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RADAR SIGNATURE DETERMINATION : TRENDS AND LIMITATIONS

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I. INTRODUCTION

Knowledge of the backscattering characteristics of earth surface features is essential for reliable interpretation of radar image data, particularly if tonal discrimination, as against structural interpretation, is required. Information on backscattering behavior can be derived from measurements or by constructing and utilizing models of the interaction of radar incident energy with cover types of interest. An appealing aspect of the latter approach is that a suitably derived model might be invertible, allowing significant physical properties of a surface to be determined using radar remote sensing data as an input. Several different approaches may be adopted in endeavoring to derive backscatter models, including the use of a theoretical framework based upon propagation and scattering theory or the adoption of regression fits to experimental data. One can also adopt a phenomenological approach in which an apparently complicated situation can be viewed as a set of readily handled components.

Modelling studies, as means for assessing what could be called radar signatures, are a part of two radar remote sensing research programs with which the author is affiliated. First, at the University of New South Wales, assessment of SIR-B data is being undertaken for a number of purposes including its value in arid land geomorphological and geological studies, forest and crop assessment, and mapping. A number of early results have been reported [1-6]; however modelling aspects are still at an early stage. Secondly, the author recently spent 6 months working on SIR-B invertible forest canopy modelling in the Department of Geography at the University of California, Santa Barbara. Results from this work are outlined in the following; fuller details will be found in Richards, Sun and Simonett [7].

II. SIMPLE FOREST BACKSCATTER MODELLING AT L-BAND

A forest stand, particularly at L-band, is a composite scattering environment. In establishing a model one may need to account therefore for volume scattering from the foliage, scattering from the underlying surface or understory and scattering from the branches, branchlets and trunks. There is also ample evidence to suggest that significant radar return can result from bistatic scattering from tree elements onto the surface, followed by specular reflection from the surface to the sensor [6,8]. Guided by tractability and invertibility considerations, those components considered important need to be realised as a model and then aggregated with forest statistical data to form a model of a forest stand.

The simplified model adopted in the current treatment is shown in Figure 1, consisting of four components that are easily described. A simple exponential dependence of diffuse surface backscatter was chosen for the soil component, modified suitably for two way path loss in the canopy. An order of magnitude of 0.1 Npm^{-1} was chosen for the attenuation coefficient, with other parameters chosen from Figure 11.98 of Ulaby et al. [9]. A simple water cloud model was chosen for the foliage [10] while the work of Engheta and Elachi [11] was used to account for backscattering via multiple reflection from the foliage and surface. Parameter values for these were established from Attema and Ulaby, and from the chosen value of the attenuation coefficient.

The fourth component adopted is strong reflection via the trunk and surface, with the trunk viewed as a lossy dielectric cylinder standing on a lossy plane. However, rather than using available expressions for bistatic scattering from cylinders [12], considerations of computational speed and the need to keep the model simple if inversion is to be entertained, led to representing the trunk/ground combination as a simple planer dihedral corner reflector. An expression for the radar cross section for this structure is available. In the work undertaken [7] this was modified to account for Fresnel reflections at the trunk and ground and for the two way path loss through the canopy. A correction factor was also incorporated to match the reflection from the dihedral arrangement to that for a cylinder over a plane.

Figure 2 shows simulated levels of backscatter versus incidence angle for 20 trees of 20m height, added incoherently. Both the individual backscattering components and the composite value are shown, suggesting that at L band with the parameter values chosen, the trunk/ground component is dominant over the midrange of incidence angles.

The importance of the trunk term is also evident in the results of Figure 3. These compare simulated backscatter to measured (SIR-B) backscatter of a region of the Klamath forest in the Mt. Shasta region of northern California for 6 different natural stands and two plantations of Ponderosa Pine; the stands were of differing heights and densities. Owing to the uncalibrated nature of SIR-B, it was necessary to match the simulated and measured values for one experimental site. As seen, when contribution from the trunk is included there is a much better match of simulated and measured results.

III. CONCLUDING REMARKS

Development of the forest canopy model is continuing at the University of California, Santa Barbara. Present intentions are to incorporate generalizations to other wavebands and polarization configurations, which almost certainly will require better models for canopy scattering. The trunk scattering term however is easily adjusted for these different conditions.

In the Australian experiment it is intended to modify the trunk term to account for the different morphologies of native Eucalypts. In addition however it is planned to extend the nature of the model to allow simulations of backscatter from sugar cane plantations.

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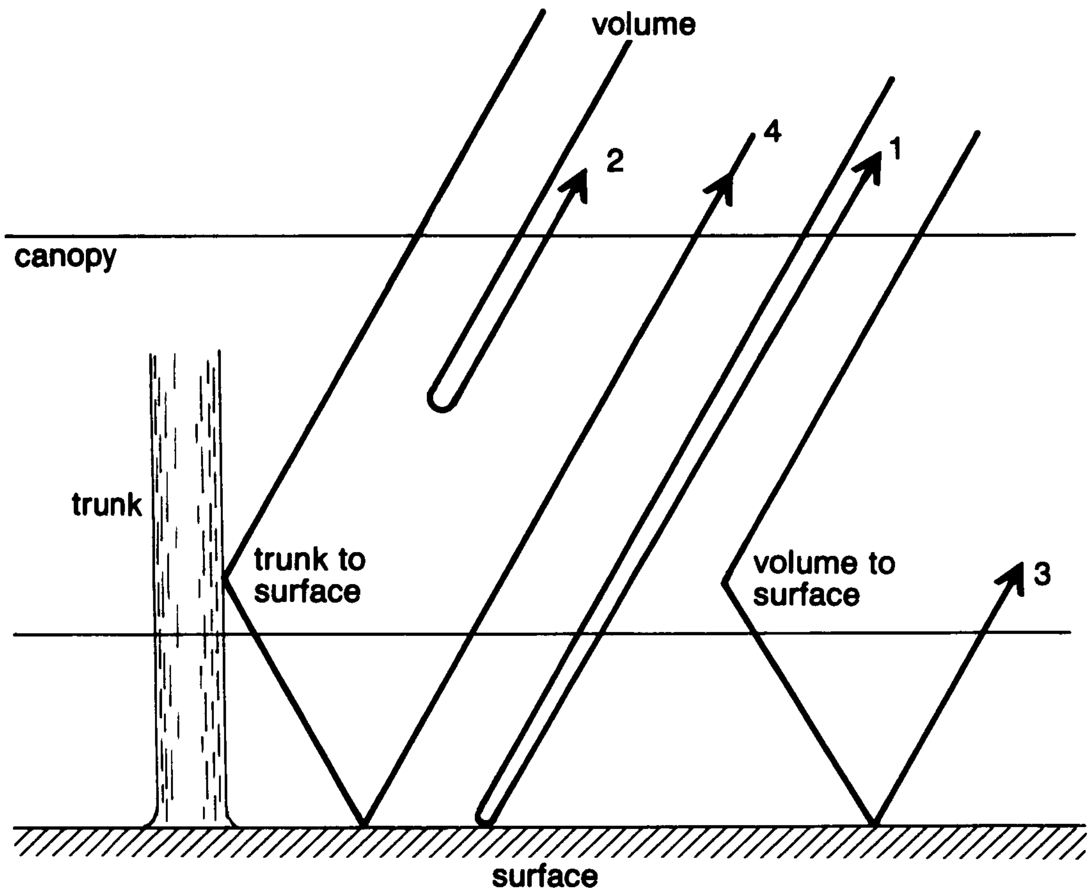

Figure 1. Components of forest backscatter considered in the model.

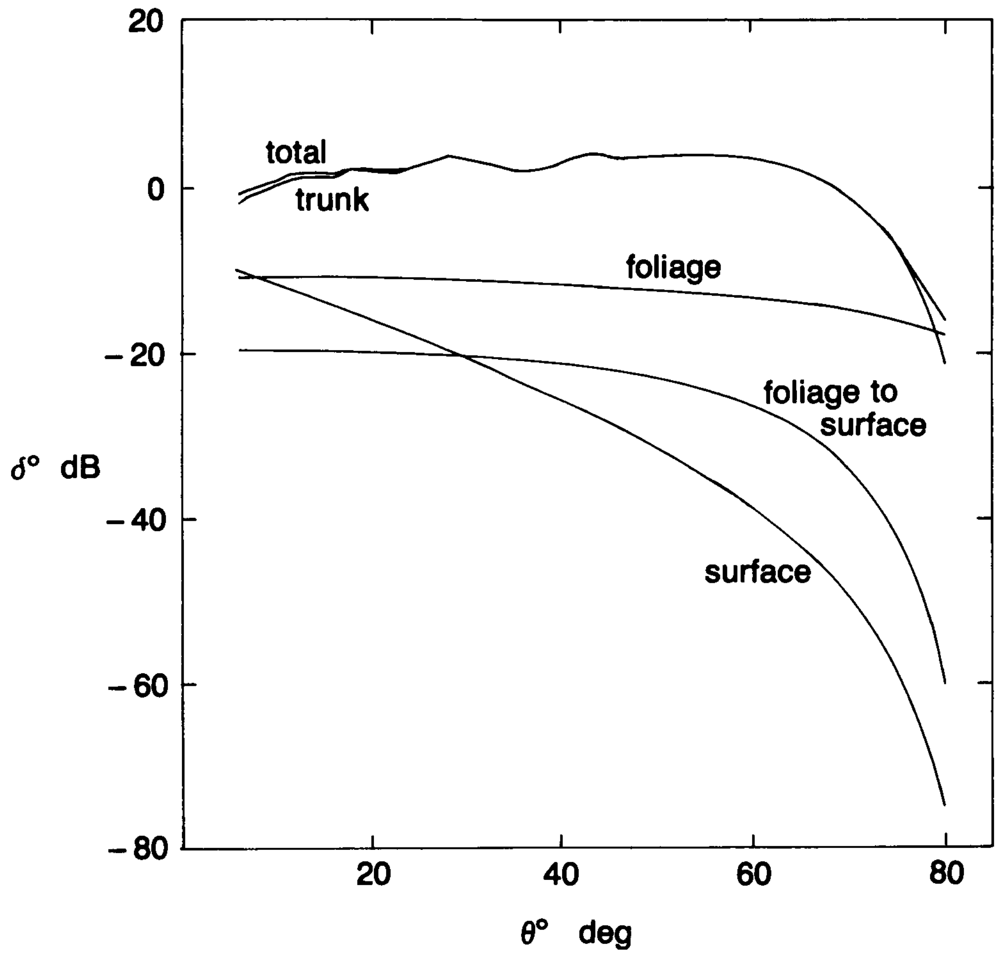

Figure 2. Simulated backscattering coefficient as a function of incidence angle for each of the four components of forest scattering and for their aggregate (from Ref. 7).

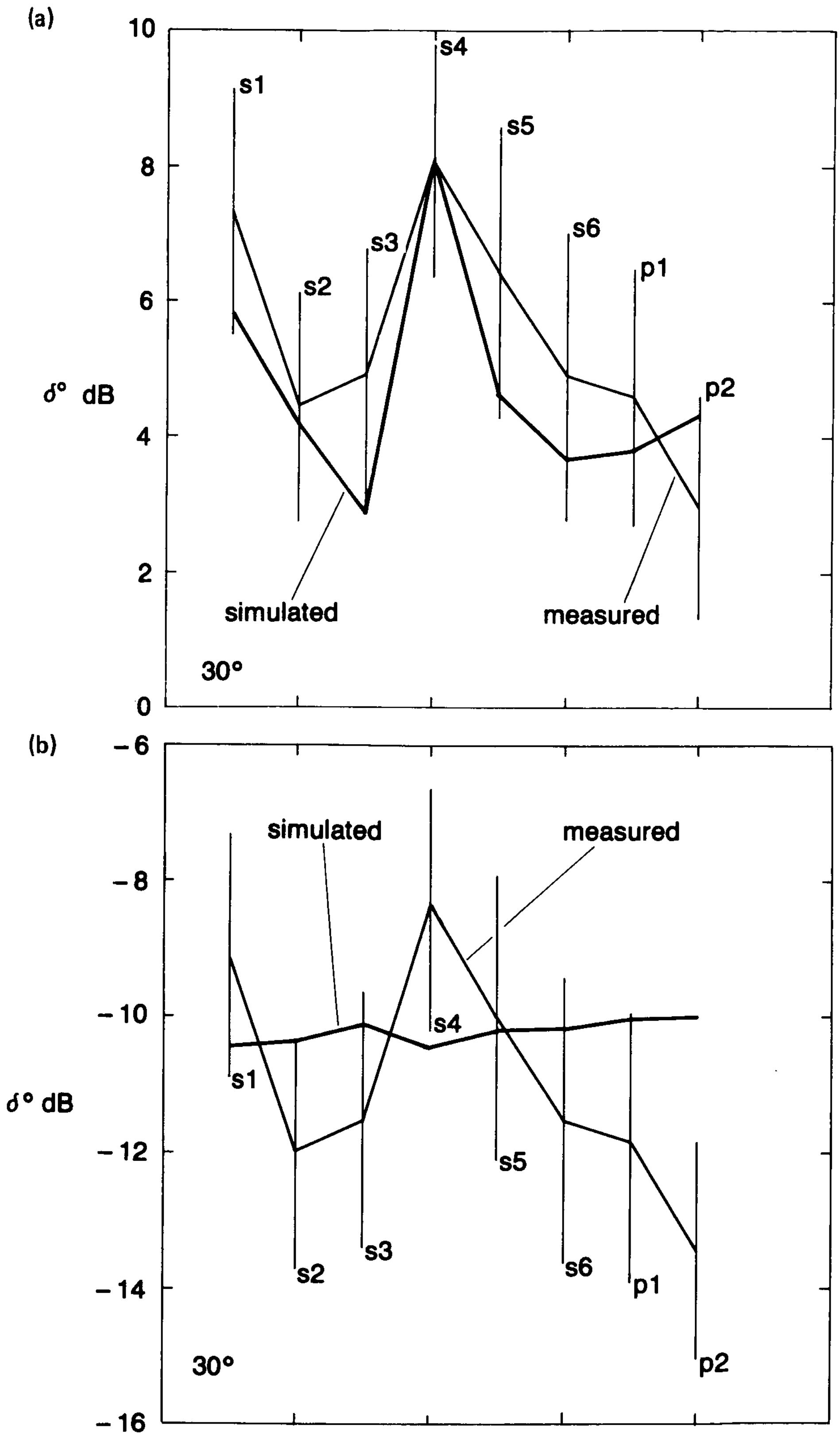

Figure 3. Comparison of measured and simulated forest backscattering coefficient for six natural stands and two plantations of Ponderos Pine (a) with trunk term included (b) without the trunk term (from Ref. 7).