Analysis on the LUCC on Annual Distribution of Runoff in Liusha River Basin

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Abstract. Natural tropical forests in the Liusha river basin of xishuangbanna have been replaced by artificial economic forests such as rubber and tea trees since1976. Land use/cover change has affected the annual distribution characteristics of river runoff in the basin. This paper based on Liusha river basin in Menghai hydrology station monthly runoff data from 1963 to 2015. It analyzed the watershed runoff annual distribution of each seasons and month under land use and cover change analyzing the characteristics of distribution of annual runoff by Non-uniform Coefficient C_u, Concentration Ratio C_d, Absolute change ΔR and Relative changes C_m. The Cumulated filter method, Mann Kendall method and R/S analysis method also are used to study the historical and future trends of runoff and its characteristic indexes. Results show that the decade and annual runoff of Liusha river of each season are large difference. The current and future monthly runoff differences are gradually reduced and the annual runoff distribution tends to be concentrated. It can optimize the utilization of water resources and guarantee the regional water security to study the characteristics of land use and cover change on the annual distribution change of river runoff.

1. Introduction
With the economic developing, the expansion of planted rubber and tea in the Liusha River Basin in Xishuangbanna have caused the destruction of tropical forests which caused the fragmentation of forest landscapes [8] in the half past century. A large number of studies [9-11] also showed the replacement of the original tropical forest by the rubber plantation in Xishuangbanna has caused problems such as local climate change, soil degradation, water pollution and water conservation. Especially during the period from 1976 to 1999, the forest land in the Liusha River Basin was seriously damaged [1] that the rubber and tea plantation and construction land increased by nearly three times which had a certain impact on regional water resources security.

2. Materials and methods

2.1 Study Site
The Liusha River Basin is located in the west of Xishuangbanna in Yunnan Province (about100°5'-100°35'E, 21°40'-22°06'N). The drainage area is about 2067km². It is controlled by the southwest monsoon and is a tropical monsoon climate. There are dry seasons and rainy seasons throughout the year, with an average annual temperature of 21.8°C and an average annual precipitation of 1492.9 mm,
80% of which is distributed during the rainy season. The height difference of the basin is large and fluctuating, with a maximum altitude of 2400m and an elevation of 499m[^1].

At present, there are few studies on the distribution of runoff during the year even relevant research has been carried out on the factors affecting land use and topography in the Liusha River Basin. During the year to provide reference for future regional water resources allocation and planning management, this paper uses a variety of characteristic indicators and methods to analyze the distribution characteristics of runoff within the Liusha River Basin.

### 2.2 Data Collection
The data comes from the monthly runoff data from 1963 to 2015 in the Liusha River hydrologic station located in Menghai County, Xishuangbanna. The station is the main control station in the middle and lower reaches of the main stream of the Liusha River. The controlled drainage area is 1032km².

### 2.3 Runoff annual distribution characteristic index
The uneven coefficient $C_u$[^2], Degree of concentration ($C_d$)[^2,3], and Change magnitude $C_m$[^4] are used.

### 2.4 Analysis of annual variation trend of runoff
The cumulative filter method[^5], the Mann-Kendall method[^9], and the R/S analysis method[^7] are used.

### 3. Variation characteristics of annual runoff distribution

#### 3.1 Annual distribution of runoff

##### 3.1.1 Seasonal distribution
The Liusha River is a typical inland river. Due to the combined effects of climate change and human activities, the basin runoff is unevenly distributed during the year. The statistical results of the inter annual average and anomaly values of the Liusha River four-season runoff are shown in Table 1.

| Period        | Spring (Mar.-May) | Summer (June-Aug.) | Autumn (Sep.-Nov.) | Winter (Dec.-Feb.) |
|---------------|------------------|--------------------|--------------------|-------------------|
|               | average          | anomaly value      | average            | anomaly value     |
| 1963-1969     | 3.12             | -2.33              | 35.02              | 5.37              |
| 1970-1979     | 4.11             | -1.34              | 32.04              | 2.39              |
| 1980-1989     | 3.05             | -2.40              | 25.86              | -3.79             |
| 1990-1999     | 4.94             | -0.51              | 31.09              | 1.44              |
| 2000-2009     | 10.01            | 4.56               | 31.37              | 1.72              |
| 2010-2015     | 7.45             | 2.00               | 22.51              | -7.14             |
| 1963-2015     | 5.45             | 29.69              | 24.29              | 8.11              |

It can be seen from Table 1 that (1) the runoff presents a certain fluctuation so the epochs of the runoffs in each season have positive and negative values. Among them, from 2000 to 2015, the spring runoff was relatively peak. In the spring of the 1980s, the average annual runoff of the runoff was 5.45×10⁶m³, accounting for 8.07% of the annual runoff, and 0.412×10⁸m³/10a. The trend rate has been increasing. The average annual runoff in summer is 29.65×10⁶m³, accounting for 43.92% of the annual runoff, and the trend rate of -0.526×10⁶m³/10a is decreasing. On the whole, the spring and winter,
summer and autumn, and inter annual runoff of the Liusha River Basin are quite different, and the runoff changes are not stable in each season, but the inter-annual and inter-annual runoffs between spring and winter, summer and autumn are not the same. Large, the current runoff is relatively dry.

3.1.2 Distribution of each month
The statistical results of annual distribution characteristic values of runoff in menghai station of liusha river basin in each year are shown in figure 1.

(1) The distribution of runoff in each year of the Menghai Station is “single-peak” and the runoff is mainly distributed from May to October. The average runoff in this period accounts for 74.84% of the whole year especially from July to September. it is more concentrated. The average runoff in this period accounts for more than 51% of the whole year. The average runoff for the largest continuous period of 2 months (July to August) is 8.6 times of the minimum minimum of 2 months (3 to 4 months). (2) The maximum monthly average runoff of Menghai Station mainly occurred in August. The maximum monthly average runoff accounted for 18.25%~23.97% of the whole year. The minimum mainly occurred in March and April. In general, the Liusha River runoff was unevenly distributed during the year. Also monthly runoff was relatively slanted during the year in the 1960s and 1970s. Currently, the monthly runoff is relatively dry which limits the social and economic development of the basin.

3.1.3 Annual trend
The actual measured runoff in the basin changed during the year under the influence of multiple factors such as climate change and human activities. The cumulative filter values of runoff in four seasons and each month of the year show that the runoff of the river increases in spring and decreases in other seasons. It decreases in all months except those in March to May and December.

3.2 Characteristics of annual runoff distribution

3.2.1 Index variation
The inter annual process of runoff annual distribution index, its linear trend line, polynomial fitting line and statistical results of the annual characterist runoff in spring (Mar to May) showed an increasing trend, while the rest of the runoff was a decreasing trend in the future.
Figure 2 Inter-annual process of distribution characteristic index of menghai station

The cumulative filter calculation process of the distribution characteristics of the river runoff shows that the $C_u$, $\Delta R$ and $C_m$ of the annual flow of the Liusha River all show a decrease. It indicates that the monthly runoff gap tends to decrease and the $C_d$ increases and changes. So it indicated the distribution of runoff is more concentrated during the year.

4. Conclusion

a. The four seasons runoff distribution in the Liusha River Basin is uneven. Except for the runoff in the spring of 1980, the runoff in the Summer to Winter of 2010-2015 is the driest. The spring runoff increases by $0.412 \times 10^8 m^3/10a$. The other seasons are $-0.526 \times 10^8 m^3/10a$, $-0.956 \times 10^8 m^3/10a$, and $-0.219 \times 10^8 m^3/10a$ is continuously tendency decreasing. The monthly distribution of runoff mainly from May to October is “single peak type”. During this period, the runoff accounts for more than 74.84% of the whole year. The maximum monthly average runoff mainly occurs in August and the minimum monthly mean runoff appears in March and April. The runoff in other months showed a decreasing trend except for the trend of increased runoff in March and December.

b. During 1963 to 1969, the variability of runoff was large during the year in the Liusha River Basin. The maximum runoff difference was the largest in each month. The distribution of runoff was the most concentrated during the year. During 2010 to 2015, the variability of runoff was small during the year. The monthly extreme runoff gap was the smallest. The runoff was distributed during the year. The distribution of runoff is the most even in a year. At the same time, $C_u$, $C_d$, $\Delta R$, and $C_m$ change at a rate of $-0.42/10a$, $-0.052/10a$, $-1.226 \times 10^8 m^3/10a$, and $-3.159/10a$, respectively. $C_u$, $\Delta R$, $C_m$, and $C_d$ are expressed in the future. It indicates that the runoff variation tends to decrease during the year of runoff and the runoff variation decreases in each month the runoff distribution tends to concentrate during the year.

c. With the population growth and economic development in recent decades, the area of tropical forests in Xishuangbanna has declined sharply. It has been replaced by rubber plantations, wheel rests
or other artificial economic forests. According to statistics, the rubber planting area increased from 127,300 km² to 366,300 in 1990 km² nearly 3 times. Also, the planting density increased from 7.82% to 22.49%. Taking the Menghai area of the Liusha River Basin as an example, the rubber forest expanded from 0.36×10⁴ km² in 1990 to 1.11×10⁴ km² in 2014 with a growth rate of 67.58%. The LUCC in the basin has led to changes in local climate. Some problems have affected the runoff of the main control stations in the year such as soil degradation, water pollution and water conservation. It has caused a certain degree of regional water resources security influenced by season and part of the month.

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