Characteristics of the Seasonal Variation of the Surface Total Heating over the Tibetan Plateau and Its Surrounding Area in Summer 1998 and Its Relationship with the Convection over the Subtropical Area of the Western Pacific

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ABSTRACT

Using the dataset of 1998 TIPEX, the data of 6 automatic heat balance observational stations (AWS) from May to August 1998, a dataset of 52 surface observational stations over the Tibetan Plateau (TP) and its adjacent region, the daily rainfall amounts from about 300 stations in China, the outgoing longwave radiation (OLR) data received by the National Satellite Meteorological Center(NSMC) of China, and TBB data from GMS remote sensing of Japan, the characteristics of the seasonal variation of the surface total heating over TP and its surrounding area in summer 1998 and its relationship with the convection over the subtropical area of the western Pacific is studied in this paper. The results show that the surface total heating over TP had a close relationship with the onset of the rainy season, and after the onset of the rainy season, the regional mean surface total heating over TP decreased distinctly. Furthermore, the regional mean surface total heating over TP had very good negative correlation with TBB over the subtropical area of the western Pacific along 20–30°N, which shows that the surface total heating over TP was able to affect the convection over the subtropical area of the western Pacific.

Key words: Tibetan Plateau, surface total heating, seasonal variation

1. Introduction

As a strong heat source in summer, which rises to the height of the middle troposphere, the heating effect from the underlying Tibetan Plateau (TP) is fairly important. Ji (1984) studied the relationship between the surface net radiation over the western TP and the onset of the Indian monsoon, and indicated that when the departure of the surface net radiation over the Shiquanhe station of the western TP had a positive (negative) value in May, the onset of the southwest monsoon of India was late (early). For the characteristics of the spatio-temporal distribution of the surface radiation balance over TP, the studies of some scholars (The first program group of QXPMEX, 1984) showed that the seasonal variation of the surface radiation over most parts of TP had little change at all. The middle and lower reaches of the Brahmaputra River was an important area for the balance of radiation energy over TP. Wu (1984) studied the surface heating condition over TP by defining the intensity of surface heating as the sum of sensible heat and latent heat of evaporating condensation and indicated that for the mainland of TP in 1979, the intensity of surface heating lay in a decreasing phase for nearly 10 days before the onset of the rainy season, while after the onset of the rainy season, it increased immediately. Zhao (1999) studied the spatio-temporal distribution of the 35-year mean surface total heating over TP from 1961 to 1995 and indicated that in the process of seasonal variation, the range of variation of the surface total heating over the southwest part was much greater than over the east part. Furthermore, they found that the impact of the surface total heating on the atmosphere over the western TP was possibly more distinct than over the eastern TP during spring and summer. In this paper, the characteristics of the seasonal variation of the surface total heating over TP during the period of May-August 1998, as well as the relationship with the convection over the subtropical area of the West Pacific, are studied through correlation analysis.

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2. Datasets

The datasets used in this paper are:

1) Routine surface data of 12 stations over TP provided by 1998 TIPEX; routine daily observational data of 194 stations covering China (which includes about 52 stations in TP and adjacent area);

2) Radiation data of 6 AWS stations of TP (Lhasa, Xigaze, Nagqu, Nyingchi, Gerze, and Shiquanhe) from May to August of 1998 with interval of 20 minutes;

3) Daily precipitation data of 300 weather stations covering China from May to August 1998;

4) OLR data received by NSWC during the period of May to August 1998, two times per day, covering the domain 0°–50°N, 80°–160°E with a resolution of 0.5°×0.5°;

5) TBB data from GMS remote sensing of Japan, with observational domain 0°–60°N, 80°–160°E with resolution of 1°× 1°.

3. Characteristics of the seasonal variation of the surface total heating over TP and its surrounding area during the period of May to August 1998

The surface total heating calculated in this paper is defined as:

$$Hs = SH + LE + Re$$

where SH is sensible heat at the surface, LE is latent heat of evaporating condensation, and Re is surface effective radiation. After interpolating the calculated surface total heating from each station to its nearby grid points, we performed a regional average for each grid point value. Figure 1 shows the daily variation of the calculated regional mean surface total heating over TP and its components during the period of May to August 1998. It can be seen that during this period, the regional mean surface total heating over TP was between 120 W m^{-2}– 270 W m^{-2}, and had obvious change before and after the onset of the rainy season. Before the onset of the rainy season, the surface total heating was strong, while afterwards, it decreased evidently; besides, an obvious catastrophe phenomenon occurred in the variation of the regional mean surface total heating, which means that it can increase or decrease promptly during some period. Wu and Li (1990) studied the catastrophe phenomenon of the intensity of surface heating over TP from August 1982 to July 1983 and found that 2–4 catastrophes occurred during the increasing and decreasing periods of the intensity of surface heating over the Lhasa, Gerze, and Nagqu stations. In addition, seen from the daily change of surface heating and its components, the earth effective radiation accounted for the main part in the surface total heating, and the second part was sensible heat, for from May to August, the daily changes of surface total heating and earth effective radiation were almost synchronous. After the onset of the rainy season, the decrease of both the earth effective radiation and sensible heat resulted in the decrease of the surface total heating.

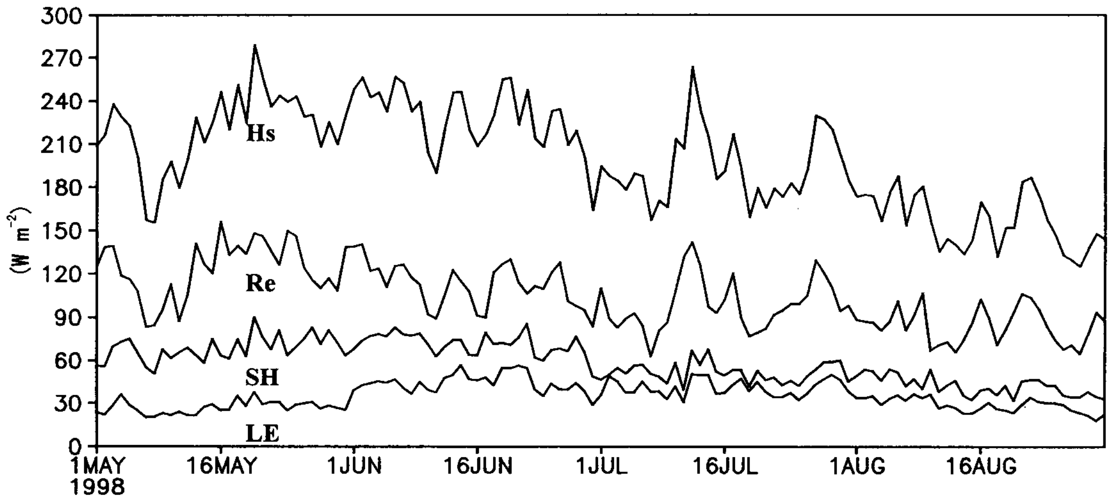

Fig. 1. Daily variation of the regional mean surface total heating over the Tibetan Plateau and its components during May–August 1998. Hs: surface total heating, Re: surface effective radiation, SH sensible heating, LE: latent heat of evaporating condensation.

The distribution of the surface total heating over TP during the period of May to August was basically weak over the southeastern part while strong over the western and northern parts (Fig. 2). With the coming of the rainy season, the surface total heating over the monsoon region of TP mainly decreased. The rainy season over the eastern TP came earlier and the whole eastern region entered into the rainy season until June. Therefore, from May to June, the surface total heating over most of the TP region east of 95°E decreased by 50%. However, from then on to July, there was little cloud over the northern and western TP; the radiation heat was strong, which made the intensity of the total heating over these regions increase, whereas the decreasing tendency of the surface heating from east to west was still shown. The rainy season over the western TP started later, and the rainy season over some stations of this region did not start until August, therefore the surface total heating over the western TP decreased more obviously than in June and July. The Chadamu Basin of the northern TP is arid during the whole year, which made the surface total heating over this region maintain a high value above 350 W m^{-2}. From the distribution of the monthly mean surface

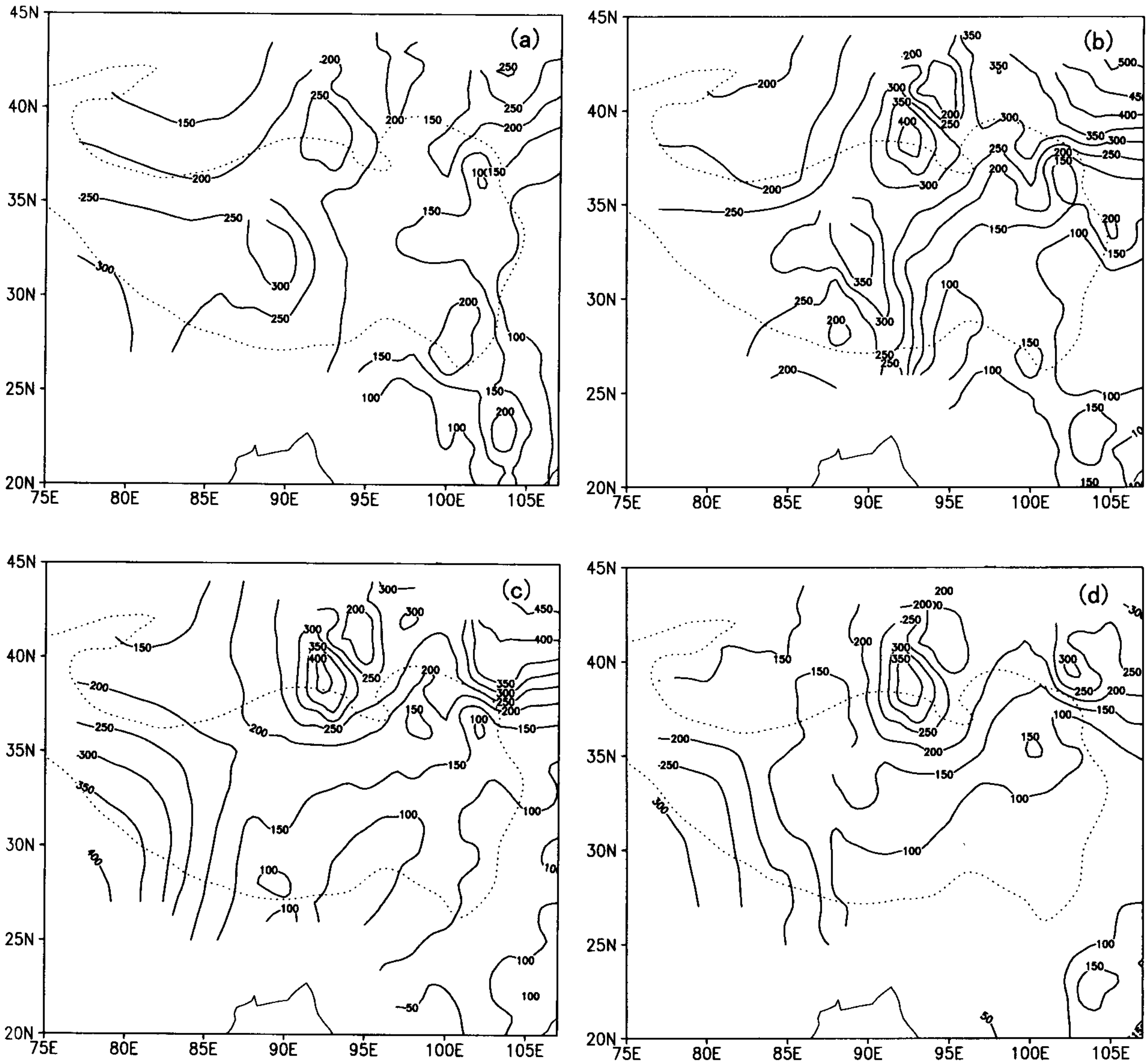

Fig. 2. Distribution of monthly mean surface total heating over the Tibetan Plateau during May–August 1998. (a) May; (b) June; (c) July; (d) August.

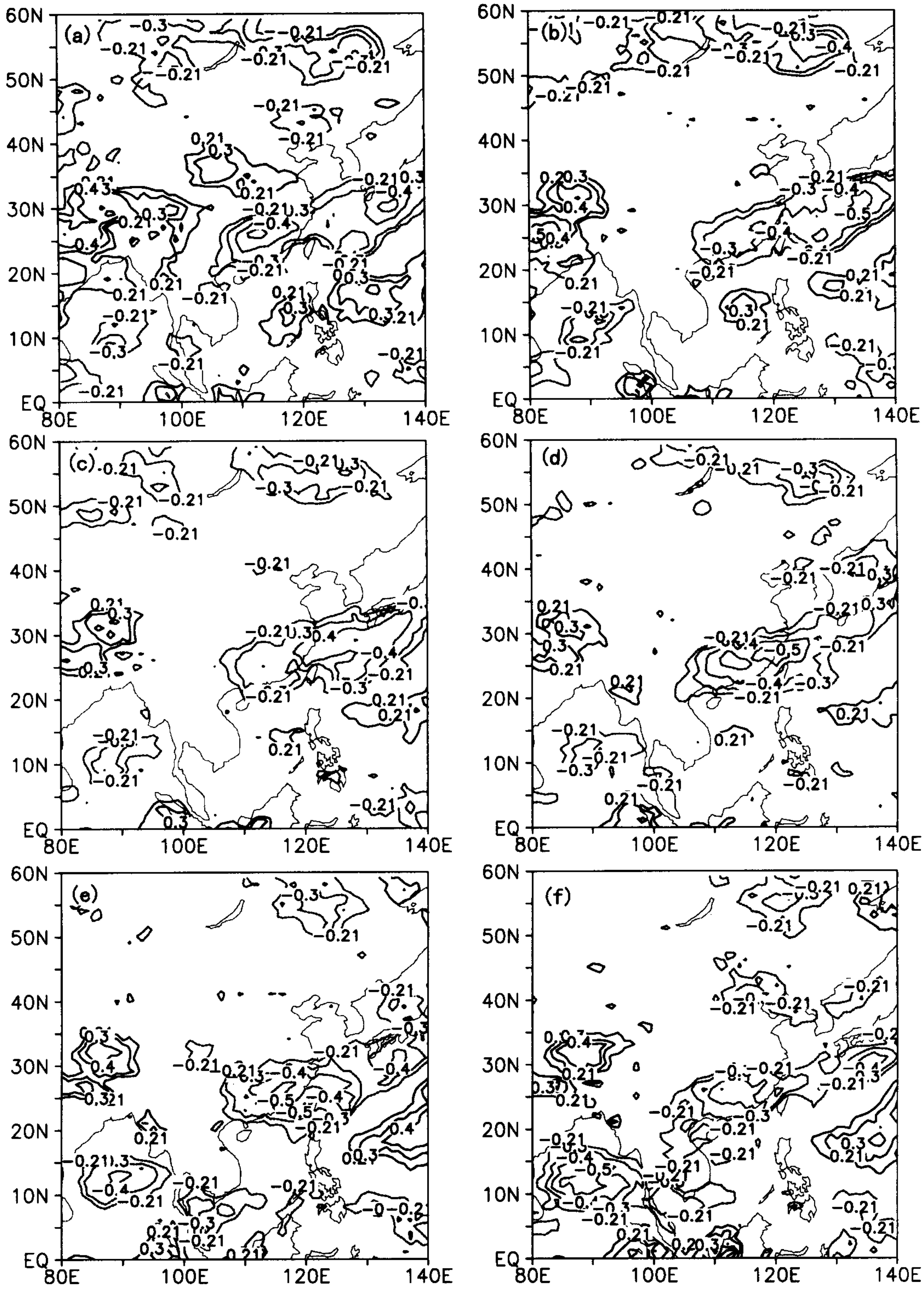

Fig. 3. Lag correlation between the regional mean surface total heating over the Tibetan Plateau and the TBB over other regions. (a) contemporary correlation; (b) 3 day surface total heating leading TBB; (c) 5-day; (d) 7-day; (e) 9-day; (f) 11-day (± 0.21 reached 95% credibility, solid line denotes positive correlation, dashed line denotes negative correlation).

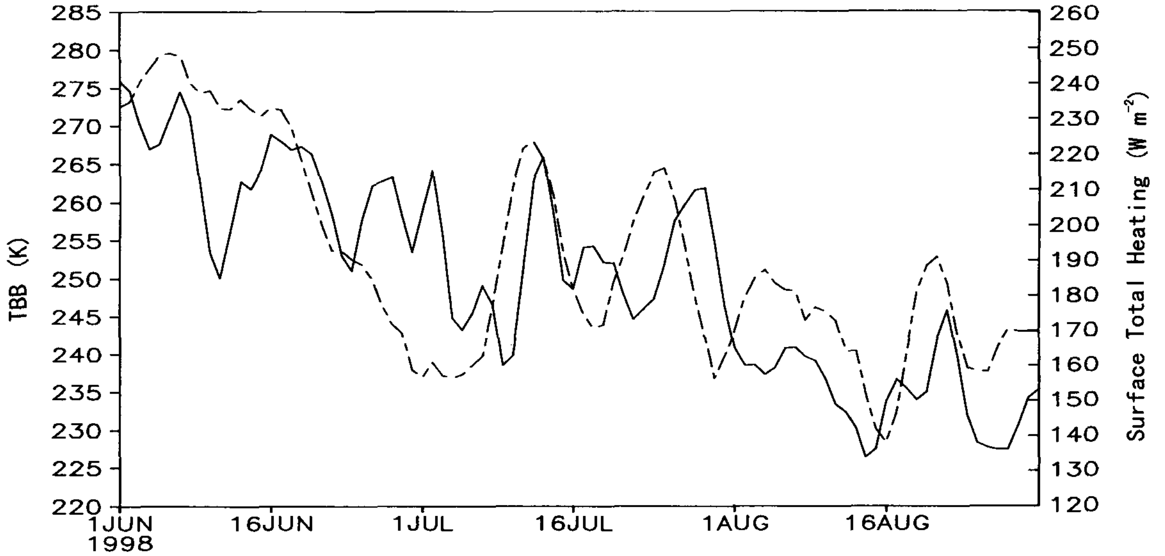

Fig. 4. Daily variation of the surface total heating over the Tibetan Plateau (TP) and TBB over the western TP during June–August 1998. (solid line: TBB over the western TP, dashed line: surface total heating).

total heating over TP from May to August, we can see that the intensity of the surface total heating over the western TP was about 3 times that over the eastern part, which indicates that the heating effect of the surface total heating on the atmosphere was far stronger over the western TP than over the eastern part in summer. So that is to say that the heating effect was more prominent over the western TP.

4. Relationship between the surface total heating over TP and the convection over the subtropics of the western Pacific.

To study the relationship between the surface total heating over TP and its adjacent area and the convection over the subtropics of the western Pacific, we performed a lag correlation analysis of the regional mean surface total heating over TP and its adjacent area and TBB over other regions (Fig. 3). We found that the surface total heating over TP had a good negative correlation with TBB over the subtropical region of the western Pacific along 20°–30°N, and the correlation lasted at least 11 days. The intensification of the surface total heating over TP was able to enhance the convection center over the above region and make it move northward (Fig. 3d–e). Li and Chen (2000) studied the relationship between the convection over the western TP and that over the subtropical region of the western Pacific along 30°N in summer 1998 and indicated that a zonal circulation existed between the two regions, and that the intensification of the convection over the western TP could make the western Pacific subtropical high move either northward or southward. Thus we can see that the result shown in Fig. 3 is very similar with that conclusion. To further study the phenomenon, we performed a daily variation analysis of the regional mean surface total heating over TP and the TBB over the western TP for June–August (Fig. 4). The result showed that the changes in the two parameters were approximately in phase with each other. The correlation coefficient reached 0.64 during the 92 days of June-August, which means that the regional mean surface total heating over TP had a negative correlation with the convection over the western TP (because it had a positive correlation with TBB, and strong TBB corresponds with weak convection). That is, when the intensification of the surface total heating over the whole TP was strong (weak), the convection over the western TP was weak (strong). In fact, when there was little cloud in the sky, the earth effective radiation was strong, thus making the surface total heating strong, whereas when the convection was deep, the cloud amount was comparatively more, and the decrease in the earth effective radiation led to the weakening of the surface total heating. From the figure we can also find that the change of the surface total heating was a little in advance of that of the TBB over the western TP, and this means that for most regions of the whole TP and its surrounding area, the change of surface total heating over the western TP was a little later than the former regions.

5. Conclusion

In this paper, the characteristics of the spatio-temporal distribution of the surface total heating over TP and its adjacent region during the period of May–August 1998 is discussed. The results show that:

1) The surface total heating over TP and its adjacent region had a close relationship to the onset of the rainy season: before the rainy season, the surface total heating was strong, while afterward, it decreased obviously. The surface total heating during the period of May–August 1998 had obvious catastrophe phenomena;

2) The surface total heating over the eastern TP was weaker than over the western TP, while the seasonal variation of the surface total heating over the eastern part was more evident;

3) The regional mean surface total heating over TP had a good negative correlation with TBB over the subtropical region of the western Pacific along 20°–30°N, and had an obvious lag correlation.The correlation lasted for at least 11 days, which indicated that the intensification (weakening) of the surface total heating over TP could enhance(weaken) the convection center over the above region and make it move northward;

4) The change of the regional mean surface total heating was a little in advance of that of the TBB over the western TP. During the period of June–August, their changes were almost in phase, which indicated that for most regions of the whole TP and its surrounding area, the change of surface total heating over the western TP was a little later. This occurred because the convection affected the earth effective radiation first, then the earth effective radiation affected the change of surface total heating.

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1998年夏季青藏高原及其邻近地区地面总热源季节变化特征及其与西太平洋副热带地区对流的关系

李 薇 陈隆勋

摘 要

利用98’TIPEX实验资料、1998年5–8月青藏高原6个自动热量平衡站（AWS）资料、青藏高原常规观测资料、中国300多个站的逐日降水资料、国家卫星中心接收的1998年5–8月OLR和日本GMS的TBB资料，研究了1998年5–8月青藏高原及其邻近地区逐日地面总热源的季节变化特征及其与西太平洋副热带地区对流的关系。结果表明：高原地面总热源与高原雨季开始有密切关系，高原雨季开始以后，高原平均的地面总热源明显减小；高原平均的地面总热源与20–30°N 附近的西太平洋副热带地区的TBB有很好的负相关关系，表明高原地面总热源可以通过某种机制影响副热带地区的对流。

关键词: 青藏高原, 地面总热源, 季节变化