Modeling and Diagnostic Studies on the Variations of the Subtropical High over the Western Pacific from 1880 to 1999

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Wang Shaowu (王绍武)①, Cai Jingning (蔡静宁), Mu Qiaozhen (慕巧珍), Xie Zhihui (谢志辉), and Zhu Jinhong (朱锦红)

Department of Atmospheric Sciences, School of Physics, Peking University, Beijing, 100871

Gong Daoyi (龚道溢)

Key Laboratory of Environmental Change and Natural Disaster, Beijing Normal University, Beijing 100875

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ABSTRACT

Index series of Subtropical High over the western Pacific was extended to AD 1880 by using of statistical and modeling method. Reconstructed indices by both methods show good accordance each other. Association of the indices to the rainfall patterns over eastern China indicated the robustness of the reconstructions.

Key words: subtropical high over the western Pacific, modeling, diagnostics

It is well known that the geographical pattern of the summer rainfall anomaly over Eastern China depends to a great extent on the behavior of the Subtropical High (STH) in the western Pacific. Therefore, examination of the variability and controlling factors of the STH is critical to the study of summer rainfall prediction. Unfortunately, STH data is limited to the second half of the 20th century. This prevents us from understanding the decadal variability of the STH, and from testing the robustness of the association of summer rainfall with the STH over a longer time series. Recently, the series of STH indices have been extended from 1950 back to 1880 in two independent ways: statistics and modeling. This provides for the first time the opportunity to examine the STH variability with a consistent series from 1880 to 1999.

New approach to define Subtropical High (STH) indices

Usually three Subtropical High (STH) indices are used in practice of climate forecasting and prediction: I_S representing the intensity of the STH, I_W representing the western border of the STH, I_N representing the northern border of the STH. The index I_S is defined by a weighted sum of grid points in which the 500 hPa height $\geq$ 588 dm within the region of 10°–50°N, 180°–110°E, with a weighting number of 1 if the 500 hPa height equals 588 dm, of 2 for 589 dm, of 3 for 590 dm, and so on. The index I_W shows the longitude of the STH's western border represented by the 588 dm contour. The index I_N provides the northern border of the STH, which equals the average latitude of the northern sector of the 588 dm height contour

①E-mail: swwang@pku.edu.cn

from 110°E to 150°E.

However, it is impossible to use these definitions directly in the reconstruction of STH indices before 1951 because the grid points of the 500 hPa height series differ from those for 1951–1999, and the reconstructed normal also departs from the 1961–1990 normal. Therefore, correlation coefficients were calculated between grid point 500 hPa heights of NCEP reanalysis data and STH indices of the NCC (National Climate Center of China) for 1958–1997, where the latter were found according to the original definitions mentioned above. The average of heights at five points where the highest correlation coefficients were observed was used to construct each of the three indices for a calendar month. Constructed indices showed significant correlation coefficients to the original indices of NCC (Mu et al. 2001; 2002a, b). Table 1 shows the possibility of using grid point heights to simulate the STH indices instead of applying the original definitions of the NCC.

Table 1. Correlation coefficients between the constructed indices and the original NCC indices of STH (1958–1997)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
I_S	0.81	0.84	0.91	0.89	0.88	0.74	0.83	0.68	0.70	0.86	0.79	0.92
I_W	0.70	0.82	0.87	0.60	0.64	0.64	0.70	0.52	0.53	0.40	0.57	0.67
I_N	0.73	0.74	0.80	0.75	0.42	0.67	0.43	0.67	0.63	0.69	0.59	0.62

Reconstruction of the STH index series for 1880–1950

The next step in the reconstruction of the STH indices in earlier times is to determine the 500 hPa heights before 1951. Initially, the 500 hPa heights of the Northern Hemisphere were reconstructed using stepwise regression equations from January 1880 to December 1950, with predictors Sea Level Pressure (SLP) and Sea Surface Temperature (SST) by Gong and Wang (2000). Recently, numerical simulations were carried out using GCM CCM3.6 (Mu et al. 2002a, b). Integrations were made for three time intervals, 1880–1899, 1900–1950, and 1951–1999, with forcing by observed SST. Details of the integration are described in Mu et al. (2002a, b), where preliminary results in the simulation of index I_S for the latter two time intervals are given. Now, the I_S, I_W, and I_N series were extended back from 1950 to 1880 by using the new method outlined above, based on two independent 500 hPa heights series: statistics and modeling.

Figure 1a gives modeling series of I_S. Figure 1b shows statistics and observations, the first part from 1880 to 1950 is the result of statistics, the second is from the observations. Correlation coefficients between the modeling, statistics, and observations are shown in Table 2. Figure 1 and Table 2 indicate that the modeling gives quite satisfactory results in simulating the STH variations for the period 1951–1999. At the same time, the correlation coefficients remain high for the period 1880–1950, though the modeling results were only compared to the statistics and not to the observations, since the latter were limited since 1951. Figure 2 gives I_W and I_N, following the same pattern of statistics and observations as Fig. 1b.

Figure 3 shows correlation coefficients between I_N and rainfall over East China in summer. Positive correlations are found in North China and negative ones in the area of the Changjiang River valley. This characteristic predominates over the three panels. Similarity in the correlation patterns proves the robustness of the relationship between I_N and summer rainfall, and also demonstrates the reliability of the STH reconstructions. Of course, the latter can be improved with an increasing amount and accuracy of original data and improvement in the method used for reconstruction.

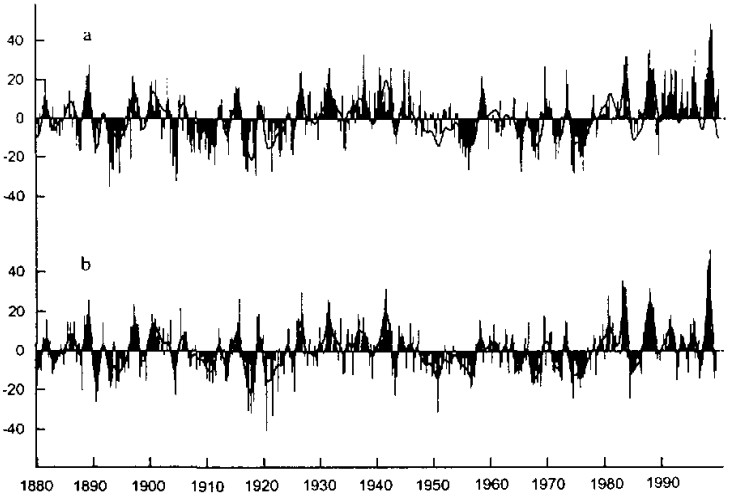

Fig. 1. Seasonal mean anomalies of the STH index I_S for 1880–1999.

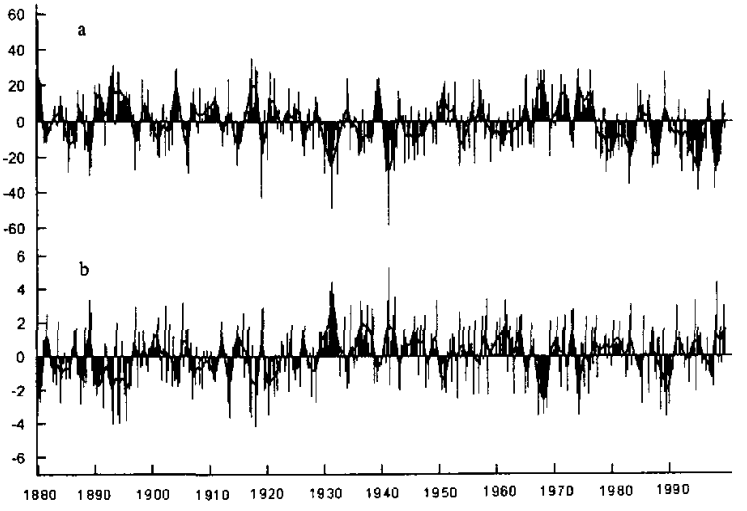

Fig. 2. STH indices (a) I_W and (b) I_N. 1880–1950 statistical reconstruction, 1951–1999 observations, for both indices.

Table 2. Correlation coefficients between modeling (M), statistics (S), and observations (O)

	O, M	S, M	S+O, M
	1951–1999	1880–1950	1880–1999
I_S	0.73	0.60	0.66
I_W	0.57	0.62	0.60
I_N	0.45	0.43	0.44

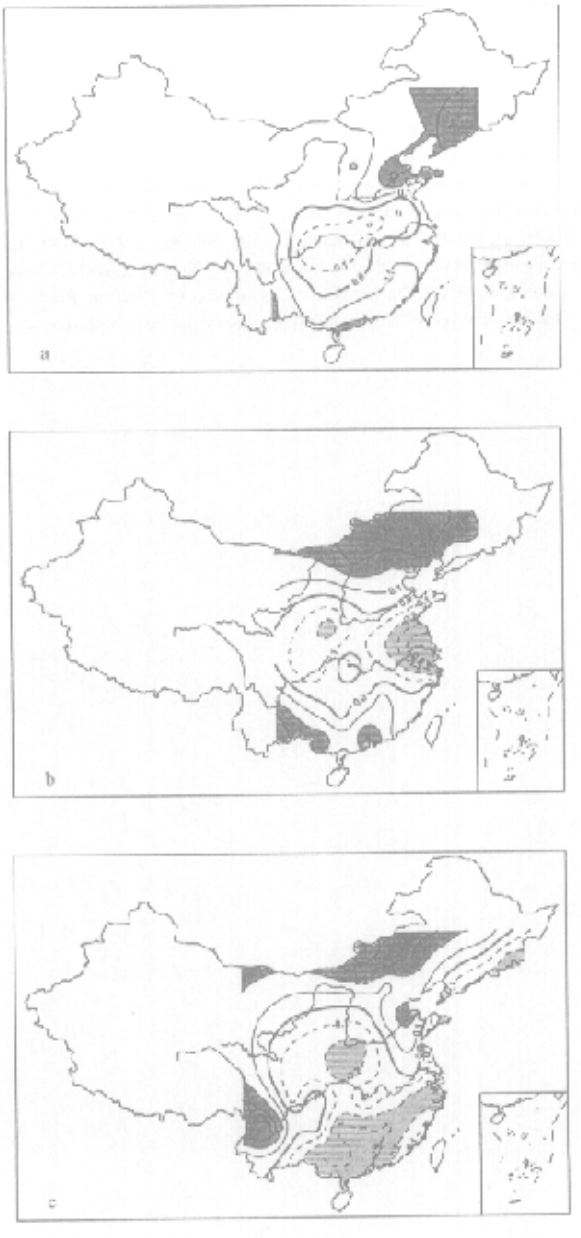

Fig. 3. Correlation coefficients between rainfall (R) and I_N in summer (Jun. to Aug.). (a) I_N (observations) and R (observations) for 1951–1999, (b) I_N (statistic) and R (observations) for 1901–1950, (c) I_N (modeling) and R (modeling) for 1901–1950.

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