Master's internship

Discrete element modelling of bedload sediment transport and size segregation

Laboratory : *Irstea*, ETNA (torrent control and snow avalanche research unit), Grenoble
Supervisors: Philippe Frey philippe.frey@irstea.fr - Julien Chauchat julien.chauchat@grenoble-inp.fr
Period : February to June 2017
Profile: Fluid- or GeoMechanics, Physics of granular media, Geophysics, experience in programming
Gratification : about 550 Euros/month

A follow up in a fully funded PhD programme is possible

Bedload transport is characterized by a granular medium sheared by a turbulent fluid flow driven by gravity. By opposition to suspension, bedload is defined as the part of the sediment load in "contact" with the bed (Fig.A), in which the granular interactions are important. This represents typical situations observed in rivers or mountain streams, which are important to predict, for flood prevention or aquatic ecology for example. Despite more than a century of research efforts, our understanding of bedload transport is still limited. Semi-empirical formulas are classically used to estimate the sediment flux associated with bedload transport for a given water discharge or fluid bed shear stress. These approaches can give differences of up to two orders of magnitudes from what is observed in the field. The polydispersity of the grains leads to segregation processes (see Fig.A) in the granular bed which is suspected to be one of the main processes responsible for this inaccuracy.

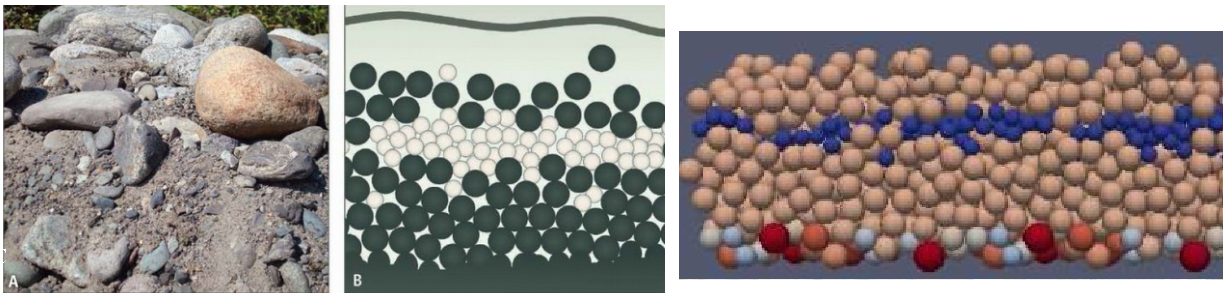

Fig. A : armouring in a mountain river B. two-size experiments (Frey and Church 2009) C. preliminary numerical result (R. Maurin PhD)

Segregation in bedload was studied at Irstea Grenoble mainly experimentally, in a narrow inclined channel* which enabled us to film each particle trajectory with a camera placed at the side of the channel (see example on fig.B). The idea of the experimental setup is to follow each particle independently and analyze the phenomenon from a granular point of view. The numerical approach is based on the discrete element method to describe the particles (open source yade-dem.org), coupled with a Reynolds average description of the turbulent fluid. The code is operational today (collaboration with LEGI, J. Chauchat and 3SR, B. Chareyre) and has been validated with experimental data in the monodisperse case (Maurin *et al.* 2015).

The proposed internship consists in applying the code to bidisperse granular media to study vertical size segregation (example of simulation in Fig. C). The candidate will first have to do a literature review to understand segregation and modelling issues. He/she will have to get familiar with the code testing different configurations and parameter effects. The second part will consist in simulating configurations with two-size samples and to compare with existing experimental results and theories.

Irstea, French Institute in Science and Technology for Environment and Agriculture, is a public research organisation specialising in interdisciplinary research in the field of environmental sciences, natural risks, rural life, agriculture, soil conservation, water quality, vegetation and wildlife. The research laboratory ETNA in Grenoble (Erosion torrentielle, neige, avalanches) addresses experimental, numerical and theoretical modelling of complex geophysical flows such as bedload sediment transport, debris flows and snow avalanches

Frey P, Church M. 2009. How river beds move. *Science* **325**(5947): 1509-1510.
Maurin R, Chauchat J, Chareyre B, Frey P. 2015. A minimal coupled fluid-discrete element model for bedload transport. *Physics of Fluids* **27**(11): 113302.

*http://www.irstea.fr/en/research/research-units/etgr/narrow-flume-tool-studying-steep-slope-bedload-transport.