Weather-Climatological Study of Changma and Kaul Changma in Korea in relation to two Rainy Seasons of East Asia

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INTRODUCTION

In the summer half year from June to October, there are two rainy seasons in Korean Peninsula, which are called Changma (meaning a long rainy season in Korea) in early summer and Kaul Changma (meaning an autumnal rainy season) in early autumn. Changma and Kaul Changma are the seasonal phenomena, which are correlated respectively with Baiu in early summer and Shurin in early autumn over Japanese Islands. In China the rainy season in early summer is called Maiyü. The Changma season in Korea appears normally from end of June to the end of July. Maiyü in the middle and lower parts of the Yangtze Basin of China appears on the average from June 14 to July 3 (Hsu Chun, 1965). The Baiu season in Japan appears normally from the second decade of June to the middle of July. Kaul Changma in Korea lasts for about twenty days from the third decade of August to the first decade of September. The Shurin season in Japan lasts from the first decade of September to the middle of October. There may be no obvious early autumn rainy season in China.

Owing to its climatological characteristics and agricultural importance, there have been many studies on these rainy seasons. Especially in Japan, attention to Baiu and Shurin has long been paid by meteorologists and climatologists, and many of theories and explanations have been proposed.

The pionneer work on Baiu was accomplished by Okada (1970). He emphasized the importance of the anticylone over the sea of Okhotsk. Up to date, the previous studies on Baiu and Shurin can be classified greatly into two categories, one is the analysis from the standpoint of natural season (Takahashi, 1942; Yazawa, 1949; Sakata, 1952; Maejima, 1961, 1962, 1967; Kimura, 1966, 1967, 1968; Kawamura, 1973), and the other is the dynamic and genetic analysis (Murakami, 1951, 1958, 1959; Suda and Asakura, 1955; Asakura, 1968; Yoshino, 1963, 1965, 1965b). Takahashi(1942) classified systematically the natural seasons of Japan. Yazawa (1949) investigated the regional characteristics of the seasnal profile of all over Japan using pentad means of several climatic elements, temperature, vapor pressure, cloud amount, sunshine duration. Maejima (1961, 1962, 1967) classified and determined characteristics and periods of natural seasons, using the daily normals of 50 years such as cloudiness, sunshine duration, precipition, air temperature and vapor pressure, Especially he considered the occurrence of weather singularities associated with the atmospheric circulation and its spatial relations.

After World War II, according to the development of world wide upper air observations, the analytical studies from the view points of general circulation and genetics increased.

Flohn (1956, 1957) studied water vapor transport during summer rainy season and discussed summer monsoon in South and East Asia in the aspects of large scale circulation and weather singularities and their teleconnection. He indicated that the disintergration of the jet stream in India is connected with contemporaneous increasing of air temperature over the Tibetan Plateau. Suda and Asakura (1955) pointed out that Baiu season has a close relationship with the world wide stationary wave system.

Asakura (1968) classified the upper air circulation in East Asia into six flow types. He emphasized the synoptic processes and causes of the formation of the blocking flow pattern in East Asia. He revealed that the causes of Baiu in East Asia relating to the atmosphere circulation and the heat source near the Tibetan Plateau by emploing the numerical experiments.

Yoshino (1963, 1964, 1965) classified the four stages of rainy seasons in early summer over East Asia by analysing the position of frontal zones and Jet Streams.

Kimura (1966, 1967, 1968) systimatically studied Shurin. He disclosed that distinctive weather patterns during 1957 Shurin are typhoons and downgraded depressions, stationary frontal condition, cyclonic depressions with warm and cold fronts, and clear conditions owing to Siberian High (Kimura, 1967b). Murakami et al. (1962) explained that Shurin is a rainy seasonal phenomenon which is formed between the Siberian and the North Pacific Anticyclones.

Lee (1974) verified that early autumn rainy season in East Asia is caused by the cold front from higher latitudes and stationary front, employing the time cross section of polar front along 120°E, 128°E and 140° E. From the viewpoint of weather climatology, Lee (1975) reported on the weather-climatological situation of the two rainy seasons, Changma and Kaul Changma, in Korea using the bad weather day on the basis of bad weather index as reported in his previous paper (1974).

This paper aims to confirm the weather-climatological features of Changma and Kaul Changma in Korea in relation to two rainy seasons in East Asia. The characteristics of rainfall distribution and precipitation intensity (chapter I), the bad weather index as a weather climatic index and its sesonal trend (chapter II) will be reported. And then the seasonal trend of summer half year is weather-climatologically analysed by using the bad weather days on the basis of the bad weather index (chapter III). And finally, the seasonal shifts of the polar front and the North Pacific Anticyclone are discussed (chapter IV).

I. CHARACTERISTICS OF PRECIPITATION IN THE SUMMER HALF YEAR

I. 1 Aereal Distribution of Pentad Precipitation

In Korean Peninsula, the annual precipitation is on the average about 1400mm in the southern region, about 1200mm in the central region and about 900mm in the northern region north of 39°N.

The precipitation from June to September amounts about 60% of the annual total precipitation in the southern and central regions, and is over 70% in the northern region. The distribution of pentad precipitation from June to October was investigated by Lee (1974), the three dimensional diagram being used. As concerns of trend of precipitation, two peaks of precipitation are commonly recognized both in the western and eastern region of the southern part of the peninsula. From the lst to the 23rd of June, the amount of pentad rainfall is normally 15～30mm. The rainfall amount suddenly increases immediately after the 24th of June. This period from the lst to the 23rd of June is designated as the forerunner Changma as will be pointed out in chapter III. The primary peak of pentad mean precipitation of which rainfall is about 45～60mm appears during the first decade of July. The secondary peak, the amount being about 35～45mm, appears during the first decade of September. Between the two peaks, the pronounced drier period appears in the middle of August. However, in the region north of 30°N, only one peak stands out in August. It is remarkable that all of the stations of the northern

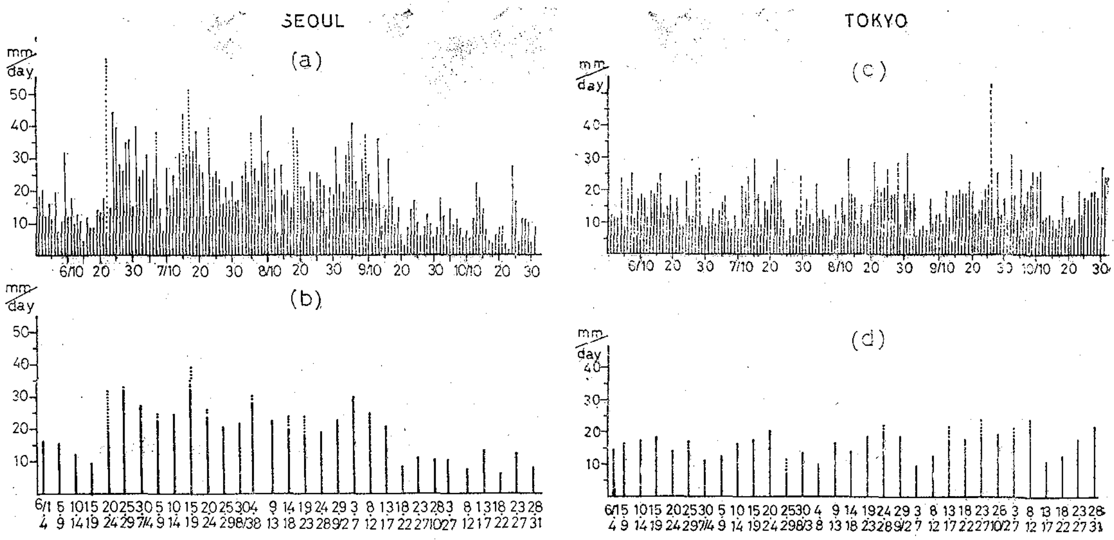


Fig.1. Seasonal trend of average precipitation intensity (in the case of days with precipitation ⩾1.0mm, 1941∼1972)
Dotted bar: including the day with over 150mm
(a), (c): daily average precipitation intensity
(b), (d): pentad mean precipitation intensity

region have a single peak. The northern region receives considerably greater amount of precipitation in August than in the southern region. This is is caused by she northward migration of polar front as depicted in chapter IV.

I. 2. Intensity of Precipitation

In order to examine the rainfall characteristics in the summer half year, the precipitation intensity was calculated from June 1 to October 31 during 1941∼1972 based on the data of daily rainfall with more than 1.0mm. Fig. 1-a shows the daily rainfall intensity mm/day) in Seoul. Fig. 1-b shows the pentad mean of daily rainfall intensity. While the daily rainfall amount in the period from June 1 to 23 is about 15mm, it rapidly increases directly after the pentad of June 20∼24 which normally corresponds to the onset of Changma season. After then, the amount of daily rainfall intensity becomes greatest in the pentad of June 25∼29 and July 15∼19, exceeding 30mm/day. The rainfall intensity of August which corresponds to mid-summer season slightly decreases, but the frequency of days with precipitation more than 1.0mm decreases rapidly. This means that the rainfall intensty is strong during the mid-summer season. After the pentad of August 29∼Septemiber 2, the rainfall intensity increases again and reaches over 30mm/day in the pentad of September 3∼7. This secondary peak of rainfall intensity corresponds to

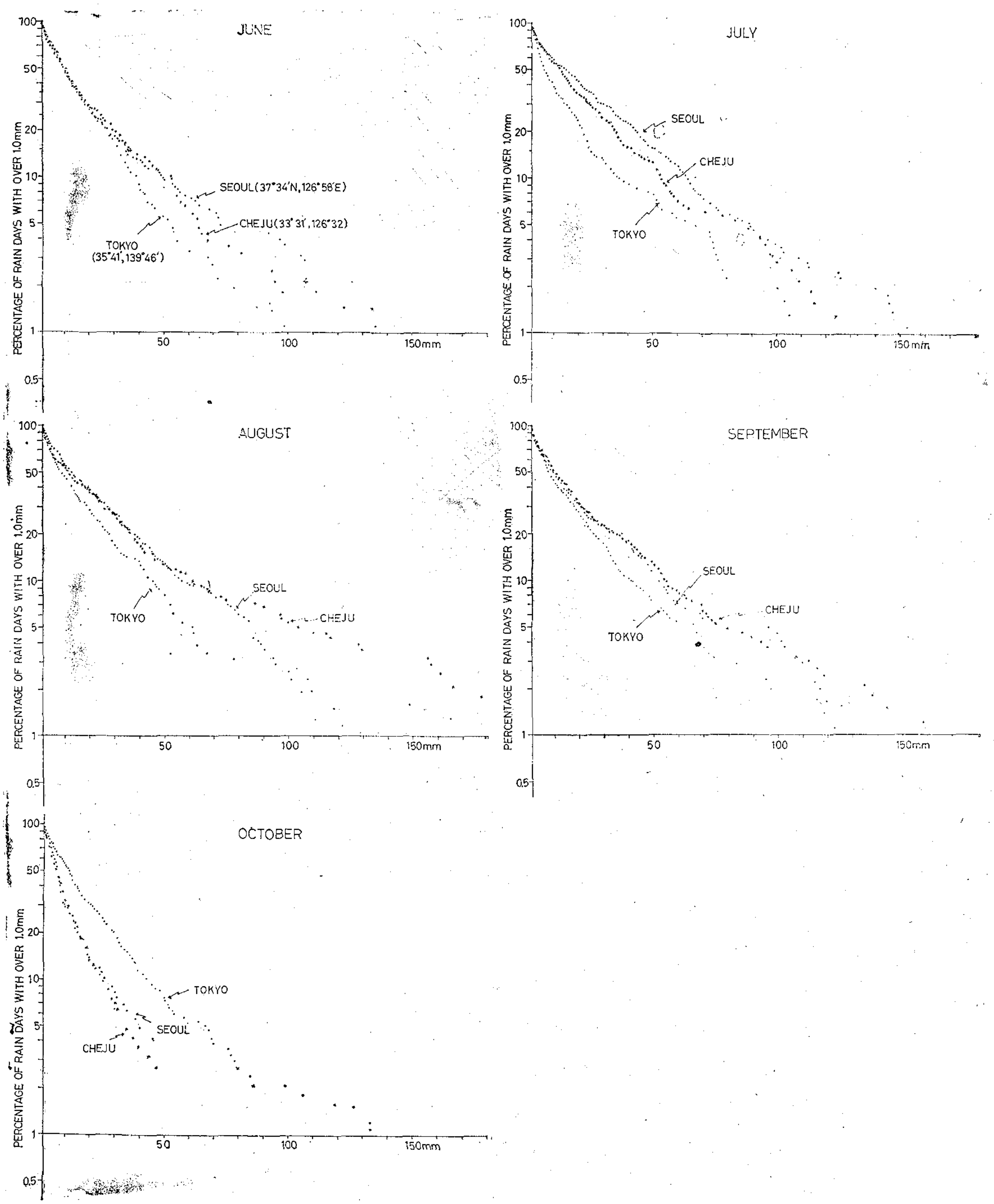


Fig. 2 The ratio (%) of rainy days by precipitation, exceeding a given amount (1941~1972)

Kaul Changma. After the pentad of September 13~17, the rainfall intensity sharply decreases, so that it is below 15mm/day at the end of October.

Fig. 1-c and d shows the rainfall intensity of Tokyo in the same period. Generally, the daily rainfall intensity of Tokyo is smaller than that of Seoul. The pentad mean of daily rainfall intensity is below 20mm/day during the period from June 1 to October 31. There are several peaks during the summer half year. Especially, the period from the end of July to the first decade of August corresponds to the mid-summer dry spells in Tokyo. The daily rainfall intensity of that spells is about 10mm/day. In the case of Tokyo it is remarkable that the rainfall intensity of Shurin is greater than that of Baiu.

Fig. 2 illustrates the ratio (%) in which the rainfall during a single day will exceed a given amount. The data for each station are delivered from June to October for the period 1941~1972 (in the case of days with more than 1.0mm). The points on the various dotted curves indicate the mean percentage of rainy days with more than a given amount of daily rainfall in three stations.

Table 1 shows the frequency of days with rainfall amount more than 1.0mm for the period 1941~1972. In June the frequncy of rainy days with more than 1.0mm is 30.1% at Seoul, 29.0% at Cheju, whereas 37.6% at Tokoy.In July the ratio in Seoul reaches the greatest amount 47.6%. On the contrary, those of Cheju and Tokyo are 31.5% and 30.6 % resepctively. This results from the fact the end of early summer rainy season at Cheju and Tokyo is earlier than Seoul. In August the ratio of Seoul is greater than those of Cheju and Tokyo. In September the frequency of rainy days with more than 1.0mm is 27.2% at Seoul, 34.2% at Cheju and 36.4% at Tokyo. In October it rapidly decreases in Seoul. The ratio of Tokyo is twice as great as that of Seoul. This fact shows that the early autumn rainy season in Tokyo continues for a longer time than in Seoul until October as is stated later.

In Fig. 2, the cuves almostly coincide with each other at three stations in June within the range of less than 30mm, over 30mm, however, are diversified. The probability of occurrence of rainy days with more than 50mm is about 10% at Cheju as well as Seoul, meanwhile, about 5% at Tokyo.In the range of more than 100mm, those of at Seoul, Cheju and Tokyo are 3.5%, 2.0% and 1.0% respectively. In July the curve of Seoul is smoother than those of Cheju and Tokyo. It means that the daily rainfall intensity in Seoul is stronger than those of two other stations.

The probability of days with more than 30mm is about 30% at Seoul, 25% at Cheju and 13% at Tokyo, and within the range of more than 100mm is 3.8%, 3.0% and 2.9% at Seoul, Cheju and Tokyo respectively. In August, the curves of Seoul and Cheju coincide with each other within the range of below about 70mm. The probability of rainy days with more than 50mm is 13% at Seoul and Cheju, and 8% at Tokyo. In the range of more than 80mm, however, is greater at Cheju than those of Seoul and Tokyo. In September the probability trend of the three stations less than 20mm is no difference at first. However, the more the daily precipitation is, the more the curves of Seoul and Cheju trend apart from that of Tokyo. The probability of rainy days with more than 50mm is 13% at Seoul, 12% at Cheju and 7% at Tokyo. In October the trend of curves reverse to any other months. The curve of Tokyo has smoother trend than those of Seoul and Cheju. This means the daily rainfall intensity of the former is stronger than those of the latters. The probability of rainy days with more than 50mm is 53% at Tokyo, 20% at Seoul and Cheju. That of more than 50mm is 7.8% at Tokyo, 2% at Seoul and 3% at Cheju. Such differences between Tokyo and in Korean Peninsula are caused by the difference of Shurin.

II. BAD WEATHER INDEX AS WEATHER INDEX AND ITS SEASONAL TREND

In the previous paper by Lee (1974), the bad weather index as weather index was proposed. It was obtained on the basis of the daily occurrence frequency of precipitation, cloud amount and sunshine duration from June 1 to Octobor 31 for the period 1941~1972. In order to determine the bad weather index, the threshold values of three daily climatic elements, i.e. precipitation, cloud amount and sunshine duration, were taken into consideration. At first, the frequency of the day with daily precipitation more than 1.0 mm from June 1 to October 31 during the period 1941~1972 were counted. Thereafter, the threshold value of daily cloud amount and sunshine duration were determined so that the total number of days with daily cloud amount over the threshold value and the total number of days with daily sunshine duration below the threshold value equal respectively to total number of days with daily precipitation more than 1.0mm. As was mentioned above the threshold value of each climatic element is used to determine bad weather index. A day with daily precipitation more than 1.0mm, with cloud amount exceeding the threshold value and with sunshine duration shorter than the threshold value is given 3 points of bad weather index. A day satisfying any two of the three conditions is given 2 pints of bad weather index. In the case of a day satisfying one condition only, one point is given. Thereafter, the bad weather index of each day from June 1 to October 31 during 32 years is calculated, counting the days satisfying the above condition one by one. However, since the length of the statistic period differs from station to station, the occurrence frequncy (%) of bad weather index was employed. For example, if a specific day has total 48 points of bad weather index during 32 years, the occurrence frequency of bad weather index of that day becomes to be 50%.

On the basis of the above mentioned bad weather index, the occurrence frequency of bad weather index were calculated for each day from June 1 to October 31 for the period 1941~1972. The occurrence of frequency of bad weather index well reflects the trend of natural season. The occurrence frequency of bad weather index from June 1 to June 22 is 20~30%, showing two minor peaks at all of the stations (Lee, 1974). Cheju

Table 1. Frequency of the days with 1.0mm of rainfall (1941-1972)

	Seoul			Cheju			Tokyo		
	A	B	B/A(%)	A	B	B/A(%)	A	B	B/A(%)
June	900	271	30.1	960	278	29.0	960	361	37.6
Jully	930	443	47.6	992	312	31.5	992	304	36.6
August	930	309	33.2	992	280	28.2	992	262	26.4
September	900	245	27.2	960	328	34.2	960	349	36.4
October	930	144	15.4	992	187	18.9	992	331	33.4

A : Total Number of days
B : Number of days with over 1.0mm of rainfall

has the greatest value, about 25~35%, in this period. Tokyo has 30~40% of the occurrence frequency of bad weather index in the same period. The period from 10th to 23rd of June corresponds to the early Baiu in Japan. On the 23rd of June, the minimum of occurrence frequency of bad weather index simultanously occurs at all of the stations without exception. This date of June 23 is apricable to the intermission of season in Japan (Maejima, 1967), and the beginning of Changma in Korea, having a very important meaning of seasonal weather system as will be stated later. The great daily variability of the occurrence frequency of bad weather index is presented in the period preceding June 23 in Korea. The variability coefficient of precipitation during the period of 1908~1960 at Seoul is 67.1, 58.9 and 61.7 for June, July and August respectively (Lee, 1970). It was reported that because of its unreliable precipitation of planting season the second rice cultivation is considerably unstable in Southwestern Japan (Yazawa, 1960). In Korea, rice agriculture is influenced to a extent by this large variability of rainfall at this time. In the case of Cheju located at the lowest latitude in Korea, the occurrence frequency of bad weather index is the greatest, and the seasonal march of bad weather index bears close resemblance to that of Tokyo. After June 24, the frequency of bad weather index abruptly increases at all of the stations. The maximun appears on lst-3rd of July in the southern coastal part (Cheju, Mokpo, Pusan), on llth∼15th of July in the central part(Seoul, Kangnung) of Korean Peninsula. It occurs much earlier, on June 29, in Tokyo. The peaks of the occurrence frequency of bad weather index in the southern region are more pronounced than those of Seoul and Kangnung. The trend of occurrence frequency of bad weather index shows a sudden decrease around the 17th∼20th of July for the stations of the southern region, abruptly. On the other hand, it appers on July 30 at Seoul and on August 2 at Kangnung. In the case of Tokyo, it decreases rapidly on July 14, which corresponds to the end of the Baiu season. In Seoul, the minimum of the occurrence frequency of bad weather index appears on July 12 during the middle of Changma season. It may be regarded as the intermission of Changma season. Since the end of Changma, the occurrence frequency of bad weather index decreases rapidly to about 10∼20%. This trend is continued to August 20. The same trend also appears in Tokyo. The minimum takes place between 12th∼15th of August with about 10%. In Cheju, it appears two times, on July 25 and on August 15 respectively. This cccurs on similar date in Tokyo. There are several minor peaks of the occurrence frequency of bad weather index which may mean the seasonal intermission of mid-summer in August as will be stated later.

Hereafter on August 20, the occurrence frequency of bad weather index increases suddenly. It may be considered the seasonal turning point of weather system from the stable anticyclone system of mid-summer to the unstable cyclonic system (Maejima, 1967). Kimura (1966) made it clear that the beginning of Shurin is August 26 in the Kanto Region of Japan. Based on the trend of bad weather index at Tokyo, the beginning of Shurin is found on August 22. And the beginning of Kaul Changma is around August 16 in the central region and around August 20 in the southern region in Korea. Several minima of the occurrence frequency of bad weather index appear during the Kaul Changma season which indicate the seasonal intermissions. The period of Kaul Changma lasts for about 20 days. On the other hand, the Shurin season in Japan lasts for from forty three to fifty seven days (Kimura, 1966). After September 14 in the central region, and September 25 in the southern region in Korea, there occurs a sudden decrease of the occurrence frequency of bad weather index, followed by fine weather condition in autumn which is subjected to the migrating high broken off the continental anticyclone. The date around October 15 was indicated as the end of Shurin (Maejima, 1961). The 16th of October is a singularity of the occurrence frequency of bad weather index with the smallest value of 10% in Tokyo. However, it is found that a tendency of high values are to be continuing to the end of October in Tokyo.

III. WEATHER-CLIMATOLOGICAL CHARACTERISTICS OF CHANGMA AND KAUL CHANGMA

Flohn (1954) maintained the weather-climatological approach for the study of climatology, and classified the weather characteristics of Central Europe into three type of weather-climatological landscape in the viewoint of the weather regularity. Baur (1953) also classified the daily weather types of Central Europe employing the rainfall data.

In general, the bad weather continually appears day by day in a rainy season. However, the appearing conditions of bad weather are extremely various. They are 1) the bad weather day with some amount rainfall including cloudy and no sunshine. 2) in spite of cloudiness and no sunshine, the day without rainfall. 3) the day with rainfall, but scanty cloud and some sunshine duration. 4) the bad weather day with only cloud or short sunshine duration, etc. Therefore in this paper, the classification of bad weather is performed, using the data of rainfall, cloud amount and sunshine duration.

In order to consider the occurrence of bad weather in time and space, the bad weather days based on the bad weather index were classified and the calendar of bad weather day was made from June to October during the period 1941~1970 (Fig.3). This calendar offers the basic data for weather climatological study in Korean Peninsula.

The bad weather day was synoptically classified as follows;

1) rainy bad weather day (●sign in Fig. 3): the day with $\geqslant$1.0mm of precipitation, $\geqslant$threshold value of daily cloud amount and $\leqslant$threshold value of sunshine duration or the day with $\geqslant$1.0mm of precipitation and $\geqslant$threshold value of daily cloud amount.
2) cloudy bad weather day or scanty rainy bad weather day (⊙sign): the day with $\geqslant$threshold value of daily cloud amount and $\leqslant$threshold value of sunshine duration.

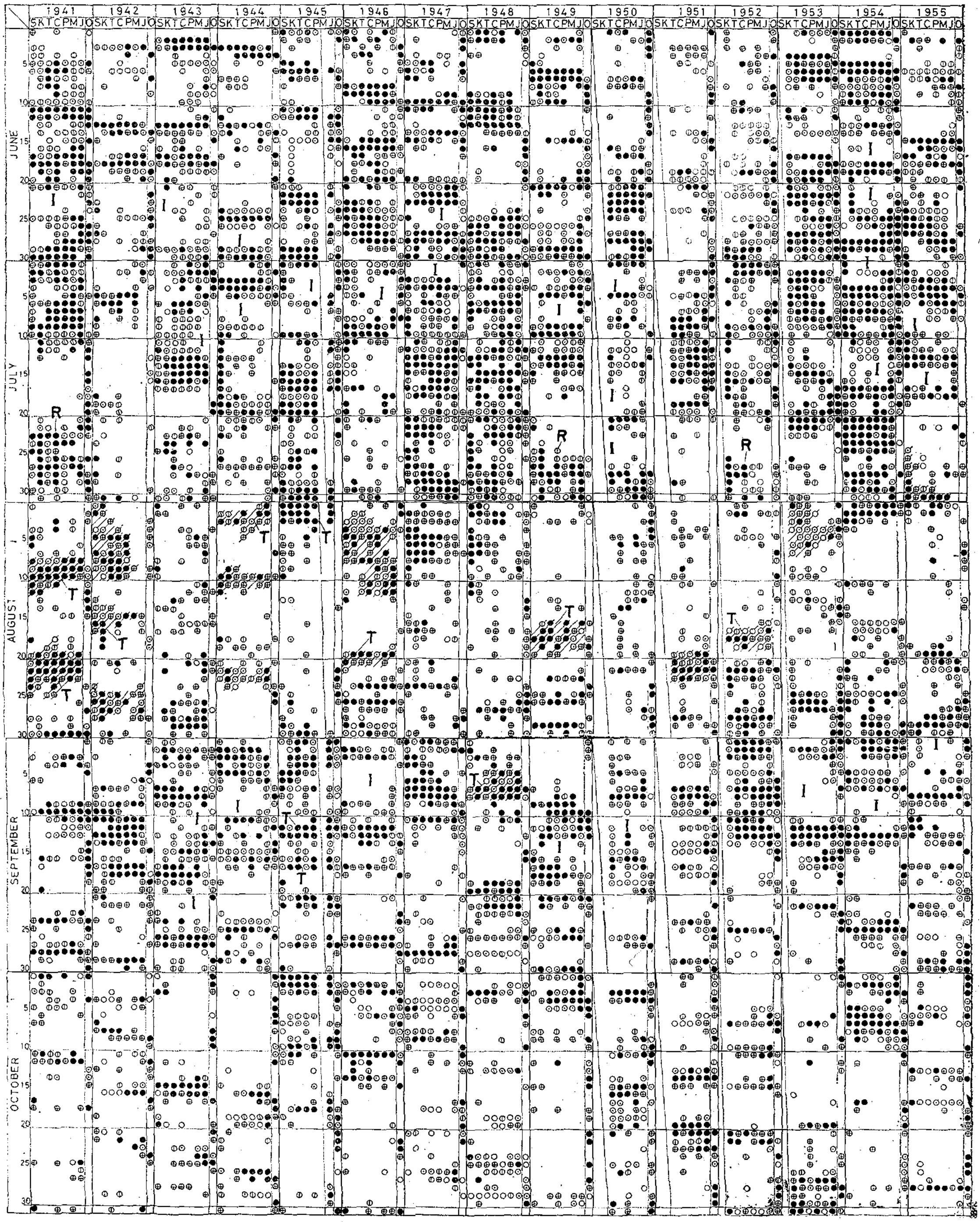
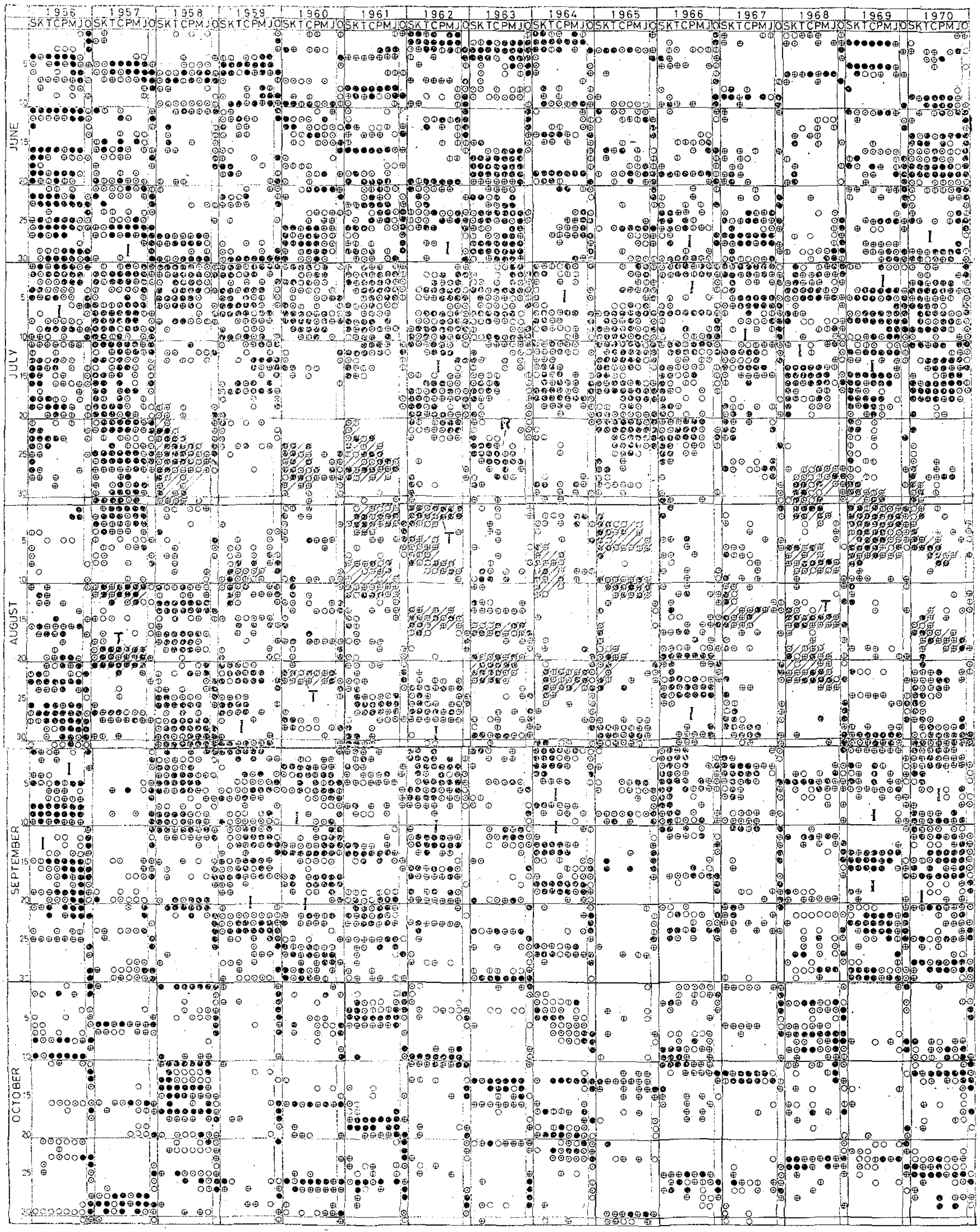


Fig. 3. Calendar of bad weather day

I : intermission of season, R : return of Changma, T : typhoon Slant line part : intermission of summer, ● : rainy bad weather day, ⊙ : cloudy bad weather day or scanty rainy bad weather



day, ⊕ : showery bad weather day, ⓘ : cloudy bad weather day, ○ : scanty sunshine bad weather day, S : Seoul, K : Kaugnung, T : Taegu, C : Chonju, P : Pusan M : Mokpo, J : Cheju, ○ : Tokyo.

3) showery bad weather day (⊕sign) : the day with ≥1.0mm of precipitation and ≤threshold value of sunshine duration or the day with ≥1.0mm of precipitation.
4) cloudy bad weather (⦶sign): the day with ≥threshold value of daily cloud amount.
5) scanty sunshine bad weather day (○sign): the day with ≤threshold value of sunshine duration.

The determination of the threshold value is to be referred to the previous paper by Lee (1974).

III.1. Forerunner Changma and Onset of Changma

On the average after June 24, Korean Peninsula enters into the Changma season. As shown in Fig.3, the bad weather day appears for several days between the first decade and the second decade of June. Thereafter, the fine weather appears before the Changma season, and the Changma season begins. The bad weather before Changma is considered as the forerunner of Changma. The appearance type of the forerunner Changma, however, varies from year to year. In some years such as 1943 and 1949, the time interval between the forerunner and the onset of Changma is very short. In the case of 1941, it is difficult to separate the forerunner from the onset of Changma (Fig. 3). However, in a normal year Changma begins after the forerunner of Changma. The onset of the early summer rainy season in East Asia is much irregular year to year. The onset of Maiyü in China is from June 5 to July 5 (Zou et al., 1964). The onset of Baiu in Japan is May 12 to June 27. The onset of Changma in Korea is normally June 24. But its variability is also large year to year as shown in Fig.3. During the period of 1941~1970, the earliest onset of Changma is found in 1954. It dates on June 5. The latest cccurs in 1951. It dates on July 2. From Fig. 3, the secular change of its onset is represented. It has about 8 or 9 year periods. Next, the type of the onset of Changma is various. Generally, the Changma begins at same time all over the countries. But, as in 1964 and 1965, the onset of Changma becomes gradually later towards the north. In 1961 and 1966, Changma begins from the centeral region of peninsula, thereafter, it spreads to the south. This various pattern of the onset of Changma is due to the shift of the polar front as to be stated later. The stagnating of polar front during the period of the first and the second decade of June below 30°N rapidly moves northward around June 24.

III.2. Seasonal Trend of Changma (Early Summer Rainy Season)

According to the study of Chang (1973), in a statistical study of Maiyü season for *the eighty year period 1885～1964, Hsu (1965) found that on the average it lasted for* twenty days from June or terminated after July 14. In 12 percent of the years Maiyü lasted for more than a month and in 22 percent for fewer than ten days. There were seven years when Maiyü was virtually absent. In the case of Baiu, the longest was 70 days and the shortest 4 days (Yoshino, 1963).

The Changma season is normally from June 24 to July 20 in the southern region and from June 24 to the end of July in the central region as stated in a former chapter. However, Fig. 3 indicates that its duration and seasonal trend of Changma varies considerably from year to year. In some years, the duration of Changma is three times more than that the shortest year. The bad weather condition continues throughout the season from the beginning to the end of Changma, but in other years, it is difficult to recognize the bad weather situation of Changma, e.g. 1942. In the case of 1950 the bad weather of Changma appeared, including several intermissions. In 1958 Changma fades away, as soon as it came. Even in the same year, the different pattern of seasonal trend appears between the central and the southern regions. For example, contrary to the plenty of rainfall in the southern region, the drought takes place in the central region.. Reversely,the southern region bears heavy drought,but the central region has long bad weather.

The longest durations of Changma were 59 days from June 5 to August 3 in 1954, for 50 days from June 15 to August 4 in 1957 and for 49 days from June 20 to August 8 in 1947. No matter how Changma is long, the seasonal trend is various year by year. In the years of 1947, 1948, 1957 and 1963, the bad weather conditions persisted continually to the end of the Changma season, and the otherwise the bad weather intermittently appeared, e. g. 1950, 1954 and 1966..

In the case of the short duration of Changma in 1942, it is diifficult to recognized the Changma season. The duration of Changma in 1958 was only for 12 days from June 27 to July 8, for 19 days from July 2 to 20 in 1951, and for 18 days from June 30 to July 17 in 1959.

In the case of 1965 the duration of Changma is long in the southern region and it becomes shorter towards the north. Reversely, in the years of 1944, 1948 and 1956 it is short in the southern region and longer in the central region. In the year of 1944 the southern region has 12 days duration of Changma (bad weather rainy day is only for 4 days as is shown in Fig. 3), but the central region for 30 days.

III.3. Intermission of Changma

There are the some reports on the intermission of Baiu(Oosawa, 1951, Maejima, 1967). Maejima reports that the intermission of Baiu appears on June 23 and he classified the early Baiu and the late Baiu based on around this date. Lee (1974, 1975) verified that this date of June 23 is applicable to the intermission of Baiu and the fine weather singularity as the prelude to Changma just before the onset of the Changma season. This intermission of early rainy season around June 23 is caused on the temporary retreat of the polar front (as seen in Fig. 3 there is the intermission of Changma season, "I" sign in Figure). It appears several times within a season. However, the length and appearing type are varing in time and space.

The weather situation of changma intermission is characterized by the fine weather for two or three days. In the years of 1943, 1945 and 1968, the fine weather of intermission continues for about one week. In the case of 1943, it is characterized by cloudy bad weather day. Meanwhile, no Changma intermission appears in 1948, 1958 and 1959. The reason why Changma intermission occurs is that the Changma Front shifts to north and south as shown in Fig. 4 of chapter IV. Though the southern region is in the intermission period but there is bad weather predominates in the central region (in the years of 1944, 1947 and 1964). Reversely, the central region is ruled by the intermission weater, but not in the southern (in the years of 1953, 1956 and 1969).

III.4. Ending and Regeneration of Changma

To see the seasonal trend of occurrence frequency bad weather index, the end of Changma is on July 20 in the southen region and at the end of July in the central region. Baiu is over on July 14 at Tokyo (Lee,1974). However, the calendar of bad weather day in Fig. 3 shows that the time and type of ending of Changma are varing year after year. The ending type of Changma can be classified into twe types, the one is Changma ends at the same time all over the country, the other is that the ending gradually propagates from south to north in Korean Peninsula. The former results from the gradual northward shift of the Changma Front.

As is shown in Fig. 3, the sign of "R" represents the regeneration of Changma. This regeneration of Changma is the revival of bad weather after Changma ends, caused by the returning shift of Changma Front. There are two types of regeneration of Changma simultaneously appearing after the Changma season ends at the same time all over the country (e.g. 1946). The other is that the regeneration of Changma appears gradually from north to south on the way when the Changma season is ending from south to north (e.g. 1963).

III.5. Mid-summer and Intermission of Mid-summer

After the early summer rainy season ends, the mid-summer season which is ruled by the North Pacific Anticyclone appears in Eastern Asia. In mid-summer, the stable fine weather with the highest temperature of the whole year is recorded. However, despite of this fact, the bad weather appears occasionally during this stable summer season. This bad weather during the *mid- summer* is the *intermission of mid-summer*. It is illustrated by the slanted part in Fig. 3.

Synoptically, the bad weather of summer is resulted from the southward shift of cold front from a cyclone in higher latitudes and the attack of typhoon ("T" sign in Fig. 3). So to speak, the stable fine weather of mid-summer to be ruled by the North Pacific Anticyclone is temporarily interrupted by the southward moving cold fronts and the typhoons. This weather situation repeats several times in some years until the onset of early autumn rainy season. However, this bad weather of intermission by the cold front in mid-summer does not exert its influence upon the southern region as is shown in Fig. 3 (in the years of 1942, 1953, 1964, 1967 and 1970). This coincides with the that the cold fronts in mid-summer could not reach to lower latitudes as shown in Fig. 4. In Fig.3 the bad weather day in August is distributed without any spatial trend. In mid-summer, the showery bad weather day is predominant comparing to any other rainy bad weather day.

III.6. Seasonal Trend of Kaul Changma (Early Autumn Rainy Season)

In the seasonal trend of occurrence frequency of bad weather index, the secondary peak appears from the end of August to the early September. This secondary peak indicates the occurrence of Kaul Changma in the central and southern region in Korea. After the cold front passed away several times during mid-summer, it suddenly shifts southward and stagnates north of 30°N. This is the Kaul Changma Front in Korea and Shurin Front in Japan as is shown in Fig. 4. But it is easily recognized that the movement type of the polar front in the early autumn rainy season is different from that of the early summer rainy season. The cold front in the autumn season swings from northwest to southeast in East Asia. The stagnation of Kaul Changma Front is weaker than that of the Changma Front, so that the bad weather situation is not continuous during the Kaul Changma season.

Kawamura (1973) pointed out that the onset of Changma dates on August 16 in his study of "Classification of Natural Seasons in East Asia".

To see the seasonal trend of occurrence frequency of bad weather index, after the fine weather appeared on August 15, it rapidly increases and then rapidly decreases on September 9 in the central region. In the southern region it rapidly increases on August 20 and rapidly decreases on September 25. This fact is in good agreement with Kawamura's results of which Kaul Changma of central Korea is from August 16 to September 10 by consulting the equivalent potential temperature.

From Fig. 3 it is evident that the bad weather of Kaul Changma gradually transits from north to south (in the years of 1945, 1950 1955, 1967 and 1970). This is attributed to the fact that the Kaul Changma Front is pushed southward by the expansion of the Siberian High or the migratory anticylone as described later.

By the investigation of the shift of the polar front along 120°E, 128°E and 140°E, it is found that the early autumn rainy season can not be recognized along 120°E. The early autumn rainy season along 128°E appears, but its period is shorter than that on 140°E and its variability is very large from year to year (Lee,1974). In some years, Kaul Changma fails to appear. Kimura (1966) reported that the duration of Shurin in normally from 43 days to 57 days.

As is shown in Fig. 3, the time of onset and period of Kaul Changma is not uniform. The appearing pattern of Kaul Changma is very intermittent. In the years of 1952, 1956, 1958, 1959 and 1970, Kaul Changma is long and comparatively continuous. Especially in the cases of 1956 and 1958, Kaul Changma continued for one month long. In the years of 1941, 1957, 1963, 1965 and 1968, Kaul Changma failed to appear. In some cases, Kaul Changma appears in the central region but it does not in the southern region. Reversely, it may appear in the southern region but not in the central region. This due to the movement of the Kaul Changma Front, too.

After Kaul Changma, the weather situation in Korean Peninsula is extremely fine. The occurrence frequency of bad weather index in October is less than that of the forerunner Changma season, about 20%. However, to see Fig. 3, there are the bad weather days in October. This results from the influence of the strong Shurin Front in Japan.

IV. DAILY SHIFTING OF POLAR FRONT AND DISPLACEMENT OF NORTH PACIFIC ANTICYCLONE

Generally, the synoptic situation in the early summer rainy season in East Asia is as follows; The anti cyclone is centered in the Sea of Okhotsk, and the stationary front runs along the Pacific coast of Japan, accompanied with bad weather of rainy, cloudy and short duration of sunshine. Along the stationary front, migratory cyclones generated in the vicinity of the Yangtze River region move eastward in sequence and traverse through the Japanese Islands one after the other. In East Asia the early summer rainy season begins when the polar front stagnates almost linearly from west to east north of 30°N. This stationary polar front in the early summer is called the Changma Front and the Baiu Front in Korea and in Japan respectively.

Synoptically, when cyclone and typhoons pass through the peninsula and the Changma Front stagnates along the southern coast of peninsula, the almost all stations of south Korea become to experience the bad weather day as defined in chapter II. Then we find that all seven stations become continuously to record the rainy bad weather for several days, when the Changma Front stagnates between 30°～35°N from the Yangtze River region to the southern sea of Japanese Islands (Lee, 1975).

Therefore, the various sequences of bad weather day in Fig. 3 result from the various manners of displacement of this Changma Front.

In order to disclose the synoptic situation for summer half year, the daily position of polar front along 120°E, 128°E and 140°E was consulted, using the daily surface chart at 0000 and 1200GCT from June 1 to October 31 during the period 1961～1970 (Lee, 1974). In the present paper, it is revised again with complements the northern limit of 5880 gpm contour area at 500 mb surface as a measure of the displacement of North Pacific Anticyclone. Fig. 4-a, b and c are the time cross sections for daily shifting of polar front and the northern limit of 5880 gpm contour area in 500 mb chart. In these Figures, a curved solid line denotes the polar front, and a dashed line represents the northern limit of 5880 gpm contour area in 500mb chart. Black dot shows the cyclone. "T" sign is typhoon. "H" sign is anticyclone of the surface and "U" is the maximum curvatue point of 5700 gpm trough in 500 mb chart. A shaded portion denotes the early summer rainy season and the early autumn rainy season. "I" is the intermission of each

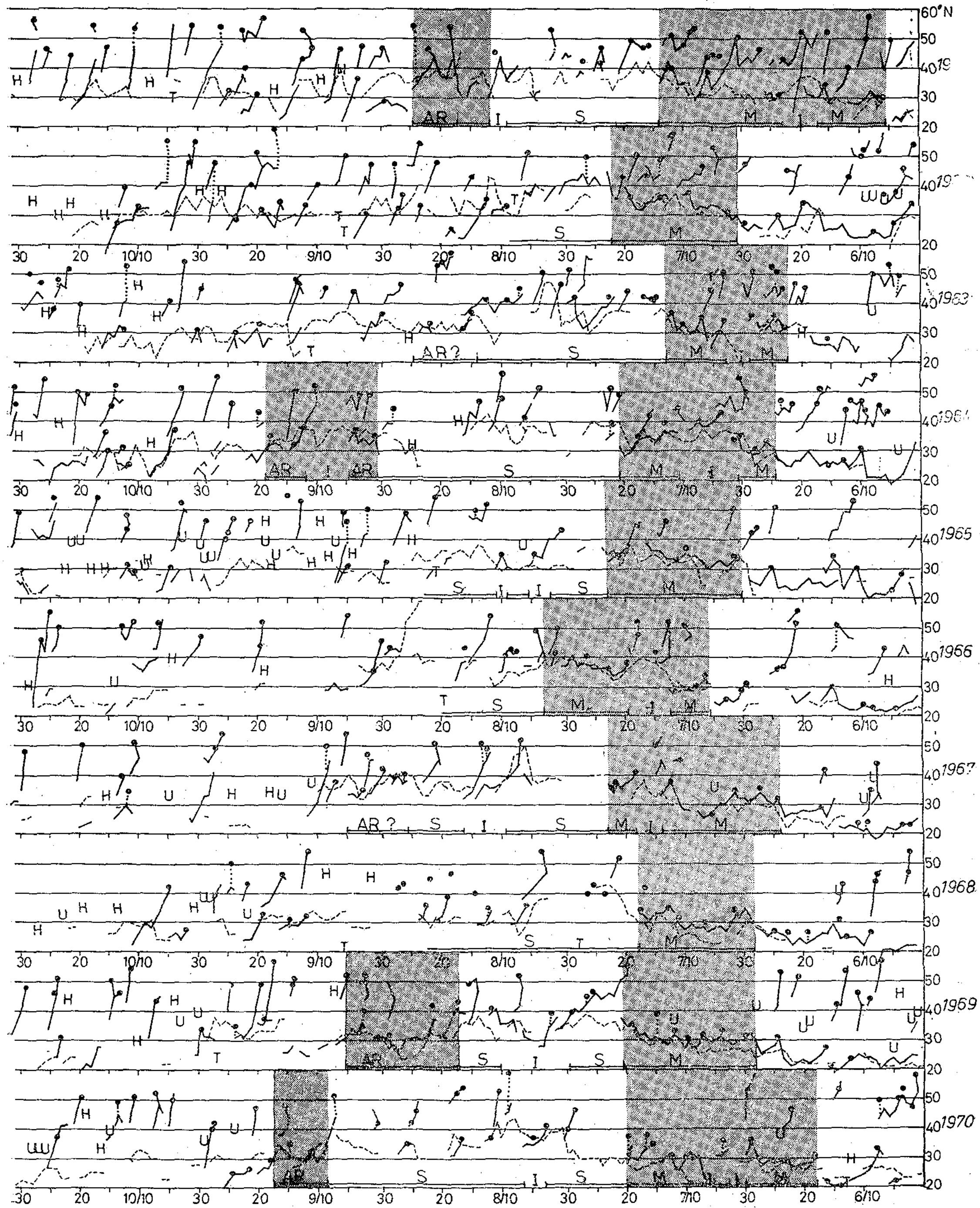


Fig. 4-a Time cross section of daily shifting of the polar front and the northern limit of 5880 gpm area at 500 mb surface along 120°E
Full line: Polar front Dot: Cyclone H: Anticyclone T: Typhoon Dashed line: Northern limit of 5880 gpm area U: Maximum curvature point of trough of 5700 gpm M: Maiyü AR: Autumn rainy season I: Intermission of each season

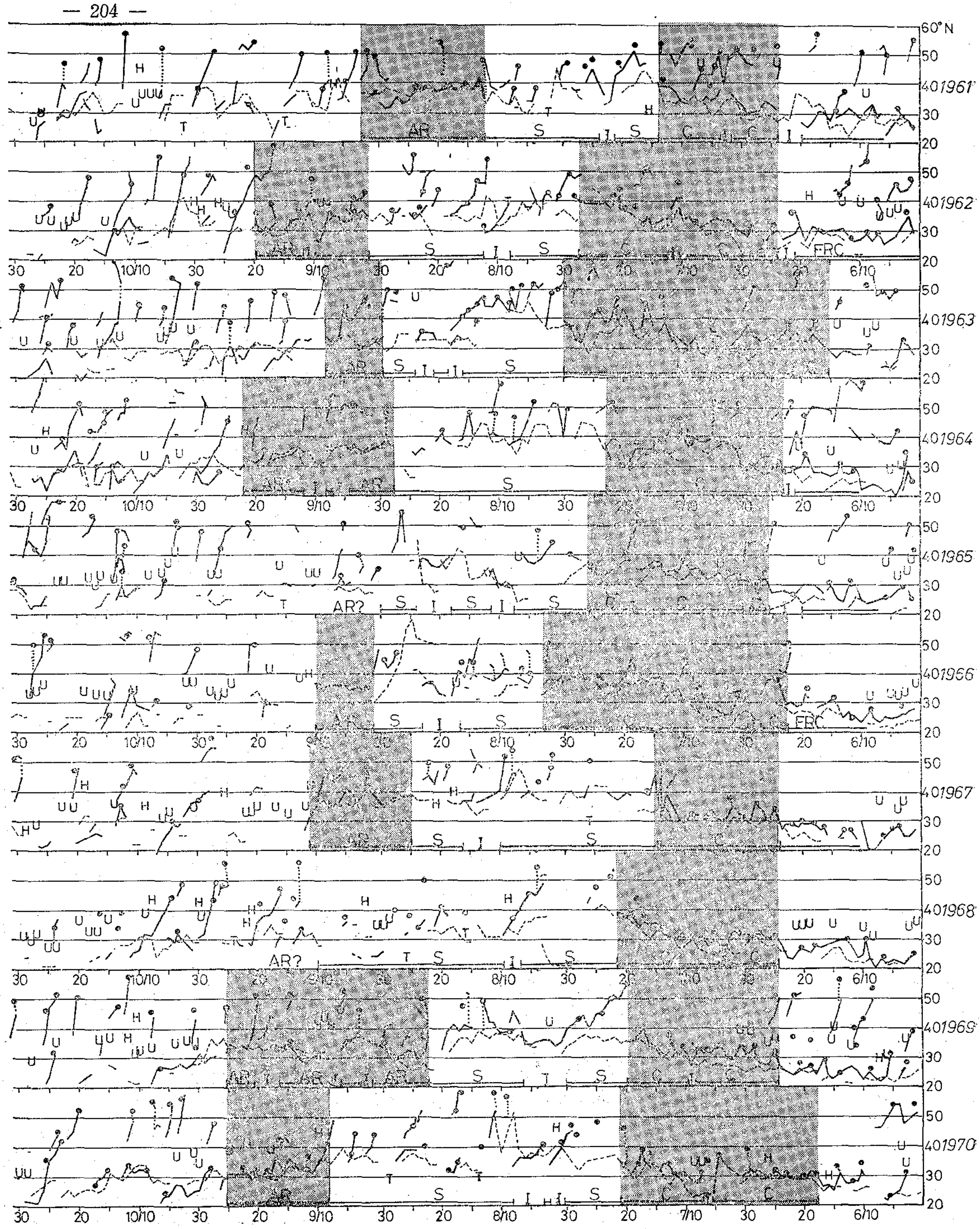


Fig. 4-b Time crcss section of daily shifting of the polar front and the northern limit of 5880 gpm area at 500 mb surface along 128°E
Full line: Polar front Dot: Cyclone H: Anticyclone T: Typhoon Dashed line: Northern limit of 5880 gpm area U: Maximun curvature point of trough of 5700 gpm FRC: Forerunner Changma C:Changma AR: Autumn rainy season
I: Intermission of each season

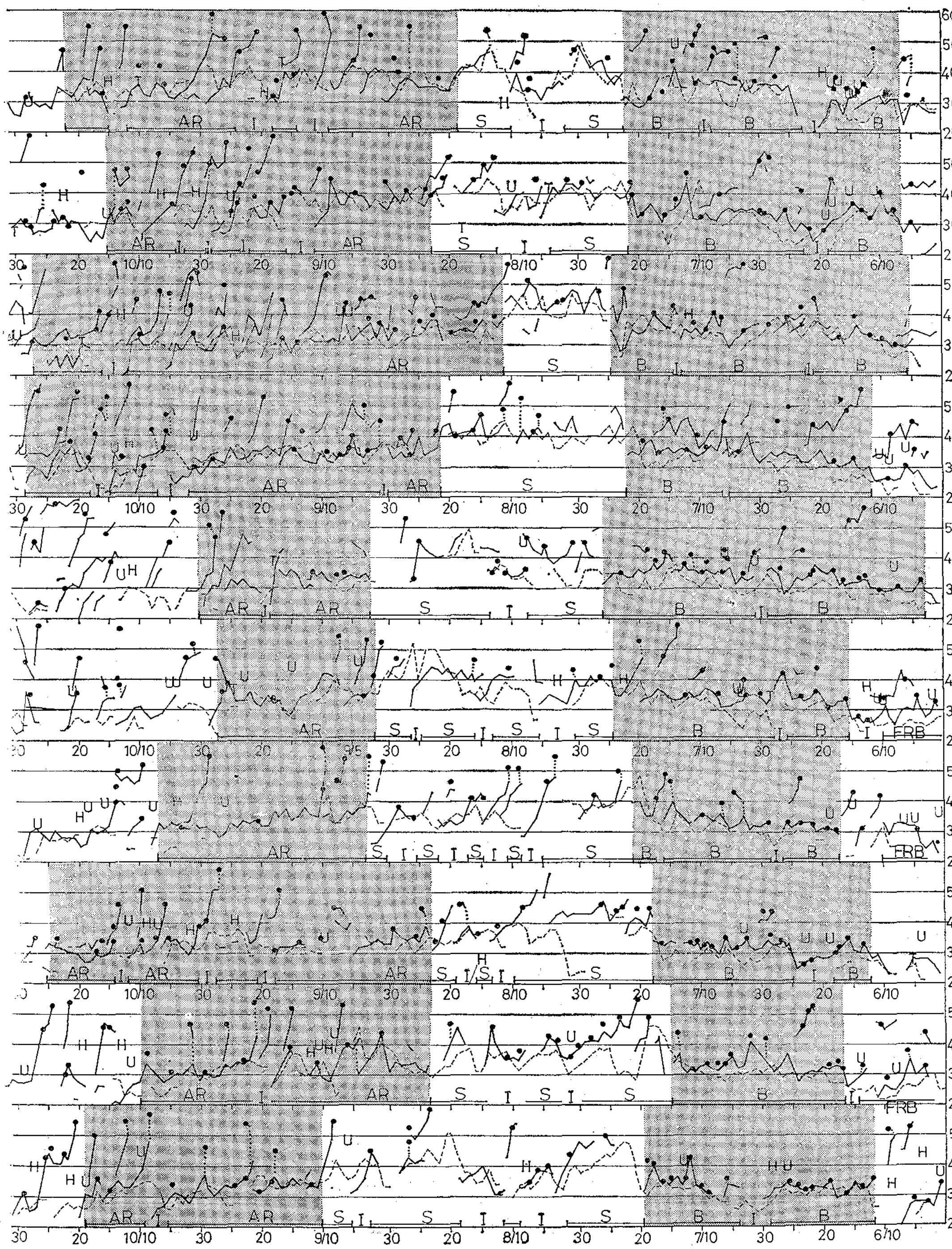


Fig. 4-c Time cross section of daily shifting of the polar front and the northern limit of 5880 gpm area at 500mb surface along 140°E
Full line: Polar front Dot: Cyclone H: Anticyclone T: Typhoon Dashed line: Northern limit of 5880 gpm area U: Maximum curvature point of trough of 5700 gpm FRB: Forerunner Baiu B: Baiu AB: Autumn rainy season I: Intermission of each season

season. "S" is the mid-summer season.

IV. 1. Early Summer Rainy Season

Fig. 4-a, b and c indicate that the polar front is stagnating and vibrating mainly between 20°～30°N in early June. This period of the first decade of June corresponds to the forerunner of Baiu in Japan. This period coincides with the Stage 1 of early summer rainy season in East Asia of Yoshino's study (Yoshino, 1965). During the same period, the polar front along 120°E and 128°E are stagnating and vibrating south of 30°N. As shown in Fig. 4～c, the polar front suddenly shifts northwad around the middle of June. This is the onset of Baiu season in Japanese lslands. Just before this beginning of the Baiu season, the polar front retreats southward or shades away for the moment almost every year during 1961～1970. At the same time as the onset of Baiu, there is a sudden northward shift of the polar front not only along 128°E but also along 120°E. The similar shift is recognized when the forerunner of early summer rainy season occurs in Korea and in China.

Throughout the period from the beginning to the 23rd of June that corresponds to the forerunner of Changma in Korea, the average position of the polar front along 140°E is deviated about 2～6 degree latitudinally to the north than those of 120°E and of 128°E. That is the polar front runs with the declination from northeast to southwest direction. This is well presented in Fig. 5, which shows the daily shifting of the polar front along 120°E, 128°E and 140°E. A solid line is that of 140°E, a dashed line is that of 128°E, and a dotted line is that of 120°E.

Judging by Fig. 5, the position of polar front along 140°E is higher about 2～6 degree latitudinally than those along 120°E and 128°E in early of June.

Normally, in the period from the beginning to June 23, the North Pacific Anticycl-one is not fully developed. The northern limit of 5880 gpm contour line area does not yet reach to Japanese Islands, is far off from the southern sea of Japan (Lee, 1975). However, after June 23 the polar front along 120°E ; 128°E and 140°E becomes stagnant and runs linearly from west to east of 30°N. But the shifting type of polar front with which the weather situation of early summer rainy season is closely linked is varying year by year. The fact that the onset of Maiyü in China is very irregular from year to year may be interpreted by the areal extent of westward expansion of the North Pacific Anticyclone (including the Indo-China Peninsula Anticyclone as poited out in the

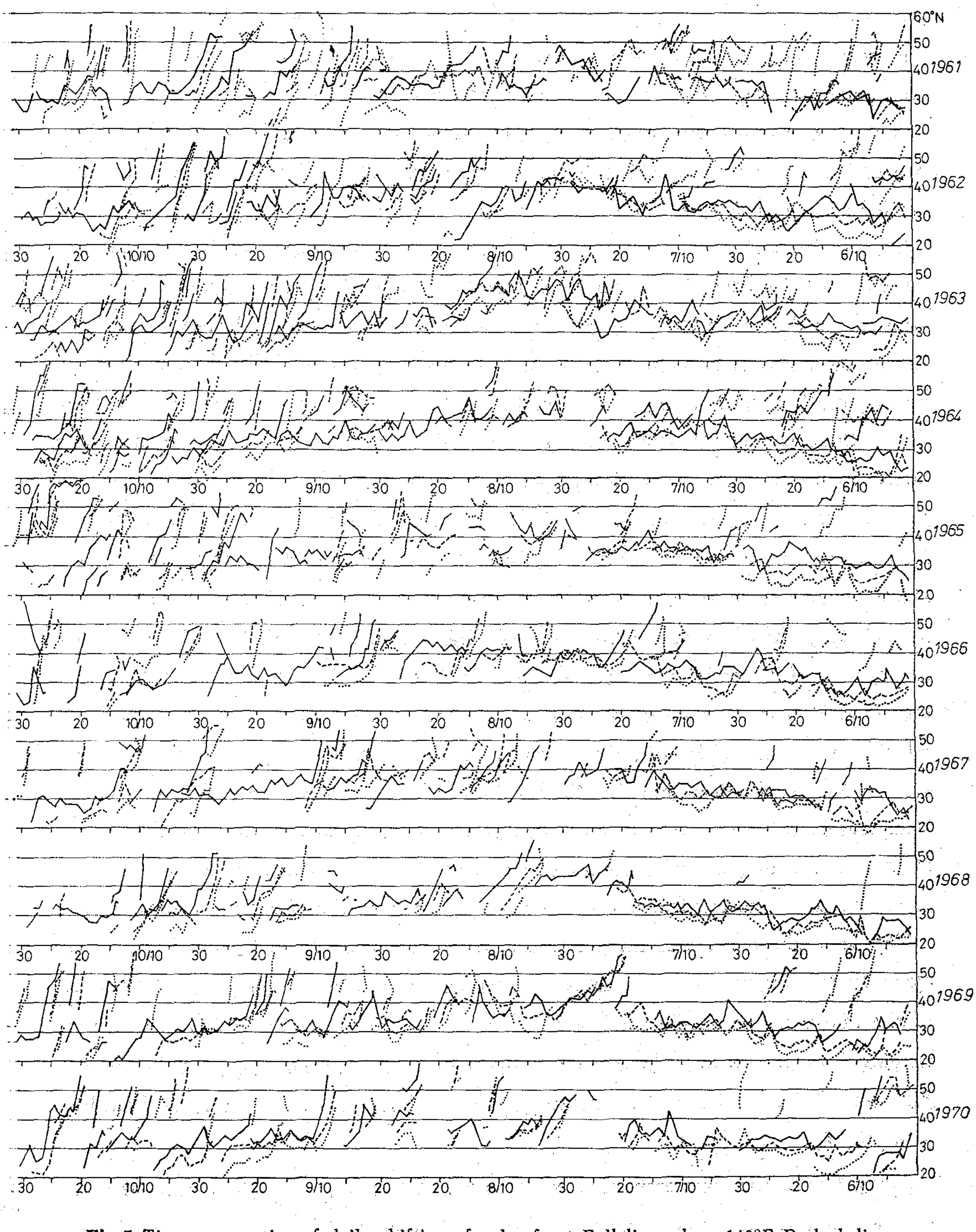


Fig.5 Time cros section of daily shifting of polar front Full line: along 140°E Dashed line: along 128°E Dotted line: lalong 120°E

previous paper by Lee, 1975). In other words, in the year when the North Pacific Anticyclone rapidly expands westward to the middle of China or the Indo-china Peninsula Anticyclone develops, the onset of Maiyü is rather earlier.

After June 23, the polar front along 128°E is pushed northward over 30°N by the North Pacific Anticyclone which expands westward. Thereafter, the southern region of Korean peninsula enters into the Changma season.

To see Fig. 4-a, b, the polar fronts are stagnating and vibrating in the latitudes lower than 30°N from the beginning of June to the second decade of June. In the early Baiu season during which the polar front stagnates, and repeatedly advances and retreats in the lower part of 30°~40°N along 140°E, the polar fronts represent the same trend of moving south of 30°N along 128°E and 120°E. The polar front that is stagnating in the southern part of 30°~40°N retreats southward around June 23 and two or three days after, it abruptly moves nohrthward. This time around June 23 is the intermission of the Baiu season in Japan and is a fine weather before the onset of changma season in Korea as was mentioned above. The southward retreat of the polar front takes place almost every year as is shown in Fig.4. It may be considered that this intermission is generated by the advancing of Okhotzk Sea High or the retreating of North Pacific Anticyclone. After this intermission of Baiu, Japanese Islands enters into the late Baiu season which has the characteristics of heavy rainfall. And along 128°E the polar front which is stagnating south of 30°N up to this time is abruptly pushed northward. Then, Korean Peninsula enters into the Changma season as mentioned above. During the late Baiu season, the polar front is stimulated by the inflowing of southwest current which is called a wet tongue, and there are heavy rainfall in Japan and in Korea. As indicated in chapter I, the precipition intensity is very great during the Changma season.

The same phenomenon of the abrupt northward advancing of polar front appears also along 120°E, but its occurrence dates are very irregular from year to year. The onset of the Maiyü in the middle and lower Yangtze Valley has a great year to year variability ranging from June 3 to 29 in the period 1954~1962 (Zou et al., 1964). As is seen in Fig. 4-a, the onset of Maiyü is extremely irregular from year to year ranging from June 5 to July 5.

Along 140°E, the polar front that is stagnating between 30°~40°N during the late Baiu season goes up suddenly further north of 40°N around the middle of July. This is the end of Baiu season over Japanese Islands. From this time Japanese Islands enters into the mid-summer season which is under the control of North Pacific Anticyclone. Along 128E°, the polar front abruptly goes northward of 30°N around June 24, and becomes stagnant between 30°~40°N. Hereafter, Korean Peninsula enters into the Changma season. There is also the intermission of rainy season by the shifting or shading away of Changma Front, but its occurrence time and duration are more irregular than along 140°E. In some years,the intermission appears several times as was mentioned in chapter III. The end of Changma season is on the average on 20 in the southern region and the end of July in the central region. However, while the onset of Changma is comparatively synchronous and distinct, the end of Changma is different from year to year ranging from July 15 to August 2. After the end of Changma season, the Changma Front moves further north of 40°N, and becomes stagnant in higher latitudes (in Manchuria) or to be extinguished. From this time Korean Peninsnla enters into the mid-summer season which is ruled by the Pacific Anticyclone as same as Japanese Islands. But the northern part of the peninsula north of 40°N is still affected by the Changma Front, thus, there is a period with largest peak of rainfall amount in August as was mentioned in the previous paper by Lee (1974).

After the end of Changma, the bad weather, called the regeneration of Changma, appears by the temporary southward shift of the Changma Front as was mentinoned chapter III. The phenomanon of regeneration Baiu appears also in Japanese Islands.

Along 120°E, the end of Maiyü is also irregular. The duration of the Maiyü season is comparativly shorter than along 128°E and 140°E as is seen in Fig. 4 and 5.

According to Fig. 5, it is confirmed the average position of the polar front after around June 23 along 120°E, 128°E and are the same latitudinally. That is, the polar front moves parallel to the latitudes after that time. As far as the movement of polar front is concerned, Maiyü in China, Changma in Korea and Baiu in Japan are the same seasonal phenomena which are associated with the polar front of East Asia.Especially the ends of those in East Asia are synchronous as seen in Fig. 5. The displacement of the North Pacific Anticyclone in the summer half year is approximately parallel to the shifitng of polar front. From Fig. 4-a, b and c, it becomes evident that the position of polar front is related with the displacement of North Pacific Anticyclone. With a few exceptions, the polar front is located north of the northern limit of 5880 gpm contour area of 500 mb surface. In accordance with the advance and retreat of the North Pacific Anticyclone, the polar front advances and retreats through the early summer rainy season.

In the extreme years which have either low or high bad weather index as defined in the previous paper (Lee, 1975), the characteristic of distribution of polar front is as follows;

In June of a low bad weather index year, the average position of polar front is south of 30°N, and the average position of the northern limit of 5880 gpm area is from the southern sea of Japanese Islands, between 20°～30°N. In contrast to this, the polar front and the northern limit contour of 5880 gpm at 500 mb surface are concentrated between 30°～35°N in a high bad weather index year.

In July of a low bad weather index year the occurrence frequency of polar front over the Korean Peninsula is very small, and the center of 5880 gpm area at 500 mb surface is over the peninsula and its surroundings.

Conversely, in a high bad weather index year the polar front are concentrates over Korean Peninsula and Japanese Islands. And the contours of the northern limit of 5880 gpm at 500 mb surface are concentrated south of Japanese Islands.

IV. 2. Mid-summer

After the end of early summer rainy season, East Asia enters into the mid-summer season with fine weather situation which is influenced by the North Pacific high pressure. During this season, the temperature over 30°C is observed in Korean Peninsula and Japanese Islands, and what is called the summer pressure pattern is conspicuously established. The investigations on the dry spells of mid-summer in Japan are reported by Fukui (1964) and Yazawa (1968).

By Fig. 4-a, b and c, we find that the polar front mainly stagnates in the latitudes north of 40°N, even near 50°N, throughout the period of mid-summer. The southward shift of cold front brings temporary bad weather in this season. This is an intermission of mid-summer as mentioned above. Chang (1971) reported that the cold fronts are a major source of summer rainfall in north China, which accounts for 70 percent of the annual total.

August rainfall in the northern region of Korean Peninsula amounts to 26.3 percent of the annual total, that of the southern region 14.1 percent.

This temporary southward shift of polar front in mid-summer is not yet studied in detail. On the intermission of mid-summer, there are a few reports. Yoshino (1968) pointed out that the intermission of mid-summer appears on the 4th～6th of August in

Japan. Mikami (1974, unpublished) reported that the intermission of summer appears twice during the mid-summer. Based on the investigation of daily sea level weather charts, two types of synoptic situation which causes the seasonal intermission of mid-summer are recognized as follows;

1) the polar front stagnated in higher latitudes moves down for a few days toward lower latitudes due to the temporary retreat of the North Pacific Anticyclone.
2) the polar front is pushed down by the outbreaks generated from the continental high pressure.

It is worthwhile to notice the facts that this southward shifting front develops in the low pressure belt of higher latitudes. These fronts are mostly cold fronts, running from northeast to southwest. Especially along 140°E, the southward shifting of front occurs several times during the whole of mid-summer. Another cause of the intermission of mid-summer is Typhoon. The average position of northern limit of 5880 gpm area at 500 mb surface is near of 39°N during the mid-summer as shown in Fig. 4. Occasionally, it is located near of 48°N as in 1963.

IV. 3. Early Autumn Rainy Season

Seeing Figures 4-b and c, the cold front extending from the low pressure in higher latitudes rapidly moves southward in the last decade of August, and then stagnates between 30°～40°N for a long time until the end of this season. This is the early autumn rainy season what is called Kaul Changma in Korea and Shurin in Japan. However, the fronts of this season are not so obvious as the early summer fronts and more intermittent. In some years the intermittent front migrations from northwest to southeast are repeated several times as shown in Fig. 4-a, b and c, and Fig. 5. This fact is conspicuous especially along 140°E, and its end is very irregular too. Along 140°E the years of 1963 and 1964 have typically long period of Shurin dating from August 20 to October 25, but the year of 1966 is the shortest, 20 days only.

In Korea, the Kaul Changma season is relatively short. In some years such as 1965 and 1968, the autumn rainy season in unobvious or even lacking. Along 120°E it is almost free from an early autumn rainy season, but in the years of 1961, 1969 and 1970, a short rainy season is observed. These years brought out a long autumn rainy season in Korea and Japan.

As shown in Fig. 5, the time lag of moving of cold front between 120°E, 128°E and 140°E is very short in autumn. This means that the cold front moves with very high speed from northwest to southeast. That is, the cold front flowing out by the continental anticyclone is hard to be stagnated along 120°E, and it becomes to be stagnated along 140°E.

In early autumn the northern limit of 5880 gpm area at 500 mb surface retreats rapidly to south as seen in Fig. 4-a b and c. Asakura (1968) pointed out that there occurs the reversal of the flow pattern aloft over the Asian Continent from mid-summer to Shurin, and the ridge over Japan, which brings on warm summer weather there, gives place to a trough. Fig. 4-a, b and c show that the main trough of 5700 gpm appears chiefly early June and in late October. It is remarkable that the occurrence frequency of trough is largest at 128°E.

The characteristics of weather situation in early autumn rainy season are determined by the cold front developed from higher latitude low pressure and by the migrating continental high pressure. Murakami et al. (1962) explained that Shurin is a rainy seasonal phenomenon which is formed between the Siberian and the North Pacific Anticyclones. As seen in Fig. 4-a, b and c, it is found that there is a high pressure behind the cold front without fail. Especially, it is typical along 120°E. Owing to the direct influence of the continental anticyclone, there is almost no early autumn rainy season. The stationary fronts are hardly formed there. Even if the stationary front develops at all, its life time is very short.

The weather pattern of the Shurin season in Japan is somewhat more complex, because of the coaction of typhoons, migration cyclones and stationary fronts. Hence, this season has the largest amount of precipitation in the central and northern regions of the Pacific side of Japanese Islands (Maejima, 1967).

The Kaul Changma season is shorther than the Shurin season, about 20 days long, and its end dates around September 10 in the central region as mentioned above. After the Kaul Changma season, the fine weather is to be continued throughout the autumn season in Korean Peninsula. The average percentage of possible sunshine is 62.4% in the southern region and 67.5% in the northern region.

After the early autumn rainy season, East Asia enters into the autumn season where the weather is controlled by the migration high or the continental air mass. During this autumn season with fine weather, the cold front extending from a low pressure in higher latitudes moves southward intermittently too, but it rapidly moves away and its life time is very short, about one day on the average. The weather situation like this pattern appears in early September along 120°E, after the middle of September along 128°E and after the middle of October along 140°E. In this season, the northern limit of 5880 gpm area retreats south of 25°N.

CONCLUSION

The present paper aims at revealing the seasonal trend of weather situation for a summer half year with focusing on two rainy seasons Changma (early summer rainy season) and Kaul Changma (early autumn rainy season) in Korean Peninsula, in relation to the two rainy seasons of East Asia, employing the statistical and synoptic methods from the standpoints of weather climatology. Changma is a rainy seasonal phenomenon which is caused by the movement of polar front such as Baiu in Japan. The Changma season begins synchronousely around June 24 by the rapid nortward advance of polar front all over the southern part of the peninsula. There is the intermission of Baiu in Japan around June 23. It corresponds to the prelude to Changma season which is fine weather around June 23. The period from the beginning of June to June 23 corresponds to the early Baiu in Japan and the forerunner Changma in Korea. During this period, the polar front is declined from northeast to southwest with the declination of 2～6 degrees latitudinally in East Asia as seen in Fig.5. The polar front is not active during this period, and the rainfall amount and its intensity is not large. The polar front has the trend to move with advancing and retreating of the North Pacific Anticyclone. The North Pacific Anticyclone is not yet developed, and the frequency of westward expansion is not so much until June 23.

After June 23, the North Pacific Anticyclone begins to expand westward to central China. In some years, it has a strong zonal shape adjoining with the Indo-China Peninsula Anticlone as stated in the previous paper by Lee (1975).

According to westward expansion of the North Pacific Anticyclone, the polar front which is stagnating south of 30°N until June 23 rapidly goes north of 30°N and becomes stagnant. From this time the polar front runs almost parallel to latitude. Thereafter, the whole of southern peninsula simultaneously enters into the Changma season. However, the time and the type of onset of Changma is various from year to year due to the moving type of the Changma Front. It may be considered that the movement of the Changma Front depends on the tendency of the North Pacific Anticyclone as mentioned before. During the Changma season, the weather situation in Korean Peninsula is characterized by its bad weather with large amount of rainfall, large amount of cloud and low sunshine duration. The precipitation intensity is over 30mm/day. It is larger than that of Tokyo. The peak time of precipitation appears in early July all over the southern region in Korean Peninsula. Its occurrence time becomes later as the latitude increases. The occurrence frequency of bad weather index has two peaks in early July and in early September in the central and southern region. But the northern region has a single peak in August.

The bad weather day as defined in chapter II is concentrated in this Changma season. However, its distribution pattern is different from year to year. There is the intermission of Changma with fine weather. It appears in several times by the year. The time and duration of intermission is various in time and space, too. The end of Changma is normally on July 20 in the southern region and at the end of July in the central region. The Changma season ends synchronously all over the country, but in some years, makes gradually progress from south to north. In some years, the regeneration phenomenon of Changma is appeared by the returning of the Changma Front. The period of Changma is various from year to year. The longest is about for 60 days and the shortest is not more than 10 days. Changma may be totally absent as in 1942. After the end of the Changma season, Korean Peninsula enters into the mid-summer season with fine weather which is ruled by the North Pacific Anticyclone. The polar front stagnates or shade away north of 40°N in East Asia as shown in Fig.4. The cold front associated with the cyclone in higher latitudes shifts occasionally southward. So then, the intermission of mid-summer appears. The intermission of mid-summer along 140°E appears several times in some years. August 15 is a singularity of low occurrence frequency of bad weather index in Korea. After this day, the occurrence frequency of bad weather index rapidly increases and reaches to the peak around September 5 again. And the occurrence frequency of bad weather index rapidly decreases on September 10 in the central region of Korea. This secondary peak corresponds to Kaul Changma. By the time cross section of polar front (Fig.4), the cold front intermittently shifts southward during the Kaul Changma season. It is found that the movement pattern of polar front in the early autumn rainy season is different from that of early summer rainy season. The Kaul Changma season is short in duration and does not bring so much rainfall. There is a year which has no Kaul Changma season.

It is worthwhile to notice that the southward migration of polar fronts oriented from northwest to southeast in East Asia in early autumn rainy season, causing by the development and outbreak of the continental air mass. Owing to the direct influence of the continental anticyclone, there may be no early autumn rainy season along 120°E. On the contrary, the duration of autumn rainy season along 128°E is shorter. The Shurin season along 140°E which is least influenced by the continental anticyclone is longer, and the cold front and the stationary front pass alternately through Japanese Islands in the Shurin season.

The early summer rainy season Maiyü in China, Changma in Korea and Baiu in Japan seem to be the same phenomena which are brought out by the stagnation of polar front between the Okhotsk Sea and the North Pacific Anticyclones. The migration of early summer rainy season in East Asia makes a gradual progress to the northwest direction according to the expansion of the North Pacific Anticyclone. The ends of early summer rainy season along 120°E, 128°E and 140°E are synchronononous as shown in Fig. 5. On the contrary, the polar front in early autumn rainy season migrates from northwest to southeast according to retreat of the North Pacific Anticyclone and advance of the Siberian High.

The northern limit of 5880 gpm area 500 mb surface retreats to south of 30°N in early autumn rainy season. The trough of 5700 gpm at 500 mb surface begins to appear around September 10. Throughout the summer half year, the polar front and the northern limit of 5880 gpm at 500mb surface moves almost parallel. That is, the polar front moves parallel to the movement of North Pacific Anticyclone.

After the early autumn rainy season, the weather situation is very fine in East Asia, but the Shurin season in Japan long continues until the middle of October. The relationship between the Indo-China peninsula Anticyclone and the polar front must be solved in near future.

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要　約

장마와 가을장마에 관한 天候氣候學的硏究 —東 Asia의 暖雨季와 關聯하여—

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暖雨季에 韓半島에는 장마와 가을장마의 두 雨季가 나타난다. 본 論文에서는 統計的, 天候氣候的觀點에서 惡天示數라고 하는 一種의 天候示數를 考案하여 두 雨季의 季節推移의 特性을 밝힘과 同時에 日本의 Baiu(梅雨)와 Shurin(秋霖), 中國의 Maiyü(梅雨)를 比較 分析하였다. 120°E, 128°E 및 140°E에 있어서의 寒帶前線의 매일매일의 位置와 500mb 等壓面에서의 5880m領域의 北限의 매일매일의 움직임을 추적하여 東 Asia에 있어서의 暖候季의 寒帶前線과 北太平洋高氣壓의 動態를 把握하려 하였다.

初夏의 장마季는 6月 24日頃 장마前線의 급격한 北上으로 開始 되나 장마의 始作日이나 開始樣相은 해마다 다르며 대체로 6月初에서 6月24日 사이에 장마前兆현상의 惡天候가 나타난다. 장마기간중에는 장마전선의 南北振動에 의해 장마休息현상이 나타나는데 이의 發現樣相도해에 따라 各樣各色이다. 장마終息은 平年的으로 南海岸에서 7月20日頃 서울에서 7月末頃이 되고 있으며 해에 따라서는 장마가 일단끝난후 북상했던 장마전선의 일시적인 南下로 "되돌이 장마"현상이 나타나기도 한다. 장마가 끝난 후 北太平洋高氣壓의 支配를 받는 盛夏季에는 高緯度의 低氣壓으로 부터 形成되는 寒冷前線의 通過와 颱風의 영향으로 일시적인 惡天現象이 나타나는데 이것이 盛夏의 休息현상이다. 가을장마는 8月下旬 이후, 北部地方으로 부터 始作되는데 高緯度低氣壓에서 發達한 寒冷前線의 停滯로 形成된다. 東 Asia의 가을雨季는 120°E에 있어서는 거의 나타나지 않으며 128°E에서는 短期間形成되고 140°E에서는 장기간 雨季를 形成하고 있음이 밝혀졌으며 Sibera 高氣壓은 가을장마 前線의 움직임에 중요한 영향을 주고 있다.

暖候季, 東Asia에 있어서 寒帶前線의 움직임은 500mb面의 5880gpm 領域의 變位와 밀접한 관계가 있음이 밝혀졌다.