Lithospheric Imaging through Reverberant Layers: Sediments, Oceans, and Glaciers

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The Earth, in large portions, is covered in oceans, sediments, and glaciers. High-resolution body wave imaging in such environments often suffers from severe reverberations, that is, repeating echoes of the incoming scattered wavefield trapped in the reverberant layer, making interpretation of lithospheric layering difficult. In this study, we propose a systematic data-driven approach, using autocorrelation and homomorphic analysis, to solve the twin problem of detection and elimination of reverberations without a priori knowledge of the elastic structure of the reverberant layers (Figure 1). We demonstrate, using synthetic experiments and data examples, that our approach can effectively identify the signature of reverberations even in cases where the recording seismic array is deployed in complex settings, for example, using data from (1) a land station sitting on Songliao basin, (2) an ocean bottom station in the fore-arc setting of the Alaska amphibious community seismic experiment (AACSE), and (3) a station deployed on ice-sediment strata in the glaciers of Antarctica. The elimination of the reverberation is implemented by a frequency domain filter whose parameters are automatically tuned using seismic data alone. On glaciers where the reverberating sediment layer is sandwiched between the lithosphere and an overlying ice layer, homomorphic analysis is preferable in detecting the signature of reverberation. We expect that our technique will see wide application for high-resolution body wave imaging across a wide variety of conditions.

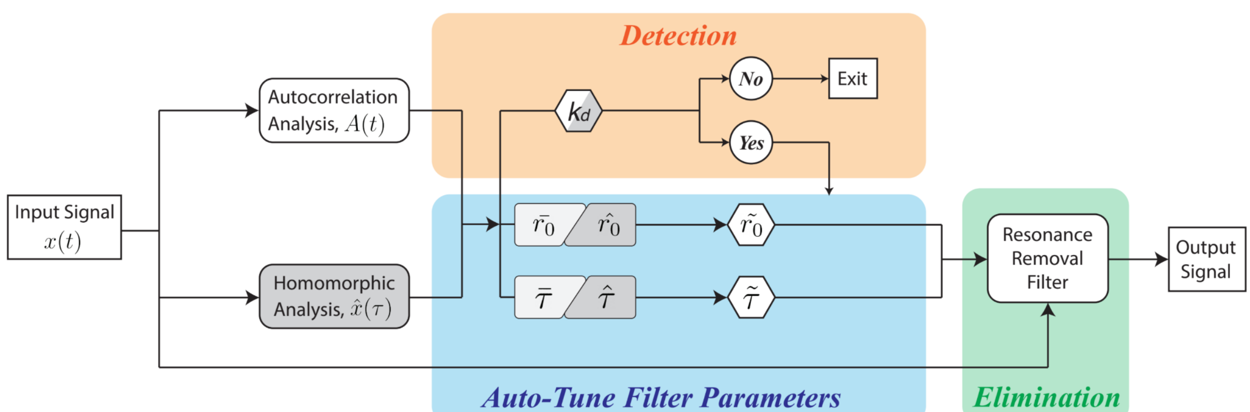

Figure 1. Signal processing workflow for fast detection and elimination of echoes and reverberations (FADER). Detection is obtained from an estimate of the echo number (k_d), and the response of the reverberating layer(s) is characterized by reverberation strength ($\tilde{r}_0$) and echo delay time ($\tilde{\tau}$). All parameters can be obtained using autocorrelation (denoted by $\bar{r}_0$ and $\bar{\tau}$ with bars) or homomorphic analysis (denoted by $\hat{r}_0$ and $\hat{\tau}$ with hats) alone, and are compared for robustness. The resonance removal filter is the inverse of the reverberation response and is applied only when repeating echoes (reverberations) are detected.