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2D Travel-time tomography of downward continued streamer multichannel seismic data followed by a band-limited full waveform inversion. Application to the Alboran basin (SE Iberia)

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High-resolution velocity models can be retrieved by applying adjoint-state full-waveform inversion (FWI) to controlled source data. However the strong non-linearity of the problem makes the solution strongly dependent on the initial model chosen and on the low frequency content of the seismic source. Besides, typical relatively-short offset multi-channel seismic (MCS) data lacks first -refracted- arrivals that are commonly used to obtain a suitable starting model for FWI.

Here we show that this problem can be solved by combining a joint refraction and reflection Travel Time Tomography (TTT) of a re-datumed version of the same data set to obtain an appropriate reference model with the correct low wavenumber on it that is subsequently refined by FWI. The proposed workflow is first described and then applied to MCS data acquired with 6 km-long streamer during the TOPOMED-2011 experiment in the Gulf of Cadiz (SE Iberia).

The applied strategy includes as a first step a wave equation-based downward continuation (DC) or redatuming of the MCS data to simulate a sea bottom acquisition geometry, followed by a joint travel-time tomographic inversion of first arrivals identified in the DC data set together with the top of the basement (TOB) reflection from the MCS common mid point gathers to finally perform the multi-scale FWI of the original streamer data using the model obtained by TTT as initial model. The robustness of the Vp and TOB geometry model obtained by joint refraction and reflection TTT is assessed by comparing the results obtained using three independent data sets (different groups of shotgathers). The three models coincide within parameter uncertainty bounds, and the two-way-time transformed TOB geometry is also coincident with the time migrated image. We conclude therefore that the velocity and reflector depth model obtained is robust. The joint DC refraction and reflection travel-time inversion scheme helps to reduce the inherent existing velocity-depth trade-off. As a third step, we apply FWI using the TTT model as initial model. We show that in this case FWI can be done starting at realistic frequencies, because the starting model has the low wavenumber information needed to avoid cycle-skypping problems. The main limitation is the depth of the inverted model ($\sim$2 km) severely limited by the short acquisition offset.