Comparison of flash flood early-warning indicators considering soil moisture variability

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Objectives

Flash flood disaster induced by heavy rainfall with short duration is regarded as one of the most devastating natural hazards in China (Fig. 1), which are characterized by sudden onset, fast rising and declining processes, and pose great challenges for flash flood disaster prevention and control. The accurate determination of flash flood early-warning indicators (EWIs), which are commonly classified as rainfall and water discharge indicators, is of great significance for flash flood forecasting and warning. The main objective of this study is to compare the accuracy and lead times of commonly adopted EWIs in China, which is expected to provide insights into operational flash flood early-warning.

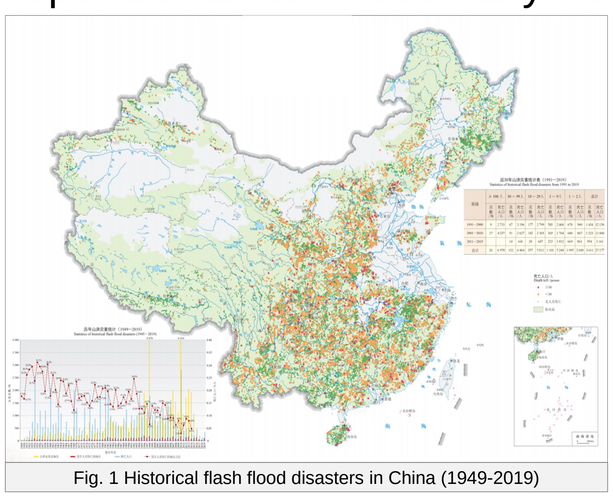

Fig. 1 Historical flash flood disasters in China (1949-2019)

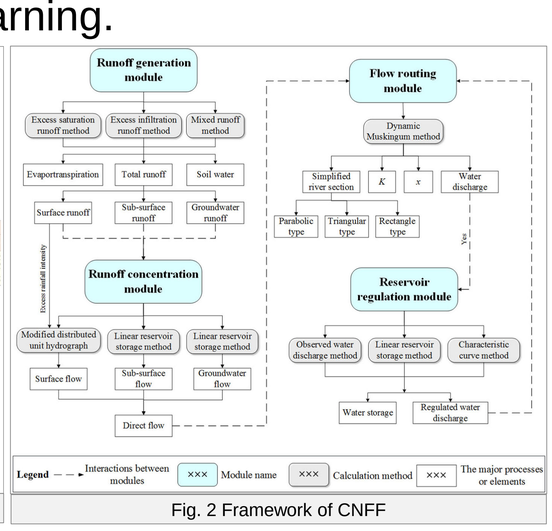

Fig. 2 Framework of CNFF

Study area

- The flash flood event on June 21, 2022 in Jianger village Guangdong province with upstream drainage area of 214 km^2 is selected for case study. By investigation, the inundation water depth was about 0.8 m (Fig. 3).
- The observed maximum 3-h rainfall depth is 125 mm at Pingdong station with a return period>20 year (Fig. 4 and Fig. 5). Soil moisture is almost saturated at 8 o'clock on June 18 (Fig. 6). The critical water stage and discharge of the study area is 103.19 m and 750 m^3/s, respectively.

Fig.3 Field investigation of flash flood disaster

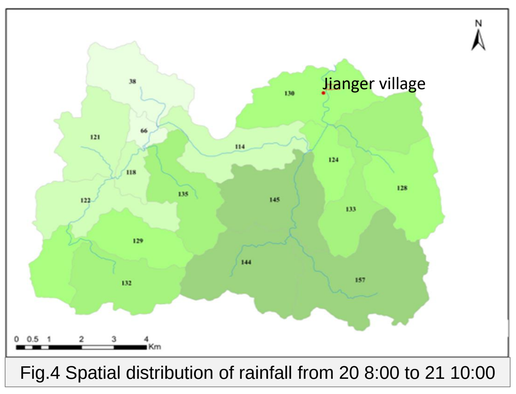

Fig.4 Spatial distribution of rainfall from 20 8:00 to 21 10:00

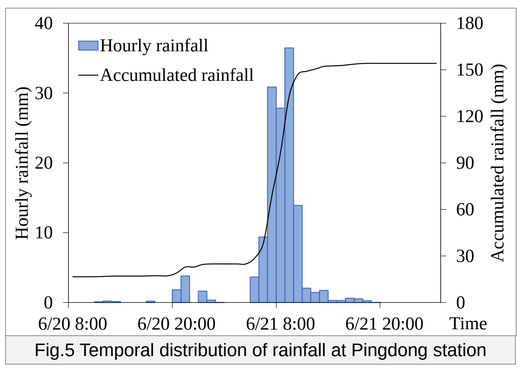

Fig.5 Temporal distribution of rainfall at Pingdong station

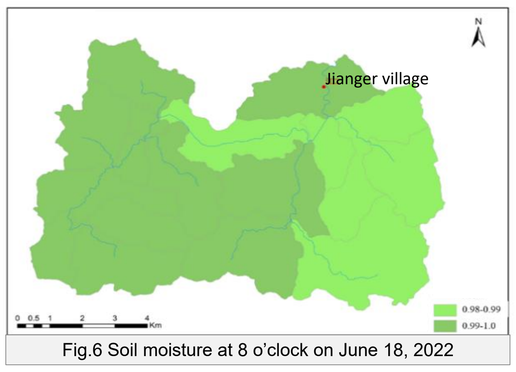

Fig.6 Soil moisture at 8 o'clock on June 18, 2022

Methods

Three widely used methods are adopted for determination of EWIs, including water stage-discharge inversion method (WSI), dynamic rainfall threshold method (DRT), and flood simulation method (FS), and the accuracy and lead time of EWIs are compared in operational flash flood warning. EWIs are calculated based on China Flash Flood hydrological model (CNFF, Fig. 2), which has been implemented for the national flash flood disaster prevention.

Results

- EWIs were determined as 67 mm (time span: 3h), 49~56 mm (time span: 3h), and 450 m^3/s at alert level based on WSI method, DRT method and FS method, respectively, and were 95 mm, 71~80 mm, and 750 m^3/s at alarm level, respectively.
- With the progress of rainfall process, the soil moisture was gradually saturated, the forecasted peak rate based on FS method was updated from 50 m^3/s to 775 m^3/s within four hours, and the rainfall EWIs based on DRT method decreased by 16%~26% compared with those based on WSI method.
- EWIs arrived at alarm warning level based on DRT method and FS method, and arrived at alert level based on WSI method. Meanwhile, the warning lead times were one hour earlier than that of WSI method.

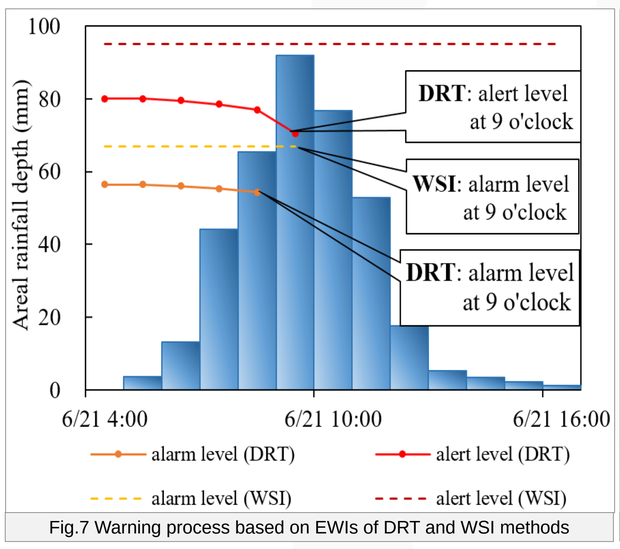

Fig.7 Warning process based on EWIs of DRT and WSI methods

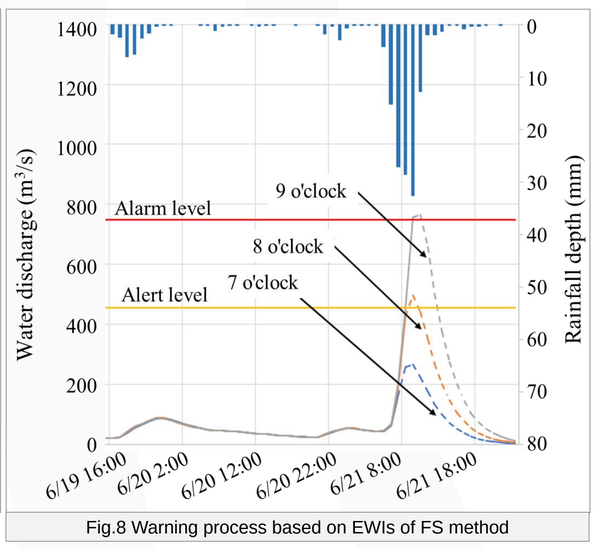

Fig.8 Warning process based on EWIs of FS method

Conclusions

This study compared three EWIs commonly used in China. WSI method initially sets up the antecedent soil moisture and design storm pattern, DRT method takes soil moisture variability into consideration, and FS method further considers the spatio-temporal heterogeneity of rainfall process. The warning performances are consistent for DRT method and FS method, both of which are better than WSI method. These two methods should be promoted in operational flash flood warning.

Acknowledgments

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