Continuous Measurement of Atmospheric Nitrogen Oxides (NO_x) at Syowa Station in East Antarctica

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南極昭和基地における大気中窒素酸化物（NO_x）の連続測定

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要旨：地球大気の汚染をモニタリングするために，第16次南極観測隊によって，1975年の越冬期間中，昭和基地において大気中の窒素酸化物（NO_x）の連続測定が行われた．その結果，7月初旬から9月中旬にかけて，ブリザード襲来に伴う大気中の窒素酸化物濃度の変化が観測されたが，これは低気圧によって低緯度地方から運ばれてくる空気によるものと思われる．

Abstract: For the purpose of monitoring the global atmospheric air pollution on the earth, the atmospheric nitrogen oxides at Syowa Station in East Antarctica were continuously measured by the 16th Japanese Antarctic Research Expedition (JARE) during the wintering period in 1975. In the period of early July to mid September the regular variation of the atmospheric NO_x concentration was clearly observed whenever a blizzard hits Lützow-Holm Bay. This variation would indicate the possible existence of NO_x compounds that have been transported from the lower latitudes by a cyclone.

1. Introduction

The determination of the atmospheric concentration of nitrogen oxides in global background becomes important in view of the environmental pollution. In the northern hemisphere the anthropogenic and the natural emissions of nitrogen oxides are almost comparable in magnitude, although the contribution of the latter is estimated slightly larger than that of the former (GALBALLY, 1975). Recent measurement at Mauna Loa Observatory (Hawaii) indicates a marked increase in the atmospheric concentration of NO_2 compared with those measured 11 years ago (GOLDMAN, 1975). The polar regions are the most clean parts of the earth, hence the best areas for monitoring the global air pollution. At the beginning of 1975 a program was initiated for the continuous measurement of the atmospheric nitrogen oxides at Syowa Station in East Antarctica by the JARE-16.

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2. Observation Site

Syowa Station is located on East Ongul Island (69°00′S, 39°35′E) in Lützow-Holm Bay, East Antarctica (Fig. 1). The climatic conditions around the

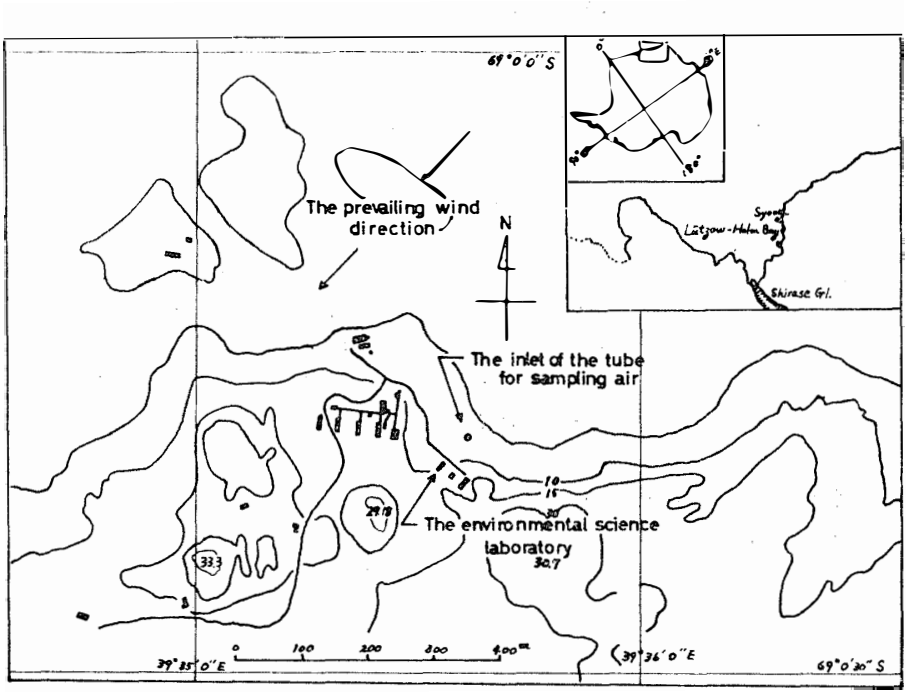

Fig. 1. A sketch map of Syowa Station. Sampling point of air is 30 meters northeast from the environmental science laboratory. This direction corresponds to that of the prevailing wind.

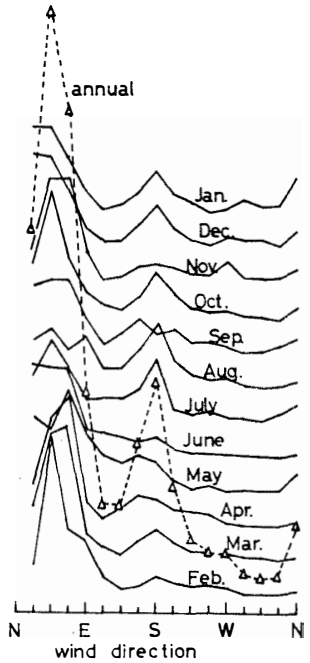

Fig. 2. The frequency of the wind direction. Solid and dotted lines are the monthly and yearly frequencies of the wind direction.

island belongs to the category of Antarctic oases. The average annual atmospheric temperature is −10.6°C and the wind speed is 5.9 m/s from the northeast which prevails (75%) throughout the year (Fig. 2). The southern wind was also often observed when the Antarctic High developed in the winter.

The inlet of the tube for sampling air was placed at a height of 3 m from the ground. This site is 30 meters northeast of the environmental science laboratory of Syowa Station (Fig. 1). As this direction corresponds to that of the prevailing wind, the contamination of NO_x from the station seems to be small.

3. Determination of Nitrogen Oxides

Atmospheric nitrogen oxides were continuously determined with the chemical-luminescence method, the principle of which is based on the following reaction;

$$NO + O_3 = NO_2 + O_2 + h\nu$$

A Toshiba-Beckman type-952 NO_x analyzer was used. In order to determine the total concentration of nitrogen oxides ($NO_x = NO_2 + NO$) the sample air passed through a convertor, decomposing NO_2 to NO. Standard gas (10.07 ppm as NO) was used for the calibration of the instrument. The detection limit was 0.005 ppm.

4. Results and Discussion

4.1. The variation of the atmospheric NO_X when a blizzard hits Lützow-Holm Bay

Figs. 3, 4 and 5 show the results on the variation of the NO_x concentration and of the wind direction in the period between July and September 1975. When a dot-mark, expressing the wind direction, is not indicated in the figures, it means that the weather is calm. It is apparent that, when the weather is calm or the wind blow from the main facilities of Syowa Station, the concentration of the atmospheric NO_x compounds was high. This may be attributable to the contamination from the exhaust of the station. When the prevailing wind, its direction between the north and the east, began to blow, the concentration of NO_x usually decreased. When this wind continued to blow for several days, however, the concentration increased again and then decreased. Such a tendency is clearly found in the data of July 19, 26, August 6, 12 and September 13. Results on the more detail observation of the atmospheric NO_x and the daily meteorology are shown in Figs. 6, 7, 8, 9 and 10. In this period an oceanic depression which often induces blizzard frequently hits Lützow-Holm Bay dominated usually by the Antarctic continental air mass. It is interesting that the appreciable fluctuation

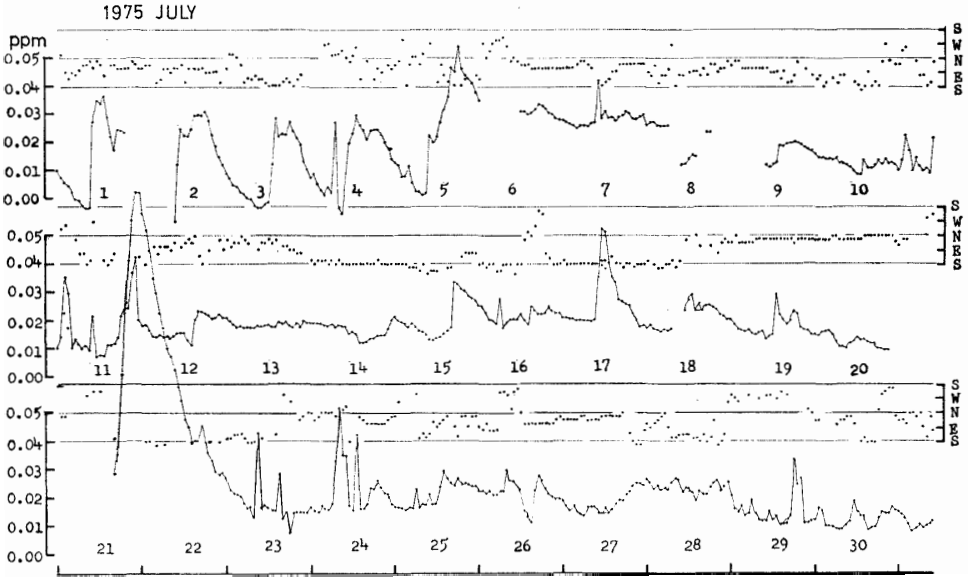

Fig. 3. The variation of the atmospheric NO_x and the wind direction at Syowa Station in July 1975. The dot-mark is the wind direction (right side scale) and the solid line with dots is the variation of the atmospheric NO_x concentration (left side scale).

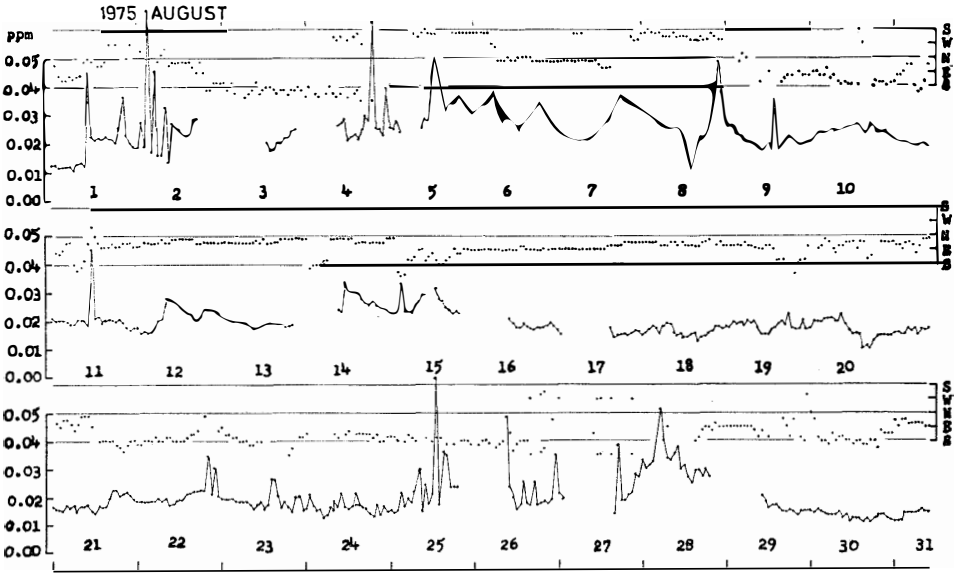

Fig. 4. The variation of the atmospheric NO_x and the wind direction at Syowa Station in August 1975 (Legend is the same as Fig. 3).

of the NO_x concentration was clearly observed throughout the blizzard. This would be caused by the mixture of the atmosphere of the continental air with that of the oceanic air, the former is lower than the latter in the concentration

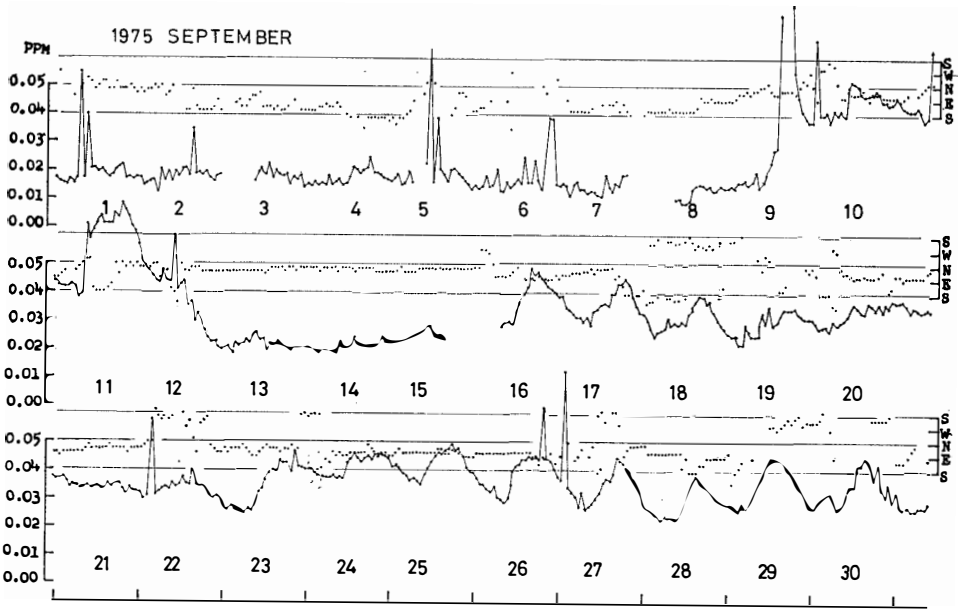

Fig. 5. The variation of the atmospheric NO_x and the wind direction at Syowa Station in September 1975 (Legend is the same as Fig. 3).

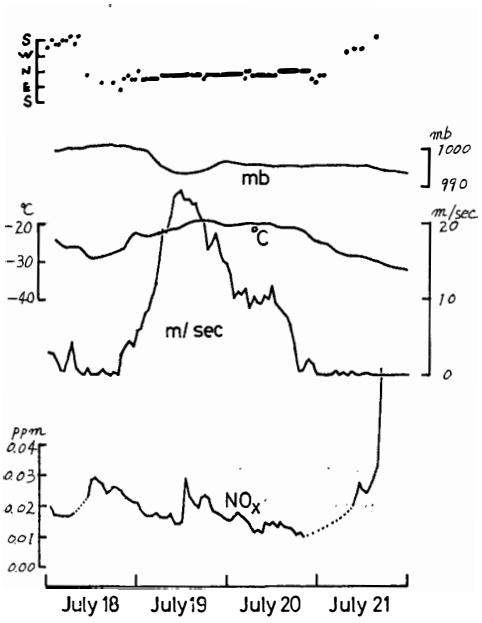

Fig. 6.

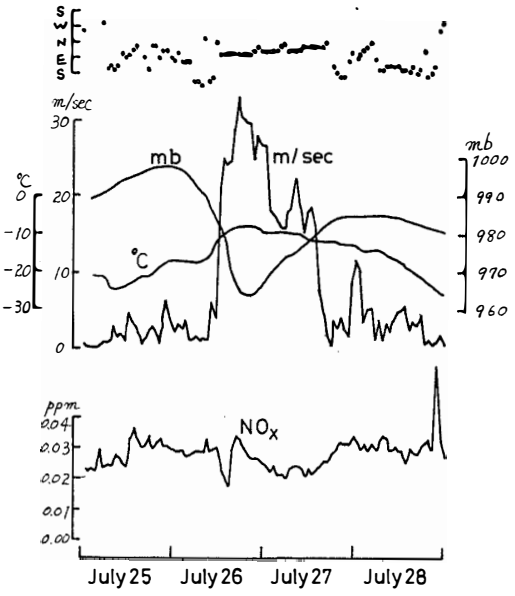

Fig. 7.

Figs. 6, 7. The variation of the atmospheric NO_x and the meteorological data at Syowa Station when a cyclone was passing nearly.

of the atmospheric NO_x. Therefore, in the early stage of the blizzard the concentration of NO_x became lower due to the dilution of the polluted air from the station by the atmosphere of the continental air. In the next stage of the blizzard the curve of the atmospheric NO_x rose and fell with the passage of the depression. From early July to mid September such a variation was always observed. Until

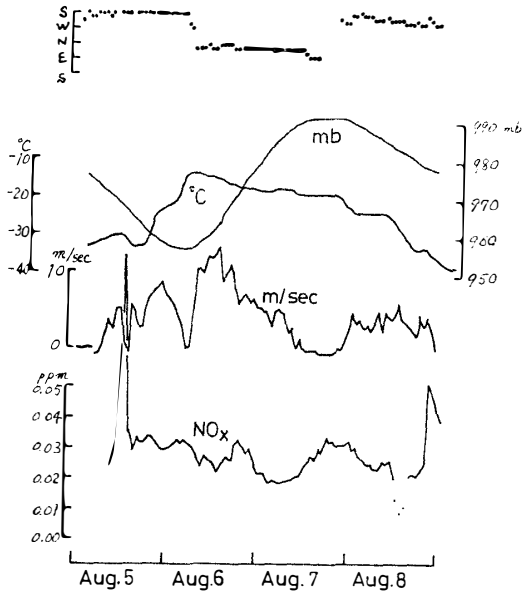

Fig. 8.

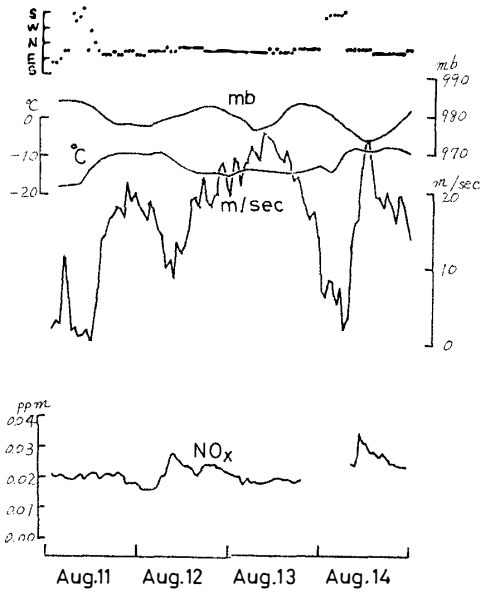

Fig. 9.

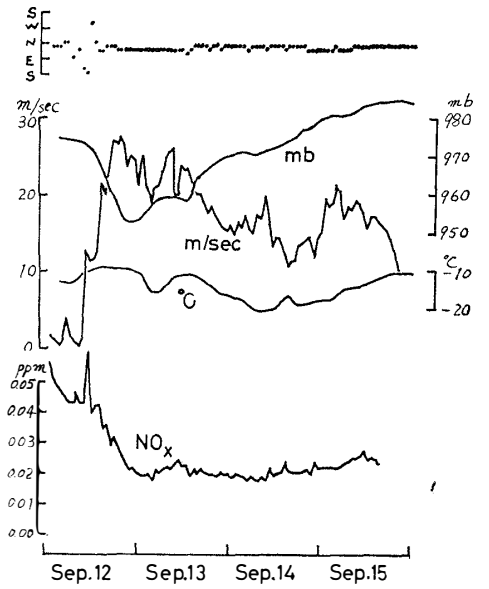

Fig. 10.

Figs. 8, 9, 10. The variation of the atmospheric NOx and the meteorological data at Syowa Station when a cyclone was passing nearly.

early July and from mid September to early October it was impossible to obtain reliable data because of a trouble of the temperature control of the instrument. After early October the variation of the NO_x concentration was never observed, because of the decline of the Antarctic High.

4. 2. The variation of the monthly mean of the atmospheric NO_x concentration and the frequency of the wind direction

Fig. 11 shows the variation of the monthly mean of the atmospheric NO_x

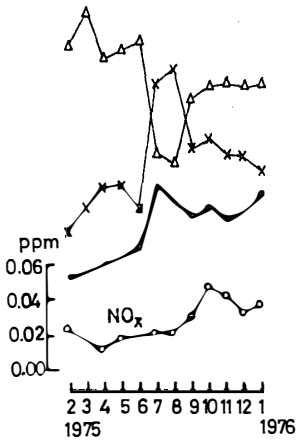

Fig. 11. The variation of the monthly mean values of the atmospheric NO_x and the frequency of the wind direction.

○—○ *The monthly mean value of the atmospheric NO_x.*

△—△ *The prevailing wind (N, NEN, NE, NEE, E).*

×—× *Except for the prevailing wind.*

●—● *The wind speed <1m/s.*

concentration and the frequency of the wind direction. The monthly mean tends to be low in the early period of a year and to be high in the later period of a year. This trend corresponds to that of the frequency of the wind direction except for July and August. That is, although it is impossible to ignore the influence of the polluted air from the station in the period between July and August, the mean concentration in this period is possibly reduced by the high frequency of the south wind from the Antarctic High of the low NO_x concentration.

Annual mean concentration of the atmospheric NO_x was 0.031 ppm. This value is larger than that of Hawaii already reported (GOLDMAN, 1975). This difference may be attributable to the fact that the present value was based on the data slightly influenced by the contamination of NO_x from the station.

5. Conclusion

In the period of early July to mid September 1975, the regular variation of the atmospheric NO_x concentration was clearly observed whenever a blizzard hits Lützow-Holm Bay. This variation would indicate the possible existence of NO_x compounds that have been transported from the lower latitudes by a depression. The annual mean concentration of atmospheric NO_x was determined as 0.031 ppm.

Acknowledgments

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References

GALBALLY, I. E. (1975): Emission of oxides of nitrogen (NO_x) and ammonia from the earth's surface. Tellus, **27**, 67–70.

GOLDMAN, M. A. (1975): NO_2 measurements on the Island of Hawaii. Tellus, **27**, 71–74.