Geophysical Research Abstracts,
Vol. 10, EGU2008-A-01632, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-01632
EGU General Assembly 2008

Recent developments in full-waveform inversion of georadar data

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Crosshole radar tomography is a useful tool in diverse geological, hydrogeological, and engineering investigations. Conventional tomograms provided by standard ray-based techniques have limited resolution, primarily because only a fraction of the information contained in the radar data (i.e., the first-arrival times and maximum first-cycle amplitudes) is included in the inversion. Higher resolution tomograms can be derived by using full-waveform inversion schemes. We recently developed an algorithm for inverting vertical electric fields recorded in crosshole configurations. Our synthetic tests demonstrated that the full-waveform inversions usually provided substantially better results than those supplied by traditional ray methods. We have also demonstrated the potential and limitations of full-waveform tomographic inversions via applications to two field data sets. The resolution of all full-waveform tomograms was shown to be markedly superior to that of the associated ray tomograms. Small subsurface features a fraction of the dominant radar wavelength and boundaries between distinct geological/hydrological units were sharply imaged in the full waveform tomograms. Here, we improve the algorithm by taking into account the vectorial nature of the problem and use both the vertical and horizontal electric fields in the inversions. Our new algorithm can be used to invert efficiently surface and borehole data at the same time. We show the results of applying the new algorithm to synthetic and observed data. Several tests demonstrate that the new inversion algorithm provides reliable and stable inversions and that the locations, sizes, and electrical properties of the causative structures are much better reconstructed when combined borehole and

surface data sets are jointly inverted.