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On spatial complexity of parameters in agro-ecosystem watershed models: confounding or illuminating?

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On spatial complexity of parameters in agro-ecosystem watershed models: confounding or illuminating?

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Abstract: Increased confidence is often sought by adding spatial complexity to watershed models and model parameters; does increasing complexity improve the results or just make us feel better about the modeling effort? The answer to this question can depend upon the dominant biophysical properties of a watershed, knowledge of different types or layers of spatial variability, and the information content of the measured responses. The context for this study comprises a large literature base, particularly in the field of hydrology, some of which will be discussed. A balance of “lumping” and “splitting” is proposed in a conceptual framework, where lumping (spatial uniformity) is the preferred starting point. Splitting, or adding spatial detail, follows a step-wise approach. The challenge is to identify an appropriate level of trade-offs, related to diminishing returns, where the computational and simulation management costs don't outweigh the benefits of improved system responses in the simulated results. These issues are addressed using the AgroEcoSystem-Watershed (Ages-W) model. Ages-W is applied to a field-scale (56 ha) agricultural watershed in semi-arid northeast Colorado, USA, and to a headwater tributary (1,200 ha) of a large water supply in tropical southeastern Brazil. The Colorado site is managed as primarily a wheat-fallow system before being converted to native grasses for soil conservation. The Brazil watershed has mixed land comprised of pastures, forests (native and silviculture), and small-scale cropping systems (e.g., sugarcane, maize, and potatoes). Payments for ecosystem services are drivers for landuse change in both watersheds. Simulation of soil water, overland flow, and streamflow in these watersheds provides comparative studies to address the above questions of model parameter complexity. Results to date fall within the spectrum of confounding to illuminating. Despite rigorous calibration of Ages-W in both watersheds, where runoff and streamflow are estimated fairly well with uniform spatial parameters, certain runoff thresholds and hydrograph characteristics are not emulated well in the model results. Adding spatial parameter complexity improved the results in some cases, but at higher set-up and computational costs. Future work may explore the effects of different surface water infiltration sub-models within AgES-W on soil water and streamflow predictions.

Keywords: Watershed modeling; Parameter complexity; Streamflow; Surface runoff; Landuse.