Integrating physics into stochastic weather generators for extreme rainfall assessment

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Stochastic weather generators provide a powerful framework for producing long synthetic time series of climate variables that are essential for hydrological analysis and design. Their ability to be re-parameterized with climate model outputs makes them particularly attractive for exploring the response of hydrological systems to future climatic conditions and extremes. However, conventional weather generators often struggle to capture the statistical behavior of extremes, limiting their reliability in risk assessment and adaptation planning. To address this, recent developments have focused on embedding physical processes and constraints within stochastic frameworks, thereby enhancing their capacity to reproduce rare, high-impact events. In this talk, I will present two physically-based stochastic models that we have developed: one operating at the event and point scales, and the other continuous in both time and space. I will highlight how these approaches improve the representation of rainfall extremes across different spatial and temporal scales, while also reflecting on the methodological challenges that remain.

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