Some Statistical Properties of ssc Storms at Kakioka

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Abstract

The frequency distributions of such quantities as usually reported in tables of magnetic storm are examined, based on the recent data at Kakioka. The frequency distribution of the rise time of ssc's may be different from that obtained from the old data.

The relations among the amplitude, the rise time, the maximal K, the range etc. at Memambetsu, Kakioka and Kanoya are examined. The main results are as follows. 1) The larger the amplitude of ssc's, the larger the maximal K and/or the range of storms. 2) Any relation between the amplitude of ssc's and the duration of the initial phase is obscure. 3) The relation between the amplitude and the rise time of ssc's in middle latitude is different from those in low latitudes and in high latitudes. 4) The relation between the range and the maximal K can be represented by the formula $y = ae^{bx}$.

Introduction

A typical magnetic storm begins suddenly and simultaneously all over the world within about half a minute. The sudden commencement of a magnetic storm (ssc) is very clearly seen at middle and low latitudes, and an abrupt change in the horizontal component is generally positive in low latitudes(1). The increase in H amounts to 10–100γ, and the time interval from the beginning to the final stage of an ssc is several minutes. The abrupt changes of declination and vertical component are also recognized simultaneously.

In high latitudes, the irregular disturbances are of considerable magnitude and ssc's are not always distinguishable. Moreover, in high latitudes, a change in H is not always positive.

After an ssc, the horizontal component is for some hours above the pre-storm level and then begins to decrease. This stage is called the main phase and lasts about half a day. The final stage is the recovery of H to its pre-storm level. Usually, the maximum K and range of storm are reported together with occurrence time of each stage, magnitude and rise time of ssc in each component, and quality.

For a long time, magnetic storms and ssc's have been researched from the various stand points of view at many observatories over the world and many facts have been clarified.

The characters of them at Kakioka were also examined by some authors. Among them, Y. Yokouchi examined statistically such quantities of storms as usually reported, using the data for the period from 1924 to 1951(2).

Also, H. Maeda et al. studied some statistical relations among characteristic quantities such as the amplitude, the rise time, the magnitude and the duration of the initial phase and the main phase etc., which are the average values based on the data at some observatories in low latitudes or high latitudes for the IGY and IGC(3).

In this paper, some statistical characters are presented on the basis of the recent data at Kakioka (geom. latitude: 26.0°, geom. longitude: 206.1°), Memambetsu (geom. latitude: 34.0°, geom. longitude: 208.4°) and Kanoya (geom. latitude: 20.5°, geom. longitude: 198.1°).

§1 Frequency distribution and mean value

We picked up ssc storms at Kakioka during the period from July 1957 to 1966 from the tables of magnetic storms in the "Report of the Geomagnetic and Geoelectric Observations", published by the Kakioka Magnetic Observatory, then the frequency distributions of the amplitude, the rise time, the maximal K and the range were examined for the events of each quality and all the events. The definition of the quality is given by IAGA as follows; A: very remarkable, B: fair, ordinary, but unmistakable, C: very poor, doubtful.

The frequency poligons are shown in Figs. 1–4. The numerals in the figures are the number of the events. Generally speaking, the frequency distributions of quality A are nearly the normal distribution and those of quality B, C and All are alike to the Poisson distribution. But the frequency distribution of the rise time of quality B, C and All have two maxima and seem to be divided into two groups. The tendency may be different from that for the period 1924–1951 and ought to be examined in detail.

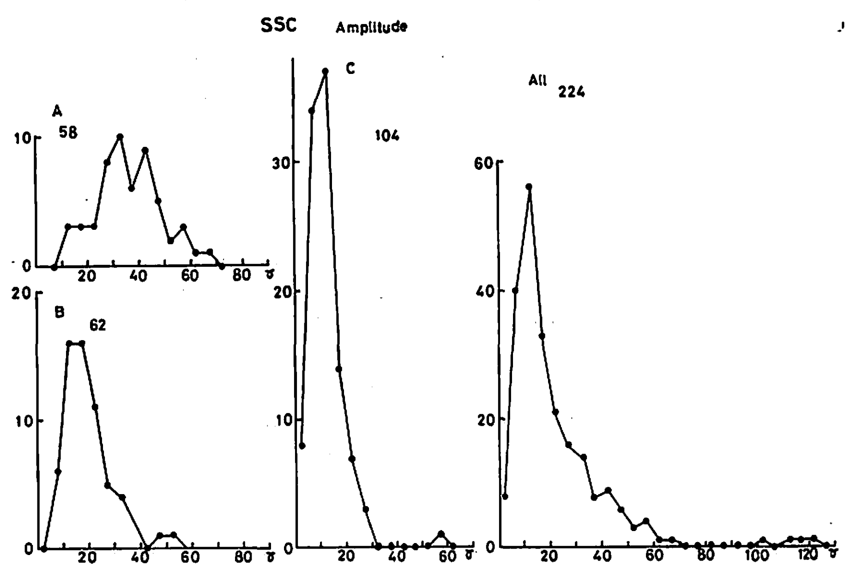

Fig. 1. Frequency distribution of the amplitude of ssc's. A part of quality A is omitted.

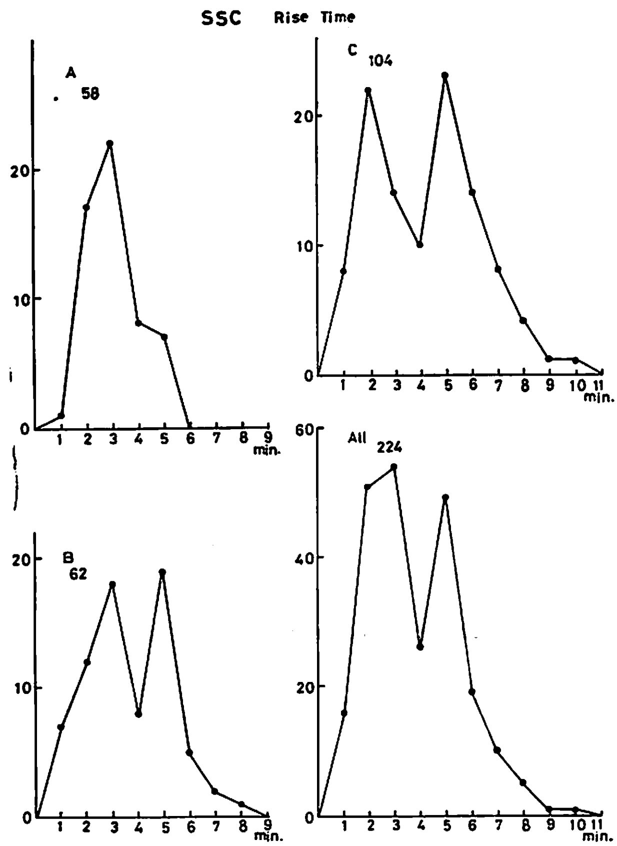

Fig. 2. Frequency distribution of the rise time of ssc's.

The arithmetic means of the amplitude etc. of ssc's are given in Table 1.

Table 1. Mean values for each quality

Quality	Amplitude	Rise time	Max. K	Range
A	41.6γ	4.0 min.	6.3	212γ
B	19.6	4.3	5.6	126
C	12.3	4.6	5.4	97
All	21.9	4.4	5.7	137

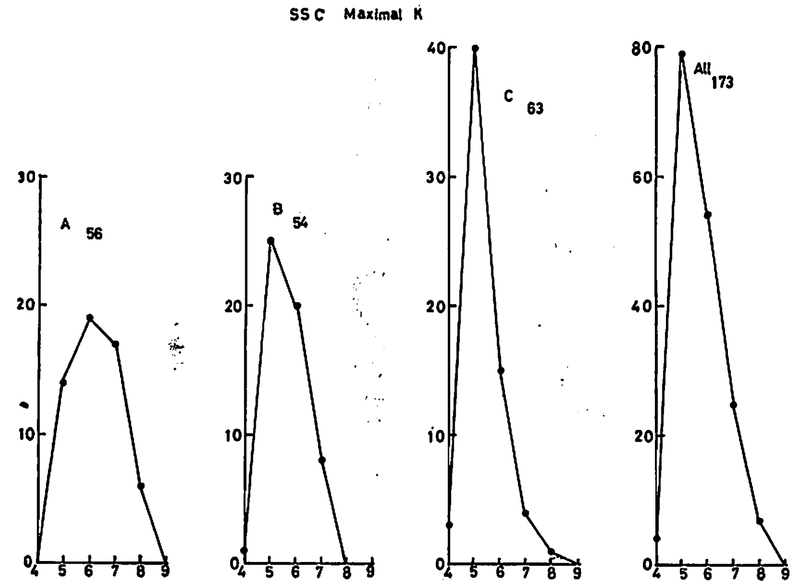

Fig. 3. Frequency distribution of the maximal K.

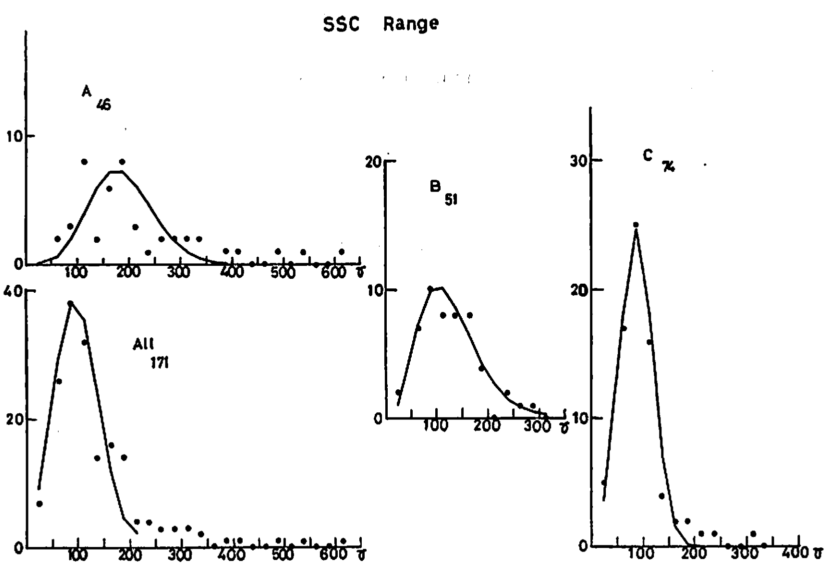

Fig. 4. Frequency distribution of the range.

§2 Some statistical relations

We used the data for the period from July 1957 to 1968 at Kakioka and Memambetsu, and from 1958 to 1968 at Kanoya. These are picked up from the tables of magnetic storms in the "Report of the Geomagnetic and Geoelectric Observations", published by the Kakioka Magnetic Observatory.

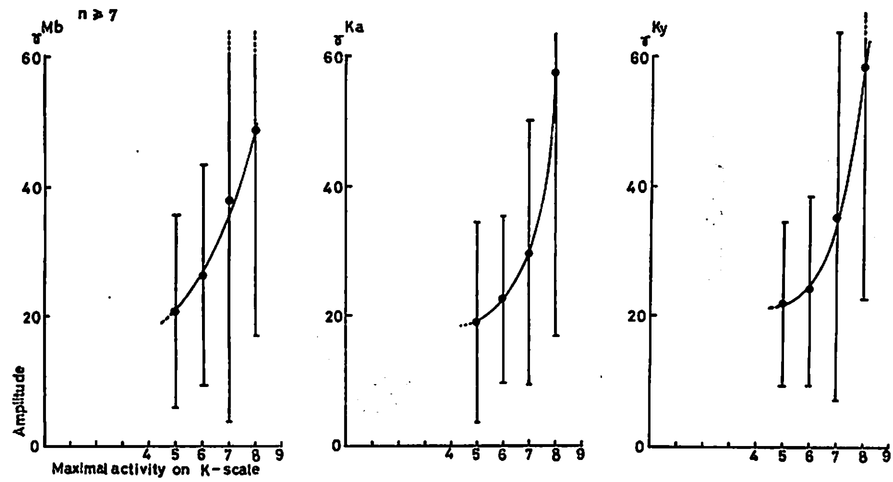

Fig. 5. Relation between the amplitude of ssc's and the maximal K of storms.

1) amplitude vs. maximal activity on K-scale

In Fig. 5, the means of 7 or more amplitude values for each K-index are plotted together with the lines of twice the standard deviation. Although the standard deviations arè moderate, the means show a regular distribution. Moreover, the curvature of the most fitted curves increases regularly as the latitude of the observatory decreases.

2) amplitude vs. range

Fig. 6 shows the relation between the amplitude and the range. It is seen that there is a positive correlation between them, i.e., the larger the ssc amplitude, the larger the storm range. The circumstances are nearly same at three observatories.

3) amplitude vs. initial phase duration

We calculated the initial phase duration from the occurrence time of ssc and that of the main phase, and made the scatter diagrams of the amplitude of ssc's and the initial phase duration.

In Fig. 7, one at Kakioka is given, for simplicity, because those at three observatories resemble to each other.

It may be difficult to find out any relation between the amplitude of ssc's and the initial phase duration.

4) amplitude vs. rise time

Fig. 8 shows the relation between the amplitude and the rise time of ssc's.

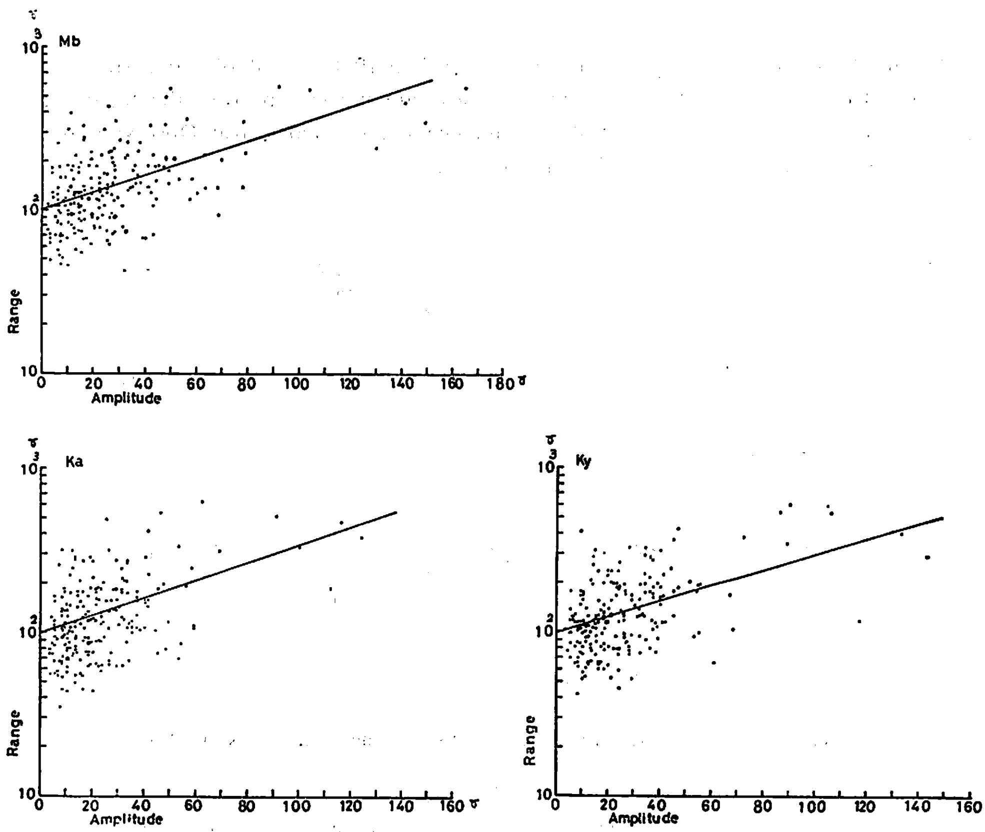

Fig. 6. Scatter diagram of the amplitude of ssc's and the range of storms.

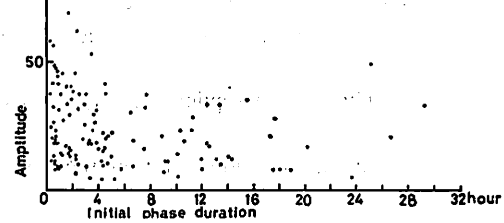

Fig. 7. Scatter diagram of the amplitude of ssc's and the duration of the initial phases.

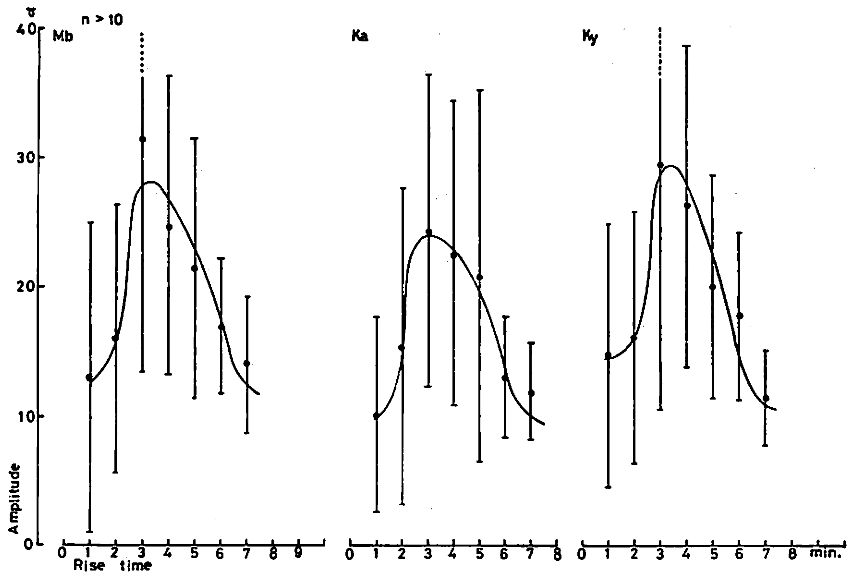

Fig. 8. Relation between the amplitude and the rise time of ssc's.

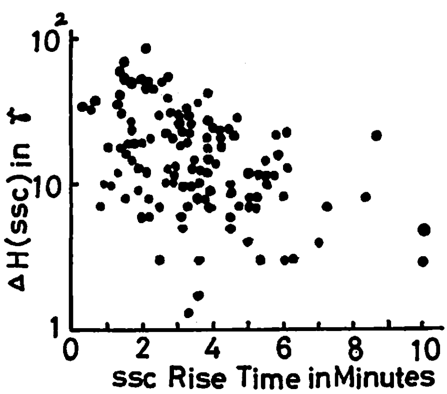

Fig. 9. Relation between the amplitude, ΔH(ssc) and the rise time, ΔT_1, of ssc's at low latitudes (after H. Maeda et al).

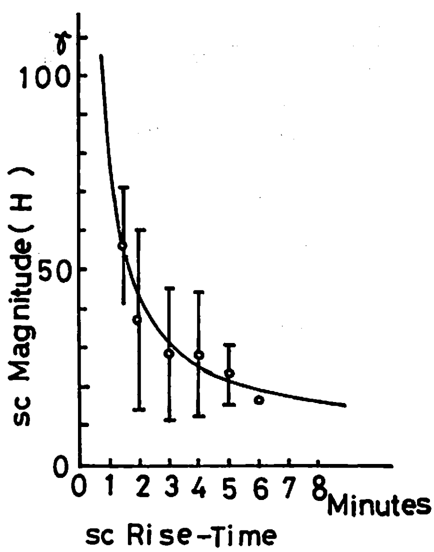

Fig. 10. Rise time versus magnitude of SC in H at Alibag, 1949–1960. Open circles represent the mean value of magnitudes of SC for the corresponding rise times. The vertical lines represent twice the standard deviation of SC magnitude. (after P.R. Pisharoty et al).

Although the standard deviations are large, the curves at three observatories have the similar tendency, showing the one maximum around 3 minute. The tendency may be different from those at high latitudes and at low latitudes. H. Maeda et al. obtained the result that the larger the amplitude of ssc's the shorter the rise time of them, from the H-traces on magnetograms at Apia and Honolulu[3]. P.R. Pisharoty and B.J. Srivastava also concluded the inverse relationship between the rise time and the magnitude of ssc's from the analysis of the rapid-run records of H at Alibag, as shown in Fig. 10[4]. On the other hand, Bouška investigated the dependence of ASc (the amplitude of ssc's) on ISc (the rise time of ssc's) from the quick-run records on the Budkov observatory ($\lambda = 14° \, 01' \, E$, $\varphi = 49° \, 04' \, N$)[5], and found a correlation opposite to those obtained by H. Maeda et al. and P.R. Pisharoty et al., as

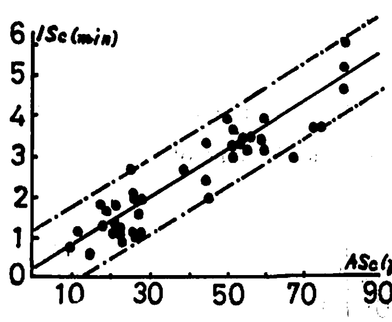

Fig. 11. Relation between the amplitude, ASc, and the rise time ISc, of ssc's at high latitudes after Bouška) ◎—La Cour instrument, ●—with the use of induction variometer, ○—with the use of earth currents recording instrument.

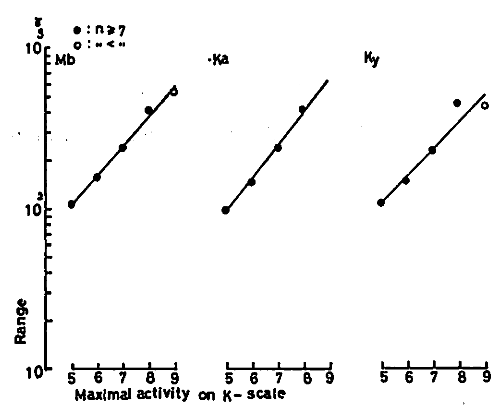

Fig. 12. Relation between the range and the maximal K of storms.

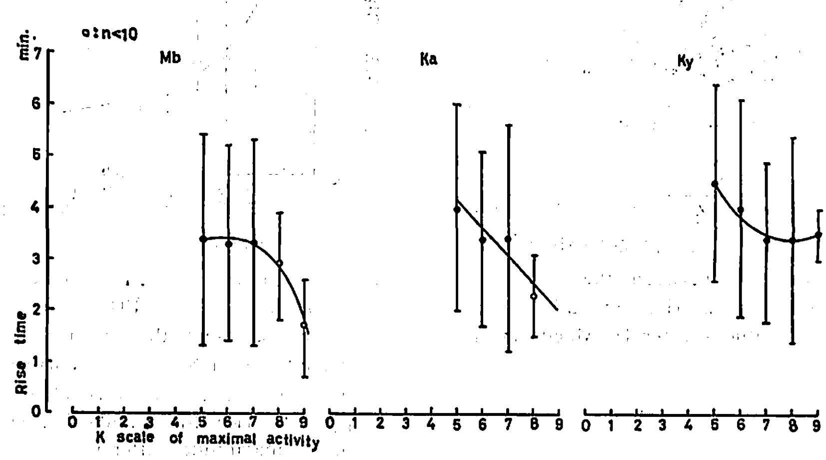

Fig. 13. Relation between the rise time of ssc's and the maximal K of storms.

given in Fig. 11. Our results are different from each of the above mentioned ones and suggest the close dependency of the relation on the latitude.

5) range vs. maximal activity on K-scale.

The relation between the range and the maximal activity on K-scale is simple as shown in Fig. 12. The relationship can be represented by the formula $y = ae^{bx}$, where y: range, x: maximal activity on K-scale, a, b: constants. The constants (a, b) are respectively (13.01, 0.42) for Mb, (8.23, 0.49) for Ka and (16.03, 0.38) for Ky. The relation might be attributed to the semilogarithmic scale of K-index.

6) rise time vs. maximal activity on K-scale

The relation between the rise time and the maximal activity on K-scale at three observatories differs from each other. But white circles in the figure are calculated from events under 10 and less reliable.

Conclusions

As seen above, our main results may be summarized as follows.

(1) The frequency distribution of the rise time of ssc's for this period has two maxima.

(2) The larger the amplitude of ssc's, the larger the maximal K and/or the range of storms.

(3) Any relation between the amplitude of ssc's and the duration of the initial phase is obscure.

(4) The relation between the amplitude and the rise time of ssc's in middle latitude is different from those in low latitudes and in high latitudes. It is not linear.

(5) The relationship between the range and the maximal K can be represented by the formula $y = ae^{bx}$.

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柿岡における急始磁気嵐の特性

山 口 又 新

概 要

IGY 以降の資料をもちい，ssc 振巾，ライズタイム，磁気嵐の最大 K インデクス，較差の柿岡における頻度分布を調査し，平均値を求めた。1924～1951の資料をもちいた結果と多少異なる点があるが，その原因を明らかにするにはより詳細な調査が必要である。又通常の磁気嵐資料に読取られている諸量間の統計的関係を，女満別，柿岡，鹿屋について調査した。急始の大きさが大きい程，統計的には，磁気嵐の較差も大きくなる。急始の大きさとライズタイムの関係は，他の研究者が低緯度地方および高緯度地方で求めた関係と相違し，この関係が緯度によって著しく異なることを示した。