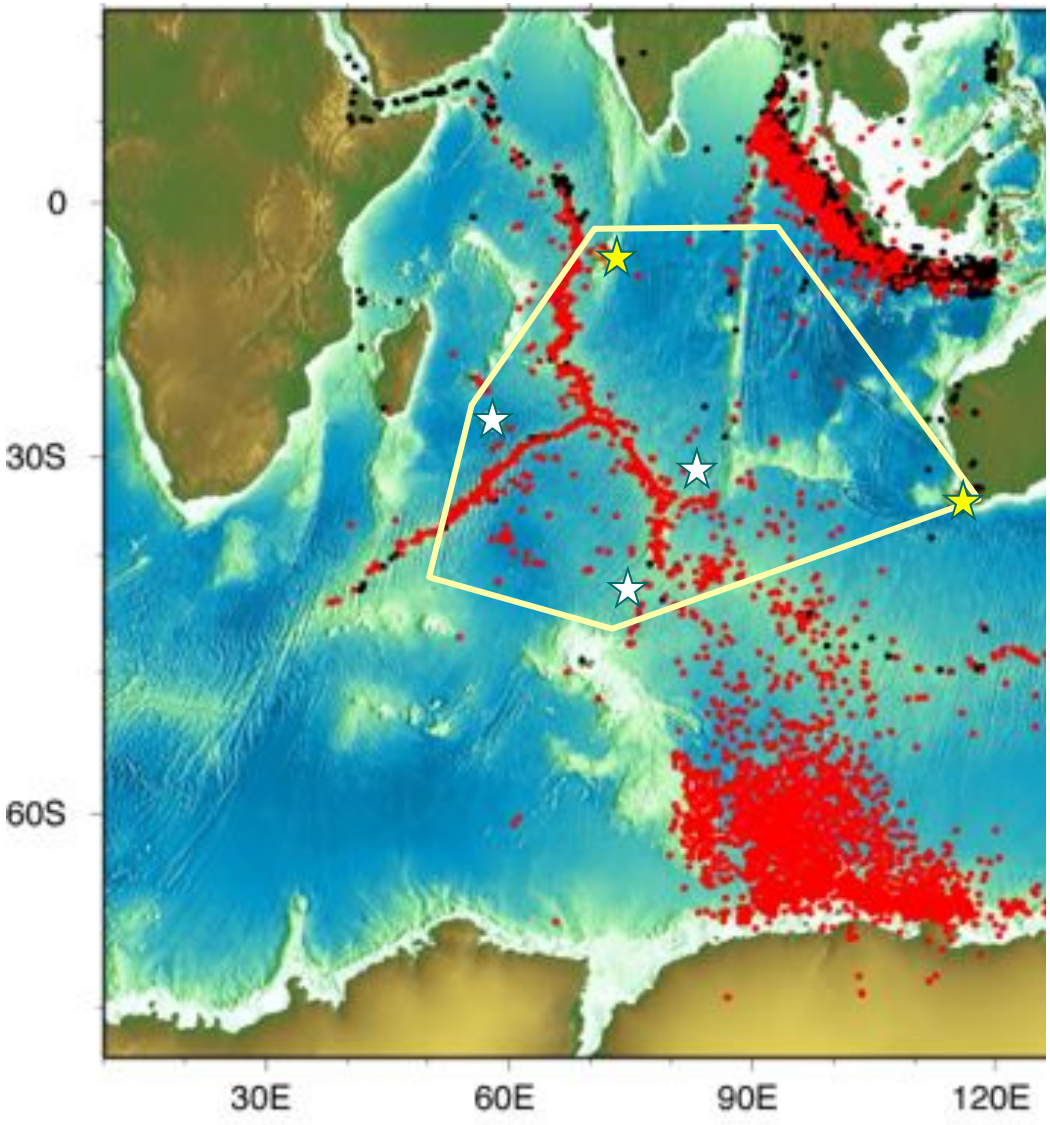
Hydrophone WKER-1 2010

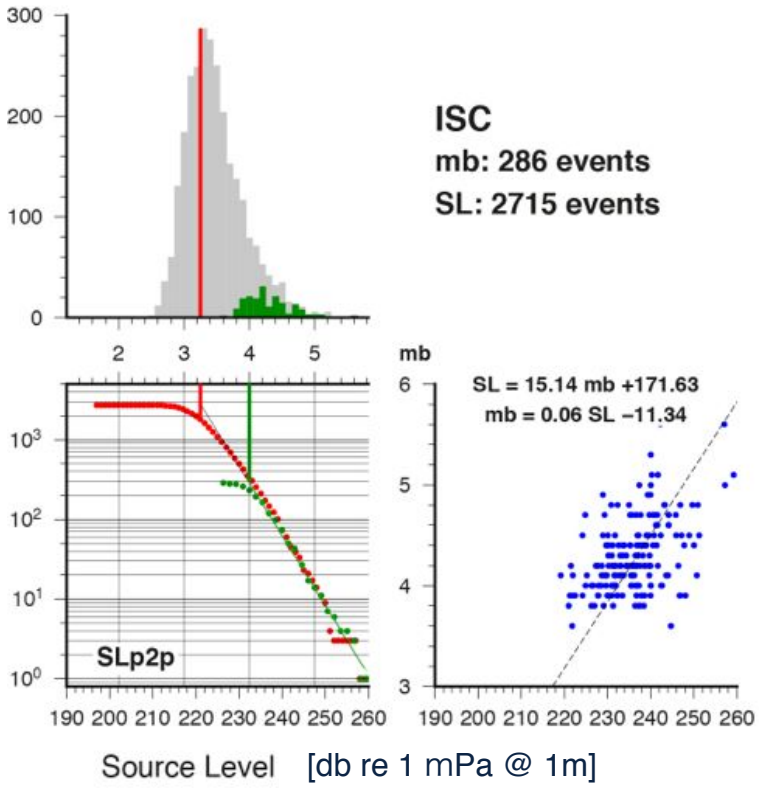
46°S Southern Indian Ocean

- VLF recording of the sea-state



Deflo array (oct. 2006 - jan. 2008) : > 10000 detected events





Level of completeness :

- hydrophones **SL=220**
- hydrophones **mb≈3.2**
- ISC **mb=4.0**

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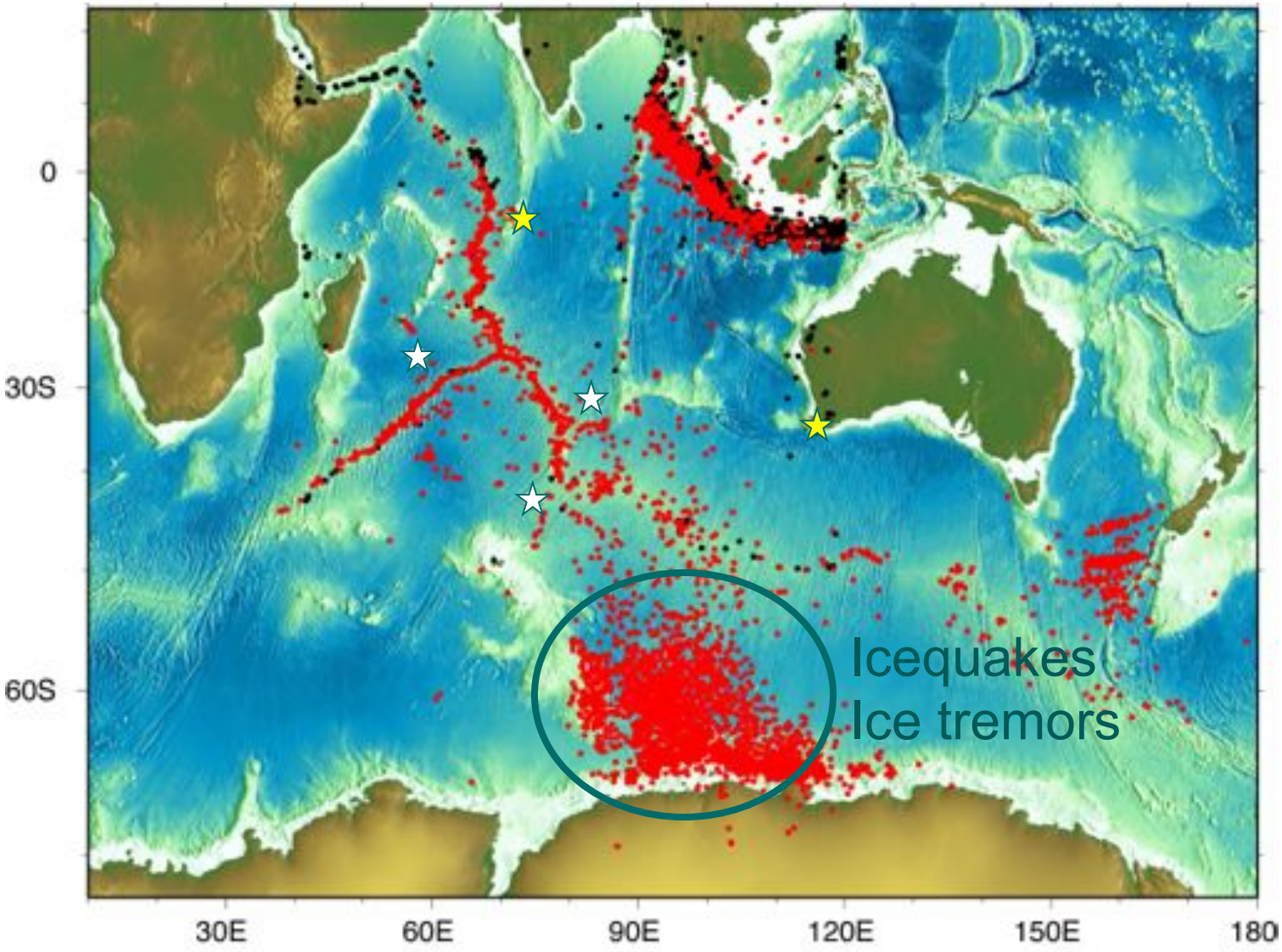
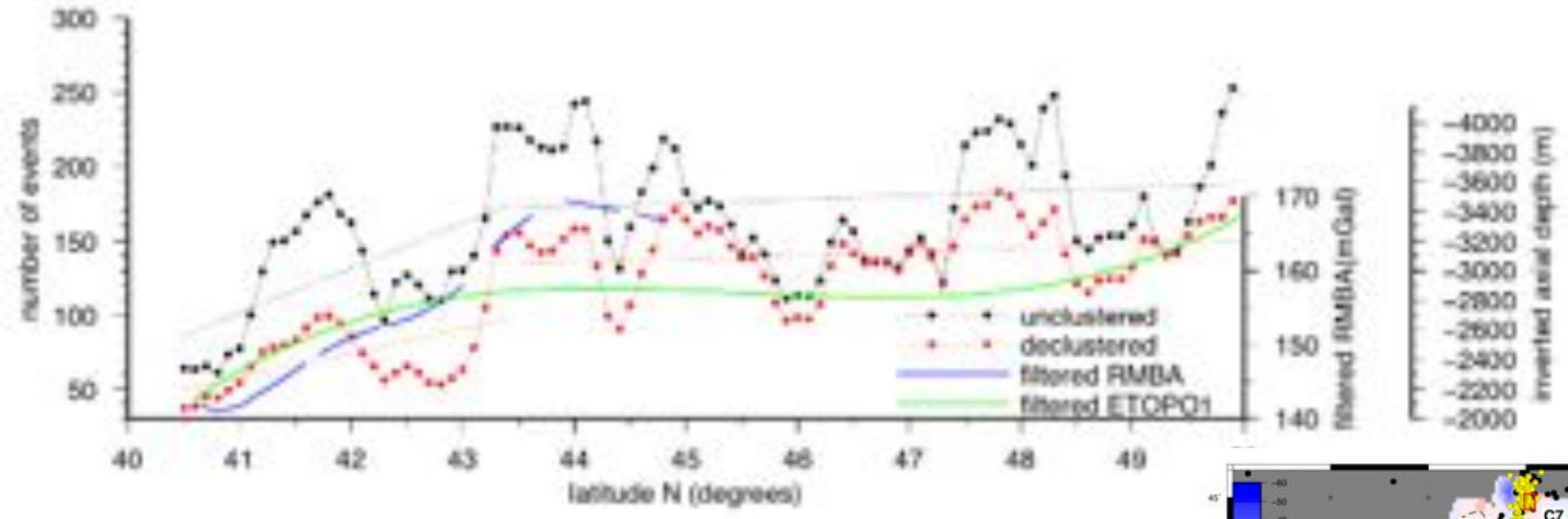
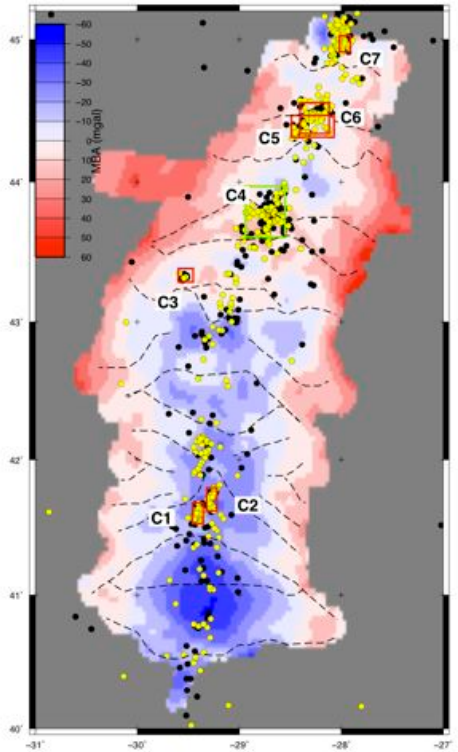


Seismicity vs thermicity of the MAR

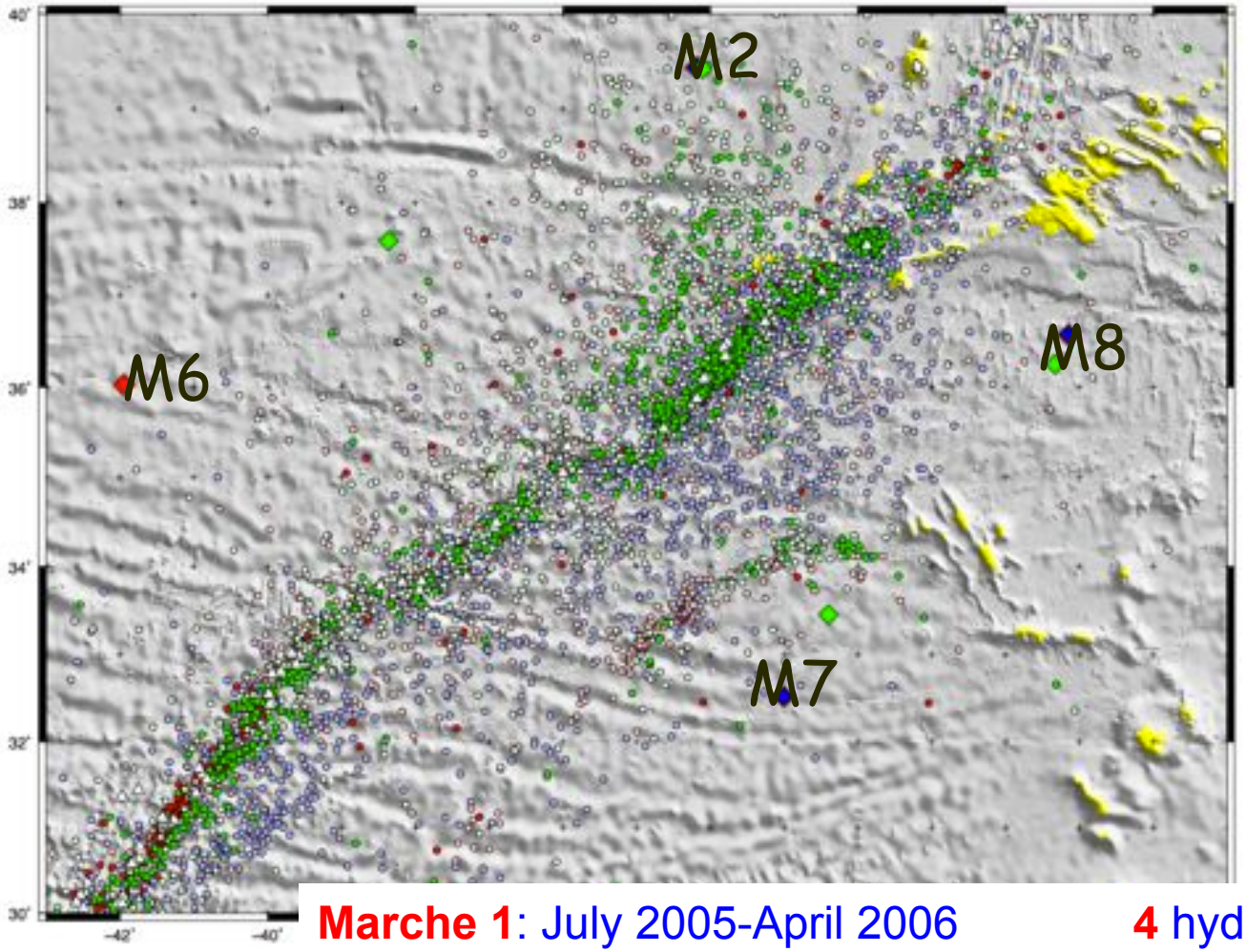


- Number of earthquakes increases away from the Azores Plateau:
  - Link with mantle temperature (« MBA »)
  - Lesser seismic activity in hot and thick oceanic crust up to 43°N
  - More tectonic events in thin and cold oceanic crust, north of 43°N



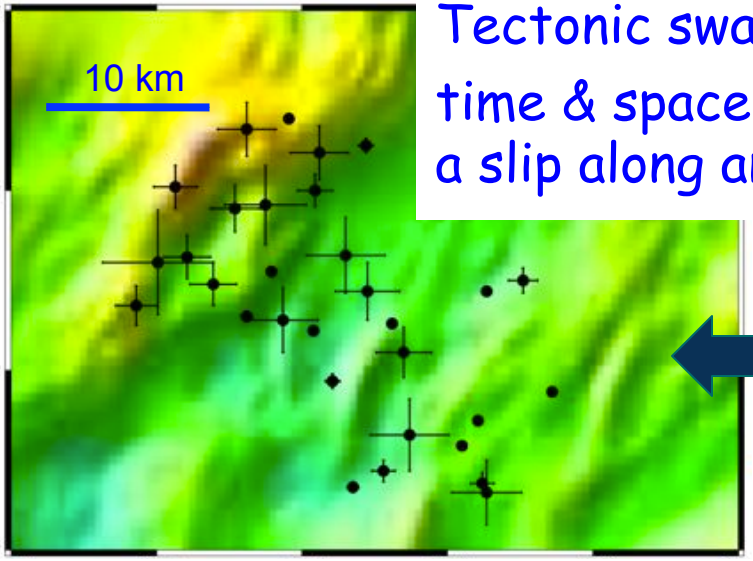
Goslin et al. (G3,2012)

2005-2008 seismicity in the MOMAR area



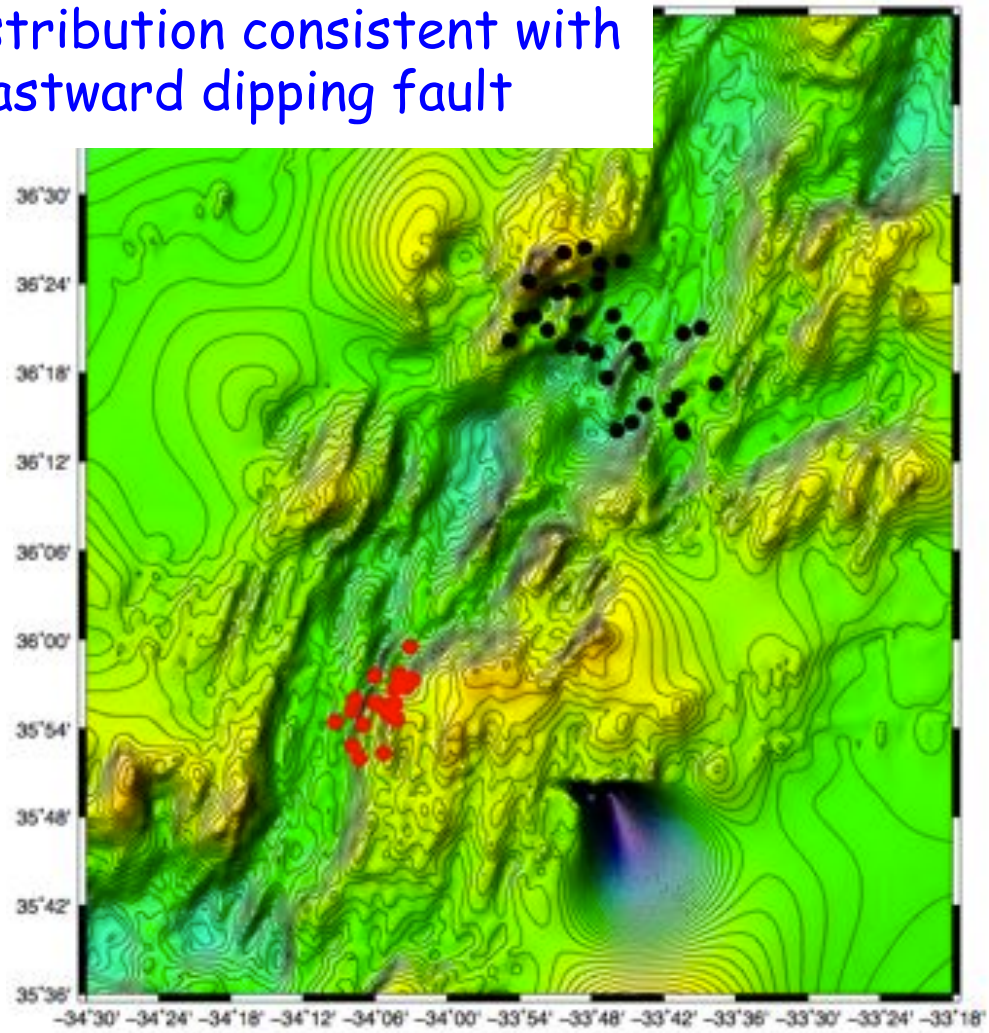
Marche 1: July 2005-April 2006 — **4** hydrophones 2350 events
Marche 2: April 2006-August 2007 — **3** hydrophones 2610 events
Marche 3: August 2007-August 2008 — **4** hydrophones 2024 events

2008 swarms in the MoMAR area

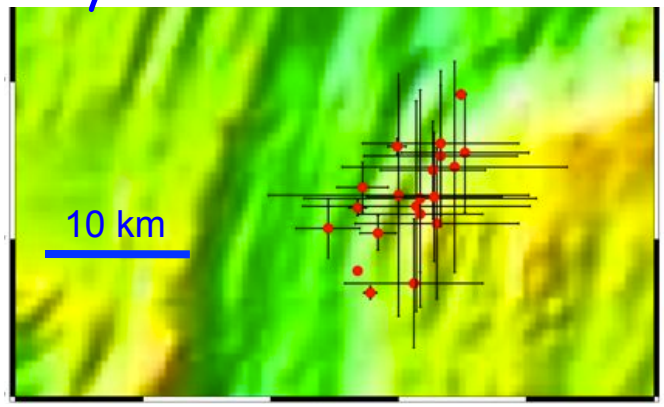


Tectonic swarm after a M=5 event:

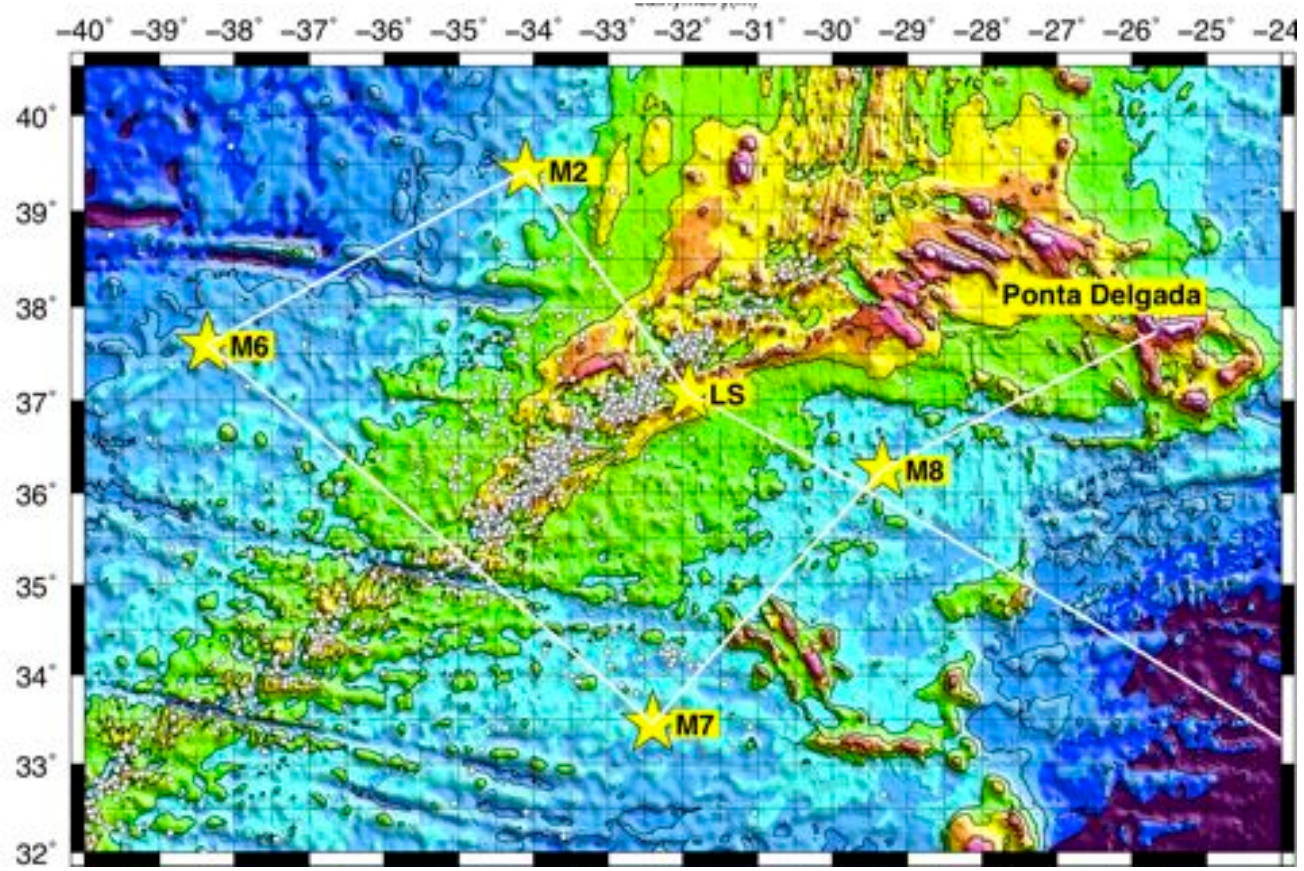
time & space distribution consistent with a slip along an eastward dipping fault



Magmatic swarm lacking temporal decay distribution

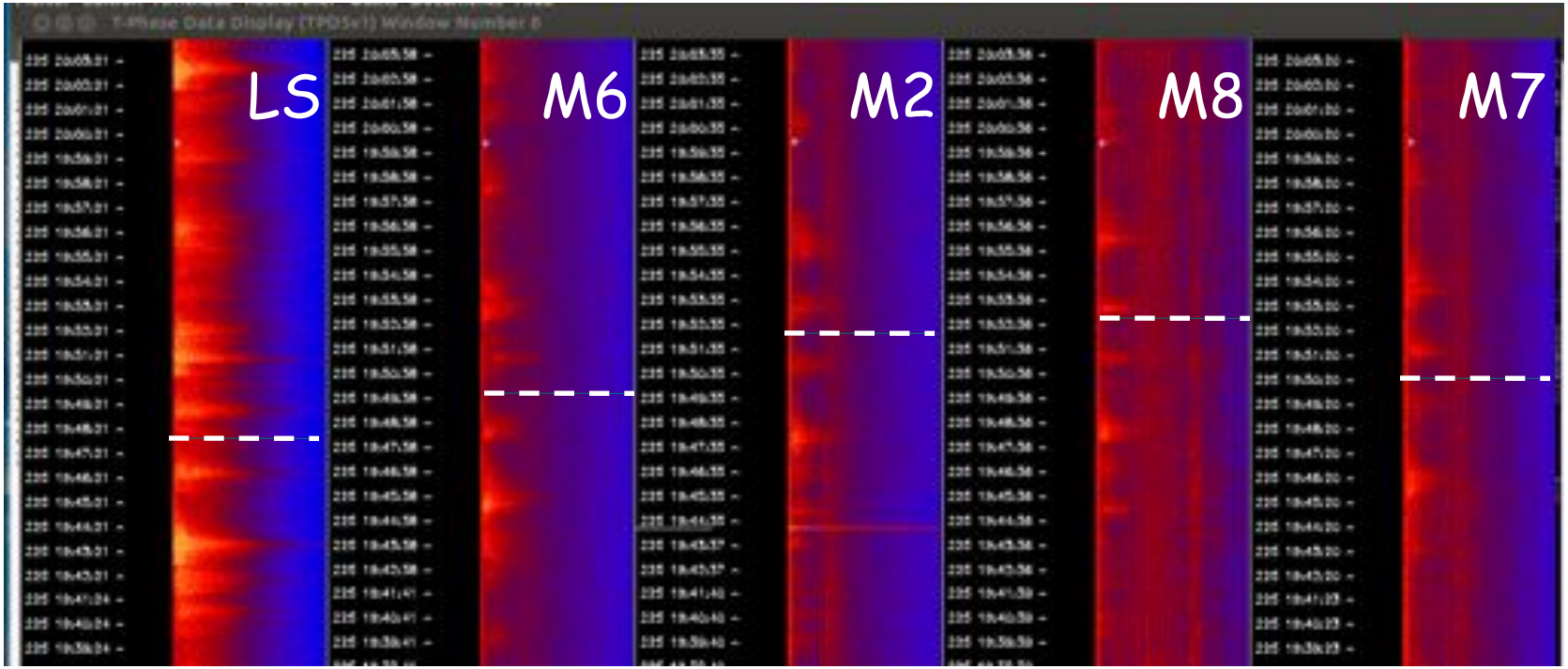


HYDROMOMAR experiments



- HYDROMOMAR : 5 instr. 2010-2011 & 2012-20?

Hydrobs-MoMAR 2010/2011

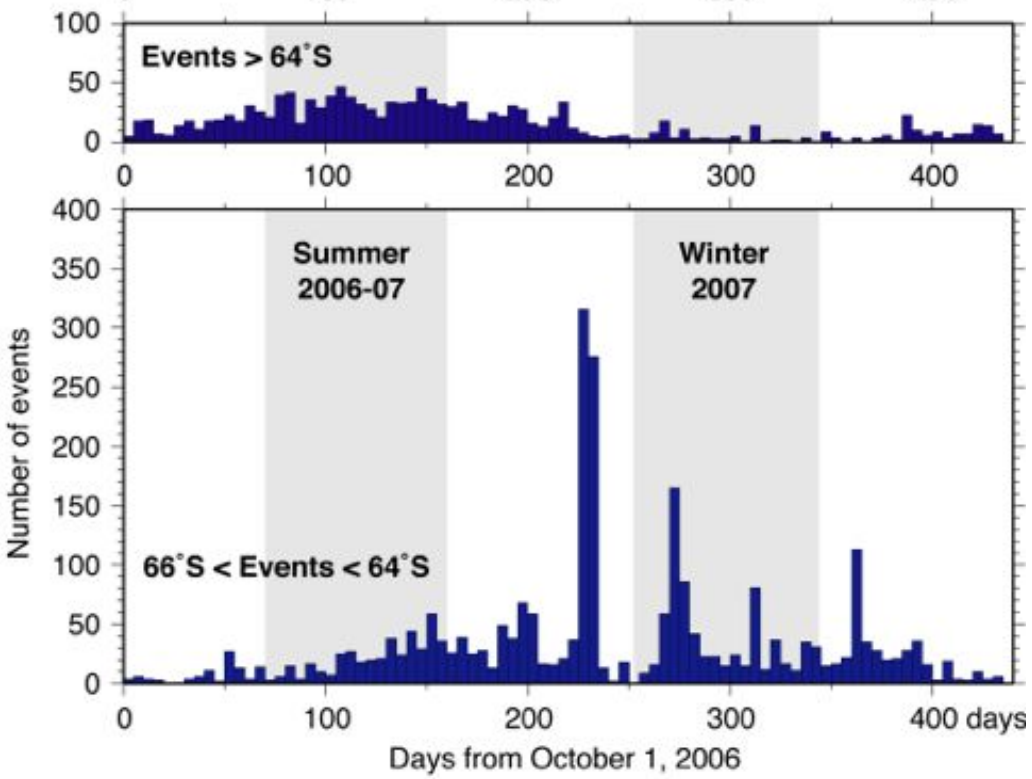


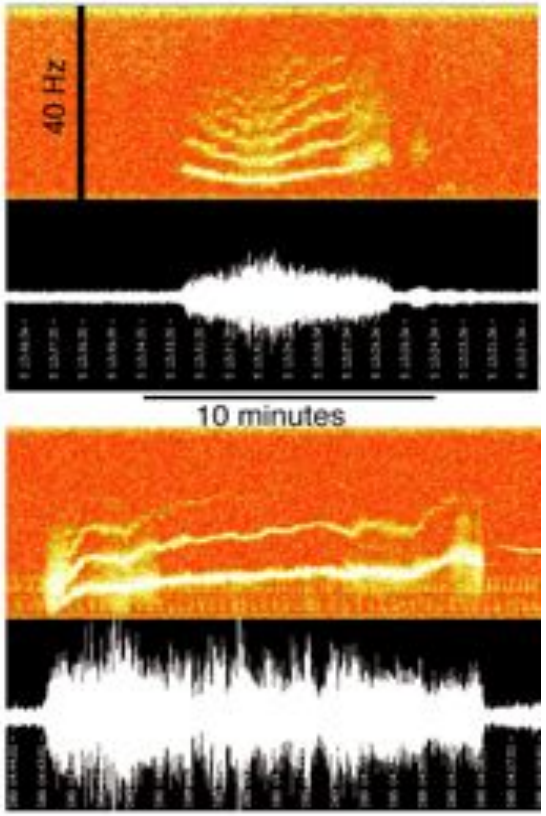
- Spectrograms of 5 hydrophones from Hydrobs-MoMAR 2010
  LS is located at the North-Famous and Famous segment.

- Seismic crisis on August 13-??, 2010 in the MoMAR area :
  Plus 500 events detected in 5 days !

Distribution of cryogenic events

~4500 events oct. 2006-dec. 2007

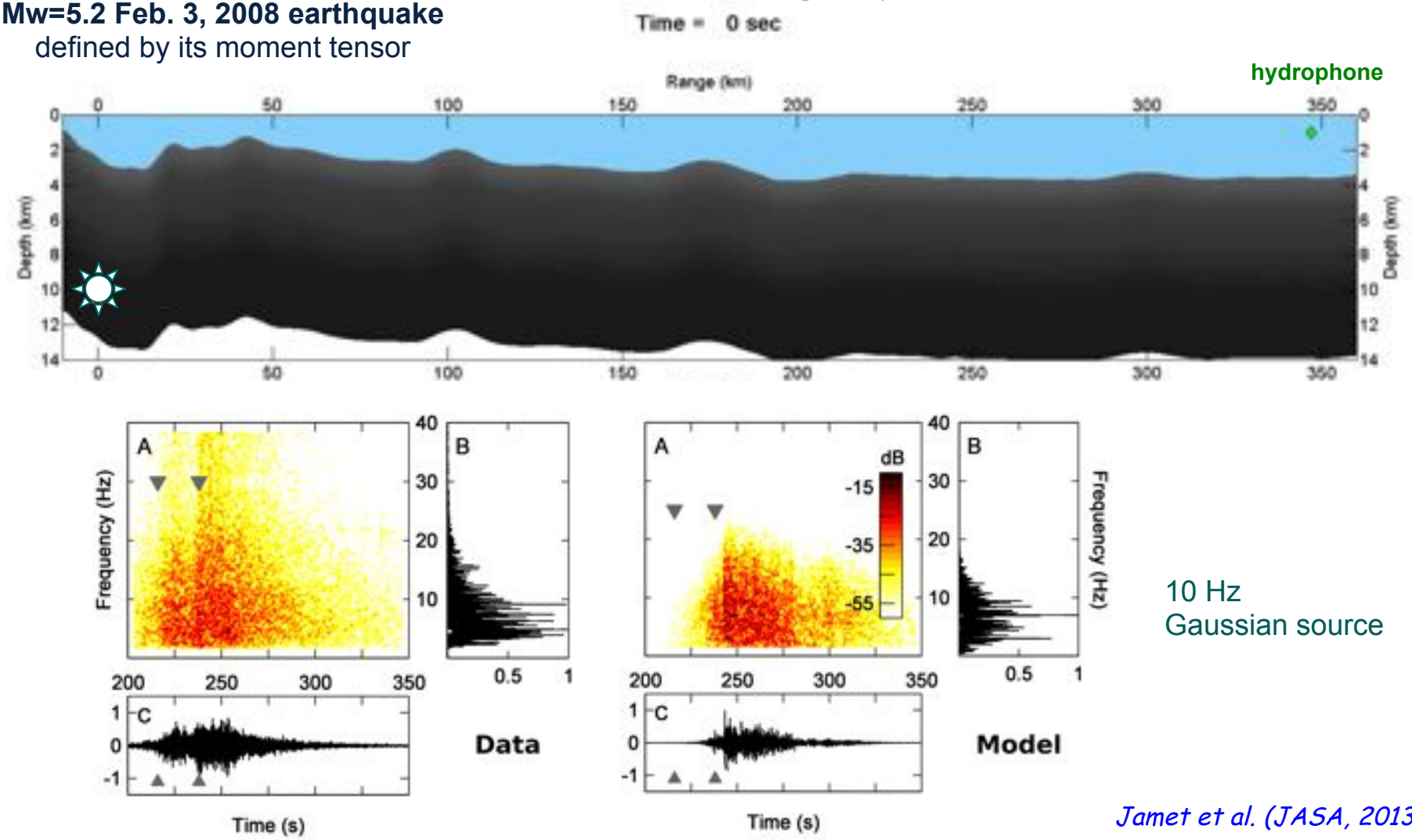




T-wave modeling

Modeling of the seismic/acoustic conversion and T-wave propagation using a spectral element method

Mw=5.2 Feb. 3, 2008 earthquake
defined by its moment tensor



10 Hz
Gaussian source

Jamet et al. (JASA, 2013)

Automatic signal classification

Method :

- Run STA/LTA algorithm to detect P and T waves and Ice quake signals
- Manually identify a certain percentage of the detected signals to create "training set"
- Use the training set to construct a statistical model (using GBDT)
- Classify all the remaining signals using the statistical model

Test: using the data set of two hydrophones

With a training set of 10% manually identified signal

99% T waves detected

77% and 89% for the P waves

95% Ice quake signals

→ A. Sukhovich et al., JGR, under review

In summary : Long-term hydroacoustic monitoring

- Complete the land-based seismological networks :
  - Over large and remote oceanic areas
  - With improved completeness (down to mb=2.5-3.2)
- Provides a wealth of information on the :
  - Seismic and volcanic activity of spreading ridges
  - Presence and migration pattern of large baleen whales
  - Climatic activity (sea-state, iceberg calving, …)
- Requires steady efforts :
  - In the analysis of large data sets (event localization and cataloging, detection of whale calls, …)
  - In the logistics (long and repeated cruises)

Perspectives

- Improve the acquisition systems :
  - For longer deployments (2-3 years)
  - With data-logging on messengers
- Automate the data processing
- Improve forward modeling (source, 3D, longer range)
- Broaden the community to share the sea-going and funding efforts

Région Bretagne

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FONDATION TOTAL

IPEV Institut Polaire Français Paul Emile Victor

Acquisition system