Active Microwave Remote Sensing for Soil Moisture Detection : An Analysis of C-band Scatterometer Results

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The presence of surface roughness and vegetation on the soil surface complicate the use of radars for soil moisture determination. These factors reduce the sensitivity of radars to the dielectric constant. An experiment with a C-band dual antenna, multi-polarization and multi-incidence angle has been carried out both on bare and vegetation fields. The results indicate both good and poor statistical relationships betweent the backscattering coefficient σ^0 and the observed volumetric soil moisture for different polarizations at differnt incidence angles for both bare and vegetated fields.

Key Words : *Backscattering coefficient, volumetric soil moisture, dielectric constant, wavelength, specular reflection, incidence angle, polarization,*

1. INTRODUCTION:

The soil moisture information obtained from microwave remote sensing plateforms can be of great use to the modelling of hydrological and climatological processes at land surface. It has been proved in a No. of studies that soil moisture determination is quite possible using microwaves but it is fraught with challenges. Only the moisture in the top few centimeters of soil can be detected. Algorithm development is complicated by the need for surface roughness and vegetation corrections. The objective of this research is to assess the influences of various surface and vegetation parameters on the soil moisture sensing. The experiment was conducted on 12 occassions, for both bare and vegetated fields, at Chiba Experimental Station, Japan. A detailed analysis of the influence of these factors in light of the theory of differaction of surfaces is a subject another publication.

2. SCATTEROMETER SYSTEM:

The scatterometer employed in collecting the data in this study is the 5.2 G Hz microwave active scatterometer (5.8 cm wavelength). This is a mobile van-mounted dual antenna system capable of making scattering measurement at a single frequency (C-Band) with all the linear polarization. The details of the system specifications and characteristics can be found from Mushiake et. al., (1997). During the experiment, The measurements were recorded at all the three linear polarizations; HH, VV and HV at fixed incidence angles of 23^0, 35^0, and 43^0. The two fields, one bare and other vegetated with tall grass, are lying opposite to each other. The σ^o was measured by recording the scatterometer response alternately along the bare and the grass fields. Simultanously when the scatterometer was being used, the point soil moisture measurements were also recoreded using gravimetric method as well TDR instruments. The surface characteristics like rms height, and vegetation parameters like vegetation water content, Height, LAI, Leaf size dimensions and angular distribution were also measured during each occassion.

3. RESULTS:

(1) Bare field

the temporal relationship between the backscattering coefficient σ^0 and volumetric soil moisture is reasonably good at all angles of incidences tested at VV polarization while as in case of HH and HV polarization, a reasonbly good relationship was found at an incidence angle of 23^0 only while as at other angles of incidence tested during the experiment, the relationship is low.

Table 1: Summary of statistical relationship of σ^o with soil moisture and plant Height.

(a)*

Polar-ization	Inci. Angle	Bare condi. ρ	Bare condi. slope	Veg. condi. ρ	Veg. condi. *slope*
HH	23^o	.74	.35	.67	.22
HH	35^o	.29	.12	.59	.15
HH	43^o	.30	.10	.58	.12
VV	23^o	.76	.31	.50	.14
VV	35^o	.65	.31	.28	.08
VV	43^o	.69	.38	.13	.04
HV	23^o	.67	.46	.51	.20
HV	35^o	.34	.24	.28	.09
HV	43^o	.33	.23	.17	.06

(b)*

Polar-ization	Inci. Angle	Plant Height ρ	Plant Height slope
HH	43^o	.76	.04
VV	43^o	.67	.05
HV	43^o	.86	.08

$(a)^*$ shows relationships with Vol.Soil moisutre $(b)^*$ shows relationships with plant height.

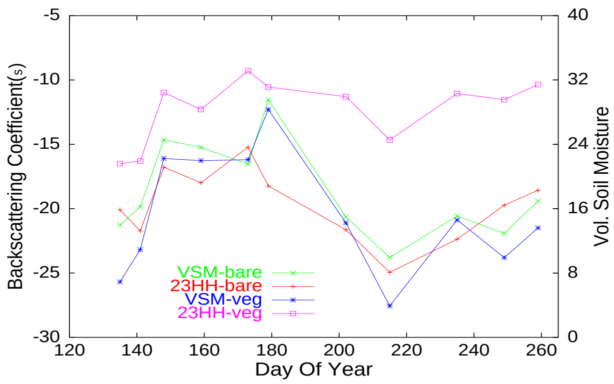

Fig. 1 Time history of σ^0q and soil moisture over bare and grass fields at 23^o incidence angle for HH polarizations

(2) vegetated field

The experimental relationships derived between the backscattering coefficient σ^0 and the volumetric soil moisture are reasonably good for all the angles of incidence tested over the vegetation in case of HH polarization. While as at other polarizations, the relationship is reasonably good at lowest angle tested, i.e., 23^0 only while as at higher angles of incidence, the relationship is expectedly poor. The correlation coefficient of of backscattering coefficient σ^0 with plant height which is one of the indicator of the plant growth is better at all the polarizations and at all the angles of incidence tested but exhibits poor sensitivety.The relationship get stronger with with the increase in angle of incidence as the incident wave interacts better with the vegetation structure (Shakil et al., 1999)

4. CONCLUSIONS:

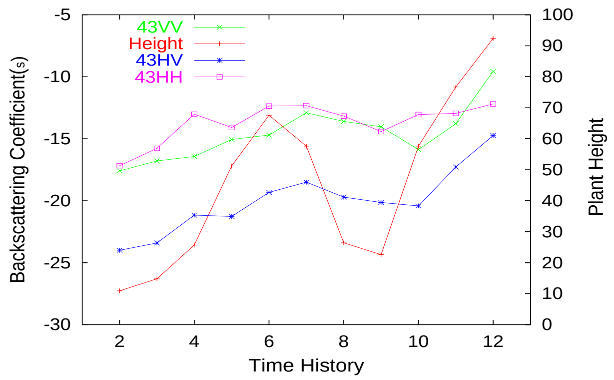

Fig. 2 Time history of σ^0 and plant height over grass field at 43^o angle for all polarizations

It seems that under comparatively smooth surface roughness conditions, the backscattering coefficient is sensitive to the soil moisture only at lower angles of incidence for all the polarization tested.In case of vegetation, the backscattering is sensitive to the soil moisture content only at the lower angles of incidence which has been earlier reported by Ulaby et al., (1979) while as the backscattering coefficient is sensitive to the plant parameters like height at all the incidence angles for all the polarizations. The relationships may be viewed in light of the average standard deviation and coefficient of variation of the soil moisture samples which is 0.0314 g/cm^3 and 0.21 respectively.

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