RECENT ADVANCES IN FDTD MODELING OF ULF/ ELF PROPAGATION WITHIN THE GLOBAL EARTH-IONOSPHERE WAVEGUIDE

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2. F - Wave Propagation and Remote Sensing

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4. I - Invited Paper, Program chair: Kamal Sarabandi and Mark D. Casciato

5. Invited paper for: Recent Advances in Analytical and Numerical Propagation Channel Modeling

In a recent publication (Simpson and Taflove, IEEE Trans. Ant. Prop., vol. 52, pp. 443-451, Feb. 2004), we reported a novel, finite-difference time-domain (FDTD) algorithm suitable for highly detailed three-dimensional (3-D) modeling of extremely low-frequency (ELF) propagation within the entire Earth-ionosphere waveguide. The algorithm incorporates a latitude-longitude FDTD space lattice which wraps around the complete Earth-sphere. Our technique permits an efficient, direct time-domain calculation of impulsive, round-the-world ELF propagation accounting for arbitrary horizontal as well as vertical geometrical and electrical inhomogeneities / anisotropies of the excitation, ionosphere, lithosphere, and oceans.

While the above latitude-longitude gridding technique has shown promise for whole-Earth models of ELF propagation, it still requires the use of a large parallel computer to model fine-grained details of the lithosphere that may be important for simulations of earthquake precursors and remote sensing of mineral deposits. Therefore, we have pursued alternative whole-Earth meshes that have the potential for improved efficiency. In this spirit, we are constructing a new, 3-D spherical geodesic FDTD grid model for the Earth-sphere (Simpson and Taflove, IEEE Ant. and Prop. Lett., in press) that is considerably superior to our previously reported latitude-longitude grid. This geodesic grid is based on the work of Dr. David Randall and Dr. Ross Heikes at Colorado State University.

Our current work is geared towards applying the latitude/longitude and geodesic FDTD grids summarized above to study the response of the inhomogeneous global Earth-ionosphere waveguide to potential seismically-induced sources in the lithosphere. Specifically, we have calculated what amounts to be the Greens function of the global Earth-ionosphere waveguide for impulsive electrokinetic current sources located at various depths below the Earths surface in the vicinity of the epicenter of the 1989 Loma Prieta earthquake near San Francisco. More generally, we are exploring the possibility of the global ELF electromagnetic environment being perturbed by localized transient currents within the lithosphere generated by several mechanisms resulting from accumulating stress. Our ultimate goal is to provide as rigorous as possible a physics basis for proposed earthquake prediction schemes employing either land-based or satellite-based detectors of ELF anomalies.