PhD Projects - Glacier Fluid Dynamics

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I am broadly interested in low-Reynolds number flows and porous media flows, particularly those inspired by the Cryosphere (ice, permafrost and glaciers). My work describes these glaciological systems using differential equations, constructing minimal models explored through a mix of numerics and pen-and-paper asymptotics. Some of my work is experimental, either using analogue materials in tabletop settings or in collaboration with colleagues in specialised laboratories. Below is a brief description of some projects I am interested in working on.

Pattern formation in water transport through sediment-rich glacier beds

Glaciers in Antarctica and Greenland flow primarily by sliding over wet, slippery sediments. The speed of the glaciers therefore depends strongly on the water pressure at the bed. Water at the bed is transported through connected cavities between the ice and the sediment, and within the gaps between sediment grains. When cavities link up via melt to create large channels, water can drain from the bed more easily leading to the glacier slowing down. A similar efficient drainage system is believed to form when sediment gets eroded away to form deep canals. This project would look at the stability of a model with both melt and erosion, the pattern of channels and canals that forms in this case, aiming to discover what controls the overall permeability of the final drainage network.

Tidally driven seawater intrusions beneath Antarctic glaciers

Warm, salty ocean water drives the melting of ice where glaciers meet the ocean. The denser salt water can propagate as an intruding current into the freshwater system that exists in small pockets beneath otherwise grounded ice, causing melt further inland than models currently account for. Previous work has looked at the pumping of water into this "grounding zone" due to the interaction of tides with the elastic properties of glacial ice, without including the different properties of the salty and fresh waters. This project would add salinity-driven density differences, mixing between the two currents, and heat transfer to understand how tidal processes may enhance glacier melting.

Non-local granular flow of ice-infiltrated sediments and soils

The flow of fast outlet glaciers is controlled by the deformation dynamics of the sediments they sit on top of. These sediments are wet granular materials, deforming at very low shear rates, beyond the usual range of applicability of continuum granular rheologies developed for e.g. underwater avalanches. The water in the top layer of the sediment may also be partially frozen. This project would develop continuum descriptions of the grain-scale ice, water, and sediment dynamics to constrain the relationship between applied stress, water pressure, and glacier speed, for both steady and time-dependent configurations. Such results may also be important for the slumping of Arctic permafrost in warming climates.