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RETRIEVAL OF PINE FOREST BIOMASS USING JPL AIRSAR DATA

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1. INTRODUCTION

The analysis of JPL AIRSAR data over the Landes forest in South-West France revealed strong correlation between L- and especially P-band σ^o and the pine forest biomass (*Le Toan et al. 1992*). To explain the physical link of radar backscatter to biomass, a polarimetric backscattering model was developed and validated (*Hsu et al. 1992*). Then the model was used in a simulation study to predict σ^o sensitivity to undesired canopy and environmental parameters (*Beaudoin et al. 1992*). This paper reports main results concerning the data analysis, modeling and simulation at P-band.

2. EXPERIMENT AND DATA ANALYSIS

The test site is a managed forest of maritime pine (*Pinus Pinaster*), including clear-cuts and forest stands from seedlings up to 46 years old, providing a wide range of forest parameters (height, dbh, tree density, etc.). The collected parameters concern forest inventory, measurements during radar overflight and tree structure sampling. P-L-C band quad-pol AIRSAR data were acquired on August 16, 1989. A complete polarimetric calibration procedure was appplied to the data.

Of particular interest for applications are the above-ground biomass by parts (needle, branch and trunk biomass), which can be estimated using tree basal area and tree density. Fig. 1 shows biomass by parts which is increasing quasi linearly with age. High correlation was found between L- and especially P-band σ^o and most forest parameters, especially biomass (tons/ha), for example total above-ground biomass as shown in Fig. 2. As σ^o was found statistically correlated to many forest parameters (age, height, dbh, biomass), which are themselves biologically interrelated, theoretical modeling is needed to explain the interaction between incident wave and different parts of forest canopies.

3. MODELING

A radiative transfer model is used for the modeling of the pine forest backscatter (*Hsu et al. 1992*), which includes a branching model for vegetation clusters found in pine forests. The forest is modelled as a 4-layer discrete random medium over a slightly rough ground (crown, trunk, bush and grass layers). Vegetation constituents are modelled as clusters of dielectric cylinders accounting for needles, twigs, branches and trunks. Both incoherent and coherent scattering from these multiscale clusters are computed. The model gives the expression of the 1st-order solution to the RT equations as the sum of volume and surface-volume scattering terms in each layer. For hilly terrains, the model considers the ground slope and aspect angles. Fig.2 shows model/measurement comparison of P-band σ^o at HH,HV and VV polarizations at $\theta = 45°$, as a function of the total above-gound biomass, while Fig. 3 presents the main scattering contributions at HH and VV. The HH return is mainly governed by crown and crown-ground scattering for young forest, and trunk-ground scattering for mature forest. The VV and HV returns are dominated by crown scattering, which comes from the primary branches. Thus, VV and especially HV σ^o are directly linked to radius, length, density and moisture content of primary branches. Hence σ^o increases with increasing branch fresh biomass. Relations between σ^o and forest height, trunk or total biomass are therefore indirect. The above results provide a significant improvement of our knowledge on the scattering mechanisms and consequently our understanding of the relationships σ^o- forest biomass.

4. CHANGING FOREST AND ENVIRONMENTAL PARAMETERS

To extend the above observations to various forest and environmental conditions, a simulation study is performed.

1) Ground slope effects: Fig.4 presents σ^o as a function of local ground slope facing the radar. VV and HV are not changed significantly, whereas HH is fastly decreasing for old forests where the trunk-ground term dominates, and is approaching to the crown scattering term.

2) Varying understory conditions: σ^o is computed for a canopy without and with an understory vegetation (1m high, LAI=1.0). As expected, HV and VV returns are not affected, whereas a 1dB decrease of σ^o for HH is due to the attenuation of the trunk-ground term.

3)Vegetation moisture condition was varied from 55% to 65% to simulate seasonal or diurnal effects. HH is not significantly sensitive to this variation, whereas VV and HV returns are more affected (about 1dB).

3) Crown structure: σ^o was simulated as a function of β, the mean elevation angle of the primary branches, which is a major species-dependent structural parameter. At HV and VV, the maximum sensitivity to crown biomass is found in the range 45°-60°. For low or high β (erectophile or planophile species), there is no significant sensitivity to crown biomass. For HH returns, no effect of β on the σ^o sensitivity to biomass is observed, as the return results mainly from trunk-ground interaction.

5. DISCUSSION & CONCLUDING REMARKS

At present, the modeling and simulation studies were performed at P-band, which was found optimal for retrieval of forest biomass. HH return was found governed by trunk-ground scattering, and thus can be significantly affected by environmental conditions such as soil moisture, ground slope and bush layer. On the other hand, VV and especially HV returns were found tightly linked to crown biomass and thus unaffected directly by environmental conditions. Therefore, it is possible to derive total above-ground biomass from P-band HV or VV SAR data, knowing relations between biomass by parts. HH return offers the advantage of being less species dependent.

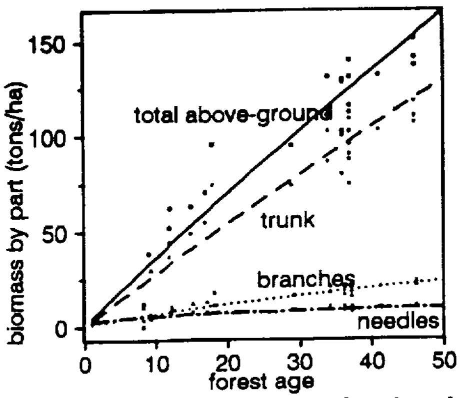

Fig.1: biomass by parts as a function of age

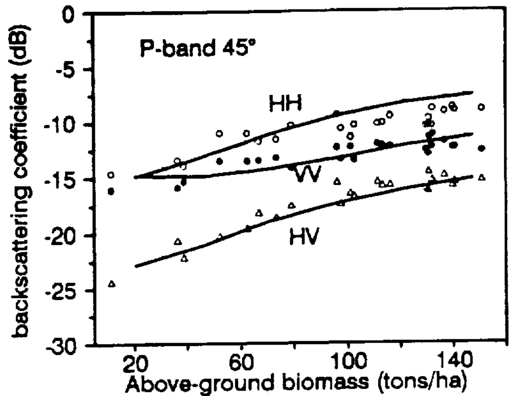

Fig.2: Model/measurements comparison

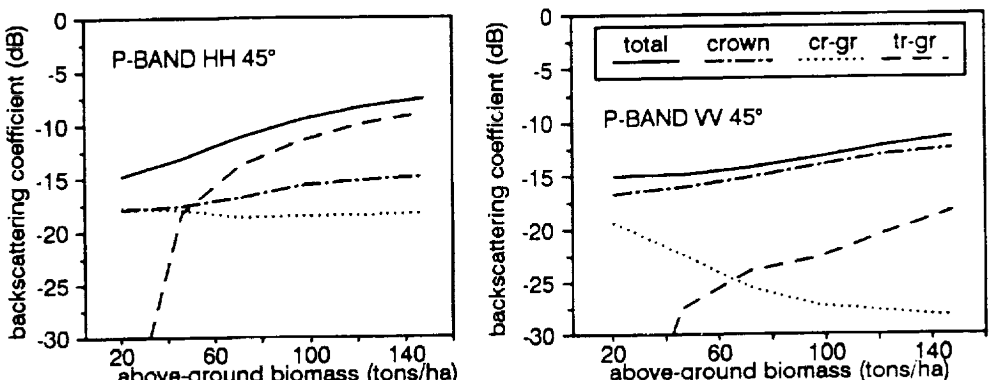

Fig. 3: Major contributions to total HH and VV P-band backscatter, as a function of total above-gound biomass

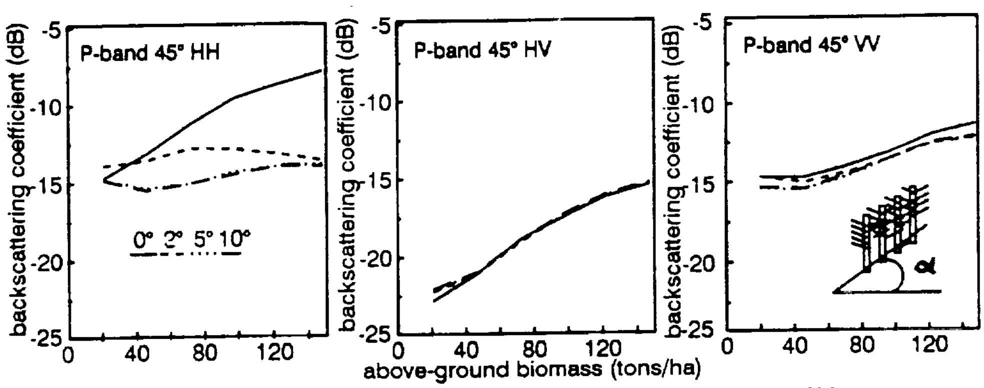

Fig.4: P-band backscatter at HH,HV and VV as a function of biomass, for different ground slope angles

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