FUSION OF PASSIVE AND ACTIVE MICROWAVE SENSORS DATA FOR ENHANCEMENT OF GEOPHYSICAL FEATURE

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ABSTRACT

In microwave remote sensing the passive sensor measures the brightness temperature, which depends upon the physical temperature and emissivity. The active sensor measures scattering coefficient. These parameters are function of geophysical parameters of the natural materials. When both electrical parameters are used in fusion there is enhancement in the geophysical parameters. The saline soil has been used for study of enhancement of its geophysical parameters using both passive and active sensors. The effects of polarization look angle have also been included for the study. The measured and estimated value of these parameters have been included in the study.

INTRODUCTION

Microwave remote sensing[1] of natural earth materials such as soil and water has a very close dependence on their electrical parameters. The most important parameter is the dielectric constant. The dependence of emissivity and backscatter coefficient of the soil on this particular parameter is used for designing passive and active microwave sensors. Microwave remote sensors are having unique capabilities over other sensors. Microwave sensors are usually divided into two groups according to their mode of operation: Active sensors and Passive sensors. *Active sensor* illuminates the target with its own energy and uses the scattering properties of the terrain and target to collect data about them and to identify them. The energy scattered in the direction of sensor is processed to study their physical properties. In other words the active remote sensors (Scatterometer) measure the scattering coefficient of the material, where back scattering coefficient depends on the dielectric constant. Passive Sensors are those, which don't have their own source of illumination. *Passive sensors* use the natural emission from the targets to identify and study their physical characteristics i.e. emissivity, transmitivity and reflectivity. Hence, Passive microwave measurements from earth orbits provide global data on a wide range of geophysical and meteorological phenomena. They are simply receivers that measure the radiation emanating from the scene under observation. The emitted energy is related to the temperature and moisture properties of the emitting object or surface. In this present study, a total power radiometer and a cw scatterometer has been used at microwave frequency for measurements, which will be done for different parameters and both the data will be combined to see which of the parameter of passive or active sensor gives more or enhanced feature in terms of salinity, or the moisture content in the saline soil. The study will be done for a dry soil, than saturated soil with water and the variable moisture content in the soil. The main aim of this paper is to compare the emissivity and scattering coefficient as parameters obtained directly from the sensors with the estimated values of emissivity and scattering coefficient obtained from the measured values of dielectric constant.

MEASUREMENT OF DIELECTRIC CONSTANT[2]

Dielectric constant describes the interaction of a material with an electric field. It is equivalent to relative permittivity ($\varepsilon_r = \varepsilon/\varepsilon_0$) or the permittivity relative to the free space. In present study, wave-guide cell method is used for measurement of dielectric constant and the measured dielectric constant of the saline soils at different salinity at frequency 10GHz are given in table 1 and plotted in Fig1.

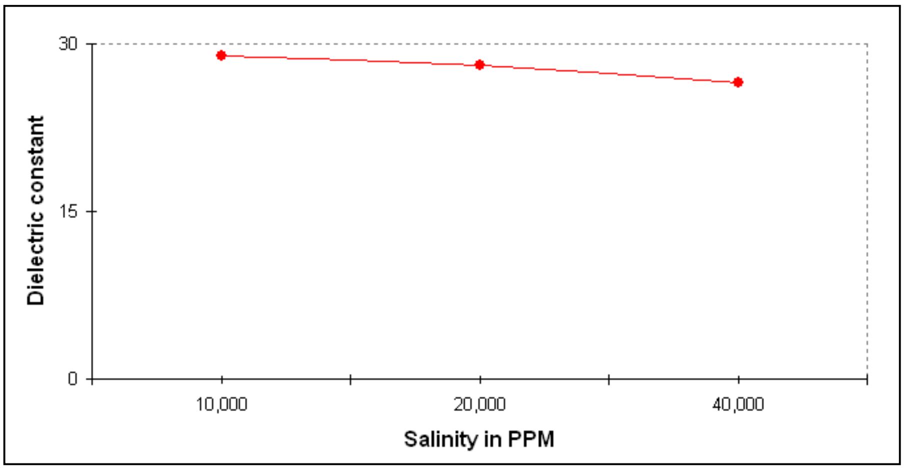

Fig 1: Variation of dielectric constant with salinity at frequency 10GHz

Frequency	Salinity in PPM	10K PPM	20K PPM	40K PPM
10GHz	Dielectric Constant	28.8914	28.032	26.4945

ESTIMATION OF EMISSIVITY & BRIGHTNESS TEMPERATURE[3,4]

The emissivity is the ratio of energy emitted by an object as compared to that emitted by a perfect blackbody at same physical temperature. The microwave temperature is the product of the physical temperature and emissivity of the object. The emissivity depends on the surface roughness, dielectric properties, Chemical composition, physical temperature, frequency, angle of observation etc. The emissivity is estimated using emissivity model[3] and measured using a radiometer at 10 GHz and look angle of 45°. The fig 2 shows the setup for measurement of the brightness temperature and from this the emissivity is calculated.

Fig 2 Experimental setup for Measurement of T_B

MEASUREMENT OF EMISSIVITY

From measured $T_{B,}$ emissivity is calculated using the physical temperature. The measured emissivity is given in table 2.

Soils	Emissivity at incidence angle 45deree			
	Estimated		Measured	
	Vp	Hp	Vp	Hp
Dry soil at T=30C	0.9885	0.8929	0.9939	0.9939
Wet soil at T=28 C	0.5454	0.3258	0.5546	0.5546

ESTIMATION OF SCATTERING COEFFICIENT[5,6]

The scattering coefficient (σ^0) represents the scattering behavior of an object at a given frequency, incident angle and polarization & defined directly in terms of incident & scattered fields. Depending on electrical & physical properties, every natural object has a different scattering coefficient (σ^0).
There are three different models for the estimation of scattering coefficient. Here the perturbation model is used for estimation of scattering coefficient.

Fig 3. Experimental setup for measurement of scattering coefficient

MEASUREMENT OF SCATTERING COEFFICIENT

In our experiment we measure the scattering coefficient of saline soil at three different salinity i.e. 10 ppm, 20ppm and 40 ppm. The test bed is prepared by putting the dry soil in square area of 8ft× 8 ft and thickness of 5cm. Then it is made saline by putting required amount of saline soil and it is made up to 20% moisture.For the experiment the transmitted signal at the 10 GHz frequency is made to incidence on it. The horn antenna is used for both the transmitting and receiving purpose. The receiver section measures the scattered signal from the soil. So by knowing the transmitted power, received power, the range and the area of illumination we calculate the scattering coefficient.

$$\sigma^0 = \frac{P_r}{P_t} \frac{R^4 (4\Pi)^3}{A G_t G_r (\lambda)^2} \tag{1}$$

The scattering coefficient of the soil is measured using a scatterometer operating at 10 GHz and at 45° look angle. The experimental setup is shown in fig 3.

RESULTS AND DISCUSSION

The dielectric constant measured for different salinity is given in Table 1 and fig 1. From the figure 1 it appears that the dielectric constant is decreasing with increase in salinity. Table 2 gives values of emissivity for different salinity estimated using emissivity model and measured using radiometer setup shown in fig 1 and plotted in fig 4. It is observed that in both cases of estimated and measured values of emissivity the values are very close and the emissivity for VV polarization is more as compared to the HH polarizations. The estimated scattering coefficient is plotted in fig 5 and the measured scattering coefficient is plotted in fig 6. it is observed that the estimated scattering coefficient with salinity is not changing much where as in the case of measured scattering coefficient for vertical polarization shows decrease in scattering coefficient with salinity. The values of scattering coefficient for both horizontal & vertical polarizations are decreasing with salinities. For vertical polarizations the slope is more as compared to horizontal polarization.

CONCLUSIONS

The combination of two sensors operating at microwave frequencies provide information about the same geophysical parameter the measurement of scattering coefficient of saline soil is measured and the emissivity is obtained by measuring the brightness temperature and the physical temperature. The idea of fusion of these tow electrical parameters for study of salinity of soil has been explored and the results presented.

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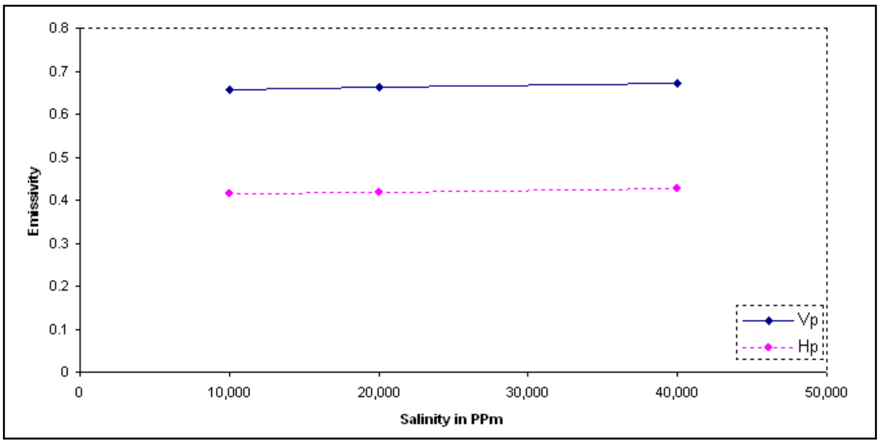

Fig 4: Variation of emissivity for both polarizations at 45-incidence angle with different salinity at frequency 10GHz

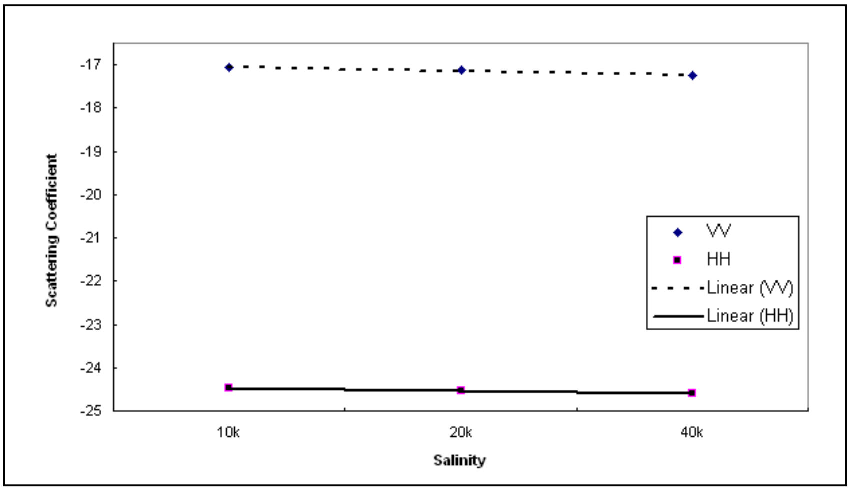

Fig 5:Variation of estimated scattering Coefficient With Salinity

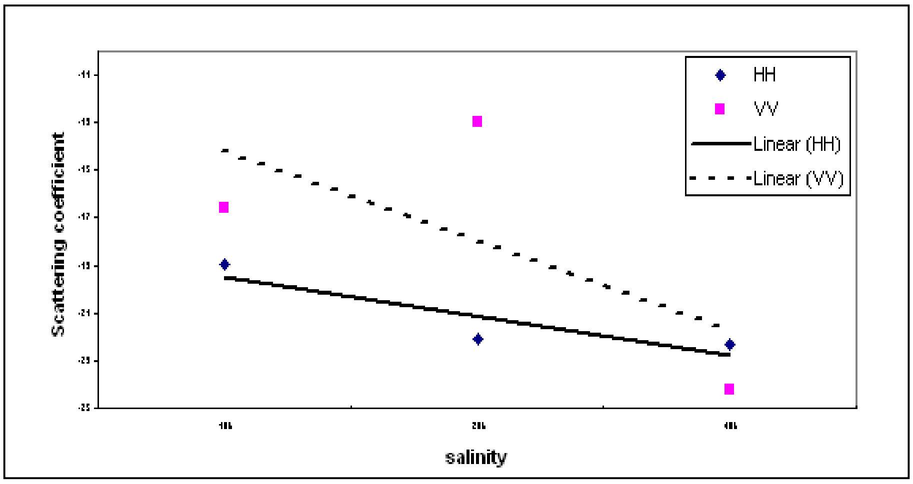

Fig 6: Variation of measured scattering Coefficient With Salinity