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RELATING P-BAND AIRSAR BACKSCATTER TO FOREST STAND PARAMETERS

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1. Introduction

As part of research on forest ecosystems, the Jet Propulsion Laboratory (JPL) and collaborating research teams have conducted multi-season airborne synthetic aperture radar (AIRSAR) experiments in three forest ecosystems including temperate pine forest (Duke Forest, North Carolina), boreal forest (Bonanza Creek Experimental Forest, Alaska), and northern mixed hardwood-conifer forest (Michigan Biological Station, Michigan). The major research goals were to improve understanding of the relationships between radar backscatter and phenological variables (e.g. stand density, tree size, etc.), to improve radar backscatter models of tree canopy properties, and to develop a radar-based scheme for monitoring forest phenological changes.

In September 1989, AIRSAR backscatter data were acquired over the Duke Forest. As the aboveground biomass of the loblolly pine forest stands at the Duke Forest increased, the SAR backscatter at C-, L-, and P-bands increased and saturated at different biomass levels for the C-band, L-band, and P-band data (Dobson et al. 1992). Due to the 4-page-length limit, we only use the P-band backscatter data and ground measurements to study the relationships between the backscatter and stand density, the backscatter and mean trunk dbh (diameter at breast height) of trees in the stands, and the backscatter and stand basal area.

2. Study area and forest stand data

The tree stands used in this study are located in the Duke University Forest, which is located west of Durham, North Carolina (36° 00' N, and 79° 00' W). The Duke Forest contains forest stands with a total area of 3400 hectare, one-quarter of which are pure stands of loblolly pine, *Pinus taeda L.* These pine stands range in age from < 1 to > 100 years in age.

This forest has been the site of ongoing research focused on developing a better understanding of the potential use of imaging radars for monitoring southern U.S. pine forests. Airborne SAR data were collected over this forest in 1984 and 1989 (Kasischke and Christensen 1990, Kasischke et al. 1993a), and satellite data have collected with both the ERS-1 and JERS-1 SARs since 1991 (Kasischke et al. 1993b). This site represents one Terrestrial Ecology Supersite that will be imaged by SIR-C/X-SAR system in 1994 (Evans et al. 1993).

A total of 23 pine stands are used in this study. The densities of the pine trees in these stands range between 200 and 1844 trees/hectare. The average dbh of tree trunks in the stands ranges between 13.7 and 33.9 cm. The average tree height in the stands ranges from 11.7 to 25.6 m, and the average canopy depth from 5.3 to 9.2 m. The ground surface in the selected 23 stands is level, which minimizes topographic effects on the SAR data.

3. Results

3.1. JPL AIRSAR backscatter data

JPL AIRSAR data were acquired on 2 September 1989. The data were collected between 11:30 and 14:30, local time. The AIRSAR data were processed and calibrated by using 8 ft. (2.44 m) trihedral corner reflectors. The estimated calibration uncertainty was ± 2.0 dB for P-band (0.68 m wavelength) backscatter. The standard 4-look compressed data with pixel spacing of 12.1 m (azimuth) and 6.7 m (slant range) were provided by JPL. To compute the mean of SAR data for a stand, we located the stand on the SAR imagery, and the largest possible window within the stand was extracted. For each stand, at least 200 image pixels were averaged.

3.2. Stand density vs. P-band SAR backscatter

There is almost no relationship between the P-band backscatter and stand density (Figure 1). Of the 23 stands, as the stand density increases, tree size parameters (e.g. dbh, tree height, and canopy depth) vary irregularly (Kasischke 1992). Thus, the stand density is not a good parameter to explain the variation in the SAR backscatter.

3.3. Stand mean dbh vs. P-band SAR backscatter

As the mean trunk dbh of trees in the stands increases, the P-HH and P-HV backscatter increases. The P-HH and P-HV backscatter is saturated at stand mean dbh ≥ 25 cm (approximately) (Figure 2a, c). The observed increase in backscatter may be attributed to the increase of tree sizes. There is almost no relationship between the P-HV backscatter and stand mean dbh (Figure 2b).

3.4. Stand basal area vs. P-band SAR backscatter

The P-HH and P-HV backscatter increases when the stand basal areas increase. There are large variations in the HH and HV backscatter for a given stand basal area (Figure 3a, c). The P-VV backscatter show almost no trend as the stand basal area varies (Figure 3b).

4. Concluding remarks

For loblolly pine stands at the Duke Forest, there is almost no correlation between the observed AIRSAR P-HH, P-HV, and P-VV backscatter and stand density, and no correlation between the P-VV backscatter and stand mean dbh or stand basal area. The P-HH and P-HV backscatter increases as the stand mean dbh or the stand basal area increases. The complex behavior of observed P-band backscatter from the loblolly pine stands shown in this study can not be explained by a single stand parameter (such as stand density, stand mean dbh, and stand basal area). Ongoing studies on the backscatter by using forthcoming spaceborne and airborne SAR data, particularly multi-frequency, multi-angle, and multi-polarization data, and by using a theoretical canopy backscatter model coupled with the collected ground measurements (Wang et al. 1993) should help complete the picture.

5. References

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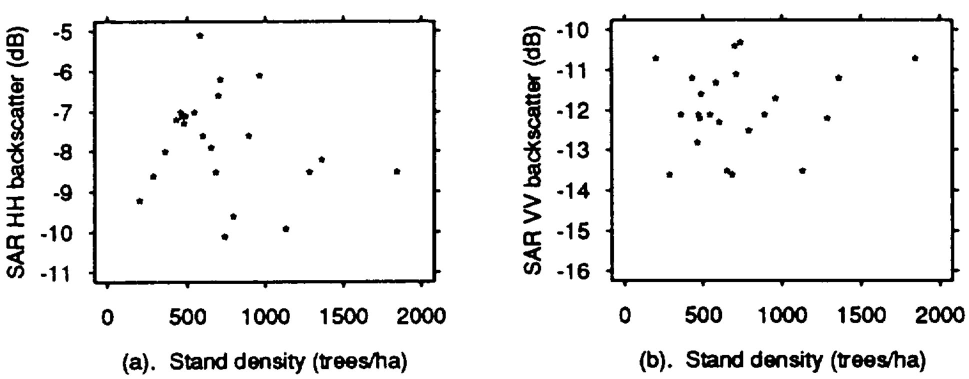


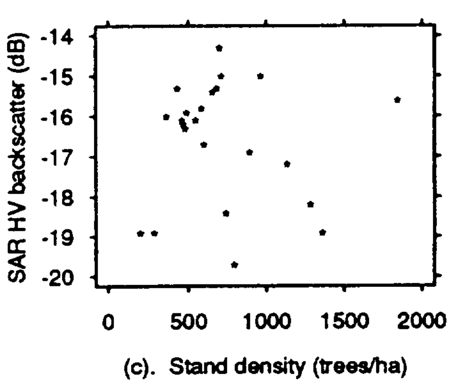
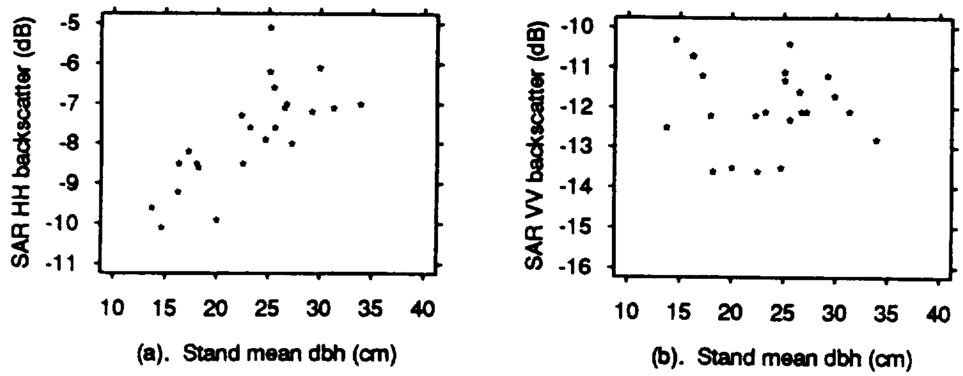


Figure 1. Stand density vs. P-band SAR backscatter for loblolly pine forests at the Duke Forest



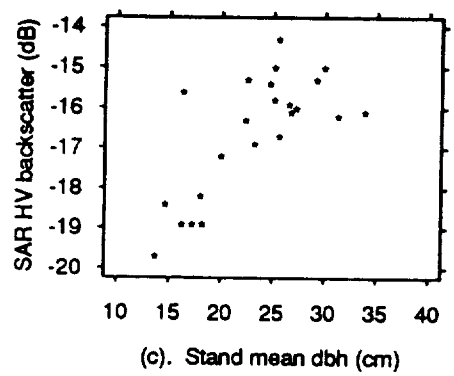
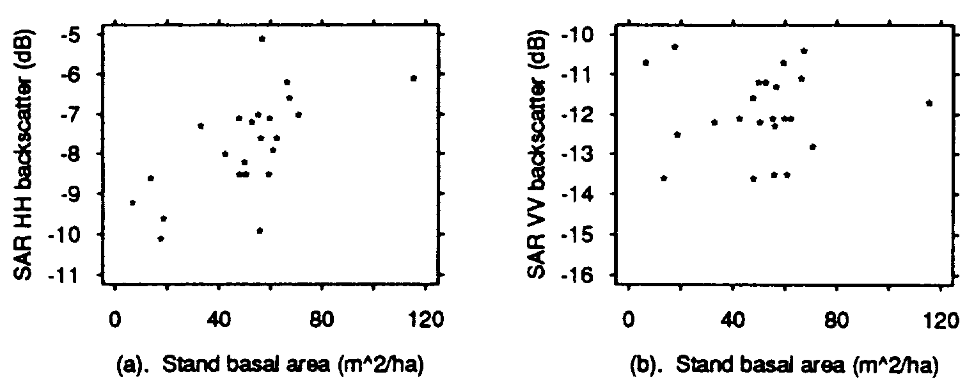


Figure 2. Stand mean dbh vs. P-band SAR backscatter for loblolly pine forests at the Duke Forest



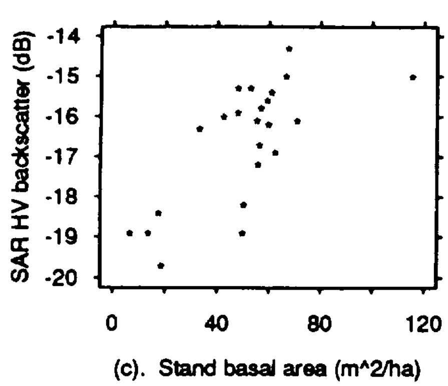


Figure 3. Stand basal areas vs. P-band SAR backscatter for loblolly pine forests at the Duke Forest