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Ground-based measurements of turbulence in electrified clouds

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A problem of the electric field dynamics in turbulent electro-active clouds (Cumulus, Stratus, Cumulonimbus) is one of the most relevant and complex problems of dynamical meteorology and atmospheric electricity. This problem is important for the study of intense large-scale electric field and its fluctuations that may lead to high-energy particle flows and lightning discharges, for electric current parameterization. Direct field measurements in convective clouds with a developed electrical structure are very difficult; so one of urgent tasks is the development of remote sensing methods for turbulence characteristics in electro-active clouds.

The growth of a large-scale electric field in a turbulent atmosphere is caused by the generation of an electric charge on colliding particles (hydrometeors and dust). Meanwhile, observations (including preliminary observations of the authors) and theoretical studies (Mareev and Dementyeva, 2017) show that intensification of thunderstorm activity can be associated with increased turbulence in the cloud. This paper presents new ideas and results of experimental and theoretical studies of the role of turbulence in electro-active clouds.

The main attention is paid to complex remote observations of different types of clouds with an experimental set-up including the microwave radiometers of 3 cm and 8 mm wavelengths (with a time resolution of order of one second), the network of electrostatic fluxmeters spaced by several kilometers each from another, and the meteorological radar. The data of recent several years were used for analysis. Note that recently space-borne passive microwave radiometry of intense convective clouds (see, for example, Peterson et al., 2017) attracted more attention compared to ground-based microwave observations. A principal idea of our approach is to use the wave-length channels allowing us to reveal both optically thick and optically transparent cloud events from the data on fluctuations in the brightness temperature of the atmosphere.

A special attention was paid to comparative analysis of the turbulence characteristics in thunderclouds and in clouds that do not have a developed electrical structure. The spectral characteristics of electric field and brightness fluctuations were found to be associated with atmospheric air turbulence and mostly are quantitatively described by Kolmogorov-type spectra. Compared with ordinary Cumulus and Stratus clouds, a limited band near a frequency 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 spectra of fluctuations of the electric field caused

by thunderclouds, as well as turbulence interior thundercloud, are significantly different from the spectra caused by ordinary Cumulus and layered clouds.

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