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Flash flood forecasting in ungauged basins: Integrated use of the flash flood guidance method and of model-based runoff thresholds

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This paper investigates the use of the Flash Flood Guidance (FFG) method and a method of model-based threshold runoff computation to improve the accuracy of flash flood forecasts at ungauged locations. The FFG is the minimum depth of rain of a given duration, taken as uniform in space and time on a certain basin, necessary to exceed a peak flow threshold which is representative of potentially hazardous flash floods. This rainfall depth, which is computed based on a hydrological model and accounts for initial soil moisture conditions, 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 methodology proposed in this paper requires running a semi-distributed hydrological model to derive flood frequencies at the outlet of the ungauged basin under consideration, and then to derive the threshold runoff from these model-based discharges. The study examines the potential of this method to account for the hydrological model's uncertainty and for biases originated by lack of model calibration, which is the typical condition in ungauged basins. The study provides an assessment of this technique based on operational quality data from 11 mountainous basins (six nested included in five larger parent basins) located in north-eastern Italy and central France. The model is calibrated on the larger parent basins and the model parameters are transposed to the nested basins to simulate operations in ungauged basins. The FFG method is applied by using the 2-yr discharge as the threshold runoff. The threshold runoff is derived both by using local discharge statistics and the model-based approach advocated here. Examination of the results obtained by this comparison shows that the use of model-based threshold leads to improvements in both gauged and ungauged situations. Overall, the Critical Success Index (CSI) increases by 15% for gauged basins and by 34% for ungauged basins by using the model-based threshold with respect to use of local data. As expected, the increase of CSI is more remarkable for ungauged basins, due to lack of local model calibration and the greater likelihood of occurrence of a simulation bias in model application over these basins. This shows that the method of threshold runoff computation provides an inherent bias correction to reduce systematic errors in model applications to ungauged (and gauged) basins.