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Location of micro-seismic events with a systematic grid-search approach

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Microseismicity detection has become an increasingly important research topic in the last years, especially in connection with the monitoring of the seismicity possibly induced by a number of industrial activities that cause stress field perturbations in the seismogenic layer. Improving the event detection sensitivity will not only benefit the understanding of geomechanical processes driving induced seismicity but also allow the prompt application of safety procedures.
Given the large number of events handled by microseismic monitoring, automated procedures for detecting and locating micro-events are mandatory. The main difficulty in the implementation of these procedures consists in the low signal to noise ratio which characterizes the traces of the micro-events collected by a local seismic network. To overcome this difficulty, the most promising approaches are the waveform stacking location methods which consist in the transformation of the seismic traces collected by the network in a coherence distribution across a suitable discretized parametric space in which the seismic events are defined. By discretizing the volume under study with a suitable number of nodes , we can evaluate the coherence function for the entire volume and, by a systematic grid-search procedure, estimate the event location. The proposed procedure makes use of multiple detection functions based on either statistical or physical principles. We also address the issue of the detection threshold as well as that of computational efficiency and accuracy by means of synthetic tests.
The computational cost of this procedure grows rapidly with the size of the investigated parametric space, therefore High Performance Computing (HPC) resources are required in order to fully exploit the potential of this approach. Our grid-search procedure is based on a hybrid MPI/OpenMP programming approach, and it works on the continuous signal recorded by a local seismic network. The HPC resources from the CINECA consortium, Bologna, Italy, have been used for all calculations. Our procedure can be easily applied to quasi-real-time data analysis.
The overall procedure is now being tested on the Collalto Seismic Network, the seismic network aimed at monitoring the natural seismicity and the induced micro-seismicity of a natural gas storage field, in North-Eastern Italy.