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A data-driven processing scheme for the GPR signal analysis and noise patterns removal

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GPR signal events are inevitably interfered by a variety of noises. Noise waves degrade the quality of subsurface reflections, mask the reflections from targets, and may appear like true reflections. Some investigators have proposed ways to minimize the interference of specific noise events; however, a generalized noise removal methodology is still an interesting issue. In this study, we demonstrate an effective methodology for analyzing GPR data and suppressing noise events. The processing scheme is framed by the modified multidimensional ensemble empirical mode decomposition (MDEEMD), a multidimensional extension of the EMD algorithm. The MDEEMD is a data-driven time-frequency approach that has the advantages of dealing with nonlinear and non-stationary multichannel signals, and outperforms other univariate EMD algorithms with better uniformity, closer scale alignment, and more reliable intrinsic mode functions (IMFs). The procedure is implemented by performing the EEMD (ensemble empirical mode decomposition) in both directions of the B-scan GPR data set consecutively to obtain a 2D image matrix in which the elements are images representing fragmentary features of the B-scan GPR data. The final 2D EEMD filter bank is achieved by applying the comparable minimal scale combination technique to the 2D image matrix. With the velocity analysis and pattern recognition, the noise components can be distinguished from the signal components in the 2D EEMD filter bank. By subtracting the noise components from the filter bank and combining the rest components or directly picking the signal components for final image reconstruction, the noise events in the B-scan are suppressed effectively while most of the true reflections remain.
The developed approach provides an alternative efficient method for GPR signal enhancement and can be applied to extract information from other noisy multidimensional geophysical data with limited modifications.