

# Characteristics analysis of severe drought events in the Yangtze River Basin based on water balance

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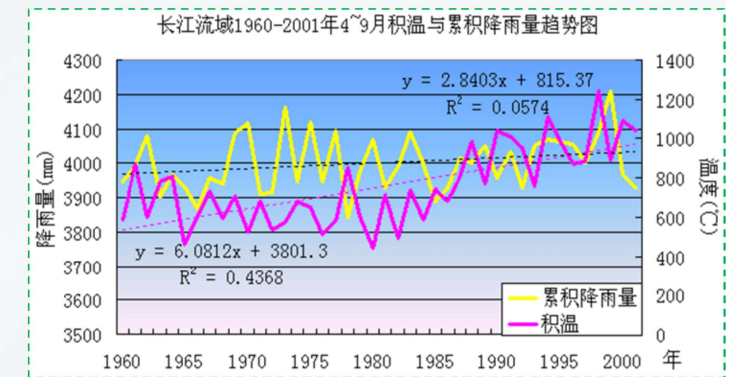
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# Content

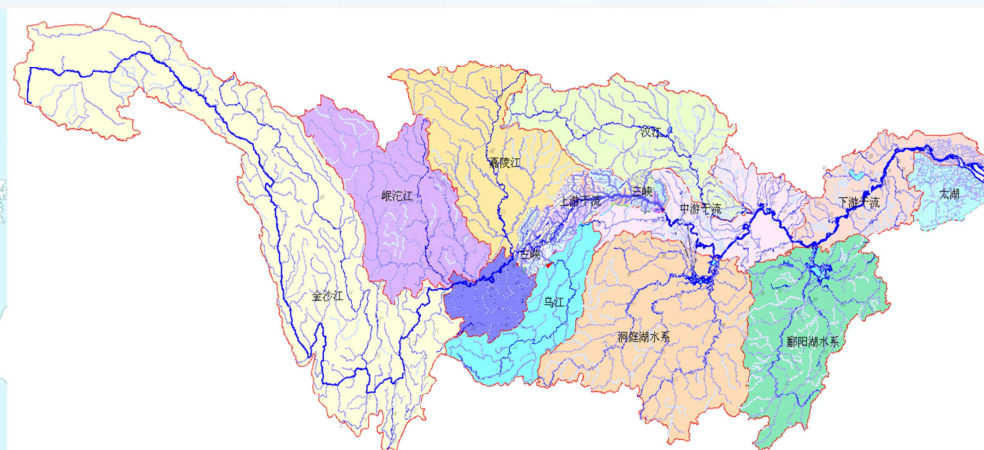
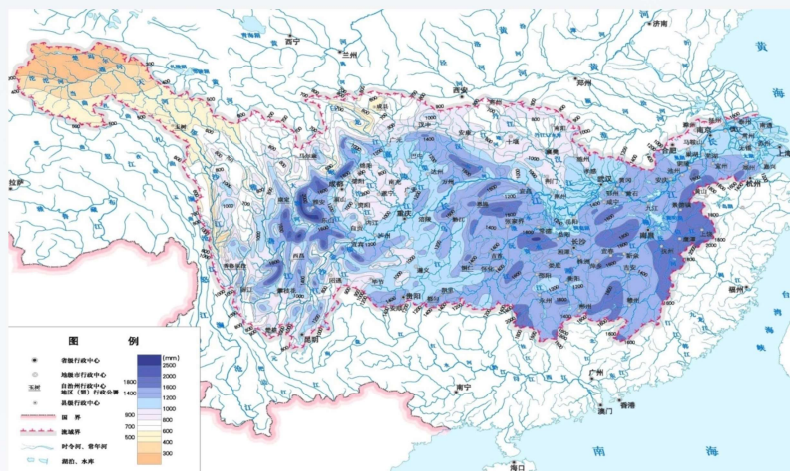
- **Background**
- **Principle and method**
- **Data and analysis**
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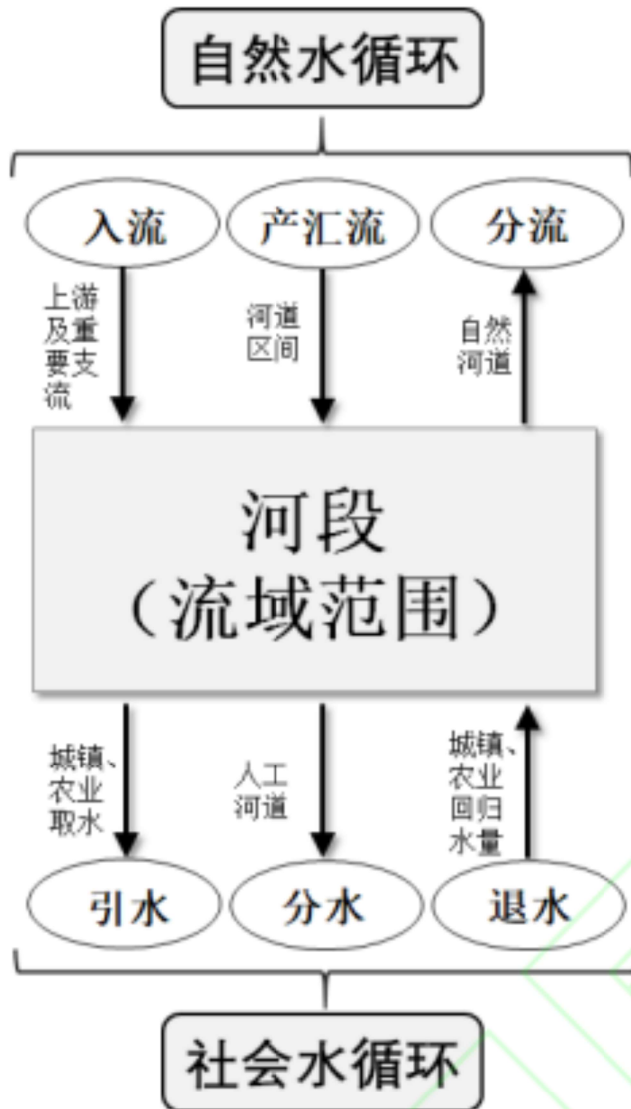


1. The Yangtze River basin covers an area of 1.8 million  $\text{km}^2$ , accounting for 18.75% of the country's total area, but the annual average sur-face water resources are 985.7 billion  $\text{m}^3$ , accounting for 36% of the country's surface water resources, and the natural endowment of water resources is superior.
2. There are 12 secondary water resources zones in the Yangtze River basin.
3. From 1900 to 2000, there were 27 floods and 9 droughts in the Yangtze River Basin. From 1980 to 2000, there were 8 floods and 3 droughts.



For 40 years 0.3-0.92°C ↑





$$P = E + Q_t + \Delta W$$

$$Q_t = Q_{na} + Q_{ar}$$

• Natural circulation

$$Q_{na} = Q_{up} + Q_{up} - Q_{ls}$$

• Social circulation

$$Q_{ar} = W_p - W_c - W_d$$

$Q_t$  为该流域的总径流量 ( $m^3$ ) ;  $Q_{na}$  为自然端径流量 ( $m^3$ ) ;  $Q_{ar}$  为社会端径流量 ( $m^3$ )

$Q_{up}$  为上游入流量 ( $m^3$ ) , 在流域节点处;  $Q_{ls}$  为与地下水的交换量 ( $m^3$ )



## Supply and demand

- T-P correlation ( The Clausius-Clapeyron relationship )

The correlation between daily rainfall and temperature

is 0.5 CC

- P-Q correlation ( Linear positive correlation )
- Water use demand ( Quota method )

Industry domestic agriculture ecology

- Agriculture and Domestic water

1 degree in temperature increases domestic water use by 1%

Agricultural water use varies with the drought

## ■ Index

□ water supply/water demand

## ■ Scenario setting

□ Water storage

□ No water storage

□ The water supply capacity is insufficient

## Meteorological data——国家青藏高原科学数据中心

### - Calculate the annual SPI to determine whether there is drought.

1) 假设某时段降水量为随机变量 $x$ ，则其 $r$ 分布的概率密度函数为：

$$f(x) = \frac{1}{\beta^\gamma \Gamma(\gamma)} x^{\gamma-1} e^{-x/\beta}, x > 0$$

$$\Gamma(\gamma) = \int_0^\infty x^{\gamma-1} e^{-x} dx$$

其中， $\beta > 0$ ， $\gamma > 0$  分别为尺度和形状参数， $\beta$ 和 $\gamma$ 可用极大似然估计方法求得：

$$\hat{\gamma} = \frac{1 + \sqrt{1 + 4A/3}}{4A}$$

$$\hat{\beta} = \bar{x} / \hat{\gamma}$$

其中

$$A = \lg \bar{x} - \frac{1}{n} \sum_{i=1}^n \lg x_i$$

式中  $x_i$  为降水量资料样本， $\bar{x}$  为降水量多年平均值。

确定概率密度函数中的参数后，对于某一年的降水量 $x_0$ ，可求出随机变量 $x$ 小于 $x_0$ 事件的概率为：

$$P(x < x_0) = \int_0^{x_0} f(x) dx$$

利用数值积分可以计算用(1)式代入(6)式后的事件概率近似估计值。

2) 降水量为0时的事件概率由下式估计：

$$P(x = 0) = m/n$$

式中 $m$ 为降水量为0的样本数， $n$ 为总样本数。

3) 对 $r$ 分布概率进行正态标准化处理，即将(6)、(7)式求得的概率值代入标准化正态分布函数，即：

$$P(x < x_0) = \frac{1}{\sqrt{2\pi}} \int_0^\infty e^{-Z^2/2} dx$$

对(8)式进行近似求解可得：

$$Z = S \frac{t - (c_2 t + c_1) t + c_0}{((d_3 t + d_2) t + d_1) t + 1.0}$$

其中  $t = \sqrt{\ln \frac{1}{P^2}}$ ， $P$ 为(6)式或(7)式求得的概率，并当  $P > 0.5$  时， $P = 1.0 - P$ ， $S = 1$ ；当  $P \leq 0.5$  时， $S = -1$ 。

$c_0 = 2.515517$ ， $c_1 = 0.802853$ ， $c_2 = 0.010328$ ，

$d_1 = 1.432788$ ， $d_2 = 0.189269$ ， $d_3 = 0.001308$ 。

由(9)式求得的 $Z$ 值也就是此标准化降水指数SPI。

SPI值	等级
$-0.5 < \text{SPI}$	正常
$-1.0 < \text{SPI} \leq -0.5$	轻旱
$-1.5 < \text{SPI} \leq -1.0$	中旱
$-2.0 < \text{SPI} \leq -1.5$	重旱
$\text{SPI} \leq -2.0$	特旱

## Water resources data——水资源公报

- Statistics of available water supply
- Calculated water supply capacity
- Water demand forecast

二级区	平均	供水	分项	本地	外调水	地下水	其他
	供水	总量	汇总和	地表水			
金沙江石鼓以上	1.39	1.8	1.8	1.73	0	0.07	0
金沙江石鼓以下	71.54	90.17	93.26	86.11	0.71	4.13	2.3
岷沱江	106.98	135.12	134.15	121.89	1.82	9.75	0.68
嘉陵江	81.49	113.8	114.4	99.12	5.02	6.76	3.5
乌江	52.22	63.93	70.06	59.3	0.38	4.29	6.1
宜宾至宜昌	79.06	110.93	113.98	109.82	0	2.66	1.5
洞庭湖水系	363.27	422.12	427.98	397.06	0	25.72	5.2
汉江	181.49	170.07	174.54	154.24	0	19.8	0.5
鄱阳湖水系	199.59	317.55	317.33	307.17	0	10.16	0
宜昌至湖口	158.87	207.88	209.19	200.37	0.67	6.13	2.02
湖口以下干流	240.89	318.69	318.03	303.98	9.25	4.12	0.69
太湖流域	300.9	357.9	359.1	267.12	89.75	1.82	0.4

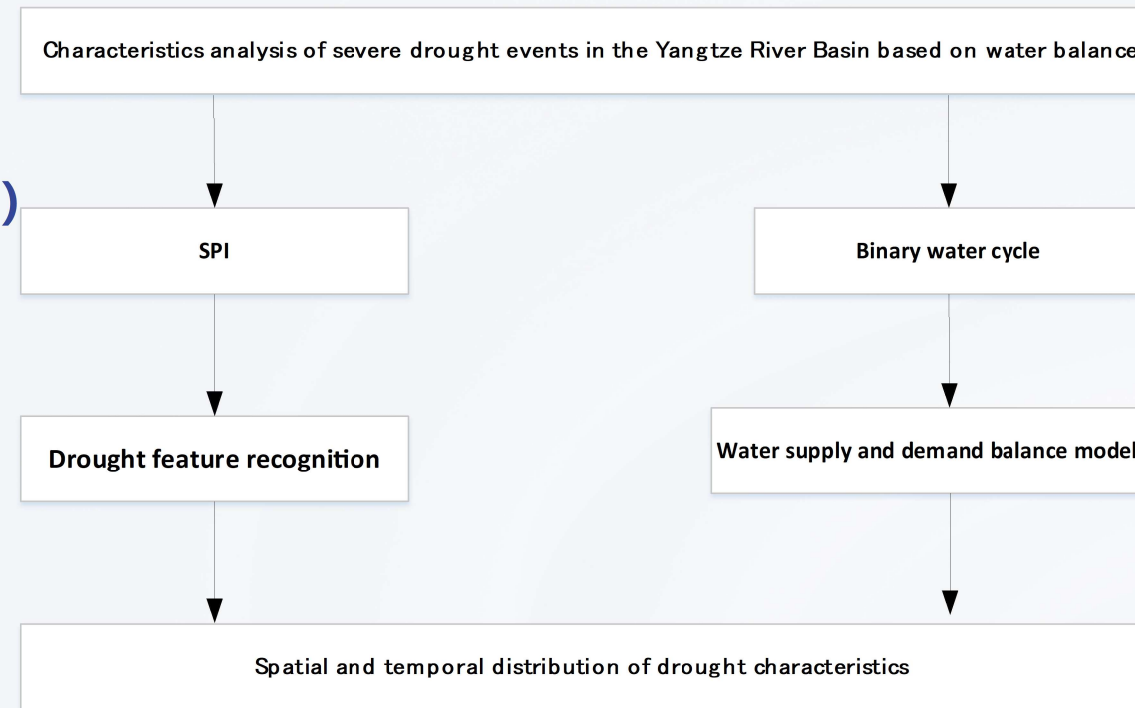
For specific projects, water supply systems and regions, the total water supply that can be provided under given incoming water conditions, water demand and system operation and scheduling requirements.

Water supply capacity can actually include single project water supply capacity, water supply system water supply capacity, regional water source water supply capacity and regional overall water supply capacity.



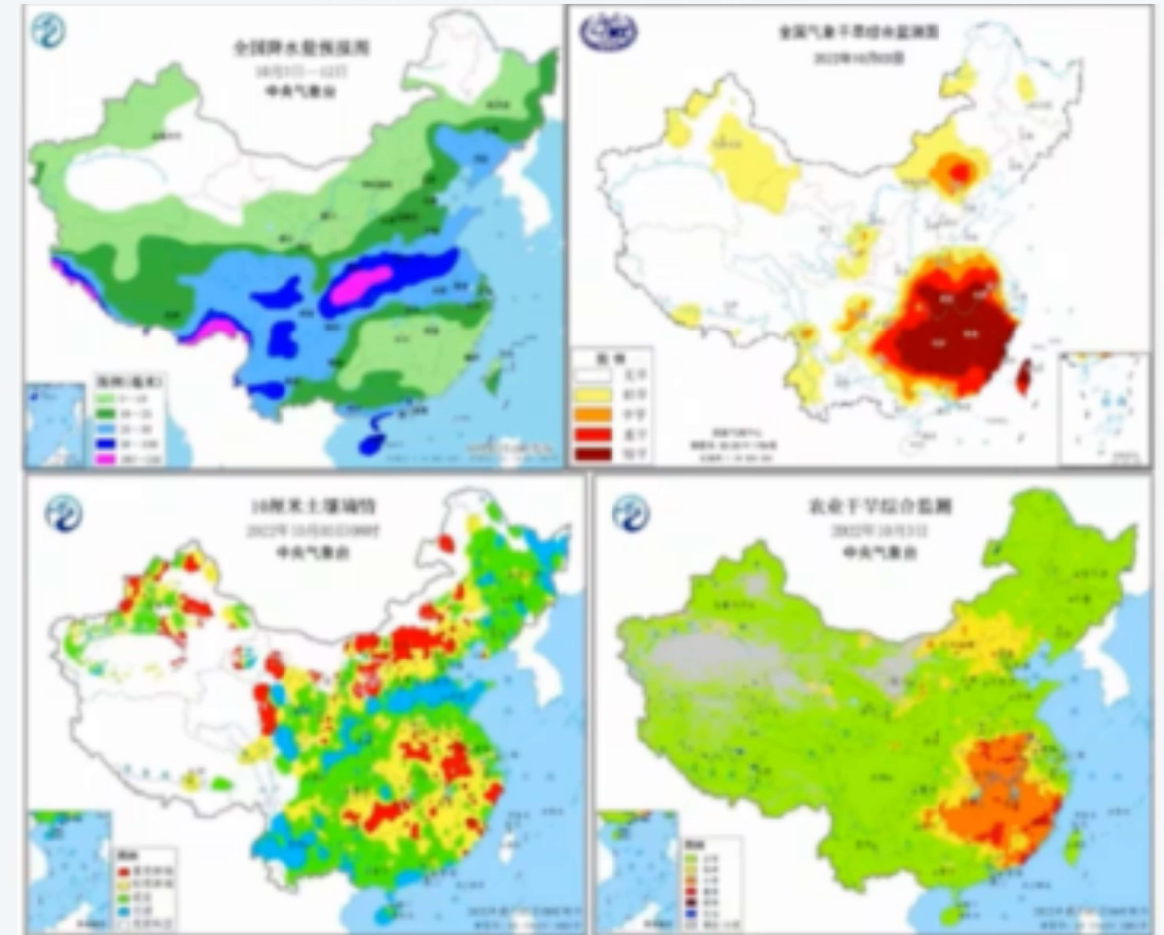
## Setting of different drought scenarios

- Sort by frequency ( 50%、75%、90%、95% )
- P、 water supply、 water demand
- water supply/water demand
  - Resource-based drought
  - Engineering-based drought
- Resource or Engineering drought?



频率	可供水量/亿 m <sup>3</sup>				需水量/亿 m <sup>3</sup>				CRDRA
	地表	地下	其它	合计	生产	生活	生态	合计	
55%	2.889	2.128	0.000	5.018	4.133	1.304	0.000	5.437	0.923
75%	3.231	2.281	0.000	5.512	5.220	1.080	0.000	6.300	0.875
90%~95%	1.541	2.319	0.000	3.859	5.527	0.819	0.000	6.346	0.608
97%	1.335	2.087	0.000	3.422	7.114	0.763	0.000	7.877	0.434

- In the summer of 2022, there will be moderate drought in the Yangtze River basin, severe drought in some areas, and special drought in some areas.
- Whether the climate decision for 2022 is consistent.
- Water resource supply and demand balance
- Evaluation results of drought characteristics



## Findings

### ■ Drought characteristics

- SPI recognition
- Frequency recognition

### ■ Spatial variations

- The middle part is dominated by drought
- In the south, the trend of wetting is predominant

### ■ Temporal variations

- Widespread aridification

## Shortcomings and Prospects

### ■ Deficiency

- low recognition accuracy
- large time scale

### ■ Innovation

- Comparison of frequency method and SPI
- Water demand in relation to temperature

### ■ Future research

- Coupling methods
- Uncertainty analysis





**Thanks  
for your listening!**