SEMIANNUAL VARIATION OF MICROPARTICLE CONCENTRATION IN SNOW DRIFT AT MIZUHO STATION, ANTARCTICA IN 1977

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Abstract: The concentration of microparticle in snow drift collected at Mizuho Station, Antarctica in 1977 shows a semiannual variation with two maxima in January and February of the summer season and in May to July of the winter seasons, and two minima in March and August to October of the intermediate seasons. The semiannual cycle is probably ascribed to (1) the dilution of microparticle transported from the lower latitudes by fallen snow in the intermediate seasons and (2) the semiannual cycle of stratospheric aerosol concentration and precipitation over Antarctica.

1. Introduction

Recent studies on microparticle concentration in ice cores from Byrd Station (MARSHALL, 1962; THOMPSON *et al.*, 1975), and Dome C (THOMPSON *et al.*, 1981), Antarctica, and from Camp Century (HAMILTON and LANGWAY, 1967; THOMPSON, 1977a, b), Greenland indicate two important results: one is that the highest concentration occurs when oxygen isotope ratios exhibit the greatest negative value, and

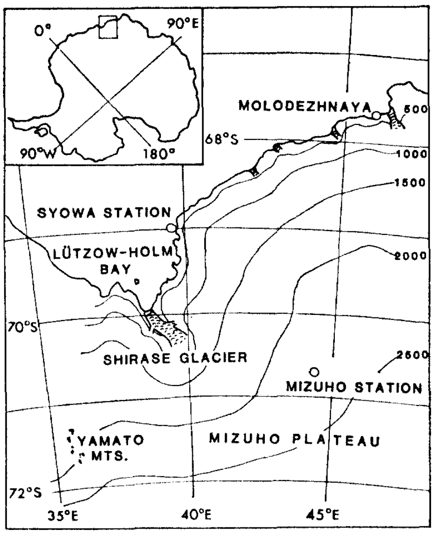

Fig. 1. Location of Mizuho Station.

the other is that annual microparticle variations provide a means of dating ice cores.

Preliminary microparticle analysis in the sections from a 147.5 m long Mizuho core partly shows a cyclic variation. This variation, however, cannot be assumed to be annual as in the Byrd ice core analyses by MARSHALL (1959, 1962) and THOMPSON *et al.* (1975), and in the Camp Century core analysis by HAMILTON and LANGWAY (1967) and THOMPSON (1977a, b), because of the lack of a seasonal sequence of layer formation at Mizuho Station (44°20′E, 70°42′S, 2230 m a.s.l.) which is located in the strong katabatic wind region (Fig. 1). Especially, longterm (a year to ten odd years long) interruptions in snow accumulation and the disappearance of pre-formed surface layers due to sublimation and wind erosion make the stratigraphic chronology of snow and ice cores from Mizuho Station difficult (WATANABE, 1978; WATANABE *et al.*, 1979; FUJII, 1981). The absence of seasonal or annual layers is, therefore, the first consideration in the interpretation of the variation of microparticle concentration in an ice core from a strong katabatic wind region.

The purpose of the present study is to clarify the seasonal variation of microparticle concentration in snow drift which becomes a perpetual snow layer when the necessary conditions are satisfied.

2. Sample Collections and Laboratory Techniques

2.1. *Sampling*

Collections of snow drift formed within a day were conducted upwind from any possible contaminant source at Mizuho Station every three to four days from February 1977 to January 1978. To eliminate impurities from the inside wall of polyethylene sample containers with a volume of 250 m*l*, the containers were cleaned by rinsing several times with drifted snow.

After sampling, containers were numbered, sealed with vinyl tape and placed in a snow cave, where the air temperature is $-29 \sim -35$°C throughout the year, to avoid melting of the samples and dissolving of the impurities which remained on the inside walls of the containers. These samples were transported to the low temperature laboratory (−25°C) of the National Institute of Polar Research, being kept below −20°C.

2.2. *Laboratory equipment*

The facilities and equipment for analyzing samples for microparticle concentration consist of the following: a multichannel particle counter (Coulter Model TA II counter with an X-Y recorder); a class 100 clean bench which is placed in a low temperature laboratory for resampling the inner part of the samples; a class 100 clean glove box in which a sample stand of a counter is set; a Millipore 4-housing Milli-Q2 system which produces reagent grade water excluding insoluble particles of diameter greater than 0.22 μm; and several kinds of Millipore filtering equipment.

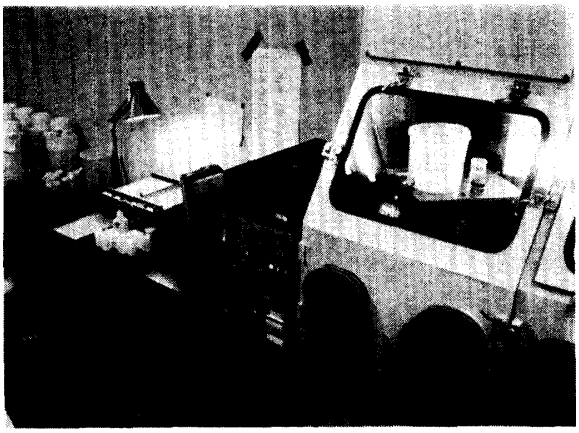

Fig. 2. A multichannel particle counter, Coulter Model TA II, and a class 100 clean glove box where a sample stand is placed.

Figure 2 shows the multichannel particle counter with an X-Y recorder and the clean glove box. Note that a sample stand is placed in the clean glove box.

2.3. *Sample preparation*

The procedure for counting particles in snow samples is summarized in Fig. 3, showing the procedure of sample preparation in the flow chart on the left.

The first step is to resample the inner part of each snow sample by scooping from the cut end of the sample container with a rinsed container. The procedure is done in a class 100 clean bench set in a low temperature laboratory to avoid the outer part which has been in contact with the inner wall of the container.

Second, after melting the snow sample under room temperature, the melted

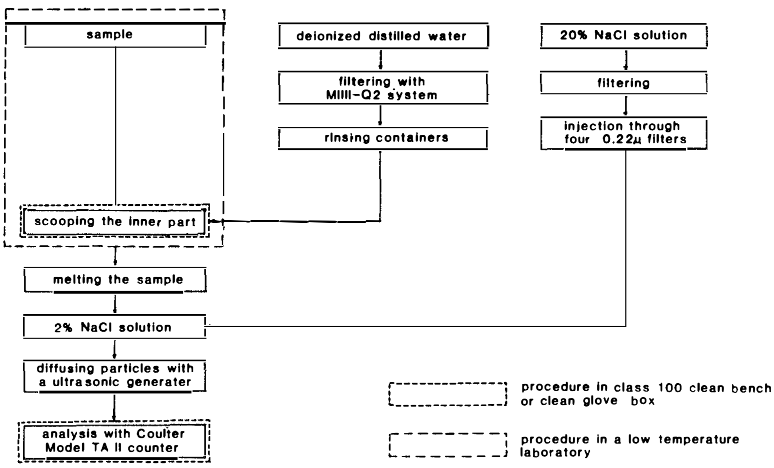

Fig. 3. Flow chart of sample preparation for counting particles in snow samples.

sample is converted into 2.0% NaCl electrolyte by injecting the appropriate amount of 20.0% NaCl solution using a plastic syringe with four 0.22 μm pore-sized Millex filter units.

The third step is to diffuse particles uniformly in an electrolyte with an ultrasonic stirrer for about ten seconds immediately prior to analysis in the Coulter counter. This procedure is important to avoid the precipitation of suspended particles. About 60 to 80% of the total number of particles precipitates within one month in the case of the present samples.

2.4. Particle counter

The Coulter Model TA II counter determines the number and sizes of particles suspended in a conducting liquid by forcing the suspension to flow through a small aperture and monitaring the electrical current through the aperture. Electrodes are immersed in the conducting liquid on opposite side of the aperture. As a particle passes through the aperture, it changes the resistance between the electrodes. This products a current pulse of short duration having a magnitude proportional to the particle volume. The series of pulses is electronically scaled and counted.

In this analysis, an 11 μm aperture tube was used and particle sizes were electronically separated into 16 ranges between 0.25 and 8.00 μm in diameter, but smaller-sized particles less than 0.63 μm in diameter were excluded from the analysis since the counts below this diameter are subject to inaccuracies due to electronic noise.

Fifty μl samples were pulled through the aperture by the pressure difference established by means of a mercury manometer. This operation was conducted in a class 100 clean glove box.

The data such as elapsed time, total count, differential and cumulative population were printed out and two histograms of population drawn by an X-Y recorder.

3. Variations of Particle Concentrations in Snow Drift in 1977

Microparticle concentration and size distribution have been analyzed for the melted samples of snow drift which were collected at Mizuho Station every three to four days during the period from February 1977 to January 1978.

The result of the analyses of these snow drift samples are presented in Fig. 4. The concentration of particles is shown as the total number greater than 0.63 μm in diameter per 50 μl of sample.

The dashed line in the figure shows the variation of the minimum level of particle concentrations which provides a more reliable indication because the concentration is thought to be less contaminated. As is seen in the figure, a semiannual cycle is predominant in the particle concentration. Two maxima are seen, in January and February of the summer season and in May to July of the winter season, and two minima, in March and August to October of the intermediate seasons between

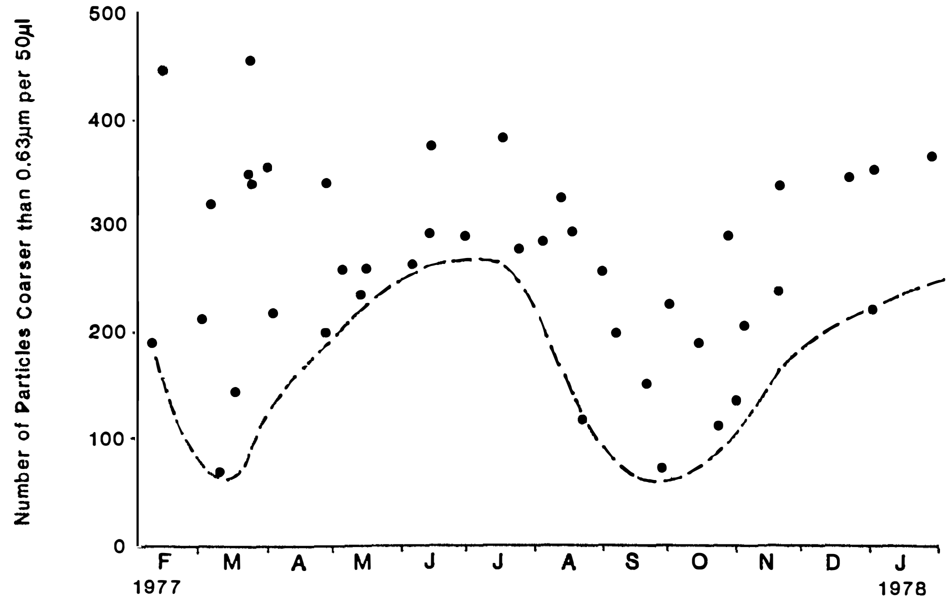

Fig. 4. Seasonal variation in microparticle concentration in snow drift collected at Mizuho Station in 1977. The concentration is given as the total number greater than 0.63 μm in diameter per 50 μl of sample.

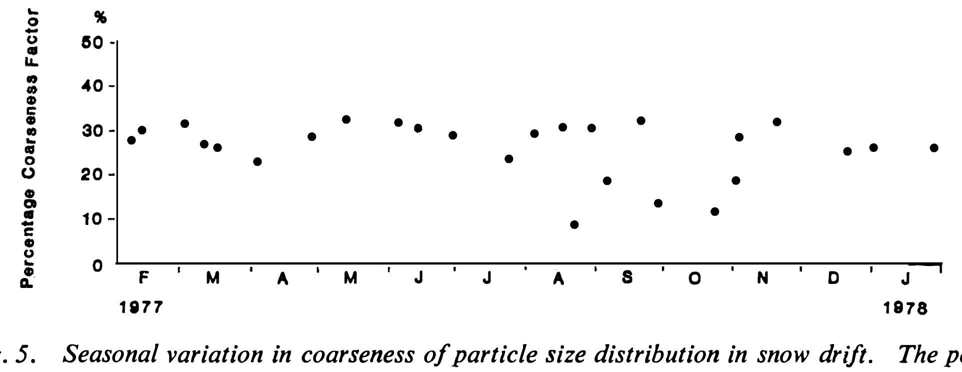

Fig. 5. Seasonal variation in coarseness of particle size distribution in snow drift. The percentage coarseness factor is 100 times the number of particles with diameters between 1.0 and 8.0 μm divided by the number of particles with diameters between 0.63 and 8.0 μm.

summer and winter.

The variation in coarseness of particle size distribution in snow drift with a smaller total number of particles in each month is presented in Fig. 5, where percentage coarseness factor is defined as 100 times the number of particles greater than 1.0 μm in diameter per total number of microparticles greater than 0.63 μm in diameter.

The figure indicates that the percentage coarseness factor has a range between

20 and 35% throughout the year from February 1977 to January 1978, except for some cases in the season from the end of August to early November, when the values decrease to 10∼20%.

4. Discussion

The semiannual cycle examined in the particle concentration of the melted samples of snow drift collected at Mizuho Station may be ascribed to the single or the combined causes of the following phenomena which have a semiannual cycle.

Air mass transport from the lower latitudes to the Antarctica is strengthened by the development of predominant low pressure systems when the zonal index is high. The zonal index at four standard isobaric surfaces between Marion Island (37°52′E, 46°53′S) and Syowa Station (39°35′E, 69°00′S) in 1977 shows a semiannual cycle, being high in March and September and low in June and December throughout the troposphere (Fig. 6). The transport of insoluble particle in water and mois-

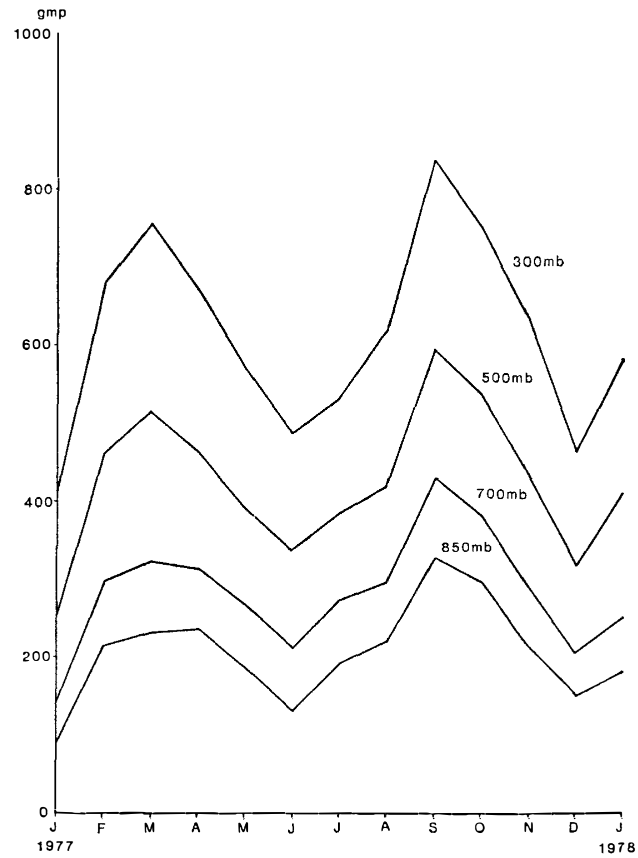

Fig. 6. Zonal index at four standard isobaric surfaces between Marion Island (37°52′E, 46°53′S) and Syowa Station (39°35′E, 69°00′S) in 1977.

ture mass flux, therefore, increase in the intermediate seasons.

Corresponding to the increase of moisture mass flux, the number of snowfall days at Mizuho Station in 1977 increased as is shown in Fig. 7 (FUJII and KAWAGUCHI, 1977), indicating the maxima in March and September to October of the intermediate seasons. The particle concentration in snow drift may, therefore, have been diluted with snowfall. Since snowfall at Mizuho Station generally occurs when there are synoptic scale disturbances (NAKAJIMA *et al.*, 1981), the seasonal variation of microparticle concentration may be influenced by the seasonal variation of synoptic scale disturbances through such a process as the dilution of particle concentration by snowfall.

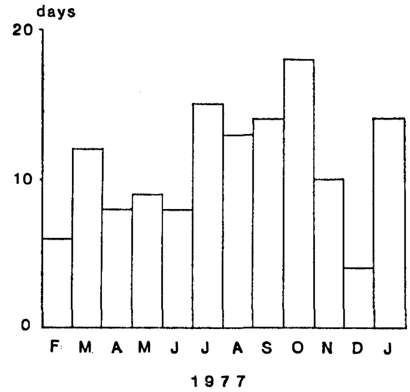

Fig. 7. Monthly number of snowfall days at Mizuho Station in 1977.

A semiannual variation in stratospheric aerosol concentration (*i.e.* IWASAKA *et al.*, 1980) is thought to be one of the possible causes of the same cycle in particle concentration in snow drift examined by the present study. The simultaneous measurements of sulfur content of gases and particles in the stratosphere made before and after the eruption of Volcan de Fuego (14°15′N, 91°W) by LAZRUS *et al.* (1979) suggest that the stratospheric aerosol is transported from high altitudes over low latitudes to lower altitudes at polarward latitudes. According to the recent studies on atmospheric particulate material at the South Pole, the aerosol mass is dominated (~80–90%) by sulfate, which is believed to be of stratospheric origin (MAENHAUT *et al.*, 1979) and the sulfate and condensation nucleus concentration increase corresponding to a lowering of the tropopause (HOGAN, 1975).

As is shown in Fig. 5, particles in snow drift collected in the period around September and October tend to be finer than those collected in the remainding seasons in 1977. This implies that the pattern or strength of the atmospheric circulation over Mizuho Station which transports particles changes in the period around September and October.

Figure 8 shows the relation between the percentage coarseness factor and the total particle number in snow drift collected in 1977. The smallest percentage of

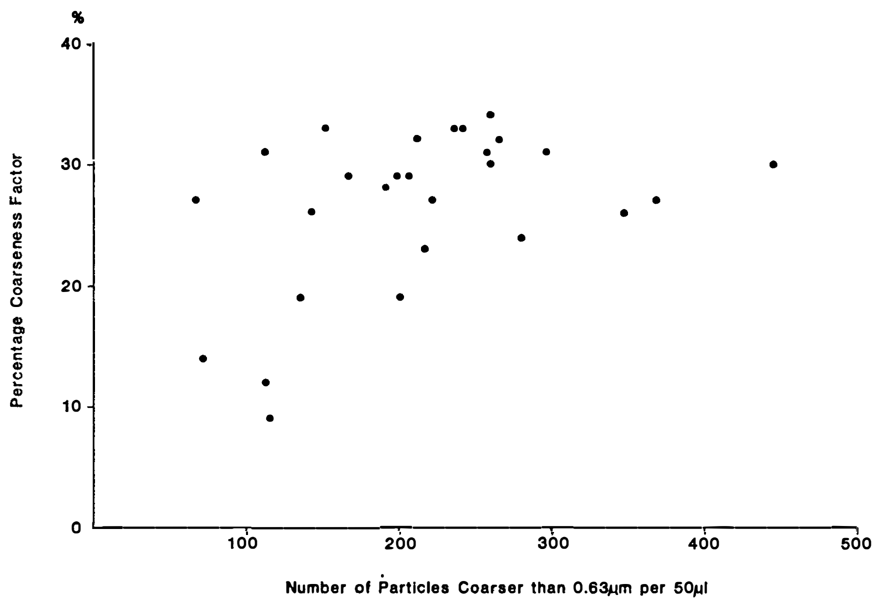

Fig. 8. Relation between the percentage coarseness factor and the total particle number greater than 0.63 μm in diameter in snow drift collected in 1977.

particle coarseness occurs in snow drift with the smallest total number of particles and the coarseness tends to increase with the total number. The present tendency seems to suggest that the predominant inflow of air masses transports a larger number of coarser particles from lower latitudes to Antarctica because no extensive land area exists between Mizuho Station and the ocean, or from a terrestrial source of microparticles windward of the prevailing katabatic wind at the Station.

5. Concluding Remarks

The present study has clarified the semiannual cycle in microparticle concentration in snow drift collected at Mizuho Station in 1977. This cycle does not appear in the surface snow layer because of the lack of a seasonal sequence of layer formation owing to the absence of snow accumulation, especially on a glazed surface such as is representative of the surface at Mizuho Station, and to the disappearance of the pre-formed snow layer by sublimation and wind erosion, as is described by FUJII (1981).

Therefore, further studies as are shown below are required to obtain chronological understanding of the variations of microparticle concentration in snow and ice cores from not only Mizuho Station but also any given site in the katabatic wind region. These studies are on the time of deposition of snow which will remain perennially, on the microparticle concentration in the surface snow layer and on the rate of concentration on the surface by surface lowering owing to sublimation and by dry fallout.

The present study preliminarily shows some possible causes for the interpretation of the semiannual cycle in particle concentration in snow drift. Further studies are also necessary on the atmospheric circulation which is associated with microparticle transportation from lower latitudes to the Antarctic ice sheet surface through the troposphere and/or stratosphere.

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