THE DETECTION OF PETROLEUM FLOODS ON THE GROUND SURFACE BY MEANS OF PASSIVE LOCATION IN MM WAVELENGTH RANGE

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Introduction.

The purpose of this work is the investigation of an opportunity of detection of dielectric anomalies located on ground surface. Poured petroleum completely absorbed by the ground is considered as an example of dielectric anomaly.

According to the U.N.O. information about 10 million tons of mineral oil annually get Earth surface. Moreover, 6 million tons from them spill to the rivers, seas and oceans, and 4 million get continent surface. In this connection the detection of petroleum floods is extremely important problem.

The analysis of radiation characteristics of terrestrial covers is very complicated since these characteristics depend on many factors. The task can be simplified under certain assumptions. We shall assume [1, 2], that cover roughness are large in comparison with wavelength, their heights are statistically homogeneous and isotropic and they are distributed under the normal law. Then effective temperatures of soil are determined by following parameters of radiation model of system "terrestrial surface - atmosphere": the variance of surface slope, complex dielectric permittivity of surface layer, thermodynamic temperature of the earth surface and the indicatrix of sky radiation.

The permittivity of covers in MMW range is well known only for some artificial coverings (concrete and asphalt) and water surfaces (both sweet, and salty water). There are not enough reliable theoretical models and experimental data for dielectric permittivity of such covers as land without vegetation now [3]. The determination of mix "land - petroleum" permittivity is even more complicated problem.

Results.

We have chosen a three-componential semiempirical model from theoretical models available now, namely the ground, the connected moisture and petroleum. With the help of this model complex dielectric permittivity of such grounds as sandy loam, loam and firm loam are calculated for soil humidity, not exceeding a point of maximal hygroscopicity (MH). The situation corresponds to that when petroleum completely filters into soil without leaving a film on the surface.

Dielectric permittivity for such mix is defined by formula [4]:

$$\sqrt{\varepsilon_{mix}} = \sqrt{\varepsilon_d} * W_M + \sqrt{\varepsilon_p} * P + q\sqrt{\varepsilon_w}\ , \qquad (1)$$

where ε_{mix}, ε_d and ε_p are dielectric permittivity of a mix, a dry soil and petroleum respectively, W_M is the volumetric contents of a monolith in a mix, P is porosity of dry soil, q ($q \leq$ MH) is relative volumetric humidity, MH is value of the maximal hygroscopicity, ε_W is dielectric permittivity of water. The values of parameters W_M, P and MH are given in [5].

As physical and chemical properties of petroleum extremely differ, transported on main pipelines petroleum of mark "Urals" was chosen for the analysis. It is the so-called normalized petroleum with dielectric permittivity $\varepsilon_p = 2 + i\,0{,}001$.

In Table 1 the values of dielectric permittivity of various types of soil and mix "a ground - the normalized petroleum" are given for wavelength λ = 3,3 and 8,6 mm calculated by formula (1). Here thermodynamic temperature of surface T_0 = 293 K. The case is considered when moisture concentration achieves maximal value at which petroleum is still absorbed in the ground (q = MH).

An effective cover temperature strongly depends on its dielectric permittivity. As seen from Table 1, that contrast between the sites polluted and unpolluted with petroleum is more for sandy loam. Values of dielectric permittivity of "a mix ground + petroleum" are closer to the appropriate values for the unpolluted ground, than for pure petroleum.

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Calculations of effective temperatures for different types of soil given in Table 1were carried out on the basis of techniques described in [6, 7]. Effective temperatures at orthogonal (vertical and horizontal) polarization for pure atmosphere in July at 60^0 North latitude are calculated in atmosphere transparency windows (λ = 3,3 and 8,6 mm), the variance of surface slope γ is 0,1.

Table 1. The complex dielectric permittivity of various types of soil for λ = 3,3 and 8,6 mm.

Wavelength, mm	Type of soil	Dielectric permittivity
3,3	Loam	3,41+ i0,54
	Loam + petroleum	3,19+ i 0,48
	Firm loam	3,56+ i0,76
	Firm loam + petroleum	3,39+ i0,73
	Sandy loam	3,2+ i0,25
	Sandy loam + petroleum	2,82+ i0,2
8,6	Loam	3,85 + i 0,78
	Loam + petroleum	3,61 + i 0,71
	Firm loam	4,2 + i 1,14
	Firm loam + petroleum	4,01 + i 1,1
	Sandy loam	3,37 + i 0,33
	Sandy loam + petroleum	2,98 + i 0,28

Angular dependences of effective temperature for sandy loam and for mix of sandy loam with the normalized petroleum are given on Figure 1 for wavelength λ = 3,3 mm.

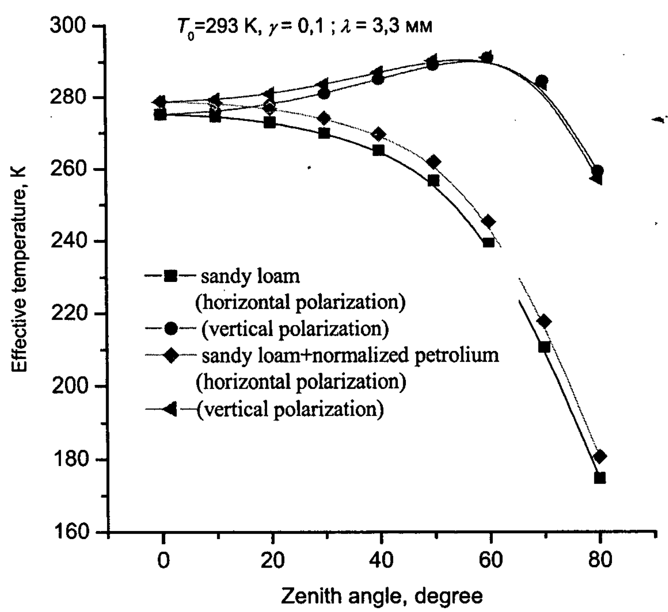

Figure 1. Dependences of effective temperature of sandy loam and mix sandy loam + normalized petroleum from zenith angle for λ = 3,3 mm.

As calculations show, the maximal contrast between polluted and unpolluted sites of a sandy ground may achieve 6 - 9 K. Moreover this maximum corresponds to horizontal polarization and to zenith angles 50 - 60^0. These values of angle make some percents from effective temperatures. For clay soil radiocontrast is a little bit less. To increase a probability of recognition of pure sites and sites with petroleum, it is possible to use a combination of effective temperatures of these sites. It may be relation P of difference of effective temperatures on vertical T_{ef}^{v} and horizontal T_{ef}^{h} polarization to their sum. That is similar to the relation of second and first Stoks parameters [1] of natural radiation of a surface:

$$P = \frac{T_{ef}^{v} - T_{ef}^{h}}{T_{ef}^{v} + T_{ef}^{h}} \quad (2)$$

Preliminary estimations based on application of parameter P for comparison of covers show that the relative difference in values of P may achieve 10 - 15 % for different sites under consideration [7].

Conclusion.

Thus, results of this work can be formulated as follows.

Radiocontrasts between the sites polluted and unpolluted by petroleum are analyzed at wavelengths λ = 3,3 and 8,6 mm for vertical and horizontal polarization and for various soil types. Preliminary computations show, that maximal value of contrast between the polluted and unpolluted sites of a sandy ground is 6 - 9 K. Moreover the maximum is achieved for horizontal polarization and for zenith angles 50 - 60^0.

The principal opportunity of detection of the sites polluted with petroleum by using their effective temperatures is shown.

It is also shown, that for detection of petroleum pollution it is more preferable to use measurements on orthogonal polarization at zenith angles θ= 40 - 60^0 on two wavelengths of MM range.

The detection parameter P that is the relation of second and first Stoks parameters of surface natural radiation is assumed.

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