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Towards ambient noise attenuation monitoring: Time-varying noise source effects on noise-based attenuation estimates

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Ambient seismic noise is a useful tool to monitor the crust and shallow subsurface, with application cases that vary widely, including for example fault zone, volcano, and groundwater monitoring. Classic ambient-noise monitoring applications are based on observing changes in seismic velocity, or changes in cross-correlation waveforms. Here, we explore the possibility of monitoring crustal attenuation (both viscous and scattering) with ambient seismic noise.

Attenuation monitoring is envisioned to be an immensely useful complement to velocity monitoring, because it is sensitive to the material properties of the subsurface, and can be used together with seismic velocities to monitor the crust, for example to track crustal fluids. However, short-term measurements of attenuation from ambient seismic noise may suffer biases due to the variability of natural ambient seismic noise sources. This is of particular concern when working with the ocean-generated primary and secondary microseismic noise, which provide energy to monitor the crust at several kilometer depth, but have sources that vary strongly and rapidly.

To examine the limitations imposed by oceanic seismic noise source variability quantitatively, we first investigate the temporal behavior of Rayleigh wave attenuation coefficient α, as well as Coda-Q of ambient noise cross-correlations, at broadband seismic stations in Switzerland and in the Hengill region of Iceland, over 12 and 2.5 years, respectively. These parameters have previously been used to study crustal attenuation with ambient noise and have been shown to yield geologically meaningful information as long as long-term and array averaging is performed, which makes the observations more robust with respect to noise source variability (Soergel et al., 2020, Magrini et al., 2021).

Second, we simulate ambient noise cross-correlations with secondary microseism source models based on ocean wave hindcasts. To generate the synthetic ambient noise cross-correlations, we consider the spatiotemporal variation of the noise source spectra as well as realistic seismic wave propagation computed using the spectral element technique.

Based on the simulated and observed time series of α and Coda-Q, we evaluate the effect of noise source variability on the attenuation parameters. In this way, we intend to estimate the presence and severity of noise source bias. We consider this as a necessary step towards regional ambient noise-based attenuation monitoring.

Soergel, D., Pedersen, H. A., Stehly, L., Margerin, L., Paul, A., & AlpArray Working Group. (2020). Coda-Q in the 2.5–20 s period band from seismic noise: Application to the greater Alpine area. *Geophysical Journal International*, *220*(1), 202–217. https://doi.org/10.1093/gji/ggz443

Magrini, F., Boschi, L., Gualtieri, L., Lekić, V., & Cammarano, F. (2021). Rayleigh-wave attenuation across the conterminous United States in the microseism frequency band. *Scientific Reports*, *11*(1), Article 1. https://doi.org/10.1038/s41598-021-89497-6