Biomass Characterization from Microwave Attenuation Using Ground-Based GPS Receivers

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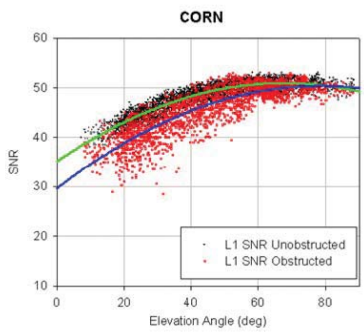

Figure 1. L1 SNR for corn in comparison to an unobstructed antenna.

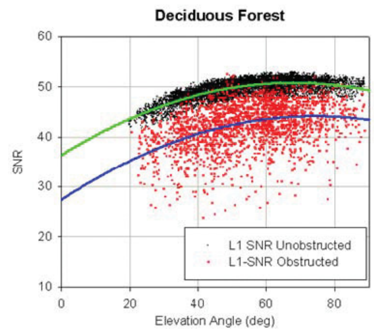

Figure 2. L1 SNR for deciduous forest in comparison to an unobstructed antenna.

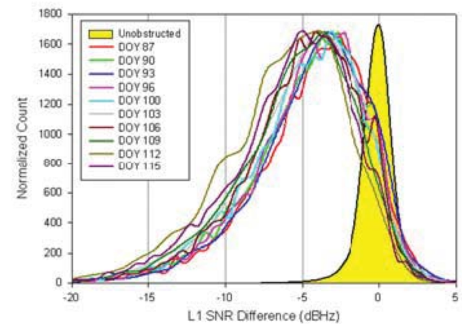

Figure 3. L1 SNR difference under deciduous forest canopy as leaves dropped in the fall.

Soil moisture is a key parameter for understanding Earth's climate and the global water and energy cycle. Numerous experiments have demonstrated that L-band (~1.4 GHz) radiometry is the ideal approach for measurements of this key parameter from space (Jackson, 1993). Nevertheless microwave emissions are highly sensitive to variations in vegetation transmissivity especially at biomass quantities greater than about 5 kg m^{-2} (pasture or mature row crop). Unfortunately, there is little knowledge about the spatial-temporal variability of vegetation properties to develop appropriate attenuation and scattering correction procedures for soil moisture retrieval algorithms.

A rather large body of literature exists concerning the propagation and interaction of electromagnetic waves in vegetation as applied to telecommunications and remote sensing. However, there are no definitive methods relating radio frequency propagation to generalized quantities such as biomass. The objective of this study was to assess the potential of using radio frequency attenuation and multipath scattering from GPS signals to detect differences in vegetation biomass and obtain a preliminary assessment of its sensitivity.

Ground-based GPS observations were made beneath vegetation canopy with a Trimble NetRS Reference Station and Trimble Zephyr Geodetic antenna. L1 and L2 carrier frequency signals were obtained in fields of corn and cotton and beneath deciduous and pine forest canopies. Concurrent control observations with an unobstructed view of the sky were made nearby using a second receiver and antenna. We also placed the antenna and receiver beneath single tree specimens to quantify the spatial attenuation characteristics.

The GPS receivers were able to track significant numbers of satellites from beneath vegetation canopies. The signal to noise ratio (SNR) as a function of incidence angle is different for each vegetation type and differs from unobstructed SNRs by as much as 10 dBHz. For row crops there is no detectable difference in SNRs for obstructed and unobstructed antennas at 90° incidence. As the incidence angle increases, however, the SNR difference also increases (Figure 1). In forests, the SNR difference is quite variable at all incidence angles and only slightly greater at lower angles (Figure 2). L2 data are compared in the same manner with L1. Data are being filtered to isolate contributions from multipath scattering.

Clearly, there is a strong relationship between signal attenuation and scattering and biomass. This relationship is, however, very specific to vegetation type insofar as scattering is a direct function of plant architecture. Sensitivity to small changes in biomass under forest canopy is demonstrated by slight changes observed in the L1 SNR data as the leaves dropped from the trees during the fall (Figure 3).