

Improvements in the Kirchhoff Term of the Average Scattered Field

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Analytical/Numerical analysis of scattering from rough surfaces has been driven largely by the pressing need to understand radar performance in the presence of such scattering. With a few exceptions, this has put significant emphasis on backscattering geometries. However, there is also a need to understand forward scattering for problems involving communications, remote sensing and bistatic radars. This is particularly true for communications systems wherein the forward scattering from rough surfaces adds to the direct path signal either in a reinforcing or reducing manner. This situation is merely another direction to analyze and therefore introduces no new problem elements. However, this is not quite true because backscattering usually involves incoherent scattering while forward scattering comprises both coherent and incoherent scattering. In such cases it is the coherent scattering that is of most importance because of its effect on the direct path signal. For example, previous analyses have shown that the Kirchhoff approximation for the specular scattered field appears to over predict the degree of attenuation of this coherent scattered field based upon the comparisons between theory and scattering measurements. One of the drawbacks to dealing numerically with this forward scattering is that it truly requires considering the actual 2-D surface rather than its 1-D simplification often used in the backscattering problem. This extension to 2-D surfaces along with the use of broad-beam antennas leads to a great deal of computations. Another approach to the forward scattering problem and the coherent scattered field is the Method of Smoothing (MoS). With the MoS, the scattered field is split into an average value and a zero mean fluctuating part. This along with the governing integral equation such as the Magnetic Integral Equation (MFIE) leads to coupled integral equations for the mean and fluctuating parts of the current or scattered field. In the case of dealing with the scattered field, if the point of observation is sufficiently far from the surface, the average scattered field can be calculated directly, and this can be done without the need for Monte Carlo simulations. This provides a significant reduction in computer needs at the expense of accurate knowledge of the surface height correlation function. In this paper the resulting coupled integral equations for currents will be reviewed and the integral equation for the average scattered field will be developed. It will be shown that this formulation leads to a new “source term” that is superior to the conventional Kirchhoff term, but they are the same under certain conditions. It will also be shown that while it is difficult to decouple the average from the fluctuating parts, it is possible to develop an equation in which the fluctuating part’s contribution is small.