Array-based earthquake detection with multiple techniques

Qiushi Zhai[1] Zhigang Peng[1] Zefeng Li[2] Chenyu Li[1] Liang Zhao[3]

1) School of Earth and Atmospheric Sciences, Georgia Institute of Technology, Atlanta, Georgia, USA
2) Seismological Laboratory, California Institute of Technology, Pasadena, California, USA
3) State Key Laboratory of Lithospheric Evolution, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing, China

Seismic arrays are important for studying deep earth structure and seismic activities of their target regions. The recent development in ultra-dense arrays also greatly promote the development of new array techniques in earthquake detection. In this study, we propose an earthquake detection method that combines existing array techniques and multiple signal processing methods for different size arrays with different apertures and inter-station spacings. Specifically, the array technique is similar to the beamforming (or back projection), where we time-shift the characteristic functions based on the predicted travel times with 3-D grids. The characteristic function includes envelope function, short-term average/long-term average (STA/LTA), and local similarity, which measures the waveform similarity between nearby stations. We apply this method to seismic data recorded by the China-Italy-France Alps (CIFALPS) linear array (~10 km spacing and ~600 km long) and Incorporated Research Institutions for Seismology (IRIS) community wavefields demonstration experiment (YW network) in north-central Oklahoma (~0.1 km spacing and ~15 km long). We compare the results from different datasets and different methods. We find that large apertures array needs time-shift stack (like beamforming), using predicted travel times from a reference velocity model, to enhance the signal for array-based earthquake detection. Sparse array works better with the energy-based envelope function or the signal-to-noise-ratio-based STA/LTA, while dense array works better with the waveform-similarity-based local similarity method. In the end, we propose a combined strategy with general suggestions for array-based earthquake detection. Our study could be helpful for future studies on detecting microseismic events with different arrays.

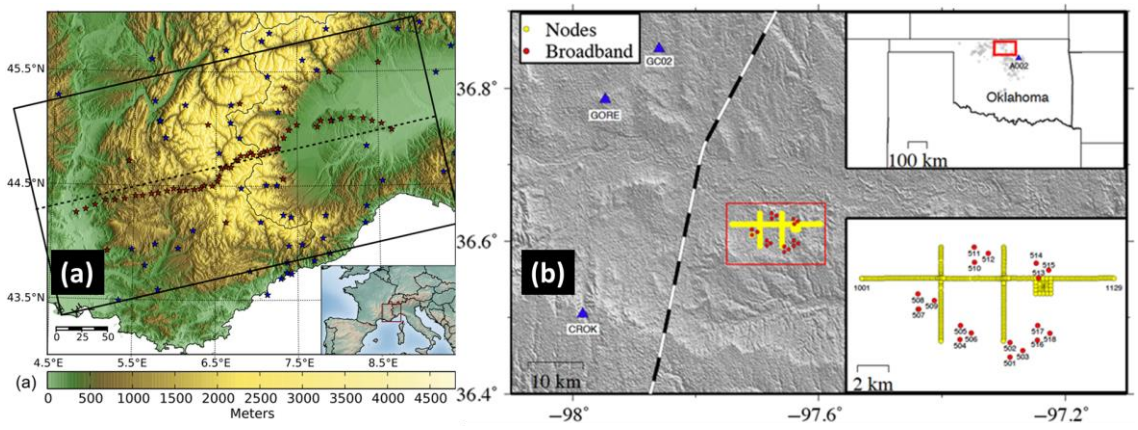

Figure1. (a) Map of the study region and the CIFALPS Array in Europe (Modified from Beller et al., 2018). (b) Map of the study region and IRIS YW Network in north-central Oklahoma (Modified from Li et al., 2018).