UN GEONOW 2024
首届联合国地信周

Effectiveness of flood and drought disaster defense in China and the application of digital twins

刘昌军

1、New characteristics of flood control in China under changing environment

Chapter 1 New characteristics of flood control in China under changing environment

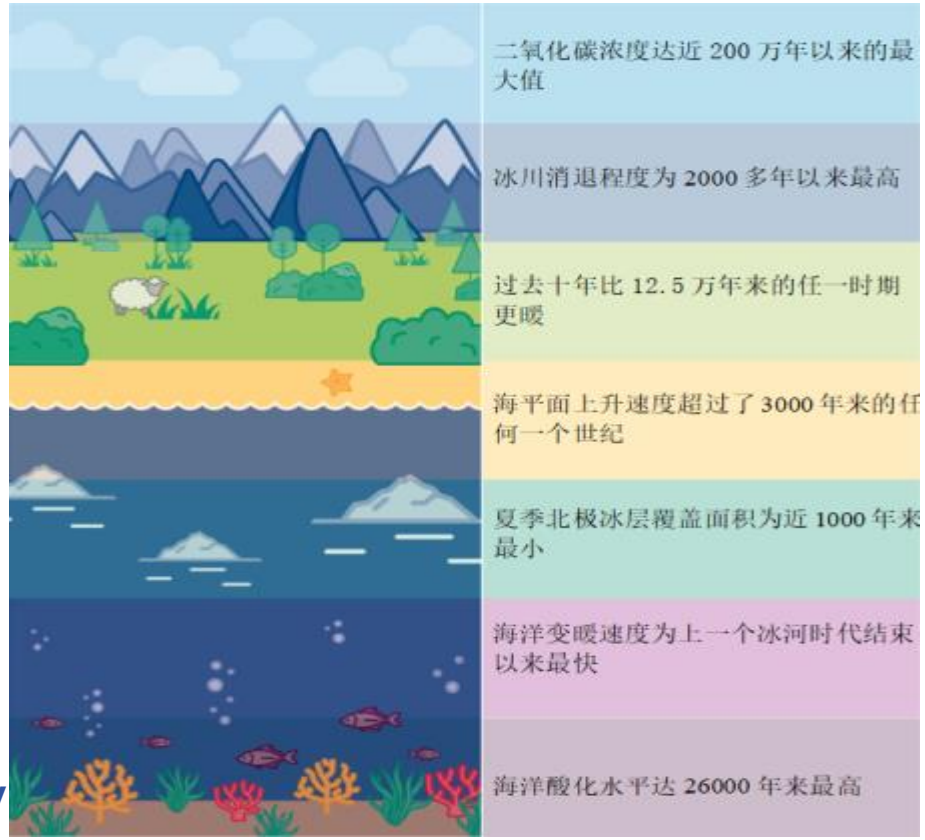
1.1 Continued warming of the climate

AR6 Synthesis Report: Climate Change 2023-IPCC

1、The global surface temperature in the last decade (2011-2020) has increased by **1.1°C** compared with 1850-1900. The continued increase in global greenhouse gas emissions is the main cause of global warming.

2、The atmosphere, oceans, cryosphere and biosphere are undergoing **extensive and rapid changes**. Human-induced climate change has affected many extreme weather and climate events in every region of the globe. It has resulted in a wide range of adverse impacts on nature and humans and associated loss and damage.

3、Between 2021 and 2040, there is **more than a 50 percent chance that global temperature rise will reach or exceed 1.5°C**. Especially under a high-emissions pathway, global temperatures could reach this tipping point even sooner (between 2018 and 2037); by 2100, global temperatures could rise by 3.3°C to 5.7°C, whereas the last time global temperatures exceeded pre-industrial levels by 2.5°C was more than 3 million years ago.

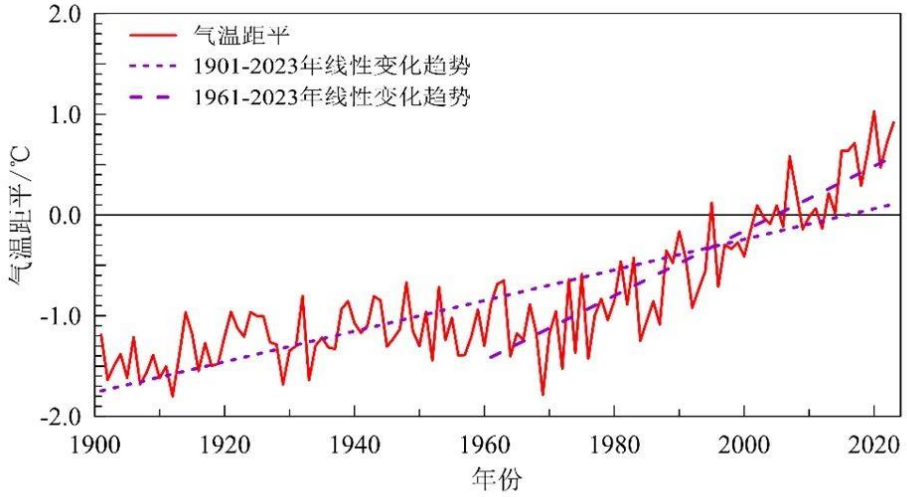


Impact of global warming . Figure source: WRI

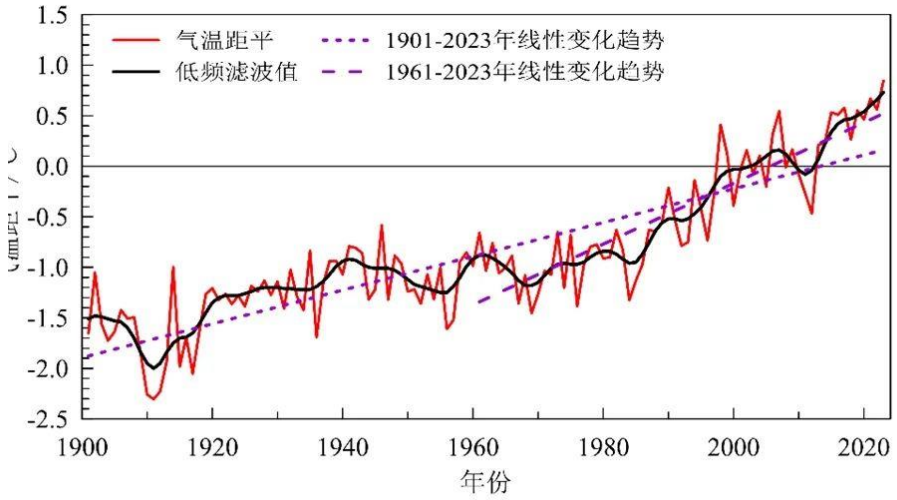
Chapter 1 New characteristics of flood control in China under changing environmentt

1.1 Continued warming of the climate

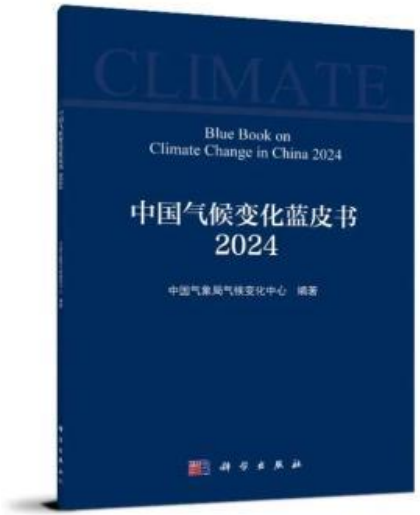
- *Blue Book onClimate Change in China 2024.* In 2023, the global average temperature, ocean heat content and sea level altitude were all at record highs, and the Antarctic sea ice extent was at a new low. China is a sensitive area and has significant impacts on global climate change. in 2023, China's annual average temperature, the distance of retreat from the end of glacier No. 1 at the source of the Urumqi River, and the thickness of the active layer of the perennial permafrost zone along the Qinghai-Tibet Highway, and other monitoring indicators, **all reached new highs**
- In 2023, the regional average temperature in Asia is 0.92°C above the normal value (reported using the 1991-2020 climate base period), the second highest since 1901; the annual average surface temperature in China is **0.84°C above the normal value**, the **warmest year since 1901**



1901～2023年亚洲陆地表面年平均气温距平（相对于1991～2020年平均值）



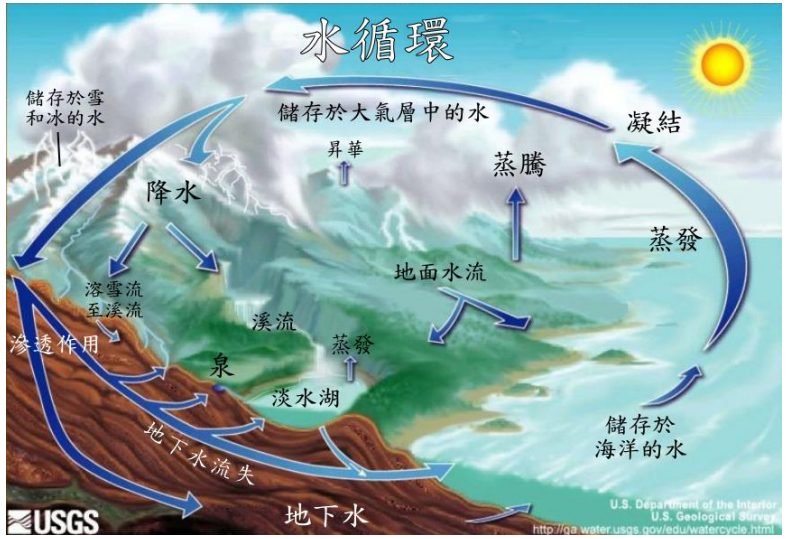
1901～2023年中国地表年平均气温距平（相对于1991～2020年平均值）



Chapter 1 New characteristics of flood control in China under changing environment

1.1 Continued warming of the climate

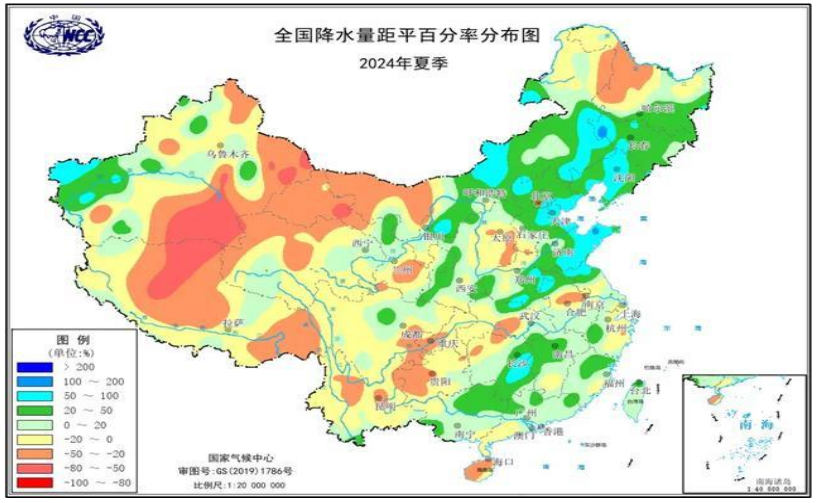
- Rising temperatures lead to increased evaporation and faster water cycling
- According to the Clausius-Clapeyron (C-C) law, for every 1°C increase in temperature, the atmospheric water content increases by about 7%. Due to the increase in temperature, the saturated water vapor pressure increases, the actual atmospheric water vapor content increases, and if rainfall is formed, the amount of rainfall will be larger and the number of extreme events will increase.
- Enhanced snowmelt from glaciers due to global warming, altering hydrological rhythms in watersheds
- Changes in the extent and thickness of permafrost as a result of global warming, affecting water movement and energy exchange in land-surface processes, such as seepage and evapotranspiration processes, and altering watershed catchment flow regimes



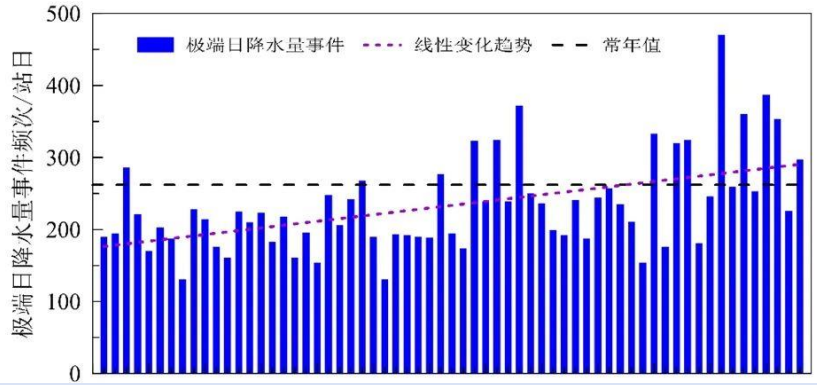
Chapter 1 New characteristics of flood control in China under changing environment

UN GEONOW 2024 首届联合国地信周

1.2 Extreme weather events show a tendency to increase



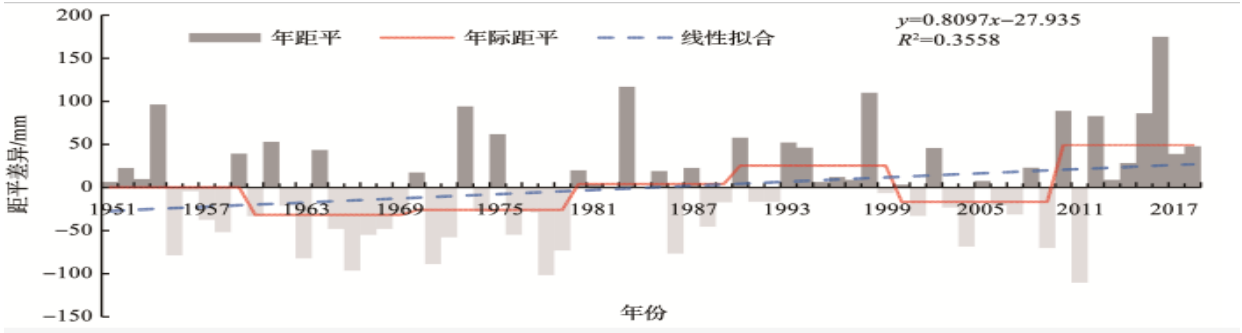
National Distribution of Precipitation Distance Plane (%) for Summer 2024



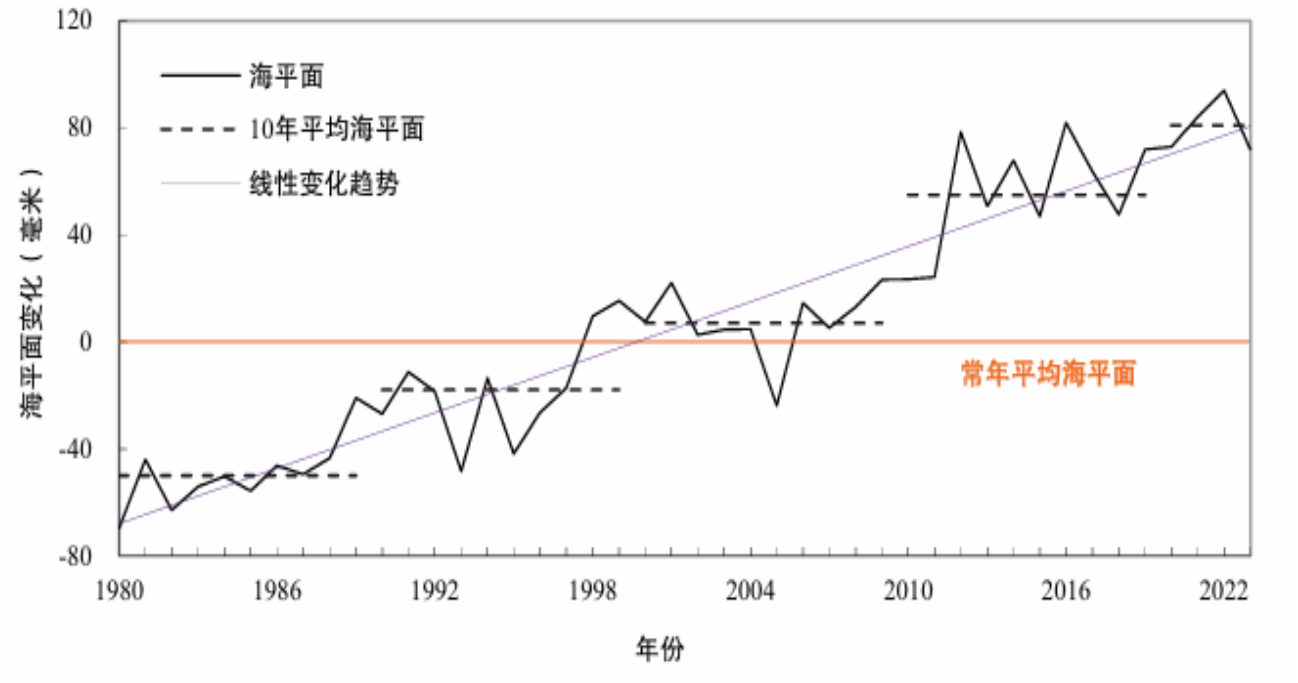
Extreme rainfall events tend to increase in number and intensity

- The perennial value of the regional mean annual precipitation in China (1981-2010) is 630 mm.Since 1961, the annual precipitation has been on a general increasing trend, about 4.2 mm/10a
- Against the background of global warming, the spatial distribution of precipitation has changed. The lower reaches of the Yangtze River, the south-eastern rivers, southern China, northern north-eastern China, north-western China and most of Tibet show a strong increasing trend in annual precipitation.

Fourth National Assessment Report on Climate Change of China，2022



1.3 Volatile sea level rise



Coastal sea level change in China, 1980-2023

CHINA SEA LEVEL BULLTIN，2023

CHINA SEA LEVEL BULLTIN，2023

The results of sea level monitoring and analysis indicate that the overall trend of sea level rise along the coast of China is accelerating

- China's coastal sea level rises at a rate of 3.5 millimeters/year, 1980-2023.
- From 1993 to 2023, the rate of sea level rise along the coast of China is 4.0 mm/year, which is higher than the global average of 3.4 mm/year in the same period.

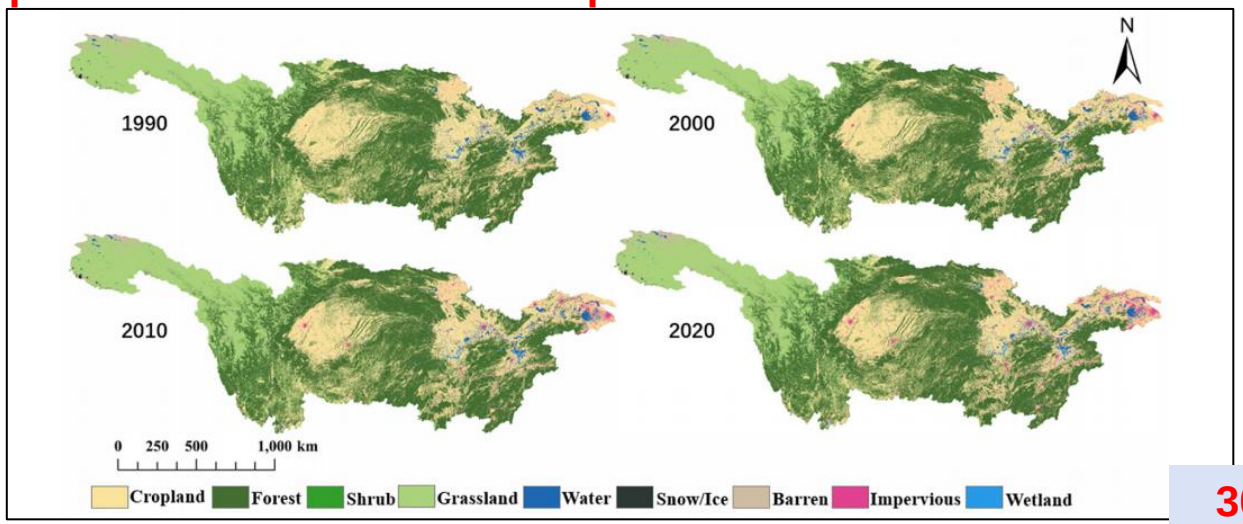
Impact.

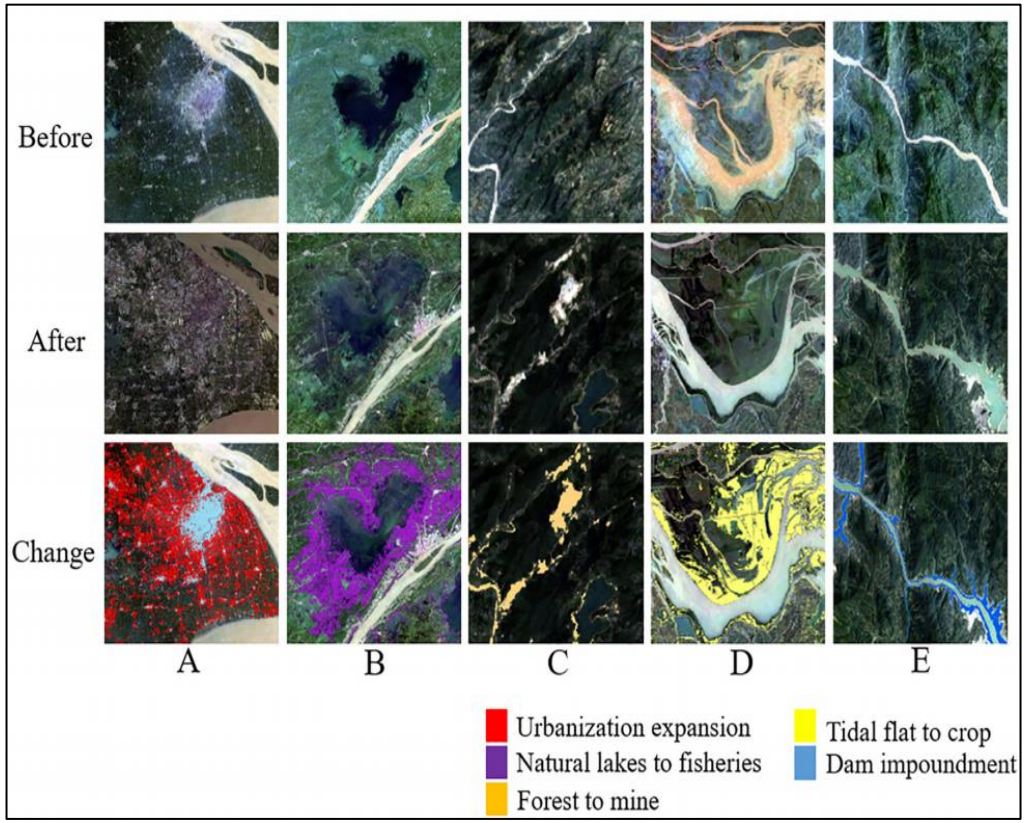
- Trend towards stronger storm surge periods
- Coastal sea mentioned the ability to reduce the defense, preliminary analysis, if the century has not sea level rise of 0.5 meters, the Shanghai area sea mentioned the standard of defense against storms towards the present dry years, reduced to 300 years.
- Increased risk of flood control due to increased superimposition of storms on estuaries

Chapter 1 New characteristics of flood control in China under changing environment

1.4 Increasing human activity in the subsurface

- Changes in the subsurface that change the parameters of evaporation and infiltration in the watershed **change the pattern of production and sinking in the watershed**
- **Significant reduction in runoff coefficients** and significant changes in rainfall-runoff relationships in northern rivers
- Construction destroys the consistency of the data series and **the representativeness of the model parameters is lost**



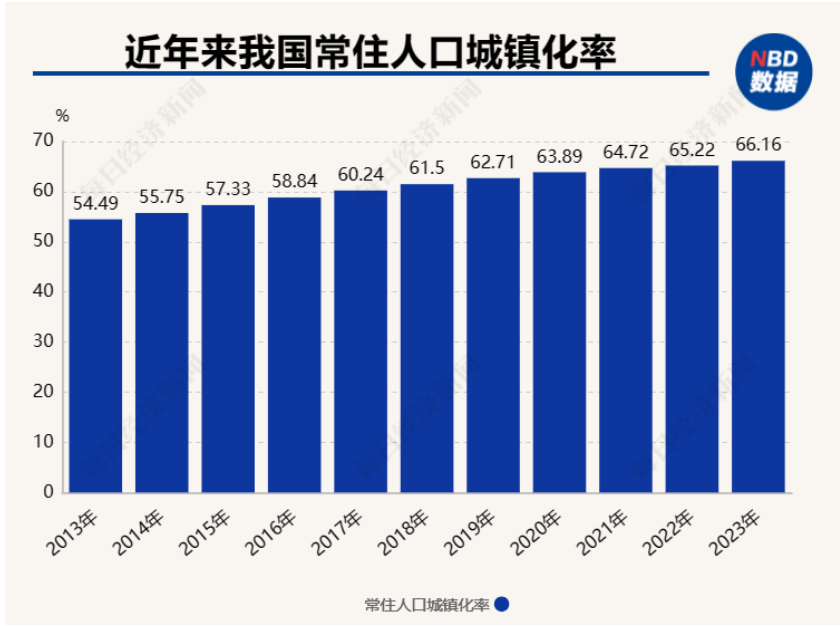


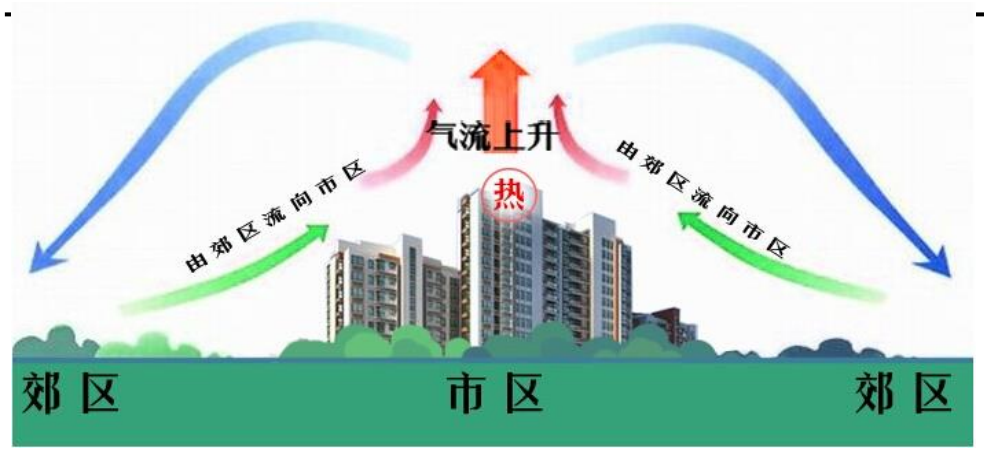
30 years of land use change in the Yangtze River Delta

- **Relevant studies show that in the 30-year period from 1990 to 2020, the land use and land cover of the Yangtze River Delta have changed drastically, the area of impervious surfaces more than tripling, the area of cultivated land decreasing by 6.12%, and the area of watersheds decreasing by 6.09%.**

1.5 Rapid urbanization and the growing problem of urban flooding

- Urbanization rate increased from 19.4% in 1980, 36.3% in 2000 to 65.22% in 2022.
- Urban Heat Island Effect:Most of the buildings in the city are made of stone and concrete, with low heat capacity and high thermal conductivity, coupled with the blocking or attenuating effect of the buildings themselves on the wind, resulting in the city's average annual temperature is higher than that of the suburbs, and in the spatial distribution of temperature, the city is like a warm island.
- Rain Island Effect: Condensation nucleation enhancement, microtopographic barrier effect





Chapter 1 New characteristics of flood control in China under changing environment

1.5 Rapid urbanization and the growing problem of urban flooding

- In 2012, extreme rainstorms in Beijing resulted in 79 deaths and 11.6 billion yuan in direct economic losses.
- In 2013, 70% of Yuyao City was flooded for more than a week after heavy rainfall in Ningbo and Shanghai.
- In 2016, cities along the Yangtze River in Wuhan, Nanjing, Zhenjiang, and Changzhou were severely flooded, and Wuhan's high-speed rail station was flooded
- In 2016, heavy rainfall in Xingtai City, with rainfall exceeding “63.8” and “96.8”, a record high, caused 25 deaths and 13 missing persons
- April 2019, Shenzhen localized short duration heavy rainstorms, resulting in 11 people killed
- September 2023, Hong Kong was hit by the rainstorm of the century, with an hourly rainfall of 158.1 millimeters, killing 2 people and injuring 117 others.

1.6 Typhoons, flash floods and geologic disasters, small and medium-sized river flooding are the current focus of defense

Main points of the current study:

(1) Under the combined effects of climate and ocean warming, the number of typhoons in the north-west Pacific has decreased, but their intensity has increased markedly. since 1970, the intensity of typhoons making landfall in East and South-East Asia has increased by 12 to 15 percent.

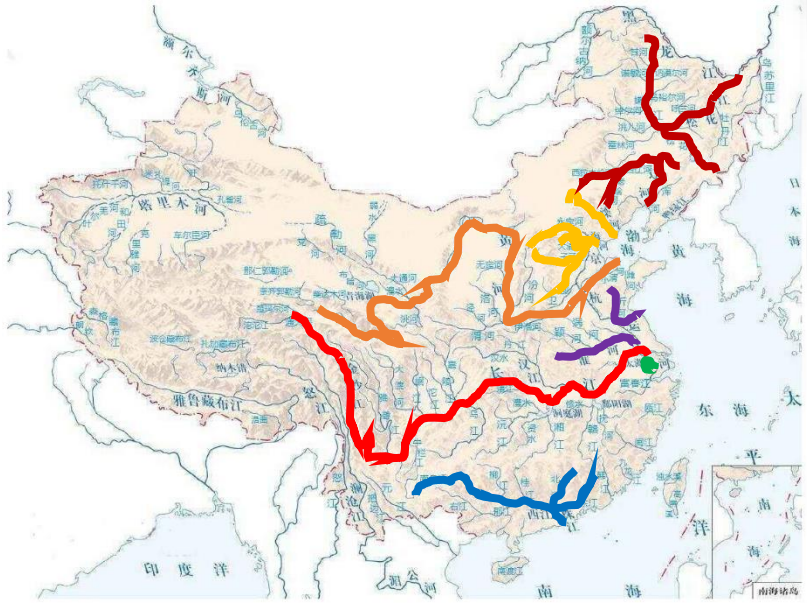
(2) Global sea temperature rise to the typhoon "north drift", the northern region of the typhoon disaster risk increased. 2023 No. 6 typhoon "Kanu" in August 11, 23:00 landing in the city of Zhuanghe, Liaoning Province." Kanu" into the East China Sea after the path of the two large angle sharp turn, 1 to China's northeastern region to bring significant precipitation. 。

(3) As a result of global warming, the strong typhoon season has advanced, aggravating extreme precipitation in summer. For example, "Dusu Rui" in 2023 caused 23.7 floods on the Haihe River, "Fireworks" in 2021 caused extreme rainstorms in Zhengzhou, and "Heigbi" in 2020 caused huge economic losses in Wenzhou, Zhejiang Province. The 2020 "Hegebi" brought huge economic losses to Wenzhou, Zhejiang Province.

1.6 Typhoons, flash floods and geologic disasters, small and medium-sized river flooding are the current focus of defense

Long-term and cyclical nature of floods

- Many basins have a long span of time since the last flood disaster, and there is still a possibility of a repeat of the historical mega-flood disaster, which needs to be prepared to deal with at all times.



• 2020 Yangtze River Basin

• 1982 Yellow river

• 2007 Huaihe River Basin

• 2023 Haihe River Basin

• 2005 Pearl River Basin

• 2013 Songliao River Basin

Small and medium-sized reservoirs

- a large number of reservoirs at risk
- Inadequate monitoring and early warning facilities
- Inadequate emergency response plans
- Inadequate emergency response coverage

Flood storage and detention area

- Activation involves large-scale mass relocation
- Lagging construction of security facilities
- The control engineering system is still not perfect
- Most of the national flood storage areas have not been used for many years

Mountain flash flood

- Wide-ranging impact and large number of people involved
- Short warning time makes defense difficult
- Highly susceptible to large casualties

Small or medium sized river

- Governance tasks have not been completed
- Large gaps in water monitoring and early warning

Flash floods and geologic hazards are the disasters that cause the highest number of deaths and injuries

Chapter 1 New characteristics of flood control in China under changing environment

1.1 Increased frequency of drought disasters

The results of the study show:

- The frequency of severe drought or more between 1949 and 1979 was 16.1%.
- The frequency of severe drought or more between 1980 and 2017 was 52.6 percent
- More than threefold increase in frequency
- Increasing frequency of drought on time scales

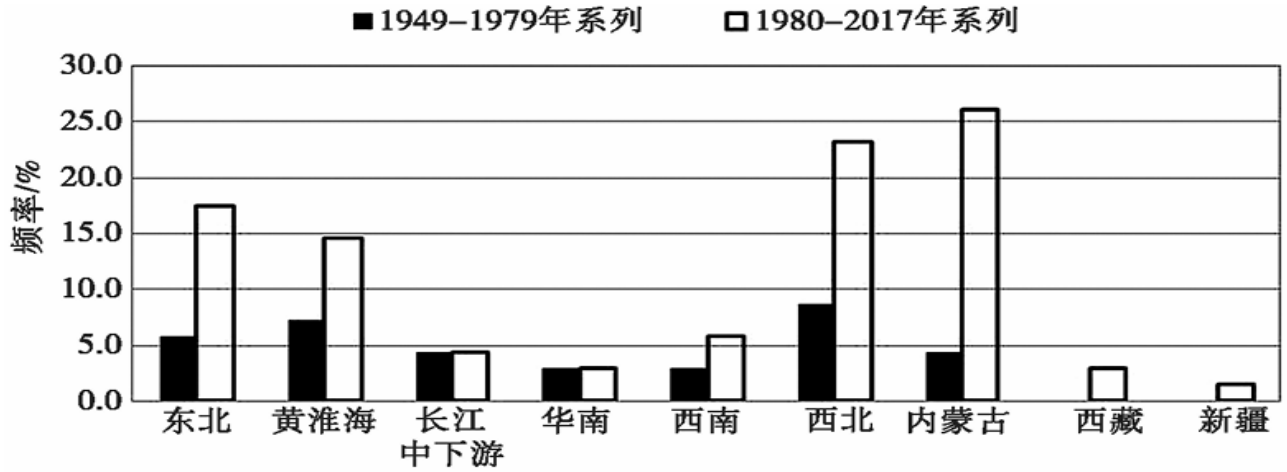
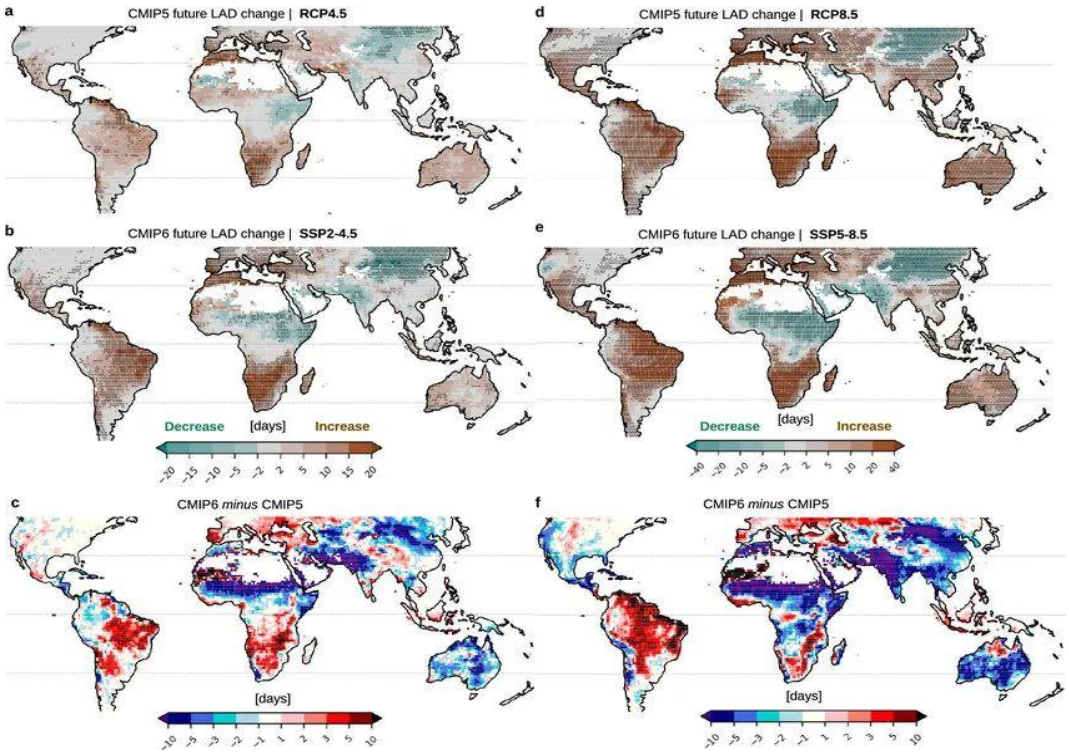


Diagram of drought frequency above heavy drought in various large areas around 1980

《Spatio-temporal pattern and evolution trend of drought disaster in China in recent seventy years》



- Forecasts indicate that future droughts may last longer than expected

Petrova et al.《Nature》2024

2、Effectiveness of drought and flood defense

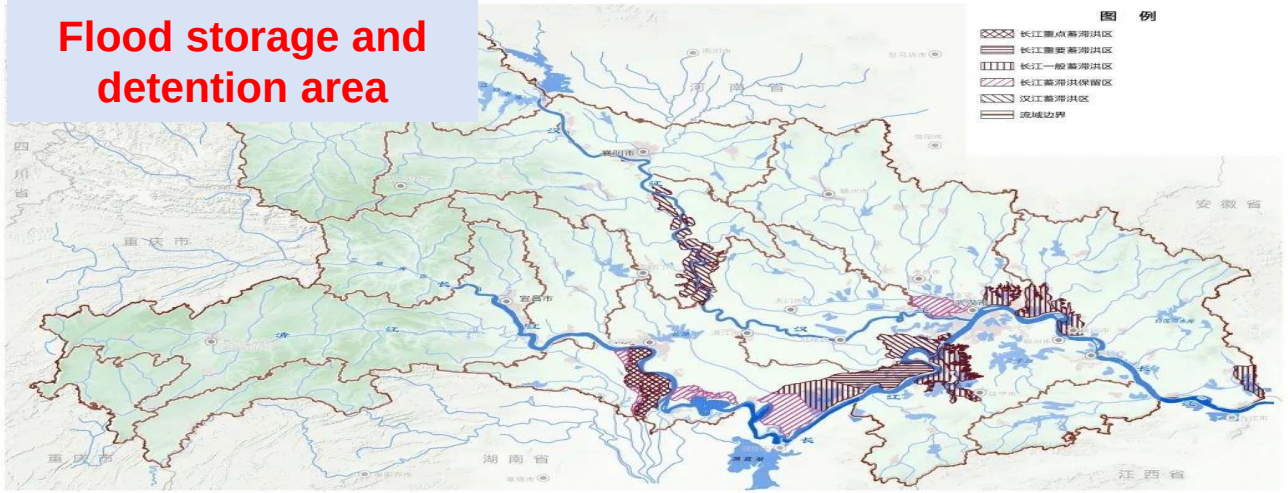
2.1 Basin flood and drought control engineering system

Three Gorges Dam

By the end of 2023:

- 94,877 reservoirs and hubs, with a total capacity of 999.9 billion m^3
- 325,000 kilometers of river embankments above level 5
- The cumulative number of pumping stations with an installed flow rate of 1m^3/s or a power of 50KW or more is 91,324.
- The cumulative number of pumping stations with an installed flow rate of 1m^3/s or a power of 50KW or more is 91,324.
- 41,114 existing rural hydropower stations
- Comprehensive soil and water erosion control area of 162.7km^2 nationwide

Flood storage and detention area



Data from the Department of Flood and Drought Disaster Prevention show that:

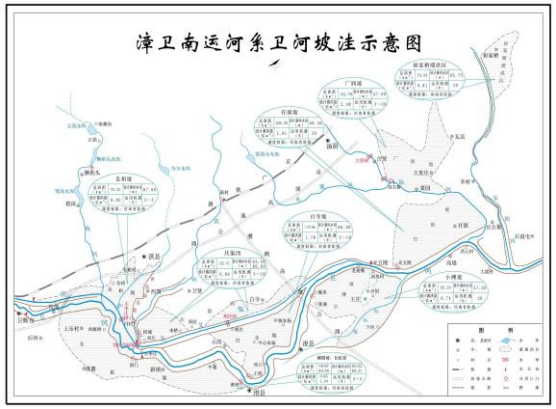
During the 2023 flood season, 4,512 (times) large and medium-sized reservoirs were put into operation across the country, impounding 60.3 billion m^3 of floodwater, reducing flooding in 1,299 (times) towns and cities, reducing flooding of 16.1 million mu of arable land, and avoiding the transfer of 7.21 million people (times)

2.1 Basin flood and drought control engineering system

In recent years, as China has continued to improve the engineering system for flood control and drought relief in river basins, it has formed a full-coverage engineering network **from upstream to downstream, from main streams to tributaries, and from regions to basins.** Through scientific planning and layout, it has realized **the construction of all-round flood control and drought-resistant capacity** enhancement for large river and lake basins, effectively reducing the loss of people's lives and property

July 20 Heavy rainstorm in Zhengzhou

- **Reservoirs stop floods and cut peaks.** 135 large and medium-sized reservoirs have accumulated a total of 2.9 billion m³ of stopping and storing floods.
- **Flood storage and retention areas are utilized.** The Haihe River Basin enabled 11 flood storage and retention areas, with a maximum storage capacity of 1.187 billion cubic meters of water, effectively lowering the water level of the Weihe River and the main stream of the Busan River.



Weihe flood storage and detention area

severe drought event over Yangtze River Basin in summer of 2022

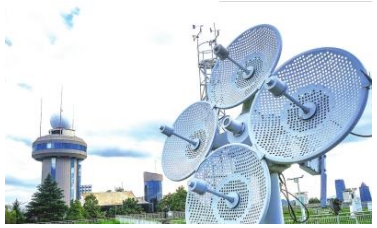
- Organize and implement two rounds of **special joint scheduling actions for drought relief and water supply protection** for reservoirs in the Yangtze River Basin during the critical time for the growth of autumn grain crops in the Yangtze River Basin.
- Precise scheduling of 75 large and medium-sized reservoirs in the Yangtze River Basin, with a cumulative water replenishment of **6.16 billion m³.**
- Guaranteed water supply to **356 large and medium-sized irrigation areas** along the recharge route, **28.56 million** mu of rice and other fall grain crops and many small irrigation areas.

Recharge of the middle and lower reaches of the Yangtze River

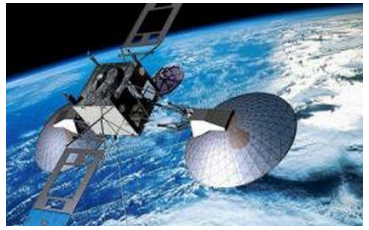
2.2 Rainwater monitoring and forecasting system

China has built a relatively complete **meteorological and hydrological monitoring system**, a **typhoon forecasting and warning system**, a **flood forecasting system** for important sections of large rivers and small and medium-sized rivers, and a **monitoring and warning system for flash floods**. In accordance with the rainfall monitoring sky and land "**three lines of defense**" , effectively extending the flood forecasting period, improve the accuracy of flood forecasting.

Meteorological three-dimensional monitoring station network



546 weather radars



21 meteorological satellites of the Fengyun series

416,000 sets of rural tweeters

More than 70,000 surface weather observation stations

Hydrological Information Collection

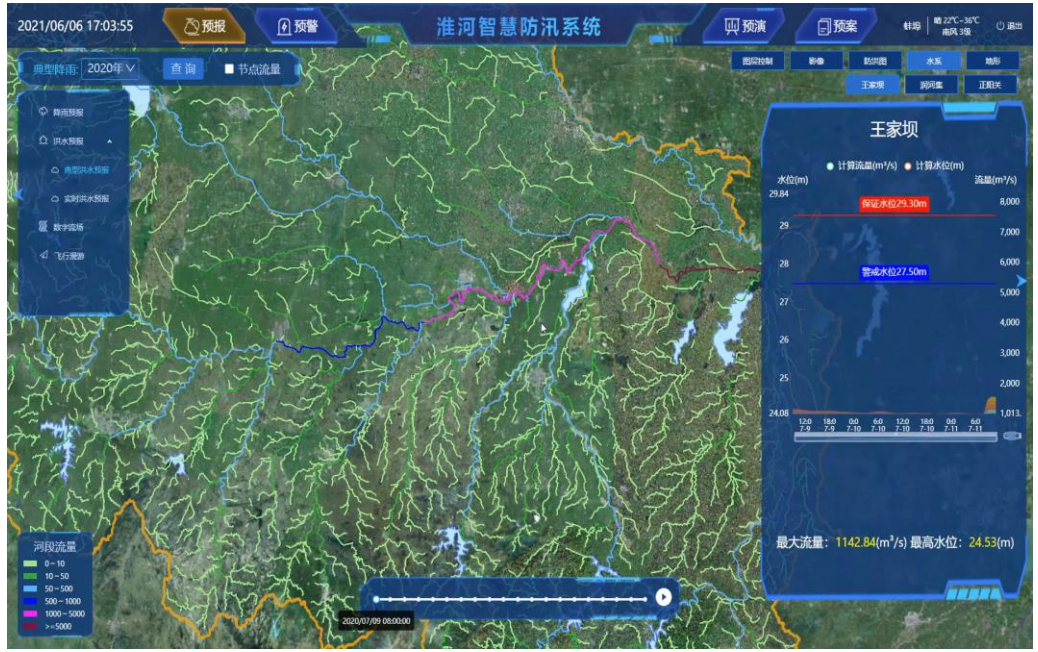
3,312 national basic hydrological stations

56279 rainfall stations

2033 water level stations

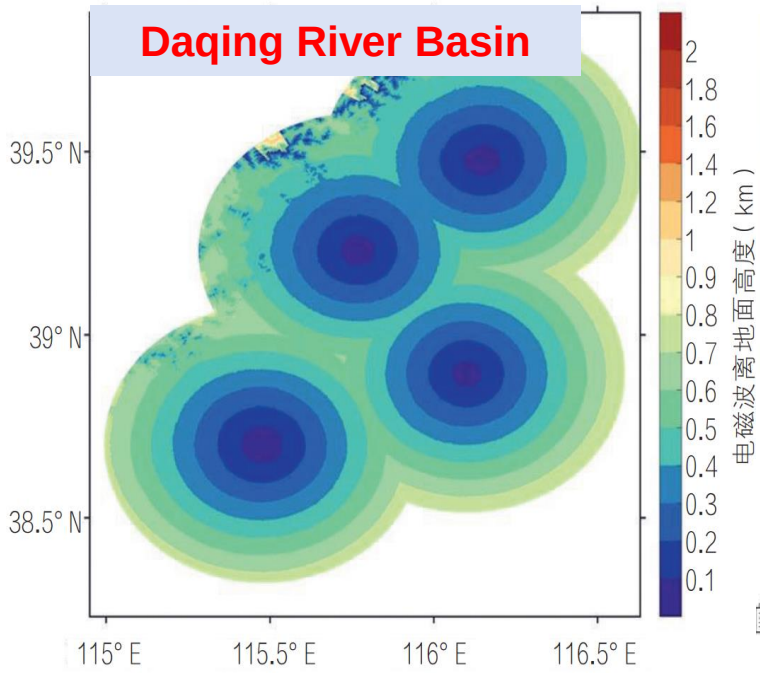
5809 moisture stations

early warning and forecast

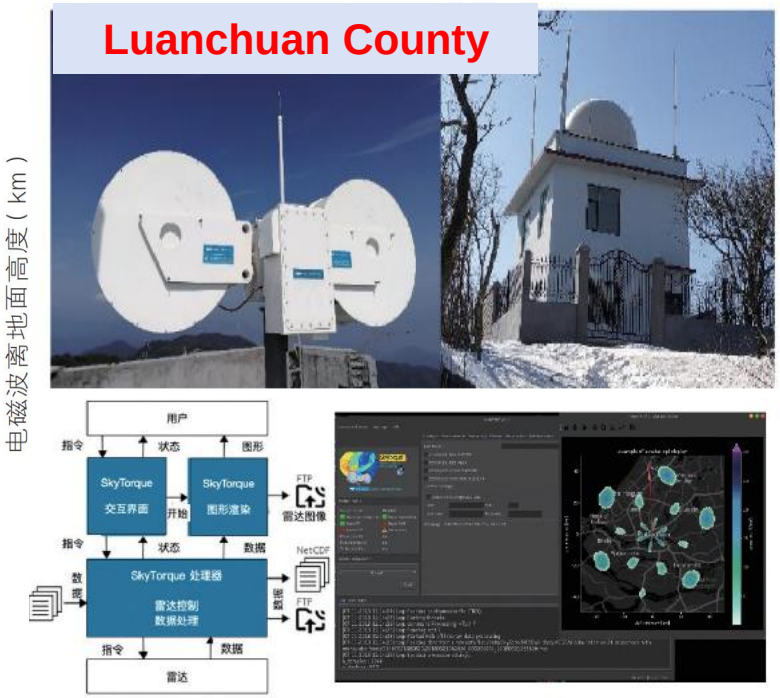


2.2 Rainwater monitoring and forecasting system

- Since 2020, the construction and pilot application of **High-Precision X-Band Hydrological Rainfall Radar**(Phased Array Type and Dual-Polarization Mechanical Type) has been carried out in the Yongding River Basin in Beijing and the Daqing River Basin in Xiong'an New Area in Hebei Province
- Based on **7** phased array rainfall radars, **automated township-level radar short-term quantitative grading warnings** (blue, yellow, orange, red) for heavy rain have been implemented in the Daqing River Basin in Hebei, as well as in the Laodao River and Liuyang River Basins in Hunan.



（a）河北大清河流域试点区



Radar network deployment in the Daqing River Basin:

- Temporal resolution of 40 s and spatial resolution of 30 m
- Radar products are highly consistent with data observed at rainfall stations
- High correlation coefficient between estimated rainfall and actual observations

The National Flash Flood Disaster Prevention Pilot and Demonstration Base in Luanchuan County:

- Accurate forecasts and warnings for the 2019 heavy rain flash flood process
- High-resolution rainfall monitoring and flash flood forecasting and early warning
- Research and development of an early warning system for forecasting flash floods in small watersheds

2.3 Digital twin water conservancy system

- **Digital twin water conservancy** is oriented to the new stage of high-quality development needs of water conservancy, water conservancy decision-making and management to provide forward-looking, scientific, accurate and safe support to realize the integration of water conservancy business and modern information technology development of intelligent water conservancy **implementation measures**.
- **Digital twin basin, digital twin water network, digital twin water conservancy project**, to realize the "2 + N" business application "four pre" (forecast, early warning, preview, preplanning), synchronization and strengthening of network security and protection system, is the main task of the digital twin water conservancy system.

	Project name	Province	Main construction content
1	Digital twins of the Yimu-Si water system (Jiangsu part)	Jiangsu Province	**Data substrate**: Xinyi River and water conservancy projects, Tongshan urban area, Shiliang River Reservoir, sea-entry waterway, and Sisi County area; **modeling platform:** three-dimensional simulation model; **knowledge platform:** river hydrodynamics, flood forecasting and scheduling, intelligent scheduling program and dispatch rules for urban areas, and real-time monitoring of the project for early warning of the health status prediction
2	Digital Twin Flying Cloud River	Zhejiang Province	**Data Substrate:** Aggregate all kinds of basic data in Fiyun River Basin to provide data substrate for Fiyun River Basin through data governance, mining and services; **Model Platform:** Main Stream Hydrological Model, Water Conservancy Project Safety Model, Visualization Model; **Knowledge Platform:** Based on the historical flood scheduling process, provide intelligent analysis of scheduling programs and decision-making, such as the Knowledge Mapping.
3	Digital Twin Lean River	Jiangxi Province	Build a **3-level data substrate**, construct a basin flood control intelligent simulation model platform with multi-model coupling of future rainfall, hydrological forecasting, water project scheduling, one-dimensional and two-dimensional algorithms, etc., and focus on breakthroughs in the "four-prevention" technology of flood control in small watersheds based on digital Li Sheng.
4	Digital Twin Xiaoqing River	Shandong Province	Construction of **L2-level data baseboards**, construction of component-level (LOD3.0) model units for hydromechanical, electrical, and automation equipment, development of equipment operation and maintenance databases and data connection, and construction of operation and maintenance information fusion and visualization scenarios for project operation and management.

2.3 Digital twin water conservancy system

After nearly three years of active action at all levels of the water conservancy sector, scientific planning, and vigorously promote, China's digital twin water conservancy construction has achieved **Phased results**, has been actively exploring, pilot into a **comprehensive deepening of the promotion** and **strengthening of the application** of the new stage

- **Sky-earth-plumbing monitoring and sensing**
  - **Space-based airborne sense**
    - 23 remote sensing satellites
    - 2500 drones
  - **Ground Sense**
    - 15,000 video flow monitoring locations
    - 155,000 surface hydrological reporting stations
  - **hydro-perception**
    - Ten million engineering safety monitoring locations

- **Relevant results**
  - ◆ National water conservancy data baseboard of **16 million** water objects in **55 categories** basically completed
  - ◆ calculation of output and sinks
  - ◆ Multidimensional flood evolution and inundation analysis
  - ◆ Reservoir scheduling
  - ◆ river ice dynamic
  - ◆ Tidal upwelling effects
  - ◆ Salinity Analysis
  - **Important breakthroughs** in the R&D and application of more than 40 independently controllable water conservancy professional models
  - ◆ Water Conservancy Artificial Intelligence Big Model Realizes Business Applications

Digital twin water conservancy construction for flood disaster defense work to provide **strong decision-making support**. It played an important role in major disaster prevention and mitigation work, such as the drought protection of water supply in the Yangtze and Pearl River Basins in 2022, the defense of the Haihe River Basin flood in 2023, and the disposal of dangerous situations in Hunan Tuanzhouwan and the Laoha River in Inner Mongolia in 2024.

2.4 Flood and drought disaster prevention work system

- New Ideas: People First, Life First, "Two Insistences", "Three Transformations"
- New requirements: people's aspirations for a better life put forward new requirements for flood prevention
- New organization: the Ministry of Emergency Management (MEM) was established in 2018 to coordinate the main responsibilities of flood control, drought prevention and disaster relief, with both opportunities and challenges
- New situation: With the new normal brought about by China's rapid socio-economic development, China's flood control situation is still facing a severe test.

新思想	新要求	新机构	新挑战
基本内涵 习近平总书记提出，自然灾害防治要坚持以防为主、防抗救相结合，实现"两个坚持、三个转变"	**基本内涵** 广大人民群众对优质安全的需求更加强烈	**基本内涵** 2018年机构改革，防汛抗旱应急管理职能由水利部调整至应急管理部，承担防汛抗旱指挥协调机构的办事机构职责，统筹防汛抗旱和减灾救灾的主要职责	**基本内涵** 改革初期面临的挑战，例如不合时宜的理念、传统思维定势、条条框框的限制等
解决问题 习近平总书记的重要指示是做好防汛抗旱应急管理工作的根本遵循，需要转变思路	**解决问题** 以人为本，生命至上的理念要求更加深入人心	**解决问题** 整合优化各种应急力量和资源，形成统一指挥、专常兼备、反应灵敏、上下联动、平战结合的中国特色的防汛抗旱应急管理体制	**解决问题** 建立健全政策法规、规章制度、风险防范和应急管理机制、技术体系等，构建以防为主、防抗救相结合、常态减灾和非常态减灾相统一的机制
			

实现灾前准备、灾中抢险救援和灾后救助恢复的全过程应急管理

2.4 Flood and drought disaster prevention work system

- In the construction of the working system of water and drought disaster defense, it is proposed to build a vertical to the end and horizontal to the edge of the water and drought disaster defense matrix
- Anchoring the goal of "no casualties, no dam breaks in reservoirs, no breaches in important levees, and no impacts on critical infrastructure"
- The soundness of the early warning "call and response" mechanism for flash floods has greatly enhanced risk warning and prevention capacity
- Reserve drought-resistant water sources in advance, accurately locate the scope and measures to effectively safeguard urban and rural drinking water safety and crop irrigation needs
- Improving the legal framework and clarifying the division of responsibilities for flood prevention and drought relief has provided institutional safeguards for disaster prevention and mitigation.

Relevant laws and regulations

water and drought disaster defense matrix

降雨	产流	汇流	演进
流域	干流	支流	断面
总量	洪峰	过程	调度
技术	物料	队伍	组织

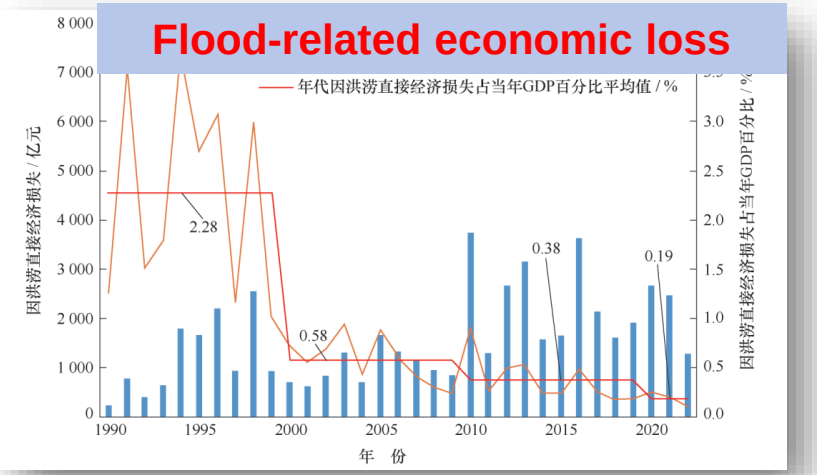
Group Surveying and Group Defense System with Chinese Characteristics

2.5 Analysis of the effectiveness of flood prevention and disaster reduction

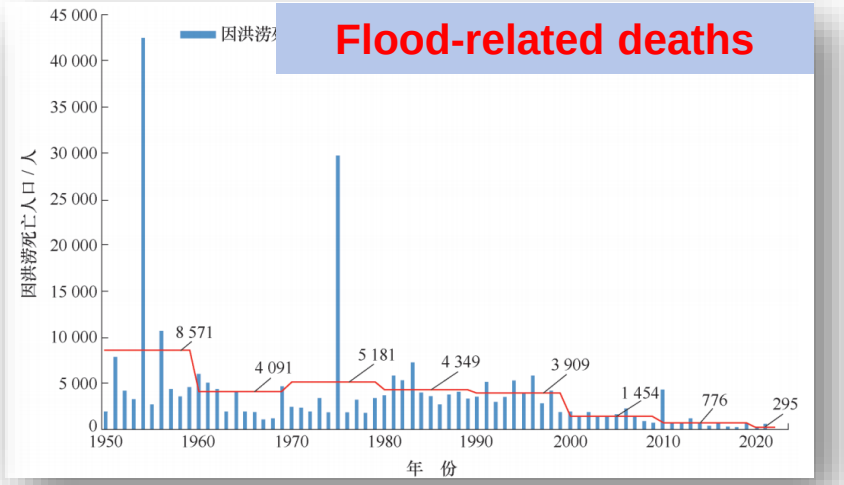
☐ Ensuring flood safety

- Combining **engineering and non-engineering measures,** it effectively responded to river floods such as the Yangtze River flood in 1998, the Henan River flood in 2021, and the Hai River flood in 2023.
- Economic losses as **a percentage of GDP** decreased from an annual average of **2.28%** in the 1990s to an annual average of **0.19%**
- **Flood-related deaths** have steadily declined from an average of **8,571** deaths per year in the 1950s to an average of 295 deaths per year
- The number of Flood-related **housing collapses** has declined steadily, from an annual average of 2.4 million in the 1950s to an average of 200,000 per year.

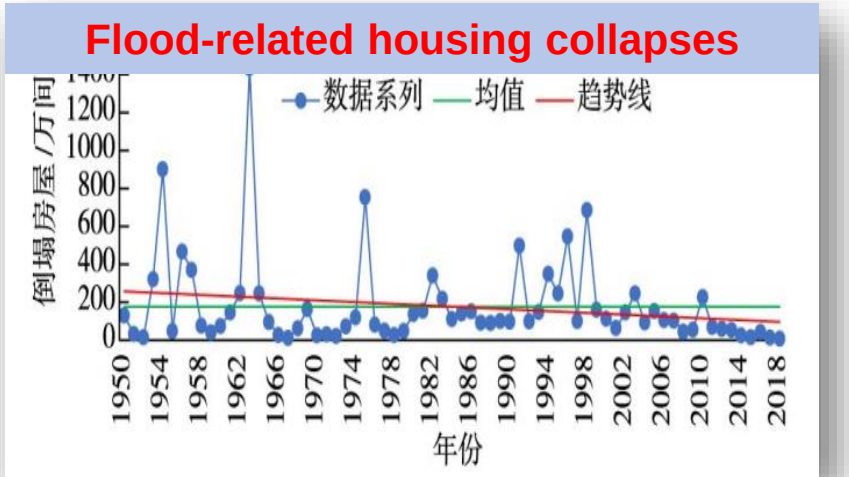
Flood-related economic loss



Flood-related deaths



Flood-related housing collapses

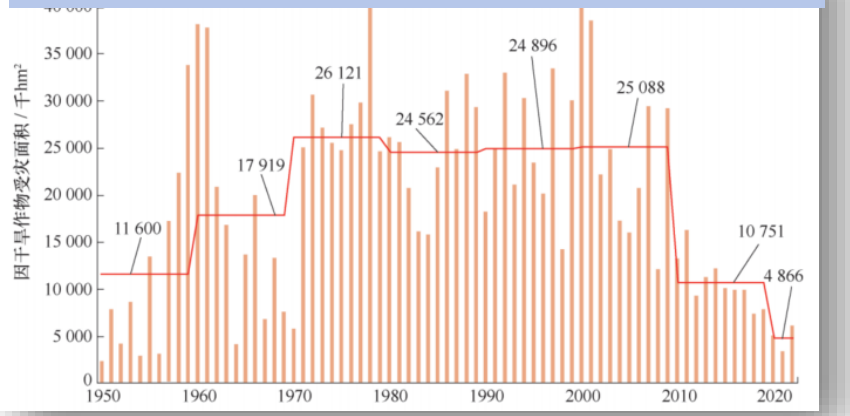


2.5 Analysis of the effectiveness of flood prevention and disaster reduction

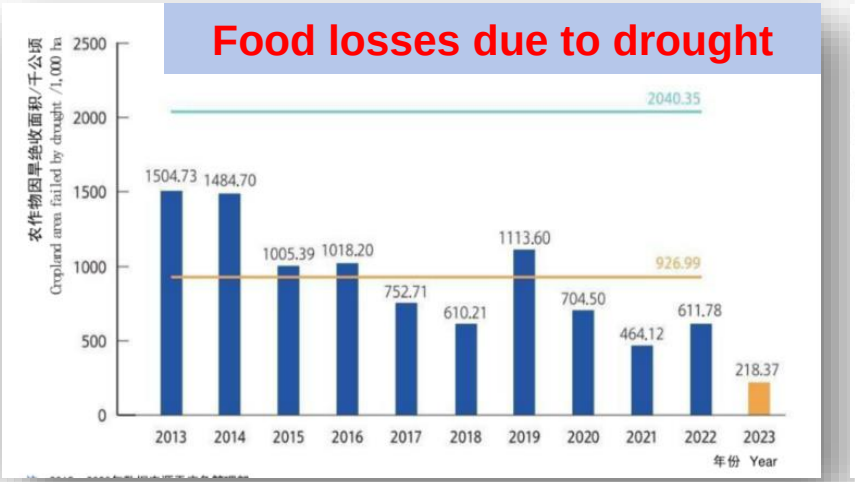
☐ Water supply in dry areas secured

- Various places in the drought-stricken areas have made every effort to guarantee water for drought relief through comprehensive measures such as water release from reservoirs and various means such as river and lake, lake reservoirs and reservoir-gate intermodulation.
- The area of drought-affected crops nationwide remained at an annual average of about 25,000hm² until 2010, when it began to decline steadily to an annual average of 10,751hm² from 2010 to 2019, and to an annual average of 4,866hm² in recent years.
- Trend towards a significant reduction in the number of people and livestock suffering from water stress as a result of the drought disaster
- In 2023, 2,747,400 people suffered from drinking water difficulties due to drought, and the area of crop failure was 21,837hm², both of which were the lowest in the past 10 years.

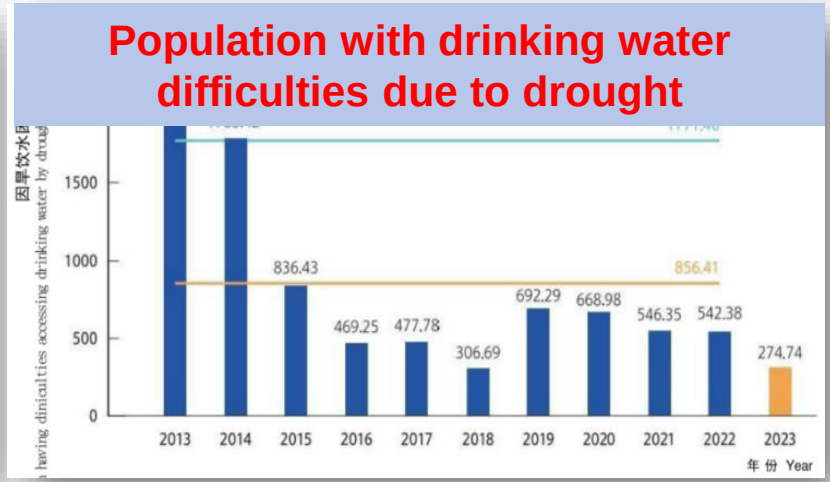
The area of drought-affected crops



Food losses due to drought



Population with drinking water difficulties due to drought



2.5 Analysis of the effectiveness of flood prevention and disaster reduction

- The number of deaths from flash floods was high until the 1990s, with an annual average of 1,178 deaths from 2000-2010
- After the implementation of the flash flood prevention and control project in 2011-2022, the average annual deaths were reduced to 326, which is a significant effect

☐ Flash flood damage mitigated

Development of prevention and control zones

386

万km²。其中重点防治区120万km²，涉及17万个村、6746万人；一般防治区266万km²、40万个村、2.3亿人；

- 防治对象：小流域溪河洪水（200km²以下）
- 防御目标：减少山丘区沿河村落因暴雨溪河洪水造成的人员伤亡，特别是群死群伤。
- 防治手段：非工程措施（监测、预警、转移、安置）。

山洪灾害可以防治，但不能根除，应树立人与自然协调共处的思想。

Largest investment in non-engineered disaster prevention and mitigation projects

时间段	2010年以前（试点建设）	2010--2012年	2013--2015年	2016--2018年
累计新建自动雨量和水位站点数	1866个	5.2万个	7.5万个	7.8万个

- 试点建设阶段对监测预警设施、监测预警平台、转移预案、组织体系、宣传培训和培演练等非工程措施进行了试点。
- 2010--2012年，集中建设阶段。初步形成山洪灾害防治县级非工程措施体系。
- 2013年--2015年，补充完善阶段。自动监测站点密度达到45km²一处，进一步完善了山洪灾害防治县级非工程措施体系。
- 2016年—至今，巩固提升、拓展深化阶段。更新了部分自动监测站点，扩大了预警信息的覆盖面，重点区域预警平台延伸至乡镇。

Establishment of a monitoring and early warning platform

（提示性预警）

- 国家级山洪灾害气象预警平台
- 省级山洪灾害气象预警平台
- 地市级气象风险预警平台

预见期长、预警范围大、精准度低

（指令性预警）

- 国家级监测预警平台
- 省级平台（将来主导）
- 县级平台（目前主导）

预见期短、预警范围小、精准度高

有先有后、递进补充

Establishment of a comprehensive mass measurement and prevention system

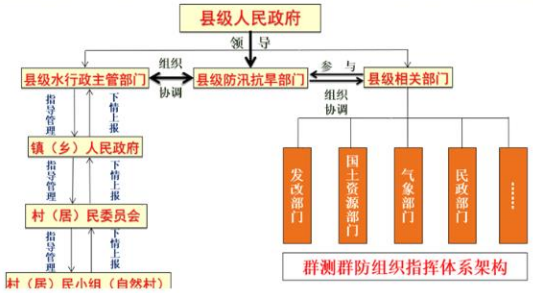
Establishment of a sound system for the preparation of plans

◆ 县级、乡镇级山洪灾害防御预案包括的主要内容：基本情况；危险区划定；组织指挥体系；监测预警；转移安置；抢险救灾；保障措施；附图附表。

◆ 村级山洪灾害防御预案包括防汛责任人员、危险区划定、监测预警、转移安置等内容，按照可操作原则适当简化。

Establishment of a sound system of accountability

根据山洪灾害防御特点和现状，在区（县）、乡镇、行政村分别编制和完善县、乡、村山洪灾害防御预案，建立县、乡（镇）、村、组、户五级山洪灾害防御责任制体系。

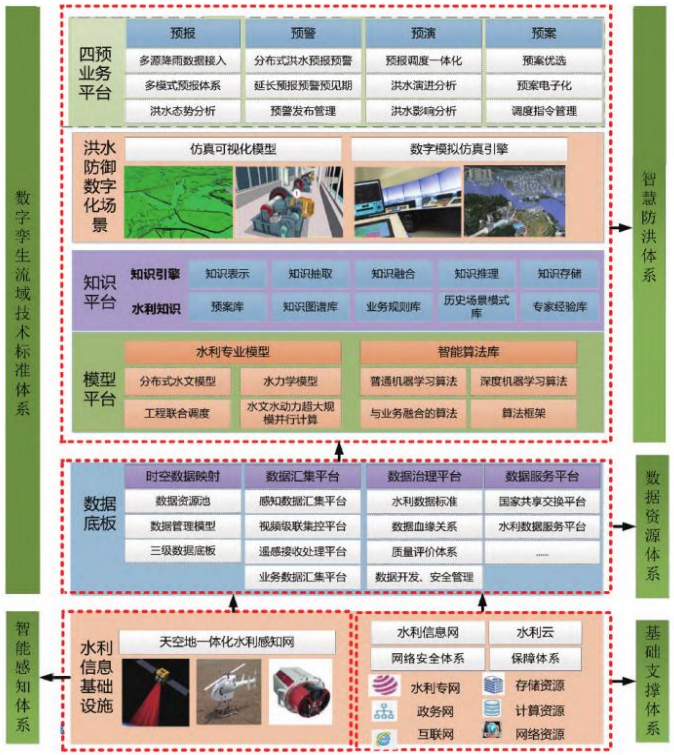


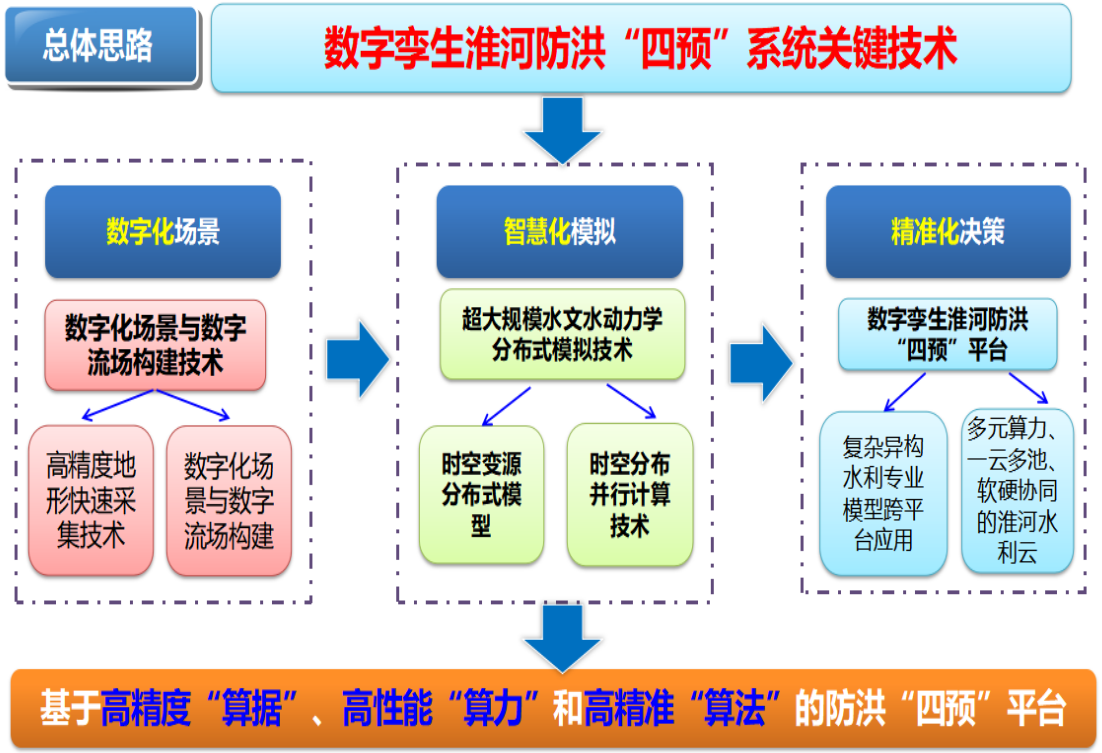
3.Digital Twin Construction and Application

Case 1：Digital Twin Huai River Basin Smart Flood Control System

Construction goals

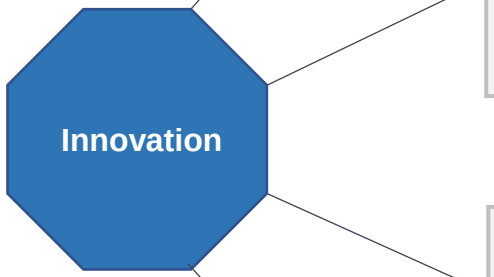
- The idea and framework of the construction of the "54321" intelligent flood control system of the Huai River were proposed, and the "four precautions" system for flood control in the Huai River basin was developed
- Support the Huai River Commission's 2021 flood prevention "four-prediction" drills





- On June 9, 2021, the Huaihe River Commission held a "four-precaution" drill for flood and drought disaster prevention

Key innovations



High-precision terrain rapid acquisition technology

We have developed a rapid acquisition technology for high-precision terrain in watersheds based on 3D LiDAR, oblique photography, and satellite remote sensing. This technology has enabled us to obtain, for the first time, high-precision terrain data and three-tier data bases above Zhengyangguan in the Huai River basin in a swift manner.

Ultra-large-scale hydrology and hydrodynamics integrated real-time dynamic simulation and forecasting parallel computing technology

We have created a super-large-scale coupled simulation technology for hydrology and hydrodynamics based on a distributed parallel framework featuring "one horizontal and one vertical, one hardware and one software." This technology supports three-dimensional visualization of hydrodynamic calculations involving billions of units, reducing the calculation time from several hours to within 3 minutes. It has achieved rapid and refined flood simulation.

Forecast and dispatch integration and real-time risk impact calculation and assessment technology

We have developed intelligent flood forecasting models and intelligent reservoir scheduling models, initially forming an integrated process simulation encompassing "hydrological forecasting - flood warning - engineering scheduling - digital simulation (preview) - emergency plan generation - dynamic display."

Digital flow field, digital twin and digital mapping 3D visualization display technology

We have created a three-dimensional simulation scenario for the main stream of the Huai River, major flood diversion areas, and key projects, based on technologies such as dynamic visualization of the basin's natural background, dynamic visualization of upstream and downstream flow fields, real-time rendering of large-scale terrain, and second-level loading of three-dimensional model data.

High-precision terrain rapid acquisition technology

- For the first time, we have obtained **high-precision** topographic data for the river channels above Zhengyangguan on the main stream of the Huai River, as well as for important flood storage and detention areas. Additionally, we have acquired **three-dimensional** data for significant water conservancy projects and **high-density** cross-sectional data for the river channels.

Space-air-ground integrated monitoring technology

- High-precision topographic data with a 1m resolution, covering a total area of 742 km² in five flood storage and detention areas along the main stem of the Huai River.
- Cross-sectional data at 50m intervals for a 130 km stretch along the main stem of the Huai River.
- Three-dimensional data models and BIM models of key projects with a relative error of 5 cm.
- High-precision digital elevation data with a 10m resolution, covering an area of 330,000 km² within the Huai River basin.

Integrated multi-source and multi-scale data totaling approximately 3T.

High precision

One, two, and three levels through

Two-dimensional and three-dimensional integration

● Ultra-large-scale hydrology and hydrodynamics integrated real-time dynamic simulation and forecasting parallel computing technology

□ A two-dimensional hydrodynamic flood simulation model based on distributed GPU parallel computing technology has been developed, enabling rapid and refined simulation of floods in the basin from Zhengyangguan to Chushandian Reservoir.

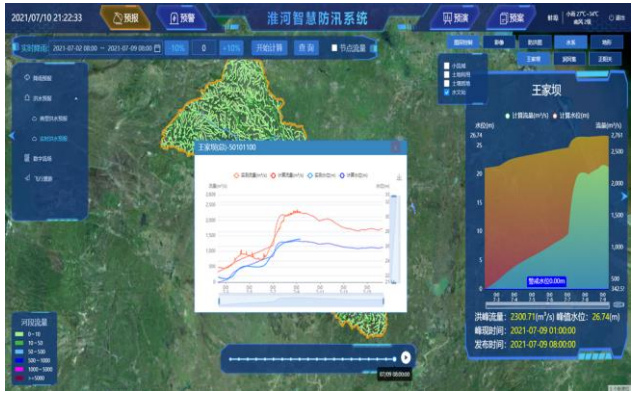
One horizontal and one vertical, one hard and one soft

Distributed parallel algorithm

- One horizontal: Huai River's main stem, 7 flood storage and detention areas, 7 tributaries
- One vertical: Runoff generation and concentration, River channel evolution, Flood control and dispatch process
- One hard: GPU/CPU multi-threading parallel computing
- One soft: I/O read/write scheduling parallelism

- **Forecast and dispatch integration and real-time risk impact calculation and assessment technology**

  - The "Four Pre-" system platform for the Huai River basin has been innovatively developed, with an integrated process simulation of "hydrological forecasting - flood warning - engineering dispatch - digital simulation (pre-enactment) - emergency plan generation - dynamic display" initially formed in the area from Wangjiaba to Zhengyangguan along the Huai River.



Digital flow field, digital twin and digital mapping 3D visualization display technology

- A three-dimensional simulation scenario has been constructed for the main stream of the Huai River, major flood diversion areas, and key projects.
- Utilizing dynamic triangular mesh rendering and loading technology, the flood situation along the main stem of the Huai River, the flooding situation at Wangjiaba, and the flood discharge process in Mengwa during the 2020 flood period were displayed in real-time and dynamically, providing a more intuitive representation of the flood control and dispatch process.

Chapter 3 Digital Twin Construction and Application

- **Initially build the "four pre-" system framework and explore digital twin, digital mapping and digital flow field technologies.**

Initial construction of the "digital baseboard": High-resolution terrain data, river cross-section data.

Initial construction of "digital flow field": Realize the digitization and mapping of watershed spatiotemporal scenes.

Initially provide "computing power" support: Enhance and improve the computational resources and capabilities of the Huai River Water Conservancy Commission.

Provide"data" support: Expand the existing data resource library of the Huai River Water Conservancy Commission.

Initially provide "algorithm" support: Expand and improve the digital twin basin flood control model, parallel.

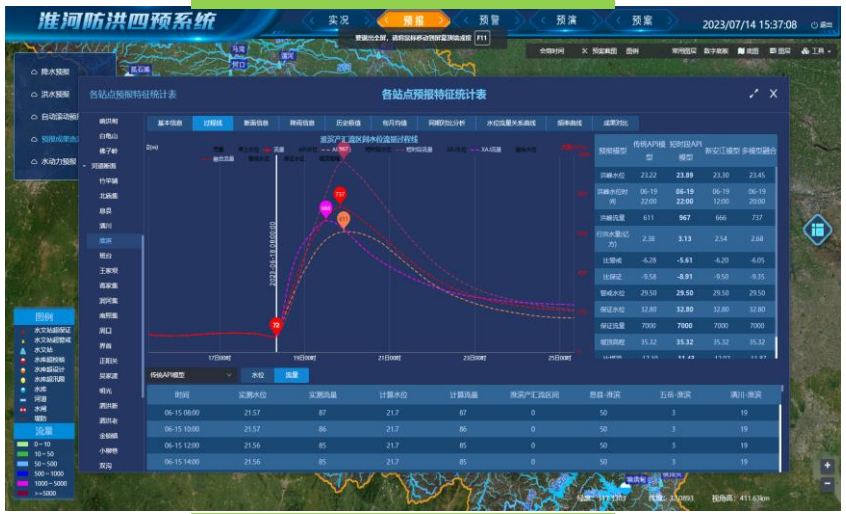
Initial construction of the "four-precaution" system for smart flood prevention: Enhance the levels of digitization, intelligence, and smartness.

- **A smart flood prevention and four-prevention system has been initially developed, and through visualization technologies such as simulation, the real-time dynamic display of physical flood control projects in digital scenes has been initially realized.**

Application in 2023

In 2023, the system was put into practical application, and in early June, it supported the "four pre-" exercise for flood control scheduling. During the main flood season and critical periods, the practical application system operated stably in multiple types of floods along the Huai River, and the forecast and pre-drilling calculation results were reliable. In mid-to-late September, the system provided important support for accurate forecasting of inflow rates in the upper reaches of the Huai River during floods.

6月中旬降水偏南型



7月上旬降水偏北型

8月下旬北部降水型

9月中下旬降水上游型

Chapter 3 Digital Twin Construction and Application

Multiple mainstream media outlets, including the China Government Network, People's Daily, Xinhua News Agency, Science and Technology Daily, and China Water Resources News, have featured special reports on the "Four Pre-" system of the Huai River.

人民日报 2023年5月9日 星期二 13 生态

入汛以来50条河流发生超警以上洪水，主汛期南北方均有多雨区

全力以赴应对汛情

美丽中国

核心阅读

降水量总体略偏多，部分中小河流超警

人力、脑力、算力齐发力，织密水旱灾害防御网

下足绣花功，加强排查，全力消除风险隐患

本周华南降水较为频繁

西部地区有雨雪天气

最高法发布青藏高原生态保护典型案例

司法守护雪域高原生态环境

青藏高原生态保护司法保障研究中心成立

切实发挥科技和司法的作用

中国气象局印发行动计划

到2025年实现16个气候系统关键观测区全覆盖

今年4月全国自然灾害情况发布

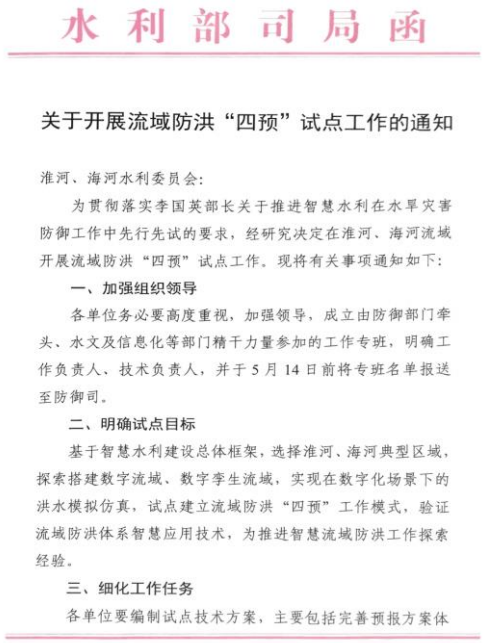
20余年来

湖北完成退耕还林超110万公顷

环岛公路生态美

□ Mid-term Evaluation of the Pilot Program for the Construction of Digital Twin River Basins Initiated by the Ministry of Water Resources

➢ **The project undertaken for the construction of the Digital Twin Huai River Basin has successfully passed the mid-term evaluation conducted by the Ministry of Water Resources with high marks and received an "Excellent" rating. Furthermore, the submitted case study on the "Application of the 'Four Pre-measures' System for Flood Control in the Digital Twin Huai River" received a high number of votes and was selected as an outstanding application case for the pilot program of digital twin river basin construction by the Ministry of Water Resources.**



水 利 部 司 局 函

关于开展流域防洪“四预”试点工作的通知

淮河、海河水利委员会：

为贯彻落实李国英部长关于推进智慧水利在水旱灾害防御工作中先行先试的要求，经研究决定在淮河、海河流域开展流域防洪“四预”试点工作。现将有关事项通知如下：

一、加强组织领导

各单位务必要高度重视，加强领导，成立由防御部门牵头、水文及信息化等部门精干力量参加的工作专班，明确工作负责人、技术负责人，并于5月14日前将专班名单报送至防御司。

二、明确试点目标

基于智慧水利建设总体框架，选择淮河、海河典型区域，探索搭建数字流域、数字孪生流域，实现在数字化场景下的洪水模拟仿真，试点建立流域防洪“四预”工作模式，验证流域防洪体系智慧应用技术，为推进智慧流域防洪工作探索经验。

三、细化工作任务

各单位要编制试点技术方案，主要包括完善预报方案体

数字孪生淮河建设先行先试工作荣获水利部“双优”表彰

澎湃 政务：水利信息化和水文监测预报 2023-02-10 20:27

近日，水利部公布了数字孪生流域建设先行先试中期评估结果，淮委数字孪生淮河先行先试工作高分通过水利部中期评估并获得“优秀”等次，申报的“数字孪生淮河防洪‘四预’系统应用”案例高票入选水利部数字孪生流域建设先行先试优秀应用案例。

2022年，数字孪生淮河（干流出山店水库 - 王家坝河段）列入水利部先行先试台账，并被授予“水利部数字孪生流域建设先行先试证书”。淮委高度重视此项工作，构建了主要负责人总负责，分管领导具体抓，责任部门单位分工合作、协同推进的工作机制，成立领导小组和工作专班，加强顶层设计，多方筹集资金，整合委内资源，有力保障先行先试工作顺利开展，圆满完成2022年度目标任务。

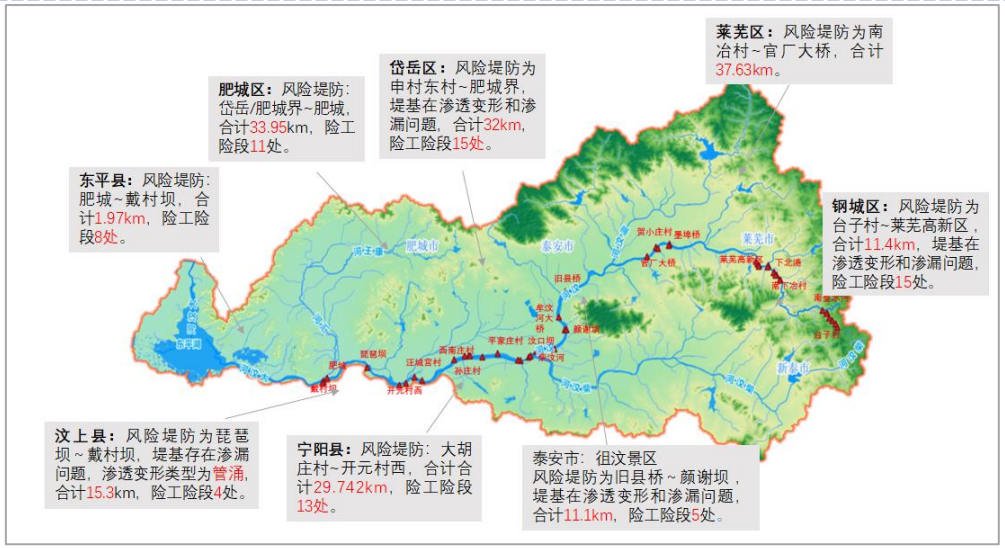
水利部在中期评估意见中充分肯定了数字孪生淮河建设先行先试工作。一是注重关键技术研究，研发了基于三维激光雷达和卫星遥感的流域高精度地形数据融合技术；创建了基于分布式并行计算的超大规模水文水动力学分布式模拟技术；构建了基于高性能计算、高精度时空数据和一体化强合模拟模型的数字孪生淮河防洪“四预”平台。二是重视成果应用实践，建设成果纳入9月8日人民日报要闻板块“新技术赋能水利建设”；有效复盘2020年淮河流域性较大洪水，获得部领导充分肯定，圆满防御淮河中上游2022年3月份历史同期最大洪水过程、台风暹芭暴雨洪水过程；实现河南郑

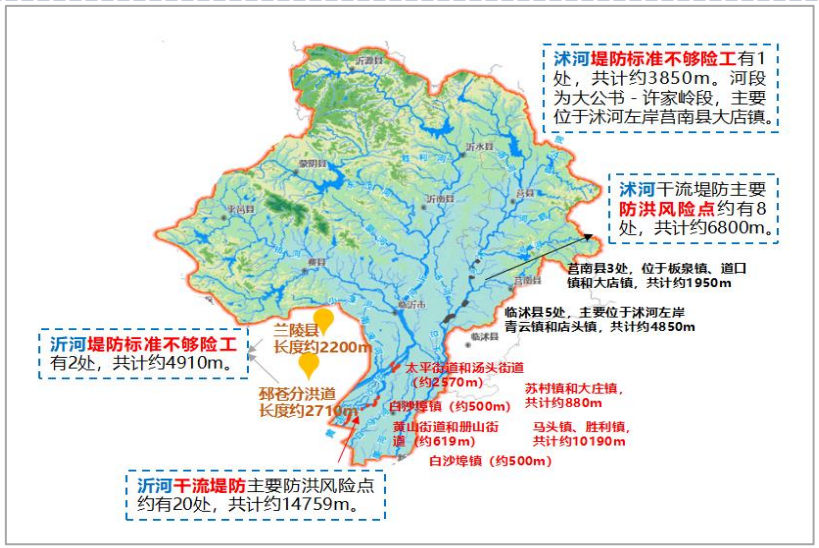
数字孪生流域建设先行先试应用案例
推荐名录（2022年）

序号	应用案例名称	先行先试单位	承担单位	合作单位	简介
			一、优秀应用案例（32项）		
10	数字孪生淮河防洪“四预”系统应用	水利部淮河水利委员会	淮委水文局（信息中心）	中国水利水电科学研究院	聚焦淮河王家坝以上流域防洪“四预”关键技术难题，研发高精度数字流场构建技术，创建基于并行计算的水文水动力学精细化模拟技术，构建了基于高精度算据、高精准算法和高性能算力的防洪“四预”平台，实现数字化场景下防洪“四预”全链条在线协同模拟。在2022年淮河多场次暴雨洪水防御、2020年淮河洪水复盘分析等得到应用，显著提升流域水旱灾害防御水平，可为其他流域数字底板和防洪“四预”系统建设提供示范
11	珠江水旱灾害防御“四预”平台	水利部珠江水利委员会	珠江水利科学研究院、珠委水文水资源局、珠委珠江水利综合技术中心、中水珠江规划勘测设计有限公司	广东华南水电高新技术开发有限公司	以西江流域为单元，基于委内信息化基础设施，搭建数据底板，构建模型和知识平台，研发适应国产环境的水利三维可视化仿真、模型管理及服务等关键技术，开发具有“四情”态势感知、分级分类智能预警、多维多尺度场景全链条预演的珠江水旱灾害防御“四预”平台，为珠江流域水旱灾害防御工作提供支撑。支撑珠江委成功防御2022年初珠江流域60年一遇干旱，以及2022年西江4次、北江3次编号洪水
12	数字孪生支撑太浦河多目标统筹调度	水利部太湖流域管理局	太湖流域管理局水文局（信息中心）	北京金水信息技术发展有限公司、上海高起信息技术有限公司	聚焦平原感潮河网地区的多目标统筹调度，打造精细化太浦河三维场景，优化水量水质一体化模型算法，对太浦河防洪、供水业务进行“四预”流程再造。在2022年“梅花”台风防御中对太浦闸不同调度方式下洪水变化过程和淹涝情况进行了预演，发挥重要作用。在协助上海抗咸潮保供水工作中，滚动预报重要断面水量水质，强化补水水质安全预警，确保太浦河上游水源地持续稳定供水
13	水库视频感知融合系统	河北省水利厅	河北省水务中心黄壁庄水库	河北省水利规划设计研究院	数字孪生黄壁庄水库工程中开展的水库视频监控融合系统，采用“监控设备+AI算法+业务平台+水利一张图”的综合技术路线，通过建

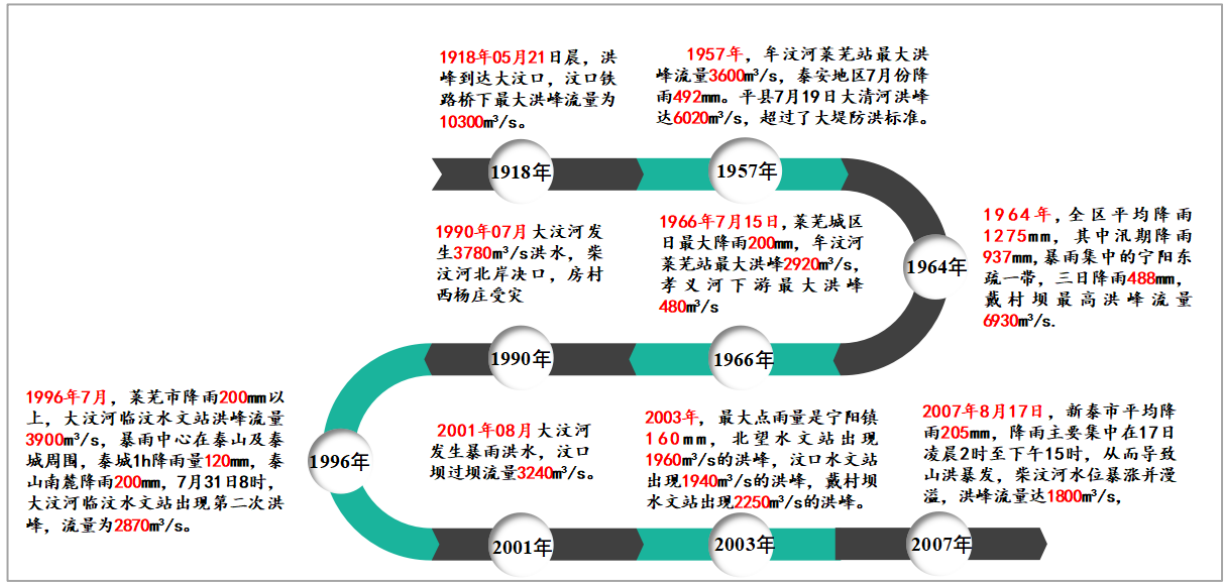
Case 2 : Construction of Dawen River Digital Twin Watershed

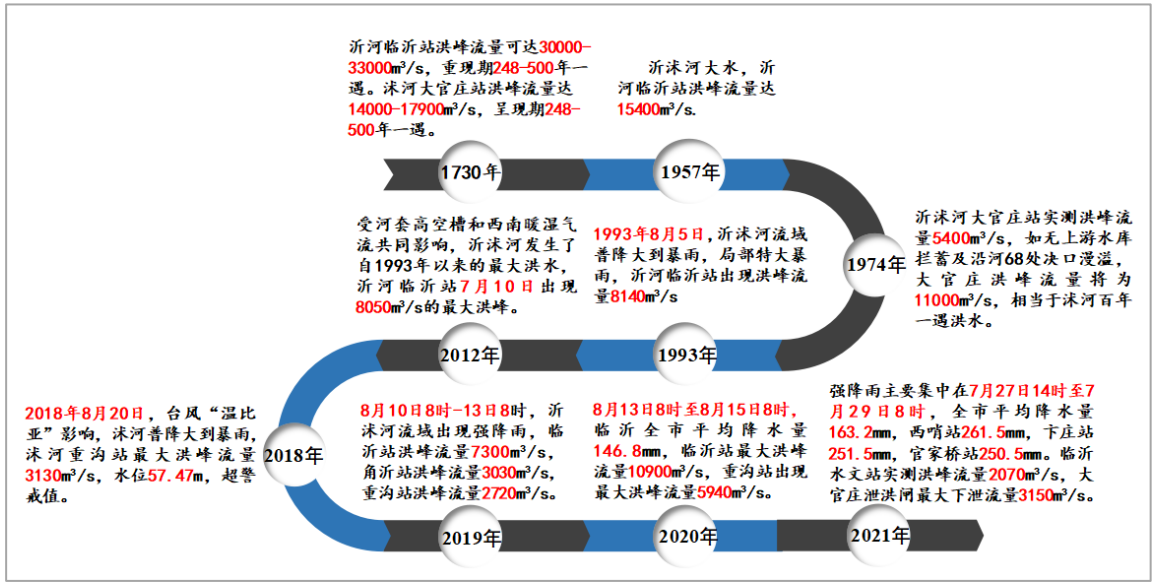
- The Dawen River Basin is the largest tributary of the lower Yellow River, with a drainage area of 8944.1 km^2 and 266 tributaries at all levels; There are 24 large and medium-sized reservoirs and 738 small reservoirs built in the basin; There are a total of 221.302m embankments on both sides of the Dawen River, with flood control standards of once every 50 years, but there are some dangerous construction and sections in some areas.
- The Yishu River Basin belongs to the Yishu River system of the Huaihe River Basin, with a total basin area of 17,253 km^2. There are 9 large reservoirs, 33 medium-sized reservoirs, and 1,022 small reservoirs in the basin; 15 key flood control gates, all of which are designed to meet the flood control standard of once in 20 years; the overall flood control standard in the basin is low, the current embankment is discontinuous, and dangerous works such as embankment collapse and embankment foot seepage have not been completely eliminated.





- There are 67 years of recorded flood disasters in Dawen River (including Daqing River). Rainstorm mostly occurs from late July to early September. The center of rainstorm is mainly concentrated in Laiwu District in the upper reaches of Dawen River and Ningyang County in the lower reaches.
- In the history of Yishu River, floods have been relatively frequent. Before the founding of the People's Republic of China, there were 105 major floods. After the founding of the People's Republic of China, there were 16 years of floods exceeding 5000m ³/s at Yishu River Linyi Station, and 17 years of floods exceeding 2000m ³/s at Shu River Daguanzhuang Station.





“Seven ones” + “Two applications” + “Seven standards” + “Five difficulties” : abbreviation “7+2+7+5”

- A set of flood control dispatch Space infrastructure
- A data backplane
- A set of flood inundation and dam breach maps
- A hydraulic knowledge platform
- A hydraulic modeling platform
- A digital simulation engine platform
- A "Four Pre" Business Software

+

- Business application in Dawen River Basin
- Business application of Yishu River Basin

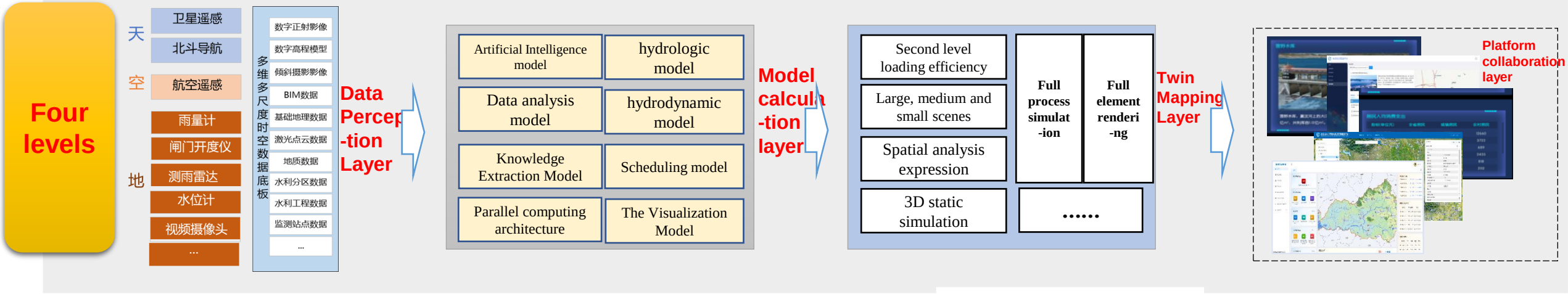
+

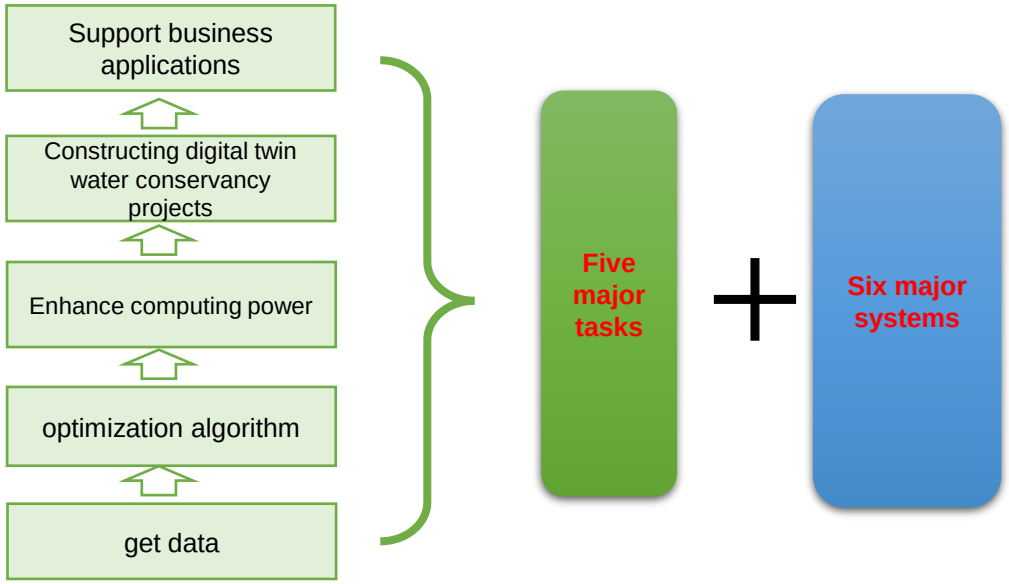
- Technical requirements for the construction of intelligent perception of space, sky, and ground
- Technical Specification for Data Backboard Construction
- Model platform and interface standards
- Technical requirements for digital scene construction
- Technical requirements for knowledge graph on knowledge platform
- Technical requirements for joint scheduling decision system
- Database Table Structure and Identifier Standards

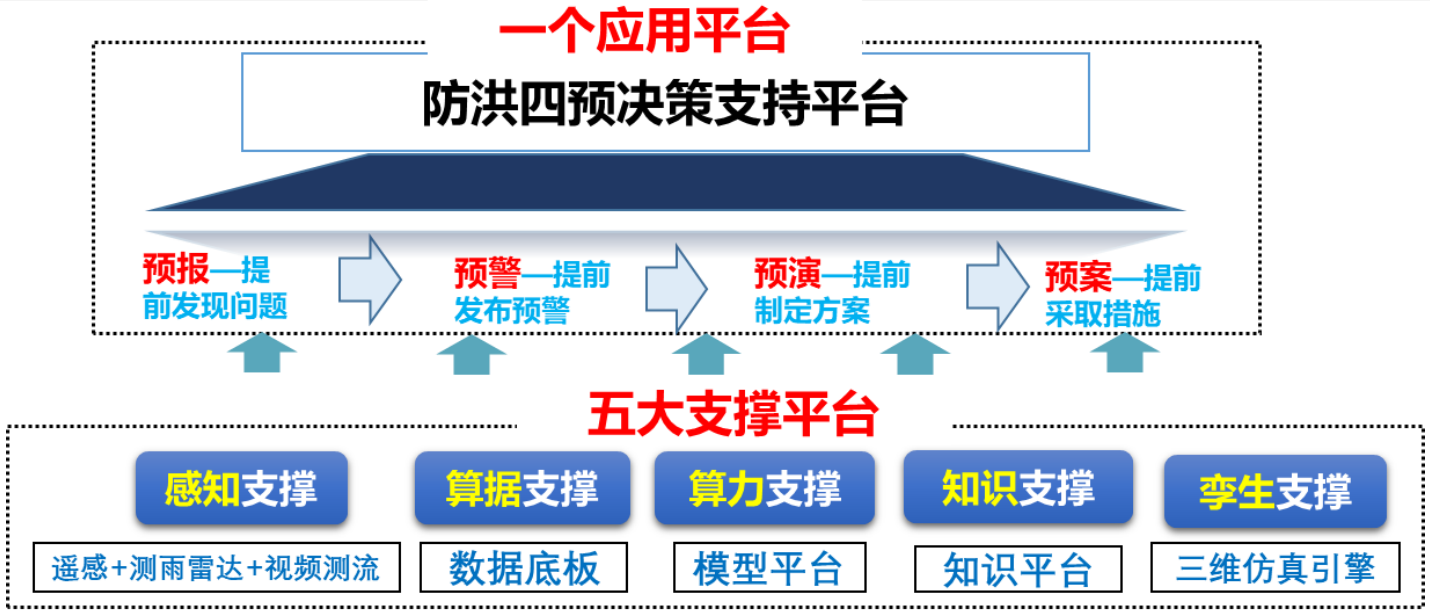
+

- Difficulty 1: Digitalization of scenes and digital flow fields using multi-source high-resolution data
- Difficulty 2: Digital Mapping and Digital Twin of All Factors in the Watershed
- Difficulty 3: Parallel computing for large-scale hydrological and hydrodynamic simulation
- Difficulty 4: Visualization rehearsal of the entire watershed process scene
- Difficulty 5: Watershed Smart Defense Platform and Integration

Chapter 3 Construction and Application of Digital Twins







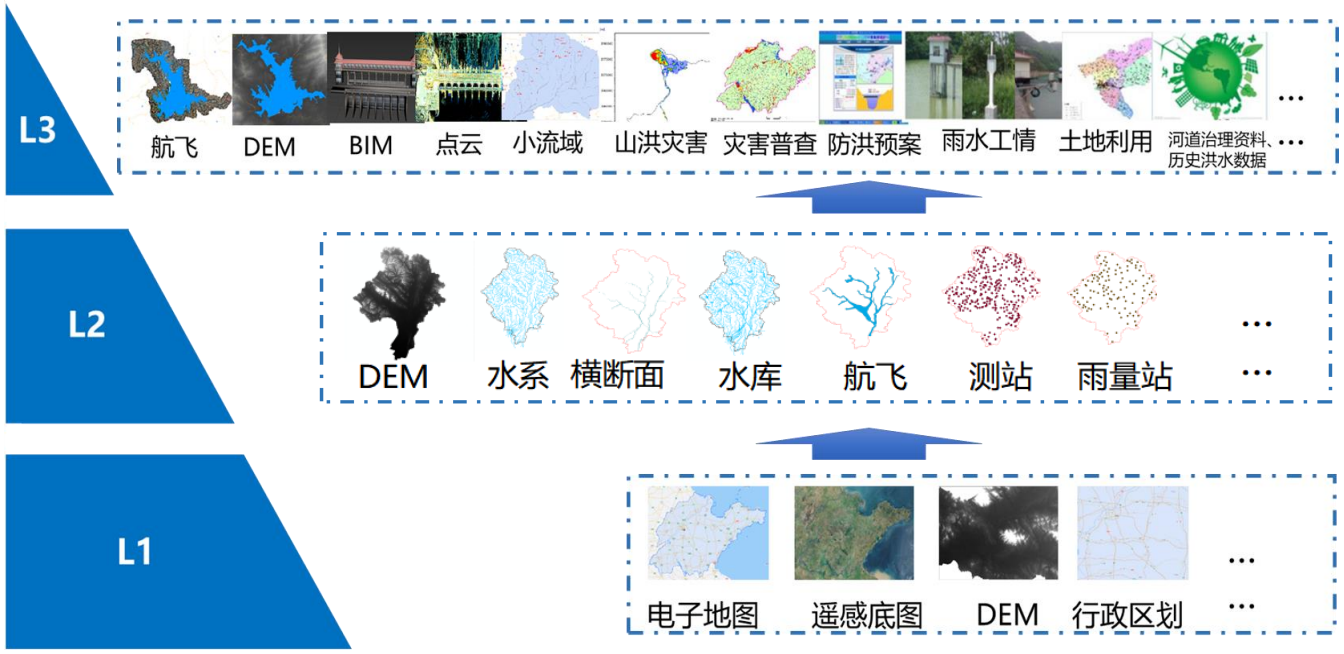
Decision Support Platform

Preliminary implementation of four major plans for river basin engineering joint scheduling, personnel transfer, material allocation, and emergency rescue through real drills

Built effect

- support: Twin platform - Building **14 3D models and dynamic simulation of flow field, achieving second level loading.**
- support: Knowledge Platform - Collecting **39724 contingency plan knowledge from 118 categories and building 6 major knowledge bases.**
- support: Model Platform - Integrate **12 models, build 9 partitions, and achieve integrated computing.**
- support: Data Base Plate - Aggregate **over 200 terabytes of data and compile over 100 terabytes of L1-L3 level data.**
- support: Flood Control Space - Building **an Integrated Water Conservancy Perception Network of Sky and Ground in the Dawen River Basin.**

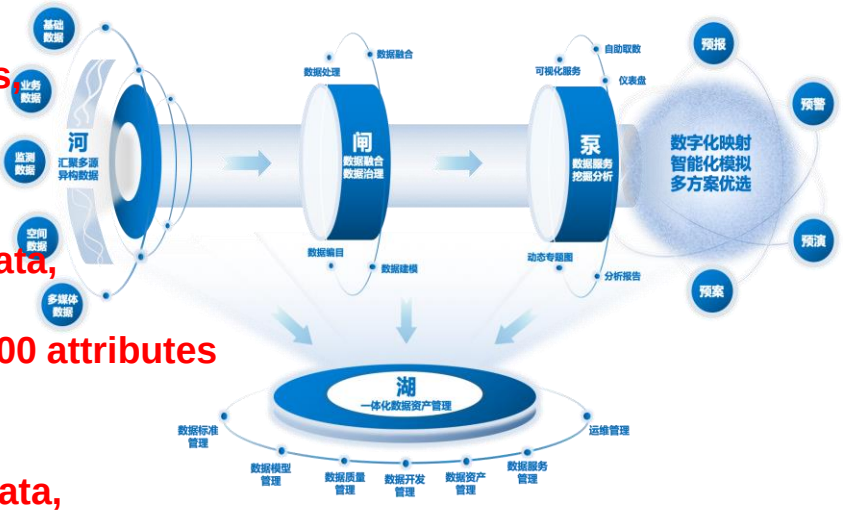
We have comprehensively collected **600T** data from the Dawen River and Yishu River basins, **forming 37 types of data, over 352 layers, and more than 2337 types of attribute information**. We have formulated a unified data governance standard and constructed a **"lake warehouse integrated"** flood control data resource pool for the Yishu River basin; Assemble as needed to form a thematic map of the watershed floor; **Breaking down data barriers, achieving data interoperability**, and providing the most sufficient data support for the business application of the Yishu River digital twin basin.



7 types of ata, 113 layers, 337 attributes

35 types of data, 108 layers, More than 1600 attributes

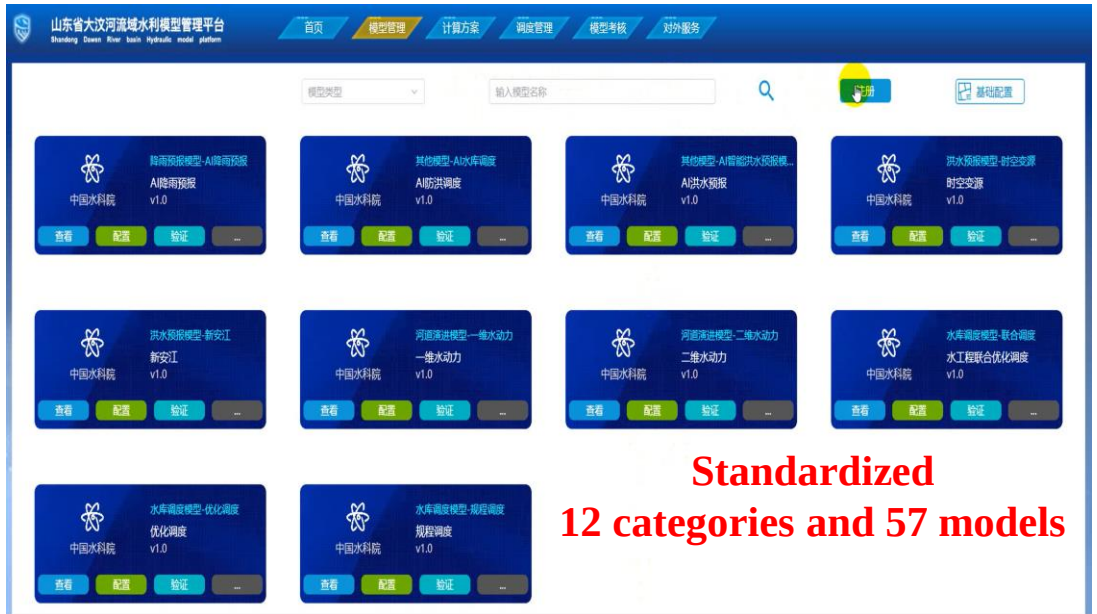
31 types of data, 59 layers, More than 350 attributes



Integrated Lake Warehouse Flood Control Data Resource Pool

Chapter 3 Construction and Application of Digital Twins

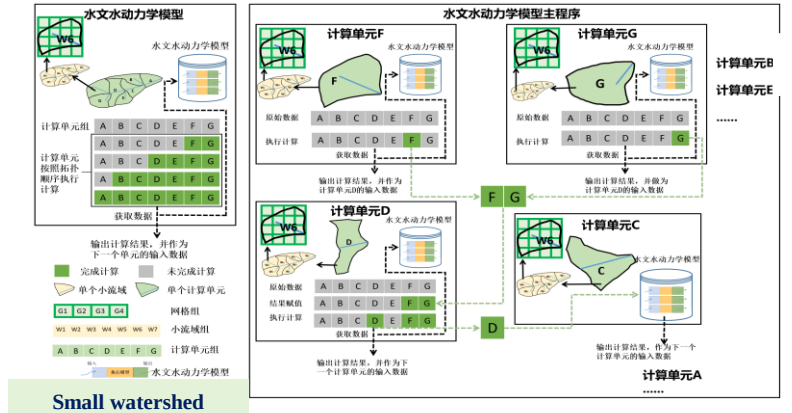
- Hydrological models (2 types): Xin'anjiang model for 72 sections of Dawen River and 218 sections of Yishu River, and construction of spatiotemporal variable source mixed model for 607 sections of Dawen River and 1,217 sections of Yishu River.
- Operation model (3 types): single reservoir regulation operation and whole basin joint operation model for 23 large and medium-sized reservoirs in Dawen River and 42 large and medium-sized reservoirs in Yishu River basin.
- Hydrodynamic model (2 types): one-dimensional calculation of river flood impact in the basin (Dawen River 1185.5 km, Yishu River 802.9 km) and two-dimensional hydrodynamic model construction (Dawen River 3888.3 km^2, Yishu River 4218.8 km^2).
- Intelligent models (5 types): intelligent rainfall forecast, intelligent flood forecast, intelligent scheduling, intelligent parameter transplantation, intelligent underlying surface extraction.
- Platform architecture: Adopting a "one hard and one soft, one horizontal and one vertical" three-layer topology parallel computing architecture, creating 16 parallel computing partitions, 140,000 grid computing time <5min, preliminarily realizing the integrated simulation calculation of hydrology and hydrodynamics, effectively supporting the simulation forecast calculation and pre-analysis of the physical basin runoff generation-confluence process and the flood evolution process after water project scheduling.



Standardized
12 categories and 57 models

Hydrological process

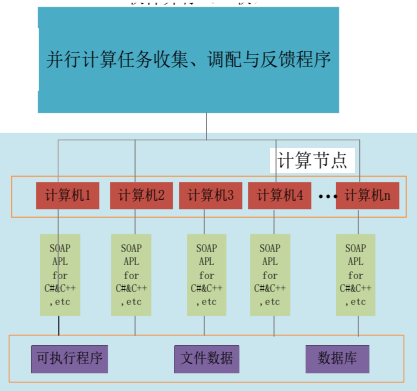
one vertical: Parallel rainfall-runoff model



Small watershed binary tree structure

one horizontal： Inter-basin parallel

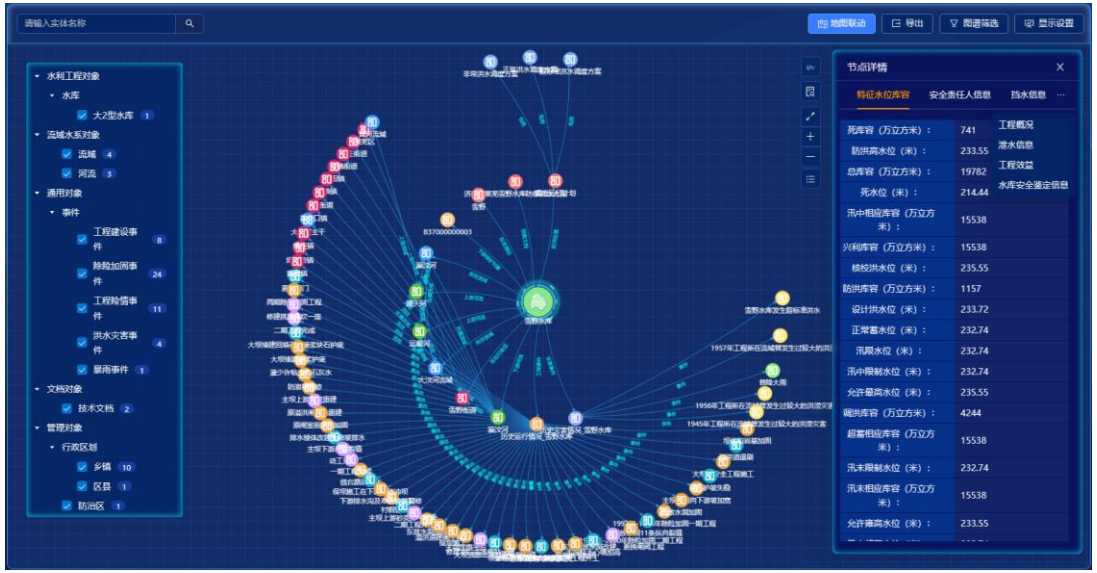
one soft：Scheduling read and write parallelism



one hard: CPU/GPU Parallel

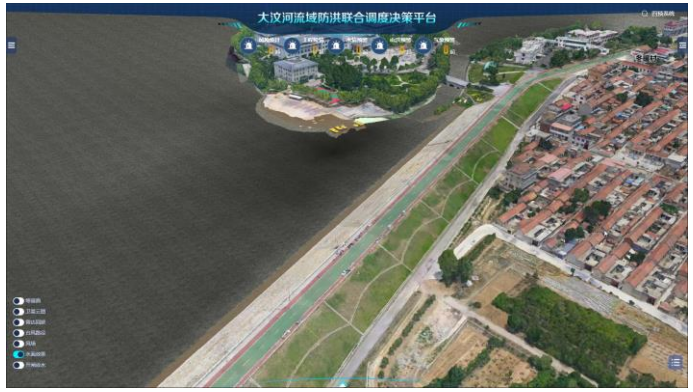
Overcoming the challenge --- Parallel computing of ultra-large-scale hydrological and hydrodynamic simulation, leading the country in computing efficiency

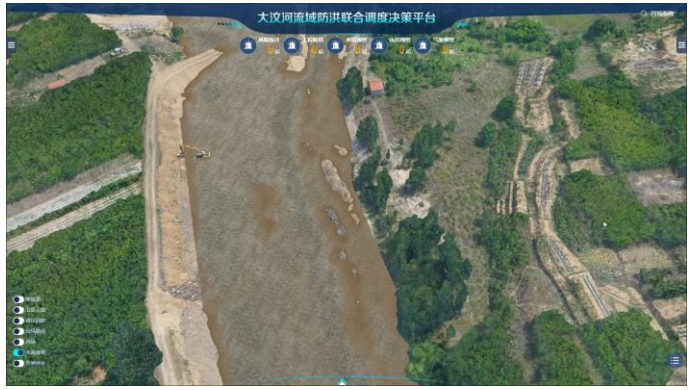
- It brings together 980 items of emergency plan knowledge in 4 categories for the entire river basin, and constructs a knowledge system of "six major libraries" including a business rule library, an expert forecast experience library (9 categories and 36 items of knowledge, and integrates 14 types of water network entities and encyclopedia entities of the Water Question Platform built by the China Institute of Water Resources and Hydropower Research, and nearly 10,000 books and knowledge content of the Water Conservancy Media Group), a historical typical flood scenario model library (3 types of historical collections and annotations, 34 rainfall spatiotemporal processes, and 166 rainfall distributions), a water conservancy project scheduling rule library (5 categories and 1,167 scheduling data), a forecast scheme and emergency plan knowledge library, and a basin flood control knowledge graph library (555,028 knowledge graphs).
- Realize the production from data -> information -> knowledge, complete the construction of three levels: collection query -> mining analysis -> intelligent recommendation, and form flood control auxiliary decision-making knowledge serving the Dawen River Basin.



Chapter 3 Construction and Application of Digital Twins

- Rendered visualization models of 14 key water conservancy projects and built a watershed simulation scene with multi-level data fusion;
- We have mastered a number of key technologies, including the construction of digital scenes and digital flow fields with multi-source high-resolution data, digital mapping of all elements of the watershed, and digital twins, to achieve ultra-realistic loading of TB-level watershed data in seconds.
- Realize the real texture effect of static water surface in reservoirs and rivers, and simulate and visualize the dynamic flow field in the upstream and downstream of rivers.



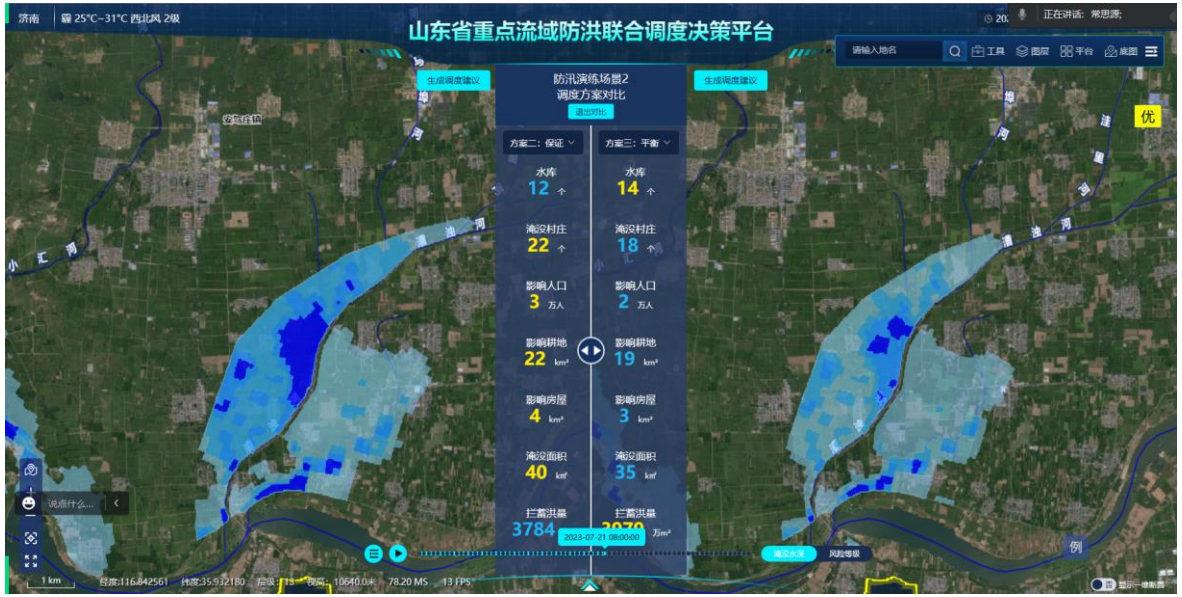


Water surface effects (static)

Dynamic visualization of upstream and downstream flow fields (dynamic)

Chapter 3 Construction and Application of Digital Twins

- **Visual analysis of four major solutions**: Based on multi-sensing support, rich data support, real-time computing support, intelligent knowledge support, and real twin support, it realizes visual analysis of river basin joint scheduling, population transfer plan, material allocation plan, and emergency response plan;
- **Real-time rolling forecast for the entire river basin:** coupled with weather forecast, achieving 290 forecast sections and 1,824 river sections in the two river basins, and 72 hour second-class or above forecasts;
- **Full-process 3D evolution analysis:** 3D flood evolution full-process preview, real-time quantitative statistics of disaster-affected population and area, etc;
- **Joint and coordinated defense for the entire river basin:** Joint and collaborative defense of the entire basin: The coordinated command and defense of the "whole basin one game" involves the overall and local linkage of the basin, as well as the coordination of water conservancy projects and rescue supplies.



Overcoming the challenges

Real-time rolling calculation -> loading 3D visualization effects in seconds -> comparative analysis of multiple solutions -> integrated business flow of generating decision solutions with one click

Chapter 3 Construction and Application of Digital Twins

- On June 20, 2023, we supported the Shandong Provincial Water Resources Department in conducting a flood defense dispatching exercise, forming an integrated flood forecasting and dispatching exercise plan of "hydrological forecast -> engineering dispatching -> digital simulation -> dynamic display", which was reported by mainstream media such as Shandong Provincial News Broadcast and Dazhong Daily.
- The two reports by the governor on June 20 and August 14 were highly praised.


大众日报

首页 党建 党规 山东 时局 短视频 财经 民生 文体 思想 读者 济南

山东开展洪水防御调度演练 初步建成大汶河流域防洪联合调度决策支持系统

大众日报记者 方垒

2023-06-20 19:05:57 发布 来源：大众报业大众日报客户端

“预计未来72小时大汶河流域将出现持续强降雨过程，通过洪水预报数字流场来看，河道颜色越深，代表流量越大，点击可查看全水系每个节点的流量及流量过程……”6月20日，在山东水工程调度指挥中心，一条条指令传到沿大汶河一线，一段段视频回传指挥中心，这是山东省水利厅正在举行的大汶河洪水防御调度演练。

此次演练以大汶河发生超保证流量洪水为背景，采取桌面推演和现场处置相结合的方式进行。“不同于往年，此次演练结合已初步建成的大汶河流域防洪联合调度决策支持系统，能扩展预报内容、提高预报精度、延长预见期，为水利工程安全运行和优化调度提供超前、快速、精准的决策支持。”省水利厅水旱灾害防御处处长武甲庆介绍。

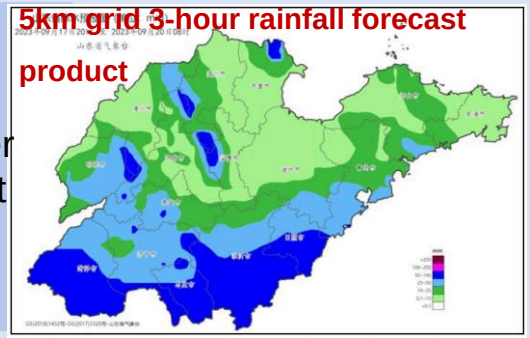
演练共分降雨预报调度、流域联合调度、应急响应联[illegible]大板块。演练过程

This exercise, combined with the Dawen River Basin flood control joint dispatch decision support system that has been initially built, can expand the forecast content, improve forecast accuracy, extend the forecast period, and provide advanced, fast and accurate decision support for the safe operation and optimized dispatch of water conservancy projects.

Carry out twin river basin construction in accordance with national and industry requirements, form a Shandong paradigm, and lead the national demonstration.

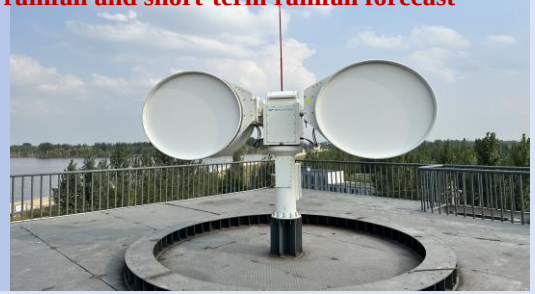
The "three lines of defense" facilitate precise prevention and control, and will be put into commercial use during the 2023 flood season, supporting three level IV emergency responses and 238 forecast dispatches.

Weather forecast

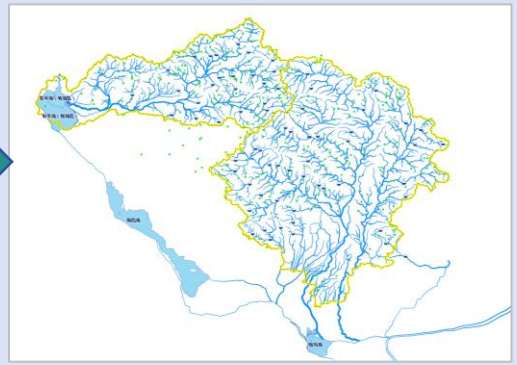


Space support platform

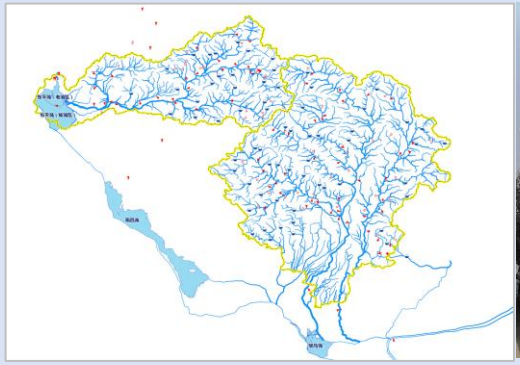
Radar Rainfall Measur e-ment System



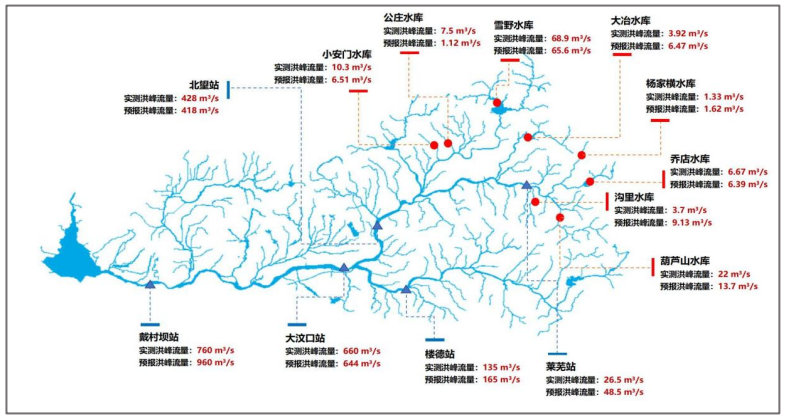
531 rainfall stations



139 river stations + 188 video flow measurements

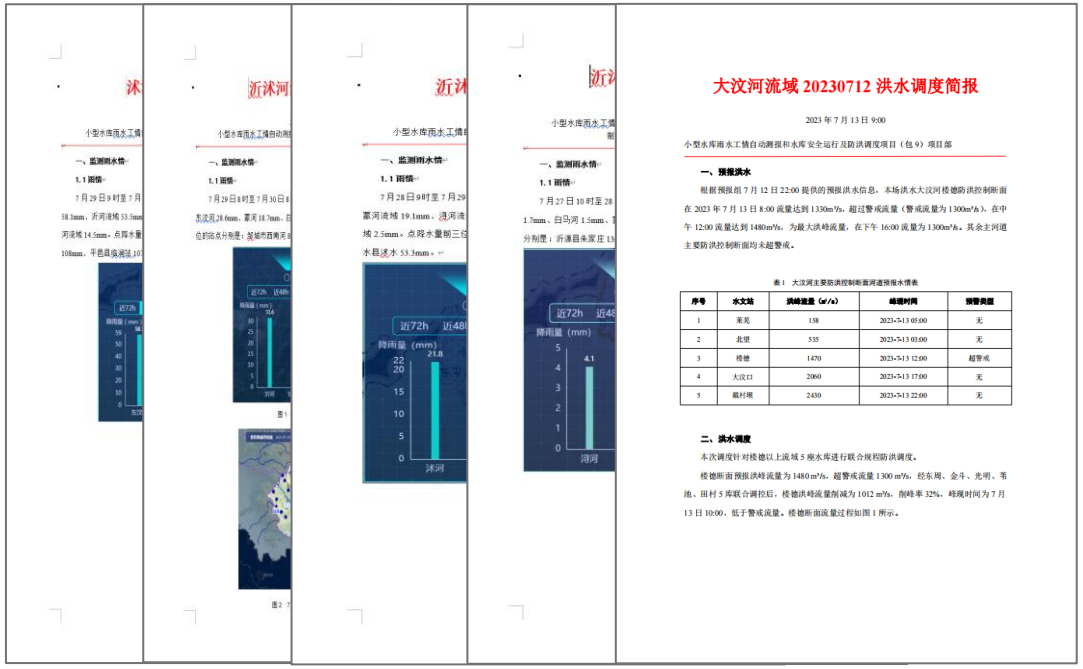


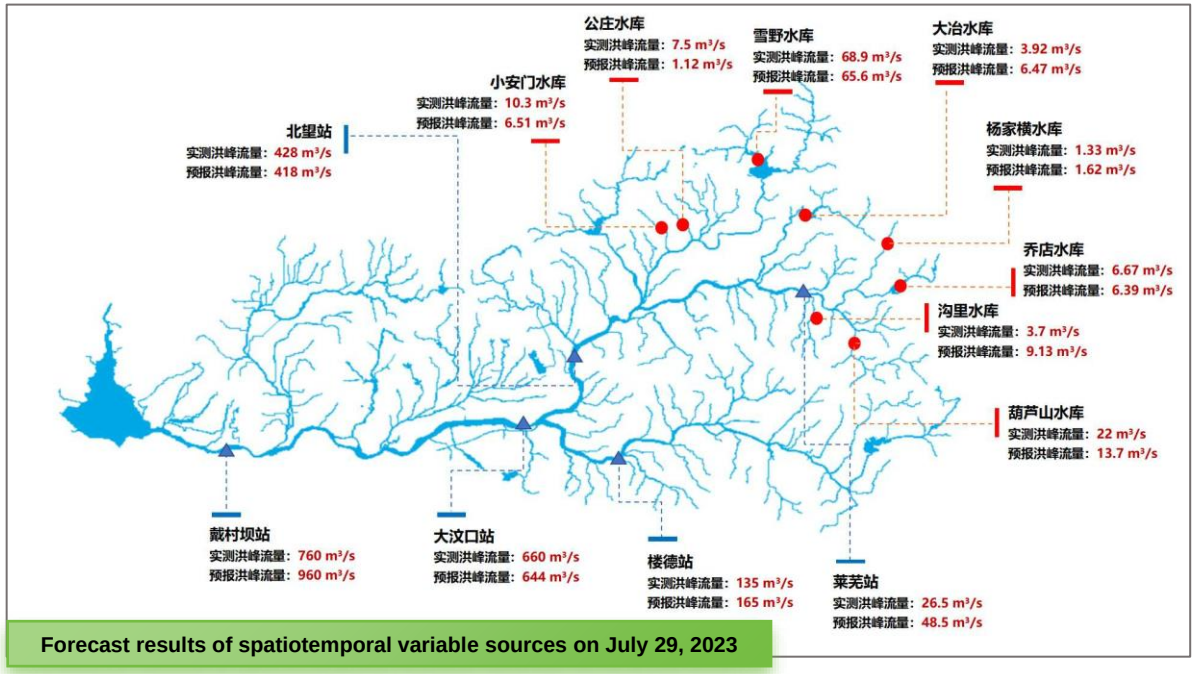
369 forecast sections, 1824 river sections, Rolling flood forecast for the next 3-10 days



Du Surui's actual combat test results on Dawen River

- During the three times that Shandong Province initiated Level IV emergency response, rolling flood forecasts were conducted for 369 forecast sections and 1,824 river sections of the Yishu River and Dawen River for the next 3-10 days, with a total of 238 forecasts and 30 flood forecast dispatch briefings generated.





Forecast results of spatiotemporal variable sources on July 29, 2023

Establish a flood rolling forecast and multi-project joint simulation scheduling mechanism of 10-day prediction - 3-day warning - 24-hour forecast - 1-hour response, realize 1-hour emergency response and relief during disasters, and reduce disaster losses.

UN GEONOW 2024
首届联合国地信周

THANK YOU