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Predicting flood event class using a novel class membership function and hydrological modeling

Yongyong Zhang[a], Yongqiang Zhang[a], Xiaoyan Zhai[b]

[a] Key Laboratory of Water Cycle and Related Land Surface Processes, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing, 100101, China.
[b] China Institute of Water Resources and Hydropower Research, Beijing, 100038, China.
Email: zhangyy003@igsnrr.ac.cn

Abstract: Flood prediction in term of different event classes is helpful to investigate comprehensive patterns and causal mechanisms from massive flood events, and provide detailed dynamics of flood regime for flood early warning and emergency plan development. Existing flood predictions mainly focused on magnitude or timing metrics, but ignored other regime metrics (e.g., frequency, duration and variability) and the class variations. Our study proposed a prediction scheme of flood event class based on the class membership functions of flood regime metrics with hydrological modelling, which were cross-validated using 1446 flood events in 68 headstream catchments with different hydrometeorological and underlying surface conditions across China.

Results showed that: 5 statistically significant classes were identified, i.e., the high, moderate or small spiky flood events with single peak and short durations (Classes 1, 2 and 4: 24.0%, 21.2% and 25.9% of total events, respectively), the high or moderate dumpy flood events with long durations and multiple peaks (Class 3, 13.5%) or single peak (Class 5, 15.4%). The class membership functions of flood regime metrics were determined by their frequency distributions, and showed persuasive performance with class hit rates of 72.4% for all the events, and 63.1%, 71.2% and 69.9% for the spiky classes, 83.6% and 83.0% for the dumpy classes, respectively. The prediction performance of flood events and their classes were promising using the five-fold cross-validation of hydrological modelling at both event and class scales. At the event scale, the comprehensive criteria of flood event prediction aggregated by mean absolute relative error, correlation coefficient and efficiency coefficient were robust for 70.1% of total events, particularly in Classes 1 (77.2%), 2 (74.1%) and 3 (70.5%). The average class hit rates were 65.6%±0.3% for all the events, 53.1%±1.7%, 63.8%±1.1% and 65.0%±1.2% for the three spiky classes, 75.4%±0.9% and 79.6%±1.3% for the two dumpy classes, respectively. At the class scale, the prediction performance of both flood events and classes were improved considerably. The comprehensive criteria of flood event prediction increased 9.7% for all the events, 8.0~12.4% in Classes 1~5, and the most considerable improvement was the efficiency coefficient with the ranges of 20.5~38.5%. The class hit rates were 68.3%±0.4% for all the events, 56.8%±0.9%, 69.5%±0.9% and 65.8%±0.6% for the three spiky classes, 75.4%±1.1%, and 82.5%±1.2% for the two dumpy classes, respectively. The hit rates increased most considerably for Class 1, followed by Classes 2, 5, 4 and 3, or in the Songliao, followed by Yangtze, Pearl, Southeast, Yellow, Southeast and Huaihe River Basins for individual basins. Therefore, hydrological model with different calibrated parameters could be more robust to predict the flood events and their classes due to the distinct hydrological mechanisms among different classes. This study proved that the flood prediction scheme by classes was more effective and informative and provided deep insights into comprehensive variation patterns of flood events for flood control management.

REFERENCES

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