**Modeling of Coherent and Diffuse Scattering from Rough Surface with Small and Moderate Rayleigh Parameter**

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Frequently, microwave radar scattering from Earth natural surfaces, such as ocean or land, manifests itself in the form a strong diffuse scattering both for monostatic or bistatic geometry. This regime is characterized by a large value of the Rayleigh parameter, $R_a$, representing a product of the surface roughness standard deviation and the vertical component of the wavenumber for the incident/scattered wave. In this case, the scattered field is totally diffuse because it is formed by summation of large number of uncorrelated field contributions originated from a large surface area. However, in the case of a small $R_a$, the rough surface acts more like a mirror, only slightly degrading the coherence of a reflected wave. Still, a weak diffuse scattering simultaneously exists at non-specular directions. When the value of $R_a$ grows the weak diffuse scattering becomes increasingly stronger, whereas the coherent specular component quickly decays.

For practical applications it is important to understand details of the transition from partially-coherent to completely non-coherent, diffuse scattering. In the general case, the power of the coherent component is proportional to the power of the signal produced by a mirror image of the source (or the receiver) multiplied by square of the average reflection coefficient, $|\bar{V}|^2$. Whereas the power of the diffuse component is proportional to the surface integral associated with the non-coherent bistatic radar cross section, $\sigma$. For further calculations one needs to know expressions for $|\bar{V}|^2$ and $\sigma$ which can be obtain using the small slope approximation of the first order (SSA1). Note that for the case of Gaussian statistics $\sigma$ can be fully described by a correlation function of surface heights.

In what follows, we assume that the value of $R_a$ is small or moderate. In this case, following the perturbative approach the exponential under the SSA1 surface integral can be approximated by the polynomial with a finite number of terms. As a result, the expression for $\sigma$ becomes a finite sum of terms each of which contains a Fourier transform of the surface correlation function raised to the power equaled to the index of the corresponding term of the sum. The larger $R_a$ is the larger number of terms needs to be accounted for in order to have a converging result. It is important, however, that such a Fourier transform being proportional to the multiple convolution of the roughness spectrum is always a positive value. Therefore, summation of even a large number of terms does not lead to the effect of catastrophic cancellation. For a reasonable range of $R_a$, calculations of such sums can be quickly performed using standard desktop computers. At the end, we demonstrate results of such calculations for $\sigma$ at moderate $R_a$ and its transition to $\sigma$ at large values of $R_a$.