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Impact of rainfall spatial variability on Flash Flood Forecasting

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According to the United States National Hazard Statistics database, flooding and flash flooding have caused the largest number of deaths of any weather-related phenomenon over the last 30 years (Flash Flood Guidance Improvement Team, 2003). Like the storms that cause them, flash floods are very variable and non-linear phenomena in time and space, with the result that understanding and anticipating flash flood genesis is far from straightforward. In the U.S., the Flash Flood Guidance (FFG) estimates the average number of inches of rainfall for given durations required to produce flash flooding in the indicated county.
In Europe, flash flood often occurred on small catchments (approximately 100 km2) and it has been shown that the spatial variability of rainfall has a great impact on the catchment response (Le Lay and Saulnier, 2007). Therefore, in this study, based on the Flash flood Guidance method, rainfall spatial variability information is introduced in the threshold estimation. As for FFG, the threshold is the number of millimeters of rainfall required to produce a discharge higher than the discharge corresponding to the first level (yellow) warning of the French flood warning service (SCHAPI: Service Central d'Hydrométéorologie et d'Appui à la Prévision des Inondations). The indexes $\delta 1$ and $\delta 2$ of Zoccatelli et al. (2010), based on the spatial moments of catchment rainfall, are used to characterize the rainfall spatial distribution. Rainfall spatial variability impacts on warning threshold and on hydrological processes are then studied.
The spatially distributed hydrological model MARINE (Roux et al., 2011), dedicated to flash flood prediction is forced with synthetic rainfall patterns of different spatial distributions. This allows the determination of a warning threshold diagram: knowing the spatial distribution of the rainfall forecast and therefore the 2 indexes $\delta 1$ and $\delta 2$, the threshold value is read on the diagram. A warning threshold diagram is built for each studied catchment.
The proposed methodology is applied on three Mediterranean catchments often submitted to flash floods. The new forecasting method as well as the Flash Flood Guidance method (uniform rainfall threshold) are tested on 25 flash floods events that had occurred on those catchments.
Results show a significant impact of rainfall spatial variability. Indeed, it appears that the uniform rainfall threshold (FFG threshold) always overestimates the observed rainfall threshold. The difference between the FFG threshold and the proposed threshold ranges from 8% to 30%. The proposed methodology allows the calculation of a threshold more representative of the observed one. However, results strongly depend on the related event duration and on the catchment properties. For instance, the impact of the rainfall spatial variability seems to be correlated with the catchment size. According to these results, it seems to be interesting to introduce information on the catchment properties in the threshold calculation.

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