Wind Turbine Noise Reduction from Seismological Data

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Over the last years, installations of wind turbines (WTs) increased worldwide. Owing to negative effects on humans, WTs are often installed in areas with low population density. Because of low anthropogenic noise, these areas are also well suited for sites of seismological stations. As a consequence, WTs are often installed in the same areas as seismological stations. By comparing the noise in recorded data before and after installation of WTs, seismologists noticed a substantial worsening of station quality leading to conflicts between the operators of WTs and earthquake services.

In this study, we compare different techniques to reduce or eliminate the disturbing signal from WTs at seismological stations. For this purpose, we selected a seismological station that shows a significant correlation between the power spectral density and the hourly windspeed measurements. Usually, spectral filtering is used to suppress noise in seismic data processing. However, this approach is not effective when noise and signal have overlapping frequency bands which is the case for WT noise. As a first method, we applied the continuous wavelet transform (CWT) on our data to obtain a time-scale representation. From this representation, we estimated a noise threshold function (Langston & Mousavi, 2019) either from noise before the theoretical P-arrival (pre-noise) or using a noise signal from the past with similar ground velocity conditions at the surrounding WTs. Therefore, we installed low cost seismometers at the surrounding WTs to find similar signals at each WT. From these similar signals, we obtain a noise model at the seismological station, which is used to estimate the threshold function. As a second method, we used a denoising autoencoder (DAE) that learns mapping functions to distinguish between noise and signal (Zhu et al., 2019).

In our tests, the threshold function performs well when the event is visible in the raw or spectral filtered data, but it fails when WT noise dominates and the event is hidden. In these cases, the DAE removes the WT noise from the data. However, the DAE must be trained with typical noise samples and high signal-to-noise ratio events to distinguish between signal and interfering noise. Using the threshold function and pre-noise can be applied immediately on real-time data and has a low computational cost. Using a noise model from our prerecorded database at the seismological station does not improve the result and it is more time consuming to find similar ground velocity conditions at the surrounding WTs.