WHISTLER PROPAGATION IN MAGNETICALLY DISTURBED PERIODS AT TWO LOWER LATITUDES

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Abstract

Using the data of whistlers observed at Wakkanai during the period January 1959 to November 1962 and at Moshiri during the period December 1962 to December 1966, the variations of occurrence rate, and of dispersion, of whistlers have been individually examined for eleven magnetic storms. It is found that whistler occurrence rises rapidly from the beginning of a magnetic storm and reaches a maximum one to three days after the date when $\sum K_p$ attained a maximum, and whistler activity lasts about a few days. Dispersion of whistlers on these occasions has been found to decrease gradually by about 10—20 $sec^{\frac{1}{2}}$.

1. Introduction

The whistler activity is thought to depend on the propagation condition in the exosphere as well as on the thunder-storm activity in source region of whistlers. While the source of whistlers has nothing to do with geomagnetic activities, the propagation condition of whistlers may be modified by the activities. If there would be some changes of physical state appearing in the exosphere during the periods of geomagnetic disturbances, its effect would be expected on the occurrence rate, and on the dispersion, of whistlers.

Outsu and Iwai (1962 a, b) investigated the variation of whistler activity at Toyokawa and Wakkanai during severe geomagnetic storms, and showed that the whistler activity is enhanced 1—2 days after the storm day.

Yoshida and Hatanaka (1962) reported the latitude effect of the dependence of whistler rate upon the K_p index of the world-wide geomagnetic disturbance during the IGY-IGC.

Maeda (1962) reviewed the fundamental features of whistlers and VLF emissions and studied their important characteristics in disturbed days.

Laaspere et al. (1963) suggested that there might be a link between spread-F irregularity and magnetospheric whistler duct, both being produced by the same cause.

Recently Allcock (1966) has examined the relationship between whistler propagation and geomagnetic activity using the data for winter nights at middle and high latitudes. He has shown that the whistler activity reached a maximum when the planetary magnetic index, K_p attained to a certain level.

In this paper we re-examine the effect of magnetic storms upon the whistler propagation at lower latitudes. The whistler data used here are those obtained from the observations at Wakkanai (WK, geomag.lat. 35°N) and Moshiri (MO, geomag. lat. 34°N) during the period January 1959 to December 1966. 22 severe storms whose changes in horizontal component of the geomagnetic field ΔH were larger than 200 γ are picked up from the report of Kakioka Geomagnetic Observatory.

2. Daily sum of K_p index and geomagnetic activity

Twenty two geomagnetic disturbances are picked up, whose ΔH exceeded 200γ and they are listed in Table 1. The magnetic storms thus selected followed ssc or ssc* except for two occasions. In Table 1, the degree of storm activity is represented by s or ms, where s means a severe storm with maximal K 8 or 9, and ms a moderately severe storm with maximal K 6 or 7. Of the twenty two magnetic storms, only eleven cases are analysed, because the number of whistlers observed was very limited supposedly due to the weak thunder-storm activity in the southern hemisphere. The eleven storms are shown in Figs. 1—11. In these figures, O on the abscissa indicates the commencement day of a magnetic storm and its date is shown at the top of each of them. The symbols + and − indicate the number of days after and before the storm commencement day, respectively. We adopt planetary magnetic index K_p as a measure of geomagngtic activity rather than K index, because whistlers propagate in the magnetosphere.

From these figures, we obtain the following results.

1) The daily sum of K_p index ($\sum K_p$) is very enhanced during two to three days period of each of the eleven selected storms and its peak in the eleven storms is found to exceed forty for almost all of the storms.
2) The peak of the daily sum of K_p index occurs on the day when the geomagnetic storm is found in a period from the later part of a main phase to the last phase.

Table 1. List of severe magnetic disturbances ($\Delta H > 200\gamma$ at Kakioka)

Date		Type	ΔH in γ	Deg. of activity
1959	Feb. 25	—	227	ms
	Mar. 26	ssc*	274	ms
	Jul. 15	ssc*	533	ms
	Jul. 17	ssc	330	ms
	Aug. 16	ssc*	248	ms
	Nov. 27	ssc*	218	ms
1960	Mar. 31	ssc	319	s
	Apr. 30	ssc*	380	ms
	Aug. 29	ssc*	206	ms
	Sep. 4	ssc*	271	ms
	Oct. 6	ssc	221	ms
	Nov. 12	ssc	417	s
	Nov. 15	ssc	225	ms
1961	Mar. 9	ssc*	246	ms
	Jul. 13	ssc	334	ms
	Jul. 26	ssc	261	ms
	Sep. 30	ssc*	318	ms
	Oct. 28	ssc*	244	ms
1963	Sep. 21	ssc*	275	ms
	Oct. 23	—	206	ms
1965	Apr. 17	ssc	278	ms
1966	Sep. 3	ssc	284	ms

3. Whistler occurrence rate and geomagnetic activity

Allcock (1966) showed that the parameters 'whistler rate' as well as 'percentage occurrence' are the good indicators for representing the propagation conditions. Whistler occurrence rate is given by the number of whistlers observed in a day and the rate has been individually studied for the eleven magnetic storms. To estimate the time lag effect of a magnetic storm on whistler rate, we pick up several days before and after the storm commencement day. In Figs. 1—11, the solid lines show the daily variation of the whistler occurrence during the several days before and after the storm commencement day.

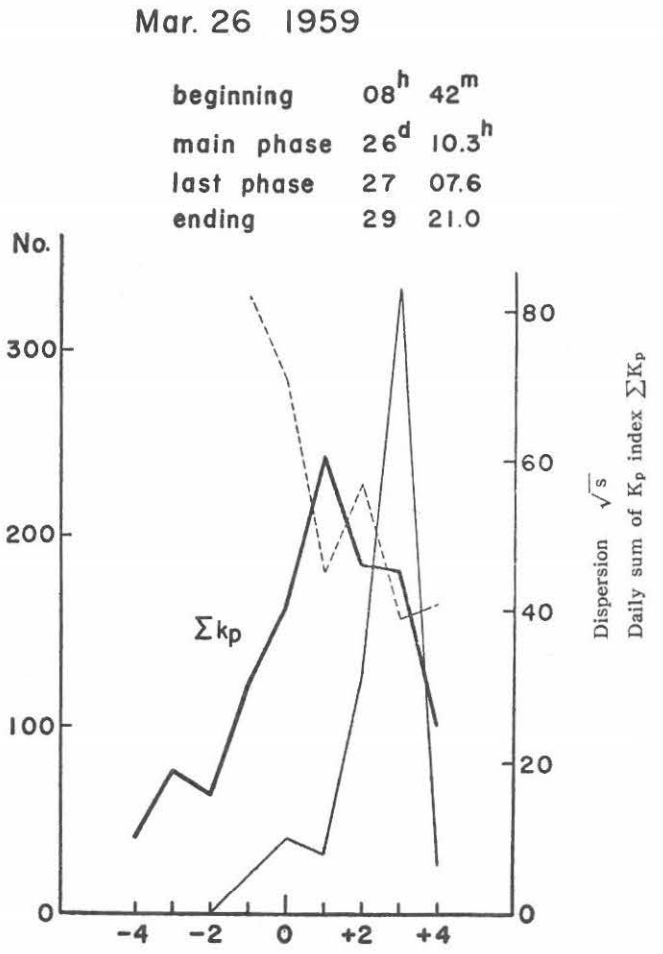

Fig. 2 Magnetic strom on Mar. 26 1959

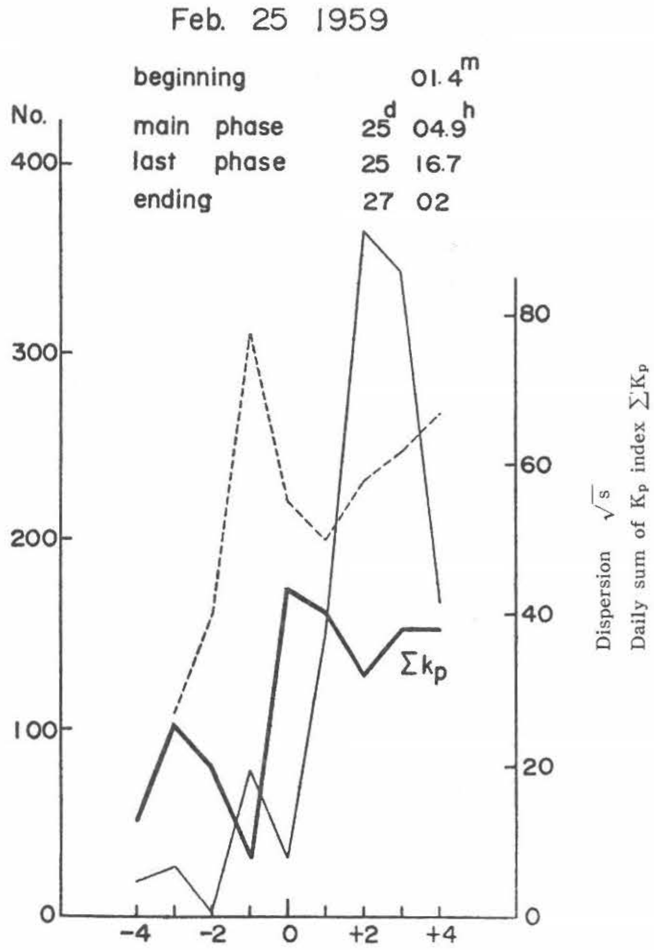

Fig. 1 Magnetic storm on Feb. 25 1959
solid line : whistler occurrence rate,
broken line : whistler dispersion

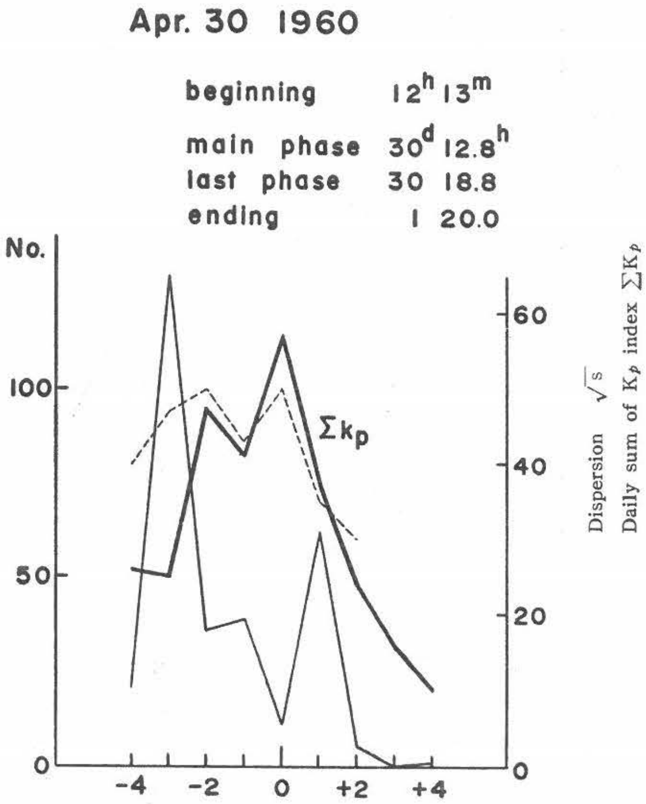

Fig. 4 Magnetic storm on Apr. 30 1960

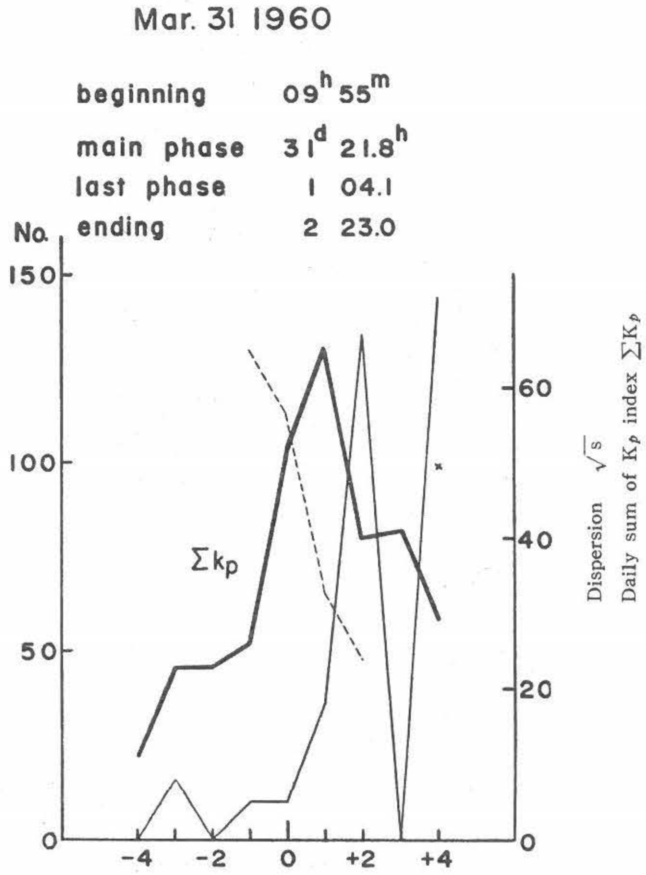

Fig. 3 Magnetic storm on Mar. 31 1960

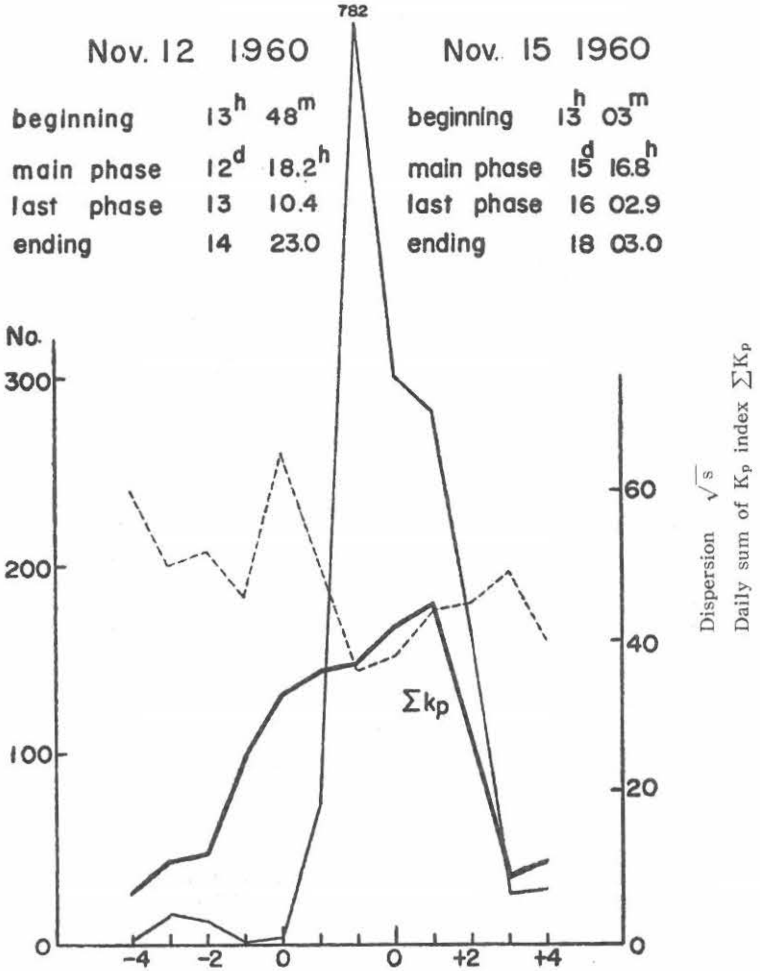

Fig. 6 Magnetic storm on Nov. 12 and 15 1960

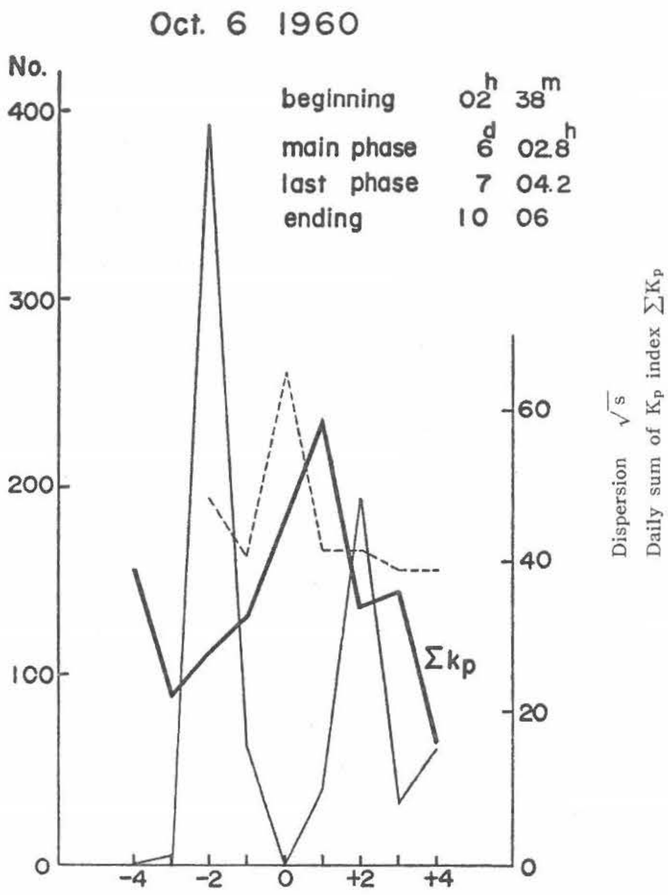

Fig. 5 Magnetic storm on Oct. 6 1960

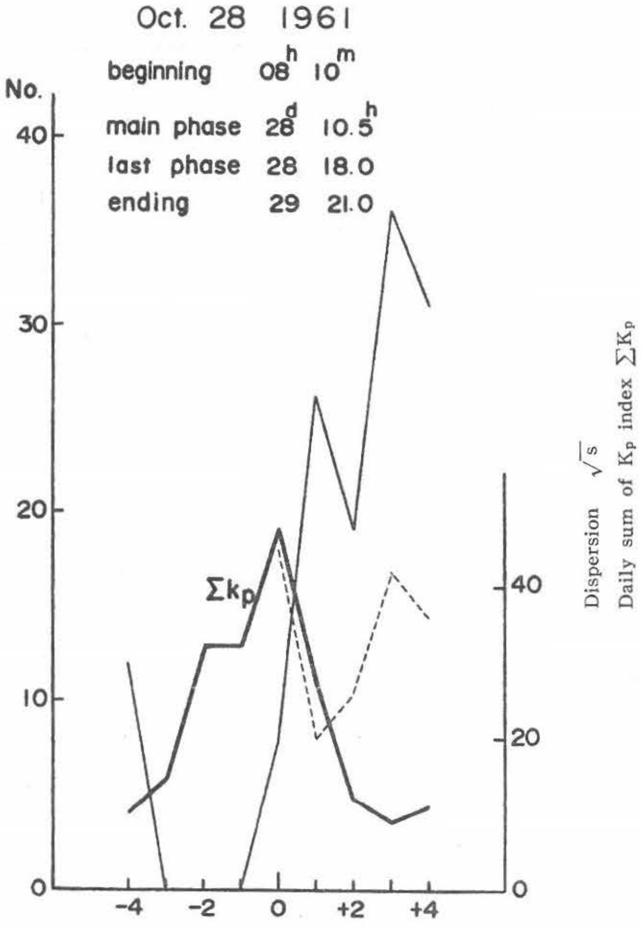

Fig. 8 Magnetic storm on Oct. 28 1961

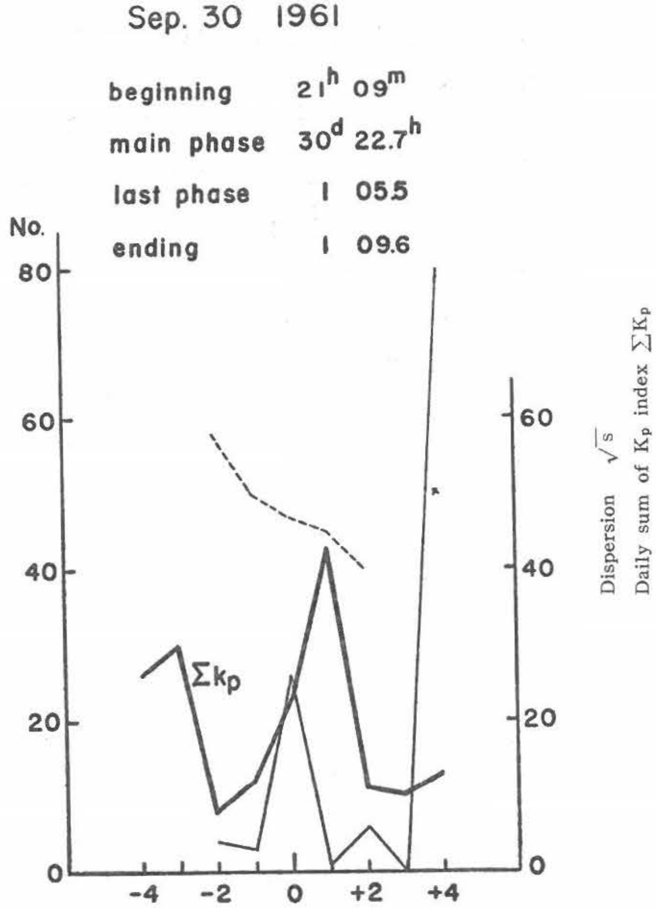

Fig. 7 Magnetic storm on Sep. 30 1961

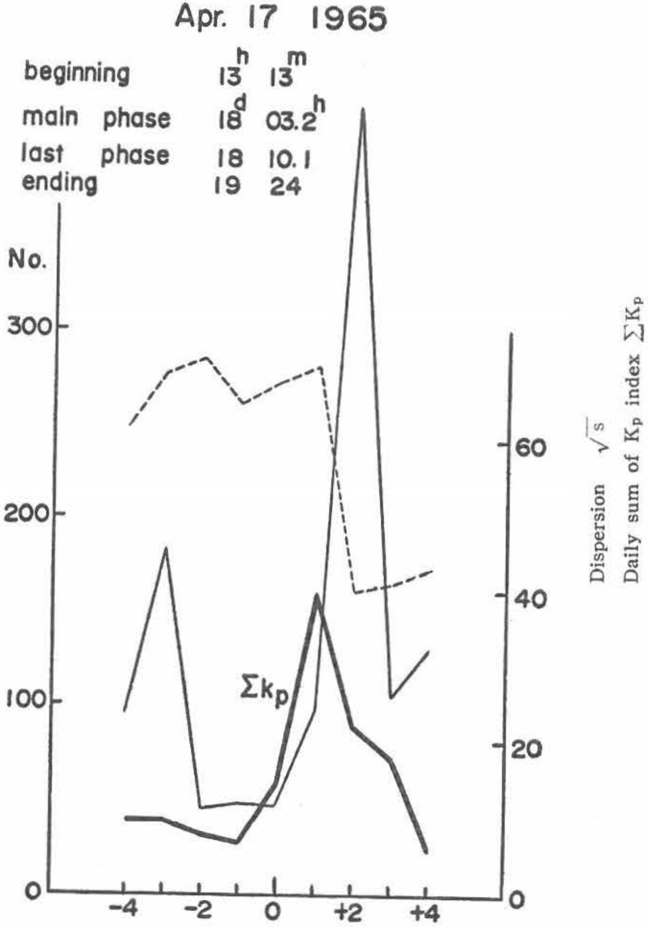

Fig. 10 Magnetic storm on Apr. 17 1965

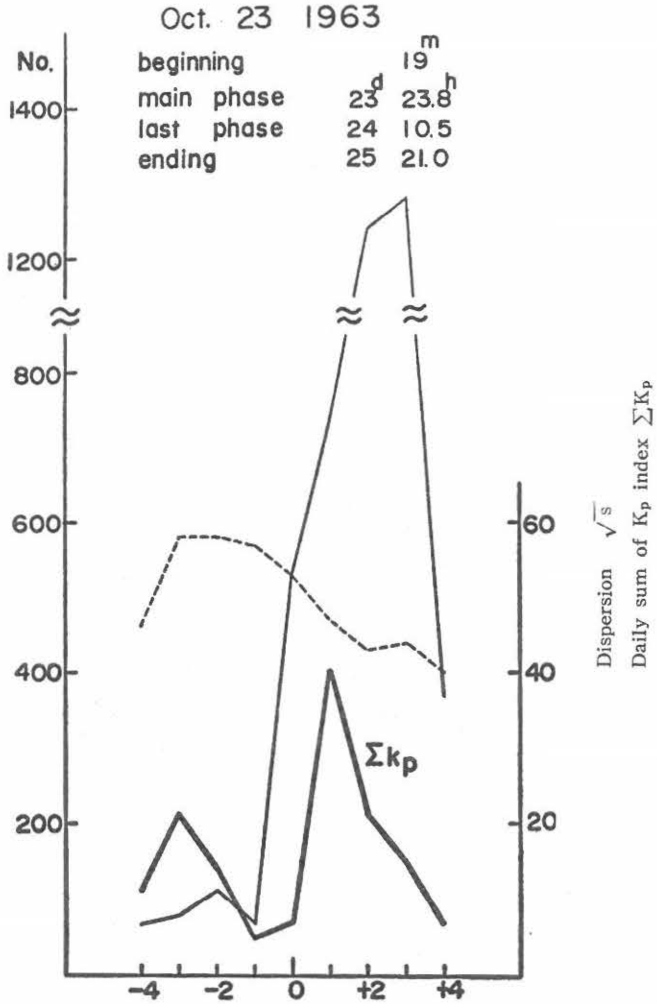

Fig. 9 Magnetic storm on Oct. 23 1963

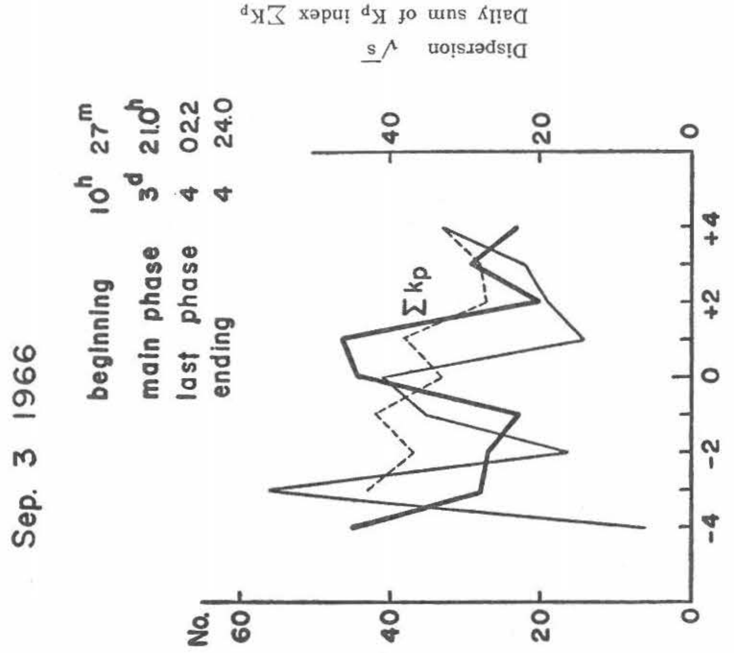

Fig. 11 Magnetic storm on Sep. 3 1966

Following facts have been found from the figures.

1) The whistler occurrence rate for about 80% of the selected storms continue to increase sharply from the first to the second day after the beginning of magnetic storms and decrease thereafter.
2) The peak of whistler occurrence rate appears one to three days after the date when the daily sum of K_p index reaches a maximum.
3) The enhancement of whistler occurrence rate lasts about two or three days around the date when the peak occurrence appears.
4) The ratio of the whistler occurrence rate on the severe storm days to that on magnetically quiet days is found to be about 5, and in very extreme cases the ratio reached 10.

4. Whistler dispersion and geomagnetic activity

We have investigated the dispersion of whistlers during severe storm days. It is well known that the dispersion of whistlers is given by

$$D=\frac{1}{2c}\int_{path}\frac{f_p}{\sqrt{f_H}}ds$$

where f_p and f_H are a plasma frequency and an electronic gyro-frequency, respectively, and the integration is carried out along the path a whistler propagates.

Therefore the dispersion is affected by electron density distribution, propagation path length, etc.. So the investigation of characteristics of the dispersion (D) in quiet, and disturbed, periods will be useful to the study of the mechanism of formation and decay of the ducts which control the whistler propagation.

In Figs. 1—11, the broken lines show the daily variation of the dispersion of whistlers. But when the whistler data are insufficient in number, the dispersion curves are not drawn in the figures.

From the figures, we can show the following results.

1) The whistler dispersion is found to decrease around the beginning of the storms.
2) A minimum of the dispersion appears around two days after the date when the daily sum of K_p index comes to a maximum and thereafter the dispersion increases gradually.
3) The difference between normal and minimum values of dispersions is about 20 $\sqrt{\text{sec}}$.

5. Discussion and conclusion

Investigating the whistler activity in lower latitudes, we have reached a conclusion that there is an enhancement of whistler activity one to three days after the commencement of a severe magnetic storm. This phenomenon is likely a characteristic feature in low latitudes, but it is not so clear in middle or high latitudes as in low latitudes. The dispersion of whistlers has been found, in majority of cases, to decrease around the beginning of a magnetic storm and reach a minimum around two days after the date when the daily sum of K_p index attains a maximum, thereafter it increases gradually.

These results obtained above may be interpreted, if we assume the following mechanism that disturbances produced in ionosphere, and in magnetosphere, during a severe magnetic storm, form the whistler duct which is believed to be an enhancement of electron density along a magnetic line of force, and the disturbances which result in producing the ducts, occur one to three days after ssc of a magnetic storm, or after a maximum of the daily sum of K_p index.

Accordingly whistler study is expected to be one of the useful tools to solve the dynamics in ionosphere, and in magnetosphere, in the transition periods between magnetically disturbed, and quiet, conditions. The theoretical investigation of the mechanisms of formation and decay of whistler ducts is a future problem.

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