VARIABILITY OF THE SIZE DISTRIBUTIONS
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Abstract.

Observations of the size distribution of atmospheric aerosols larger than $0.004\ \mu\text{m}$ in radius have been made with an electric mobility spectrometer and an optical particle counter. And the variations of size distribution were discussed under such conditions as the normal calm weather, rain, and the exchange of air masses.

The size distributions indicating the particle number concentration were converted into the particle surface and the volume distributions.

The volume distribution was usually bimodal on calm days, but it sometimes changed into trimodal resulting from the exchange of air masses. The change in the size distribution at night was found to depend on two factors: the coagulation of aerosols, and the condensation of water vapor on the particles.

Introduction

Clark and Whitby(1967) measured the size distributions of atmospheric aerosols with their continuous-sampling sizing system over the size range from 0.001 to $3.0\ \mu\text{m}$ in radius in Mineapolis. They found that the magnitude and shape of the distribution below $0.05\ \mu\text{m}$ in radius depend highly upon the local source and natural ventilation conditions, and that the number of particles from 0.001 to $0.015\ \mu\text{m}$ depends also on the degree of photochemical activity as well as on the source and ventilation conditions.

Haaf and Jaenicke(1980) reported that the appearance of small particles closely related to the sun irradiation in the case of the mountain measurements.

The authors(1979a, 1979b) have measured the size distributions of submicron aerosols for a few years and discussed the characteristic changes in the size distribution under different weather conditions in different seasons. These data, however, can provide the informations only about the limited size range of 0.004 to $0.04\ \mu\text{m}$ and are not sufficient to know the behavior of the aerosols in the atmosphere.

Thus, simultaneous observations of the size distributions ranging from 0.004 to $2.5\ \mu\text{m}$ were made with an electric

mobility analyzer and an optical particle counter.

The observations were carried out in the period from October to November 1980 and some remarkable phenomena were found.

Measurements

Line(N) in Figure 1 shows a typical number distribution as a function of particle radius obtained on a calm day. The values in the size range smaller than $0.1 \mu\text{m}$ were obtained by making use of the electric mobility spectrometer developed by the authors(1976), and the other values were obtained with an optical particle counter(Rion KC-01). Each value obtained is combined smoothly by a spline function.

The surface and volume distributions are calculated from the number distribution and are also shown in Figure 1 (line (S) and (V)).

The volume distribution is typically bimodal as shown in Figure 1 (line(V)) with maxima in radius range of about 0.2 and $1.0 \mu\text{m}$, which is similar to that obtained by other investigators (e.g. Kadowaki, 1976).

Figure 1. Typical number(N), surface(S) and volume(V) distributions. The symbol "E" in the ordinate and abscissa represents a power of 10. E-3, for example, means 10^{-3} .

Figure 2. Diurnal variations of the number concentrations in subranges of (1) .006-.013, (2) .025-.057, (3) .15-.62 and (4) .62-2.5 μm .

This result demonstrates the reliability of the measured size distribution curve despite the lack of the data near the size region of 0.1 μm .

Results

(1) Typical diurnal variations

Figure 2 shows the typical diurnal variations of particle concentration fractions within four size intervals of (1) 0.006-0.013, (2) 0.025-0.057, (3) 0.15-0.62 and (4) 0.62-2.5 μm in radius. The variations in Figure 2 are presented by the deviation from each mean number concentration.

In any subranges, the concentrations have maxima in the morning and the evening as was mentioned in the previous paper (Sekigawa et al, 1979). It is interesting that the concentration in the smallest size range (1) increases from midnight to daybreak while those in the larger size ranges still decrease. More detailed information on this aspect is to be considered in a future report.

The change in the size distributions from evening to midnight is shown in Figure 3. Solid and broken lines indicate the distributions obtained at 1820 and at 2310 respectively. The distribution shifted toward larger size

Figure 3. Change in the size distributions during the night. Solid and broken lines indicate the distributions obtained at 1820 and 2310 respectively.

Figure 4. Rapid decrease of the concentration resulting from the exchange of air masses. Most remarkable decrease occurred in around 0.1 μm .

region and the total number concentration decreased from 40×10^3 to 38×10^3 particles/cc, but on the other hand, the total volume concentration increased from 12 to $20 \mu\text{m}^3/\text{cc}$.

Therefore, the change in the distribution during the night may be the result of not only the coagulation of particles but the condensation of water vapor on particles.

(2) Remarkable decrease of the particle concentration

The particle concentration frequently changed resulting from the rapid change in the weather condition such as the exchange of air masses. A result is shown in Figure 4. Solid and broken lines indicate the distributions at 0745 and 1325 respectively.

The clean air mass flowed into the observation site at noon, and the concentration decreased except in the smaller size region. Most remarkable decrease occurred in the size

range of $0.1 \mu\text{m}$ and the volume distribution changed into a trimode distribution. This change was found so far only when the total particle concentration was rapidly diminished.

Further, it should be noticed that small particles increased in contrast to the decrease of large particles. This may suggest that the characteristics of small particles differs from those of large particles.

(3) The effect of rain

Figure 5 represents the distributions before and after the rainfall. In this case, both small and large particles were removed by precipitation scavenging. But in most cases, the distribution changes variously due to the additional effects such as convection or advection of air mass, and it is difficult to extract the scavenging effect of the rain.

Conclusion

Continuous observations of the size distribution of atmospheric aerosols were made and some new results were obtained.

(1) Under calm conditions, small particles increased before daybreak while larger particles still decreased.

(2) The change in the size distribution at night was caused not only by the coagulation of particles but the condensation of water vapor on particles, therefore, the total number concentration decreased, on the other hand however, the total

Figure 5. The effect of rain. Both small and large particles are diminished.

volume increased.

(3) Some weather conditions such as the exchange of air masses caused the rapid decrease of particle concentration especially in the size region of $0.1\ \mu\text{m}$ in radius, and bring about a trimode volume distribution.

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