

MACHINE LEARNING EMULATORS OF POLAR OCEAN DYNAMICS

Scientific Context and Objectives

Machine learning (ML) emulators are transforming the physical sciences,¹ including polar oceanography.² This postdoctoral project asks: can neural networks emulate ocean dynamics beneath Antarctic ice shelves? Ice shelves, which are floating extensions of the grounded ice sheet tens to hundreds of kilometers long, overlie ocean cavities with currents that are multi-scale, chaotic, and susceptible to tipping points (abrupt regime changes), making them a stringent test for ML emulators. Most Earth System Models (ESMs) ignore or crudely approximate these currents because of their complexity, thereby misrepresenting processes of global significance such as the formation of Antarctic Bottom Water.³ Thus, skillful cavity emulators could substantially improve ESMs and climate projections.

This position is part of the ERC project *IceAblation*, which aims to build ML emulators of cavity dynamics that can be embedded in ESMs, an approach only starting to be explored by the polar ocean community.² Our team has run simulations of polar currents near and within ice-shelf cavities in idealized geometries with the **NEMO** ocean code. These feature multi-scale spatio-temporal variability and regime changes, providing a controlled, high-quality testbed already available for the project. Depending on your background and long-term project, possible research directions include:

- ▶ Physics-constrained training losses and architectures, with or without latent-space compression: how do they affect generalization and uncertainty across ocean regimes (cold vs. warm cavities)?
- ▶ Purpose-built architectures versus pretrained physics foundation models⁴
- ▶ Offline versus online training strategies, and long-rollout stability when coupling the emulator to NEMO through Eophis⁵
- ▶ Transfer from idealized to realistic ice-shelf cavities, using data from collaborating institutes (IGE Grenoble, LOCEAN Paris)

Practical Information

- ▶ **Profile:** We seek candidates with a PhD (completed or about to be defended) in Machine Learning, Computer Science, Applied Mathematics, Physics, Earth System Science or a related field. Prior experience with machine learning is required. No prior knowledge of oceanography is needed.
- ▶ **Scientific Environment:** You will work within the **Climate Physics Group** of the **Laboratoire de Physique** at *ENS de Lyon*, France, under the supervision of **Louis Coustou**. Close interaction with ML experts at the Laboratoire de Physique (e.g. J. Tachella, N. Pustelnik), INRIA's **OCKHAM team** and peers working on similar topics within our team will provide technical guidance and a stimulating environment in ML research. GPU nodes will be available on our **CBPsmn** cluster.
- ▶ **Appointment term:** One-year contract, renewable annually for a total of up to three years (funding secured through the ERC project *IceAblation*), with a competitive salary (net monthly salary before income tax from €2311 to €2938, depending on experience) and a dedicated budget for conferences and travel. The start date is flexible.
- ▶ **Application process:** Interested candidates should email a **single pdf**, titled **LASTNAME-FIRSTNAME-OCEANML26.pdf**, to louis.coustou@ens-lyon.fr. It should concatenate a CV (with publications), contact details of three professional references, and a one-page statement describing how your research experience, interests and future plans match the topic of the position. Review of applications will start on November 2nd, 2026 and continue until the position is filled.

¹Kochkov et al. "Neural general circulation models for weather and climate." *Nature* 632 (2024).

²Ockenden et al. "DeepMelt-GL v1: a neural network emulator..." *Geosci. Model Dev.* 19, 7979 (2026).

³Bennetts et al. "Closing the loops on Southern Ocean dynamics..." *Rev. Geophys.* 62.3 (2024).

⁴Chu et al. "Do Physics Foundation Models Learn Generalizable Physics..." *arXiv:2605.29283* (2026).

⁵Barge et al. "Deploying Machine Learning components ... Eophis (v1.1)." *EGU sphere* 2026 (2026).