# Towards more physically constrained freshwater injection

## the role of gateways in glacial runoff export from the Arctic Ocean

Ryan Love[1], Lev Tarasov[1], Alan Condron[2]

Goal:

We seek to quantify the role of the primary processes which drove high frequency climate variability during the last deglaciation. This is achieved in part through a series of sensitivity experiments conducted using a set of eddy permitting glacial ocean circulation model configurations. These sensitivity experiments will explore the routing of glacial runoff in the glacial Arctic ocean as determined by an eddy permitting ocean circulation model. These simulations will allow us to construct 'freshwater fingerprint' products for use in achieving greater realism in future coarse resolution freshwater injection experiments.

Summary :

- In our experiments the typical hosing region 50-70N is not where freshwater enters open ocean. As such, simulations of climate transitions using injections in that region may not be robust
- With LGM background climate and bathymetry we find that glacial runoff from the Mackenzie River basin is long lived in the Arctic ocean
- Opening/deglaciation of the Barents Kara sea during expedites export of glacial runoff from the Arctic Ocean

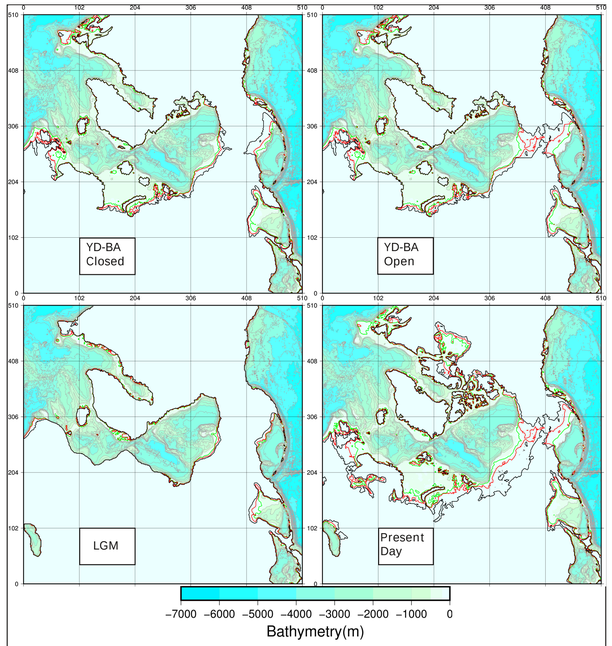
To Do :

- Refine metric used to define optimal timestep from which to extract freshwater fingerprint
- Examine climatological response in MITGCM to freshwater injection
- Examine lower freshwater injection volumes, within the range of uncertainty provided by the work of Tarasov et. al. (2012)
- Explore the impact of the freshwater fingerprints, by comparison to conventional 'hosing', in a coarser resolution climate model

References:
Condron, A., & Winsor, P. (2012). Meltwater routing and the Younger Dryas. Proceedings of the National Academy of Sciences, 109(49), 19928-19933.
Lev Tarasov, Arthur S. Dyke, et. al. (2012) A data-calibrated distribution of deglacial chronologies for the north american ice complex from glaciological modeling. Earth and Planetary Science Letters, 315-316(0):30–40. Sea Level and Ice Sheet Evolution: A PALSEA Special Edition.
Lev Tarasov, W.R. Peltier., (2005) Arctic freshwater forcing of the Younger Dryas cold reversal. Nature, 435, 662-665

1: Memorial University of Newfoundland, NL, Canada
2: Woods Hole Oceanographic Institution, MA, USA

Contact: rlove@mun.ca




The simulated bathymetry used in the freshwater injection simulations shown at native resolution. The black contour denotes the coastline, the red contour represents 50m depth and the green contour denotes 100m depth. Grey contours are 500m depth contours.

### Simulation Bathymetry

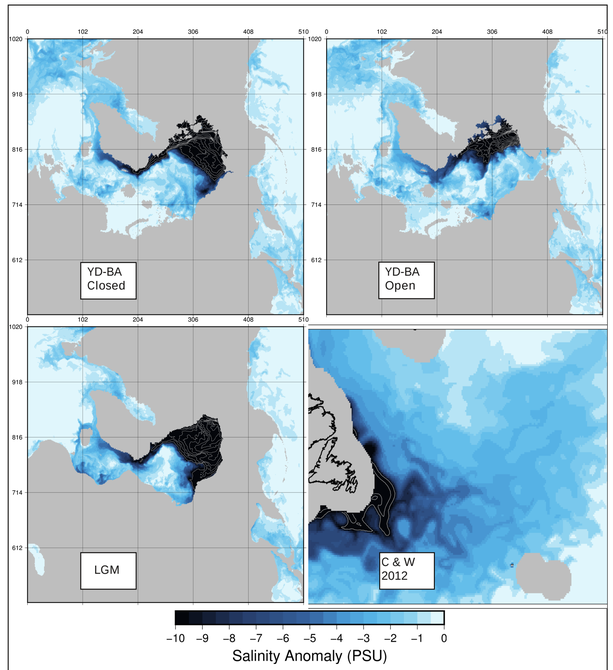
Our simulations utilize 3 bathymetries representative of the Last Glacial Maximum (LGM) and the Younger Dryas (YD) - Bolling Allerod (BA) transition. The Last glacial maximum bathymetry was generated by globally lowering sea level by 120m and masking off regions covered by the ice sheets, as provided by a recent reconstruction, and is the same as was used in Condron and Winsor (2012). The YD-BA bathymetry was generated by applying a relative sea level (RSL) anomaly to the present day CS510 bathymetry using output from the gravitationally self-consistent RSL model incorporated into the Glacial Systems Model (GSM) of Tarasov et. al. (2012).

The reconstruction of Tarasov et. al. (2012) has the Bering Strait closed at the time of the transition. However, to examine the impact that an opened Bering strait would have on export of glacial runoff from the glacial Arctic ocean we replaced the region surrounding the Bering Strait with its modern bathymetry.

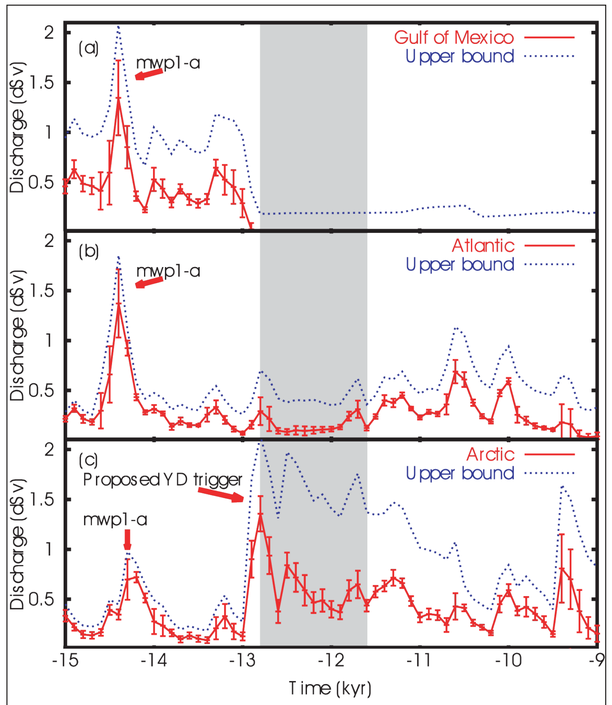
### Experimental Design and Preliminary Results

Our simulations utilize the MITGCM ocean model configuration at CS510, approximately 18km spatial resolution globally. Each simulation is comprised of a continual 0.2Sv injection at the mouth of the Mackenzie river as well as a control simulation for the calculation of anomalies. The surface boundary conditions are provided by CCSM PMIP LGM climatology data.

Thus far, results indicate that using LGM bathymetry results in a stagnant Arctic ocean with little export of water from the basin. Glacial runoff is long lived for an injection rate of 0.2Sv. Opening of the Barents Kara sea enhances export but the opening of the Bering strait provides the largest change to the system.




Maximum salinity anomalies for the last year of each of the ongoing simulations are shown. The open Bering Strait and Closed Bering Strait simulations have similar distributions in the North Atlantic, but the closed simulation has taken ~10a longer to achieve this. As well, the maximum open ocean salinity anomaly from the data of the 5Sv injection experiment in Condron and Winsor (2012) is shown for comparison.




Regional drainage chronologies from an older North American Ice Sheet calibration. The upper bound is the maximum of the 1 sigma range of the ensemble. Of note is the rather large range of potential drainages into various basins, we seek to examine the range of responses of the climate system to the introduction of such forcings (Tarasov & Peltier, 2005). We presently focus on the drainage into the Arctic ocean through the Mackenzie river. We constrain the upper limit of our injection rate using this data.

Acknowledgements:
The authors would like to ackownledge the German Climate Modeling Initiative PALMOD for providing funding assistance for this project

This presentation participates in OSPP

Outstanding Student Poster & PICO Contest