Transient Response from a Vegetation Canopy to Stepped-Frequency Radar

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A solution for the time domain response of a stepped frequency signal (chirp pulse) from a layer of sparsely distributed lossy dielectric particles over a lossy dielectric half-space is presented. Traditionally, such problems have been analyzed in the frequency domain under the assumption that the incident field is a plane wave. Results of this type of analysis lack the details found in a transient solution where the tree crown and ground effects appear at different times. In addition, the angular spread of the plane waves, excited by a finite antenna aperture, is not accounted for. Here, we find the transient response due to the plane wave spectral components that are excited by the antenna. The results are then used to model the data obtained from an L-band truck-mounted radar overlooking a plot of small trees.

In this paper, the radar is directly incorporated into analytical wave theory in conjunction with distorted Born approximation (DBA), and the antenna fields are replaced with their plane wave representation. The incident waves travel through the mean medium and are scattered by the particles embedded in this medium. This analytical wave formulation accounts for the spread of the beam within the medium and for the variation of its intensity with the propagation direction. The backscattered signal received by the radar is expressed as a weighted coherent sum involving the antenna spatial spectrum and backscattered radiation. The source of each ray of the spatial spectrum of the scattered field received by the antenna is associated with statistical characteristics of individual scatterers in the discrete media.

The scatterers in the illuminated volume are randomly positioned, and the backscattered field over N frequency points, spanning the desired bandwidth, is calculated. Performing a chirp-z transform on this backscattered field produces the time domain radar profile. This follows closely the data acquisition and signal processing technique employed by network analyzer-based radar (stepped frequency measurements). Radar data collected over stands of deciduous paulownia trees of different densities under full canopy and leaf-drop conditions are compared to model results. The radar data are provided by a truck-based radar/radiometer system called ComRAD (for Combined Radar/Radiometer).

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