

First-arrival travelttime tomography in anisotropic media using the adjoint-state method

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Conventionally, travelttime tomography using transmission data has been widely used for static corrections and for obtaining near-surface models for seismic depth imaging. More recently, travelttime tomography is also employed to build initial models for full-waveform inversion. The classical travelttime tomography approach based on ray tracing has serious limitations in handling large data sets resulting from current seismic acquisition surveys. Some of these difficulties can be overcome by using the adjoint-state method, due to its low-memory requirement and numerical efficiency. The need for explicit computation of the Fréchet derivative matrix is avoided by coupling the gradient computation to nonlinear optimization (Taillandier et al., 2009). Furthermore, the computation cost is equivalent to twice the solution of the forward modeling problem, irrespective of the size of the input data. Another advantage of the adjoint-state method is that the gradient calculation can be carried out shot-by-shot; therefore, the adjoint-state computation can be distributed over many processors. Despite these attractive features of the adjoint-state method for first arrival travelttime tomography, its development has been limited to isotropic medium due to unavailability of efficient eikonal solvers for anisotropic media. The recent works of Waheed et al. (2014, 2015) on efficient anisotropic eikonal solvers has made it possible to extend the adjoint-state method to the anisotropic case.

We develop the adjoint-state technique for first arrival travelttime tomography in vertical transversely isotropic (VTI) media. Since the Thomsen’s parameter δ is weakly resolvable from surface seismic alone (Plessix and Cao, 2011), we invert for the normal moveout velocity v_{nmo} and the anellipticity parameter η . Numerical tests on the VTI SEAM model demonstrate the capability of the algorithm to invert for near-surface model parameters and reveal the accuracy achievable by the algorithm.

References

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