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Impact of precipitation and physical characteristics spatial variabilities on hydrological response at large catchment scale

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The spatial variability of the hydrological response is controlled by the interaction of two spatial variabilities: (i) meteorological forcing and (ii) physical characteristics. This work aims at evaluating their relative impact on streamflow modeling throughout a catchment. To tackle the issue, a spatially distributed rainfall-runoff model, named MORDOR-TS, is used. It is a distributed version of the conceptual rainfall-runoff model currently used at Électricité de France (EDF, French electric utility company) for operational applications.

The analysis is conducted at large catchment scale, on the French Loire catchment at Gien (35 707 km^2) discretised at the maximum into 387 hydrological meshes of about 100km^2. Within this one, 106 streamflow time series are available between 1980 and 2012. According to a spatial split-sample test scheme, the data is split into two similar parts: a calibration and a validation sample of 53 gauges each.

For a model calibrated on the catchment outlet only, the impact of the rainfall pattern is assessed by testing several aggregations of the precipitation field, from uniform to mesh scale. Then, the spatial physical information is added in two steps. Firstly, the valuable information about interior gauges is taken into account by calibrating a uniform set of parameters on the whole calibration sample. Secondly, the parameters are spatialised to represent the physiographic and pedologic spatial variabilities. Dividing the catchment into sub-basins, there could be as many parameter sets calibrated as there are calibration sites.

Regarding the validation sample, the worst performance is provided by a unique lumped model, while the best is given by a set of 53 independent distributed models calibrated on each validation station. The main progress from the worst towards the best case is obtained with the precipitation spatial variability (around 85% of the total progress). Interior gauges and parameters spatialisation bring some additional improvements (about 15% of the total progress).