Analysis on the Characteristics of Climate about Korean Summer Season 1998

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Abstract

The climatic characteristics of summer in 1998 are analyzed with the weather observational data and the upper air observational data. The temperature of that period is lower than that of normal years and the precipitation is larger. Due to the heavy rainfall which started at July 31, rain poured down compared to normal years and the maximum precipitation recorded at the many observational stations, particularly in Seoul, Kyunggi-Do region and mountainous districts like Taegwallyong, Mt. Sokri and Mt. Chiri.

The patterns of general circulations in 1982/83 and 1997/98 are compared each other and are analyzed. The anomaly patterns of stream functions on winter in two El Niño years are similar. The counterclockwise circulation occurred near the date line and the clockwise circulation was appeared near the Hwanam region and Alaska. These patterns are opposite to those of La Niña year, 1988/89. And the anomaly patterns of 500hPa geopotential height in summer are similar, too.

The low temperature and much rain were dominated in summer of 1997/98. These phenomena is similar to the existing results of research, that temperature is low and precipitation is large in summer of El Niño years.

1. Introduction

Recently, the unusual weather phenomena have been frequently occurred over the whole earth. Particularly in 1998, severe weather disasters and unusual weather phenomena occurred around the world. Heavy rainfall damaged the China, Korea, and Japan tremendously. While the typhoons were rarely activated in the northern Pacific area, the hurricanes in the Atlantic ocean occurred more oftener and stronger than normal years. And it is recognized that the ENSO (El Niño Southern Oscillation) having occurred during 1997/98 affected the generation of unusual weather phenomena, but the mechanism, and the dynamical and physical processes about these phenomena are not clearly explained yet.

Refering to the researches about ENSO and the variation of precipitation, there are tendencies of small rain in Indonesia and New Guinea, and of much rain in the middle tropical Pacific region (Ropelewski and Halpert, 1987). Rasmusson and Carpenter (1982, 1983) showed that the drought occurred frequently in India and Sri Lanka had rainy weather. Harger (1995) presented the relationship between ENSO changes and the drought which occurred in Indonesia and the Philippines. And Nigam (1994) discussed the dynamical basis about the connection between the Asian Monsoonal precipitation during summer season and ENSO. Miyazaki (1988, 1989) analyzed the characteristic climate in Japan during El Niño season, and Nitta (1990) showed that convections over the warm pool near the Philippines largely affect the weather changes of Japan. Cha (1998) also analyzed the characteristic climate over the Korean Peninsula during ENSO years.

In this research, the climatic characteristics over the Korean Peninsula during the summer season are studied. Section 2 describe the data used in this study. In section 3, we discuss the tendencies of temperature and precipitation over the Korean Peninsula during summer, and in section 4 we analyze the heavy rainfall. Section 5 presents the comparison and analysis about the atmospheric general circulations of 1982/83 and 1997/98 El Niño years. The summary and conclusions are contained in section 6.

2. Data

We used the observational daily temperature and precipitation from KMA (Korean Meteorological Administration) and the grid data from ECMWF (European Center for Medium Weather Forecast).

3. The horizontal distribution of anomaly of the temperature and the precipitation over the Korean Peninsula during summer in 1998.

During 26 years (1973-1998), the anomalies of monthly the averaged temperature and the precipitation were obtained on the 61 stations where the data exist. Fig.1 shows the horizontal distribution of mean temperature anomaly averaged during June, July, August and the summer season over the Korean Peninsula. The shaded area represents the negative anomaly region and the interval of isotherm is 0.4℃. There was lower tendency of temperature compared to normal years except Chupungnyong, the part of the west coastal area in July and August.

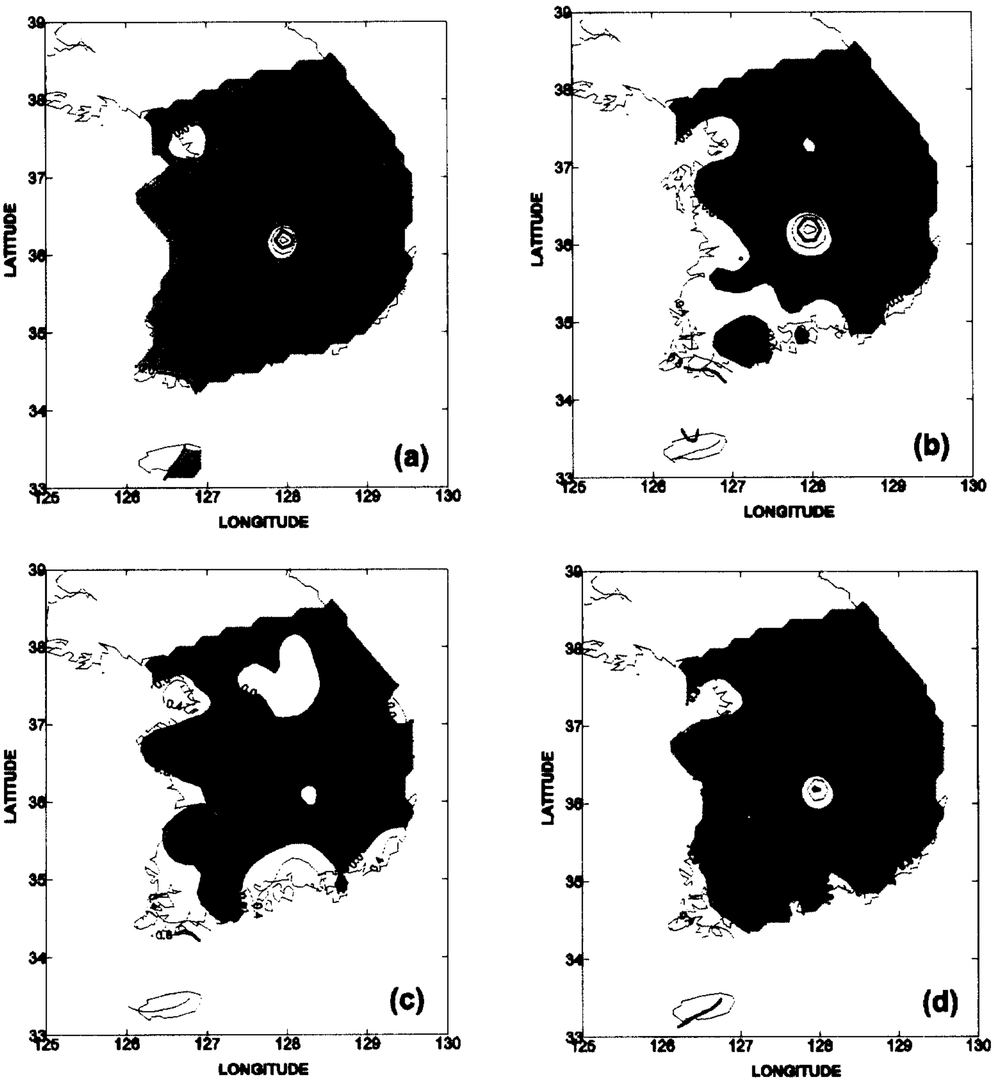


Fig.1. Horizontal Distribution of mean surface temperature anomaly in (a) June, (b) July, (c) August, and (d) Summer of 1998.

Particularly Kyungsang-Do and the east coastal region showed much lower temperature than that of normal years. Because of the weakness of North Pacific High and anomalous development of Okhotsk High, the tendency of low temperature distinctly appears specially in the east region of Korea and the northeastern part of Japan. The distribution of summer season mean temperature is lower compared to that of normal years, so it is similar to the existing result, the distribution of the summer season temperature during El Niño is lower than normal years.

Fig.2 shows the horizontal distribution of the precipitation anomaly. The shaded area

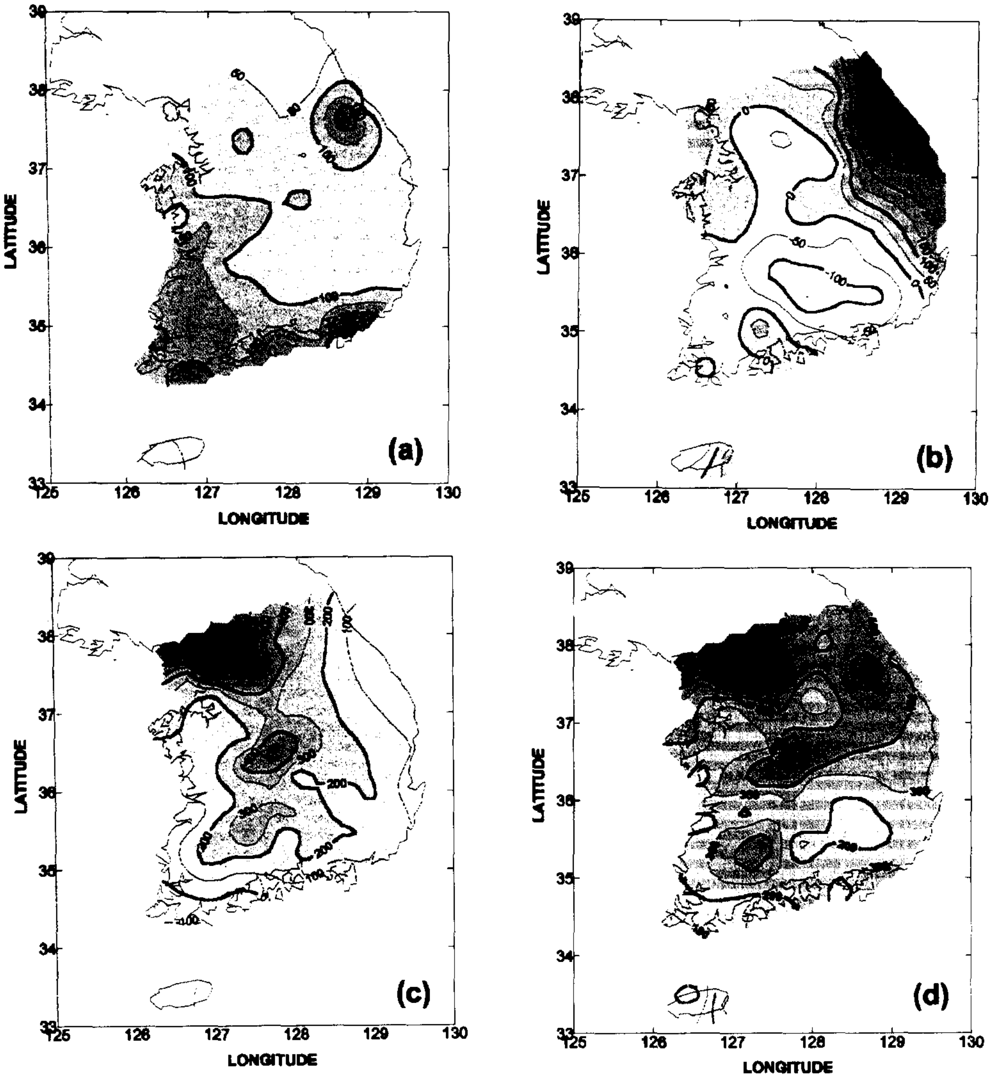


Fig.2. Horizontal Distribution of precipitation anomaly in (a) June, (b) July, (c) August, and (d) Summer of 1998.

represents positive anomaly and the intervals are 50mm in (a) and (b), and 100mm in (c) and (d). In June, the precipitation is larger than that of normal years, specially in southwestern part of the Korean Peninsula. In July, there are much rainfall in Taegwallyong, Kangwon-Do, north part of Kyunsang-Do, Kyunggi-Do and the south coastal area, Chunrado, but small rainfall in Kyunsang-Do and Chunra-Do. In August, there are, however, much precipitation in the northern part of Kyunggi-Do, Mt. Chiri and Mt. Sokri due to localized torrential downpour, so the summer time precipitation in the Korean Peninsula is larger than normal years.

4. Summertime precipitation in the Korean Peninsula in 1998

From July 31 when heavy rain started to pour down in Mt. Chiri to August 18, the heavy rainfall continued to develop. Particularly in the case of the heavy rainfall at Mt. Chiri, the lifetime of the meso-scale convective system (or convective cell) is merely 1~2 hours. The hourly precipitation (21:50~22:50) of Sunchon area on 31 July which is 145 ㎜ records the maximum precipitation since the meteorological observations have been made in Korea. From table 1, rainband moved between middle districts and south districts and the heavy rainfall

Table.1. Date of Heavy rainfall and accumulated precipitation(Jul.20~Aug.20).

Date	Location	Precipitation(mm)
Jul.31~Aug.2	Mt. Chiri	Sunchon: 298 Sancheng: 236.5 Haenam: 208 Namwon: 134.5
Aug.3~Aug.8	Seoul · Kyunggi-Do	Seoul: 838.2 Kanghwa: 793.5 Tongduchon: 739.2 Yangpyong: 654.5 Ichon: 435 Chunchon: 431.2
Aug.8~Aug.12	Chungcheng-Do	Poun: 546 Taejon: 458 Puyo: 283.5 Chungju: 178
Aug.14~Aug.15	Seoul · Kyunggi-Do	Seoul: 180.2 Yangpyong: 127.5 Kanghwa: 124 Suwon: 97.4
Aug.15~Aug.16	Chungcheng-Do	Kumsan: 182.5 Chupungnyong: 170.1 Poun: 157 Chechon: 118.5
Aug.15~Aug.18	the southern part	Changsu: 303 Kunsan: 212.5 Kochang: 203 Yongju: 170.3

was concentrated for a short time. Fig. 3 shows the distribution of the accumulated precipitation from July 20 to August 20. We can know that much precipitation was all over the country and specially in Seoul, Kyunggi-Do area, and mountainous districts like Mt. Sokri, Mt. Chiri and Taegwallyong. Particularly, the accumulated precipitation of Seoul during this period is 1,225.7 mm which records the maximum precipitation in August since the meteorological observations have been made in 1905, and this amount equivalent to 90% of yearly mean precipitation. On August 8, only one day, rainfall of 332.8 mm existed (Fig.4).

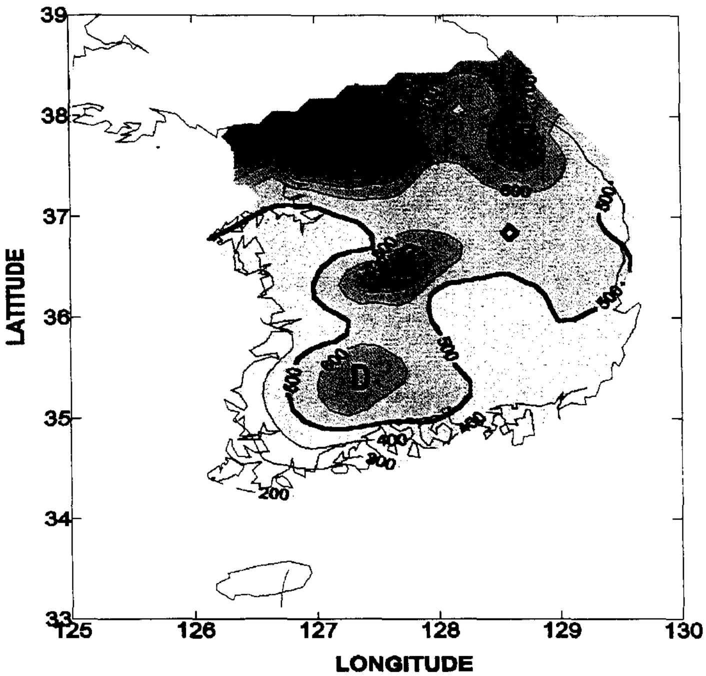


Fig.3. Horizontal distribution of precipitation in a period of Jul. 20~Aug. 20. 1998. (A: Seoul · Kyunggi-Do, B: Taegwallyong, C: Mt. Sokri, and D: Mt. Chiri)

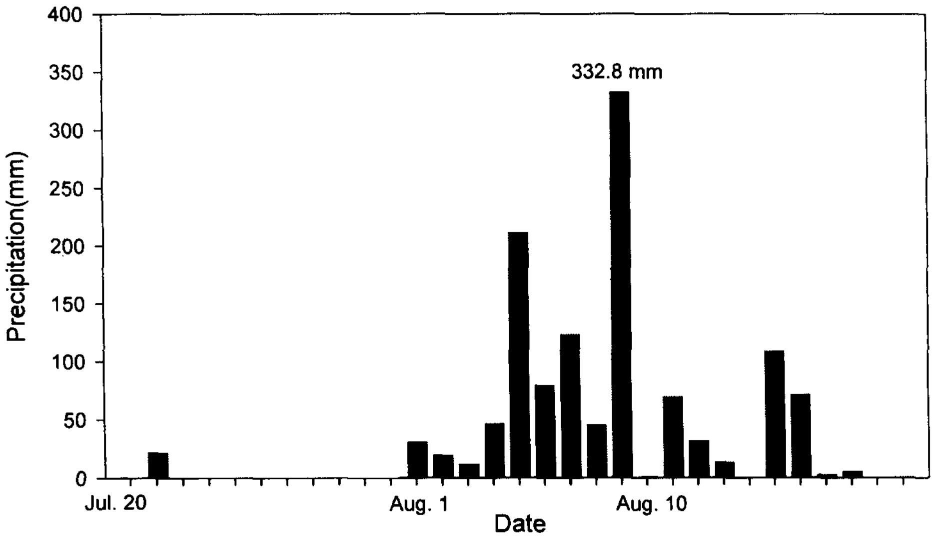


Fig.4. Time series of precipitation at Seoul in a period of Jul. 20~Aug. 20. 1998.

The tremendous pourdown in the Korean Peninsula was generated by triangularly mixed collisions and effects among the extra-large high pressure, low pressure and the Yangtze air mass (Fig.5). North Pacific High located in the southeastern part of Korea met the cold low

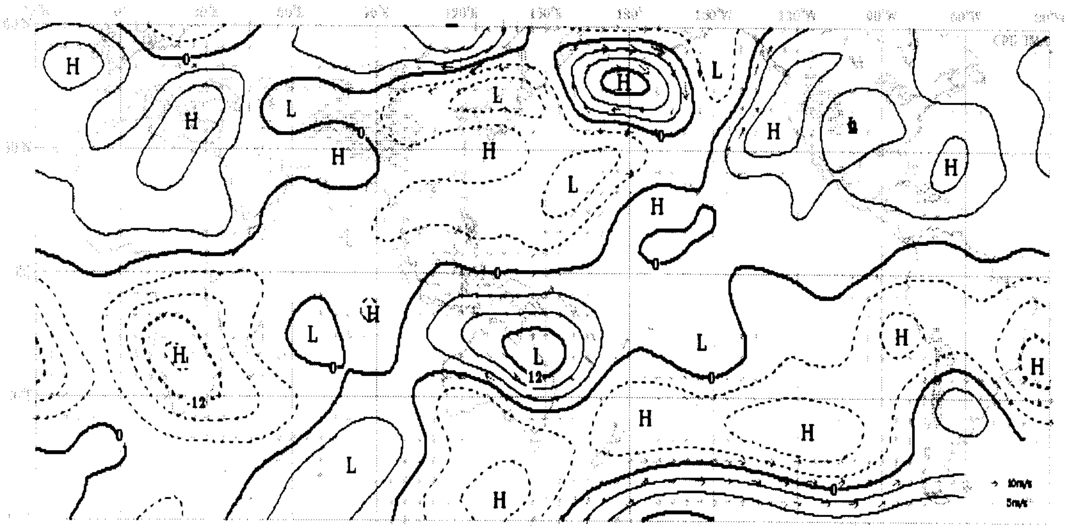


Fig.5. Stream function anomaly on the 200hPa level in Aug. 1998. (from CPD/JMA)

in Monju of china, so the front was formed over the central regions, where warm and moist air in the Yangtze Basin flew in and produced the deep convective rain-cloud belt. Especially , warm and moist southwest air current which is produced by the large evaporation for the flood in the Yangtze Basin is weak rain-cloud in the Yellow Sea. But the moment this rain-cloud belt reached the coast in the midwestern of Korea, heavy rain-cloud is generated by rapid condensation and contraction. This heavy rainfall is related to the cause of the flood in the Yangtze Basin of China. The reason for the heavy rainfall starting from late July is that the rain-belt moves northward contrary to normal year by the intensification of trade wind when the moisture is abundant in the air by the rise of sea surface temperature. This rain belt located in the Yangtze Basin was activated by the supply of moisture from the tropical regions. This rain belt made the heavy rainfall in the Yangtze Basin, and moved with westerly to the Korean Peninsula in late July as Okhotsk High decayed. Synoptic state over the Korean Peninsula is that Okhotsk High moved eastward and North Pacific High which is underdeveloped contrary to normal year stayed south ocean. In the normal year, North Pacific High was well developed and advanced the northern regions of Korea in this time. So the discontinuous belt of cold and warm air masses was formed in the central and southern regions and a convective cell from China developed rapidly in 1~2hour passing the

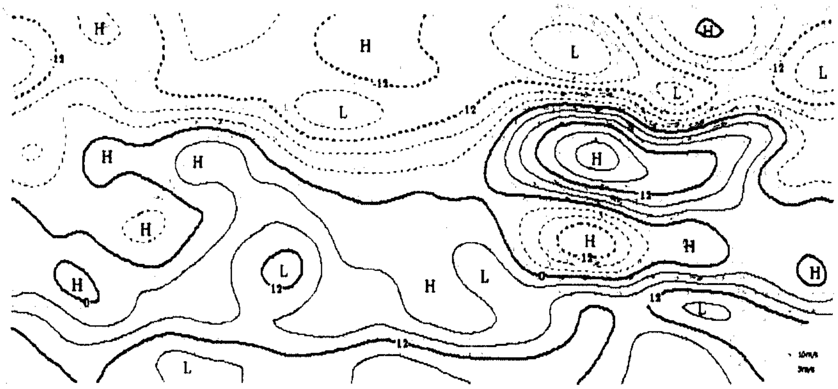
Yellow Sea. In the Case of Mt. Chiri and Mt. Sokri, the air current ascending by the force due to the mountain effect located in windward side caused the heavier rainfall. In central regions, warm and moist North Pacific High is centered on the south ocean of Korea and is around over central regions. At the same time, the atmosphere is very unstable and warm and moist air flew in from southwest, so the heavy rainfall occurred.

5. The general circulation patterns in 1982/83 and 1997/98

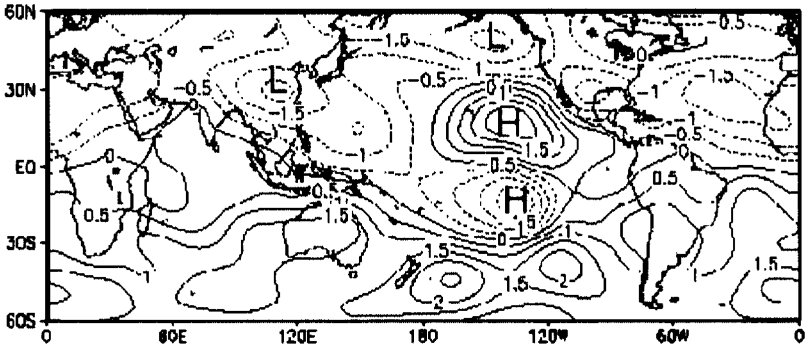
In this section, we compare and analyze the atmospheric general circulation fields of 1982/83 and 1997/98 El Niño years. So we investigate the relationship between El Niño and the climatic characteristics of this summer. First examining the characteristics on winter of the northern hemisphere, the observed snow cover in Tibet in 1997/98 winter season recorded the maximum value of this century. It is known that the snow cover is increased in Europe and Asia in winter and spring season during El Niño year

Fig. 6a shows the anomaly pattern of the wintertime stream function. Two high pressuresshaping a saddle centered in the equatorial region near the date line and low pressure of Hwanam region are characteristic. The equatorial part of two high pressures is anomalous easterly and the other part becomes westerly wind anomaly. Particularly in winter of the northern hemisphere, westerly wind anomaly induced by El Niño intensifies the subtropical jet. As the subtropical jet is strengthened, Hadley cell is fortified and consequently the angular momentum transport to a pole is increased in upper troposphere in winter of the El Niño year (Bjerkness, 1966). In Fig. 6b, the stream function of 1997/98 similar to that of 1982/83 is represented. The anomaly pattern of stream function of 1988/89, La Niña year (Fig. 6c), shows the opposite tendency of the pattern of El Niño year. Particularly if we compare that of 1982, the obvious difference between El Niño and La Niña is shown. Two high pressures shaping a saddle centered in the equatorial region near the date line in 1982/83, but the low pressures was located in similar places in 1988/89. From only the anomaly pattern of the stream function, the circulation fields of El Niño and La Niña have opposite patterns.

Fig. 7 shows the anomaly of 500hPa height in summer season of the northern hemispherein 1997/98 (a) and 1982/83 (b) The anomaly of 1997/98 is positive in northern part of Canada~Greenland, Siberia and the middle Pacific and negative in the northern Europe, the vicinity of the Bering Sea, and some part of northern America. In both years (1982/83 and 1997/98), negative anomaly exists in 30°N~60°N and the positive anomaly is located in the northern and southern part. Such upper atmospheric pressure pattern is the typical pattern which cold air easily inflows into far east Asia region and the low temperature is on the surface. Analysis on the anomaly of the mean surface temperature in El Niño year shows this pattern in which the low temperature is dominated (Cha, 1998).



(a)



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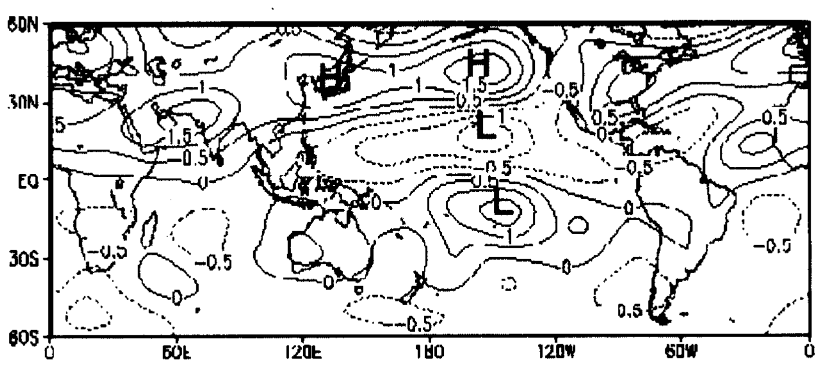
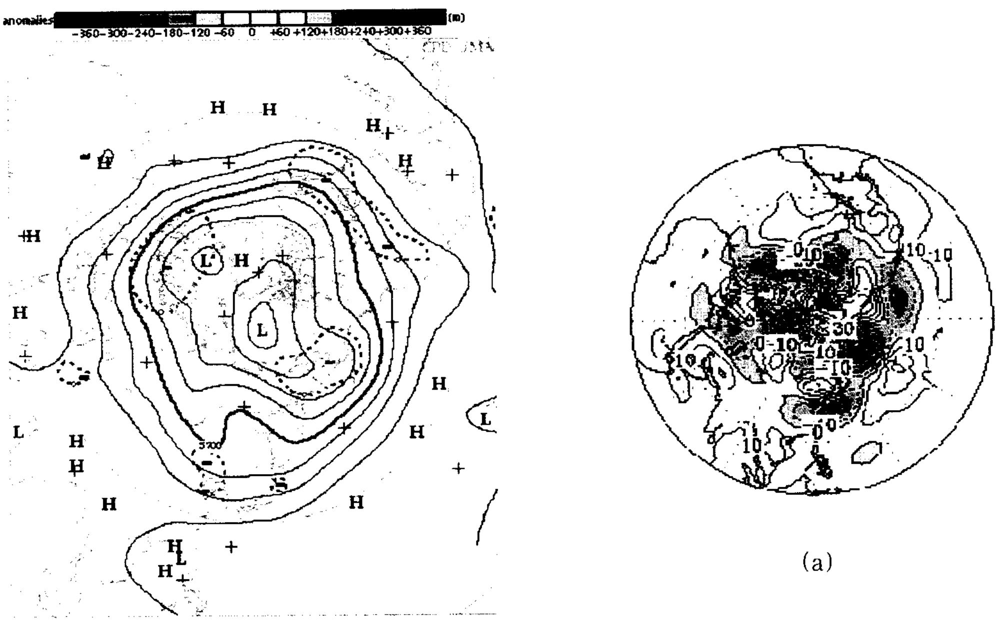


(c)

Fig.6. Stream function anomaly on the 200hPa level in winter (a) 1997/98(from CPD/JMA), (b) 1982/83, and (c) 1988/89; The contour interval is $4\times10^{6}m^{2}$ (a) and $0.5\times10^{7}m^{2}$(b and c)



(b) (a)

Fig.7. Geopotential height anomaly on the 500hPa level in summer (a) 1997/98 (from CPD/JMA), (b) 1982/83.

The airmasses dominating east Asian climate in summer are North Pacific High, Tibetian High, Okhotsk High, and Yangtz High. In 1998, North Pacific High was not activated and Okhotsk High developed anomalously compared to normal years, so low temperature was dominated in the east coastal area of Korea and the northeastern part of Japan. The weakness of North Pacific High caused the anomalous atmospheric circulation in the mid-latitude region and consequently the cold air of north advanced southward. And also the weakening of high pressure in upper air of Tibet brought about the southward movement of trough of mid-latitude upper air. The general circulation in this summer like this is the typical pattern in summer season of El Niño year. That is to say, North Pacific High does not develop like normal years, and the center is shifted to southeast. As the result, the North Pacific High is not extended to East Asia and Okhotsk High replaces that. And also the lingering summer heat appears easily because the time of development is late (Miyazaki, 1989).

6. Conclusions

The summaries and conclusions of the results on analyses are as follows:

(1) In 1998, the mean surface temperature in summer is lower than that of normal years, and the precipitation is larger. This is similar to the existing result of Cha (1998) in which the mean surface temperature is lower and precipitation is larger than normal years in El Niño years.

(2) From July. 31 to August. 20, the heavy rainfall occurred in whole country and particularly the phenomena were severe in Seoul, Kyunggi-Do region and mountainous districts like Taegwallyong, Mt. Sokri, and Mt. Chiri. The event was caused by the front which was formed acrossing the middle region between the North Pacific High located in southeast part of the Korean Peninsula and cold Low of Manju in China, and the continuous inflow of warm and moist air formed in the Basin of Yangtze river.

(3) The anomaly of the stream function in winter of 1982/83 and 1997/98 are similar to the anomaly pattern of 500hPa height.

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