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DIAGNOSIS AND IDENTIFICATION OF DYNAMIC CORRELATION FACTORS BETWEEN WEST-PACIFIC SUBTROPICAL HIGH AND EAST ASIA MONSOON SYSTEM INDEXES

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Abstract: Based on the daily reanalysis data of NCEP / NCAR and by using the method of phase space reconstruction, the point conditional probability density of the subtropical high ridge index are determined and then used, together with their power spectra, to seek the correlation between them and individual monsoon-affecting factors and their power spectra. Through diagnosis, six indexes are discovered that have the most important effects on the subtropical high index. The results of the diagnosis indicate that the technique can identify the factors which are dynamically correlated. It can offer the basis in determining and choosing dynamic conceptual factors.

Key words: subtropical high; ridge indexes; phase space reconstruction; conditional probability density; monsoon indexes

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1 INTRODUCTION

One of the hot issues in many of the natural science research fields is to extract implicit information from a system based on the time series of univariates, but it is scarcely the case in meteorology. As the theory of phase space reconstruction goes, the time series of a given physical parameter contains implicitly information about other physical parameters in the system acting on it non-linearly, making it possible to retrieve other physical quantities following the time series of univariates. According to some theoretical studies [1-2], it is ensured that information about the system can be extracted from the phase space reconstructed with single time series. In the past ten years, with the advancement of the theory, extracting implicit information about physical parameters has become one of the important issues in non-linear data analysis [3-6].

The method of correlation coefficient analysis is commonly used to distinguish the correlation between elements. Being simple and direct, the method has inherent shortcomings in that any two time series may be correlated in one way or another even though they are not linked physically at all. It is then theoretically and practically useful to search for new ways of understanding the dynamical correlativity between individual factors.

Being an important synoptic system that affects the weather and climate in China, the western Pacific subtropical high (to be shortened as “the subtropical high” below) has been much studied in atmospheric sciences [7 - 18]. The ridge of the subtropical high is a key index in describing its activity.

The research work by previous scientists mainly focuses on the factors affecting the subtropical high in one particular way. In order to diagnose them comprehensively to identify those with the closest links

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with short-term activity of the subtropical high and to further establish factors of dynamical systems needed in establishing a conceptual model for the subtropical high, it is intended in our study that by computing the time series of conditional probability density for the reconstructed points of phase space, monsoonal factors affecting the ridge index can be retrieved and identified so that theoretical basis and methodological guidance can be provided for the determination of the inherent dynamic factors responsible for the activity of the subtropical high and the retrieval of its dynamic model.

2 DATA USED IN THE STUDY AND DEFINITION OF CHARACTERISTIC FEATURES

Ten years of daily NCEP / NCAR reanalysis from 1995 to 2004 are used, which have 2.5° × 2.5° gridpoints and an effective length of 3653. The following characteristic indexes (in italic letters) are computed and defined based on the data.

A. Determination of the ridge index: Following the method described in Peng and Sun [19], a total of 17 longitudes, with an interval of 2.5°, are selected for the area from 110°E to 150°E on a 2.5°× 2.5° 500-hPa geopotential height map before averaging the latitude of each of the longitudes with the maximum geopotential height to yield what is to be called the index of the subtropical high.

B. Definition of the characteristic indexes of individual members of the Asian summer monsoon system (Fig.1):

1) *A*, the Miscarene cold high, sea surface pressure averaged over the gridpoints for 40°E – 60 °E, 25°N – 35 °S;
2) *B*, the Australian cold high, sea surface pressure averaged over the gridpoints for 120°E – 140 °E, 25°N – 35°S;
3) *C*1, sensible heat over Indo-china Peninsula, sensible heat flux averaged over the gridpoints for 95°E – 110 °E, 10°S – 20°S;
4) *C*2, sensible heat over Indian Peninsula, sensible heat flux averaged over the gridpoints for 75°E – 80 °E, 10°S – 20°S;
5) *D*, low-level jet stream over Somali, meridional wind averaged over the gridpoints for 40°E – 50 °E, 5°S – 5°N;
6) *E*, low-level jet stream over the South China Sea, meridional wind averaged over the gridpoints for 100°E – 110°E, 5°S – 5°N;
7) *F*, Indian Monsoon, 850-hPa zonal wind (*U*), flux of latent heat (FLH), growth of convective precipitation (GCP) and Outgoing Longwave Radiation (FULW) averaged over the gridpoints for 70°E – 85°E, 10°S – 20°N;

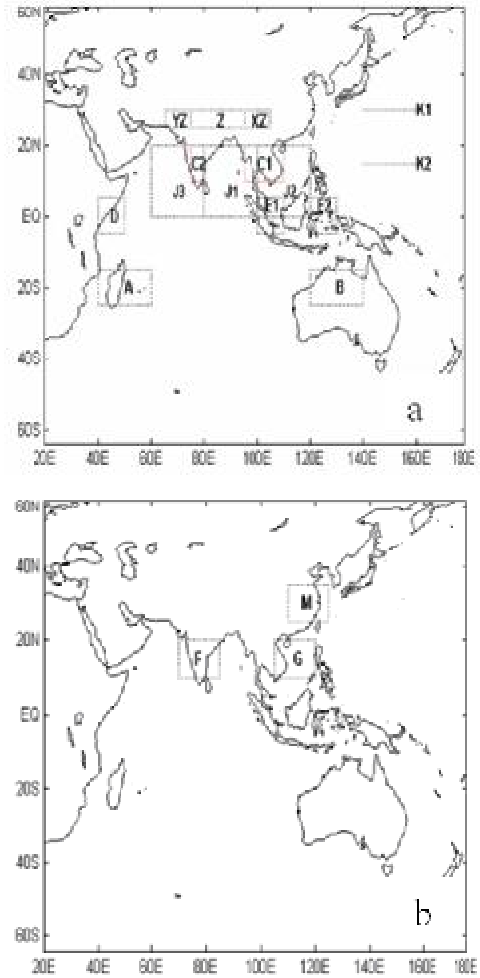

Fig.1 Schematic chart of individual members of the summer monsoon system in Asia.

8) *G*, South China Sea and East Asian Monsoons, 850-hPa zonal wind (*U*), growth of convective precipitation (GCP), and Outgoing Longwave Radiation (GULW) averaged over the gridpoints for 105°E – 120 °E, 10°N – 20 °N;
9) *Z*, Qinghai-Tibetan high, 200-hPa geopotential height averaged over the gridpoints for 75°E – 95°E, 25°N – 30°N for normal location; *X*, 200-hPa geopotential height averaged over the gridpoints for 95°E – 105°E, 25°N – 30°N for eastward location.
10) *J*, Monsoonal circulation.

3 DIAGNOSIS OF DYNAMIC CORRELATION FACTORS FOR THE SUBTROPICAL HIGH RIDGE INDEX

Simultaneous correlation is sought between the subtropical high ridge index and the aforementioned monsoonal indexes and correlation coefficients are determined for both the monsoonal indexes lagging behind the ridge index by five days and the ridge index lagging behind the monsoonal indexes by five days (See Table 1). Correlation coefficients have passed the $\alpha = 0.05$ significance test.

Table 1 Analysis of time-lagging correlation between the subtropical high ridge index and the indexes of individual summer monsoon members

Serial No.	Indexes of monsoonal system	Simultaneous correlation	Time-lagging correlation I	Time-lagging correlation II
1	*A*	−0.186 4	−0.100 9	−0.191 4
2	*B*	0.260 8	0.290 1	0.237 1
3	C1	−0.595 5	−0.571 8	−0.599 0
4	C2	−0.630 3	−0.590 8	−0.666 9
5	D	0.623 8	0.656 6	0.588 2
6	E	0.538 1	0.555 0	0.545 9
7	F: rainfall	−0.499 8	−0.525 7	−0.494 8
8	F: FLH	0.349 0	0.376 1	0.404 5
9	F:U	0.538 3	0.606 6	0.532 5
10	G(GCP)	−0.537 5	−0.529 9	−0.555 4
11	G: U	0.339 6	0.439 3	0.388 5
12	J: Bay of Bengal (*U*)	0.659 9	0.697 1	0.657 4
13	J: South China Sea (*U*)	0.604 4	0.637 9	0.609 2
14	J: Indian Peninsula	0.570 0	0.592 9	0.557 8
15	J: Indian Peninsula (*U*)	0.712 2	0.734 6	0.696 8
16	Mei-yu: rainfall	−0.462 2	−0.535 7	−0.459 3
17	Mei-yu: FLH	0.242 5	0.253 5	0.316 5
18	Z: X	−0.164 4	−0.163 9	−0.154 3
19	Z:	0.697 8	0.716 4	0.686 0

The correlation coefficients for standardized time series of conditional probability density for the phase space reconstructed points of the subtropical high ridge index and individual monsoonal indexes are shown in Table 2, together with their correlation coefficients of the series of power spectra. The coefficients have passed the $\alpha = 0.05$ significance test.

The power spectra for the standardized series of conditional probability density of the subtropical high ridge index are studied (Figures omitted), together with those for individual indexes. They can be compared in terms of the frequency domain.

See the Chinese edition of the journal for more details.

4 CONCLUSIONS AND DISCUSSIONS

By means of the aforementioned methods and analyses, this study has identified six important indexes of dynamic correlation that affect the index of subtropical high ridge and has come to the following conclusions.

(1) From the computations of the correlation between the ridge index and 21 monsoonal indexes, it is discovered that the sensible heat fluxes over the Indo-china and Indian Peninsulas, low-level jet streams over Somali and South China Sea, monsoonal activity over India and South China Sea (850-hPa zonal wind for the former and rainfall for the latter), monsoonal circulation indexes over the Bay of Bengal, South China Sea and Indo-china Peninsula (850-hPa zonal wind for both) and the activity of Qinghai-Tibetan high pressure are the ten factors that correlate significantly with the index of the subtropical high ridge.

Table 2 The correlation coefficients for standardized time series of power spectra of the subtropical high ridge index and individual monsoonal indexes and their power spectral series

Serial No.	Indexes of monsoonal system	with standardized data of density of point conditional	Correlation with power spectral series
1	A	0.154 4	0.978 7
2	B	−0.283 6	0.998 5
3	C1	0.456 0	0.989 4
4	C2	0.540 1	0.997 8
5	D	−0.639 1	0.994 4
6	E	−0.522 5	0.995 6
7	F: rainfall	−0.647 8	0.999 3
8	F: FLH	−0.367 2	0.999 3
9	F: U	−0.615 2	0.970 1
10	G (rainfall)	−0.512 6	0.998 9
11	G: U	−0.510 5	0.949 2
12	J: Bay of Bengal (*U*)	−0.606 7	0.984 7
13	J: South China Sea (*U*)	−0.544 7	0.987 1
14	J for South China Sea: Indian Peninsula (*V*)	−0.552 9	0.942 0
15	J: Indian Peninsula (*U*)	−0.671 7	0.965 5
16	Mei-yu: rainfall	−0.644 8	0.999 9
17	Meiyu: FLH	−0.273 6	0.998 2
18	Z: X	0.205 5	0.585 7
19	Z	−0.645 2	0.998 5

(2) The series of point conditional probability density for the subtropical high ridge index is best correlated with the six indexes of Somali low-level jet stream, Indian Monsoon (850-hPa zonal wind), Bay of Bengal (850-hPa zonal wind), Indian Monsoon, Mei-yu in the Yangtze-Huaihe River basins (rainfall) and Qinghai-Tibetan high pressure, which are also highly correlated (with the coefficient all above 0.95) with the power spectra of the standardized series of conditional probability density of the subtropical high ridge index. They may be considered the six inherently and dynamically correlated factors for the subtropical high ridge index.

(3) While conventional statistical correlation analysis can reflect significant statistic correlativity between the time series of characteristic indexes, it is incapable of distinguishing the dynamic correlation between them. Based on the density of point conditional probability, the diagnostic identification

method is able to distinguish factors that are dynamically correlated, providing basis for the determination and selection of dynamic model factors. It is our next plan to examine how the diagnosed monsoon-impacting factors are used to construct a dynamic system model with the subtropical high ridge index and to see if the model reacts sufficiently to the activity of the subtropical high.

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