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Neural network flash flood forecasting : generalizing to ungauged basins

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In the French Mediterranean regions, heavy rainfall episodes frequently occur, leading to flash floods that often cause fatalities and heavy damage. In order to cope with this issue, the public authorities implemented countermeasures in which hydrological forecasting plays an essential role.

In this context, the French Flood Forecasting Service (called SCHAPI for Service Central d'Hydrométéorologie et d'Appui à la Prévision des Inondations) initiated the BVNE (Digital Experimental Basin, for Bassin Versant Numérique Expérimental) project in order to enhance flash flood forecasting. This study is a part of this project and aims at three main purposes: providing flash flood forecasts on well-gauged basins, poorly gauged basins and ungauged basins.

The study area chosen, the Cévennes range, concentrates the major part of these intense hydrometeorological events in France. Regarding the complexity of the rainfall-discharge relation in the focused basins and the difficulty experienced by the physically-based models to provide accurate information in forecast mode, mostly due to the lack of reliable rainfall forecasts, the use of neural networks imposed itself in the research of operational solutions. Indeed, this kind of model is able to provide output forecasts without using any forecast of its inputs.

These models are thus designed and applied to the Cévennes range for event forecasting on well gauged basins (feed-forward model with measured output as a model input), leading to develop a degraded version adapted to poorly gauged basins (recurrent model, without measured output as a model input). The lead times are limited to the response time of the basin and can reach two hours.

The encouraging results obtained led to select a basin representative of the region. The selected basin is the Gardon de Mialet basin (220 square kilometres) which presents a significant quantity of data and shows average characteristics in the region. Its output variables have been normalized as a function of the size of the basin and of the extreme events observed in the Cévennes range. For this elementary basin, a neural network model has been built and trained.

This flexible structure allowed to generalize the model to 15 other basins of the Cévennes range, from four square kilometres to 600 square kilometres, without a new training. The results show the ability of the model to adapt itself to other basins having similar morphological and climate characteristics, as soon as the targeted basin is not too small (above 30 square kilometres) and as soon as the rainfall information is representative. On theses basins, more than 80% of the forecast peak discharge were included in the +/-30% range of the observed peak discharge.

This study shows the relevance of the use of neural networks to provide forecasts for that kind of non-linear systems. Also, the so demonstrated great ability of neural networks to take advantage of parsimonious information to provide a relevant result broadens the research horizons, previously limited by the need of extensive data exclusively on the targeted site.