Global 3-D FDTD Earth-Ionosphere Models on Existing Petascale and Future Exascale Supercomputers

Alireza Samimi(1) and Jamesina J. Simpson* (2)
(1) ECE Department, University of Utah, Salt Lake City, UT, USA
(2) Nanometrics, Milpitas, CA 95035, USA

Three-dimensional (3-D) finite-difference time-domain (FDTD) models of the Earth-ionosphere waveguide were first introduced in the early 2000's [Simpson, J. J., *Surveys in Geophysics*, 30(2), 2009]. Over the past decade, these models have been applied to a wide variety of applications at ultra-low frequency (ULF) and extremely low frequency (ELF), including hypothesized earthquake precursors, Schumann resonances, space weather hazards to electric power grids, and remote sensing. The recent deployment of petascale supercomputers and future plans for exascale supercomputers introduce for the first time the possibility of generating ultra-high resolution FDTD models of the Earth-ionosphere waveguide of 1 km and higher on a global scale. When including a magnetized ionospheric plasma algorithm, these models may simulate higher frequency electromagnetic phenomena than previously possible (well above 1 kHz), and the grids may extend to higher altitudes (which were previously limited to ~100 km when using isotropic conductivity profiles). Not only is more memory required for these models due to the large number of grid cells, but the grid cells must be distributed approximately equally onto a large number of processors in order for the simulation to complete within a reasonable amount of time. Equal distribution of the grid cells is especially challenging in the Polar Regions.

In this presentation, we will discuss nuances of implementing ultra high-resolution global FDTD Earth-ionosphere models on petascale supercomputers. We will also discuss new applications of these models as the resolution is increased. As before, the global FDTD models account for the Earth's topography, oceans, geomagnetic field, and ionospheric variations with both position and time.