Imperial College London

Natural Environment Research Council

2023_01_A new generation of ice-sheet fracture models to predict iceberg calving and sea-level rise

Supervisor: Dr Emilio Martinez-Paneda (e.martinez-paneda@imperial.ac.uk)

Department: Civil and Environmental Engineering

(a) Motivation for the project

Sea-level rise due to the melting of Greenland and Antarctic icesheets is one of the many consequences of global warming. However, the processes causing this sea-level rise are poorly understood, and are often based on vast simplifications. One of the major sources of ice loss happens near the terminus of glaciers and icesheets, where ice bergs are created due to fractures penetrating the full thickness of the glacier. To better predict the processes leading to ice loss, a new generation of ice-sheet models is needed. These novel models are based on fracture mechanics to accurately capture the iceberg calving process. This project involves exploring opportunities for coupling these highly detailed but computationally expensive fracture-based models to easy-to-use two-dimensional approximations of ice-sheets. These coupled models allow the opportunity of combining the best parts of both approaches, allowing for a relatively easy-to-use and yet highly accurate approach to glacial modelling. As a result, this project offers the opportunity to use and gain experience with these two different modelling methodologies. Through applying these models to predict glacial changes due to external factors such as temperature, it further allows gaining a wider understanding of the complex interactions leading to sea-level rise.

(b) Context and background

The project directly falls within the Glacial and cryosphere systems remit due to its links with glacial modelling, and is strongly adjacent to the â€œclimate and climate change objective as it explores the interactions between temperature changes, glacial ice loss, and sea level rise.

As the proposed placement involves approaching glacial modelling from several perspectives, they offer the student a good overview the different options related to this topic. Additionally, through performing research within a sizeable research group consisting of PhD and postdoctoral researchers the student will gain experience with the research environment and will have the opportunity to discover whether a postgraduate research degree would be a good option for them to pursue..

(c) Objectives and methodology

The proposed project aims to combine pre-existing codes together: A COMSOL-based finite element code which captures the iceberg calving of icesheets, and the open-source MATLAB-based shallow-ice code UASource (http://ghilmarg.github.io/UaSource/) which can capture glacial-scale geometries. Since both these codes already exist, the student will be able to quickly get started with their research, while still gaining the experience of using these different methodologies. Once coupled together (estimate: 5-6 weeks into the project), the model will allow for studying the interactions between global temperature changes and large-scale glacial motions, and the coupling between these large-scale glacial motion and small-scale fracture propagation and ice-loss. Collecting data through these numerical schemes will thus provide context to the complete chain of processes involving ice-loss.

In addition to the project itself, the student will also partake in bi-weekly research group meetings, in which topics both closely related to this research project and more distant are presented and discussed, providing examples of research being performed within this field and showcasing other applications for the methods used by the student. Students will also have the opportunity to discuss their research results during these meetings and present a seminar-style presentation about the final findings.

Project length: 10 weeks