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Spectral-Element Simulations of Global Seismic Wave Propagation using the Earth Simulator

Seiji Tsuboi[1], Dimitri Komatitsch[2], Jeroen Tromp[2]

[1] IFREE, [2] Caltech

We simulate global seismic wave propagation throughout a 3-D model, which includes a 3-D velocity and density structure, a 3-D crustal model, ellipticity as well as topography and bathymetry. We use the spectral-element method (SEM) developed by Komatitsch and Tromp (2002) on the Earth Simulator, which is the world's largest and fastest parallel supercomputer recently built in Yokohama, Japan. The Earth Simulator has 640 nodes, each consisting of eight vector processors with 16 GB of memory. Peak performance of each node is estimated to be 64 GFLOPS. Total measured sustained LINPACK performance is 35 TFLOPS on the new Top500 list of supercomputers, on which the Earth Simulator ranks #1. Because the parallel SEM code is implemented using a message-passing technique (MPI), it is well adapted to the architecture of the Earth Simulator, except that loops need to be vectorized to take advantage of the vector processors. We have modified the software such that we obtain a high vectorization ratio and optimal performance on the Earth Simulator.

We use 243 nodes of the Earth Simulator (1944 processors) and calculate synthetic seismograms accurate up to 5 sec for global seismic network stations.

The number of grid points in the mesh used in this simulation amounts to 5.5 billion and the degree of freedom is 16.5 billion.

Horizontal grid spacing is 0.026 degree in average.

It should be noted that current normal mode catalogs, which is used to calculate synthetic seismograms for 1D Earth model as a reference, do not have those modes which have period as short as 5 seconds.

This shows that we could calculate for the first time synthetic seismograms for realistic 3D Earth model with much higher accuracy than the normal mode synthetics for 1D Earth model can achieve.

We will discuss a variety of synthetic seismograms that are accurate up to 5 seconds by taking full advantage of the Earth Simulator.