High Frequency Ice-Climate Variability During the Last Deglacition

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Goal:

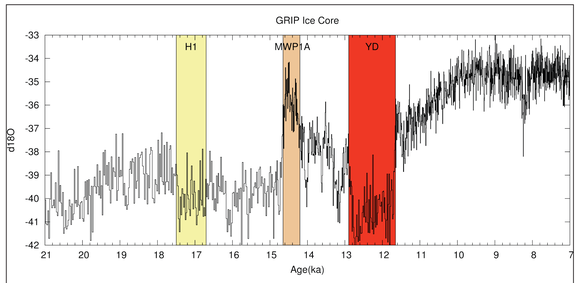
We seek to **quantify the role of the primary processes which drove high frequency climate variability** during the last deglaciation. This will be achieved through a series of sensitivity experiments conducted using a set of ocean circulation models, atmospheric circulation models, ice sheet model and a coupled ice-atmosphere-ocean general circulation model.

Our first set of experiments explore the role of freshwater forcing in the climate system, particularly the importance of a realistic meltwater distribution upon the strength of ocean circulation and heat transport to high latitudes. This will be achieved by utilizing the output of a calibrated glacial systems model to introduce a set of meltwater distributions, comparable to those at the initiation of the Younger Dryas and Heinrich Event 1, into the ocean models and examining the range of responses exhibited by the system.

Role of Proxy Data:
Constrain/validate role of climate system feedbacks.

To Do:

- Determine appropriate proxy records. Criteria:
  - Spatial and temporal coverage
  - Readily compared to GCM fields
- Investigate how we can reliably compare proxy data to GCM model output given the difference in spatio-temporal scales in the context of process constraint
- Determine the optimal configuration between the computational cost trade-off between higher model spatial resolution and ensemble size
- Implement a stochastic representation of sub-grid scale ocean transports
- Nonlinearity of GSM/GCM coupling : Investigate the impact of coupling frequencies between the glacial systems model and climate models



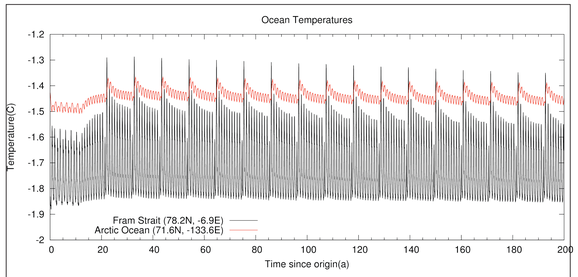
GRIP ice core d18O record with regions of rapid climate change denotes as coloured regions. H1/H0 are Heinrich events 1 and 0 respectively, YD is the Younger Dryas and M1P1A marks the region where meltwater pulse 1A likely occurred. Our work is focused mainly with the initiation H1 with the potential to examine those influences involved with the initiation of the Younger Dryas period.

Experiments:

- Investigate ocean and sea ice model **responses to realistic freshwater forcing** distributions as determined from output of a calibrated glacial systems model
- Examine response and determine the range of responses of the atmosphere to **changes in surface orography** from ice sheets
- Explore the role that these **changes in orography, land-mask, and bathymetry** play in the climate system in **tandem with freshwater forcings**
- Explore the responses of the glacial ice/climate system when **sea ice extent** is fixed or dynamic
- Evaluate the magnitude of the **non-linear responses** of the climate systems to these forcings
- Examine the influence of a **stochastic subgrid** representation of ocean transports

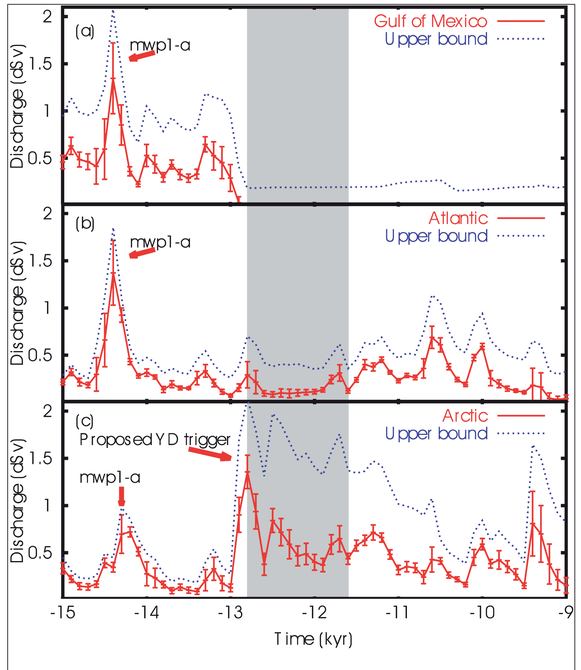
Experimental Setup:

We will utilize several different computational models to examine the influence of each component separately in fairly isolated sensitivity experiments. For our ocean modelling experiments involving the influence of freshwater injections and sea ice extent and thickness distributions we will use the Nucleus for European Modelling of the Ocean (NEMO) as well as the MIT-GCM model.
For atmospheric studies examining the role of ice sheets and orography we will utilize the Community Atmosphere Model (CAM3). Subsequent to those studies we will progress into models of greater complexity so as to attempt to examine the entirety of the climate response to each of the forcings in turn.
Long duration experiments will be conducted with the Earth model of intermediate complexity Planet Simulator (PLASIM) with the potential of coupling the model to the glacial systems model(GSM) while shorter duration studies will be conducted with the Community Earth System Model (CESM).

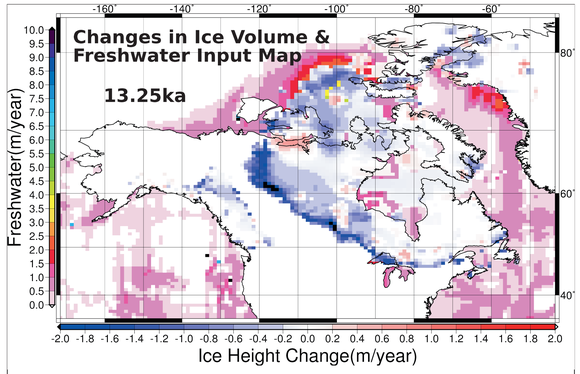


Sample ocean temperature output from the NEMO ocean model at two high latitude sites at approximately 100m depth. Of note here is the regularity of the signal.

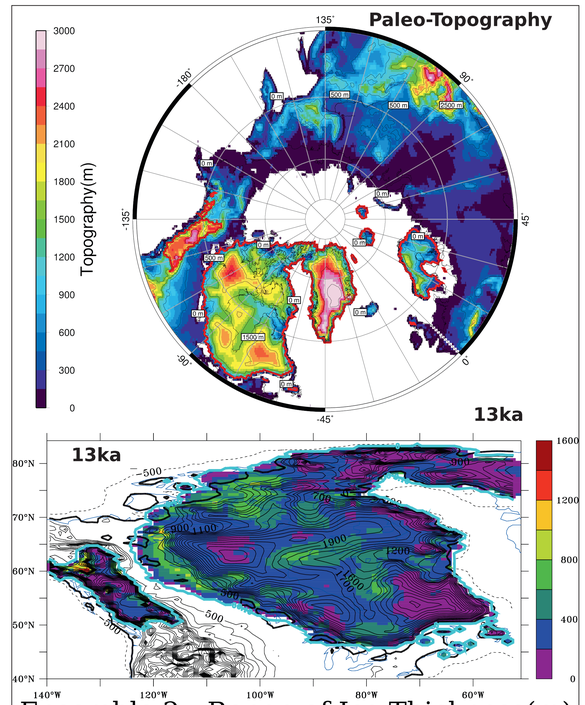
Example Forcings:



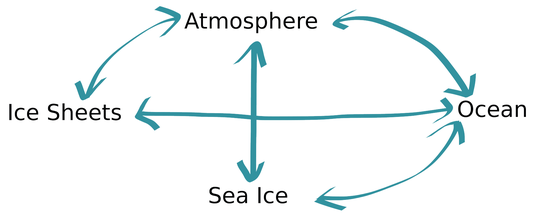
Regional drainage chronologies from an older North American Ice Sheet calibration. The upper bound is the maximum of the 1 sigma range of the ensemble. Of note is the rather large range of potential drainages into various basins, we seek to examine the range of responses of the climate system to the introduction of such forcings (Tarasov & Peltier, 2005).



Rate of change of ice height between 13.5ka and 13ka as determined from the best scoring North American ice sheet calibration of the glacial systems model. Also shown is the resultant freshwater input as determined from the GSM pointer field output and GCM runoff fields. We use this output to modify the freshwater forcing field of the paleoclimate ocean model experiments.



Northern hemisphere 13.5ka topography. The boundary of the ice sheets are demarcated by a thick red line. The ice thickness shown below is 2 sigma deviation across the NAIS ice sheet reconstruction sample set . Note the magnitude of the differences are of the order of several hundred meters in many areas and should result in marked differences in melt distributions.



References:

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