K Indices at Syowa Station, Antarcitica

Takasi OGUTI*

昭和基地に於ける地磁気 K 指数

小 口 高*

要　旨

昭和基地におけるK指数の撰択は，1959年2月より7月までの半年の資料に基いて行なわれ，その結果，$K=9$ の最小 Range を 2500 ガムマと決定した．この Range により 1959 年の1年間に於けるK指数を求め，更にこれを，地球全体の平均的擾乱の指数と見做される K_p 指数と比較した．$K_{Syowa}-K_p$ の関係は顕著な季節変化を示し，K値の小さい方では昼半球の極光帯の擾乱の方が夜半球のそれよりも大きく，逆にK値の大きい方では昼半球の擾乱は夜半球よりも小さいこと，即ち云いかえれば，小さい擾乱は昼半球の極光帯に起り易く，大きい擾乱は夜半球の極光帯に起り易いことが結論された．

Abstract

Range determination for K indices at Syowa Station (69°00′S, 35°39′E) is briefly discussed first, then the obtained values of K indices for about a year (from Feb. 8, 1959 to Jan. 9, 1960) are tabulated. Some discussions are also given, especially on the seasonal variation of regression coefficient of K_{Syowa} to K_p, which was known from correlation between K_{Syowa} and K_p for the period.

1. Introductory note: A flux-gate type self-recording magnetograph was set up at Syowa Station of the Japanese Antarctic Research Expedition. The magnetograph consists of three detector coils with small cores of molybdenum-permalloy for detecting geomagnetic three components, three parallel circuits of amplifier and three electronic recorders of self-balancing type (Fig. 1).

The observatory was built up near the north shore of East Ongul Island. Geomagnetic field at the locality is somewhat disturbed by magnetization of rocks, but as far as possible the least disturbed place was selected on land. Magnetic three components and a temperature curve are recorded on each separated recording chart of 15 cm in width, therefore even on most disturbed days, no confusion and mixing occurs among the curves, which are usually serious on the oridinary optical magnetograms during severe magnetic storms. The routine observation was commenced on Feb. 8, 1959, and is still being continued.

* 東京大学理学部地球物理学教室，第1次及び第2次南極地域観測隊員，第3次南極地域観測隊越冬隊員. Geophysical Institute, Faculty of Science, University of Tokyo. Member of the Japanese Antarctic Research Expeditions, 1956–57 and 1957–58. Member of the Wintering Party, the Japanese Antarctic Research Expedition, 1959–60.

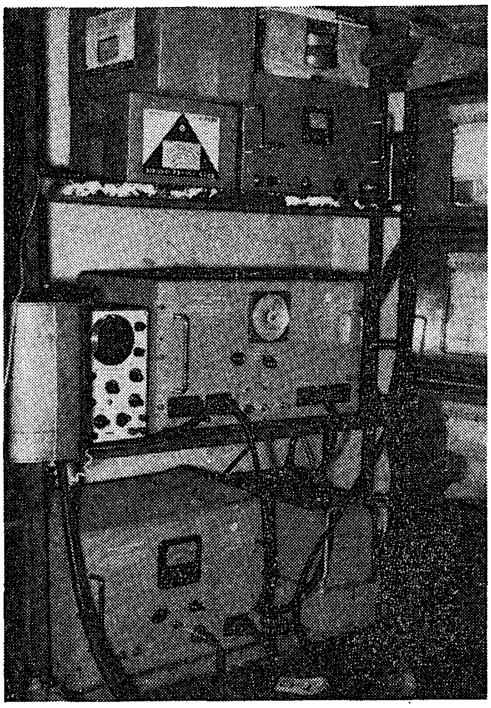

Fig. 1. An amplifier (at the middle row) and three recorders (at right hand side) with a power source (at the lowest row), set up at a corner of the living hut.

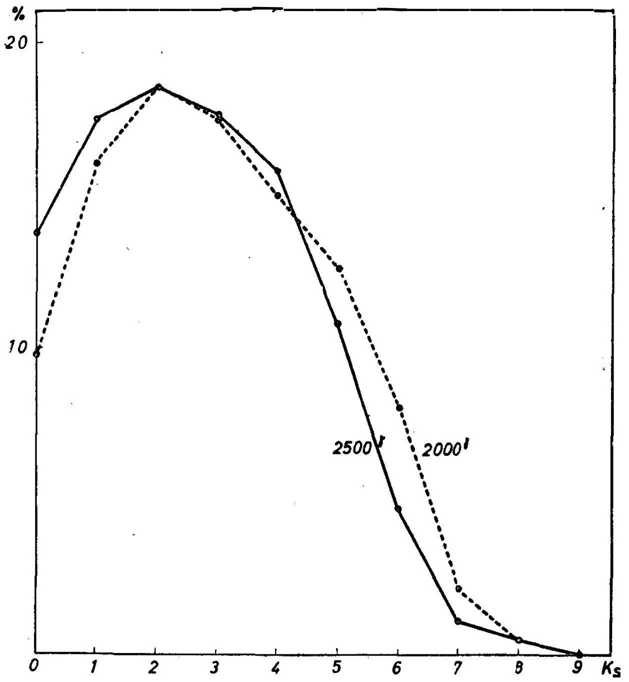

Fig. 2. Distribution of occurrence frequency of K_s (*K* at Syowa), where the minimum range for $K_s=9$ is provisionally adopted to be 2000 γ or 2500 γ.

2. Ranges for *K* indices at Syowa Station: The 181 day records of horizontal force H, declination change multiplied by H, and vertical force Z were used for determing *K*-index range. Three different values for minimum range of $K=9$, namely 1500 γ, 2000 γ, and 2500 γ were tested to examine the distribution pattern of *K* indices.

The result is shown in Fig. 2, where full circles and full line denote the occurrence probability of *K* indices in case of 2500 γ, while the hollow circles connected by dotted line represent that in case of 2000 γ. The former, as shown in Fig. 2, agrees better than the latter with the general distribution pattern. Thus, value of 2500 γ was adopted as the minimum range of $K=9$ at this place. Consequently, the minimum ranges for each *K* index at Syowa Station were determined as follows.

K	0	1	2	3	4	5	6	7	8	9
minimum range	0	25	50	100	200	350	600	1000	1660	2500 γ

3. *K* indices at Syowa Station: *K* indices for 1959 at Syowa Station are given in Table 1. As a rule, each index was obtained by the range of the maximum deviated component of the three, but the index values for the period when one or two of the three were missed are given in italics in the table.

4. Some statistical results: i) Distribution of *K* indices at Syowa station (K_s).

The total distribution pattern of K_s is shown in Fig. 3. The maximum occurrence frequency is found around $K_s=2-3$, and $K_s=5$ or 6 has still fairly large frequency of

Table Γ1

	Feb. (1959)		Mar.		Apr.		May		June		July		Aug.		Sept.		Oct.		Nov.		Dec.		Jan. (1960)	
1			4664	4455	5562	1100	3422	3134	4331	1114	3220	0015	4442	2332	5432	2353	5653	3255	4544	4345	5444	4333	3222	2101
2			4553	3364	0111	1234	4420	0004	3332	2345	5551	1100	5452	1231	5653	2144	3652	0123	5754	5766	3544	5454	1112	1222
3			4543	2357	4432	1104	1111	0025	5433	2233	3300	0000	5541	3313	3433	2446	2452	3676	6643	4565	4654	5544	3321	3303
4			4323	2344	4310	0023	3113	2233	5433	2325	0001	1255	3323	3324	5575	3456	4543	4334	2333	4464	3532	2233	4422	3323
5			5542	2344	5210	1010	6533	4111	4432	2133	5543	2132	2011	0223	6443	2336	6532	3576	5553	3233	2234	5665	5544	4334
6			4411	0020	4101	1223	1000	0000	3222	1235	3222	2224	3533	3455	5343	1201	5564	3465	6433	3345	2422	3224	4431	3222
7			2201	1445	1101	0144	0001	0003	4331	0112	4533	2221	4432	2234	2111	1122	3522	3136	0422	1252	4421	3313	2322	1321
8	2321	3225	5441	0102	4432	2435	4654	2222	2122	1123	3433	2233	3133	3105	2322	1204	3322	1112	3522	3332	2322	1332	3422	0133
9	5453	3223	3311	1110	6443	1244	4322	1233	3333	2221	3543	2234	4123	3264	3211	1013	4310	0133	1211	1354	3342	3313	3322	111-
10	3211	0133	0111	0001	5565	5544	4232	1121	5632	1212	5442	0011	4521	1134	1211	0005	3211	0223	4422	2224	4321	0232		
11	2446	4435	2211	1111	4433	2036	3333	3345	3213	3211	6552	3666	4521	1103	3553	2025	3200	0154	3221	1123	1332	2223		
12	3333	3345	4422	2332	3421	1003	7676	5756	0000	0211	7332	4434	3221	0005	6532	1223	2111	1243	3321	1233	4433	2345		
13	5323	4446	2332	2223	4111	1144	3333	2334	0000	0000	4332	3314	4311	1022	5222	0026	1111	1003	3422	3334	5532	2335		
14	4553	4543	1322	2113	4421	0014	3100	2211	0010	1104	5543	4222	3311	0102	4533	2124	3223	3234	5544	4444	5544	4644		
15	5674	3442	5512	1003	5121	0022	4423	3556	2233	1001	5678	8668	4412	1246	3231	2354	4433	2255	3221	1114	4554	3344		
16	6663	3477	4112	1002	4121	0021	5674	2214	3412	0001	5563	2246	4476	5566	5432	2243	3111	1121	1121	2453	4422	3334		
17	5653	2232	2211	0212	0122	2113	2223	2212	0000	0014	4554	3677	7865	3646	3212	1255	1233	2344	4532	3212	3322	1233		
18	1010	0100	0001	1203	3201	0000	5643	0336	3421	0133	6886	3547	3663	2245	4433	2256	5543	3455	3322	3452	3122	3224		
19	3442	2221	1122	1000	0011	0003	4423	2254	3331	0002	6554	3435	5553	1244	6642	2322	4432	1125	2323	2313	3433	4342		
20	1212	1100	3311	1001	2001	0020	5232	1143	4211	0003	4443	4326	4754	2345	5544	5466	5221	2110	4221	1112	4322	1323		
21	1121	2122	2111	1022	4423	2100	4431	1335	3110	0023	5442	2245	7555	2466	7674	5565	0111	1123	3322	5433	3221	1223		
22	2543	2115	2112	0002	1001	0000	5522	1224	3322	2223	4441	2215	5462	2365	7655	3444	4333	4345	4323	3333	3221	1324		
23	5543	2010	4421	0212	0001	2545	5421	0222	3210	0235	4442	0024	5563	2356	4332	2356	5533	2000	5564	3453	3452	3655		
24	0111	1102	4311	0222	4343	4325	4444	3446	6631	0135	5133	2256	5554	2225	4542	4334	1121	2223	4411	2224	4433	4323		
25	3464	5655	3651	2352	4442	2455	5453	2224	4211	1104	5554	3455	5333	2215	5543	4556	4433	2324	3322	3234	4422	2224		
26	5664	3365	2234	5356	5532	1246	5101	1143	3433	2221	4644	2366	4221	0113	6352	3356	3443	4435	3323	2223	4552	4455		
27	4532	3665	7754	5545	4542	2335	4201	1011	1012	3536	6554	3266	5111	0001	4443	3354	3332	2213	4432	2333	4545	4456		
28	5533	4566	3533	5476	3433	0245	0110	0002	5553	3344	5443	3324	0111	0002	5432	2334	2112	1011	6665	4455	5544	5555		
29			7664	4563	4442	3544	2000	0001	5454	2446	4531	2102	3112	1123	3222	1013	2111	1112	4423	4333	4434	4324		
30			5544	3245	3431	3454	1001	1101	6335	4645	3201	0001	2231	1221	3122	3343	5432	3235	3334	5556	3333	3331		
31			5532	2356			2421	3356			4432	2134	2322	3244			3333	3476			2222	2131		

occurrence. This is in agreement with the general tendency of the distribution for the period of high solar activity[1].

Fig. 4 represents the same kinds of distributions of K_s, obtained for individual three-hour intervals. There is a remarkable difference in the types of distribution of K_s at different local times. In daytime, from 9 h to 21 h lt, frequency of occurrence has a maximum around $K_s=2$, and it decreases rapidly with increase of K_s. At night time, from 21 h to 9 h lt, however, instead of falling from $K_s=2$ with increase of K_s, the freqency shows a tendency to increase to a maximum around $K_s=4$, and it results in a marked rightward shift of the distribution pattern.

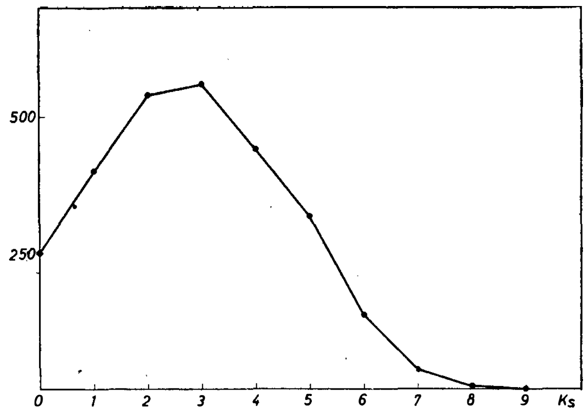

Fig. 3. Total distributition pattern of K_s.

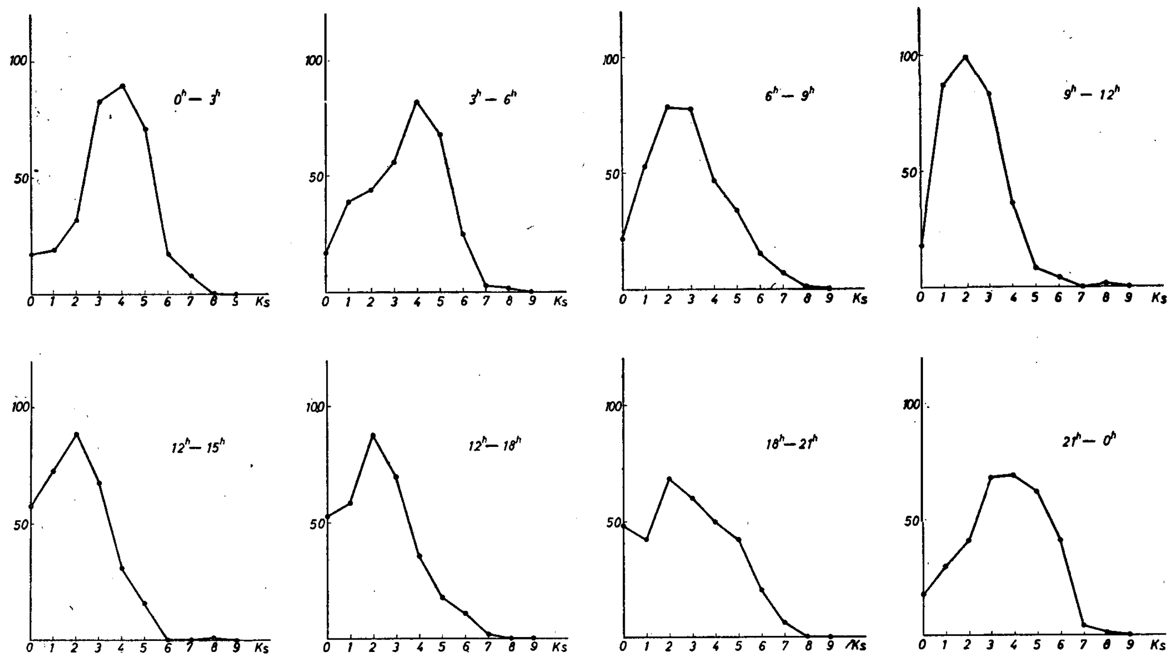

Fig. 4. Local time dependence of the distribution pattern of K_s.

The above-mentioned distributions in one year data are not so smooth naturally, but their general tendency is still quite similar to that known so far, showing that the geomagnetic activity at Syowa Station in night time is characteristically higher than that in daytime as is so at other high latitude stations[1].

ii) Relationship between K_s and K_p

The variation of K_s was compared with that of K_p and K_{Kakioka} for the period from February to December 1959, as is shown in Fig. 5.

A good parallelism in the changes in K_s and K_p may be noticed. Considering that K_p is determined mostly by the northern high latitude data and K_s by a southern auroral

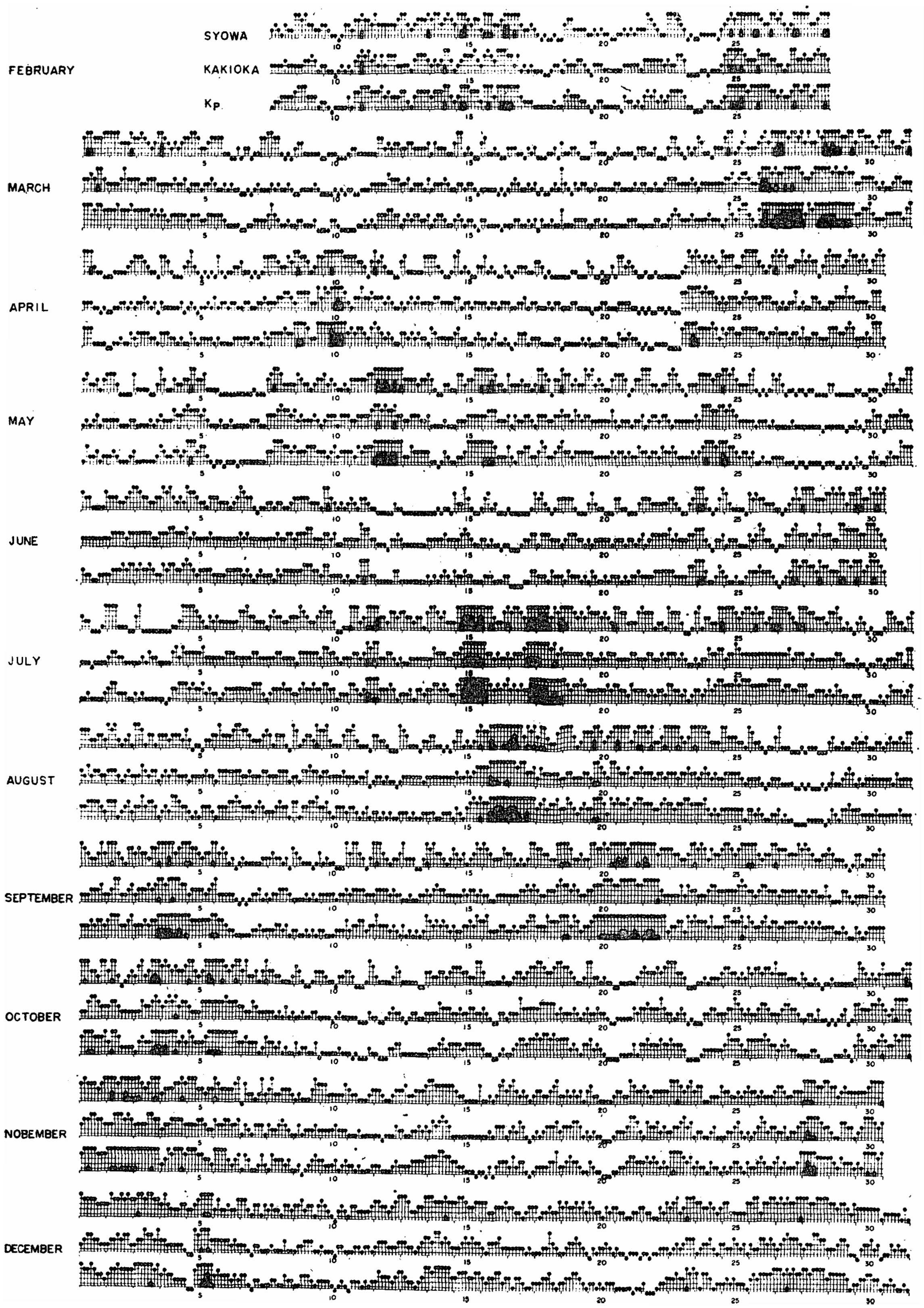

Fig. 5. K indices at Syowa Station during IGC with K_p and K at Kakioka, Japan.

zone station's data, these two localities being apart from each other some 15,000 km, this good agreement is rather surprising.

In order to repersent the relationship quantitatively, correlation and regression coefficients between K_p and K_s are computed. Fig. 6 illustrates the seasonal variations of correlation coefficient between K_s and K_p, and regression coefficient of K_s to K_p ($\beta K_s K_p$). It may be noticed in the figure that a seasonal feature of regression coefficient ($\beta K_s K_p$) is appreciable, though the correlation coefficient ($r_{K_sK_p}$) has no remarkable seasonal changes, being a little dispersed around the mean value of 0.75 through the year. $\beta_{K_sK_p}$ takes a broad maximum around June solstice, which gradually decreases towards December solstice. Besides, there is a systematic change of mean K_s at $K_p=0$, i. e., the mean K_s represented by the intersection of regression lines with ordinate of $K_p=0$, on K_s-K_p diagram, the phase of which is inverse to the change of $\beta_{K_sK_p}$.

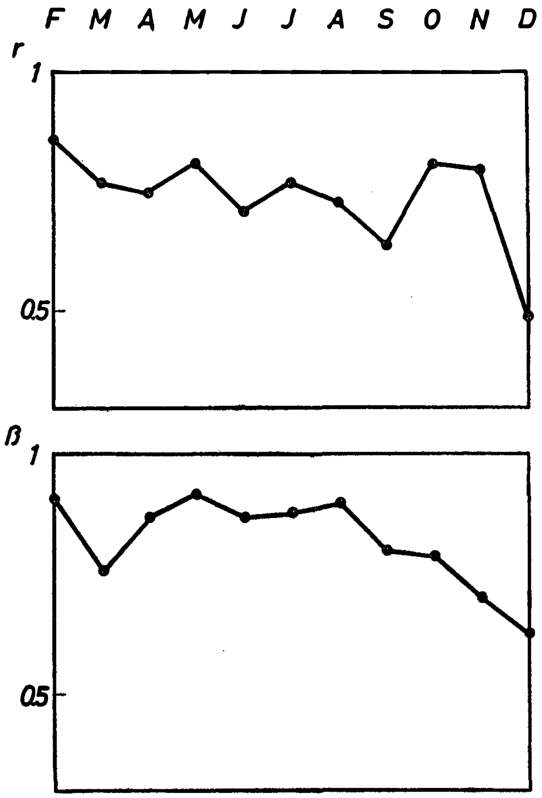

Fig. 6. Seasonal variations of correlation coefficient (upper) and regression coefficient (lower) between K_s and K_p.

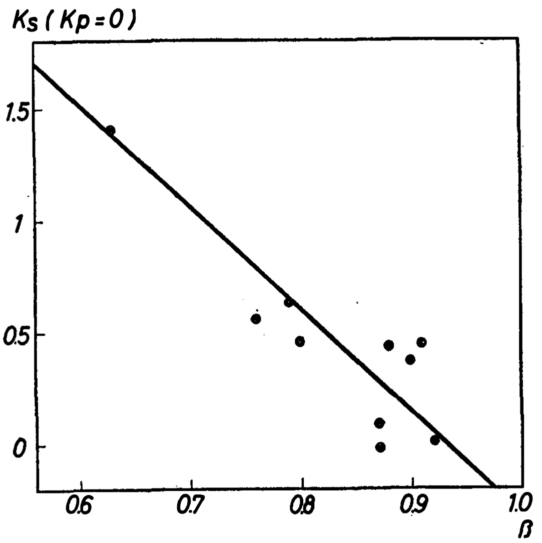

Fig. 7. Correlation between regression coefficient and K_s ($K_p=0$).

The relation of $\beta_{K_sK_p}$ with $K_s(K_p=0)$, linear as shown in Fig. 7, indicates that all regression lines can be drawn through a characteristic point, the position of which is given, on K_s-K_p diagram, by

$$K_s=\frac{K_s(K_p=0)_i\beta_{K_sK_p}-K_s(K_p=0)_j\beta_{K_sK_p}}{\beta_{K_sK_{pj}}-\beta_{K_sK_{pi}}}$$

$$=4.3$$

and

$$K_p=\frac{K_s(K_p=0)_i-K_s(K_p=0)_j}{\beta_{K_sK_{pj}}-\beta_{K_sK_{pi}}}=4.7$$

where the regression lines of each month are represented by general forms as

$$K_{si}=\beta_{K_sK_{pi}}(K_p-\overline{K_{pi}})+\overline{K_{si}}\,.$$

It may be concluded that small perturbations ($K\leqq 4.5$) around June solstice occur in the northern auroral zone without (or with very small) corresponding disturbances in the southern auroral zone, but the magnitude of disturbances in the southern auroral zone during severe storminess tends to overcome that of northern auroral zone. In other words, the small perturbation in the summer (sunlit) auroral zone is larger than that in winter (dark) auroral zone, while the severe disturbance contrarily is larger in summer than in winter. This may mean that the magnetic activities do not change seasonally as a whole, but the changing mode depends on the storminess, as schematically illustrated in Fig. 8.

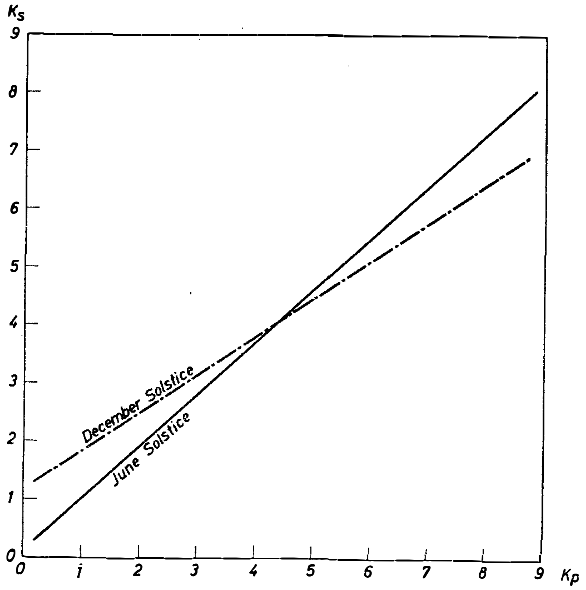

Fig. 8. Schematic diagram of seasonal change of regression lines.

5. Concluding remarks: The conclusion stated avove, however, may involve some ambiguity, due to the fact that the K_p means activities averaging around the northern auroral zone, while K_s represents those in only one station in the southern auroral zone. But, the effect of averaging operation for K in the northern auroral zone is only an addition of some constant value to $\beta_{K_sK_p}$, when the diminution effect of K by averaging operation can be regarded as statistically independent of activity, and then, the result stated may not be seriously affected.

It is quite curious that, in severe storminess, the sunlit auroral zone is less active than the dark one, considering that the ionospheric condition is much more favorable for inducing the electric current in the former than in the latter, when viewed from the standpoint of the conductivity distribution in the normal ionosphere. An attempt to interpret the seasonal change of $\beta_{K_sK_p}$ may encounter a difficulty, unless the change of original disturbing agent, regardless of its origin, onto the two auroral zones is taken into cosideration. Further research is desirable on the partition of the external disturbing agent onto each auroral zone, which may be closely connected with mechanism of the earth storms[2].

The author's harty thanks are due to Prof. T. NAGATA for his kind encouragement and guidance and to the members of the third wintering team of the Japanese Antarctic Research Expedition for their valuable assistance.

References

1) For example: IATME Bull., No. 12.
2) T. Nagata and S. Kokubun: Rep. Ionos. Space Res. Japan, **14**, 273 (1960).

(*Received Dec. 21, 1960*)