Exploration of innovative methods for the inversion of seismological data and their optimization for seismic tomography models

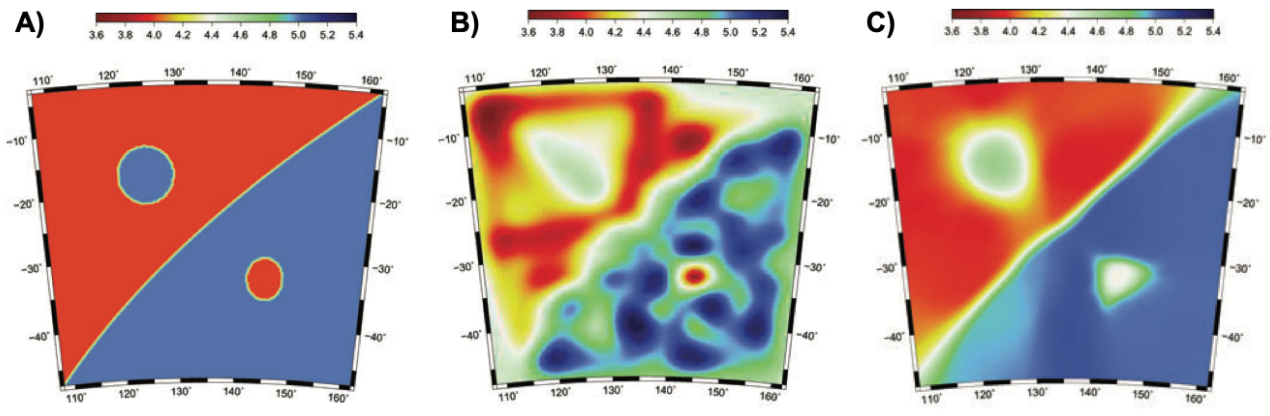
(Proposer: Prof. Manuele Faccenda – Funded by Istituto Nazionale di Geofisica - INGV)

The research project aims at exploring innovative mathematical methods for the inversion of seismological data and their optimization for the construction of large-scale multi-parameter seismic models. In particular, the research activities are intended to improve the 3D representation of the Earth's interior, with particular attention to the inversion of seismic anisotropy from which it is possible to reconstruct crust and mantle structures and flow patterns, and minimize artefacts present in models of isotropic velocity variations.

The standard inversion methods are mostly based on iterative linearized schemes (e.g., Gauss-Newton and gradient descent methods), with the downside that (i) the solution may depend on the starting model, (ii) convergences is typically slow and may yield a solution corresponding to a local minimum of the misfit function, (iii) no accurate estimates about the errors of the inverted parameters are provided, and (iv) require a number subjective choices made by the user (e.g., parameter discretization and damping) in order to regularize the ill-posed inverse problem. Additionally, these methods require computation of derivatives that may not be easily defined. An alternative approach is to use fully non-linear sampling methods (e.g., Markov chain Monte Carlo) where the model parameters are explored more systematically and error estimates are provided. While these non-linear sampling methods generally overcome the aforementioned limitations, they have a much higher computational cost and require careful optimization. As such, we propose to test and compare the performances of these different inversion methods applied to the non-linear anisotropic tomography problem (i) at first on synthetic seismological datasets generated from geodynamic models that reproduce the structural complexities observed in nature, and (ii) subsequently in the Mediterranean area where high-quality seismological data are available through the INGV.

Collaborations: INGV – Bologna

Funds: INGV, DOR Faccenda



Comparison of different tomographic methods. A) True model; velocities in km/s. B) Results from a linearized inversion after 6 iterations. C) Results of a reversible jump Markov chain Monte Carlo tomography. From Bodin and Sambridge, 2009, GJI.