Chapter 14

The Influence of Smoke From Forest Fires on the Meteorological and Electrical Characteristics of the Atmosphere

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ABSTRACT

The impact of smoke from forest fires in western Siberia on meteorological, atmospheric electric, and aerological variables has been analyzed. The anomalous distribution of water vapor in the atmosphere associated with the peculiarities of the evaporation regime and the absence of advective moisture transfer over the southern regions of Western Siberia during the fires. With an increase in the height of the homogeneous surface smoke layer with an unchanged aerosol optical thickness, the cooling of the earth’s surface and heating of the atmosphere was weakened. The smoke plume spreads predominantly in the middle of the troposphere, creating aerosol layers elevated above the ground, the lower part of which had a negative volume charge. The effect of diurnal variations in the electrical field in the near-surface layer, differs from the known similar effects.

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INTRODUCTION

This chapter presents the effects of forest fires on the meteorological variables and electric field variations of the atmosphere. The electric state of the surface layer of the atmosphere with intense smoke is the least studied among other meteorological variables, so the most attention has been paid to the study of this factor.

The complex interrelation between the temporal variations in this field on the one hand and the physical, chemical, and biological processes that form the environmental state on the other hand determines the interest in monitoring atmospheric electricity as both an affecting factor and an indicator of the observed environmental changes. Among the found regularities of temporal variations of electric field strength ($E$), the most well-known ones belong to the “fair weather”. These regularities are the following (Chalmers, 1967; Sedunov, 1991; Kupovych, Morozov, & Shvarts, 1998; Anisimov & Mareev, 2008; Donchenko, Kabanov, Kaul, Nagorskiy & Samokhvalov, 2015; Mareev et al. 2016): diurnal unitary variations caused by change in the Earth’s charge as a whole; the electrode effect related to accumulation of voluminous positive charges near the Earth’s surface; electrooptical correlation in the optical hazes expressed as the dependence of field intensity on aerosol particle concentration; and some others.

Yet the least known are processes of electrical charge accumulation and the $E$ variations under disturbed “fair weather” (thunderstorm, volcanic eruptions and dust storm, natural and technogenic smoke, etc.). Since these atmospheric phenomena are episodic and hardly predictable in time, they complicate field studies in the sense of interpretation of their results. Nevertheless, some of the recently discovered effects related to the dynamics of atmospheric electricity indicate the necessity of taking these effects into account during complex monitoring and simulation of natural climatic processes (Ippolitov, Kabanov, & Smirnov, 2011; Ippolitov, Kabanov, Nagorskiy, Pkhalagov, & Smirnov, 2013; Donchenko et al., 2015). For example, low-frequency oscillations in electric field have been detected in the atmosphere prior to thunderstorms; records of these phenomena can provide control over development of mesoscale convection systems and dynamics of acoustical and gravity waves emerging during such a development (Ippolitov, Kabanov, Nagorskiy, & Smirnov, 2012). The studied effects of selective electrical charge accumulation of aerosol particles depending on their size and composition in the cases of cloud formation (Smirnov, 2010; Mareev et al., 2016), volcanic eruptions (Leblanc et al., 2008; Adushkin, Soloviev, & Spivak, 2018; Firstov et al., 2019) and dust storms (Sow et al., 2011; Gorchakova, Mokhov, & Rublev, 2015; Adushkin et al., 2018; Katz et al., 2018) also indicate the essential differences of variations in electrical field under these conditions compared to “clear weather” ones.

Among the insufficiently studied atmospheric processes, there are those implemented in the smoke from forest fires (Kondrat’ev & Grigor’ev, 2004; Pkhalagov, Uzhegov, Panchenko, & Ippolitov, 2006; Elanskii et al., 2011; Van Donkelaar et al., 2011; Ippolitov et al., 2013; Donchenko et al., 2015). In particular, the size and composition of smoke aerosol particles was changed due to the photochemical transformation of organic compounds (Seinfeld, & Pandis, 1998; Abel, Haywood, Highwood, Li, & Buseck, 2003; Vakkari et al., 2014; Konovalov et al. 2015). It was found (Pkhalaqov et al., 2006) during the period of forest fires in Tomsk region in 2004 that as smoke intensified (the concentration of smoke particles increased), electric field potential gradient in the near-surface layer did not increase with respect to the electrooptical ratio, but reduced in contrast (from 200 to 30–60 V/m). With the great spatial extent of smoking during the vegetation period taken into consideration, studies of the meteorological and electric field variations under these conditions are topical for monitoring and modeling of both meteorological and ecological processes.
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