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Alternative spatial configurations to reflect landscape structure in a hydrological model: SUMMA applications to the Reynolds Creek Watershed and the Columbia River Basin

Bart Nijssen (1), Martyn Clark (2), Naoki Mizukami (2), and Oriana Chegwidden (1)

(1) Civil and Environmental Engineering, University of Washington, Seattle, United States (nijssen@uw.edu), (2) Research Applications Laboratory, National Center for Atmospheric Research, Boulder, United States

Most existing hydrological models use a fixed representation of landscape structure. For example, high-resolution, spatially-distributed models may use grid cells that exchange moisture through the saturated subsurface or may divide the landscape into hydrologic response units that only exchange moisture through surface channels. Alternatively, many regional models represent the landscape through coarse elements that do not model any moisture exchange between these model elements. These spatial organizations are often represented at a low-level in the model code and its data structures, which makes it difficult to evaluate different landscape representations using the same hydrological model. Instead, such experimentation requires the use of multiple, different hydrological models, which in turn complicates the analysis, because differences in model outcomes are no longer constrained by differing spatial representations. This inflexibility in the representation of landscape structure also limits a model's capability for scaling local processes to regional outcomes.

In this study, we used the Structure for Unifying Multiple Modeling Alternatives (SUMMA) to evaluate different model spatial configurations to represent landscape structure and to evaluate scaling behavior. SUMMA can represent the moisture exchange between arbitrarily shaped landscape elements in a number of different ways, while using the same model parameterizations for vertical fluxes. This allows us to isolate the effects of changes in landscape representations on modeled hydrological fluxes and states. We examine the effects of spatial configuration in Reynolds Creek, Idaho, USA, which is a research watershed with gaged areas from 1-20 km^2. We then use the same modeling system to evaluate scaling behavior in simulated hydrological fluxes in the Columbia River Basin, Pacific Northwest, USA. This basin drains more than 500,000 km^2 and includes the Reynolds Creek Watershed.