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Flash flood warning based on rainfall depth-duration thresholds and soil moisture conditions: An assessment under European conditions

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The main objective of this study is to evaluate a threshold-based flash flood warning approach, by considering a wide range of climatic and physiographic European conditions, and by focusing on ungauged basins. The system is derived from the Flash Flood Guidance (FFG, hereafter) approach. The FFG is the depth of rain of a given duration, taken as uniform in space and time on a certain basin, necessary to cause minor flooding at the outlet of the considered basin. This rainfall depth, which is computed based on a lumped hydrological model, is compared to either real time-observed or forecasted rainfall of the same duration and on the same basin. If the nowcasted or forecasted rainfall depth is greater than the FFG, then flooding in the basin is considered likely.

The study provides an assessment of this technique based on operational quality data from eleven basins (six nested included in five larger parent basins) located in two European regions: north-eastern Italy and central France. The model used in this study is a semi-distributed conceptual rainfall-runoff model, following the structure of the PDM (Probability Distributed Moisture) model. System performances are evaluated by means of categorical statistics, such as the Critical Success Index (CSI).

The simulation experiments described in this study are designed to understand the potential benefits and limitations of the flash flood warning approach under different

scenarios of data availability for model calibration and use, and to guide further developments. The study explores three major questions: How technique accuracy at ungauged interior points, simulated by using transposed parameters from parent basins, compares with results obtained for parent basins where calibration has been carried out? Which are the technique performances when soil moisture status is transposed from the larger scale parent basins? Which is the decrease in accuracy associated to use of time-constant soil moisture status, compared to results obtained by using estimates of soil moisture status provided by the hydrological model?

Results show that overall CSI is equal to 0.43 for the parent basins, where the hydrological model has been calibrated. CSI reduces to 0.28 for the interior basins, when model parameters are transposed from parent basins, and to 0.21, when both model parameters and soil moisture status is transposed from parent basins. Performance differences between FFG and use of time-constant soil moisture status are very high for the parent basins and decrease with decreasing the system accuracy. The percent difference amounts to 53% for the parent basins, to 25% for interior basins with parameter transposition, and to 19% for interior basins with parameter and soil moisture status transposition.

These results improve our understanding of the applicability and reliability of this technique at various scales and under various scenarios of data availability.