XVIII World Water Congress
International Water Resources Association (IWRA)

Digital Twinning Watershed for Qinghai Lake Basin

Jiahong Liu & Yunzhong Jiang et al.
China Institute of Water Resources and Hydropower Research

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：人与自然和谐共生

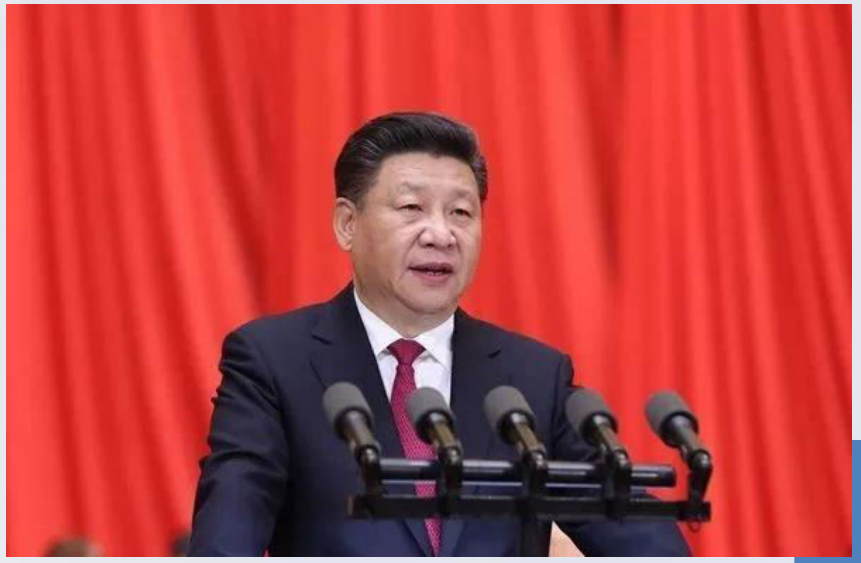
XVIII World Water Congress
International Water Resources Association (IWRA)

Content

- Introduction
- Study area and methodology
- Results and discussion
- Summary

1 Introduction

The 19th National Congress of the Communist Party of China made strategic arrangements for Digital China in 2017.



The Ministry of Water Resources is now promoting the construction of **digital twin river basins.**

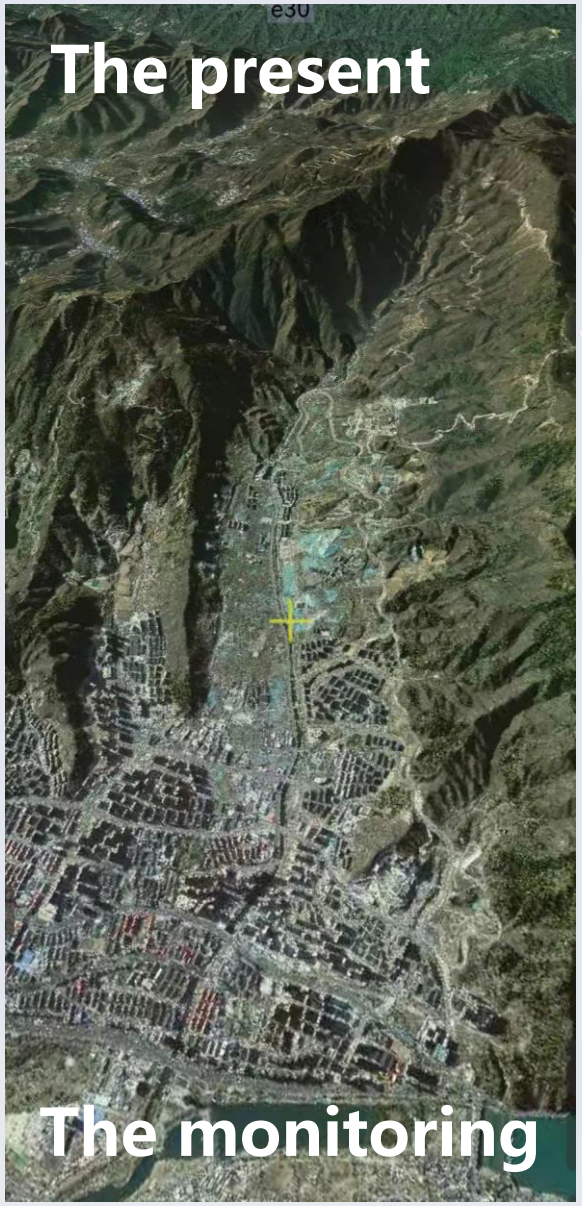
implementation

Digital scene | **Intelligent simulation** | **Precise decision**

Digital Twinning Watershed

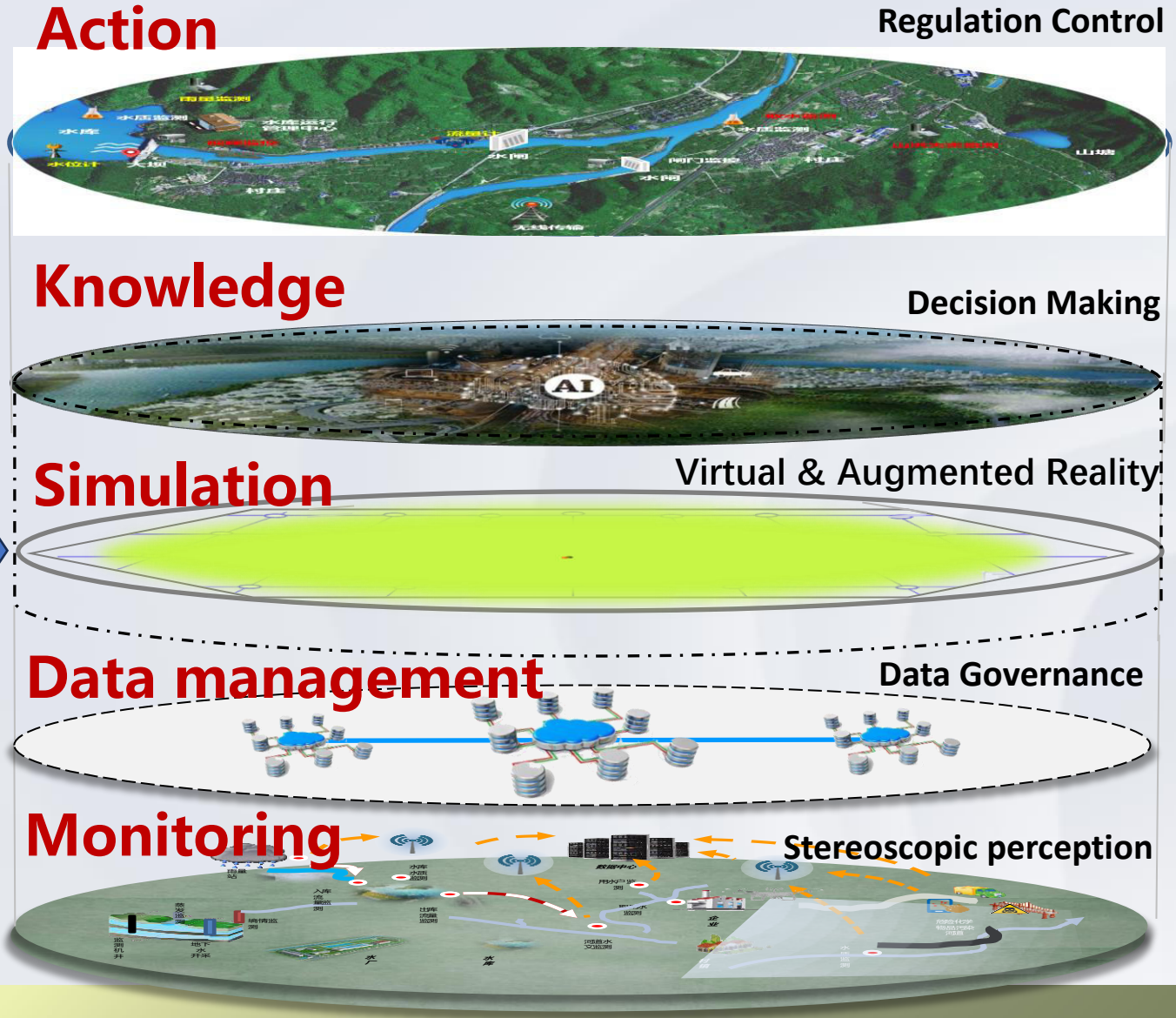
Data | **Algorithm** | **Hardware**

1 Introduction



How can we make the future projections ?

Digital Twinning Watershed

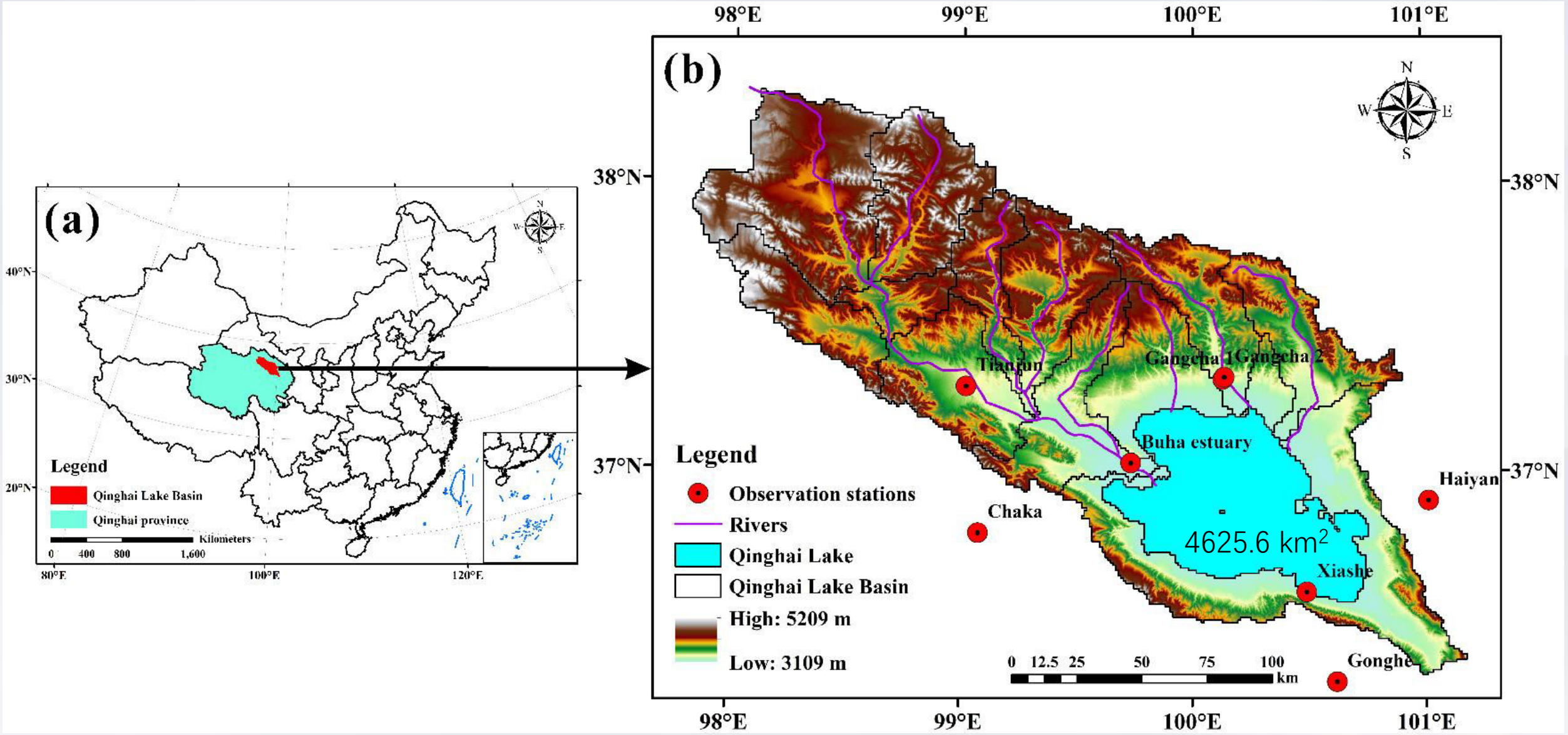


XVIII World Water Congress
International Water Resources Association (IWRA)

Content

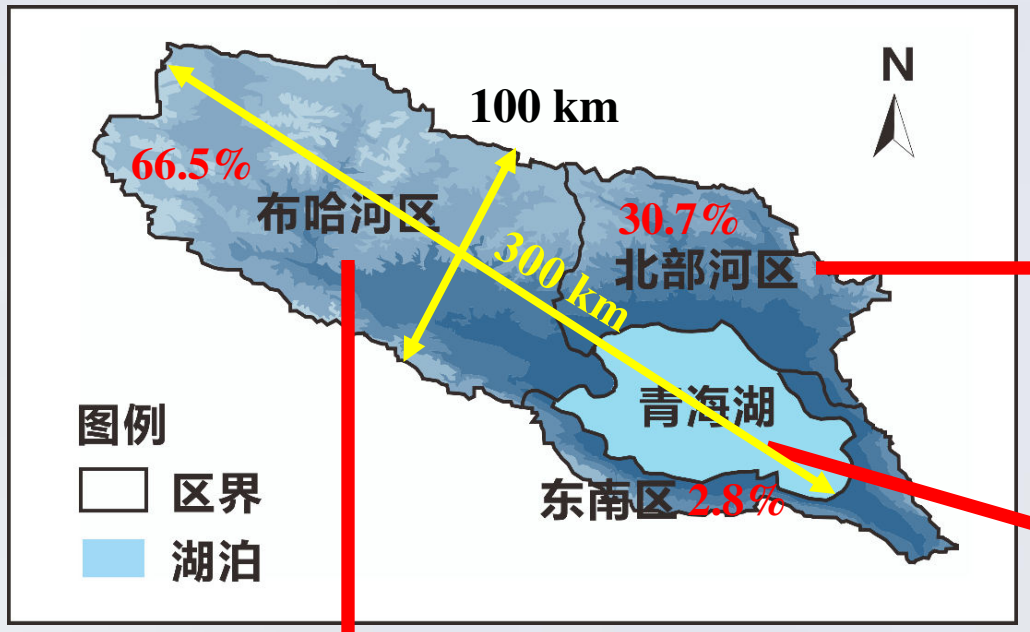
- Introduction
- Study area and methodology
- Results and discussion
- Summarize

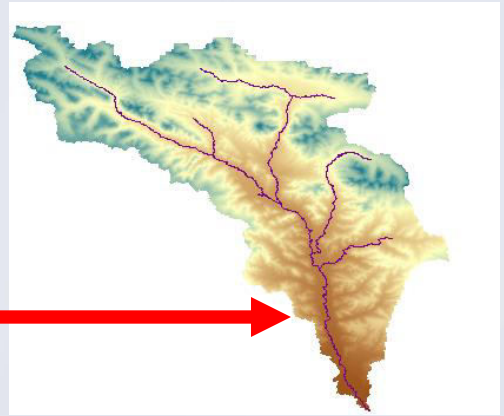
2.1 Study area



2.1 Study area

34,950 km²





Shaliu River Basin

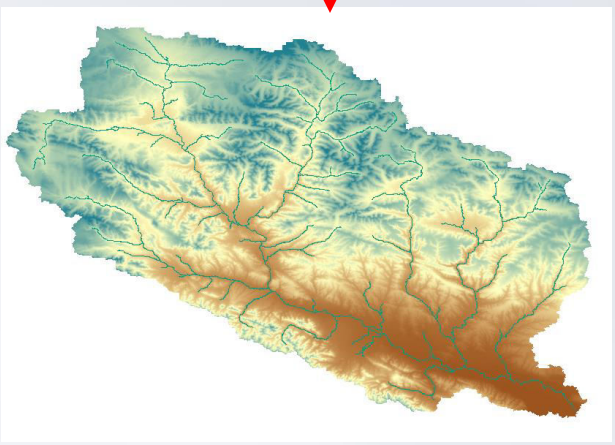
Area：11,066 km²

Annual Runoff：283 million m³

Proportion of Total Runoff：12.7%

Qinghai Lake Around

Area：9,400 km²



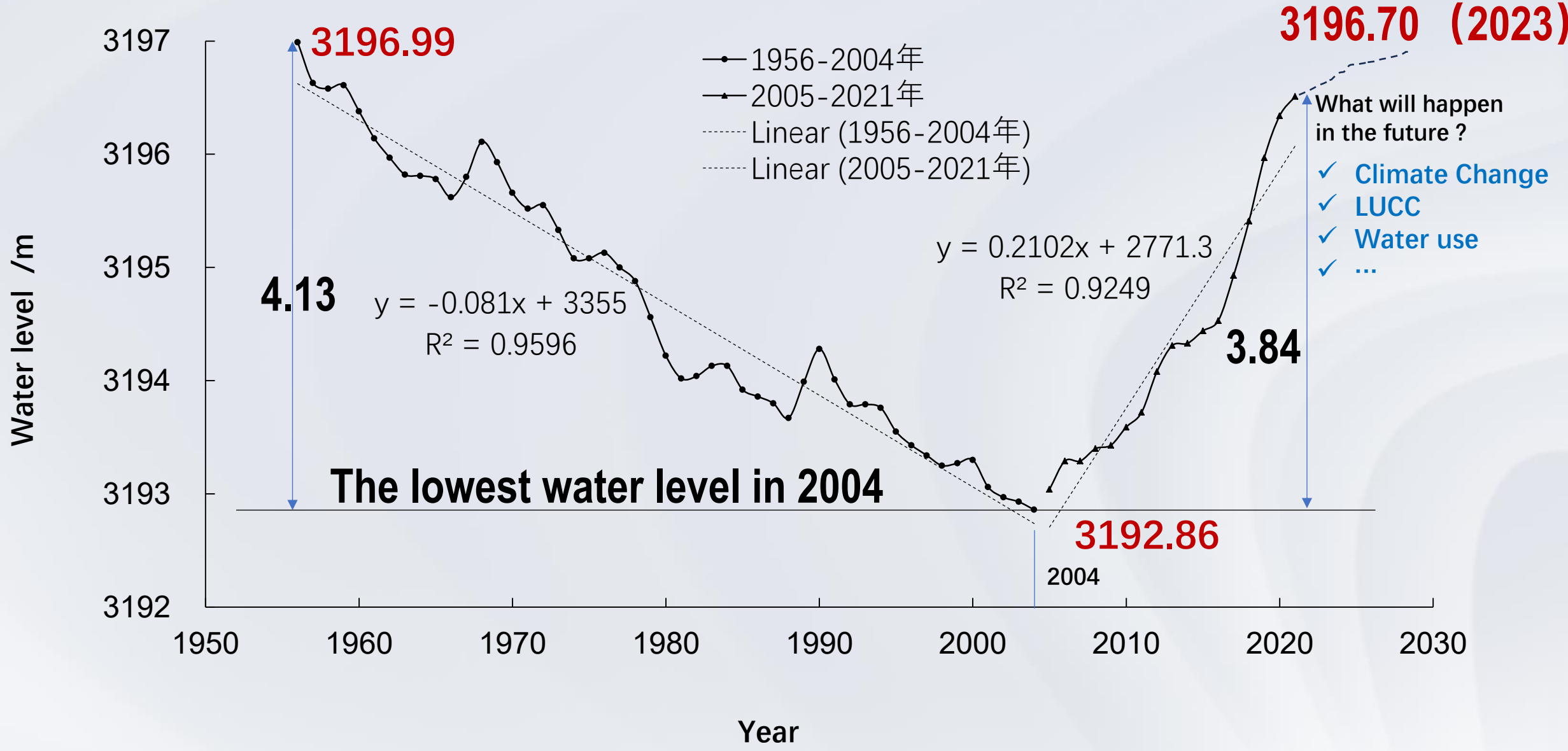
Buha River Basin

Area：14, 484 km²

Annual Runoff：1482 million m³

Proportion of Total Runoff：66.5%

2.1 Study area



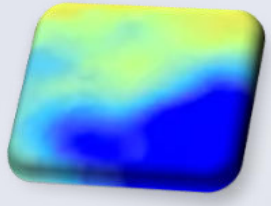
2.2 Methodology (Digital Twinning Watershed)

XVIII World Water Congress
International Water Resources Association (IWRA)

Digital twinning the river system

降水空间插值

Precipitation Input (Recorded & Climate pattern)

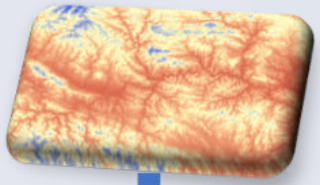


降水
（格点或站点）

Parameter interpretation

分布式参数提取

河网提取及单元划分

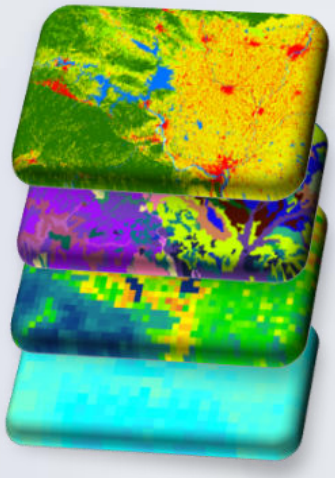


DEM

河网及分区

数字流域模型

Digital Watershed Model



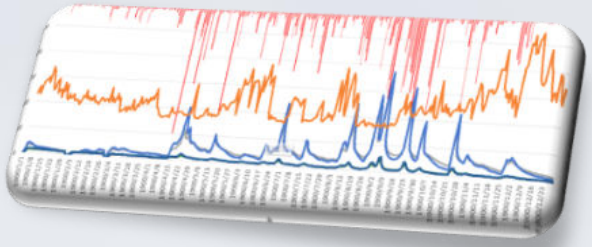
土地利用 Land use

土壤 Soil type

植被 Vegetation cover

蒸散发 Potential ET

Water level change of Qinghai Lake
(Water balance equation)



Runoff simulation result

径流模拟结果

2.2 Methodology (Digital Twinning Watershed)

XVIII World Water Congress
International Water Resources Association (IWRA)

Five steps for the river basin digital twinning

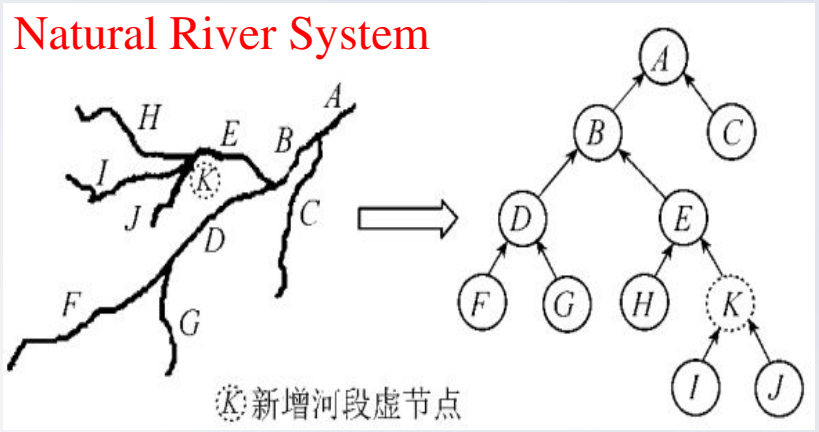
1 **2** **3** **4** **5**

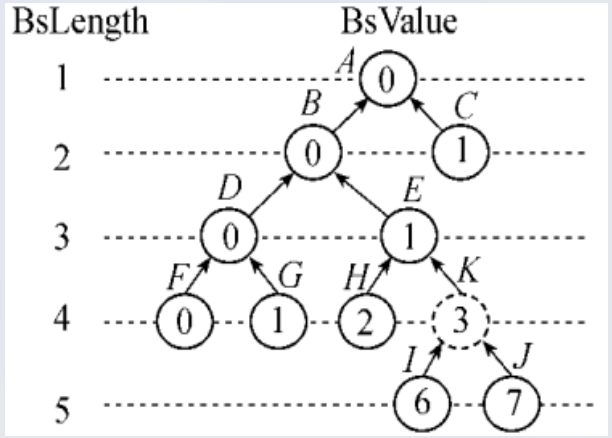
Binary tree structure

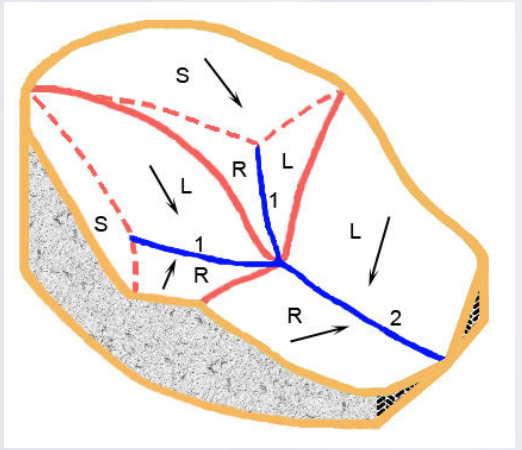
Coding for binary tree

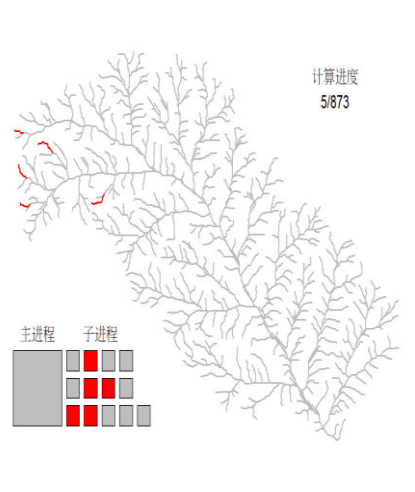
Hydrological modelling for each element

Parallel computing for the watershed









XVIII World Water Congress
International Water Resources Association (IWRA)

Content

- Introduction
- Study area and methodology
- Results and discussion
- Summarize

3.1 Model construction

XVIII World Water Congress
International Water Resources Association (IWRA)

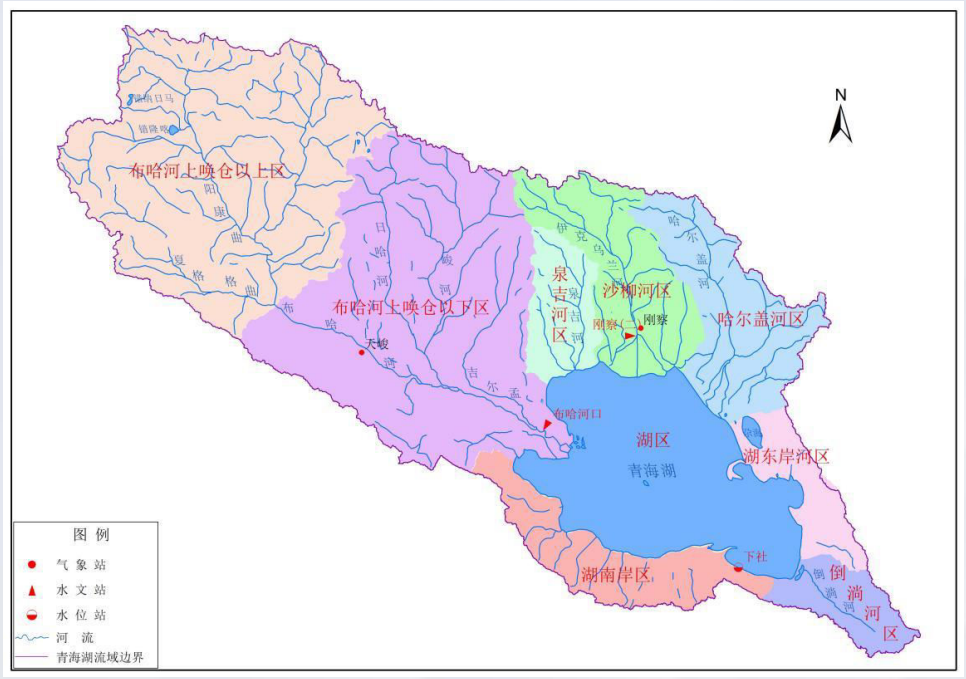
Historical observation → lake level, precipitation, runoff → Historical change process of hydrological elements

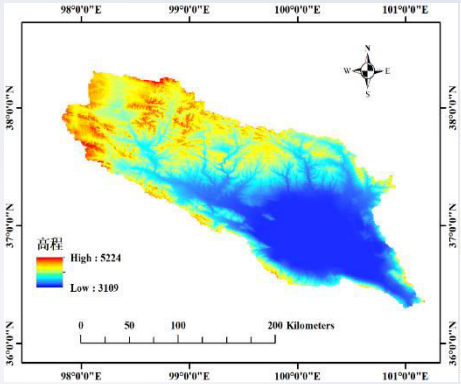
↓

Model Calibration and Validation

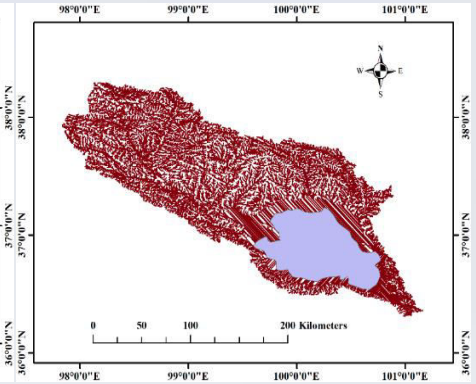
↓

Future prediction → statistical downscaling, deviation correction, scenario prediction → Future trends in temperature and precipitation

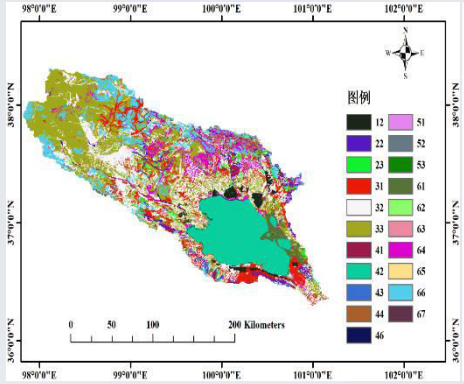




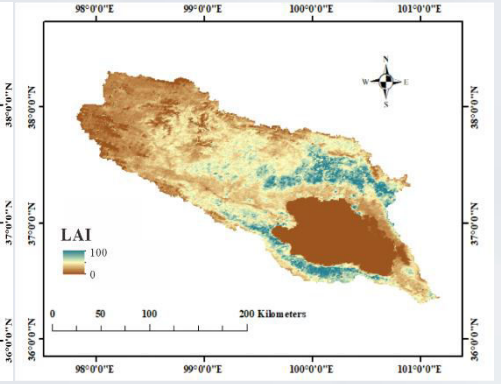
DEM



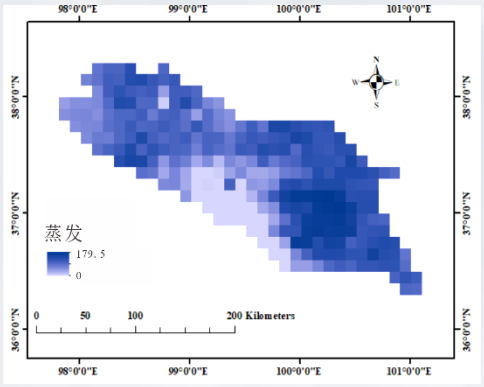
River network



Landuse

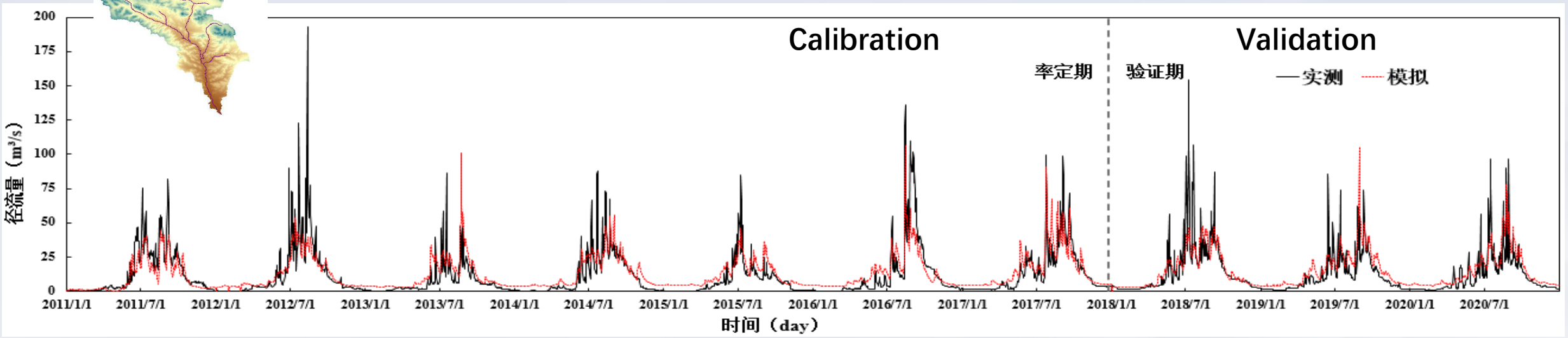


Vegetation Cover



Potential ET

3.2 Model Calibration & Validation



Comparison of simulated and observed discharge of Shaliu River

Main parameters in Shaliu River basin

ID	Sensitivtiy	Parameter	Unit of the parameter	Value
1	Sensitive parameters	PKV0	m/h	0.0009
2		PKV1	m/hr	0.0013
3		PKV2	m/hr	0
4		PKH1	m/hr	0.97
5		PKH2	m/hr	0.0016
6	Non-sensitive parameters	UTHETA1	m/hr	0.15
7		UTHETA2	m/hr	0.35
8		MTHETA1	m/hr	0.2
9		MTHETA2	m/hr	0.325
…	…	…	…	…

- correlation coefficent R^2

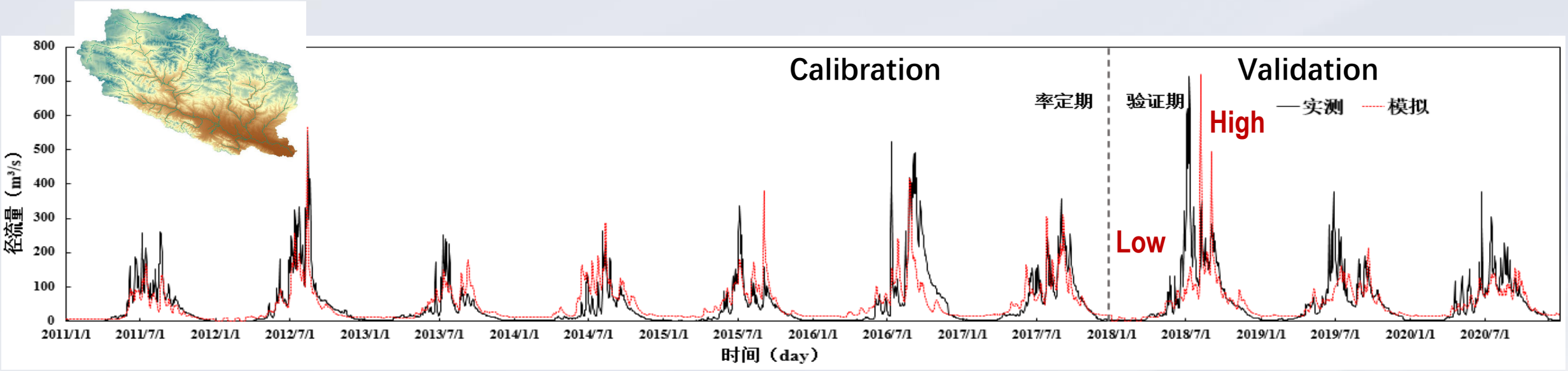
$$R^2=\frac{\left(\sum_{i=1}^{n}\left(Q_{sim,i}-\overline{Q}_{sim}\right)\left(Q_{obs,i}-\overline{Q}_{obs}\right)\right)^2}{\sum_{i=1}^{n}\left(Q_{sim,i}-\overline{Q}_{sim}\right)^2\sum_{i=1}^{n}\left(Q_{obs,i}-\overline{Q}_{obs}\right)^2}$$

- Nash efficiency coefficient E_{ns}

$$E_{ns}=1-\frac{\sum_{i=1}^{n}\left(Q_{obs,i}-\overline{Q}_{sim,i}\right)^2}{\sum_{i=1}^{n}\left(Q_{obs,i}-\overline{Q}_{obs}\right)^2}$$

- Calibration: R^2=0.84 ; E_{ns}=0.81; Validation: R^2=0.86 ; E_{ns}=0.84
- The runoff simulation results from 2011 to 2020 show that the model accuracy is reliable.

3.2 Model Calibration & Validation



Comparison of simulated and observed discharge of Buha River

Main parameters in Buha River basin

ID	Sensitivtiy	Parameter	Unit of the parameter	Value
1	Sensitive parameters	PKV0	m/h	0.0008
2		PKV1	m/hr	0.0013
3		PKV2	m/hr	0
4		PKH1	m/hr	0.97
5		PKH2	m/hr	0.0016
6	Non-sensitive parameters	UTHETA1	m/hr	0.15
7		UTHETA2	m/hr	0.35
8		MTHETA1	m/hr	0.2
9		MTHETA2	m/hr	0.315
…	…	…	…	…

- Calibration: R^2 =0.74 ; E_{ns}=0.72; Validation: R^2 =0.71 ; E_{ns}=0.67
- The runoff simulation of Buha River basin is accurate on the whole, but the discharge have a phenomenon of "low before precipitation and high after precipitation" , especially in 2018. The reason maybe the snow and glacier melting under the changing temperature weather, which leads to a large flood peak error.

3.3 Precipitation Projection in the future

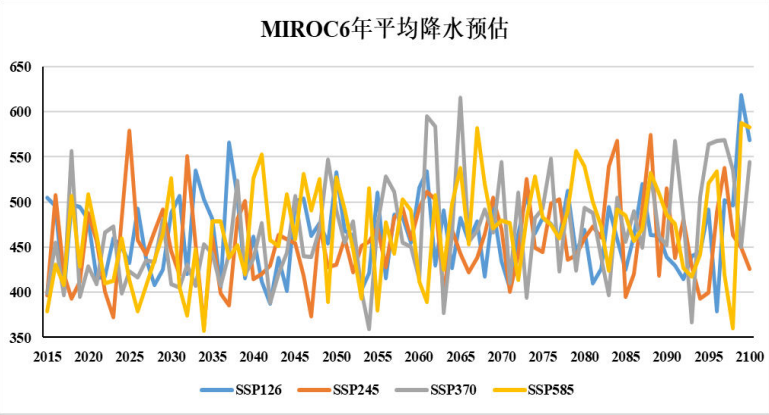
XVIII World Water Congress
International Water Resources Association (IWRA)

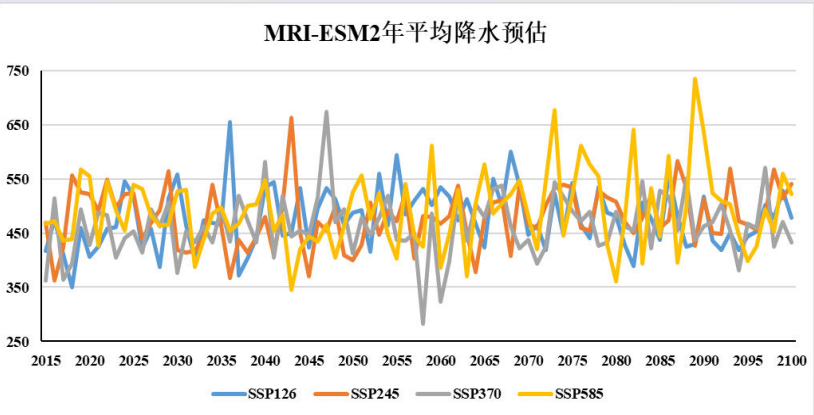
4 scenarios:

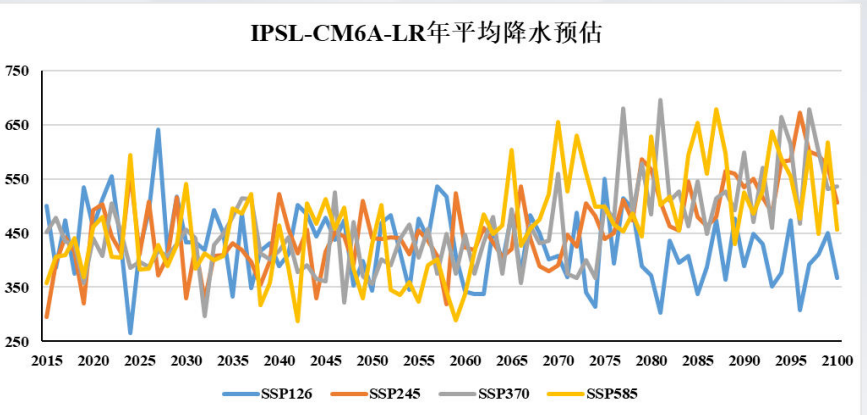
SSP1-2.6: 456.2mm; SSP2-4.5: 464.5mm
SSP3-7.0: 465.0mm; SSP5-8.5: 465.9mm

Climate Model	1980-2014	2015-2100
MIROC6	439.4mm	455.8-467.7mm
MRI-ESM2	443.0mm	470.8-491.3mm
IPSL-CM6A-LR	441.7mm	426.8-465.9mm

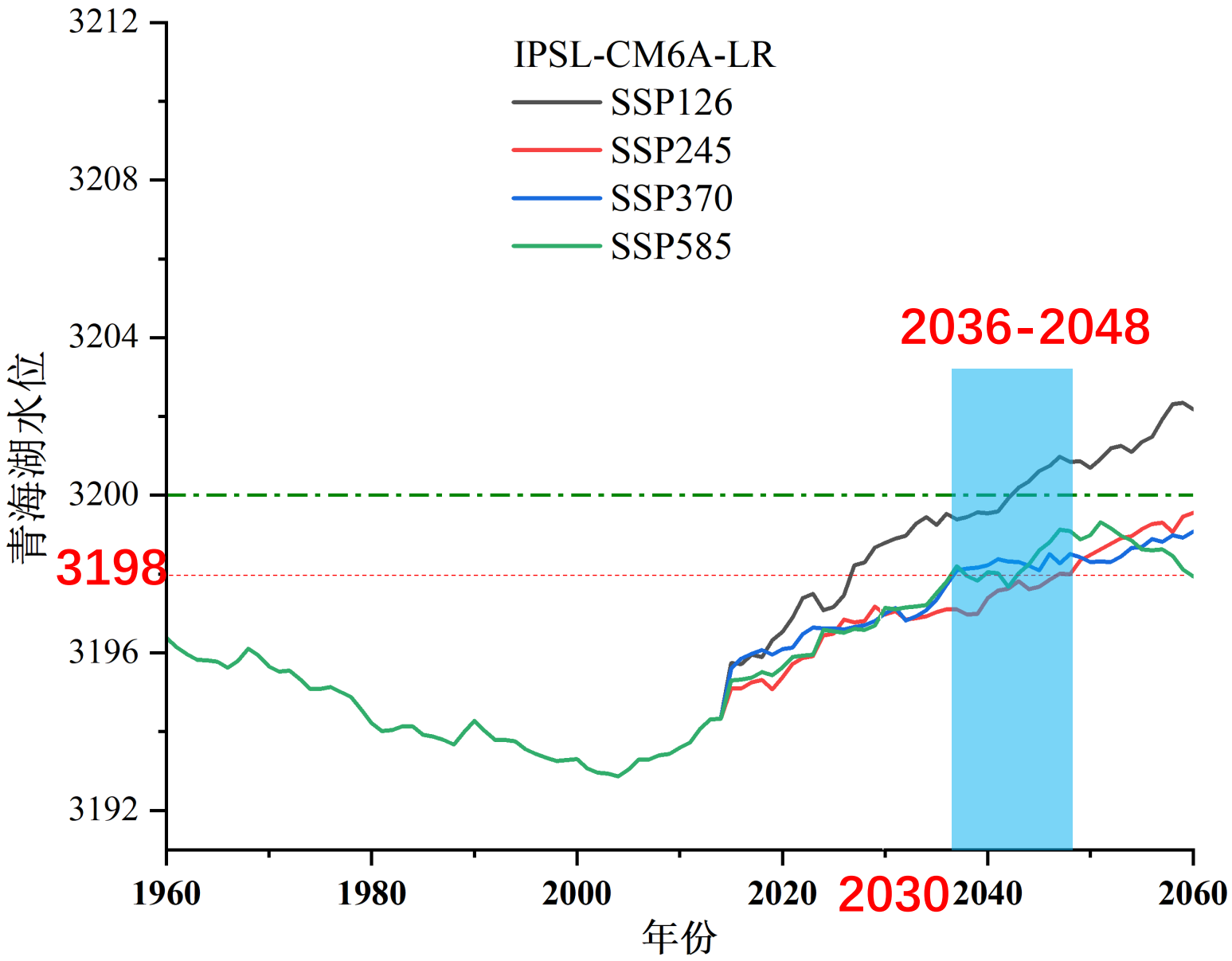
The precipitation under medium and high carbon emission scenarios is higher than the low emission scenario. The average annual precipitation for the medium and high emission scenarios is **465mm**, and the average precipitation in the low emission scenario is **456mm**. Compared with the annual average precipitation in the past and the future, there is a **certain increase** compared to the past.





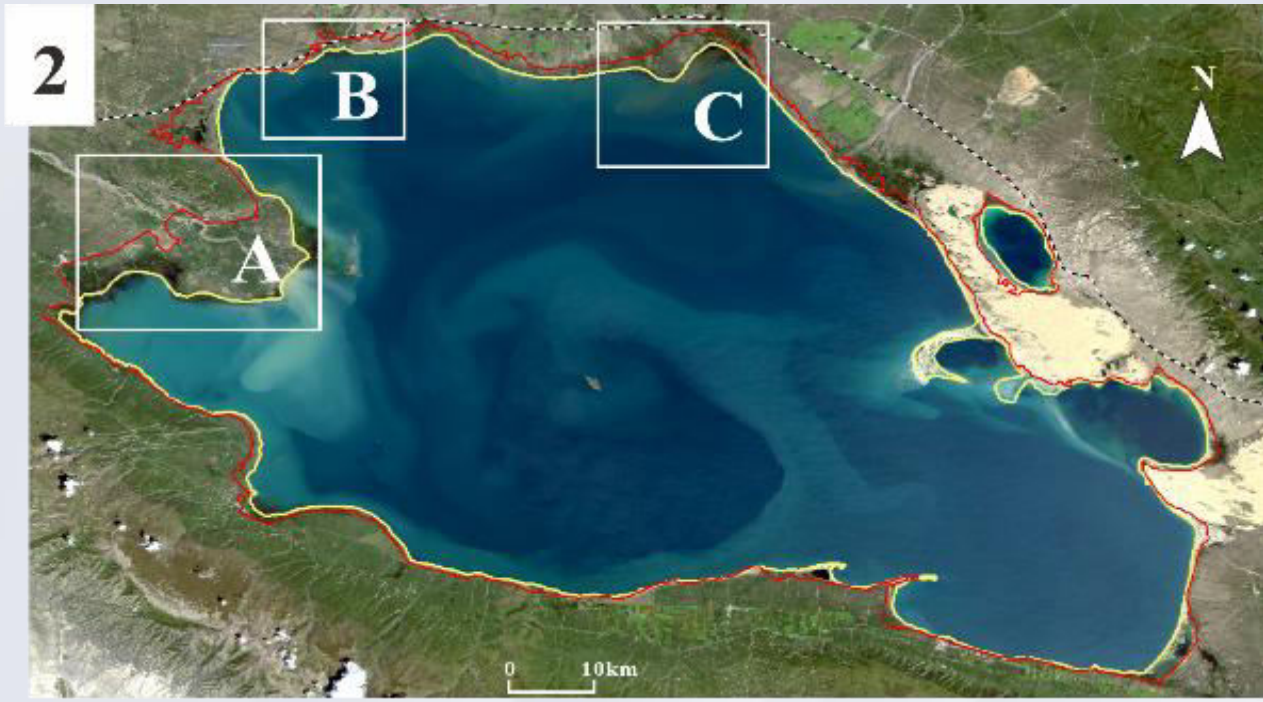


Water Level: m



- ✓ Based on the above precipitation scenario （IPSL-CM6A-LR）, the water level of Qinghai Lake will continue to rise.
- ✓ For most majority of the scenarios, the rising rate will slow down.
- ✓ The most likely period for the water level exceeding 3198 meter is between 2036 and 2048.

3.4 Water level in the future



- The measured water surface area of Qinghai Lake in 2020 was 4488.8 km^2, and the estimated water surface area in 2050 is 4915.3 km^2, which increased **426.5 km^2** compared with 2020. The average annual increase is 14.2 km^2. There are three positions that increase significantly, the estuary of Buha River (2A), Quanji River (2B) and Shaliu River (2C).
- The infrastructure construction in these three areas should consider the future submerging impact.

XVIII World Water Congress
International Water Resources Association (IWRA)

Content

- Introduction
- Study area and methodology
- Results and discussion
- Summarize

4 Summarize

- Digital Twinning Watershed could provide a platform to simulate the past hydrological processes, in addition, it also could help us project the future scenarios. Of course, there is uncertainty for future estimation.
- The digital watershed model was constructed in Qinghai Lake Basin, based on which the water level change was estimated in the next several decades before 2100.
- The water level of Qinghai Lake will exceed 3198 meter between 2036 A.D. and 2048 A.D., which should have great impacts on the surrounding pastures, especially in the delta of Buha River and Shaliu River.


Manual cleaning


Cladophora in the submerged pasture area
——2023.8.17

XVIII World Water Congress
International Water Resources Association (IWRA)

Thanks for Your Attention!