

Estimation of Moisture Content of Forest Canopy and Floor From SAR Data Part 1: Volume Scattering Case

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To understand and predict the functioning of forest biomes, their interaction with the atmosphere, and their growth rates, the knowledge of moisture content of their canopy and the floor soil is essential. Since moisture is a rapid dynamic parameter and changes over time scales as small as hours and days, it is important that efficient measurement schemes and interpretation tools be available which make such information readily available. The synthetic aperture radar (SAR) on airborne and spaceborne platforms has proven to be one of the most flexible tools for measuring electromagnetic backscattering properties of vegetation directly related to their moisture content, mainly the complex dielectric constant. Since the radar backscatter is a function of several different scattering mechanisms, to retrieve the moisture content or the dielectric constant of various forest constituents requires that each of these mechanisms be considered individually at first. These are volume scattering from the branch layer, double bounce scattering between trunk and ground, double bounce scattering between branches and ground, and ground scattering. In this work, we will estimate the dielectric constant, hence moisture content, of branch layer components by focusing on the volume scattering case. The methodology is as follows: assuming the radar backscatter is almost entirely caused by volume scattering, we use a numerical forest scattering model to derive parametric expressions for polarimetric multifrequency backscattered radar cross section with the real and imaginary parts of the dielectric constant as parameters. The branch layer components are taken to be primary and secondary branches and leaves. The parametric models are found by performing many simulations of the numerical model where architectural parameters such as branch length and diameter are fixed, and the complex permittivity is allowed to vary over reasonable ranges. High-order polynomials are fit to the data such generated to give the parametric expressions. Once these are derived, they are used in a nonlinear estimation algorithm, which is based on a least-squares criterion. The validity of this algorithm is shown by first applying it to synthetic backscatter data. It is then applied to AIRSAR data from one of the BOREAS study sites, namely the young jack pine stand in the southern study area in Saskatchewan, Canada. Extensive ground-truth measurements and multiple AIRSAR data sets exist over this area. Classification algorithms have indicated that volume scattering is the primary backscatter mechanism for this stand, and hence this area is quite suitable for the application of the present estimation algorithm. The good agreement between the inversion results and ground-truth measurements of moisture and dielectric constant indicate the utility of this algorithm for retrieval of canopy moisture content. This is also a valuable tool for quantitative monitoring of this parameter over small time intervals if the data are available, e.g., from a spacecraft in a repeating orbit.

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