Propagation of Coherent and Incoherent Waves in a Trunk Dominated Forest

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In this study, two dimensional electromagnetic propagation through trunk dominated forests is considered. The problem consists of a half space medium of vertical dielectric cylinders where the cylinders are randomly distributed and have small fractional area. A vertically polarized plane wave is incident on the half space of cylinders; the intensity of the wave is analyzed inside the half space. The analysis of the problem is simplified by assuming that the frequency is low so that the cylinders can be replaced by two dimensional Rayleigh scatterers. The behavior of the coherent and incoherent waves is examined as a function of distance from the half space interface. The analysis is performed using three different methods, and the results are compared.

The problem is first examined analytically. Using the assumed small fractional area, a Foldy equation for the mean and an equation for the spatial correlation function are obtained. By using the Rayleigh assumption, a simple wave equation for the mean is obtained and solved to yield a plane wave solution with an equivalent propagation constant. The Rayleigh assumption also reduces the correlation equation to an equation for the intensity. The solution of the intensity equation shows, as expected, that as the distance increases the coherent intensity decreases while a relative increase is observed in the incoherent intensity.

In the second method, the problem is formulated using transport theory. A discrete ordinate analysis approach is then used to solve the transport equation for the intensity inside the half space. In the final method, Monte-Carlo simulations of wave propagation through infinite length vertical cylinders are performed. The cylinders are distributed randomly in a rectangular slab region of sufficient depth and width. The wave equation is solved numerically and all multiple scattering is taken into account in this approach. Many realizations are computed and averaged to obtain estimates of the coherent and incoherent intensity.

A comparison between the three methods will point out the difference in results obtained by the correlation equation approach, by the transport method and by the Monte-Carlo simulations. Although the simulation method provides the most accurate results, it requires long computer runs.