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Prestack First-break Traveltime Tomography with the Double-square-root Eikonal Equation

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Conventional traveltime tomography with shot-indexed eikonal equation fixes shot positions then relies on inversion to resolve any contradicting information between independent shots. An alternative approach is provided by the double-square-root eikonal equation. While giving the same first-break traveltimes, it allows not only the receivers but also the shots to change position.

Our analysis shows that the double-square-root eikonal equation can be solved by a version of the fast-marching method with special treatment for its singularity at horizontal waves and non-causal branches. We demonstrate through synthetic model examples that the tomographic inversion based on double-square-root eikonal equation provides faster convergence and higher model accuracy than those of conventional tomography with the shot-indexed eikonal equation. Since it takes into account source communication inherently, we also find that the double-square-root eikonal based tomography relies less on regularization. We expect this novel approach could outperform the conventional tomography in presence of noisy data and complex near surface geologies.

Keywords: double-square-root eikonal equation, tomography