Glacial Inception in North-East Canada:
The Role of Topography and Clouds

Leah Birch
Timothy Cronin
Eli Tziperman

Clouds over Baffin Island
Causes and Location of Glacial Inception

Milankovitch theory suggests that cool summers allow for snow survival and thus glacial inception.

There was a minimum in insolation before the last glacial inception.

Baffin Island glacial deposits were seen at 115kya. Deposits in western Canada are dated much later.

Clark et. al. 1993
To obtain persistent snow cover growth, Otieno & Bromwich 2009 had to artificially lower temperature, as seen in BP116.

Jochum et. al. 2012 found higher/more realistic topography increases glacial susceptibility.
Model Set Up

WRF  Version 3.7
- Parent: 12km Resolution
- Nested: 4km Resolution
- Realistic Ice Extent and Land Type

Experiments used boundary conditions from recent climatology and were run for 3 years with the following perturbations:
1. Insolation
2. Summer Temperature Anomaly
3. Topography
Perturbations to Model Configuration

1. Orbital Parameters for:
   Present Day (average), 115kya (min.), and 128kya (max.)

2. Boundary Conditions from ECMWF ERA-Interim:

   **Average:** Average summer temperature, average snowfall
   **Cold:** Anomalously cold summers, wet winters
   **Warm:** Anomalously warm summers, dry winters

3. Realistic Topography (m)

   ![GCM Topography (m)]
All experiments have net melting, except for cold boundary conditions. GCM topography causes the ice cap to lose 1000 kg/m² of snow.
Results: Annual Precipitation

Realistic Topography enhances the accumulated precipitation. The average difference over the ice cap is around 100 mm, with over 600 mm in some places.
Results: Precipitation Rates

Lowered Topography changes the amount and type of precipitation, particularly during the summer.
Results: Ice Cap Growth by Height

The accumulation zone is largest with cold boundary conditions, and the integrated mass balance reveals the ice cap will grow with cold conditions.
Results: Cloud Radiative Forcing

When insolation is decreased, the net radiative forcing becomes less negative. Low topography has more low clouds and reflects more shortwave.
Conclusions

We use a 4km WRF configuration to address two main issues GCMs may have with glacial inception: (1) poor horizontal resolution, leading to low topography over Baffin Island and (2) their use of convective and cloud parameterizations.

Findings:

1. We did not get snow growth into unglaciated regions.
2. Cold summers and wet meteorology have the most ice cap growth and the mass balance integration reveals the lowest ice cap extent.
3. Realistic topography increases accumulation and decreases melting but makes the cloud forcing less negative.

Future Work:

1. An Analysis of Large Scale Weather Patterns
2. The Fate of Mountain Glaciers in the Future
Questions?

Contact me at: lbirch@seas.harvard.edu
## Model Set Up

<table>
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<tr>
<th>T</th>
<th>Z</th>
<th>( \Phi ): integr. Insol.</th>
<th>Init. Snow</th>
<th>Land Type</th>
<th>Comments</th>
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<td>( Z ) Perturbation</td>
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