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Towards quantifying fuzzy stream power

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Deterministic flow direction algorithms such as the D8 have wide application in numerical models of landscape evolution. These simple algorithms play a central role in quantifying drainage basin area, and hence approximating—via empirically derived relationships from regional flood frequency and hydraulic geometry—stream power or fluvial erosion potential. Here we explore how alternative algorithms that employ a probabilistic choice of flow direction affect quantitative estimates of stream power. We test a probabilistic multi-flow direction algorithm within the MATLAB TopoToolbox in model and real landscapes of low topographic relief and minute gradients, where potentially fuzzy drainage divides are dictated by, among others, alluvial fan dynamics, playa infill, and groundwater fluxes and seepage. We employ a simplistic numerical landscape evolution model that simulates fluvial incision and hillslope diffusion and explicitly models the existence and capture of endorheic basins that prevail in (semi-)arid, low-relief landscapes. We discuss how using this probabilistic multi-flow direction algorithm helps represent and quantify uncertainty about spatio-temporal drainage divide locations and how this bears on quantitative estimates of downstream stream power and fluvial erosion potential as well as their temporal dynamics.