Effects on the Change Of Polarization Of Plane Electromagnetic Waves Propagating In The Troposphere

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The relative dielectric absorbance ε , which is related to the refractive index of the tropospheric medium, is characterized by the magnetic absorbance μ and the conductivityσ , whose value is constant and equal to the vacuum magnetic permeability. The relative value of dielectric absorption is determined as follows:

$$\varepsilon = 1 + \frac{1,552 \cdot 10^{-6}}{T}\left(p + \frac{4810\, p_{bug'}}{T}\right), \tag{1}$$

where, $p-$ is atmospheric pressure, mBar; $p_{bug'}-$ absolute air humidity which is air vapor pressure, mBar; T - temperature, K.

It can be concluded from the formula that the value of dielectric constant ε is directly proportional to the values of p and $p_{bug'}$. This means that as the values of p and $p_{bug'}$ increase, the number of molecules per unit volume increases and the polarization current increases. As the value of T (Kelvin temperature) increases, the speed of chaotic thermal movement of molecules increases and interferes with the orderly movement of bound charges. As a result, the polarization current decreases. [1.] The value of relative dielectric constant on the Earth's surface does not differ much from one, but the propagation of radio waves is affected by its variation in time and space.

Along with the concept of dielectric refraction, the concept of refractive index of the troposphere, whose value is in the range of 1.00025-1.00046, is used in various meteorological and climatic conditions on the Earth's surface $n = . \sqrt{\varepsilon}$

The relative dielectric strength of the troposphere is related to the refractive index of the troposphere as follows [2]:

$$n = \sqrt{\varepsilon} = 1 + \left[\frac{77,6}{T}\left(p + \frac{4810 P_{bug'}}{T}\right)\right] \cdot 10^{-6}. \tag{2}$$

In the troposphere, the value of the refractive index depends on height and has a linear relationship.

$$n(h) = 1 + N_0 \cdot 10^{-6} \cdot e^{-\frac{h}{7{,}35}} \qquad (3)$$

Here, N_0 – is the average value of the refractive index at sea level (N in units), $N_0 = 315$, h – is the height above sea level, km [2-6].

The movement of waves in the troposphere is affected by the height dependence of the refractive index.

Layered inhomogeneities consist of formations whose horizontal dimensions are much larger than their vertical dimensions. Inhomogeneities are caused by the temperature inversion and cloudiness. The density of layered heterogeneous media varies from approximately 10^{-6} to $5\cdot10^{-5}$ $-10\cdot10^{-5}$. As you move away from the Earth's surface and as you go up, the number of layers decreases and the speed slows down, and the sizes of layered heterogeneous environments change on a large scale. The thickness of the layers can reach hundreds of meters, and the horizontal dimensions can reach tens of kilometers [2]. Due to the fact that radio waves are transmitted over large distances in an inhomogeneous medium, very small changes in the refractive index are observed, as well as a deviation of the wave from the direction of propagation which is called refraction.

To determine the curvature of the wave trajectory, the troposphere is divided into layers, each of which has a constant refractive index (Fig. 1). As the height increases, the value of the refractive index decreases $(n_1 > n_2 > n_3 > n_4 > \ ...)$ and according to the law of refraction, it is observed that it deviates towards the earth's surface [1-3].

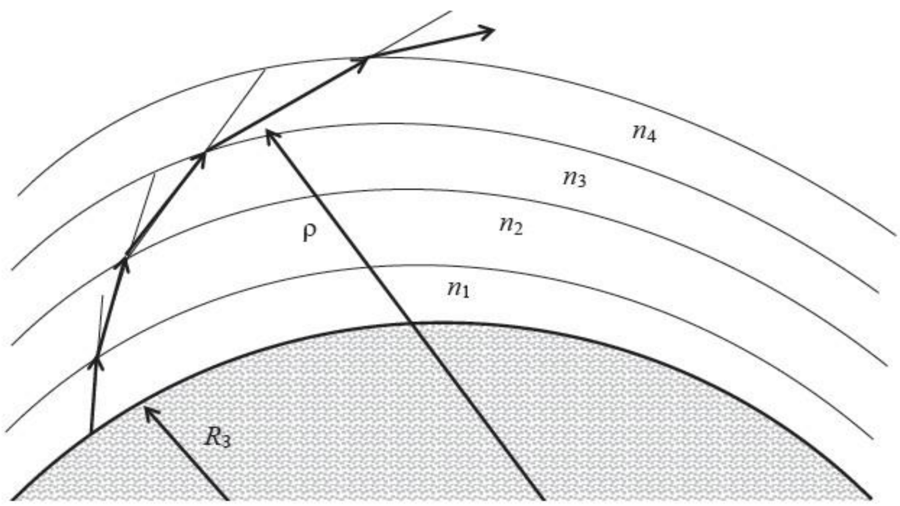


Figure 1. Radio wave refraction in the troposphere

In the troposphere, the radius of the curvature trajectory of radio waves is calculated by the following expression [1].

$$R_T = \frac{n_T}{\frac{dn_T}{dh}\sin\phi} \quad (4)$$

It is known that the value of the refractive index in the troposphere is equal to $n_t \approx 1$, and therefore, when the ray falls under an angle, the condition $\sin\varphi \geq 1$ is fulfilled, and the following expression is derived:

$$R_T = \frac{10^6}{-\frac{dN_T}{dh}} \quad (5)$$

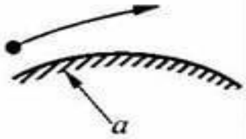
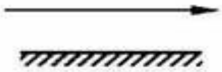
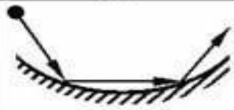
Based on expression (5), the radius of deviation of light in the deep layers of the troposphere is determined by the rate of change of the refractive index with increasing height. The negativity of the product indicates that the radius of curvature is positive only when the refractive index decreases with height.

This indicates that the convexity of the wave trajectory in its path is directed upwards. In the normal troposphere, which is characterized by the fact that the gradient has a constant value throughout its thickness, the trajectory of radio waves has the shape of an arc with a circular radius $R = 25000$. At the same time, water molecules with a constant dipole moment and a limited mass move under the influence of a high-frequency electromagnetic field corresponding to the light range ($4\cdot10^{14}$ Gs...$7{,}5\cdot10^{14}$ Gs). Because it cannot change its wavelength, radio waves are refracted more than light rays in the normal troposphere.

On the other hand, in the range of radio frequencies below $3\cdot10^{11}$ MHz (radio wave range), polar molecules fully participate in the vibration process and a change in the refractive index in the troposphere layer of the atmosphere is observed.

The values of the equivalent ratio of the Earth, a comparative analysis of the real and equivalent trajectories of the beam for different tropospheric refraction conditions are presented in Table 1.

Table 1.

The name of atmospheric refraction	$\frac{dN}{dh}$, 1/m	R, m	$a_э$, m	Real trajectory	Equivalent trajectory
Negative subrefraction	>0	<0	$<6{,}37\cdot10^6$	 a	 $a_э<a$
There is no refraction	0	∞	$6{,}37\cdot10^6$	 a	 $a_э=a$
Positive	$-0{,}04$	$2{,}5\cdot10^7$	$8{,}5\cdot10^6$	 a	 $a_э=\frac{4}{3}a$
Positive critical refraction	$-0{,}157$	$6{,}37\cdot10^7$	∞	 a	 $a_э=\infty$
Positive extreme refraction	$<-0{,}157$	$<6{,}37\cdot10^7$	<0	 a	 $a_э<0$

It can be noted that the development of propagation models and analytical expressions of dielectric absorption fluctuations of flat electromagnetic waves in the tropospheric environment based on fractals is one of the current trends [3-5]. Currently, enough scientific work is being done in this regard.

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