Formation of sulfate aerosols in the troposphere and lower stratosphere

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A new improved 3D mathematical model of has been developed to reproduce the global transport of gaseous pollutants and aerosols in the atmosphere and the formation of sulfate aerosols in the troposphere and lower stratosphere (Yunge layer, polar stratospheric clouds). The model incorporates the main chemical and physical mechanisms (photochemical transformations, nucleation, condensation/evaporation, and coagulation) for their evolution in the atmosphere. The numerical modeling domain includes 144 nodes in longitude, 73 nodes in latitude, and 20 vertical levels. The upper boundary of was fixed at a height of 46 km above the Earth's surface. The aerosol size range is divided into 25 intervals from 0.003 to 1.5 microns. The fields of wind velocity, temperature, and specific humidity were taken from the ECMWF data for 2000.

Using this model, two types of numerical experiments were performed. The first problem was to simulate the geoengineering impact of emissions of sulfuric species into the lower stratosphere at different heights and latitudes in the Northern and Southern hemispheres. The calculations assume a sulfuric dioxide emission of 53.72 t/h in the latitude belt of both hemispheres (symmetrically). The results of numerical calculations show that as early as in 10 days of the emission there appear submicron-size aerosol particles. This study made it possible to find the local areas of increased aerosol concentrations and generation of contrails in the atmosphere.

In the second case, we considered the formation of sulfate aerosols in the atmosphere due to anthropogenic (SO_2, NOx, CH_4) and biogenic (H_2S, CS_2, COS, CH_3SCH_3, CH_4) species. The emissions of biogenic dimethylsulfide from the Pacific, Atlantic, and Indian oceans were specified for winter and summer seasons separately. Using this model, numerical experiments were performed to reproduce the spatial and temporal variations in gaseous species and aerosols with account of sulfate aerosol size distributions in the northern and southern hemispheres. For winter and summer periods, we investigated the spatial and temporal variations in gas concentrations, nucleation rate, H_2SO_4 threshold concentration, and critical size of cluster. The calculation results revealed an active generation of sulfate aerosol particles at heights from 20 to 25 km after 10 days.