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Analysis of Flood Evolution and Operation Mode in Mega City

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Background

• **The persistent high frequency of extreme rainstorms** has significantly increased the challenges associated with urban flood disaster prevention, posing considerable difficulties for flood control and drainage operations in mega cities such as Beijing.
• **Intensive human activities** in mega city results in drastic change of underlying surfaces, runoff generation/ concentration conditions, causing frequent localized heavy rainstorms.
• Substantial research on urban flood has been conducted after the Rainstorm “2012.7.21” in Beijing, while multi-level analysis of the city's flood evolution and operational patterns from the perspective of **extreme rainfall, urban flood, and flood peak staggered regulation** remain scarce.

Highlights

- Raintorm centroid movements, rainfall-runoff characteristics and urban flood disaster threshold are analysed in this case study of the North Canal River Basin (NCRB) in Beijing.
- Urban flood and waterlogging evolution patterns are explored and the event-based schematic of flood operation modes are summarized.
- Findings provide valuable foundation for systematic flood prevention in Beijing and useful insights for other mega cities.

Materials & Methods

✓ Four typical rainstorms within the recent decade in Beiyun River are collected, shown as Table.1.

Table1. Employed data and materials

Data	Time	Contents	Resolution
Basic Geo-information	2018	LUCC (Raster)	1:10000
	2011	Stream network (Vector)	1:2000
Hydrometeo rological data	2012 /2016	meteorological rainfall	1 hour
	2018 /2020	hydrologic rainfall	1 hour
	2012 -2020	flood element records	flood event based

✓ Rainstorm centroid movements analysis:

$$Y_t = \sum_{i=1}^{n}(P_{it}\times Y_i)\Big/\sum_{i=1}^{n}P_{it}$$

$$X_t = \sum_{i=1}^{n}(P_{it}\times X_i)\Big/\sum_{i=1}^{n}P_{it}$$

Xt, Yt—Rainstorm centroid coordinate; *Xi, Yi*—Precipitation (*P*) station coordinate;*Pit*—*P* at time t in *i*th station; *n*—number of *P* stations.

✓ Mathematical statistics
✓ Mapping knowledge domains

Results

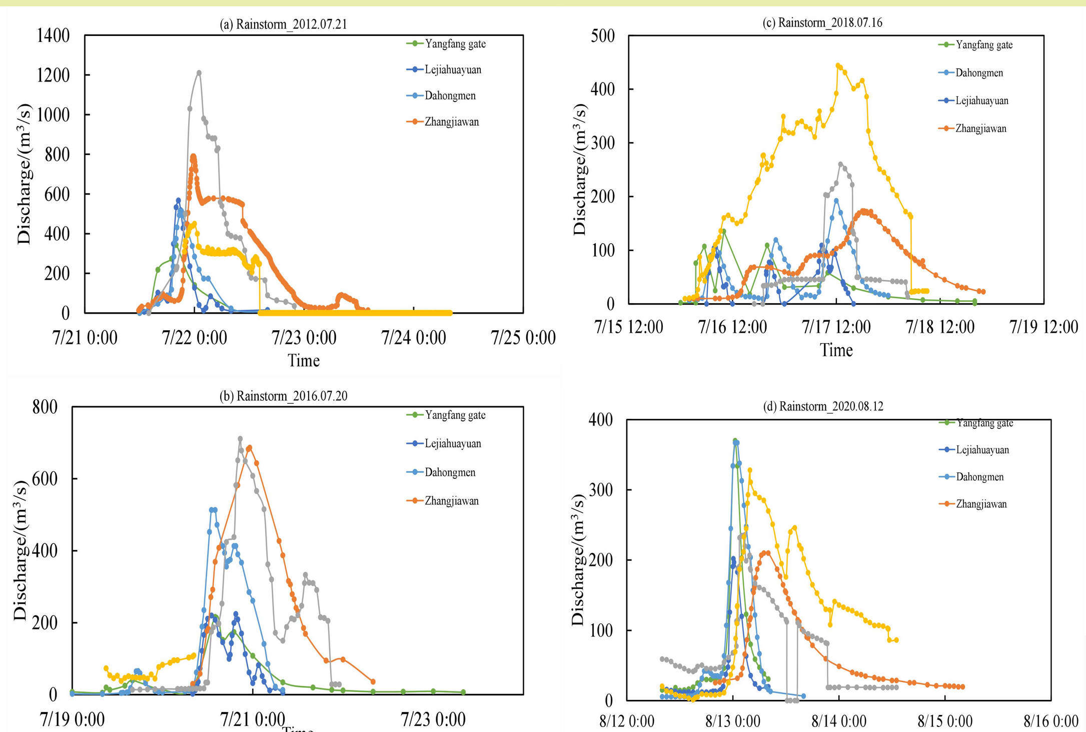

Fig.2 Observed hydrographs of hydrological stations in the NCB during 4 typical raintorms.

Rainstorm Characteristics

- Rainstorm “2012.7.21” and “2020.8.12” were both characterized by **short duration** and **high rainfall intensity**. The rainfall centroid moved back and forth between north and south, causing significant damage.
- Rainstorm “2016.7.20” and “2018.7.16” **lasted longer with larger total rainfall** but **lower intensity**, moving along a similar path.

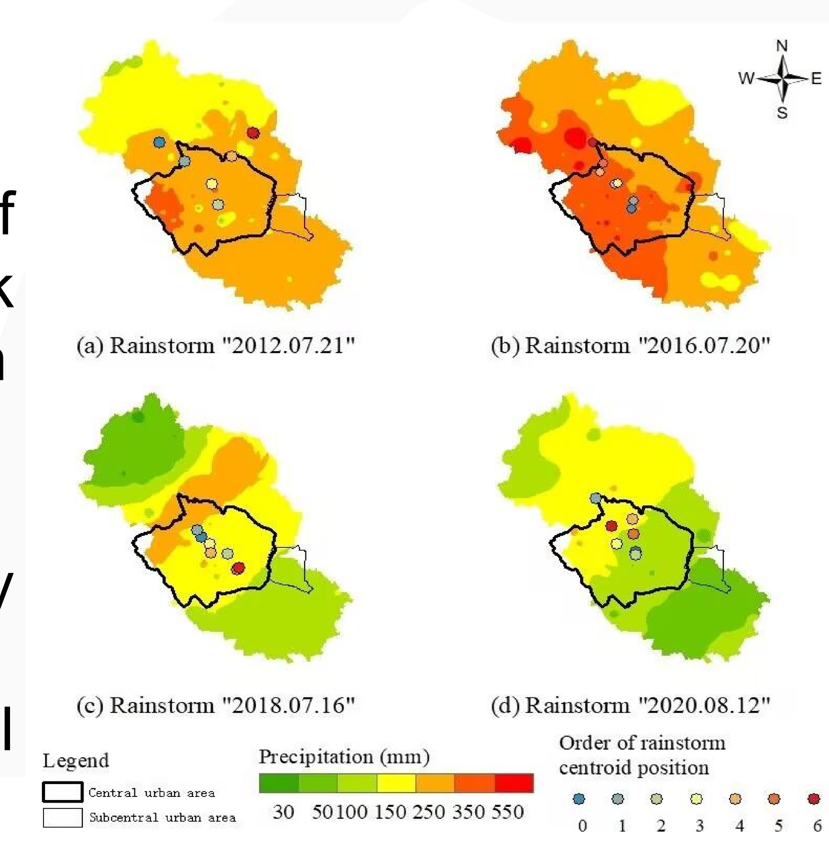

Fig.1 Rainfall distribution and centroid of the four typical rainstorms in the NCRB.

Flood Characteristics

- Significant positive correlation: IMP area ratio~runoff coefficient (**R^2=0.852**)/ IMP area ratio~flood peak modulus (**R^2=0.900**)/Urban area flood peak~Maximum 1h rainfall intensity(**Avg. R^2=0.925**).

Waterlogging Characteristics

- Waterlogging zone and Rainstorm area are highly overlapping.
- Positively correlated: waterlogging depth~rainfall intensity (**TH. 30mm/h**).

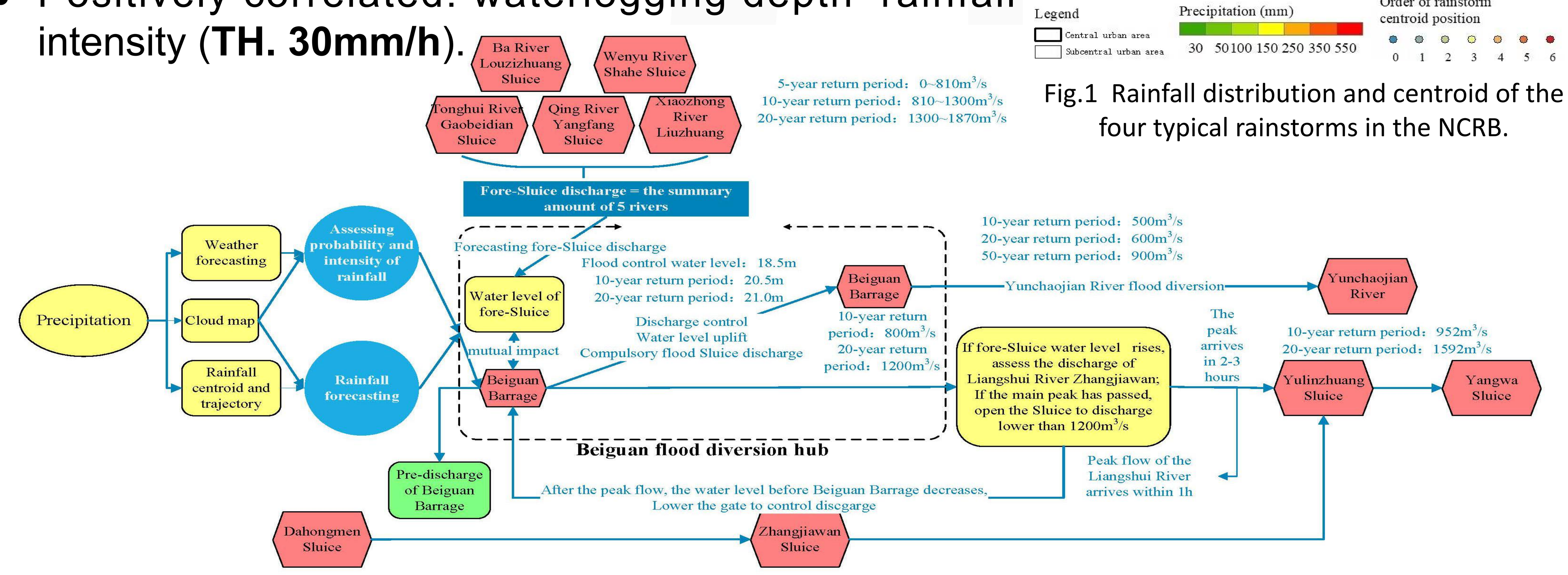

Fig.3 The North Canal dispatch event logic graph.

Discussion

- Highly **impermeable surfaces** in urban area considerably raises the runoff coefficient and peak flow modulus, along with **higher flood risk**.
- Urban flood rises sharply, while model running with finer resolution costs more time. **Timely decision-making** is required for flood control.

Conclusions

☐ To avoid overlapping flood hazards and ensure the safety of the downstream citiy cluster, attention should be paid to **flood peak staggered regulation**.
☐ **Real-time monitoring capabilities** of sub-basins in the Beiguan Hub should be strengthened to improve the flood control effectiveness.

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