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An Objective Classification of Map-patterns over Japan in the Summer Season

by

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Abstract

Surface pressure patterns of summer around Japan were classified objectively by use of correlation method. Surface pressure at 36 stations, not at grids point, was used. Although 8 types of map-pattern were found, difference among them is not always clear, and 30% of the entire samples can not be classified into the 8 types. However, an improvement of this method may find the relation between some weather phenomena and pressure patterns, with reference to the other meteorological elements.

1. Introduction

Many persons pay attention to the relation between pressure distribution and regional weather, and it has been an indispensable factor in routine forecast. And as the classification of map-patterns is necessary, many types of patterns are called by particular names in Japan. But they are the so-called subjective classification.

Recently the development of high-speed computers has made it possible to classify a number of map-patterns objectively and statistically. COURT (1957) proposed an interesting statistical method, which compares map-pattern configurations by correlation coefficients. LUND (1963) tried actually to classify Winter maps of the northeastern United States by the method of Court and found out 10 typical maps. Further, Lund touched on the relation between those types and the weather. Court's Method is explained in the next section. In Japan NOMOTO (1971) classified maps of the Far-East through a year by use of his own Analogy Index (referred to in section 4 of this paper). The present author chose the same method as Lund's.

2. Data and Procedure

Used data were chosen in sets of surface pressure at OOZ of every day during June, July and August of 1961–1965, and the total number of sets is 240, but the days lacking some of the values at the 36 points were omitted. The distribution of stations is shown in Fig. 1 and Table 1.

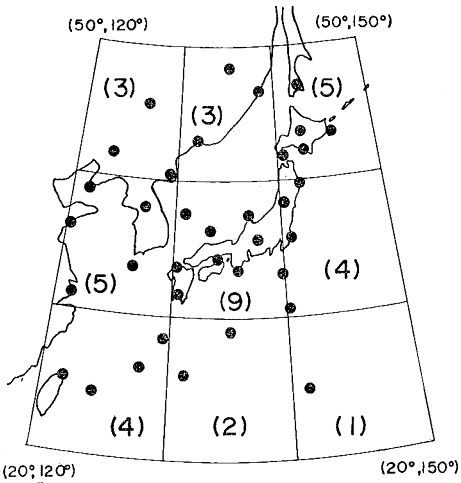


Fig. 1. Distribution of Stations.
Numerals in parentheses indicate the numbers of stations in the fanshaped regions surrounded by latitudinal and londitudinal lines for each 10°.

Table 1.
List of stations.

Asahikawa	Fukuoka	Taipei
Nemuro	Kagosima	Kim shaik
Urakawa	Takamatsu	Seoul
Hakodate	Naze	Ullungdo
Miyako	Ishigakijima	Cheju
Yamagata	Minamidaitojima	Harbin
Wajima	Torishima	Shemyang
Iida	Naha	Tailen
Chosi	Habarovsk	Tsingtao
Hachijojima	Mys Sosunova	Shanghai
Saigo	Vladivostok	Iwojima
Shionomisaki	Juzuno Sahalinsk	Tango

The meaning of Court's Method is as follows. Let the pressure value at time t, at point P $(i=1, 2, \dots, n)$ be $P=f(t,P_i)$. We estimate the minimum value of $E\equiv\Sigma_{i=1}^{n}\varepsilon_i^2$ in order to see the similarity of two maps at time t_1, t_2, where

$$\varepsilon_i=f(t_2,P_i)-af(t_1,P_i)-b \qquad (i=1,2\cdots,n) \tag{1}$$

and a, b are variables independent of point P_i. In other words we compare the configurations of curved surfaces which show the pressure distributions. If $a>0$, and $\varepsilon_i=0$ $(i=1, 2, \dots, n)$, two curved surfaces agree in uneveness everywhere. And

$$E=\Sigma\varepsilon_i^2=\Sigma\{f(t_2,P_i)-af(t_1,P_i)-b\}^2$$

$$\frac{\partial E}{\partial a}=-2\Sigma[(f_1,P_i)\{f(t_2,P_i)-af(t_1,P_i)-b\}]$$

$$\frac{\partial E}{\partial b}=-2\Sigma\{f(t_2,P_i)-af(t_1,P_i)-b\}$$

We obtain from simultaneous linear equations, $\frac{\partial E}{\partial a}=\frac{\partial E}{\partial b}=0$,

$$a=\frac{s_2}{s_1}r,\ b=\overline{f(t_2)}-\frac{s_2}{s_1}r\overline{f(t_1)} \tag{2}$$

$$\sqrt{\frac{E}{n}}=s_2\sqrt{1-r^2} \tag{3}$$

where s_1, s_2 are the standard deviations of $f(t_1,P_i)$, $f(t_2,P_i)$ respectively, and $\overline{f(t_1)}$, $\overline{f(t_2)}$ are the means, and r is the correlation coefficient between $f(t_1,P_i)$ and $f(t_2,P_i)$. In this paper similarity is judged by the value of r. Further more, the following weights were considered in computing correlation coefficients, because the distribution of the 36 stations is not uniform. Divide the controversial region into nine little fan-shaped regions by the latitudinal and longitudinal lines for each 10°. For instance, if a fan-shape includes five points, the weights of those five points are all 1/5, and so on.

The procedure of classification is as follows:

Step 1. Correlate each map of all samples with all other maps and make N-th order symmetric matrix (N is the number of samples).

Step 2. Select the row having most elements larger than or equal to C_0 (C_0 is a finite criterion of similarity), and name the corresponding map Type A. The maps correlated with it higher than C_0 make a group of Type A.

Step 3. All rows and columns an element of which belongs to the above group are omitted, and then make a new matrix. Select Type B and its group like Type A and its group.

Step 4. Repeat the above process until no row of a matrix has N_0 elements larger than or equal to C_0 (N_0 is defined in advance).

Step 5. If a map is correlated higher than C_0 with some types selected above, it belongs to the one with which the controversial map is correlated highest.

In the present experiment $C_0=0.70$ and $N_0=10$.

Table 2.
Numbers of maps included in each group. M1 is the numbers before Step 5, and M2, after Step 5.

Type	Date	M1	M2
A	1962. 7. 4	72	47
B	1962. 7. 8	35	29
C	1965. 8.16	23	28
D	1964. 6.16	22	36
E	1964. 6.19	12	20
F	1961. 6.30	10	14

Table 3.
Correlation coefficients of each pair of types

	A	B	C	D	E	F	G	H
A	1.000							
B	0.038	1.000						
C	0.583	0.529	1.000					
D	0.676	−0.379	0.165	1.000				
E	0.646	0.612	0.586	0.231	1.000			
F	0.327	0.656	0.541	0.246	0.614	1.000		
G	0.236	−0.822	−0.376	0.711	−0.339	−0.317	1.000	
H	0.186	0.295	0.754	0.034	0.212	0.314	−0.312	1.000

Table 4.
Numbers of maps included in each group

Type	Date	
A	1962. 7. 4	72
B	1962. 7. 8	35
G	1965. 8. 25	17
H	1964. 8·14	6

Table 5.

	A	B	C	D	E	F
A						
B	0					
C	13	1				
D	32	0	0			
E	10	6	5	0		
F	1	5	3	0	5	

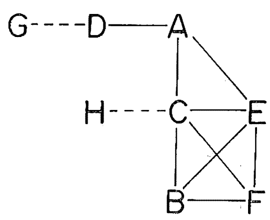


Fig. 2.

Table 6. Change of types.

date	type	date	type	date	type	date	type	date	type
61. 6. 1	D	26	B	25	A	18		17	
4	AC	27	B	27	A	23	B	18	G
6	DG	29	BF	29		25	F	20	
11	DG	30	F	8. 1		26		22	B
13	DG	7. 2	ACEF	2	BE	30	B	24	
14	DG	3	AD	3	BE	62. 6. 1	C	15	
15	D	10	AD	5		2	ACE	26	
16	AC	12	ACE	8	AD	3	E	28	AD
17		14	AD	11	ACE	4		29	AD
18		15	D	12	AC	7	B	7. 1	AD
20	C	16	C	13	C	9	F	3	AD
22	C	17		15		14	DG	4	A
25	BF	20	CF	17		16		7	B

3. Result

Six types were defined and 174 maps, 70% of all, belong to these six types. Figs. 3~8 shows six types and the respective three elements of these six types. Trapezoids in those figures show the region considered in this study. Comparing M_1 and M_2 in Table 2, many maps belong to some of the six types simultaneously. In Table 6, some maps correspond similarly to four types. Table 3 shows correlation coefficients between each pair of six types, and some of these correlation coefficients are very near to the criterion C_0. In Fig. 2, the correlation coefficient of two types bound by a straight line or a broken line is larger than 0.50. Numerals in Table 5 mean the numbers of maps belonging to two types corresponding to a row and a column respectively. Table 6 shows the types of daily map-patterns. Table 7 shows the number of cases in which a pattern changes from the group of a column to that of a row, and for instance, the change of types from 15th to 16th June 1961 is regarded as both changes, $D \rightarrow A$ and $D \rightarrow C$. Moreover, numbers in parentheses show how many times the controversial type is expected to appear by chance in proportion to its frequency in total samples. Though on account of deficiency of data we cannot say definitely, we see the following facts in Table 7:

(1) Type A, B, C, D and E have a tendency to persist, Type B being most persistent.

(2) Each of Type A and B can be replaced by each other less frequently than expected by chance. Situations are similar for pairs of Types B and D, Types D and E and Type D and F.

The above six types are not always independent of each other, and so I adopted another method of classification, somewhat different from the previous method, as follows:

When we find Type B in step 3, it should be correlated with Type A lower than 0.30. The third must not be similar to Type A or Type B, and so on.

Table 6. (continued)

date	type	date	type	date	type	date	type	date	type
8	B	26	B	17		11	AC	19	AE
9	BF	27	E	19		14	CH	24	
10	CE	29	C	20	E	17		25	
12	DG	63. 6. 1	D	21	BE	18	B	27	AC
13	AD	3	B	22	ACE	19	B	28	A
15	AE	9	C	24		23		29	A
17	AE	12	D	27	BCE	28	B	30	DG
18	E	13		30	A	65. 6. 1		31	A
19	CE	14		64. 6. 1		4		8. 1	A
21	AE	15		3		8		2	B
22		16	F	5	A	9		3	B
23	BF	18	F	6	CH	10	D	6	E
24	B	19	BEF	8		11		7	A
26	B	21	AD	13	B	12		9	ADG
27		23	A	16	DG	17	E	10	AD
29	AC	28	AC	17		19	AD	12	A
30	F	29	AD	19	E	21	D	13	
8. 2	E	7. 4	BE	22	AD	22	AD	14	
4		5	B	26	ADG	23		15	CH
5	F	9	DG	28		24		16	CH
6		11	AD	30	CEF	26		17	C
7	A	12	AD	7. 3		27	AD	18	F
8	A	13	AD	4	C	30	AD	19	
9	D	14	AD	5	AC	7. 1	AD	20	
10	DG	15	AE	6	AD	2	AD	21	
11	DG	16	EF	22	C	3	A	22	
13		20	C	23	AD	5	A	23	AD
14	A	21	CH	24	DG	6	A	24	AD
15		24	A	27	F	8	EF	25	DG
16		8. 2	F	29	B	9	CE	26	G
18		4	C	30		11	A	27	
20		6		8. 1	B	13	AD	28	
22	E	10		5	AD	14	E	29	B
24		11		8	D	17	A	30	B
25	B	16	AD	10	CH	18	A	31	B

Result by this method is shown in Table 4, and 130 maps belong to these four groups. Though the former two types are the same as Types A and B by the previous method, the latter two (G, H) do not agree with C, D, E and F.

4. Discussions and Remarks

As shown in the previous section, results of this experiment are not so satisfactory as LUND's. The reasons may come from the difference of geography and seasons and that the distribution of stations is not so uniform in this experiment as in LUND's. Seeing my result, it seems to be impossible to relate map-pattern types with daily weather phenomena.

NOMOTO improved COURT's Method as follows:

He used pressure values at grid points read from daily maps. I have omitted the meanings of a and b in equation (2), but Nomoto defined Analogy Index considering those effect, as follows:

$$I=r\left(1-\frac{D}{4\sigma}\right)$$

where, σ is the mean of daily standard deviations, I is Analogy Index, and D is defined in the equation,

$$D=\sqrt{\frac{1}{n}\Sigma\{f(t_1, P_i)-f(t_2, P_i)\}^2}.$$

Moreover he adopted as a type, the mean chart of all elements of a group. But NOMOTO's method is not always effective from a meteorological view point. Court's Method is planned so as to classify general patterns mathematically, but it is desirable, for a classification of pressure patterns, to adopt a method having meaning in meteorological recognition. In fact, our results yielded types which imply the piling-up of some meteorological typical patterns and do not have interest in themselves. No method will be satisfactory unless based on synoptic meterology. However, COURT's Method or NOMOTO's may be available to some extent, for the prediction of some weather phenomena with the aid of other information, as in NOMOTO's attempt to forecast daily visibility.

The help of all members of my laboratory, DR. MARUYAMA and MR. NOMOTO extended in discussion is deeply appreciated.

Table. 7.
Frequency of type transition from one day to the next day (expected values in parentheses).

next day \ one day	A	B	C	D	E	F	total
A	22 (11.9)	1 (6.2)	9 (6.8)	14 (10.1)	4 (6.2)	1 (3.6)	51
B	1 (5.8)	12 (3.1)	0 (3.3)	0 (4.9)	3 (3.1)	3 (1.7)	19
C	3 (5.3)	2 (2.8)	8 (3.0)	1 (4.5)	4 (2.8)	2 (1.6)	20
D	6 (8.9)	0 (4.7)	4 (5.1)	17 (7.6)	1 (4.7)	1 (2.7)	29
E	6 (5.1)	4 (2.7)	1 (3.0)	2 (4.4)	8 (2.7)	3 (1.5)	24
F	2 (3.0)	2 (1.6)	1 (2.9)	0 (2.5)	1 (1.6)	2 (0.9)	8
total	40	21	23	34	21	12	151

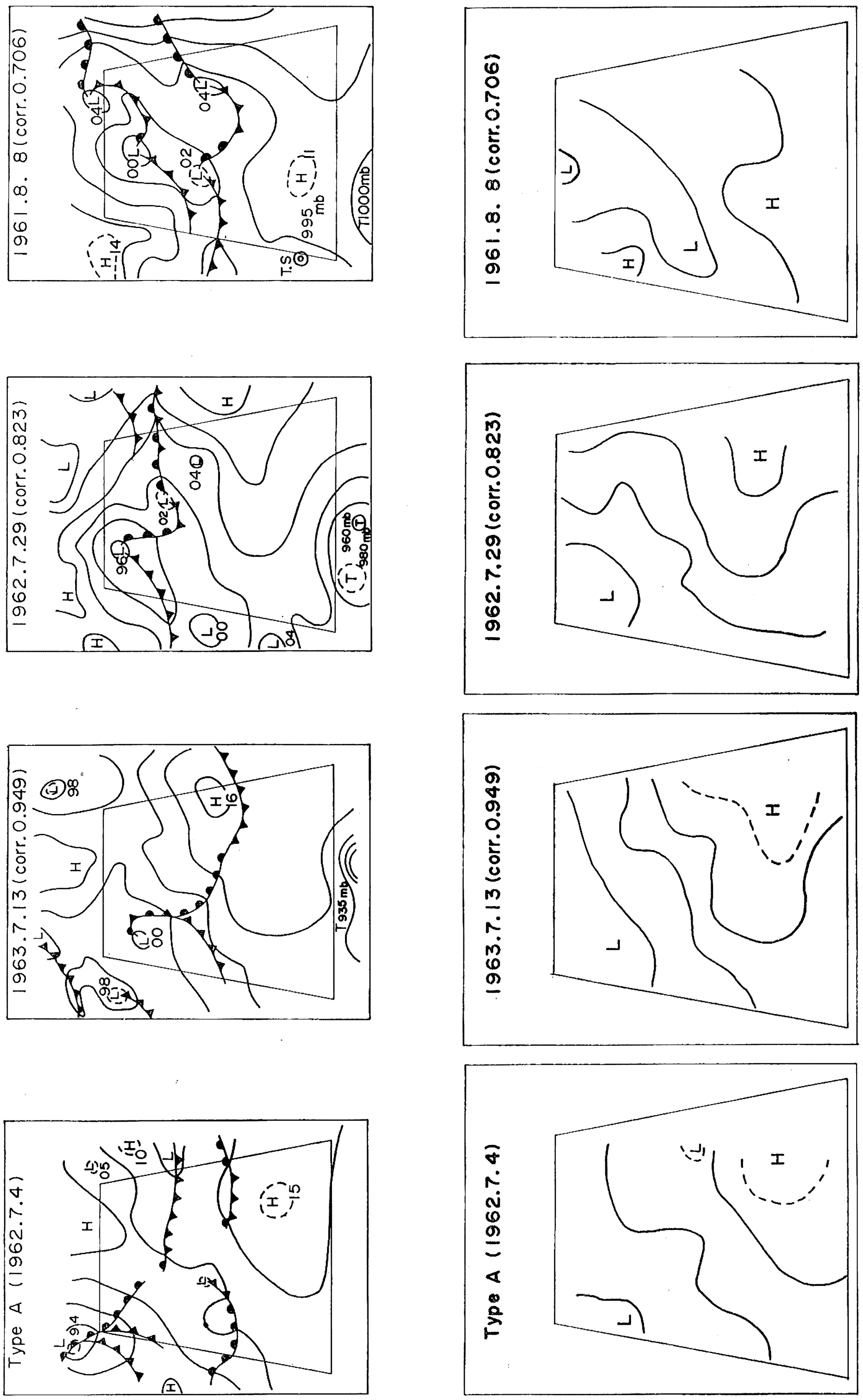


Fig. 3. Map-patterns selected as types and those similar to them (charts having no front were drawn according to pressure values only).

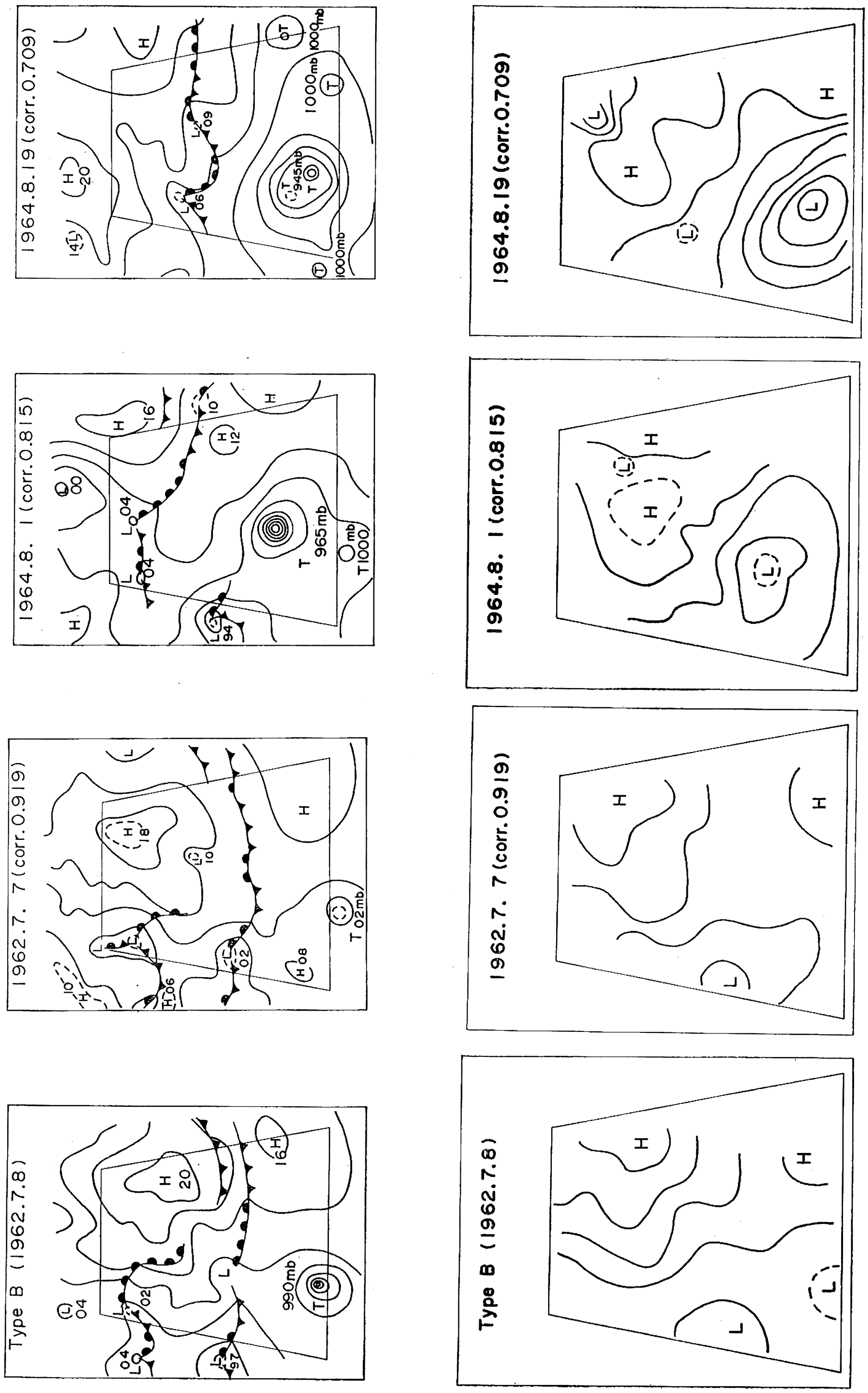
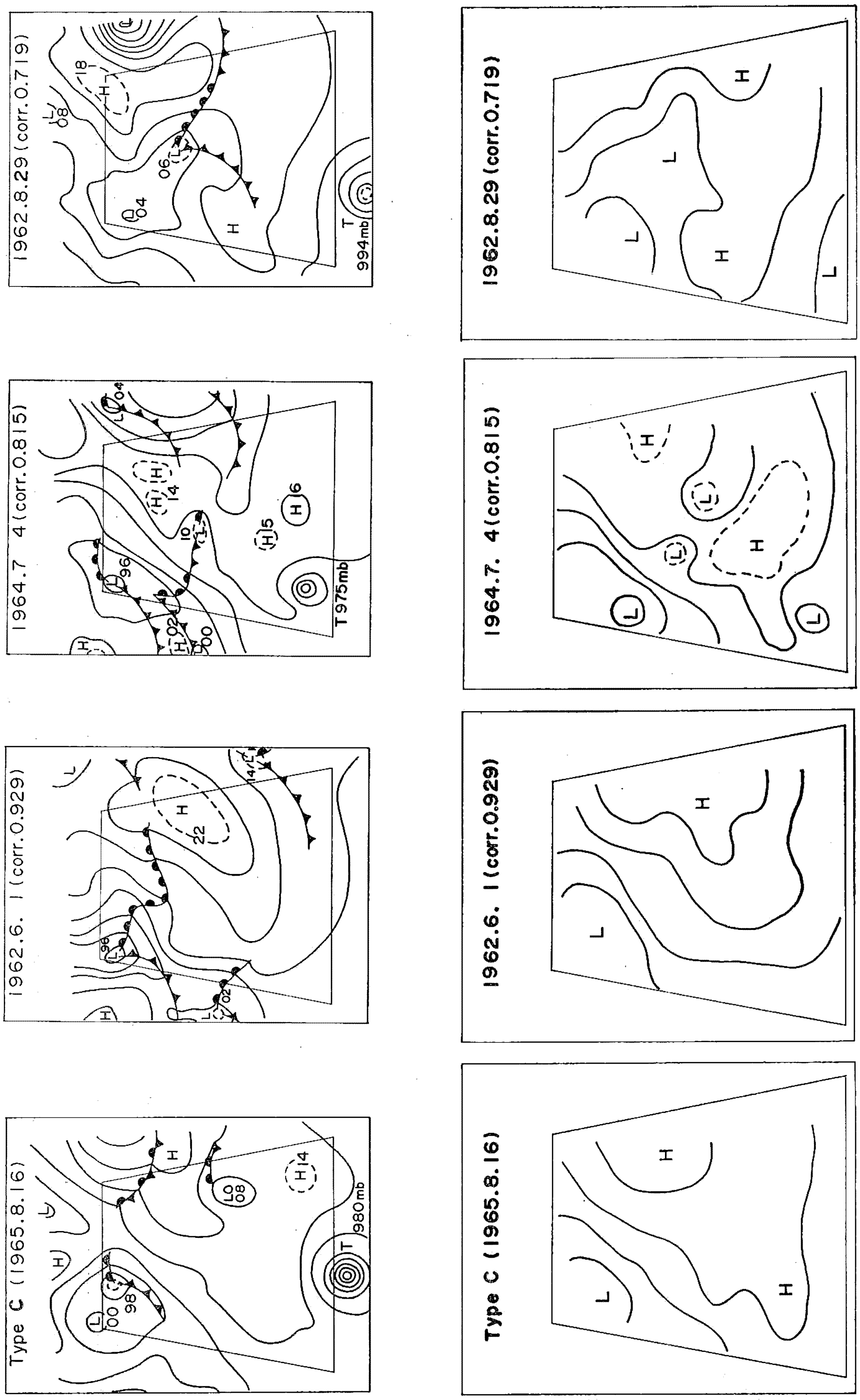


Fig. 4. Map-patterns selected as types and those similar to them (charts having no front were drawn according to pressure values only).



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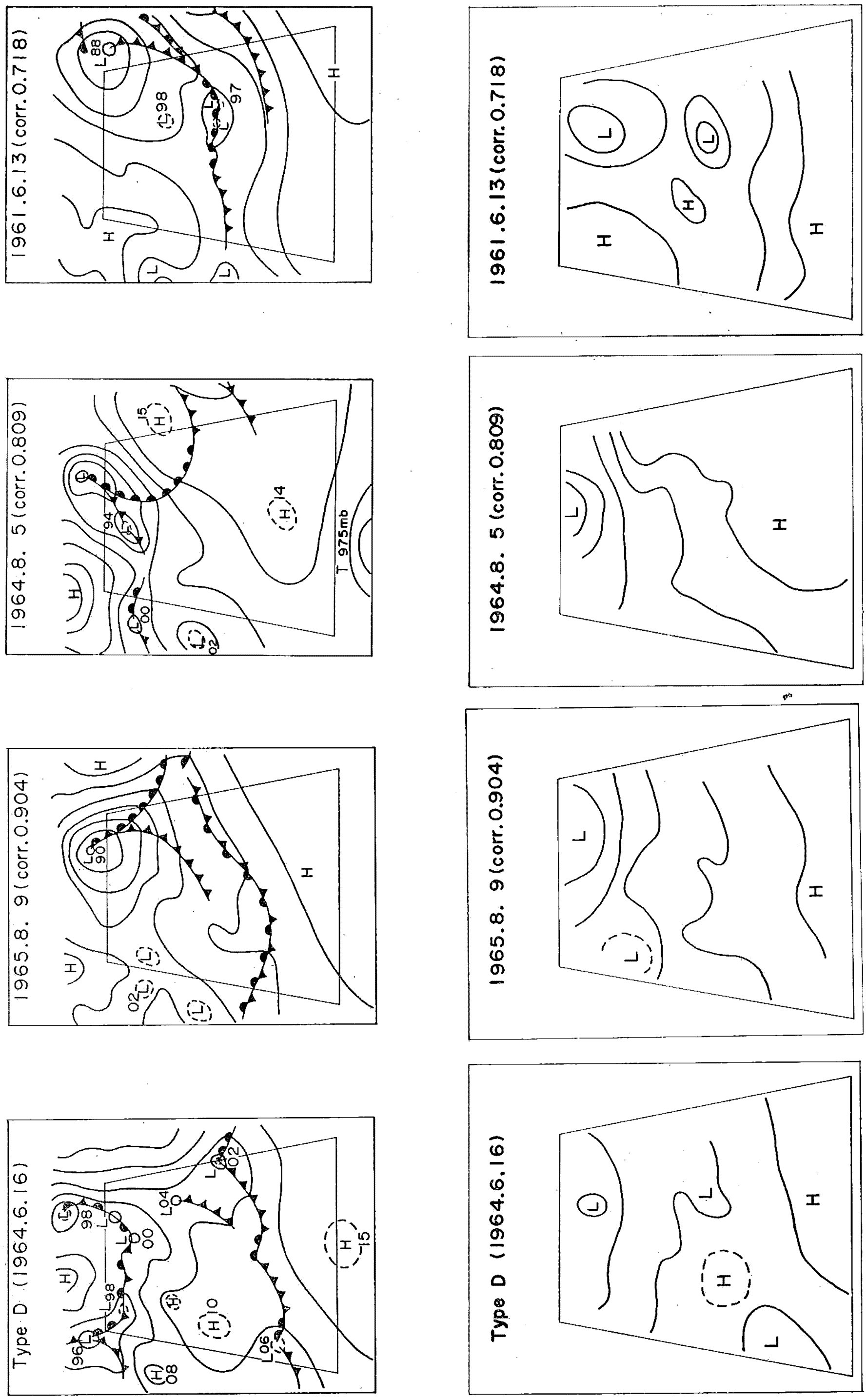

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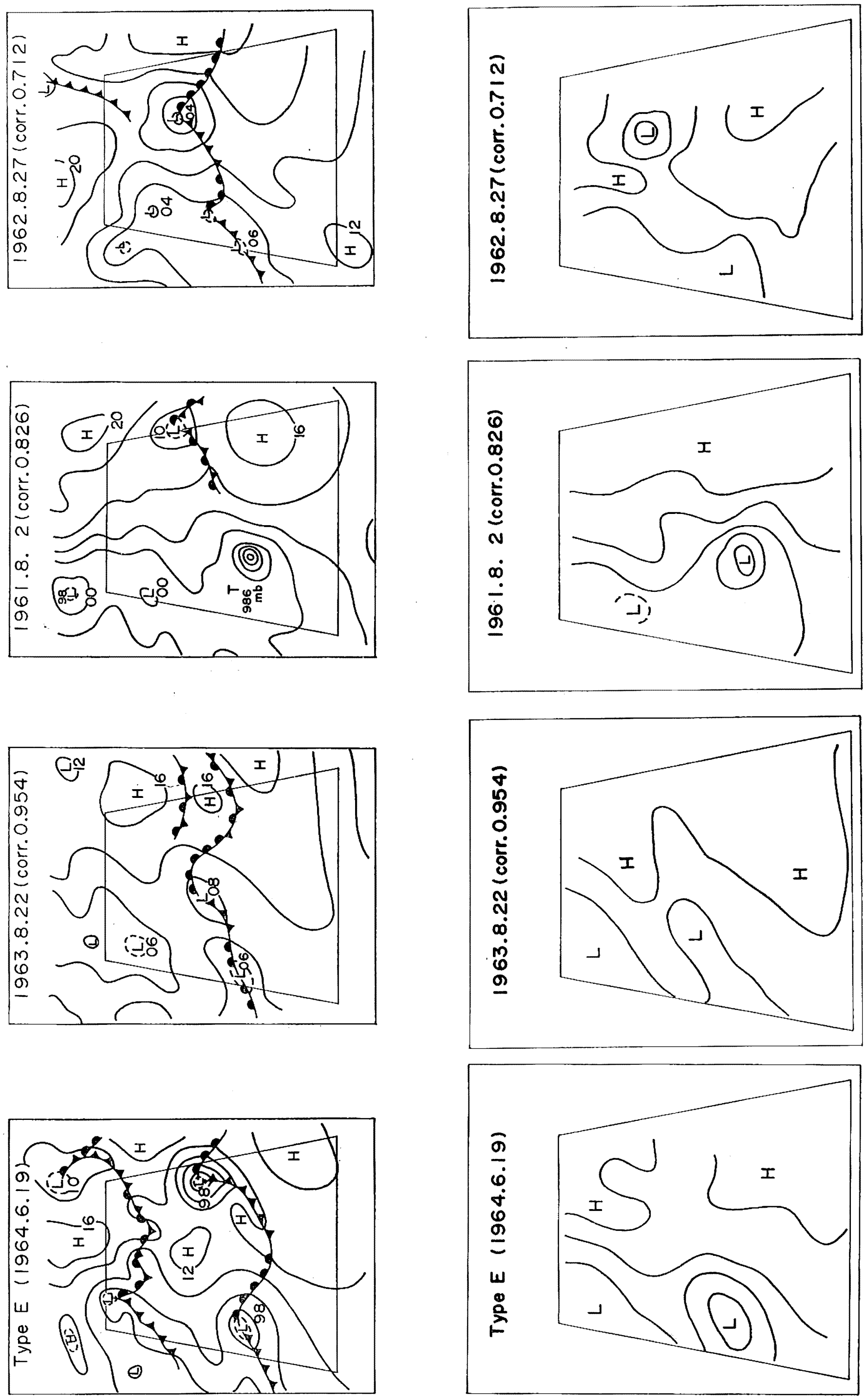

Fig. 7. Map-patterns selected as types and those similar to them (charts having no front were drawn according to pressure values only).

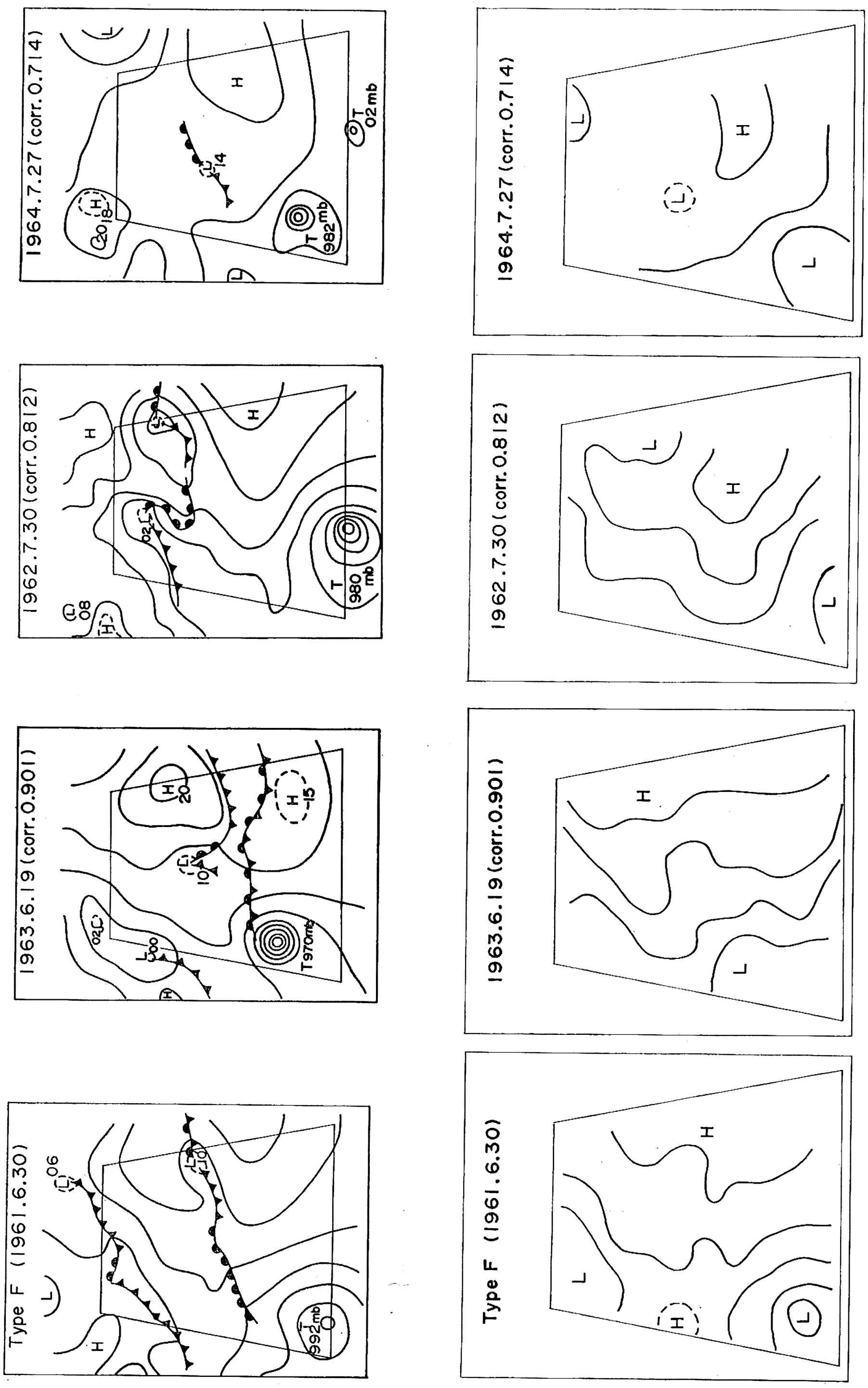

Fig. 8. Map-patterns selected as types and those similar to them (charts having no front were drawn according to pressure values only).

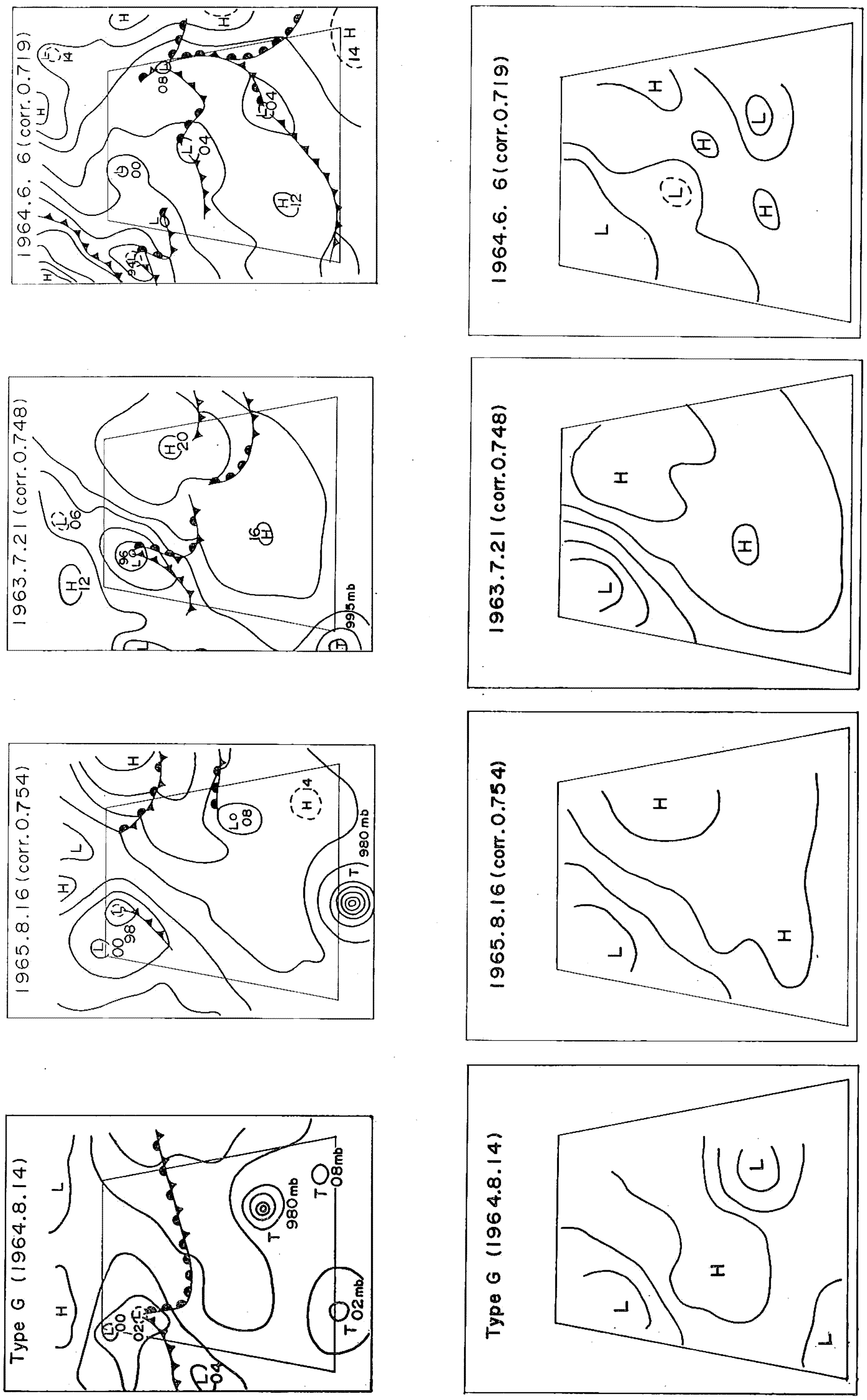

Fig. 9. Map-patterns selected as types and those similar to them (charts having no front were drawn according to pressure values only).

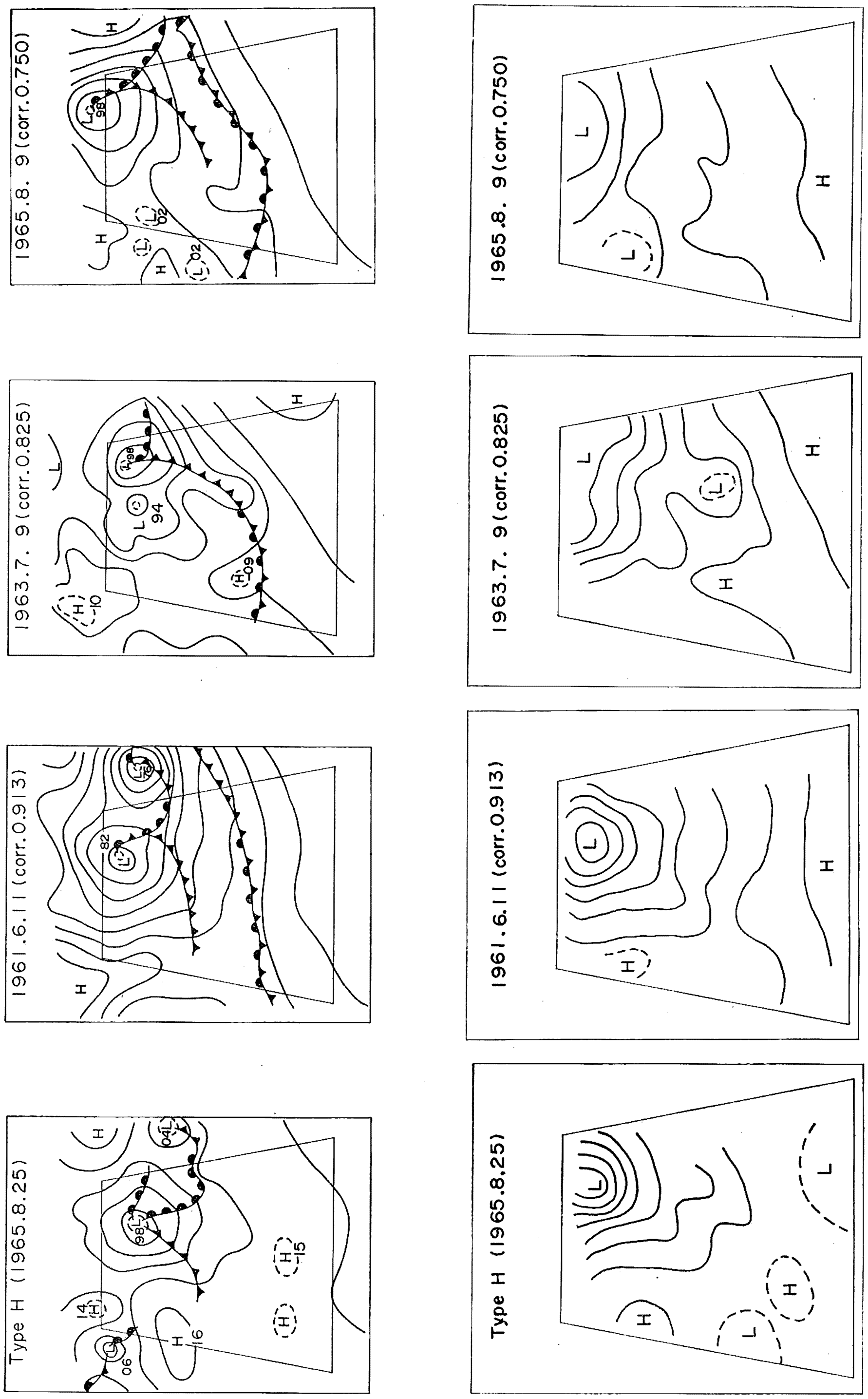

Fig. 10. Map-patterns selected as types and those similar to them (charts having no front were drawn according to pressure values only).

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日本付近の夏の天気図の客観的分類

阿 部 克 也

日本付近の夏の気圧配置の分類を相関法によって行なった。これには格子点における値ではなく，36の観測所の地上気圧を用いた。8つの気圧配置の型が見い出されたが，それらの間の違いが必ずしも明確でなく，全体の30%はそれらの型のいずれにも分類されなかった。しかし，この方法を改良すれば，他の気象要素を参照して，気圧配置と特定の天気現象との関係づけが可能であろう。