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Characteristics of brightness temperature and electric field fluctuations in a cloudy atmosphere

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Experimental and theoretical investigations of atmospheric electric field fluctuations in the wide range of time periods are being of interest for atmospheric turbulence diagnostics and global source signal recognition [1]. The present paper is devoted to investigation of short time electric field fluctuations in the lower atmosphere and their correlations with other troposphere parameters. Simultaneous measurements of fluctuations in the surface atmospheric electric field and brightness temperature were carried out in Nizhny Novgorod in 2013-2014 and 2018-2020. The electric-field sensors, i.e.., electrostatic fluxmeters, and two microwave radiometers with a wavelength of 8 mm and 3 sm were located in Nizhny Novgorod City on the roof of the Institute of Applied Physics of the Russian Academy of Sciences (IAP RAS) [56°19'25'' N 44°01'21'' E].

In this paper, we consider both long-period measurements in fair weather conditions and stratified clouds, as well as case-studies of several powerful thunderstorm events. It is shown that the spectral density of fluctuations in the brightness temperature of the atmosphere consists of a high-frequency component due to turbulence of the air mass in the surface layer of the atmosphere and a low-frequency component associated with turbulent movements in drip clouds at altitudes of the order of 1 km. The frequency dependence of both components is consistent with the Kolmogorov turbulence spectrum [2]. Compared with ordinary (convective and stratified) clouds, a limited band in the vicinity of 0.01 Hz with a higher level of fluctuations is distinguished in the spectral density of fluctuations in the brightness temperature of thunderclouds. The electric field fluctuations spectra caused by thunderclouds, as well as turbulence in the cloud, are significantly different from the spectra of the electric field caused by ordinary cumulus and stratified clouds. It turned out that the spectra of the electric field and brightness temperature oscillations in a wide frequency range have a power-law character with a slope of -8/3.

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