Pc–type pulsations and Geomagnetic Disturbances

By

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概　要

pc型脈動と他の諸現象との関連を調査するための一手段として，変化度記録に於ける pc 型脈動の活動を表現する簡単でしかも効果的な方法を試みた。それは0から9までの10段階をもつ指数表示で，これを仮に"Pc-index 又は P-index" と名付けた。この index は5分毎に区切つた時間間隔内に於ける pc 型脈動の最大全振巾のみを以つて決められる。こゝでは IGY 期間中の地磁気観測所女満別出張所に於ける地磁気変化度の早廻し記録を用いて，それに適用する各段階の尺度を決定した。次にこのP-index を用いて pc 型脈動の活動度の日変化，磁気嵐時の変化，地磁気擾乱度との関連等について解析を行つた。この為に利用された資料は IGY 期間中に於ける春秋分点，夏冬至点を含む月即ち1957年12月，1958年3月，6月，9月，の各月に於ける女満別の地磁気変化度の早廻し記録である。

§ 1. Introduction

For the purpose of analysing the relation between the pc–type pulsations and the other phenomena, the author has made an attempt to express quantitatively the activity of pc–type pulsations, strictly speaking, of their time-rates by a more effective and simpler method than hitherto used. That is the index in a scale with 10 grades which is first introduced and examined in this paper. It is named "Pc–index or P–index" here by the author. This index is decided by the amplitude only of the pulsation in each 5 minutes interval.

In order to express more accurately the activity of oscillations, it is needed generally to know both the amplitude and period, but such a method as two factors expression is complex and labourious.

Then the author has examined the above mentioned method in the anticipation that the index decided by the amplitude alone may express the general behaviour of the activity of pc–type pulsation with respectable accuracy for the pc–type pulsations with narrow range of periods distributed from about 10 to 40 seconds, with mushroom growth of occurrence–frequency at about 20 seconds.

Now, in this paper, the P–index is utilized in order to study the relation between pc–type pulsations and geomagnetic disturbances, and some results will be described. This study has been carried out using the induction magnetograph at the Memambetsu Observatory (φ=43.°9 N, λ=144.°2 E) during the equinoctial and solstitial months in the IGY, December 1957, March, June and September 1958.

As the pulsations studied here contain not only the so–called pc–pulsations but

also all of comparatively regular oscillations having the period between about 10 and 40 seconds, those oscillations are called especially "pc-type pulsations" in this paper.

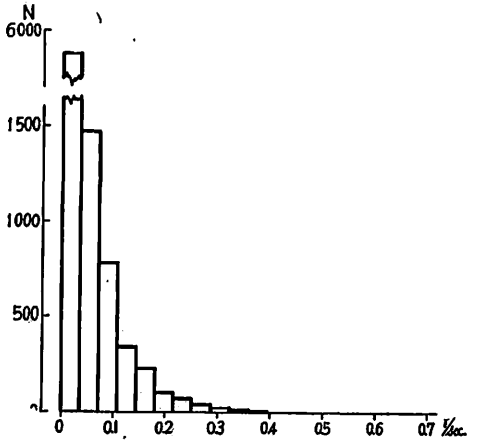
§ 2. Determination of P-index

In order to decide the criteria of the P-index applying to the induction magnetogram at the Memambetsu Observatory, mean and maximum amplitudes of pc-type pulsations in each 5 minutes interval are measured during a month, December 1957. From this results, it is confirmed that there is a linear relation between mean and maximum amplitudes. Consequently, it seems to be evident that the index to express the activity of pc-type pulsations may be sufficently defined by their maximum amplitudes in each interval without averaging process.

Then, the occurrence-frequency-distribution of magnitudes of their maximum amplitudes is studied in order to decide the scale of this index in like manner as K-scale, and its result is shown in Fig. 1. Thereupon, the scales for 10 grades from 0 to 9, are decided by the following formula,

$$A_n = A_1 + \frac{1}{2} \cdot n \cdot (n-1) \cdot d,$$

where A_n is the lower-limit-value for the n - th index from 1 to 9, and d is the difference between lower-limit-values of the index 1 and 2. Firstly, A_1 is decided from Fig. 1 as 0.04 γ/sec. Secondary, 1.12γ/sec for A_9 are decided so as to give the index "9" only to several intervals with the highest activity of pc-type pulsations in the IGY period. The d is obtained by the formula and the value of A_1 and A_9. The lower-limit-values of each index thus obtained are shown in Table. 1, the name "P-scale" for them being given in this paper.



Ffg. 1. Frequency-distribution of amplitude of pc-type pulsation Dec. 1957 at Memambetsu.

Table 1. P-scale in P-index.

	0	1	2	3	4	5	6	7	8	9
Lower limit of each index in γ/sec.	0.00	0.04	0.07	0.13	0.22	0.34	0.49	0.67	0.88	1.12

§ 3. Occurrence-frequency-distribution and diurnal variation of P-index

Measurements are made using the P-scale for Memambetsu's rapid-run induction magnetograms during the months, December 1957, March, June and September 1958, and the occurrence frequencies of each index are illustrated in Fig. 2. In two months pc-type pulsations were very active and in the other two months they were not active. Then it seems to be sure that Fig. 2 shows a mean distribution of occurrence-frequency of P.

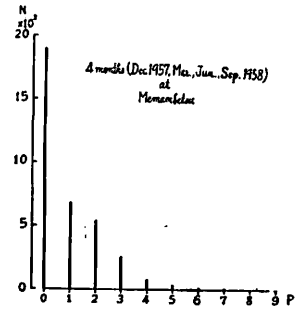


Fig. 2. Frequency-distribution of P-index.

Then hourly-sums of P are plotted, to study hour to hour variation of P, as show in Fig. 3. It seems to be sure from these figures that the diurnal variation of P has a constant form, their mean type being shown in Fig. 4. As shown in this figure, the diurnal variation of P has a principal maximum at or near 10 h (L. M. T.) and a secondary lower maximum at or near 15 h (L. M. T.). These are the same result as Yanagihara's (1957).

§ 4. Relation between P-index and Kp

Hitherto, many authors have studied and discussed relations between Kp and occurrence frequency or activity of pc. Here, the author studies the relation between Kp and the activity of pc-type pulsations using P-index in place of occurrence frequency or a rough measure of activity.

Now, $\Sigma\Sigma P$ and ΣKp, which are the daily-sums of P and Kp respectively, are culculated for each local-time one day, the day to day variation of $\Sigma\Sigma P$ and ΣKp being shown in Fig. 5 a. Then, the relation between ΣKp and $\Sigma\Sigma P$ is shown in Fig. 5 b with the abscissa of ΣKp and the ordinate of $\Sigma\Sigma P$, which shows that there is good correlation between them, or that $\Sigma\Sigma P$ increases with increasing ΣKp.

Then relations between $\Sigma\Sigma P$ and ΣKp are studied by superposed-epoch method, these results being shown in Fig. 6. In Fig. 6(A) the zero-day means the day in which the day to day change of $\Sigma\Sigma P$ shows the maximum peak. From this, it is first noticed that almost all principal maximum peaks of $\Sigma\Sigma P$ appear as if they coincide with those of ΣKp. But increases of $\Sigma\Sigma P$ may be divided roughly in two types as it is obvious in Fig. 3; in one type, the range of diurnal variation increas holding its general form, and in another type, the diurnal variation-form is

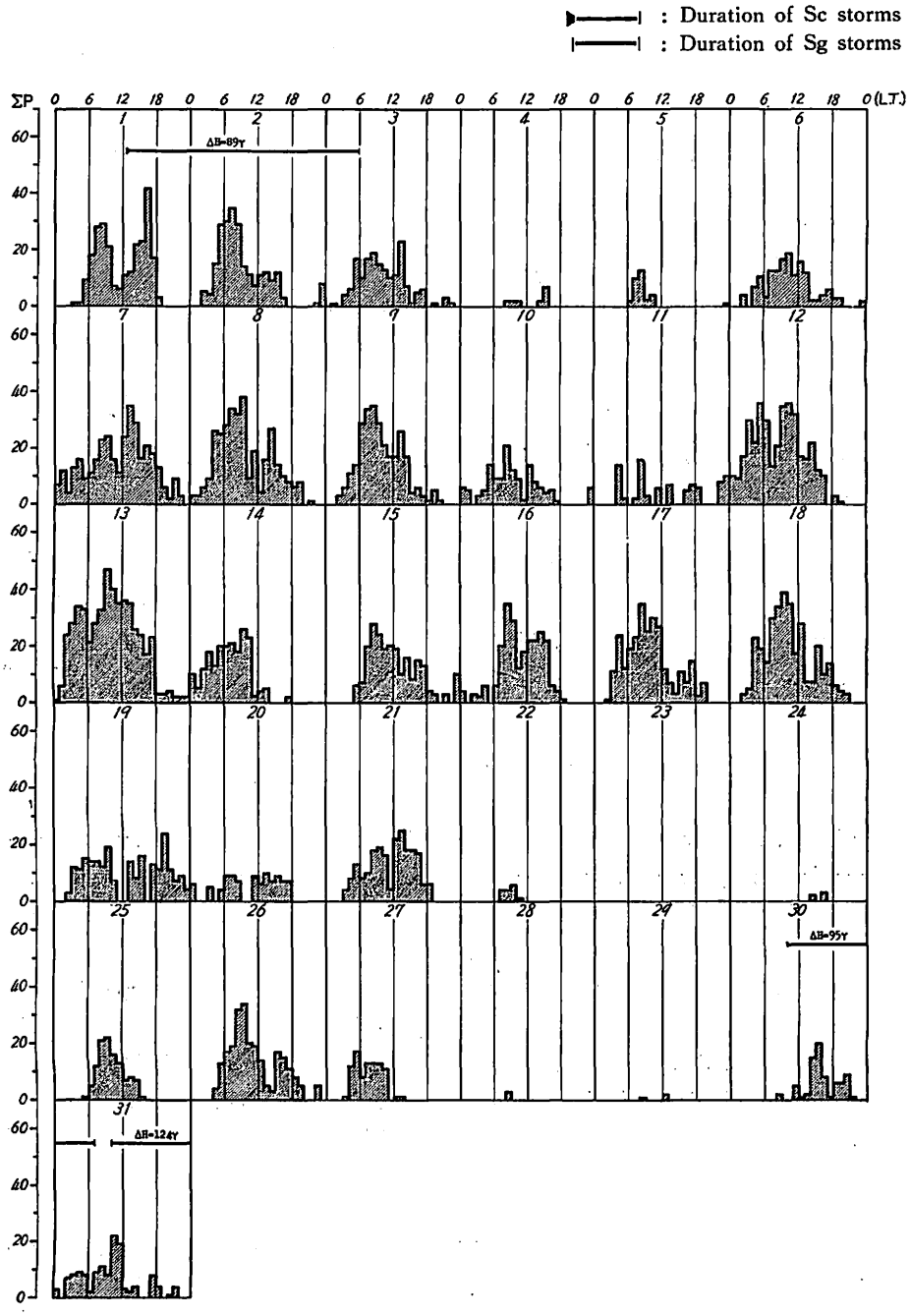


Fig. 3. Hour-to-hour changes of hourly sums of P, ΣP, Dec. 1957. at Memambetsu Obs.

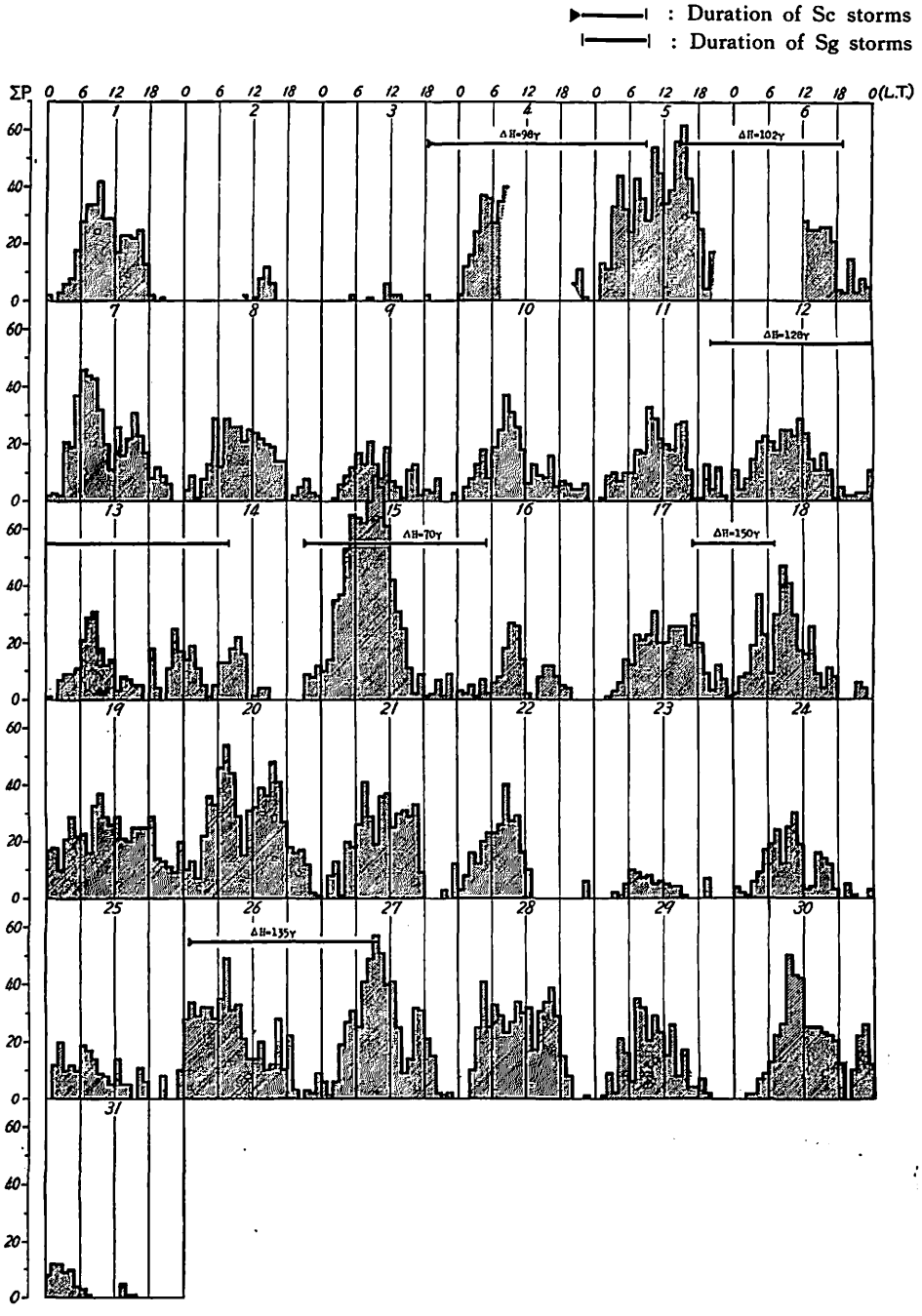


Fig. 3. Hour-to-hour changes of hourly sums of P, ΣP, Mar. 1958. at Memambetsu Obs.

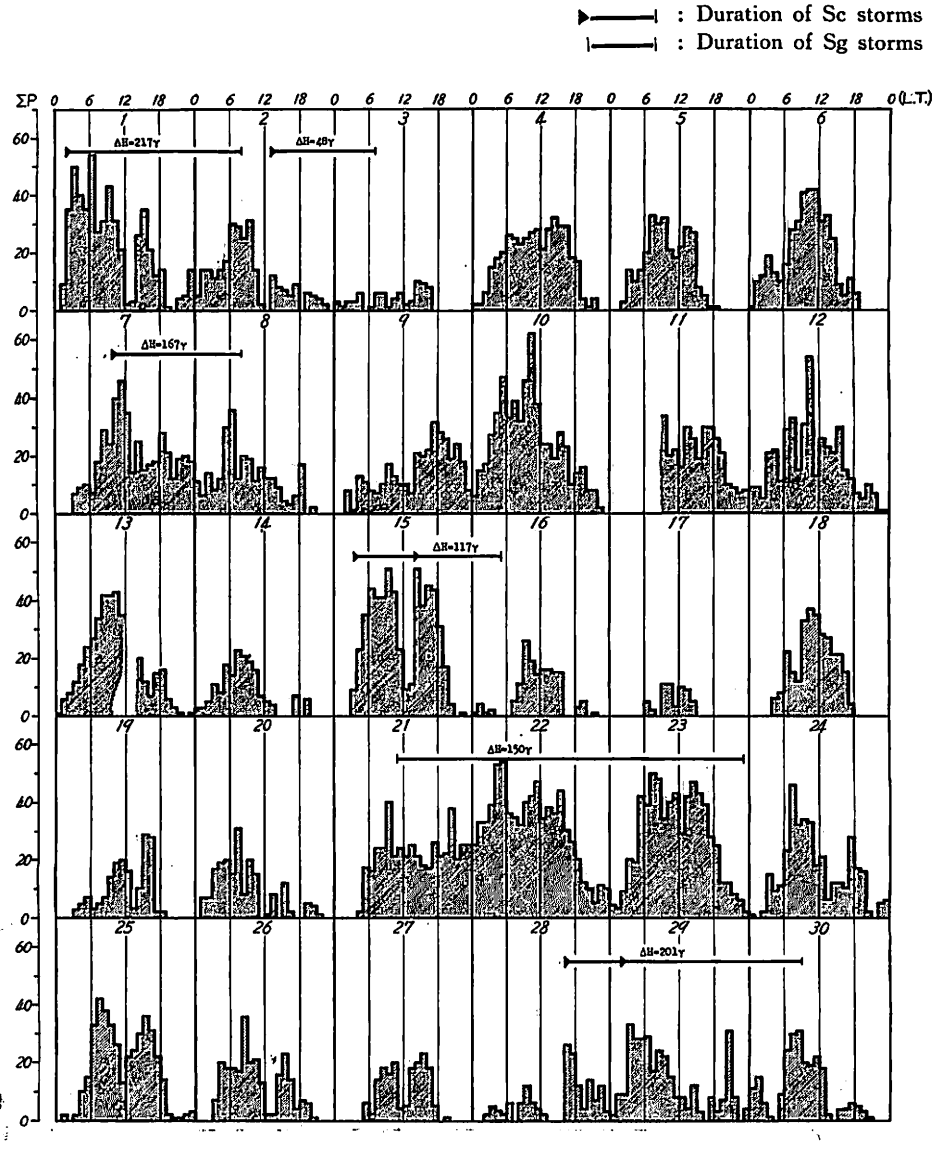


Fig. 3. Hour-to-hour changes of hourly sums of P, ΣP, Jun. 1958. at Memambetsu Obs.

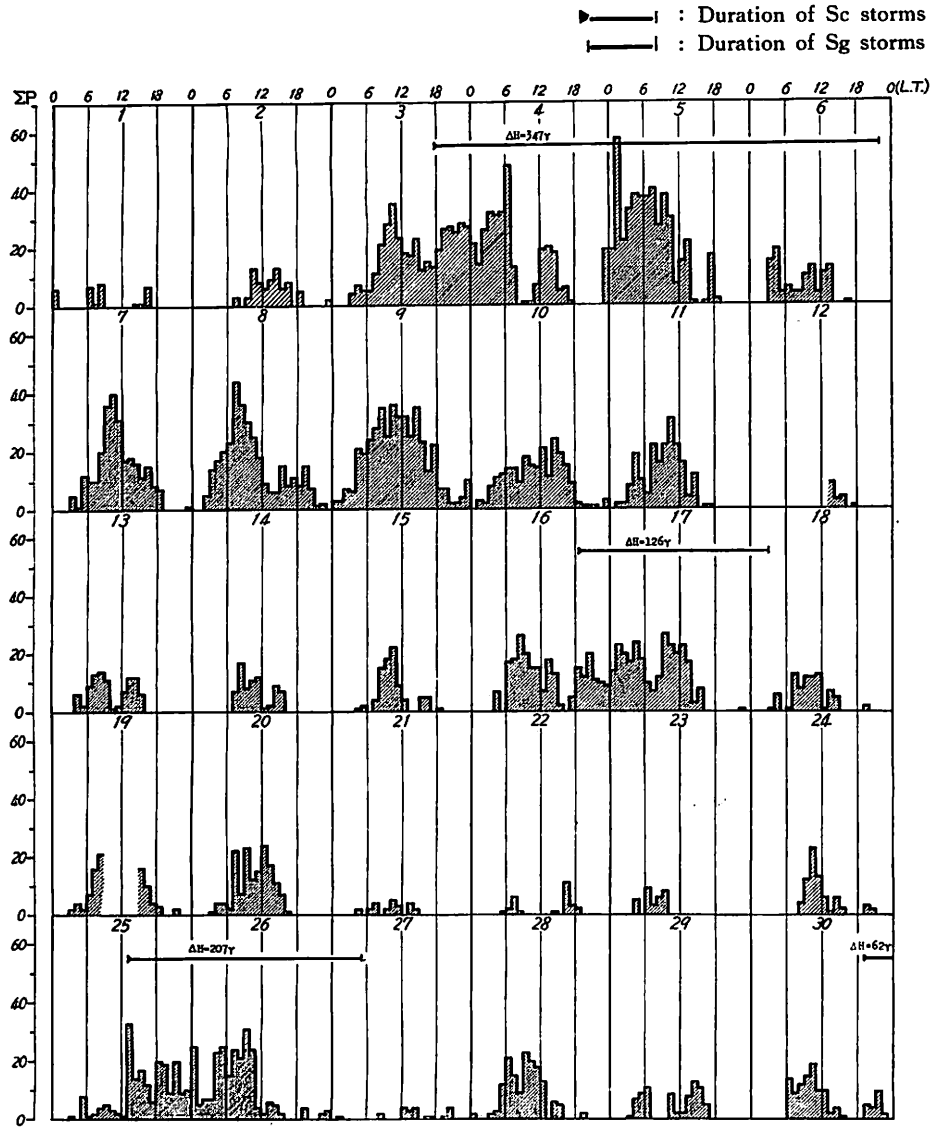


Fig. 3. Hour-to-hour changes of hourly sums of P, ΣP, Sep. 1958. at Memambetsu Obs.

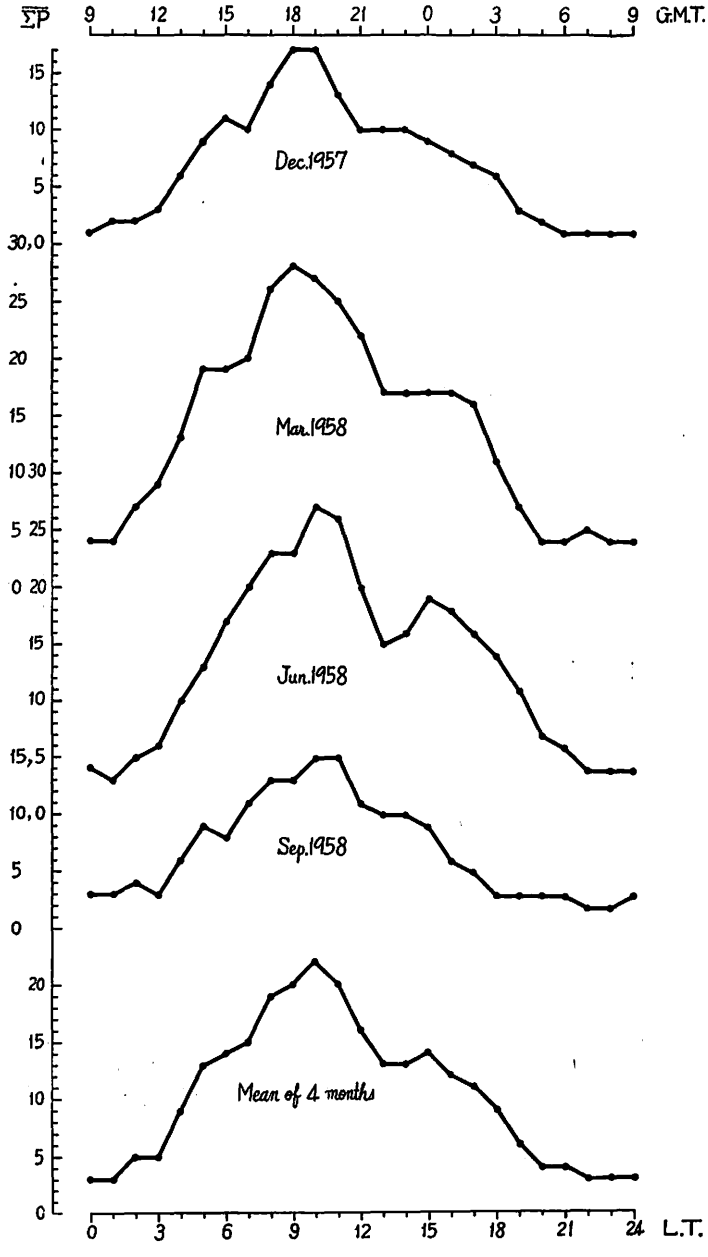


Fig. 4. Diurnal variation of hourly sums of P, ΣP.

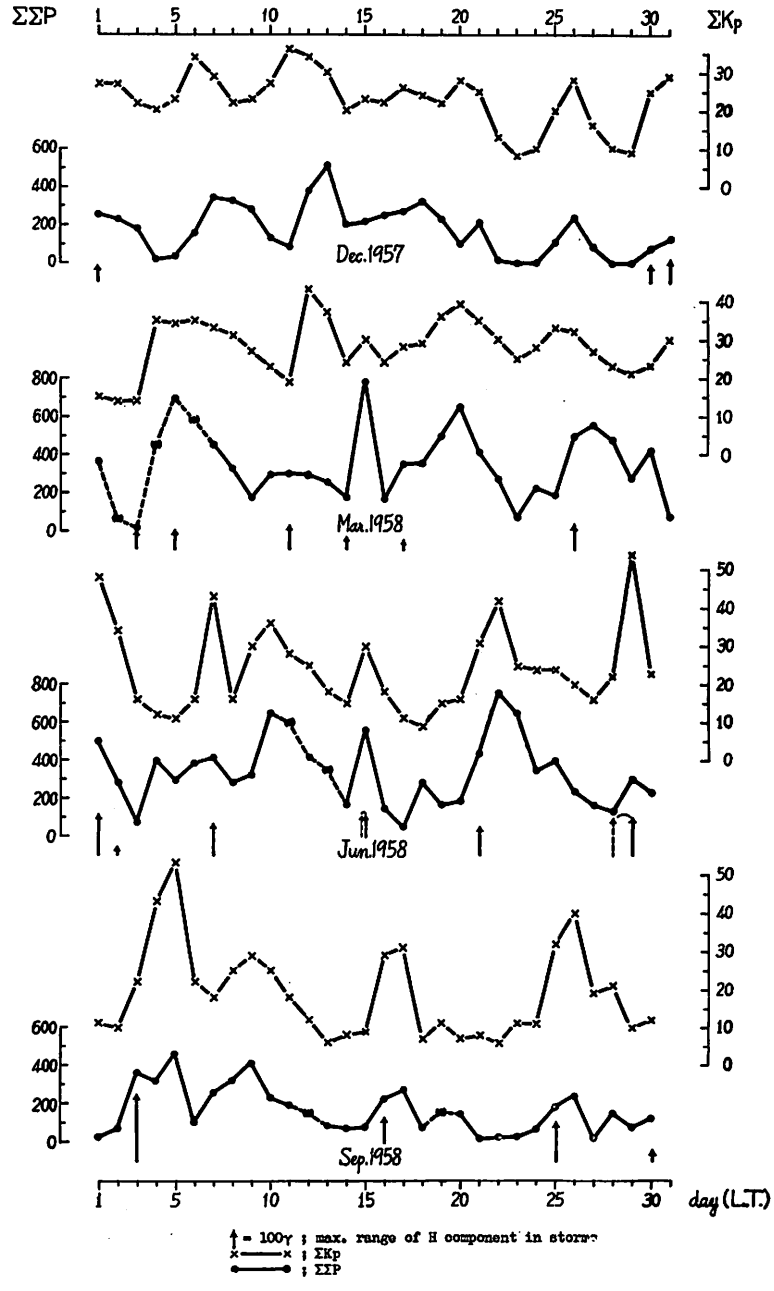


Fig. 5 a. Comparison of day-to-day variation of Kp and daily sums of P, ΣΣP.

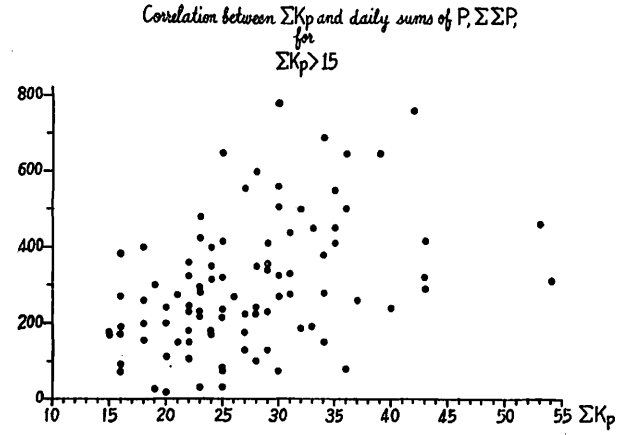
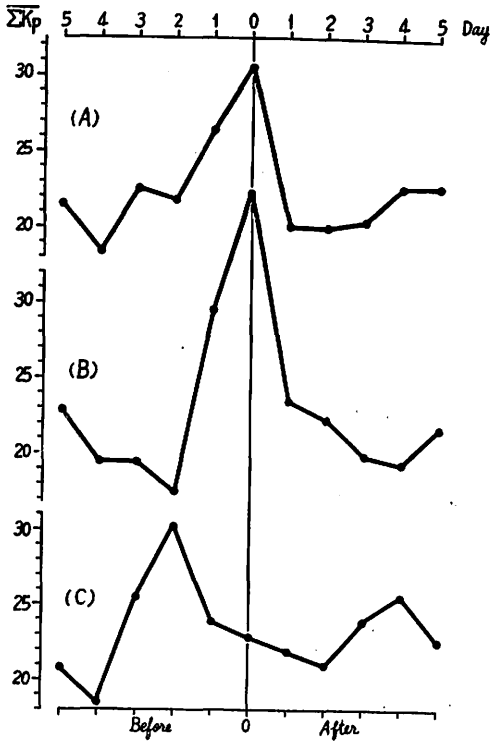


Fig. 5 b.



The zero-days are :

(A) : All of 20 days in that daily sums of P, ΣΣP, are maximum in the course of its day-to-day change.

(B) : 11 days of the above 20 days and few additional days, in that days, diurnal variations of ΣP, hourly sums of P, are disturbed, and ΣΣP are greater than adjacent days.

(C) : 13 days of the above 20 days and few additional days, in that days, diurnal variations of ΣP are undisturbed and typical, and ΣΣP are greater than adjacent days.

Fig. 6. Activity of pc-type pulsation and geomagnetic activity.

terribly disturbed. Then applying the above mentioned superposed-epoch method to these two types separately, almost all of the maximum peaks of $\Sigma\Sigma P$'s appear about two days after the maxima of ΣKp's in the former case, and coincide with those in the latter case, as these are shown in Fig. 6(B), and (C). For an expectation that some obvious discrimination must exist between those two groups if this is true, their features are studied. As the result, the days belonged to the former group were distant more than 3 days from the days having storm commencements with two exceptions in 12 cases, on the other hand, in the 7 out of 11 cases of the latter group the storms began in the previous or concerned days.

These may suggest that there exist pc-type pulsations becoming particularly active in storm-time, which may be called as storm-time-pc.

§ 5. Relation between P-index and geomagnetic storm

It seems that a great portion of the such cases that the increase of $\Sigma\Sigma P$ appears simultaneously with increasing ΣKp are closely connected with occurrence of geomagnetic storm. To confirm this, the change of daily sum of P is studied for storms which occurred in the said 4 months using the superposed-epoch method, the result being shown in Fig. 7.

In Fig. 7, the zero-day for the curve showing $\overline{\Sigma\Sigma P}$ or $\overline{\Sigma Kp}$ means the day on which geomagnetic storm occurred. This result shows that the remarkable increases of $\Sigma\Sigma P$ or ΣKp appear at the day or within one day after the storm-commencement, and $\Sigma\Sigma P$ varies in nearly parallel with ΣKp before and after those days.

Thus, in the day to day changes, $\Sigma\Sigma P$ is closely connected with the occurrence of geomagnetic storms. Then it is studied in more detail what kind of form is the hour to hour change of ΣP, which is the hourly-sums of P, in connection with the commencement of storm. This result obtained using superposed-epoch method is shown in Fig. 8, in which

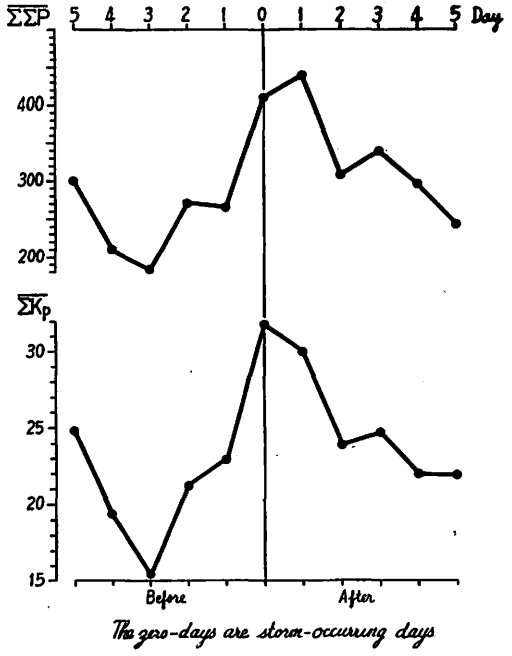


Fig. 7. Activity of Pc-type pulsations or geomagnetic activity and storm-occurring day.

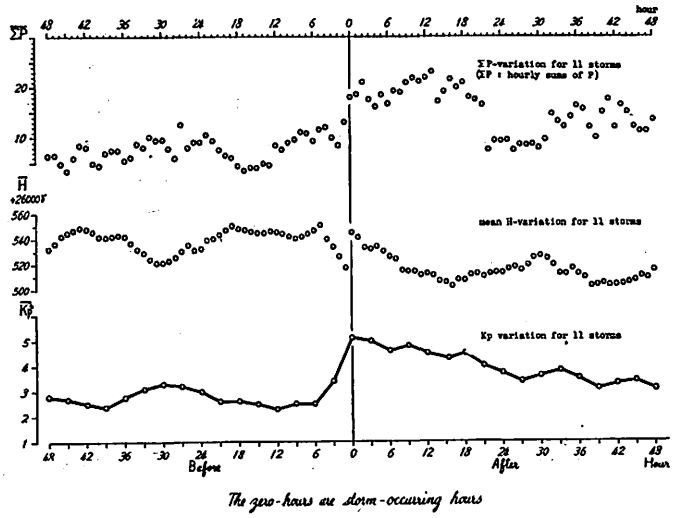


Fig. 8. Activity of pc-type pulsations and geomagnetic activity.

the zero hour means the hour of the beginning of storm. In Fig. 8, the storm time variation of Kp and the horizontal component of magnetic field at Memambetsu is illustrated together with the variation of ΣP for comparison.

In the present stage, the detail of ΣP variation for storm times can not be discussed on account of insufficency of data, but it may be stated clearly that ΣP increases suddenly at the same time as the storm commencement, irrespectively of its typical diurnal variation form.

§ 6. Conclusion

Though a great number of problems are left behind in view points of oscillation-analysis and labourious work, even P-index examined in this paper gives effective means for analysis of the activity of pc-type pulsations. The abstracted results in this study are arranged as follows.

(1) Pc-type pulsations are generally active in the geomagnetically disturbed period.

(2) Even if there are no geomagnetic disturbances, it happens frequently that the great typical diurnal variations of ΣP appear. This does not mean no relation between ΣP and geomagnetic activity, but there is a tendency that the great typical diurnal variation of ΣP appears also in the period of rather high geomagnetic activity.

(3) It seems that there are characteristic increases of ΣP in storm-time which

are not due to increases of the typical diurnal variations. But the increased amounts are the same order with the amounts of typical diurnal variations, therefore it is difficult to separate them perfectly. And now, on account of insufficiency of data, the details of change in storm-times can not be discussed, but it may be stated clearly that ΣP increases suddenly at the same time as storm-commencement, having no connection with the form of its typical diurnal variation.

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