

# Evaluating the added value of impact-based models for flash flood detection in the French Mediterranean region

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**Keywords:** impact-based, validation, flash floods

## Abstract:

The World Meteorological Organization strongly encourages the development and use of impact-based early warning systems (IBEWs), along with recent advancements in research, e.g., Merz et al. (2020). As Potter et al. (2021) notes, IBEWs improve public understanding of warnings, enhance interagency communication, and reduce "false alarms". This study aims to quantify the added value of an IBEWS specifically designed for flash flood anticipation by focusing on the detection of impacted sectors.

In France, local flood forecasting services assess flood risk on major rivers, coordinated by the Central Service of Hydrometeorology and Flood Forecasting (SCHAPI), which provides a national risk map with four levels (green, yellow, orange, red) that incorporate both hazard intensity and potential impacts. However, small ungauged rivers are not covered by this service. For municipalities along these rivers, an automated warning system based solely on flood return period exceedance has been implemented.

We extended this hazard-based system to an impact-based approach for  $\approx 20,000$  km of river network in the French Mediterranean area, which is particularly vulnerable to flash floods (Gaume et al., 2016). The model structure aligns with existing European methods (Dottori et al., 2017), using hydrological and hydraulics approaches developed in France (Piotte et al., 2020, Davy et al., 2017). The real added value of this work lies in the quality and diversity of observed impact data sources for evaluating the benefits of impact-based versus hazard-based warnings, as well as in the validation methods employed.

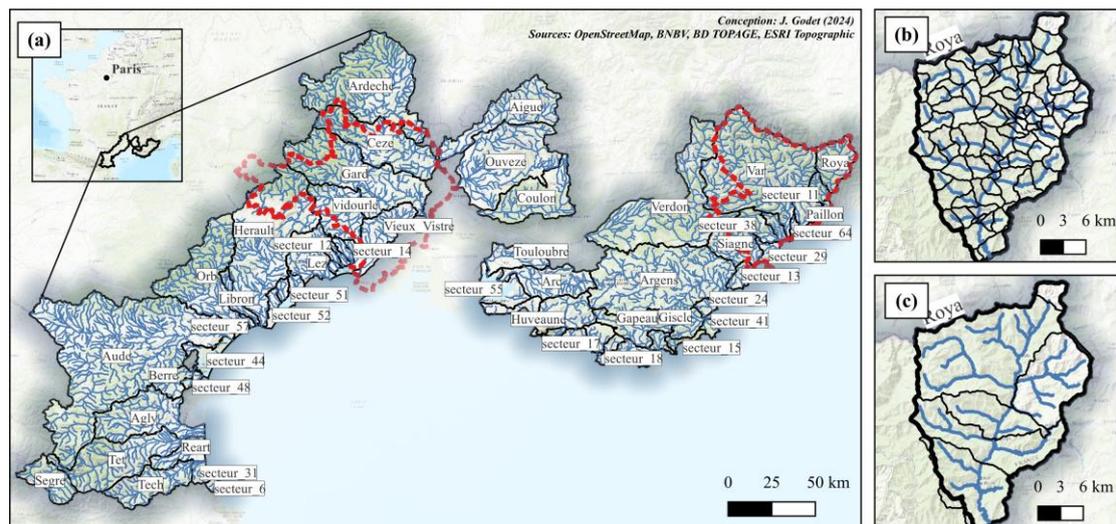


Figure 1. (a) Presentation of the studied river network and of the catchments on which the CatNat decrees and the insurance database were collected. The red dotted lines represent the areas on which the fire service operations records were collected. (b) Illustration of the river reach scale on the Roya catchment. (c) Illustration of the municipality scale on the Roya catchment.

Three data types were used to evaluate the hazard- and impact-based models (see Figure 1): (1) "CatNat" decrees, legislative decrees recognizing a state of natural disaster in municipalities; (2) an insurance database that ranks affected areas

by building damage across numerous flood events; and (3) fire service operation records from two French departments. While each dataset has notable limitations, their complementarity provides an unusually comprehensive assessment. Validation using contingency scores showed that, at the river reach scale ( $\approx 2$  km; see Figure 1b), the impact-based model significantly outperformed the hazard-based model in identifying and prioritizing impact areas, primarily due to a six-fold reduction in false alarms (see Figure 2 for insurance-based validation results). However, this added value decreases at broader scales: at the municipality level (Figure 1c), both models performed similarly, with some reduction in false alarms, though not as pronounced.

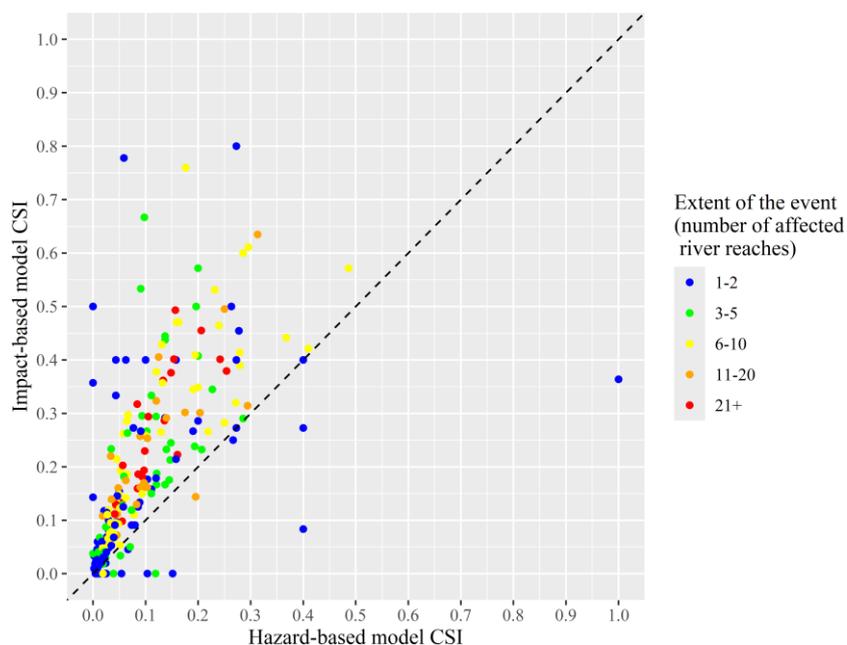


Figure 2. Performance of the models in ranking affected river reaches by the number of impacted buildings. Each point represents the CSI (Critical Success Index) achieved by the impact-based model (y-axis) versus the hazard-based model (x-axis) for a specific flood event on one of the catchments shown in Figure 1. The CSI ranges from 0 to 1, with 1 indicating perfect performance.

### Acknowledgements

The authors would like to thank the French Ministry of the Interior and Overseas for providing the iCatNat database, the fire services of Gard and Alpes Maritimes departments for providing their operation records, and the CCR reinsurance company for sharing their database.

### References

- Davy, P., Croissant, T. and Lague, D., 2017. A perception method to calculate river hydrodynamics, with applications to flood prediction, landscape evolution models, and braiding instabilities. *Journal of Geophysical Research: Earth Surface* 122(8), pp. 1491–1512.
- Dottori, F., Kalas, M., Salamon, P., Bianchi, A., Alfieri, L. and Feyen, L., 2017. An operational procedure for rapid flood risk assessment in Europe. *Natural Hazards and Earth System Sciences* 17(7), pp. 1111–1126.
- Gaume, E., Borga, M., Llasat, M. C., Maouche, S., Lang, M. and Diakakis, M., 2016. Sub-chapter 1.3.4. Mediterranean extreme floods and flash floods. In: J.-P. Moatti and S. Thiébaud (eds), *The Mediterranean region under climate change : A scientific update*, Synthèses, IRD Éditions, Marseille, pp. 133–144.
- Merz, B., Kuhlicke, C., Kunz, M., Pittore, M., Babeyko, A., Bresch, D. N., Domeisen, D. I. V., Feser, F., Koszalka, I., Kreibich, H., Pantillon, F., Parolai, S., Pinto, J. G., Punge, H. J., Rivalta, E., Schröter, K., Strehlow, K., Weisse, R. and Wurpts, A., 2020. Impact Forecasting to Support Emergency Management of Natural Hazards. *Reviews of Geophysics* 58(4), pp. e2020RG000704.
- Piotte, O., Montmerle, T., Fouchier, C., Belleudy, A., Garandeau, L., Janet, B., Jauffret, C., Demargne, J. and Organde, D., 2020. Les évolutions du service d'avertissement sur les pluies intenses et les crues soudaines en France. *La Houille Blanche* (6), pp. 75–84.
- Potter, S., Harrison, S. and Kreft, P., 2021. The Benefits and Challenges of Implementing Impact-Based Severe Weather Warning Systems: Perspectives of Weather, Flood, and Emergency Management Personnel. *Weather, Climate, and Society* 13(2), pp. 303–314.