# ACTIVE AND PASSIVE MICROWAVE SENSING OF SOIL MOISTURE THROUGH CORN FIELDS OF VARYING DENSITY

**R.H. Lang(1), C. Utku(2), P. de Matthaeis(3), T.D. Tsegaye(4), P. E. O'Neill(5), C. Laymon(6)**

*(1) Department of Electrical & Computer Engineering, George Washington University, Washington, DC 20052*
*E-mail: lang@seas.gwu.edu*

*(2) As (1) but E-mail: cuxu@seas.gwu.edu*

*(3) As (1) but E-mail: pdematth@seas.gwu.edu*

*(4) Department of Plant and Soil Science, Alabama A & M University, Huntsville, AL*
*E-mail: ttsegaye@aamu.edu*

*(5) Hydrological Science Branch/974, NASA/Goddard Science Flight Center, Greenbelt, MD 20771*
*E-mail: peggy@hsb.gsfc.nasa.gov*

*(6) Global Hydrology and Climate Center, National Space Science and Technology Center, Huntsville, AL 35805*
*E-mail: Charles.Laymon@msfc.nasa.gov*

## ABSTRACT

This paper explores the synergetics of passive and active microwave remote sensing to determine soil moisture under a corn canopy. An experiment has been performed at Alabama A&M Winfield A. Thomas Agricultural Research Station near Huntsville, Alabama in June, 1998. The fields were observed with a truck-mounted L-, C- and X-band polarimetric radar and a second truck-mounted L- and S-band radiometer. The paper will present a comparison of active and passive models with the observed data. The effect of the corn in obscuring the soil moisture variations will be discussed.

## INTRODUCTION

As part of the Huntsville '98 experiment, the NASA/GWU truck-mounted radar with frequencies at L-, C-, and X-band and a Department of Agriculture L- and S-band radiometer were employed to obtain active and passive data over cornfields of varying density. The data was collected over several test fields for the period of two weeks. Soil moisture changed daily due to irrigation and natural rainfall. Instrument calibration was accomplished using the response to targets of known scattering properties for the radar and known reference temperatures for the radiometer. Ground truth data was also collected and used as input to a discrete scattering model for the vegetation.

## MEASUREMENTS

The controlled experiment was performed at Alabama A&M Winfried A. Thomas Agricultural Research Station (June, 1998). A test site consisting of two 50m X 60m plots - one with a bare surface and the other with grass cover - and four 30m X 50m plots of corn at different planting densities was prepared. One cornfield was planted at a full density of 9.5 plants/$m^2$ while the others were planted at 1/3, 1/2 and 2/3 of the full density. The fields were observed from a truck-mounted L, C and X band polarimetric radar and from a second truck-mounted L and S band radiometer at incident angles between 15 and 50 degrees.

Observations were made over a period of 13 days in which several rain events occurred, interleaved with periods of dry-down. Variations in gravimetric soil moisture from 18 % to 34 % were seen during this period. The corn was characterized carefully for modeling purposes. Randomly selected corn plants were measured. Stalk diameter at the base and midpoint, as well as, stalk height were recorded. Leaf inclination angles at the stalk, leaf mid-point and tip were measured. The leaves of sampled plants were removed from the plant and their outlines were traced on large sheets of paper. Dielectric constants of the stalks and leaves were measured with a dielectric semi-rigid coaxial probe connected to a network analyzer in the frequency range from 1 to 10 GHz.

## MODELING AND RESULTS

The corn was modeled using a discrete scatter approach with corn stalks being replaced by tapered vertical cylinders and corn leaves represented by thin elliptical dielectric discs having a prescribed inclination angle distribution. A radar model was constructed by employing the distorted Born approximation with the scatterers being embedded in an equivalent dielectric medium [1,2]. The underlying ground was taken as a half space and its dielectric constant was related to the soil moisture by using a well-known relationship [3]. The model, as formulated, predicted two principal components: the direct scatter from the stalks and leaves and the scatterer-ground interaction term. The passive response was obtained from Peak's formulation that related the passive and active problems. By using this method, the brightness temperature was found by integrating the bistatic radar response over a hemisphere.

Results for the L band radar response agree with the data within experimental limits. The findings are interpreted by examining model outputs for attenuation and component scattering. These results show that leaves are the most important vegetation component for predicting the attenuation of horizontally polarized waves, while both leaves and stalks contribute in the vertically polarized case. An examination of the backscatter contributions shows that, at L band, the direct backscatter from canopy stalks and leaves is small compared to the scatterer-ground interaction term. Finally, by simplifying the model based on dominant contributing terms, an inversion methodology for soil moisture using active and passive data has been developed.

## REFERENCES

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