Laboratory modelling of ice melting in stratified salt water: impact of a turbulent mean flow and application to the melting of Antarctic ice shelves

Étude expérimentale de la fonte des glaces en environnement salin stratifié : impact d'un écoulement moyen turbulent et application à la fonte des plateformes glaciaires antarctiques

Start date: Fall 2025 – Applications open until the position is filled (or January 31st, 2025)

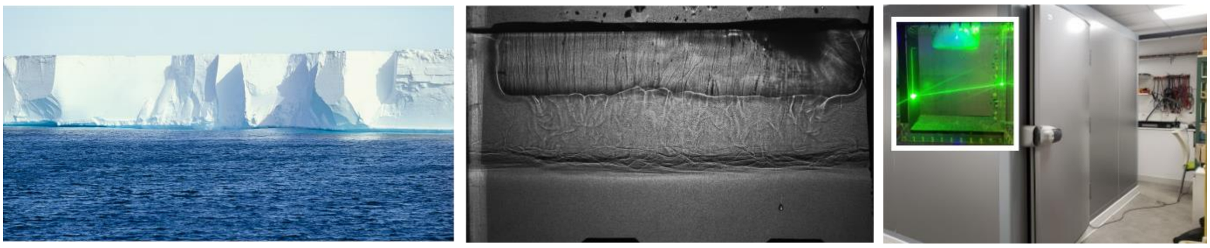

Figure 1: (left) Front of the Ross Ice Shelf, Antarctica, which can loom up to 50 meters above the water surface, (middle) shadowgraph image of ice melting in the lab, and (c) our cold room with (inset) our current setup with a laser sheet for PIV.

Practical Information

- Supervisors: Louis-Alexandre Couston, Romain Volk, Sylvain Joubaud
- Contact: louis.couston@ens-lyon.fr
- Fully-funded position (source: ERC IceAblation, PI: Couston): 3-year PhD (or 2-year postdoc)
- Work Placement : Laboratoire de Physique, ENS de Lyon, Lyon, France
- Relevant Academic Background and Training: Fluid mechanics, Turbulence, Thermodynamics, Physical oceanography, Polar science, Lab work, Statistical analysis
- Spring 2025 internship in our group preferable for prospective PhD candidates

Context and objectives

The future of the Antarctic Ice Sheet is uncertain because the rate at which it loses mass depends on ice-ocean interactions that are difficult to investigate and represent in climate models. Observations over the last few decades have shown that warming ocean currents are driving the retreat of ice shelves—the floating tongues buttressing upstream grounded ice—triggering higher contributions of the Antarctic Ice Sheet to sea level rise (1). Yet, major gaps remain in our understanding of how ice-shelf basal melt responds to variations in ocean conditions – for instance, state-of-the-art parameterizations of ice melting perform poorly in strongly-stratified conditions, a widely encountered situation in the field, and we lack observations of under-ice internal waves to evaluate their contribution to melt rates (2).

This project will utilize laboratory experiments to investigate the dynamics of ice melting in saltwater, which significantly influences oceanic conditions on the continental shelf near Antarctica. A novel meter-size experiment will be constructed to unlock investigations of ice melting in a turbulent mean flow, complementing current experiments on ice melting in a quiescent background (3) by Brivaël Collin (expected PhD end date in spring 2026). The experiments, which will be performed in a 3×3 m^2 cold room, will consider a broad range of mean flow velocities (up to 10 cm/s) and background temperature and salinity conditions (e.g. $-2 < T < 20$ °C ; $0 < S < 100$ g/L), which are to a large extent inaccessible to numerical simulations. Thus, the experiments will chart large and unexplored regions of the parameter space relevant to ice shelf melting (and more), providing invaluable information for a detailed analysis of ice-ocean boundary layers and a critically required update of ice melting parameterizations in climate models.

The successful candidate will receive training in the use of temperature and conductivity sensors, dataloggers, Particle Induced Velocimetry and shadowgraphs, as well as stratified turbulence analysis, phase changes and polar science. They will benefit from stimulating discussions with other group members leveraging machine learning and high-performance simulations to address outstanding questions in polar science (e.g. (4)). The project offers excellent opportunities for travel, laboratory placements with worldwide collaborators and to present findings at international scientific meetings.

How to apply

All applications must be sent via email to louis.couston@ens-lyon.fr and include a short motivation letter (<1 page), CV and under/graduate (L3/M1/M2) transcripts. Do not hesitate to send us an email if you have questions before applying, or to reach out to PhD students in our group (including Brivaël Collin ; brivael.collin@ens-lyon.fr).

Research group

The successful candidate will join the Glacial Ocean and Lake Dynamics group, which currently consists of 4 PhD students and 1 postdoctoral researcher. We combine laboratory experiments, numerical simulations, artificial intelligence and field observations (soon!) to address outstanding questions in physical oceanography, physical limnology (focusing on polar and alpine environments) and geophysical fluid dynamics. We collaborate with several colleagues from the Laboratoire de Physique, who are experts in hydrodynamics/climate research (about 15 PIs) and/or machine learning (about 10 PIs). The Laboratoire de Physique is about 180-member strong and conducts world-leading research on a broad range of topics, including quantum technology, statistical physics, biophysics and climate physics. Roughly 30 new doctoral students and postdoctoral researchers join the Laboratoire de Physique every year.

Fair and inclusive environment.

We know diversity fosters creativity and innovation. We are committed to equality of opportunity, to being fair and inclusive, and to being a place where all belong. We therefore encourage applications from all candidates, including those who are likely to be underrepresented at the Laboratoire de Physique.

References

(1) IPCC “Polar Regions. Special Report on the Ocean and Cryosphere in a Changing Climate.” (2019).

(2) Rosevear, Madelaine G., et al. "How Does the Ocean Melt Antarctic Ice Shelves?." *Annual Review of Marine Science* 17 (2024).

(3) Collin, Brivaël, et al. “Experimental Study of Ocean-Driven Ice-Shelf Melting.” *European Fluid Dynamics Conference 1 abstract* (2024).

(4) Couston, Louis-Alexandre. "Turbulent ice-ocean boundary layers in the well-mixed regime: insights from direct numerical simulations." *Journal of Physical Oceanography* (2024).