ID de Contribution: **55** Type: **Talk**

An Efficient Workflow for Global Seismic Tomography

mercredi 5 juillet 2023 09:00 (30 minutes)

Understanding the Earth's interior properties is vital for various research branches like geodynamics and plate tectonics and helps crucial estimations for seismic risk assessments and shake maps. Full seismic waveform inversion has emerged as a promising methodology to recover improved tomographic images of the mantle and crust. As the workflow solves the wave equation through numerical modelling, the resulting models are capable of accurately capturing and accounting for any observed wiggles in the seismic data. However, the computational demand of full-waveform inversion is a notorious drawback.

We present two approaches to reduce computational requirements for global tomography: dynamic mini-batches and wavefield-adaptive meshes. With dynamic mini-batches, only a subset of events is considered for each iteration, significantly reducing the overall number of required forward and adjoint simulations to compute model gradients. Wavefield-adaptive meshes minimize the number of elements in simulation meshes by designing the spectral-element meshes with a preferable geometry for each event. Applying this economic workflow to a global dataset of ~2000 events, we obtain a tomographic model explaining global waveform propagation for a minimum period of 35 s.

Building upon the previous concepts, we introduce the Collaborative Seismic Earth Model (CSEM), which embeds finely detailed regional tomographic models within a global context, resulting in a multi-scale representation of the Earth's mantle and crust. In its current state, the model not only provides global waveform fits for minimum periods of 50 s but also surpasses this resolution down to 20 s in targeted regions.

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Classification de Session: Methodologies and numerical approaches to inversion problems