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New perspectives on crustal imagery leveraging offshore submarine fiber optic cables

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Distributed acoustic sensing transforms fiber-optic cables into giant and very dense seismic networks. Although less sensitive to ground motion than traditional networks, they offer new possibilities for passive imaging and temporal monitoring, especially in hardly accessible locations such as the seafloor. From two case studies - in South of France, on a 42km long cable off-shore Toulon and in Central Chile on the northern leg of the Concón landing site of the GTD telecom cable - we explore the capability to perform passive imagery using ambient seismic noise and coda waves.

Despite a higher instrumental noise level and uneven ground coupling, underwater telecom cables can record the microseismic noise. This may be strong microseismic noise generated locally, or microseismic noise amplified by the resonance of the water column. The recorded microseismic noise at the seafloor allows a better understanding of its generation and provides high resolution images of shallow crustal structures.

From the observation of ocean gravity waves and microseismic noise, we highlight the strong localization of seismic noise sources near the coast, which can be highly variable over short time scales. Due to the localized nature of the noise sources, and because it is not always possible to average the noise recorded over long periods of time (months, years), conventional methods for ambient noise imagery show significant discrepancies in velocity estimates, up to 30%, especially at greater depths. We present here a method that minimizes the errors due to highly localized sources by carefully correcting the apparent velocities from the azimuth of the sources.

In seismic areas, in addition to microseismic noise, it is possible to expand the frequency content toward higher frequencies using seismic coda. Coda waves are dominated by multi-diffracted surface waves on local heterogeneities. The spatial distribution of their energy is more isotropic. Using dispersion curves stacked over the coda of several earthquakes, we image the shallow crustal structure of the sediments. This innovative approach opens up new horizons for structural imaging and monitoring.In coastal environments, the distribution of noise sources must be systematically studied in order to obtain reliable results.