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A complex network based approach coupled with information theory for the optimal design of hydrometric monitoring networks

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Hydrometric monitoring networks have a crucial role in water resources management, flood forecasting and hydrologic modelling. They should be designed to provide as much information as possible and to reduce uncertainty in the ungauged locations. Among the several methods proposed in literature for the optimal design of monitoring networks, the one based on information theory is one of the most common. Recently, new methodologies based on complex network theory have been employed to identify the most and the less influential stations in a monitoring network. Despite complex network theory is dated back in time, its application in hydrology is still under development.

In this work we apply a complex network based approach for the optimal design of hydrometric networks in a small catchment in Italy. The optimal monitoring network is here defined as the one that, among all the potential monitoring networks, allows a better modelling both in terms of simulated discharges and rainfall field. In our approach, the catchment area is divided in homogeneous sub-regions using the Louvain method for community detection, which is a clustering technique typical of complex network theory. For each simulation, one point for each sub-region is selected randomly to be a potential monitoring station.

The goodness of each set of potential monitoring stations in terms of simulated flow rates is evaluated with the Nash Sutcliffe Efficiency (NSE) of a distributed rainfall-runoff model estimating discharge. The error in the estimation of the rainfall field is evaluated comparing the real rainfall field with the one interpolated from the records collected by the selected points.

The optimal set of points are those that provide the maximum NSE and the minimum error estimation for the precipitation field. For each set of monitoring points the joint entropy (JH) and the total correlation (C) were also computed in order to compare the results with information theory metrics. From our preliminary results, although no clear relationship between NSE and joint entropy was found, it was observed that high NSE values are associated with high C values regardless the quantization value adopted, which opens opportunities to include information theory concepts in the construction of complex networks for hydrometric network design.