2024 Flood Prevention Practices and Reflections in the Huaihe River Basin

Su Cui

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Flood features

Flood prevention

Experience and Reflections

Outlook

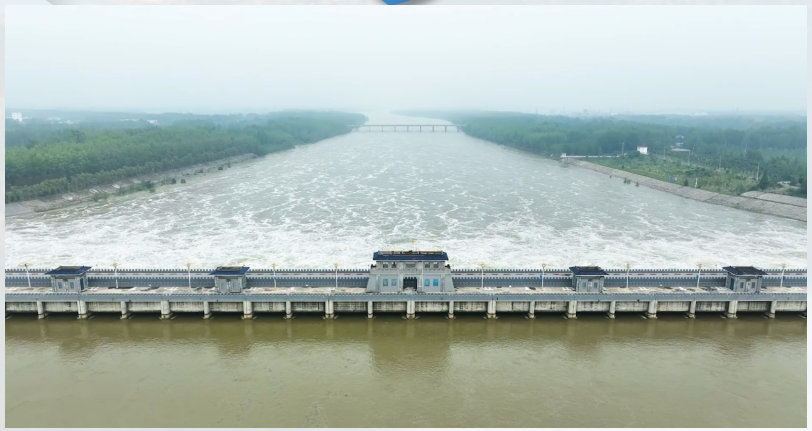
Overview of the Huaihe River Basin

The Huai River Basin is located in the transitional zone between the northern and southern climates of China; Special terrain and landform conditions; Asymmetric tributary water system; In addition, the long-term impact of the Yellow River's occupation of the Huai River has led to frequent floods and droughts in the Huai River.。

Torrential Rain & Flood Characteristics

During the 2024 flood season, the Huai River basin experienced continuous heavy rainfall, leading to multiple flood outbreaks. A total of 67 rivers, including the main Huai River, the Pihe River, and the Shaying River, exceeded flood warning levels, while five rivers—such as the Bailu River, the Xiaohong River, and the Si River—exceeded flood control standards. The Huai River Flood Control Headquarters and the Huai River Commission maintained emergency responses for 31 days and 16 hours

- 9 heavy precipitation processes
- 5 numbered floods
- 67 rivers exceeded the warning level
- 5 rivers exceeded the guaranteed level
- 31 days and 16 hours of emergency response

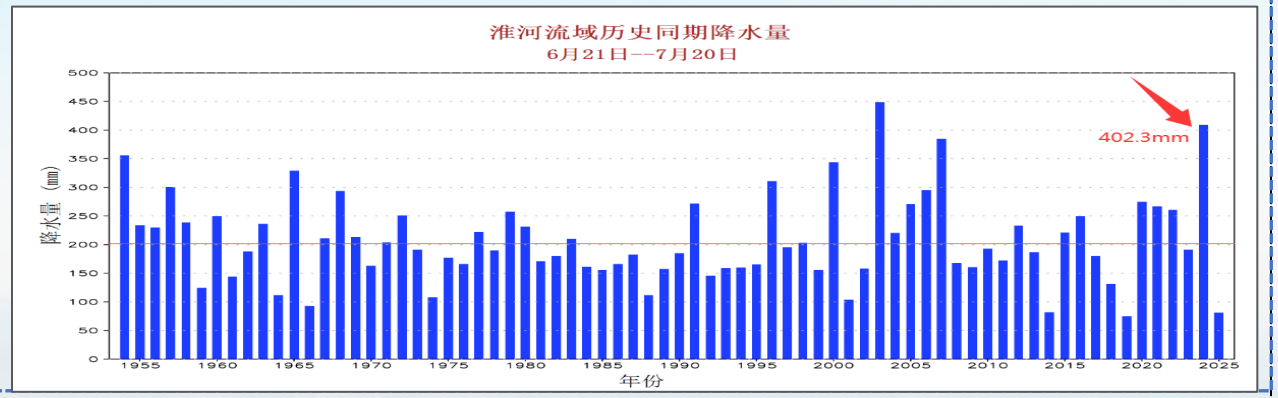


Torrential Rain & Flood Characteristics

1： Meiyu with extensive coverage and heavy total precipitation.

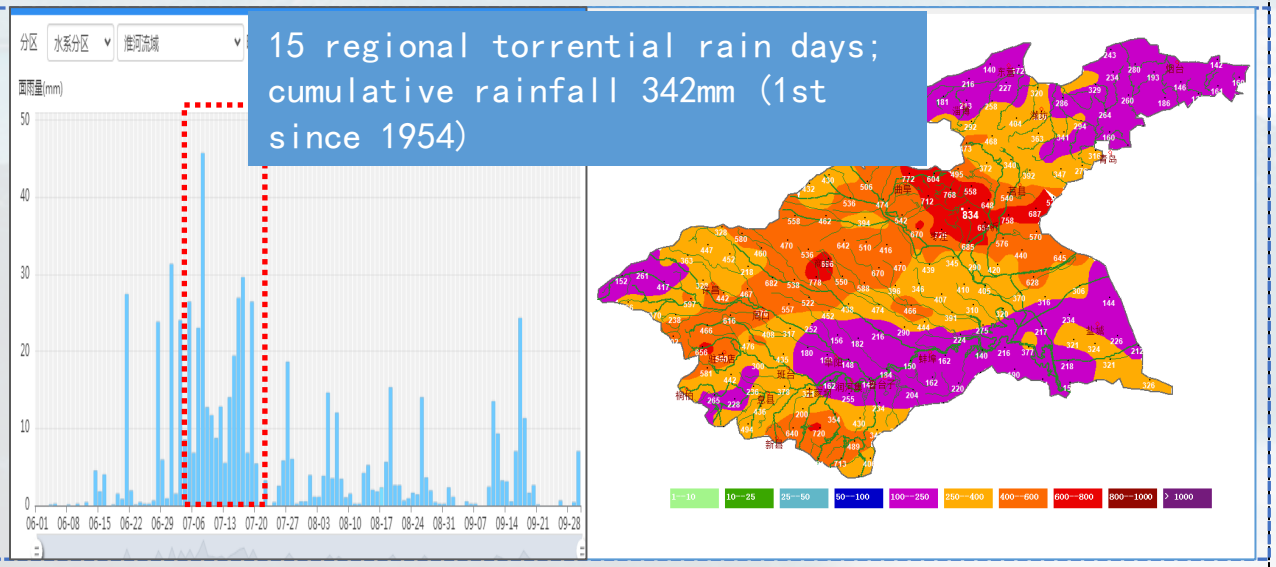
☐ The Meiyu season has a long duration and heavy rainfall

The Meiyu period started on June 21 and ended on July 21, lasting 6 days longer than the multi-year average. The cumulative rainfall during the period reached 402.3 millimeters, doubling the historical average for the same period and ranking the 2nd highest since 1954



☐ Concentrated rainfall in time with extensive spatial coverage.

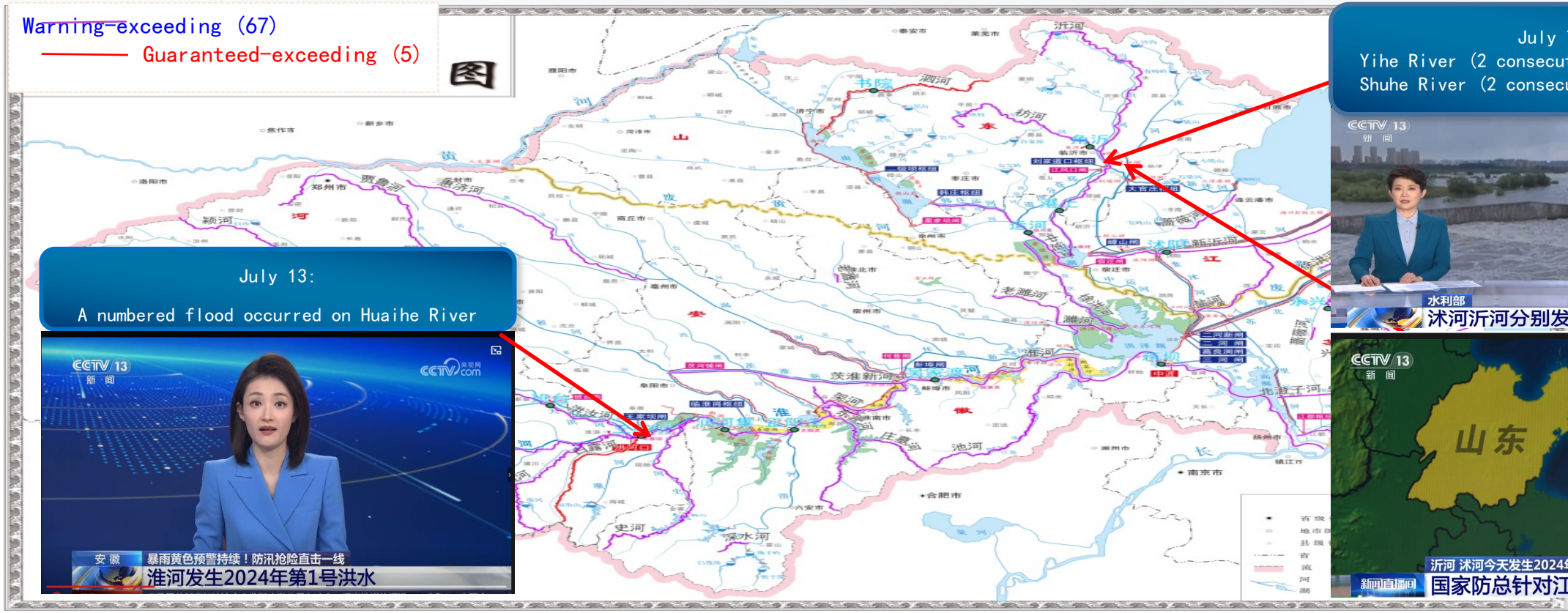
Early-Mid July: 5 consecutive heavy rainfall events in 19 days, 15 regional torrential rain days; cumulative rainfall 342mm (1st since 1954). Rainfall >200mm: 250,000 km² (93% of basin); >300mm: 210,000 km² (78% of basin).



Torrential Rain & Flood Characteristics

2 Multiple rivers with the same frequency exceeding the alarm , covering the entire area：

- **67 rivers (main Huaihe, Pihe, Shaying, etc.) above warning levels; 5 rivers (Bailuhe, Xiaohonghe, Sihe, etc.) above guaranteed levels. 45 rivers over warning in 19 days (unprecedented for the period); 5 numbered floods (July 7–13).**

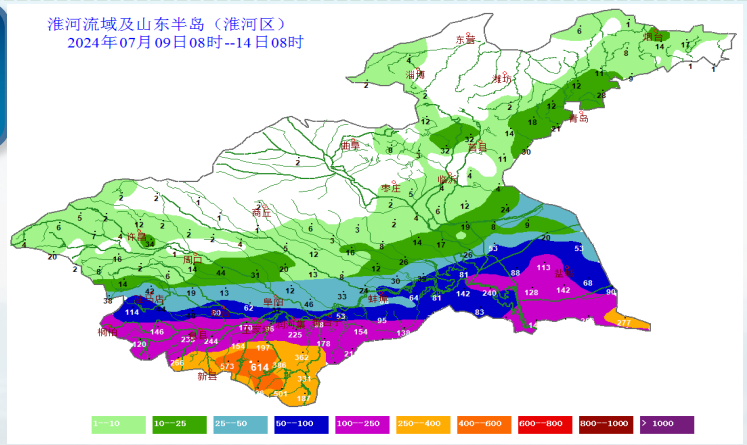


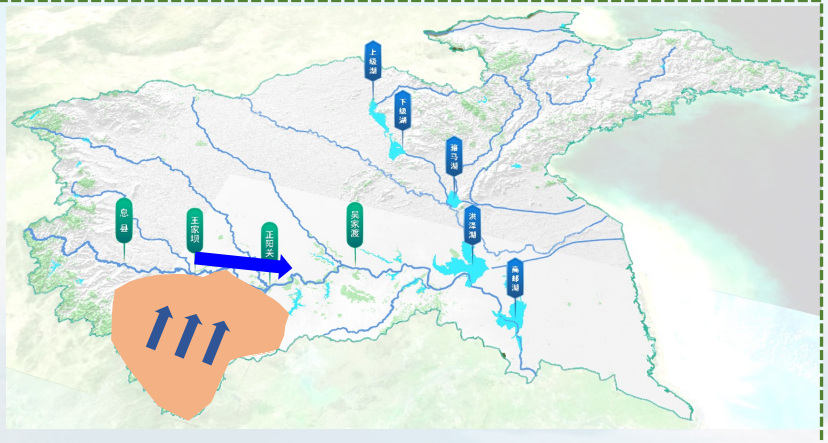
Torrential Rain & Flood Characteristics

3 Main streams and tributaries successively forming floods with synchronized evolution

July 11–13: Multiple consecutive flood peaks in Huainan's tributaries

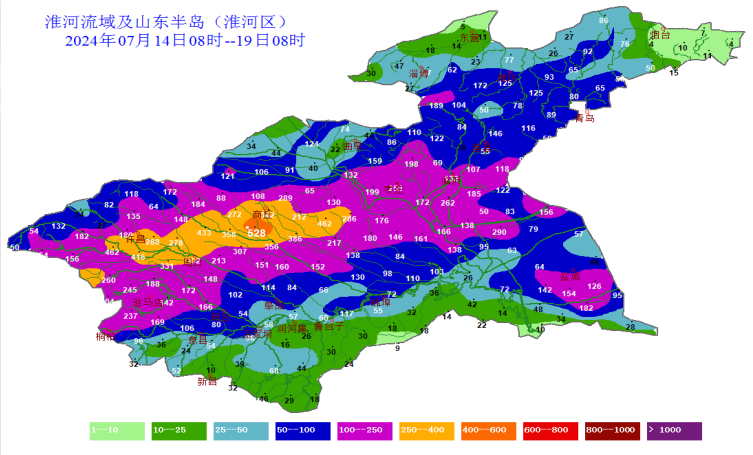
Rapid discharge of floodwaters from Huainan mountainous areas → early inflow to Huaihe main stream → raising its water level.

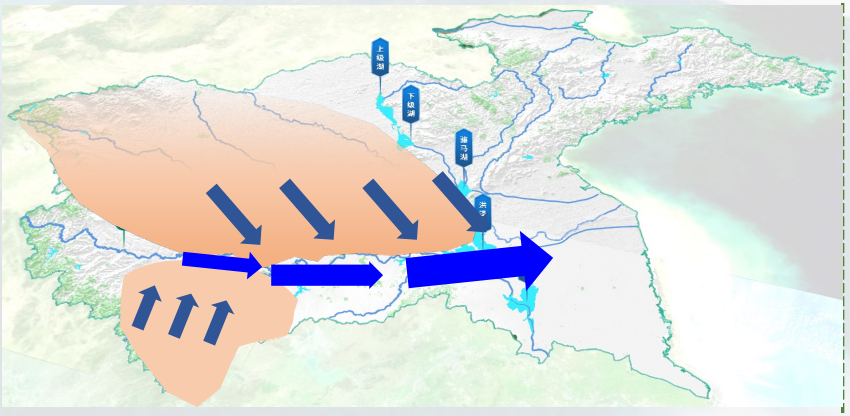




July 14–18: Sustained inflow of floods from northern Huaibei tributaries into main stream

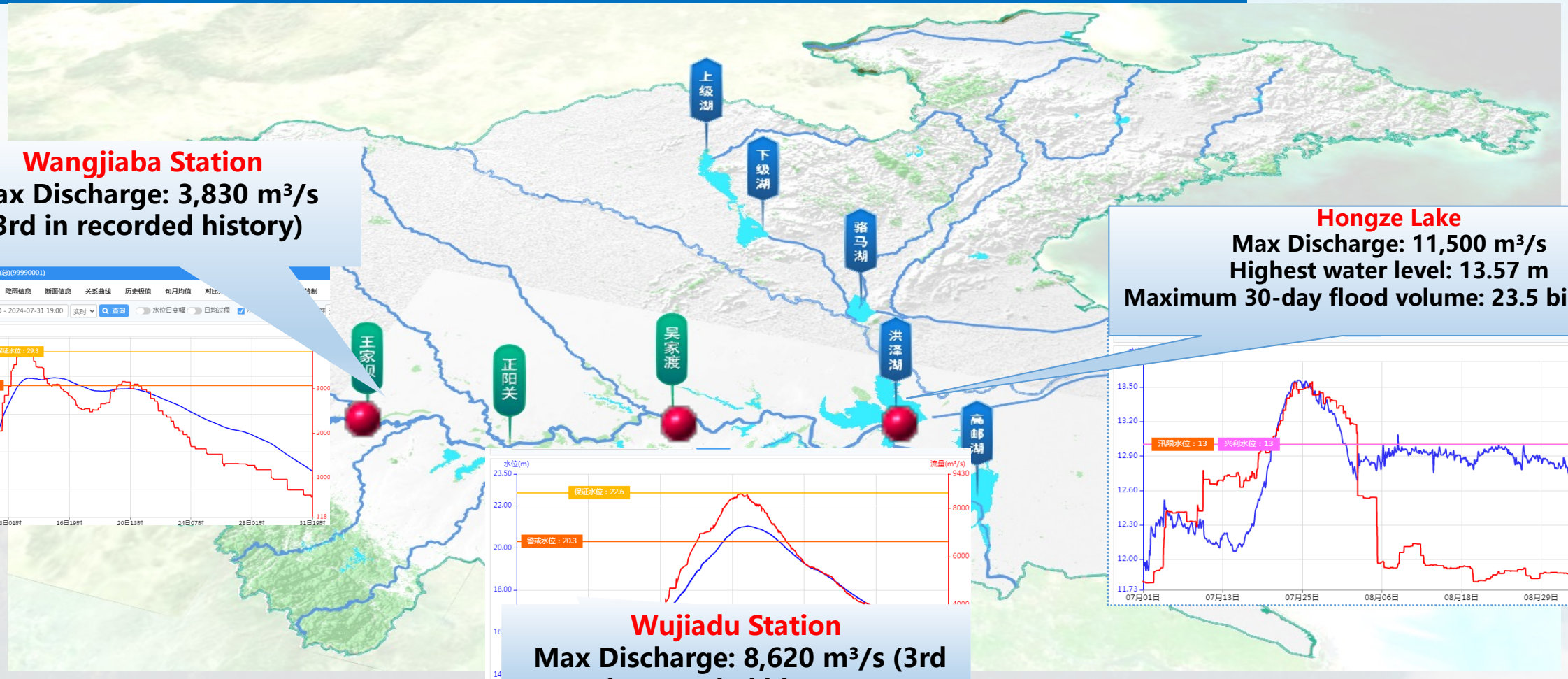
From July 14 to 18, floodwaters from the northern tributaries have continuously converged into the Huaihe main stream, further elevating its water level.





Torrential Rain & Flood Characteristics

4 Huaihe main stream: High peak, large runoff, long duration



Wangjiaba Station
Max Discharge: 3,830 m³/s (3rd in recorded history)

Hongze Lake
Max Discharge: 11,500 m³/s
Highest water level: 13.57 m
Maximum 30-day flood volume: 23.5 billion m³

Wujiadu Station
Max Discharge: 8,620 m³/s (3rd in recorded history)

Flood features

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Outlook

Flood prevention

Effective and orderly intelligence work

More than 10,000
hydrological information and forecasting stations

250 million
Hydrological information

Issue 209
Meteorological forecast

Issue 113
Hydrological Forecast

5
numbered floods

13
hydrological warnings

Issue 78
rainfall and hydrological situation materials

16,000 person-times
short messages

迎战！5次编号洪水背后的水利担当

中国水利 2024年07月27日 10:56 北京

沂河、沭河发生1号洪水！

沂河、沭河发生2号洪水！

淮河发生1号洪水！

2024年入汛以来，淮河流域迎来多次强降
一周时间，沂沭泗河水系、淮河干流相继
以来，流域累计降水量342毫米，较历史
第1位。淮河干支流出现连续涨水过程，
山等17座中型水库，242座小型水库超汛
超保证水位。


本报记者跟拍蓄滞洪区一线直击

充分发挥拦洪削峰错峰作用应对2024年第1号洪水

淮河流域水库群彰显“王牌”本色

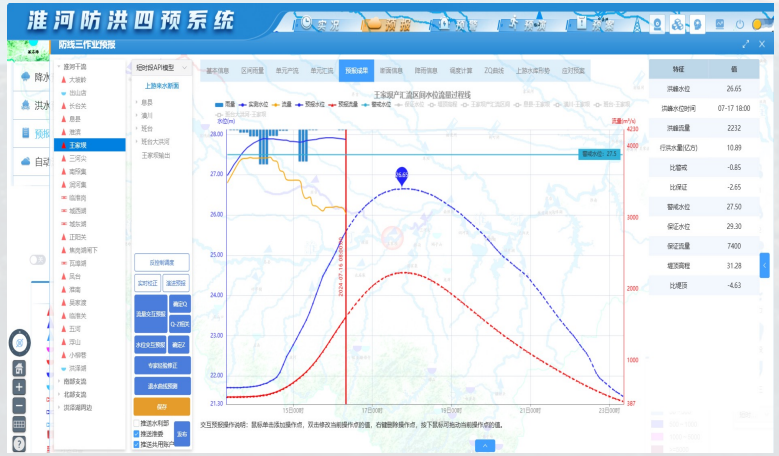
Flood prevention

Remarkable highlights in forecasting work

We established for the first time a multi-dimensional and multi-level collaborative forecasting mechanism with linkage among the Ministry, river basins, provinces/autonomous regions/municipalities, prefectures/cities, and hydrological stations.

We formulated for the first time a river system forecasting scheme with full coverage of key flood control areas in the basin and multiple models, initially realizing the connection of the "three lines of defense" for rainfall and hydrological monitoring and forecasting and the "four pre-" link for flood control.

We achieved for the first time on-site support of flood control business systems for "four pre-" analysis and judgment, and implemented real-time forecasting and simulation through the mechanism of "weekly consultations + local rainstorm consultations + individual flood event consultations".

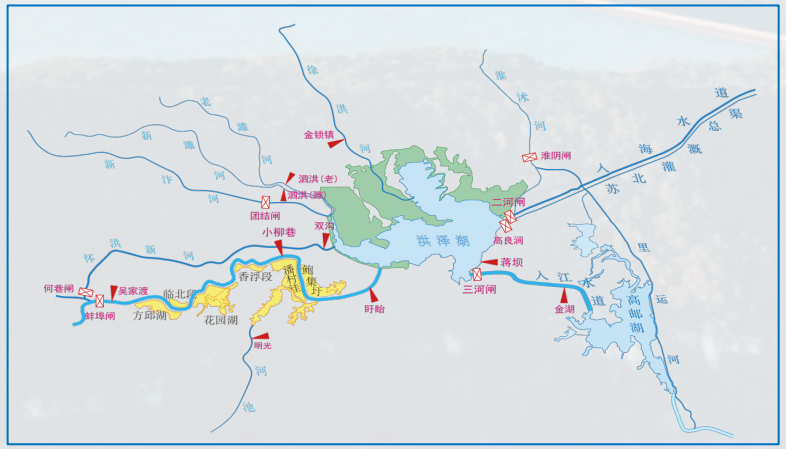


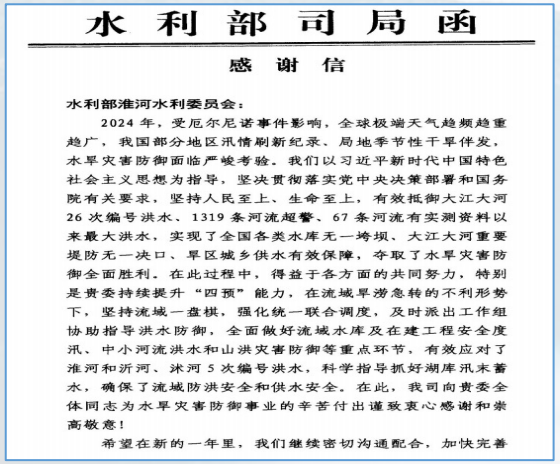
Flood prevention

Remarkable highlights in forecasting work

We accurately forecast the peak discharge of Wangjiaba Station at 4,000 m³/s 40 hours in advance (measured 3,830 m³/s), the highest water level of Hongze Lake at approximately 13.60 m 7 days ahead of schedule (measured 13.57 m), and the peak discharge of Bantai Station on the Hongru River at 2,200 m³/s 30 hours in advance (measured 2,060 m³/s). Additionally, we predicted the heavy rainfall process in the Yishuisi River system 5 days early.

These forecasting results provided solid technical support for the basin's flood control scheduling, effectively avoiding the activation of flood storage and detention areas, the relocation of nearly 30,000 people, and reducing the submergence of approximately 83,000 mu of cropland. They also prevented Hongze Lake from exceeding the warning water level and the activation of the Huaihe River to the Sea Waterway, minimizing flood disaster losses to the greatest extent. The relevant work was commended by leaders at all levels of the Ministry of Water Resources and the Huaihe River Water Conservancy Commission (HRWCC).





水 利 部 司 局 函

感 谢 信

水利部淮河水利委员会：

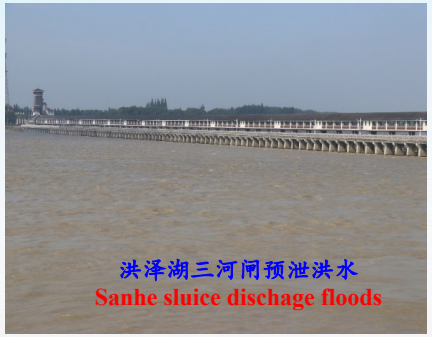
2024年，受厄尔尼诺事件影响，全球极端天气趋频趋重趋广，我国部分地区汛情刷新纪录、局地季节性干旱伴发，水旱灾害防御面临严峻考验。我们以习近平新时代中国特色社会主义思想为指导，坚决贯彻落实党中央决策部署和国务院有关要求，坚持人民至上、生命至上，有效抵御大江大河26次编号洪水、1319条河流超警、67条河流有实测资料以来最大洪水，实现了全国各类水库无一垮坝、大江大河重要堤防无一决口、旱区城乡供水有效保障，夺取了水旱灾害防御全面胜利。在此过程中，得益于各方面的共同努力，特别是贵委持续提升“四预”能力，在流域旱涝急转的不利形势下，坚持流域一盘棋，强化统一联合调度，及时派出工作组协助指导洪水防御，全面做好流域水库及在建工程安全度汛、中小河流洪水和山洪灾害防御等重点环节，有效应对了淮河和沂河、沭河5次编号洪水，科学指导抓好湖库汛末蓄水，确保了流域防洪安全和供水安全。在此，我司向贵委全体同志为水旱灾害防御事业的辛苦付出谨致衷心感谢和崇高敬意！

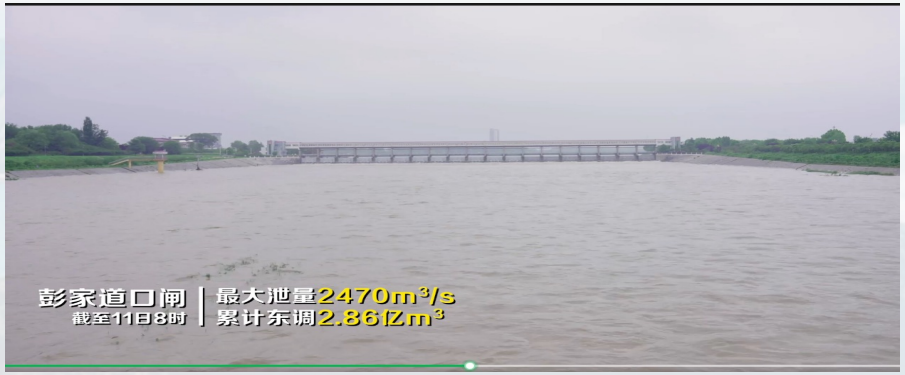
希望在新的一年里，我们继续密切沟通配合，加快完善

Flood prevention

Flood scheduling was conducted in an orderly and systematic manner

- ✓ Before the flood: Unblock flood discharge channels and fully reserve flood control storage capacity.
- ✓ During the flood: Implement joint operation of project groups, including reservoir groups and barrage/sluice groups.
- ✓ After the heavy rainfall: Schedule staggered peak discharges from reservoir groups to alleviate pressure on the main stream of the Huaihe River.





Flood features

Flood prevention

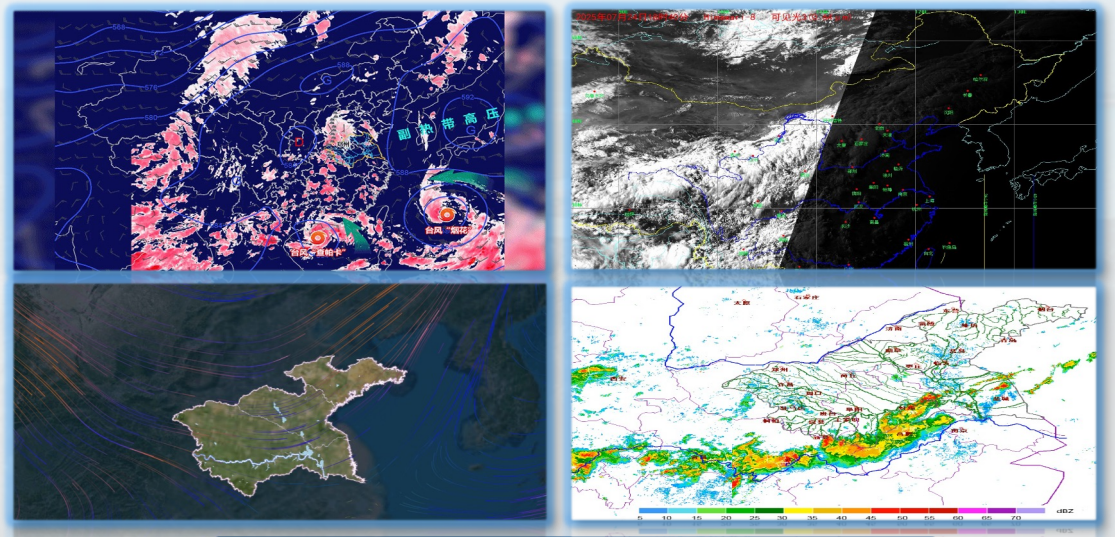
Experience and Reflections

Outlook

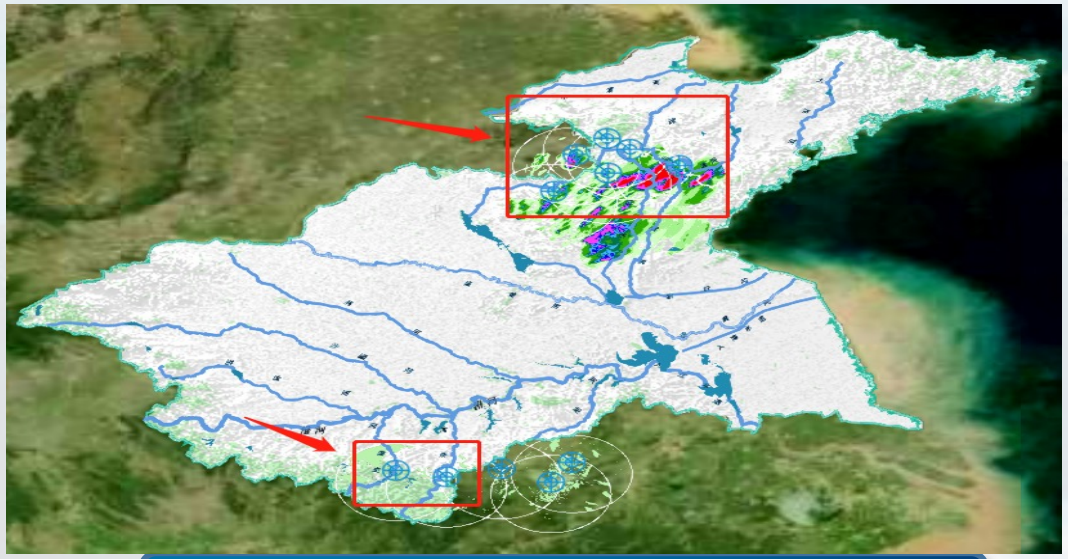
Reflection 1: Continuously Strengthen Monitoring Support Capacity

"Three Lines of Defense" Upgrade: Weather & Rain Gauge Radars

- Real-time integration of meteorological department's 11 weather radar systems, receiving meteorological satellite cloud images, and monitoring the development and changes of weather systems in the basin as well as the occurrence and progression of rainstorms and floods around the clock
- Access data from two hydrological rainfall measurement radars in the Dabie Mountain area and six hydrological rainfall measurement radars in the Yishu River region



Meteorological Satellite Cloud Images & Weather Radar



大别山区2部、沂沭河区6部测雨雷达

Reflection 1: Continuously Strengthen Monitoring Support Capacity

"Three Lines of Defense" Capacity Upgrade: Automatic Discharge Monitoring

To address the inadequacies of traditional discharge measurement capabilities, the Hydrological Bureau of the Huaihe River Water Conservancy Commission (HRWCC) has conducted years of exploration and research. Through a series of technological breakthroughs and experiments, it has successfully developed bottom-mounted and radar wave automatic discharge monitoring systems. Comparative tests have verified that these systems operate stably, with complete functions and accurate data. Their precision meets application requirements, demonstrating significant potential for promotion and application.

Traditional manual discharge measurement:
Time-consuming, low frequency

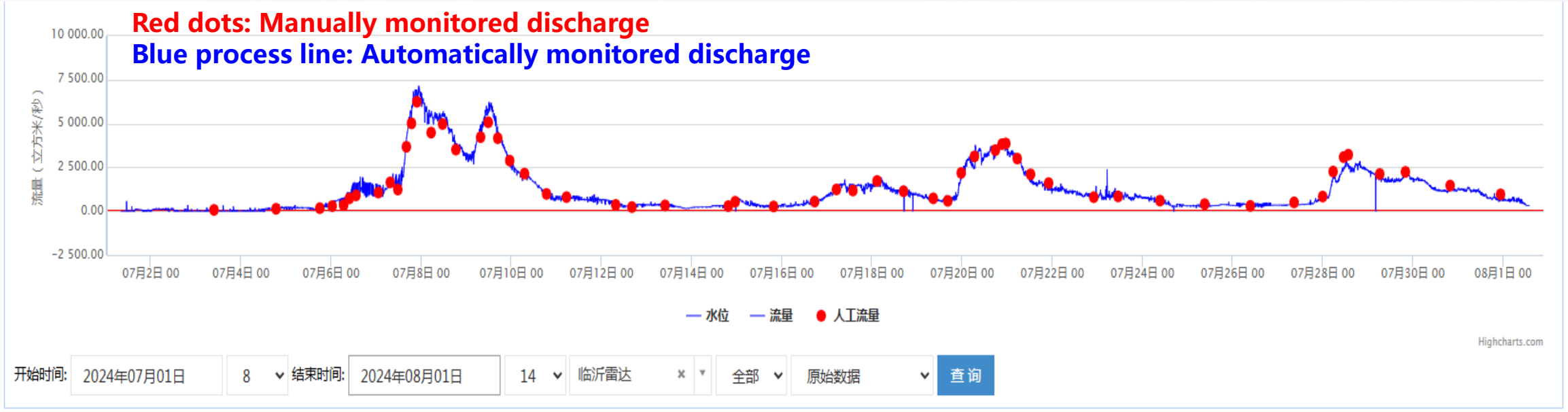
Improve

Automatic Discharge Monitoring

Reflection 1: Continuously Strengthen Monitoring Support Capacity

"Three Lines of Defense" Capacity Upgrade: Automatic Discharge Monitoring

- In the 2024 numbered flood of the Yihe River, Linyi Station' s manual measured peak discharge was 6,240 m³/s, and the radar wave automatic system got 6,540 m³/s (relative error: 5%). The system fully recorded the flood process with a trend highly consistent with manual data, strongly supporting flood forecasting and dispatching.

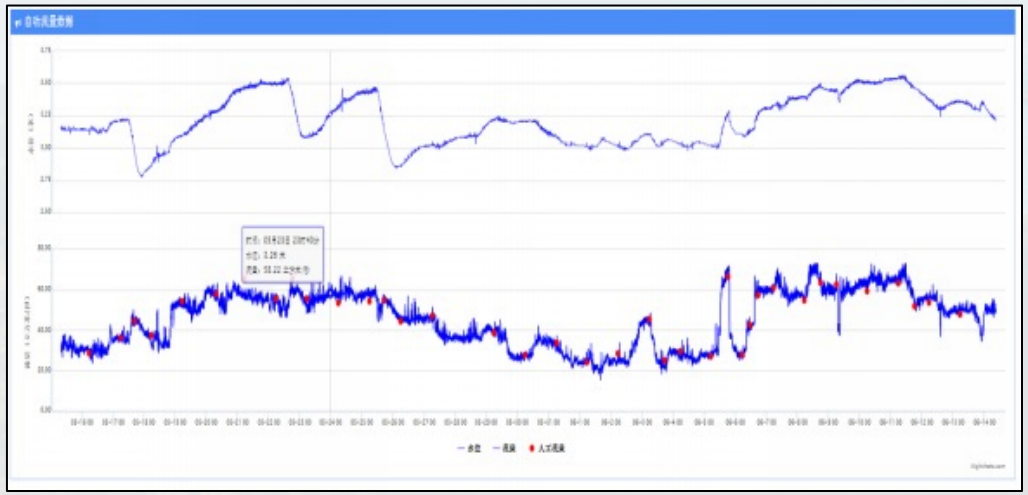


Stage-Discharge Hydrograph of Linyi Station

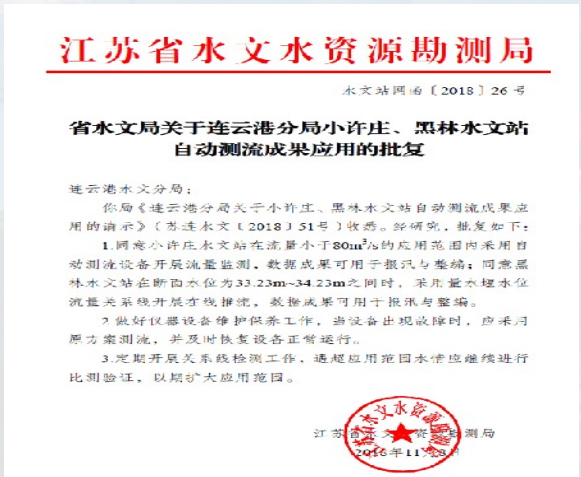
Reflection 1: Continuously Strengthen Monitoring Support Capacity

"Three Lines of Defense" Capacity Upgrade: Automatic Discharge Monitoring

The automatic discharge monitoring system at Xiaoxuzhuang Hydrological Station in Lianyungang City has been incorporated as an official measurement method into the station's flood measurement plan and flood reporting assignment document. The Jiangsu Provincial Hydrological Bureau has approved that the results of the relevant automatic discharge monitoring system can be used for flood reporting and hydrological data compilation, which has effectively improved the level of automation and informatization in flood measurement and reporting.



Stage-Discharge Hydrograph of Xiaoxuzhuang Station



江苏省水文水资源勘测局

水文站网函〔2018〕26号

省水文局关于连云港分局小许庄、黑林水文站自动测流成果应用的批复

连云港水文分局：

你局《连云港分局关于小许庄、黑林水文站自动测流成果应用的请示》（苏连水文〔2018〕51号）收悉。经研究，批复如下：

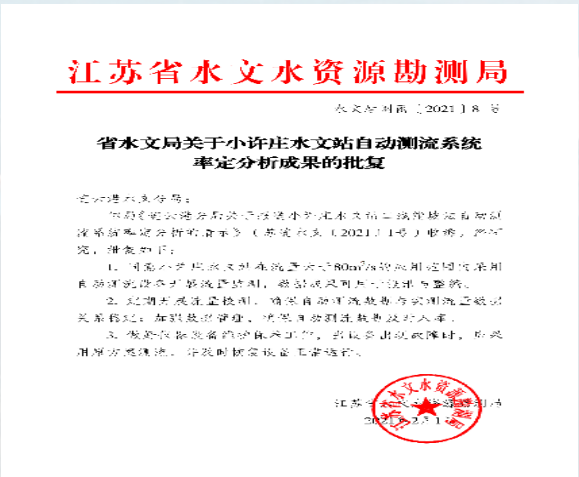
1.同意小许庄水文站在流量小于80m³/s的应用范围内采用自动测流设备开展流量监测，数据成果可用于报汛与整编；同意黑林水文站在断面水位为33.23m~34.23m之间时，采用量水堰水位流量关系线开展在线推流，数据成果可用于报汛与整编。

2.做好仪器设备维护保养工作，当设备出现故障时，应采用原方案测流，并及时恢复设备正常运行。

3.定期开展关系线检测工作，超应用范围水情应继续进行比测验证，以期扩大应用范围。

江苏省水文水资源勘测局

2018年11月8日



江苏省水文水资源勘测局

水文站网函〔2021〕8号

省水文局关于小许庄水文站自动测流系统率定分析成果的批复

连云港水文分局：

江苏省水文水资源勘测局

2021年3月15日

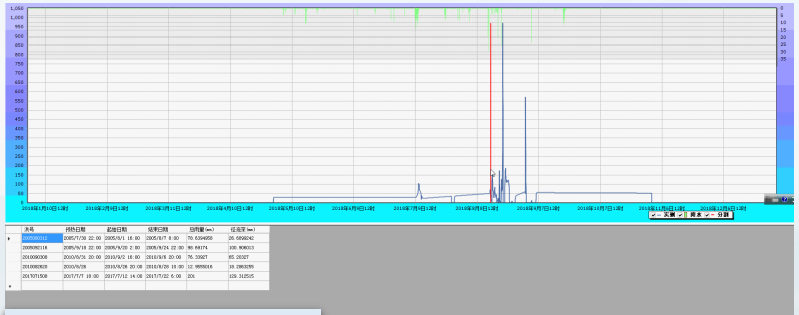
Automatic discharge monitoring results approved for flood reporting & hydrological compilation

Reflection 2: Gradually Consolidate Hydrological Info & Flood Forecasting Foundation

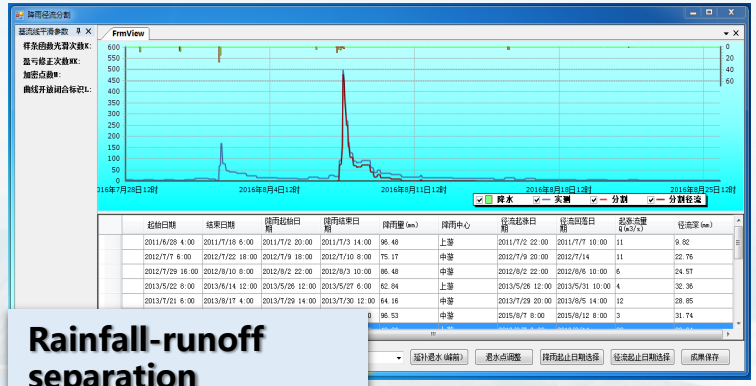
Independently developed software for program development, dynamically calibrating forecast model parameters

Full-process production of forecast scheme

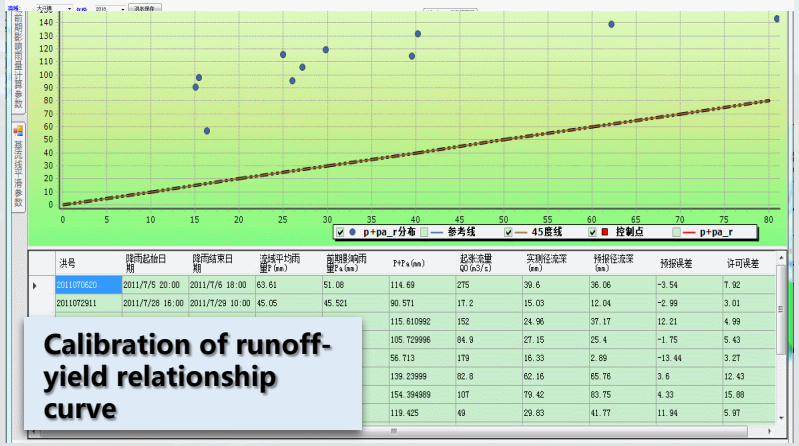
- Flood selection
- Rainfall-runoff separation
- Calibration of runoff-yield relationship curve
- Calibration of unit hydrograph for confluence



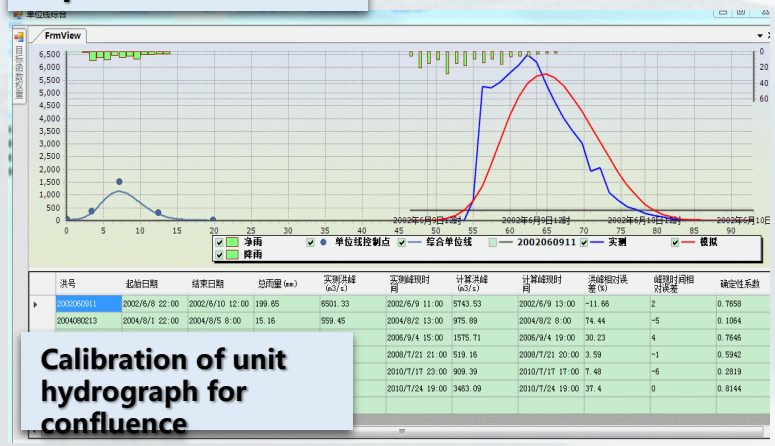
Flood selection



Rainfall-runoff separation



Calibration of runoff-yield relationship curve

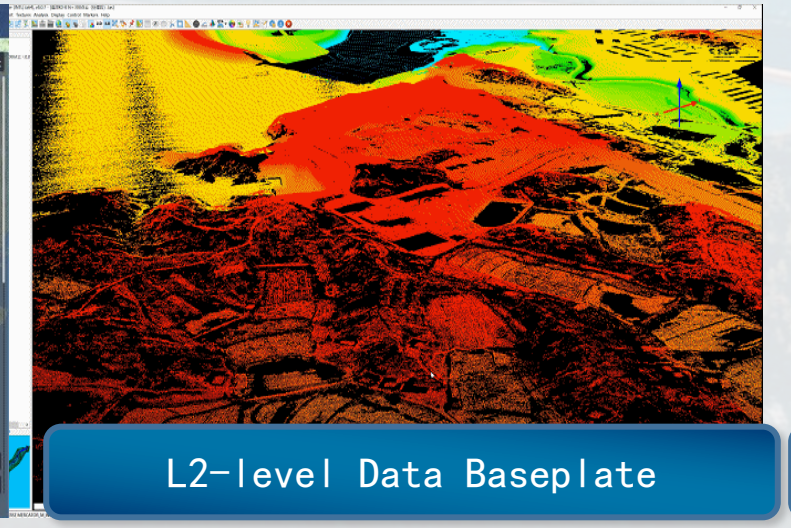


Calibration of unit hydrograph for confluence

(1) High-standard "Three-Level Data Baseplate

- L1-level Data Baseplate: Full Coverage (330,000 km²) & Multi-element Integration for Huaihe River Basin
- High-precision L2-level Data Baseplate Constructed, Covering Key Sections of Huaihe Main Stream, Hongru River, Shaying River, etc., and Nansi Lake Area。
- L3-level data baseplate under continuous improvement.Completed oblique photography for Chushandian Reservoir, Wangjiaba Sluice, etc.; accomplished oblique photography/BIM integration for Bengbu Sluice, Nansi Lake Second Dam Hub, etc.。

L1-level Data Baseplate

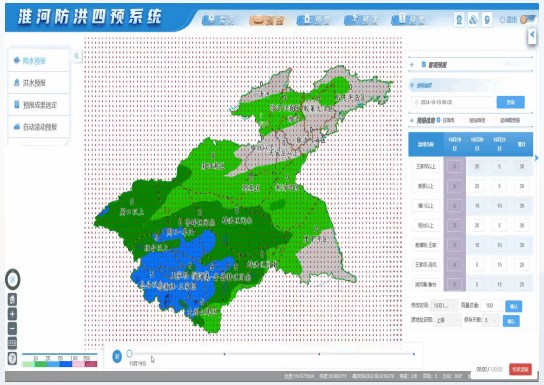

L2-level Data Baseplate

L3-level Data Baseplate

(2) Independent develop of a Huaihe River-characteristic Model Library

Based on the actual conditions of the Huaihe River, a refined water conservancy professional model library has been constructed, including the Huaihe Distributed Hydrological Model, 1D-2D Hydrodynamic Model, Forward and Reverse Simulation Models, Rainwater Holding Capacity Calculation Model, and Huaihe Practical Hydrological Model. Additionally, a multi-scale and multi-process coupled model integrating "meteorology-hydrology coupling, lumped-distributed coupling, 1D-2D coupling, hydrology-hydrodynamics coupling, and forecast-dispatch coupling" has been fully established, providing solid "algorithmic" support for the business applications of the Digital Twin Huaihe River.

(3) Full-chain "Four Preparations" Application Development

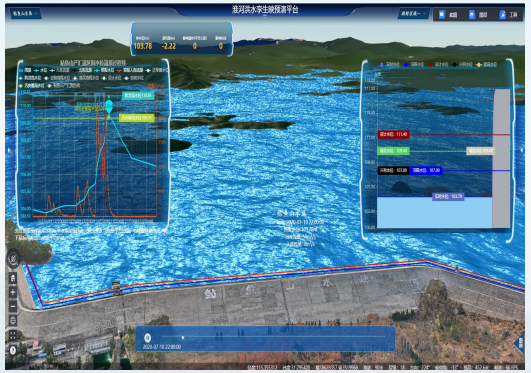


Forecast

River system-based basin unit, meteorology-hydrology & forecast-dispatch coupling, full rainfall-runoff-confluence-routing process coverage, real-time online analysis & routing.

Early Warning

Classified & graded early warnings (real-time/forecast scenarios), multi-element coverage (reservoirs, river courses, projects), coupled with MWR/HRWCC platforms, direct information to frontline.



Simulation

Multi-project & Multi-mode Dispatch Simulation — Efficient "Forward"/"Reverse" Simulations (Integrated Forecast-Dispatch & Excess Water Allocation

Emergency Preplan

Intelligent online preplan response & execution (per river system/node) — covering dispatch instructions, risk area evacuation, flood control material allocation, emergency rescue technologies.

Flood features

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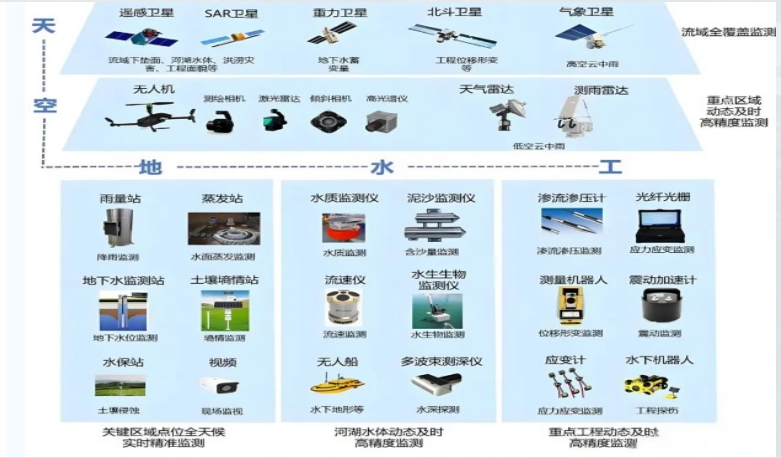
Outlook

Outlook1：Further Improve River Basin Monitoring and Sensing Capacity

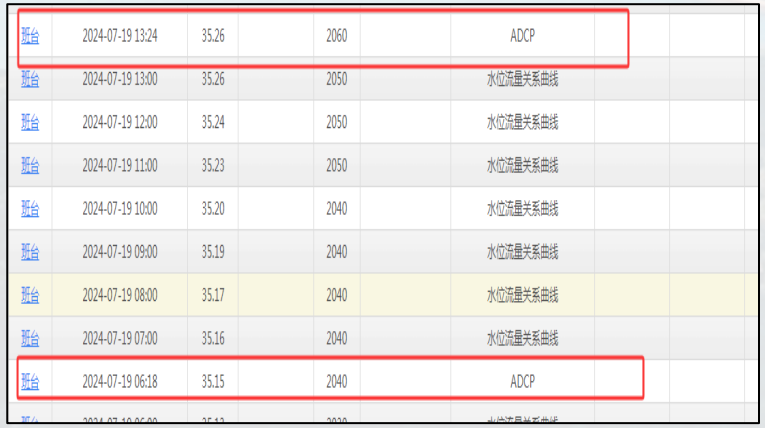
Situational requirements

In 2024, the Ministry of Water Resources, PRC issued the Action Plan for Consolidating Foundations and Enhancing Capabilities of the "Sky-Space-Earth-Water-Project" Integrated Monitoring and Perception for Digital Twin Water Resources (2024 - 2026).



Existing Problems

- **Incomplete hydrological monitoring station coverage**
- Insufficient measurement frequency in some sections (e.g., Bantai Station: flow measurement interval>6h)
- Insufficient hydrological station density in small/medium rivers — hydrological monitoring "blank areas" exist."



蚌台	2024-07-19 13:24	35.26	2060	ADCP
蚌台	2024-07-19 13:00	35.26	2050	水位流量关系曲线
蚌台	2024-07-19 12:00	35.24	2050	水位流量关系曲线
蚌台	2024-07-19 11:00	35.23	2050	水位流量关系曲线
蚌台	2024-07-19 10:00	35.20	2040	水位流量关系曲线
蚌台	2024-07-19 09:00	35.19	2040	水位流量关系曲线
蚌台	2024-07-19 08:00	35.17	2040	水位流量关系曲线
蚌台	2024-07-19 07:00	35.16	2040	水位流量关系曲线
蚌台	2024-07-19 06:18	35.15	2040	ADCP

Outlook for Future Work

- Improve hydrological station network —: fill small/medium river monitoring gaps, achieve "full coverage without blind areas"”
- Accelerate automatic hydrological monitoring promotion — address insufficient manual monitoring capabilities;
- Upgrade hydrological data communication transmission： promote Beidou dual-channel transmission, ensure stable/reliable info transmission in extreme weather

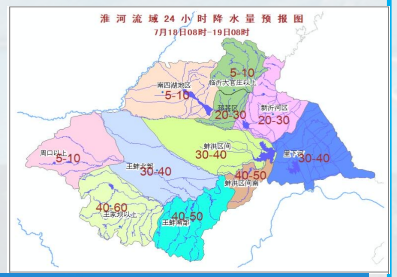
Outlook 2: Continuously Enhancing Intelligence and Forecasting Capabilities

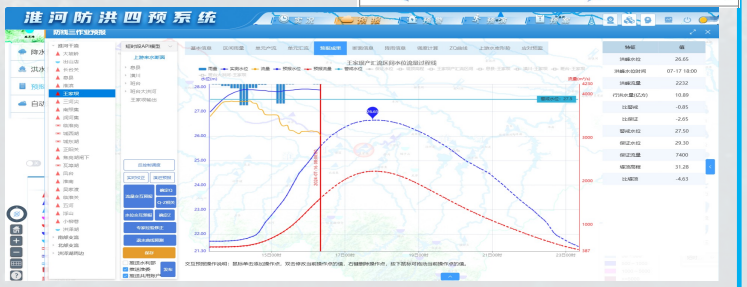
Situational requirements

- In 2025, Li Guoying, Minister of the Ministry of Water Resources, emphasized the need to accelerate the construction of a modern rainwater and hydrological monitoring and forecasting system, achieving the effective integration of "extending flood forecast lead time and improving flood prediction accuracy." This will provide strong support for enhancing China's flood and drought disaster prevention capabilities, advancing high-quality water conservancy development, and safeguarding national water security.

Existing Problems

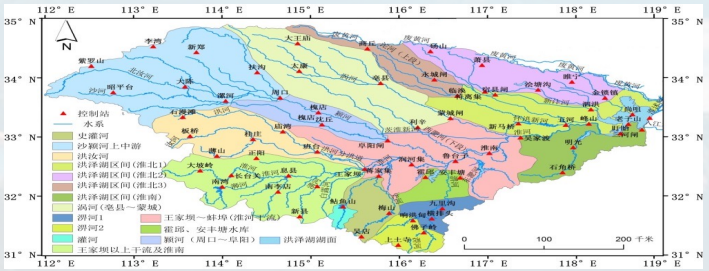
- Insufficient refinement of flood forecasting:
- Further optimization required for flood forecasting models and schemes.
- Forecast accuracy and lead time need to be enhanced





Outlook for Future Work

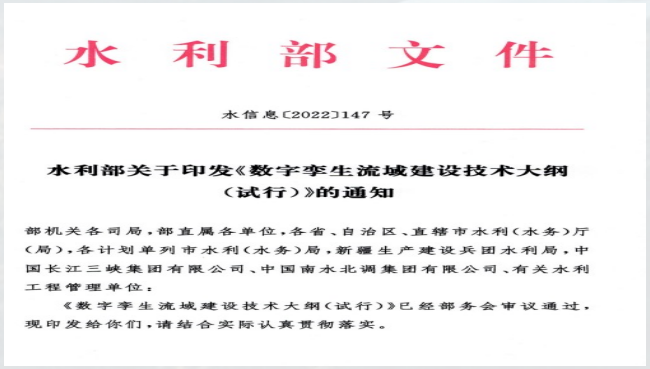
- Refine meteorological-hydrological coupling
- Improve flood forecast schemes
- Build multi-scale coupling models (rainfall-runoff-confluence-routing-dispatch) → higher accuracy & longer flood lead time



Outlook 3: Sustained Advancement of the Digital Twin Huaihe River Construction

Situational requirements

Smart Water Conservancy is the most prominent symbol of high-quality water conservancy development in the new stage. The Digital Twin Basin serves as the core and key to advancing the construction of Smart Water Conservancy, and constitutes an important measure and grasp for realizing the "Four Unities" and high-quality development of the Huaihe River Basin in the new stage.



水 利 部 文 件

水信息〔2022〕147 号

水利部关于印发《数字孪生流域建设技术大纲（试行）》的通知

部机关各司局，部直属各单位，各省、自治区、直辖市水利（水务）厅（局），各计划单列市水利（水务）局，新疆生产建设兵团水利局，中国长江三峡集团有限公司、中国南水北调集团有限公司、有关水利工程管理单位：

《数字孪生流域建设技术大纲（试行）》已经部务会审议通过，现印发给你们，请结合实际认真贯彻落实。

Existing Problems

Currently, as a core business system, the Digital Twin Flood Control "Four Previsions" System has been fully applied in real combat scenarios at the Huaihe River flood control consultation sites in 2024 and 2025. However, there is room for further improvement in the timeliness of simulation analysis and the intelligence level of preplan generation. Additionally, deficiencies exist in co-construction, sharing, and system integration, and the supporting capacity for flood control consultations needs to be enhanced.

Outlook for Future Work

Construct a flood control "Four Previsions" system based on high-precision data, high-accuracy algorithms, and high-performance computing power, so as to further enhance the digitalization, precision, and intelligence levels of flood forecasting and dispatching.

Thanks!