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Concentration of black and brown carbon in the atmospheric column during extreme smoke event over Siberia

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The estimates of the annual carbon emission from forest and peat fires in Russia range from 4-35 to 500 million tons according to various sources, comparable to the industrial emission. To improve the quality of climate models and the reliability of forecast the continuous measurements of carbonaceous particle concentration with high spatial resolution are required. To date, much of the information is accumulated on the basis of the methods for the physical-chemical analysis in the local volume, as well as on the basis of in situ measurements in the near-ground atmospheric layer at stations located far apart. The continuous monitoring of the troposphere by means of aircraft sensing is expensive; therefore, the data on the vertical distribution of aerosol characteristics are obtained only for separate regions around the globe and pertain to time-limited observation periods. This all indicates a need to develop semi-empirical methods for the evaluation of temporal and regional (peat, steppe, forest fires) variability of the concentration of carbon-containing components of the smoke aerosol using remote sensing data.

In this work, a modified Shuster's approach (G. Schuster et al., 2005) is used to estimate volume fraction, mass concentration and absorption efficiency of organic and inorganic carbon in the atmospheric column using the aerosol optical and microphysical properties retrieved from ground-based measurements of direct and diffuse solar radiation. The approach is implemented by introducing the aerosol model composed of mineral dust, brown and black carbon as well as the predominately scattering components, namely, ammonium sulfate and water. The density and optical constants of the components are assumed to be a priori known. The aerosol medium is approximated by internal mixture of the components. The effective refractive index of the medium is formed on the basis of the Maxwell-Garnett effective medium approximation.

The approach was tested on data collected at Tomsk AERONET station under background conditions and extreme smoke event in summer 2012. It is shown that brown carbon is prevalent in smoke emissions leading to decreased aerosol absorption spectrally from 440 to 675 nm and relatively weak absorption in the spectral range 675-1020 nm. It was found that in periods of extreme aerosol loading in the atmosphere the volume fraction of brown carbon in aerosol particles significantly higher than the black carbon volume fraction.

The temporal dynamics of the estimated mass concentration of black and brown carbon in the atmospheric column is analyzed; the estimates are compared with the data of soot mass concentration measurements, obtained in the surface layer by means of the Aethalometer for the whole smoke episode. The similar variability of the characteristics being compared is demonstrated.

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