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Full waveform inversion of high-resolution seismic data - a quest for maximizing subsurface information

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High-resolution seismic data are typically analyzed using either migration-style reflection data processing schemes or tomographic inversion techniques. During the past 20 years, attempts have been made to extend the data space from purely kinematic to dynamic by including the full seismic waveforms into the inversion schemes. While time-domain inversions still require substantial computing resources in the form of large clusters, frequency-domain approaches can nowadays be implemented such that they are run on affordable computers within reasonable time limits. In this paper we investigate the information content offered by seismic data by means of a rigorous sensitivity and model resolution analysis. For that purpose we consider cross-hole configurations and employ a 2D frequency-domain acoustic inversion procedure. As a first step we study the sensitivity kernels for various source-receiver configurations, frequencies and model parameterizations. For higher temporal frequencies the sensitivity kernels exhibit rapid spatial oscillations, which may require small inversion cells to avoid aliasing problems. Interestingly, satisfactory inversion results can be also achieved with relatively coarse model parameterizations. As the next step we investigate the information content offered by various experimental setups. The parameters varied for the different designs include (i) data representations, (ii) source- and receiver spacings and (iii) temporal frequencies. As a measure of information content we examine the eigenvalue spectra and model resolution matrices. On the basis of these analyses we propose data acquisition and inversion strategies which yield optimized benefit/cost ratios. In particular, we inspect potential trade-offs between source- and receiver spacings and the choice of temporal frequencies. The robustness of our experimental design procedures is evaluated using a range of velocity models with an

increasing degree of complexity.