OBSERVATIONS OF SEA-SALT PARTICLES IN THE AIR IN MIZUHO PLATEAU

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Abstract: This paper presents the observational results on the concentrations of sea-salt particles in the air in the area of Mizuho Plateau, East Antarctica. The sea-salt particles are transported to the area more than 200 km inland from the coast by cyclonic disturbances, but they are not found even in the coastal area when meteorological conditions are not effective for the transportation of them. Seasonal variation of the concentration of sea-salt particles is controlled by the activities of cyclones.

1. Introduction

The Antarctic ice sheet is nourished with water circulated through the sea, the atmosphere and the ice sheet in a cycle. Stationary katabatic winds due to the stable surface inversion layer characterize the state of the lower atmosphere in Mizuho Plateau (KOBAYASHI and YOKOYAMA, 1976). It seems likely, however, that the activities of cyclones over the sea near the coast play a dominant role in the transport of water vapour from the sea to the Antarctic Continent and that they control the distribution of snow accumulation on the ice sheet.

Sea-salt components, as well as water vapour, are transported from the sea to the ice sheet by an atmospheric circulation; hence, their amount remaining in the air and their amount in deposited snow on the ice sheet are important indicators of air and water circulation.

Observations of sea-salt particles in the air were made in Mizuho Plateau in 1969–1970 by AGETA and in 1973-1974 by KOBAYASHI. The relations between the observational results of sea-salt particles and the atmospheric circulation in Mizuho Plateau and its vicinity are discussed in this paper.

2. Observations of Sea-Salt Particles in the Air and the Results

Air was sampled by the use of a hand-operated jet impactor (TOBA and

TANAKA, 1967), whereby sea-salt particles were caught on a Farlow's chloride reagent gelatin film. Using this film, particles larger than about $10^{-11.5}$ g were countable (TOBA and TANAKA, 1967). However, most of halos on the films due to sea-salt particles were quite small and obscure in the present observations. The amount of air sampled at a time of an observation was 30–80 litres and 1–10 litres respectively in 1969–1970 and in 1973–1974. The number of sea-salt

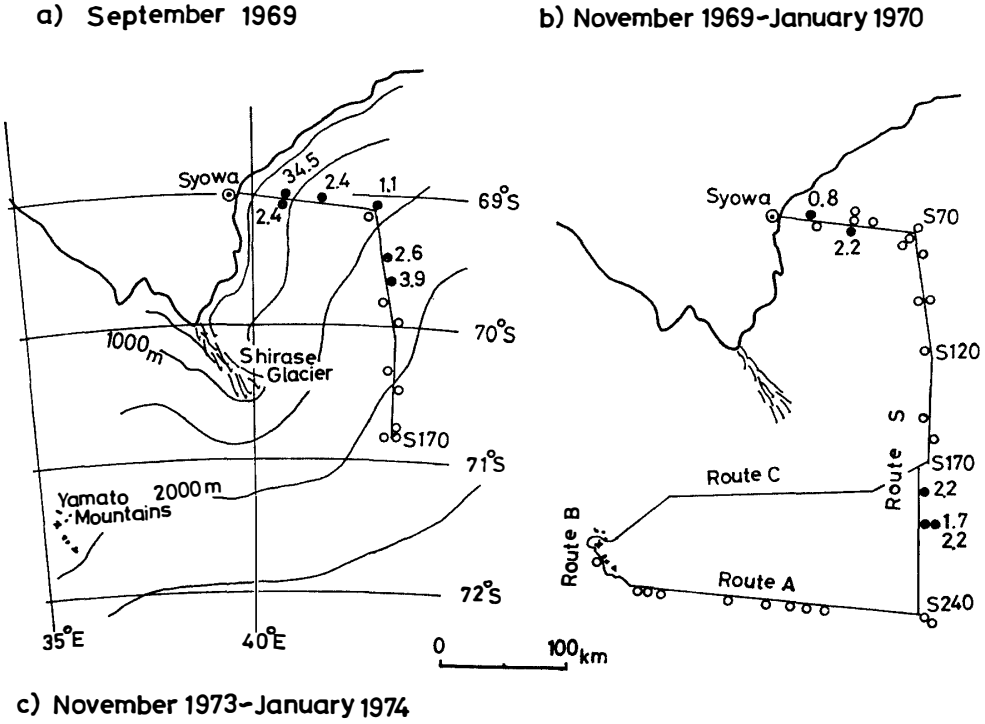

Fig. 1. Sampling positions and the concentration θ, the number of sea-salt particles per litre of air on traverse routes.
Solid circle: θ is more than 0.5/1.
Blank circle: θ is less than 0.5/1 or not found.

particles on a film was counted without taking the 'retention factor' (TOBA and TANAKA, 1967) into account.

The sampling positions of sea-salt particles on the traverse routes are shown in Fig. 1 by solid and blank circles. A solid circle indicates the sampling position where a number of sea-salt particles per litre of air, θ is more than 0.5/1, while a blank circle does that where θ is less than 0.5/1 or sea-salt particles were not found. According to KIKUCHI and FUJIWARA (1971), sampling of sea-salt particles was carried out at 42 points on the way from Syowa Station to the South Pole in 1968–1969, but they were counted only at 2 points; namely θ was 10/1 around the latitude of 71°S and 0.5/1 around the latitude of 77°S. At other points, there were no particles or θ was very small (less than 5 particles per 40 litres).

The results of sampling in 1973 at Mizuho Camp (70°41′53″S, 44°19′54″E,

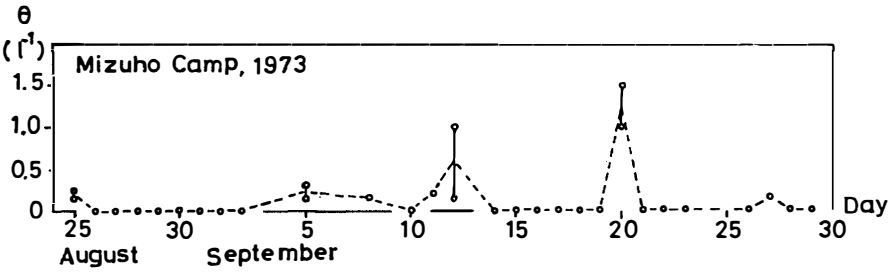

Fig. 2. The concentration θ of sea-salt particles at Mizuho Camp. The indication which has a range shows different concentrations at a time, when samplings were made with two different volumes of air.

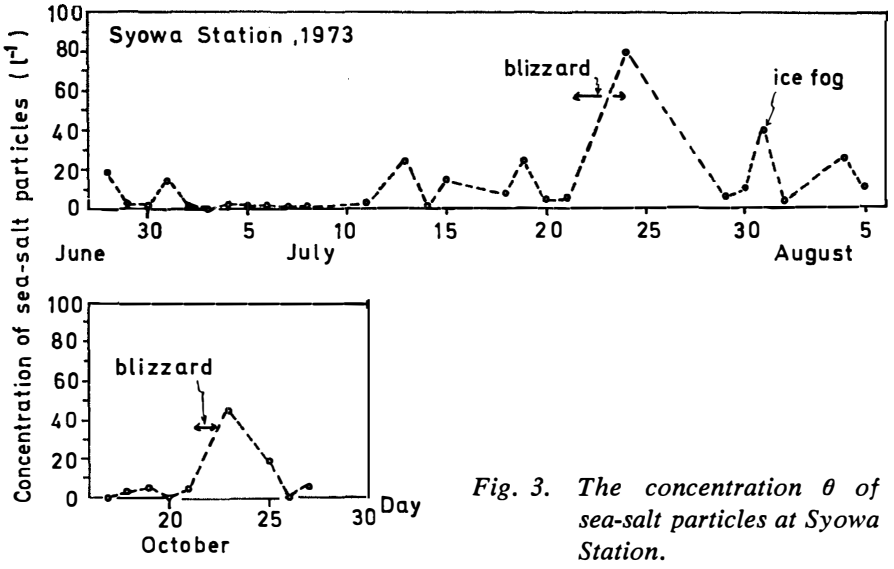

Fig. 3. The concentration θ of sea-salt particles at Syowa Station.

2230 m above sea level; 270 km to the southeast of Syowa Station) and at Syowa Station are shown in Fig. 2 and Fig. 3 respectively.

3. Sea-Salt Particles and Atmospheric Circulation in Mizuho Plateau

3.1. Effect of atmospheric circulation under cyclonic disturbances

Since stationary katabatic winds, which blow from inland to seaward, are dominant in Mizuho Plateau, small values of θ in Fig. 1 may be attributed to them.

Fig. 1 shows that θ does not decrease with increase of the distance from the seacoast. Therefore, it is supposed that a meteorological condition at a sampling time has more important effect on θ than the distance from the seacoast, as described in the following: In the area more than 200 km inland from the coast during the period of November 1969–January 1970, sea-salt particles were found only at 2 points, S186 and S200 on Route S, on 16, 17 and 18 November, as shown in Fig. 1b. Meteorological conditions of these days were that the wind direction changed counterclockwise (E-NNE) from the prevailing direction of katabatic winds in this area (ESE), and weak wind blew with light snowfall.

It is known in the case of Mizuho Plateau that the direction of stationary katabatic winds is deflected counterclockwise by cyclonic disturbances which produce snowfall on the ice sheet (AGETA, 1971; ÔNO *et al.*, 1971; WATANABE and AGETA, 1972; WATANABE and YOSHIMURA, 1972), and that the speed of these deflected winds is weaker than that of stationary katabatic winds (AGETA, 1971; SASAKI, 1974). NARITA (1977) found fresh crystals of fallen snow due to precipitation in blowing snow when the wind direction changed counterclockwise towards the north from the prevailing wind direction.

Variations of meteorological elements at Mizuho Camp have good coincidences with those at Syowa Station in terms of air temperature (ÔNO *et al.*, 1971; WATANABE and YOSHIMURA, 1972; YAMADA, 1974; SASAKI, 1974) and air pressure (YAMADA, 1974; SASAKI, 1974). Variations of air pressure at the points around the Yamato Mountains and along Route A at 300–350 km south of Syowa Station have also good coincidences with those at Syowa Station (YOSHIDA *et al.*, 1962; AGETA, 1971). To sum up the reports concerned, coincidences of variations of wind speed and weather at Mizuho Camp and the points along Route A with those at Syowa Station are not so good as above (AGETA, 1971; ÔNO *et al.*, 1971; YAMADA, 1974; SASAKI, 1974), but it can be said that the influences of activities of cyclones over the sea near the coast reach the area at least 300 km inland from the coast (YOSHIDA *et al.*, 1962; AGETA, 1971; YAMADA, 1974; KOBAYASHI and YOKOYAMA, 1976).

On the basis of the results described above and the pictures obtained from the ESSA satellite, Fig. 4 shows an inferred example of the typical model of air

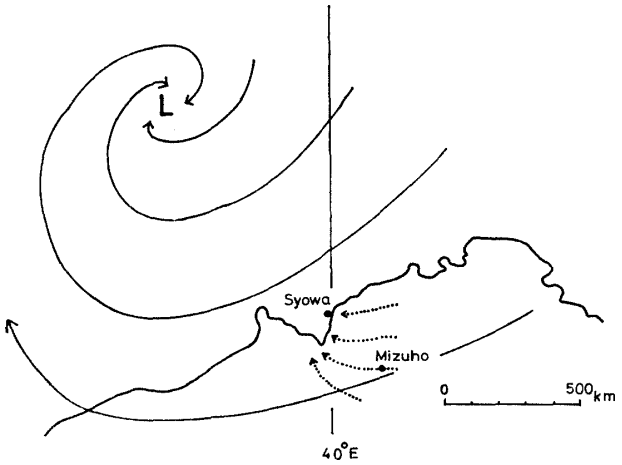

Fig. 4. A typical model of air flows when a cyclone near the coast disturbs the katabatic winds.
Solid lines: flow lines of the cyclonic winds
Dotted lines: flow lines of the stationary katabatic winds

flow when the activities of a cyclone over the sea near the coast disturb the stationary katabatic winds in Mizuho Plateau.

Consequently, it can be said that sea-salt particles were transported to the area more than 200 km inland from the coast by cyclonic disturbances, but they were not found even in the near-coast area on the days when meteorological conditions did not favor the transportation of them, as seen in Fig. 1. Even at Syowa Station, sea-salt particles were not found at half of the sampling times throughout the year 1968 (KIKUCHI and YAURA, 1970); according to the observational results in 1973, they increased under effective conditions, *i.e.*, cyclonic disturbances and ice fogs, as shown in Fig. 3.

3.2. Seasonal variation of sea-salt particle concentration and atmospheric circulation

The pack-ice edge on the meridian of 40°E advances northward about 1500 km in winter in comparison with that in summer (KUSUNOKI, 1975). Therefore, seasonal conditions of the transport of sea-salt particles to the ice sheet are supposed to be controlled greatly by such seasonal advance and retreat of the southern limit of the open sea. However, it can be seen in Fig. 1 that θ had larger values in September than in November–January. KIKUCHI and YAURA (1970) also reported as a result of observations from February 1968 to January 1969 at Syowa Station that θ increased in March, August, September and October, and the monthly mean of θ was found to vary in parallel with the number of storm days (>15 m/s) per month. Consequently, it can be said that the seasonal change of the activities of cyclones plays a dominant role in controlling conditions

of transport of sea-salt particles.

4. Concluding Remarks

Since the atmospheric circulation plays an important role in the mass transport from the sea to the ice sheet as described in this paper, it is necessary to pursue further studies through a year on meteorological conditions in the upper layer of the atmosphere and the mass transport toward the interior parts of the ice sheet, including the observations in the inland plateau. It is especially required to make measurements of sea-salt particles and conduct the observations of radio sondes more extensively under cyclonic weather conditions so that sufficient clues may be gathered to look into important influences of the cyclones on the nourishment of the ice sheet.

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