Three-Dimensional Numerical Modeling of Sound Propagation and Scattering in the Deep Ocean with Elastic Bottoms

I. A. UdoYdychenkov, R. A. Stephen, D. Komatitsch, Z. Xie, and J. Tromp

1Woods Hole Oceanographic Institution, Woods Hole, MA, USA
2Laboratory of Mechanics and Acoustics, CNRS, University of Aix-Marseille, Marseille, France
3Princeton University, Princeton, NJ, USA

Spectral Finite-Element Model SPECFEM3D

- 3D model.
- Finite-element (time domain).
- Solves equations of motion in the weak form (integrated momentum equation with stress-free boundary condition at the earth’s surface and absorbing boundary condition at other model boundaries).
- Supports environments with rigidity.
- Supports all interactions between body waves, interface waves (Rayleigh and Stoneley) and guided waves (modes and T-phases).
- Allows heterogeneities at the sub-wavelength scale.
- Designed for parallel computations on a cluster or a supercomputer.

Some problems in marine seismology that would benefit from modeling with SPECFEM3D

- Excitation of Earth’s hum by surface gravity wave loading on coastlines. (0.001-0.03 Hz)
- Inferring crustal rigidity from seafloor compliance. (0.001-0.03 Hz)
- Ice shelf excitation by surface gravity waves. (0.01-0.1 Hz)
- The excitation and propagation of microseisms. (0.1-0.5 Hz)
- The T-phase excitation problem. (5-30 Hz)
- Interpreting 3-D multi-channel seismic data over axial magma chambers. (5-100 Hz)

SPECFEM3D vs RAM2D

- Wave field snapshots produced by the source S1 on the DVLA with a fluid bottom (top left panel) and with a bottom with rigidity (bottom left panel). The bathymetry is shown in the right panel. This is the first time acoustic bottom interaction has been studied in three dimensions with shear wave properties in the bottom. The effects of out-of-plane seamounts are significant.

Conclusions

- 3D topography and bottom rigidity are important considerations in numerical modeling of underwater sound propagation.
- SPECFEM3D is a promising technique for numerical modeling of bottom interaction problems in ocean acoustics.
- Convolutional perfectly matched layer efficiently reduces reflections from the boundaries of the computational domain.
- Computational attenuation recently implemented in SPECFEM3D agrees well with estimates based on “spectral ratio method”.

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References.