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THE INTERPRETATION OF THE STATISTICALLY ROUGH SURFACE REMOTE SENSING RESULTS ON THE BASIS OF THE ELECTROMAGNETIC MODELS

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1. On dissipated surfaces investigated by means of remote sensing with the help of active and passive radiolocation systems the determination of the experiment conditions providing the best qualitative measurement results becomes necessary. In this paper there is a solution to a number of surface condition and electrodynamic model parameters estimation identity problems where the latter ones are functionally connected with structure-determinated and stochastic signal models received with the help of the solution of electrodynamic direct problems on wave dissipation by the finite conductivity surfaces. Algorithms of the optimal parameters estimations of the dissipated surface electrodynamic models are synthesized by maximum likelihood function. Here the mathematic field strength dependencies on the desired parameters for the flat small-scale, large scale and two-scale surface approaching small disturbances and Kirhof are used.

The first equation pattern of the observation is the additive field mixture when the field is found through the solution of direct diffraction problem of wave dissipation of means of the section statistically rough surface and white Gaussian noise

$$U_{kl}(t, \underline{r}) = \mathrm{Re}\dot{A}_{kl}(\underline{\lambda})\,\dot{S}_{ol}(t, r) + n_{kl}(t, \underline{r}) \quad , \qquad (1)$$

where $A_{kl}(\underline{\lambda})$ - is a complex multiplier depending on the unknown or random electrodynamic surface model electrophysical parameters $\underline{\lambda}$; $\dot{S}_{ol}(t, \underline{r})$ - determines the known field characteristics and their registration systems; k - characterizes a kind of reception field polarization; and l - that of the investigated field; kl=(VV, VH, HV, HH).

The system of nonlinear equations, connecting the desired parameters(dielectric permittivity, surface slope) with optimal filter output signals were found.

The boundary measurement errors of the electrodynamic models are investigated by means of diagonal matrix elements analysis conjugated to the information matrix of Fisher:

$$B_{n\nu} = 2\mu_o \sum_{k,l=(V,H)}^{n} \partial\dot{A}_{kl}/\partial\lambda_n \ \ \partial\dot{A}^*_{kl}/\partial\lambda_\nu \ , \qquad (2)$$

here μ_o -energy signal/noise ratio. E.g. for the electrodynamic model coinciding with small disturbance approach [1] in and the opposite dissipation direction

$$A_{VH} = A_{HV} = 0 \quad \text{for} \quad \lambda = (\varepsilon,\ \theta) \quad \text{or} \quad \lambda_1 = \text{Rek},$$
$$\lambda_2 = \text{Jmk},\ \ \lambda_3 = \theta \quad \text{or} \quad \lambda_1 = \text{Rek},\ \ \lambda_2 = \text{Jmk},\ \ \lambda_3 = \varepsilon \ . \qquad (3)$$

where k -coefficient connected with the spatial Fourier spectral component of the underlaying surface height for the direction angle θ ; ε -value of the dielectric permittivity.

2. Plots of the square mean values of the dielectric permittivity and surface slope estimation ($|k|$ and θ) have been found in the paper. Plots $\sigma_{|k|}$ show that minimum errors of the spectral component $|k|$ are for angles $\theta \rightarrow 0$ and set up about 0.2...0.3 but for angles $\theta = 35^o..65^o$ these values $\sigma_{|k|}$ are about 0.45...0.6. The values σ_θ and σ_ε are maximum in the case $\theta \rightarrow 0$ and values σ_ε increases σ_θ decreases when dielectric permittivity ε increases. Besides that plots of square mean values σ_ε and σ_θ of the dielectric permittivity and surface slope estimations have been analysed in the paper.

3. For the stochastic field models the parameter estimations $\underline{\lambda}$ and different rough surface stochastic characteristics have been received. For example the dielectric permittivity and surface slope estimations and that of effective dissipation cross-section, square mean values of rough heights, correlation radius as well as that of small-scale rough heights energetic spectrum components have been found.

When registering one polarization field one can derive the effective cross-section of dissipation according to the formula:

$$\sigma^0_{kl} = \frac{1}{4} \sum_{i=1}^{m} | Q_{okli} |^2 \ / \ m\Delta S\mu_o \ - \ 1/\mu_o\Delta S \qquad (4)$$

and the square mean of the estimation error equals to

$$\delta_{kl} = \left[\frac{1}{m(\mu_o \Delta S)^2} + \frac{\sigma^{0}_{kl}}{m\mu_o \Delta S} + \frac{\sigma^{02}_{kl}}{m} \right]^{1/2} , \qquad (5)$$

where ΔS - is the area of the investigated surface; m - the number of location acts of independent statistically homogeneous surface areas ($m > 1$).

On registering two polarization fields of the equations for the $\underline{\lambda}$ parameter and rough surface energy spectrum component $W(\underline{q}_{\perp})$ were found.

$$\left| \frac{\dot{A}_{VV}(\underline{\lambda})}{\dot{A}_{HH}(\underline{\lambda})} \right|^2 = \frac{\sum\limits_{i=1}^{m} \left| Q_{oVVi} \right|^2 - 4m\mu_o}{\sum\limits_{i=1}^{m} \left| Q_{oHHi} \right|^2 - 4m\mu_o} , \qquad (6)$$

$$W(\underline{q}_{\perp}) = \frac{\sum\limits_{i=1}^{m} \left| Q_{oVV(HH)\,i} \right|^2}{4m \left| \dot{A}_{VV(HH)}(\underline{\lambda}) \right|^2 \mu_o} - \frac{1}{\mu_o \left| \dot{A}_{VV(HH)}(\underline{\lambda}) \right|^2} \qquad (7)$$

where $\underline{q}_{\perp}$ - is a dissipation vector [1]; Q_{okl} -are optimal filter output signals for given reception k and investigated field polarization.

4. The analysis of the estimation errors for parameters enabled us to determine the wave angles inclined to the investigated surface, with which these errors are kept to a minimum. The typical regions of such angles are about 0, 90° and about the Breuster's angle. In particular, the maximum errors of dielectric permittivity for the small-scale surface are known to be about Breuster's angle.

The minimum inclined surface summed-up estimation errors and those of dielectric permittivity are known to exist when small wave angles $\theta = (35°, 65°)$.

REFERENCES

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