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Microphysical and chemical characteristics of near-water aerosol over White and Kara Seas

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The results are presented of five-year-long (2003-2007) study of the spatial - temporal variability of the near-water aerosol in the water area of White and Kara Seas (55, 64, 71 and 80-th cruises of RV “Professor Shtockman”; 53 and 54-th cruises of RV “Akademik Mstislav Keldysh”).

Measurements of aerosol microphysical characteristics were carried out by means of the automated mobile aerosol complex consisting of nephelometer, photoelectric counter and aethalometer. The aerosol disperse composition was studied with photoelectric counter in 256 size intervals from 0.4 to 10 μm. About 1500 series of measurements were carried out in White Sea, and about 1400 series in Kara Sea.

Chemical characteristics of aerosol were determined from samples collected on aerosol filters (92 samples were collected in White Sea and 48 in Kara Sea). The ion composition was determined under laboratory conditions. The H^+, Na^+, K^+, Ca^{2+}, Mg^{2+}, NH_4^+, Cl^-, NO_3^-, HCO_3^-, SO_4^{2-} ions were under examination.

Comparing aerosol characteristics of two seas, one can note that the mean values of the aerosol content parameters in Kara Sea are less than in White Sea. The ratio of the aerosol mass concentration are from 2 (Yamal Peninsula, northern part of Novaya Zemlya) to 9 times (Blagopoluchia Bay, Ob’ Gulf). The differences in the concentration of black carbon vary from 3 (Yamal Peninsula) to 17 times (Blagopoluchia Bay). The differences in the aerosol number concentration N_A are not so big. The values N_A near Kara Gate, Yamal Peninsula and northern part of Novaya Zemlya are practically the same as in White Sea. The concentration N_A at Ob’ gulf is one order of magnitude less than in White sea.

The obtained aerosol volume size distributions were approximated by the sums of two fractions, submicron and coarse, with lognormal size distributions. The mean volume size distribution of submicron fraction in White Sea is approximated by the distribution with the variance of the radius logarithm σ_s=0.6 and modal radius R_{s0}=0.096 μm, and the total volume concentration V_s=37.6 $\mu m^3 cm^{-3}$, and the distribution of coarse fraction has the following parameters σ_c=1.19, R_{c0}=2.15 μm and V_c=19.7 $\mu m^3 cm^{-3}$. The distribution of submicron particles in the central part of Kara sea is approximated by lognormal function with parameters σ_s=0.443, R_{s0}=0.215 μm and V_s=1.01 $\mu m^3 cm^{-3}$, while parameters of the coarse fraction are σ_c=0.825, R_c=2.04 μm and V_c=3.29 $\mu m^3 cm^{-3}$.

The main differences in the size spectra in White and Kara Seas are observed in the submicron size range R $<$ 1 μm. The higher values of the distribution function in this range are explained by the fact that White Sea, on the contrary to Kara Sea, is internal sea, so near-water aerosol undergoes the effect of continental sources, which can have anthropogenic origin and generate great amount of submicron aerosol, which is transferred to long distances.

Comparison of ion composition of aerosol over White and Kara Seas has shown that the concentrations of practically all ions, on average, are greater in the region of White Sea. The enhancement of ions of marine origin (Cl^-, Na^+, Mg^{2+}) is from 1.4 to 1.7 times. This differences in “continental” ions (Ca^{2+}, SO_4^{2-}, NO_3^-, NH_4^+) reach 2.3$\div$3.7 times. The exception is the ion K^+, the concentration of which in Kara Sea is 1.4 times greater.

To estimate the contribution of continental and marine sources into formation of the chemical composition of near-water aerosol, the technique was applied using the factors V_{cont} and V_{ocean} representing the fraction of the mass concentration of ions of continental and marine origin, respectively. Depending on the hydrometeorological

conditions, V_{cont} varies in wide range ($\sim 0.1 \div 1$), and its mean value in White Sea is 0.38 (respectively, V_{ocean} = 0.62). That means, the contribution of continental sources is essential, although the role of marine sources prevails on average. The mean value of V_{cont} in central regions of Kara Sea is 0.3, but this factor in the regions adjacent to the continent can reach the values of $0.6 \div 0.8$.

The obtained long-term data on the aerosol microphysical characteristics and chemical composition are convincing evidence of the fact that significant parts of the water area of White sea undergo anthropogenic pollution through the atmospheric channels and are under permanent anthropogenic loading. They are coastal regions of Dvina Gulf and river Severnaya Dvina mouth, Kandalaksha Bay (near to the river Kandalaksha mouth), as well as coastal regions of Kola Peninsula.

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