Large-scale parallel simulations of earthquakes at high frequency: the SPECFEM3D project

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In the last thirty years, many methods have been used for the numerical simulation of seismic wave propagation in complex geological models, initially in two dimensions and more recently in three dimensions. Among them, the spectral-element method (SEM), which is based on a variational formulation of the wave equation, combines the flexibility of a finite-element method with the accuracy of a global pseudospectral method and leads to a diagonal mass matrix. The finite-element grid is adapted to all the major discontinuities of the geological model and the effects of a complex rheology (for instance attenuation and anisotropy) can be taken into account. We show applications of this technique to the study of the anisotropy of the inner core of the Earth as well as to the study of acceleration and crater filling at the surface of an asteroid. Calculations are performed in parallel on 2166 processors based upon message passing with MPI.

A significant hurdle in the context of numerical methods that simulate elastic wave propagation is often their high computational cost. In the case of local or regional calculations, i.e. in geometrically unbounded domains, it is necessary to define artificial absorbing edges surrounding the model. Therefore, implementing efficient absorbing boundary conditions is of major interest in seismics and seismology to be able to increase the resolution of 3D calculations. Following the work of Roden and Gedney (2000) for Maxwell's equations, we introduce a Convolutional Perfectly Matched Layer (C-PML) absorbing condition which includes a filtering term in order to improve the behavior of the PML condition for waves at grazing incidence.