Effects of Out-of-Plane Terrain Slopes on Tropospheric Radar Propagation – Results and Applications

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The two dimensional (2D) parabolic equation has become a powerful tool for modeling radar propagation over terrain. The efficiency afforded by a 2D approximation allows one to model propagation over hundreds of kilometers using Fourier split-step marching techniques; however, the cost is that effects of lateral terrain slopes are ignored. While this limitation is well known, its implications have not yet been adequately quantified.

In this paper we use our recently-developed Vector Electromagnetic Parabolic Equation (VEMPE) code to investigate the effects of lateral terrain variations on radar propagation. These effects are assessed by comparing VEMPE's 3D results to results from our popular 2D propagation code, the Tropospheric Electromagnetic Parabolic Equation Routine (TEMPER). Quasi-3D results are obtained from TEMPER by generating 2D solutions across multiple slices in azimuth. Because this quasi-3D approach is a common way of representing realistic environments in practical radar simulations, lessons learned from our comparisons have direct implications for current radar clutter and radar performance models.

Numerical examples that involve simple urban-like terrain are presented. Full 3D modeling of propagation through rectangular structures reveals salient 3D scattering effects, such as horizontal interference patterns, that are absent from the quasi-3D results. We then present cases involving propagation over realistic terrain environments that have been created from digital elevation maps (DEM's). Numerical issues involved in performing these realistic terrain calculations, such as DEM resolution, terrain slope limitations and domain size, are discussed. Results from these cases are then examined and related to potential improvements in practical radar clutter modeling.