Some Annual Variation Characteristics for the Northern Hemispheric Monthly Mean Precipitation Fields

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ABSTRACT

By the utilization of monthly precipitation data from all stations in the Northern Hemisphere annexed to the "World Survey of climatology, Vol. 1–15", the distributions of the maximum precipitation months (MPM), the annual relative precipitation (ARP) and the monthly relative precipitation (percent of annual) in January and July are respectively mapped. Moreover the distributions of intermonthly relative precipitation variabilities from January to December are plotted as well. From these figures, the precipitation in the Northern Hemisphere may be classified into three types(continental, oceanic and transitional types) and 17 regions. The precipitation regime may also be divided into two patterns, the global and regional patterns. The global pattern consists of planetary front system and ITCZ and its inter–monthly variation shows the north–and–south shift of the rain belt; the regional pattern consists of the sea–land monsoon and plateau monsoon regime, in which the inter–monthly variation of rain belt shows a east–and–west shift.

According to the longitudinal cross section profiles, the precipitation systems in the Northern Hemisphere are mainly the ITCZ and polar fronts, while in the three circulation systems they are related with the upward branches of Hadley circulation and middle latitude anticirculation. But at the same latitude,they are mainly the sea–land and large–topography monsoon systems, with the effects of middle and small–topography and the precipitation systems show perfect complex features. To what extent these systems take a control and what intensity they are? The author has made some studies on the ranges of North American plateau monsoons and sea–land monsoons by using the index of monthly relative variation of precipitation (Tang and Reiter, 1984). The same method will also be used here to discuss the precipitation systems in the whole Northern Hemisphere. The data are adopted from the World Climate Survey(Landsberg(edit) Vol. 1–15). In the discussion concerning Chinese portion, the data used are the means from 1951 through 1980; for the North America, the results from Tang and Reiter, (1984) are used here.

I. THE DISTRIBUTION OF MONTHS OF MAXIMUM PRECIPITATION AND RELATIVE ANNUAL DIFFERENTIALS

Fig. 1 is geographical distribution of MPM, (maximum precipitation months). In the oceanic areas, the MPM generally appears in the winter half year (from October through March). On the continents and the Arctic area, the MPM usually appears in the summer half year (from April till September). This is the so–called "sea–land principle" of MPM. Howev–

er, the following regions are evidently of some exceptional cases.

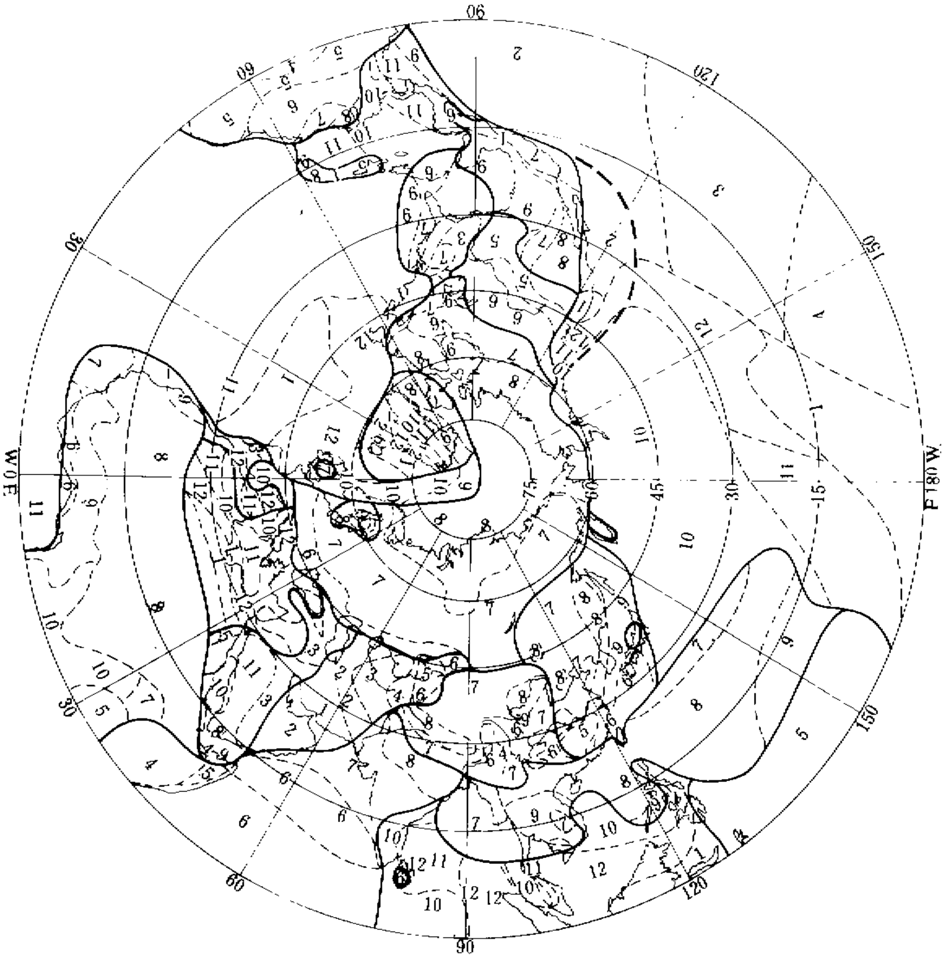

Fig. 1. Distribution of maximum precipitation months (MPM). Note: heavy solid lines denote the boundary lines of precipitation area; numerals in the figure denote the respective months.

1) In the low–latitude west Pacific Ocean (about west of 160 ° E), and on South China Sea and the Bay of Bengal, the MPM appears not in the winter half year but in the period from July to September; while the MPM appears in May in the tropical region of West Pacific (120 ° E to 160 ° E). The MPM also appears in summer in the East China Sea, Yellow Sea, Sea of Japan and Sea of Okhotsk.

2) In the Atlantic to the east of United States and the Gulf of Mexico, there is also a MPM during the summer half year (June to September). For the geographical position, this region is similar to the above region, both to the southeast of the two continents. But here the region is much smaller.

3) In the Mediterranean–near East–Mid–Asian region, the MPM appears in the winter half year, in agreeing with the " ocean regions ". This region can be divided into several sub–regions and they will be discussed in detail later.

4) The MPM also appears in the summer half year in the Indian Ocean and Arabian Sea. It is the result of the effect of SW monsoon.

From Fig. 1, some effects of meso–small topography can also be found clearly.

(1) As the third largest plateau of the Northern Hemisphere, the Greenland Plateau has its own precipitation regime. The MPM appears in the summer half year in west part of the plateau. while in the east part it appears in the winter half year. The MPM appears in turn from July to next February toward the east direction. This is just opposite to the precipitation characteristics of the two other plateaus, the Tibetan and western United States plateaus. As a plateau covered by ice and snow. it seems that the Greenland has a clear cold–source effect in summer. But in winter the effect is not clear, for the short wave radiation from the sun is very weak. There is a very interesting fact that the MPM in the Kamchatka peninsula also shows the same feature as Greenland, though the peninsula is much smaller than the former. In the peninsula, the MPM appears early in the western part in October and develops in turn to the east till next January. In winter, we guess, effects of the volcanic activities on the atmospheric heat source in the peninsula must be the strongest, since in winter the atmospheric temperature is the lowest and therefore the thermal contrast is the strongest.

(2) In the large islands on the oceans, say the West Indian Islands, the British Islands, Srilanka and so on, there also appears MPM in summer. This means that the thermal effects on those islands are clearly added to the average climate. Since England is under the westerlies wind all the year round, the summer MPM region is mostly to the leeward of the islands, that is, the east side.

(3) In some large inland lake areas, such as the Baltic Sea, the Hudson Bay and the Five Great Lakes in the United States, there are regions where the MPM appears several months later than that in the lands around them, especially, the latest appearing time of the MPM in the Baltic Sea may be as late as in November. From this we can infer that the formation of the "Mediterranean Climate" may be related to heat source effect of Mediterranean water body contrast on the surrounding land in winter.

(4) On the edges of East Asian monsoon and in some islands and peninsulas such as Honshu of Japan. Luzon Island and the Malaysia peninsula, etc., though they belong to different climate zones, there prevail south (or southwest) wind in summer, and north (or northeast) wind in winter, causing the MPM to appear in summer (or autumn) in the western (or southern) parts and in winter in the eastern (or northern) parts of the islands. This is due to the effects of the topography.

(5) In the Continents, the MPM comes forth early in the low–latitude regions and they progressively appear later and later poleward. But in the oceans, the occurrances of MPM follow in opposite direction from north to south and most of them start in October. In the Mediterranean area the appearing time starts from north to south, but in the Arabian Sea it is from south to north. The former is similar to that for oceans and the latter to that for lands.

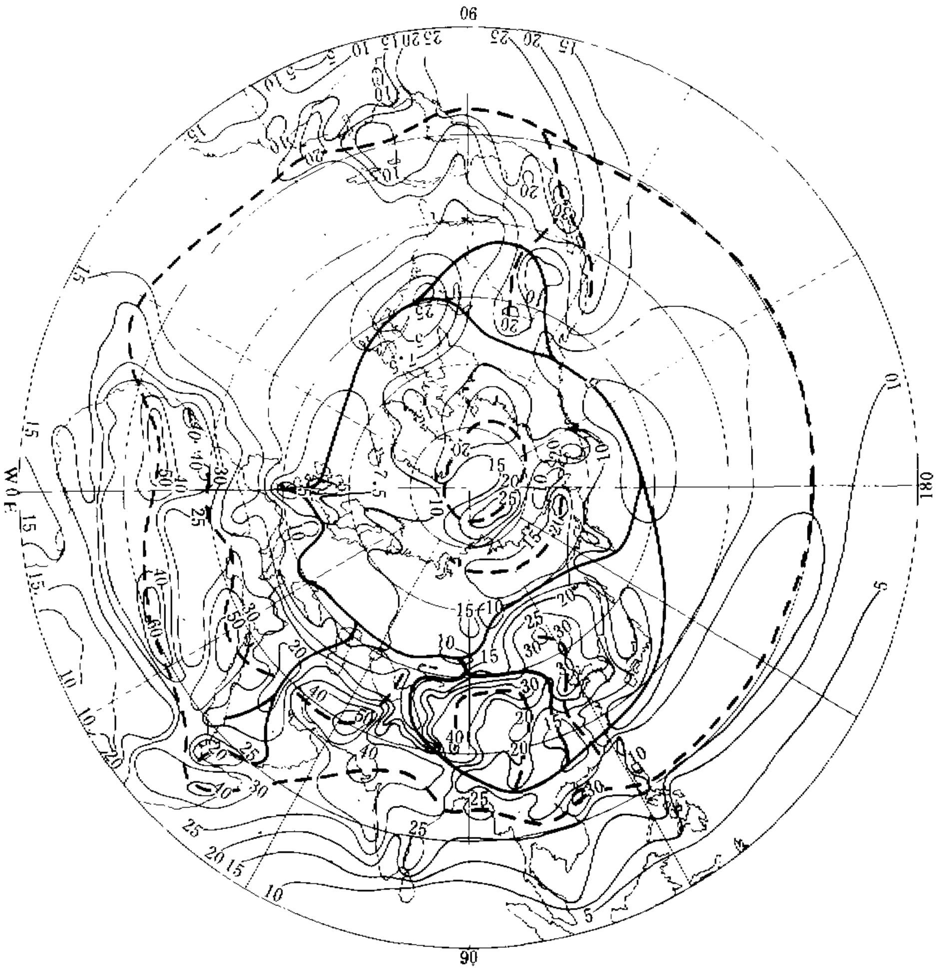

Fig. 2. Distribution of annual range of relative precipitation. Note: heavy solid lines show low value axes: heavy dashed lines show high value axes.

The relative annual precipitation range is defined as

$$ARP = \frac{R_{max} - R_{min}}{R_{year}} .$$

R_{max}, R_{min} and R_{year} are maximum monthly precipitation, minimum monthly precipitation and yearly precipitation respectively. Fig. 2 shows the values of ARP calculated by using the formula mentioned above. On the latitudinal average, there is a high ARP value zone in the pole region; a low ARP value zone in the mid–latitude zone (about 50 ° –60 ° N), obviously related to the prevailing west wind over that zone; while in low–latitude zone along about 15 ° N, there is another high ARP value zone around the earth, which may be related to the yearly vibration of the position of ITCZ. In the zone between 15 ° N and 50 ° N, the values of ARP are most changeable. Most ridges of high and low ARP values run south–north direction. There are two high value zones along the east and west sides of the plateau in the western United States and they are the products of plateau monsoon activities. The two high value zones related with the Tibetan Plateau in the regions 65 ° E – 70 ° E and 85 ° E – 90 ° E are also the reflections of the summer and winter plateau monsoons. Generally, it is considered that the high value zone along 115 ° E is caused by the sea–land monsoon activities in East Asia. But the most interesting fact is that this high value zone is not along the coast but to the east of the second topographic stage of the mainland of China. The positions of this zone and another high value zone, between 100 ° E and 105 ° E, are basically consistent with the maximum axes of interannual precipitation variability (Tang and Peng, 1985). We may say that the presence of maximum ARP value zone is mainly related to the annual variation of the heating effects of the topography, rather than that of the seas and lands.

All three centers of low ARP values (< 5%) are for the Western Hemisphere, one for the northern part of North Pacific, one for the eastern coast of America and the third for the western coast of Europe. While all high value centers (ARP > 40%) are for the Eastern Hemisphere. It suggests that the annual variation for Eastern Hemisphere is more obvious than that for the Western Hemisphere, and it reflects the characteristics that "the Eastern Hemisphere is a land hemisphere and the western, a water hemisphere" (Gao and Li, 1982).

Fig. 3 is the distribution of peak months on the curves of the annual variations of monthly precipitations. Most curves of the stations on the oceans have two peaks, since the planetary fronts generally move over one position twice per year. It is quite complex on the lands. For the Eurasian continent, most curves have single peak. But between single peak regions are regions where one curve may have three or four peaks. According to the uncontinuous curves of the distribution of MPM in Fig. 1 and with reference to the ridges of minimum ARP in Fig. 2, the annual variation characteristics of precipitation in Northern Hemisphere can be divided into several regions.

The boundaries of those regions are shown in Fig. 1 with heavy solid lines. Putting those lines on Fig. 3, it is easy to find that almost all the regions where the curves have three or more peaks are near the boundaries, and therefore, the three –(and up) peak pattern is a pattern of transition.

II. CLIMATIC DIVISION OF ANNUAL VARIATION OF PRECIPITATION

According to Fig.1, Fig.2 and Fig.3, some general characteristics of the annual variation of regional precipitation can be divided into 16 regions as follows.

I. **High–latitude region** The maximum precipitation is in summer (June to August). For the lands, the precipitation value curves mainly have one peak, but for the sea areas those curves have two peaks, one in summer, the other in midwinter, but not very sharp.

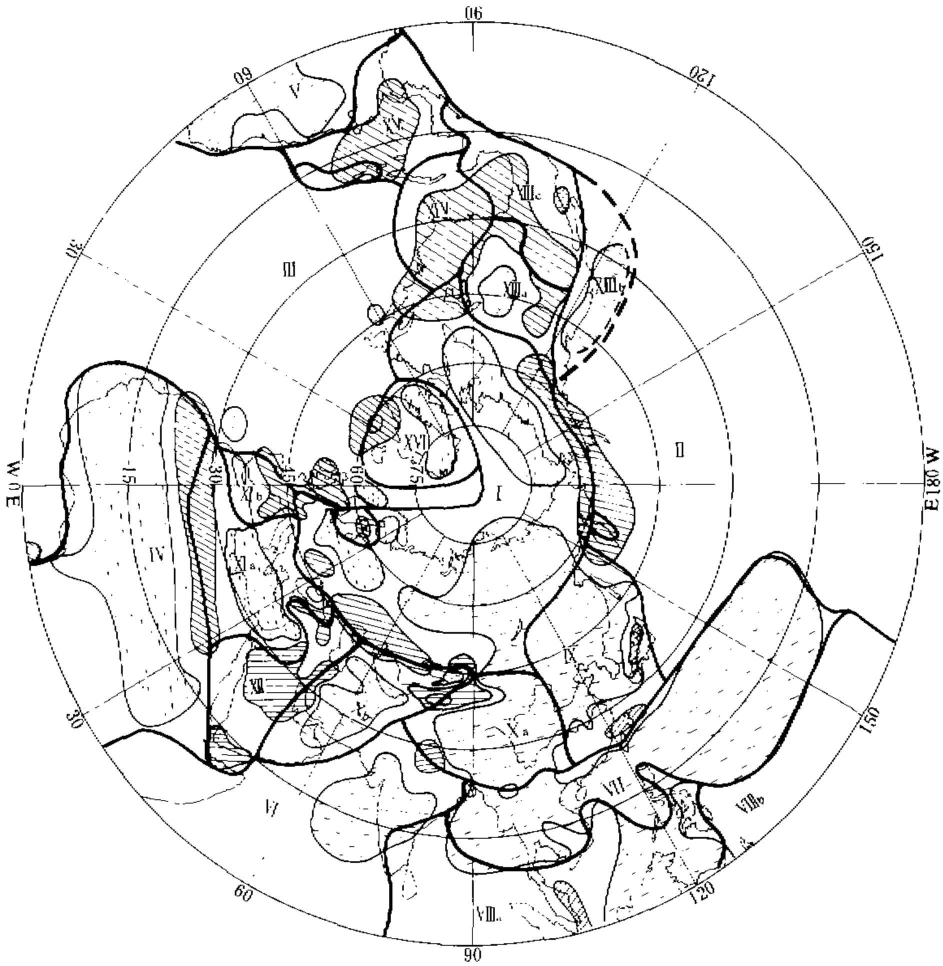

Fig. 3. Distribution of wave mumbers of annual variation of monthly precipitation. Note: heavy solid lines show the boundary line of precipitation area, Roman numerals indicate the number of regions, areas shaded by dashed lines denote the single peak region, areas shaded by solid lines denote the three– or more–peak regions, others are the two–peak regions.

II. **Pacific region** The curves have two peaks, and the one in winter half year is sharper than that in summer half year, therefore, the maximum precipitation values appear in the months from October through April. The peaks of the curves move gradually from north to south from October to January, while in the low–latitude region, they move from east to west, through February to April. The relative annual range of precipitation in these regions is much smaller than that in lands and in the polar regions.

III. **Atlantic region** The general characteristics of precipitation in the Atlantic are similar to those in the Pacific. There is a narrow zone stretching from the coast of North Europe to the pole, and it belongs to the Atlantic region as viewed from its precipitation characteristics of annual variation. The formation of this zone should be related to the warm Gulf stream.

The above are three large regions and they together occupy more than half of the whole area of the Northern Hemisphere. The following regions are some small ones.

IV. **North Africa region** The annual variation pattern of precipitation generally has a single peak and from spring to summer the MPM appears and gradually moves northward. In August it arrives at its northernmost position. This is consistent with the annual variation of the position of ITCZ.

V. **Northern region of South America** The characteristics of precipitation are similar to that of North Africa, but this region is smaller than North Africa and it stretches only as north as 10°N, suggesting that the annual variation range of the position of ITCZ in this area is much smaller than that in North Africa.

VI. **Southwest monsoon region** The General characteristics of precipitation in this region are also similar to that in North Africa. The MPM appears on the east part of North Africa in April and it moves northeastward till it arrives at north India in August, where the ARP is the largest of all the world, suggesting a strong continental feature. But in the Arabian Sea and along the coast of East Africa, the precipitation curves have two peaks, which show the "marine climate characteristics."

VII. **The low-latitude monsoon region of East Asia** The typical characteristics of monsoon rain (say, large ARP, single peak, MPM appears in summer) are shown very clear here. But it is shown the nature of marine climate and the MPM appears early in the north and moves southward progressively as seasons go by.

VIII. **Equator region of East Asia** The volume of annual precipitation is well-distributed and the ARP has two peaks and its value is small; In the VIIIa region (west to 125°E) the winter monsoon makes the MPM in the eastern coast appear from November to January and it is two to five months later than that along the western coast. For instance, the MPM along the eastern coast of Malay peninsula is two months later than that along the western coast; In the VIIIb region (east to 125°E) the precipitation is not influenced by the winter monsoon and the MPM appears in May when the ITCZ is passing over this region.

IX. **The continental monsoon region in East Asia** This region has typical features of "continental monsoon": large ARP value, precipitation volume curve having only one peak; MPM appearing in spring or summer and moving northward. The boundary between this region and the region I (high-latitude area) can be drawn according to the ridge of the maximum gradient of ARP (see Fig.2), but it can not be drawn according to Fig. 1.

X. **The Tibetan Plateau monsoon area** The plateau summer monsoon area (region Xa) has almost the same precipitation characteristics as region IX. As we have already pointed out that the boundary between regions IX and Xa is roughly along 110°E (Tang et al., 1979). In Fig. 2, there is also a minimum ARP zone near 110°E. The winter plateau monsoon region (region Xb) also has typical annual variation characteristics of continental monsoon precipitation. However, the appearing period of MPM is in winter-spring (December to May), just opposite to the summer monsoon region.

XI. **The Mediterranean area** In this area the MPM appears in winter (October to February) and moves southward, showing the feature of marine climate. This area may be divided into two sub–regions (XIa and XIb) according to the moving speeds of MPM toward south.

XII. **The mid–East transition region** This region is the climatic transition area from plateau winter monsoon to the Mediterranean climates. The geographical distribution of MPM is not regular and the annual range of precipitation has two or three peaks. Also, the value of ARP is relatively small.

XIII. **North American plateau monsoon region** The general characteristics of this region is similar to that in region X. but in XIIIb the MPM moves southward. showing the feature of marine climate. It is just opposite to that in region Xb. The western and southern boundaries of region XIIIb are difficult to define, since there are not enough data for the ocean. According to the appearing time of MPM. the summer monsoon region can be divided into two sub–regions. regions XIIIa and XIIIc. The MPM in region XIIIc shows a tendency to move southward.

XIV. **The east region of North America** In this region, the ARP value is relatively small and the annual variation shows a two–peak. even a three–peak pattern, having the distinguished feature of a transitional region.

XV. **Caribbean Sea region** The ARP value is considerably high. It has the characteristics of monsoon climate, and it is similar to the area VII in East Asia as viewed from its geographic position. but its latitude is lower than area VII. The MPM appears in October–November and the annual variations are of two–peak or three–peak pattern. Therefore. we may say that this region is a non–typical monsoon precipitation zone.

XVI. **Greenland region** This area bears the distinguished precipitation climate. The MPM shifts eastwards sequentially from the west area in July and reaches to the east until February. The ARP value for the west is also high and exhibits a single–peak pattern, while for the east it is low and has two peaks. This shows that the west has a distinct feature of "monsoon precipitation" and the east has the marine climate characteristics. It is the possible cause of the Atlantic warm flow in winter.

Besides, the Baltic. the Antilles Islands and the Kamchatka peninsula can be all defined individually as a precipitation climate area, but their areas are too small to list here.

From the above, if we classify those characteristics such as (1) MPM appearing in spring and summer and moving northwards. (2) the annual precipitation variation being of one–peak pattern and (3) the relative variability of annual precipitation being comparatively high (generally over 10%) as the "continental climate". Then the high–latitude or pole regions (I), the continent of North Africa (IV), the northern part of South America (V), the Arabian Sea area (VI), the monsoon regions in East Aisa (IX and Xa) and the summer plateau monsoon region in North America(XIIIa) all are of typical "continental climate" regions. The characteristics of Tibetan Plateau winter monsoon region (Xb) is of "continental climate", too. except where the MPMs appear from winter to spring.

If the characteristics concerned basically opposite to those mentioned above, i.e. (1) the MPM appearing in autumn and winter and shifting southwards. (2) the annual precipitation being of two–peak pattern, (3) the relative variability of annual precipitation being comparatively low (generally less than 15%) are defined as "marine climate". Then the Pacific (region

II), the Atlantic (region III), the tropic area in East Asia (VIII) and the Mediterranean region (XV) all are of the "marine climate" regions. The low–latitude monsoon regions of East Asia, the western coast of North America (region XIIIb) and the Caribbean Sea area (XV) all belong to the "transitional marine climate" region, because the ARP values are high and the precipitation value curves have one peak only.

III. DISTRIBUTION OF RELATIVE PRECIPITATION IN JANUARY AND JULY

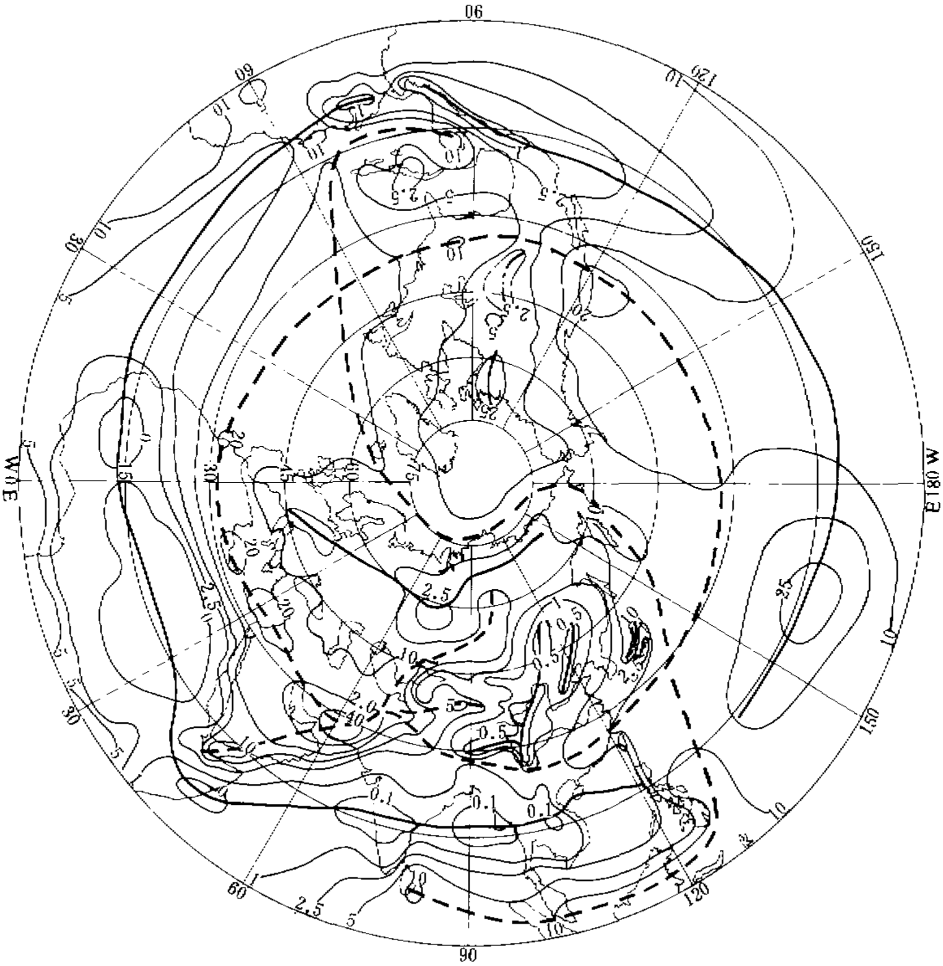

Fig.4. Distribution of monthly relative precipitation (annual percent) in January. Explanations are the same as in Fig. 2.

The precipitation depends on many factors, of which some factors have no annual variations (e.g., the distance from ocean). Therefore, if one should study the law of annual precipitation variation only, it would be best to use "relative precipitation" as an index instead of using precipitation itself. The "monthly relative precipitation" is defined as $RP_i = R_i / R_y$, where R_i is the precipitation in ith month, R_y is the annual precipitation at the station studied.

Fig.4 and Fig.5 are the distribution of relative monthly precipitations in January and in July respectively. From Fig.4, it can be seen:

(1) Between latitudes 25 ° N and 35 ° N in January, there is a relative maximum rainy belt surrounding the earth. The southernmost point of this belt is at East Asia (about 25 ° N), while its northernmost point is at Atlantic (about 36 ° N); which well agrees with the mean position of planetary frontal zone as a whole. The most intensive precipitation center on this belt is in the plateau winter monsoon area, and 40% of the annual precipitation is in January. The secondary intensive center is in the plateau winter monsoon region in North America, and the third center is situated at the region over Mediterranean Sea.

(2) In January, the eastern coast of two continents, there exists a relative maximum rainy belt in the direction of northeast–southwest, matching respectively the two frontal zones of planetary long–wave trough. The rainy belt in East Asia extends southward all the way to the position about 3 ° N, and that in North America extends only to the neighbourhood of 15 ° N. This indicates that the activities of winter cold air in East Asia are stronger than that in North America.

(3) The third SW–NE relative rainy belt is situated in the plateau winter monsoon region (region Xb) on the western side of Tibetan Plateau. This belt happens to be located also in the front of Ural planetary long–wave trough in winter. As we have indicated, the cause of formation of rainy belt is due to the air–flow to north at the rear of winter cold high over the Tibetan Plateau. Thus we may consider that the formation of Ural planetary trough is also related to the effect of winter cold source over Tibetan Plateau.

(4) In the area along the west European coast of Arctic Sea, there is a relative rainy belt caused by the remaining influence of Atlantic warm current. Besides the above mentioned rainy belts, some belts can also be found along the northern slope of Kunlum Mountains and the northwestern side of Japan, owing to the effects of middle and small topographies.

It is also seen from Fig.5:

(1) There is a relative rainy belt around the earth between 7 ° N and 23 ° N in July. This is the reflection of the position of ITCZ. The center of maximum precipitation on this belt is in West India, having more than 40% of annual precipitation in July. The other maximum center is at the western coast of Mexico. Viewed from its geographic position (both located at the western side of plateau) and from the characteristic of annual precipitation variation (see Figs. 1–4), this region (XIIIc) is very similar to the southwest monsoon area (region VI) in India.

(2) Along the latitude of about 30 ° N, there is a relatively less rainy belt surrounding the earth, and its position is hardly different from the relative rainy belt in January. Two minimum precipitation centers are located respectively in the plateau winter monsoon areas (regions Xb and XIIIb), and the maximum gradient of relative precipitation is in the transition area between winter and summer monsoon regions.

(3) In the middle latitudes, there are four relative rainy zones which lie respectively in the plateau summer monsoon regions (Xa and XIIIa), the East Asia monsoon region (IX) and the east of North America (region XIV).

(4) In the high-latitude area, there are all high-value regions of relative precipitation, except those oceanic regions.

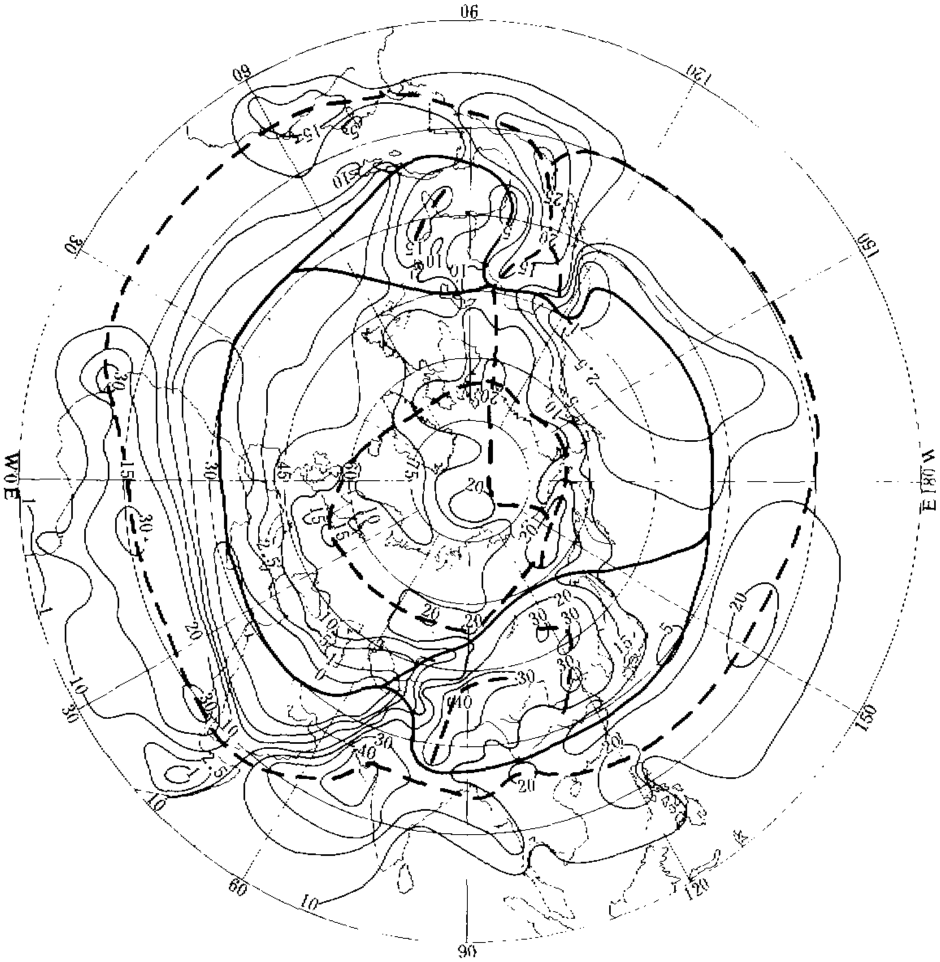

Fig.5. Distribution of monthly relative precipitation (annual percent) in July. Explanations are the same as in Fig.2.

IV. ANALYSES OF MONTHLY PRECIPITATION VARIABILITY

If we define the intermonthly precipitation variability (RV_i) as

$$RV_i = (R_i - R_{i-1}) / R_{year},$$

where R_i is the precipitation received during the ith month. Twelve maps of intermonthly precipitation distribution can be constructed (for saving space three maps have been selected only, see Fig.8). From these maps, various annual activities of precipitation systems are then analysed.

1. In the global rainfall regime, there are two types:

(1) The planetary front (polar front) system. On each of the twelve maps there is a relative maximum belt of RV surrounding the earth, which moves and reaches the southernmost position about 25 ° N in January–February (see Fig. 6), while in the period of July–August, it is drawn back into the Arctic circle.

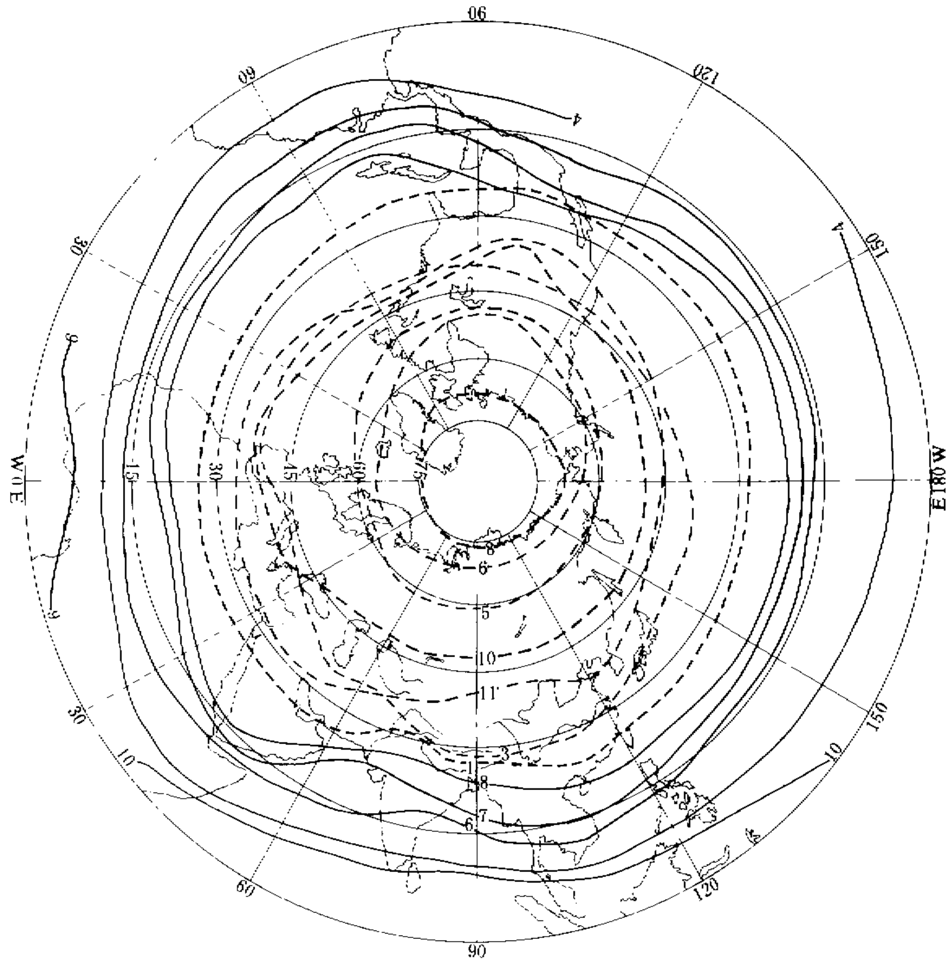

Fig.6. Position of axes of maximum values of intermonthly precipitation variabilities (global precipitation system). Note: solid line shows the ITCZ system and dashed line shows the polar front system. Numbers marked are the respective months.

(2) The intertropical convergence zone (ITCZ). The maximum RV belt connected with the ITCZ moves firstly across the equator in Eastern Hemisphere in April (see Fig. 6). In May, a closed circle of maximum RV axis can be found along the latitude about *10* ° N, and its northernmost point is in the continent of Africa, reaching 23 ° N, and till June, this point

then moves into the Indian subcontinent; while on the contrary, the African portion withdraws southwards (explained in the followings). During August, the ITCZ reaches its northernmost position, and this maximum RV circle is about at 20° N with its two northernmost points at Indian subcontinent and Mexico respectively, both at the northern side of 25° N. In October, the RV circle had turned back to the tropic area, still at the north of equator in Eastern Hemisphere and the southern latitudes in Western Hemisphere. We may see from Fig. 6 that, the poleward advancing time of ITCZ lasts about four months in the Northern Hemisphere and its southward retreating period has only two months.

2. The monsoonal precipitation regime has three types:

(1) **The land-sea monsoon system** In April, a maximum RV zone in the direction of north and south appears firstly on the near sea along the eastern coasts of the two continents (see Fig. 7). It migrates progressively into the continent and arrives at its westernmost position in July. Then, it gradually moves back eastward and reaches its easternmost position in December. In January–March this maximum RV zone disappears.

(2) **The plateau summer monsoon system** In April and east of two great plateaus (the Tibetan Plateau and the west plateau of North America), there appears initially a maximum RV zone in the direction of north and south. Afterwards, it gradually migrates westward to the inner part of the two plateaus and reaches its westernmost position in August. From September, it moves back rapidly nearby the southeastern border of the two plateaus. Hence, we may say that, at each of the southeastern boundary of the great plateaus, there exists an "unbroken autumn rainfall" region which is a representation of plateau summer monsoon withdrawal.

(3) **The plateau winter monsoon system** During September and west of Tibetan plateau and during October west of North American plateau, there appear maximum RV zones in the direction of north and south respectively in the order of their initial appearing times, and then they shift eastward to the inner part of both plateaus and arrive at each easternmost ends in January–February. After February, there is also a westward and northward retreating process, but the maximum RV zone at this time coincides mainly with the polar front precipitation system and they are hard to be distinguished.

3. Along the northern fringe of Africa and starting from March, there is a maximum RV zone appearing firstly from East Africa to the Arabian peninsula (see Fig. 7). It turns counterclockwise along the continent and reaches the west of North Africa till June. Due to the interference of this maximum zone, the ITCZ precipitation system passing through North Africa in May has to shift north and it comes back southward during June. Whether this maximum RV zone is related with the heating effect of the North African land surface is worth investigating.

For acquiring the relationship between the distribution of RV and different precipitation systems in more detailed forms, three distribution maps of RV values (in April, September and December) are given herein and those features mentioned above may be clearly seen. It can be found from Fig. 8 that a maximum RV zone appears from Iceland and toward its northeast, which lasts until December (see Fig. 8c) and January (figure omitted). This is due to the effect of heat source caused by the Atlantic warm current in next half year with respect to its surrounding lands. It can also be seen, there is another maximum RV zone appearing from Atlantic to Mediterranean, which does not coincide with the maximum RV zone in polar precipitation system. This illustrates that the relative effect of Mediterranean heat source begins to reveal itself in September.

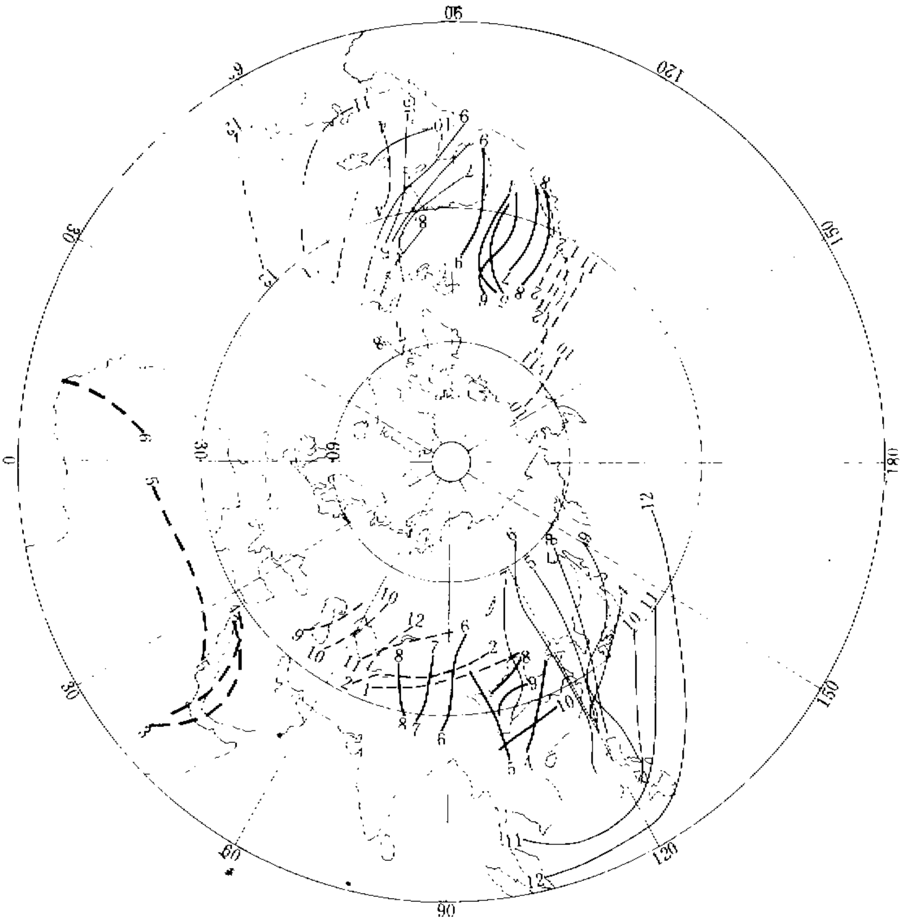

Fig. 7. Positions of axes of maximum intermonthly precipitation variabilities (monsoonal precipitation systems). Fine solid lines indicate sea–land monsoon system, heavy solid lines indicate plateau summer monsoon system. Fine dashed lines show plateau winter monsoon system and heavy dashed lines show the African monsoon system.

V. CONCLUSIONS

Through the analyses of the climatological data of monthly precipitation in Northern Hemisphere, the following clear and definite understandings can be reached.

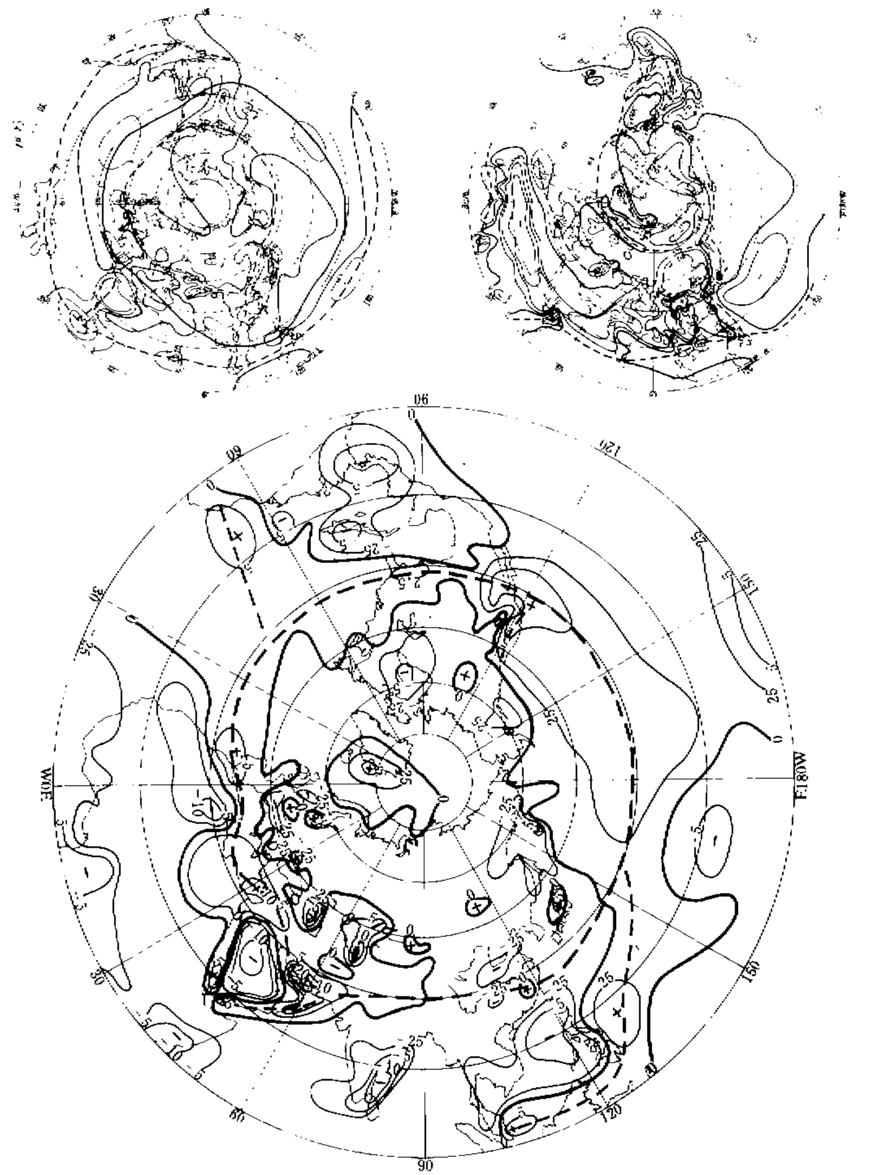

Fig. 8. Distribution of the intermonthly relative precipitation variabilities (a–April, b–September, c– December). Explanations are the same as in Fig. 2.

(1) According to the characteristics of annual variation of precipitation and on basis of the time of appearing maximum precipitation, we may divide the Northern Hemisphere into sixteen regions. These regions may also be summarized as three types. In the first type, the MPM appears in autumn or winter with its appearing sequence from north to south. This

type may be called the "Oceanic type". All the regions of the Pacific, the Atlantic, the Mediterranean and the North American plateau winter monsoon area are of this type. In the second type, the MPM appears in spring or summer in the progressing order from south towards north. This may be named the "continental type". Areas of high latitudes, Africa, South America, and the sea–land monsoon (including the Arabian Sea area) and the plateau summer monsoon area fall into this type. All other regions, except those mentioned above are of the "transitional type".

(2) The precipitation system may also be classified into two patterns, namely, the global pattern and regional pattern. The global pattern consists of planetary front zone and ITCZ. It has a distinguished feature of hemispherical migrating process of southward advancing and northward retreating. The axis of its monthly precipitation variability around the earth shows a quasi east–west direction. The regional precipitation system includes sea–land monsoon, plateau summer monsoon and plateau winter monsoon. Their activities show similarities both in Asian and North American continents, all appearing along the continent coast and on the eastern and western sides of respective plateaus. Their axes of maximum intermonthly precipitation variabilities show mainly a north–and–south direction, almost perpendicular to the axis of global precipitation system. Therefore it is quite easy to distinguish between these two patterns of systems.

(3) The topography in meso and small scales such as Greenland, the Baltic, the Kamchatka and Honshu of Japan has evident influences on the annual distribution of precipitations.

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