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Spatial disaggregation of a nationwide flood frequency analysis method

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Small catchments are largely under-represented in gauged catchments samples used to calibrate nationwide flood quantiles estimation methods. For instance, in France, catchments of less than 10 km^2 represent 3% of the gauged catchments but 40% of the sites of interest. Those small basins can generally be found upstream of a gauging station. This size gap should be fulfilled by regionalisation techniques. Those methods aim to transfer information from gauged basins to ungauged ones, but they rarely address the size gap issue. The work presented her aims to question about what happens inside the gauged catchments. Are the model calibrated at gauged catchments scale still valid at a finer one or is it useful to implement some downsizing method?

To address this question we propose several downsizing techniques of the calibrated parameter of the SHYREG method. SHYREG is a flood frequency analysis method providing flood quantiles estimations at a fine spatial resolution throughout the French territory. It is based on the association of a stochastic rainfall generator and an event-based rainfall-runoff conceptual model. The rainfall events are simulated at each cell of a 1 km resolution mesh. Nonetheless, the rainfall-runoff model calibration and regionalisation are traditionally performed in a global way at the catchment scale. SHYREG appears suitable for the presented study because it takes into account the catchment size effect and distributed rainfall information, therefore the calibrated parameter is assumed to represent the sole rainfall-runoff transformation.

The proposed downsizing techniques include a semi-distributed calibration and a cell-based regional calibration of the SHYREG rainfall-runoff model parameter. The impact of this different spatial disaggregation methods are evaluated thanks to a split-sample procedure based on the catchments size, the smallest basins being used for validation. A particular focus is given to some well instrumented nested catchments groups in France.

Results suggest that the downsizing process implies a better discharge consistency between upstream and downstream sites, especially when simulating flows at a fine resolution along a river channel. Then, more realism is introduced in the spatial distribution of the rainfall-runoff model parameter. Finally, the decrease of the number of degree of freedom implied by the downsizing process does not affect the overall quality of the flood quantiles estimations. This last result illustrates the existence of a spatial equifinality in the distribution of model parameters, hence the necessity to control this distribution.