Global FDTD Modeling of ULF Scatterings from Submerged Objects

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The feasibility of locating underwater objects at ultra low frequencies (ULF: < 3 Hz) is studied using the finite-difference time-domain (FDTD) method. ULF electromagnetic waves are chosen due to their ability to propagate deep into the ocean, possibly allowing for deep detection of underwater objects from above the surface of the ocean or just below the surface of the ocean. An electric current is modeled as a source of ULF waves on one electric field component within the ocean of the global FDTD model of the Earth-ionosphere waveguide. The global FDTD model then solves for the global propagation of the ULF waves and the electromagnetic fields just above and below the ocean in the vicinity of the object are recorded. The submerged electric current represents ULF scatterings from a submerged object. As such, the investigation is independent of the source of the ULF waves: it is assumed the ULF waves have already reached the object and are scattering off of it when the simulation begins.

The global FDTD model is run at a resolution of ~1.25 km x 1.25 km x 500 meter resolution within the ocean / lithosphere region, and variable gridding is used in the radial direction to increase the grid cell sizes in the atmospheric region where the wavelength of the ULF waves are larger. The model extends from the bottom of the ocean to an altitude of 100 km above sea level. It accounts for the Earth's complete topography / bathymetry and the ionosphere. The simulation runs on ~26k processors of a supercomputer and a time-step increment of 1.3 microseconds is used.