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Evaluation of the reconstruction limits of a non-dispersive waveform inversion scheme for crosshole georadar data acquired in dispersive environments

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High-resolution imaging of the shallow subsurface is extremely important for a wide range of environmental, hydrological, and engineering applications. To this end, the waveform-based tomographic inversion of crosshole georadar data has gained increasing popularity because of its ability to provide vivid images of the constituitive electromagnetic parameters in complex near-surface environments. Such methods indeed hold the promise of providing images of subsurface structure with a spatial resolution comparable to that of borehole logs. While significant developments have been made with respect to seismic waveform inversion over the past two decades, corresponding advances in the georadar domain have been few and far apart. To our knowledge, all existing waveform inversion schemes for crosshole georadar data are based on the assumption of non-dispersive media. Here, we explore the reconstruction limits of a recently developed non-dispersive waveform inversion procedure for crosshole georadar in the presence of dielectric dispersion. Our results indicate that, at least for weak to moderate degrees of dispersion, the non-dispersive inversion scheme remains robust and provides remarkably faithful reconstructions even for strongly heterogeneous media. While the resolution of our waveform-based tomographic images systematically deteriorates with increasing dispersion, their overall quality remains vastly superior to corresponding ray-based tomographic reconstructions. Quite importantly, our results also demonstrate the viability of a recently proposed source wavelet estimation scheme based on an iterative deconvolution for georadar data acquired in dispersive environments.