Radial river

Martin Chaigne*[1], Olivier Devauchelle[1], and Éric Lajeunesse[1]

[1]Institut de Physique du Globe de Paris (IPG Paris) – Université Paris Cité, CNRS – 1 rue Jussieu, 75005 Paris, France

Résumé

Alluvial rivers shape their channels by exchanging sediment with their bed. Increasing sediment discharge typically widens the channel (Popovic2021). Yet, above a critical threshold, laboratory rivers destabilise into several intertwined channels - the experimental analogue of a braided river. The physical mechanism controlling the number of channels and their dynamics, however, remains poorly understood.
To investigate this transition, we design a radial experimental setup consisting of a vertical cylinder filled with grains. A mixture of water, glycerol, and sediment injected at the centre forms a thin laminar film that spreads outward while exchanging grains with the underlying granular bed. Although initially axisymmetric, the flow rapidly destabilises into one or several channels where sediment transport concentrates. The number of channels increases with sediment discharge.

To rationalise these observations, we model the evolution of two channels sharing fixed fluid flow rate and sediment discharge. Mass balance leads to a two-dimensional dynamical system with a subcritical pitchfork bifurcation. The model predicts that a stable symmetric two-channel state exists only above a critical sediment discharge, in quantitative agreement with experiments.
Despite the simplicity of our laminar experiment, we believe that these results represent a first step toward a better understanding of natural braided rivers.

*Intervenant