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Full waveform inverse modeling of GPR Data of layered media

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Geophysical methods are increasingly being used to provide quantitative information of layered structures. Traditionally, geophysical data are inverted with the aid of a non-linear inverse modeling package. Full waveform inversion is then implemented by minimizing some penalty or objective function. The objective function is usually the measured data subtracted by the modeled data and the modeled data is modified to fit the measured data. Because the data is not touched, this is called a model-driven, or data-fitting problem. The objective function is non-quadratic making data fitting a hard task, generally requiring many iterations. Non-uniqueness of the solution leads to the question what the model quality is even when the data fit is very good.

In this study, I explore an alternative method by finding a filter that allows for full waveform inverse modeling using reflection data only. The filter does not require model information and hence is completely different than solving a data fitting problem. The approach taken here creates the inverse model in two steps. First a true amplitude migration image of primary reflections is found directly from the data through an iterative procedure that converges very fast. Hence, it is a data-driven method. This image can be constructed for any point in space independently and therefore does not suffer from error propagation. The result of this step is a unique solution, but of course it is exact in terms of reflection amplitude as a function of one-way travel time. The second step is to find the electric permittivity from the image as a function of depth by assuming no magnetic contrasts occur in the layered model. Here the accuracy of the permittivity of the layer where the data is measured is crucial. Possible errors in this number lead to error propagation in the resulting permittivity profile as a function of depth. The present model is shown to work for one-dimensional media that do not dissipate energy. Extending the method to layered media with non-zero conductivity is possible. Extension to three-dimensional media seems possible.