A Discrete Element Model of Sea Ice Melange

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Objectives

The project attempts to improve understanding of the interaction between sea ice melange and the parent ice sheet in a fjord. Specifically, the force exerted on the ice sheet by the melange can be estimated from the simulation.

Introduction

The calving process, through which pieces of ice break away from ice sheets and become icebergs of various shapes and sizes, is complex and incompletely understood. One interesting case is when calving occurs in a fjord. The pieces of ice that break away form what is called a "melange", essentially a debris field, between the rock faces that form the fjord. This melange exerts force on the ice sheet that should vary through the year due to the temperature changing with the seasons.

Figure 3 shows a satellite view of a portion of the Jacobshavn Glacier in Greenland where it flows through a fjord into the ocean. Note that the ice flow is constrained from two sides and appears somewhat like a river. This portion of the ice is floating and consists of icebergs of various sizes (some as large as 500 meters wide).

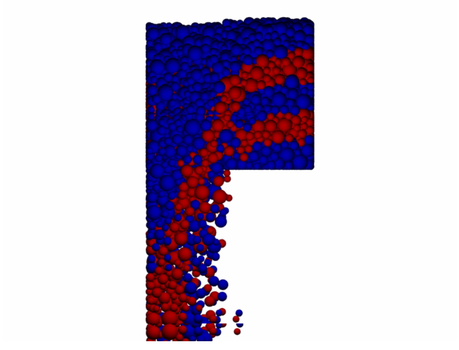

Figure 1: Example DEM simulation

Software

The software being used is a package called ESyS-Particle. This provides a library for building discrete element simulations using the Python programming language. ESyS-Particle itself is written in C++ and takes advantage of multi-core CPUs when necessary. This allows large simulations to be run much more quickly than would be possible otherwise.

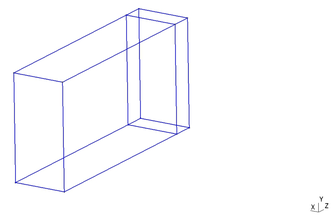

Figure 2: Example fjord mesh

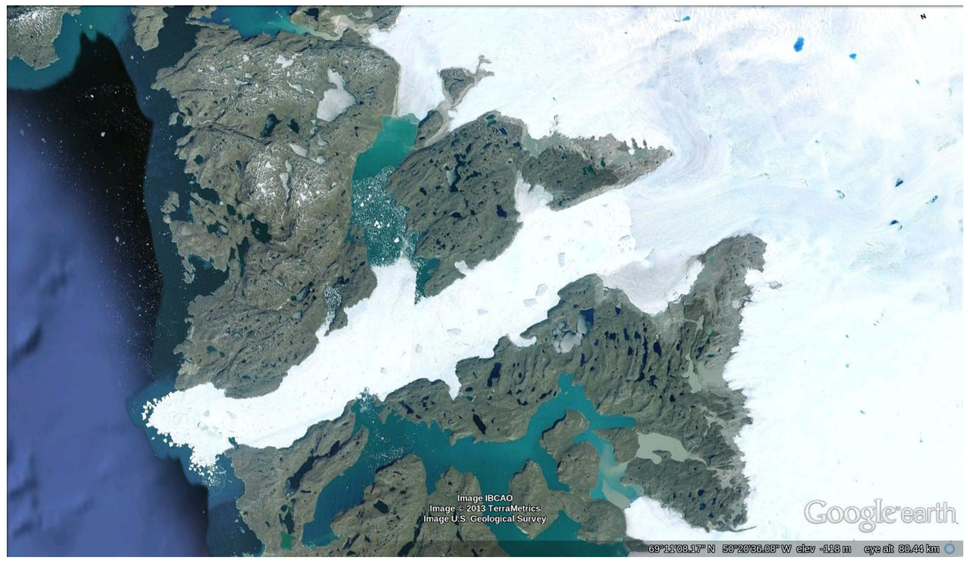

Figure 3: Jacobshavn Glacier in Greenland

Methods

This project relies on a simulation technique known as the Discrete Element Method. Essentially, a large number of discrete particles are used to simulate the behavior of various materials. Forces and bonds are applied to the particles in order to mimic various bulk material properties. For example, a lattice of particles might be used to simulate a chunk of ice and buoyant forces applied to simulate floating.

Figure 1 shows an example of a DEM. In this case, a mesh of particles is being used to simulate a granular material falling through a hopper. The layers have been colored to demonstrate the pattern of movement.

Simulation Design

Particles will be pushed through a mesh structure that simulates a fjord. Forces applied to the ice sheet due to jamming will be measured. An example fjord mesh is shown in Figure 2.

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