Seismic arrays and frequency-wavenumber spectrum analysis to detect and monitor natural/induced microseismicity

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Seismic arrays are instruments capable of lowering the magnitude threshold of earthquake detection by improving the signal-to-noise ratio of recordings. Seismic arrays have been used since the 1960s, to investigate global earthquakes or small-scale structure of the Earth's interior. We designed a cost-effective seismic monitoring array-system made by autonomous stations specifically designed for studying local micro-seismicity. The data collected by this system allow to develop and apply a new method for earthquake detection and location of micro-seismicity based on a frequency-wavenumber (f-k) domain analysis of continuous data recorded by small seismic arrays, in order to separate the coherent signal of low magnitude events from the surrounding noise.

Field surveys have been carried out in two Italian regions, which are seismically active and already monitored by high quality, standard seismic networks, so to allow us to test the performance of the proposed array configuration and processing algorithm.

The first survey was carried out in the Irpinia region (Southern Italy), near the main fault segment activated during the Ms 6.9 Irpinia earthquake occurred in 1980. The natural seismicity of the area features occasional small seismic sequences, with magnitude (ML) less than 3, that are recorded by the local seismic network that monitors the Irpinia fault-system (ISNet - Irpinia Seismic Network). Three small aperture seismic arrays (few hundred meters wide) were deployed at distance of few tens of kilometers each other for three months. Each array was made up of seven 3-component stations, arranged in irregular geometry.

The second experiment was carried out in the Montello-Collalto area (Veneto region, North-East Italy), where an underground gas storage concession, known as “Collalto Stoccaggio”, exists. The gas storage activity is monitored by a local seismic network named “Collalto Seismic Network” (Rete Sismica di Collalto, or RSC). This dense network was designed and is managed by the National Institute of Oceanography and Applied Geophysics (OGS) on behalf of Edison Stoccaggio S.p.A., the storage concession holder. A seismic array composed of eight 3-component stations with 2 km of maximum aperture was deployed for a couple of months to monitor the micro-seismicity occurring nearby.

Our preliminary results suggest that the f-k earthquake detection algorithm of micro-seismicity using seismic arrays can become a valid tool to complement standard seismic networks in monitoring and studying natural and induced seismicity. In the Irpinia region, for instance, we have detected and located about six times the earthquakes recorded by the local network.
lowering the magnitude down to 0.1, smaller than the catalogue minimum magnitude that is equal to 1.2.