Geophysical Research Abstracts
Vol. 17, EGU2015-7666, 2015
EGU General Assembly 2015

Data-driven layer-stripping strategy in 3-D joint refraction and reflection travel-time tomography with $TOMO_3D$

Adrià Meléndez (1), Jun Korenaga (2), Valentí Sallarès (1), Alain Miniussi (3), and César Ranero (4)

(1) Barcelona Center for Subsurface Imaging, Institut de Ciències del Mar (CSIC), Barcelona, Spain (melendez@icm.csic.es), (2) Department of Geology and Geophysics, Yale University, New Haven (CT), USA, (3) Observatoire de la Côte d'Azur, CNRS, UMS Galilée, Boulevard de l'Observatoire, Nice, France, (4) Barcelona Center for Subsurface Imaging, ICREA at Institut de Ciències del Mar (CSIC), Barcelona, Spain

We present a new 3-D travel-time tomography code ($TOMO_3D$) for the modelling of active-source seismic data that uses the arrival times of both refracted and reflected seismic phases to derive the propagation velocity distribution and the geometry of reflecting boundaries in the subsurface. The combination of refracted and reflected data provides a denser coverage of the study area. Moreover, because refractions only depend on the velocity parameters, they contribute to the mitigation of the negative effect of the ambiguity between layer thickness and propagation velocity that is intrinsic to the reflections that define these boundaries.

This code is based on its renowned 2-D version $TOMO_2D$ from which it inherited the methods to solve the forward and inverse problems. The forward travel-time calculations are conducted using a hybrid ray-tracing technique combining the graph or shortest path method and the bending method. The LSQR algorithm is used to perform the iterative inversion of travel-time residuals to update the initial velocity and depth models. In order to cope with the increased computational demand due to the incorporation of the third dimension, the forward problem solver, which takes by far most of the run time ($\sim$90%), has been parallelised with a combination of MP and MPI standards. This parallelisation distributes the ray-tracing and travel-time calculations among the available computational resources, allowing the user to set the number of nodes, processors and cores to be used.

The code's performance was evaluated with a complex synthetic case simulating a subduction zone. The objective is to retrieve the velocity distribution of both upper and lower plates and the geometry of the interplate and Moho boundaries. Our tomography method is designed to deal with a single reflector per inversion, and we show that a data-driven layer-stripping strategy allows to successfully recover several reflectors in successive inversions. This strategy consists in building the final velocity model layer by layer, sequentially extending it down with each inversion of a new, deeper reflector. One advantage of layer stripping is that it allows us to introduce and keep strong velocity contrasts associated to geological discontinuities that would otherwise be smoothened. Another advantage is that it poses simpler inverse problems at each step, facilitating the minimisation of travel-time residuals and ensuring a good control on each partial model before adding new data corresponding to deeper layers. Finally, we discuss the parallel performance of the code in this particular synthetic case.