On the Techniques for Solving the Problems of High-Frequency Wave Field Propagation in the Inhomogeneous Ionosphere with Local Variations of Electron Density

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The paper presents a review of the analytical techniques for treating various effects of the high-frequency wave field propagation in the inhomogeneous ionosphere with local variations of the electron density, and the results of their numerical modelling based on the approaches, developed by the authors. The background ionosphere is considered to be inhomogeneous and isotropic, and the effects of the Earth's magnetic field are solely present by the anisotropic shape of the local variations of the electron density of the ionosphere. Some of the effects of local inhomogeneities are considered in the deterministic statement, others require stochastic treatment. The problems of propagation in the HF ionospheric reflection channel and higher frequency propagation in the transionospheric stochastic channel are discussed. The consideration is confined by the case of forward scattering approximation.

When describing the deterministic effects of a single-path geometrical optics field, perturbed by a local random inhomogeneity of the electron density of the ionosphere (e.g., a local depletion of the electron density, or a TID), it is normally sufficient to develop a simple perturbation theory for a ray field of the type as in (N. N. Zernov, *Radiophysics and Quantum Electronics*, **23**, 1980, pp. 109-114) for the case of a layered background medium, or as in (V. E. Gherm, et al., *Vestnik* (*Herald*) of *St.Petersburg University* (in Russian), Series 4, **2**, 2001, pp. 32-38) for an arbitrary 3D background medium. Both are just the extensions of classic Rytov's approximation to the case of the inhomogeneous background medium, which we term as the complex phase method (CPM). Alternatively, in order to account for multipath effects, which may occur due to local perturbations of the electron density of the ionosphere, the integral representation of the wave field is required, e. g., as the representation of the wave field in terms of the diffracting component waves, developed in (N. N. Zernov, B. Lundborg, *Radio Science*, **31**, pp. 67-80, 1996). In this representation each component wave is constructed in the style of the CPM.

In the stochastic problems of propagation two approaches have been developed to describe the effects of strong scintillation of the high frequency wave field propagating on the transionospheric paths. There are two different scenarios of forming the regime of strong scintillation on the transionospheric paths. According to the first one, there is no strong scintillation in the inhomogeneous ionospheric layer, but it can well be formed when propagating below the ionosphere down to the Earth's surface. This case is described by the Hybrid Scintillation Propagation Model (HSPM) (V. E. Gherm, et al., *Radio Science*, **40,** 2005, doi:10.1029/2004RS003093). The hybrid method is the combination of the CPM and the rigorous technique of the random (not necessarily purely phase) screen. The second case occurs when the regime of the field strong scintillation is formed in the inhomogeneous ionospheric layer. To describe it the appropriate Markov's parabolic equations were extended and solved for the case of the inhomogeneous background medium. The solutions are obtained employing the quasi-classic approximation for Markov's parabolic equations, developed in (A.A.Bitjukov, et al., *Radio Science*, **37**, 2002, doi:10.1029/2001RS002491, and **38**, 2003, doi:10.1029/2002RS002714). All the described above will be discussed in the talk.