ID de Contribution: **86**

Type: **Talk**

Growth of a drainage network in the lab

vendredi 23 mai 2025 10:45 (15 minutes)

In most environments, rainfall infiltrates into the porous ground, and forms a body of groundwater which flows into the neighbouring river network. The groundwater discharge is particularly strong near river heads where it triggers seepage erosion, causing existing channels to grow headward. Occasionally, this process initiates the development of new river branches, leading to the formation of a ramified network. Because seepage erosion is slow, drainage networks take hundreds to thousands of years to build. Therefore, observing their evolution in the field is difficult if not impossible. To bypass this issue, we build a laboratory experiment that allows us to replicate the formation of a drainage network over a few days. The experimental set-up consists of a square box of side 1.5 meter and height 30 cm. We fill the box with a 10 cm layer of cohesionless plastic grains (size 0.8 mm). The layer of grains forms an erodible aquifer. We inject water into the aquifer from below, at a rate controlled by a water tower. Groundwater homogeneously fills the aquifer, and flows towards the outlet of the set-up, positioned along one side of the box. If the discharge is large enough, the flow erodes the aquifer, and entrains sediments out of the system. This process initiates the growth of a drainage network. With time and increasing discharge, the network grows until it covers the entire experiment. Using a simple 2D model to solve the Poisson equation, we compute the shape of the groundwater table as the network changes. The numerical solution, validated by piezometric measurements, reveals the interplay between channel head growth and groundwater flow. Our laboratory experiment thus demonstrates that seepage erosion alone is sufficient to generate a branching network, offering a unique opportunity to observe the formation and evolution of river networks within a confined drainage area.

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Classification de Session: Flows of Change: Climate, Water, and Surface Processes

Classification de thématique: Methods: Experimentation