ABSTRACT

Microwave remote sensing provides an important method to monitor the snow distributions globally. To accurately analyze microwave measurements, models of electromagnetic wave propagation, scattering, and emission of snow on ground or over sea ice are required. We used the bi-continuous model to characterize the microstructure of snow that contains information of snow grain size, grain clustering, and snow density, specific surface area (SSA), etc. The bi-continuous model can be used to generate microstructure of snow based on a computer algorithm. The microwave solutions for the bi-continuous medium (computer snow) are then calculated by the numerical method of solving Maxwell equations in 3-dimensions (NMM3D). The NMM3D is able to calculate the scattering properties (phase matrix, extinction coefficient, and effective permittivity) of snow samples, which are subsequently used in DMRT to obtain scattering coefficients and brightness temperatures. This approach is called partial coherent model (The RT is incoherent while NMM3D is fully coherent). Recently, we have also used NMM3D to solve the entire problem of snow cover fully coherently without using DMRT. In both DMRT methods and fully coherent methods, the NMM3D has high costs because of the Monte Carlo procedure of calculating the scattering solutions over many samples and the averages of the results calculated. Thus, we have revisited analytic method. With the single assumption of statistically homogenous medium, the Feynman diagram method is used to derive the Dyson’s equations and the Bethe Salpeter equations from Maxwell equations. The method is exact and is fully coherent as Maxwell equations are the basis of the derivations. The Dyson’s equations and the Bethe Salpeter equations have the mass operator and the intensity operator, which contain infinite number of operators with the higher order operators representing higher order statistical moments of the heterogeneous permittivity. In the past, only the first order operator was used, giving the bi-local approximation with the mass operator approximated by the product of the pair function and the Green’s function. The complexities of calculating higher correlation functions of medium prevent the use of higher order approximations beyond the bi-local approximation. We now return to the full Feynman diagrams because it is possible to calculate higher order correlation properties of the bi-continuous medium. The bi-continuous medium is generated by a Gaussian random process with the permittivity as a function of this Gaussian random process. Thus, higher-order statistical moments of the properties of the bi-continuous medium can be calculated. The Feynman diagram approach provides a fully coherent model without the costly Monte Carlo simulations. In this paper, we use the Feynman diagram method based on the layered medium Dyadic Green’s function to solve the problem of layered bi-continuous medium. The mean field and scattering properties are calculated. The analytical Feynman diagram model is useful for applications to passive microwave radiometer polarimetry and active radar polarimetry and interferometry.