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The Early Stages of Groundwater-fed River Bifurcation

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Recent work shows, both theoretically and empirically, that river networks fed by subsurface flow bifurcate on average at an angle of $2\pi/5$ (Devauchelle et al. 2012). However, the network's existence within a complex natural framework obscures the emergence of this pattern. Fortunately, this ambiguity betrays the presence of processes that have had some effect on the channels during the network's long history. In particular, we concern ourselves with the signature of the third dimension | the topographic relief | on the early stages of channel bifurcation. While, on average, channels grow in a direction dictated by the shape of the groundwater table, we hypothesize that the valley relief plays a crucial role in determining the opening angle and its relaxation to $2\pi/5$ in this regime. A network-wide averaging of several thousand channel bifurcations driven by subsurface flow on the Florida panhandle reveals that rivers on average branch initially at an angle wider than $2\pi/5$, yet quickly relax to $2\pi/5$ after a few meters. We hypothesize that this initial wide growth direction is governed by the shape of the topography. As these channels form independent valleys, the Laplacian field exerts its dominance, yielding a persistent $2\pi/5$ branching angle. Our results therefore suggest that the path-selection of incipient channels fed by subsurface flow is coupled both to the local topography and the surrounding groundwater field.