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System for automatic detection and location of seismic events for arbitrary seismic station configuration NSDL

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The problem: Existing systems of automatic detection and location produce a lot of false alarms. Results of the systems require time-consuming checking by human analyst. Many systems have limitations on the number of phases, stations, types of stations, etc. It is difficult to reconfigure.

The goals of the new system were: monitoring of mining and glacial seismic events by small number of stations, retrospective processing of old data, combination of data obtained from different sources including both seismic bulletins and wave forms. The main requirements were 1) modularity of the system i.e. simple adding of new stations and 2) minimizing the work of human analyst.

The data processing is made in two steps. In the first stage data of single stations are processed independently as carefully as possible. During the processing the following algorithms are used: making envelopes, statistical estimation of noise, STA-LTA phase detector, automatic threshold selection depending on impulse noise, autoregressive (AR_AIC) onset picker.

For each couple of phases a hypothesis is checked that the two phases are P and S of the same seismic event. Joint polarization analysis for 3C sensors and joint beamforming for arrays are used.

Bayesian 'naive' classifiers are used for screening out false alarms.

In the second step the results of the single station processing are used as the basis for the association by method close to the generalized beamforming. The approach is as follows:

All event lists are united. Each 'single station event' is a candidate for the association. Its time and place is a starting point for a grid search.

A grid search is done in a big circle with its centre in the start point for time interval with the centre in the estimated single-station origin time.

A rating function is estimated in each cell of the grid depending on circular parameters of phases-candidates (polarization, beamforming) and station-amplitude logics estimation.

The grid is diminished several times (nodes with small ratings are removed and the rest ones are divided).

Gradient minimization of origin time residual is made if enough phases were associated (optionally with depth estimation)

Complex travel time model can be used. Several 1D models with Bondar-style regionalization + Source Specific Station Corrections (SSSCs) can be specified.

The system was used for observations of weak glacier-related seismicity in Spitsbergen. It is installed in KRSC and in Kyrgyz Institute of seismology for routine monitoring of regional seismicity. It can be adjusted for near real time seismic monitoring in any region. The system can be used for retrospective processing of old data including relocation of events by seismic bulletins as well as joining of seismic bulletins.