Polarimetric Scattering from Dielectric Targets Buried Beneath 2-D Randomly Rough Surfaces

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Abstract

The three-dimensional scattering problem solver, the Steepest Descent Fast Multipole Method (SDFMM), is used to calculate the equivalent electric and magnetic surface currents on the random rough ground interface and the buried targets. The fully polarimetric scattering matrix *S* is evaluated for hundreds of computer generated rough surface realizations. The modified Mueller matrix relates the incident with the scattered waves, which is defined in terms of the modified Stokes vector $I = \left[\,|E_v|^2 \quad |E_h|^2 \quad 2\,\mathrm{Re}\left(E_v E_h^*\right) \quad 2\,\mathrm{Im}\left(E_v E_h^*\right)\right]^T / \eta$. This implies that the Mueller matrix has sixteen complex elements representing all combinations between real and imaginary parts of co- and cross-polarized waves. The co and cross polarized waves are the elements of the polarimetric scattering matrix *S*, i.e. the *vv*, *hh*, *vh* and *hv*. The polarization of the incident or scattered waves is denoted by *h* or *v*, for horizontal or vertical polarization, respectively, while η is the intrinsic impedance of the surrounding medium. Using the SDFMM made it possible to compute hundreds of Monte Carlo simulations for scattering from dielectric objects buried under the random rough ground. The statistical average of each element in the Mueller matrix is computed for two cases; rough ground only and rough ground with buried targets. In the current work, the statistical average of the scattered electric fields from one and from two buried objects is calculated in the far-zone. It is important to emphasize that the subtraction process often used to obtain the target signature is not used in the current work. In other words, the far-fields scattered from the rough ground with the buried objects are directly compared with those scattered from the rough ground with no buried objects. The numerical results clearly show that if one relies only on the co- or the cross-polarized intensities (i.e. the magnitude of the four elements in the polarimetric scattering matrix *S*); it is very difficult to sense the buried objects. However, investigating all the sixteen Mueller matrix elements significantly help in detecting these objects. This phenomenal was persistent in the results of statistical averages and in the results of individual rough surface realizations as well.