XVIII World Water Congress
International Water Resources Association (IWRA)

Evolutionary response and countermeasures of typical urbanization rainstorm in Yunnan

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XVIII WORLD WATER CONGRESS
Water for All
Harmony between Humans and Nature
第18届 世界水资源大会
水与万物:
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Content

- Background/形势和背景
- Data and methods/数据和方法
- Main conclusions/主要结论
- Coping strategies/应对策略

Background/形势和背景

In the context of climate change and urbanization, the recurrent and serious urban storm floods and waterlogging are the current research hotspots, and are also important measures to implement the people-centered idea of disaster prevention and mitigation.




- **Climate change**

Glacier melting, extreme climate, sea level rise, etc, extreme weather events such as rainstorm, flood and drought

- **Increase of rainstorm**

2012-2016,Rainstorm days increased by 22.5% in china. (China Meteorological News)

- **Urbanization**

The urbanization rate in China has increased from 30.48% in 1996 to 65.22% in 2022.

- **Frequent urban rainstorm, flood and waterlogging**

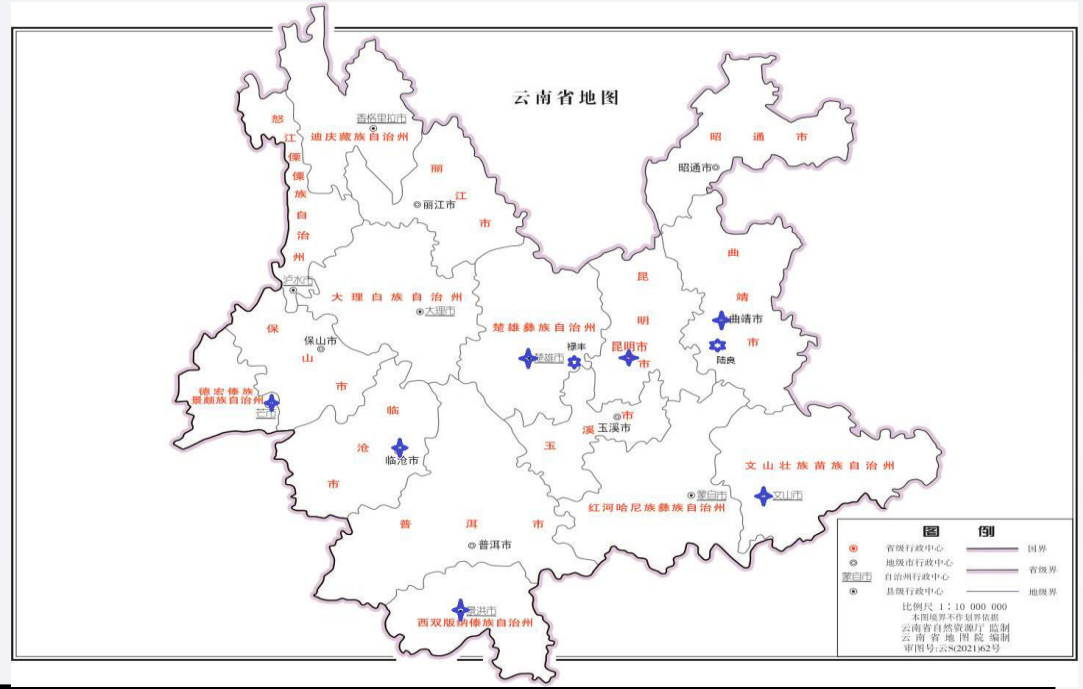
During the rainy season, we often see reports of urban waterlogging.

Background/形势和背景

- Yunnan Province is located in southwestern China, The rainy season precipitation is jointly influenced by the southeast monsoon from the Pacific Ocean and the southwest monsoon from the Indian Ocean.
- 9 typical cities of different scales：

  1 provincial capital

  6 municipal-level　　2 county-level.



序号/No	级别/level	城市/City	Urban built-up area in 1990/km²	Urban built-up area in 2000/km²	Urban built-up area in 2010/km²	Urban built-up area in 2020/km²
1	省级/provincial capital	昆明/Kunming	70	180	313	446.1
2	市级/municipal-level	麒麟/Qiling	12	23.5	64.3	109.5
3		楚雄/chuxiong	6.5	12.7	25.9	63.7
4		文山/Wenshan	9.8	15.9	31.2	46.1
5		临翔/Linxiang	0.5	1	15.3	20
6		景洪/Jinhong	10.6	13.9	23	37.8
7		芒市/Mangshi	3.7	8	17.5	21.1
8	县级/county-level	陆良/Luliang	-	-	15.5	18.4
9		禄丰Lufeng/	2.4	4.9	7.6	9.2

Data and methods/数据和方法

◆ **Data/数据:**

- 17 urban rainfall stations with more than 30 years data;
- 10 min, 1 h, 6 h and 24 h maxima rainstorm of each station over the years.
- The frequency and time of 1 h, 6 h and 24 h rainstorm in each year .

◆ **Methods/方法:**

- Trend analysis
- Comprehensive index
- P-Ⅲ Hydrological frequency analysis
- Comparative analysis
- Mann-Kendall test

Left are Satellite imagies of Kunming in 1990 and 2020, respectively

main conclusions/主要结论

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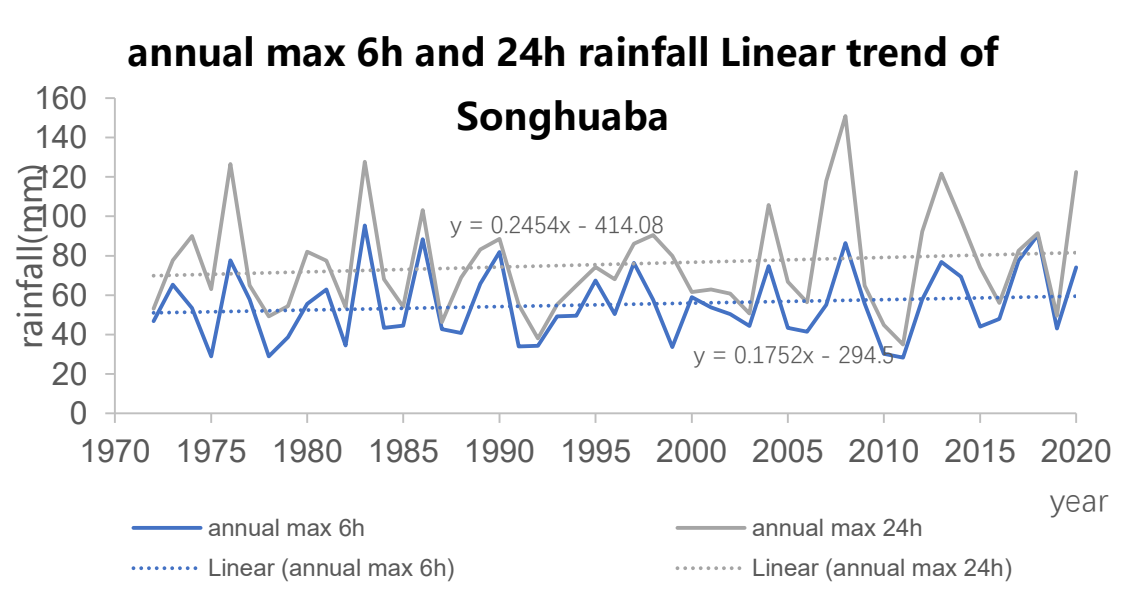
◆ 1.Intensity, frequency and seasonal evolution of urban rainstorm/典型城市暴雨强度、次数及季节演变

Kunming, Linxiang, Wenshan, Mangshi, Luliang and Lufeng which have long series data of the same period are selected as representative cities to carry out urban rainstorm evolution analysis.

➢ The increasing trend of rainstorm intensity in Kunming, Lufeng, Wenshan and Mangshi is more significent.

Linear trend evolution/线性趋势演变

Serial Number	City	Representative Station	annual max 10min	annual max 1h	annual max 6h	annual max 24h
1	Kunming	Songhuaba	-0.02	-0.02	0.18	0.25
2	Linxiang	Dawen	0.04	-0.07	-0.06	0.29
3	Wenshan	Longtanzhai	-0.02	0.15	0.26	0.31
4	Mangshi	Mukang	-0.02	0.05	0.15	-0.25
5	Luliang	Xiqiao	-0.04	-0.16	-0.08	-0.21
6	Lufeng	Donghucun	0	0.15	0.18	0.11



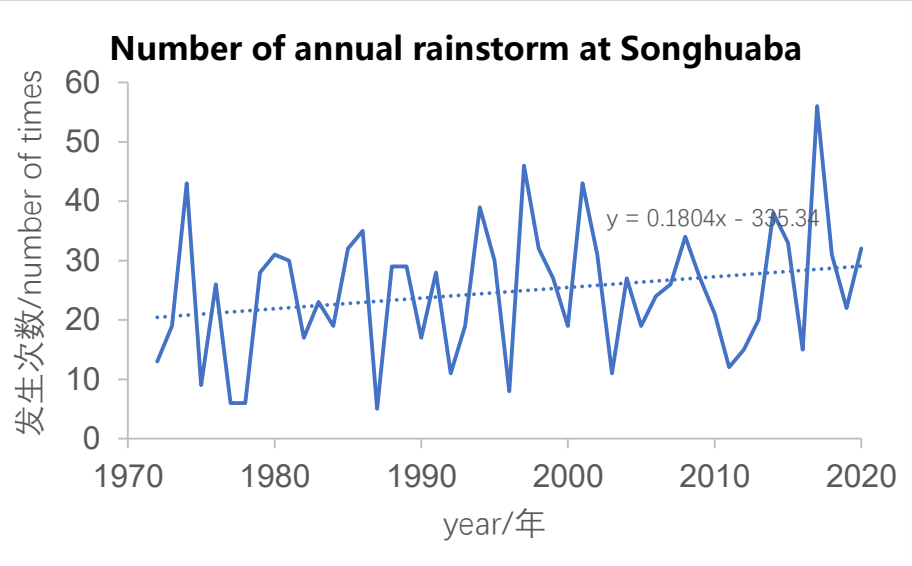
main conclusions/主要结论

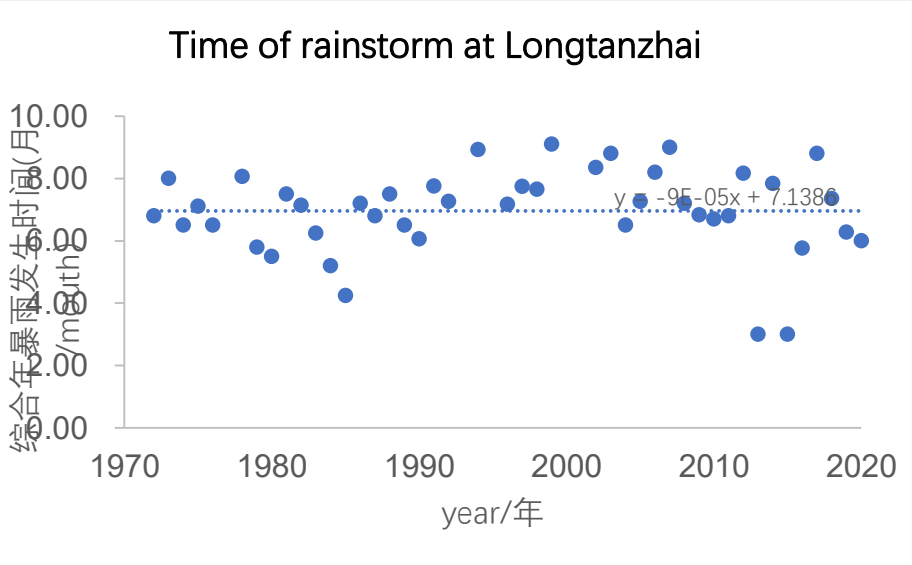
- The frequency of rainstorm in Kunming and Wenshan tends to increase.
- The probability of occurrence in Mangshi and Wenshan during dry season increases.
- The occurrence time of Kunming and Lufeng is more concentrated in June and August.

However, the above trends did not pass the Mann-Kendall test (p=5%).

The calculation formula of average comprehensive occurrence time Y of rainstorm is:

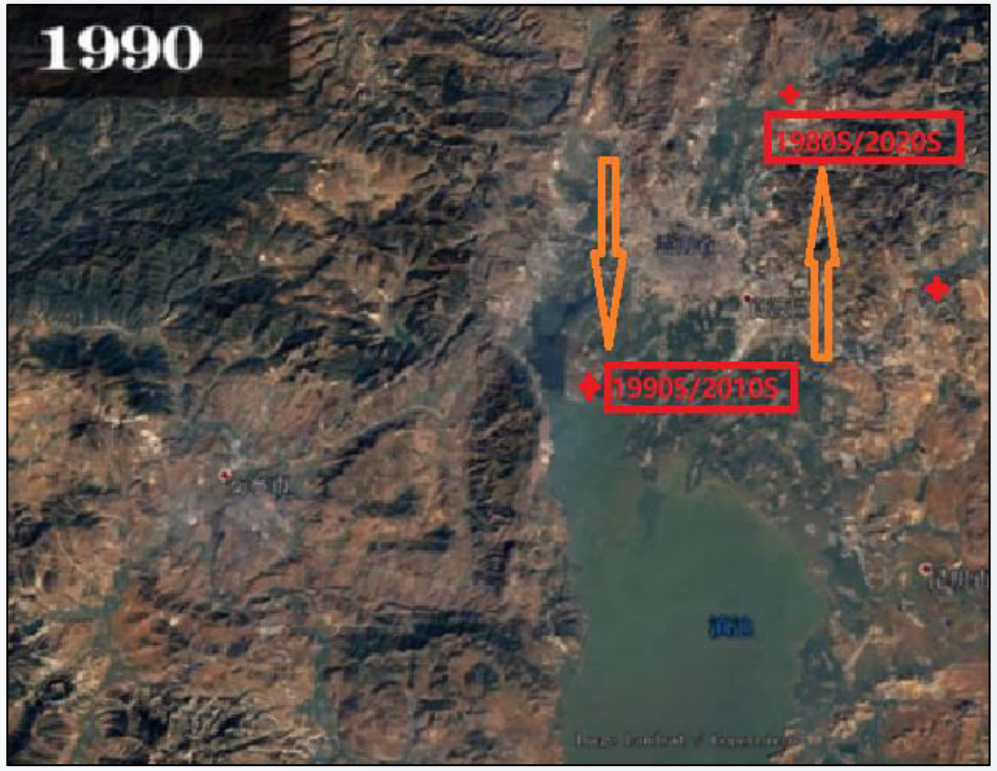
$$Y = (\sum t_i \times n_i) / N$$





◆ 2.Change of rainstorm center under urban development/城市发展下昆明暴雨中心的变化

With the pace of urban construction, the location of the extreme rainstorm in Kunming experienced the evolution process from north to south to north.



- 1980s, the maximum precipitation of 10min, 1h, 6h and 24h located in the north.
- 1990s, the maximum annual precipitation of 10 min located in the north ; the maximum precipitation of 1 h, 6 h and 24h located in the south.
- 2000s, the maximum annual precipitation of 10 min、1h located In the south, other time periods appeared located in other locations.
- 2010s,the maximum annual precipitation of 10min, 1h, 6h and 24h occurs located in the north.

main conclusions/主要结论

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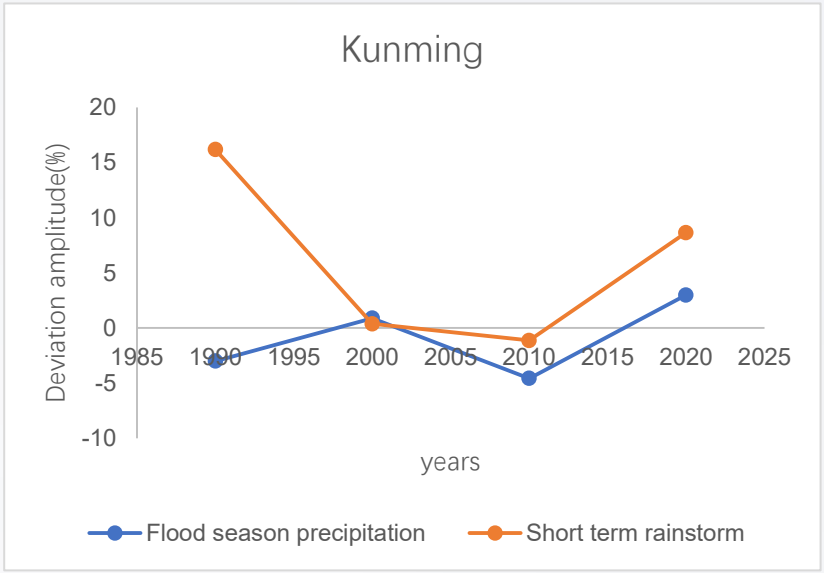
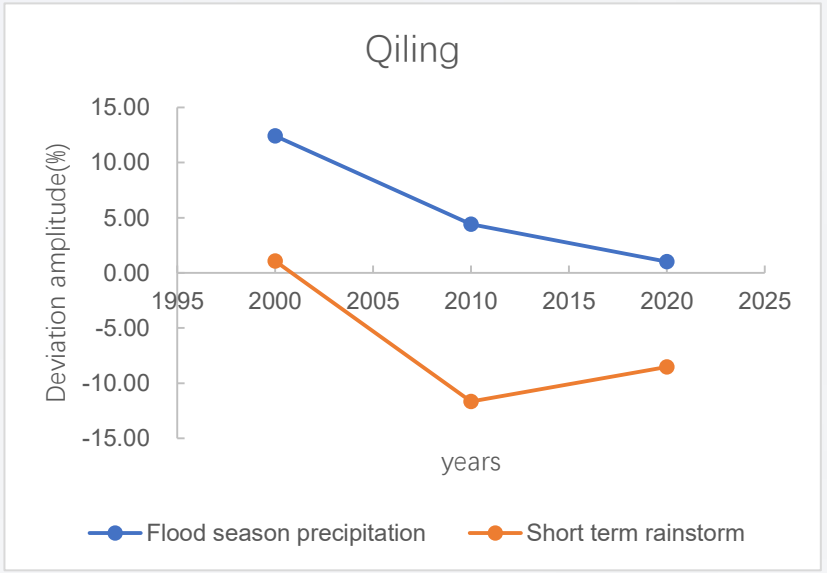
◆ 3.Impact of urban development on rainstorm/城市发展对暴雨影响

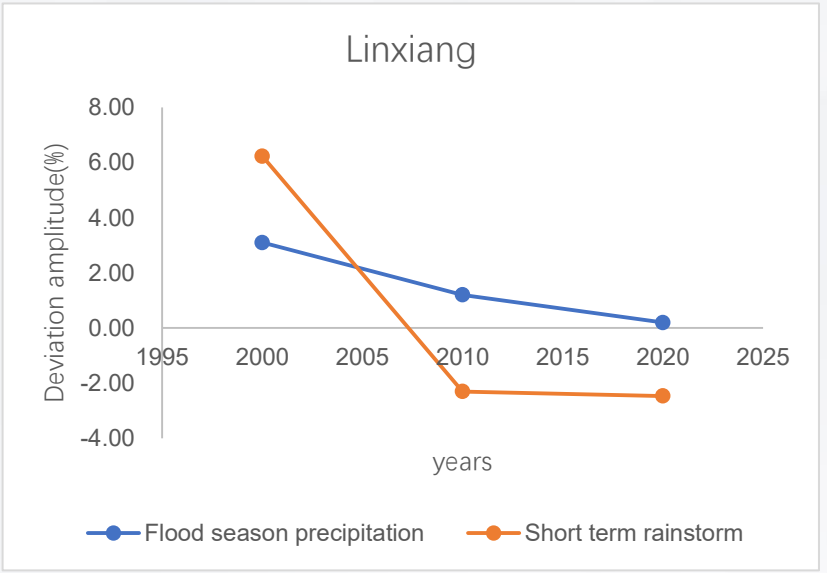
Comparative analysis on the evolution trend of urban and suburban representative stations in Kunming, Qilin, Chuxiong, Jinghong, Linxiang and Lufeng with rainstorm data in the same period.

When the built-up area is greater than 40Km^2, the impact of urbanization on rainstorm begins to appear, and the impact increases with the increase of the city size.

Example:Comparison of short-term and long-term deviation amplitude between representative stations in Kunming\Qiling\Linxiang urban area and suburban areas.







main conclusions/主要结论

The rainstorm extreme value in the central urban area of Kunming, which has the most significant impact in 2011-2020, increases by 21-31.8% in different periods on average, and the frequency increases by 15-25%.

This change has no significant impact on the hydrological frequency analysis results of rainstorm P Ⅲ in different periods at representative stations.

Station name	Location	10min（mm)	1h（mm)	6h（mm)	24h（mm)
Kunming(from 2003)	center	16.7	33.6	65.6	82.6
Songhuaba	north	13.7	29.7	58.1	78.9
Haigeng	south（Comparison station）	12.6	27.6	50	67.8
Zhonghe	Northern suburbs（Comparison station）	13	28.6	53.6	69.4
Dabanqiao	Eastern suburbs（Comparison station）	12.4	26.9	46.7	67.5
Songhuaba station compared to the average of comparison stations		8.2%	7.1%	16.0%	15.7%
Kunming station compared to the average of comparison stations		31.8%	21.3%	30.9%	21.0%

Coping strategies/应对策略

- 1. Limit the scale of large cities and promote the development of small and medium-sized cities.
- 2. Improve the design standards of urban flood control and drainage.
- 3. Take engineering and non-engineering measures to enhance the flood regulation capacity of storm flood in the upper reaches of the city.
- 4. The dry season is dry and the water supply situation is severe. It is suggested to strengthen the resource utilization of urban rainstorm and flood in rainy season.

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Thanks for attention!

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