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A quantitative method to map microseismic sources and associated velocity bias in Sweden

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We introduce a method for mapping the noise-source distribution of microseisms which uses information from the full length of noise covariograms. We derive a forward calculation based on the plane-wave assumption in 2D, to formulate an iterative, linearized inversion of covariogram envelopes in the time domain. The inversion exploits the well-known feature of noise cross-correlation, i.e. that an anomaly in the noise field that is oblique to the inter-station direction appears as cross-correlation amplitude at a smaller time lag than the in-line, surface-wave arrival. Therefore, the inversion extracts more information from the covariograms than that contained at the expected surface-wave arrival, and this allows us to work with few stations to find the propagation directions of incoming energy. The inversion is naturally applied to data that retain physical units, i.e. that are not amplitude normalized in any way, therefore, the final inversion results give the absolute strength of the noise sources. By dividing a network into groups of stations and combining the directions from all of those, we can constrain the source location. The method is useful when strong localized sources produce precursory arrivals (arrivals near zero lag).

First, we demonstrate results of the method with one year (2012) of data from the Swedish National Seismic Network (SNSN). After preprocessing and cross-correlation, the stations are divided into 5 groups of 9 to 12 stations. We invert the envelopes of each group in 8 period ranges between 2 to 25 sec. Results show that the noise sources at short periods (less than 12 sec) lie predominantly in the North Atlantic Ocean and the Barents Sea, and at longer periods the energy appears to have a broader distribution. Second, we use the forward calculation to estimate the group and phase velocities biases by comparing the arrival time differences of the actual noise-source distribution and a uniform distribution. The strongly anisotropic source distribution in this area can cause significant biases of velocity measurements compared to the level of heterogeneity in the region.