Improvements to Three Dimensional Modeling of Radar Propagation Using the Vector Parabolic Wave Equation

Ra'id S. Awadallah, Tara K Echlin*, Jonathan Gehman and Chad Sprouse
Johns Hopkins University/Applied Physics Laboratory (JHU/APL), Laurel, MD 20723, http://www.jhuapl.edu

Three-dimensional (3D) modeling of radar propagation has advantages over two-dimensional (2D) modeling in that it takes into account out-of-plane diffraction and scattering effects. These out-of-plane effects must be ignored in traditional, 2D modeling to maintain numerical efficiency. However, for some applications these out-of-plane diffraction and scattering effects are important.

We have revised the JHU/APL 3D vector parabolic wave equation (3DVPWE) model, a finite difference frequency domain (FDFD) model that was developed for modeling radar propagation over general terrain/ocean surface profiles. The original 3DVPWE model was benchmarked against canonical problems that could be solved analytically, e.g. forward scattering by perfectly conducting cylinders and spheres. While the benchmark results clearly demonstrated the model's accuracy, the simulation runtime was relatively slow – two orders of magnitude slower than sampling the same domain size with multiple 2D results.

The FDFD process involves solving algebraic systems, $\boldsymbol{Ax} = \boldsymbol{b}$, where $\boldsymbol{A}$ is a tridiagonal matrix. Profiling the code revealed that 2/3 of the execution time was spent in the tridiagonal solver function. In this paper, we show the impact of applying parallelization techniques to enhance the computational performance of the model. We initially cut the execution time in half by using OpenMP. We have applied Bondeli's algorithm to parallelize the solution of tridiagonal linear systems to speed up the code. We will discuss the speedup achieved as well as further steps that could be taken to improve the execution time.