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SPATIAL/TEMPORAL FEATURES OF DROUGHT/FLOOD IN FUJIAN FOR THE PAST FOUR DECADES

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Abstract: 41a (1961 – 2001) seasonal Z index series of 25 representative weather stations are investigated by virtue of EOF, FFT, continuous wavelet transformation (CWT) and orthogonal wavelet transformation (OWT). It shows that: (1) Fujian drought/flood (DF) has a significant 2 – 3a cycle for the periods 1965 – 1975 and 1990's; (2) the pattern, which represents the opposite DF trend between the southern and northern parts, has 1a and 3 – 4a cycles since the middle of 1980's; (3) EOF3, which denotes the reverse change between the middle-west region and other areas, has significant 1 – 2a cycle for the period from 1985 to 1998 and 9 – 13a cycle since 1980s; (4) there is an obvious drought trend for the last 40a (especially in the 1990's), which is more outstanding in the south (east) than in the north (west); (5) the 1960's and 1980's are in relatively wet phases and the 1970's and 1990's are in drought spells.

Key words: Fujian; drought and flood; spatial/time features; EOF; wavelet analysis

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1 INTRODUCTION

Well-defined quasi-14-a periods are found in the historic evolution of intense rainfall in Fujian province[1]. There has been much more rain in the spring since the 1980's, much less rain during the annually first rainy season[2] and precipitation is much affected by the topography[3]. Rainfall varies much from one stage to another with different periods for the northern and southern coasts[4]. The periods of drought and flood fluctuate differently[5]. A climatic jump occurred around 1975 in terms of summer precipitation in China[6, 7, 8]. The start and sustaining of the rainy season in the south of China, including Fujian, is well related with the total rainfall[10]. A quasi-3-a period is present in both the first and second annual rainy seasons there[11, 12]. The 11-a and 22-a solar periods and 19-a period for the relative movement between the sun, moon and earth all have good corresponding links with long-term variation of drought and flood in the area[5]. The periodicity of drought and flood variation does not remain unchanged and their significant periods are changing with time, which was not much addressed. In addition, previous work on the regional drought and flood was mainly based on the temporal series only, without much study on the periodic variation of the spatial distribution pattern of rainfall field and the temporal variation of its significant periods. It can be seen that much more work needs to be done on the drought and flood in Fujian. Over the past few years, with the widespread application of wavelet technique[13, 14], analyses of temporal climatological series have obtained not only the overall periodicity of series but also the information about the temporal changes of significant periodic signals. For instance, the variation of air temperature and precipitation in Yunnan province were studied with the Marr and Morlet wavelets (You[15]). Wavelet analysis was conducted for the temporal series of precipitation in northern China using the Mexican-hat wavelet (Kuang et al.[16]). The indexes for the Southern Oscillation (SO) and North Atlantic Oscillation (NAO) were analyzed with

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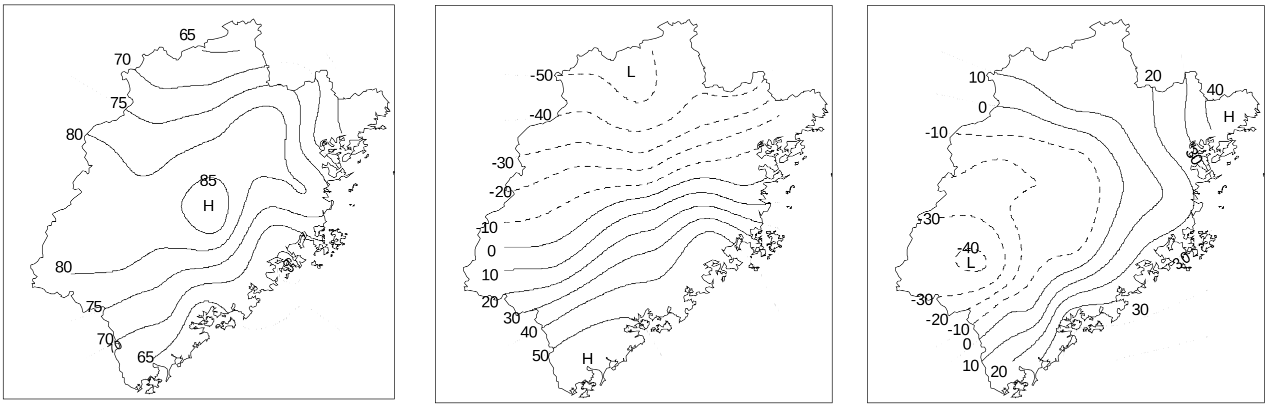

Fig.1 Spatial distribution of the load for the first three primary components of the Z index for Fujian. (×100).

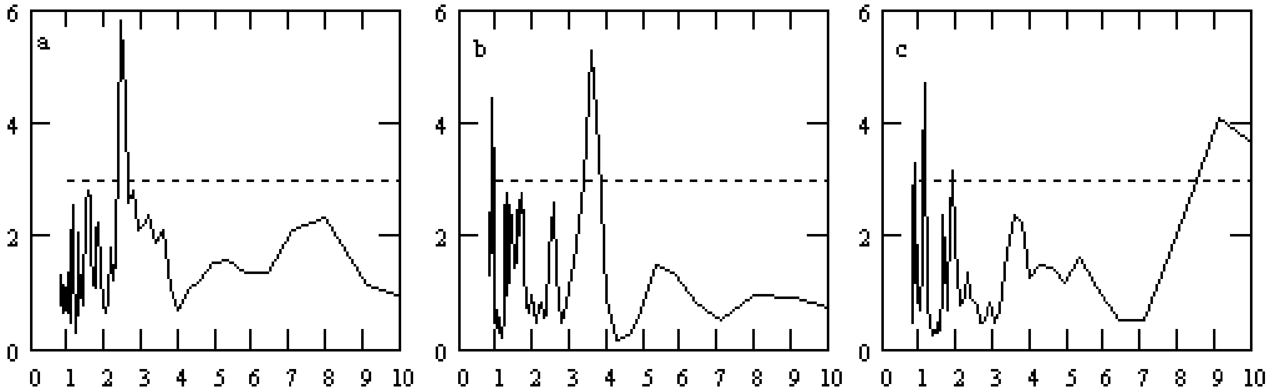

Fig.2 Frequency spectra for PC1, PC2 and PC3.

orthogonal wavelet transformation of DB16 for the latest data of precipitation field in Fujian, with more emphasis on the spatial and temporal characteristics.

2 DATA

The precipitation data is the rainfall measured at 25 representative observation stations in the province for the early spring (Mar. and Apr.), the annually first rainy period (May and Jun.), annually second rainy period (Jul. – Sept.) and fall / winter (Oct. – following Feb.). The index Z for all of them is connected to become a series by the order of time, being 164 in total length. The larger (smaller) the Z index is, the wetter (drier) it will be. In spite of varied temporal length represented by the four seasons, no significant effect is around for the analysis of interdecadal and interannual variations.

3 ANALYSIS OF THE RESULTS

The first three primary components of the Z index contribute to the variance by 71.6%, 12.5% and 4.5%, respectively, or, accumulating to a rate of 88.6%. The load of PC1 (Fig.1a) is positive all over the province with the maximum value in the central part, about 0.9. PC1 describes the temporal variation of consistent precipitation across the province that is caused by systematic anomalies of atmospheric circulation. Positive (negative) PC1 indicates drought (flood); positive (negative) PC2 shows that the southern part of the province is positively (negatively) anomalous while the northern part negatively (positively) anomalous; positive (negative) PC3 suggests positive (negative) anomalies in the eastern part but negative (positive) anomalies in the western part.

Spectral analysis of the standardized series is done using the FFT method and the results are shown in Fig.2. PC1 has significant periods of 2 – 3a and less significant periods of 8a. PC2 has two significant periods, one of 3 – 4a and the other of 1 a, with the former more significant than the latter. PC3 has periods of 1a, 2a, and 9 – 13a, and less significantly, a period of 3 – 4a. It shows that there are drought and flood in Fujian every 2 to 3a, with north-south differences at 1a and 3 – 4a and east-west differences at 1a, 2a and 9 –

13a.

It is known from the wavelet transformation of temporal coefficients for the first three primary components of the drought and flood in the province (figure omitted) that flood was more severe in the 1960's and 1980's while drought was more dominant in the 1970's and the 1990's. The wettest time was between 1965 and 1968. It is known from the point where the coefficient curve for wavelet transformation crosses the zero line that the turning point between the drought and flood was at the early stages of 1970's, 1980's and 1990's. It is also known from the magnitude of the absolute value of the wavelet transformation coefficients and alternation of positive and negative signs that there is a nested framework in which Fujian's drought and flood vary on multiple temporal scales. Following the interdecadal variations, the province should be facing a time of relatively more rain in the next 10 years if no long-term tendency is taken into account.

It is also known from the analysis that the variation of PC2 is not significant on scales of 8a and above and variational signals are not significant on all temporal scales except for limited spans of time. It is indicative that the signals are basically the same as white noise in the pattern of variation. In contrast, variations at the period of 1 – 8a were all with significant signals prior to 1985. For the interdecadal variation, it was relatively wet in the southern part of Fujian but relatively dry in northern part in 1961 – 1968 and 1977 – 1985. It was just the opposite for the other time. At the present stage, it is drier in the southern part than in the northern one.

The analysis indicates that there were just a few wavelet coefficients that reach the level of significance before 1985 but significant signals were with the periods of 1 – 2a and 4 – 16a after it. On the interdecadal scale, it was relatively wet in the eastern part of the province but relative dry in the western one from early 1960's to the end of 1970's; it was just the reversed from the 1980's.

The rates of variance contribution by PC1, PC2 and PC3 are shown in Tab.1. Based on the results of the table, components of interdecadal and interannual variation are composed and shown in Fig.3. For analyses of other aspects, refer to the Chinese edition of the journal.

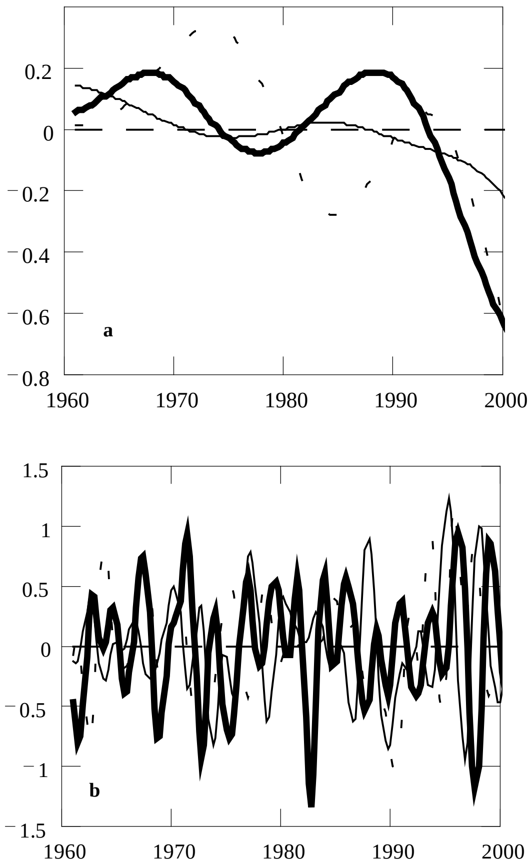

Fig.3 Components of interdecadal (a) and interannual (b) variation for PC1(bold, solid line), PC2(fine, solid line) and PC3 (dashed line). The abscissa is the year.

4 DISCUSSIONS AND CONCLUSIONS

Three main patterns of spatial distribution have been extracted using EOF for the drought and flood in Fujian to perform spectral analysis of their corresponding temporal coefficients. Significant

Tab.1 The rates of variance contribution by seven scales of drought and flood for PC1, PC2 and PC3

scale/year	2^0	2^1	2^2	2^3	2^4	2^5	$\geqslant 2^5$
	Seasonal change		Interannual change			Interdecadal change	
period/year	<0.875	0.875-1.75	1.75-3.5	3.5-7	7-14	14-28	⩾28
PC1	0.52	0.19	0.15	0.05	0.01	0.02	0.06
PC2	0.57	0.23	0.12	0.04	0.02	0.00	0.02
PC3	0.50	0.20	0.09	0.02	0.07	0.03	0.09

periods for the patterns are identified. Then, continuous wavelet transformation is conducted to investigate the variation of the significant periods. In the final approach, orthogonal wavelet decomposition and reconstruction are used to study the components of the three distribution patterns of drought and flood in Fujian on the seasonal, interannual and interdecadal scales. It is then found that the combined use of the three statistical methods is supplementary to each other to enable us to have fuller and deeper understanding of the periodic variation of the series.

In summary, there is a tendency of getting drier over the past 40 years, with the southern part more pronounced than the northern one and southeast coast more evident than the central and western parts. The tendency was the most significant in the 1990's. It was relatively humid in the 1960's and 1980's while relatively dry in the 1970's and 1990's.

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