ETH zürich

Versuchsanstalt für Wasserbau, Hydrologie und Glaziologie

ETH – Master Thesis project 2023

Modeling icequakes at the base of Alpine glaciers

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Scope and motivation

Glacier slip is the primary mechanism governing the migration of ice from land into the oceans, contributing to sea-level rise. Friction (or basal drag) at the bed of a glacier fundamentally limits the speed at which this ice can slide. The frictional properties at the bed are controlled by a number of factors, including bed material, effective normal stresses, and the presence and development of basal hydrological systems. However, basal drag remains poorly understood or constrained by observations.

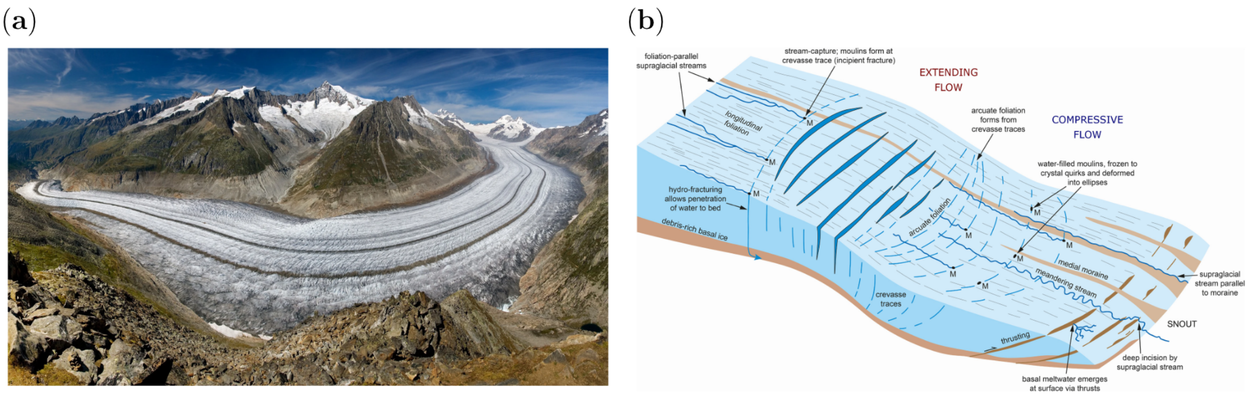

Figure 1: (**a**) Photo of the great Aletsch Glacier, Switzerland. (**b**) Conceptual model of a valley glacier, showing the relationship between structure and drainage. Surface drainage is influenced by foliation, crevasses, and crevasse traces. Routing of water to and from the glacier bed via thrust-faults is also illustrated. Modified after Jennings and Hambrey (2021).

In this master thesis project, we seek a motivated student to investigate both frictional shear stress and slip at the bed of an ice stream. In particular, we aim to characterize the solid-fluid interactions responsible for repetitive stick-slip icequakes at the bed of Alpine Ice Streams, in combination with a rate-and-state friction model. The source properties and repetitive nature of these earthquakes will allow us to calculate temporal and spatial variations in effective normal stress, pore-fluid pressure, ice stream permeability, total frictional shear stress, bed shear modulus, slip and slip-rate following sequences of sticky patches on the bed. This project have potential strong implication implications for ice dynamics models used to inform sea-level rise projections, which typically make theoretical assumptions regarding basal friction at entire system-level scales.

Goals

This thesis aims to target the following tasks:

- Investigate the effect of bi-material (i.e., bed material and ice stream), frictional shear stresses — which are highly dependent on lateral location at the bed — and the hydraulic properties of the ice stream.
- Investigate spatial and temporal variation in friction and slip, and assess whether is caused by bed heterogeneities in combination with the active hydrological system.
- Assess whether friction at the bed of an ice stream can vary by orders of magnitude over durations of hours and distances of 10s metres, and if rate-and-state friction model can describe the first-order ice stream friction behaviour.

We expect a highly-motivated student to be interested in geophysics, glaciology, have some experience in Numerical Modeling (e.g., finite difference method) and in programming software (e.g., MatLab), and be motivated to work in an international and interdisciplinary team.

Questions can be directed to Dr. Luca Dal Zilio (*luca.dalzilio@erdw.ethz.ch*).