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New tools for 2D full-waveform inversion: applications on Brazilian Pre-Salt velocity model from Santos Basin

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In this work, we present full-waveform inversion (FWI) results of a typical Brazilian Pre-Salt model (Santos Basin) using new open-source tools. The large accumulations of oil with excellent quality and high commercial value discovered in the pre-salt carbonates of southeastern Brazil, especially in the Santos Basin, have made this province one of the most prospective in the world. Velocity model building in areas of highly complex geology (like the Santos Basin) remains a challenging step in seismic processing. FWI proved to be an efficient tool for the determination of high-resolution details in multiparameter models of complex subsurface structures, and it has been applied in different geophysical problem scales. However, since FWI is a computationally and mathematically challenging problem, many issues remain open, such as more efficient ways to deal with multiparameter inversion problems such crosstalk and different orders of magnitude in the seismic signal for different classes of parameters. Inversions for more than one class of parameters are of particular importance in the estimation of the physical properties of rocks (poroacoustic or poroelastic applications), for example, to monitoring oil and gas reservoirs and for monitoring the injection of carbon dioxide into geological structures. Also, programming complex numerical algorithms for each application is time-consuming and often evades the expertise of researchers from the geoscientific community. In this sense, a high-level computational tool for simulations and inversions would greatly improve the working time for researchers. Existing finite difference based FWI tools such as Devito, and finite elements based partial differential equations (PDE) solvers tools such as FEniCS and Firedrake are being explored and used for these purposes. In this work, we initially present an FWI acoustic isotropic inversion test (velocity inversion only), performed with the Devito software while a particular code is being developed in FEniCS and Firedrake computer programs. Devito is also a new and under development software and therefore must be tested under different conditions. Our first numerical results indicate the potential of using freely available computational programs in a real case scenario.