ONE Planet
Doctoral Training Partnership

Natural Environment Research Council

Project title: Forecasting and Studying Ocean-induced Ice-Shelf Melt Rates using Machine Learning

Ref: OP2401

Keywords: Machine learning, glaciers and global warming, Antarctica, glaciology, oceanogrpahy

One Planet Research Theme:

Climate & Climate Change ☒ | Earth System Processes ☐ | Anthropocene ☐ | Environmental Informatics ☒

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Key Research Gaps and Questions:

Can machine learning framework be used to accurately simulate complex and large data sets produced by global ocean circulation models?

Can emulators based on machine learning, replace ocean models in coupled ice-sheet/ocean-circulation modelling of the Antarctic Ice Sheet?

What is the performance gain achieved in this way, and will this make fast coupled ice + ocean simulations possible?

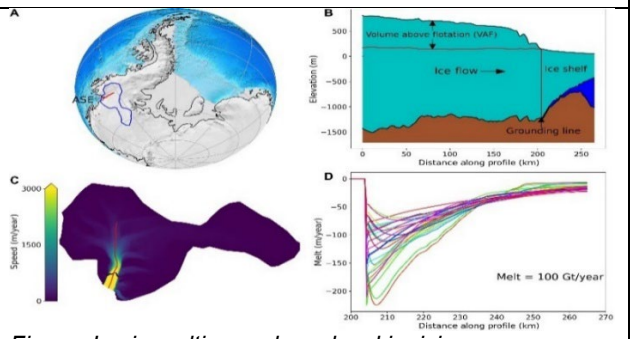

Figure: Ice is melting and sea level is rising

Project Description: The project matches the scopes of ONEPlanet in training researcher and developing new computational tools to better understand and forecast ocean-induced ice-shelf melt rates in Antarctic. Antarctic ice shelves play an important part in regulating future sea level change [1]. Reduction in ice-shelf buttressing caused by increased ocean-induced melt along their undersides is now understood to be one of the key drivers of ice loss from the Antarctic Ice Sheet. However, despite the importance of this forcing mechanism, most ice-sheet simulations currently rely on simple melt-parametrisations of this ocean-driven process since a fully coupled ice-ocean modelling framework is prohibitively computationally expensive [2]. This project aims at developing an alternative approach to capture the greatly improved physical description of this process provided by large-scale ocean-circulation models over currently employed melt-parameterisations, but with considerably less computational expense. **The project will leverage machine learning (ML) [3] technology and physical modelling to develop a new framework that can emulate ocean model predictions of sub-ice shelf melt rates. The study intends to demonstrate that melt rates can be accurately predicted by the ML model for a wide range of complex geometries with several orders of magnitude faster than the ocean model**. Correctly predicting spatial patterns of ice shelf melting, rather than just the magnitude, is crucial because the sensitivity of an ice shelf to thinning will vary across that ice shelf. ML approach is not limited in terms of input fields, any missing information required to properly train the model with new physics could easily be added. Conversely, processes could be removed by reducing the amount of inputs used to train model. Doing this would provide insights into which processes are important for producing realistic melt rates, possibly aiding the development of alternative parameterisations. The proposed project builds on previously **DEFRA**-funded project on flood prediction[4] for "Future Flood Prevention", investigating the latent factor of climate change through measuring variables attributed to snow melt using ML, and **NSF/NERC** funded project on the future of the Antarctic Ice Sheet. The project partners include Environment Agency, Northumberland County Council, Arup, Isle Utilities, and US academic partners at Dartmouth College and MIT. In the project, the researcher will be trained with advanced informatic skills in developing ML methodologies to understand climate change process and explain how/why ML can make better prediction than traditional ocean models. The researcher will attend courses in Python and Machine Learning (i.e., AI Studio KV7004) held in CIS Department. The researcher will also gain knowledge in high-performance computing and visualisation modelling (i.e., Environmental Modelling KE7031).

[1] Ocean-induced melt volume directly paces ice loss from Pine Island Glacier
[2] The predictive power of ice sheet models and the regional sensitivity of ice loss to basal sliding parameterisations: a case study of Pine Island and Thwaites glaciers, West Antarctica
[3] Predicting ocean-induced ice-shelf melt rates using a machine learning image segmentation approach
[4] Flood Prediction and Analysis on the Relevance of Features using Explainable Artificial Intelligence

Prerequisites: Glaciology, ocean-circulation modelling, GIS, machine learning, python programming

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