MULTI-HIERARCHICAL STRUCTURE AND JUMP OF TEMPERATURE FOR THE GLOBE, CHINA AND YUNNAN OVER THE PAST 100 YEARS[1]

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ABSTRACT

An analysis has been conducted of the multi-hierarchical structure and jump of temperature variation for the globe, China and Yunnan Province over the past 100 years using an auto-adaptive, multi-resolution data filter set up in You, Lin and Deng (1997). The result is shown below in three aspects. (1) The variation of global temperature in this period is marked by warming on a large scale and can be divided into three stages of being cold (prior to 1919), warm (between 1920 and 1978) and warmer (since 1979). Well-defined jumps are with the variation in correspondence with the hierarchical evolution on such scale, occurring in 1920 and 1979 when there is the most substantial jump towards warming. For the evolution on smaller scales, however, the variation has shown more of alternations of cold and warm temperatures. The preceding hierarchical structure and warming jump are added with new ones. (2) The trend in which temperature varies is much the same for China and the Yunnan Province, but it is not consistent with that globally, the largest difference being that a weak period of cold temperature in 1955 – 1978 across the globe was suspended in 1979 when it jumped to a significant warming. while a period of very cold temperature in 1955 – 1986 in China and Yunnan was not followed by warming in similar extent until 1987. (3) Though there are consistent hierarchical structure and jumping features throughout the year in Yunnan, significant changes with season are also present and the most striking difference is that temperature tends to vary consistently with China in winter and spring but with the globe in summer and fall.

Key words: auto-adaptive multi-resolution data filter, hierarchical structure, climatic jump

I. INTRODUCTION

One of the heated issues of the atmospheric science has been the research on global climatic change over the past 100 years. The work is aimed to study the hierarchical structure and features of climatic jump for the temperature variation in the globe, China and the Yunnan Province over the past 100 years. It is hoped that it is of great significance for the understanding of why the climate changes and the prediction of how it will behave in the future.

Much of the existing research in this aspect has revealed a multi-hierarchical evolution on

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scales from the month, season up to 10,000 years (Ye, Zeng and Guo, 1991; Liu and Liu, 1989 and Lin, 1990). A similar weakness is with all of them (including the Fourier analysis) that they are incapable of reflecting truly the multi-hierarchical and jumping features in the behavior of climatic change due to the lack of localized, multi-hierarchical and multi-resolution treatment. For instance, when the low-pass filter with fixed temporal scales is applied, the noise and fine-scale perturbations are removed together with drastic changes and jump on larger scales. It is inappropriate when the study is right relevant with them and the hierarchical structure of the climatic evolution. In addition, the conventional filter is inconclusive or hardly conclusive for series with complex structures and fails to give a unique point of climatic jump, because it is either ambiguous in telling the difference or only recognizes series with only one climatic jump (Fu and Wang, 1992; Lin, 1993). The method in Yamamoto et al. (1985) gives much too wide the jump area while Mann-Kendall approach (Goossens and Berger, 1986) filters out all other information in addition to the jump, though the point and area of which are highly desirable. Apart from all the disadvantages presented above, the techniques up to now are insufficient in diagnosis of the inherent structure of the climatic change due to the absence of multi-resolution analysis.

For this purpose, You et al. (1997) exploit the idea of multi-resolution that is based on the wavelet theory (Meyer, 1992; Mallat, 1989) and the auto-adaptive filter technique (Keppenne and Chil, 1992; Mallat and Hwang, 1992; Penland, Chil and Weickmann, 1991 and Howel and Mahrt, 1994) to set up a low-pass data filter. Analyzing simultaneously the multi-hierarchical structure and the jump features, the auto-adaptive and multi-resolution filter includes a movable window, which is fixed on the side and has restrictive reservation of variance to decompose and reconstruct the data in a multi-resolution way. In other words, each of the data inside the window is specifically determined by its own location and variance. For the multi-hierarchical structure and jump features of temperature variation over the past 100 years, the second part of the paper deals with the globe and the third part discusses the hierarchical structure in China and Yunnan, comparing with the former, and the fourth part studies that on the basis of season in Yunnan.

II. MULTI-HIERARCHY AND JUMP IN GLOBAL TEMPERATURE VARIATION

Without any modification, the auto-adaptive multi-resolution data filter in You et al. (1997) is used to analyze the series of anomalous annual temperature across the globe as given in Jones, Raper and Bradley (1986) and Jones, Raper and Wigley (1986). To maintain a high resolution and keep the study from effects of interannual variation of temperature, results of the 5-year smoothing mean of the series are taken as input for the filter.

1. *Hierarchical and jump features corresponding to the 64-year scale*

Let's set $M=6, L=2^6=64, a=0.8$. It is obvious that the assumption is equivalent to reconstructing a 64-year-scale window that is conditional to a fine-scale truncation at 0.8 for a variance reservation within the window. Fig.1 gives the output of the filter being used for 4 times repeatedly with the series of global temperature anomalies.

It is known from Fig.1 that warming seems to be the principle tendency over the past 100 years on the temporal scale of $L=2^6=64$ for the variation of global temperature. It is marked with significant hierarchical and jump features in three of the following periods of being anomalously cold before 1919 and warm from 1920 to 1978 and warmer after 1979. Two major jumps of large scale warming occurred in 1920 and 1979.

2. Hierarchical and jump features corresponding to the 32-year scale

Let's set $M=5, L=2^5=32, a=0.8$. It is also clear that the assumption is equivalent to reconstructing a 32-year-scale window that is conditional to a fine-scale truncation at 0.8 for a variance reservation within the window. Fig.2 gives the output of the filter being used for 4 times repeatedly with the series of global temperature anomalies.

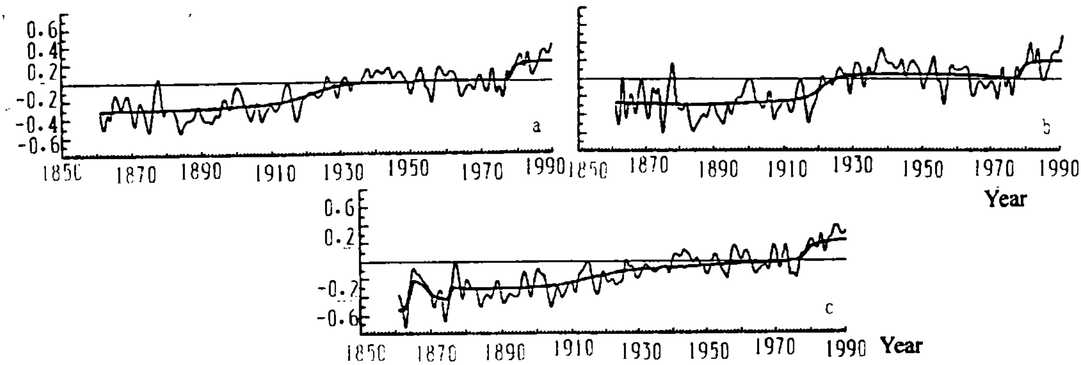

Fig.1. The hierarchical structure and the jump features of temperature variation over the globe during the last 100 years corresponding to the 64-year scale. (a) The globe; (b) NH; (c) SH.

Analyzing Fig.2, we know that for a time scale of $L=2^5=32$ the variation of global temperature over the past 100 years is divided into 6 hierarchies of being anomalously cold before 1879, colder between 1880 and 1895, cold between 1896 and 1919, warm between 1920 and 1954, relatively cold between 1955 and 1978 and warm again after 1979. Corresponding to the

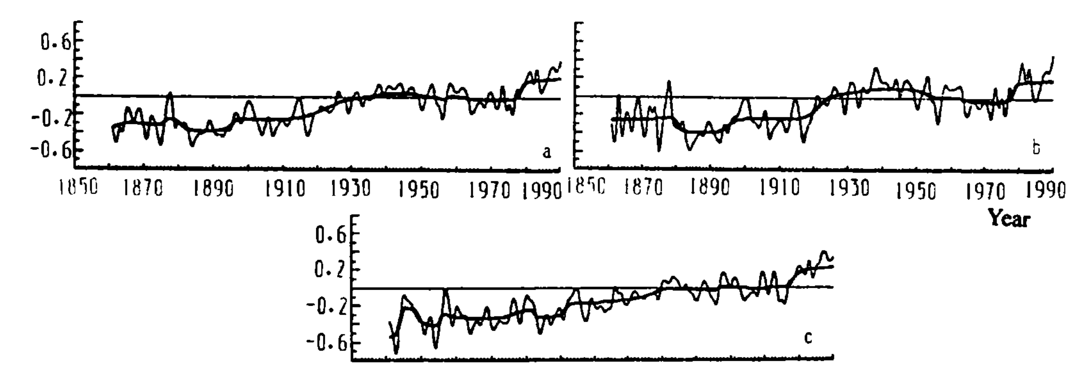

Fig.2.The hierarchical structure and the jump features of temperature variation over the globe during the last 100 years corresponding to the 32-year scale. (a) The globe; (b) NH; (c) SH

climatic evolution on such hierarchies, the global temperature undergoes well-cut jumping variation, with points of warming or cooling in 1880, 1896, 1920, 1955 and 1979.

3. Hierarchical and jump features corresponding to the 16-year scale

Let's set $M=5, L=2^4=16, a=0.8$. It is also clear that the assumption is equivalent to reconstructing a 16-year-scale window that is conditional to a fine-scale truncation at 0.8 for a variance reservation within the window. Fig.3 gives the output of the filter being used for 4 times repeatedly with the series of global temperature anomalies.

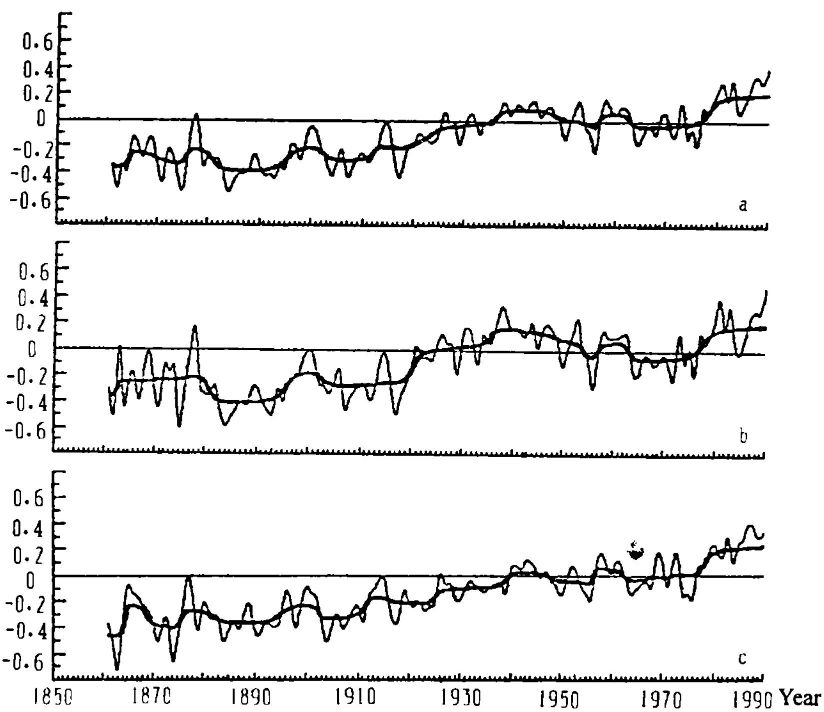

Fig.3.The hierarchical structure and the jump features of temperature variation over the globe during the last 100 years corresponding to the 16-year scale. (a) The globe; (b) NH; (c) SH

Analyzing Fig.3, we know that for a time scale of $L=2^4=16$ the variation of global temperature over the past 100 years is of more hierarchies of evolution and jump features.

It is concluded studying Figs.1–3 that the multi-hierarchical structure and jump features are accompanied with the variation of global temperature over the past 100 years for varied time scales. For the large (64-year) scale of hierarchical evolution, the variation is marked by warming in three periods of being anomalously cold before 1919, warm between 1920 and 1978 and warmer after 1979, with two significant warming jumps in 1920 and in 1979 again. For the smaller (32- and 16-year) scales of hierarchical evolution, however, the variation is characteristic of alternation of cold and warm periods when more hierarchies and jumps are added to the original ones. It is obvious to note that multi-hierarchical and jump features are with the climatic change.

III. HIERARCHY AND JUMP OF TEMPERATURE VARIATION IN CHINA & YUNNAN

The annual anomalies of temperature for the past 100 years given in Yi and Wang (1992) and Wang (1994) are taken as the case for China and that for Kunming as the case for Yunnan. Following the same reason as set in the last section of the paper, the 5-year smoothing mean of the two series are also taken as the input data for the filter.

Here, we take $M=5, L=2^M=32, a=0.8$. It is obvious that the assumption is equivalent to reconstructing a 32-year-scale window that is conditional to a fine-scale truncation at 0.8 for a variance reservation within the window. Fig.4 (a, b) gives the output of the filter for the hierarchical structure and jump features over the past 100 years in China and Yunnan and Fig.4 (c, d) gives the ones in the globe and Northern Hemisphere.

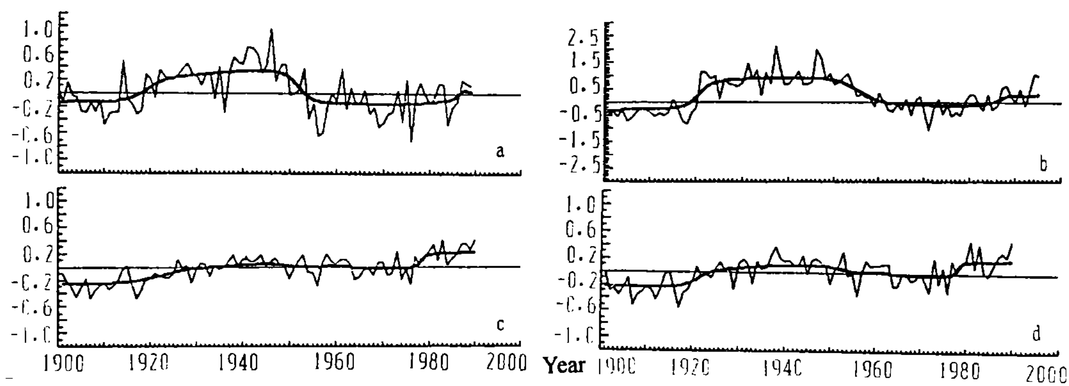

Fig.4.The hierarchical structure and the jump features of temperature variation in China and Yunnan during the last 100 years and comparisons with the globe. (a) China; (b) Yunnan; (c) the globe; (d) NH.

Analyzing Fig.4 (a, b), we know that the variation of temperature in China and Yunnan is consistent. It is marked by four large-scale evolutions of being anomalously cold before 1919, warm between 1920 and 1954, cold again between 1955 and 1986, and warm again after 1987. Corresponding to the climatic evolution on such hierarchies, temperature in China and Yunnan also undergoes well-cut jumping variation, with points of warming or cooling in 1920, 1955 and 1987.

Comparing Fig.4 (a, b) and Fig.4 (c, d), we conclude that the variation of temperature in China and Yunnan does not have the same tendency as that across the globe and Northern Hemisphere. The largest difference is that a weak period of cold temperature in 1955 – 1978 across the globe and Northern Hemisphere was suspended in 1979 when it jumped to a significant warming, while a period of very cold temperature in 1955 – 1986 in China and Yunnan was not followed by warming in similar extent until 1987.

IV. HIERARCHY AND JUMP OF SEASONAL TEMP. VARIATION IN YUNNAN

The temperature anomalies averaged over 3 months for DJF, MAM, JJA, and SON of the year in Kunming are taken to represent Yunnan in terms of the seasonal variation in winter, spring, summer and fall, respectively. The data covers a period 1901 through 1995. In a similar as in the last section, the hierarchical structure and jump features are given in Fig.5 for all of the seasons.

Analyzing Fig.5, we see that the hierarchical structure and jump features of the seasonal variation of temperature over the past 100 years in Yunnan are consistent with the same four

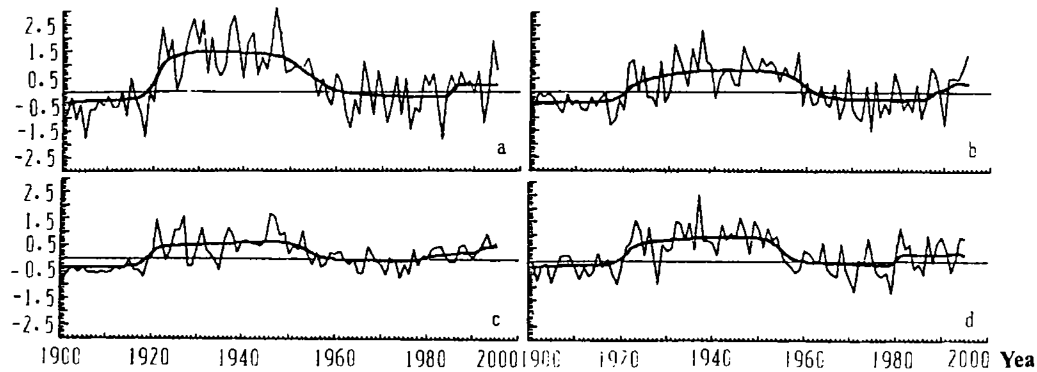

Fig.5.The hierarchical structure and the jump features of temperature variation with season in Yunnan during the last 100 years. (a) winter; (b) spring; (c) summer; (d) fall.

large-scale evolutions and two jumps in 1920 and 1955. The only difference is seasonal in that temperature in winter and spring tends to vary consistently for Yunnan with that for China when it is in a period of very cold temperature during the seasons from 1955 to 1986, followed by a jump to significant warming in 1987. On the other hand, temperature in summer and fall tends to vary consistently with that for Northern Hemisphere and the globe when it is in a period of mildly cold temperature during the seasons from 1955 to 1978, followed by a jump to significant warming in 1979. In addition, temperature varies by amplitudes that change much with season, with the largest in winter and smallest in summer.

V. CONCLUSIONS

a. For evolution on a large scale, the variation of global temperature in the last 100 years is marked by warming and can be divided into three stages of being cold (prior to 1919), warm (between 1920 and 1978) and warmer (since 1979). Correspondingly, the global temperature undergoes well-cut jumping variation, with jumps of warming in 1920 and 1979.

b. For evolution on a small scale, the variation in this period is characteristic of alternation of cold and warm periods when more hierarchies and jumps are added to the original ones due to the filtering of multi-resolution data treatment. It is obvious to note that multi-hierarchical and jump features are with the climatic change.

c. The variation of temperature in China and Yunnan is consistent. It is marked by four large-scale evolutions of being anomalously cold before 1919, warm between 1920 and 1954, cold again between 1955 and 1986, and warm again after 1987. Corresponding to the climatic evolution on such hierarchies, temperature in China and Yunnan also undergoes well-cut jumping variation, with points of warming or cooling in 1920, 1955 and 1987.

d. The variation of temperature in China and Yunnan does not have the same tendency as that across the globe and Northern Hemisphere. The largest difference is that a weak period of cold temperature in 1955 – 1978 across the globe and Northern Hemisphere was suspended in

1979 when it jumped to a significant warming, while a period of very cold temperature in 1955 – 1986 in China and Yunnan was not followed by warming in similar extent until 1987.

e. Temperature in winter and spring tends to vary consistently for Yunnan with that for China when it is in a period of very cold temperature during the seasons from 1955 to 1986, followed by a jump to significant warming in 1987. On the other hand, temperature in summer and fall tends to vary consistently with that for Northern Hemisphere and the globe when it is in a period of mildly cold temperature during the seasons from 1955 to 1978, followed by a jump to significant warming in 1979. In addition, temperature varies by amplitudes that change much with season, with the largest in winter and smallest in summer.

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