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CHARACTERISTICS OF MEI-YU PRECIPITATION AND SVD ANALYSIS OF PRECIPITATION OVER THE YANGTZE-HUAIHE RIVERS VALLEYS AND THE SEA SURFACE TEMPERATURE IN THE NORTHERN PACIFIC OCEAN

MAO Wen-shu (毛文书)[1, 2], WANG Qian-qian (王谦谦)[1], PENG Jun (彭　骏)[3], LI Yong-hua (李永华)[4]

(1. Institute of Atmospheric Science, NUIST, Nanjing 210044 China; 2. Center of Plateau Atmospheric and Environmental Research, Chengdu University of Information Technology, Chengdu 610225 China; 3. Chengdu Institute of Plateau Meteorology, CMA, Chengdu 610072 China; 4. Chongqing Institute of Meteorology Science, Chongqing 401147 China)

Abstract: Based on the precipitation data of Meiyu at 37 stations in the valleys of Yangtze and Huaihe Rivers from 1954 to 2001, the temporal-spatial characteristics of Meiyu precipitation and their relationships with the sea surface temperature in northern Pacific are investigated using such methods as harmonic analysis, empirical orthogonal function (EOF), composite analysis and singular value decomposition (SVD). The results show that the temporal evolution and spatial distribution of Meiyu precipitation are not homogeneous in the Yangtze-Huaihe Rivers basins but with prominent inter-annual and inter-decadal variabilities. The key region between the anomalies of Meiyu precipitation and the monthly sea surface temperature anomalies (SSTA) lies in the west wind drift of North Pacific, which influences the precipitation anomaly of Meiyu precipitation over a key period of time from January to March in the same year. When the SST in the North Pacific west wind drift is warmer (colder) than average during these months, Meiyu precipitation anomalously increases (decreases) in the concurrent year. Results of SVD are consistent with those of composite analysis which pass the significance test of Monte-Carlo at 0.05.

Key words: Meiyu; harmonic analysis; EOF; SVD; Monte-Carlo test; Sea Surface Temperature (SST) of North Pacific Ocean

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1 INTRODUCTION

China is located in the well-known monsoon climate zone in East Asia. When annual northward progressions of the East Asian summer monsoon take place in June and July, an extended time of sustained rain appears over the Yangtze and Huaihe River basins, which is also known as “mei-yu”, or Rain of Plum, for it happens to be in a time when plums ripen in the region [1]. One of the important weather and climate phenomena in the transitional season from spring to summer in the region, mei-yu has well been studied [2]. As shown in Ye et al.[3], most of the droughts and floods in June and July in this region result from the anomalies of mei-yu. Sea surface temperature anomalies (SSTA) have long been considered one of the essential factors in causing circulation and climate anomalies, which are playing a key role in global climate change [4 - 13]. In fact, as the variation of the climate system is subject to multiple factors that govern the mei-yu, it is necessary to study them from different angles. With the use of rainfall data for the region provided by Jiangsu Provincial Bureau and such diagnostic approaches as EOF [14], harmonic analysis [15], composite analysis, SVD [16 -18] and Monte-Carlo significance test [19], the relationships between the interannual and interdecadal variations and North Pacific SST are studied in detail in the hope that they will help identify signature signals affecting the mei-yu and provide ideas and theoretical foundations for the

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Biography: MAO Wen-shu, male, native from Sichuan province, M.S., lecturer, mainly undertaking short-term climate prediction and numerical simulation.

E-mail for correspondence author: mws1225@163.com

prediction of the mei-yu in the region.

2 DATA

They are composed of the mei-yu rainfall data for the region compiled by Jiangsu Meteorological Bureau and global monthly SST gridpoints extracted from the reanalysis data of NCEP / NCAR. The former covers the region of Yangtze and Huaihe River valleys for a 48-year period from 1954 to 2001 and the latter spans from January 1953 to December 2001 with a gridpoint interval of 2°×2°.

3 TEMPORAL AND SPATIAL DISTRIBUTIONS OF RAINFALL VARIATION DURING MEI-YU

EOF analysis is applied to the anomalies of mei-yu rainfall for 37 observation sites over the 48-year period from 1954 to 2001 and the spatial distribution of the first three modes are determined that have relatively large rates of variance contribution (Fig.1).

What is shown in Fig.1 is several large-scale patterns of spatial distribution of the rainfall during the mei-yu, with the rate of accumulative variance being 73.4%. The empirical methods by North et al.[20] are used to assess the sampling error to find fast convergence of eigenvalues from EOF results, with the indication that energy can be evenly and stably divided according to the degree of freedom and therefore physically significant. Mode One, the most important spatial pattern of rainfall distribution for the mei-yu, takes up 56.3% of the total variance and shows that it is consistent across the whole region. Mode Two takes up 11.5% of the total variance and shows that the rainfall in the basins of Yangtze-Huaihe Rivers has inverse-phase variations that the rainfall is more (less) south of the latitude of 31°N versus less (more) rainfall north of it, a pattern of north-south contrast. Mode Three takes up 5.7% of the total variance and shows that there are inverse-phase changes across 115°E such that the rainfall is more (less) east of the longitude versus less (more) west of it, a pattern of east-west contrast. The study above shows that it is reasonable to take the first-order approximation to analyze the temporal and spatial variations of the mei-yu rainfall by treating the Yangtze-Huaihe region as a whole.

The method of harmonic analysis is applied to the time series of the mei-yu rainfall for scale separation on the interannual and interdecadal basis and long-term evolution trends are determined using the linear trend estimation technique. Fig.2 gives such curves.

It is known from Fig.2 that the long-term trends of the coefficients are increasing, indicating the same tendency in the rainfall during the mei-yu season in the region. As shown in the study, the variation is inhomogeneous in both spatial and temporal distribution and characteristic of significant interannual and interdecadal differences. The temporal evolution for the Yangtze-Huaihe Rivers basins is different from either the area south o f the Yangtze [21] or South China [22].

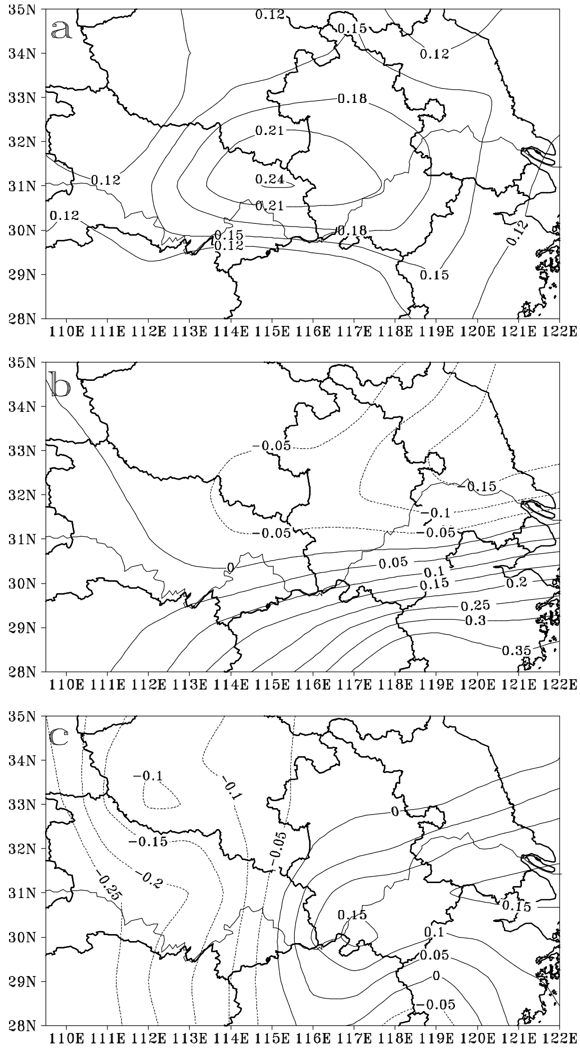

Fig.1 The spatial distribution of the first three modes for the EOF decomposition of the mei-yu rainfall. a. Mode One; b. Mode Two; c. Mode Three.

4 RELATIONSHIPS BETWEEN THE RAINFALL AND NORTH PACIFIC SST

Fig.3 gives the global regions of waters that are significantly correlated with the mei-yu rainfall, which are determined by taking into accounts the magnitude of the coefficients, stability and duration of the correlation and predictability and by comparing and analyzing monthly distribution of point-to-point correlation.

It is seen from Fig.3 that the key SST region for the mei-yu rainfall in Yangtze-Huaihe Rivers basins can be primarily located within the area (38°N – 50°N, 148°E – 172°E) and the affecting time is from January to March of the current year.

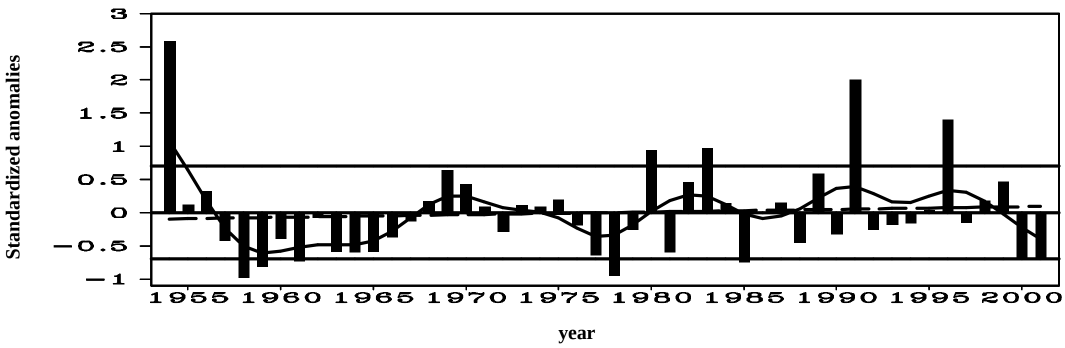

Fig.2 Temporal curves of interannual components (the column line) and interdecadal components (the smooth curve) and long-term trends (the dashed line) for the rainfall during the mei-yu.

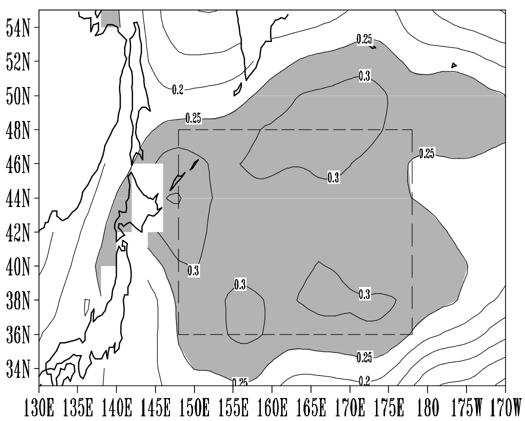

Fig.3 Coefficients of the correlation between the mei-yu rainfall and the mean SSTA in the west wind drift of North Pacific for the concurrent January – March. The shaded area indicates the passage of the 0.05 significance test. The box indicates where the key region is.

Fig.4 gives the coefficients of homogeneous correlation between the standardized anomaly field of monthly rainfall in the region and SVD-decomposed Mode One of the standardized anomaly field of the SST in the west wind drift of North Pacific.

5 CONCLUSIONS

(1) The rainfall during the mei-yu season is inhomogeneously distributed in both space and time and is characteristic of significant interannual and interdecadal variations.

(2) As shown in an analysis of point correlation (not elaborated in this article), a key region of waters that is closely correlated with the mei-yu rainfall is identified to be in the west wind drift of North Pacific (38°N – 50°N, 148°E – 172°E) and the period of key influence is determined to be from January to March in the current year. The correlation coefficient has passed the 0.05 significance test.

(3) As shown in the composite analysis, an anomalously warm (cold) west wind drift is associated

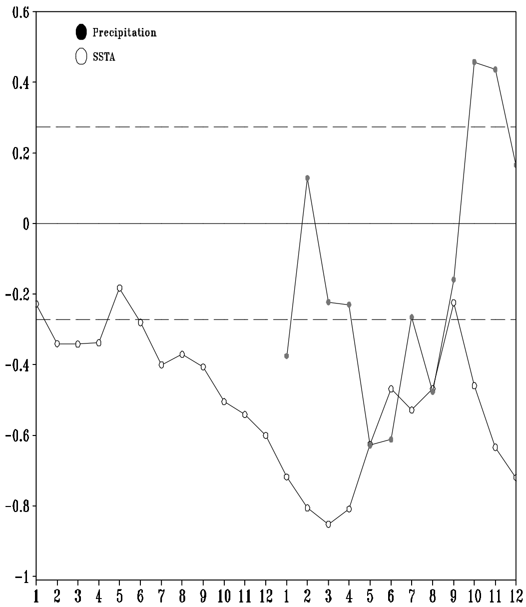

Fig.4 Homogeneous correlation coefficients for standardized SSTA over a 24-month period from the preceding to the current year for the west wind drift in North Pacific versus the SVD-analyzed rainfall of Yangtze-Huaihe Rivers basins from January to December of the current year. The dashed line is the threshold for the passage of the 0.05 Monte-Carlo significance test.

with anomalously more (less) rainfall during the mei-yu. They are positively correlated, as indicated in an SVD analysis, and the result is completely coincident with that of the composite analysis.

See the Chinese edition of the journal for more details.

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