Analysis on Evolution of Meteorological Factors in Central Guizhou

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Abstract: Due to human activity and climate change, hydrolocial effect of environment change is always a study focus. Changes of the underlying surface reflect the effect of human activity while effect of climate change is mainly reflected in the change of meteorological factors. Alteration diagnosis of meteorological factors was conducted in in the karst area of the Central Guizhou. The results show that annual cumulative precipitation (ACP) and annual extreme maximum temperature are stable from 1959 to 2012. The maximum daily precipitation in annual series, annual averaged temperature series and annual extreme minimum temperature series had medium variation. The variation indicated that the study area was greatly affected by climatic change.The impact of human activities needs further study.

1 INTRODUCTION

Guizhou province is rich in water resource and water resources availability per capita amount is higher than the national average. It main aquifer is a karst system that extend from karst ground water and fissures. However, meanwhile however, because of its complex structure, such as difficult to store surface water, surface water transform to groundwater faster, etc., water resources development is difficult. In addition, drought occurred frequently because of the aquifer cannot hold water (Chu et al, 2008; Wang et al, 2006). In recent years, serious soil erosion and flood disaster increase have negatively impacted the social development and ecological protection. Part of disaster are due to the climate change and special karst geological conditions (Peng et al, 2012; Tong et al, 2012; Tang et al, 2016). Ecological protection and development are two important aspects of the regional development. For the last twelfth five-year, strong effort have been made to develop health, big data, ecology and tourism of the 13rd five-year plan in Guizhou province. Multi-timescale analysis to rainfall in Karst is necessary for regional water resources development, ecological management and protect, and social sustainable development.

Taking Guiyang city of Guizhou province as the representative of central Guizhou region, this paper analyses the meteorological elements impacting karst region in southwest China, to reveal the influence of changing environment on regional climate. As a preliminary study on the analysis of meteorological elements in central Guizhou, the research results analyse the temporal relationship between rainfall and temperature and but also provide references for the study of meteorological problems under the changing conditions of karst mountainous areas.

2 STUDY AREA AND DATA

Guiyang is located in the southwest of China and the middle of Guizhou Province and is the capital of Guizhou Province. The geographical coordinates of Guiyang weather station are 106°44′ E and 26°36′ N. Guiyang is located in the Yunnan-Guizhou Plateau in the middle of the original hills, Guiyang in 1100 meters altitude, perennial controlled by the westerlies, a subtropical humid mild climate, annual average temperature 15.3℃, annual extreme maximum temperature 35.1℃, annual extreme minimum temperature of 7.3℃, annual average relative humidity is 77%, the average annual total rainfall of 1129.5 mm, annual average cloudy days to 235.1 days, annual average sunshine hours for 1148.3 hours. Guiyang is in the watershed of the Yangtze River and the Pearl River. The altitude of Guiyang is high in the

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southwest and low in the northeast, alternating with denuded hills, basins, valleys, and depressions.

Annual cumulative precipitation (ACP), maximum one-day precipitation in a year (MP), average temperature(AT), annual extreme maximum temperature(MAXT), annual extreme minimum temperature(MINT), time series data from 1959 to 2012, come from National Meteorological Science Center in China are used.

3 ANALYSE OF THE TREND PRECIPITATION AND TEMPERATURE ON GUIYANG STATION

3.1 Trend Analysis

Linear regression is used to simulate the change trend of time series. In this method, the least square method is used to solve the change slope of time series, and the change trend of time series is analyzed. The method can fit the change characteristics of time series and reflect the real change of time series more truly, the calculation method is as follows (Li et al, 2017):

$$Slope=\frac{n\times\sum_{i=1}^{n} i\times S_i-(\sum_{i}^{n} S_i)\cdot(\sum_{i}^{n} i)}{n\times\sum_{i=1}^{n} i^2-(\sum_{i=1}^{n} i)^2} \quad (1)$$

Where, Slope is the slope of the regression equation; S_i is the sequence value of *S* element in year *i*; n is the length of the time series of the elements. When Slope>0, show that the series increases in the research time, that is, an upward trend, when Slope<0, show that the series decreases in the research time, that is, a downward trend.

3.2 The Results of Trend Analysis

It can be seen from table 1, Figure 1 and Figure 2, the average annual precipitation is 1103.7mm and Perennial mean annual temperature is 15.1℃ from 1959 to 2012, the slopes are -1.9766 and -0.0147, which show that these are downward trends, and the annual average temperature has greater downward trend than annual precipitation.

Table 1: Annual cumulative precipitation and average temperature from 1959 to 2012 time series.

Year	ACP/mm	Year	AT/℃
1959	1126.2	1959	15.2
1960	1074.2	1960	15.6
1961	1100.3	1961	15.5
1962	900.6	1962	15.1
1963	1198.3	1963	15.8
1964	1251.5	1964	14.9
……	……	……	……
2010	1010	2010	14.6
2011	735.2	2011	14
2012	1226.4	2012	13.7
Slope	-1.9766	Slope	-0.0147
Average Mean	1103.7	Average Mean	15.1

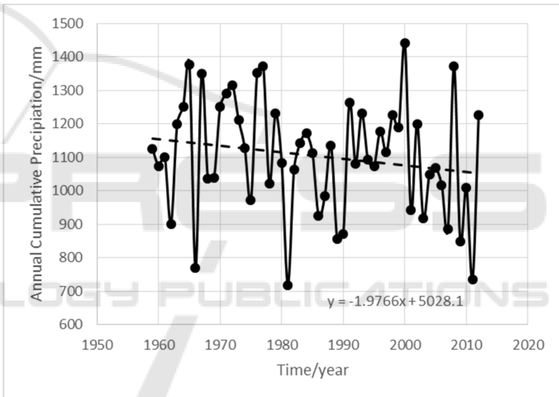

Figure 1: Scatter plot of annual precipitation series and the trend line.

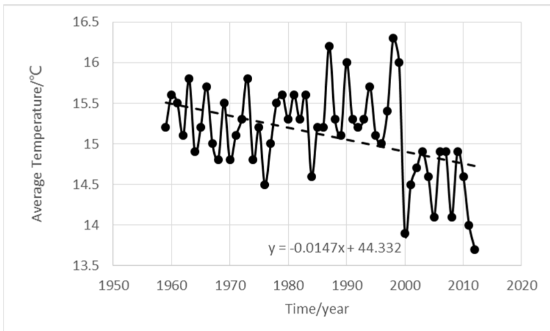

Figure 2: The scatter diagram of average temperature series and the trend line.

4 ALTERATION DIAGNOSIS OF METEOROLOGICAL FACTORS

4.1 Hydrological Alteration Diagnosis System (Xie et al, 2010)

Deterministic components and stochastic components are included in the hydrological series, while deterministic components include cycle, trend, and jump components. If the hydrological series has nothing to do with cycle, trend and jump components, it is a stable series, which indicates that the whole hydrological series has the same physical causes, and its statistical regulations is consistent, that means the distribution form (such as p-III type) and distribution parameters (such as mean value, coefficient of variation) remain unchanged in the whole time range of the series, the hydrological series only has the same physical causes. Otherwise, the hydrological series is non-stationary, which indicates that the physical causes of the hydrological series have changed, and the statistical regulation is inconsistent, the distribution form or (and) distribution parameters have changed. Therefore, from a statistical point of view, the alteration of hydrological series mainly refers to the significant change of the distribution form or (and) distribution parameters of hydrological series.

Hydrological alteration diagnosis system was composed by Xie in 2010 to diagnose the alteration of hydrological series. The system mainly considers two alteration forms of trend and jump, and consists of three parts: preliminary diagnosis(PD), detailed diagnosis(DD) and comprehensive diagnosis(CD). Firstly it adopts the Hurst coefficient method etc. to make a primary diagnosis and judges whether or not the series contains alteration. If it does, then various examination methods may be used to conduct a detailed diagnosis, including three trend diagnosis methods and eleven jump up diagnosis methods. The diagnosis results are also classified into two types, trend and jump results, for which the trend comprehensive and jump comprehensive are used respectively. Nash efficiency coefficients are calculated to identify alteration form of the series, and the alteration form may be judged if the coefficient is bigger than the other one, but a hydrological survey analysis is often needed before making the conclusion to confirm the diagnosis results. The system can overcome the shortcoming of either a single-method examination in producing unreliable results on occasion or a multiple-methods examination in producing a conflict among the results.

The system can not only identify and test the time series alteration and its alteration degree (no variation, medium variation, strong variation, and great variation) as a whole, but also identify the variation form (trend, jump variation point) of inconsistent series. The test indexes are comprehensive, the weight assignment is objective, and the diagnosis result is reliable.

4.2 The Results of Alteration Diagnosis

Under the condition of the first reliability level $\alpha=0.05$ and the second reliability level $\beta = 0.01$, the HADS was used to diagnose the meteorological factors of Guiyang Station from 1959 to 2012, the alteration diagnosis results shown in Table 2 as below.

Table 2: Meteorological factors series alteration diagnosis results per area.

Factors	AP	MP	AT	MAXT	MINT
Hurst coefficient	0.643	0.743	0.837	0.633	0.757
Total alteration degree	no	medium	medium	no	medium
Sliding F Test		1989(+)	1986(+)		1968(-)
Sliding T Test		1990(+)	1999(+)		1977(+)
Lee-Heghinan		1990(0)	1999(0)		1977(0)
Sequential Cluster		1990(0)	1999(0)		1977(0)
RS analysis		1963(0)	1977(0)		2009(0)
Brown-Forsythe		1990(+)	1999(+)		1977(+)
Sliding Run Test		1973(+)	2011(+)		2000(+)
Sliding Rank-Sum Test		1990(+)	1999(+)		1977(+)
Optimal information two segmentation		1993(0)	1999(0)		1977(0)
Mann-kendall		1990(+)	1999(+)		1982(+)
Bayesian analysis		1990(+)	1999(+)		1977(+)
Tendency alteration degree		none	trend medium		none
Relevant coefficient method		-	+		-

Table 2: Meteorological factors series alteration diagnosis results per area (cont.).

Factors	AP	MP	AT	MAXT	MINT
Kendall		-	+		-
Jump point		1990	1999		1977
Comprehensive weight		0.73	0.74		0.71
Comprehensive significant		5(+)	5(+)		4(+)
Comprehensive significant		3(-)	3(+)		3(-)
Efficiency coefficient of jump alteration(%)		15.57	46.74		15.14
Efficiency coefficient of tendency alteration (%)		6.18	17.15		5.02
FINAL result		1990(+)↑	1999(+)↓		1977(+)↑

Where: the "+", "-", "0","↓"," ↑" means significant, not significant, could not be tested, decrease and increase

It can be seen from Table 2 that in the area annual precipitation (AP) and annual extreme maximum temperature (MAXT) series of the center in Guizhou, the series are not alterated. The maximum one-day precipitation in a year (MP) series of the center in Guizhou, the series had medium alteration of jumping upward, and the jumping points is 1990. The average temperature (AT) series of the center in Guizhou, the series had medium alteration of jumping downward, and the jumping points is 1999. The annual extreme minimum temperature (MINT) series of the center in Guizhou, the series had medium alteration of jumping upward, and the jumping points is 1977.

It can be seen from Figure 1, Figure 2 and table 2 that in the area AP and AT series of the center in Guizhou, the trend are downward, and AP series had no alteration and AT series had medium alteration. It is shown that there is no connection between trend and alteration, variation occurs when the trend or jump exceeds a certain threshold.

MP, AT and MINT had medium alteration, the variation indicate that the area is greatly affected by climatic conditions, and whether it is affected by human activities needs further study.

5 CONCLUSION AND DISCUSSION

Deterministic components and stochastic components are included in the meteorological series. ACP and MAXT series had no alteration, show that annual scale rainfall and annual extreme maximum temperature had no obvious feedback to the climatic conditions, from the perspective of statistics, the deterministic components have little influence on the series.At the same time, MP, AT and MINT had medium alteration, the variation indicate that the area is greatly affected by climatic conditions.

The maximum one-day precipitation in a year series had medium alteration of jumping upward, shows that extreme rainfall will be more frequent in center Guizhou, and the time point is 1990. The average temperature series had medium alteration of jumping downward, shows that the temperature is on the rise in the area, and the time point is 1999. The annual extreme minimum temperature had medium alteration of jumping upward, shows that the lowest temperature is on the rise in the area, and the jumping points is 1977.

Above all, precipitation has little impact on the climatic conditions in the study area, but extreme precipitation event is influenced by environmental factors. Meanwhile, changes in temperature and extreme temperature indicate a gradual warming trend. Climate change has a great impact on the local area. The extreme rainfall anomaly began in 1990, the annual average temperature anomaly began in 1999, and the extreme minimum temperature anomaly began in 1977.

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