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Space-time modeling of a rainfall field ; Application to daily rainfall in the Loire basin

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Water resources management for a watershed necessitates to assess both high flow volumes and the impact of the management practice for different stakeholders (hydropower, irrigation, ecology...). To test different management strategies, hydrologists have developed hydrological distributed models incorporating several computational objects such as digital elevation model, sub-basins, and distances to the basin outlet. A good characterization of rainfall variability in space and time is crucial for the relevance of a hydrological model as a basis for the choice of water management strategy.
Climatological references of rainfall hazard must be built from observation over decades. Daily rainfall measurements from raingauge networks are therefore still an invaluable source of information for a precise representation of precipitation hazard despite the recent availability of radar estimates.
Based on either raingauge or radar observations, it is possible to mathematically model rainfall field as a space-time intermittent process (superposition of inner variability field and rainfall indicator field, both influenced by advection). Geostatistics enables to investigate the link between an instantaneous process space-time structure and the evolution of spatial structure with time aggregation.. A method is proposed to infer a relevant instantaneous process from observed rainfall statistics. After fitting the parameters of the instantaneous space-time variogram with the simplex method, spatial variograms for different duration respecting time aggregated variograms is calculated.
With this basis, an avenue is open to simulate homogeneous rainfall fields which respect major statistical characteristics for hydrologists: expectation and variance of rainfall distribution and spatial variogram for different durations.
Benefits and limits of this approach are investigated using daily rainfall data from the Loire basin in France. Two sub-regions are highlighted. A downstream zone where a quite homogeneous rainfall process can be modeled by the space-time model, and an upstream zone where interaction with orography is more present and the homogeneity assumption questionable. Statistical characteristics of rainfall vary also according to the season and to the atmospheric circulation pattern. An easy way to take into account this variability is the use of a weather type classification as the one presented by Paquet et al (2006). Each day of the precipitation measurement time series is described by one of the eight types. Parameter set of an instantaneous space-time process is estimated for each weather type so that rainfall field might be simulated relative to each weather type.
Suggestions are given to take into account spatial and temporal heterogeneity so that an operational space-time model of daily rainfall on the Loire basin can be achieved.