Interpolation of large precipitation fields with space and space-time stochastic local interaction models

Sofia D. Nerantzaki[1,2,3,4], Dionissios T. Hristopulos[3,4], Simon Michael Papalexiou[5]
[1]Department of Civil, Geological and Environmental Engineering, University of Saskatchewan, Saskatoon, SK, Canada, [2]Global Institute for Water Security, Saskatoon, SK, Canada, [3]School of Electrical and Computer Engineering, Technical University of Crete, Chania, Greece, [4]EURECA-PRO/European University on Responsible Consumption and Production, [5]Department of Civil Engineering, University of Calgary, Calgary, Canada

Precipitation is the main variable used as input in hydrological models and risk assessment studies. Precipitation data of fine spatial scales contribute to a better understanding of the local effects on the hydrologic cycle, urbanization, and agriculture. At fine temporal scales, precipitation is essential for assessing weather patterns and estimating the timing and peak of floods and other hazards. At the same time, we need precipitation data over large areas, in order to better understand the global climate system and manage water resources, floods, droughts, and other climate risks. However, observations at fine spatial scales are difficult to acquire; observational stations are scarce, especially in mountainous regions, and rarely provide complete time series. Observational data at fine temporal scales (e.g., hourly or sub-hourly) are even more limited. Typically, interpolation methods are used to overcome these limitations. However, such methods usually do not take into account the spatial and temporal dependencies of the data; the methods that do are generally computationally intensive and, therefore, not applicable to large-scale datasets. A different approach for obtaining large fields of fine-scale precipitation is the use of simulation models. Precipitation at fine spatiotemporal scales is a complex process characterized by strong dependence, anisotropy, and advection; hence, even simulation models have limits in the size of the random fields that they can generate, due to computational constraints.

In this presentation we use the Complete Stochastic Modeling Solution (CoSMoS) framework to generate random fields (RFs) of precipitation having complex patterns and motion, imitating the movement of rainfall storms. This approach preserves any non-Gaussian marginal distributions and spatiotemporal correlation structure, locally varying anisotropy, and the general advection vector generated by velocity fields with locally varying speed and direction. To increase the sampling density of the generated fields in a fast and effective way, we use the Stochastic Local Interaction (SLI) model. SLI estimates the spatial (Space SLI, S-SLI) and spatiotemporal (Space-Time SLI, ST-SLI) dependence based on energy functions with local interactions that involve near neighbors. The interaction strength and the neighborhood size are defined by means of kernel functions and local bandwidths, allowing the formulation of sparse and explicit precision (inverse covariance) matrices for spatial or spatiotemporal dependence. SLI does not require matrix inversions; this feature implies modest computational requirements and allows the interpolation of large precipitation fields. We apply both S-SLI and ST-SLI to a combination of Gaussian and non-Gaussian, isotropic and anisotropic RFs generated by CoSMoS. We test the accuracy of the SLI models for predicting missing values, and we assess their ability to generate large moving fields of precipitation. The study provides a framework for the generation of large moving precipitation fields which can be used as input to large-scale hydrological models.

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