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SENSING OF THE STRUCTURE OF THE RADIO WAVE REFRACTIVITY IN THE TROPOSPHERE BY A NETWORK OF SATELLITE NAVIGATION SYSTEM RECEIVERS IN THE CITY OF KAZAN

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We present the results of an experimental study of the structure of the radio-wave refractivity and its dynamics by a network of seven ground-based GPS and GLONASS receivers in Kazan, Russia. It is shown that the remote sensing results agree well with the data of weather stations, radio sounding, and reanalysis. The standard deviation of the refractivity value, which are obtained using the sensing results from the radio sounding data amounts to 2% of the average value at altitudes of up to 500 m. It is found that the refractivity structure has overnight variations, as well as and mesoscale spatial and temporal variability.

1. INTRODUCTION

Currently, the problems of developing means for all-weather atmospheric sensing are of topical importance. In this connection, it is undoubtedly interesting to study the wide opportunities of using radio signals of global positioning systems GPS and GLONASS. In the USA, Japan and Western Europe, numerous studies deal with measurements of variations in three-dimensional distributions of the water vapor content in the troposphere, which are performed by ground-based GPS receivers (see, e.g., [1–5]). It was shown that the data of GPS receivers are a tool for tropospheric studies having a large time resolution [5], whereas the spatial resolution depends on the receiver distribution density. In Russia, global satellite navigation systems are used for tomography of the ionosphere or stratosphere [6–8]. However, there are few papers on using satellite navigation systems for studies of the troposphere, especially the boundary layer. One can mention papers [9–11], which consider the issues of methods of radio sensing of the tropospheric parameters on the basis of refractometry. However, so far no experimental results of sensing the troposphere by using ground-based receivers of global satellite navigation systems have been obtained in Russia.

The purpose of this work is to present experimental results, which were obtained in the troposphere by sensing of the structure of the radio-wave refractivity by using the system of ground-based spatially separated GPS and GLONASS receivers.

The satellites of global navigation systems emit radio signals at wavelengths of 19 and 24 cm, which ensures all-weather reception on the Earth's surface. Signals of global satellite navigation systems depend on the radio-wave refractive index in the atmosphere. The main characteristic of the atmosphere as a propagation medium is the refractivity. The following relationship, which relates the refractivity N and the refractive index n of radio waves to the parameters of the atmosphere and the radiation frequency, is commonly used:

$$N = (n-1)\cdot 10^6 = 77.6p[\text{mbar}]/T[\text{K}] + 3.73\cdot 10^5 e[\text{mbar}]/(T[\text{K}])^2 + 4.03\cdot 10^7 N_e[\text{m}^{-3}]/(f[\text{Hz}])^2, \quad (1)$$

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