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Characterizing the spatial correlation of streamflows

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The spatial variability of streamflow dynamics is the byproduct of complex interactions between heterogeneous climatic, morphological, geological and ecological conditions across the landscape.
The spatial correlation or streamflows represents a synthetic statistical indicator of similarity between flow dynamics at two arbitrary river sites. Streamflow correlation can therefore be used to track changes in flow dynamics along river networks, with implications for studies where spatial patterns of flow regimes are critical.
In this work we develop an analytical model to quantify the seasonal linear correlation between daily streamflow timeseries at the outlet of two arbitrary unregulated catchment. The framework is based on a parsimonious and physically based stochastic description of the main geomorphoclimatic drivers of flow dynamics, ultimately leading to analytical expressions for the flow correlation. Streamflow correlation between two rivers sites results as a function of the main physical drivers characterizing flow dynamics at the relevant sites, namely the frequency and intensity of runoff-generating rainfall, and the catchment recession rates.
The performances of the model are assessed on a set of catchment in the Eastern United States providing satisfactory performances. Different parameter estimation techniques are also developed, including a method which enables the estimate of the streamflow correlation in absence of discharge data.
The role played by the spatial heterogeneities of the hydrological processes considered in the model on the resulting streamflow correlation are analytically assessed and evaluated in the study sites. The analysis shows how seasonal spatial correlation of flow dynamics is mainly controlled by the frequency and intensity of runoff-generating rainfall events, whereas heterogeneous recession rates have a limited influence in the study area. Additionally, the framework accounts for the topological arrangement or river networks, showing how flow correlation is maximized in case of nested catchments.
The method provides new insights to quantify how the spatial variability of hydrological forcings eventually shape flow regimes along river networks, providing a clue for the identification of river reaches characterized by similar flow dynamics.