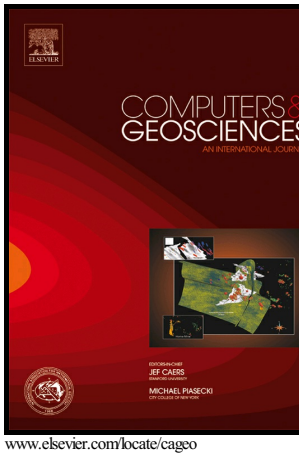

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Finite-difference time-domain modelling of through-the-Earth radio signal propagation

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Abstract

This research seeks to extend the knowledge of how a very low frequency (VLF) through-the-Earth (TTE) radio signal behaves as it propagates underground, by calculating and visualizing the strength of the electric and magnetic fields for an arbitrary geology through numeric modelling. To achieve this objective, a new software tool has been developed using the finite-difference time-domain method. This technique is particularly well suited to visualizing the distribution of electromagnetic fields in an arbitrary geology. The frequency range of TTE radio (400–9000 Hz) and geometrical scales involved (1 m resolution for domains a few hundred meters in size) involves processing a grid composed of millions of cells for thousands of time steps, which is computationally expensive. Graphics processing unit acceleration was used to reduce execution time from days and weeks, to minutes and hours. Results from the new modelling tool were compared to three cases for which an analytic solution is known. Two more case studies were done featuring complex geologic environments relevant to TTE communications, that cannot be solved analytically. There was good agreement between numeric and analytic results. Deviations were likely caused by numeric artifacts from the model boundaries; however, in a TTE application in field conditions, the uncertainty in the conductivity of the various geologic formations will greatly outweigh these small numeric errors.

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