Climate Chamber Studies of Solar Radiation Attenuation by Model Stratospheric Aerosol

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The paper presents the results of experimental studies (made in climatic chambers) of transmission characteristics of radiation with the wavelength λ= 0.63 μm close to the wavelength of solar radiation spectrum maximum by artificial aerosol. The studies are of interest for developing geo-engineering methods of modern climate conservation with the use of an artificial aerosol. The experiments were carried out with the formation of a modeled stratospheric aerosol in full-scale climatic chamber (the volume of 3,200 m^3) of RPA «Typhoon». Light attenuation at the wavelength of 0.63 μm by a modeled stratospheric aerosol (metal chlorides, alumina oxides Al_2O_3, silicas $(SiO_2)_n$, soot) and liquid-drop (sulfuric acid) aerosols close in optical and microphysical properties to stratospheric aerosol was studied in laboratory conditions. The sulfuric acid aerosol was formed as a result of sulphur dioxide conversion under the action of a solar radiation simulator. Microstructure parameters and optical characteristics of modeled solid-phase and sulphuric acid aerosols were studied. It is shown that their modal spectrum is, in general, within the range of 0.3-0.5 μm, and the number concentration is within $10\text{-}10^3$ cm^{-3} depending on the mass of an aerosol introduced. The optical depth determined from the values of radiation transmission (λ=0.63 μm) linearly depends sufficiently accurately on the aerosol mass concentration. It has been found that at the number concentrations of modeled aerosols of about 10^2 cm^{-3} , that corresponds to aerosol density in a precipitated layer of ~ 1 mg/m^2 at its thickness (along the ray path) of about 10^2 m radiation attenuation by artificial aerosol layers is about 1%. According to estimates, solar radiation attenuation by 1% can decrease an average temperature over the Earth's surface by about $(0.6\text{-}1)^0$ C, that is sufficient for the stabilization of modern climate. A change of air relative humidity from 30 to 75% leads to radiation attenuation at the wavelength of 0.63 μm with hygroscopic metal chloride aerosol by more than 2.5 times. The data obtained on radiation attenuation with solid-phase non-hygroscopic aerosol Al_2O_3 and hygroscopic metal chloride aerosol indifferent to temperature and pressure of the environment may be directly used for assessing or forecasting radiation attenuation in real conditions of the lower stratosphere characterized by low relative humidity. The data on radiation attenuation dependence on humidity for hygroscopic metal chloride aerosol will make it possible to forecast the variations of solar radiation attenuation under humidity fluctuations

in the lower stratosphere. On the basis of simulation experiments determined were the reaction rates and typical times of SO_2 conversion under the action of solar radiation simulator. Based on the data obtained estimated was the efficiency of the solar radiation simulator determining the velocity of sulphur conversion into the complex radical $OHSO_2^{\bullet}$, forming sulphuric acid as a result of further reactions with hydroxyl, oxygen and water vapor. Qualitative estimates of SO_2 conversion rates and typical times in the lower stratosphere were made for real parameters of SO_2 reaction with hydroxyl at the temperature of minus 50^0C. A typical lifetime of SO_2 in the lower stratosphere relative to major reactions with hydroxyl with the formation of a complex radical $OHSO_2^{\bullet}$ is $\tau_e \sim 5 \cdot 10^6$ s. The results of model experiments carried out in climatic chamber are used for preparation and conduction of limited field experiments. They show a principal possibility to use artificial aerosol layers for controlling incident solar radiation intensity.