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Innovative high resolution optical geophysical instruments at the termination of long fibers: first results from the Les Saintes optical ocean bottom seismometer, and from the Stromboli optical strainmeter

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In June 2022, in the frame of the PREST interreg Caraïbe project, we installed an optical OBS offshore the Les Saintes archipelago (Guadeloupe, Lesser Antilles), at the termination of a 5.5 km long optic cable buried in the sea floor and landing in Terre-de-Bas island (FIBROSAINTES campaign: Antea vessel from the FOF, plow from GEOAZUR). This innovative seismometer, developped in the last decade by ESEO, is based on Fabry-Perot (FP) interferometry, tracking at high resolution (rms 30 pm) the displacement of the mobile mass of a 10 Hz, 3 component, purely mechanical geophone (no electronics nor feed-back). This optically cabled OBS is the marine version of the optical seismometer installed at the top of La Soufrière volcano of Guadeloupe, in 2019, at the termination of a 1.5 km long fiber (HIPERSIS ANR project). Both seismometers are telemetered in real-time to the Guadeloupe Observatory (IPGP/OVSG). The optical seismometer, located at a water depth of 43 m near the edge of the immersed reef, is aimed at improving the location of the swarm-like seismicity which still persists after the Les Saintes 2004, M6.3 normal fault earthquake. The considerable advantage of such a purely optical submarine sensor over commercial, electric ones is that its robustness, due to the absence of electrical component, guarantees a very low probability of failure, and thus significantly reduces the costs of maintenance. In May 2022, an optical pressiometer and an optical hydrostatic tiltmeter designed and constructed by ENS shoud be installed offshore and connected to the long fiber, next to the optical OBS.

Based on the same FP interrogator, ESEO and IPGP recently developped a high resolution fiber strainmeter, the sensing part being a 5 m long fiber, to be buried or cemented to the ground. A prototype has been installed mid-September 2021 on the Stromboli volcano, in the frame of the

MONIDAS (ANR) and LOFIGH (Labex Univearth, Univ. Paris) projects. The interrogator was located in the old volcanological observatory, downslope, and the optical sensors, at 500 m altitude, were plugged at the end of a 3 km optic cable. They consist of three fibers, 5 m long each, buried 50 cm into the ground. Their different orientation allowed to retrieve the complete local strain field. The four weeks of continuous operation clearly recorded the dynamic strain from the frequent ordinary summital explosion (several per hour), and, most importantly, the major explosion of the 6th of October (only a few per year). The records show a clear precursory signal, starting 120s before this explosion, corresponding to a transient compression, oriented in the crater azimuth, peaking at 0.9 microstrain 10 s before the explosion.

These two successfull installations of optical instruments open promising perspectives for the seismic and strain real-time monitoring in many sites, offshore, on volcanoes, and more generally in any site, natural or industrial, presenting harsh environmental conditions, where commercial, electrical sensors are difficult and/or costly to install and to maintain, or simply cannot be operated.

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