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Modeling sediment transport as a spatio-temporal Markov process.

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Despite a century of research about sediment transport by bedload occuring in rivers, its constitutive laws remain largely unknown. The proof being that our ability to predict mid-to-long term transported volumes within reasonable confidence interval is almost null. The intrinsic fluctuating nature of bedload transport may be one of the most important reasons why classical approaches fail.

Microscopic probabilistic framework has the advantage of taking into account these fluctuations at the particle scale, to understand their effect on the macroscopic variables such as sediment flux. In this framework, bedload transport is seen as the random motion of particles (sand, gravel, pebbles...) over a two-dimensional surface (the river bed). The number of particles in motion, as well as their velocities, are random variables.

In this talk, we show how a simple birth-death Markov model governing particle motion on a regular lattice accurately reproduces the spatio-temporal correlations observed at the macroscopic level. Entrainment, deposition and transport of particles by the turbulent fluid (air or water) are supposed to be independent and memoryless processes that modify the number of particles in motion. By means of the Poisson representation, we obtained a Fokker-Planck equation that is exactly equivalent to the master equation and thus valid for all cell sizes. The analysis shows that the number of moving particles evolves locally far from thermodynamic equilibrium.

Several analytical results are presented and compared to experimental data. The index of dispersion (or variance over mean ratio) is proved to grow from unity at small scales to larger values at larger scales confirming the non Poisonnian behavior of bedload transport. Also, we study the one and two dimensional K-function, which gives the average number of moving particles located in a ball centered at a particle centroid function of the ball's radius.