Modeling of High Frequency Radio Wave Absorption During Solar Events.

N. Y. Zaalov*[(1)], N. N. Zernov[(1)], E.V. Moskaleva[(1)], D.D. Rogov[(1,2)]
(1) University of Saint Petersburg ,Russia
(2) Arctic and Antarctic Research Institute, Saint Petersburg, Russia
nzaalov@gmail.com

The high frequency (HF) radio band is important for long distance communications, particularly in the polar region, where the ground infrastructure is limited. Space weather events adversely affect HF radio propagation. The influence of HF radio wave absorption induced by solar Ultra-Violet, X-ray flux and energetic particle precipitation on the ionogram structure is studied. The influence of the solar event observed on 11 April 2013 on the structure of vertical and oblique sounding ionograms in the Northern hemisphere of the Earth is considered. An adjustable model of the ionosphere developed for high frequency propagation problems was suggested and employed for this purpose. The simulation algorithm has been developed to describe a large variety of ionospheric conditions.

Effective ionogram simulations require realistic models of the ionosphere and the facilities for observations of radio signals propagated through the ionosphere obliquely, or vertically. Generally speaking, the wave propagation is outlined by complicated solutions to Maxwell's equations, which are however adequately reduced to the Geometric Optics solutions in the case of the HF band. Therefore, the treatment of the problem under consideration is based on the appropriately arranged ray-tracing codes. The complexity of codes depends on the structure of the ionospheric features that it is necessary to include. For ionograms simulation the model of the background ionosphere (i.e. electron density profile) was developed based on the vertical sounding data, which are now available in real-time. The original model includes the peculiarities of the high-latitude ionosphere such as mid-latitude trough, auroral oval and polar cap patches and arcs.

The absorption of HF radio waves in the D-region of the ionosphere caused by the enhancements in the electron densities has a strong impact on the ionogram structure. During the solar events the ionogram structures vary significantly. On the basis of the SWPC D-region Absorption model the absorption effects in the ionosphere were calculated (see also E. V.Moskaleva and N. Y. Zaalov, Adv. Space Res. **54**, 9, 2014, pp.1743-1750). The main advantage of this approach is that it does not require knowledge of the electron density and the electron collision frequency profiles of the D-region ionosphere.

Comparison of the experimentally observed ionograms with those modelled employing the developed codes reveals a good similarity in the ionogram structure, shape of the traces and main numerical characteristics between simulated and observed ionograms corresponding to the different paths of the propagation, even if the absorption effect are strong. It is necessary to additionally note that the results corresponding to the two oblique paths located in the vicinity of the auroral oval and 5 ionosondes localized in the latitude from 40°N to 80°N will be presented in this work, while simulations were also performed for a number of other geophysical conditions and the geometry of propagation.