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Exploring the impacts of topographic representation on large scale hydrologic simulations: a modified algorithm for physically based modeling applications

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Topography is one of the most basic inputs to hydrologic models, providing critical gradients that drive flow and determine the configuration of stream networks. There are a multitude of established approaches for developing hydrologically consistent Digital Elevation Models (DEMs) suitable for modeling. However, existing approaches still have limitations which can be particularly problematic for PDE based simulations. We present a topographic processing tool, PriorityFlow, designed to improve the topographic inputs datasets which are required for physically based hydrologic models. PriorityFlow, combines multiple approaches and includes several key innovations over previous work: (1) a novel approach for incorporating a-priori stream network information with priority flood routing DEM processing, (2) improved slope calculations that incorporate flow directions, (3) options for incorporating slopes perpendicular to the primary flow direction, (4) more flexible options for defining subbasins and enforcing slopes along stream reaches. Here we document the approach and explore the impact of topographic processing choices on hydrologic simulations for an integrated hydrologic model spanning the continental US. Results demonstrate that the modified priority flood algorithm can better reproduce observed stream networks across spatial scales without relying on traditional stream burning approaches. Additionally, we demonstrate the impact of slope processing options on runoff timing and magnitude. Specifically, we highlight the sensitivity of the hydrograph to slope processing choices along stream reaches for a variety of hydrologic settings.