*Proceedings of the 3rd International Workshop on Terrestrial Change in Mongolia, Tsukuba, Japan, 2004*

# Some features on a "break" in rainy season over Mongolia

**IWASAKI Hiroyuki[1] and NII Tomomi[1]**

[1] Faculty of Education, Gunma University, Maebashi, Japan

*Key words: rainy season, break, Mongolia*

## I Introduction

Grassland in Mongolia covers 1.26 × $10^6$ $km^2$ occupies 97% of the country. These grasslands are the main source of forage for nomadic livestock, so that, vegetation activity in the grassland gives their life and Mongolian society direct influence. On the other hand, Xue (1996) showed that decrease in vegetation activity over Mongolian grassland plays an important role in modification of the East Asian monsoon circulation and in producing the rainfall anomaly over China using a coupled atmosphere-land-vegetation model, and the results are consistent with the observed rainfall anomaly during the past 40 years. It is suggested that interannual variability of vegetation activity in the grassland had a significant impact on not only Mongolian society but the East Asian scale climate.

Iwasaki (2004) showed that the vegetation activity over Mongolian grassland was impacted by interannual and seasonal variation of rainfall, and positive correlations at 99% significant level between precipitation in June to July and vegetation activity in the mature stage are recognized for 42% of meteorological stations. Miyazaki *et al*. (2004) also pointed out the same feature for a station in central Mongolia. Although knowledge on the interannual and seasonal variation of rainfall are indispensable to understand variability of vegetation activity over Mongolian grassland, there are a few detail studies on the climatology of rainfall due to the lack of accessible meteorological data. Annual precipitation over Mongolia is characterized by a large variability from one year to another year (Slemnev *et al*., 1994; Hilbig, 1995; Gunin *et al*., 1999). As to the seasonal change, it is well known that about 80% of annual precipitation falls as rain in summer season and monthly rainfall amount reaches a maximum in August (*e.g.* Hilbig, 1995; Natsagdorj, 2000). However, these descriptions are based on monthly meteorological data, we could not find any studies on the detailed seasonal variation of rain over Mongolia. In other words, there is no sufficient knowledge on the relationship between seasonal evolution of the synoptic situation and seasonal variation of rain.

In this paper, seasonal variation of rain over Mongolia will be analyzed using twice daily meteorological data. As the result of the analysis, we found that there is a break in a Mongolian rainy season in the middle of July, which has not been reported till now. Purpose of this paper is to report the existence of a break in Mongolian rainy season, and describe features on the break and the seasonal evolution of synoptic scale features around the break.

## II Data

Data used in the present analysis are surface meteorological data set provided by the Institute of Meteorology and Hydrology, Mongolian and NCEP/NCAR reanalysis data.

The surface meteorological data set contains 3-hourly air temperature, 3-hourly relative humidity and twice-daily precipitation from 1993 to 2001 for 103 stations. Since there are more than a few erroneous values in the data set, precipitation data are carefully screened for each station before the analysis. The year that contained more than 5 erroneous values from April to September are omitted from data set. After the screening, number of stations in which 7, 8 and 9 years data are survived are 8, 37 and 47, respectively. These 92 stations are used for the present analysis (Fig. 1).

Since this paper will focus on the decrease in precipitation in July, data quality in July should be examined. Fig. 2 shows number of erroneous data every 10-day period in a data set after screening. The erroneous data are not so many in July that data quality is enough to discuss the decrease in precipitation in rainy seasons.

## III Definition of a break in rainy season for each meteorological station

### 1. A break in Mongolian rainy season

Mongolia is located in transition zone for vegetation, where it ranges from tiga forest in the north to desert in the south. As well as, mean annual precipitation decreases from north to south Fig. 1. Annual precipitation exceeds

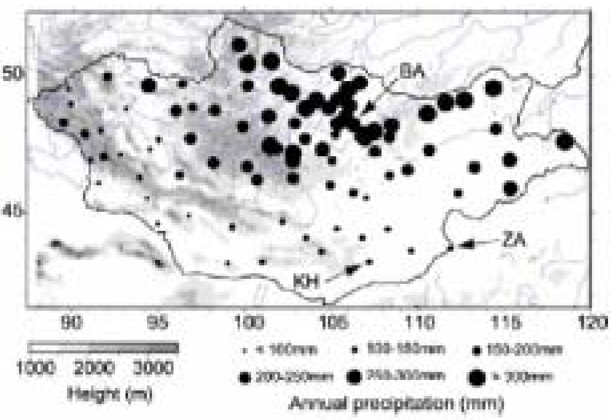


**Fig. 1 Location of surface stations and their annual precipitation.**

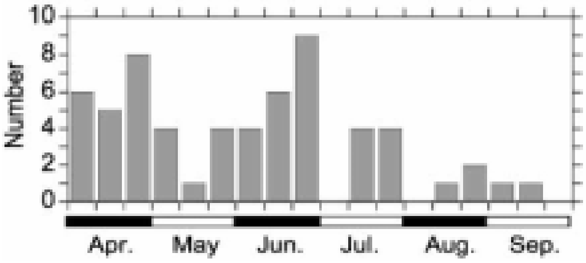


**Fig. 2 Time series of number of erroneous data after data screening.**

350 mm in tiga vegetation zone and annual precipitation is less than 100 mm in semiarid and arid region. Fig. 3 shows seasonal variation of mean10-day precipitation averaged for all 92 stations. Mean precipitation increases rapidly from the beginning of June and decrease rapidly in the middle of August. About 80% of annual precipitation amount is brought from June to August, which is referred to as "Mongolian rainy season" in this paper.

There is a minimum in the middle of July in Fig. 3, which is "break" in a Mongolian rainy season. Because 55% of stations do not have a clear break as describe in the next section, a signal of the break is weak in this mean 10-day precipitation averaged in all stations. Some previous studies on the climatology described seasonal variation of precipitation using monthly mean value (*e.g.* Hilbig, 1995). However, the break in a rainy season had not been reported since more shorter term average is required so as to find out it.

Fig. 4 shows typical seasonal variation of mean 10-day precipitation at Bayanchandanima with high annual precipitation (BA in Fig. 1), and Khanbogd with

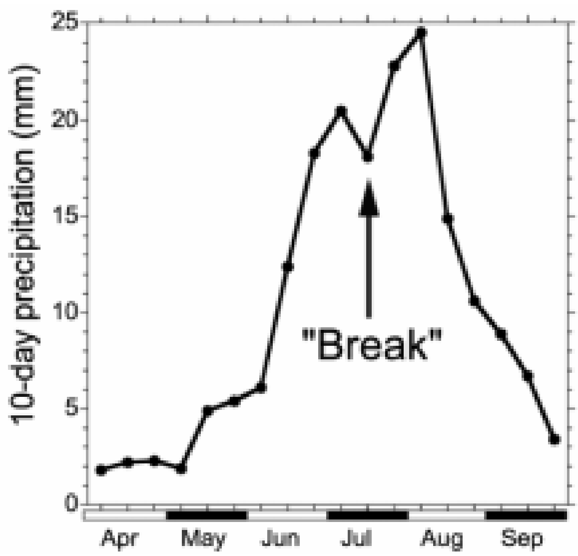


**Fig. 3 Seasonal change of mean10-day precipitation averaged for 92 stations. A arrow indicates the "break" in a Mongolian rainy season.**

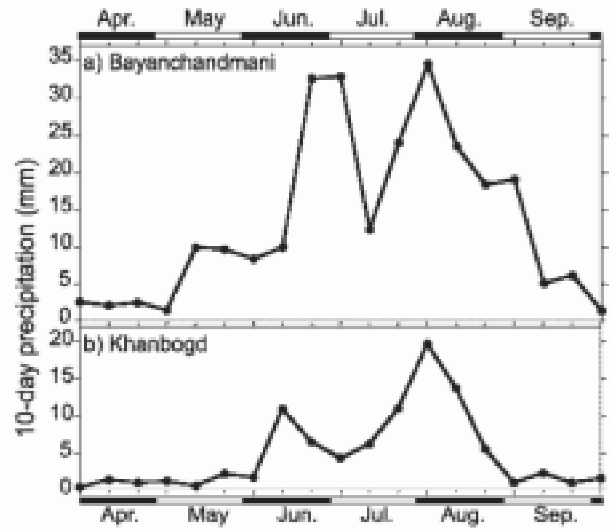


**Fig. 4 Time series of mean 10-day precipitation at Bayanchandanima (a) and Khanbogd (b). Average period of Bayanchandanima and Khanbogd is 8 and 9 years, respectively.**

low annual precipitation in desert vegetation zone (KH in Fig. 1). Mean 10-day precipitation in Fig. 4a reaches a maximum in beginning of July (the first maximum), decreases in a one-thirds in the middle of July (break), and recovered in the beginning of August (the second maximum). Khanbogd in desert also have a clear break and two maxima. The break is unrelated to the difference of a climatic region.

Fig. 5 shows the time series of twice-daily rainfall amount for these two stations in 1996, 1999 and 2001 when the break well recognized over eastern Mongolia. It is difficult to determine the break for each station using raw data, so that period of the break is defined referring to other stations. The break in 1996 was about 10 days of the middle of July, when precipitation was not observed over the wide area. The break in 2001 had a length of about 30 days, and weak rain were observed during the break. Features of the break is not always the same. However, there is a tendency not to rain during the break in a semi-arid and arid regions, and weak rain were brought in the north Mongolia with a large annual precipitation.

Although two maxima were usually observed in the north Mongolia with a large annual precipitation, the either maxima was not observed in some years for semi-arid and arid regions.

**2. Definition of a break in rainy season**

In order to extract the stations with clear break in a rainy season, we adopt two empirical criteria. Raw data are edited in mean 10-day precipitation for each station. Although many stations have the minimum in July, degree of the decrease in precipitation are very diverse because data contain high frequency "noises" due to short analysis period (black line in Fig. 6). The break was defined using smoothing precipitation with a three

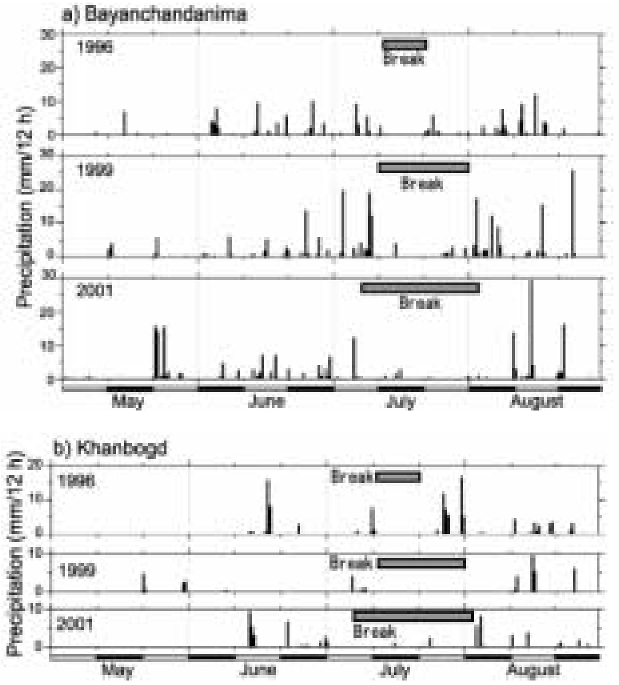


**Fig. 5 Time series of twice-daily precipitation at Byanchandanima (a) and Khanbogd (b) in 1996, 1999 and 2001. Open bars indicate the period of the break in a rainy season.**

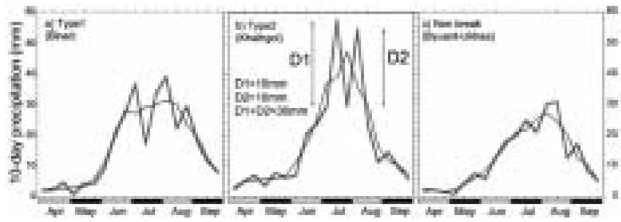


**Fig. 6 Time series of mean 10-day precipitation for stations with typical break in rainy season ( a and b) and without a break ( c). Solid lines and dotted lines indicate 10-day precipitation and smoothing precipitation with three 10-day periods running mean.**

10-day periods running mean (dotted line in Fig. 5) so as to eliminate these "noise." As shown in Fig. 5 a, Biner has a minimum in a rainy season, and it is considered that Biner has a break in rainy season. On the other hand, since Byuant-Ukhaa dose not have a decrease in smoothing 10-day precipitation, the minimum in mean 10-day precipitation is regarded as "a noise" (Fig. 5c). The break extracted by this simple criterion is referred to as Type I.

The second criterion is adopted for another type of the break. Although smoothing precipitation does not have minimum in rainy season, Khahgol has a clear decrease in a mean 10-day precipitation (Fig. 5b). This type of stations are extracted using following standards;

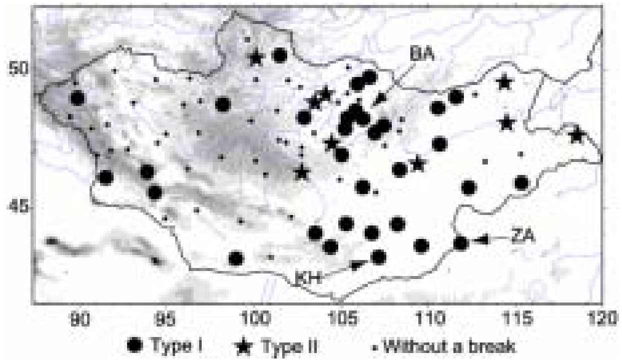


**Fig. 7 Distribution of stations with a break in rainy season. Closed circles and closed stars indicate the location of stations with the break of Type I and Type II, respectively.**

1) Both difference between minimum and two maxima (D1 and D2) exceed 10 mm.
2) Sum of two differences (D1+D2) exceeds 30 mm.

The station which satisfied two standards is also considered to have a break in rainy season, and this break is referred to as Type II. However, we could not elucidate the difference between Type I and II in a physical process, and two types will be treated as the same.

## IV Results

32 and 9 stations satisfied the criteria for Type I and Type II, respectively. 45% of stations have a break, and their locations are shown in Fig. 7. There are two features in Fig. 7. One is that break in a rainy season is well recognized over the eastern Mongolia where plane prevails. The other is that stations around the mountains like M in Fig. 7 and Ulaanbaatar do not have a break even if stations of the vicinity have clear break.

As shown in Fig. 8, the timing of the break and the second maximum of 10-day precipitation concentrate in the middle of July and the beginning of August, respectively. As well known interannual variability in precipitation is large in Mongolia, however, timing of the break and the second maximum are rather fixed to calendar. It is suggested that the precipitation changes simultaneously over the eastern Mongolia in the break and the second maximum. On the other hand, timing of the first maximum fluctuates.

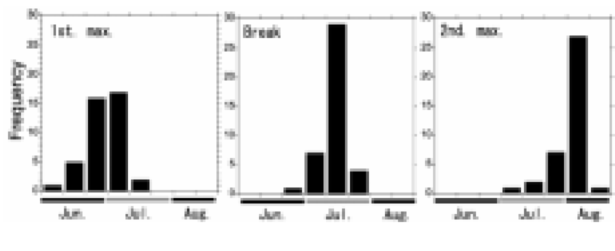


**Fig. 8 Timing of the break and two maxima of 10-day precipitation.**

Seasonal evolution of synoptic scale is investigated for the break in 1999 since the break in this year was distinctive. Synoptic scale troughs passed over the north of Mongolia during the first and second maxima, and rain was brought. There are no apparent systematic patterns over Mongolia in the first and second maxima. On the other hand, ridge was developed over Mongolia to Siberia in the break period (Fig. 9).

This transition from the first maximum to the break suddenly occurred. 500 hPa height increased rapidly from 11 July, 1999 over Mongolia and decreases rapidly on 30 July just before the second maximum. Furthermore, this ridge was rather stagnant.

It should be noted that timing of the developing of the ridge was coincident with northward propagation of subtropical jet stream at 100 E and disappearance of jet over the Tibetan Plateau (90-95 E: not shown) . It is well known that the northward propagation of subtropical jet is associated with onset of Indian monsoon (*e.g.* Yin, 1949) and withdrawal of Baiu season (*e.g.* Murakami, 1951). It is suggested that the break in Mongolian rainy season is linked to seasonal evolution of the Asian monsoon.

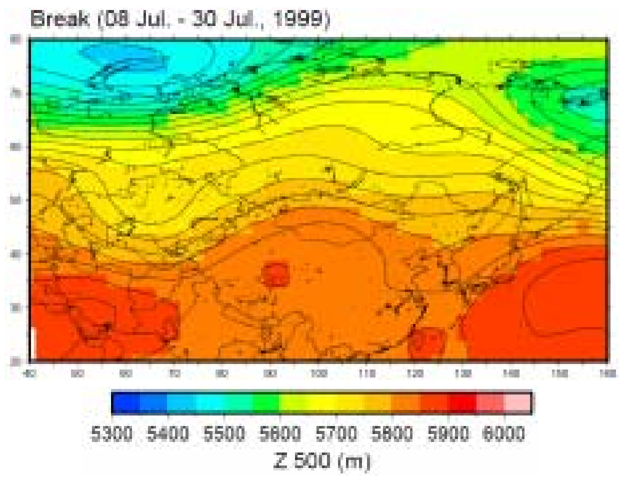


**Fig. 9 Distribution of mean 500 hPa height in the break in 1999 ( 8 to 30 July).**

## References

Gunin, P. D., Vostova, E. A., Dorofeyuk, N. I., Tarasov, P. E. and Black, C. C. (1999): Natural and anthropogenic factors and the dynamics of vegetation distribution in Mongolia. *Vegetation dynamics of Mongolia*. Kluwer academic publishers, 7-43.

Hilbig, W. (1995): Introduction to the country. *The vegetation in Mongolia*. SPB Academic Publishing, 13-32.

Huffman, G. J., Adler, R. F., Morrissey, M. M., Bolvin, D. T., Curtis, S., Joyce, R., McGavock, B. and Susskind, J. (2001): Global Precipitation at One-Degree Daily Resolution from Multisatellite Observations. *J. Hydrometeorology*, **2**, 36-50.

Iwasaki, H. (2004): Impact of interannual variability of meteorological parameters on vegetation activity over Mongolia. *J. Appl. Meteor.* (submitted)

Miyazaki, S., Yasunari, T., Miyamoto, T., Kaihotsu, I., Davaa, G., Oyunbaatar, D., Natsagdorj, L. and Oki, T. (2004): Agrometeorological conditions of grassland vegetation in Central Mongolia and their impact for leaf area growth. *J. Geophs. Res.*, **109**. (in press)

Murakami, T. (1951): On the study of the change of the westerlies in the last stage of Baiu season (Rainy season in Japan). *J. Meteor. Soc. Japan*, **29**, 24-37. (in Japanese with Emnglish abstract)

Natsagdorj, L. (2000): Climate change. Climate change and its impacts in Mongolia. *JEMR Publishing*, 13-42.

Slemnev, N. N., Gunin, P. D. and Kazantseva, T. I. (1994): On the problem of natural restitution of dominating plants in the ecosystems of the desert zone of Mongolia. *Vegetation Resources*, **4**, 1-14. (in Russian)

Yin, M. T. (1949): A synoptic-aerologic study of the onset oh the summer monsoon over India and Burma. *J. Meteor.*, **6**, 393-400.

Xue, Y. (1996): The Impact of desertification in the Mongolian and the Inner Mongolian grassland on the regional climate. *J. Climate*, **9**, 2173-2189.