DISTRIBUTION FEATURES OF GIANT SEA-SALT NUCLEI IN ATMOSPHERE OVER YONGXING ISLAND, XISHA ISLANDS, DURING NORTHEAST WINTER MONSOON

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ABSTRACT

In this paper, the chlorine ions nuclei data, observed at Yongxing (Xisha Islands) during November 1987, are analyzed. The main results are: 1) The average concentration of chlorine ions nuclei with dry diameters larger than 2 μm is 878 per litre and the average salt content is 105.4 $\mu g/m^3$; in which the special giant nuclei with dry diameters larger than 4 μm are 190 per litre. The largest dry diameter of chlorine ions observed reaches 57 μm, which are larger than that observed there during the southwest summer monsoon. The spetrum type shows quasi-unimodal and exponential lapse. 2) The salt content decreases with the height over sea surface. 3) The concentrations of chlorine ions nuclei reach the maximum value at 0800 (Local time, same below), and minimum at 0200.

Key words: giant sea-salt nucleus, salt content, spectrum distribution

I. INTRODUCTION

Absorbant giant atmospheric particulates are not only closely linked with the formation of clouds and fogs and the growth of precipitable particles, but also an essential ring in a series of biological cycles that drain anthropologic pollutants discharged in the atmosphere into water bodies on the ground and soil through homogeneous and inhomogeneous phase transformations and dry, wet scavenging. More and more attention has been drawn in recent years to the important role played by the absorbant aerosols in the biological environment and the effect of human activities on climate. Though observational studies have been done over the past 30 years on giant salt nuclei for eastern mainland China (Chen and Huang, 1986), much remains to be known about the distribution of the sea-salt particles over the tropical ocean of China. It led to an observation of giant salt nuclei at Yongxing, Xisha Islands, during the prevailence of southwest (SW) monsoon in May 1987 (Wu, Mao and Guan , 1990). A similar observation was carried out at the same location during the prevailing period of northeast (NE) monsoon in November 1988 to understand the difference, if any, in the way in which the giant salt nuclei distribute in the interior area of the South China Sea. Results of the research in this aspect are reported in this paper.

II. OBSERVATIONAL METHODS AND DATA PROCESSING

1. *General description of observational site, observation items and time*

Being the principal island of Xisha Islands, Yongxing is located at 16°50′N, 112°20′E at 5.6 m above sea level with a size of 1.82 km^2 in the interior part of northern South China Sea. Due to coverage by black coral phosphorite soil on the whole island, its pH value is greater than 7.5 and tropical rain forest of the coral-reef type prospers there. Fallen within the belt of central tropical monsoon climate, it receives rainfall of about

1500 mm annually in the season from June to October which is accompanied by frequent typhoon activity. The SW monsoon prevails May through September and the NE monsoon from November to the following March, with April and October being the transitional months of wind direction. The observation of interest took place in November 1988 when the NE monsoon was prevailing which is featured by alternative control of the subtropical high and the ridge of cold highs which had been transformed in southward advancement, the activity of tropical cyclones in nearby oceanic areas, and the prevalence of steady northeasterly at the surface in 6 azimuthal ranges (112.5°) clockwisely from NW to ENE with 96.5% of directional variation concentrating on N through ENE and little diurnal change. Compared with the prevailing SW monsoon in May 1987, the wind is marked by smaller range of directional variation, more steady and stronger velocity.

Three points of observation were set up at layers 6, 15 and 28 m above sea level on a monitoring tower more than 40 m from the seaside. The point at 15 m was made the basic one (Fig. 1). Cl^- sea-salt particulates are the central item of observation, apart from the pH value and electric conductance of rainwater, and graded aersol samples were also collected for analyses of graded soluable components in both rainwater and aerosols. The observation of Cl^- lasted from 14 November to 2 December at 0800, 1100, 1400, 1700, 2000, and 2300 each day. Temporarily, more observations of Cl^- were made at 0200 and 0500 from 29 November to 1 December and those of the gradient were made at all of the three observing points from 18 to 27 November at 0800, 1400, and 2000, amounting to 177 items of Cl^- sea salt particulate observation.

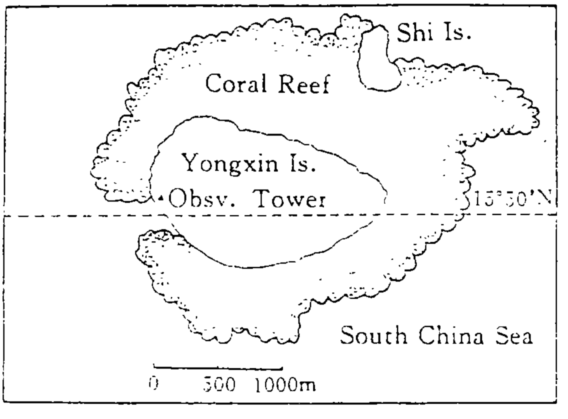

Fig. 1. Diagram of observational point.

2. *Cl^- nuclei observation and data processing methods*

The Cl^- nuclei were observed by the method of Liessegang root ring in a 3-use drop-size (Zhang, 1963) meter for a size ranging from 0.7 to 2.4 L; the sampling plates were coated with colloidal silver nitrate and the stain was transformed in coefficients following Ye (1966). Readings were taken with an optical microscope for 500-times amplification, revealing a lower limit of 1.27 μm for dry Cl^- nuclei. In the data processing, the experimental efficiency value of collision was corrected on capture, following Rang and Wong's theory (1952) on aerosol jetting on a laboratory device with round holes and narrow slots, which included the effect of humidity. Spectral distribution was processed for relativity at equal intervals of 1 μm, which represents sea-salt particulates with *d* greater than and or equal to 2 μm (Giant salt nuclei).

Ⅲ. OBSERVATIONAL RESULTS

1. *Concentration of giant salt nuclei and spectral distribution*

Observational results for both periods of NE and SW monsoon at Yongxing, Xisha Islands are listed in Table 1. It is shown in the table, in which *N* is the concentration, *d* the diameter of dry nuclei and *c* the salt level, that the mean concentration is higher in the NE monsoon than in the SW monsoon and so is the case with larger particulates ($d \geqslant 3$ μm, $d \geqslant 4$ μm), resulting in larger observational values of mean salt level during the northeast monsoon. Table 1 also gives observations for islands off the northern China coast (Shen , He and Shen, 1981), from which one can see the average concentrations of salt nuclei is close to each other for the two places and the maximum concentration and dry diameter are higher at the oceanic islands than at the Yongxing Island.

Table 1. Observational results of chlorine ions giant sea-salt nuclei over Yongxing Island.

Date	Obsv. Times	$\overline{N}$ (Drop/L)	$\overline{N}_{d\geqslant 3\mu}$ (Drop/L)	$\overline{N}_{d\geqslant 4\mu}$ (Drop/L)	N_{max} (Drop/L)	d_{max} (μm)	$\overline{C}_{(\mu g/m^3)}$
Nov. ,1988	115	878	367	190	5090	57	105.4
May,1987	113	618	232	118	8993	32	57.2
oceanic is. * Sept. ,1978	96	847	—	—	11609	190	—

* Shen et al. ,1981.

Fig. 2 gives the percentage by which various measurements of giant salt nuclei concentration and maximum dry diameter occur during the period of NE monsoon. The dashed line is the value of observation for the prevailing period of SW monsoon. By com-

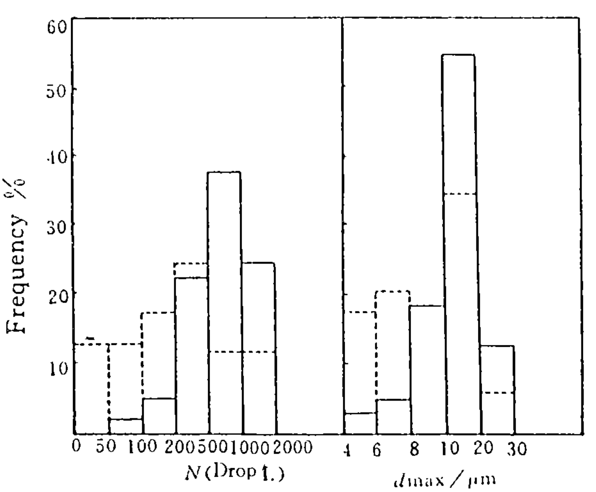

Fig. 2. Frequency of appearence of concentration of giant salt nuclei and maximum dry diameter over Yongxing Island.

parison, the concentration of salt nuclei varies between 200 and 2000 drops per litre in the NE monsoon, and below 500 drops per litre in the SW monsoon; the maximum dry diameter is mostly between 8 and 30 μm for the former and between 6 and 20 μm for the latter. It is indicative that as compared with the SW monsoon, the giant salt nuclei has higher concentration and larger particulates at Yongxing in the NE monsoon. The cause leading to the difference can be accounted for by the difference in the mean velocity of wind between the two seasons. It is generously held that wind velocity is the main cause for the difference in concentration of giant salt nuclei for the same location.

Fig. 3 gives the mean spectra of giant salt nuclei observed at Yongxing, Xisha Islands. It is clear that the spectra decrease quasi-monotonously as a wide-band power function. Concentration in spectral segments of different scale is higher in the NE monsoon than in the SW monsoon, with 30 μm being the longest, continuous spectral segment; the maximum dry diameter is 57 μm for the NE monsoon but 32 μm for the SW monsoon. Although the spectra of salt level for both observations are quite close to each other, that for NE monsoon is higher due to greater contribution by larger particles. Peak diameters in the content of salt occur at 4 μm (6 μm for SW monsoon) and the local mass of giant atmospheric salt nuclei is mainly contributed by particles up to 21 μm in size.

When the continuous spectrum of giant salt nuclei are regressed into a curve in spectral distribution following He et al. (1984), the spectral distribution (2 μm$\leqslant d \leqslant$30 μm) for NE monsoon is expressed in

$$N(d) = 10^2 N_0 d^{-4.45}, \qquad (1)$$

where N_0 is the total concentration, d the diameter of a giant salt nucleus and α a negative index that is related with the spectral pattern. The continuous spectrum (2 μm$\leqslant d \leqslant$30 μm) for SW monsoon is separately derived as in

$$N(d) = 10^2 N_0 d^{-4.53}. \qquad (2)$$

Comparisons indicate close identity between the two, in spite of the fact that the giant nuclei spectra for NE monsoon are featured with discontinuity in the direction of giant particulates.

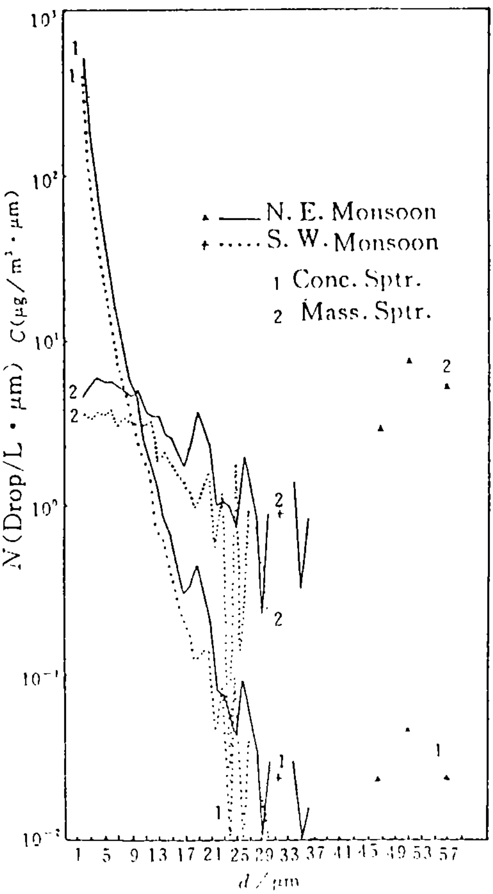

Fig. 3. The average spectrum distribution of giant sea-salt nuclei over Yongxing Island.

2. *Concentration and spectral distribution of giant salt nuclei at different heights above the sea*

Table 2 gives the concentration and spectral distribution of giant salt nuclei at 6, 15 and 28 m above the sea. Only mild difference exists in the mean concentration among three heights, though a decreasing tendency is true for both greater particles ($d \geqslant 3$ μm) and salt content as it is getting higher above the sea level. Despite a larger width for the continuous spectra at the lower level than that at the middle and upper levels, there is a general tendency, though with a mild gradient, for the giant salt nuclei to decrease as it is getting further away from the sea, a fact that differs from the observations for SW monsoon. Analysing alongside with the observations for SW monsoon, a thin layer of highly concentrated giant salt nuclei is found through the range from just a few meters above the sea surface while the gradient is not quite large through that from 6 to 28 m. In his observational study of scale distribution of giant particles just above the sea surface in the northern Atlantic, G. Deleeum (1986) also discussed what he called a buffer

Table 2. Observational results of giant sea-salt nuclei at different heights above the sea level.

A. S. L. ht (m)	Obsv. times	$\overline{N}_{\geqslant 2\mu m}$ (Drop/L)	$\overline{N}_{\geqslant 3\mu m}$ (Drop/L)	$\overline{N}_{\geqslant 4\mu m}$ (Drop/L)	N_{max} (Drop/L)	W. of CNS sptr (μm)	$\overline{C}$ ($\mu g/m^3$)
6	30	1060	475	246	2315	34	144.0
15	30	966	390	196	2403	24	87.7
28	30	1105	335	154	3934	24	78.7

layer—a concentration maximum of particles at 1 to 2 m above the sea. He argued that it was caused by a superposition of the upward transfer of the layer in which particles are formed and the sinking action of the layer in which particles are mixed. It is noteworthy that the anomalously higher concentration at the upper level (28 m) may be resulted from the location of the observational point which is on the southwest leeward side of the island of Yongxing, when relatively large mean wind velocity in the NE monsoon period maintains considerably high aerial concentration of salt nuclei, and some portions of smaller particulates are obstructed and filtered through by vegetation on the island while those at upper levels are not obstructed or scavenged due to higher position above the vegetation. Nevertheless, particulates of larger size tend to decrease with increasing height because of the sinking action of salt nuclei.

Fig. 4 gives th distribution curves of giant salt nuclei spectra at the 3 heights above the sea. It is shown that except at 28 m where there are more 2 μm particulates than at the other two heights, no significant difference exists in the spectral distribution for all three heights, which is quasi-monotonously decreasing, though relatively more particulates in larger size gather at 6 m with wider spectra than at higher levels. In a similar way, regressive curves are also given to the continuous spectra of giant salt nuclei at different heights, which bear the shape of $N(d) = 10^2 N_0 d^{-\alpha}$ with the index α taking the values as in Table 3. From the table one knows that α is more or less the same for all of the heights and the spectral slope is mildly greater at the two higher heights than at the third.

Table 3. The index (α) of giant sea-salt nuclei distribution of different height above sea level.

A.S.L. ht(m)	6	15	28
α	−4.54	−4.72	−4.69
γ	0.983	0.983	0.983

3. *Diurnal variation of giant salt nuclei and its characteristics*

Fig. 5 gives the characteristics of diurnal variation of Cl^- giant salt nuclei and the changes in mean wind velocity and wave height. It is seen that poor correspondance is found between the concentration of giant salt nuclei, salt content, and maximum diameter of dry nuclei and the changes in wind velocity and wave height. It is different from the result for SW monsoon and may be accountable by synoptic background. During the observation in the prevailing period of SW monsoon, there was no clearly-defined activity at the synoptic scale, exposing the point of observation to the steady control of the subtropical high. In contrast, the waters nearby were influenced by the tropical cyclone, mid-latitude frontal weather or under the control of the

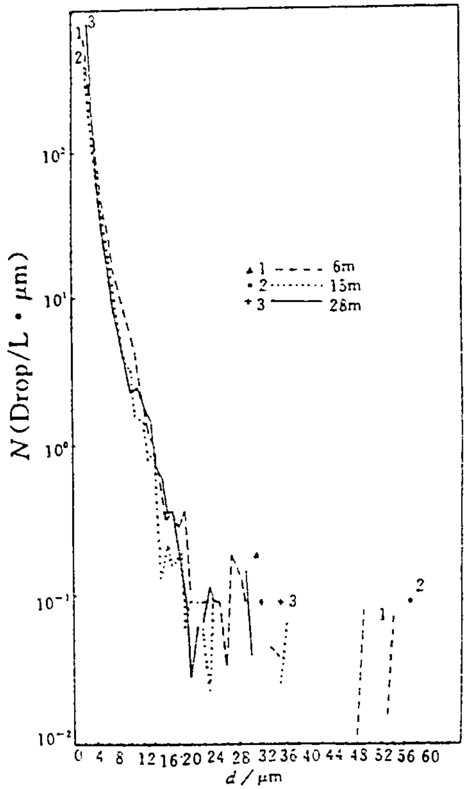

Fig. 4. Spectral distribution of giant salt nuclei at different heights above sea level.

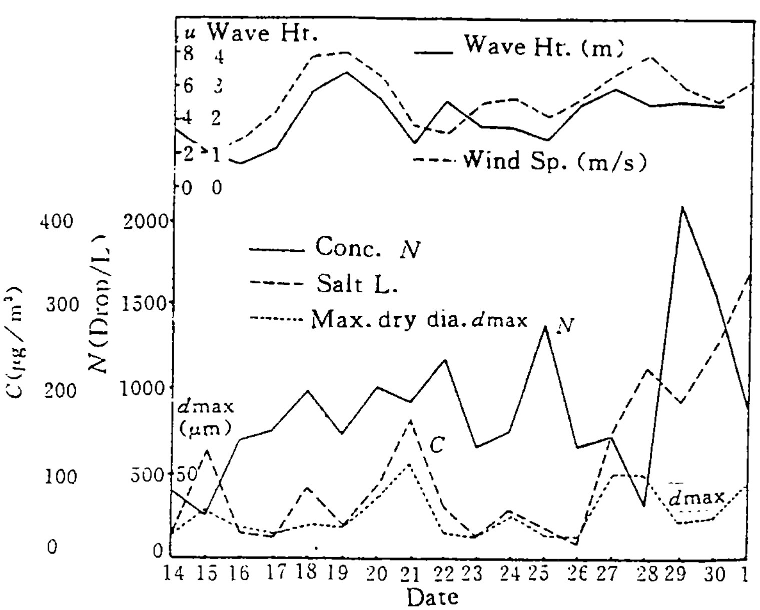

Fig. 5. The feature of daily variation of chlorine ions nuclei over Yongxing Island.