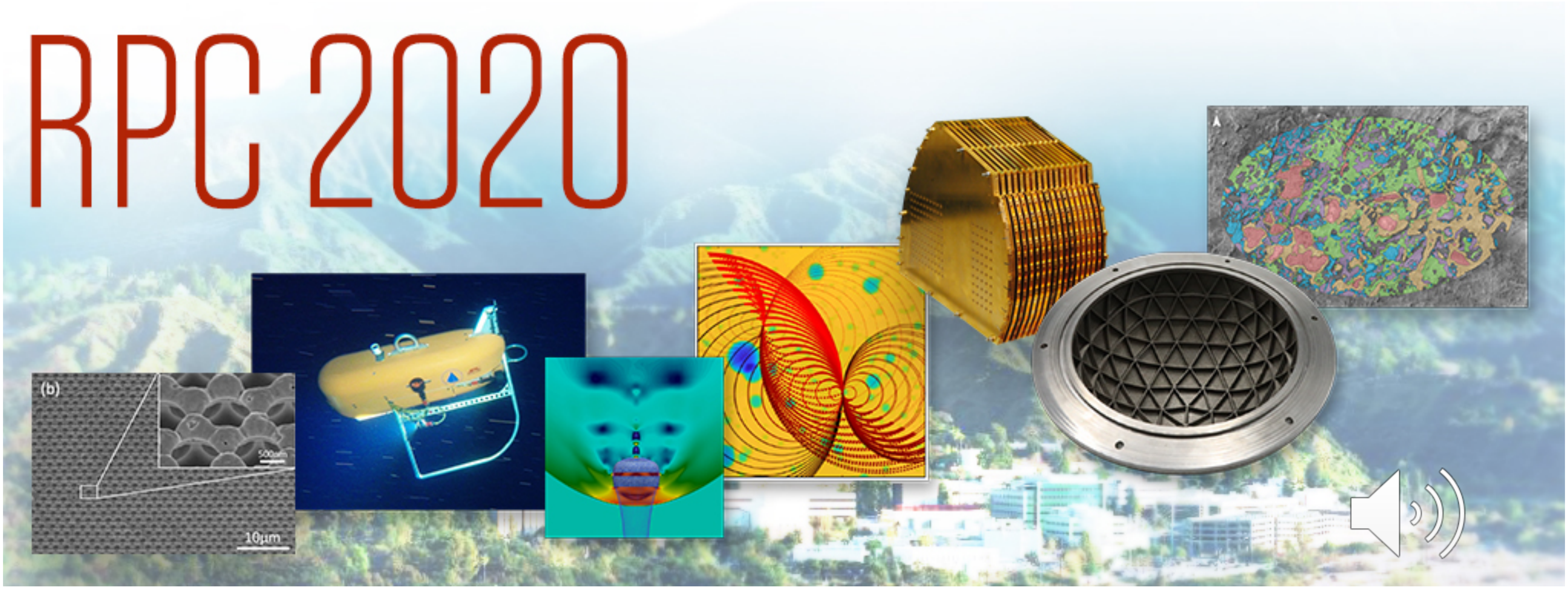

Virtual Research Presentation Conference

Quantifying the role of climate variability in driving the recent acceleration of Earth's fastest glacier

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Program: SURP

Assigned Presentation #RCP-051

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Tutorial Introduction

Abstract

Understanding the causes of recent ice sheet mass loss is critical to improve sea level projections. This project aims to quantify the importance of multi-decadal internal climatic variability in driving the recent evolution of Jakobshavn Isbrae in West Greenland, Earth's fastest glacier. We will estimate the multi-decadal climate variability from different sources and perform large ensemble simulations of the glacier evolution. These ensembles will provide an envelope against which to compare observations of ice loss, and to quantify the mass loss attributed to climate variability. This project will also provide an improved framework for including climate variability in sea level projections.

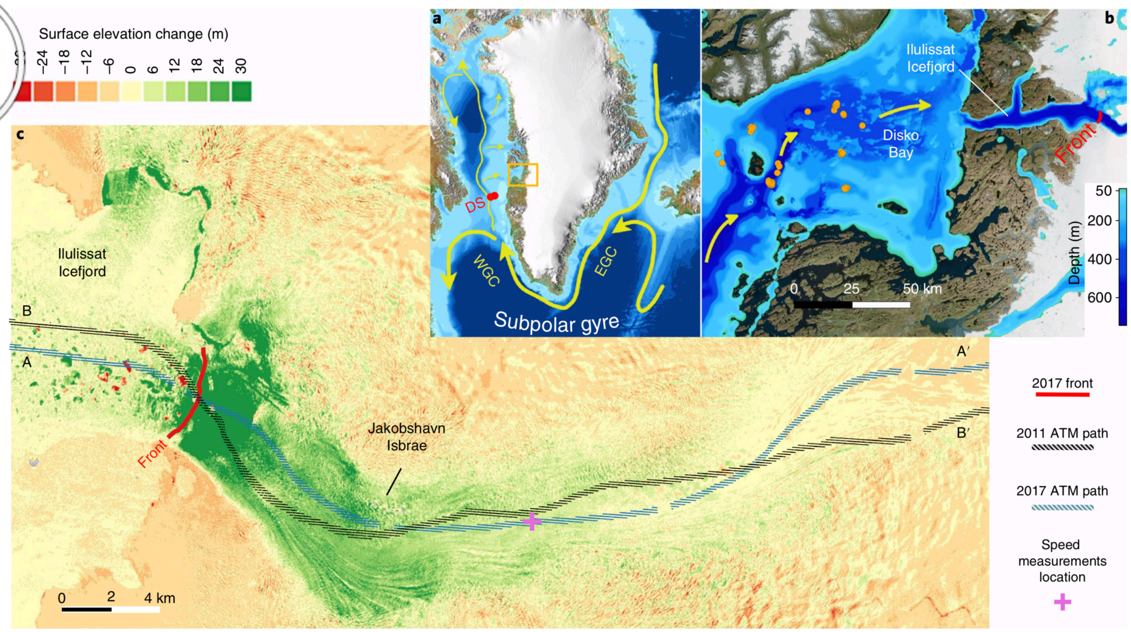


Figure 1: Ice front readvance and ice thickening of Jakobshavn Istrae in West Greenland in 2017 [1]

Problem Description

a) Jakobshavn Isbrae is Earth's fastest glacier and drains a significant fraction of the Greenland Ice Sheet. Its accumulated mass loss has reached more than 1.5 mm sea level.

Jakobshavn Isbrae has slowed and thickened over the 2016-2019 period after 20 years of continued acceleration, which happened as large-scale conditions in the North Atlantic ocean evolved and colder waters reached the front of its fjord [1]. There is no established approach for disentangling the drivers of recent glacier melt, including local climatic variability, long time-scale anthropogenic trends, and the dynamic glacier response to climate forcing.

b) Numerical models of ice sheet evolution only start to include dynamic ice front retreat, and do not include the spread of possible climate variability in projections of ice sheet evolution over the coming decades and centuries, and therefore do not assess the impact of such variability on sea level rise uncertainties.

This work will fill this gap by providing a new framework to include climate variability uncertainty in ice sheet model projections and to perform the first attribution study for observed mass loss from a large marine-terminating outlet glacier

b) This project will result in a framework for producing ensemble projections of future sea level rise that quantify the impact of uncertainties associated to climate variability, which is not currently done in any ice sheet modeling group and will be available for all future ice sheet model simulations.

Methodology

a) Development of an ice flow simulation of Jakobshavn Isbrae (see Figure 2) including:
- ice front retreat based on tensile stress calving [2]
- grounding line migration with sub-element parameterization [3]
- ice rheology estimated from a thermal model of the ice

b) Comparison of modeled evolution of glacier with observations of ice front retreat

c) Analysis of the Community Earth System Model (CESM) large ensemble in the Disko Bay area, next to Jakobshavn Isbrae
- Upper ocean temperature
- Atmospheric temperature

d) Simulations of small ensembles of Jakobshavn Isbrae to test the sensitivity to oceanic and atmospheric conditions and implementation of framework to perform large ensembles of simulations

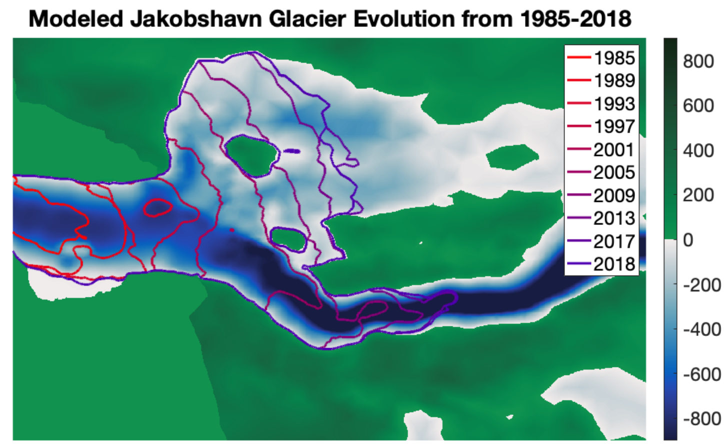


Figure 2: Example of modeled evolution of the ice front position of Jakobshavn Isbrae over the 1985-2018 period, background shows the bedrock elevation (in meters) in this region.

Results

a) Tasks for year one have been accomplished:
- Set-up of Jakobshavn Isbrae dynamic ice flow model
- Analysis of CESM large ensemble runs
- Visit of student had to be postponed but regular contacts and meetings

b) The results achieved during the first year of this project highlight the large climate variability in the Disko Bay region (see figure) that is superimposed on top of a trend of warming in this region, captured in the CESM large ensemble project. These forcings will provide important information to force the evolution of the ice sheet simulations

c) Next steps:
- Framework to run large ensembles of simulations simultaneously
- Preparation of ice sheet forcings (surface mass balance, ice front retreat) from climatic conditions in Disko Bay region
- Large ensemble simulations of Jakobshavn Isbrae (hundreds of simulations) from individual CESM members and ensemble means to test the role of climate variability and trend

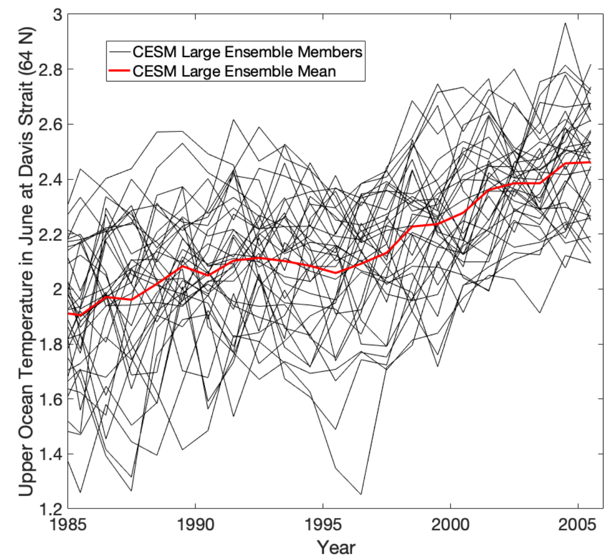
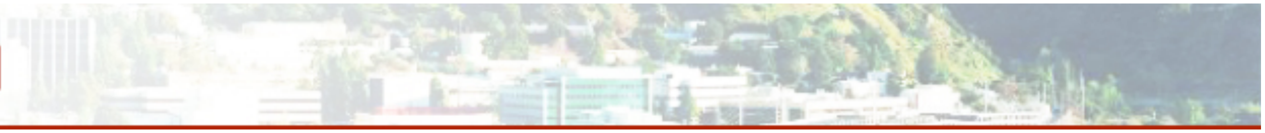


Figure 3: Variability of the Upper Ocean Temperature (in degrees) in June at Davis Strait from the CESM (Community Earth System Model) large ensemble over the 1985-2005 period. Red line shows the ensemble average over this period.



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