Application of FWI in real seismic oceanography data

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Abstract

The objective of Full Waveform Inversion (FWI) is to reconstruct a model of physical parameters, for example, a model of sound propagation velocity distribution in an elastic medium, fitting computationally generated synthetic data to experimentally obtained seismic data. Due to the high nonlinearity of the inverse problem, the success of the FWI is directly linked to the accuracy of the initial model, presence of low-frequency energy in the experimental data and a presence of noise in the input data. In Seismic Oceanography, the application in real data is extremely recent, not consolidated, being necessary to deal with challenges such as a low signal-to-noise ratio in the raw seismic data (less than 0.4), lack of energy at low frequencies and a possible lack of an initial model from in-situ measurements. These aspects make it difficult to recover the model from seismic data. The aim of this work is the application of the FWI to real reflection data obtained in oceanographic structures, contaminated due to processing done by third parties.

Therefore, a functional seismic data processing workflow is proposed for a better conditioning of the input data in the inversion. Using the multiscale approach in the frequency, 15 Hz to 25 Hz, being monitored the convergence and reduction of the objective function, a good adjustment of the results (mainly up to 800m), however there is also the appearance of structures not consistent with the observed data. This behavior suggests a change in the approach, possibly aimed at increasing the tolerance of the method with the presence of noise. Some options found in the literature use the L-BFGS approach with changes in the construction of the Hessian matrix and step size. Others suggest the greater robustness in the objective function within the objective function, seeking to reduce the influence of minima locations and sensitive to the presence of noise. Finally, an approach for the reconstruction of temperature and salinity maps, from of the sound velocity profile results was developed. For this, an equation is made to relate the dependence of temperature to speed, from the diagram $T-S$ location in the region of interest. As input, the resulting sound velocity profiles were used after cycling at 25 Hz, resulting in salinity and temperature profiles. In general, the results have similar characteristics to the velocity profile obtained, with the temperature contrasts aligned with the variations profile associated with different water masses (up to 800m) and a smoother behavior is observed in salinity, mainly from 1000m.

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