The Analysis and Predictions of Agricultural Drought Trend in Guangdong Province Based on Empirical Mode Decomposition

Zhiqing Zheng, Jiusheng Fan, Huiping Liu & Dang Zeng
School of Geographical Sciences, Guangzhou University, Guangzhou 510006, China
E-mail: zhiqingzheng@hotmail.com

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Abstract

This paper utilizes the Empirical Mode Decomposition (EMD) to carry on the analysis and the predictions of the agriculture drought trend in Guangdong Province, trying to provide a reference for predictions and forecasting of the agricultural drought trend. After decomposing the anomaly signals of precipitation and undulating signals of agriculture drought condition, four IMF components were obtained respectively. According to Guangdong's practical situations, the four components can be interpreted to be four fluctuating cycles: light-disaster, medium disaster, heavy disaster, mega disaster. Their quasi-periods are: Light disaster for three years, medium disaster for 5-7 years, heavy disaster for 13-15 years and 26-28 years for mega disaster. To predict the next few years of drought in Guangdong province by the change cycles of medium disaster, heavy disaster and mega disaster, the results are as follows: medium disaster will happen between 2009 and 2011 and probably in 2010; heavy disaster will happen between 2017 and 2019 and probably in 2018; mega disaster will happen between 2030 and 2032, and probably in 2031.

Keywords: Agricultural Drought disaster, Trend, Empirical Mode Decomposition (EMD) Prediction, Guangdong

Drought is one of the natural disasters which cause the largest economic losses in the world and an important type in various natural disasters in China, which is also one of important natural disasters in the disasters structure in Guangdong Province. Guangdong Province, on the verge of the South China Sea, is located in south subtropics with rich quantity of heat and plentiful precipitation. Because of the influence of special geographical location, monsoon climate and topography, the spatiotemporal distribution of atmospheric precipitation is very imbalanced, which leads to obvious temporal-spatial differences of the distribution of drought and even some districts are serious. Studying on the space-time distribution of agricultural drought and carrying on prediction and foresting of drought trend has an important significance both in theory and reality for ensuring regional economic sustainable development, ecological security and food security et. al.

There are many methods to predict agricultural drought and traditional prediction adopts statistical method mainly. Recently, many scholars predicted agricultural drought with the grey catastrophe model GM(1,1)(Liang, Hongmei, Liu, Huiping & Song, Jianyang et. al. 2006), Fourier transform analytical method, weighted Markov model(Wang, Yanji, Liu, Junming & Wang, Pengxin et. al. 2007) and wavelet analysis(Xue, Jibin, Zhong, Wei. 2006) et. al and a lot of achievements were obtained. But the methods have defects to some degree.

Empirical Mode Decomposition is an excellent time-frequency signal analysis method and in fact one circular iterative algorithm. It can deal with unsteady and nonlinear signal well, especially there will be better prediction results for series increasing or decreasing exponentially and it can predict the year which the next agricultural drought will happen in short run more simply and accurately. The method is direct, based on experience and used conveniently and it is also the best one to extract data series trend at present(Liu, Huiyu, Lin, Zhenshan, Zhang, Mingyang. 2005). For the time being the method has been applied successfully into nonlinear scientific fields including signal processing, image processing, turbulence, earthquake and atmospheric science and ecology et. al. (Lin, Zhenshan & Wang, Shuguang. 2004)(Guan, Weihua, Lin, Zhenshan & Gu, Chaolin. 2006)(Zhang, Yanguang & Li, Maoling. 2008)(Sun, Xian & Lin, Zhenshan. 2007)(Wan, Shiquan, Feng, Guolin & Zhou, guohua. 2005)(Zhu, Zhihui, Sun, Yunlian & Ji, Yu. 2007)(Xuan, Zhaoyan & Yang, Gongxun. 2008) as well as many fields such as the analysis of the fluctuation regularity of precipitation, analysis of changes of temperature, analysis of changes of energy supplies, the changes of food supplies, study of ecological footprint and so on. But there is still few reports to use EMD in the aspect of agricultural drought prediction.

According to nonlinear and unsteady characteristics agricultural drought happens, to predict agricultural drought with the method of EMD can accurately and quickly decompose stepwise the fluctuation with different frequencies in the signal, extract effectively a trend term of the data series and decompose the regularity agricultural drought happen in order to meet the need of multi-scale analysis and prediction of agricultural drought theoretically.

The article adopted EMD method to make a multi-scale analysis on the fluctuation of agricultural drought in Guangdong Province so as to reveal the fluctuation cycle of drought from 1950 to 2006 in Guangdong Province. At the same time according to the fluctuation cycle decomposed the article predicted the agricultural drought trend in Guangzhou Province in future in order to integrated control agricultural drought in Guangdong Province and make contingency plans so as to provide references for the prediction and foresting of agricultural drought in the future.

1. Fundamental principles and its calculation of empirical mode decomposition (EMD)

Fundamental principles of empirical mode decomposition (EMD): in essence, the result of stabilized processing of a signal is to decompose stepwise the fluctuation or trend with different scales in signals and generate a series of data sequence with different characteristics. Each sequence is an intrinsic mode function (IMF). Each component decomposed contains partial feature information about original signal with different time scales. Generally the components with the lowest frequency represent the trend or mean of original signal and through decomposition all kinds of unclear regularity will become clear. Its method of calculation:

(1) Initialize $r_0(t)=X(t)$. x(t) represents the time series to be analyzed;

(2) Extracting IMF component after cycles operation is one decomposition of empirical mode decomposition;

(3) Let $r_i(t) = r_{i-1}(t) - imf_i(t)$

(4) If ri(t) still has at least two extreme points, let i=i+1, return to (2), continue the iteration, otherwise all the components of IMF are extracted and the process of decomposition finishes and the residual of $r_i(t)$ obtained is trend component.

After iterative algorithm of EMD finishes, the time series realizes decomposition:

$$X(t)=\sum_{i=1}^{n} imf_i(t)+ r_n(t) \quad (1.1)$$

Each IMF component obtained by EMD is the process of decomposition with different scales respectively. Every time high-frequency signal is separated out and the low-frequency signal is remained. Finally the trend component $r_n(t)$ is obtained.

The boundary problem of EMD and its handling is mirror symmetry extension method (Deng, Yongjun, Wang, Wei & Qian, Chengchun et. al. 2001): write a program with matlab software and limit to decompose four modes in order to satisfy the need of the calculation of each index of analysis and prediction.

According to the principles and calculation of EMD the article makes a multi-scale analysis on the undulating signals of precipitation anomalies and agriculture drought condition in Guangdong province. From Guangdong's practical situations, quasi-periods that medium disaster, heavy disaster and mega disaster happen are drawn. According to the period that medium disaster, heavy disaster and mega disaster appears the article predict the medium disaster, heavy disaster and mega disaster which may happen in the next 30 years in Guangdong Province so as to reduce the impact of its stability on forecast precision.

2. Multi-scale time analysis of agricultural drought in Guangdong Province

2.1 Multi-scale time analysis of the precipitation anomalies percentage in Guangdong Province

2.1.1 The selection of precipitation index and the classification of rank system

Studying the problem of agricultural drought can adopt various qualitative and quantitative indexes, in which the most usual indexes are precipitation index, soil water content, the crop drought level, comprehensive drought index et.al. (Deng, Yongjun, Wang, Wei & Qian, Chengchun et. al. 2001).

In the article, the precipitation anomalies percentage which is most used in precipitation index is adopted mainly to calculate and analyze. the precipitation anomalies percentage is a kind of quantitative index which reflects the ratio between the precipitation within certain time period and its average value of precipitation for many years, whose meaning is the percentage between precipitation anomalies value and average precipitation in the same time period. The formula is as follows:

$$D_p = \frac{P - \overline{P}}{\overline{P}} \times 100\% \quad (2.1)$$

Where Dp-the precipitation anomalies percentage during the period (%)

P- the precipitation during the period (mm)

P-average precipitation during the period (mm), which mostly adopts the average value within recent 30 years (Drought evaluative criteria).

Data sources are from Guangdong Province meteorological department. The precipitation data of 58 years from 1951 to 2008 are obtained through arithmetic average according to statistics over the years at important rainfall stations of each region in the province. Because of the condition limitation, some regions lack certain year's precipitation data between 1951 and 1956 to some degree. But from the integrity of data, the data from 1957 to 2008 is very complete with high creditability, which is the main source for analysis and prediction, but the data from 1951 to 1956 are just important references.

According to the formula of precipitation anomalies percentage, the average values of precipitation over 58 years in Guangdong Province are calculated out. Then according to the practical situations of precipitation anomaly in Guangdong Province, combined with the situations of droughts and damage area over years in Guangdong Province, the drought levels are classified.

The precipitation anomalies which classify agricultural drought levels are different in different places(Sun, Xian & Lin, Zhenshan. 2007) and the selection of their standards should be set out from actual condition in the area. Considering that Guangdong is located in south subtropics, the temperature is high for year with much evaporation, it is very possible to lead to water shortage of crop if the precipitation is a slightly less and the agricultural drought occurs easily. Therefore, the standard which adopts the values range of precipitation anomalies percentage D_p to classify drought levels in Guangdong Province is different from our country's northwest and northeast area. Here are the main dividing standards below:

light-drought: $-5\% > D_p \geq -10\%$

medium-drought: $-10\% > D_p \geq -20\%$

heavy-drought and mega drought: $D_p < -20\%$

2.1.2 The time distribution features of precipitation anomalies percentage

According to the formula 2.1, after calculating precipitation data in Guangdong Province by statistics, the table of precipitation anomalies percentage from 1951 to 2008 in Guangdong Province and its time distribution figure are obtained as shown in figure 1.

Periodical fluctuation appeared every four or five years during 30 years from 1951 to 1980 when precipitation is low. In 1956, 1963, the precipitation anomalies reached －36％ and －32％ respectively, which are the extremes of anomalies percentage in recent 58 years. The years when the precipitation is very low appeared between about 13-14 years from 1981 to 2008.

Moderation: from 1981 to 2008, the period which the precipitation is very low is about 13-14 years. From the time, the interval is longer than every four or five years before 30 years. From the absolute value of precipitation anomalies, the anomalies percentage is smaller and it approaches the average value more relatively. The extremes of precipitation anomalies percentage are －20％ in 1991 and －22％ in 2004 respectively and the precipitation anomalies tend to moderate compared to 1956 and 1963.

After dealing with the signals of precipitation anomalies percentage in Guangdong Province by EMD, the authors obtained each IMF component and the trend term res(see figure 2) and variance contribution rate of IMFs(see table 2.1). From trend term res, for precipitation anomalies percentage in Guangdong Province in recent 58 years, the precipitation anomalies present an ascending trend from 1960 to 1980 and reach the maximum in 1989, while the precipitation anomalies present descending trend in recent 20 years. Because of the limitation of sample numbers, there is no a complete wave shape presented, but from the trend there will be a long-period change presented.

Each IMF component represents a different periodic oscillation (see table 2.1) respectively. IMF1 represents a periodic oscillation with quasi-two to quasi-three years, whose average period is 2.8 years, and from 1951 there has been 21 periodic oscillations; IMF2 represents a periodic oscillation with quasi-seven to quasi-eight years and from 1951 there has been about 8 periodic oscillations; IMF3 represents a periodic oscillation whose average is quasi-thirteen to quasi-fifteen years and there has been about four periodic oscillations from 1951. IMF4

represents a periodic oscillation with quasi-twenty-five to quasi-twenty-seven years and there has been about two periodic oscillations. Results shows IMF1, IMF2, IMF3, IMF4's periodic oscillations becomes longer and longer, changing from relative high-frequency oscillation to relative low-frequency oscillation, which indicates the effect of EMD decomposition on precipitation anomalies percentage in Guangdong Province is good and the IMF is clear with high discrimination without generating aliasing.

From four variation contribution rate of IMF we can see(see table 2.1), IMF1, IMF2 are components which have are affected greatly by variation contribution rate, whose variation contribution rate are 66.0155%, 22.2666% respectively and their sum is 88.3%, and they should be important variation law which limits precipitation anomalies in Guangdong Province. According to practical situations of agricultural drought in Guangdong Province and combined with other scholars' research we can see, the quasi-period of IMF1, IMF2, IMF3, IMF4 are that of light-disaster, medium disaster, heavy disaster, mega disaster correspondingly. From the variation contribution rate of IMF2, IMF3 we can see, the fluctuation signal of medium disaster and heavy disaster in Guangdong Province are strongest, which indicates agricultural drought is subjected to medium disaster and heavy disaster most obviously, also means from the time we can see agricultural drought is restricted by medium disaster and heavy disaster's periods most obviously. This plays a decisive role in the form of the law of precipitation anomaly in Guangdong Province.

2.2 Multi-scale time analysis of agricultural drought in Guangdong Province

2.2.1 The selection of index and the clarification of rank system

Agricultural drought generally is measured by indexes including disaster-affected area, damage area, grain loss, economic loss and ecological loss et.al. Disaster-affected area and damage area are very important indexes for analyzing agricultural drought and the information the data carries is result of mutual superposition and interaction of all kinds of impact factors of drought. The two indexes reflect the influence area and disaster-induced degree of drought. The anomaly indices of drought-affected area ratio and drought-suffering area ratio express the extent drought-affected area ratio and drought-suffering area ratio deviate from average state. The formula is:

$$\xi_i = \frac{M_i - \overline{M}}{\delta} \tag{3.1}$$

Where ξ_i expresses crop's anomaly indices of drought-affected area ratio(AIA) or drought-suffering area ratio(AIS) in the i year; M_i expresses crop's disaster-affected rate or damage rate; $\overline{M}$ expresses crop's average disaster-affected rate or damage rate; δ expresses standard deviation of crop's disaster-affected rate or damage rate.

The article make use of the information that disaster-affected area and damage area carry to calculate anomaly indices of drought-affected area ratio and drought-suffering area ratio, and carry out the classification of light drought, heavy drought and mega drought, and damage degree according to practical climate characteristics in Guangdong Province. The standards of classification are:

light-drought: $-5\% > D_p \geq -10\%$

medium-drought: $-10\% > D_p \geq -20\%$

heavy-drought and mega drought: $D_p < -20\%$

The data is from agricultural bureau in Guangdong Province in the total 59 years from 1950 to 2008, which is the data of disaster-affected area and damage area in all counties in the province. According to the formula (3.1), the authors calculate anomaly indices of drought-affected area ratio and drought-suffering area ratio, obtain the law of time distribution of disaster-affected and damage (see figure 3 & 4), make use of the program written by matlab software to decompose with EMD and obtain four IMF 's components and their trend terms res, and IMF's periods and variation contribution rate based on the decomposition of anomaly indices of drought-affected area ratio and drought-suffering area ratio by EMD.

2.2.2 The characteristics of time distribution of agricultural drought

Figure 2 shows: the degree of the agricultural disaster in Guangdong Province is on the rise and become aggravating in recent thirties years. But between 1960 and 1980, agricultural disaster-affected rate located in trough of the wave, which is a period that was slightly damaged. After 1980, agricultural disaster-affected rate has further exacerbated. The result is in harmony with that Liang Hongmei et.al predicted with grey theory. The reason for the rise is mainly from 1980s, industry and tertiary industry developed fast, agriculture dropped in the position, government departments investment in agricultural drought reduced and the hydraulic facilities were

deserted so that the utilization efficiency of water source used for irrigation is not high as well as mismanagement.

From the fluctuation signal of anomaly indices of drought-affected area ratio from 1950 to 2006(see figure 3) it shows: IMF1 expresses a periodic oscillation with quasi-two to quasi-three years and there has been 18 periodic oscillation from 1950; IMF2 expresses a periodic oscillation whose earlier stage is quasi-seven years and later stage is quasi-five years and the average is quasi-six years, and there has been about ten periodic oscillations from 1950; IMF3 expresses a periodic oscillation with the average quasi-thirteen to quasi-fifteen years and there has been about 3.5 periodic oscillations from 1950; IMF4 expresses a periodic oscillation with quasi-twenty-six to quasi-twenty-eight years and there has been about two periodic oscillations from 1950, which shows the fluctuation periods of IMF1, IMF2, IMF3, IMF4 are becoming longer and longer, and changing from relative high-frequency fluctuation into relative low-frequency oscillation. We can see that the effect of EMD decomposition on the fluctuation signal of anomaly indices of drought-affected area ratio is good and the IMF is clear with high discrimination without generating aliasing.

From four IMF's variation contribution rate (see table 3), we can see that IMF1, IMF3, IMF2 are affected by variation contribution rate greatly, whose variation contribution rate are 51.4497%, 25.0604%, 21.4245% respectively and they should be important variation law which limits agricultural drought in Guangdong Province, whose periods are 3 years, 13-15 years, 5-7 years respectively; From practical agricultural drought in Guangdong Province, the period of IMF1, IMF2, IMF3, IMF4 are that of light-disaster, medium disaster, heavy disaster, mega disaster correspondingly; From the variation contribution rate of IMF2, IMF3 we can see, their impact on medium disaster and heavy disaster most is very great, which should plays a decisive role in the form of agricultural drought in Guangdong Province.

From the development trend of disaster rate trend term res(see figure 4), we analyze that from 2000 when agricultural drought is very serious in Guangdong Province to the next 30 years(till 2030), it should be the period when agricultural drought is descending in Guangdong Province, but the variation contribution rate of trend term res is 2.0654% only (see table 3.2), whose impact is very little, which indicts the impact of various inference factors of human society on the occurrence of agricultural drought in Guangdong Province is very great. Therefore from the viewpoint the importance of disaster prevention and alleviation should consider the influence of each social factor and take strong measures to minimize damage.

From fluctuation signal of anomaly indices of drought-suffering area ratio from 1950 to 2006 in Guangdong Province as shown in figure 4 and 3.6 and table 3.3, IMF1, IMF2 are components which are affected by variation contribution rate greatly and their variation contribution rate are 55.5431%, 30.1310% respectively, whose periods are quasi-three to quasi-four years and quasi-seven years respectively and there has been about 16 and 8 periodic oscillations from 1950 respectively. Form practical agricultural drought in Guangdong Province, the two periods are fluctuation periods of light disaster and medium disaster; For IMF3, IMF4, their fluctuation periods are quasi-fourteen years and 26-28 years and there has been about four and two periodic oscillations respectively, which are the laws of time distribution of heavy disaster and mega disaster correspondingly, which is almost the same as the fluctuation periods of heavy disaster and mega disaster of disaster rate. But the contribution rate of fluctuation is very little relatively, which shows the fluctuations of heavy disaster and mega disaster formed practically in Guangdong Province are not very obvious.

From the development trend of damage res, practical damage in the forty years from 1960 until now in Guangdong Province is becoming more and more serious, especially the twenty years in 1970s and 1980s are more obvious. This should attach great importance to the relevant departments in Guangdong Province, take care of analyzing the reasons for that and put forward measures and solutions to alleviate agricultural drought.

4. The prediction of the trend of agricultural drought in Guangdong

4.1 The prediction of drought occurrence year based on the change of precipitation anomalies percentage with time

The article makes use of EMD to discompose the fluctuation signal of precipitation anomalies percentage in Guangdong Province and obtains IMF component corresponding to different time scales, among the period of IMF1, IMF2, IMF3, IMF4 is that of light disaster, medium disaster, heavy disaster and mega disaster in Guangdong Province respectively. From the comparison of IMF's period after decomposition, the period that less slight precipitation appears is quasi-2.8 years, the period that less medium precipitation appears is quasi-7 to quasi-8 years, that less heavy precipitation appears is quasi-13 to quasi-15 years and the period of mega disaster is 25-27 years.

According to the fluctuation periods of four IMF components, combined with drought classification standards of precipitation anomalies percentage in Guangdong Province, the authors defined the year 2003 as medium drought year of precipitation anomaly in Guangdong Province and defined the year 2004 as heavy drought, mega drought year of precipitation anomaly in Guangdong Province, so on the basis we can predict that: extrapolate that the quasi-period of fluctuation of IMF2's component is seven to eight years, the next occurrence year that the medium precipitation is less appears between 2010 and 2011 and it should be medium drought year. Extrapolate that the quasi-period of fluctuation of IMF3's component is 13 to 15 years, the next occurrence year that the heavy precipitation is less unusually appears between 2017 and 2019 and it should be heavy drought year. Extrapolate that the quasi-period of fluctuation of IMF4's component is 25 to 27 years, the next occurrence year that the mega precipitation is less appears between 2029 and 2031 and it should be mega drought year.

4.2 The prediction of agricultural drought based on anomaly indices of drought-affected ratio and drought-suffering ratio

After decomposing the fluctuation signal of anomaly indices of drought-affected ratio and drought-suffering ratio from 1950 to 2006 in Guangdong Province by EMD, IMF components corresponding to different time scales are obtained respectively, in which IMF1, IMF2, IMF3, IMF4 component represents certain periodic oscillation respectively. From practical agricultural drought in Guangdong Province, four IMF components' periodic oscillation accord to the period of light drought, medium drought, heavy drought and mega drought in Guangdong Province respectively.

According to fluctuation periods of four IMF components, the authors define the year 2004 in Guangdong Province as the latest heavy year that agricultural drought occurs, and from the quasi-period of heavy-drought signal IMF component's fluctuation after decomposition of anomaly indices of drought-affected ratio is 13-15 years, the authors extrapolate and predict that: the next occurrence year of agricultural heavy drought in Guangdong Province is 2017-2019 year and the year with the biggest possibility is 2018. From the quasi-period of IMF1's fluctuation is three years we see, the next year with the biggest possibility when agricultural heavy drought occurs in Guangdong Province is 2018-2019; from the fluctuation period IMF4 components of mega and heavy drought is 26-28 years we can see the next occurrence year of mega and heavy drought is likely to appear in 2030-2032.

Likewise, after decomposition of fluctuation signal of anomaly indices of drought-suffering ratio in Guangdong Province from 1950 to 2006 by EMD the IMF components corresponding to different time scales are obtained respectively and each mode component IMF expresses certain periodic oscillation and corresponds to certain period of light disaster, medium disaster and heavy disaster.

According to fluctuation period of four IMF components after decomposition of fluctuation signal of anomaly indices of drought-affected ratio, the authors defines the year 2004 as the occurrence year of heavy disaster and mega disaster in Guangdong Province; from the fluctuation periods of heavy disaster's fluctuation component IMF3 and mega disaster's fluctuation component IMF4 are quasi-fourteen years and quasi-26 to quasi-28 years respectively, we extrapolate and predict that: the next occurrence year of agricultural heavy drought and mega drought appear between 2018 and 2030-2032 in Guangdong Province, whose result is in harmony with the prediction based on anomaly indices of drought-affected ratio. So the damage agricultural drought has close relation and correlation with the affected agricultural drought(Yang, Guohua & Zhou, Yongzhang. 2005).

4.3 The fitting of different indexes' predicting results

After decomposition of fluctuation signal of precipitation anomalies percentage, anomaly indices of drought-affected ratio and drought-suffering ratio in Guangdong Province with EMD four IMF components corresponding to light disaster, medium disaster, heavy disaster and mega disaster are obtained. From the comparison of IMF's components' periods after decomposition three indexes, we can see that the fluctuation of precipitation anomalies percentage in Guangdong Province is consistent to the fluctuation period of anomaly indices of drought-affected ratio and drought-suffering ratio basically, which means the quasi-period of light disaster is about three years, the quasi-period of medium disaster is about seven years, the quasi-period of heavy disaster is about 14 years and the quasi-period of mega disaster is about 26 years, which shows the laws of the three indexes has synchronicity.

Fitting three indexes IMF components' fluctuation periods we predict that the next occurrence years of agricultural medium drought, heavy drought and mega drought are: the occurrence year of medium drought is 2009-2011 and in 2010 it occurs with the biggest possibility; the occurrence year of heavy drought is 2017-2019 and 2018 it occurs with the biggest possibility; the occurrence year of mega drought appears in 2030-2032 and in 2031 it occur with the biggest possibility.

5. Conclusions and discussions

This paper draw the main conclusions based on the analysis and forecast of precipitation anomalies percentage and agricultural drought disaster index by EMD that: after decomposing the fluctuation signals of agricultural drought and precipitation of Guangdong province to get four fluctuant IME components, namely light disaster, medium disaster, heavy disaster, mega disaster. Comparing the periods of IME components decomposed from the three indexes, we can find that the fluctuant period of precipitation anomalies percentage in Guangdong province is consistent with the fluctuant period of agricultural drought disaster index: the period of light disaster is 3 years, the period of medium disaster is 5-7 years, the period of heavy disaster is 13-15 years and the period of mega disaster is 26-28 years. According to the periods of medium disasters, heavy disasters and mega disasters, it can be predicted that: the occurrence years of medium disaster are from 2009 to 2011, the occurrence years of heavy disaster are from 2017 to 2019 and the possibility of occurring in 2018 is biggest, the occurrence years of mega disaster are from 2030 to 2032 and the possibility of occurring in 2031 is biggest.\

The article verify the prediction results of EMD through various methods including that the calculation and analysis of IMF components' variation contribution rate according to the strength of fluctuation of each IMF component in original signals and shows there is higher reliability for the prediction of agricultural drought trend with the method.

For the prediction of agricultural drought, that how the result is more accurate and whether the method is scientific and powerful should be evaluated by the correspondence degree between prediction value and actual value. The article tried to adopt segment historical data and predict the later data sequence by the former data modeling, and then compared and fitted the later data's actual value and prediction value, and finally through revised model parameter reached the mathematic model which reflects practical laws more actually and make accurate prediction. But maybe because the years of data are short relatively and it is about 58 years, the results didn't realize and whether the prediction results are reasonable still needs to be tested by time and practice.

The laws of occurrence of agricultural drought is complex unusually and there are many impact factors, so to predict a regional agricultural drought trend accurately still needs continuous hardworking exploration and the prediction method also needs to be perfected and improved further. The article is just a beneficial attempt.

References

Liang, Hongmei, Liu, Huiping & Song, Jianyang et. al. (2006). Temporal distribution and trend prediction of agricultural drought disaster in Guangdong Province. *Journal of Natural Disasters,* 2006, 8, 15(4), 79-83.

Wang, Yanji, Liu, Junming & Wang, Pengxin et. al. (2007). Prediction of drought occurrence based on the Standardized Precipitation Index and the Markov Chain Model with weights. *Agricultural Research in the Arid Areas,* 2007.9, 25(5): 198-203.

Xue, Jibin, Zhong, Wei. (2006). Research on the Changes of the Dryness and Wetness and Their Level Analysis of Guangdong During the Historical Period. *Yunnan Geographic Environment Research,* 2006.4, 18(4): 10-14.

Liu, Huiyu, Lin, Zhenshan, Zhang, Mingyang. (2005). Multi-scale Analysis of the Fluctuating and the Cause Of Our Country's Grain Yield based on EMD. *Journal of Natural Resources,* September, 2005, 20(5).

Lin, Zhenshan & Wang, Shuguang. (2004). Emd Analysis of Northern Hemisphere Temperature Variability During Last 4 Centuries. *Journal of Tropical Meteorology,* February, 2004. 20(1), 90-96.

Fan, Chuiren, Zhou, Manyu & Han, Fuzhen. (2001). Superficial analysis of 2000 year big drought disaster in Jilin province. *Jilin Water Resources,* No. 8.

Guan, Weihua, Lin, Zhenshan & Gu, Chaolin. (2006). Multiscale Analysis of the difference and the causes of China's regional economic development. *Economic Research Journal,* No. 7, pp. 117-125.

Zhang, Yanguang & Li, Maoling. (2008). EMD Analyses and Dynamics Predictions of Energy Supply and Demand in China. *Geography and Geo-Information Science,* 2008.5, 24(3): 67-70.

Sun, Xian & Lin, Zhenshan. (2007). The Regional Changing Characteristics of Air Temperature in China under Empirical Mode Decomposition. *Journal of Geographical Science,* 2007.l1, 6(11): 1132-1141.

Wan, Shiquan, Feng, Guolin & Zhou, guohua. (2005). Study on the Information Extraction and Prediction of Observation Data Based on the Method of EMD. *Acta Meteorologica Sinica,* 2005, 8, 63(4): 516-524.

Zhu, Zhihui, Sun, Yunlian & Ji, Yu. (2007). Short-term Load Forecasting Based on EMD and SVM. *High Voltage Engineering,* 2007, 5, 33(5): 118-122.

Xuan, Zhaoyan & Yang, Gongxun. (2008). Application of EMD in the Atmosphere Time Series Prediction. *Acta*

Automatic Sinica, 2008. 1, 34(1): 98-101.

Deng, Yongjun, Wang, Wei & Qian, Chengchun et. al. (2001). The handling of boundary condition in the way of EMD and Hilbert transform. *Science Bulletin,* 2001, 46(3): 257-263.

Drought evaluative criteria. [Online] Available: http://www.aqtd.cn/yjya/HTML/166347_4.html

Yang, Guohua & Zhou, Yongzhang. (2005). Risk Analysis for Flood and Drought Disasters and Sustainable Development of Agriculture in Guangdong Province. *Journal of Catastrophology,* 2005. 9, 20(3): 16-20.

Table 2.1 Each IMF Cycle and its variance contribution rate of precipitation anomalies percentage in Guangdong province by EMD

IMFi	IMF1	IMF2	IMF3	IMF4	res
quasi-period(year)	2.8	7-8	13-15	25-27	About 76
variance contribution rate %	66.02	22.27	8.11	3.60	
Next peak after prediction		2010-2011	2017-2019	2029-2031	

Table 3.1 Each IMF Cycle and its variation contribution rate of anomaly indices of drought-affected ratio in Guangdong province by EMD

IMFi	IMF1	IMF2	IMF3	IMF4	res
quasi-period(year)	2-3	5-7	13-15	26-28	About 60
variance contribution rate %	51.4497	21.4245	25.0604	21.0654	
Next peak after prediction		2009-2011	2017-2019	2030-2032	

Table 3.2 Each IMF Cycle and its variance contribution rate of anomaly indices of drought-suffering ratio in Guangdong province by EMD

IMFi	IMF1	IMF2	IMF3	IMF4	res
quasi-period(year)	3-4	7	14	25-28	About 100
variance contribution rate %	55.5432	30.1312	9.5653	4.7605	
Next peak after prediction		2011	2018	2030-2032	

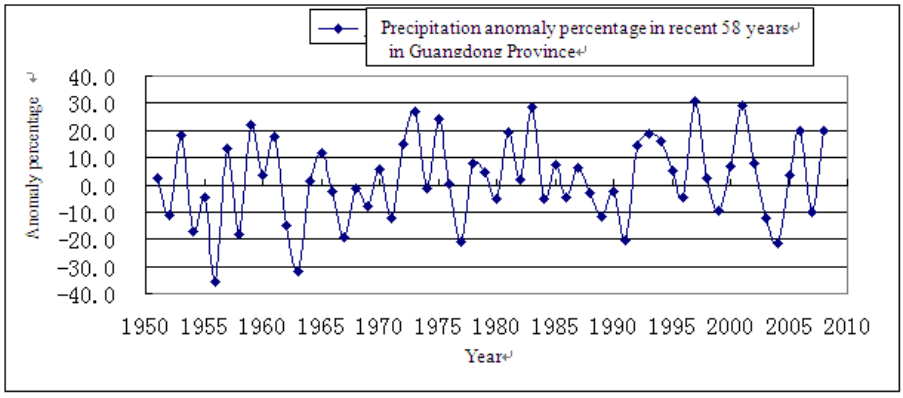

Figure 1. Time distribution of precipitation anomalies percentage in Guangdong province

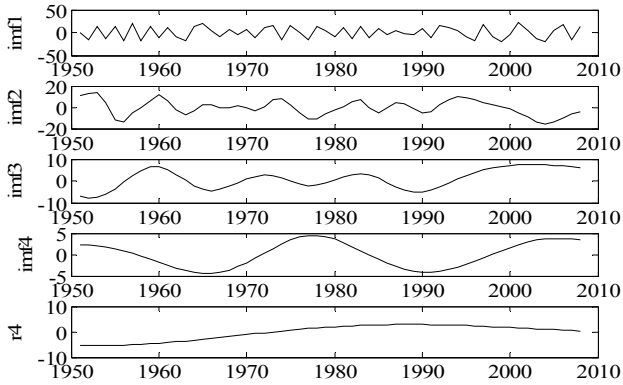

Figure 2. The IMFs and RES of precipitation anomalies percentage in Guangdong province by EMD

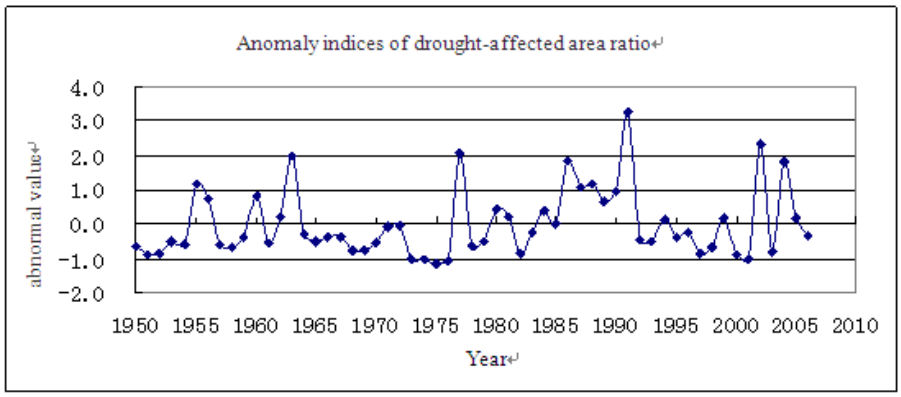

Figure 3. The variations time of anomaly indices of drought-affected ratio in Guangdong Province

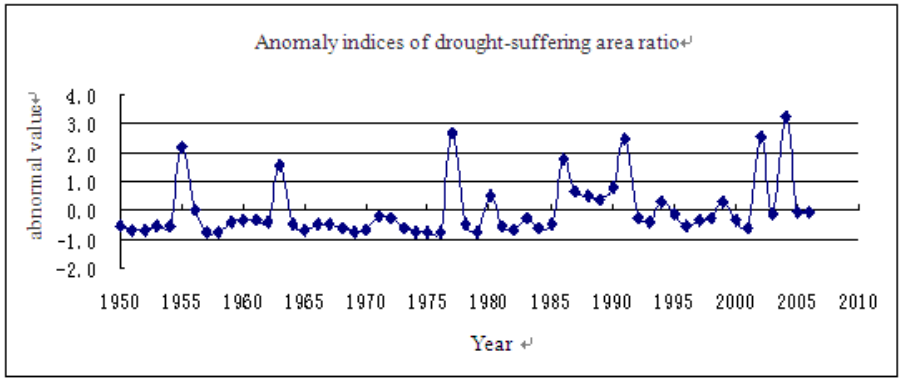

Figure 4. The variations time of anomaly indices of drought-suffering ratio in Guangdong Province

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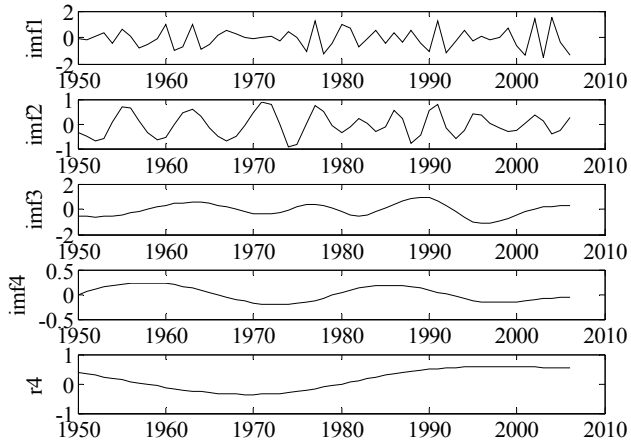

Figure 5. the IMFs and RES of anomaly indices of drought-affected ratio in Guangdong province by EMD

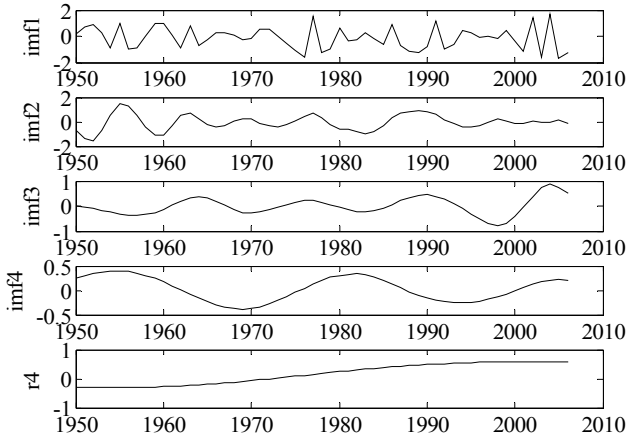

Figure 6. The IMFs and RES of anomaly indices of drought-suffering ratio in Guangdong province by EMD