ICE-FORMING PROPERTIES OF THE ANTHROPOGENICALLY POLLUTED ATMOSPHERIC AEROSOL

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The results are analyzed of ice nuclei number density measurements carried out in an industrial region (the Moscow Region) and ecologically clean regions of Moldova and Lake Baykal. Industrial aerosol pollution of the atmosphere is shown to lead to the increase of the ice-forming particle content in it. The same conclusion follows from an analysis of the effect of local industrial aerosol sources on the ice nuclei number density.

One of the possible consequences of the effect of anthropogenic pollution on the atmospheric aerosol is the change of its ice-forming ability. The results of 25-year long measurements of the ice nuclei number density carried out by Bigg[1] in Australia make one fear for the global decrease of ice-forming activity of the atmospheric aerosol. Such a decrease is possible due to the deactivating effect of industrial gases on the ice-forming particles. Laboratory investigations carried out at the Central Aerological Observatory show that some gases are capable of decreasing the ice nuclei number density by more than 1.5 times. At the same time, one can expect the increasing ice nuclei content in the atmospheric air as the total aerosol number density increases due to industrial emissions. Thus, the industrial pollution may not only increase the ice nuclei number density in the atmosphere, but also decrease their ice-forming activity. The total effect of anthropogenic contribution is ambiguous.

To study the variations of the ice nuclei (IN) characteristics in an industrial region, periodical series of measurements of the ice nuclei number density have been carried out at the Central Aerological Observatory since 1987. The total number density of the atmospheric aerosol and the meteorological parameters have been measured simultaneously. A 10-litre cloud chamber was used for investigation of the ice nuclei. The activated IN (formed on the nuclei of ice crystals) were recorded using a sugar solution.[2] The total aerosol number density (the condensation nuclei (CN) number density) was measured with the Scholtz counter as well as with the TSI-3030 electrical aerosol analyzer and the PKZV–906 counter of large particles.

The comparison of the data obtained with measurements carried out in 1977–1991 in an agricultural region of Moldova[3] and series of measurements in the Lake Baykal region[4] in 1991 makes it possible to estimate the differences in the ice-forming characteristics of the atmospheric aerosol in the regions with different degree of anthropogenic aerosol pollution.

Figure 1 shows the four-year average monthly number density of the ice and condensation nuclei from January to June in the Moscow Region and Moldova. The average ice nuclei number density in the industrial region is from five to seven times greater than that in the rural region. The fact is significant that approximately the same relation is observed between the values of total number density of aerosol particles in both regions. The average CN number density in the industrial Moscow Region is six times greater than that in Moldova. The relative content of ice nuclei in the atmospheric aerosol remains approximately the same in two regions (see Table I).

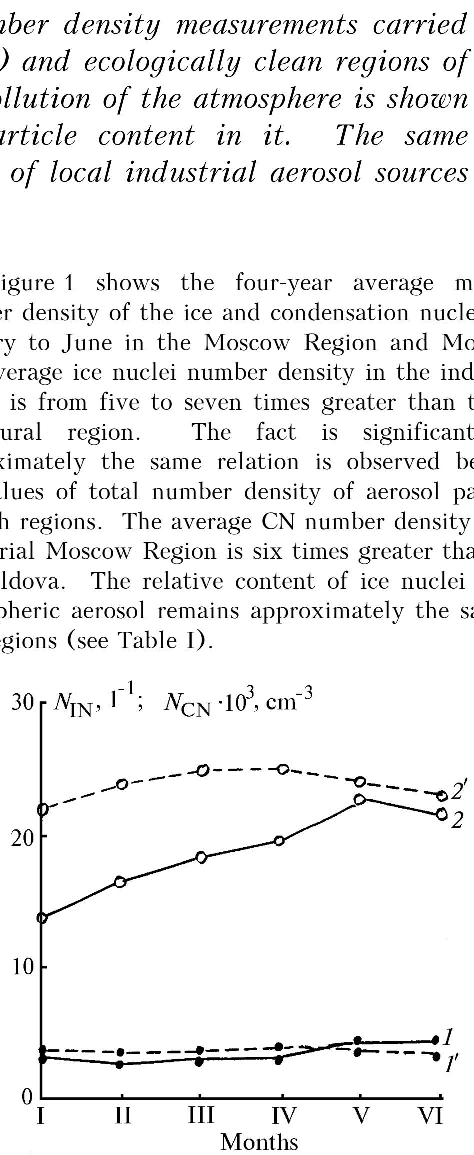

FIG. 1. Monthly average number densities of ice (solid lines) and condensation (dashed lines) nuclei in Moldova (1, 1') and the Moscow Region (2, 2').

TABLE I. The average monthly ratio $N_{IN}/N_{CN}\cdot 10^6$ in the Moscow Region and Moldova.

Region	Months					
	I	II	III	IV	V	VI
Moscow Region	0.58	0.70	0.74	0.79	1.0	0.95
Moldova	0.95	0.71	0.86	0.85	1.07	1.26

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The ice nuclei number densities close to that measured in Moldova were obtained in July 1991 in the Lake Baykal region. The average IN number density[4] measured by the filter method, which yields from two to three times lower values than the cloud chamber, was 1 l^{-1}. The total number density of the atmospheric aerosol measured by Koutsenogii[5] was 5700 cm^{-3}.

The data on the effect of the local industrial sources of atmospheric pollution show evidence of the same orientation of the anthropogenic impact on the total atmospheric aerosol number density and the number density of its ice-forming component.

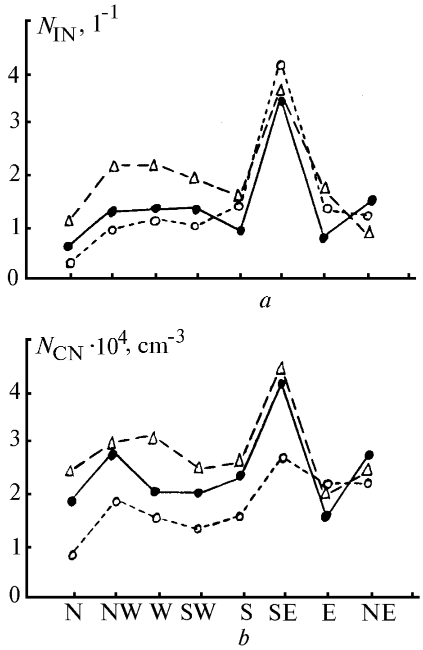

FIG. 2. Number densities of ice (a) and condensation (b) nuclei in Dolgoprudnyi in winter at different wind directions in 1987 (solid lines), 1992 (dashed lines), and 1994 (dotted lines).

The IN and CN number densities at the site of the Central Aerological Observatory in the Moscow Region obtained at different wind directions are shown in Fig. 2 for winter, when the effect of underlying surface decreases due to the snow cover and the effect of remote sources becomes more pronounced. The number densities of both aerosols (IN and CN) have maxima at the southeast wind coinciding with the direction from industrial regions of Moscow. The IN number density maximum is even more pronounced.

The number densities of ice nuclei were greater by an order of magnitude as industrial city Irkutsk was approached during route aerosol measurements near Lake Baykal.[4] The investigation of the effect of local sources of pollution on the IN number density in the Lake Sevan region carried out from on board a helicopter showed that the IN number density may increase much greater than the CN number density over some smoking sources of the aerosol.[6]

Thus, the results of systematic measurements of the atmospheric aerosol characteristics in the regions with different levels of industrial pollution and the data on the effect of local sources of pollution are evidence of the fact that the increase of the total atmospheric aerosol number density caused by the anthropogenic pollution of the atmosphere is accompanied by the increase of the ice-forming particle number density in the atmosphere. The excess of the mean level of IN number density in industrial regions reaches several times. The effect of the increase of the total aerosol content prevails over the effect of gaseous deactivators. With the increasing level of anthropogenic pollution of the atmosphere one can expect the global increase of the content of ice-forming particles in the atmosphere rather than the decrease of their number density due to deactivation processes.

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