Geophysical Research Abstracts
Vol. 16, EGU2014-13157, 2014
EGU General Assembly 2014


# Some algorithmic issues in full-waveform inversion of teleseismic data for high-resolution lithospheric imaging

Vadim Monteiller (1), Stephen Beller (1), Guust Nolet (1), Stephane Operto (1), Romain Brossier (2), Ludovic Métivier (2), Anne Paul (2), and Jean Virieux (2)

(1) Géoazur, Université de Nice Sophia-Antipolis - CNRS, France, (2) Laboratoire de Géophysique Interne et Tectonophysique - Université Joseph Fourier - CNRS

The current development of dense seismic arrays and high performance computing make feasible today application of full-waveform inversion (FWI) on teleseismic data for high-resolution lithospheric imaging. In teleseismic configuration, the source is to first-order a plane-wave that impinges the base of the lithospheric target located below the receiver array. In this setting, FWI aims to exploit not only the forward-scattered waves propagating up to the receiver but also second-order arrivals that are back-scattered from the free-surface and the reflectors before their recordings on the surface. FWI requires using full-wave methods modeling such as finite-difference or finite-element methods. In this framework, careful design of FWI algorithms is topical to mitigate as much as possible the computational burden of multi-source full-waveform modeling. In this presentation, we review some key specifications that might be considered for versatile FWI implementation. An abstraction level between the forward and inverse problems that allows for the interfacing of different modeling engines with the inversion. This requires the subsurface meshings that are used to perform seismic modeling and update the subsurface models during inversion to be fully independent through some back-and-forth projection processes. The subsurface parameterization should be carefully chosen during multi-parameter FWI as it controls the trade-off between parameters of different nature. A versatile FWI algorithm should be designed such that different subsurface parameterizations for the model update can be easily implemented. The gradient of the misfit function should be computed as easily as possible with the adjoint-state method in parallel environment. This first requires the gradient to be independent to the discretization method that is used to perform seismic modeling. Second, the incident and adjoint wavefields should be computed with the same numerical scheme, even if the forward problem operator is not self adjoint as it is the case with a first-order velocity-stress formulation of the elastodynamic equations. We will show how to satisfy these two requirements by using a pseudo-conservative symmetric form of the velocity-stress elastodynamic equations as a state equation in the adjoint-state method. The FWI code should be used on different distributed-memory architectures. We combine two levels of MPI parallelism by domain decomposition of the computational domain and distribution of events over groups of processors. These two levels of parallelism are managed by two nested MPI communicators. Up-to-date optimization algorithms should be implemented in FWI algorithms. In particular, second-order optimization methods which take into account the action of the Hessian such as quasi-Newton methods (l-BFGS) or truncated Gauss-Newton and Newton methods, provide a suitable scaling of the multi-parameter gradient and helps to correct for trade-off between parameters of different nature. A reverse communication procedure allows the optimization task to be kept as independent as possible from the other tasks performed by the algorithms (gradient, model update,...) and facilitates the interfacing of new optimization algorithms with the FWI software. FWI is implemented in the time domain, then the incident wavefields are recomputed during the adjoint simulation with check-pointing strategies in order to involve attenuation effects in seismic modeling and inversion.