A 3D Forward Model For Maxwell's Equation with Induced Polarization

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ABSTRACT

A forward model in time domain is presented to simulate the diffusion of 3D electromagnetic field generated by a source transmitter at the Induced Polarization method. We discretize the Maxwell's Equations using the Yee Algorithm. This algorithm is based on a staggered mesh with a electrical field defined at the element edges or mesh points and a magnetic field defined at the center of the element faces. As described in Maxwell's equations, the update of electric field is coupled with the curl of the magnetic field, and vice-versa. A central fourth-order derivative operator is used to discretize the space derivatives. Similarly, a central operator is used to advance the magnetic and electric field in time using Leapfrog scheme. An auxiliary field, which is coupled to Maxwell's Equations to include the Induced Polarization effects, replaces the history depended quantities that are calculated instantaneously. The solution of the Laplace equation, obtained using a fast Fourier transform (FFT), gives the parallel components of the electric field above the air-water interface without an upward-extension of the mesh. In this novel approach, we couple the analytical solution of the electric field used as boundary conditions in mesh points around the source transmitter with the numerical solver of the diffusion of the electric field. Additionally, the infinite size of the real physical system requires an adaptative mesh size to overcome the computing limitations. The error measurements confirm the effectiveness of the discretization scheme and the modeling of the air-water interface. Preliminary results focus on the transient state of the propagation of the electric field in a 3D multi-layered domain after the source transmitter is turned on.

References

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