Full-Waveform Inversion on Heterogeneous Massively Parallel Computers

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Abstract

We present a spectral-element implementation of full seismic waveform inversion in the time domain for large heterogeneous HPC systems. The time step algorithm exposes a large amount of data-level parallelism, which we exploit efficiently by using heterogeneous massively parallel computing systems. We address several engineering challenges, typical for realistic inversions, in particular the optimal parallelization configurations of individual simulations, the large I/O requirements of adjoint simulations, and the scheduling of large numbers of forward and adjoint solves. We achieved 3.5 to 4 times performance improvement over the best known homogeneous solver implementation. The GPU memory throughput is varying from 60 % to 80 % of the peak bandwidth, thus providing good utilization of hardware resources. We demonstrate the practical applicability of our solution in a real-data application in the Japan region. With the help of GPU accelerators, we are able to perform numerical simulations of wave propagation in realistic 3D visco-elastic Earth models and invert for regional crustal and upper mantle structure.