Thesis title: *Modelling the interaction between creeping snow and structures in a context of climate change*

Supervisors: S. Lambert (IGE-INRAE), B. Chareyre (3SR, UGA) and T. Faug (IGE-INRAE)

Background of the thesis

Climate change is causing mountainside snowpacks to become wetter and denser. This change in snow characteristics results in a lower stability of snowpacks on slopes, regardless of the altitude and slope orientation. This may also cause higher interaction forces with mitigation structures, as demonstrated by an increasing number of snow rack failures. There is thus a need for improving our knowledge on the interaction between creeping snow and structures.

The ultimate goal of the project to which the proposed thesis relates is to enable the design of more robust snow retention structures. In this aim, the development of a numerical model for the snowpack has been initiated. In parallel, three on-site snow racks have been equipped with multiple sensors to collect data, in particular in view of contributing to the model development and assessment.

The proposed thesis aims at investigating the interaction between creeping snow and structures, based on numerical modeling enriched with real-sites measurements and observations.

Objective of the thesis

The overarching objective of the thesis is to develop a novel, adaptable 3D modeling tool that simulates snow forces acting on structures. This model will account for the different mechanisms at play during the interaction between creeping snow and structures.

The scientific novelty in the proposed approach comes from the coupling between two types of numerical modeling with the aim of capturing the salient characteristics of creeping snow. First, a continuous modeling approach (e.g. MPM or SPH) will be considered in the far field, where the snowpack is not (or weakly) influenced by the presence of the structure. Second, a Discrete Element Method (DEM) approach will be considered to model the snowpack in the vicinity of the structure. This strategy is motivated by the capacity of DEM to account for large strains, load redistribution and compression. In addition, DEM allows accounting for different types of snow and for the interaction with any type of structure (continuous or porous, flexible or rigid). A DEM model of creeping snow is currently being developed.

The main objectives of the proposed PhD position are:

- To develop a new coupled 3D SPH- or MPM-DEM numerical method, that can capture the mechanisms of snow-structure interaction in a computationally-feasible manner;

- To evaluate the model using field data available from sites operated by IGE-INRAE, in partnership with RTM/ONF and NGE-Fondations ;

- To undertake a parametric study to attain a mechanically-based understanding of interactions between (i) dry and (ii) wet creeping snowpacks with structures.

One of the main scientific challenges to be tackled is to develop and evaluate the capabilities of the DEM model to represent the viscous properties of a large range of snow types. To that aim, the contact law and the size and shape of the aggregates being modelled will have to be carefully chosen. Suitable rheological laws for the continuous model, consistent with the mechanical behavior of the DEM-modeled region, will also have to be identified.

The candidate will also be in charge of analyzing and interpreting the data collected on-site. They will be involved in any discussion related to the instrumentation and will join the visits on the instrumented structures.

General information

The successful applicant will be hosted by the laboratory IGE (INRAE building, Grenoble) and will work under the supervision of Dr S. Lambert (IGE), Dr B. Chareyre (UGA, 3SR), Dr T. Faug (IGE) and will benefit from collaborations with Dr G. Chambon (IGE).

- Starting date: Autumn 2024
- Duration: 3 years
- Location: INRAE, 2 rue de la papeterie, 38400 Saint Martin d'hères, France
- Doctoral school : I-MEP2 (Univ. Grenoble Alps)

Qualifications of the applicant

The candidates should hold a Master's degree and/or an Engineering diploma in the fields of applied mathematics or physics, mechanics, civil engineering, or numerical simulation. They must have a solid background in continuum mechanics, computational modelling, and should have a strong interest in scientific programming (Python, C++). Past experiences related to DEM modeling, studies of flow-structure interaction, and/or in coupling different numerical methods, will be an undeniable advantage. The candidate should demonstrate their capabilities to take initiatives, work in a collaborative team, and communicate results with project partners both orally and in writing.

Application

The application must include: a curriculum vitae, copies of certificates for each university degree and grades obtained, a letter describing your motivation and interest in working on the proposed topic, and any letters of recommendation from your teachers and/or supervisors.

The application should preferably be sent by 06/28/2024 to the following contacts:

- Stéphane Lambert, stephane.lambert@inrae.fr
- Bruno Chareyre, bruno.chareyre@univ-grenoble-alpes.fr
- Thierry Faug, thierry.faug@inrae.fr