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Streak instability induced by bedload diffusion

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The bed of an alluvial river is made of the sediment it transports. Its shape and size are controlled mostly by bedload transport which, at first order, entrains sediment grains along the flow. Gravity also pulls the moving grains towards the center of the channel, thus eroding the banks continually (Parker 1978).

However, laboratory observations show that, due to the bed roughness, the trajectory of a transported grain fluctuates in the transverse direction (Seizilles et al. 2014). The bedload layer is therefore a collection of random walkers which diffuse towards the less active areas of the bed. In a river at equilibrium, bedload diffusion counteracts gravity to maintain the banks.

If an initially flat bed of sediment is perturbed with longitudinal streaks, the flow-induced shear stress is weaker where the flow is shallower. Therefore, we expect bedload diffusion to induce a flux of sediment towards the crests of the perturbation. This positive feedback induces an instability which can generate new channels. We suggest that this mechanism could explain the transition from a single-thread river to a braided one.