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A stream-scale model to optimize the water allocation for Small Hydropower Plants and the application to traditional systems

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Hydropower plays an important role in supplying worldwide energy demand where it contributes to approximately 16% of global electricity production. Although hydropower, as an emission-free renewable energy, is a reliable source of energy to mitigate climate change, its development will increase river exploitation. The environmental impacts associated with both small hydropower plants (SHP) and traditional dammed systems have been found to the consequence of changing natural flow regime with other release policies, e.g. the minimal flow. Nowadays, in some countries, proportional allocation rules are also applied aiming to mimic the natural flow variability. For example, these dynamic rules are part of the environmental guidance in the United Kingdom and constitute an improvement in comparison to static rules.
In a context in which the full hydropower potential might be reached in a close future, a solution to optimize the water allocation seems essential. In this work, we present a model that enables to simulate a wide range of water allocation rules (static and dynamic) for a specific hydropower plant and to evaluate their associated economic and ecological benefits. It is developed in the form of a graphical user interface (GUI) where, depending on the specific type of hydropower plant (i.e. SHP or traditional dammed system), the user is able to specify the different characteristics (e.g., hydrological data and turbine characteristics) of the studied system. As an alternative to commonly used policies, a new class of dynamic allocation functions (non-proportional repartition rules) is introduced (e.g., Razurel et al., 2016).
The efficiency plot resulting from the simulations shows the environmental indicator and the energy produced for each allocation policies. The optimal water distribution rules can be identified on the Pareto's frontier, which is obtained by stochastic optimization in the case of storage systems (e.g., Niayifar and Perona, submitted) and by direct simulation for small hydropower ones (Razurel et al., 2016). Compared to proportional and constant minimal flows, economic and ecological efficiencies are found to be substantially improved in the case of using non-proportional water allocation rules for both SHP and traditional systems.