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Studies on the Seasonal Weather Forecasting (V, c)

— On the Relationship of 5-day Mean 700-mb Anomaly Pattern to Amount of Precipitation —

by

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Abstract

Relationships of the 5-day mean 700-mb height anomaly pattern to the distribution of 5-day precipitaion amount over Japan are studied. Results suggest to us that the occurrence of a certain height anomaly pattern is connected well with the annual course, and that the relationship should be studied about every type of height anomaly pattern in every season or semi-season.

1. Introduction

The interpretation of the mean pattern with regard to precipitation amount depends on the presumption of disturbances and water vapour transportation on the mean chart. W. KLEIN [1] studied winter time precipitation about various components of 5-day mean 700-mb pattern, and composed a schematic precipitation model. We picked up, in this study, the 5-day mean height anomaly pattern, because of its distinct figure compared with the 5-day mean pattern, though trouble arose about the 700-mb normal height for each 5-day period throughout the year. The 5-day mean height normal adopted are those calculated by harmonic analysis of the monthly mean height normal, only the first two harmonic components being employed in the calculations, as in the method presented by BROOKS and others [2]. Such a normal in the analysis of the mean chart is likely to emboss a particular pattern which represents the seasonal character or singularity.

Almost the same treatment was done for the 5-day precipitation amount. The normal values of 5-day precipitation were calculated by interpolation of smoothed curve of monthly precipitation normal, then the frequency of 5-day precipitation anomaly was calculated for every season. The intensity of precipitation in every season is defined by the criterion dividing a station's array of 5-day precipitation anomaly into three classes, above normal (heavy rainfall), near normal (moderate rainfall), below normal (light rainfall). Thirty stations were selected over Japan and its outlying islands, and the distribution charts of 5-day precipitation anomaly for three years from October 1952 to September 1955 were drawn.

2. The height anomaly pattern which represents particular surface disturbances

21 standard types of 5-day mean 700-mb height anomaly pattern were selected

in our laboratory. Some of these represent particular disturbances and correlate well with precipitation amount over Japan.

Types with heavy rainfall are T_1*, C_1, L_2, S_2, B (except in winter and autumn), and E in winter. A detailed explanation of these types will be attempted in another paper in this number, and these types will be easy to identify because of their peculiarity, but some notice may be necessary about L_2. This is characterized by the small area of negative height anomaly and the positive area in high latitudes, and it is right to shift the centre of the negative area a little to the west of Japan but make the zero anomaly line touch Japan.

Types with light rainfall are W_2, W_3, and R_1, R_2, (except the rule (2) for spring, see Section 4), i.e. positive height anomaly over Japan and negative in the vicinity of the Kamchatka peninsula or the sea east or south-east of Japan, with a northerly or northeasterly component of anomaly wind near Japan. Here also are included type S_1, (in summer), and type L_1, (in winter). Type L_1 is distinguished from L_2 in regard to the large area of negative height anomaly which covers the Japan Island (limit of diameter between L_1 and L_2 is almost 15~20 deg. Lat.).

Typhoon type Though it is not selected in the type classification, there is another type which represents a particular disturbance in the low latitudes (typhoon or troyical storm). When the anomaly pattern is below-normal from the low latitudes to the west of Japan as far as 20°N or more, there occurs heavy rainfall (heavy rainfall typhoon type), while when it is below-normal from the low latitudes to the sea south-east of Japan (see type R_2), there occurs light rainfall (light rainfall typhoon type).

The above classification of the height anomaly patterns about rainfall is valid for all time, but the explanation was restricted in the special height anomaly pattern, and so the seasonal character of the relationship of the height anomaly pattern to precipitation amount will next be disccused.

3. Relationship in winter

In winter, precipitation amount is highly correlated with height anomaly at the same station. The stations near Japan for which height anomaly were calculated are 40°N, 140°E and 30°N, 130°E (Fig. 1). Taking the mean of height anomaly at these two stations, we compared it with the precipitation over the Pacific coast of the Japanese mainland, Tokyo (47662 in International Index Number), Maebashi (47624), Nagano (47610), Shizuoka (47656), Nagoya (47635). Results are shown in Table 1.

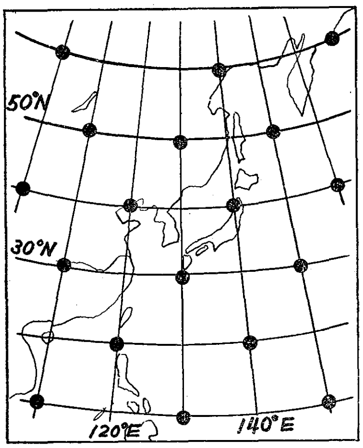

Fig. 1. Stations for which 5-day mean 700-mb height anomaly are calculated.

Seeing that the total average of height anomaly in the winters covered is plus 50 feet, we know that positive height anomaly lead to heavy rainfall, negative to light rain.

If we count one near-normal case as 0.5, the

* Symbols are the same throughout our series of the study about 700-mb height anomaly pattern.

Table 1. Relationship of 5-day mean height anomaly to precipitation in winter. (Total number of cases is 54 in three years)

Average of 5-day mean 700-mb height anomaly at 40°N 140°E, 30°N 130°E	Precipitation of the Pacific coast of Japan (Tokyo, Maebashi, Nagano, Shizuoka, Nagoya)		
	heavy	moderate	light
Above 60 feet	**15**	3	5
Below 40 feet	8	0	**23**

percentage of agreement is 72. Moreover, 14 cases are in the range from +40 feet to −30 feet, and 6 out of 14 cases are heavy, 8 light. So if we exclude such a range from the above rule, the percentage of fitness becomes 82. A study of the exceptional cases in Table 1 showed that 8 cases of these are to be classified in the above-mentioned (Section 1.) particular height anomaly pattern, 4 of these are undeterminable cases, 6 of these are not to be classified in any particular pattern at all.

Moreover, these six cases are outside of the above range (+40~30 feet), and are in the first half of January. It suggests to us the existence of some kind of "singuarity", but no further study has been done yet.

Precipitation distribution over the Japanese mainland in winter exhibits a marked contrast between the Japan sea coast and the Pacific coast: that is, long duration of snowy weather and extraordinary heavy precipitation amount along the Japan sea coast, and little precipitation along the Pacific coast. According to our study of winter-type precipitation, types W_1, B_1, T_2, i.e. the pattern in which the zero-anomaly line with west to south-west anomaly flow runs across the Japanese mainland, seemed to strengthen the contrast of winter-type precipitation. Type T_2 brought winter-type precipitation also, but in this case the probability of precipitation was a little higher along the Pacific coast.

4. Relationship in spring

It may be considered that the first decade of March still conserves the winter character, because 5 to 6 cases in the first decade of March show good conformity to the features of Table 1, and the percentage of conformity decreses suddenly after the second decade.

Many hypotheses were suggested and tested to establish the nature of the relation between 5-day mean height anomaly pattern and precipitation. At last, we found that the relation changes with time even in the same season, and that study has to be done in each group of types which show abrupt seasonal change as shown in Table 2.

Table 2. Frequency of height anomaly type in spring.

Season \ Type	T_2, E_1, E_2	R_1, R_2,	T_1
March, First half of Apr.	13	0	0
Second half of Apr., May	1	10	4

(1) Trough type height anomaly pattern (T_2, E_1, E_2 and all analogous patterns including Z_2,Z_1).

a) Just before the trough (the zero-anomaly line touches Japan), there occurs heavy rainfall (The rate of agreement is 3 out of 4).

b) In case the zero-anomaly line runs north of 45°N, heavy rainfall occurs along the south coast of the mainland (4 cases out of 6).

c) In case the zero anomaly line runs along or south of 40°N, light rain occurs in Japan (7 out of 10).

(Notice the closing of trough.)

(2) The positive height anomaly area (as in R_1, R_2 and all analogous patterns including Z_1, Z_2) brings light rainfall generally. However, exceptions are in the area of high speed of easterly anomaly flow (>−110 feet/10 deg. Lat.) and zonal drain (>40 feet/10 deg. Lat). Statistics showed that the percentage of agreement is 83; that is, 13 out of 18 cases are heavy rainfall, 1 out of 18 light, 4 not determinable whether light or heavy.

5. Relationship in summer

The first half of summer from the end of May to the first half of July is a rainy and cool period called Baiu-season, and the latter half of summer is sunny and hot being covered by the North-Pacific anticyclone.

The frequency of 5-day mean height anomaly type shows also this seasonal character.

Table 3. Frequency of 5-day mean height anomaly type in summer.

Season \ Type	B	R_1, R_2	H_1, H_2	C_1, C_2	S_1
June and first half of July	15	5	1	1	0
Second half of July, August	3	1	6	6	6

The relationship of the height anomaly pattern to precipitation differs for each group of patterns. About type B and analogous patterns, study has been done in every component of the pattern, and Fig. 2 shows the resulting composed model.

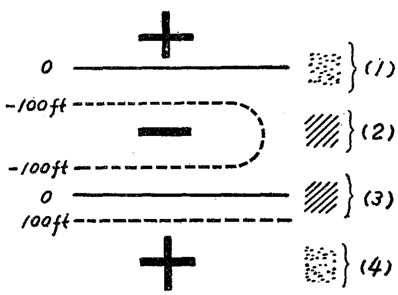

Fig. 2. Schematic model for summer precipitation associated with 5-day mean height anomaly pattern.

The area (1), which means the vicinity of zero-anomaly line with easterly anomalous flow, brings light rain (the percentage of agreement is 100, i.e. without exception).

The area (2), central strip of the negative height anomaly area, leads to heavy rain (9 out of 11, two exceptional cases have the centre of negative area located west, and northerly anomaly wind over the area studied).

The area (3), near zero-anomaly line with westerly anomalous flow, brings heavy rain (30 out of 38).

The area (4), positive height anomaly area (>+100 feet) with zero-anomaly line north of this area, light rain (12 out of 15).

It is generally difficult in summer to estimate the precipitation in the positive height anomaly area, but the following areas see light rain:

The area (4) in Fig. 2 which has some restriction as mentioned above.

The area of northerly to northeasterly anomaly wind (8 out of 8 including the typhoon type with light rain, without exception).

The type S_1 (4 out of 5)

The type C_2 (except the area (3) in Fig. 2).

Extraordinary heavy rainfall in Japan occurs in the Baiu season, summer, and early autumn. If by extraordinary heavy rain we mean a rainfall of 100 mm or more in 5-days at three or more stations in one rain area, there were fifteen cases in the three summers studied. The area (3) in Fig. 2 of type B and the area (3) with the heavy rain typhoon type lead to an extraordinary heavy rain with the probability of 9 out of 12 (moreover, the remaining 3 cases also brought considerable heavy rain). There was one example associated with the area (3) of B type with the heavy rain typhoon type, and it brought the heaviest rainfall and flood in sixty-one years over North-Kyūshū at the end of June 1953. Two cases of extraordinary heavy rainfall belonged to the area (2) in Fig. 2 (2 out of 11), and 4 cases occurred in the positive height anomaly area of type Z_1, R_1, R_2. We couldn't get any criterion by which to distinguish these 6 cases from the rest of positive height anomaly patterns.

The cause of the difficulty in estimating precipitation amount from the height anomaly pattern in summer may be attributed to the scarceness of observational stations (see Fig. 1), and to the locality and discontinuity which materially affect precipitation in Summer.

6. Relationship in autumn

This season has also very interesting characteristics as a transitional season.

Table 4. Number of cases of the type with zero-anomaly line running across Japan and with westerly anomaly flow such as type *B*, W_1 or W_4 in autumn.

Season	No. of case	Total No. of case	Freq. in %
September and October	8	36	22
November	12	18	67

Table 4 shows that some kind of "pre-winter singularity" is in November.

In November the above cases bring, as in winter, the winter type precipitation distribution over Japan (the percentage of agreement 75), and in September and October they are not determinable, then the rule of the area (3) of Fig. 2 holds only in spring and summer.

The rule of area (2) in Fig. 2 holds without exception in 5 cases in this season. The rule for spring (1) —heavy rain in the area of stronger-than-norma leasterly flow and zonal drain— holds good, 9 out of 11. Many of these cases in autumn are the rain in the southern or the southeastern tip of positive height anomaly area like type H_1, H_2, or are associated with the heavy rain typhoon type.

In this season there were 9 cases of the heavy rain typhoon type and 3 of the light rain typhoon type, all without exception.

7. Conclusion

Though, in this study, we are building on the foundation laid by previous researchers, W. KLEIN, D.E. MARTIN [3], K. TAKAHASHI, and so on, the relationships established in the above of the height anomaly pattern to precitation still remain tentative on account of few examples; however, our impression is that the 5-day precipitation is much affected by seasonal change of circulation aloft, and that the seasonal character of 5-day mean circulation aloft is embossed by extracting long periodic disturbances (twelve months and six months) which may be caused by seasonal change of solar radiation, and that the relations should be studied in each group of height anomaly types which shows seasonal character in every season or semi-season.

References

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