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A probabilistic approach to quantifying spatial patterns of flow regimes and network-scale connectivity

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The temporal variability of river flow regime is a key feature structuring and controlling fluvial ecological communities and ecosystem processes. In particular, streamflow variability induced by climate/landscape heterogeneities or other anthropogenic factors significantly affects the connectivity between streams with notable implication for river fragmentation. Hydrologic connectivity is a fundamental property that guarantees species persistence and ecosystem integrity in riverine systems. In riverine landscapes, most ecological transitions are flow-dependent and the structure of flow regimes may affect ecological functions of endemic biota (i.e. fish spawning or grazing of invertebrate species). Therefore, minimum flow thresholds must be guaranteed to support specific ecosystem services, like fish migration, aquatic biodiversity and habitat suitability. In this contribution, we present a probabilistic approach aiming at a spatially-explicit, quantitative assessment of hydrologic connectivity at the network-scale as derived from river flow variability. Dynamics of daily streamflows are estimated based on catchment-scale climatic and morphological features, integrating a stochastic, physically based approach that accounts for the stochasticity of rainfall with a water balance model and a geomorphic recession flow model. The non-exceedance probability of ecologically meaningful flow thresholds is used to evaluate the fragmentation of individual stream reaches, and the ensuing network-scale connectivity metrics. A multi-dimensional Poisson Process for the stochastic generation of rainfall is used to evaluate the impact of climate signature on reach-scale and catchment-scale connectivity. The analysis shows that streamflow patterns and network-scale connectivity are influenced by the topology of the river network and the spatial variability of climatic properties (rainfall, evapotranspiration). The framework offers a robust basis for the prediction of the impact of land-use/land-cover changes and river regulation on network-scale connectivity.