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Full waveform inversion for mechanized tunneling reconnaissance

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In mechanized tunnel drilling processes, exploration of soil structure and properties ahead of the tunnel boring machine can greatly help to lower costs and improve safety conditions during drilling. We present numerical full waveform inversion approaches in time and frequency domain of synthetic acoustic data to detect different small scale structures representing potential obstacles in front of the tunnel boring machine. With the use of sensitivity kernels based on the adjoint wave field in time domain and in frequency domain it is possible to derive satisfactory models with a manageable amount of computational load. Convergence to a suitable model is assured by the use of iterative model improvements and gradually increasing frequencies.
Results of both, time and frequency approach, will be compared for different obstacle and source/receiver setups. They show that the image quality strongly depends on the used receiver and source positions and increases significantly with the use of transmission waves due to the installed receivers and sources at the surface and/or in bore holes. Transmission waves lead to clearly identified structure and position of the obstacles and give satisfactory guesses for the wave speed. Setups using only reflected waves result in blurred objects and ambiguous position of distant objects and allow to distinguish heterogeneities with higher or lower wave speed, respectively.