ESC2016-330, 2016
35th General Assembly of the European Seismological Commission

Application Based Seismological Array Design by Seismicity Scenario Modelling

Nasim Karamzadeh (1,2), Sebastian Heimann (1), Torsten Dahm (1,2), and Frank Krüger (2)
(1) Physics of Earthquakes and Volcanoes, Helmholtz-Centre Potsdam - GFZ German Research Centre for Geosciences, Potsdam, Germany (karamzad@gfz-potsdam.de), (2) Institute of Earth and Environmental Science, University of Potsdam, Potsdam, Germany

The design of an optimal array configuration is an important task in array seismology during experiment planning. Theoretically, the array response function (ARF), which depends on the relative position of array stations and frequency content of the incoming signals, can be used as an array design criterion. In practice however, additional constraints and parameters have to be taken into account (e.g. land ownership, site-specific noise levels, or characteristics of the seismic sources under investigation). Providing a preview of the outcomes of an array by simulating the recorded signals at individual stations and processing the synthetic array data, is beneficial over purely ARF-based array design because more realistic constraints can be included.

In this study an array design framework is introduced which provides a flexible tool to perform an automatic search for an optimal array station geometry. The framework implements a customizable scenario modelling and optimization scheme. Realistic synthetic seismograms are generated, taking into account ranges of possible source mechanisms, geometry of the seismogenic zone, propagation velocities and noise levels at potential deployment sites. The synthetic array data is then used to evaluate an objective function to be minimized during the optimization process. The objective function can be defined by the user based on the monitoring goals.

We introduce and combine two different objective functions. The first one is formulated based on the average beam power in slowness space for specific phase arrivals. The second one is designed to judge the precision of the retrieved slowness vectors. This is done by means of the average location error for an ensemble of simulated events. A weighted-sum technique is used to combine both objective functions into one single scalar function to use in the optimization process.

The proposed framework and tool is tested by designing a 7-station small scale array to monitor earthquake swarm activity in North-West Bohemia / Vogtland in central Europe. The performance of the obtained optimal array geometry can be compared to the performance of a temporary array which has been deployed at this site recently. Our synthetic study shows that the optimized array geometry would performs significantly better in different aspects. For instance, the average mislocation of M_w 1 events is reduced from about 2.7 km to 1.4 km.