Temporal and Spatial Analysis of Precipitation in Guizhou Based on TRMM 3B42 Satellite Data

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Abstract: Precipitation is an important part of the earth’s climate system. This article makes full use of the advantages of remote sensing images. In this paper, the TRMM 3B42 satellite precipitation from 1998 to 2013 is selected as the data source and Guizhou Province as the research area. The temporal and spatial distribution characteristics of precipitation in Guizhou Province are studied by linear trend estimation, linear regression analysis and ArcGIS spatial analysis. The conclusion as below: Precipitation shows a decreasing trend from southeast to northwest in Guizhou Province. From the seasonal scale, precipitation is mainly concentrated in summer and the least precipitation in winter. Over the past 16 years, precipitation in Guizhou Province has shown a fluctuating change. Summer precipitation trend is more obvious. And winter precipitation is not obvious.

1. Introduction
Precipitation is an important part of the Earth’s climate system. Precipitation and its temporal and spatial distribution have a great impact on the process of terrestrial hydrology. It has a particularly significant impact on agricultural production, such as agricultural production, urban ecological security, geological disaster prevention and so on[1-2]. Analyzing the water cycle and climate prediction under the background of climate change has a great significance to analyze the distribution and variation of regional and global precipitation[3].

Tropical Rainfall Measuring Mission was the first satellite in the world to launch a rain radar in November 1997[4]. TRMM satellite data compared to the traditional weather station. It has a large area, massive, quasi-real-time, high precision, high resolution, easy to form the advantages of time series. It is geographically free from geographical constraints and has high accuracy and reliability in spatial statistical analysis. It complements the observation of traditional weather stations in extreme climates and remote areas. Domestic and foreign scholars on the temporal and spatial characteristics of precipitation and its related applications for a large number of studies. Christensen et al. studied the extreme precipitation characteristics of summer in Europe [5]. Puri et al. uses the TRMM PR back echo signal to study the wetland water level in South Florida, USA[6]. Liu and Bo used the TRMM precipitation data to analyze the summer precipitation distribution characteristics in Asia[7]. Liu et al. utilizes the precipitation data of 650 stations in the south of 50°N in mainland China and he analyzes the applicability of TRMM3B42 to the south of 50°N in China on the day, month and year scale[8].
Zhang studies the temporal and spatial distribution characteristics of precipitation in Hengduan Mountains Based on TRMM data\cite{9}. Wu et al. analyzed the applicability of TRMM data in Chongqing and the Three Gorges reservoir area, and analyzed its temporal and spatial distribution characteristics \cite{10-11}.

Guizhou Province is located in the eastern monsoon region of China, which is influenced by the movement of monsoon circulation and subtropical high pressure belt. There is a difference in the distribution of rainfall in this area. The spatial distribution of rainfall in the mountainous area of Guizhou Province is also affected by the terrain. Through the analysis of the temporal and spatial distribution characteristics of precipitation in Guizhou Province in recent years, it is helpful to strengthen the monitoring and forecasting of meteorological disasters such as floods and droughts. This will reduce the economic losses caused by floods, droughts and other meteorological disasters and geological disasters caused by differences in rainfall. Remote sensing satellite data show a strong superiority in areas where the meteorological observation is scarce, especially for areas where the mountainous and natural conditions are relatively poor in Guizhou Province. It is of great significance to comprehensively understand the temporal and spatial distribution characteristics of precipitation in Guizhou Province. Therefore, this paper uses the TRMM 3B42 daily precipitation satellite data from 1998 to 2013 in Guizhou Province. The temporal and spatial distribution characteristics of precipitation in Guizhou Province were analyzed by linear regression method and ArcGIS spatial technique. The aim of this study is to provide reference for regional flood control, water resources utilization and integrated river basin management practice.

2. Study area
Guizhou Province is located in the southwest of China's Hengduan Mountains, attached to the Yunnan-Guizhou Plateau and it located in China's first ladder and the second step of the buffer zone. Guizhou Province is a typical ups and downs of the terrain, latitude and karst topography typical development of the mountain, its average elevation of about 1100 meters. The landscape is dominated by mountains and hills. It is located in the eastern part of the eastern monsoon region of China, belonging to the subtropical monsoon climate. It is located in the Qinling Mountains Huaihe line south, the annual average temperature of 15 °C or so. Its annual precipitation is between 1000-1300 mm, But the uneven distribution of precipitation season, 80% of the rain concentrated in the summer and autumn.

3. Data and Methods

3.1. Data description
The data used in this study include the 1998-2013 TRMM 3B42 daily data and the administrative divisions of Guizhou Province. Among them, TRMM 3B42 satellite data coverage between 50 °N-50 °S between the global grid of data sets. Its time resolution is the day scale and the spatial resolution is 0.25 °× 0.25 ° (about 25km). This data is available free of charge on the NASA website (http://trmm.gsfc.nasa.gov/).

3.2. Methods - Linear Trend Analysis
Linear trend analysis is a commonly used method for estimating the trend of climate change. The concrete method is that the time series of precipitation in a region can be quantitatively described by a linear equation \cite{12}

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Y = a + bt
\]

Where Y represents the precipitation; a, b represents the regression coefficient; and t represents the time series.
4. Spatial distribution characteristics of precipitation

4.1. The spatial distribution of annual precipitation
The authors use the average precipitation from 1998 to 2013 to carry out temporal and spatial analysis of the study area. The annual precipitation in Guizhou Province shows a decreasing trend from southeast to northwest. Among them, the eastern and southern precipitation is the largest and the spatial difference is small and the annual precipitation forms three high-value centers in the spatial distribution. Annual precipitation is generally greater than 1200mm. And in the Southeast Guizhou Tianzhu, Jinping, Liping, from the river and other counties near the annual precipitation of more than 1600mm. The precipitation in the northwest region is the least, mainly including the Bijie region, the western part of the Tongren area.

4.2. The spatial distribution of annual precipitation
The seasonal variation of precipitation in Guizhou Province is quite different. Summer precipitation accounted for 48% of annual precipitation, only 5% in winter, spring and autumn were 29%, 18%. The spatial distribution of precipitation in spring and the spatial distribution of the year show a large similarity. It shows a downward trend from southeast to northwest, and the precipitation value is formed from the east to the west with three longitudinal bands (Figure 1). The study area is formed from the north to the south, including the first precipitation belt, including pine peach, Yuping, Tianzhu, Jinping, Liping and Congjiang counties. It is also the high value center of spring precipitation and the precipitation reaches 500mm. In the middle of the study area, the second precipitation zone centered on Zunyi area, Guiyang, Duyun, Anshun and Xingyi areas was formed and the precipitation is about 300mm. The study area takes the third section of the precipitation in Bijie. Precipitation is only about 100mm and the precipitation is concentrated in the west of Weining County. Summer precipitation is the highest in the year and the precipitation is generally above 400mm. The center of Xingyi and Anshun near the center as the center of the formation is the high precipitation center. Autumn precipitation In addition to the Tongren area and the northeastern region of Zunyi area precipitation is greater than 200mm, most areas of precipitation are about 150mm. Winter precipitation is generally low and the precipitation decreases gradually from west to west. In addition to Tianzhu, Jinping and Liping counties such as the eastern part of the precipitation is greater than 100mm, the other areas of precipitation are less than 50mm. Among them, most of the Bijie area and the northwest of Zunyi area have the lowest precipitation, and the precipitation is only a few millimeters.

4.3. Spatial distribution of monthly precipitation
Precipitation in Guizhou Province is very different in different months. In this paper, some monthly precipitation is selected for time and space analysis. In the whole year, the precipitation in June and

Fig 1. Spatial distribution of mean precipitation in spring and summer
July is the largest, with an average of about 200mm, while the lowest monthly precipitation in December is only 17mm. Only the southeastern region of Tianzhu, Jinping and Liping and other regions of the precipitation is greater than 50mm and the majority of the rest of the precipitation is less than 20mm. The average precipitation in April and October is only 80-90mm. The precipitation in April is mainly concentrated in the eastern region, while the precipitation in the western region is relatively small. The high value of precipitation center is always in the south and east between the cyclical movement.

5. Temporal variation of precipitation

5.1. Annual precipitation trend
The precipitation in the study area in 1998 - 2013 shows a decreasing trend. In 1998, the precipitation was 1196mm, and in 2013 it was reduced to 998mm. Compared with 1998, precipitation decreased by 17%. There is a corresponding periodic fluctuation in the precipitation of the study area. Among them, the precipitation in 2001, 2003, 2006, 2009 and 2011 is relatively reduced and form an underestimated area. On the whole, there will be a trough every three years. While the annual precipitation in 2000, 2002, 2005, 2008, 2010 showed an upward trend and there will be a crest on average every 2.5 years. In 2002 precipitation reached a high of more than 1300 mm and the minimum precipitation in 2011 is only 850mm.

5.2. Seasonal precipitation trend
The difference of precipitation in four seasons is significant. The summer precipitation is decreasing obviously. Precipitation decreased from 664mm in 1998 to 356mm in 2013 and it is the largest decline in the four seasons. Spring precipitation, in addition to 2005 is 550mm, the other year remained at about 300mm. The four seasons high precipitation centers move with seasonal changes. Spring is located in the eastern part of the study area, while the summer is moved to the southwest of Xingyi, Xingren area. The autumn moved to the northeastern part of the Tongren area, while the winter returned to the eastern region. During the spring to winter, the range of high-value centers is narrowing. The maximum precipitation in summer is 543mm. The average rainfall in spring is 327mm, the autumn is 207mm and the winter precipitation is the smallest, only 58mm (Detailed data in Table 1).

| Year | Spring | Summer | Autumn | Winter | Total precipitation |
|------|--------|--------|--------|--------|---------------------|
| 1998 | 305.1  | 664.5  | 169.5  | 57.3   | 1196.6              |
| 1999 | 295.7  | 722.9  | 216.2  | 34.6   | 1269.5              |
| 2000 | 363.5  | 652.2  | 256.1  | 38.6   | 1310.6              |
| 2001 | 304.1  | 536.9  | 219.6  | 34.4   | 1095.1              |
| 2002 | 405.6  | 652.2  | 244.4  | 38.6   | 1341.0              |
| 2003 | 329.3  | 455.8  | 145.1  | 89.1   | 1019.4              |
| 2004 | 315.9  | 593.2  | 182.6  | 85.9   | 1177.7              |
| 2005 | 548.5  | 462.9  | 169.2  | 70.8   | 1251.6              |
| 2006 | 305.5  | 483.7  | 255.5  | 53.2   | 1098.0              |
| 2007 | 260.6  | 705.3  | 154.5  | 56.0   | 1176.5              |
| 2008 | 348.1  | 584.4  | 315.4  | 34.6   | 1282.7              |
| 2009 | 332.1  | 487.9  | 105.7  | 38.1   | 964.07              |
| 2010 | 275.0  | 541.4  | 254.8  | 68.9   | 1140.3              |
| 2011 | 191.1  | 368.1  | 268.8  | 22.5   | 850.6               |
| 2012 | 283.8  | 425.4  | 149.0  | 49.9   | 908.3               |
| 2013 | 377.6  | 356.6  | 208.1  | 55.9   | 998.4               |
6. Temporal variation of precipitation

In this paper, daily precipitation data of Guizhou Province from 1998 to 2013 were collected using daily TRMM satellite data. First, the overall spatial distribution characteristics of annual precipitation in Guizhou Province are analyzed. And then analyze the seasonal and monthly spatial distribution characteristics. Then, the trend of precipitation trend in year and quarter of precipitation in Guizhou Province is analyzed. Get the following conclusion:

(1) Precipitation in Guizhou Province shows a decreasing trend from southeast to northwest. As a whole formed three high-value center. The first high-value center focused on the Qianzhu, Qianping, Jinping, Liping and other counties near Qiandongnan and the second is near Tongren County, Tongren and the third Qianxin County in Qianxinan County.

(2) From seasonal precipitation, The spatial distribution of precipitation in spring is similar to that of annual precipitation, and there is a trend of decreasing the southeast to northwest. The precipitation value is formed from the east to the west with three longitudinal bands. Summer precipitation is the largest, accounting for 48% of the year and most of the autumn precipitation is 150mm and winter precipitation is generally low.

(3) In the past 16 years, the annual precipitation in Guizhou Province has a tendency to fluctuate slightly in a small extent. The fluctuation range is small and the area is mainly in the eastern part of the study area. Four seasons precipitation showed a trend of fluctuation. Among them, the summer precipitation trend is more prominent, followed by spring and autumn and the winter trend is less obvious.

7. Discussion

Although this study has done a lot of work, but there are still some shortcomings in this paper.

(1) The TRMM satellite rainfall data selected in this paper is daily rainfall data. The data has a long time continuity, but because of the low resolution, the resulting in spatial distribution can not be more accurate.

(2) The temporal and spatial distribution of precipitation in Guizhou Province is analysed. The trends and spatial distribution of year, season and month were discussed. But, it is necessary to analyze the trend of precipitation in typical areas.

(3) This paper summarizes the satellite precipitation data of Guizhou Province in 1998-2013 for 16 years, and the data age is relatively short.

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