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The study of early-warning and forecast of rainfall-runoff process real-time matching based on data mining

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Objectives

Flood forecasting in the urban area of Beijing is challenging due to the fast flood confluence and the delayed rainfall peak. By mining historical rainfall-runoff data and establishing rainfall-runoff correlations, real-time rainfall-runoff matching early warning forecasts can be achieved, which has significant practical implications for guiding the emergency management of urban flood control and drainage. Currently, most hydrological series similarity studies focus on annual, monthly, or daily scales, which meet the needs of conventional reservoir control and water resources management. However, flood control and emergency management require real-time correction of hydrological series similarity to deduce the most probable flood development and provide a basis and time for emergency decision-making.

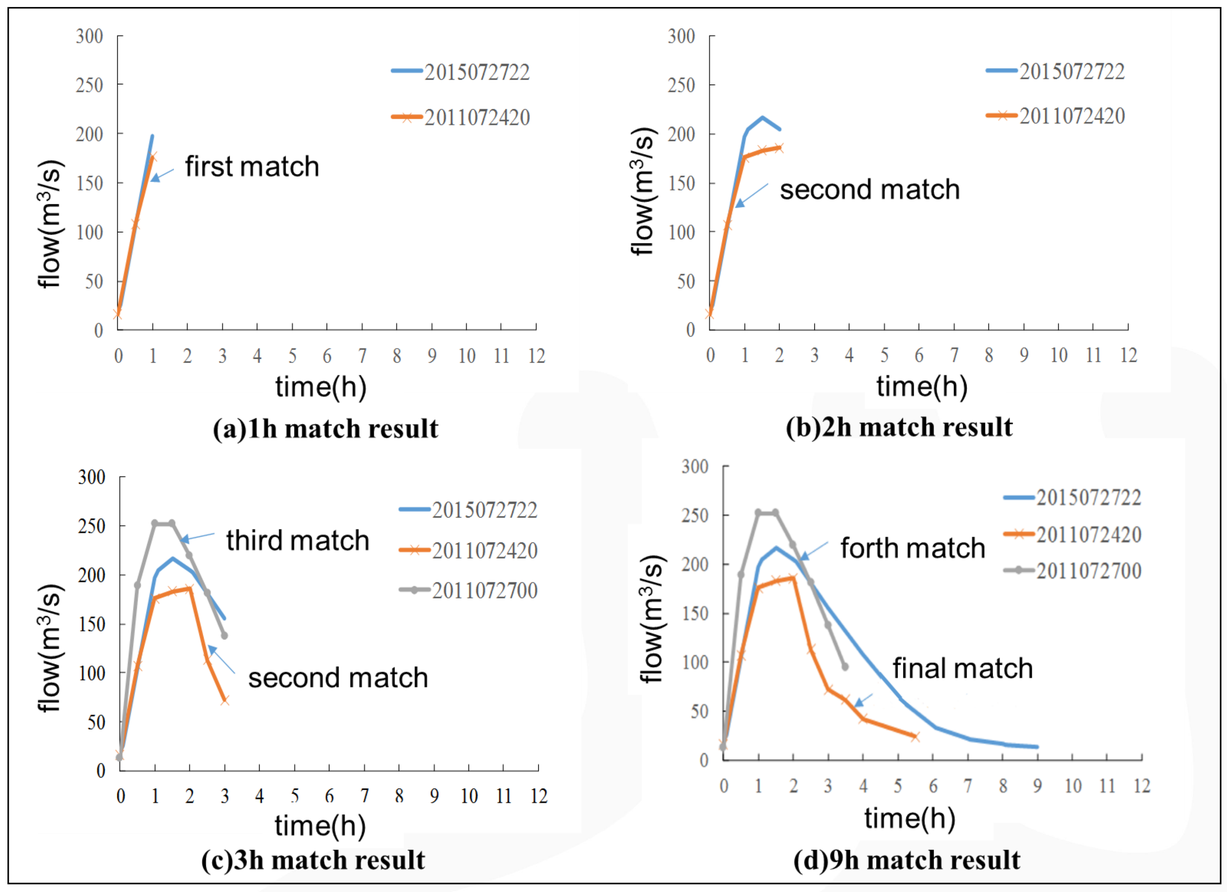

Figure1 Floods are matched hour by hour

Methods

In this study, we deeply mine rainfall-runoff data and construct a rainfall-runoff matching analysis method that combines feature similarity algorithms and the DTW (Dynamic Time Warping) algorithm. We selected the basin above Dahongmen of the Liangshui River in Beijing as the study area and used a total of 621 rainfall event data (hourly) and 63 flood data (5 min) from 2004 to 2020 to construct a sample database of rainfall-runoff similarity indices. The database includes 16 rainfall-runoff characteristics in the development stage of rainfall occurrence, the rainfall process, and the flood process. We chose the rainfall on July 27, 2015, at the Dahongmen station for time-by-time matching analysis. Firstly, we pre-matched the entire rainfall process using the feature similarity algorithm, and then matched the time-by-time process using DTW algorithm.

Conclusions

This study proposes a data mining-based rainfall-runoff matching analysis method that thoughtfully utilizes abundant historical hydrological data to achieve advanced warning and rapid forecasting, effectively extends the hydrological forecast period, compensates for the shortcomings of traditional hydrological forecasting methods, and provides a more innovative and efficient method for basin hydrological forecasting.

Results

We selected the basin above Dahongmen of the Liangshui River in Beijing as the study area and used a total of 621 rainfall event data (hourly) and 63 flood data (5 min) from 2004 to 2020 to construct a sample database of rainfall-runoff similarity indices. The database includes 16 rainfall-runoff characteristics in the development stage of rainfall occurrence, the rainfall process, and the flood process. We chose the rainfall on July 27, 2015, at the Dahongmen station for time-by-time matching analysis. Firstly, we pre-matched the entire rainfall process using the feature similarity algorithm, and then matched the time-by-time process using DTW algorithm. The historical storm floods on July 24, 2011, and July 27, 2011, were obtained as the closest to the target storm flood process, with a peak flow error within 20%, meeting the accuracy requirements. When actual rainfall floods occur, we extract the characteristic values of the actual rainfall runoff, learn the characteristics of typical storm flood fields in the sample database, analyze the storm flood process closest to the current rainfall and flood situation, quickly forecast the rising trend of floods, and realize real-time flood forecasting based on the dynamic extension of the historical flood process.