Arrival Direction and Occurrence Frequency of Atmospherics at Syowa Station in Antarctica

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南極昭和基地における空電到来方位と頻度

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要旨：極地性低気圧に伴う空電を調査する目的で，10kHzで動作する自記式空電源方位測定機を製作し，1969年3月から1970年1月にかけて運転した．この論文では調査の科学的な目標と得られた結果について要旨を述べる．

遠距離空電源について得られた結果から，次のようなことが判明した．即ち，もしこのような観測を南極で実施したとすると，これは各季節毎の地球上における定常性の雷雨頻発地区内での雷活動度を監視する有効な方法となる．さらにブリザード時の記録から，極地性低気圧はその内部に電気的に活発な領域を伴うようだという証拠をつかみえた．

1. Introduction

It has been experienced by the members of the Japanese Antarctic Research Expedition at Syowa Station that the observation of VLF emissions is often greatly disturbed by strong atmospherics. The Japanese meteorologists have suggested that the possible origin of atmospherics lies in the active polar low pressures.

The scientific objective of the study is to confirm that the active polar low pressure actually involves an electrical activity. For this purpose, we intended to observe the arrival direction and the occurrence frequency of atmospherics at Syowa Station, and constructed a newly designed self-registering direction finder. In order to separate near-by sources from distant ones, two different receiving frequencies–10 kHz for distant sources and 53 kHz for near-by sources–have been chosen. The observation for distant sources of atmospherics has been carried out by one of the present authors (S. T.), a member of the 10th Japanese Antarctic Research Expedition, and the observation for near-by sources has started in April 1970 at Syowa Station. This paper describes only the results obtained for distant sources.

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2. Method of Observation

Observation was carried out by the advanced direction-finder system of atmospherics. The antenna system was the shielded cross type loop and the one side of a cross loop antenna is oriented in the geographical north-south direction. The antenna was set up at about 100 m apart from the observation room. A newly designed equipment for distant sources is composed of three parts, the uni-direction finding part, the direction read-out part and the registering part. The details of this equipment are reported in the other paper (KAMADA and TOKUDA, 1970). The receiver was adjusted to operate for the atmospherics having the intensity over 1 mV/m, because there was an intention to shorten the receiving distance to the sources of atmospherics as much as possible.

3. Results of Observation

In the early stage, some artificial noise from other equipments in the observation room disturbed the record, but it was reduced by clearing up its origin. Then, the observation was carried out favorably from March 1969 to January 1970 except the time of a breakdown of the equipment.

3.1. Arrival direction of atmospherics at Syowa Station

Data were grouped into four seasons–spring, summer, autumn and winter and were arranged statistically so as to make the month including the vernal equinox, the summer solstice, the autumnal equinox and the winter solstice the representative of each season.

In March, which is autumn in the Southern Hemisphere, most of the arrival directions of atmospherics were located within a range of $\pm 20°$ to the north as shown in Fig. 1 (a). Small peaks existed in the west, the southwest and the east, and the frequency of arrival of atmospherics from those directions showed almost the same percentage. The center of the autumn thunderstorms area in the Southern Hemisphere exists in Central and South Africa in the north of Syowa, South America in the west and southwest, and Southeast Asia in the east. Therefore, the peaks of the frequency distribution curves may be ascribed to the atmospherics from those areas of active thunderstorms.

In June of austral winter, the center of the thunder area in the Southern Hemisphere moved toward the tropical zone of the Northern Hemisphere, but the direction for the origins of atmospherics from Syowa Station is almost the same in autumn. Then the distribution of arrival direction shown in Fig. 1 (b) is almost the same in autumn shown in Fig. 1 (a). The remarkable frequency in

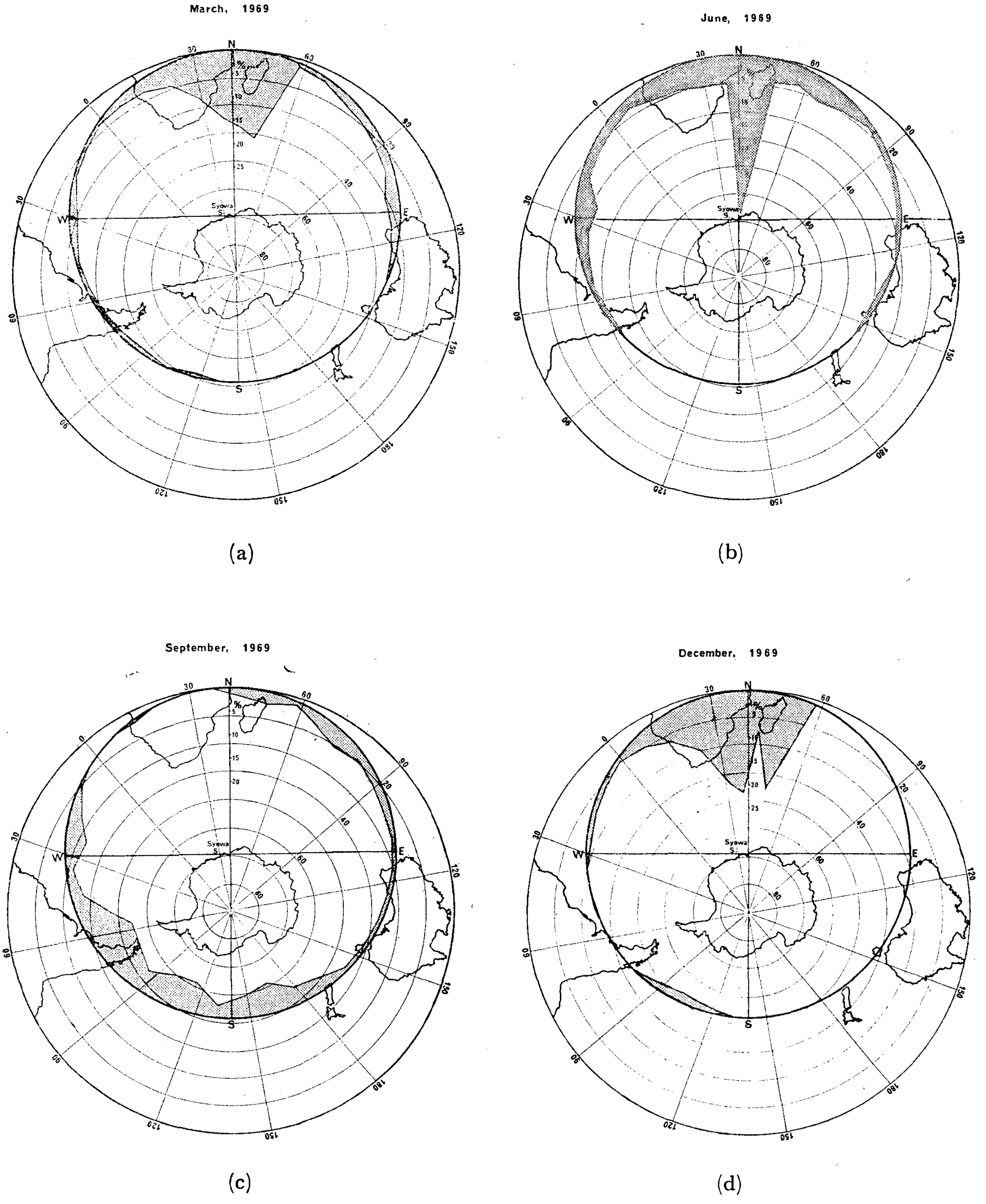


Fig. 1. Monthly average frequency of arrival direction of atmospherics on 10 kHz at Syowa Station, Antarctica.

the north may be due to the origin in Central Africa and the small peak in the west may be due to the origin in the southern part of Brazil in winter season.

In September, spring in the Southern Hemisphere, the center of the thunder area in the Northern Hemisphere moved again toward the Southern Hemisphere, therefore, the direction to the origins of atmospherics from Syowa Station ought to be almost the same in winter and in autumn. But the distribution of arrival direction shown in Fig. 1 (c) is different from the one in winter and in autumn. This distribution shown in Fig. 1 (c) may be attributed to the thunderstorm activity on the earth in 1969. Therefore, the considerable frequency of the arrival of atmospherics from the west to the south shown in Fig. 1 (c) may be explained that the thunderstorm activities in South America, Central America and Southwestern Pacific Basin were greater than the normal year.

In December of austral summer, the center of the thunder area in the Southern Hemisphere moves underneath the area of the Tropic of Capricorn, and then the arrival direction of atmospherics at Syowa Station may be occupied by the nearest origins of atmospherics in South Africa and Madagascal. Thefore, the frequency distribution curve of arrival becomes the one shown in Fig. 1 (d).

3.2. Monthly average diurnal variation of the frequency of atmospherics

The monthly average diurnal variations of the frequency of atmospherics are shown in Fig. 2, indicating the times when the thunderstorms are active at each thunder area in the respective seasons. These results show that the frequency of the atmospherics received at Syowa Station is generally greater in the nighttime than in the daytime. This is mainly because of the favorable conditions of wave propagation in the nighttime and it also indicates that the atmospherics from great distant sources in the nighttime are received fairly frequently at Syowa Station.

The received frequency at Syowa Station was the greatest in summer, the medium in spring and in winter and the smallest in autumn. The reason of the greatest received frequency in summer may be that the center of the thunder area moves underneath the area of Tropic of Capricorn and the distance from Syowa Station to that thunder area becomes shortest all the year round. The result with a fairly high frequency of received atmospherics in the winter season is different from the case of middle latitudes such as Japan. This is because of the fact that, though the distance from Syowa Station to the center of the thunder area on the earth becomes the largest in winter of all seasons, the Antarctic region in winter is always under the nighttime condition which favors the propagation of radio waves from the distant sources.

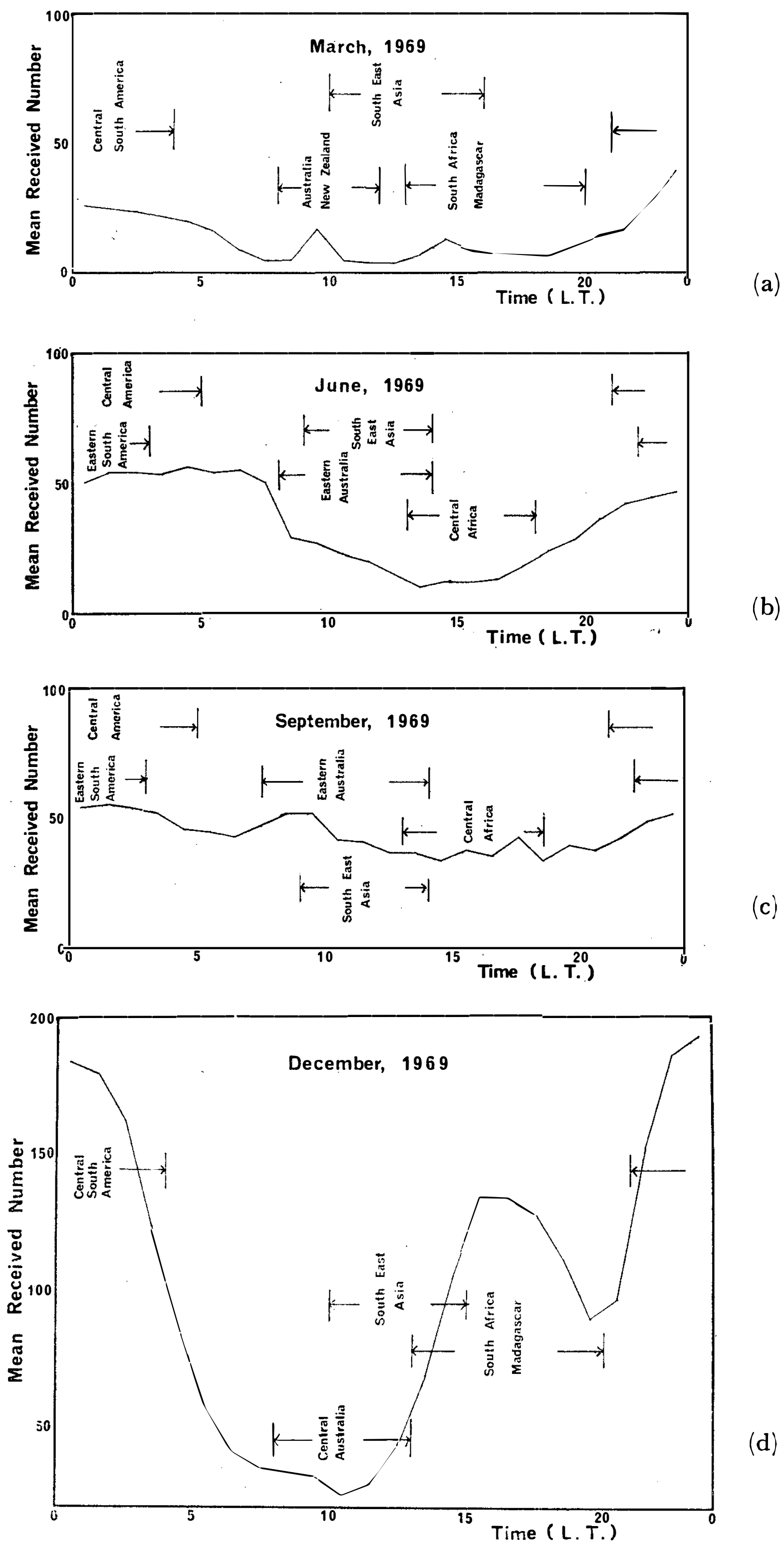


Fig. 2. Monthly average diurnal variation of mean received frequency of atmospherics on 10 kHz at Syowa Station, Antarctica.

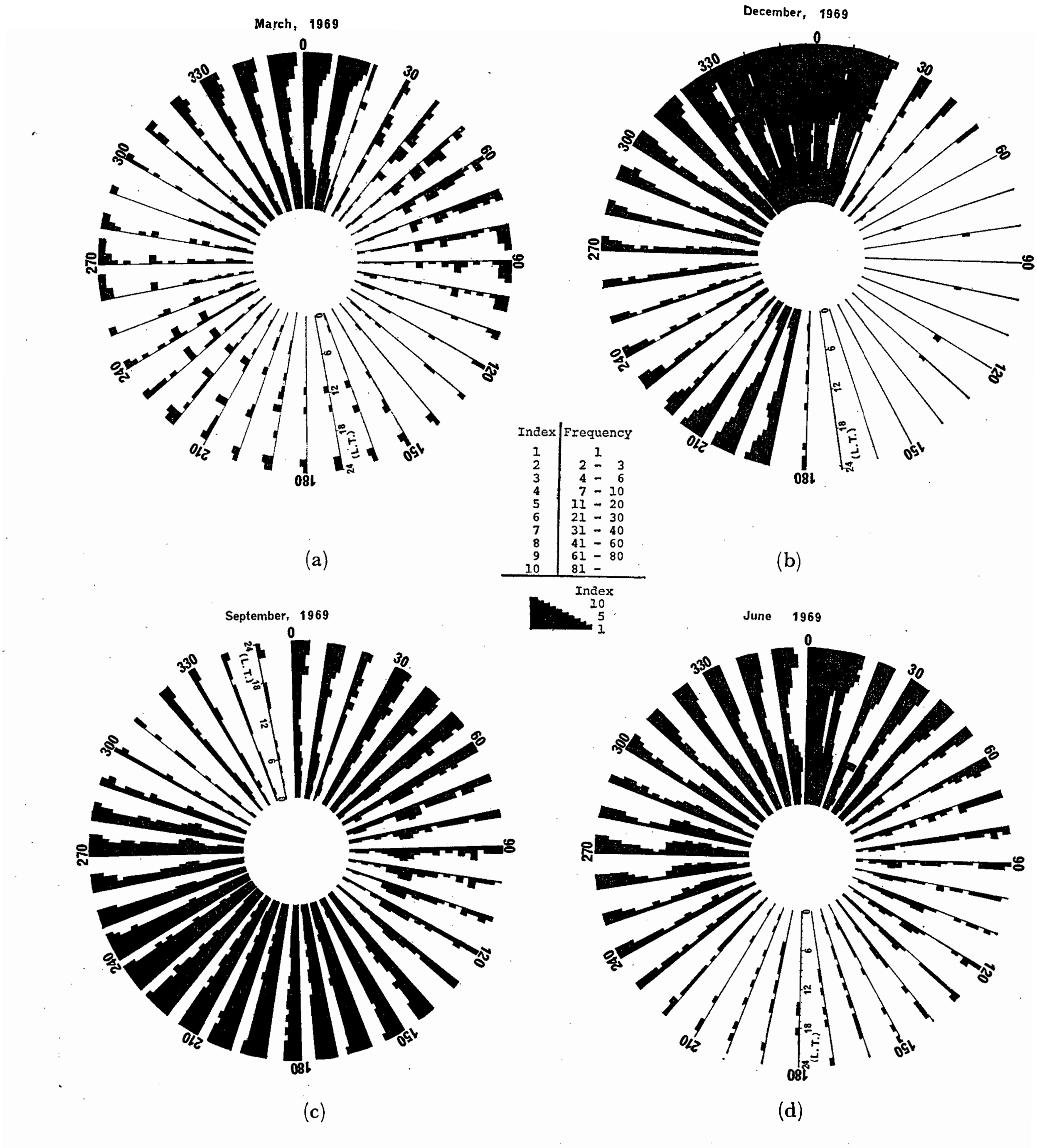


Fig. 3. Monthly average diurnal variation of frequency of atmospherics in each azimuth.

In spring and autumn, the distribution of the distance from Syowa Station to the center of the thunder area is almost the same, but the frequency of received atmospherics is different as shown in Figs. 2 (a) and 2 (c). It probably depends upon the difference in the thunderstorm activity of the thunder area in each season of 1969.

The monthly averages of diurnal variation of the frequency of atmospherics in each azimuth are shown in Fig. 3. From these figures, the diurnal activity in distant origins of atmospherics can be inferred in every season. The above results obtained from the diurnal variations of the frequency of atmospherics at each azimuth seem to indicate that there is a fair chance of watching in Antarctica the diurnal thunderstorm activity in distant sources which are distributed along the equatorial zone in every season.

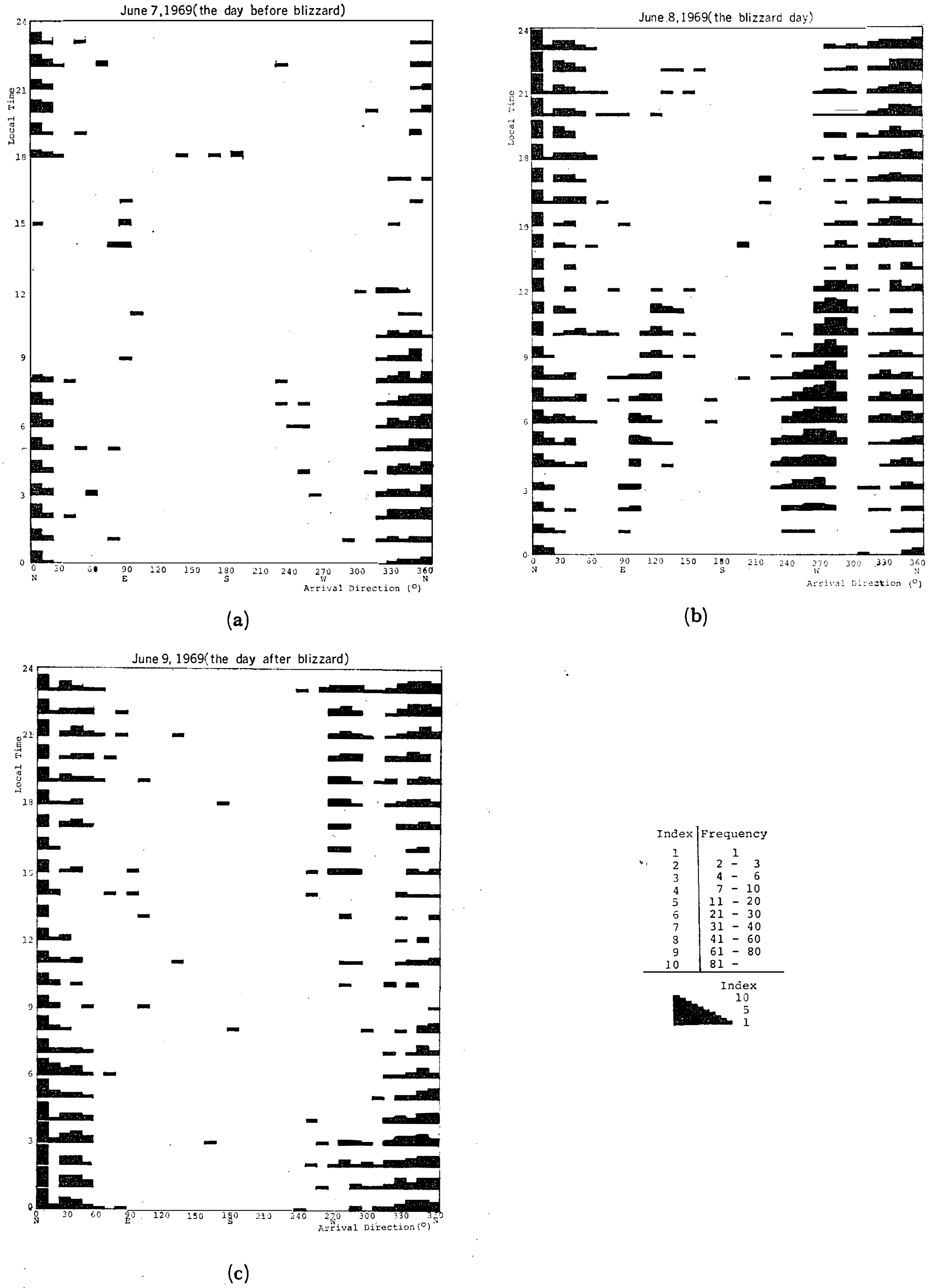
3. 3. Arrival direction and frequency of atmospherics at the time of blizzard

The frequency of atmospherics at the time of blizzard was always sharply increased during the observation periods. An example of the records before and after the time of blizzard in 8 June, 1969 is given in Fig. 4.

Fig. 4 (a) is the record of 7 June, 1969, the day before blizzard. The arrival directions of atmospherics of the day were almost within $\pm 20°$ to the north. Such distributions of the arrival direction of atmospherics are regular in June at Syowa Station as shown in Fig. 1 (b). Those distributions may be attributed to the stationary sources of atmospherics on the earth in winter season. Fig. 4 (b) is the record of the blizzard day, 8 June, 1969, at Syowa Station, which is different from the regular one in winter at Syowa Station shown in Fig. 4 (a), that is, the fairly high frequency of atmospherics was registered in the southwest-by-west direction. As those atmospherics having such arrival direction are characterized by the appearence at the time of blizzard, they are hardly considered as the atmospherics from the stationary sources in winter at Syowa Station. Moreover, there is every indication that those specific atmospherics slowly changed their arrival direction toward the northwest-by-west as shown in Fig. 4 (b). On 9 June, 1969, those specific atmospherics further changed their arrival direction from the northwest-by-west to the north as shown in Fig. 4 (c).

Such a change of the arrival direction of atmospherics indicated a movement of the origin of those specific atmospherics, and consequently it may be presumed that the origin of those specific atmospherics has closely related to the meteorological origin of blizzard.

The appearance and the movement of such a specific origin of atmospherics in the southwest-by-west were evident at the time of every blizzard which occurred at



Index	Frequency
1	1
2	2 - 3
3	4 - 6
4	7 - 10
5	11 - 20
6	21 - 30
7	31 - 40
8	41 - 60
9	61 - 80
10	81 -

Fig. 4. Record of arrival direction and frequency of atmospherics at the time of blizzard.

Syowa Station. As the blizzard has a good correlation with the movement of the polar low pressure area developed within the storm zone, the origin of atmospherics which appeared at the time of blizzard could be supposed to exist in the remarkably developed polar low pressure from this result.

4. Conclusion

The conclusions of the observation on the arrival direction and the frequency of the distant sources of atmospherics at Syowa Station are as follows:

(1) The arrival direction of atmospherics at Syowa Station is mostly the north in almost all seasons. It is explained that active thunder areas, such as Central and South Africa and Madagascal, existed in the northward direction from Syowa Station in all seasons and, what is more, the distance to those areas from Syowa Station is shorter than other thunder areas on the earth in each season.

(2) The frequency of atmospherics received at Syowa Station is the highest in summer season and is higher in nighttime than in daytime.

(3) The frequency of atmospherics at the time of blizzard is sharply increased, which may be due to the origin of atmospherics in the polar low pressure area within the storm zone.

If the reception is carried out with a constant gain, the received frequency of atmospherics is expected to be proportional to the distance from the thunder area, so that the difference of the received frequency, which is caused by the difference of the distance from Syowa Station to the origins of atmospherics, can be compensated. Thus, the simultaneous observation of the arrival direction and the frequency of atmospherics in Antarctica, even if at only one place, would make it possible to watch the diurnal thunderstrom activity in the stationary thunder areas distributed along the equatorial zone. This possibility may play an important role in the watch for the thunderstorm activity on a global scale.

Also, it has become known that at the time of blizzard the polar low pressure may be accompanied by an electrically active region, as was suggested by the meteorologists.

Acknowledgments

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Reference

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