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A 3D discontinuous Galerkin finite-element method for teleseismic modelling.

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The massive development of dense seismic arrays and the rapide increase in computing capacity allow today to consider application of full waveform inversion of teleseismic data for high-resolution lithospheric imaging. We present an hybrid numerical method that allows for the modelling of short period telesismic waves in 3D lithospheric target with the discontinuous Galerkin finite elements method, opennig the possibility to perform waveform inversion of seismograms recorded by dense regional broadband arrays. In order to reduce the computational cost of the forward-problem, we developed a method that relies on multi-core parallel computing and computational-domain reduction. We defined two nested levels for parallelism based on MPI library, which are managed by two MPI communicators. Firstly, we use a domain partitionning strategy, assigning one subdomain to one cpu and, secondly we distribute telesismic sources on different copies of the partitioned domain. However, despite the supercomputer ability, the forward-problem remains expensive for telesismic configuration especially when 3D numerical methods are considered. In order to perform the forward problem in a reasonable amount of time, we reduce the computational domain in which full waveform modelling is performed. We defined a 3D regional domain located below the seismological network that is embeded in a background homogeneous or axisymetric model, in which the seismic wavefield can be computed efficiently. The background wavefield is used to compute the full wavefield in the 3D regional domain using the so-called total-field/scattered-field technique (Alterman & Karal (1968),Taflove & Hagness (2005)), which relies on the decomposition of the wavefield into a background and a scattered wavefields. The computational domain is subdivided intro three subdomains: an outer domain formed by the perfectly-mathed absorbing layers, an intermediate zone in which only the outgoing wavefield scattered by the lithospheric heterogeneities is computed, and the inner domain formed by the lithospheric target in which the full wavefield is computed. We interface the discontinuous Garlekin finite elements method on unstructured tetrahedral mesh with the total-field/scattered-field approach to perform full-waveform modeling in the lithospheric target. This interfacing requires to modify the numerical fluxes at the boundary between the inner and intermediate domain to guarantee the consistency between the ingoing and the outgoing wavefields in the lithospheric target. Similar to the finite-difference method, the modification simply consists in adding or substracting the background solution to the original fluxes depending whether the full wavefield in the inner domain or the scattered field in the intermediate domain is updated. One advantage of the total-field/scattered-field approach is related to the fact that the scattered wavefield instead of the full wavefield enter the PMLs, hence making more efficient the absorption of the outgoing waves at the outer edges of the computational domain.