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Mobile Earthquake Recording in Marine Areas by Independent Divers: Now Landing on the Ocean Bottom

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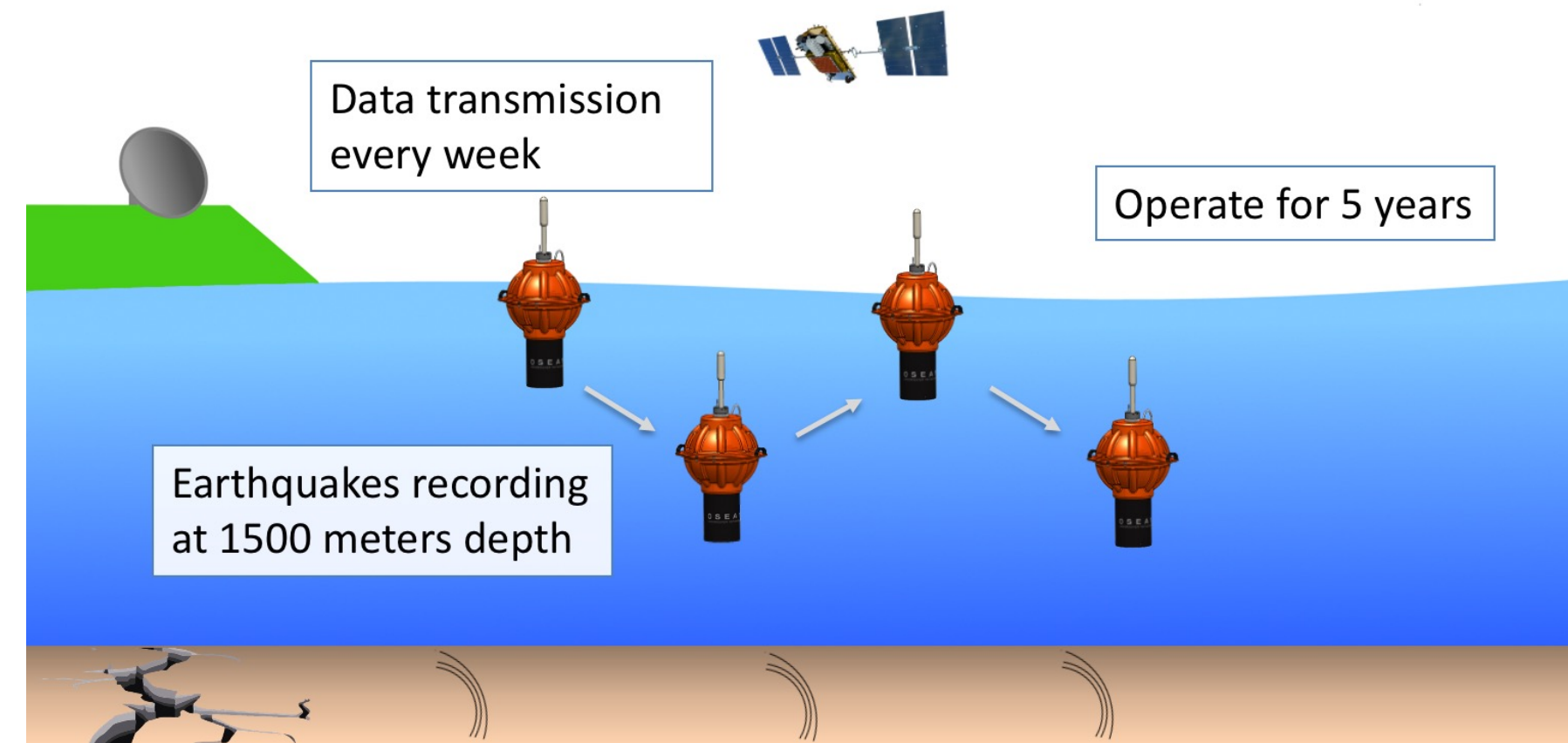
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1. MERMAID original

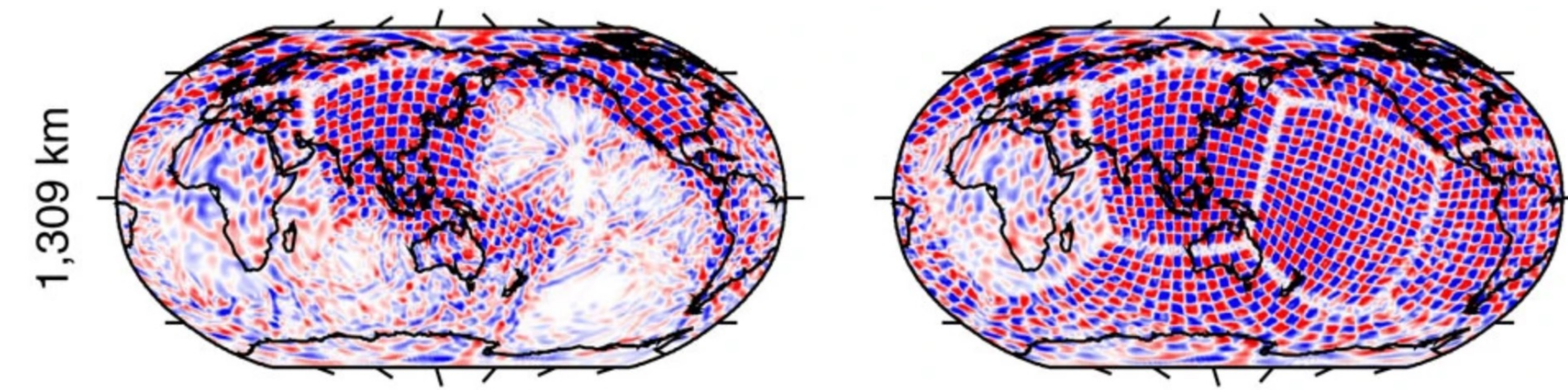
MERMAID is an autonomous robot that was originally designed to freely drifting in the oceans and recording earthquakes with a hydrophone [1].



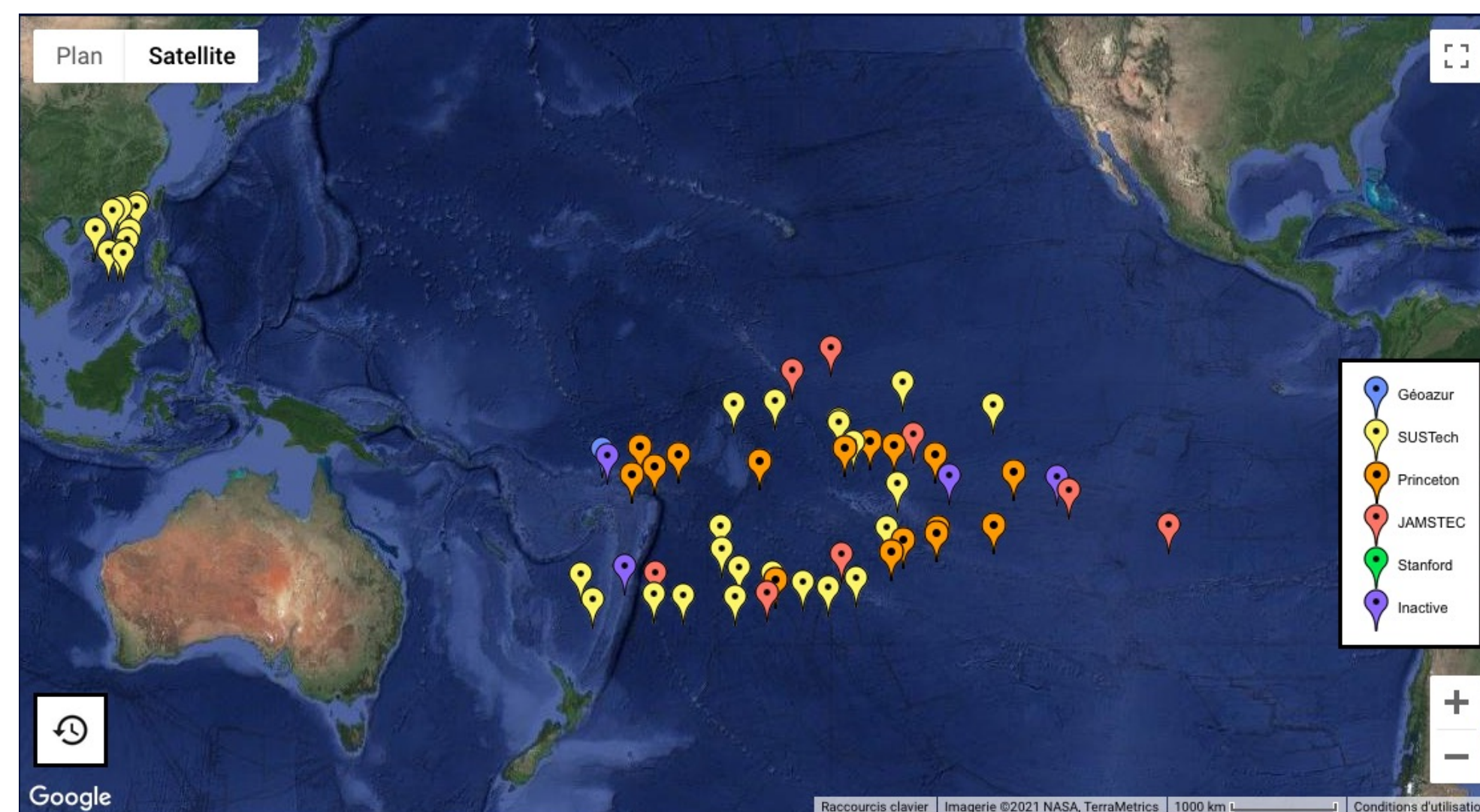
A typical Mermaid cycle with earthquake recordings.

2. Global tomography

The original MERMAID was designed for global or regional tomography. With a lifetime of 5 years, a single robot can cover several hundreds of kilometers in the oceans. A thousand of them can fill the gap of missing seismometers in the oceans.



Tomographic resolution test with ISC stations only (left) and with an expected array of 1000 additional MERMAID floats (right) [2].



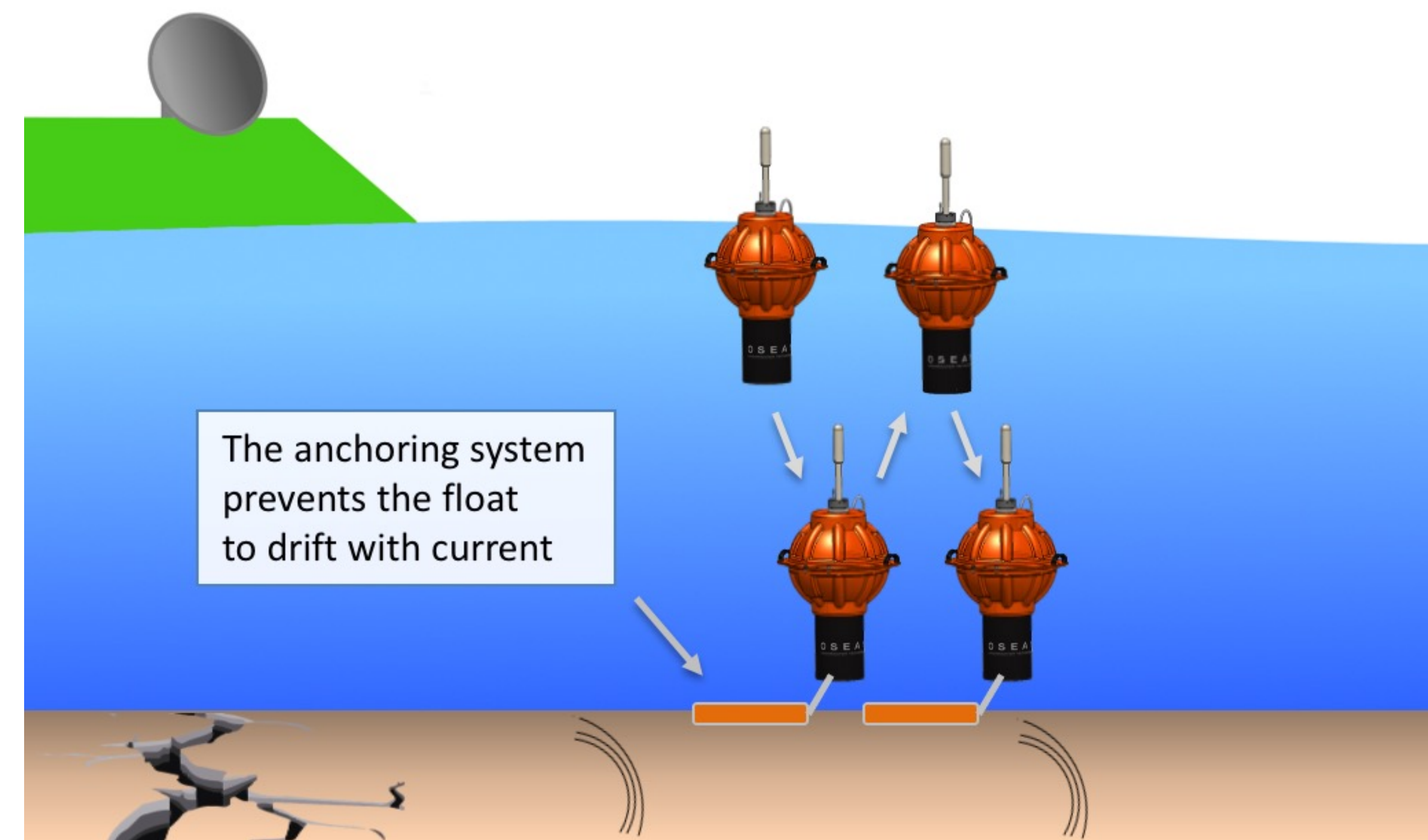
EarthScope-Oceans deployed 50 Mermaids in the South Pacific as part of the South Pacific Plume Imaging and Modeling project (SPPIM) [3].

3. MERMAID lander

The lander has the capability to **ground on the seafloor** and stay **anchored** all along a field of interest to monitor local seismicity.

Its main benefits from the original MERMAID are:

- **Fast deployment**
- **Near-real time monitoring**
- **Long lifetime**
- **Low maintenance cost**



The MERMAID lander anchor is a ballast attached with a rope. An algorithm inside the float detects when the ballast touch the ground, and then more weight is added by transferring oil from the external oil bladder of the float to the inner one.



The MERMAID lander with its anchoring system during a test in the Mediterranean Sea.

4. Local seismic crisis monitoring

Mayotte, an island off the Comoros archipelago in the Indian Ocean, faced a surge of seismic activity in early 2018 because of the birth of a new submarine volcano off its coasts. This crisis showed us that monitoring at an early stage and over a long period of time is essential to understand the geophysical process behind [4], but it requires a significant mobilization of oceanographic vessels. We expect to use the MERMAID lander for **fast intervention** and **long-term crisis monitoring**.

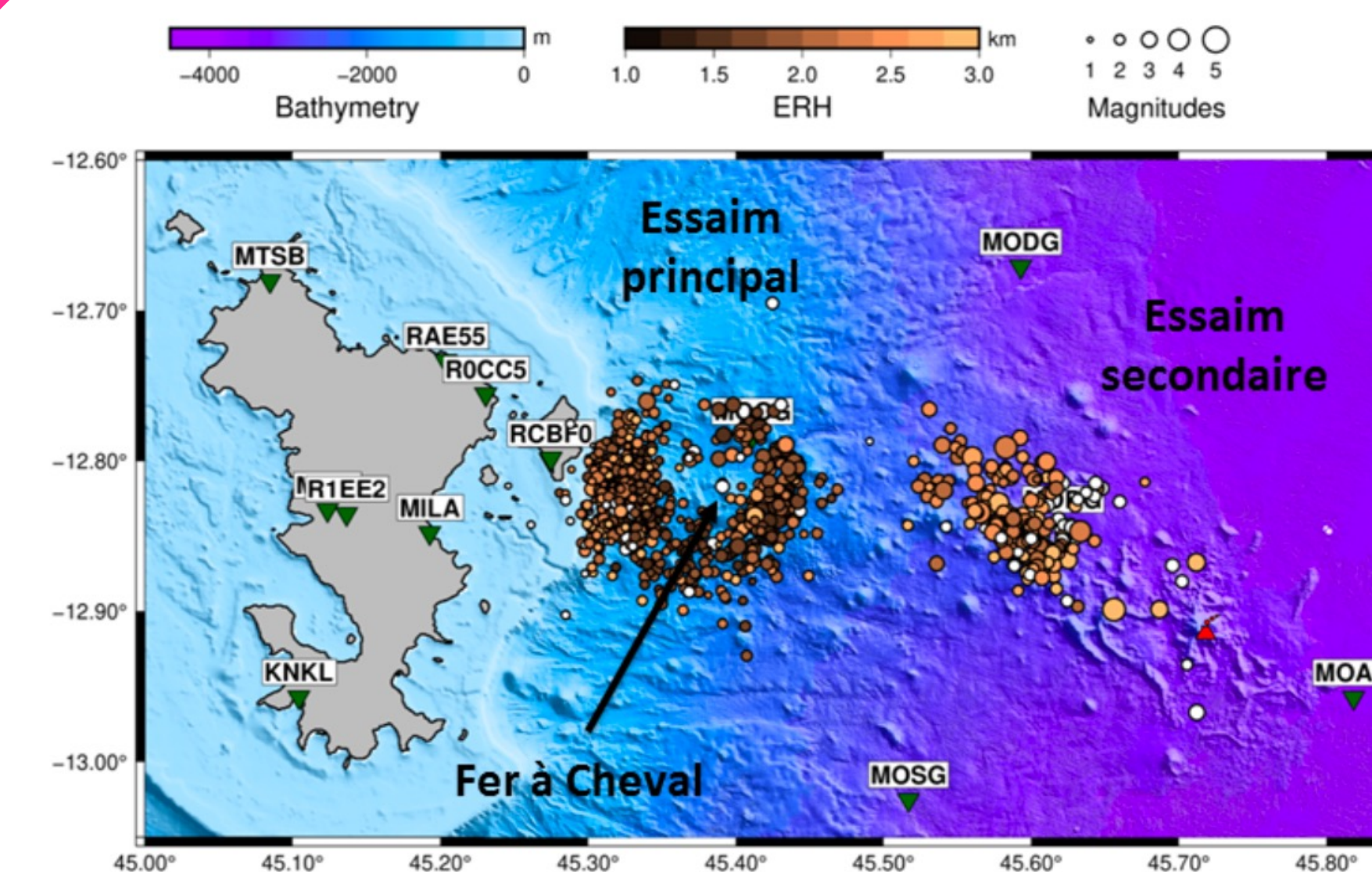
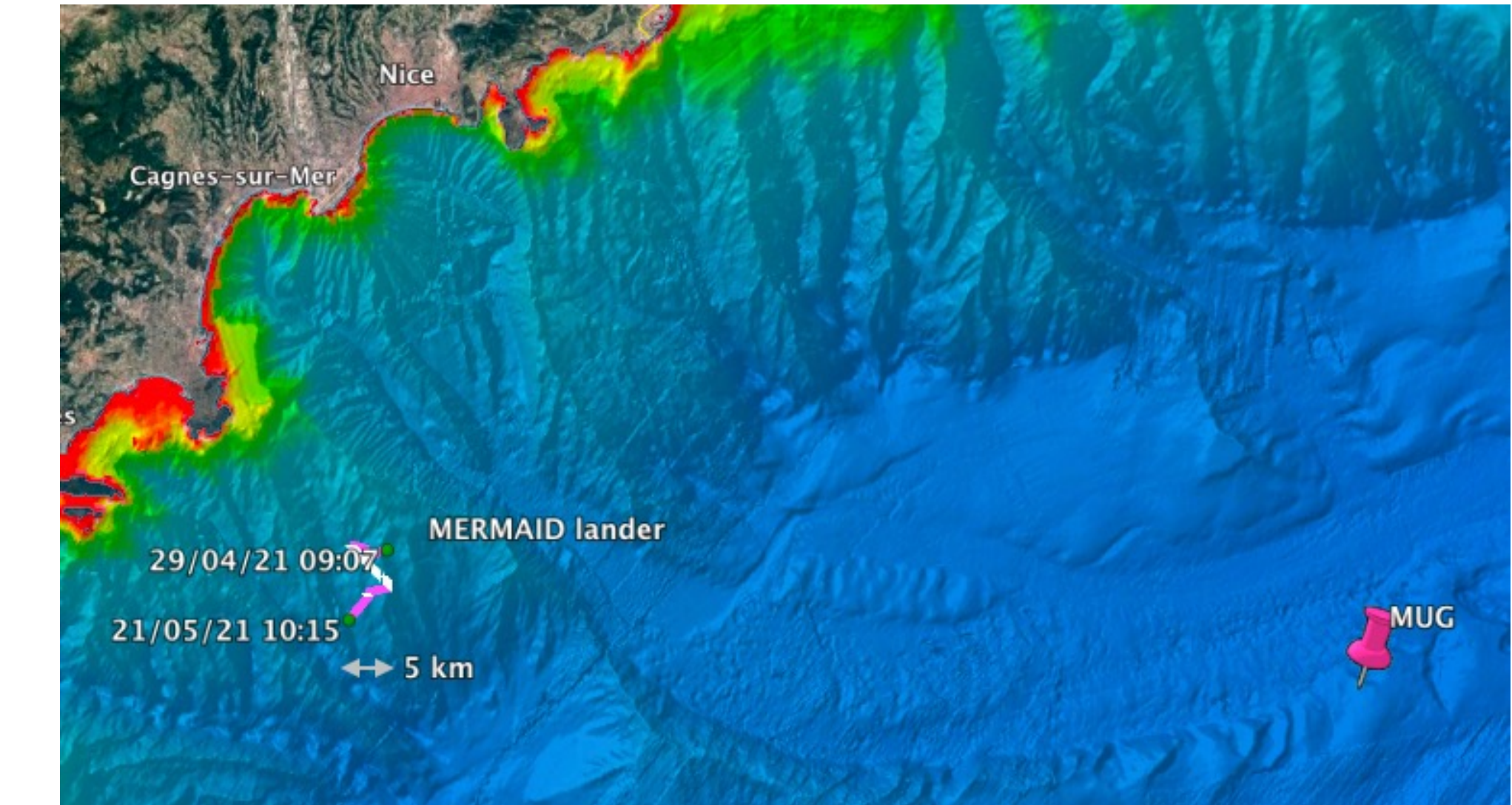


Figure taken from REVOMISA report [5]. Maps of the seismic swarms close to Mayotte from May 2020 to October 2020. The seismic events are the orange circle, with color proportional to horizontal errors (ERH) and radius proportional to magnitude. Terrestrial and ocean bottom seismometers are the inverted green triangle. The position of the volcano is the red triangle.

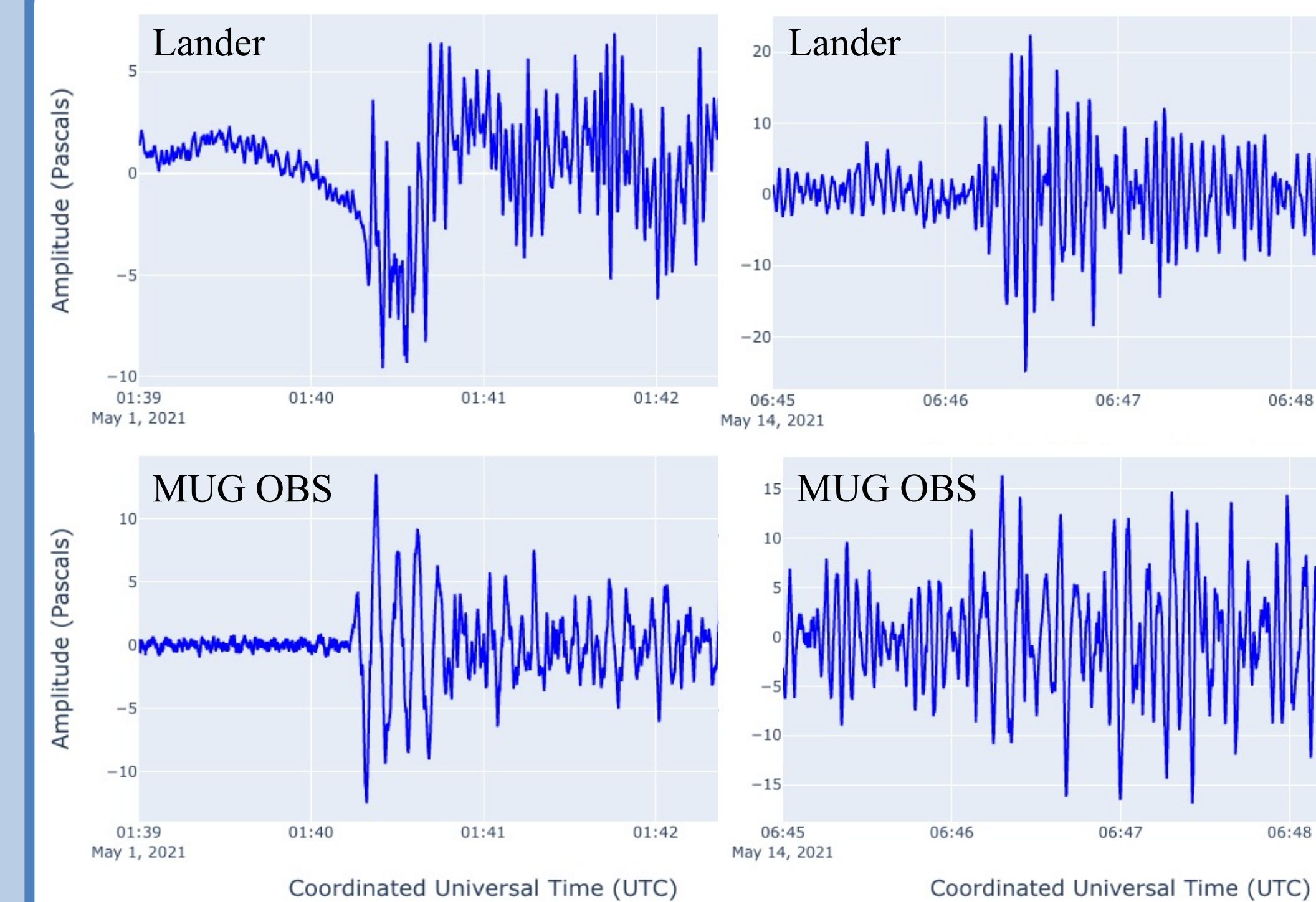
5. First results

The lander has been tested in the Mediterranean Sea close to Nice. The float still drifts when at the surface and during the descent and ascent, but the traveled distance is 10 to 100 times shorter than for a free drifting float.



Position of the MERMAID lander during a test in the Mediterranean Sea. The drift is 5 km for one month with 4 ascent to surface. The MUG-OBS station is 50 km east.

The data has been compared to the MUG Ocean Bottom Seismometer deployed at 50 km. The noise level is similar between the two stations, except for very low frequencies. It is probably due to oscillations of the instrument generated by current flow. Nevertheless, this noise is only visible when background noise is very low (less than 1 Pa). The lander is still efficient for seismic monitoring.



A magnitude 6.8 earthquake from Honshu, at 88.8°. Very low frequency noise close to 0.01 Hz is observed on the lander but has a very low amplitude of 5 Pa and is only visible because the background noise is also very low.

A magnitude 6.7 earthquake from Sumatra, at 89.5°. The signal is more visible on the lander because it has higher amplitude. The noise level is similar between the two instruments but higher than during the Honshu earthquake.

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