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Long-term self-noise estimates of broadband seismic sensors from a high-noise vault

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To understand the detection capabilities of seismic stations and for reducing biases in ambient noise imaging, it is vital to assess the contribution of instrument self-noise to overall site noise. Self-noise estimates typically come from vault installations in continental interiors with very low ambient noise levels. However, this approach restricts the independent assessment of self-noise by individual end-users to assess any variations in their own instrument pools from nominal specifications given by manufacturers and from estimations given in comparative test papers. However, the calculation method should be adapted to variable installation conditions. One problem is that microseism noise can contaminate self-noise results caused by instrument misalignment errors or manufacturing limits; this effect becomes stronger where ambient noise is higher. Moreover, due to expected stochastic and time-varying sensor noise, estimates based on hand-picking small numbers of data segments may not accurately reflect true self-noise.

We report on results from a self-noise test experiment of Güralp seismic instruments (focussing on the 3T sensor) that were installed in the sub-surface vault of the Eskdalemuir Seismic Observatory in Scotland, UK in 2017. Due to vault's proximity to the ocean, secondary microseism noise is strong, so we efficiently compute the angle of misalignment that maximises waveform coherence with a reference sensor. Self-noise was calculated using the 3-sensor correlation technique and we compute probability density functions of self-noise to assess its spread over time. We find that not correcting for misalignments as low as 0.1° can cause self-noise to be artificially higher by up to 15 dB at frequencies of 0.1-1 Hz. Our method thus efficiently removes the effect of microseism contamination on self-noise; for example, it restores the minimum noise floor for a 360s - 50 Hz 3T to -195 dB at 0.2 Hz. Furthermore, based on the analysis of our calculated probability density functions, we find at long-periods (> 30 s) the mean self-noise can be up to 5 dB higher than the minimum, best-case noise floor. Our results show that the 3T sensor with a 360 s respond crosses the New Low Noise Model at periods of greater than 100 s. We have baselined our results using data recorded from 3T installations inside the Black Forest Observatory (BFO) vault in 2018.

Our results show that robust self-noise estimates of broadband seismic sensors can be tested and verified in a range of installation settings.