MILITARY TECHNICAL COLLEGE

CAIRO - EGYPT

Vegetation-Soil Classification for Digital X-Band Single polarized SLAR Imagery

A.A.SHAHIN *

ABSTRACT

In 1978 , VIGIE single polarized SLAR radar was flown two flights in order to evaluate the capability of remote sensing by utilizing X-band radar for identification and measurement of soil and vegetation parameters . The initial data review has shown the need for proper correction of digital SLAR imagery . Specifically the data has been radiometrically corrected to remove antenna weighting effects and range cubic losses . Geometric distortion caused by the radar image being in slant range has been removed before comparison with other data such as photos , maps, ..etc. The classification of different terrains (Aerodrome, towen , wheat , barley , soil , forest) have been studied statistically utilizing the average value of radar image data intensity . Only the aerodrome , vegetation and town have been well classified . On the other hand soil , wheat , barely and forest have been merged . The studies of numerical calibrated data of VIGIE radar has permitted the determination of backscattering coefficient for each terrain. The analogy between the results obtained by VIGIE and that obtained by the experience of scatterometer RAMSES (Radar de Mesure Sol et d'Evaluation Signatures Spectrales) has shown that their responses have the same margin This attempt has demonstrated that the multipolarization radar is more helpful for such study . In addition , the indices based on textural analysis are important to complete the feature signatures .

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* Colonel Doctor , Dept. of Electrical&Spec.Equipment and Armament for Aircraft , Military Technical College , Cairo , Egypt .

INTRODUCTION

This paper deals with the use of single polarized real aperture radar SLAR "Side Looking Airborn Radar " for measuring the backscattering coefficient of soil , in addition to evaluate the radar spectral response for the classification purposes . Therefore , the paper discusses the followings ,

- Single polarized real aperture radar system VIGIE .
- The experience of scatterometer RAMSES .
- The measuring of backscattering coefficient from radar imagery and the evaluation of spectral responses in classification .

With the radar imagery , the transmitted waves interact with the different soil and vegetation structures , the radar return is influenced by the heights , densities , and surface roughness of the vegetations . Generally the SLAR systems using the centimetric wavelength can give the appearence similar to that of aerial images in the visible domain . The radar imagery simply is a transformation from the microwave domain where the radar "see" to the visible domain where the human eyes "see" . The interpretation procedures utilized for the visible and infra-red imagery must be adapted for radar imagery SHAHIN and LETOAN [1] .

The radar VIGIE was originally military SLAR system . It has been adapted for the fundemental studies for the microwave responses of soil and oceans. This system is an impulsion radar system of X-band and single polarization (HH) . The imagery resolution is about 40X40 meters . The images are in form of magnetic tape and suffer from residuals of geometric and radiometric distortions LABORDE [2].

The principal characteristics of radar VIGIE are the followings :

- Center frequency		9.345 GHz
- Resolution		40X40 meters
- Peak power		60 KW
- impulse duration	Mode 1	0.2 µs
	Mode 2	1 µs
- Antenna gain		30 dB
- Beam width		0.5°
- Depression angle		10°

SITE DESCRIPTION

The images that has been studied concern the cultivated area located at the North-East of Orleans , France , where soil surveying has been effectuated . From seven flight axes have been realized on the zone , only the axe No. 4 presents the maximum visibility and the minimum radiometric deformations . The soil informations have been determined by the laboratory of Photo-Interpretation of UER de Géographié . In 6 april 1978 , the cultivated zone has been found basically in three forms :

- soil surfaces having either plough soil or harrowed soil .
- soil seeded directly without ploughing .
- cultivated surfaces with wheat , barley or lucerne .

Figure 1 represents the surveying effectuated on the zone simulteneously with the flight on the two most important cultivated exploitations : - Landerville farme - La Briér farme .
Generally , for the terrestrial surfaces , the dynamic values of the backscattering coefficients are in the order of 40 dB De Loor [3] :

- soil	from -35 to -15 dB.
- cultivated surfaces	from -18 to - 3 dB.
- natural surfaces	from -10 to 0 dB.
- constructions	greater than 10 dB.

DIGITAL ANALYSIS METHODS AND RESULTS

The data extracted from the VIGIE imagery has 64 dynamic levels corresponding to a coding of 6 bits . The output dynamics is in the order of 30 dB . The gain of the receiving chain is regulated for each altitude and for the mean level of the over-flighted terrain . The output informations have been suffered from the scintillation effect due to the small value of the wavelength (3 cm) w.r.t. the dimension of the resolved cells (40X40 m) Fig.2 .

To decrease this effect , the average must be taken over the informations of many impulsions . The choice of the number and the intervals of impulsions must satisfy the following conditions :

- The impulsions must not be at short interval that the scintillation noise is decorrelated .
- The impulsions must not be at great interval that degrades the longitudenal resolution .

Finally for the VIGIE system , the averaging over four impulsions seperated between each other by 30 milliseconds is optimum . This filtering is realized by numerical addition over the samples corresponding to four lines (each sample is coded in 6 bits) . The result of the addition is transmitted totally on eight bits . The effectuated filtering reduces the effect but does not eliminate completelythe scintillation. Also these information suffer from a way phenomena that are observed along bands parallel to the flight axis .. This phenomena happens strongly due to multiple reflections on the fuselage . This phenomena appears for the angles of incidence inferior to 60° .

For the studied zone , the dynamic coded values have been normalized to 16 levels . These values have been changed in the same direction as the backscattered signals , i.e. the small values correspond to small rate of received energy and so on Fig. 3.

The airport : such surface is a specular type . These surfaces are considered smooth w.r.t. the wavelength ($\lambda = 3$ cm) , the incident rays are reflected in the specular direction and small echos return to the receiver . With respect to the radar VIGIE , a surface is considered smooth at the incidence angle $\psi = 60°$ if the surface roughness is inferior to 0.75 cm .

Urban zones : These zones correspond to the maximum backscattering energy . The constructions can play the same rôle as cone reflectors (levels 15 to 16) Fig. 4.

Between the last two types of surfaces , the natural surfaces are distributed between the levels 9.5 and 14 . These natural surfaces are :

The vegetation surfaces : They are divided into two groups that are the cultivations (wheat , barley , ..) and the forest .

The cultivations (levels 9.5 to 12) form surfaces more smooth than that of the forest (levels 12.5 to 13.5) and they are represented into two types :

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the raising stage . In this case the soil is detected and the soil appears rough for radar system .

The forest corresponds to more strong responses . Certain types of trees cause resonance phenomena because the leaf dimensions approach the wavelength .

The soil surfaces are seperated to smooth surfaces (harrowed soil) and rough surfaces (plough soil) . The flight has been effectuated after a rainy period therefore the surface humidity of the soil will be in a narrow band and the effective factor that determines the differences of responses is essentially the surface roughness .

The humidity effect is studied for certain type of surfaces (plough soil) where many measures of humidity have been effectuated simultaneously with the flight mission . The radar responses that correspond to surfaces of certain humidity are summarized in the table 1 . The radar responses expressed in this table give the radar backscattering coefficients in dB . For the surfaces having the humidity in the range of 12% to 25% the backscattering coefficient varies from -8.5 to -10.5 dB and differential scattering cross section per unit area from -12.5 to -15 dB . The values are comparable with the measures obtained by the scatterometer RAMSES mounted at altitude 10 meters above the soil Lannelongues [4]. In the Fig.6 , the measures of the soil are effectuated by the CESR on the site of Paris - Grignon in april 1978 , these measures are compared with the values of σ_0 extracted of the VIGIE images (incidence angle 67 to 70°). The values of radar VIGIE are less than the absolute measures of RAMSES by 0.5 to 1 dB for the regions of the same humidity range . The Fig. 5 shows also that at the same date of the mission , certain surfaces of soil and cultivations : ploughed and fores , harrowed and wheat ; have the same response range. The discrimination must be effectuated in this case by utilizing the textural information in addition to the spectral values .

Another flight has been effectuated on the same site (8 june 1979) . The images have been effected also by a way phenomena due to multiple reflections on the aircraft fuselage . The total dynamic band of the image was 64 levels as that of the first flight . The abnormal radiometric values created by the phenomena have reduced the useful band . The Fig. 6 summarizesthe statistical study of analyzed surfaces and

and the table 2 shows the values of γ and σ_0 calculated in dB . The artificial surfaces (aerodrome , town) were beter isolated than the natural surfaces . On the other hand the narrow band of backscattering coefficients (-17 to -19 dB) does not allow the differentiation of the different cultivation types (maize , wheat , beetroot) .

CONCLUSION

Before the extraction of information process for the radar imagery , the radiometric and the geometric corrections are necessary for such type of data . The study of radar responses based on the backscattering coefficients for several surfaces (aerodrome , soil , the urban zones) has permitted the discrimination of the aerodrome separately from either the urban zones or the vegetation , also the urban zones from the vegetation . For the vegetation itself , the forest and cultivations are well discriminated from each other . The soil can have different response according its condition ; the harrowed soil has smaller backscattering coefficient than that of plough soil . In addition to the surface roughness effect of the soil , the study of the soil humidity w.r.t. the radar responses has demonstrated that the values extracted from the VIGIE radar images are in good concordance with values extracted by the experiment of scatterometer RAMSES .
Finally the present study made on the fir st radar imagery established the organized messions in France for the vegetation study , demonstrated the possibility of the identification of agriculture surfaces and the determination of the vegetation structure parameters . These possibilities are limited in present study due to the lower resolution of the radar system VIGIE . To overcome such limitation , the textural indices are other hopeful tools for the future studies .

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INCIDENCE ANGLE(°)	γ (dB)	σ_0 (dB)	HUMIDITY (%)
66.5	- 9.77	-13.76	18.6
66.84	- 8.43	-12.48	18.
66.84	- 9.59	-13.64	18.2
66.15	-10.13	-14.06	11.8
67.	-10.36	-14.79	24.9
66.35	-10.22	-14.18	20.
66.84	-10.37	-14.42	13.4

Table 1: Radar responses of samples of plough soil (first flight)

SURFACE TYPE	ψ (°)	γ (dB)	σ_0 (dB)	HUMIDITY (%)
Maize	66.5	-15.74	-19.73	10.19
"	66.84	-14.32	-18.37	11.36
"	66.84	-15.58	-19.63	9.47
"	66.15	-15.74	-19.67	9.75
Wheat	67.64	-14.2	-18.4	12.1
Beetroot	67.	-14.46	-18.55	12.04
"	66.35	-12.19	-16.16	9.3
Maize	66.84	-14.5	-18.55	11.02
Wheat	59.38	-15.65	-18.58	9.85
Beetroot	57.86	-15.62	-18.36	6.29
"	58.93	-17.28	-17.56	8.34
"	58.93	-15.59	-18.46	9.96
"	59.22	-15.09	-17.99	8.18

Table 2 : Radar responses of samples at different humidity (second flight)

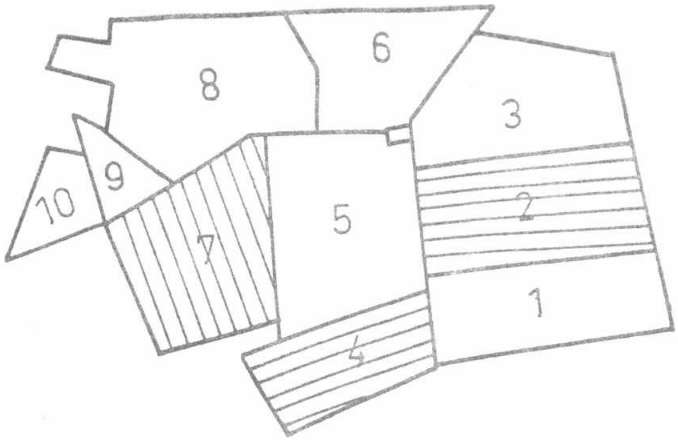

Fig.1: The direction of ploughing for the soil
(La Brier farme)

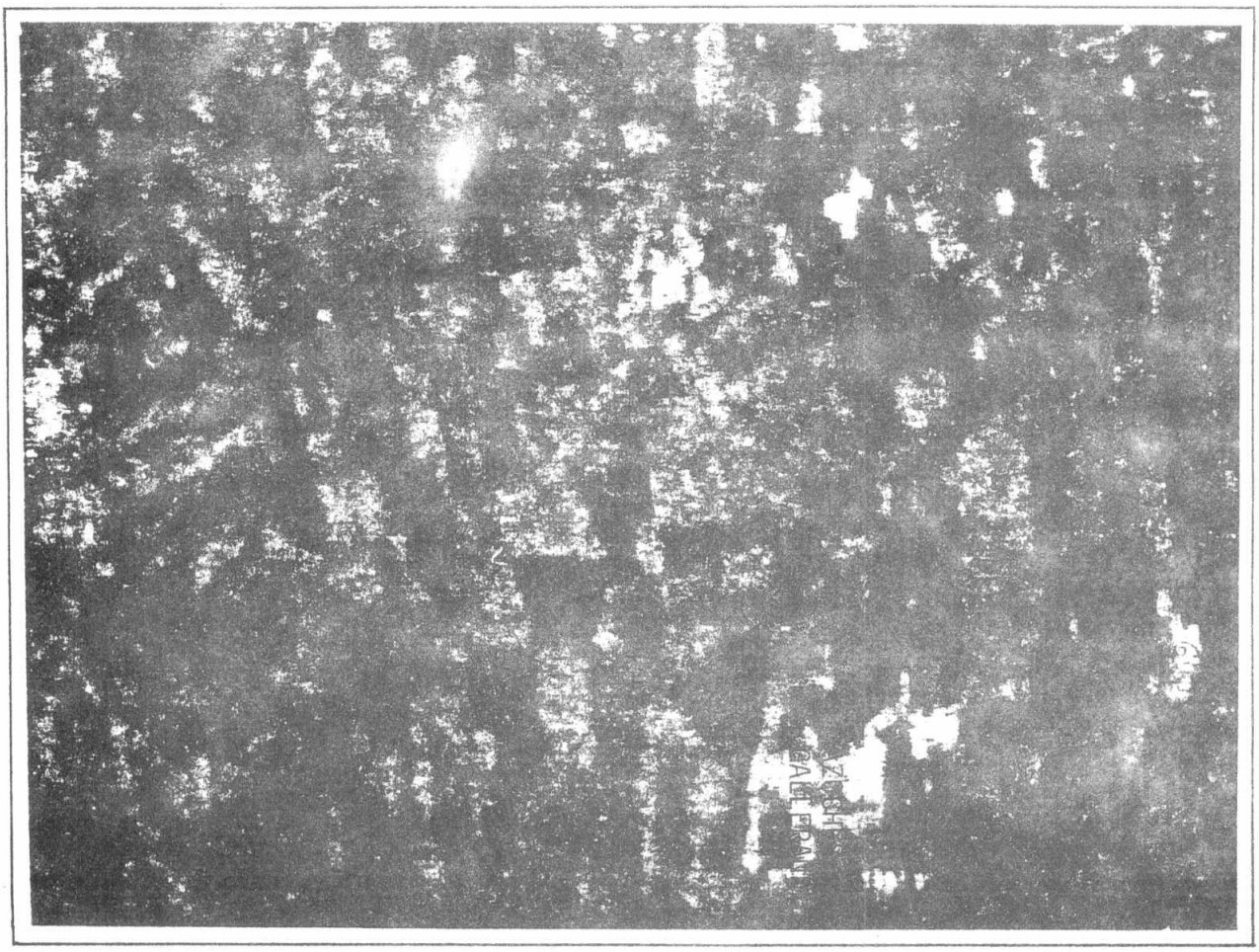

Fig. 2 : VIGIE image of the studied zone (6. 4. 1978)
1 : Landerville farme 2 : La Brier farme

Fig.3: Digitized radar image of the studied zone after the radiometric correction
1: Landerville farme 2: La Brier farme

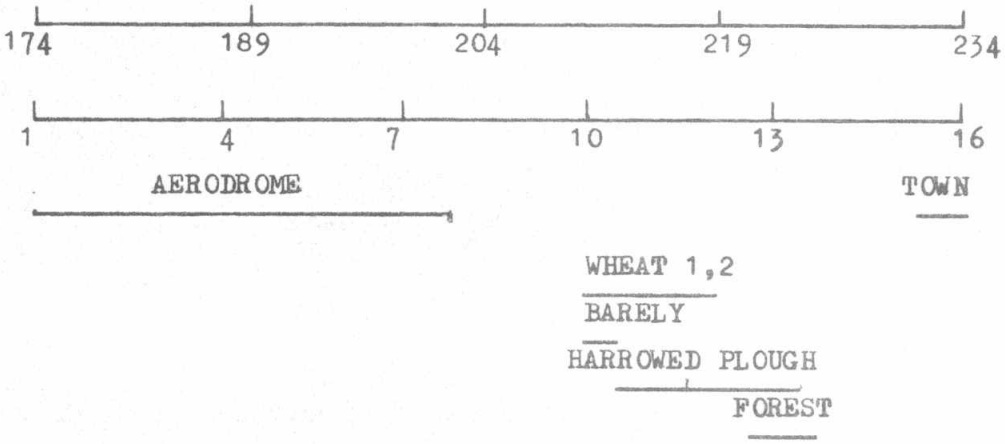

Fig.4 : Radar responses of analyzed surfaces (first flight)

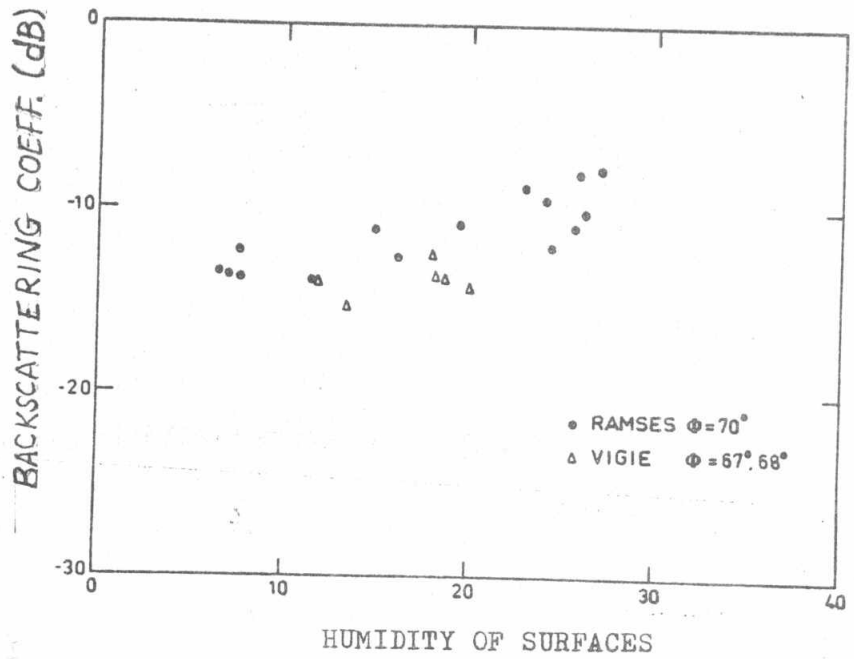

Fig.5 : Comparison of measures obtained by the scatterometer and that obtained by the radar system VIGIE .

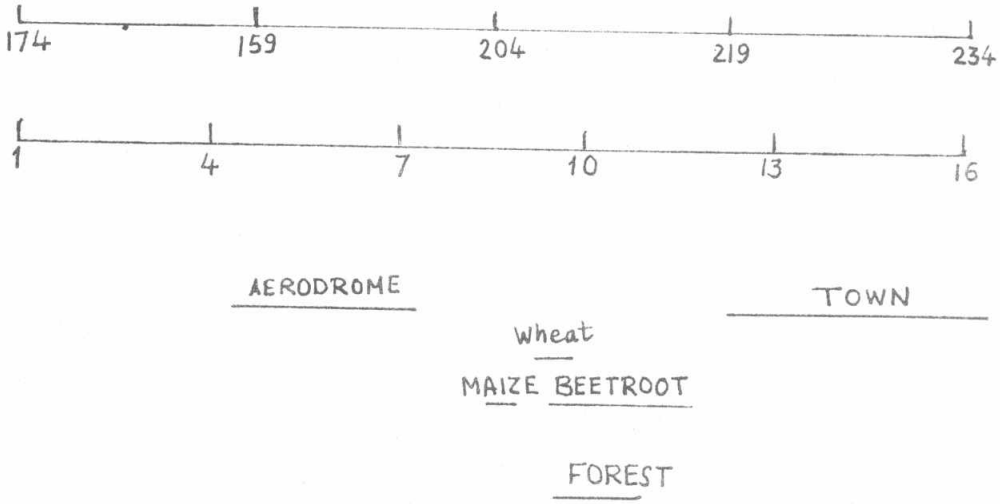

Fig.6 : Radar responses of analyzed surfaces .(second flight)