Electron Microscope Study of Cloud and Fog Nuclei,?? (Distinction between Fog and Mist Nuclei)

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Electron Microscope Study of Cloud and Fog Nuclei, II
(Distinction between Fog and Mist Nuclei)

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Abstract

Fog and mist nuclei were collected at various places on different occasions and were examined electron-microscopically. The result is that mist nuclei are mainly composed of large sea salt nuclei, while fog nuclei are mostly composed of small combustion nuclei. In addition there is evidence that large sea salt nuclei in fog fall off rapidly. These results will give support to the opinion that large sea salt nuclei are the most important agents for the initiation of precipitation by accretion mechanism in clouds.

1 Introduction

Since our first report [1] was published, we have been continuing the work of collecting fog and mist nuclei at various places, i.e., at Sendai, Mt. Zao (1300m. and 1700 m.), Kinkasan-Island, Mt. Norikura (2850 m.) and over the Pacific Ocean near Hokkaido (cf. Fig. 1), on different occasions, and we have hitherto collected about 340 nuclei, whose size, substance, nature were examined as far as possible. As a

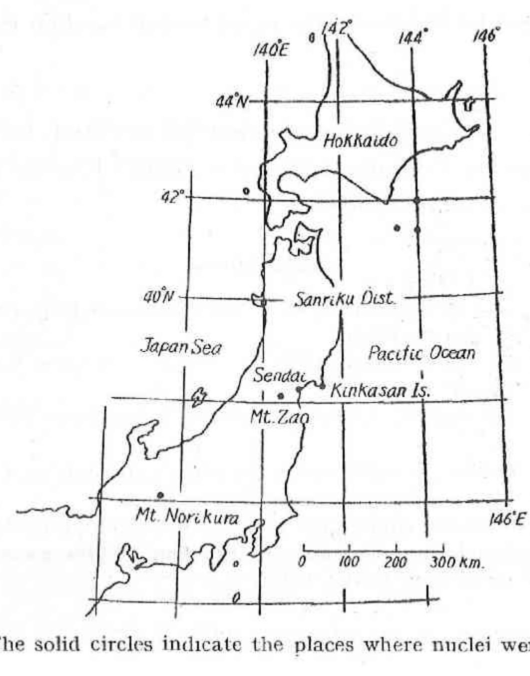

Fig. 1. The solid circles indicate the places where nuclei were collected.

result of such examination we observed that clear distinctions exist statistically between fog and mist nuclei, of which we shall describe in this paper.

2 Test

The collected nuclei were first examined electron-microscopically under weak bombardment. Next the hygroscopicity test proposed by KUROIWA [2] was carried out. The nuclei were put into a thermostat, the relative humidity of the air in it being adjusted respectively 75, 90 and 100%, and the sizes of the droplets were observed microscopically. Then again electron-microscopically the change of nuclei with increase of the intensity of electron beam was observed, which could serve to the identification of the nuclei in many cases. The electron diffraction pattern picture of the nuclei was also taken like JUNGE [3] and ISONO [4] when the sizes of the nuclei were large enough to get a good picture. In the case of an isolated nucleus the size of about 1 micron is the limit to be able to take an identifiable picture.

3 Result

It is expected that there may be some differences among the nuclei of cloud, fog and mist with regard to their nature and size, because mist droplets can happen in an unsaturated air, whereas cloud and fog droplets can develop only when the air is supersaturated, and, further, cloud and fog are distinguished by the level of their presence. The distinction between cloud and fog, however, is somewhat ambiguous when the hydrometeoric suspensions are on mountains. We met with such ambiguous cases on Mt. Zao and Mt. Norikura, which we included temporarily in fog cases in the present research. The focus of our efforts, however, was directed to find the difference between fog and mist nuclei. By the way the distinction of fog and mist was made by, according to the usual definition, whether the visibility is smaller than 1 km. or not. The obtained results are as follows.

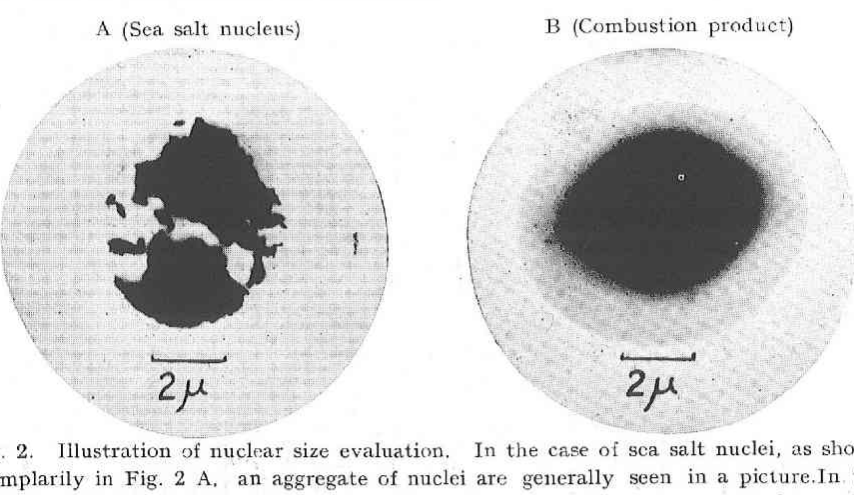

Fig. 2. Illustration of nuclear size evaluation. In the case of sea salt nuclei, as shown exemplarily in Fig. 2 A, an aggregate of nuclei are generally seen in a picture. In the present investigation, however, such an aggregate was assumed to be one nucleus. Our evaluation of size is 4.6 microns for A. Combustion products are offen blurred at the boundary. Taking the denser part only into account, we evaluated the size of the nucleus in Fig. 2 B to be 4.0 microns.

(1) *Nucleus size distribution.*

It should be remarked here that by the size of a nucleus in this research is meant the average diameter of the nucleus measured on the electron-microscope picture. This definition, in reality, involves much ambiguity owing to the irregularity of the nuclear shape, the blurring of the nuclei, and the unsettledness of these factors before and after the hygroscopicity test. So that the size measurement was carried out on a picture of the nucleus initially taken under weak electron bombardment. Some examples of our evaluation of the size are shown in Fig. 2.

The size distribution diagram for fog nuclei was obtained separately for sea, mountain and city fog nuclei and for the total of them as shown in Fig. 3. It will be seen that mountain-fog nuclei are most uniform in size and are generally smaller than sea- and city-fog nuclei. City-fog nuclei are most scattered in size. The size distribution diagram composed of the total fog nuclei shows a peak at 0.2–0.4 microns in size.

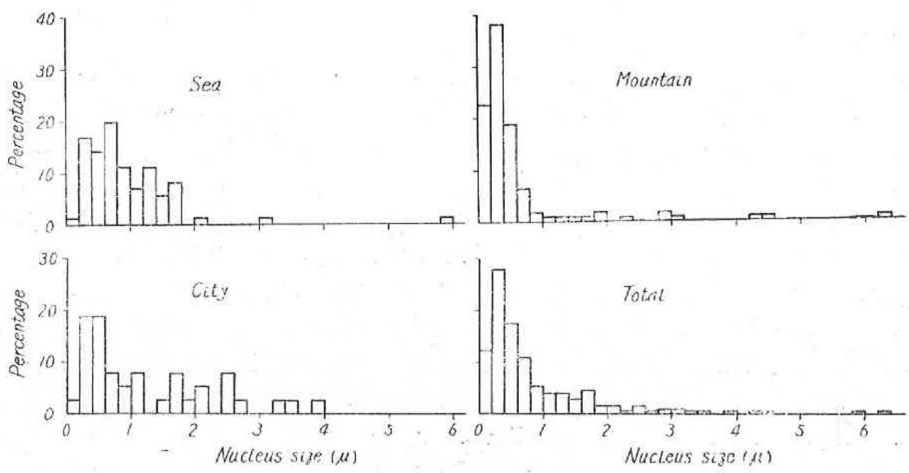

Fig. 3. Size distribution of fog nuclei.

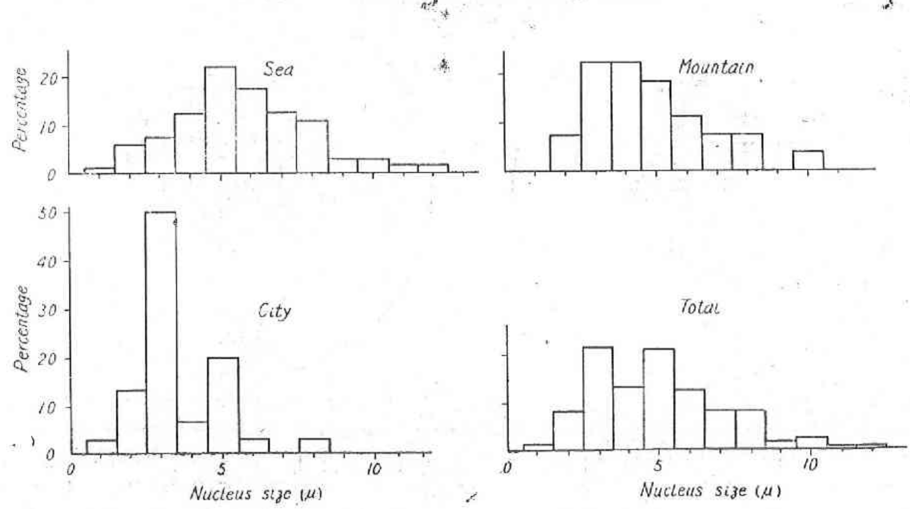

Fig. 4. Size distribution of mist nuclei.

The size distribution diagrams for mist nuclei were given in Fig. 4. In this case we lack the observations of genuine sea-mist nuclei. However, the observations at Kinkasan-Island, a small island near the coast of Sanriku district, will serve in place of the observations over the sea. As will be seen in Fig. 4, again, mountain-mist nuclei are generally smaller than sea-mist nuclei. However, it is queer that city-mist nuclei show to be smaller than sea- and mountain-mist nuclei. This result is doubtful owing to the scarcity of data, and further observations will be needed.

Now comparing Figs. 3 and 4 we can notice an interesting fact that mist nuclei, in general, are far larger than fog nuclei. Two peaks are seen in the size distribution diagram of total mist nuclei, one at 2.5–3.5 microns and the other at 4.5–5.5 microns, in contrast to the peak at 0.2–0.4 microns in the case of fog nuclei.

(2) *Droplet size distribution.*

In connection to the size distributions of fog and mist nuclei, the size distributions of fog and mist droplets, which were photographed immediately after the moment of capture, were given in Figs. 5 and 6. In this case the photographed droplets were 315 in all. Here again it should be remarked that by the droplet size we mean the apparent diameter of the droplet attached on the plate covered by a collodion film. So that the droplet size here defined will be about 1.26 times the diameter of the spherical droplet of the same mass, provided that the shape of the droplet photographed could be assumed to be a semi-sphere. We see in Figs. 5 and 6 that fog droplets are larger than mist droplets, as it ought to be. The net distribution curve for fog droplet has a peak size in the interval of 10–15 microns, while that for mist droplets has a peak in 5–6 microns. The comparison of sea-, mountain- and city-fog droplets shows no marked difference except that mountain-fog droplets in our observation are more uniform in size than sea- and city-fog. Also size distributions of sea coast-, mountain- and city-mist droplets show no marked difference.

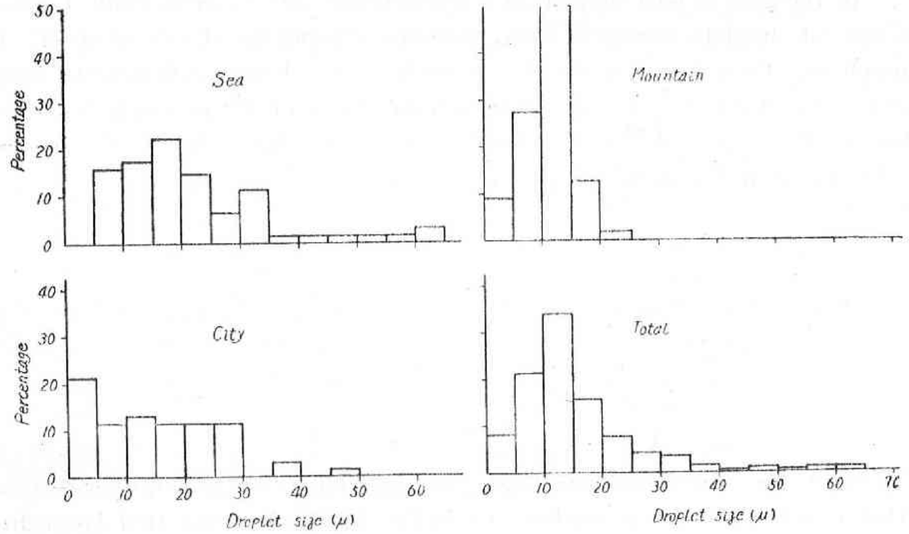

Fig. 5. Size distribution of fog droplets.

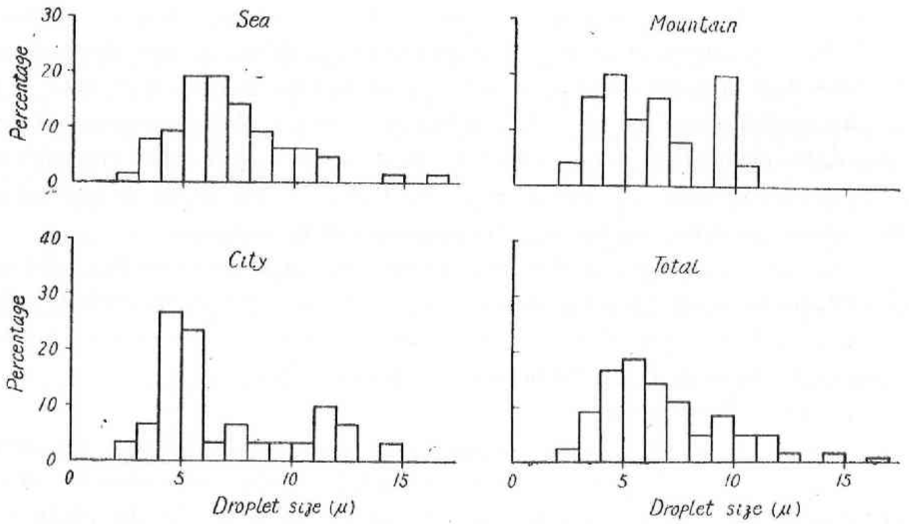

Fig. 6. Size distribution of mist droplets.

(3) *Ratio of the droplet size to the nucleus size.*

Our data enable us to know the ratio of the droplet size to the corresponding nucleus size, which will serve as a measure of growth of fog and mist droplets. The values of the mean ratio for respective cases of fog and mist are shown in Table 1.

Table 1. Mean ratio of the droplet size to the nucleus size.

	Sea	Mountain	City	Total mean
Fog	27.3	35.2	27.2	31.4
Mist	1.59	1.64	2.50	1.82

In the case of mist droplets it is theoretically and experimentally known that the size of droplets increases with humidity, causing the change of opacity in the atmosphere. From our data the change of the ratio for mist with relative humidity is as shown in Table 2. Observed data in humidity of 74–72% are only 3, so that the value for the case is doubtful. Table 2, however, shows clearly the increase of droplet size of mist with humidity.

Table 2. Mean ratio for mist and relative humidity.

Relative humidity	Number of observation	Ratio of the drop size to the nucleus size
96—92%	59	1.93
88—83	53	1.54
74—72	3	1.43

Next, the above mentioned ratio for individual fog and mist particles was plotted as a function of the nucleus size in Fig. 7, which shows that large droplets produced on large nuclei are scarce both in fog and mist. The scarcity of the droplets

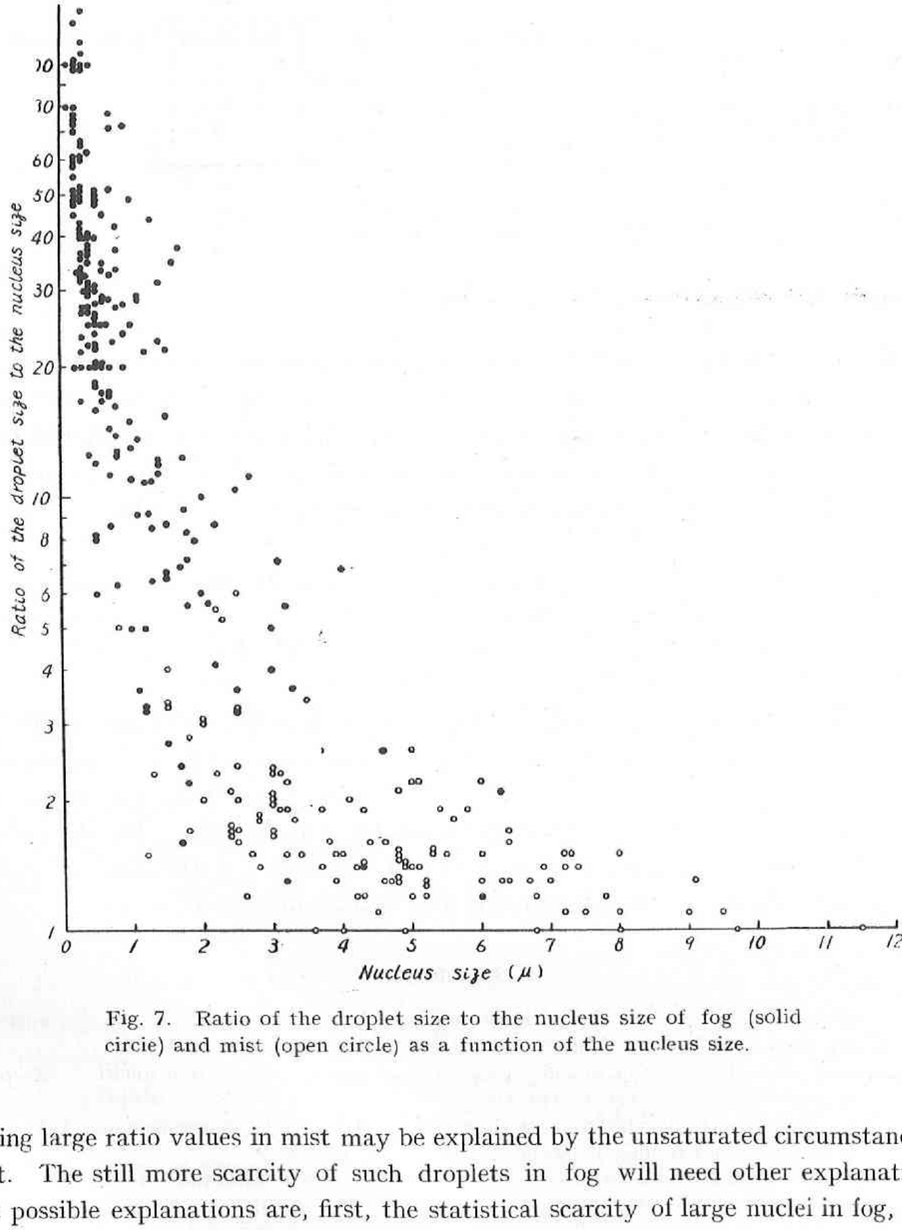

Fig. 7. Ratio of the droplet size to the nucleus size of fog (solid circie) and mist (open circle) as a function of the nucleus size.

having large ratio values in mist may be explained by the unsaturated circumstance in mist. The still more scarcity of such droplets in fog will need other explanations. The possible explanations are, first, the statistical scarcity of large nuclei in fog, and, second, the extinction of large droplets by the rapid falling in fog. Probably both the causes will be effective.

(4) *The classification of fog and mist nuclei according to their nature.*

Next we shall show in Table 3 the frequency of occurence of sea salt-, combustion-, soil- and unknown-nuclei separately for fog and mist. In the case of fog nuclei, combustion products are most numerous in all cases, and sea salt nuclei follow them, the percentage of sea salt nuclei being largest in sea fog and least in mountain fog. On the contrary, it is interesting that in the case of mist sea salt nuclei are most numerous in all cases.

Table 3. The classification of fog and mist nuclei.

		Sea salt	Combustion	Soil	Unknown	Total number
Fog	Sea	43%	51%	6%	0%	70
	City	30	49	11	10	37
	Mountain	14	64	19	3	110
	Total	26	57	13	4	217
Mist	Sea	61	33	5	1	64
	City	62	16	6	16	32
	Mountain	59	11	22	8	27
	Total	61	24	9	6	123

Resuming our results we can say that mist nuclei are mainly composed of large sea salt nuclei, while fog nuclei are mostly composed of small combustion nuclei. Of course, it will be doubtful that whether or not the present result will hold in the inland country, but at least in places not so far from sea, we think, this result will hold. The fact that large sea salt nuclei, which are most frequently observed in mist, are seldom found in fog will be explained, at least partly, by the rapid falling to ground of the large droplets developed from the large sea salt nuclei at the initial stage of fog formation. If so, the present result will give support to the prevailing opinion (for instance, given by WOODCOCK [5]) that large sea salt nuclei are the most important agents for the initiation of precipitation by accretion mechanism in clouds.

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