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Adaptative spectral subtraction for enhancing microearthquake signals

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The detection of microearthquakes is an important task in various seismological applications as volcano seismology, induced seismicity, and mining safety. Together with improvements in the seismic network technologies (e.g. network densification, borehole installations) it can benefit from techniques of digital signals processing, aimed at enhancing signals related to microearthquakes from the background noise by improving the signal/noise ratio. In this work we propose a novel technique based on a non-linear filtering procedure, which has shown to be more efficient, compared to traditional filtering, in enhancing signals related to small microarthquakes embedded in continuous recordings.
The implemented technique consists in a preliminary band-pass filtering of the signal followed by an adaptive spectral subtraction. The spectral subtraction technique is a non-linear filtering which allows taking into account the actual noise spectrum shape. It allows achieving a good filtering even in cases where the signal and noise spectrum overlaps. In order to take into account of the temporal variation in the background noise spectrum, we designed an adaptive technique. We first cut the incoming signals into short temporal windows. Each windows is classified as "noise only" or "meaningful signal" (which can be either a microearthquake or any other relevant transient signal) using different features as the signal energy and the zero-crossing rate. Windows recognized to consist of noise only are continuously accumulated in a dynamic buffer which allows the average noise spectrum to be estimated and updated in an adaptive manner.
We applied this procedure to some seismic swarms recorded by Red Sísmica Canaria, managed by Instituto Volcanológico de Canarias (INVOLCAN), on Tenerife and La Palma islands, comparing results from the proposed detection algorithm with standard approaches.