Accelerated Greenland Ice Sheet mass loss causes AMOC slowdown & increased North Atlantic icebergs

1. Introduction

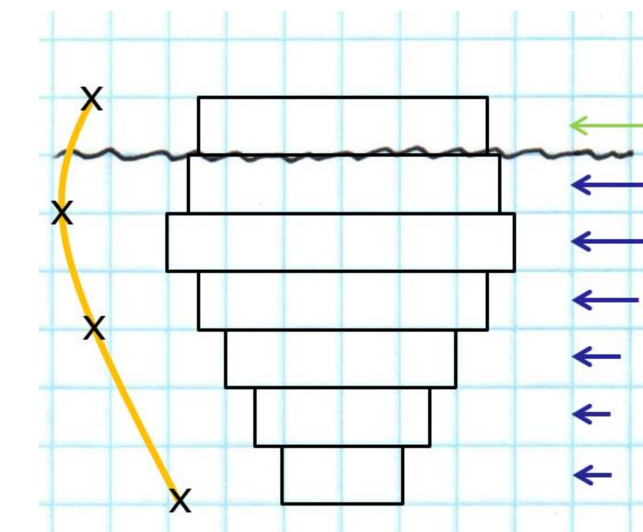
The aim of this project is to simulate the impact of future Greenland Ice Sheet (GrIS) mass loss on North Atlantic iceberg activity and ocean circulation. An iceberg model is coupled to the MITgcm ocean-sea ice model and configured globally at an eddy-permitting ($1/6^{o}$) resolution.

If observed rates of accelerated mass loss continue for the next 35 years then North Atlantic iceberg activity could increase 6-fold and AMOC weaken by 3.5% (0.4Sv). Upper-estimates of GrIS melt (0.1Sv) projected by 2100 AD weaken AMOC by 17% (2Sv).

2. The iceberg model

MITberg is a new dynamic-thermodynamic iceberg model developed at the University of Massachusetts Amherst. Icebergs are simulated as lagrangian particles.

Drag forces are derived from ocean, air, sea-ice, Coriolis force, waves, and pressure gradient forces (ref. 1). A multilevel advection scheme and keel parameterization prescribe a more authentic shape below the waterline.



Melt is caused by radiative heating, sensible heat exchange, buoyant vertical convection, wave erosion, and collapse of overhanging slabs, with model physics based on the Canadian Iceberg Model (2). Meltwater from icebergs locally cools and freshens the ocean model.

3. Simulating GrIS freshwater forcing

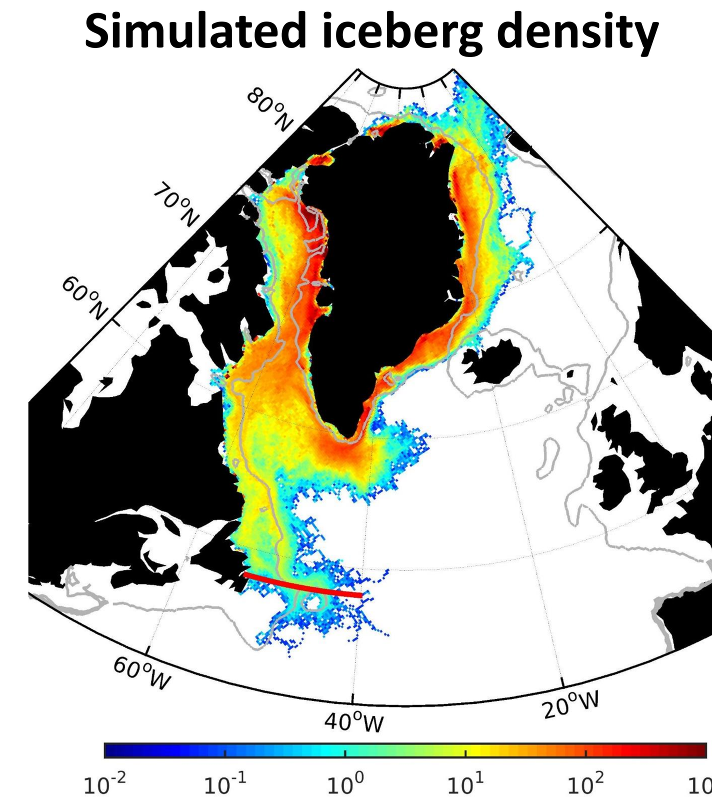
Simulated mass loss from the GrIS is partitioned into ice discharge from marine terminating glaciers and liquid discharge (surface melt + runoff). All freshwater discharge is released to the ocean from 34 catchments (3) at the ice sheet edge. A seasonal runoff cycle is prescribed (all discharge occurs May – August). The model was spun up for 25 years using ERA-40 forcing, and the Control and Perturbation experiments run forward for 35 model years.

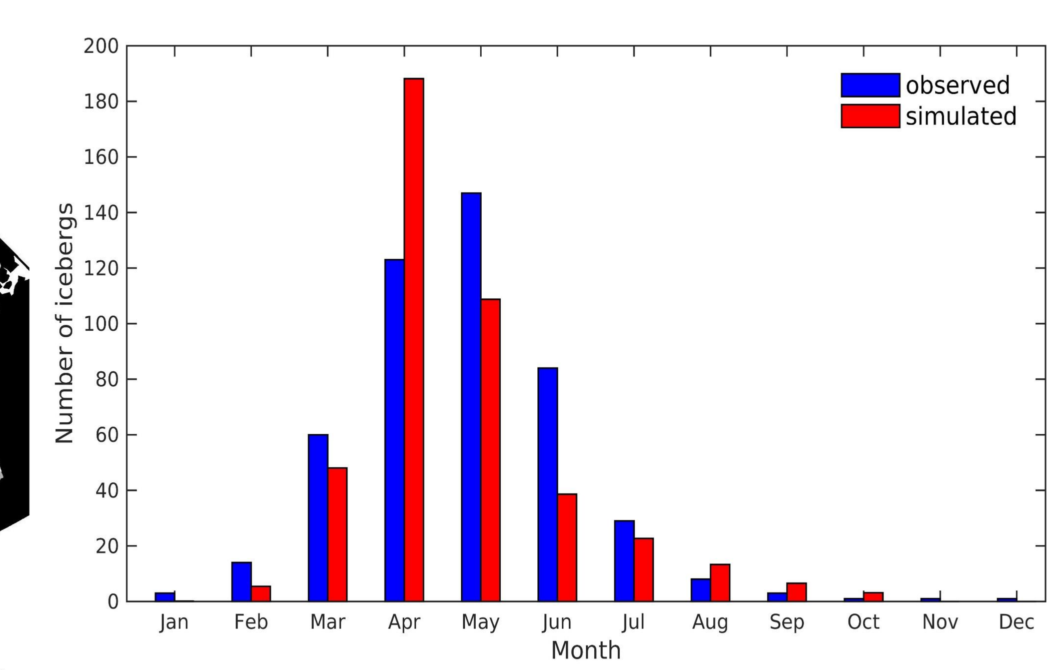
Exp. name	Ice flux	Liquid runoff	Description
Control	462 Gt/yr	503 Gt/yr	Approx. observed GrIS ice and liquid discharge (e.g. 3-5)
RAMP	+7.4 Gt/yr^2	+14.6 Gt/yr^2	FW flux increase (+22 Gt/yr^2) based on observed GrIS mass loss (4,6). By 2100 AD, FW forcing = 0.1 Sv
MELT	1578 Gt/yr	1578 Gt/yr	Upper-estimate (0.1 Sv) predicted for GrIS by 2100 & typical 'hosing' flux (7-9)

In each catchment, the ice flux is divided 50:50 into calved icebergs and melt at the ice front.

4. Validation: Control simulation

Simulated iceberg density | **Number of icebergs passing south of 48°N**

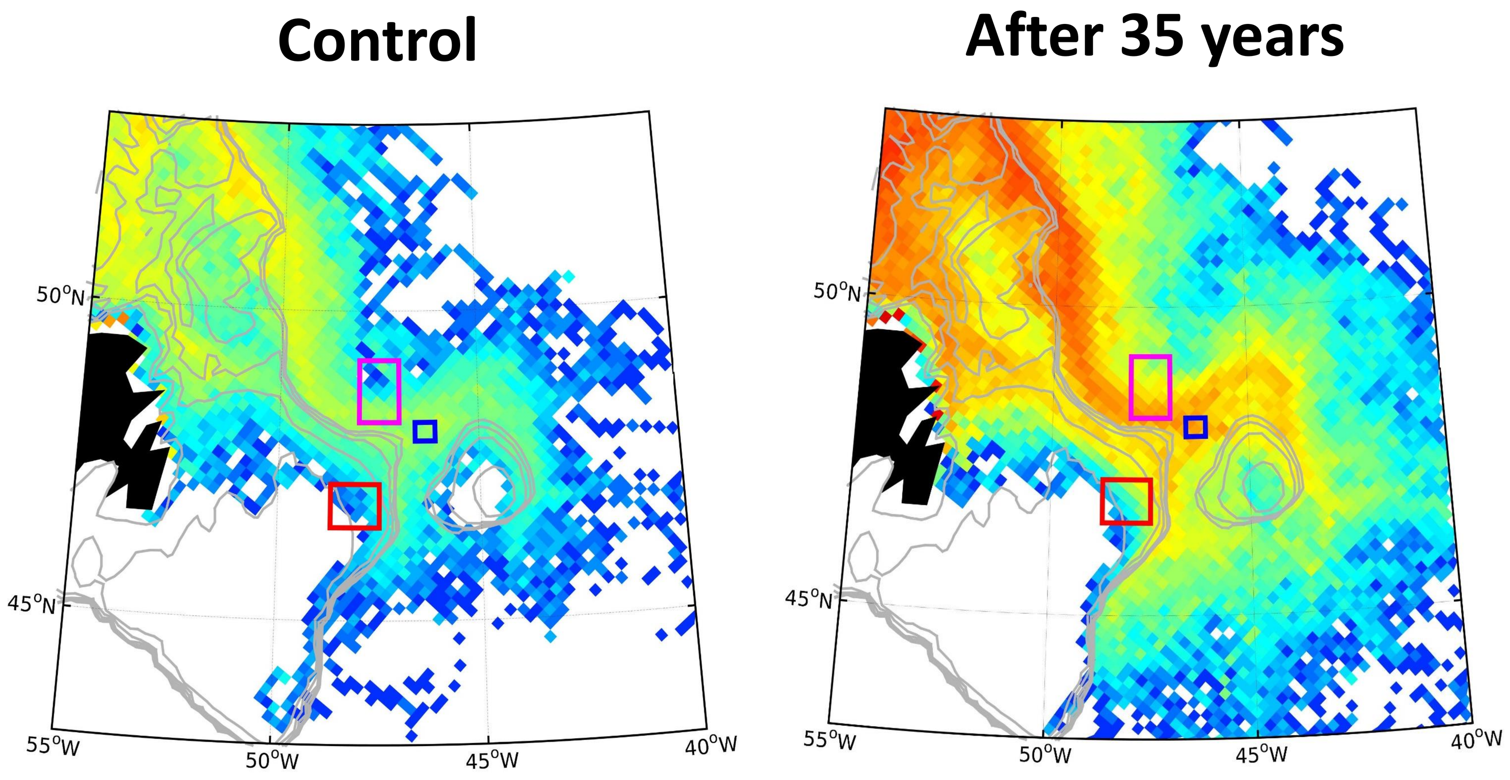




Simulated icebergs are confined to narrow coastal boundary currents. The number (and seasonality) of icebergs crossing the Grand Banks of Newfoundland 48˚N parallel agrees with observations: Control=435/yr & Obs. (ref. 10) = 474/yr

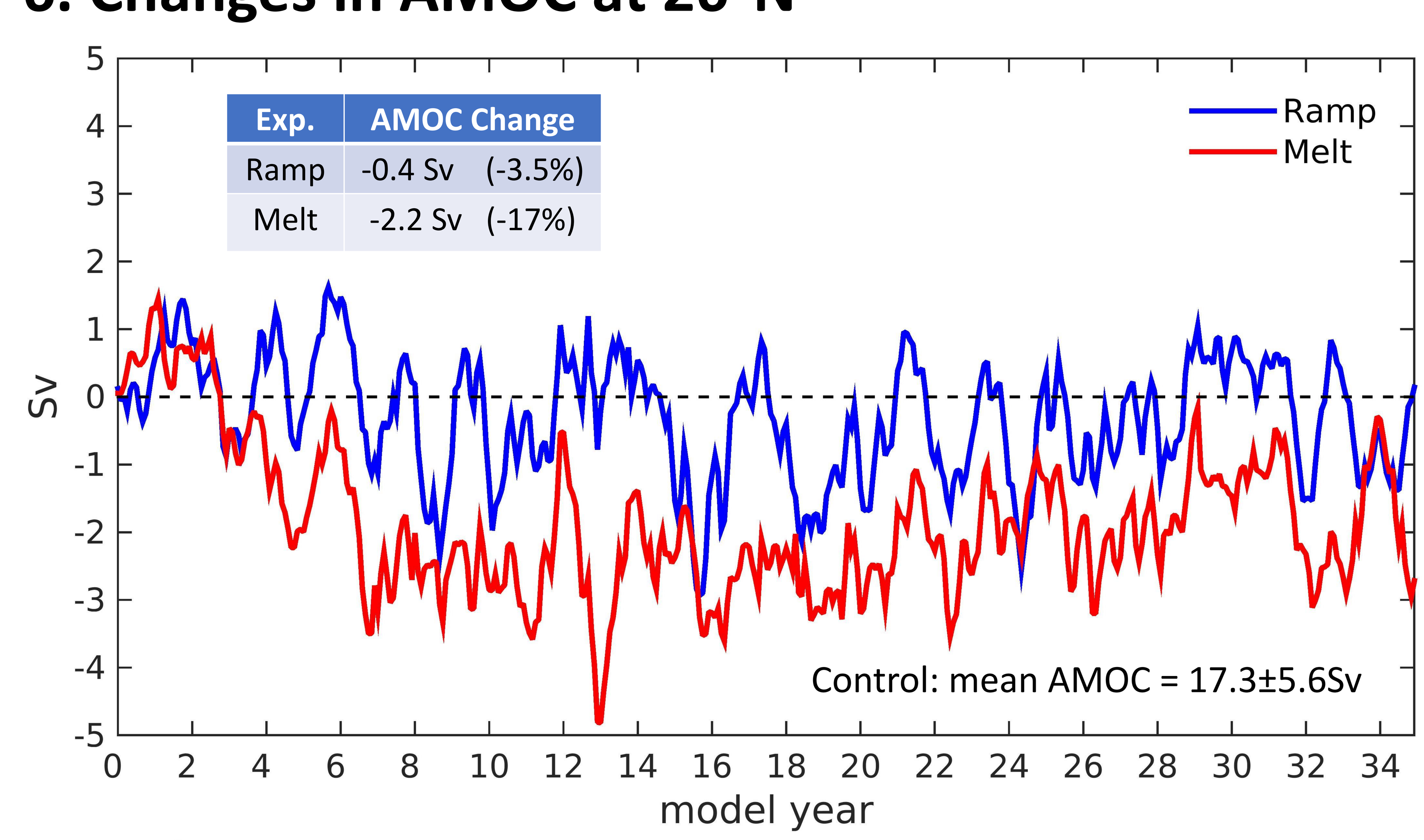
5. Future iceberg activity: Grand Banks

Control | **After 35 years**



In ExpRamp (right), the number of icebergs drifting south of 48˚N increases 6-fold after 35 years. Iceberg length and thickness also increase 1.5- and 2-fold, respectively. The rise in iceberg activity will increase the risk of iceberg collisions with commercial shipping and oil and gas platforms (Red: Hibernia oil field, Blue: Flemish Pass, Pink: Orphan Basin)

6. Changes in AMOC at 26°N



7. References

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