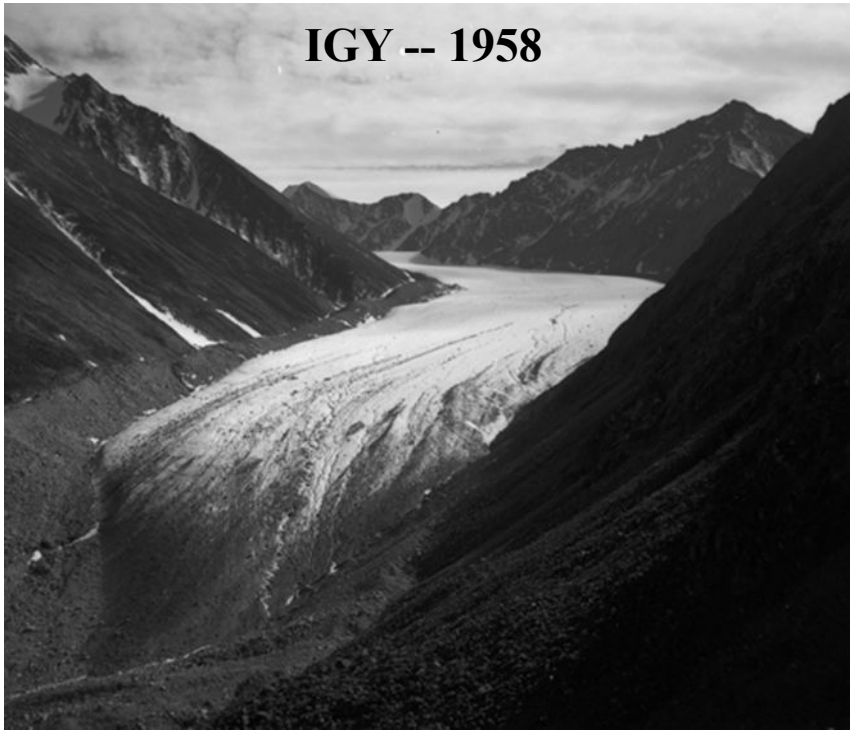
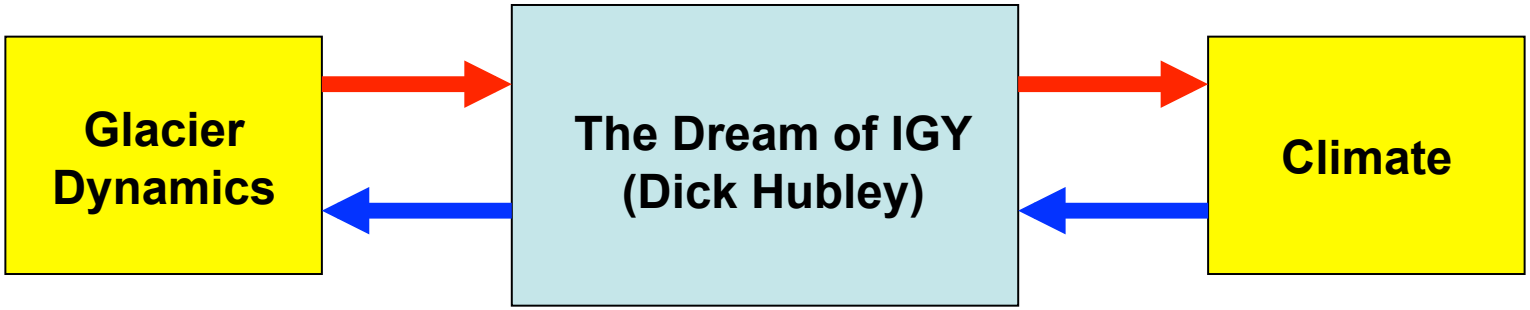
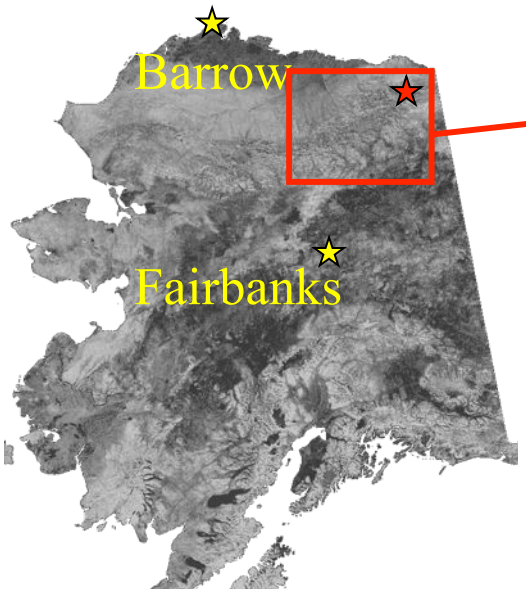
IPY3 to IPY4: Research on McCall Glacier in Arctic Alaska

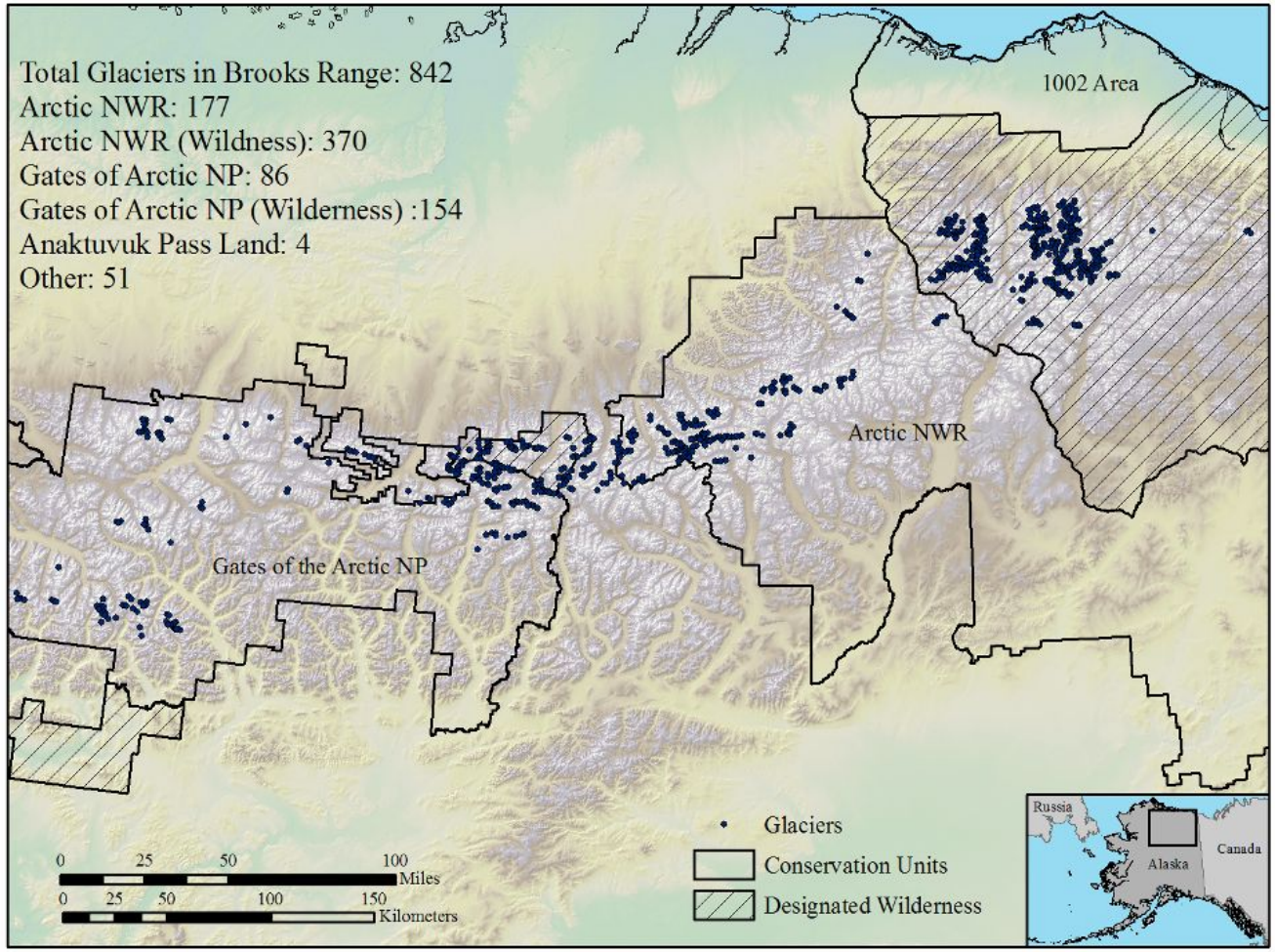
Matt Nolan
University of Alaska Fairbanks





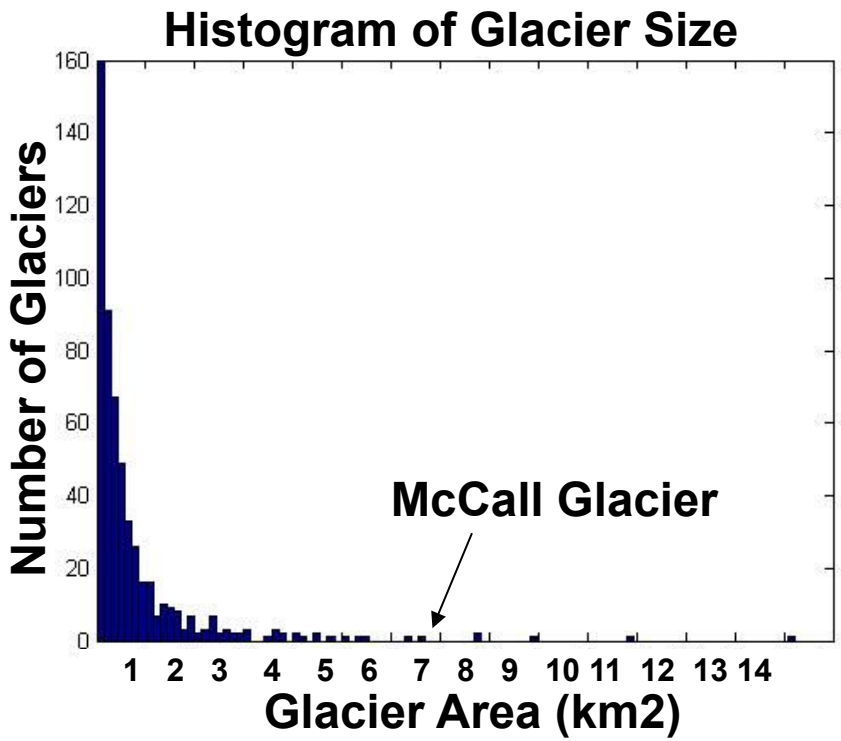
Capturing the State of All of US Arctic Glaciers

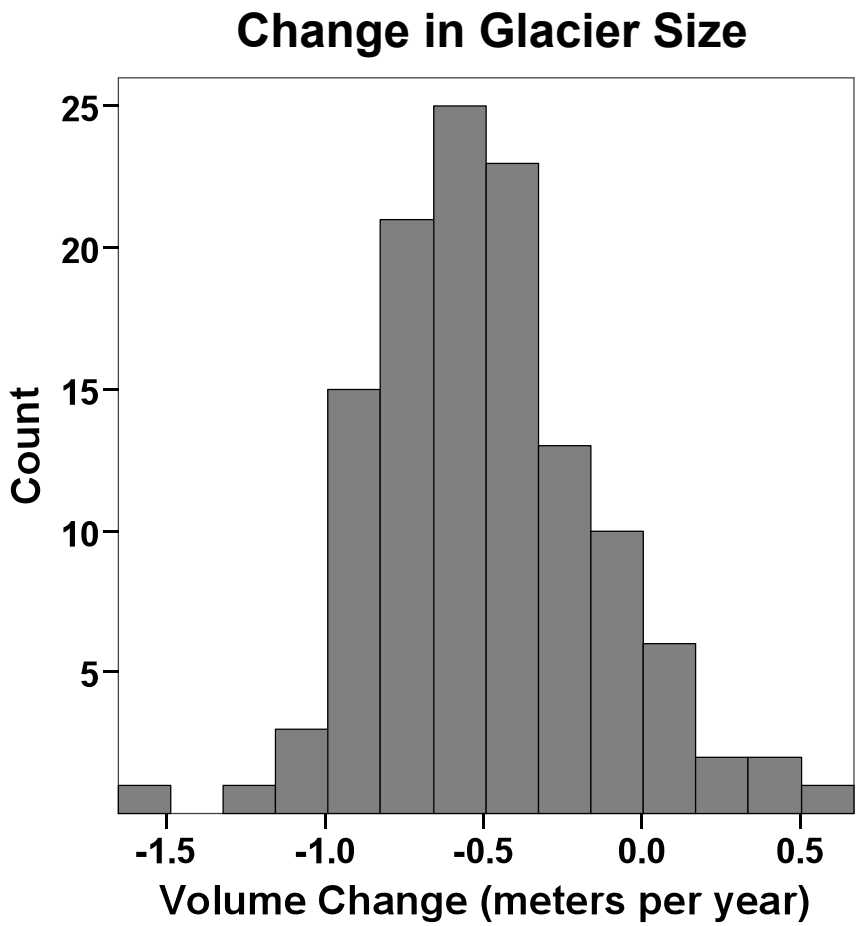




We're trying to measure volume change of ALL glaciers in the US Arctic by creating new digital elevation models (DEMs) and comparing these elevations to the old USGS maps, then using our models to understand the processes. Air photo inventories aid in these analyses and its outreach.

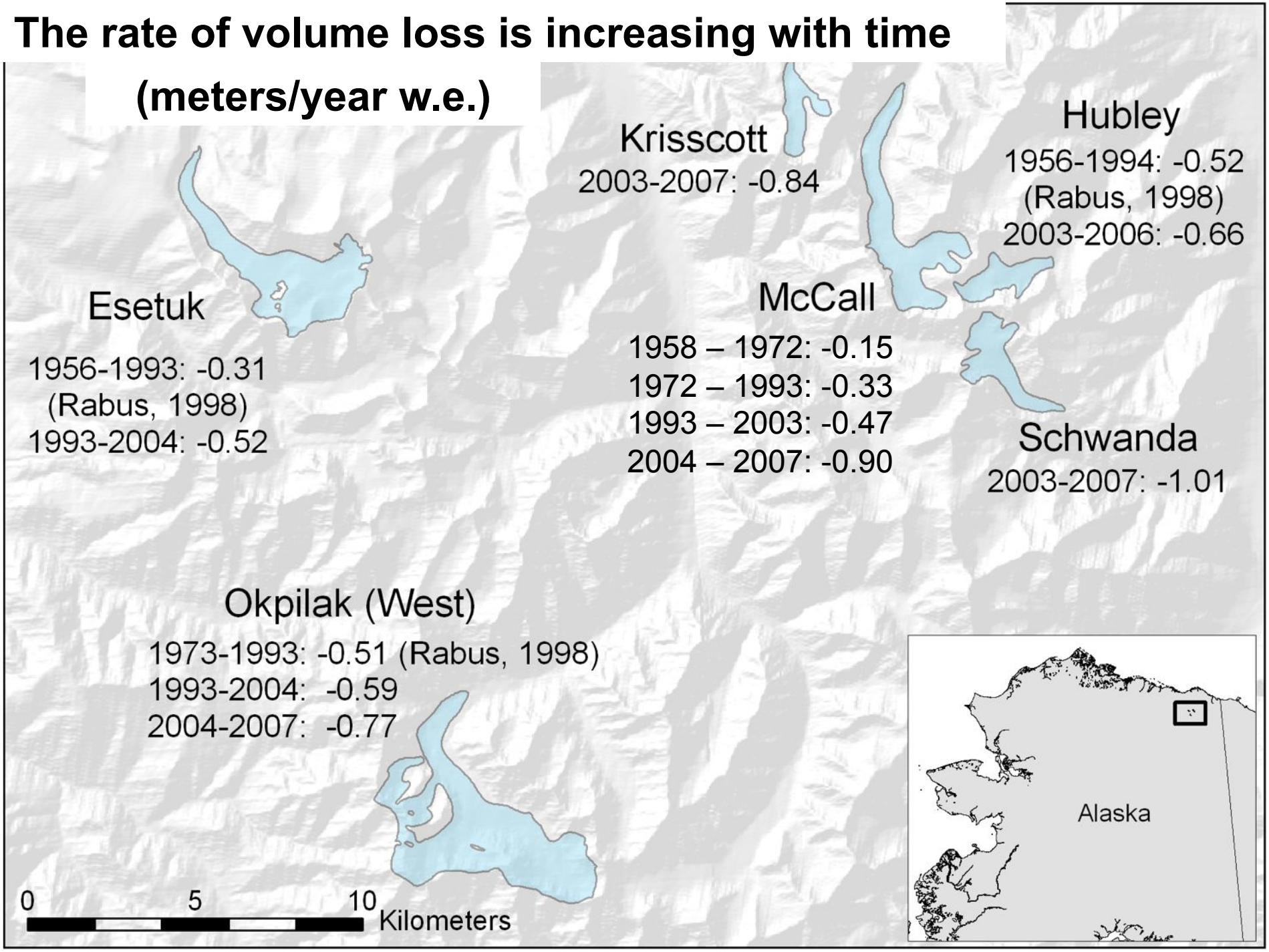
All of the US Arctic Glaciers are small, and all are getting smaller



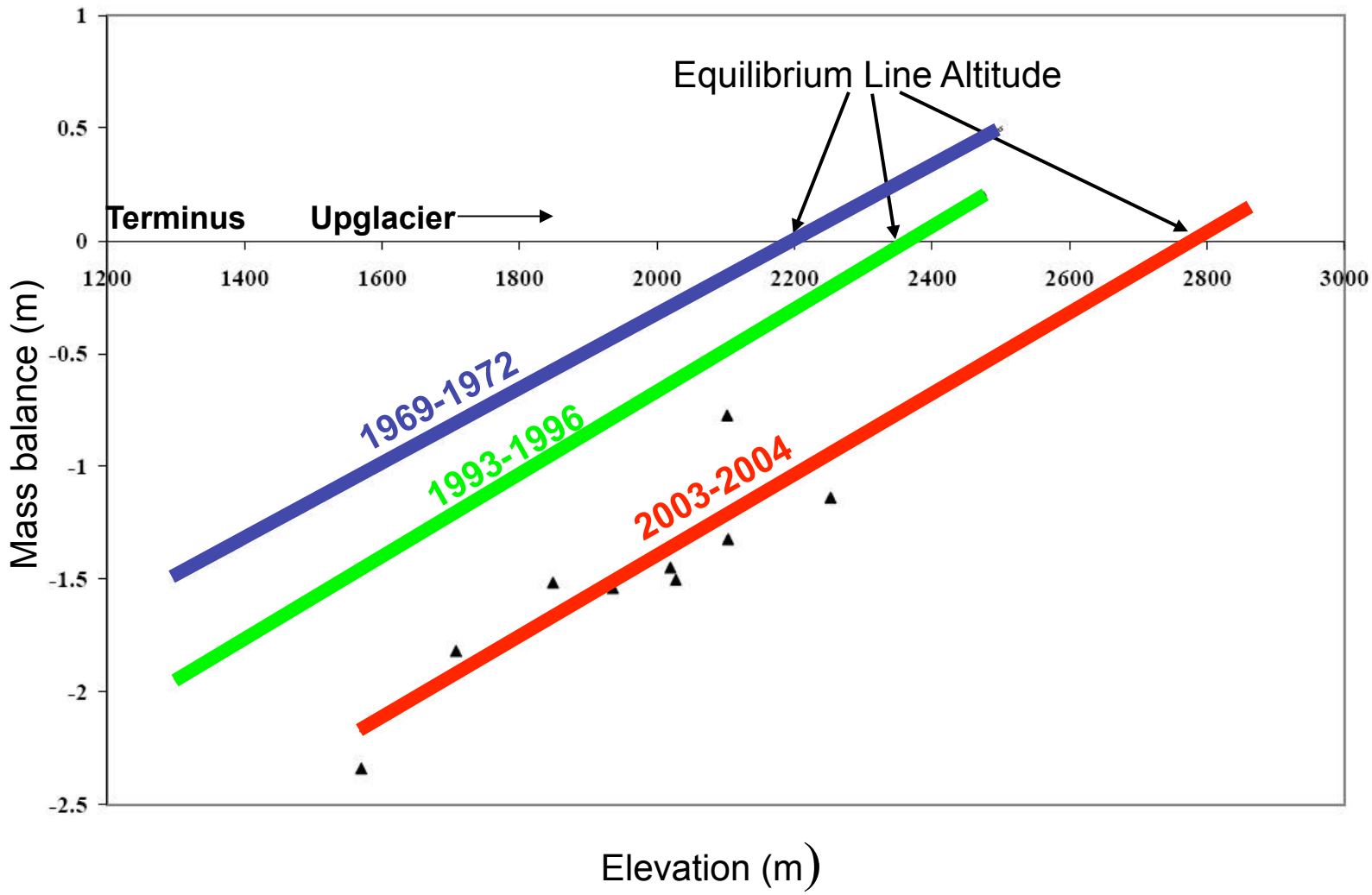


The rate of volume loss is increasing with time

(meters/year w.e.)

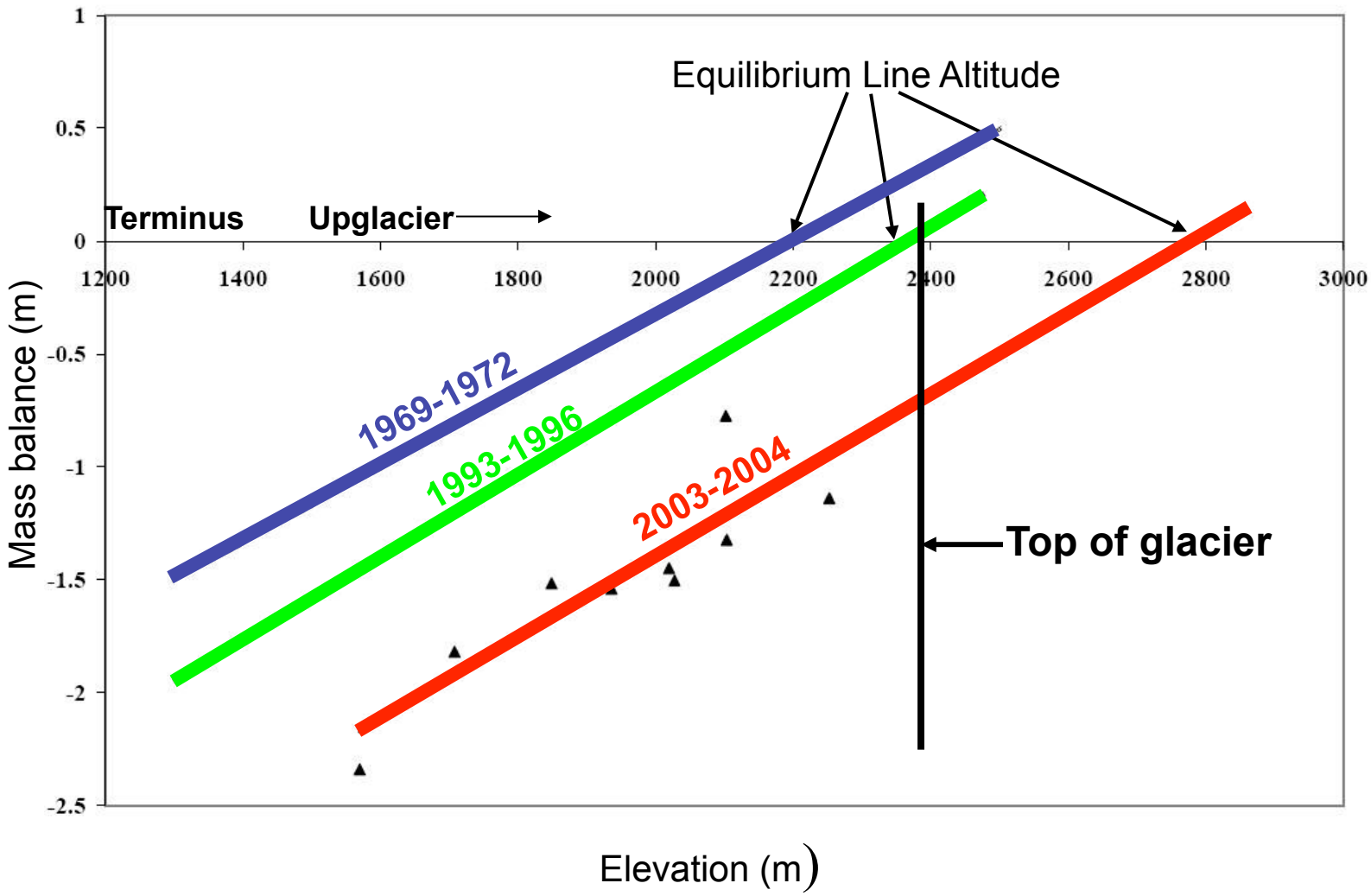


Glacier loss in the Brooks Range: Modeling future change



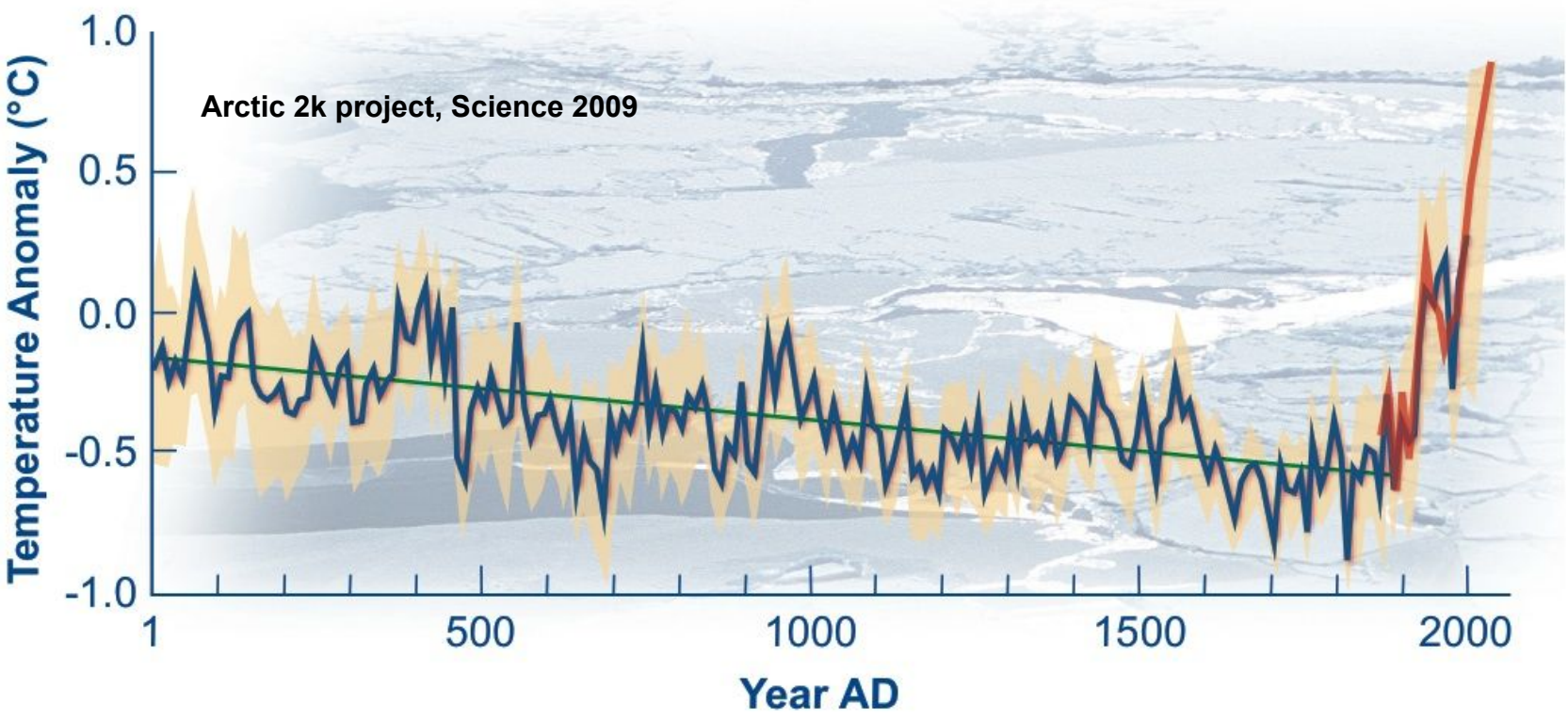
On McCall Glacier, the equilibrium line has been steadily getting higher, and this is likely the case all over the Brooks Range.

Glacier loss in the Brooks Range: Modeling future change

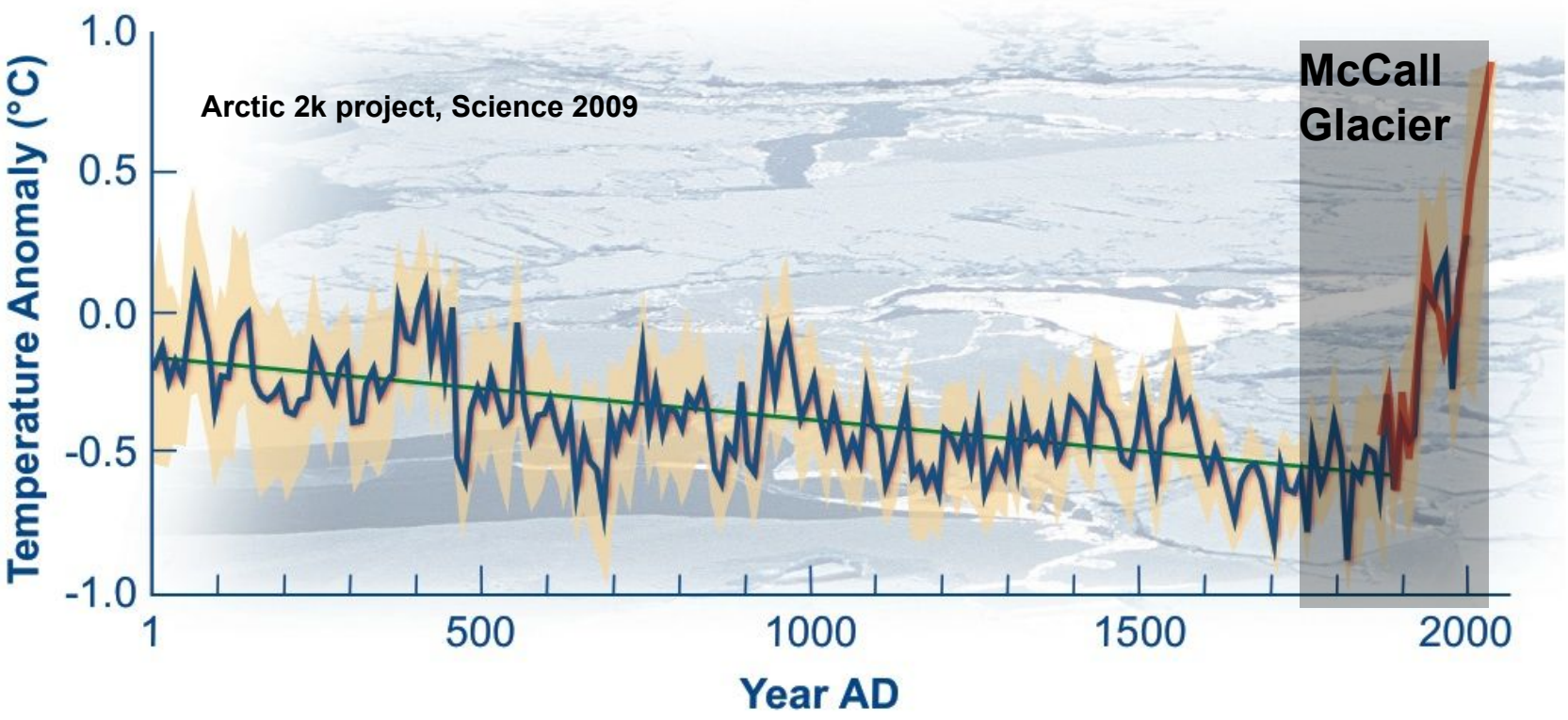


On McCall Glacier, the equilibrium line has been steadily getting higher, and this is likely the case all over the Brooks Range.

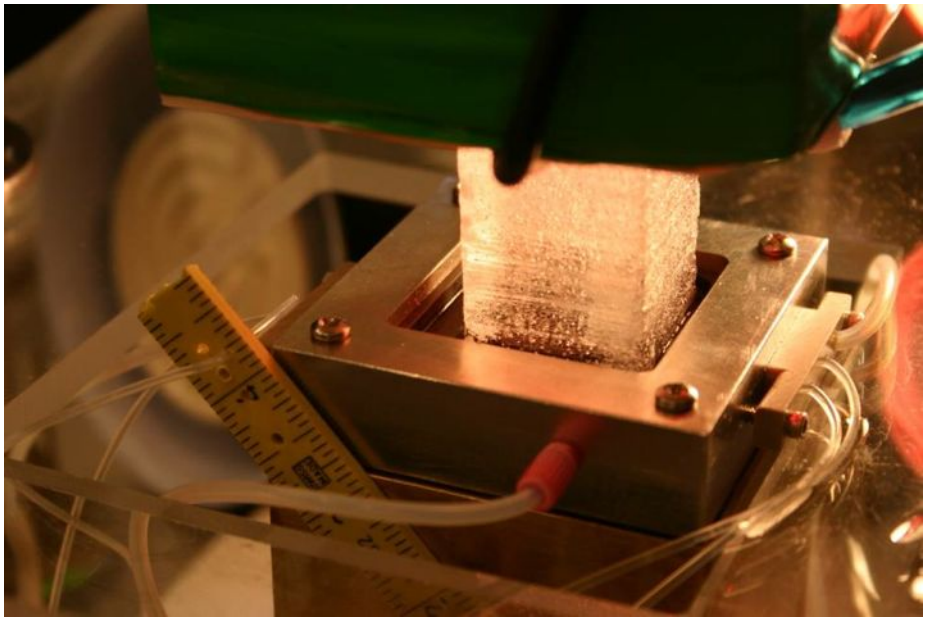
The Arctic Climate has been cooling over the past 2000 years, until the late 1800s

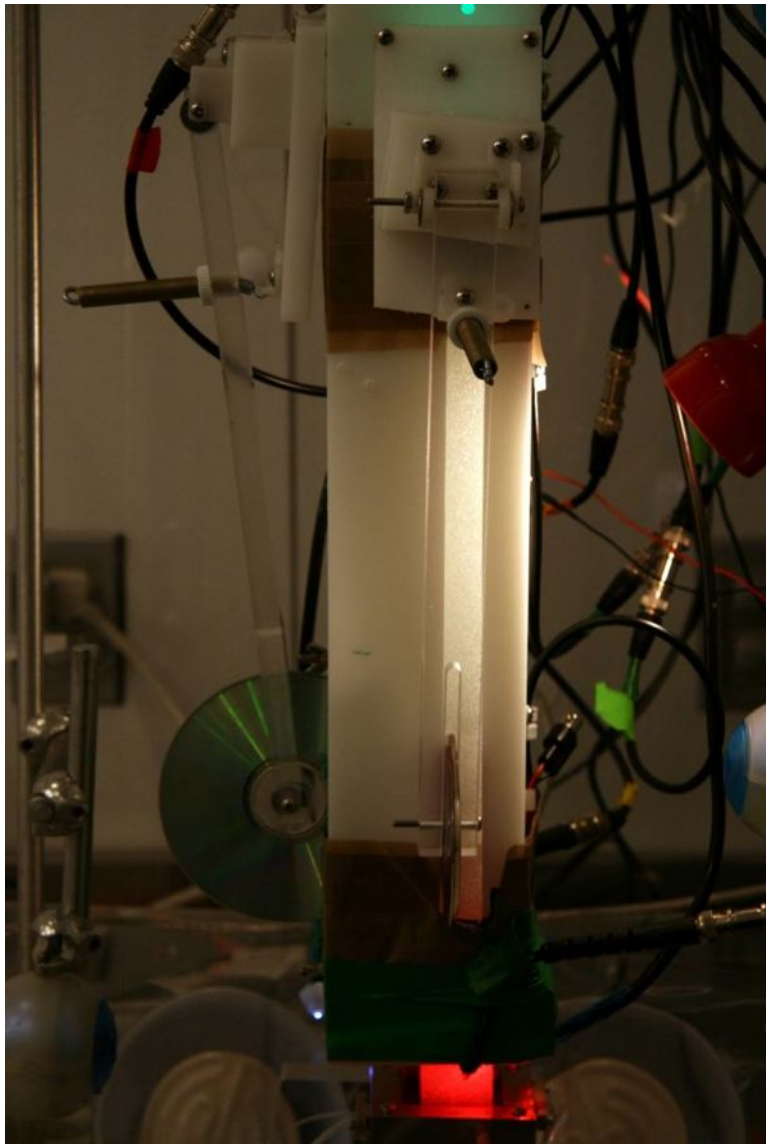


The McCall Glacier core captures the most important transition in Arctic climate in the past 2000 years, with potentially annual resolution in 40 different proxies.

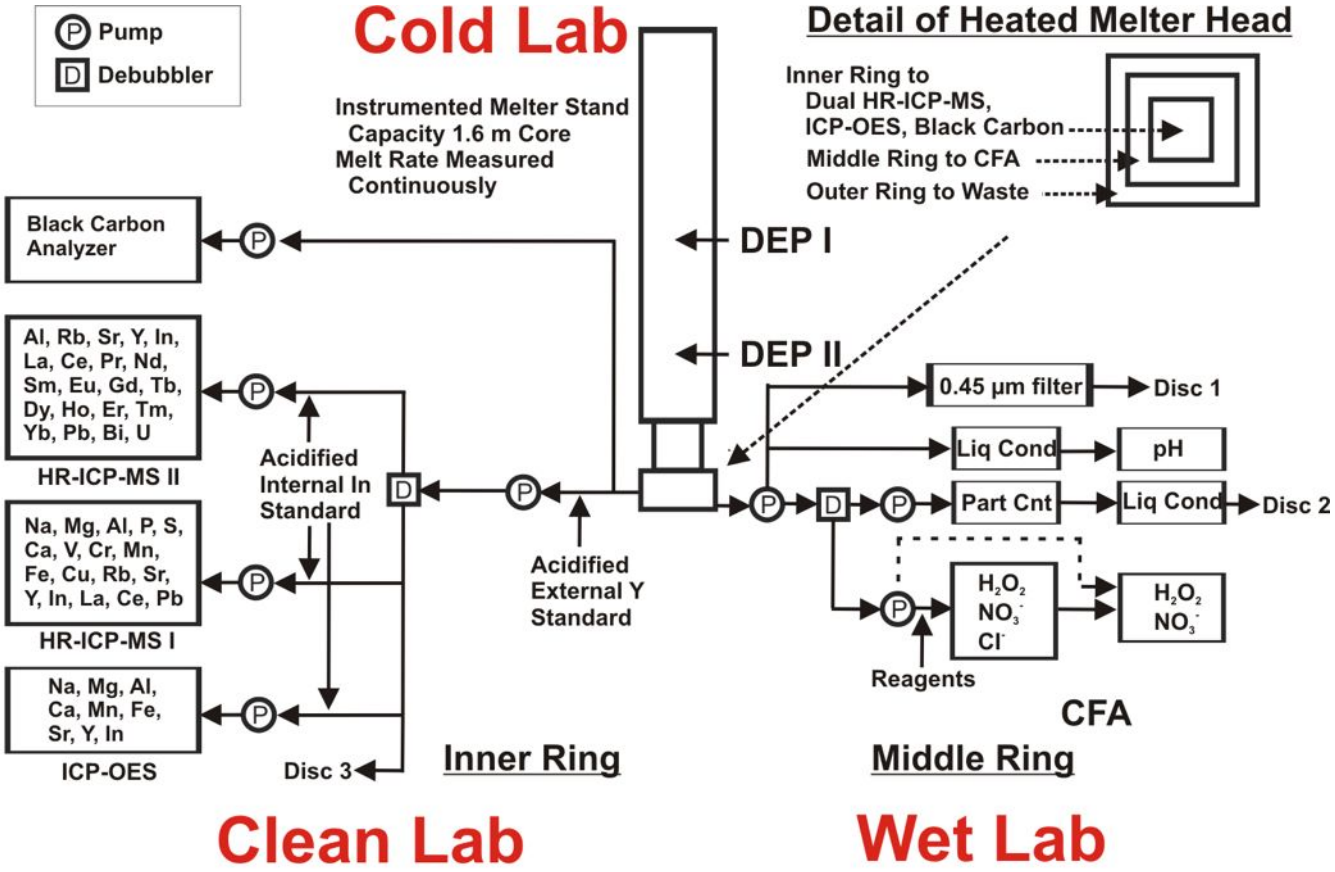


In December of 2009, Joe McConnell at DRI cut up the ice stored at NICL and completed high-resolution, continuous ice core measurements of just about everything one can measure in an ice core



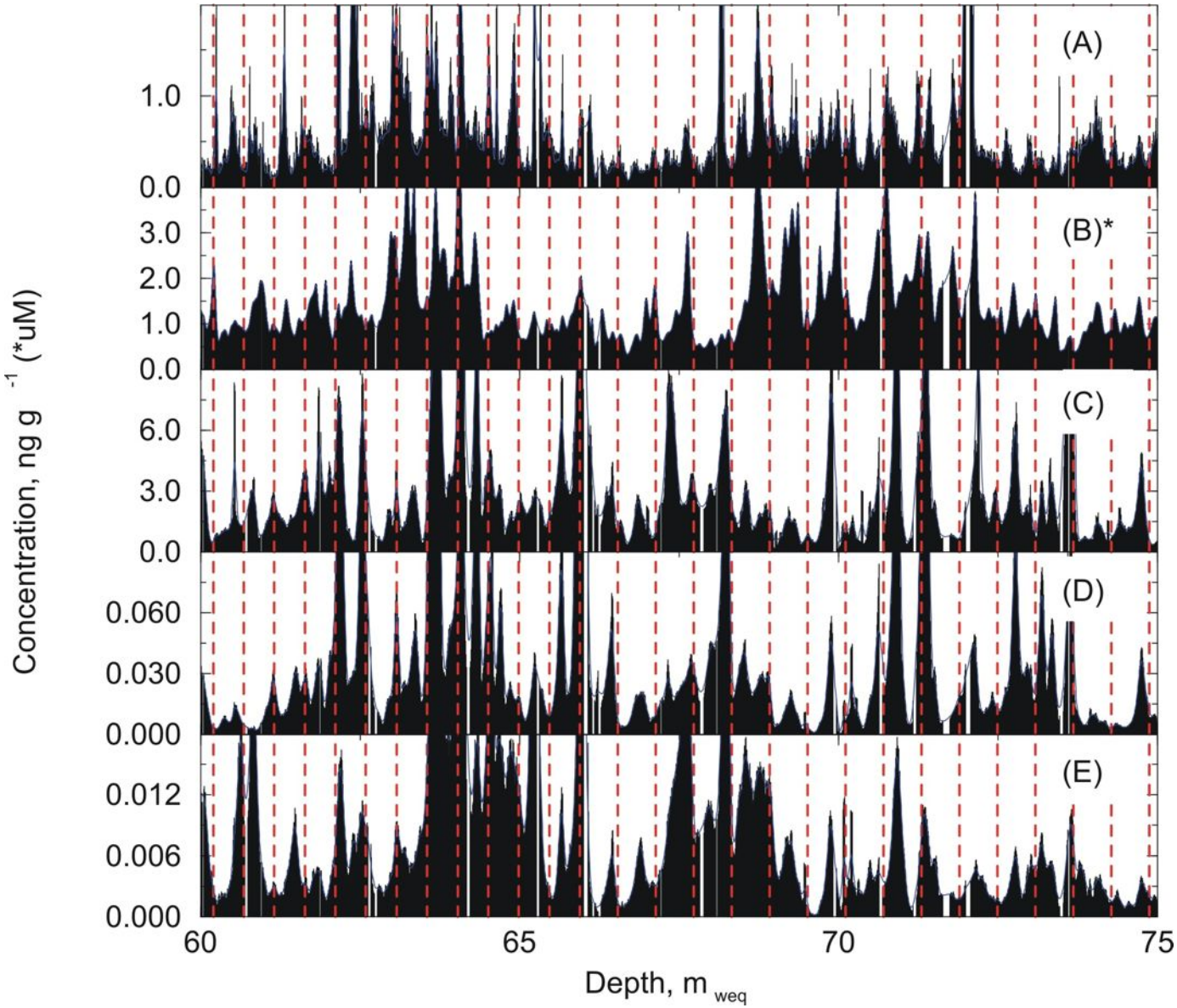


CFA-TED/BC Schematic

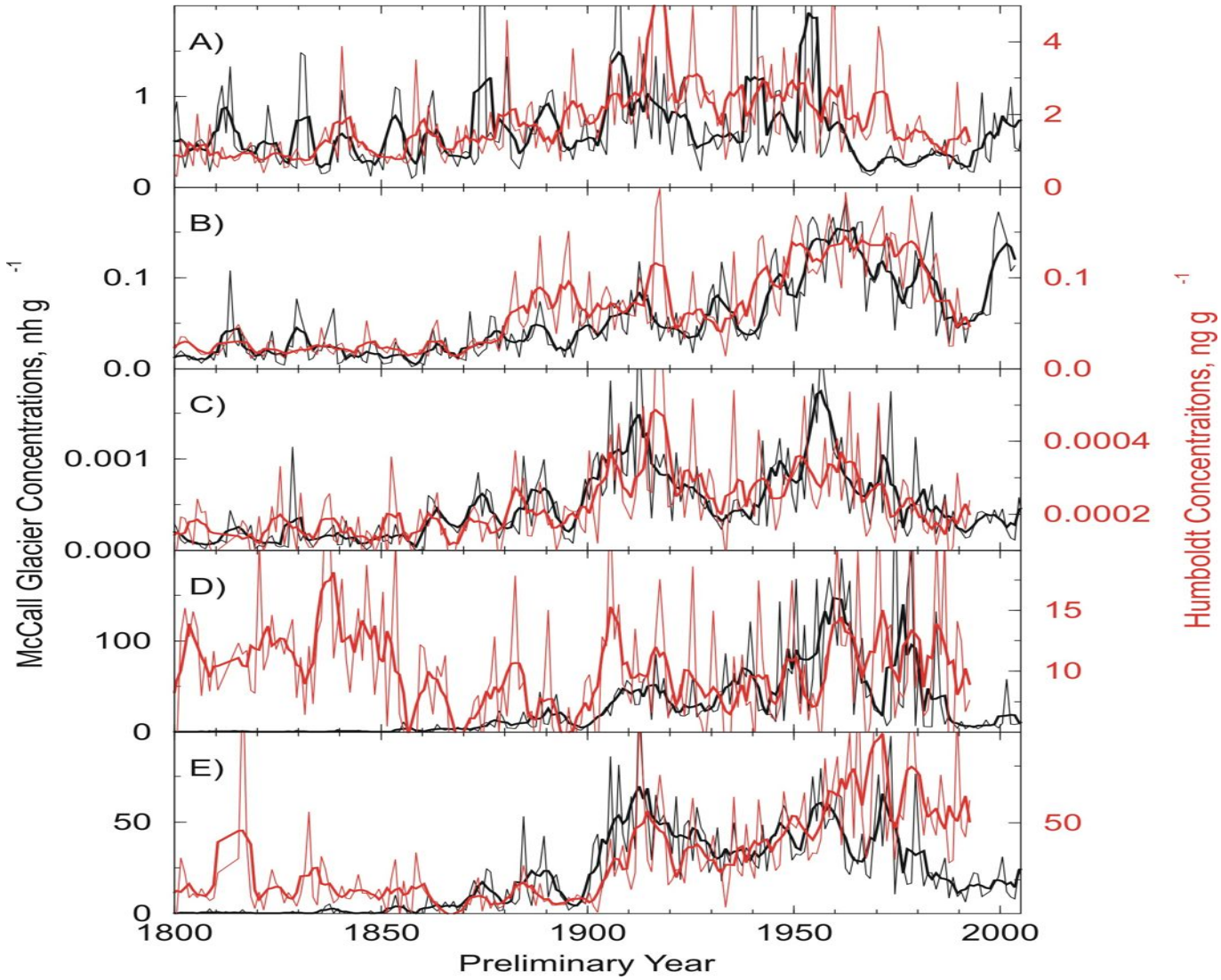


~5 sec dt ~5 mm dz

McCall Glacier Ice Core Record:
Sample annual signals from 60-75m depth



McCall Glacier Ice Core Record:
Sample long term fluctuations 1800AD - 2000AD

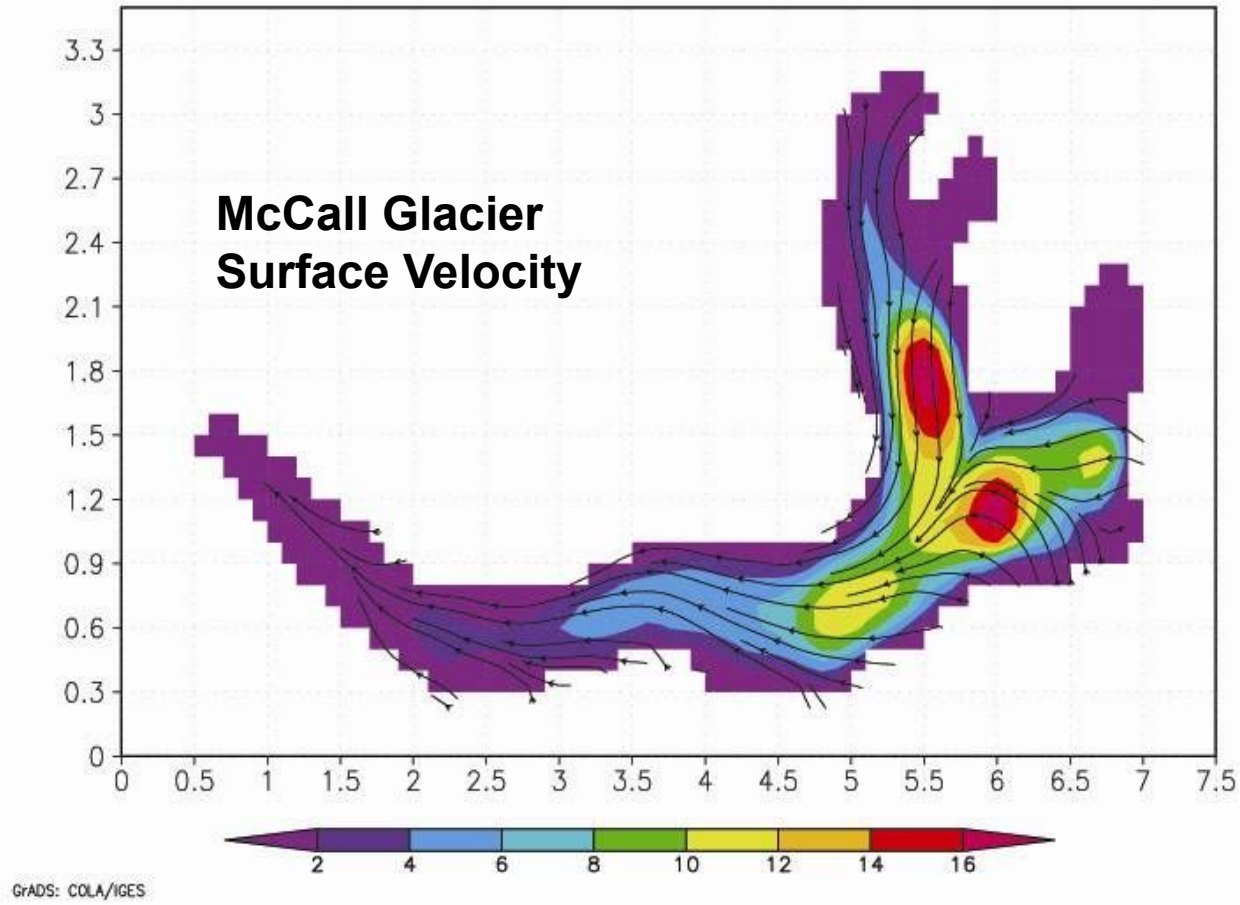


McCall Glacier is in a data-poor region of the Arctic and is unique in that it is not affected by Aleutian Lows like most of the rest of the State

John and Liz Cassano, CIRES

We will use these analyses to help constrain the past 50 years of ice core proxies, such that we will increase our confidence of the 200 years prior to that when we have no climate model data to help guide us.

Bringing it all together: 3D Flow Modeling

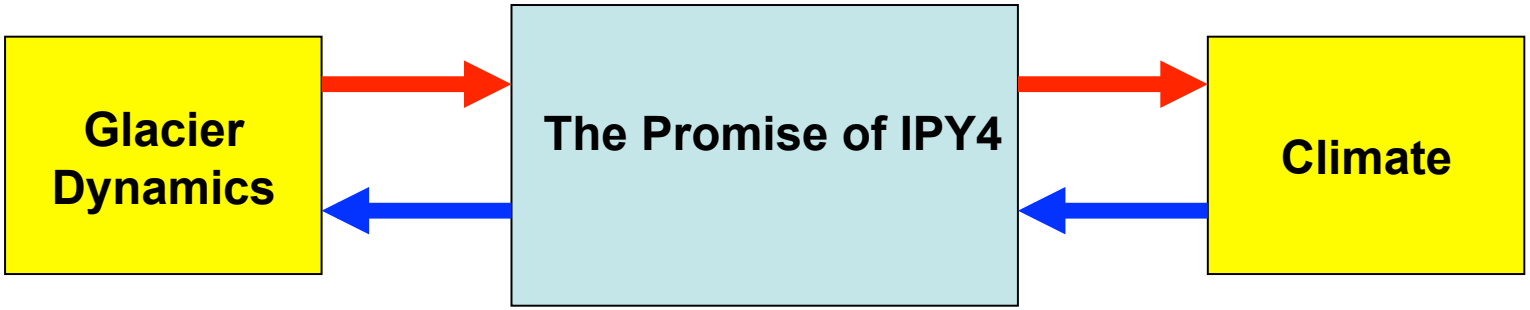


Meters/year

Pattyn and Delcourt, ULB

We have constructed and implemented a state-of-the-art 3D thermo-mechanical model of McCall Glacier using the most comprehensive data set of perhaps any valley glacier (including high resolution surface and basal topography, borehole temperatures, mass balance, and surface velocities).

Conclusions

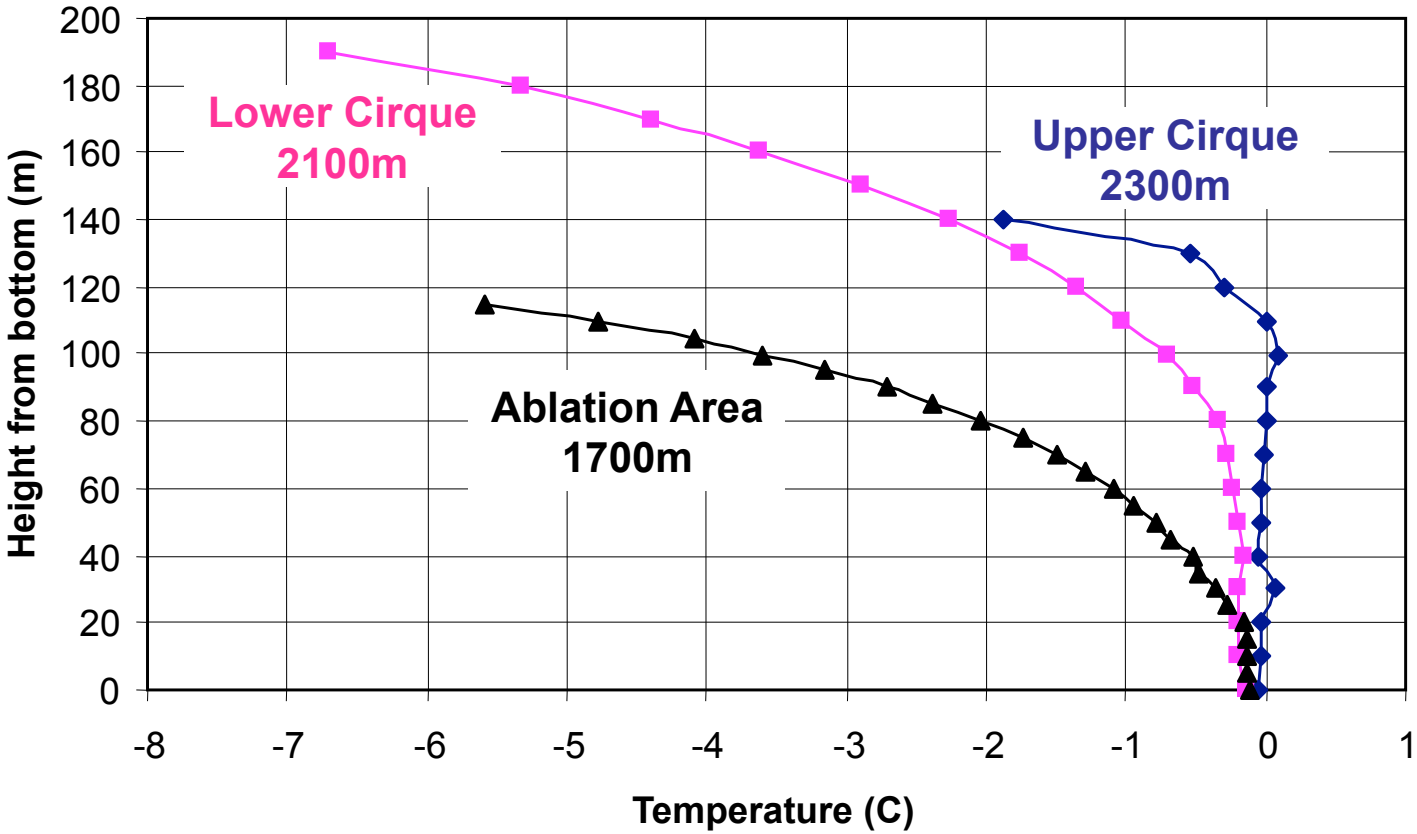


Our goal is to eliminate as much uncertainty as possible as to the State of Arctic Glaciers in the US and their future trajectories, and we think we have a great handle on this thanks to IPY4.

Thank you to the IPY4 McCall Glacier team:
Frank Pattyn and Charlotte Delcourt: Glacier dynamics modeling
Bernhard Rabus: Ice temperature studies
John and Liz Cassano: Climate analyses
Jason Geck: Volume change studies
Joe McConnell: Ice core analyses
Andy Reese: Pollen studies
Kristin and Turner Nolan: Airborne and moral support
Austin Post: Photography and History
National Science Foundation: Generous funding and support

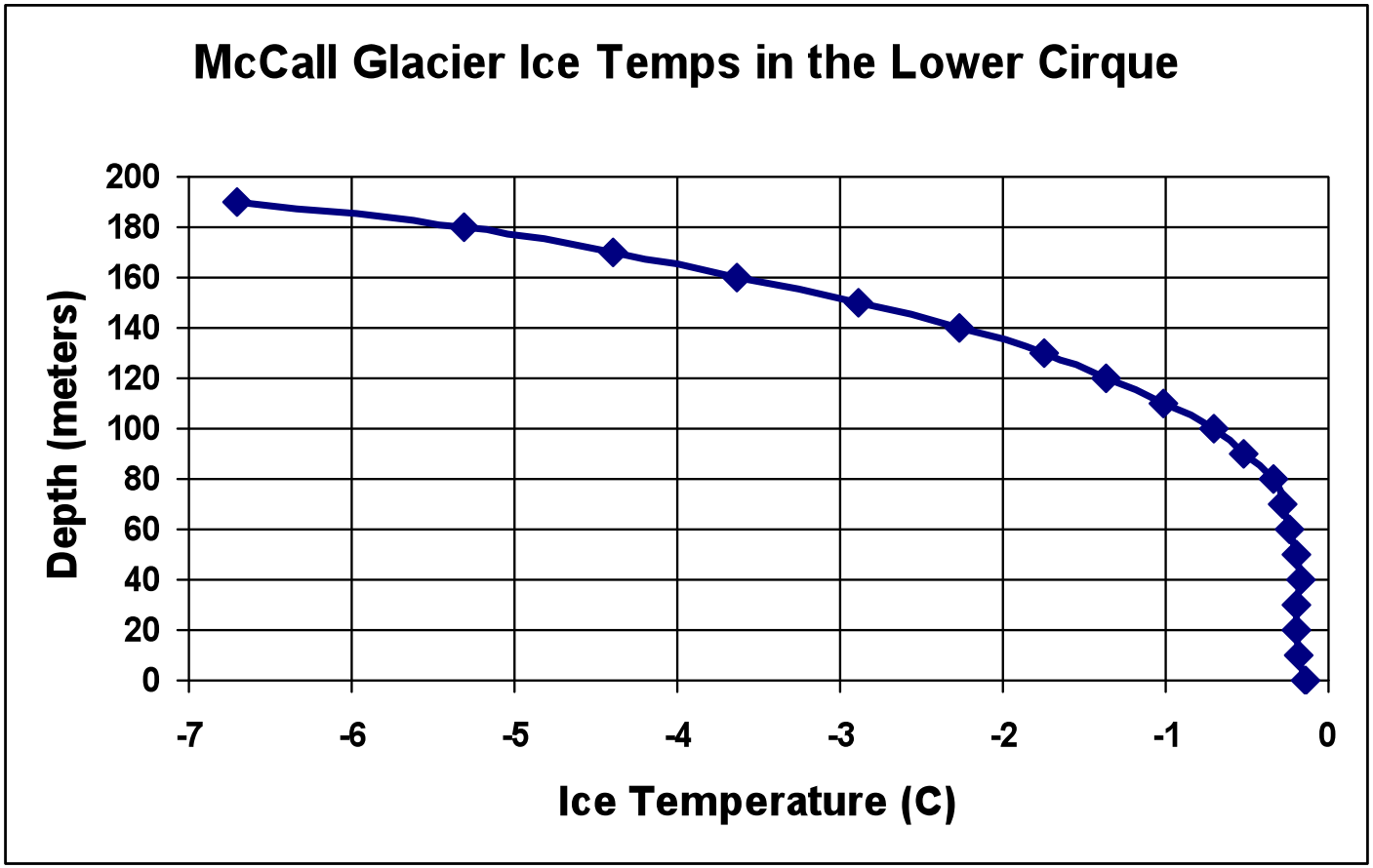
You can find a daily blog of our IPY field efforts on my web site that contains lots of images, panoramas, video, and text suitable for nearly any age group.

McCall Glacier Deep Borehole Ice Temps



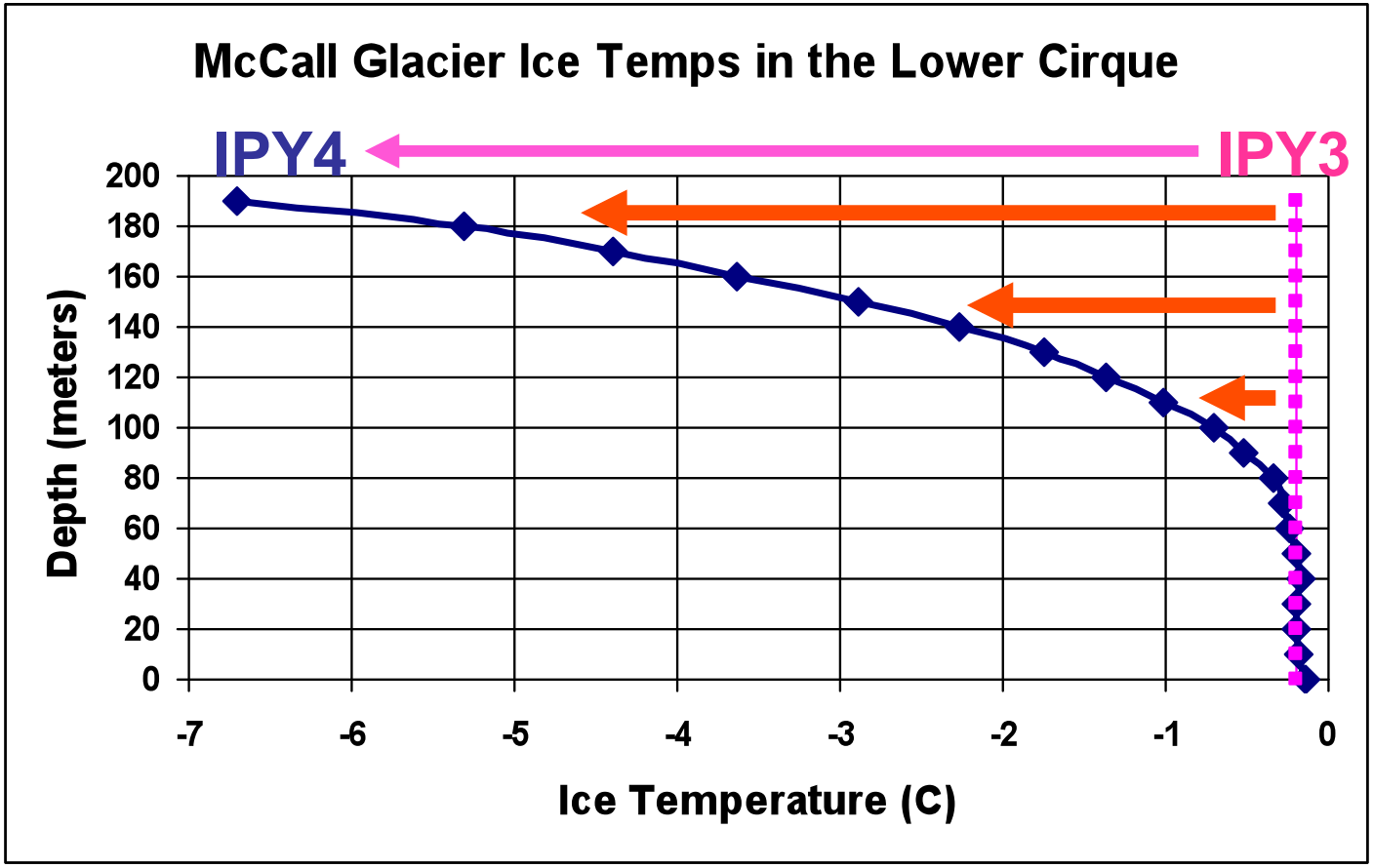
McCall Glacier today is probably as polythermal as it gets,
and the ice gets *warmer* with *higher* elevation.
But the basal ice is temperate everywhere we have a measurement!

Changes in deep ice temperature



In a lower cirque, the ice is substantially colder than it was during IGY.

Changes in deep ice temperature

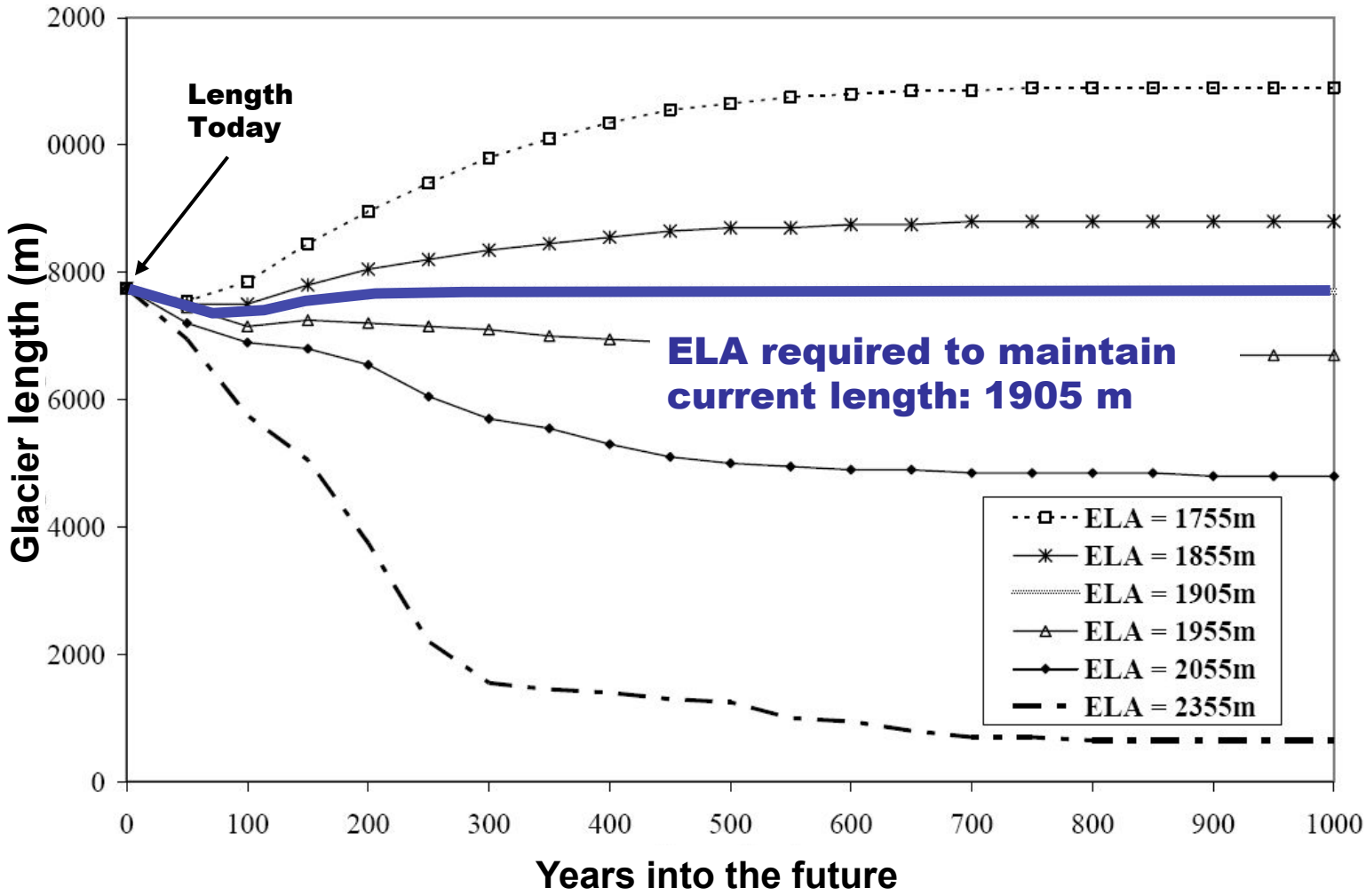


Since the IGY, this area has changed from accumulating ice to losing ice.

So, as the climate warms, the glaciers are cooling!

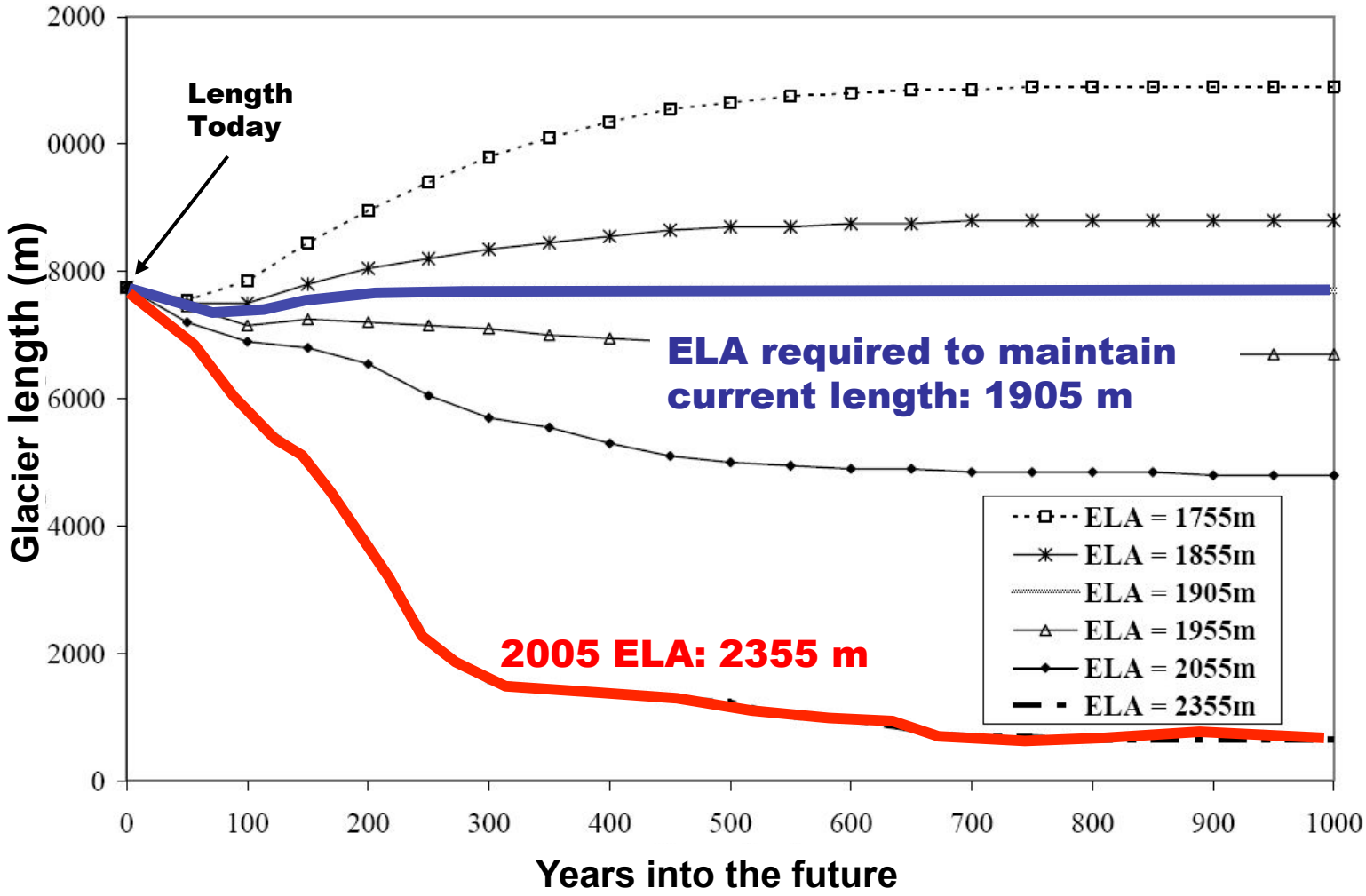
(but this will not slow down loss…)

Our glacier dynamics model integrate all available measurements to build the transfer function we need for future prediction and explanation of prior change



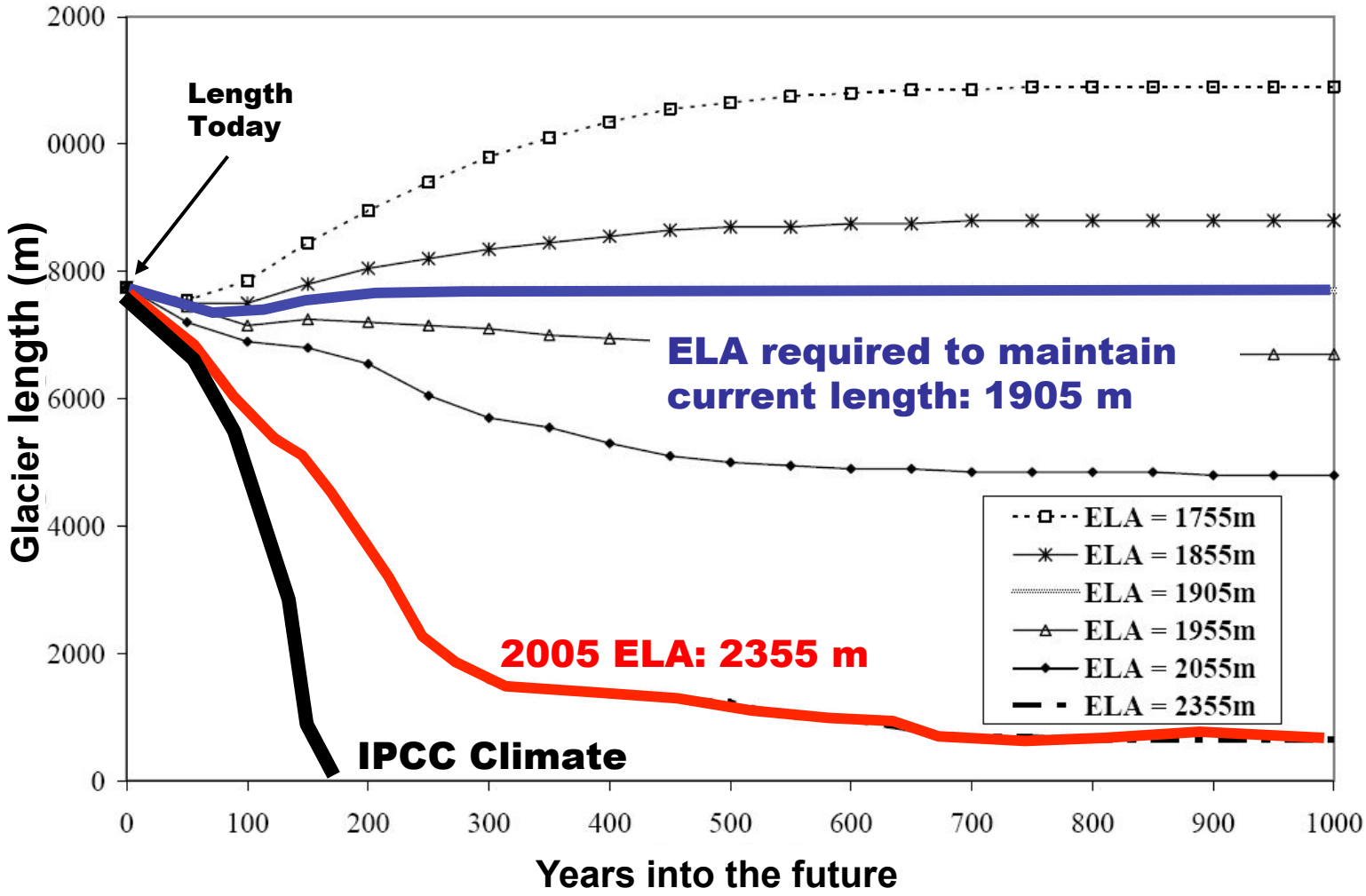
By coupling a surface mass balance model (climate) with the flow model, we can predict future glacier volume and length.

Our glacier dynamics model integrate all available measurements to build the transfer function we need for future prediction and explanation of prior change



If the future climate is exactly like 2005, McCall Glacier will disappear in a few hundred years (and probably much sooner)

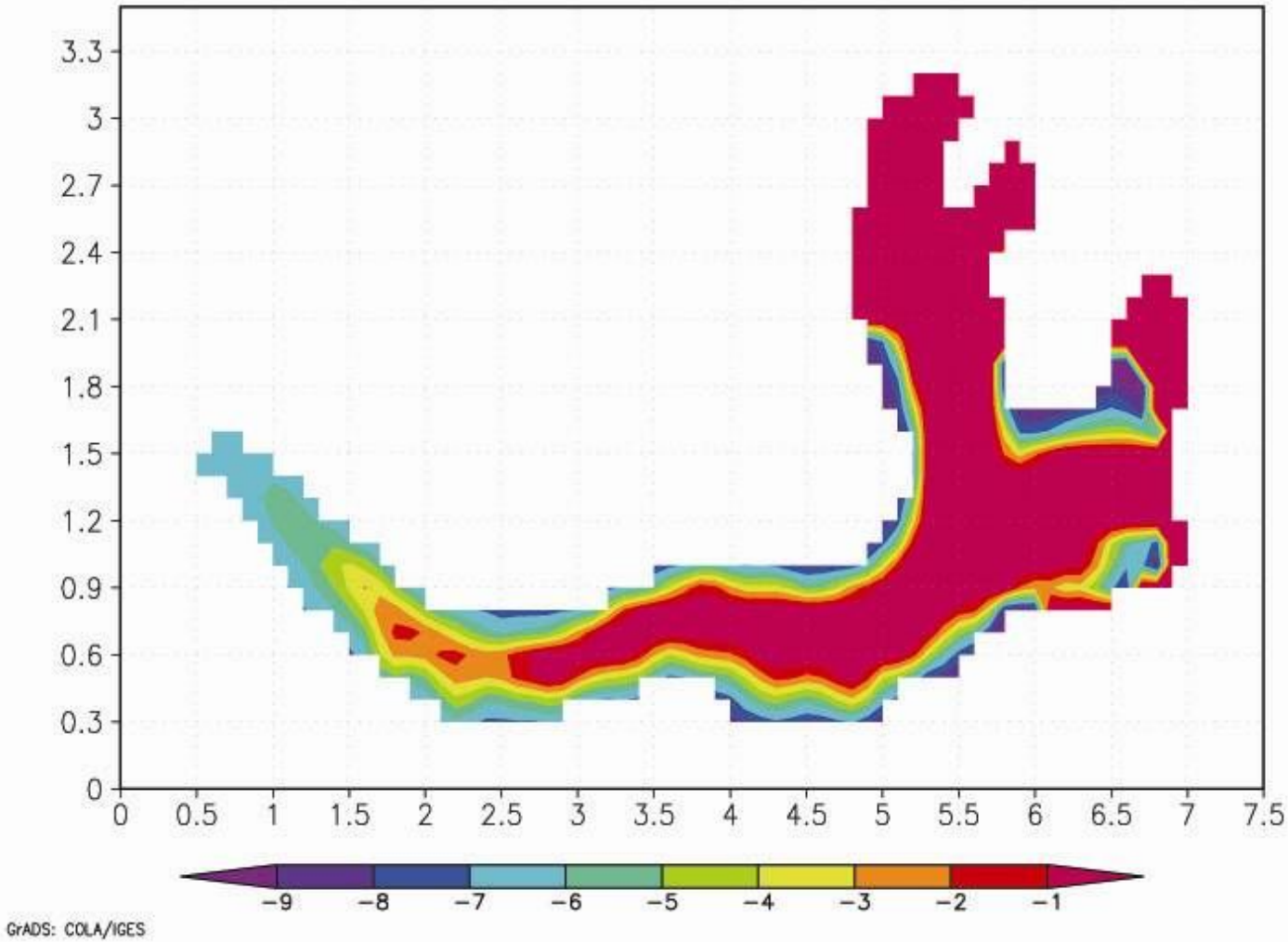
Our glacier dynamics model integrate all available measurements to build the transfer function we need for future prediction and explanation of prior change



If the future climate responds as predicted by climate models, most glaciers here will disappear in less than 100 years, and many in less than 50 years.

McCall Glacier Basal Ice Temperatures (3D Model results)

Remarkably Temperate at the Bed! (thanks to internal accumulation in firn)



Temperature (C)

Sater UC

Coring UC

Clear Ice pano

Ice core panoramas

Field coring:
http://www.360cities.net/image/pano-080503-clearice

Field storage:
http://www.360cities.net/image/ice-cores-in-freezer-on-glacier

Core transport to NICL:
http://www.360cities.net/image/big-dinosaur-in-drumheller-alberta-15-feb-09-1340

NICL Cutting:
http://www.360cities.net/image/pano-090224-1206-the-national-ice-core-laboratory

NICL Storage:
http://www.360cities.net/image/national-ice-core-laboratory-storage-room

You can find tons more panoramas and a complete blog of our 5 months in the Arctic for IPY4 on my website.