D. Ganora, E. Gallo, A. Masoero, F. Laio, and P. Claps

Spatially smooth regional flow duration curves estimation in ungauged basins.

High-resolution hydrological regional analysis is a necessary toolkit for exploring residual hydropower potential in areas with already existing hydropower plants, or with other water withdrawals. This means to devise predictions of hydrological indices at many sections along a river reach, in order to build along-stream mapping of the potential as a function of discharge and elevation drop.

Flow duration curves (FDC) are usually adopted for this kind of purposes, as they provide comprehensive representation of water availability. Their determination in ungauged basins is generally made by means of regional statistical analysis of some parameters used to represent the curves in analytical form. The representation adopted here does not constrain the identification of parameters to the assumption of an analytical form of the FDC. What we assume is that the L-moments of the daily runoff distribution can well represent its character so to allow identification of reliable analytical curves through post-regionalization model selection.

More specifically, for each of the around 120 gauging station considered in North-Western Italy the annual average FDC and the daily runoff L-moments, until the third order, were computed, to be used as parameters to regionalize. Considering possible upstream reservoirs and power plants, the L-moments were corrected to account for the effects of the above withdrawals using first-order approximations. Regional analysis is then based on the building of relations between the L-moments of the FDCs to several geomorphoclimatic parameters (more than 100) of the basins upstream the gauging stations. The method used is that of the weighted multiple regressions, where weights are represented by the length of the hydrological records available.

Due to the necessity of obtaining high-resolution spatial estimates, the method has been designed to keep the estimates of mean annual runoff (i.e. L1) congruent in the confluences. This property is obtained considering only raster-summable geomorphoclimatic descriptors, that consistently restricts the number of covariates. The same constraint could not be applied on higher order L-moments, that were available to be correlated to the whole set of usable descriptors: this entails the analysis of a very large number of candidate regression models. We therefore developed a ‘pruning’ procedure, with the aim of preventing the use of weakly-significant descriptors in the regression model selection phase. Pruning is performed using the correlation matrix of the descriptors, where the couples of parameters are first ranked based on the correlation coefficient value. In the couple with the (progressively) highest correlation above a threshold, the descriptor to get rid of is the one that also has the highest global correlation with all the other (remaining) descriptors. An exception to this rule is devised to keep very robust and easily available descriptors (Class 1 parameters) that are allowed to individually be selected as explanatory variables in the regression model alternatives.

Once the regression model for each L-moment is built, the regional FDC can be reconstructed at ungauged sites in a “spatially smooth” fashion, since the L-moments are smoothly varying with the values assumed by the descriptors as one selects new basins moving downstream. GIS raster tools are finally applied to provide maps of hydropower potential according to various hypotheses.