Ice extents:
Muller Little Ice
melts has contributed to global sea level rise. Over the past 100 years, ice extent has decreased, and the water produced as the ice melts has contributed to global sea level rise. This poster explains what we know about the history of these ice caps, and how and why they’re changing.

12,000 years ago, the Arctic Islands were covered by ice. The ice began to shrink, and by 7,000 years ago the glaciers had lost most of the area that is lost today. Continued shrinking removed many of the smaller ice caps, while the bigger ones were a lot smaller than they are now. About 2,500 years ago the ice caps began to re-grow until some time in the last 100-150 years, when another period of ice retreat began.

This poster explains what we know about the history of these ice caps, and how and why they’re changing.

Figure 1.

Today’s Arctic landscape shows clear evidence of recent ice retreat. Recently uncovered areas have little vegetation and the rocks look fresh and unweathered, making them easy to identify and map from satellite images. Comparing recently uncovered land with glacier ice cap extents seen on aerial photographs from 1959-60 shows that, by 1960, the area of permanent snow and ice in the high Arctic Islands had decreased by over 60,000 km² from a maximum that probably occurred over 100 years ago. Comparison of 1960 ice extents with those taken from 1999 and 2000 satellite images shows that nearly 20% of ice disappeared from Ellsmere, Devon, and Axel Heiberg Islands over those 40 years, with the biggest changes on Devon and southern Ellesmere Islands.

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Figure 2.

Climate records from ice caps

Ice in cores from Arctic ice caps is over 10,000 years old near the bedrock, which means that the larger ice caps still contain ice from the great ice sheets that once covered this region. Ice cores can be used to create records of Arctic temperature changes. In cold, dry conditions, snow is compressed and converted into ice with lots of air bubbles. Under warmer conditions, snow on the ice surface melts in the summer and refreezes, forming a layer of blue ice with very few air bubbles. Conditions, snow on the ice surface melts in the summer and refreezes, forming a layer of blue ice with very few air bubbles.

Changes in the amount of snow that falls in a year and the amount removed by melting and runoff. Glaciers grow when snowfall is greater than melt, and shrink when melt is greater than snowfall. Surface melt balance has been measured on four Arctic glaciers for nearly 50 years, giving us some of the best evidence of the effects of climate change on Arctic ice caps. All four glaciers have been losing mass, with the Devon ice cap having thinned an average of 7 m since 1961. The rate of thinning increased dramatically after 1987, as warm air masses from continental North America reached the Arctic more frequently during the summer season.

Figure 3.

Changing ice cap size

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Figure 4.

Glacier mass balance

Changes in glacier and ice cap extent are caused by changes in surface mass balance: the difference between the amount of snow that falls in a year and the amount removed by melting and runoff. Glaciers grow when snowfall is greater than melt, and shrink when melt is greater than snowfall. Surface mass balance has been measured on four Arctic glaciers for nearly 50 years, giving us some of the best evidence of the effects of climate change on Arctic ice caps. All four glaciers have been losing mass, with the Devon ice cap having thinned an average of 7 m since 1961. The rate of thinning increased dramatically after 1987, as warm air masses from continental North America reached the Arctic more frequently during the summer season.

Figure 5.

Ice flow and icebergs

Ice flow in Arctic ice caps is highly complex. While ice generally flows slowly (a few metres a year), areas of faster flow (hundreds of metres a year) exist deep into the center of the ice cap. These fast flowing regions often occur over deep bedrock valleys and commonly end in the ocean, forming tidewater outlet glaciers that lose mass from icebergs. On the Devon Island ice cap, iceberg calving removes more than 30% of ice cap’s mass annually, with the remaining loss caused by surface melting. The rate of iceberg calving depends on glacier flow rates, whether the glacier is advancing or retreating, and sea ice cover: as sea ice cover increases, calving decreases. Calving can also be affected by ocean tides, changes in ocean temperature, and the amount of surface meltwater entering the glacier. Because of these processes, ice caps with many tidewater outlets may respond differently to climate change than those that terminate mainly on land, and may be very sensitive to climate change. Currently 75% of the tidewater outlet glaciers in the high Arctic are retreating.

Figure 6.

Water on ice caps

Glacier meltwater ultimately makes its way to the ocean. Extensive lake and stream networks form on the ice each summer, in some cases taking meltwater directly to the ocean. In other cases, meltwater enters the glacier through crevasses and forces its way to the bottom of the glacier, where it forms a drainage network between the ice and the underlying bedrock.

Figure 7.

Summary

We’ve been working on the Belcher Glacier for three summers (2007-2009) and have collected data on: (1) ice and bedrock topography, (2) the distribution of winter snowpack over the glacier surface, (3) weather conditions across the ice cap, (4) surface meltwater production and drainage network patterns, (5) ice movement, and (6) calving at the glacier terminus. These data are being used to model ice cap responses to climate change.

Figure 8.

Acknowledgements

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Figure 9.

More information: http://people.uleth.ca/~sarah.boon/IPY_page