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Seismic tomography with traveltimes and source/receiver slopes based on Eikonal and adjoint equations

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Reconstructing the crustal properties from seismic data can rely on traveltimes and source/receiver slopes when dense acquisition is available for common source gather or common receiver gather as long as volumetric event pciking is achievable: with these extracted data, least-squares misfit optimization is performed based on linearized approximation. With efficient ray tracing tools, this so-called stereotomography (alias slope tomography) has become an effective strategy over years for such reconstruction (Lambaré, 2008). New Eikonal solvers for tilted-transverse-anisotropic (TTI) media have been recently introduced for handling efficiently uniform sampling of traveltime maps and slope maps inside the subsurface (Waheed et al., 2015; Tavakoli F. et al., 2015; Le Bouteiller et al., 2018), leading to compact slope-tomography workflows where partial differential equations to be solved depend only on the acquisition density and not on the picked-events number related to scatterers inside the medium (Tavakoli F. et al., 2017).

We shall discuss during this presentation what are the data to be used, what are the related model parameters to be reconstructed, and what are the needed partial differential equations involved in this inversion approach: Non-linear Eikonal equations for traveltimes and slopes, transport equation for getting adjoint fields needed for data misfit gradient. Through simple examples, we shall assess the sensitivity of the inversion to different subsurface parametrization. Based on the 2D BP Salt TTI model (Billette and Brandsberg-Dahl, 2004), we shall illustrate performance of the new slope tomography, where vertical velocity and Thomsen ϵ parameter will be recovered as well as scatterers positions.

A real application will be provided based on broadband towed-streamer data, for which Thomsen parameters ϵ, δ and tilt angle θ are used as passive parameters, while vertical velocity v_v and scatterers positions $\mathbf{x}_{sc}$ are jointly inverted. The quality of the reconstructed velocity model through the analysis of common-image gathers computed by reverse time migration will illustrate performance of the approach for depth targets depending essentially on the quality of the dense picking procedure.

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