Extremes of East Asian Weather during the Post ENSO Years of 1983/84 — Severe Cold Winter and Hot Dry Summer —*

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Abstract

Climate of East Asia marked significant fluctuations between winter 1983/84 and summer 1984: It was severely cold in winter and very warm and dry in summer. A diagnostic study on the features of atmospheric circulation and their association with the convective activity and SST (sea surface temperature) in the western tropical Pacific region is made in relation to these extremes of East Asian weather, with special emphasis on the midlatitudes-tropics interaction. The features are compared with those of climate 1982/83.

In winter 1983/84 a deep trough persisted northeast of Japan, sustaining a significant meridional flow over East Asia. Zonal flow index was significantly low only second to winter 1967/68 in the last 40 years, and winter mean temperature in Central Japan was lowest since winter 1944/45, indicating a contrast to mild winter 1982/83. Meanwhile convective activities were significant around Indonesian maritime continent, and very weak around the date line. Thus winter 1983/84 showed a marked difference in distribution of convective cloud from the previous winter 1982/83. It is suggested that East Asian winter weather is closely associated with the interannual fluctuation of the convective activity in the western tropical Pacific Ocean.

During summer 1984 the atmospheric circulation feature was quite different between early and later summer. During June and July a ridge northeast of Japan and a trough over China were almost stationary, and south-westerlies were prevalent over the eastern East Asia. In midsummer subtropical High (Sub High) developed north of the normal position and stayed for about a month near Japan, leading to hot and dry weather from south China to Japan. The formation of this Sub High followed the active convection around the Philippines from late July through August.

In striking contrast to the continuation of lower SST during El Nino event of 1982/83 in the western tropical Pacific, it was above normal during winter 1983/84 through summer 1984. The convective activity in the region was also significant in phase with higher SST, suggesting that higher SST may have contributed to the active convection to a certain extent.

1. Introduction

The severe cold winter 1983/84 and the hot summer 1984 were the most significant events among several East Asian extreme weathers during summer 1983 through 1984. These events occur-

red when one of the largest El Nino/Southern Oscillation (ENSO) events was in decay period and the Southern Oscillation (SO) was changing from lowest to a high index phase (Quiroz, 1984; Ropelewski, 1985). They are in strong contrast to the mild winter 1982/83 (Zhang, 1985) and the cool early summer 1983, respectively.

Reflecting changes of SO phase the convective activity was significantly active in the western tropical Pacific during late summer 1983 through 1984, in sharp contrast to its failure during

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1982/83 ENSO event (Winston, 1984). At the same time monthly sea surface temperature (SST) was more than 0.5 to 1.0°C higher than that of the ENSO period.

Thus appearance of the opposite climatic anomalies both in East Asian winter and summer between 1982/83 and 1983/84 accompanied those in the western tropical Pacific ocean and atmosphere. This implies that extremes of East Asian weather are closely associated with large fluctuations of tropical ocean and atmosphere such as ENSO event in 1982/83 or anti ENSO conditions in 1983/84.

In this paper we describe these two extreme climate events in East Asia, and discuss their association with the convective activity and SST in the western tropical Pacific region, with special emphasis on the midlatitudes-tropics interaction. The climatic features are compared with those of 1982/83 when one of the major El Nino events had a significant influence over the world weather.

2. Data

In this study we use various climatological data including surface climate, upper atmosphere and sea surface temperature data in order to describe the general features of whole climate system in East Asia, and to clarify its association with those of low latitudes region. Each data covers different area. Number of the years used for climatology is also different from each other and noted on each of the figures. The data is summarized as follows.

TEMPERATURE AND PRECIPITATION: Fig. 1 shows network of CLIMAT stations over East Asia and Southeast Asia. Monthly mean temperature and precipitation data from these stations are used.

NORTHERN HEMISPHERE ATMOSPHERIC CIRCULATION: Sea level pressure and geopotential height data is taken from JMA (Japan Meteorological Agency) daily objective analysis data except for the ones in the 500 mb height charts covering tropical region (Figs. 9, 10 and 11) for which NMC/NOAA daily analysis data are used.

OCEAN CONDITION: Monthly mean SST in the Northwestern Pacific region routinely analyzed at Oceanographic Division JMA is used

Fig. 1 CLIMAT Station network and oceanographic observation section along 137°E . 5 stations in Fig. 3 are shown by a) to e).

for the area between Equator and 53°N , and 110°E and the date line. Oceanographic observation line along 137°E is shown in Fig. 1. The depth-latitude cross sections of sea water temperature along the line in July 1984 and January 1983 observed on board Ryofu Maru are also used for a comparative study of the western tropical Pacific Ocean condition.

CONVECTIVE ACTIVITIES: As an index for the convective activity in the western tropical Pacific region we use two parameters derived from Geostationary Meteorological Satellite (GMS) observation: one is Equivalent Black-Body temperature (TBB, in deg. C) which indicates the temperature at the top of convective clouds, and the other is percent coverage of high-cloud amount (%). High-cloud is defined here as the clouds at 400 mb or above.

3. Winter 1983/84

3.1 Temperature and precipitation

Climate of East Asia in winter 1983/84 is characterized by significantly low temperature and less precipitation (Fig. 2). Winter (D-J-F) mean temperature anomalies were 1 to 2 deg. C below normal from southern China to Japan, while temperatures north of 40°N and in the western tropical Pacific were above normal (Fig. 2a). The cold weather continued more than 4 months as shown in Fig. 3.

On the other hand, monthly mean temperature anomalies in winter 1982/83 also shown in Fig. 3 indicate that mild weather prevailed in winter 1982/83, because of anomalous atmospheric circulation probably associated with

Fig. 2 Winter (D-J-F) mean temperature and precipitation anomalies from 1931–1960 mean (1951–1980 mean for Japan), winter 1983/84.

- a) Winter mean temperature anomalies. Contour interval is 1 deg. C except for lower latitude area where dashed contour is 0.5°C. Shaded $> 1^{\circ}\text{C}$, Dotted $< -1^{\circ}\text{C}$.
 b) Winter precipitation percentage. Contour interval is 20%. Shaded $> 120\%$, Dotted $< 80\%$.

ENSO 1982/83 (Zhang, 1985). Thus the climate of East Asia, especially its eastern part, in winter 1983/84 was in marked contrast to that in winter 1982/83.

Precipitation anomaly pattern was similar to that of temperature, dry in East Asia and wet in north of 50N as well as in low latitudes (Fig. 2b). Note that above normal cloud amount around the Philippines in Fig. 6 suggests above normal rainfall in the region, although contours are not shown in Fig. 2b because of lack of data.

While winter mean precipitation was less than or near normal over Japan as shown in Fig. 2b, the cold weather was accompanied by frequent snowfalls over the country including Pacific coastal regions which usually have few snowfalls, causing large socio-economical damages. The number of days with snowfall in Tokyo, for an example, was 18 during January and February, three times normal.

3.2 Circulation

Winter (D-J-F) mean 500 mb height and anomaly patterns are shown in Fig. 4. A deep trough is located over Japan to the central North Pacific, and two ridges are seen, one over Alaska and the other over the western part of USSR. Monthly mean 500 mb charts for each winter month (not shown here) indicate that although

Fig. 3 Time series of monthly mean temperature anomalies from 1931–1960 mean (1951–1980 mean for Central Japan).

Location of each station is shown in Fig. 1.

- a) LANZHOU, b) BEIJING, c) Central Japan (average of 5 stations), d) SHANGHAI, e) HONG KONG.

the ridges changed the positions from month to month, the trough remained almost stationary. Corresponding to this 500 mb flow pattern

Fig. 4 Winter (D-J-F) MEAN 500 mb geopotential height and anomalies from 1951–1980 mean, winter 1983/84. Contour interval is 100 gpm for geopotential height (solid line) except for 5850 gpm contour (dash-dotted line), and 50 gpm for anomaly (dashed line, Shaded > 50 gpm, Dotted < –50 gpm).

there persisted a large surface pressure difference between Siberian continent and the North Pacific, which sustained the strong East Asian winter monsoon.

It is known that there is an atmospheric teleconnection during winter with one of the action centers being located over Japan (Wallace and Gutzler, 1981; Gambo and Kudo, 1983), which is often referred to as Eurasian pattern. During winter 1983/84 there appeared a pattern a little similar to it in monthly mean 500 mb field of January 1984, with negative anomaly around 60N, 0E, positive one at 60N, 60E, and negative one over Northern Japan extending to the central North Pacific. The former trough and ridge changed their positions from month to month, but the trough over the northeastern Pacific was almost stationary through winter, suggesting that the persistence of the trough was not apparently connected with a teleconnection such as Eurasian pattern.

The atmospheric flow pattern in Fig. 4 shows a significant meridional flow and southward shift of the westerlies over East Asia. The strong meridional flow in this winter can be seen in the time series of winter (D-J-F) mean Zonal Index (ZI) anomaly in the East Asian midlatitudes from winter 1946/47 to winter

Fig. 5 Time series of winter (D-J-F) means of Zonal Index anomaly in East Asian midlatitudes and temperature anomaly in Central Japan, both from 1951–1980 means, for the period between winter 1946/47 and winter 1984/85.
a) Standardized Zonal Index (ZI) anomaly.
b) Temperature anomaly in Central Japan. Anomaly is the average of 5 stations data. See Fig. 1 for location. Standard deviation is 0.8°C for the 30 year mean.

1984/85 (Fig. 5a). ZI is defined here by the zonal average of 500 mb height difference between 40N and 60N along latitude lines from 90E to 170E and divided by standard deviation. The standardized ZI anomaly in Fig. 5a indicates strong (weak) westerlies or dominant zonal (meridional) flow when Index is positive (negative). Winter 1983/84, in line with winter 1980/81, recorded the very significant weak westerlies second only to winter 1967/68. This may account for the lowest winter mean temperature of Central Japan in the past 40 years since winter 1944/45, 1.8°C below normal which exceeds 2 times standard deviation (Fig. 5b).

3.3 Convective activities in the western tropical Pacific

Another prominent atmospheric feature of winter 1983/84 is the westward displaced stronger convective activities in the western tropical Pacific, which are in striking contrast to significantly weak convections over the area associated with 1982/83 ENSO event. Distribution of the

winter mean high-cloud amount and anomalies clearly displays the difference between the two winters (Fig. 6). Contrast of the positive and negative cloud amount anomalies in the western and the eastern parts in winter 1983/84 as shown in Fig. 6a suggests the active convective area, which had been displaced to the east of the date line in the winter of 1982/83, shifted to a position far west of the normal position.

Chang and Lau (1980, 1982) indicated that cold surges usually cause enhancement of tropical convection over the Indonesian maritime continents. Chang and Lum (1985) showed that a good correlation existed in the winter 1983/84 between tropical convection and intensification of midlatitude jet; they found that there were several occasions that cold surges were followed by active convection. And that development of tropical depression which was not affected by midlatitude flow was immediately followed by intensification of the jet. Thus it could be said that East Asian stronger winter monsoon contributed to the intensified convective activities around Borneo and the Philippines where winter mean high-cloud amount was more than 10% above average representing the stronger convectivity. The intensified convection, together with development of tropical depressions around east of the Philippines, in turn, enhanced the local Hadley cell, leading to the intensification of the subtropical jet as indicated by Chang and Lum (1985). The intensified jet might have contributed to maintaining of the deep trough to its north in the western North Pacific.

Thus these circulation features reflecting the midlatitudes-tropics interaction resulted in the cold winter 1983/84 in East Asia. On the other hand, in winter 1982/83 the weak monsoon, which was associated with northeast Asian mild weather, was accompanied very weak convective activities. Moreover, it can be seen in recent winters that cold (mild) winter, such as cold winter 1980/81 or mild winter 1978/79, was observed when the convective activity was stronger (weaker) than the averages as shown in the time series of winter mean temperature anomalies (Fig. 5b) and those of monthly mean high-cloud amount anomalies (Fig. 12a). Therefore it is suggested that East Asian winter weath-

Fig. 6 Winter (D-J-F) mean high-cloud amount and anomalies from 1978–1984 mean.

Contour interval is 10% for cloud amount (solid line with every 20% thickened) and for anomaly (dashed line, Shaded $> 10\%$, Dotted $< -10\%$).

a) Winter 1983/84, b) Winter 1982/83.

er may be closely associated with the inter-annual fluctuation of the convective activity over the maritime continent in the western tropical Pacific Ocean.

4. Summer 1984

4.1 Temperature and precipitation

Summer 1984 is characterized by the above normal temperatures in the northeastern area including the Korean peninsula and Japan where monthly mean temperature anomalies exceeded 2 times standard deviation at several stations (Fig. 7a). To the northwest, on the other hand, more than 1°C below normal temperatures were observed. Moreover rainfall was 60 to 80% of the normal in south China to Japan, reflecting weak Baiu front in the rainy season as well as only a little influence of typhoons to the region (Fig. 7b).

It should be noted that there is a strong contrast in rainfall anomaly between eastern

and western parts of the western tropical Pacific. This suggests that active convective area had been displaced farther west of the normal position in the summer as well. And that the condition continued during winter 1983/84 through summer 1984 as to be discussed in Section 5.

4.2 Circulation

During summer 1984 atmospheric circulation showed quite different patterns between early summer and late summer over East Asia. Fig. 8 shows monthly mean 500 mb heights and

Fig. 7 Summer (J-J-A) mean temperature and precipitation anomalies from 1931-1960 mean (1951-1980 mean for Japan), summer 1984.
a) Summer mean temperature anomalies. Contour interval is 0.5°C. Shaded > 0.5°C, Dotted < -0.5°C.
b) Precipitation percentage. Contour interval is 20%. Shaded > 120%, Dotted < 80%.

Fig. 8 Monthly mean 500 mb heights and anomalies from 1951-1980 mean.
Contour interval is 50 gpm for height (solid line with every 300 gpm thickened) and for anomaly (dashed line, Shaded > 50 gpm, Dotted < -50 gpm).
a) June 1984, b) July 1984, c) August 1984

and anomalies for June, July and August 1984. During June and July there were two persistent ridges, one at 90E in the high latitudes, and the other at 160–170E in the midlatitudes northeast of Japan (Figs. 8a and 8b). Circulation features characterized by these ridges brought about a weak trough over central China and dominant south-westerlies around Japan. This circulation pattern was associated with cooler and warmer conditions of the East Asian early summer as shown in Fig. 7a. In August, while the weakened ridge in high latitudes and the trough remained almost stationary, the ridge located in the midlatitudes east of Japan was replaced by a deep trough (Fig. 8c). Between the troughs there formed an apparent ridge over north of Japan, which was maintained by an anomalously northward-shifted subtropical High (Sub High), which had a major role in causing the hot and dry midsummer.

The significantly developed Sub High which persisted for about a month coincided with the occurrence of stronger convective activities

Fig. 9 Monthly mean 500 mb height, August 1984. Contour interval is 20 gpm.

Fig. 10 Monthly mean Equivalent Black Body Temperature (TBB), August 1984. Contour interval is 10°C, with 0°C contour thickened. Shaded < -20°C, Dotted > 10°C.

around the Philippines. Fig. 9 shows monthly mean 500 mb height in August 1984. One of the High cells is located just over Japan. To its south there can be seen a low pressure belt or a trough over the Indian sub-continent extending eastward to north of the Philippines along 20N, which is associated with monsoon activities. Fig. 10 shows monthly mean TBB of the same month. Along the belt TBB was below -20 to -30°C indicating active convective area, although the trough is not located just over the lowest TBB area around the Philippines, but is displaced a little northward. Monthly mean high-cloud amount over the area (not shown) was more than 20% above average indicating that convective activity was stronger than normal in August.

It is noteworthy that almost the same situation, concurrence of the stronger convective activity, monsoon trough to its north, and the anomalously developed Sub High over East Asia, was observed in July and August 1978, one of the warmest Japanese summers in the past decade.

Fig. 11 5-day mean 500 mb heights.

Contour interval is 20 gpm. Light and dark shaded areas indicate TBB below -20°C and -40°C respectively. a) July 14–18, 1984, b) August 4–8, 1984.

4.3 Subtropical High and convective activities

Development of the Sub High was associated with drastic changes in circulation in the tropics. Fig. 11 shows 5-day mean 500 mb height and TBB of middle July and early August 1984. A subtropical ridge stayed farther south of the normal position between 120E and 160E in July during which major convective activities were most prominent over the Bay of Bengal and relatively weak around the Philippines (Fig. 11a). With increase of convective activities around the Philippines from late July through August the Sub High appeared over Japan and persisted for about a month (Fig. 11b).

This drastic change of the conditions in the tropics and midlatitudes was coincident with weakening of trade wind in the western tropical Pacific from strong in June and July to near normal in August (Ropelewski, 1985).

Interesting to note also is the configuration of the active convective area and the center of the Sub High being located north-east of the convective area in monthly as well as 5-day mean charts (Figs. 9, 10 and 11). Moreover to the north-east of the Sub High, a series of troughs and ridges extending to North America is seen in a monthly mean 500 mb chart in August

1984 (A part of the series is seen in Fig. 8c). Troughs and ridges are almost on a great circle connecting two points: one at the center of Sub High and the other near the center of the ridge over North Pacific east of the date line.

Analyzing the time evolution of the geopotential height anomalies along the great circle, Kurihara and Tsuyuki (1986) suggested that development of this Subtropical High may be associated with barotropic energy propagation of Rossby wave forced by the active convection around north of the Philippines.

5. SSTs and convective activities in the western tropical Pacific Ocean during winter 1983/84 through summer 1984

5.1 Oceanic condition

Oceanic conditions in the post ENSO years of 1983/84 in the western tropical Pacific are characterized by higher SSTs: 0.5 to 1.0 higher than those in the ENSO period (Fig. 12b). In summer 1984, particularly, wide areas of the western tropical Pacific west of 160E were occupied by warm water (Fig. 13), while SST was below normal around the date line.

Above normal SST was associated with 10 to 20 cm higher sea levels (Wirtki, 1984). Ver-

Fig. 12 Time series of area mean monthly high-cloud amount and SST anomalies.

- Monthly mean high-cloud amount anomaly from 1978–1984 mean. Anomaly is averaged for the area (5–20N and 115–145E) and is standardized.
- Monthly mean SST anomaly from 1979–1983 mean. Anomaly is averaged for the area (0–15N and 130–150E). Note that anomaly in 1978 (dashed line) is averaged for the area (10–15N and 130–150E).

tical distribution of water temperature along 137E observed in July 1984 also indicated accumulation of warm water in the low latitudes, which was exactly opposite to the conditions in winter 1982/83, when the ENSO event was in its mature stage (Fig. 14). Thus after one of the greatest ENSO events typical anti-ENSO features were prominent in the western tropical Pacific through the period.

5.2 Relationship between SSTs and convective activities

As discussed in Sections 3.3 and 4.3, the convective activity, with active center westward-shifted, was stronger than normal around Indonesia and the Philippines in contrast to the very weak one during the ENSO event. Fig. 15 shows summer (J-J-A) mean high-cloud amount and

Fig. 13 Summer (J-J-A) mean sea surface temperature anomalies, summer 1984.

Anomaly is departure from the 1971–84 mean except for the area south of 10N where 1979–84 mean is used. Contour interval is 1°C. Contour of 0.5°C is added for south of 30N. Shaded > 1°C (> 0.5°C for south of 30N), Dotted < -1°C (< -0.5°C), $\curvearrowright$ 29 : SST is above 29°C.

anomalies in summer 1984. There was generally much cloud over the area with SST equal to or higher than 29°C. It is noteworthy that features of their distribution, *i.e.* east-west contrast of cloud anomalies and the area of strong convective activities extending from the Philippines northeastward, were quite similar to those of SST distribution as shown in Fig. 13. Positive cloud anomalies were over the higher SST region and negative cloud anomalies are over lower SST region at least south of 20N.

Fig. 12 compares time series of high-cloud and SST anomalies at the key areas. The area for cloud amount is usually the strongest convective area in August in the western tropical Pacific, where the long-term average (1978–84) of high cloud cover percentage exceeds 40%, whereas the key SST area represents the fluctuation of SST over the wide area of North western tropical Pacific (Kurihara, 1985). It is apparent that fluctuations in convective activities are closely associated with those of SSTs. For example, above normal cloud amount in summer 1978 and 1984, and winter 1980/81 correspond to higher SST, whereas below normal cloud in winter 1978/79 and 1982/83 correspond to lower SST. Thus it is suggested that above normal SST, as well as strong northeastern monsoon as discussed in section 3.3, contributed to the intensification of convective activities during winter 1983/84. And the stronger convection around Philippines during summer 1984, may be accounted for by the higher SSTs to a certain extent.

Fig. 14 Depth-latitude cross section of sea water temperature anomalies along 137E observed on board RYOFU MARU (Oceanographical Division, JMA).

Contour interval is 1°C, and negative anomalies dotted.

a) July 1985 Base period is 1972–1983.

b) January 1983 Base period is 1967–1982.

Fig. 15 Summer (J-J-A) mean high-cloud amount and anomalies from 1978–1984 mean, summer 1984. Contour interval is 10% for cloud amount (solid line with every 20% thickened) and for anomaly (dashed line, Shaded > 10%, Dotted < -10%).

6. Concluding remarks

The diagnostic study on the severe cold winter 1983/84 and the hot and dry summer 1984 in East Asia demonstrated the different process in midlatitude-tropics interactions between the two seasons, while the prominent features, *i.e.* higher SSTs and strong convective activities, were persistent through the period in the western part of the western tropical Pacific, reflecting anti-ENSO features.

In winter 1983/84 the cold winter monsoon surges, together with higher SSTs, caused the stronger convective activities, which in turn seemed to have contributed to intensifying of the midlatitudes jet and probably to maintaining of the deep trough in the midlatitudes. These circulation features were responsible for the severe cold winter 1983/84. The strong convective activity contrasted with the very weak one in winter 1982/83 when north-eastern east Asia had a mild weather.

In summer 1984 anomalously northward-displaced Sub High in the midsummer was one of the causes for hot and dry weather. Development of Sub High followed the northward-shifted stronger convective activity around the Philippines. It is necessary to study further on the relationship between them to clarify a role of tropical convection on the behavior of Sub High.

Higher SSTs probably contributed to the active convection to some extent during summer 1984. However, not discussed here, intensification of convective activities during midsummer could be partially a reflection of the low fre-

quency oscillation (30–60 days), which became much evident from summer 1984. Hence further studies should also be made on the interannual and intraseasonal fluctuations of the convective activity and its association with those of SST's.

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東アジアの異常天候：1983/84年冬と1984年夏

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(気象庁 長期予報課)

東アジアにおける1984年の天候は、大寒冬から暑夏へと極めて大きく変動した。この2つの異常天候に関連する大気循環の特徴、およびそれらと西部熱帯太平洋域における対流活動や海面水温の変動との関係を解析し、中緯度と低緯度の相互作用について考察した。

1983/84冬には、日本の東方海上で強い低圧部が持続し、東アジアでは偏西風の大規模な行が維持された。極東の東西指数は、過去40年間で1980/81年と並び、1967/68年に次ぐ低指数を記録し、中部日本の冬平均気温は1944/45年以来の低温となった。低緯度地域では、エルニーニョの最盛期だった1982/83年とは対照的に、対流活動はインドネシアやフィリピン付近で強く、日付変更線付近で弱かった。

1984夏の場合、その前半と後半で、高温・少雨をもたらした要因は異なる。6～7月にかけて、日本の東海上にリッジが、中国大陸上にトラフが持続し、東アジア東部では南西風が卓越した。盛夏期には、亜熱帯高気圧（サブハイ）が北偏して発達し、東アジア東部をおおった。このため、中国南部から朝鮮半島・日本にかけて高温・少雨となった。

日本付近で発達したサブハイの動向は、低緯度の対流活動と深く関係していた。7月中旬まではベンガル湾で平年より強い対流活動がみられたが、西部熱帯太平洋では弱かった。7月下旬からフィリピン付近で対流活動が強まると共にサブハイが日本付近で発達し、同域で強い対流が続いた約1ヶ月間、日本付近に存在した。

西部熱帯太平洋の SST は、1982-83年とは対照的に、冬から夏を通し平年より高かった。SST の変動に対応して同域の対流活動もおおむね平年より強く、SST が活発な対流活動に寄与したと示唆される。