A statistical analysis of climate change in Guiyang, Southwest China

Shuangshuang Hou¹,*, Lifei Yu¹ and Wei Yan²
¹College of life sciences, Guizhou University, Guiyang, China
²School of geographic science, Xinyang Normal University, Xinyang, China
*Corresponding author: sshou@gzu.edu.cn

Abstract. With global warming a certainty now, all human activities should adapt the local climate change. It is important to study the characteristics of climate change in Guiyang due to rapid development and little research has been carried out. Supported by meteorological data of 8 weather stations in Guiyang from 1980 to 2017, Mann-Kendall analysis results of the study area for monthly mean temperature and total precipitation show that warming and the alteration of precipitation pattern is appearing with the temporal-spatial heterogeneity. The changing of the precipitation temporal-spatial patterns will indeed increase the risk of drought and flood disasters. The abrupt warming point occurs mainly after 2000, while the abrupt point of precipitation is not significant. The temporal-spatial heterogeneity of climate change is should be considered when implementing the development strategy. Our study can provide a reference for regional climate change research and guidance for making key decisions in the development in the term of environment.

Keywords: Climate change, Monthly, temperature, precipitation, Mann-Kendall test, Guiyang.

1. Introduction
Climate change is well known widely with the characteristics of climate warming and frequent extreme weather events (ig. Heat wave and cold damage) [1-4]. Climatic warming impacts many sectors of the world such as stability of ecological system, agriculture, human healthy and economic development [5]. Sustainable development of human society depends on climate [6, 7], and it is of largest important to study regional climatic characteristics for meeting the climate warming and making key decisions in the development of society.

There are many studies about characteristics of climate change using mainly two methods of calculating with models (ig. Canadian Global Climate Model CGCM [6, 7], National Center for Atmospheric Research, United States NCAR [9]) and the statistical analysis with monitoring data from national or local meteorological Authority [7, 10]. Simulating with models are usually used in large scale, such as global, continental and national scale [8, 10]; however, large-scale climate trend generalizations may not exactly reflect climatic situations of the special region [7, 11]. As a result, studies on climate change trends have been carried out in different parts of the country, which generally use statistical analysis with the Mann-Kendall test as a main method. Many studies of climate change
for regions are mainly carried out at province-scale [15], but the city-scale climate change has been received little attention. Human activities and government development policies are indeed produced at the city-scale. Therefore, quantifying the climate change at the city-scale is important.

Facing the changing climate and aging, Guiyang City has a huge advantage to develop carbon sink and silver industry for its advantageous climate. The study of climate change trend is important for the development of Guiyang, while there is a little report unfortunately. Therefore, using Mann-Kendall test, we analysis the trend of climate change from 1981 to 2017, which will provide guidance for making key decisions in the development in the term of environment.

2. Methods
In this work, Mann-Kendall test [7, 13], widely applied in meteorology, is used for analysing the characteristics of climate change, including trends and abrupt point supporting by meteorological data of 8 stations (Fig.1) from 1981 to 2017 in Guiyang City.

3. Results and discussions
3.1. Temperature characteristic
Fig.2 displays the trend and abrupt point of monthly mean temperature using Mann-Kendal test in Guiyang from 1981 to 2017.

Results show that the monthly mean temperature has an increasing trend for all synoptic stations during most months except Guiyang station. For the weather stations having positive trend (Fig.2a-b&f-h), the trend of monthly mean temperature increasing above the significance level of 5% for some months ranges from 0.05 to 0.09 °C/yr, and these stations can be grouped into 3 general categories due to different significance level and abrupt points of every month. First type, including Xifeng (Fig.2a), Kailiang (Fig.2b) and Xiuwen (Fig.2c) station, the monthly mean temperature of these stations increases significantly during spring (February, March and April) and autumn (September and October), but other months has non-significant trend. The abrupt point appears early either 2000s or 2010s, from which climate has been warmed remarkably. Second type, including Qingzhen (Fig.2d), Huaxi (Fig.2g) and
Wudang (Fig.2h) station, the monthly mean temperature of these stations increases significantly for most months except January, June and December. The abrupt warming point appears from 2000 to 2016, different with weather stations and months. Third type includes only Baiyun station, the trend of which above the significance level of 5% occurs in April, but other months have non-significant trend. The abrupt warming point occurs in 2004 and 2016. For Guiyang station (Fig.2e), the trend of monthly mean temperature is negative almost all the months with a 5% level of significance from May to August and December but no significant trend during others.

In summary, the monthly mean temperature generally has a warming trend with significant in spring and autumn except Guiyang station, and the abrupt warming point appears almost after 2000. The results indicate temporal-spatial heterogeneity of the climate warming consisting with other studies of temperature variation [16, 17]. The national-scale studies indicate that the annual mean temperature increases overall for southwest, which is mainly due to warming in spring and autumn at the local-scale [12, 13, 18]; and our results confirm the conclusion. For Guiyang station, the monthly mean temperature trend decreases significantly in almost all the months which meets the result of Lian et al. [12]. Therefore, the negative trend of annual mean temperature is attributed to cooling in summer and winter.

3.2. Precipitation characteristic

Fig 3 shows the trend and abrupt point of monthly total precipitation using Mann-Kendal test in Guiyang from 1981 to 2017.

Results indicate that the monthly total precipitation has a non-significant trend for all synoptic stations during most months, and a small number of stations has a significant trend. Monthly total precipitation trends for Xifeng (Fig.3a) are negative but not significant in January, February, April, July, September and November, while others are positive with significant only in March and December. Monthly total precipitation trends for Kaiyang (Fig.3b) are negative in January, February, May, July, September and November with significant in February and September, while others are positive with significant only in March and December. Monthly total precipitation trends for Xiuwen (Fig.3c) are negative in January, February, April, September and November, with significant in September, while others are positive with significant only in December. Monthly total precipitation trends for Qingzhen (Fig.3d) are negative in February, April, June, September and November with significant in February, while others are positive with significant only in March and December. Monthly total precipitation trends for Guiyang (Fig.3e) are negative but not significant in February, April, September and November, while others are positive with significant only in March and December. Baiyun (Fig.3f) has only 3 months of which the Monthly total precipitation trends are positive but not significant, that is March, May and July while others are negative with significant only in January, February and November. Monthly total precipitation trends for Huaxi (Fig.3g) are negative but not significant in January, February, April, July, September and November, while others are positive with non-significant. Monthly total precipitation trends for Wudang (Fig.3h) are negative in January, February, April, May, September and November with significant in February, while others are positive with non-significant. In addition, the abrupt point is not significant for most months and stations.

To summarize, the monthly total precipitation shows a significant trend only in a few months, mainly February, September and November with negative trend and March and December with positive trend. It is sure that the temporal-spatial patterns of precipitation are changing [19]. That the annual total precipitation increased significantly revealed by Lian et al. [12] is caused by the months with negative trend more than those with positive trend. In addition, it is clear that the remarkable increasing of rainfall in March and December will lead more serious low temperature disasters, while the decreasing of rainfall in February, September and November will aggravate the drought in Guiyang as karst areas [20].
Figure 2. The Mann–Kendall test of monthly mean temperature

Note: 1) The columnar value represents the Z statistic, the value above the column is the change rate of monthly mean temperature, and the value in the column is the abrupt point. 2) The dashed line in the figure is the borderline with 95% reliability.
Figure 3. The Mann – Kendall test of monthly total precipitation

Note: 1) The columnar value represents the Z statistic, the value above the column is the change rate of monthly total precipitation, and the value in the column is the abrupt point. 2) The dashed line in the figure is the borderline with 95% reliability.
4. Conclusion
Using Mann-Kendall test, the trends of climate change from 1981 to 2017 in Guiyang are studied. The results show that the warming is significant for most of the study area and remarkable after 2000 as a result of urbanization. It cannot be ignored that the cooling appears in some specific region in the context of warming. The trend of precipitation is different with months. The changing of the precipitation temporal-spatial patterns will indeed increase the risk of drought and flood disasters. Therefore, it is necessary to take the temporal-spatial heterogeneity of climate change into account when implementing the development strategy.

Acknowledgments
This work was financially supported by the Project of National Key Research and Development Program of China (Grant No.2016YFC0502604), the Natural Science Foundation of Jiangsu Province (Grant No. BK20181059), the National Natural Science Foundation of China (Grant No. 41705069) and the Young Backbone Teachers Assistance Scheme of Xinyang Normal University (Grant No.2019GGJS-07).

References
[1] IPCC, Climate Change 2014 Synthesis Report Summary Chapter for Policymakers, IPCC (2014).
[2] P. A. Testera, R. W. Litakerb and E. Berdaletc, Climate change and harmful benthic microalgae, Harmful Algae. 91 (2020) 1 - 27.
[3] W. Schlenker and M. Auffhammer, The cost of a warming climate, Nature. 557 (2018) 498.
[4] M. Beniston, Extreme climatic events: Examples from the alpine region, J. Phys. Iv. 121 (2004) 139 - 149.
[5] N. G. Dmitruk and A. A. Stepanova, Climatic characteristics changes analysis of the agroclimatic Novgorod regions, IOP Conf. Ser. Earth. Environ. Sci. 613 (2020) 12024.
[6] B. Nerlich, Climate change through an editorial lens, Nat. Clim. Chg. 8 (2018) 458 - 461.
[7] O. Chombo, S. Lwasa and M. Tenywa, Spatial and temporal variation in climate trends in the kyoga plains of uganda: Analysis of meteorological data and farmers’perception, J. Geos. Environ. Prtec. 8 (2020) 46 - 71.
[8] S. Zakaria, N. Al-Ansari and S. Knutsson, Historical and future climate change scenarios for temperature and rainfall for Iraq, J. Civil. Eng. 7 (2013) 1574 - 1594.
[9] V. V. Kharin, F. W. Zwiers, X. Zhang and M. Wehner, Changes in temperature and precipitation extremes in the CMIP5 ensemble, Clim. Chg. 119 (2013) 345 - 357.
[10] A. Kosamic, I. Kavcic, M. van Kleunen and S. Harrison, Climate change and climate change velocity analysis across Germany, Sci. Rep-Uk. 9 (2019) 2196.
[11] J. Merilä and A. P. Hendry, Climate change, adaptation, and phenotypic plasticity: The problem and the evidence, Evol. Appl. 7 (2014) 1 - 14.
[12] Y. Lian, G. J. You, K. Lin, Z. Jiang, C. Zhang and X. Qin, Characteristics of climate change in southwest China karst region and their potential environmental impacts, Environ. Earth. Sci. 74 (2015) 937 - 944.
[13] M. G. Abrha, Local climate trends and farmers’ perceptions in southern tigray, northern ethiopia, In. J. Environ. Sustainability. 4 (2015) 262 - 277.
[14] M. D. I. Bhuyan, M. M. Islam and M. E. K. Bhuiyan, A trend analysis of temperature and rainfall to predict climate change for northwestern region of bangladesh, A. J. Clim. Chg. 7 (2018) 115.
[15] A. Lin, H. Zhu, L. Wang, W. Gong and L. Zou, Characteristics of Long-Term climate change and the ecological responses in central china, Earth. Interact. 20 (2016) 2.
[16] M. Zhang, H. Ji, B. Wang, S. Wang, S. Li, W. Liu and X. Ma, Extreme drought changes in Southwest China from 1960 to 2009, J. Geogr. Sci. 23 (2013) 3 - 16.
[17] D. Schaefer and M. Domroes, Recent climate change in japan - spatial and temporal characteristics of trends of temperature, Clim. Past. 5 (2009) 13 - 19.
[18] H. Shi and J. Chen, Characteristics of climate change and its relationship with land use/cover
change in Yunnan Province, China, Int. J. Climatol. 38 (2018) 2520 - 2537.

[19] I. WW and B. MFP, Seasonal prediction of monsoon rainfall in three Asian river basins: The importance of snow cover on the Tibetan Plateau, Int. J. Climatol. 30 (2010) 1835 - 1842.

[20] D. R. Easterling, G.A. Meehl, C. Parmesan, S.A. Changnon, T.R. Karl and L.O. Mearns, Climate extremes: Observations, modeling, and impacts, Science. 289 (2000) 2068 - 2074.