Catchment classification based on a measure of the interaction between streamflow and forcing time series: insights on the use of a transfer entropy signature and comparison with benchmark attributes

Mattia Neri¹, Paulin Coulibaly², and Elena Toth¹
¹University of Bologna, Bologna, Italy (mattia.neri5@unibo.it)
²McMaster University, Hamilton, Canada

The identification of the dominant controls for hydrological dynamics in a catchment is fundamental for the transfer of hydrological information. In particular, when the information to be transferred regards the rainfall-runoff transformation processes at fine temporal scale, as for the regionalisation of hydrological models, basin similarity should capture the sequential order and the stochastic nature of the runoff generation and propagation, considering the information content embedded in the entire streamflow hydrograph and also in its forcings.

While previous hydrological research has identified basins with similar meteorological forcings or with similar streamflow time series, a preliminary work (presented at the previous EGU General Assembly 2021, https://doi.org/10.5194/egusphere-egu21-10152) proposed, for the first time, to quantify the interaction between the entire time-series of different forcing data and streamflow observations, to be considered as novel hydrological signature and used as catchment similarity metrics. The study highlighted the potential of transfer entropy which was applied for identifying the dominant hydrological processes occurring in a catchment, measuring the transfer of information from different meteorological forcings over the basin to the corresponding streamflow time series at its outlet. The resulting transfer entropy values were then used as signatures to characterise the catchment responses, and a classification of the basins was obtained assuming that similar values of transfer entropy identify similar basins.

In the present work, the results of an improved version of the approach, applied to a large and densely gauged set of Austrian basins, are thoroughly interpreted against a set of geomorphological and climatic catchment features and a set of typical and consolidated streamflow signatures. Then, the proposed catchment classification is compared to a benchmark clustering approach based on the selected streamflow signatures and the two resulting partitions are analysed in terms of internal consistency and mutual affinity.

The outcomes of the approach are promising and demonstrate the potential of transfer entropy as an additional instrument for assessing hydrological similarity and for quantifying the connection between different governing processes: the method is able to distinguish the
predominant or partial role of snow melt and evapotranspiration in the region, it helps to assess differences in catchment response time and to highlight the role of high orographic precipitation in snow-dominated catchments.

Finally both clusterisations (transfer entropy-based and benchmark signature-based) are coupled to the regionalisation of a rainfall-runoff model across the study region, investigating the potential benefits in terms of model efficiency allowed by the use of the novel similarity metric in comparison to the benchmark approach.