

AN INVESTIGATION OF A NOVEL RADAR FOR IONOSPHERIC  
DISTURBANCES USING A GLOBAL 3-D FDTD MODEL OF THE  
EARTH-IONOSPHERE WAVEGUIDE

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We report a finite-difference time-domain (FDTD) computational solution of Maxwell's equations (A. Taflove and S. C. Hagness, Computational Electrodynamics: The Finite-Difference Time-Domain Method, 3rd. ed. Norwood, MA: Artech House, 2005) to model a novel radar for ionospheric disturbances. Specifically, we study ionospheric anomalies, such as the local lowering of the effective ionospheric height above Los Angeles. Such anomalies have been hypothesized to exist prior and during earthquakes (Hayakawa, M. and Fujinawa, Y. (Eds): Electromagnetic Phenomena Related to Earthquake Prediction, Terra Scientific Publishing Company, Tokyo, Terrapub, 1994.), for example, and their understanding is also important for naval communication systems (Ferguson, J. A., Computer Programs for Assessment of Long-Wavelength Radio Communications, Version 2.0, Space and Naval Warfare Systems Center, Tech. Doc. 3030, May 1998.). Using our novel extremely low frequency (ELF: 3 - 300Hz) radar (J. J. Simpson and A. Taflove, "A novel ELF radar for major oil deposits," IEEE Geoscience and Remote Sensing Lett., in press), we investigate the detectability of the ionospheric disturbance and its properties.

The FDTD technique employed in this study enables a direct, full-vector, three-dimensional (3-D) time-domain Maxwell's equations calculation of round-the-world ELF propagation accounting for arbitrary horizontal as well as vertical geometrical and electrical inhomogeneities and anisotropies of the excitation, ionosphere, lithosphere, and oceans. Our entire-Earth model grids the annular lithosphere-atmosphere volume within 100 km of sea level by following lines of latitude and longitude (J. J. Simpson and A. Taflove, "Three-dimensional FDTD modeling of impulsive ELF propagation about the Earth-sphere," IEEE Trans. Antennas and Propagation, vol. 52, pp. 443-451, Feb. 2004). The nominal lateral resolution is 40 x 40 km at the equator. Subgridding is used to refine the radial grid resolution in the lithosphere near the Earth's surface to 1.25 km, a factor of 4 times finer than the nominal radial resolution of 5 km used in the atmosphere and deeper within the lithosphere.

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