A revision of the OBSP after the Tomo-ETNA experiment

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In 2014 INGV acquired 18 new Ocean Bottom System for Seismic Prospecting (OBSP). These systems, being intended for seismic surveying, are complementary to the other family of OBS's in the INGV availability, with the broad-band instrument-type instead. Compared to the broad-band version, the OBSP is relatively low weight (about 50 kg) and small size, being built around a single 17" glass sphere. The maximum deployment time is also shorter, up to 4 months, depending on the configuration.

The Tomo-ETNA experiment [Coltelli et al., 2016], aimed at studying the Etna volcano inner structure, was the first test-bench for the OBSP. The experiment produced encouraging results for the OBSP project, but some flaws became also evident. The OBSP system was made up of a set of three geophones, mounted on an auto-leveling support, and a low power data acquisition system (DAS) with a local recording system. The OBSP can be equipped with an additional sensor, such as a low frequency hydrophone or an absolute pressure sensor. Hydrophones are useful to record pressure waves associated with seismic events, while absolute pressure sensors to detect tsunami waves and to monitor subsidence phenomena. This type of monitoring has been already undertaken by INGV with different instruments in the gulf of Pozzuoli achieving remarkable results [Iannaccone et al., 2018; Chierici et al., 2016]. The OBSP deployment technique is by free fall; at the end of a short in time scientific campaign, an acoustic-release system starts the recovery of the system, by releasing a couple of ballasts with the burn-wire method.

The recorder and the geophones are installed inside a glass sphere (Benthos-type). A polyethylene cover encloses the sphere, providing protection against impacts. A polyethylene disk, attached to the higher portion of the cover, provides mechanical support for the localization devices and for a ring-molded syntactic foam. The version in Tomo-ETNA experiment had a radio- and a flash-beacon anchored to the disk. These instruments, both with long cylindrical shape, extended well above the OBSP profile, rising the position of the center of mass and making the OBSP less stable. Before the experiment took place, the stability was verified by observing the instrument floating in an open-top tank. However, the OBSP behaved differently under the action of sea currents and waves.

After surfacing, some OBSPs did not reach the correct orientation automatically; this made the localization difficult. This experience showed that the floating stability had to be improved. In order to achieve this goal, the beacons were replaced with a custom localization system. The new system is based on a single electronic board, featuring both an embedded radio transceiver and a LED driver. As the radio antenna can operate from inside the glass sphere, there is no portion of the radio outside it; the flash lamp is outside the sphere instead. It is made of a string of LEDs, enclosed in a waterproof Plexiglas housing, producing 360° beam-angle light pulses. In order to bring the center of mass to the lowest possible position, other modifications were also considered. Inside the glass sphere, the Tomo-ETNA version had a fixed ballast, consisting of a set of plastic bags filled with lead spheres. The ballast is necessary to find a good balance between the buoyancy force and instrument weight. These forces determine some critical parameters, such as the fall and emersion velocity, as well as the strength that keeps the instrument anchored to the seabed and coupled to the sediments. Therefore, the ballast is

designed to provide a specific amount of downward force, depending on the overall mass and volume of the OBSP.
As the ballast weight cannot be set arbitrarily, only its position could be modified. In the new version, the internal ballast has been moved outside and under the sphere, attached to the plastic cover bottom face. The lead-filled bags have been replaced with a steel plate of opportune size and weight to match the effect of the old ballast.
In July 2019, a fleet of three new OBSPs will be deployed in the Strait of Sicily, a stretch of sea between Sicily and Tunisia, at depths ranging from 100 to 200 m. This mission is aimed at studying local regional earthquakes as well as capturing seismic events possibly induced by an oil field in the area, named VEGA-A. Two OBSPs will be equipped with a low-frequency hydrophone. As subsidence phenomena are likely to occur near oil extraction fields, the third one will be equipped with an absolute pressure sensor (BPR, Bottom Pressure Recorder).
As the Tomo-ETNA experiment involved artificial waves, see Figure 1, this campaign will be the first attempt to record earthquakes with the OBSP. For this purpose, the front-end electronics of the data acquisition system will implement a bandwidth extension method, which will increase the seismometer period. Regarding this method, two different options are being considered. The first is a revised version of the Lippmann method [Romeo and Braun (2007)], implemented with a custom pre-amplifier board, which transforms a set of three 4.5 Hz geophones into a 5 s period velocimeter. The same board can be found inside a new seismic sensor, entirely developed at INGV, the OBS & Earth Lab 3D 5 s. This sensor has gone through a long series of tests on land, producing satisfactory results (Figure 2). The second option is the implementation of a digital filter to invert the geophone transfer function. In this case, the final period depends on the digital filter parameters, so its value is configurable. Automatic calibration, lower power consumption and self-noise, are the most interesting features that this option would introduce. However, this implementation has not been fully tested yet.

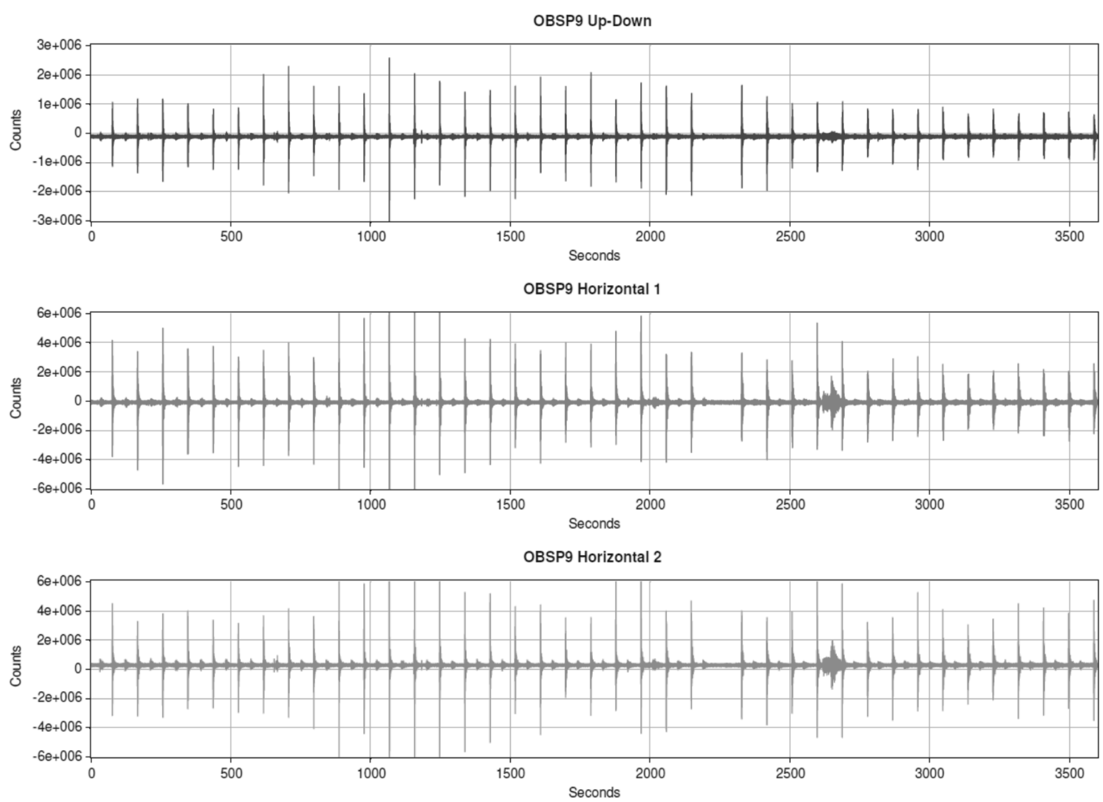

Figure 1 Sequence of pulses acquired during the Tomo-ETNA experiment by the OBSP number #9.

Compared to the INGV broadband OBS, the OBSP is anchored less firmly to the seabed. In addition, the broadband OBS relies on a shield to isolate the seismic sensor from marine currents. Lacking these important features, the OBSP should be affected by marine currents more than the broadband OBS, even though the smaller cross-section could mitigate this effect. However, the results of the Tomo-ETNA experiment, in particular the quality of the data-set, indicate that the OBSP could be able to record regional earthquakes. Hopefully, the new mission will prove this statement true and help understand more precisely the limitations of the OBSP.

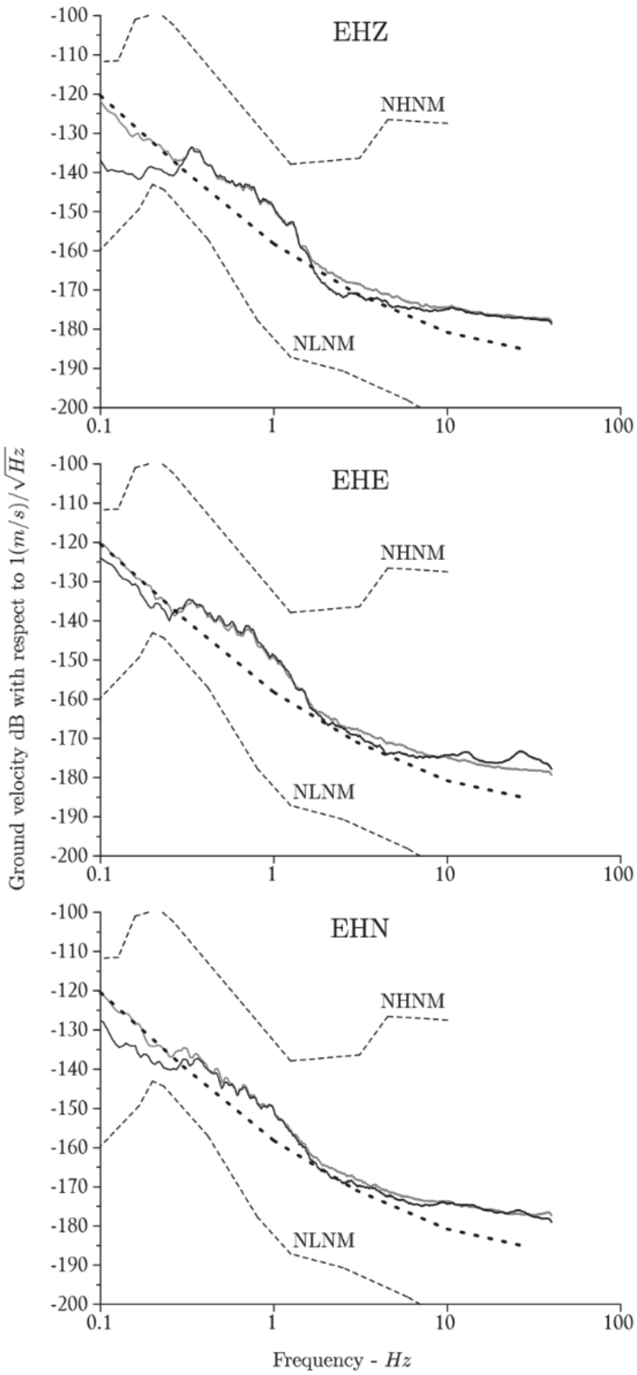

Figure 2 Ambient noise simultaneously acquired by two different seismic sensors: the Lennartz LE-3D 5/S (solid red) and the OBS & Earth Lab 3D-5s (solid black). Dashed curves show the standard noise models, high and low. The dotted curve represents the Earth Lab 3D-5s theoretical self-noise.

Figure 3 The OBSP version 2014.

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