Nanoseismic monitoring platforms: applications, performance & expectations

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Nanoseismic monitoring (NM) platforms and the data processing techniques, that were recently developed for them (Wust-Bloch & Joswig, 2006), operate as a seismological microscope. NM have been recently applied and tested for a broad range of applications in earthquake, forensic and engineering seismology. Nanoseismic monitoring is currently used to monitor aftershocks, swarms and weak seismicity; to map active faults; to obtain rapid b-values; to characterize calibration blasts; to control mining and blast activity; to detect pre-collapse sinkhole activity, landslide movements and cliff failure; as well as for source discrimination purposes at local to regional distances. By significantly reducing monitoring time and costs while generally outperforming standard monitoring techniques, nanoseismic monitoring extends the present capacities and range of existing monitoring.

The concept of nanoseismic monitoring (Joswig, 2005) was developed to detect, characterize and locate sources of seismic energy generated at distances between 10 m and 10 km and with magnitudes down to M_L -4.0 (Wust-Bloch and Joswig, 2006). It was designed with the idea that ultimate instrumental portability optimizes SNR conditions by minimizing source-to-sensor distance and allows immediate instrument deployment with minimal logistical constraints. Nanoseismic monitoring integrates data acquisition by Seismic Navigation Systems (SNS) and data analysis by SparseNet software (Joswig, 1999).

SNS consist of three single-component short-period seismometers arranged as tripartite array around one central three-component short-period sensor. A 24-bit digitizer acquires data detected by this six-channel SNS. The array aperture varies as a function of the monitoring tasks, source remoteness and field constrains. For small scale monitoring applications in engineering seismology such as sinkhole activity, landslide and cliff failures as well as for blast monitoring and discrimination tasks, an array aperture of 30 to 50 m is optimal. With a sampling rate range of 200-500 Hz, an array aperture of 100m was found to be optimal for monitoring local seismicity if one is to avoid unwanted communication and logistic challenges caused by the deployment of longer cables. With a total weight of about 35 kg and a volume of less than 0.5 m^3, SNS can be deployed and operated practically anywhere by one single person. Experience has shown that deployment is quick and that the first data can be recorded within 15 to 30 minutes after arrival (Wust-Bloch & Joswig, in review). Several arrays can be deployed simultaneously to permit dynamic and quasi-instantaneous array relocation as required for aftershock and blast monitoring tasks as well as for for On- Site Inspections (OSI) tasks undertaken within the framework of the CTBT (Leonard & Joswig, 2005).

Nanoseismic monitoring is an application of passive seismic field investigations tuned to ultimate sensitivity, which is achieved by the extreme flexibility of the SNS and by innovative approaches in signal processing (Joswig, 1996; 1999; 2000 & in review) whereby pattern recognition schemes and automated sonogram-based waveform analysis lower the processing threshold to near 0 dB SNR. By displaying and updating simultaneously, the data uncertainty of this over-determined system, *HypoLine* software allows the operator to slide through parameter space, observing in real-time the effect of each parameter change on the solution (Joswig, in review). Events are precisely located by a graphical, error-resistant jackknifing approach, which determines origin time, epicenter, depth, suited half space v_p and v_s.

Given slant distances that are shorter than 10 km, the source energy can be quantified, and related to standard seismic activity using an extended M_L scale, whereby M_L are explicitly reported for distances below 10 km (Wust-Bloch and Joswig, 2006). A new HypoLine module that permits event relocation by Master Event technique enhances further locations accuracy. In term of source process discrimination, events generated within a fluid or fluid-saturated media can be discriminated from those generated within a dry media, based on a sonogram-based frequency analysis (Wust-Bloch & Joswig, 2006).