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SeimicWaves.jl: an efficient yet user-friendly Julia package for Full-Waveform Inversion on multi-xPUs

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This work focuses on creating efficient and user-friendly tools for seismic tomography using Full-Waveform Inversion (FWI) methods. FWI has proven effective in providing detailed images of the Earth's subsurface. Despite its success, challenges persist due to its high computational costs and complexity, limiting its widespread application in research and education.

To fill the gap between theory and practice, we present efficient, easy-to-use, and scalable finite-difference-based solvers for FWI in the Julia programming language developed in the open-source package SeismicWaves.jl (part of HMCLab, a framework to perform Bayesian inversion and optimization for geophysical problems), which enable non-experts to conduct numerical experiments and address real applications with seismic data. Our device-agnostic solvers can be distributed on multiple devices (multi-xPUs), providing users with different parallelization options fitting diverse use cases.

Rigorous tests and synthetic inversions validate the solvers' correctness, offering insights into both the potentials and pitfalls of the method. Benchmark tests evaluating memory throughput, crucial for the memory-bound algorithms under study, reveal that our solvers achieve high memory throughput (up to 90% of peak) on modern GPUs and exhibit good weak scaling on distributed systems.

In conclusion, by leveraging advancements in software and hardware from the scientific computing community, our research addresses both computational and complexity challenges of FWI, making it a viable and efficient method for educational and research purposes in seismic tomography.