Pebbles that disrupt landscapes

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Credit: EPFL Alain Herzog

Transported by water or wind, sediments have a significant impact on the environment, and we cannot really quantify the magnitude of these events. A doctoral student at EPFL has proposed a new mathematical approach to these random phenomena.

Pebble by pebble, stone by stone, from the mountains to the sea, bed load sediment transforms the environment and has a substantial impact, especially on bridges. It is threatening the waterways of Venice, and so much sand has rested in the bay of Mont Saint-Michel that it could lose its island status. Switzerland is also faced with damage caused by bed load sediment. Each year, water carries millions of tons of rock from mountains to valleys, and we cannot actually anticipate their quantity and behavior. It is around precisely this question that Joris Heyman based his thesis. He became interested in the role of flow fluctuations in the

process of local sediment transport.

"We can predict the states of an electron around an atom but are unable to correctly predict how a riverbed will behave," exclaimed Christophe Ancey who heads the Laboratory of Environmental Hydraulics (LHE). Thus far, the models used have been based on averaged equations whose veracity is debatable. This method was applied to sediment transport without raising the question of the validity of such a hypothesis.

Joris Heyman therefore wants to integrate extreme fluctuations into numerical modeling of sediment transport and not simply settle for a model based on the averages. Experimental observations were also included in the research. For this, Heyman used a 2.5 meter channel filled with gravel through which he created a stream of water. He installed two high-speed cameras to track and reconstruct the trajectories of solid particles. "I wanted to return to the most basic problems in particle transport, to calculate their position and their interactions. And finally I wanted to see if the lab results translate on a slightly larger scale and what impact these changes have on the environment."

The canton of Valais is particularly affected by bed load sediment, with several rivers posing problems since the phenomenon has intensified with global climate change. Filtering dams that prevent mud flows have been constructed to stop bed load from overflowing and reaching people's homes. The canton also has local dumps to receive the gravel and rocks carried by the waves. For decades, these repositories have been emptied once every 10 years, and now it's required three times a year, which means a huge expense of energy. "In Boden, in the Bernese Oberland, the situation is so acute that one hesitates between two alternatives: construct a dyke that costs 7 million without knowing whether it will hold, or evacuate people," adds Christophe Ancey.

Joris Heyman showed that it was important to include fluctuations in the calculations. "It's necessary to be careful when modeling sediment transport, because if fluctuations are as large as the river itself, not taking them into account can lead to erroneous results. Unfortunately, that is the case with most existing models."

The stochastic equations developed by the LHE can be applied to additional environments beyond mountain rivers, such as wind transport.

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