Intrinsic non-uniqueness of the acoustic full waveform inverse problem

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Presentation summary

The context of our presentation is the one of seismic full waveform inverse (FWI) problem. We will show with numerical tests that an acoustic FWI is intrinsically non-unique, and therefore not possible to be solved in general.
Our arguments are the following

- Particle relabeling (D. Al-Attar & al 2016, GJI) : particle relabelling method shows it is possible to deform a true medium based on a smooth mapping into a new one without changing the signal recorded at seismic stations. This is a potentially strong source of non-uniqueness for an inverse problem based on seismic data. Nevertheless, in the elastic case, the deformed medium loses the elastic tensor minor symmetries and, in the acoustic case, it implies density anisotropy. It is therefore not a source of non-uniqueness for elastic or isotropic acoustic inverse problems, but it is for the anisotropic acoustic case.
- Homogenization (Y. Capdeville & al 2010, GJI) : the homogenization method shows that any fine-scale medium can be up-scaled into an effective medium without changing the waveforms in a limited frequency band. The effective media are in general anisotropic, both in the elastic and acoustic cases, even if the true media are isotropic at a fine scale. It implies that anisotropy is in general present and needs to be inverted for. Therefore, acoustic anisotropy can not be avoided in general.

Presentation summary

We conclude, based on a particle relabelling and homogenization arguments, that the acoustic FWI solution is in general non-unique.
We can distinguish four cases for a FWI :

target model	elastic	acoustic
smooth (isotropic inversion)	not a problem	not a problem
fine scale (anisotropic inversion)	not a problem	potentially a problem

In this presentation, we numerically test these four cases showing that the general acoustic FWI in indeed non-unique.
This work will be presented on Monday May 4th during the zoom meeting organized by the SM7.1 session conveners.