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Investigation of structures and mechanisms of atmospheric pollution by arid aerosol

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A systematization of experimental studies and a correlation analysis of data obtained in desertified regions field measurements allow one to distinguish three different states that characterize correlations between the mass concentrations of particles of different fractions: (1) wind removal, (2) thermo-convective emission, and (3) intermediate state, when the elements of (1) and (2) are present.

Once hot weather situation sets in, even for a short period of time (several tens of minutes), the removal of fine aerosol begins. Based on the results of laboratory research and expedition 2002, 2004 and 2007's in the deserts of Kalmykia region, we've identified one of the main mechanisms of fine (<5 microns) desert aerosol lifting into the atmosphere from the surface layer connected with the formation of vertical thermals ("columns") in unstable temperature stratification.

In the frame of project at the Black Lands of Kalmykia the expedition in 2007 year was conducted to study the phenomenon of removal of aggregate particles submicron fraction (<500 nm) in hot calm weather of air at the absence of dust storms. Objective of the studies in 2007 was the analysis of the mechanisms of arid aerosol removal in a layer 0 - 700 m to the upper atmosphere layers, in which the long-range transport of the aerosols takes place.

For the first time a group of remote sensing of the ABL conducted in the arid region simultaneous measurement by four SODARs, separated at a distance of 3.5 km. The phenomenon of removal of aggregate particles submicron fraction (<500 nm) in hot calm weather is revealed and analyzed; the fraction is particularly hazardous to the health of the population of surrounding regions. We've developed a model of fine (less than 0.4 micrometers) aerosol particles tearing off and proposed a formula of depending of the concentration of particles from surface temperatures in wind speeds of less than 3 m/s at a height of 0.5 - 1 m. Fine aerosol removal from arid surface grows in proportion to the growth of surface temperature: $C = kT_S$, where C - the concentration of fine aerosol, T_S - surface temperature, k - factor. Thus, the removal of fine aerosol can be measured on surface temperature, which can be obtained from satellite data. This allows including in numerical models an assessment of removal of fine aerosol at low wind speeds that had never before been done. The empirical formula for fine aerosol vertical flux is:

$dC_{0.5m}^{2m} = -0.02T_S(^\circ C) + 0.6\ (\mu g/m^3)$.

Based on the results group of remote sensing of the ABL, one can conclude that the use of Doppler SODAR gives a detailed information about the inner structure of large-scale vortex coherent eddies. For typical summer weather in the desert with low average wind velocity the horizontal dimensions of such entities are 3-4 km or more. Raising speeds of the air masses in such entities are 1-2 m/s or more and reach heights of more than 700-800 m. This means that the removal of submicron aerosol at the height of 1 km and more by such structures is possible.

Results of calculation of dust removal by the roll structures within the ABL turbulence models developed in Russian team also indicate, that large-scale structures, existing in the atmosphere impede fine aerosol deposition, and that effect is significant to calculate the aerosol vertical removal and its further transfer on long distances.

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