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Going to high frequency for full waveform inversion of teleseismic wavefields based upon a SEM-DSM hybrid method and massive High-Performance Computing

Dimitri Komatitsch (1), Vadim Monteiller (1,2,3), Sébastien Chevrot (2), Yi Wang (2), and Clément Durochat (1)
(1) CNRS, Laboratory of Mechanics and Acoustics, Marseille, France (komatitsch@lma.cnrs-mrs.fr), (2) CNRS, IRAP, Observatoire Midi-Pyrénées, Toulouse, France, (3) CNRS, Géoazur, Nice, France

We present a method for high-resolution imaging of lithospheric structures based on full waveform inversion of teleseismic wavefields. We model the propagation of seismic waves using our recently developed Direct Solution Method (DSM) / Spectral-Element Method (SEM) hybrid technique, which allows us to simulate the propagation of short period teleseismic waves through a regional 3-D model.

We implement an iterative quasi-Newton method based upon the L-BFGS algorithm, with a gradient of the misfit function computed with the adjoint-state method. Compared to gradient or conjugate-gradient methods, the L-BFGS algorithm finds solutions that better explain the observed waveforms, and at a much faster convergence rate.

We illustrate the potential of this method on a synthetic test case that consists in a crustal model with a crustal discontinuity at 25 km depth and a sharp Moho jump. This simple model contains short and long wavelength heterogeneities along both the lateral and vertical dimensions.

In order to do that successfully we resort to high-performance computing on supercomputing clusters using an improved version of our SPECFEM3D open-source software package, which exhibits excellent scalability on parallel machines.