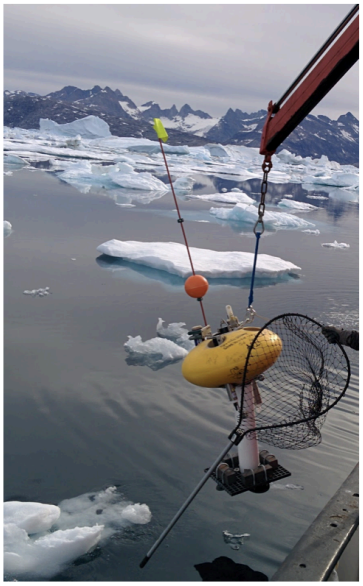
Internal wave breaking and ocean mixing in Greenland fjords

Laboratoire de Physique - École Normale Supérieure de Lyon & CNRS
Supervisors: Irena Vaňková, Sylvain Joubaud
Contact: irena.vankova@ens-lyon.fr, sylvain.joubaud@ens-lyon.fr

A funded PhD project starting in fall 2027 or earlier. The initial part of the proposal should take part as a Master 2 internship, ideally taking place in the spring of 2027.

Project context and background


Mooring recovery at Sermilik Fjord, East Greenland

Mixing across density surfaces (diapycnal mixing) is a key process for setting the structure and the circulation of the world's ocean. In glacier fjords, glacier calving[1], iceberg capsize[2], and landslides[3] can cause large external and internal tsunami waves. Further, the presence of complex boundaries in these fjords may cause wave breaking and local diapycnal mixing events. Previous research has primarily focused on external tsunamis and related coastal hazards[4], and less on internal tsunamis and the related diapycnal mixing, which is primarily due to a greater difficulty in observing and detecting internal waves in field data. However, studies addressing the internal wave mixing in fjords are beginning to emerge[5,6]. The proposed PhD project is inspired by oceanographic observations collected as part of longer term monitoring of a glacier fjord in southeast Greenland[7], and it aims to use numerical simulations and laboratory experiments to explain these data and understand the importance of large internal wave mixing events for fjord stratification, which ultimately controls ocean heat delivery and melting of marine-terminating glaciers. Numerical simulations will build on understanding of wind-driven internal hydraulic jumps in stratified lakes[8] and will investigate different generation mechanisms in the context of glacier fjords. Laboratory experiments will build on previous laboratory work on internal gravity waves to investigate the role of triadic nonlinear interactions in driving mixing[9].

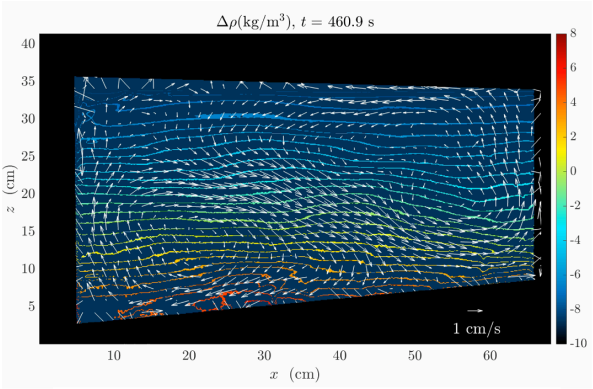
Objectives

The thesis project will focus on the characterization and quantification of diapycnal mixing from the breaking of large internal waves generated in glacier fjords. The project will consist of three parts, each employing a different technique to address this problem: analysis of observations, laboratory experiments, and numerical modeling. The modeling and experimental phases of the project can be conducted in parallel.

In the first part of the project, the candidate will work with existing field data [1] to identify and characterise large internal wave-breaking events. In addition to the oceanographic data collected by collaborators, complementary data sources (e.g., weather stations, seismic data [10], etc) may also be analyzed to identify plausible mechanisms causing large internal waves in the observed glacier fjord. Based on the results from the field data analysis the PhD candidate will design and conduct numerical

simulations and laboratory experiments to study the generation mechanisms of large internal mixing events and to quantify diapycnal mixing caused by such events.

In the second part of the project, the candidate will study internal wave breaking using laboratory experiments. The PhD student will develop the experimental set-up in a quasi-2D tank previously used in [9]. The stratification will be reproduced using salt. Internal wave fields will be visualized using Particle Image Velocimetry (PIV), a well-established experimental technique that provides velocity field data. Post-processing of field measurements with high spatial and temporal resolution will be central. Advantage will be taken of advanced signal processing techniques (Hilbert transform, time-frequency analysis, etc.). Wave breaking and its link with mixing will be quantified using the Light Attenuation Technique (LAT) or Laser-Induced Fluorescence (LIF).



Simultaneous velocity and density measurements.

In the third part of the project, the candidate will design and conduct both idealised and realistic simulations of glacier fjords. The idealised experiments will be used to test the basic hypothesis about realistic generation mechanisms of large internal mixing events and to help scale up the results from laboratory experiments. However, the final goal is to simulate internal mixing events in a realistic glacier fjord, reproduce field observations, and to quantify the impact of the mixing events on fjord stratification. This phase of the project will involve using high performance computing and existing GPU-optimised software (Oceaninigans) designed to simulate oceanic flows.

Supervision and Collaboration

The PhD candidate will work with Irena Vaňková and Sylvain Joubaud. Irena collected, together with collaborators at New York University (primarily David Holland), the field data that form the basis and the motivation for this project. The PhD candidate will work with her on the data-analysis and numerical simulation aspects of the project. Sylvain is an expert on internal waves and laboratory experiments and will guide the PhD candidate through the respective part of the project.

Prerequisites

Background in physics, applied mathematics, computing, or physical sciences is required. Fluency in English is required.

References

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