Machine learning emulation of Antarctic ice-shelf cavities for sea-level projections

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The first part of the proposal can be part of a Master 2 project.

Project background

Sea-level projections are derived using Earth-system models (ESM). The uncertainties in these projections are dominated by uncertainties and poor representation of the interactions between the Antarctic Ice Sheet (AIS) and the ocean[1]. AIS flows from the continent into the ocean, forming floating ice shelves, whose base is melted by ocean heat. At the same time, the change in the ice-shelf geometry, induced by ocean-driven melting affects the rate of ice flow into the ocean, which in turn modifies rates of melting. Accurate representation of these coupled interactions requires a coupled ice-sheet–ocean model – a feature that is missing from most state-of-the-art ESMs. Instead, sea-level projections are typically derived using standalone ice-sheet models, forced by ESM outputs that do not include a coupled ice-sheet model. Although there are several ongoing efforts to include coupled ice-sheet–ocean interactions within ESMs, high resolutions required to resolve ice-shelf cavities make this approach relatively expensive, given the large number of ensemble members needed for projections. This project aims to explore the coupling of the ocean and ice-sheet model components via a machine learning emulator of ice-shelf cavity circulation.

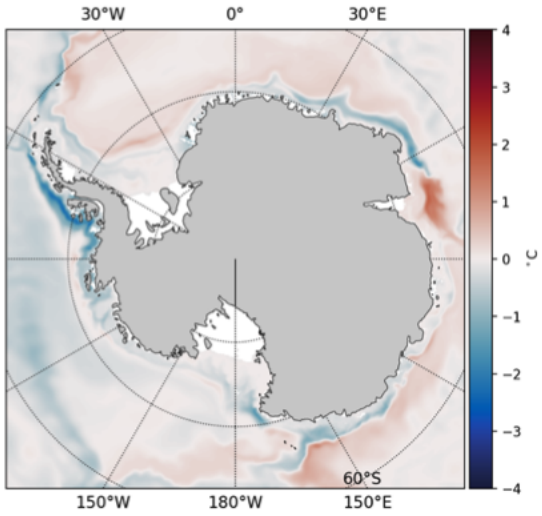


Figure 1. Subsurface temperature change around Antarctica in year 2100, as induced by interactive ice-shelf melting

Objective

While the ultimate goal of the project is to construct an emulator that provides fluxes of mass, heat, and salt exchanged between an ice-sheet model and an ocean model, the first step will involve emulation of ice-shelf cavity circulation from the output of an ocean model that does not include ice-shelf cavities. Building on previous work[2], the candidate will design strategies for constructing a suitable set of synthetic ice-shelf cavities, such that cavities formed by plausible future states of the Antarctic ice-sheet are contained within that data set. A numerical ocean model with static, but thermo-dynamically active ice-shelf cavities will then be used to generate a training dataset for the cavity circulation emulator. The candidate will test different machine learning architectures and design appropriate, physically relevant metrics to assess the emulator performance. They will also investigate the sensitivity of the emulator performance to the availability of input data from standalone ocean model outputs. In the second part of

the project, the emulator will be integrated within a continental-scale ice-sheet model. It will be used to make projections in line with the Ice Sheet Model Intercomparison Project (ISMIP3) and to assess the performance of existing, simplistic parameterizations.

Research group

The successful candidate will join the Climate Physics team at ENS de Lyon (https://climatephysics-ensl.fr/), which currently consists of 5 permanent researchers, 7 PhD students and 2 postdoctoral researchers. We combine laboratory experiments, numerical simulations, artificial intelligence and field observations to address outstanding questions in physical oceanography, atmospheric sciences, physical limnology (focusing on polar and alpine environments) and geophysical fluid dynamics. We collaborate with several colleagues from the Physics Laboratory, who are experts in hydrodynamics/climate research (about 15 PIs) and/or machine learning (about 10 PIs). The Physics Laboratory 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 Laboratory every year.

Prerequisites

Background in physics, applied mathematics, computing, or physical sciences is required.
Previous coding experience and familiarity with high performance computing is an asset.
Fluency in English is required.

How to apply

All application materials listed below should be submitted in English by July 23, 2026 using the CNRS website:
https://emploi.cnrs.fr/Offres/CDD/UMR5672-IREVAN-002/Default.aspx?lang=EN

1) CV + all higher education grade transcripts + names and email contact for 1-2 letter writers compiled as a single pdf
2) A cover letter explaining the interest and qualifications for the position

Do not hesitate to reach out by email (irena.vankova@ens-lyon.fr) if you have any questions about this position, the laboratory (https://www.ens-lyon.fr/PHYSIQUE), or the climate group (https://climatephysics-ensl.fr/) in general.

References

1. Edwards, T. L. *et al.* Projected land ice contributions to twenty-first-century sea level rise. *Nature* **593**, 74–82 (2021).
2. Rosier, S. H. R., Bull, C. Y. S., Woo, W. L. & Gudmundsson, G. H. Predicting ocean-induced ice-shelf melt rates using deep learning. *The Cryosphere* **17**, 499–518 (2023).
3. Seroussi, H. *et al.* ISMIP6 Antarctica: a multi-model ensemble of the Antarctic ice sheet evolution over the 21st century. *The Cryosphere* **14**, 3033–3070 (2020).