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Rock impact location using Matched Field Processing

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Matched Field Processing (MFP) is an array processing method, initially developed in ocean acoustics, that is used in applied geophysics to locate seismic noise sources. In this study, we test the application of MFP to short signal events. Such short signal events are typical in the realm of environmental seismology, the study of the seismic signals emitted by Earth surface processes, such as rock avalanches and rock falls.

For this study, an experiment was set up near Demmin (northern Germany) where rocks of different weight (five orders of magnitude, 0.076 - 110 kg) were released from different heights (0.5 - 36 m) to hit the ground. The seismic waves generated by the rock impacts were recorded by a dense instrumental array equipped with 30 randomly distributed geophones (4.5 Hz natural frequency) and Data-Cube3ext 3-channel data loggers, manufactured by DiGOS. Sensors inside the larger rocks and a high speed camera provided essential independent information about the impact kinetics.

The experiment allows testing the validity, accuracy and limitations of MFP with respect to short seismic signals. Based on the known parameters (rock weight, fall height) and the sensor-derived data, the seismic signals of the rock impacts can be characterized by kinetic energy. We also tested the reproducibility of MFP and compare the technique to the signal migration technique, another location approach, that is based on cross-correlating the seismic signal envelopes.

Location, location probability and accuracy of the rock impacts mainly depend on the generated kinetic energy. The smallest, successfully located rock specimen had a weight of 2.03 kg and was released from a height of 20 m. The impact generated a kinetic energy of 400 J. The overall location error is 0.6 - 13.9 m, depending on the technique, impact energy and array geometry.