An Introduction of Some Work in Luanhe River Basin and Haihe River Basin

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2014.7.2

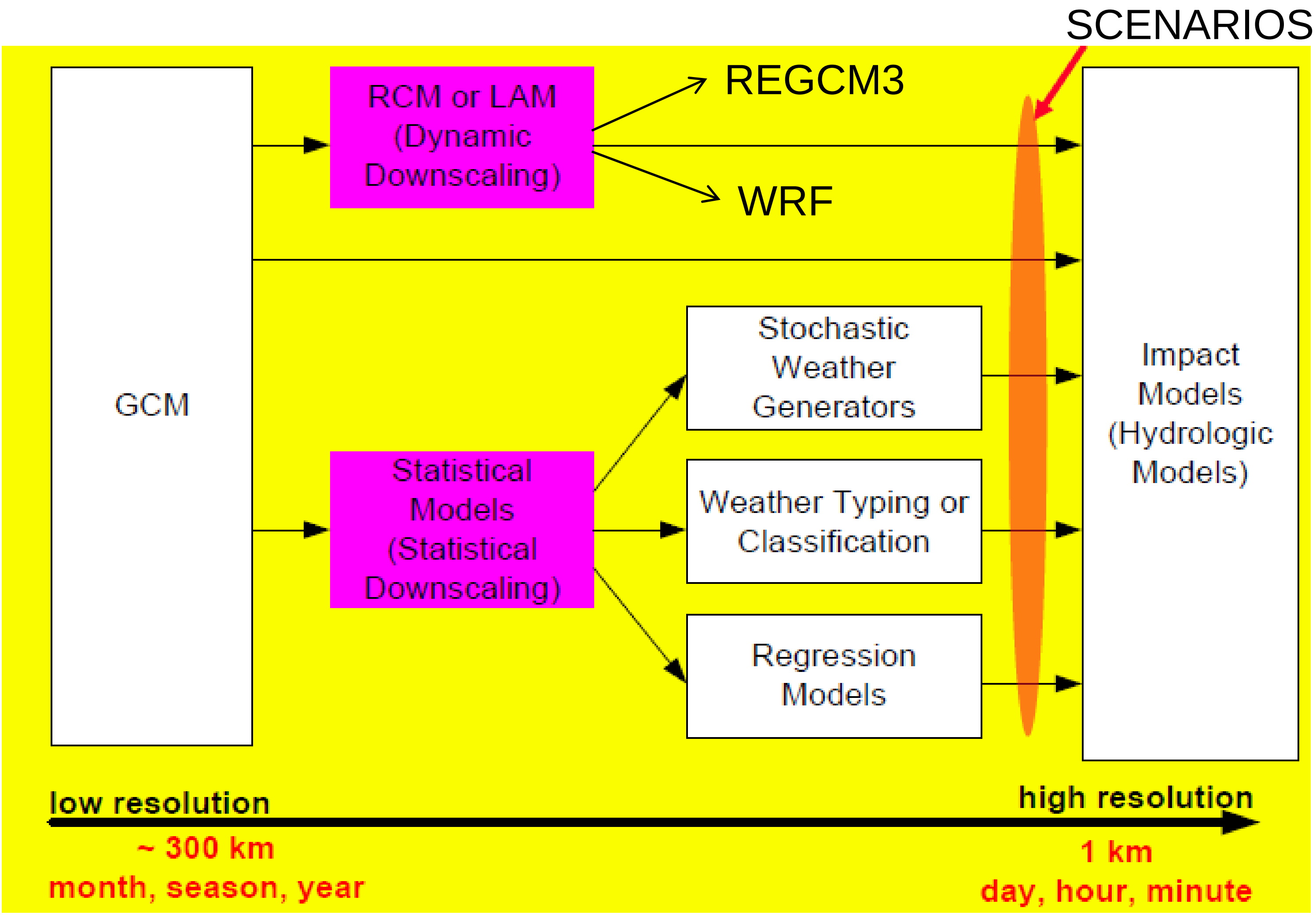
Outline

1 Dynamic Downscaling experiment

2 Runoff simulation and forecasting

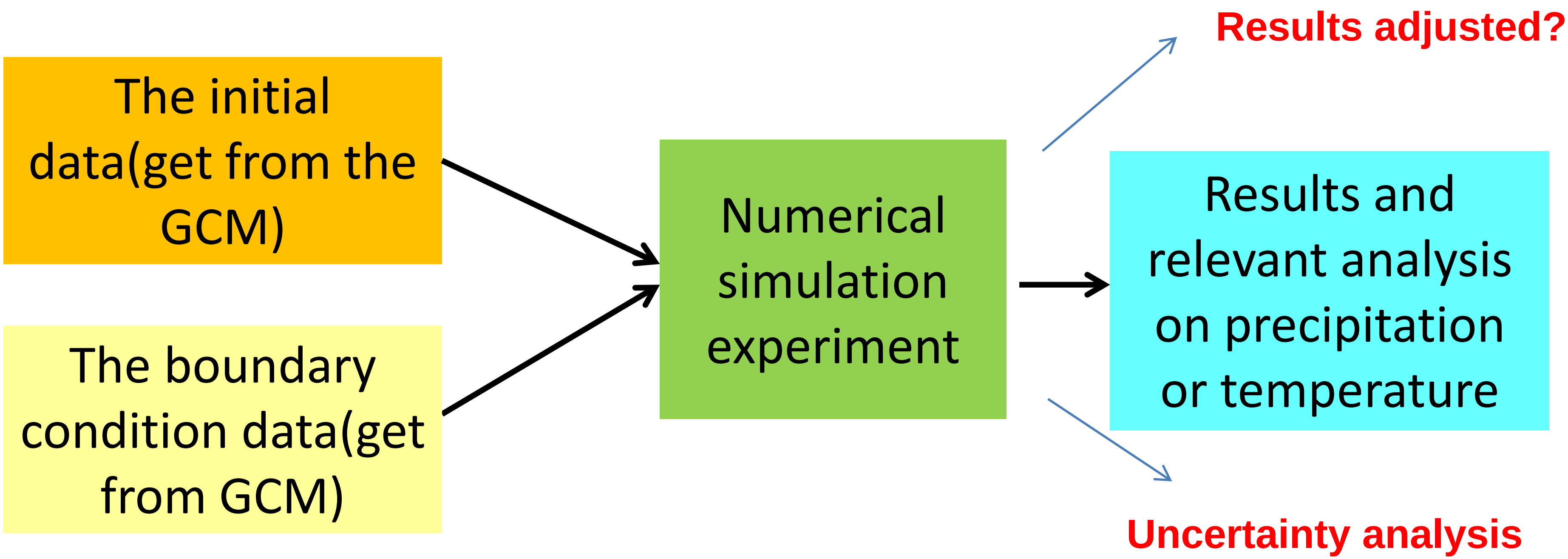
3 Drought and flood events analysis

1.Dynamic Downscaling Experiment and Analysis

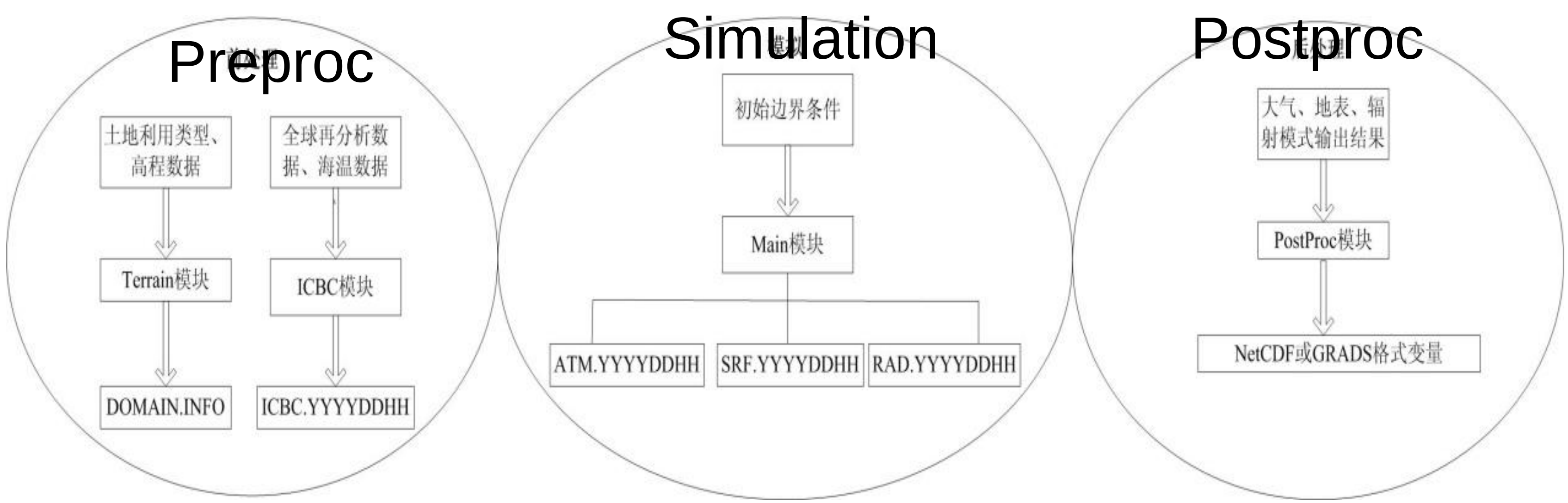


1.Dynamic Downscaling Experiment and Analysis

- Dynamic downscaling method:RegCM3
- The technical rout of the research:



- The structure of Regional Climate Model 3
- The RegCM3 include four modules: the terrain module, the ICBC module, the Main Module, the postproc module.
- The whole process can be divided into three parts: preproc, simulation and model output data postproc.

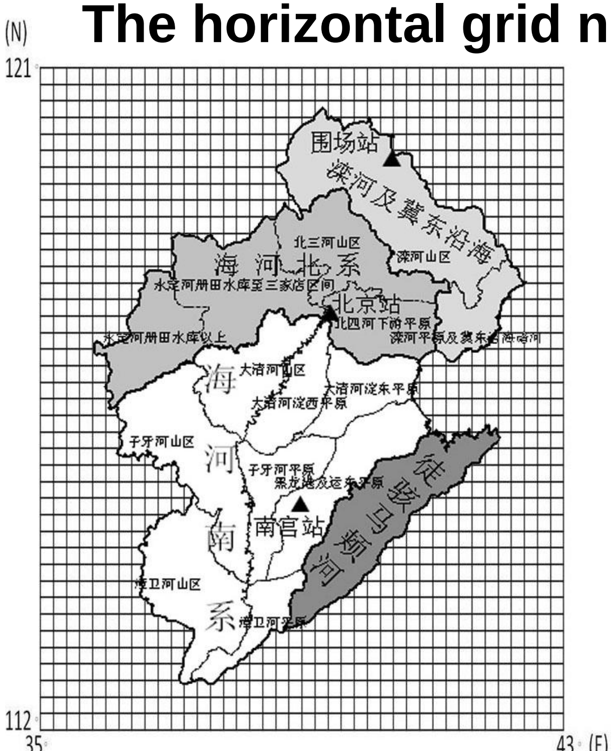


- The simulation Scheme

Study Area: Study Centre (39° N，116° E)

Horizontal resolution:20km×20km

The horizontal grid number:40×40 **Time Step:**150s



Name	Sources	Resolution
Reanalysis Data	NNPR1	2.5° ×2.5°
Topographic data	TOP30	10′×10′
Vegetation data	GLCC	10′×10′
SST Data	OI_SST	10′×10′

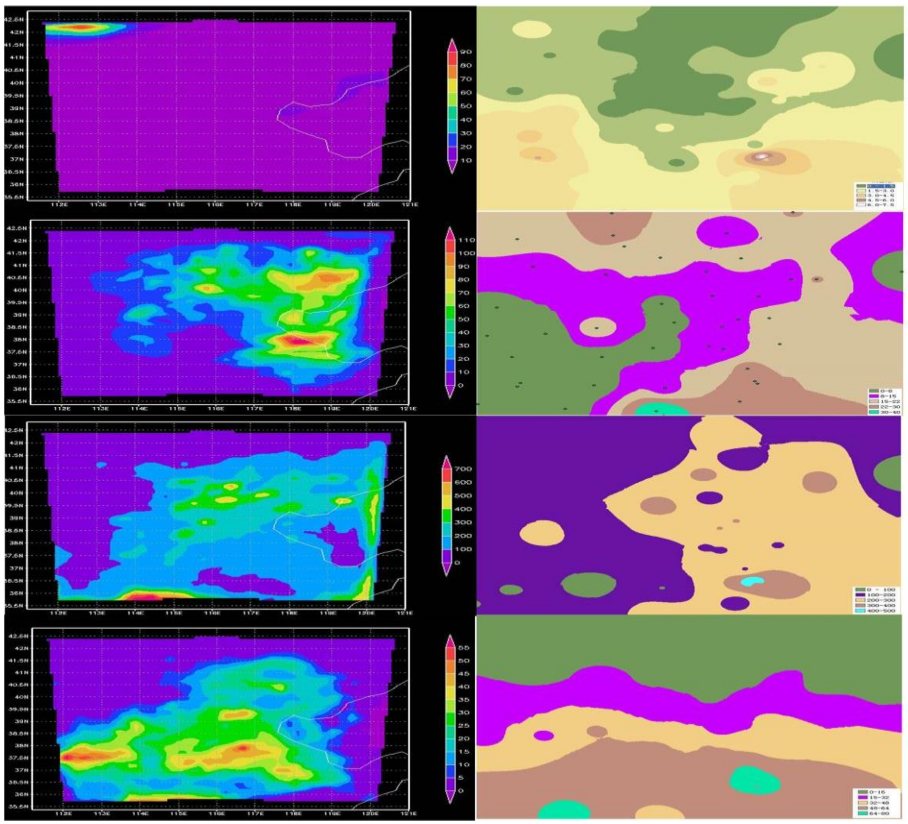
1.Dynamic Downscaling Experiment and Analysis

- Based on the simulation results, we focus on the simulation accuracy in different spatial and temporal scale.

- 43 meteorological stations are selected to evaluate the simulation accuracy on precipitation in different spatial and temporal scale.

1.Dynamic Downscaling Experiment and Analysis

- The results show that the RegCM3 can simulate the spatial distribution of precipitation in Haihe River Basin.



一月 January

四月 April

七月 July

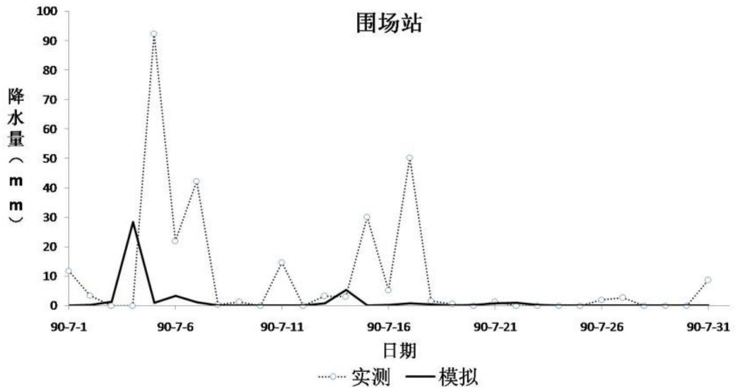
十月 October

1.Dynamic Downscaling Experiment and Analysis

- We evaluate the simulation accuracy in different temporal scale.

➢ Select the Weichang, Beijing and Nangong as the representative station. Evaluating the simulation accuracy of daily rainfall, ten day rainfall and monthly rainfall.

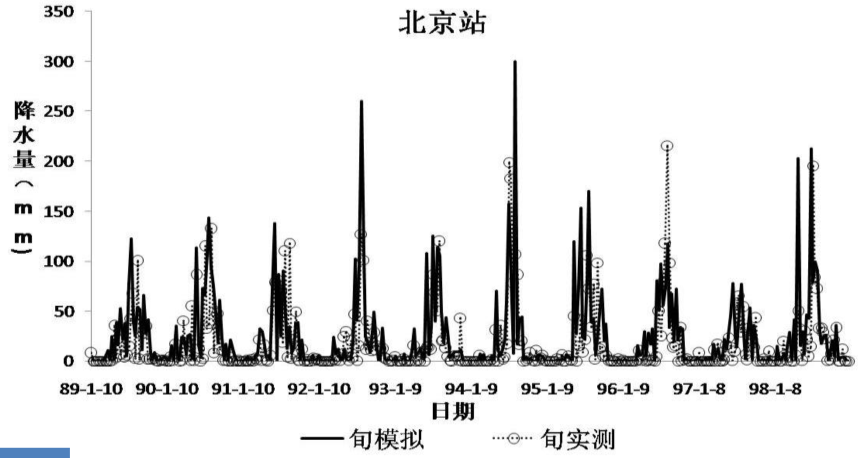
◆Daily rainfall (the simulation accuracy is low)



Station	Correlation coefficient
Weichang	0.04
Nangong	0.07
Beijing	0.001

1.Dynamic Downscaling Experiment and Analysis

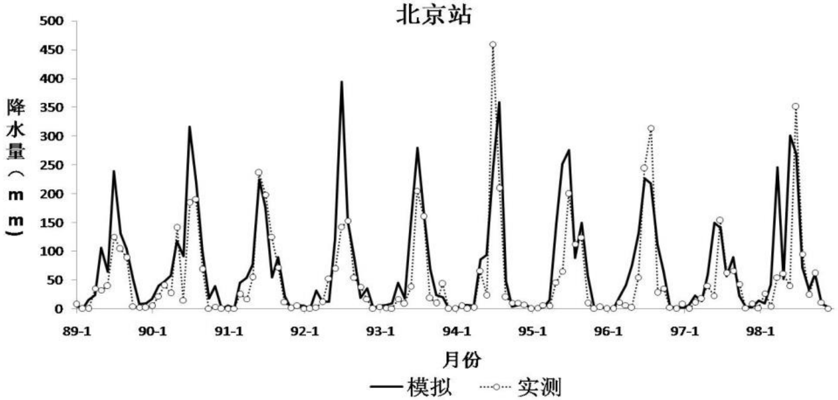
- Ten day rainfall :(the simulation accuracy is good, the correlation coefficient is more than 0.6.)



Station	Correlation coefficient
Weichang	0.62
Nangong	0.65
Beijing	0.60

1.Dynamic Downscaling Experiment and Analysis

◆Monthly rainfall :(the simulation accuracy is high, the correlation coefficient is about 0.7.)



Station	Correlation coefficient
Weichang	0.67
Nangong	0.72
Beijing	0.76

1.Dynamic Downscaling Experiment and Analysis

- We evaluate the simulation accuracy in different spatial scale.

➢ Based on the monthly rainfall, evaluating the simulation accuracy in three different spatial scale: the third water resources zone, the second water resources zone ,the whole basin.

◆ The third water resources zone scale (coefficient is more than 0.7)

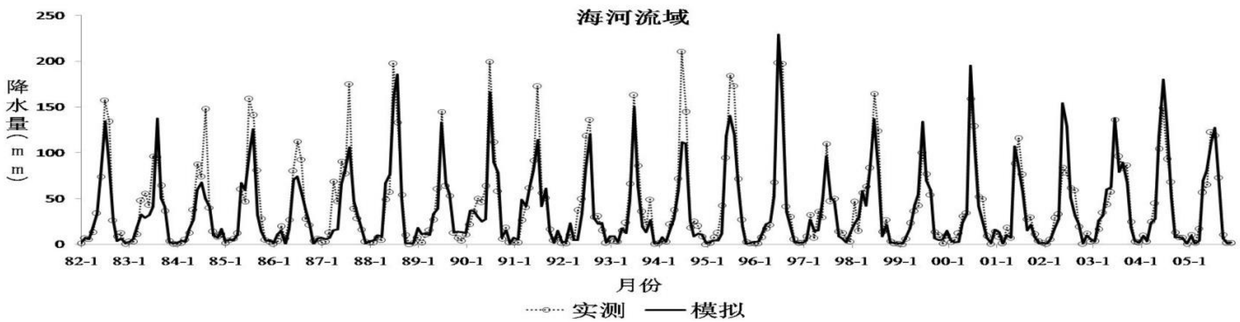
Name	Area (10 thousand km^2)	R^2
滦河山区	4.63	0.84
滦河平原及冀东沿海	1.14	0.80
北三河山区	2.44	0.88
永定河册田水库以上	1.85	0.71
永定河册田水库至三家口	2.91	0.76
北四河下游平原	1.62	0.87
大清河山区	1.94	0.81
大清河淀西平原	1.32	0.80
大清河淀东平原	1.41	0.80
子牙河山区	3.17	0.80
子牙河平原	1.55	0.81
漳渭河山区	2.63	0.72
漳渭河平原	0.92	0.71
黑龙港及运东平原	2.30	0.84
徒骇马颊河	3.23	0.85

1.Dynamic Downscaling Experiment and Analysis

◆ The second water resources zone scale (coefficient is more than 0.8)

Name	Luanhe and its surround river	North of Haihe	Southe of Haihe	Tuhaimajia River
Area(10 thousand km^2)	5.77	8.82	15.22	3.2
R^2	0.90	0.87	0.88	0.85

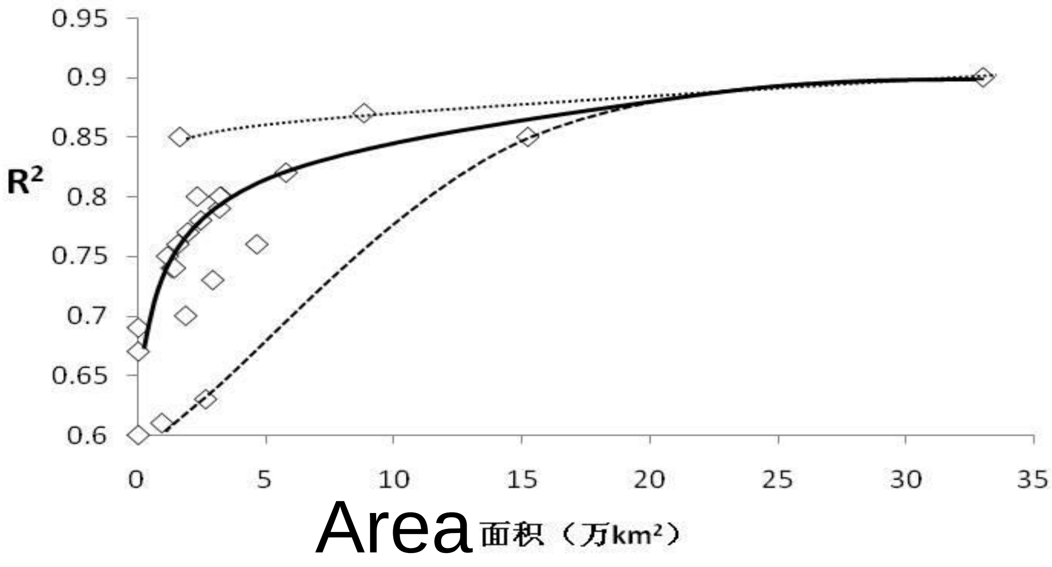
◆ The whole basin scale



The coefficient is 0.92

1.Dynamic Downscaling Experiment and Analysis

- The results show that the simulation accuracy of the model is closely linked to the area of study region.
- As the study region become larger, the simulation accuracy increased.

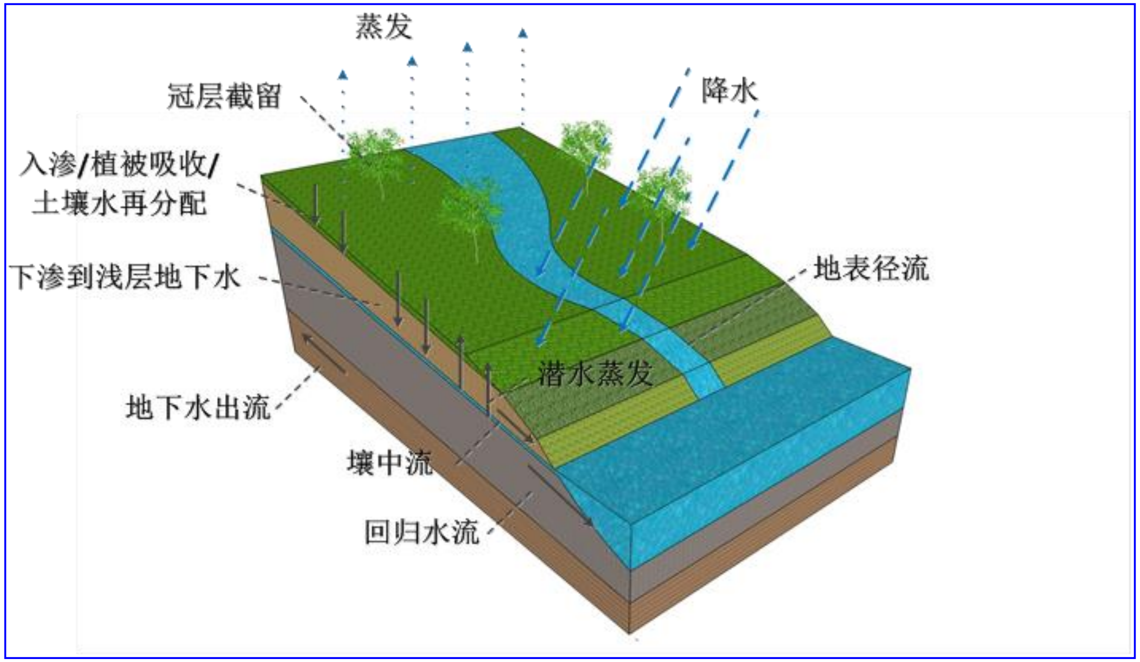


2 Runoff simulation and forecasting

2.Runoff simulation and forecasting in Luanhe River Basin

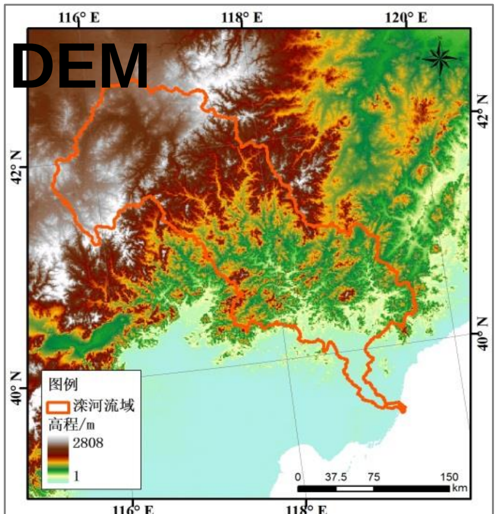
- We choose SWAT model to simulate runoff in Luanhe River Basin.

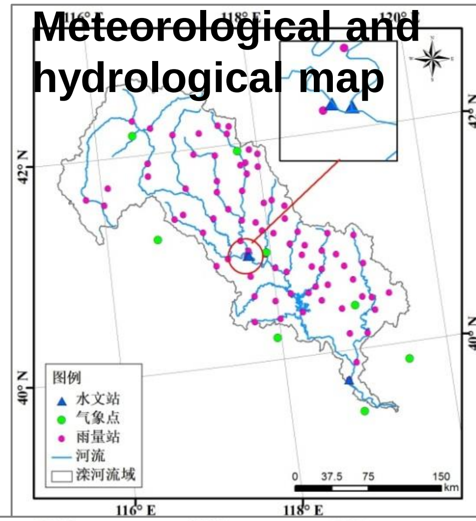
➢SWAT Model （Soil and Water Assessment Tool）

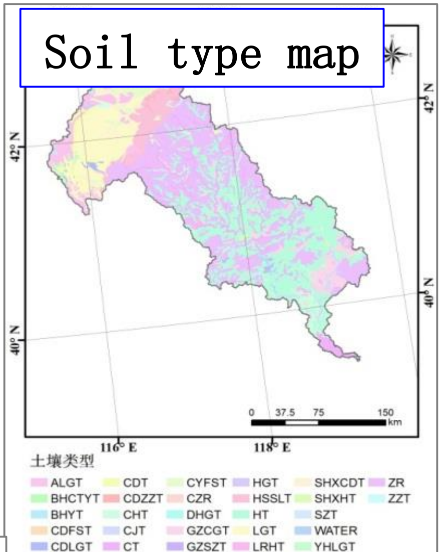


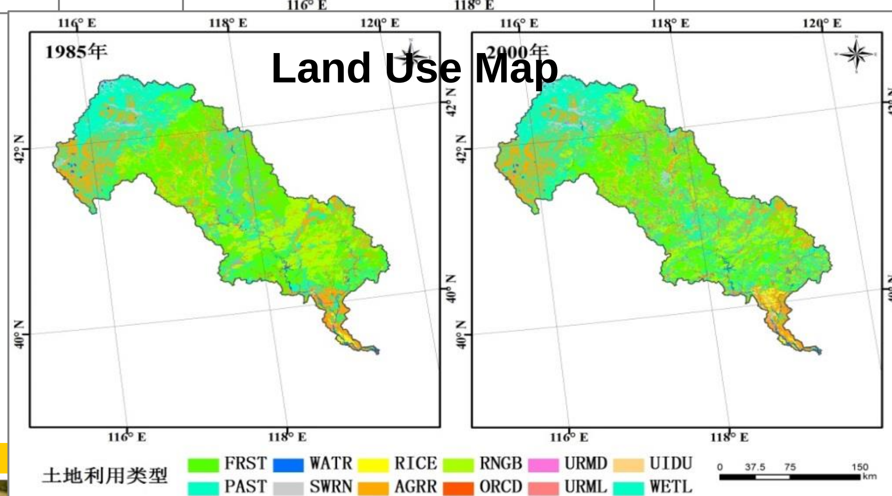
2.Runoff simulation and forecasting in Luanhe River Basin

➢ The establishment of Luanhe SWAT Model



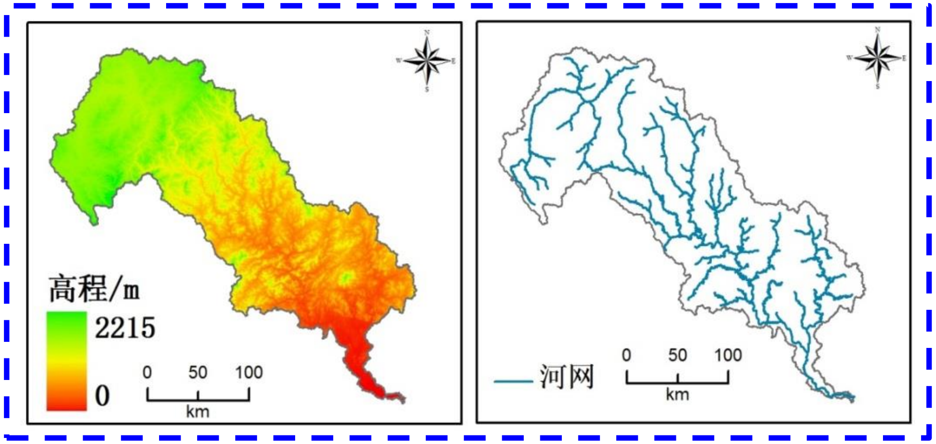




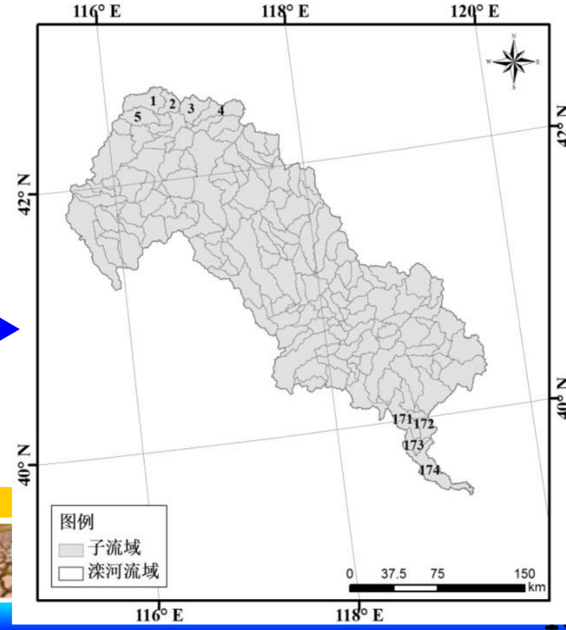


➢ The establishment of Luanhe SWAT Model

- ➢ Sub basin delineation
- ✓ The smallest catchment area:150km^2;
- ✓ The whole basin is divided into 147 sub-basin.



Sub basin delineation



➢ The calibration of model parameter

- ✓ Surface runoff simulation: SCS method
- ✓ Time Scale: Day
- ✓ Potential Evaporation: Penman-Monteit
- ✓ River flow routing: Storage coefficient method

Preparation Stage	1970~1972
The correction Stage	1973~1988
Validition Stage	1989~1995

Evaluate the applicability of the SWAT model in Luanhe River Basin

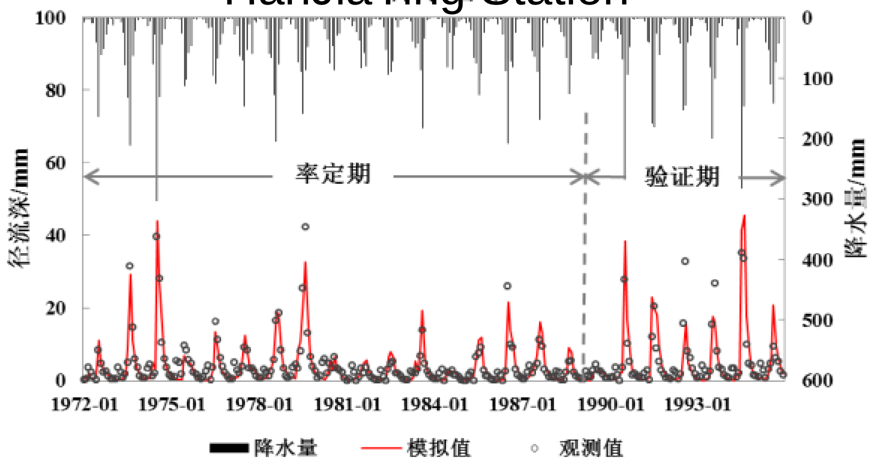
- Evaluating indicator

✓ R^2;
✓ *NSE*;
✓ *RMSE*

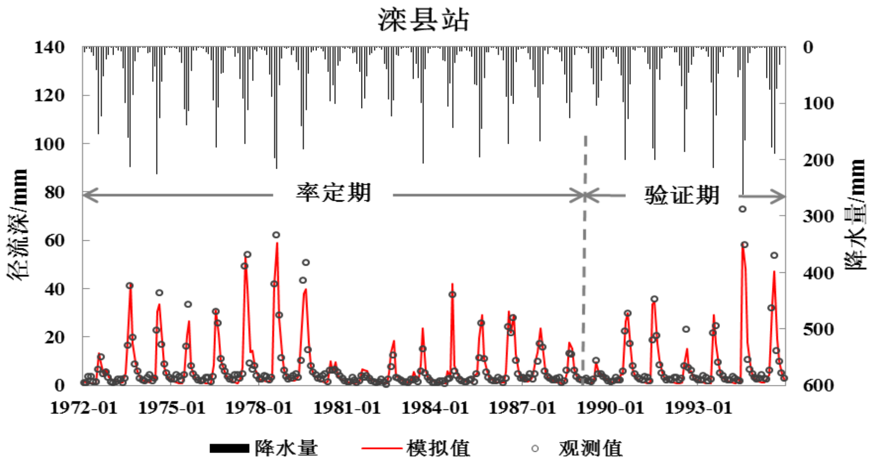
站点	模拟时段	多年平均径流深/mm		R^2	*NSE*	*RMSE*(mm)
		模拟值	实际值			
三道河子	率定期（1972-1988）	2.36	2.35	0.756	0.714	1.40
	验证期（1989-1995）	2.28	2.96	0.643	0.642	1.80
韩家营	率定期（1972-1988）	3.87	3.99	0.890	0.888	2.00
	验证期（1989-1995）	5.15	5.06	0.772	0.702	4.13
滦县	率定期（1972-1988）	7.33	7.09	0.932	0.931	2.74
	验证期（1989-1995）	7.66	8.37	0.933	0.930	3.35

2.Runoff simulation and forecasting in Luanhe River Basin

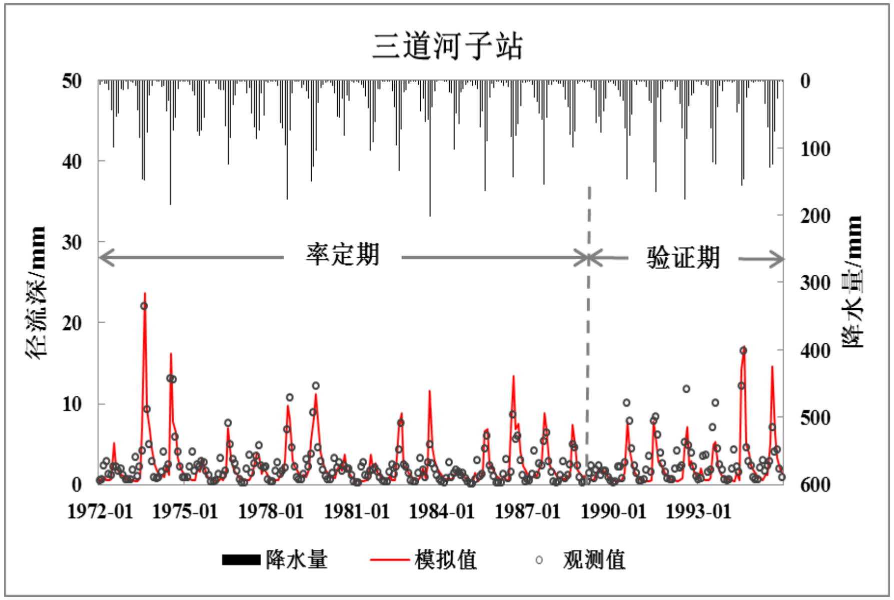
HanJiaYing Station



Luanxian Station



Sandaohezi Station



3 Drought and flood events analysis

3.Drought and flood events in Haihe River Basin

- Due to climate change and human activities, the frequency of drought and flood has changed a lot in recent years.
  - Evaluating the drought appropriately is the key of disaster prevention.
  - The traditional method cannot meet the demand.

3.Drought and flood events in Haihe River Basin

- Research method: ***Fuzzy Set Pair Analysis Assessment Method.*** The ***Fuzzy Set Pair Analysis Assessment Method*** has been proposed based on the principle of set pair analysis (SPA).

Advantage 1

It can take fuzzy property of threshold values for grade standards into full account and avoid determining the discrepancy uncertainty coefficient in SPA.

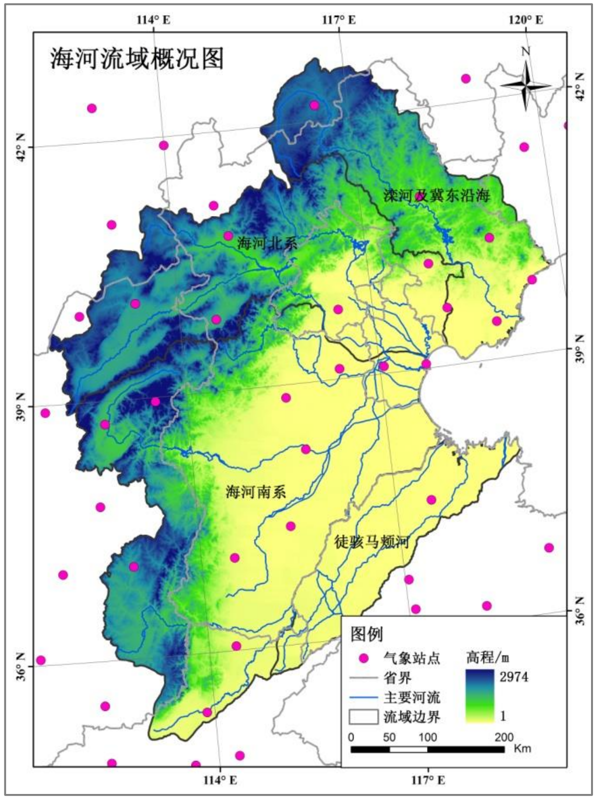
Advantage 2

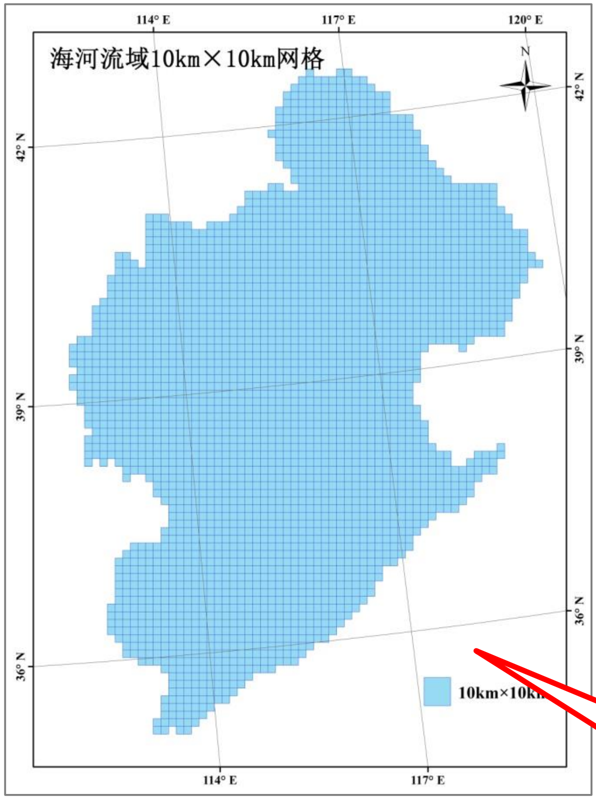
It can take the amount of evaluation object (relative moisture index) and its distribution into account .

Advantage 3

It is simple in concept, convenient to calculate and feasible for application.

3.Drought and flood events in Haihe River Basin





With grid of Haihe River Basin and the daily data of precipitation, temperature, relative humidity, wind velocity and so on, we can the precipitation and potential evaporation of each grid.

Size : 10km×10km;
PE: Penman-Monteith

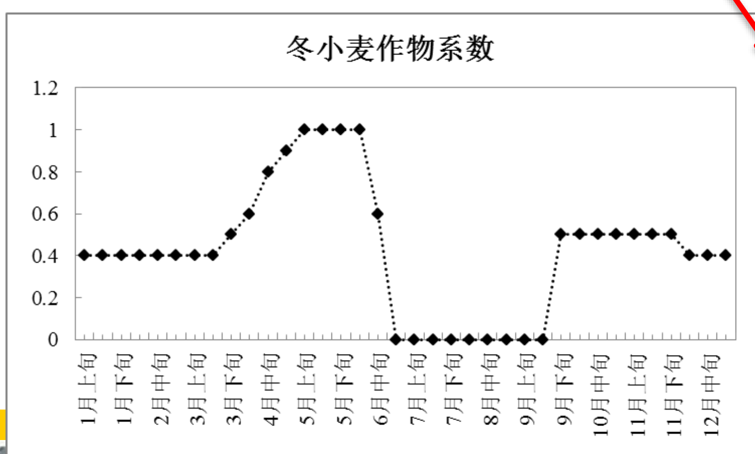
3.Drought and flood events in Haihe River Basin

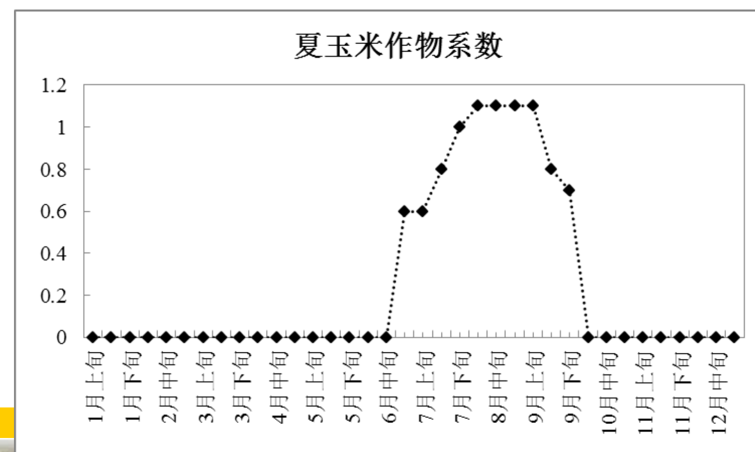
Drought Magnitude

The relative moisture index is used to evaluate the monthly drought magnitude.

$$M = \frac{\alpha \times P - K_c \times PE}{K_c \times PE}$$

- *P*-precipitation
- *PE*- potential evaporation
- *α*-the coefficient of precipitation effective utilization
- *Kc*-crop coefficient





3.Drought and flood events in Haihe River Basin

In order to take the influence of former incidents and ensuring that this study is significant to agricultural practice, we modify the relative moisture index and use the accumulated moisture index

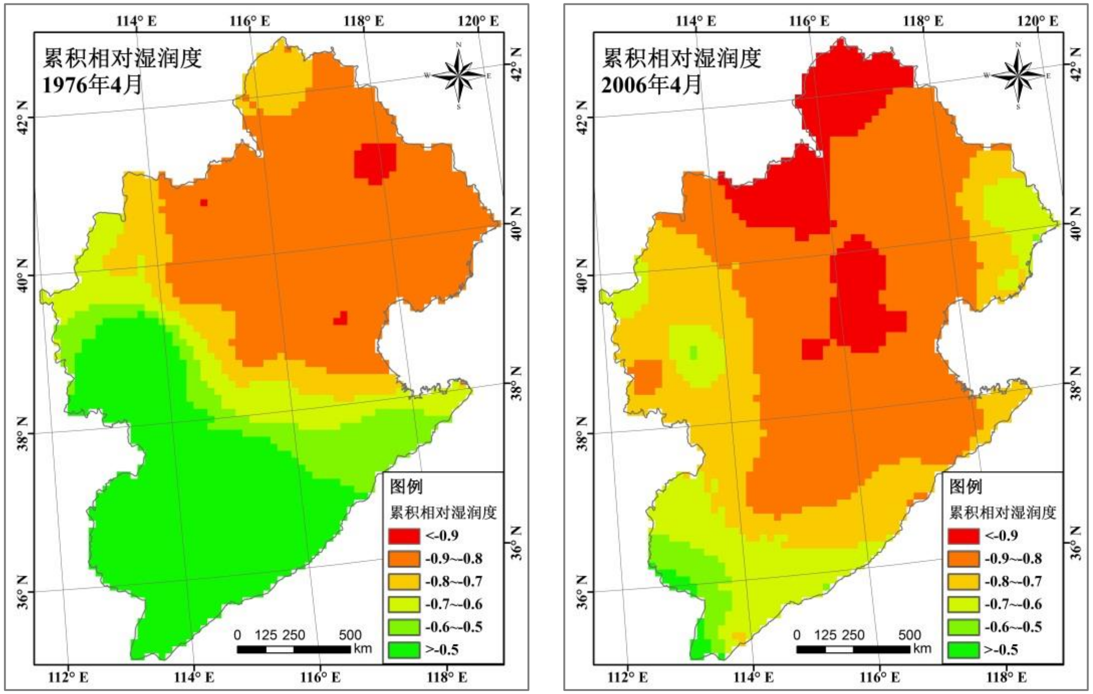
$$M_a = k \times M_0 + (1-k) \times [\sum_{i=1}^{n} (\frac{n+1-i}{\sum_{i=1}^{n} i} \times M_i)]$$

Magnitude	Type	*Ma*
1	Normal	*Ma*>-0.50
2	Mild Drought	-0.50≥*Ma* >-0.75
3	Moderate Drought	-0.75≥*Ma* >-0.85
4	Severe Drought	-0.85≥*Ma* >-0.95
5	Extreme Drought	*Ma*≤-0.95

Average monthly temperature	*k*
T≥25	0.7
25>T≥20	0.6
20>T≥15	0.5
15>T≥10	0.4
T<10	0.3

3.Drought and flood events in Haihe River Basin

By calculating the monthly accumulated moisture index of each grid, we can get the pictures of monthly accumulated moisture index of Haihe River Basin.



FSPAAM Fuzzy Set Pair Analysis Assessment Method

K=5, *the number of assessment grades;*

m=12, *the number of month;*

ω_l, *the weight of month. In this study,* ω_l *of each grid is calculated as*

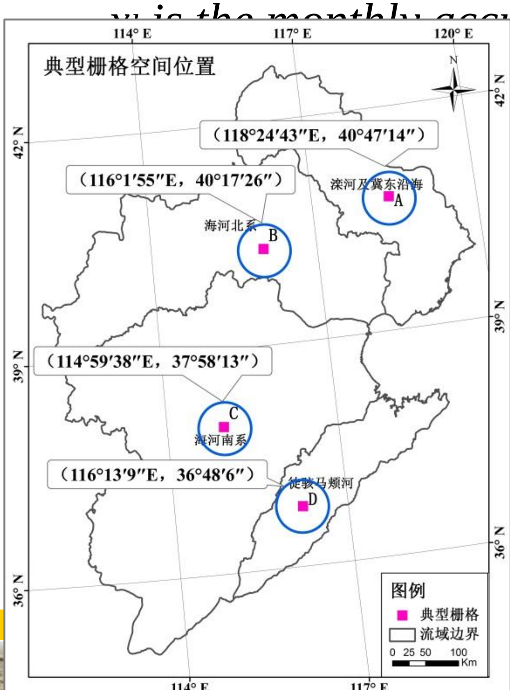
$$\omega_l = \frac{K_c \times \overline{PE}_l - \alpha \times \overline{P}_l}{\sum_{i=1}^{m}(K_c \times \overline{PE}_i - \alpha \times \overline{P}_i)}$$

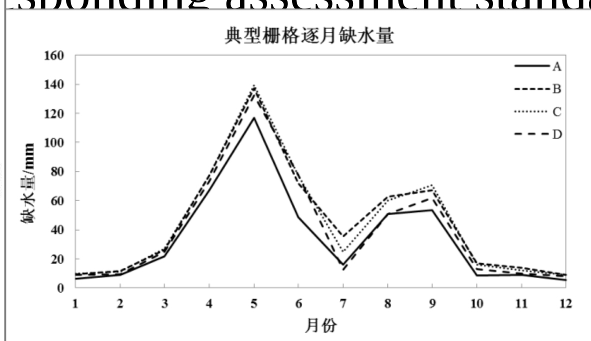
Set A_l ➢ Sample index value x_l

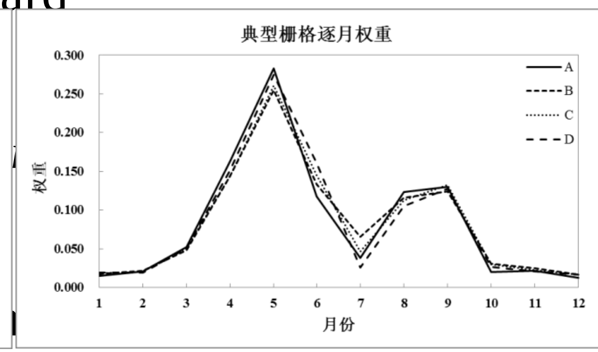
l = 1, 2, … *m*, *m is the number of assessment indexes. In this study, m is the number of month (m=12);*

x_l *is the monthly accumulated moisture index.*

…esponding assessment standard







…ree

$$+ \sum_{l=1}^{m}\omega_l b_{l,1} i_1 + \sum_{l=1}^{m}\omega_l b_{l,2} i_2 + \cdots + \sum_{l=1}^{m}\omega_l b_{l,K-2} i_{K-2} + \sum_{l=1}^{m}\omega_l c_l j$$

3.Drought and flood events in Haihe River Basin

In order to take fuzzy property of threshold values for grade standards into full account and avoid determining the discrepancy uncertainty coefficient in SPA, we modify the formula in the last page.

$$\mu_{A_l\sim B}=1+0i_1+0i_2+\cdots+0i_{K-2}+0j,(x_1\le s_1),$$

$$\mu_{A_l\sim B}=\frac{s_1+s_2-2x_l}{s_2-s_1}+\frac{2x_l-2s_1}{s_2-s_1}i_1+0i_2+\cdots+0i_{K-2}+0j,(s_1<x_l\le\frac{s_1+s_2}{2}),$$

$$\mu_{A_l\sim B}=0+\frac{s_2+s_3-2x_l}{s_3-s_1}i_1+\frac{2x_l-s_1-s_2}{s_3-s_1}i_2+\cdots+0i_{K-2}+0j,(\frac{s_1+s_2}{2}<x_l\le\frac{s_2+s_3}{2}),$$

$$\mu_{A_l\sim B}=0+0i_1+\cdots+\frac{2s_{K-1}-2x_l}{s_{K-1}-s_{K-2}}i_{K-2}+\frac{2x_l-s_{K-2}-s_{K-1}}{s_{K-1}-s_{K-2}}j,(\frac{s_{K-1}+s_{K-2}}{2}<x_l\le s_{K-1}),$$

$$\mu_{A_l\sim B}=0+0i_1+0i_2+\cdots+0i_{K-2}+1j,(x_l\ge s_{K-1})$$

Si is threshold values

s1	*s2*	*s3*	*s4*
-0.95	-0.85	-0.75	-0.5

3.Drought and flood events in Haihe River Basin

The following confidence criterion is defined

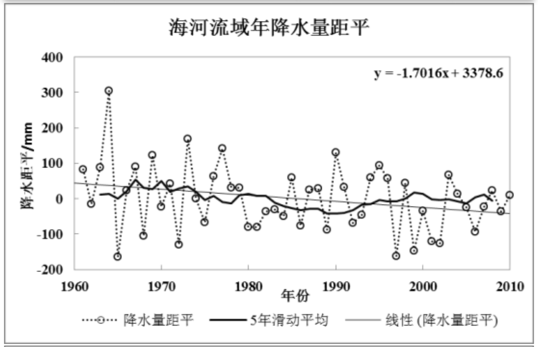
$$h_k = (f_1 + f_2 + \cdots + f_k) > \lambda, (k = 1, 2, \cdots K)$$

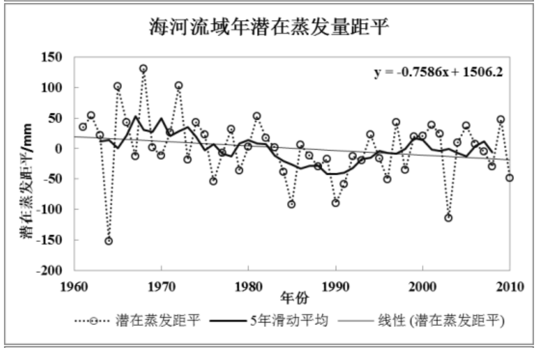
$$f_1 = \sum_{l=1}^{m} \omega_l a_l,\ f_2 = \sum_{l=1}^{m} \omega_l b_{l,1} i_1, \cdots f_{K-1} = \sum_{l=1}^{m} \omega_l b_{l,K-2} i_{K-2},\ f_K = \sum_{l=1}^{m} \omega_l c_l$$

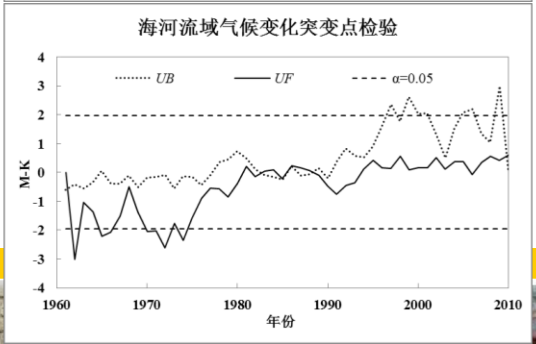
λ is the confidence degree, which has a value in [0.50,0.70].
In this study, $\lambda = 0.6$.

3.Drought and flood events in Haihe River Basin

Precipitation
Potential evaporation







Precipitation: decreasing
M_P=-1.614<-1.282

reach
the significant level of α=0.1

Potential evaporation: decreasing
M_{PE}=-1.548<-1.282

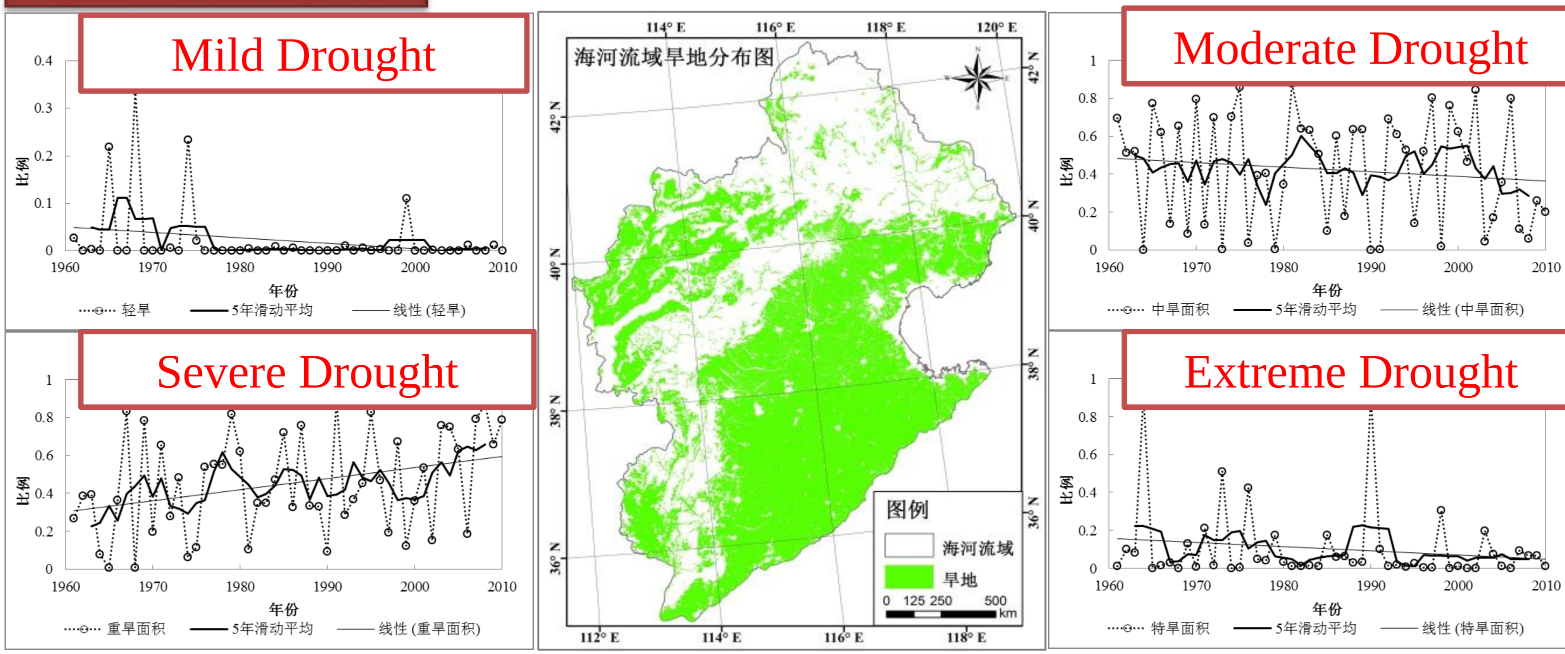
Abrupt change: 1985

we can conclude that base period was from 1961-1992 and variation period was from 1993-2010

3.Drought and flood events in Haihe River Basin

Area of drought

This study is focus on the girds in non-irrigated farmland areas.



- Moderate drought and severe drought are the main type of drought in the Huaihe River Basin;
- The areas of moderate drought and severe drought are 73,000km² and 77,800km² , accounted for 42.4% and 45.2% of the non-irrigated farmland areas;
- There has been a high increase of areas of severe drought during recent 50 years and the trend passed significance of α=0.05(*M*=2.166>1.645) by the method of M-K text.

3.Drought and flood events in Haihe River Basin

The Area of Drought during different Periods

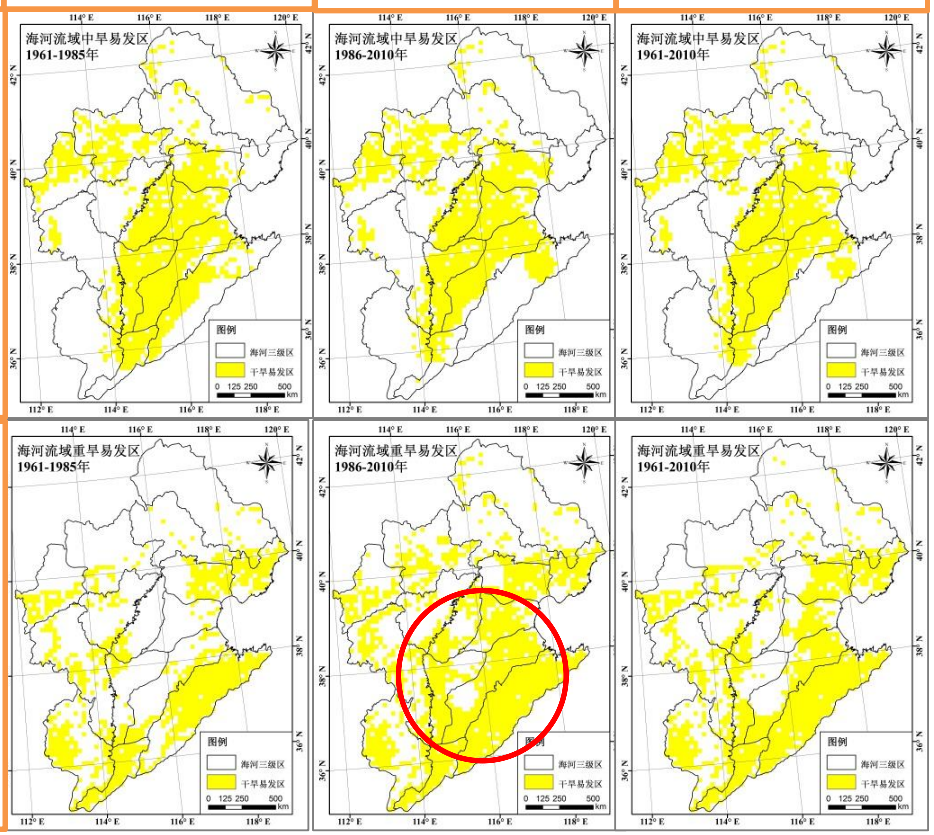
类型	不同时段干旱面积			突变点前后时段干旱面积变化率/%
	1961-2010	1961-1985	1986-2010	
轻旱	0.020	0.034	0.006	-81.14
中旱	0.424	0.446	0.403	-9.53
重旱	0.452	0.400	0.505	26.39
特旱	0.102	0.119	0.084	-29.39

From the table above we can find that the area of severe drought during variation period has increased sharply by 26.39%. It means that the problem of drought in Haihe River Basin is becoming more and more serious.

3.Drought and flood events in Haihe River Basin

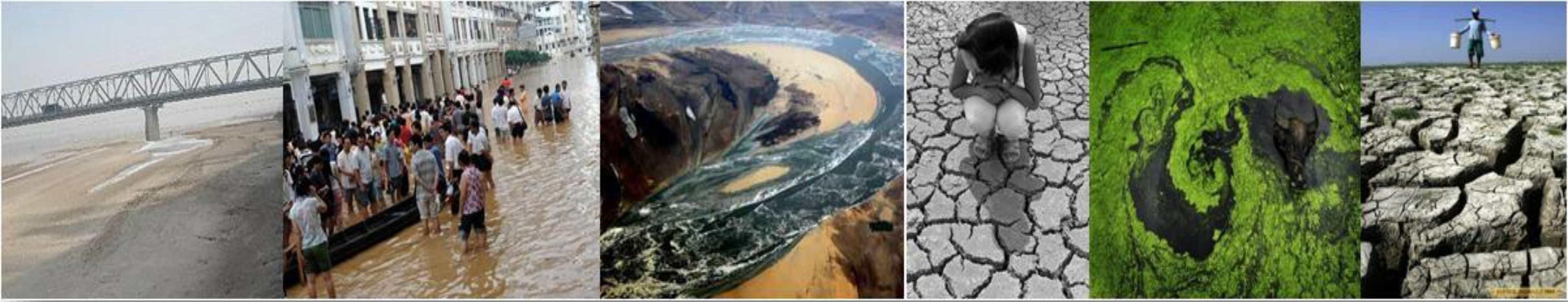
Areas Prone to Drought

	1961-1985	1986-2010	1961-2010
Moderate Drought			
Severe Drought			



The area prone to moderate drought has not changed significantly. there are high frequencies of occurrences of moderate drought in the plain which is in the south of Haihe River Basin.

The area prone to severe drought has expanded. And the area in variation period is as 1.6 times as the base period.



Thank You !


IWHR
China Institute of Water Resources and
Hydropower Research
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