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Estimation of foF2 variations using round-the-world sounding data

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Abstract

An estimation of the F2 ionospheric region critical frequency (foF2) variations using analysis of round-the-world radio sounding data has been made. Experimental data obtained by the Russian chirp-sounders network have been used. For the first time, using experimental data and numerical simulation, the quantitative dependency between the minimum foF2 magnitudes over round-the-world propagation paths and round-the-world maximum usable frequencies has been obtained.

Keywords: Round-the-world signals; F2-region critical frequencies; International reference ionosphere

1. Introduction

High-frequency round-the-world signals (RTW) were discovered in the third decade of the past century (Quaeck, 1927). It was shown that the "twilight zone" was the sole region in which RTW propagation was possible (Quaeck and Moegel, 1929). It was later concluded that the dominant propagation mode is an earth–ionosphere–earth hop mode near the great-circle line. Fenwick and Villard (1963) experimentally determined that RTW propagation is realized via the usual earth–ionosphere–earth hop modes in the daylight hemisphere and by ionosphere–ionosphere reflections, or 'tilt' modes, in a major part of the dark hemisphere. Rawer (1975) compiled a review devoted to the development of short wave forecasting methods including propagation of very large distances. In the book by Gurevich and Tsedilina (1979), a theory of round-the-world high-frequency propagation was outlined in a systematic fashion. Particular attention was given to the influence of ionosphere–ionosphere reflections on long-distance and round-the-world high-frequency propagation and to methods of calculating global propagation paths.

Shlionskii (1979) has pointed out the importance of the gradient in the critical frequency of the F2-region for the long-range transmission of short radio waves. In work by Efimuk et al. (1985), experimental data concerning the effect of the capacity of a near-surface channel (the earth–ionosphere channel) on the reception of round-the-world signals were analyzed. It was shown that variations in the critical frequency of the F2-region determine changes in the capacity of the near-surface channel and thus explain the azimuthal dependence in the reception of round-the-world signals. In work by Pakhotin et al. (1997), it was concluded that the minimum magnitude of F2-region critical frequencies over the RTW propagation path have a strong influence on RTW signal characteristics. In work by Kurkin et al. (2000), the results of observations of RTW signals by the Russian chirp-sounder network in 1997–1999 were presented. The possibility of monitoring large-scale structures of the ionosphere in regions poorly equipped with diagnostic tools, using the RTW signal characteristics of the Russian chirp-sounder network, was discussed.

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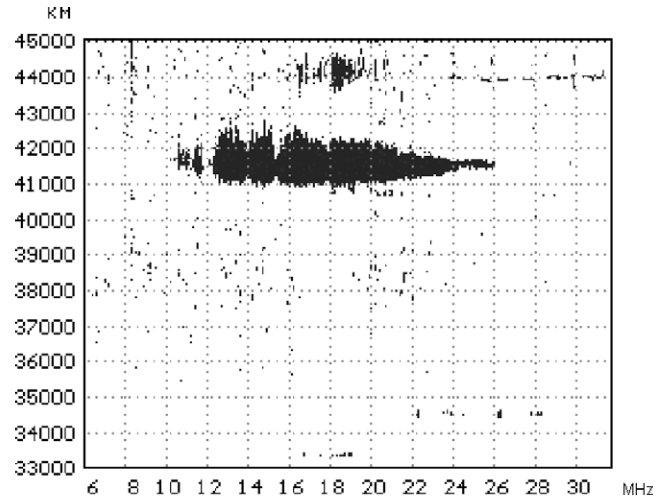

Fig. 1. An example of a RTW ionogram.

In this work, we investigate the day-to-day variations of maximum observable frequencies over Russian chirp-sounders network paths for December 3–7, 2002. These variations are related to the minimum foF2 variations over RTW propagation paths. A quantitative dependency between the minimum foF2 magnitudes over RTW propagation paths and RTW maximum usable frequencies has been obtained.

2. Experimental method

Experimental data obtained at the Russian chirp-sounders network have been used. A typical RTW ionogram obtained at the Irkutsk station (52.5°N, 104°E) is presented in Fig. 1. Operational frequencies are displayed on the abscissa axis, and distances are displayed on the ordinate axis. The maximum observed frequency for the ionogram is 26 MHz. The lowest observed frequency is 10.5 MHz.

The experiment was carried out on December 3–7, 2002. The transmitters are located in Irkutsk, Khabarovsk (48.5°N, 135.1°E) and Magadan (60°N, 150.7°E), and the receivers are in Ioshkar Ola (57.3°N, 48°E), Nizhny Novgorod (56.2°N, 44°E) and Rostov-on-Don (47.1°N, 39.7°E). The radiation power is 5 kW in Irkutsk, 100 W in Magadan

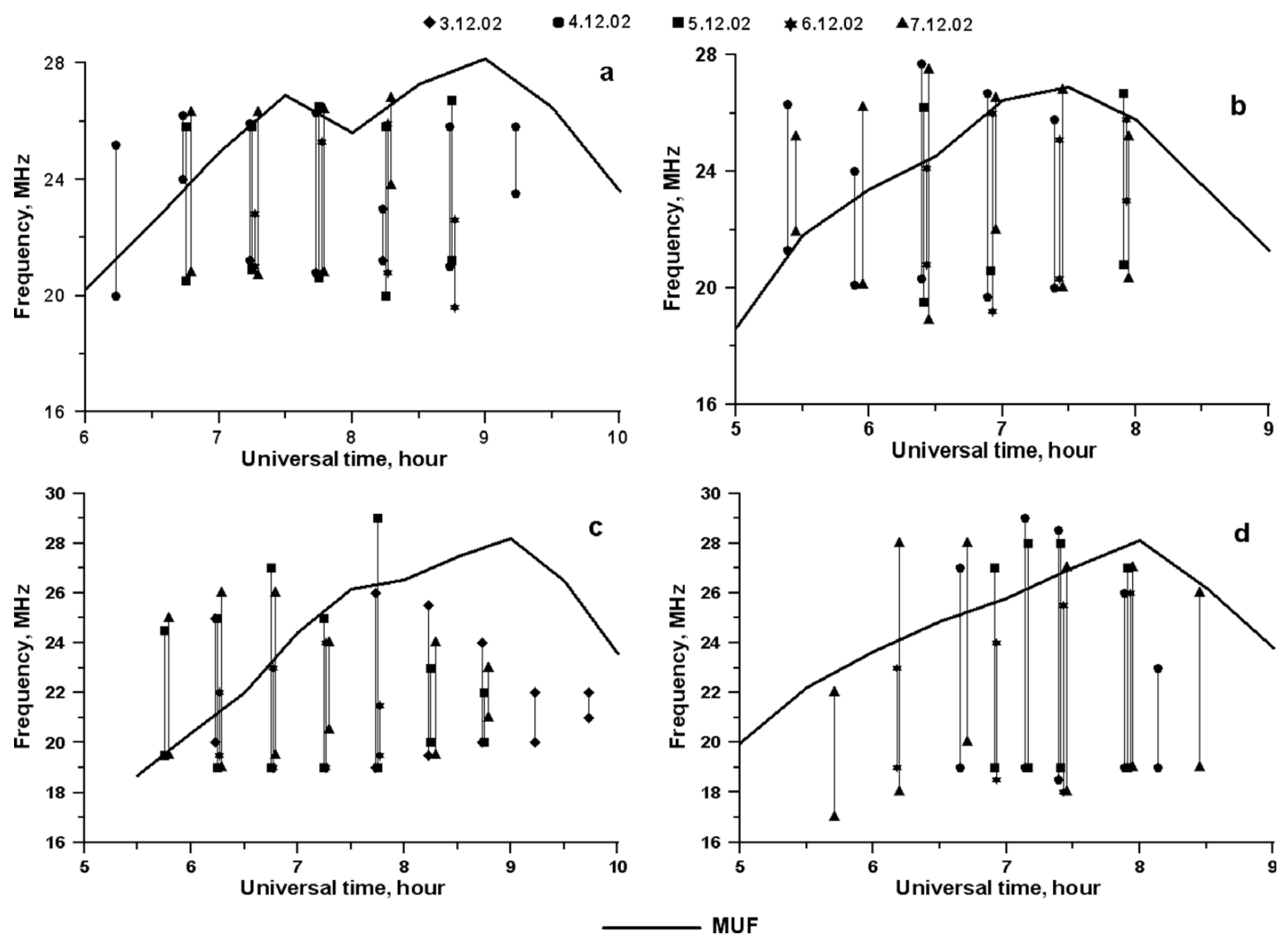

Fig. 2. Temporal dependence of the RTW maximum observed frequency, lowest observed frequency (vertical lines with different signs for each day of observation), maximum usable frequency (solid lines) observed and calculated over Irkutsk–Ioshkar Ola (a), Khabarovsk–Ioshkar Ola (b), Irkutsk–Nizhny Novgorod (c) and Khabarovsk–Rostov-on-Don (d) paths on December 3–7, 2002.