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Modeling spatial patterns in hydrology: Neglected challenges (Invited)

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In this presentation I will discuss two neglected challenges in modeling spatial patterns in hydrology. First, I will discuss challenges in simulating heterogeneous hydrologic processes. I will argue that in spite of the long history of research on hydrologic scaling, we still have limited understanding on the benefits/pitfalls of alternative approaches to represent the large-scale manifestation of small-scale variability. A particular challenge is modeling situations where multiple processes interact across a myriad of space and time scales. I will argue that the key neglected challenge is process-based model evaluation of hydrologic scaling behavior, and we need more focus on scaling in the next generation of model evaluation efforts. Second, I will discuss the challenge of parameter estimation. I will argue that our progress is limited because most of our parameter estimation strategies rely on process-weak statistical methods (i.e. inverse methods and their associated regionalization/regularization approaches). Such statistical methods focus on using geophysical data to constrain model simulations of short-term hydrologic fluxes (characteristically plagued by problems of compensatory errors), and such statistical methods ignore additional information that could be available by explicitly simulating the longer-term dynamic evolution of soils and vegetation. I will argue that progress on parameter estimation requires us to break out of our statistical deadlock and devote more resources to understand and simulate interactions across time scales. I will argue that the key neglected challenge is to use geophysical data to constrain mechanistic models of landscape evolution (e.g., to estimate spatial variations in the storage and transmission properties of soils), and use these longer-term landscape evolution simulations to constrain short-term simulations of hydrologic fluxes. Finally, I will argue that addressing both of these challenges require advances in our methods to characterize uncertainty and advances in methods for model analysis.