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What the geometry of a river network says about its growth OLIVIER DEVAUCHELLE, Institut de Physique du Globe de Paris, YOSSI COHEN, HANSJOERG F. SEYBOLD, ROBERT S. YI, Lorenz Center, Department of Earth Atmospheric, and Planetary Sciences, Massachusetts Institute of Technology, PIOTR SZYMCZAK, Institute of Theoretical Physics, Faculty of Physics, Warsaw University, DANIEL H. ROTHMAN, Lorenz Center, Department of Earth Atmospheric, and Planetary Sciences, Massachusetts Institute of Technology — The growth of a river network is governed by the flow of rainwater towards it. When the streams drain groundwater, this flow conforms to a harmonic field, thus turning the network growth into an analogue of Saffman-Taylor fingering and diffusion-limited aggregation. A theoretical description of this process should specify (i) how fast a river grows, (ii) in which direction and (iii) when it bifurcates. Simple physical reasoning suggests that a river grows along the groundwater flow lines (geodesic growth). In a harmonic field, this hypothesis sets the branching angle of the network to 72°, regardless of the other growth rules. This geometrical property appears unambiguously in nature. Inspired by fracture mechanics, we reformulate the geodesic growth in terms of local symmetry: as it cuts into the landscape, a river maintains a symmetric groundwater flow around its tip. Based on this principle, we reconstruct the history of the network by growing it backwards from its present geometry. We then use this history to infer the network's dynamics.

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