SOME CORRELATIONS BETWEEN OCCURRENCE RATE AND DISPERSIONS OF WHISTLERS AT LOWER LATITUDES AND MAGNETIC K-INDEX

Jinsuke OUTSU & Akira IWAI

Abstract Using the IGY and IGC data of whistlers observed at Toyokawa and Wakkanai during the period of July, 1957 to April, 1961 variations of some normalized occurrence rate and dispersions of whistlers have been statistically examined for periods of severe magnetic disturbance. It has been found that the rate begins to rise one day after the disturbed day and continues to rise for about two days after and the peak of rate is far greater for Toyokawa than for Wakkanai. Dispersions are found to continue to decrease from several days before until one day after the disturbed day and the decrement in dispersion is nearly 25 per cent. Variations of daily sum of k-index during both periods when the occurrence rate of whistlers increased very much and decreased very much have been also investigated. The results obtained in this case are also consistent with the first case.

Introduction

It has been already established that whistlers originate in a lightning discharge and propagate approximately along the earth's magnetic field in the ionized medium around the earth, so that the occurrence number of whistlers can be supposed to depend mainly on thunder-storm activity in source regions of whistlers and on the propagation condition in the ionized medium around the earth.

In fact, an observational fact that marked seasonal variations in the occurrence rate of whistlers correspond well to the seasonal variation of thunder-storm activity in the assumed source-regions of whistlers strongly suggests that the most influential factor on the occurrence rate is the thunder-storm activity in the source-regions of whistlers.

However, the highest rate of whistlers has been found not in low latitudes where the thunder-storm has been thought to happen most frequently, but in geomagnetic latitudes about 45 to 50 degrees. (Helliwell,[1] 1960; Crouchley,[2] 1961). This indicates that the propagation condition is also an important factor in controlling the rate of whistlers. Hence, during a magnetically active period, if some change is caused in the physical state of the ionized medium around the earth, the propagation condition will be modified and the effect will be expected on the occurrence rate and dispersions of whistlers. In fact, some cases have been found that the occurece rate of whistlers at

Wakkanai very sharply increased during periods of severe magnetic disturbance.

One of the purposes of this work is to examine how the occurrence rate and dispersions of whistlers at lower geomagnetic latitudes changed during periods of severe magnetic disturbance and another purpose is to know how the daily sum of k-index varied during both periods when the occurrence rate decreased much and increased much.

The data of whistlers used here were obtained from the observations made at Toyokawa (TO, geomag. lat. 24°) and Wakkanai (WK, geomag. lat. 35°) according to the IGY and IGC programme during the period July, 1957 to April, 1961 and the data of k-index were taken from the report of Kakioka Geomagnetic Observatory.

I. Variation of occurrence rate of whistlers during periods of severe magnetic disturbance

As days of severe magnetic disturbance fourteen days were picked up during the period of July, 1957 to April, 1961 on which the daily sum of k-index amounted to a value no less than 40. They are listed in Table 1.

Table I Date of Severe Magnetic Distabance

Date	Sum of K-index
3 Sep. 1957 4 Sep. 1957	mean 41
13 Sep. 1957	47
23 Sep. 1957	42 *
29 Sep. 1957	42 *
11 Feb. 1958	54 *
8 Jul. 1958	47
15 Jul. 1959	47
16 Aug. 1959	43
31 Mar. 1960 1 Apr. 1960	mean 47
30 Apr. 1960	48
5 Sep. 1960	42
6 Oct. 1960 7 Oct. 1960	mean 43.5*
13 Nov. 1960	54 *
1 Dec. 1960	42 *

* picked up for dispersion study

Since the occurrence rate changes greatly with the season a normalized occurrence rate was adopted insted of the occurrence rate itself which expressed the number of occurrence per day. The normalization factor is the mean value of occurrence rate during a period of about a month, the middle day of which is the disturbed day for the period. To use the normalized occurrence rate thus defined seems to be a way to diminish the seasonal effect on the whistler occurrence. A total of fourteen for Wakkanai and thirteen for Toyokawa of the normalized occurrence rate have been averaged for each day during a period of nine days which begings four days before and ends four days after each disturbed day.

The results obtained are shown in Fig. 1. From these curves the following are seen;

1. For both stations the rate begings to increase sharply one day afer the disturbed day and the rise continues for about three days.

2. The peak of the rate appears one and two days lagging behind the disturbed day for Toyokawa and Wakkanai, respectively. The

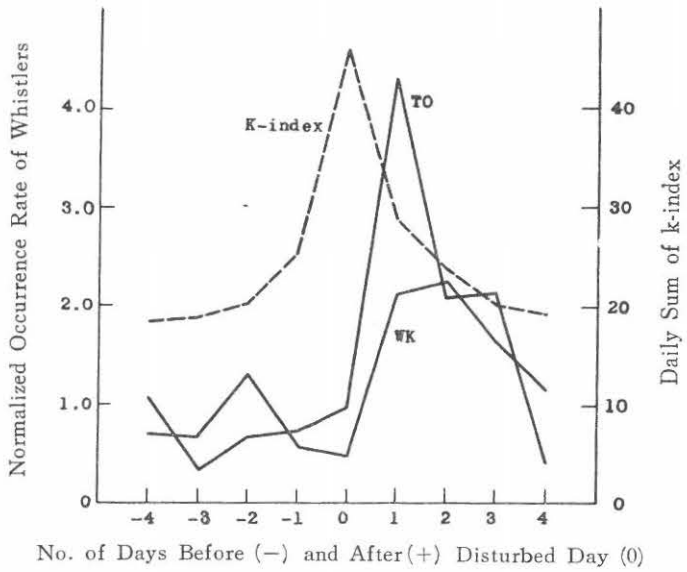

Fig. 1 Variations of normalized occurrence rate of whistlers before and after magnetically severely disturbed day

Fourteen cases of severe magnetic disturbance have been taken during the period of Jul., 1957 to Apr., 1961 and the occurrence rate for these cases have been averaged.

magnitude of the peak is about 4.3 for Toyokawa and 2.3 for Wakkanai, so it is far greater for Toyokawa than for Wakkanai.

II. Variations of daily sum of k-index during active periods of whistlers

The daily sum of k-index has been statistically studied for a period of seven days which begins four days before and ends two days after each day selected as an active or as an inactive day in the occurrence of whistlers. As in the previous case the occurrence rate has been normalized. But in this case the normalizing factor is the monthly mean of occurrence rate in each month. In general, the active and the inactive days were respectively determined by a conditicn where the normalized occurrence rate was not less than five and not greater than one-fifth. Besides, the days where the occurrence rate was not less than 100 and 500 respectively for Toyokawa and Wakkanai, were also taken as active days. But all the months were omitted that had a monthly mean of less than one, though such a case occurred only for Toyokawa, because in such a month almost all the days came into the category of inactive days.

The results obtained are indicated by the curves in Fig. 2; the solid and dashed

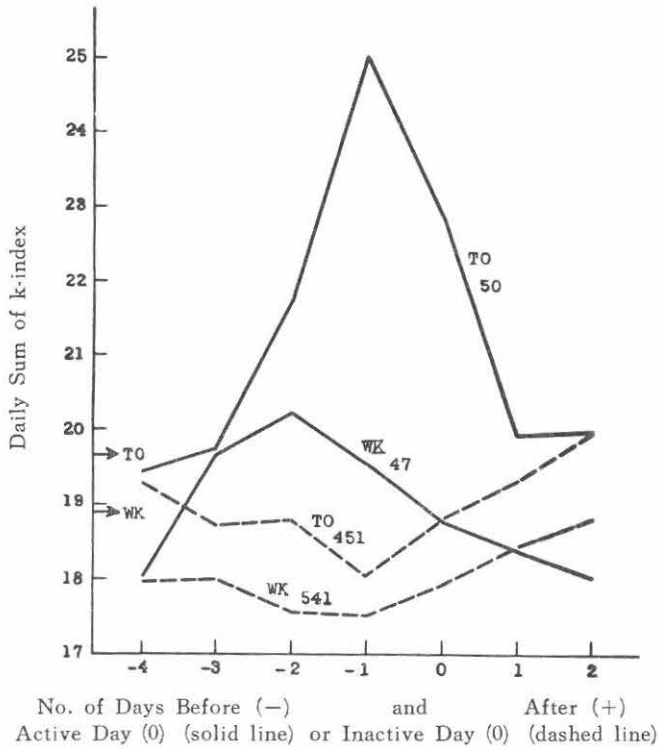

Fig. 2 Variations of daily sum of k-index before and after whistler active day and whistler inactive day

The whistler active days and inactive days have been taken during the period of Jul., 1957 to Apr., 1961 according to certain conditions. The arrow marks on the left side of this Figure indicate the averaged level of daily sum of k-index for Toyokawa (TO) and Wakkanai (WK) and the numbers above each line show the data number used.

curves correpond to active and inactive periods, respectively and the number immediately above each curve shows the number of data used. And the arrow marks in the Figure indicate the mean value of daily sum of k-index through all months adopted for Toyokawa and Wakkanai. From these curves the following are know;

1. Daily sum of k-index is much greater during the active period than during the inactive period of whistlers and it is much greater for Toyokawa than for Wakkanai.

2. The peak of daily sum of k-index takes place one and two days before the active day for Toyokawa and Wakkanai, respectively, and it is far steeper for Toyokawa.

3. During inactive period the variation of daily sum of k-index is comparatively small and a minimum occurrs one day before the inactive day for both stations.

4. For both stations daily sum of k-index for active period is greater than the mean value through all months adopted, while that for inactive period is smaller than the mean value.

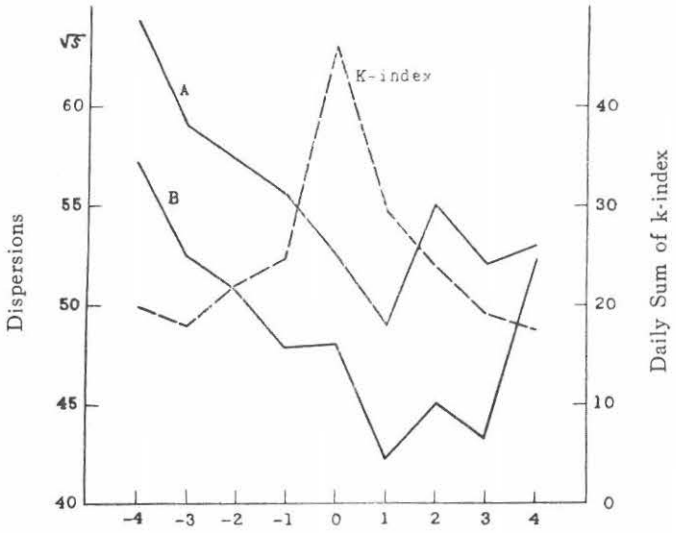

Fig. 3 Variations of whistler dispersions before and after magnetically severely disturbed day: Wakkanai

Out of the fourteen disturbances during the period of Jul., 1957 to Apr., 1961 six cases have been picked up and averaged which are suitable for this study of dispersions.

A: day time group (9005 to 1950 JST)
B: night time group (2005 to 0850 JST)

III. Variations of dispersions during periods of severe magnetic disturbance

Dispersions of whistlers during periods of severe magnetic disturbance have been statistically studied for nine days before and after each disturbed day just as in Chapter 1. But in this case six were taken from the above fourteen disturbed periods, which are suitable for the examination of dispersions and the data of Wakkanai only have been used, for those of Toyokawa are insufficient in number. As has been reported by the authors[3] (1957) dispersions at lower latitudes change from day time to night time, so they have been divided into a night time group (2005 to 8050 JST) and a day time group (9005 to 1950 JST).

The results obtained are indicated in Fig. 3. From these curves it can be seen that the value of dispersions continue to decrease from the earliest day in the Figure and they reach minimum one day after the disturbed day and then they begin to rise comparatively slowly. The difference between maximum and minimum values of dispersions are about $15\sqrt{s}$ for both groups, but the ratios of maximum to minimum values are about 0.76 and 0.74 for the night time and the day time groups, respectively. If we

assume the propagation path and the shape of the electron density along the path not to change through these periods such a diminution in dispersions corresponds to a uniform decrement of electron density of about 44 per cent.

IV. Conclusions

At geomagnetically lower latitudes the following may be concluded in a statistical sense.

A severe magnetic disturbance begins to affect positively the daily sum of whistlers, expressed in a normalized form, from one day after the severely disturbed day and it's effect continues for about three days. The maximum effect appears one or two days after the disturbance and it seems to become greater as the geomagnetic latitude lowers. In short, the activity of whistlers rises during a decreasing phase after passing the maximum in magnetic activity. This conclusion is also supproted by results obtained in examining how the magnetic activity, measured by the daily sum of k-index, corresponds to active and inactive periods in the occurrence of whistlers. During a period of severe magnetic disturbance dispersions of whistlers begin to decrease several days before the severely disturbed day and the decreasing tendency continues through the increasing phase of magnetic activity until one day after the severely disturbed day, then dispersions tnrn to rise slowly. In the case of present work the diminution of dispersions is not smaller than 24 (day time) and 26 (night time) per cent.

Authors wish to express our sincer thanks to Prof. A. Kimpara, Director of their Research Institute for his incessant encouragement.

References

1. Helliwell, R.A. : J. Research NBS 64D (1960) 642
2. Crouchley, J. : Aust. J. Phys. 14 (1961) 22
3. Iwai, A., and Outsu, J. : Proc. Res. Inst. Atmos. 5 (1958) 53