PhD Offer:
Aeolian transport of cohesive particles : From sand to snow

Funding: Agence National de la Recherche (ANR)
Duration: 3 years from October 1, 2023

Host laboratories:
Institut de Physique de Rennes, UMR CNRS 6251, CNRS, Université de Rennes 1, 35042 Rennes cedex -Laboratoire Thermique et Energie de Nantes, UMR CNRS 6607, 44306 Nantes Cedex

Supervisors:
Pascal Dupont, IPR/INSA Rennes ; Ahmed Ould El Moctar, LTeN Nantes ; Florence Naaim, INRAE, ETNA, Grenoble ; Alexandre Valance, IPR Rennes

Prerequisite: Master in Physics or Mechanics

Contact : ahmed.ouldelmoctar@univ-nantes.fr ; Pascal.Dupont@insa-rennes.fr ; alexandre.valance@univ-rennes1.fr ;

Abstract:
Transport of solid particles under turbulent airflow occurs in many geophysical processes (e.g., aeolian transport of sand or snow). Particle transport actually involves a myriad of physical mechanisms, including particle-particle, bed-particle, and fluid-particle interactions. A complete quantification of these interactions in the context of cohesive particles remains a scientific challenge. While aeolian transport of non-cohesive sand can be considered as one of the simplest two-phase air-particle flows, the transport of wet sand or snow presents a much greater complexity.

The objective of the thesis work is to elucidate the role of cohesion between particles in air-particle flows with the ultimate goal of better describing the complexity of real systems such as wet sand and snow. The originality of the approach is to model the complexity of natural cohesive beds using "model" systems whose cohesion can be adjusted over a wide range of cohesive strength with appropriate liquid or solid bonds. Our strategy will be based both on the realization of controlled wind tunnel experiments with model cohesive systems but also with natural systems such as wet sand and snow.

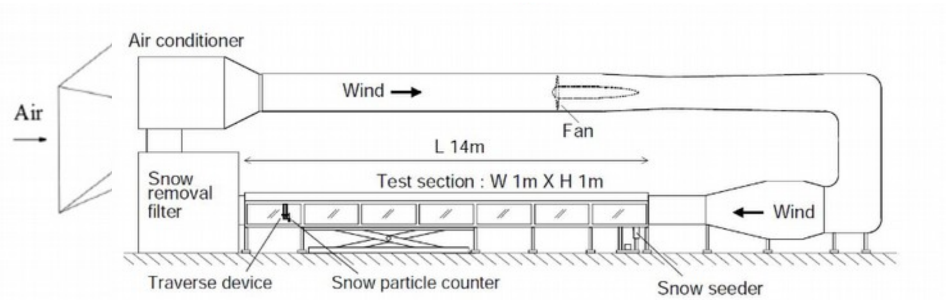

Figure 1: Soufflerie climation au NIED (Shinjo, Japan)

Research program:
The research program will be based on essentially experimental work based on two axes:
i) Elaboration and mechanical characterization of model cohesive beds:
In addition to natural beds (i.e., wet sand bed and snow), we plan to develop model granular beds for use in wind tunnel experiments. These should provide us with cohesive systems over a wide range of cohesive strength and allow us to study the continuum between non-cohesive beds to rigid beds (i.e., infinite cohesion). Their properties will be characterized by conventional soil mechanics tests.
ii) Wind tunnel experiments with natural cohesive models and beds:
Model and natural cohesive media will be used in wind tunnel experiments. We will have at our disposal two wind tunnels: (i) a 6 m ambient wind tunnel in Nantes (LTeN, Nantes) dedicated to transport experiments with model cohesive media and wet sand, ii) a cold wind tunnel at the National Research Institute for Earth Science and Disaster Prevention" (NIED) in Shinjo (Japan) for experiments with snow. An important aspect of the program is the development of new techniques to characterize the transport layer but also the modification of the cohesive properties of the bed over time. In addition to the use of classical imaging techniques (PIV, PTV) and laser Doppler methods, we will develop innovative instrumentation methods for a better characterization of the processes taking place near the bed surface and at the bed surface. inside the bed: micro-PIV, particle counters, capacitive and acoustic methods.

Scientific Context:

The thesis work will be carried out within the framework of a research program funded by the French Research Agency. This project brings together researchers with complementary skills, including physicists from the Institut de Physique de Rennes (IPR), environmental researchers from the "Torrentiel Erosion, Snow and Avalanches" laboratory in Grenoble (ETNA), and experts in the mechanics of fluids from the “Laboratory of Thermal and Energy of Nantes” (LTeN).