Statistical learning and denoising for multivariate seismic data streams

*Andrey Lokhov[1]

1. Los Alamos National Laboratory

In an effort to characterize tectonic tremor from seismic noise and probe the relationship between tremor and slow slip we use a method based on new developments in statistical learning theory. Current techniques for detecting tremor consist in looking at correlations of signals measured at different locations: in the presence of tremor, the correlation pattern should change. However, this method implicitly assumes that the noise at different location is weakly correlated; also, only tremors with high amplitude that affect signals at all seismic stations can be detected. Mathematically, the tremor detection problem can be viewed as the denoising problem in signal processing. The foundation of our method consists in exploiting recent advances in exact and sample-optimal learning of graphical models, that allows one to reconstruct structured multivariate distributions beyond Gaussian. Once the noise distribution is known, we will show how to construct a family of local likelihood estimators for extracting the tremor signal from single- or multi-stations measurements. In order to incorporate the potential time-dependence of the noise, we learn the noise model on the fly, using most recent measurements. This model allows the real-time likelihood scoring of the incoming signal in probability space, thus predicting the appearance of the tremor signal. An advantage of our method compared to black-box approaches like neural networks consists in the explicit instantiation of the multivariate noise distribution and the data-optimality guarantees.

Keywords: tectonic tremor, seismic noise, signal denoising, graphical models, multivariate time series