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Microseismic Network Performance Estimation: Comparing Predictions to an Earthquake Catalogue

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The design of networks for monitoring induced seismicity is of critical importance as specific standards of performance are necessary. One of the difficulties involved in designing networks for monitoring induced seismicity is that it is difficult to determine whether or not the network meets these standards without first developing an earthquake catalog. We develop a tool that can assess two key measures of network performance without an earthquake catalog: location accuracy and magnitude of completeness. Site noise is measured either at existing seismic stations or as part of a noise survey. We then interpolate measured values to determine a noise map for the entire region. This information is combined with instrument noise for each station to accurately assess total ambient noise at each station. Location accuracy is evaluated according to the approach of Peters and Crosson (1972). Magnitude of completeness is computed by assuming isotropic radiation and mandating a threshold signal to noise ratio (similar to Stabile et al. 2013). We apply this tool to a seismic network in the central United States. We predict the magnitude of completeness and the location accuracy and compare predicted values with observed values generated from the existing earthquake catalog for the network. We investigate the effects of hypothetical station additions and removals to a network to simulate network expansions and station failures. We find that the addition of stations to areas of low noise results in significantly larger improvements in network performance than station additions to areas of elevated noise, particularly with respect to magnitude of completeness. Our results highlight the importance of site noise considerations in the design of a seismic network. The ability to predict hypothetical station performance allows for the optimization of seismic network design and enables the prediction of performance for a purely hypothetical seismic network. If near real-time estimates of a dynamic noise field are available then it is possible to obtain near real-time, dynamic measures of network performance.