Improving depth imaging using a novel hybrid FWI approach

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Abstract

The Equatorial Margin is nowadays considered as the next exploration frontier in Brazilian offshore exploration and production. It encompasses 5 different basins, with potentially a wide range of geological challenges (da Cruz, et al. 2021), which need to be tested against current and upcoming seismic methods, both in an imaging, as well as in an inversion perspective.

Current methodologies that look promising in the Equatorial Margin include the use of ocean bottom nodes in the exploration phase versus traditional streamer acquisition; advanced imaging techniques, such as Least Squares Reverse Time Migration (LSRTM) and Full Waveform Inversion (FWI) (Costa, et al. 2022).

Here, we present a synthetic study based on a representative multiparameter model (P and S velocities and density), comparing the effectiveness and potential gains that different imaging and inversion methodologies present. We also propose a new FWI approach, which we call Hybrid Full Waveform Inversion, that brings some of the benefits of Elastic FWI while still maintaining the more simplistic and computationally less expensive approach of traditional acoustic FWI.

We evaluate the differences between acoustic and elastic modeling, for both nodes and streamer data, highlighting the importance of considering elastic effects, specially at longer offsets. Such observations have led to our implementation of a hybrid approach for FWI. From an imaging perspective, we evaluate both RTM and Least Squares RTM, and how LSRTM is capable of compensating illumination effects, deconvolving the wavelet's signature and recovering a more accurate reflectivity. With respect to inversion techniques, we apply FWI to our synthetic tests, where an initial 1D velocity model based on a geological compaction trend is added at the correct ocean depth along the horizontal direction, followed by either a traditional FWI approach or our proposed Hybrid FWI methodology. We show improvements in the obtained velocity models, specially after migration, when using such novel approach.