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AN EAST ASIAN SUBTROPICAL SUMMER MONSOON INDEX DEFINED BY MOISTURE TRANSPORT

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Abstract: Using daily NCEP/NCAR reanalysis dataset and observation rainfall data in China for the 1971 – 2000 period, a subtropical summer monsoon index has been defined by meridional moisture transport of the total atmosphere column. Results show that the subtropical summer monsoon index defined by the difference of meridional moisture transport between South China and North China can be used to describe the intensity of the subtropical summer monsoon. High (low) index is corresponding to strong (weak) subtropical summer monsoon. And the new index is well related to the summer rainfall over the middle and lower reaches of Yangtze River. In addition, the convergence of moisture transport from the west Pacific via the South China Sea and that from the North China may be responsible for the anomalously excessive summer rainfall over the middle and lower reaches of Yangtze River.

Key words: moisture transport; index; subtropical monsoon; middle and lower reaches of Yangtze River; precipitation

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1 INTRODUCTION

East Asian monsoon and its related moisture transport exert important influences on summer rainfall over China [1, 2]. Many scholars have defined East Asian summer monsoon indexes from the thermodynamic [2, 3] or dynamic [4, 5] viewpoints or by combining them together [6, 7]. Dispute still exists on existing East Asian summer monsoon indexes although these indexes have their own advantages. Moisture transport flux is a physical variable with both dynamic and thermodynamic sense. It directly influences monsoon rainfall in virtue of its strength in close relation to monsoon [8-12]. Therefore East Asian monsoon and its related rainfall may be described by moisture transport. Subtropical summer monsoon (abbreviated as STSM) and South China Sea summer monsoon are two branches with different properties in the East Asian monsoon system [13] which is independent from the Indian monsoon system [14]. And it is necessary to define a subtropical summer monsoon index by differentiating STSM from South China Sea monsoon. The definition of an East Asian STSM index is discussed in detail based on an analysis of moisture transport characteristics over East Asia in this paper.

2 DATA AND COMPUTATIONAL METHOD

Dataset used in this paper include (1) daily NCEP/NCAR reanalysis data of u and v, horizontal wind components and specific humidity at eight mandatory pressure levels, and (2) daily rainfall data of 730 weather stations over China.

Flood (drought) years for summer rainfall over the middle and lower reaches of Yangtze River (abbreviated as MLRYR) are determined by selecting average rainfall anomaly percentage of 26 typical stations more (less) than 25% (-25%). Moisture transport vector or its components are computed by vertical integration from surface pressure up to 300hPa

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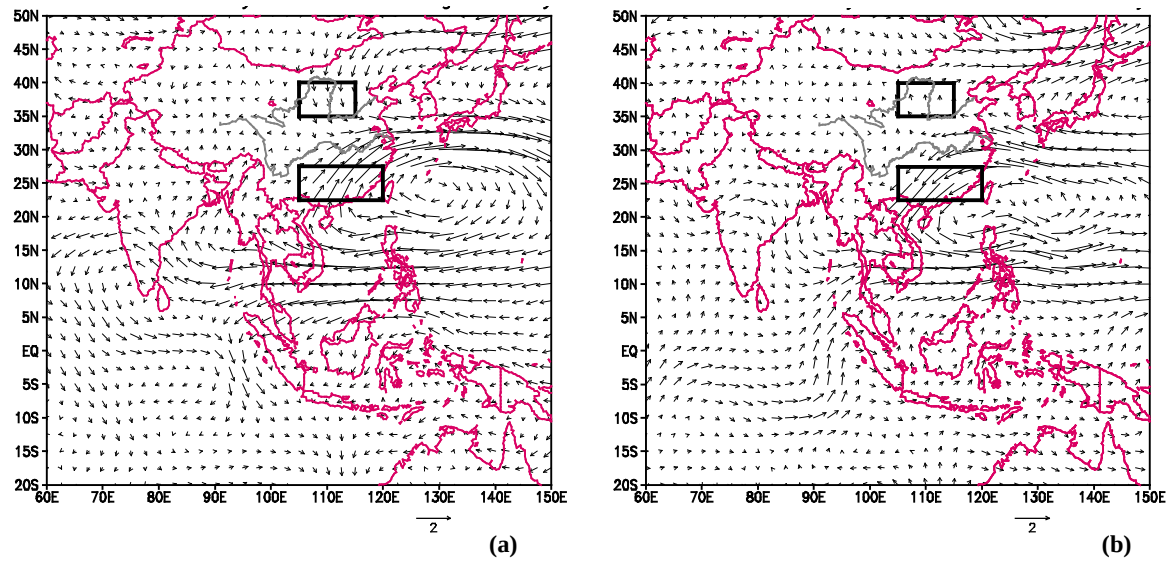

Fig.1 Composite wind anomaly on 850hPa during summer (June-August average) of high (a) or low (b) ESMI years. Unit: m/s

(the computational method is omitted).

3 DEFINITION OF STSM INDEX

3.1 *Definition of STSM index and its comparison with other indexes*

According to previous research, moisture transport flux averaged over 110°E – 120°E can well represent the advance and withdrawal of East Asian summer monsoon (figures omitted). And the meridional component of moisture transport flux does make much contribution to the description of movement of East Asian summer monsoon. In this paper, anomalous moisture transport coming from south (north) side of MLRYR is denoted by the departure of meridional moisture transport average over 22.5°N – 27.5°N, 105°E – 120°E (35°N – 40°N, 105°E – 115°E) which is approximately corresponding to South (North) China region. And the difference between the anomalous moisture transport coming from the south side (i.e. $\triangle VQ_{SC}$) and that from the north side (i.e. $\triangle VQ_{NC}$) is then defined as East Asian subtropical summer monsoon index (abbreviated as ESMI), i.e.

$$ESMI=\triangle VQ_{SC}-\triangle VQ_{NC}$$

ESMI during summer (i.e. June-August average) of 1971 to 2000 are then computed from the above expression. Here we choose those years with ESMI larger (smaller) than 25 (-25) as high (low) ESMI years. 14 high or low ESMI years selected are corresponding to 10 drought or flood years of MLRYR. And the corresponding ratio (10/14) is higher than that of other indexes [3, 15]. It seems that ESMI defined here may be a better index to reflect monsoon rainfall over MLRYR.

3.2 *Relation between STSM index and subtropical monsoon*

Fig.1 shows composite wind anomaly on 850hPa during summer (June-August average) of high or low ESMI years respectively. During high ESMI years (Fig.1a), moisture transported by the abnormally intense subtropical monsoon to the west of the west Pacific subtropical high converges with those from the north, which is favorable to more rainfall over MLRYR. The contrary is true during low ESMI years (Fig.1b). It can be seen that ESMI is a reasonable index for describing the strength of subtropical summer monsoon.

3.3 *Relation between STSM index and summer rainfall over MLRYR*

Relationship between ESMI and subtropical monsoon is studied above. Then how does ESMI connect with summer rainfall over MLRYR? Fig.2 illustrates the correlation between summer rainfall over China with four indexes including ESMI. For Fig.2a, it is evident that ESMI defined here significantly correlates with summer rainfall over Yangtze River, especially MLRYR. Contributions by the correlation between summer rainfall with $\triangle VQ_{SC}$ and $\triangle VQ_{NC}$ are shown in Fig.2b and Fig.2c respectively. It can be found from Fig.2a-c that $\triangle VQ_{NC}$ may do more contribution to summer rainfall over MLRYR compared with $\triangle V_{SC.}$ And ESMI combining both of them has better connection with summer rainfall over MLRYR. On the other hand, which is more important to ESMI, meridional wind or moisture? Similar to the definition of ESMI, the correlation (Fig.2d) is also

computed between summer rainfall and $\triangle V_{SC}$-$\triangle V_{NC}$. Here, $\triangle V_{SC}$-$\triangle V_{NC}$ means the difference between the anomalous meridional wind coming from the south side and that from the north side. Comparing Fig.2d with Fig.2a, ESMI cannot well reflect summer rainfall over MLRYR if only the meridional wind is included in ESMI.

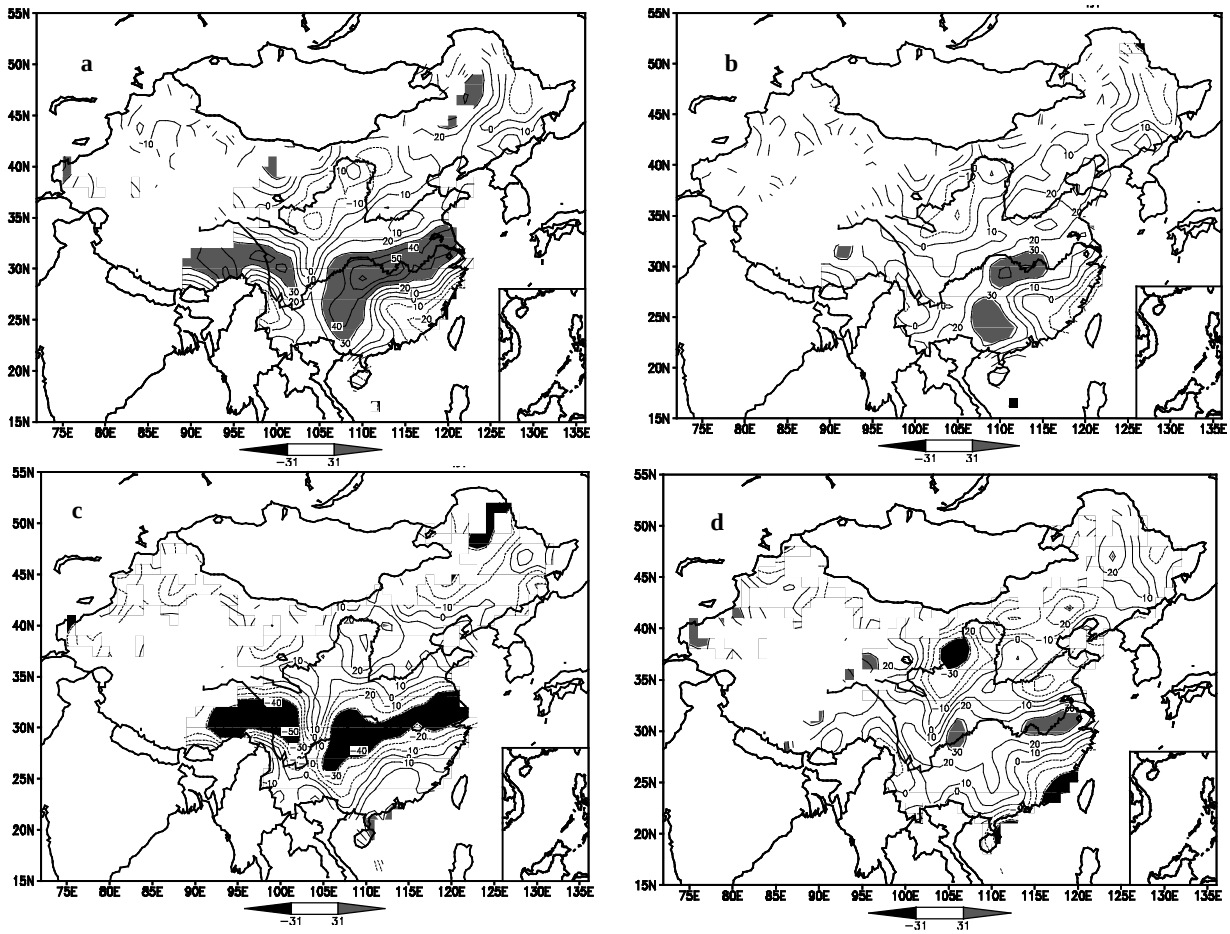

Fig.2 The correlation between summer rainfall over China with ESMI (a), mean anomaly of water vapor transport for South |China (b), North China (c) and the difference of mean anomaly of meridional wind between South China and North China. The shaded areas indicate high correlation values that pass the 95% confidence test and numerals are the coefficients that have been multiplied by 100.

For analyses of other aspects, refer to the Chinese edition of the journal.

4 CONCLUSIONS AND REMARKS

An East Asian subtropical summer monsoon index (ESMI) is firstly defined using moisture transport in this paper. Then relationships between ESMI and subtropical monsoon and summer rainfall over the middle and lower reaches of Yangtze River are analyzed. The main conclusions to be drawn from this paper are the following: (1) ESMI combining wind with relative humidity can well describe the abnormal change of East Asian subtropical monsoon. Years with high (low) ESMI are consistent with those with strong (weak) subtropical summer monsoon. (2) ESMI significantly correlates with summer rainfall over the middle and lower reaches of Yangtze River. High (low) ESMI is corresponding to more (less) summer rainfall over the middle and lower reaches of Yangtze River. (3) ESMI defined in this paper is in close relationship to the convergence of abnormal moisture transport coming from the south with that from the north, which is responsible, to some extent, for more rainfall over the middle and lower reaches of Yangtze River.

REFERENCES:

[1] HUANG Rong-hui, ZHANG Zhen-zhou, HUANG Gang. Characteristics of the water vapor transport in East Asian monsoon region and its difference from that in South Asian monsoon region in summer [J]. Scientia Atmospherica Sinica, 1998, 22(4): 460-469.

[2] CHEN Long-xun, ZHU Qian-gen, LUO Hui-bang, et al. East Asian Monsoon [M]. Beijing: Meteorological Press, 1991: 49-61.
[3] ZHU Jin-hong, WANG Shao-wu. 80a-oscillation of summer rainfall over the east part of China and East-Asia summer monsoon [J]. Adv. Atmos. Sci., 2001, 18(5): 1043-1051.
[4] SUN Xiu-rong, CHEN Long-xun, HE Jin-hai. Index of land-sea thermal difference and its relation to interannual variation of summer circulation and rainfall over East Asia [J]. Acta Meteorologica Sinica, 2002, 60(2): 164-172.
[5] WANG Ya-fei, ZHANG Yan, CHEN Ju-ying. An East Asian summer monsoon index in description of Meiyu phenomenon [J]. Cli. Env. Res., 2001, 6(2): 146-152.
[6] LI Chong-yin, ZHANG Li-ping. Characteristics of South China Sea summer monsoon and its indexes [J]. Adv. Nat. Sci., 1999, 9(6): 536-541.
[7] ZHU Cong-wen, HE Jin-hai, WU Guo-xiong. East Asian monsoon index and its inter-annual relationship with largescale thermal dynamic circulation [J]. Acta Meteorologica Sinica, 2000, 58(4): 391-402.
[8] YAO Yong-hong, QIAN Yong-fu. A study on the South China Sea monsoon index and the relationship between the index and regional rainfalls of China [J]. J. Naijing Uni. (Nat. Sci. Edi.), 2001, 37(6): 781-788.
[9] SHU Feng-min, JIAN Mao-qiu. Effects of sensible heating flux and latent heating on seasonal evolution of the subtropical high belt over Asia monsoon region [J]. J. Trop. Meteor., 2006, 22(2): 121-130.
[10] LIU Yun-yun, HE Jin-hai, LIANG Jian-yin, et al. Features of moisture transport in seasonal transition over Asian-Australian monsoon regions [J]. J. Trop. Meteor., 2006, 22(2): 138-146.
[11] LIU Yan-ju, DING Yi-hui, SONG Yan-ling. The moisture transport and moisture budget over the South China Sea before and after the summer monsoon onset in 1998 [J]. J. Trop. Meteor., 2005, 21(1): 55-62.
[12] LIN Jian-heng, WANG An-yu, FENG Rui-quan, et al. The climatic characteristics of maintaining period of South China Sea summer monsoon I - 40 yearly average [J]. J. Trop. Meteor., 2005, 21(2): 113-122.
[13] FENG Rui-quan, WANG An-yu, TANG Tian-yi, et al. Climatological characteristics of the maintaining period of South China Sea summer monsoon II - interdecadal variation [J]. J. Trop. Meteor., 2005, 21(2): 123-130.
[14] TAO S Y, CHEN L X. A review of recent research on the East Asian summer monsoon in China [M]// Monsoon Meteorology, CHANG C P, KRISHNAMURTI T N. Oxford University Press, 1988: 60-92.
[15] ZHU Qian-gen, HE Jin-hai, WANG Pan-xin. A study of the circulation differences between East Asian and Indian summer monsoons with their interaction [J]. Adv. Atmos. Sci., 1986, 3: 466-477.

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