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## Listening the Womb of the Earth: iXblue sonars, transponder & rotational seismometers for extreme environment imaging & monitoring

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iXblue company develops technologies to listen and image the Earth dynamics. Among them, Echoes high-resolution sub-bottom profilers, Seapix 3D multibeam echosounder, Canopus transponder and blueSeis rotational seismometers are particularly useful for imaging and monitoring marine and continental volcanic activities. Here, we present recent implementations and acquisitions of those systems, demonstrate the great potential of these technologies to record present and past volcanic dynamics in Hawaii, Stromboli, Sicilia and Eifel region, and emphasize their benefits to better anticipate volcanic hazard.

The Hawaii island experienced a dramatic volcanic crisis during the summer of 2018. To demonstrate the potential of observing the complete ground motion in the near field of seismic sources, Geophysical Observatory (LMU, Munich, Germany), in cooperation with USGS Hawaiian Volcano Observatory (USA), installed a high sensitive rotational motion sensor (blueSeis-3A) near the erupting crater returning spectacular data for almost daily M5 seismic events due to the collapse of the caldera. BlueSeis-3A, based on fiber optical gyroscope technology, at very close distance from the Stromboli volcano in 2016 and 2018, was installed together with classical instrumentation (i.e., translational seismometer, infra sound and tilt meter) and recorded four weeks of permanent strombolian activity at Stromboli during these two experiments. The resulting six axis measurements reveal clear rotations around all three-coordinate axis. We are furthermore able to demonstrate how these six component measurements can help to improve solving the inversion problem on large and complex system like volcanoes.

Eight Canopus transponders are involved in an ERC project in underwater geodesy, the FOCUS project headed by IUEM laboratory (Brest, France). Together with a 6 km-long optical fiber deployed across the trench at the base of the Etna volcano, two groups of four Canopus will be installed on tripods each side of the trench at 1500-2000 m of water depth. This will help quantify the speed of the southeastern flank collapsing of Etna volcano into the Ionian Sea.

In collaboration with French, Belgian and German geoscience laboratories, Echoes 10 000 (10 kHz) sub-bottom profiler and Seapix 3D multibeam echosounder, both installed on the kiXkat cataraft and remotely controlled, were mobilized to produce images of the water column and sediments of a lake formed in a volcanic crater in Germany (Laacher See). By using Seapix to obtain backscatter profiles of elements in the water column, it was possible to clearly distinguish fish and gas bubbles, which demonstrates a potential for the development of an automatic gas detection module using the Seapix software. Meanwhile, the Echoes 10 000 provided high-resolution images of the architecture of the lake deposits and visualized in real time using Delph Software. More than 30 m of penetration with a theoretical 8 cm-resolution highlight paleoenvironmental and paleoclimatic reconstruction perspectives and 3D modeling of remobilized materials and tephra deposits from volcanic activity.