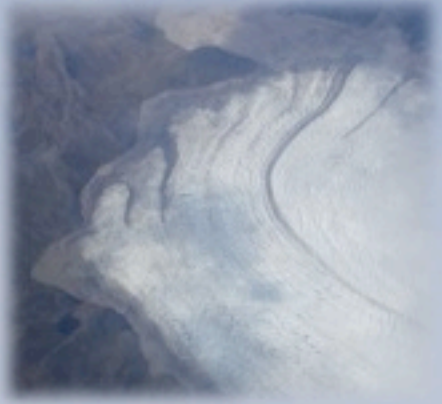
Welcome to Live from IPY!

Science of Greenland

Joint Science Education Tour 2009

8 July 2009

8:00 AM Alaska Daylight Time; 1600 UTC/GMT

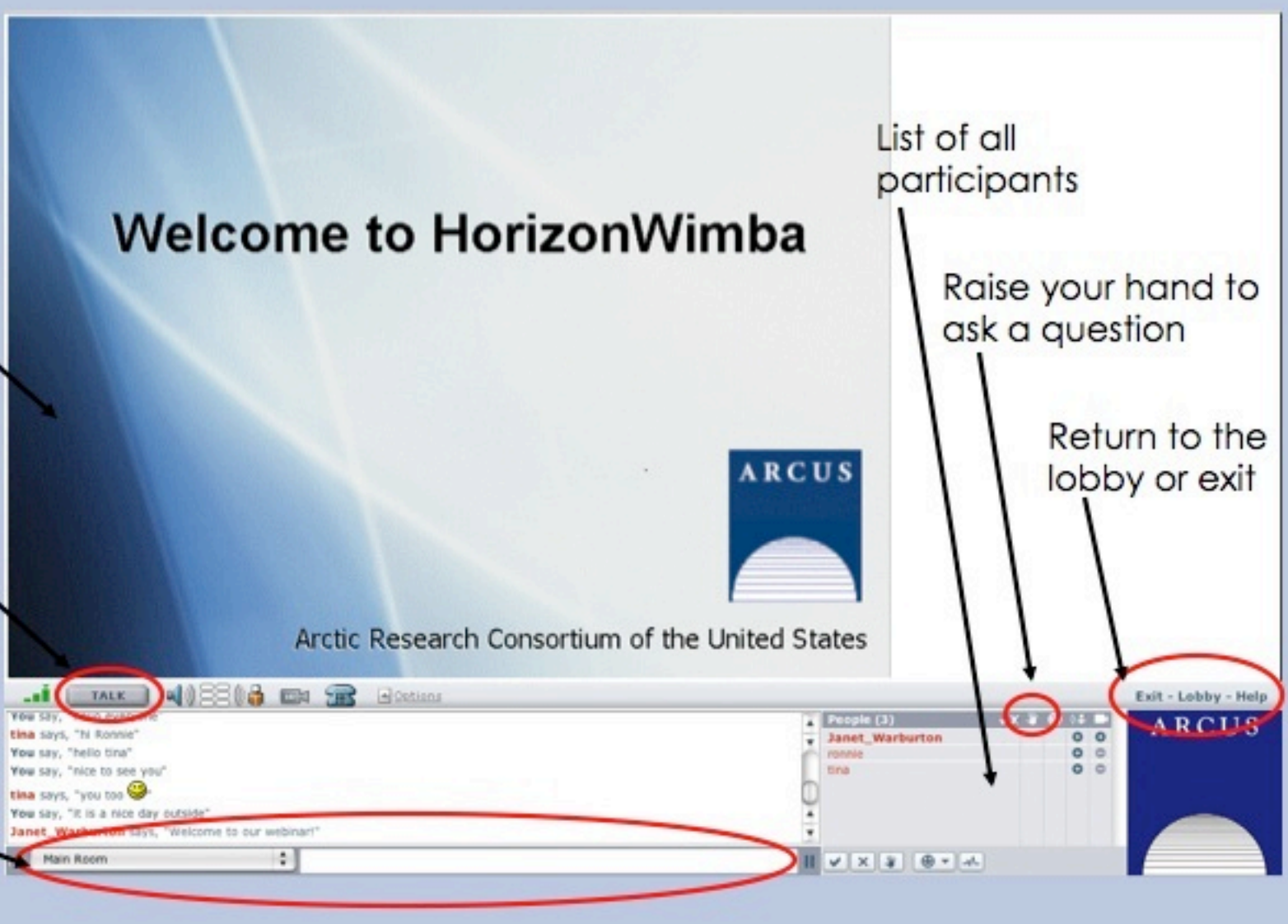
[9AM PDT, 10AM MDT, 11AM CDT, 12PM EDT].

Wimba
people teach people

Slides will be shown here

If using VOIP, press here to talk

'Chat' with one person or the entire group



List of all participants

Raise your hand to ask a question

Return to the lobby or exit

Please note: Today's event will be recorded and archived at www.polartrec.com.

Roll Call

When called, please state your:

- ✓ Name
- ✓ School / Institution
- ✓ The number of others participating with you in the same location

2009 Greenland Joint Education Tour Science Symposium

Tikilluaritsi! Welcome! Velkommen!

Symposium Goals:

Connect and engage the science with culture, education, environmental research, technical assistance, and commercial affairs for a better understanding.

Thanks to scientists for taking time out of their busy summer work days, Renee for the vision and Kristin and Janet for their tireless enthusiasm!

Presenters Locations

Science of Greenland
Science Education Tour 2009

Presenters

Dr. Mary Albert – Cold Regions Research & Engineering
Hanover, New Hampshire, USA

Dr. Carl Leuschen– Center for Remote Sensing of Ice Sheets (CRESIS) Lawrence, Kansas, USA

Dr. Gudfinna Adalgeirsdottier - Danish Climate Centre at the Danish Meteorological Institute, Copenhagen, Denmark

Joel Harper – University of Montana
Missoula, Montana, USA

Dr. Shari Gearheard - CIRES, Univ. of Colorado at Boulder
Clyde River, Nunavut, Canada

Dr. Ross Virginia – Dartmouth College
Hanover, New Hampshire, USA

Dr. Morten Rasch - National Environmental Research Institute
Roskilde, Denmark

Dr. Mary Albert

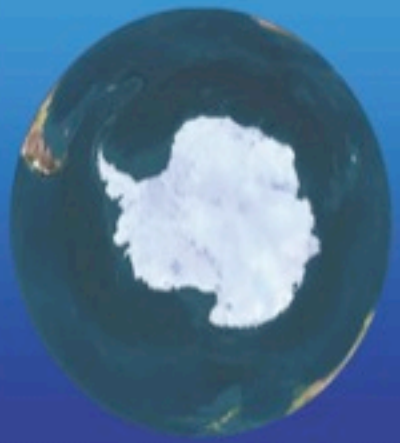
Research Mechanical Engineer - Cold Regions Research and Engineering Laboratory

Adjunct professor at the Thayer School of Engineering at Dartmouth College

Research Interests: Heat, mass, and chemical transport in porous media, Snow-air transfer processes, Snow physics, Numerical analysis and Modeling.

Climate Change and the Polar Regions

Dr. Mary R. Albert
Thayer School of Engineering, Dartmouth College
Hanover, NH

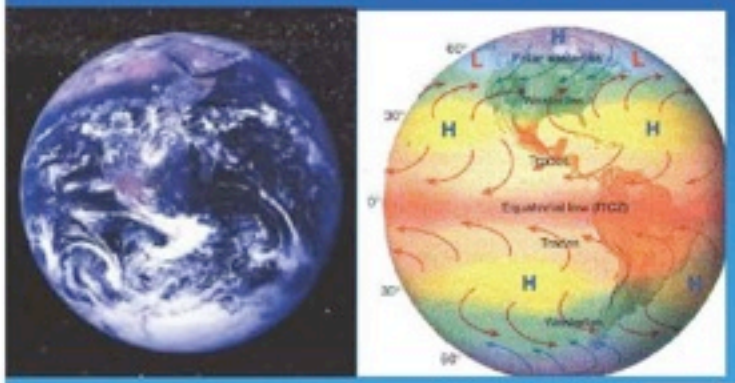


Overview

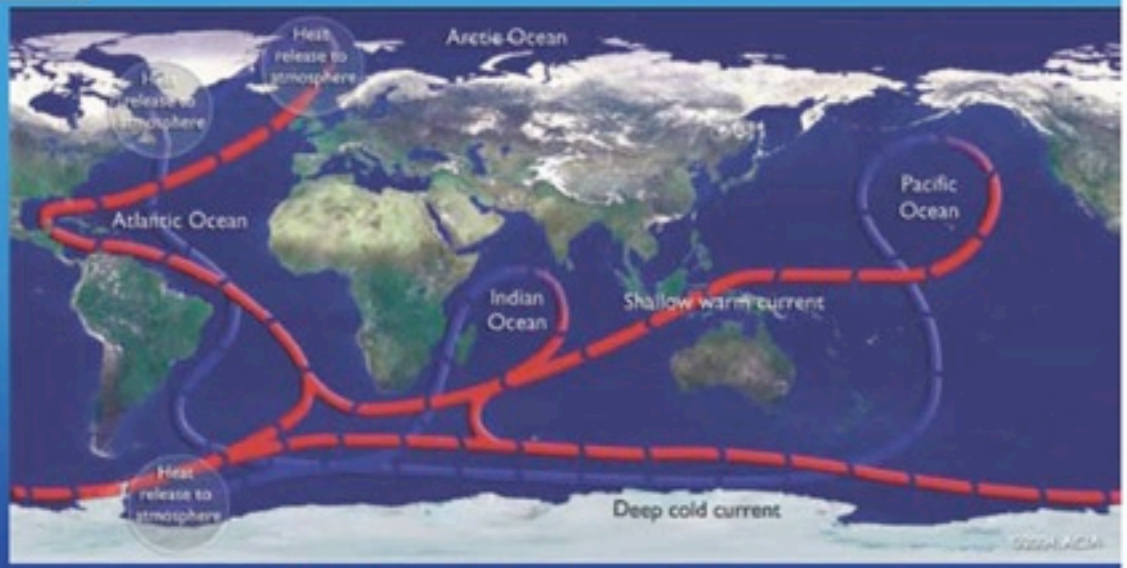
- Intro: Earth is a system of systems
- Polar ice and climate
- Do we know enough to act?

The Earth is a system of systems

what happens in one part will affect another

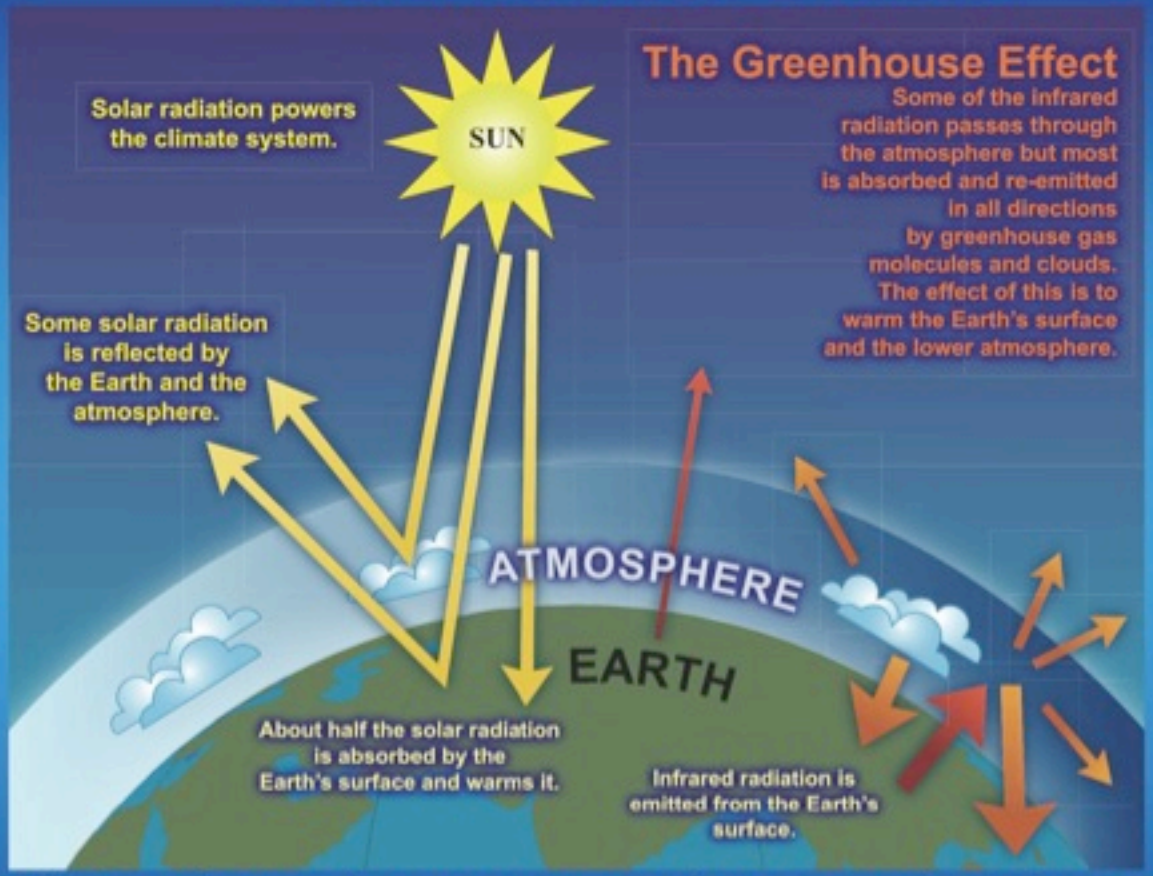


Atmospheric circulation



global ocean circulation

Greenhouse effect



The addition of greenhouse gases to the atmosphere increases the greenhouse effect, warming the earth more and more.

This is changing our climate now.

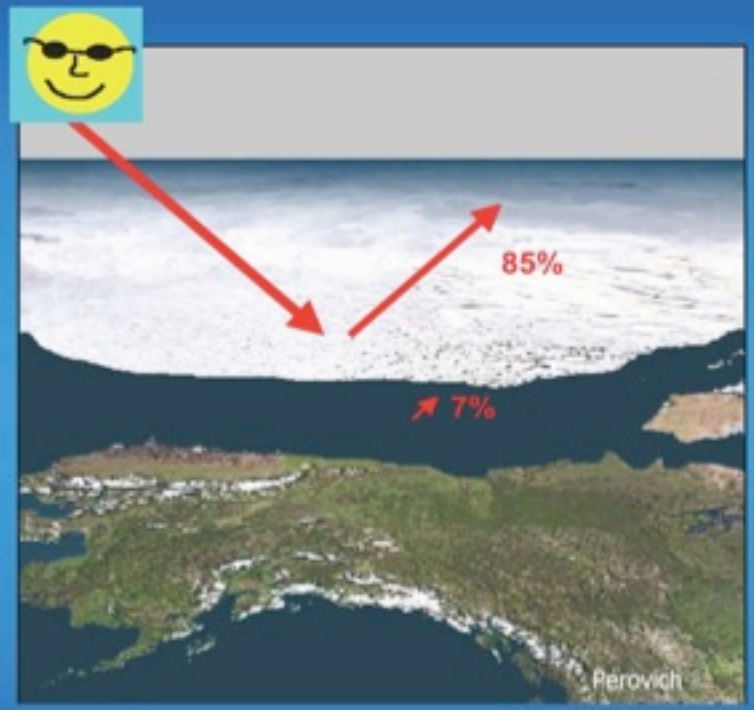
M Albert for PolarTrec 2009

Polar regions are important for global climate

Snow and ice are sensitive indicators of change

M Albert for PolarTrec 2009

Snow & ice control feedbacks of Earth's energy balance



* Snow reflects 85% of the sun's energy, water reflects only 7%
* Sun's energy warms open water, melting ice, creating more open water, melting more ice, etc. This is a positive feedback loop.

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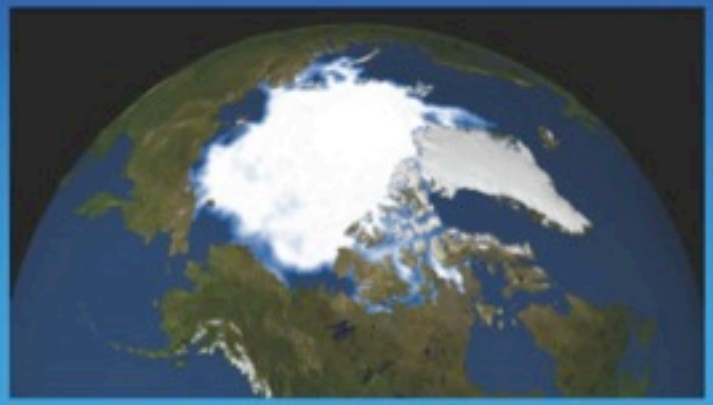
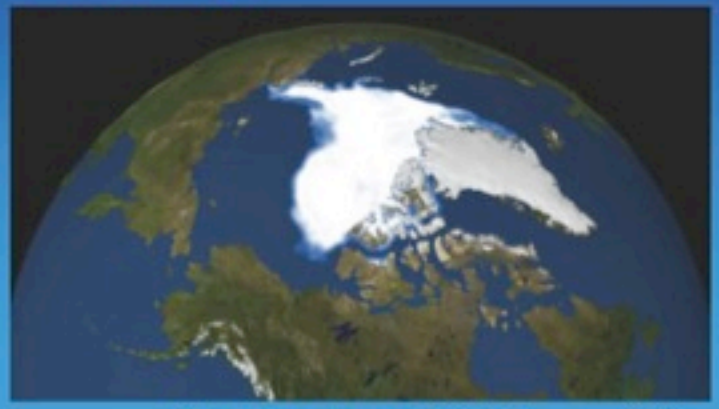
The extent of early autumn Arctic sea ice is decreasing

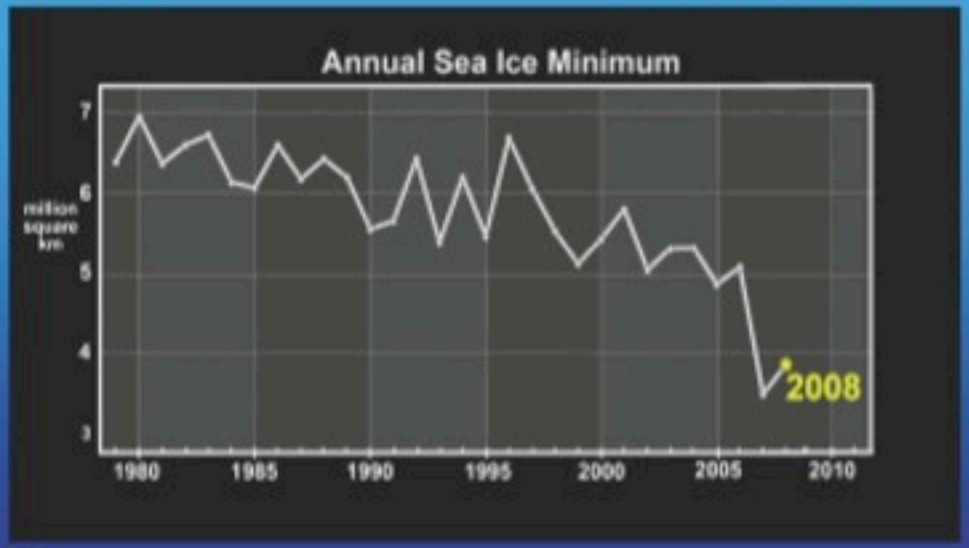


September 1980



September 2007

NASA



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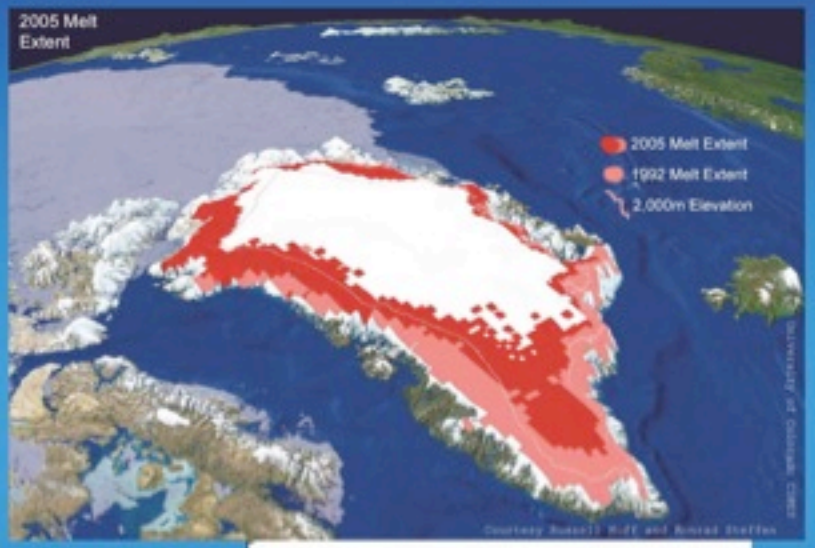
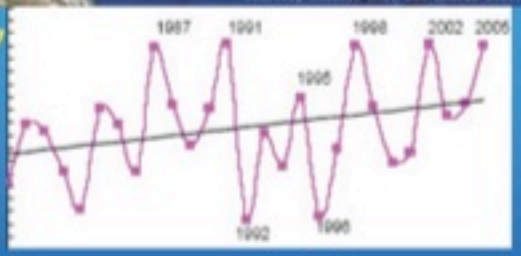
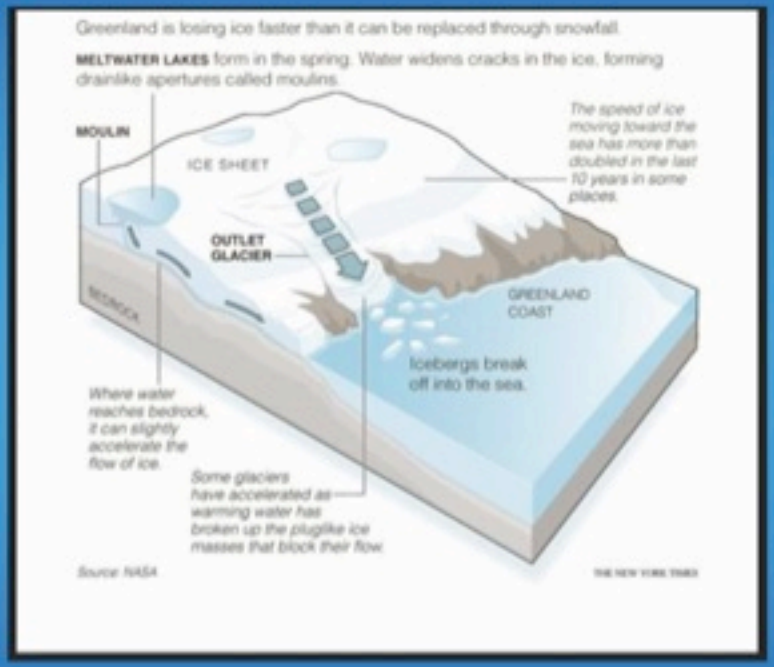
Greenland ice sheet melt extent is increasing



Steffen, 2007





Also, melt water flowing into crevasses/moulins makes the edges slide faster.
The Greenland ice sheet is losing mass faster than models predicted.

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Ice sheet melting or growing affects sea level

Burroughs, 1999

- sea level is low when ice sheets are big, and
- sea level is high when ice sheets have melted.

- Contributions: Greenland 7m, Antarctica 61 m

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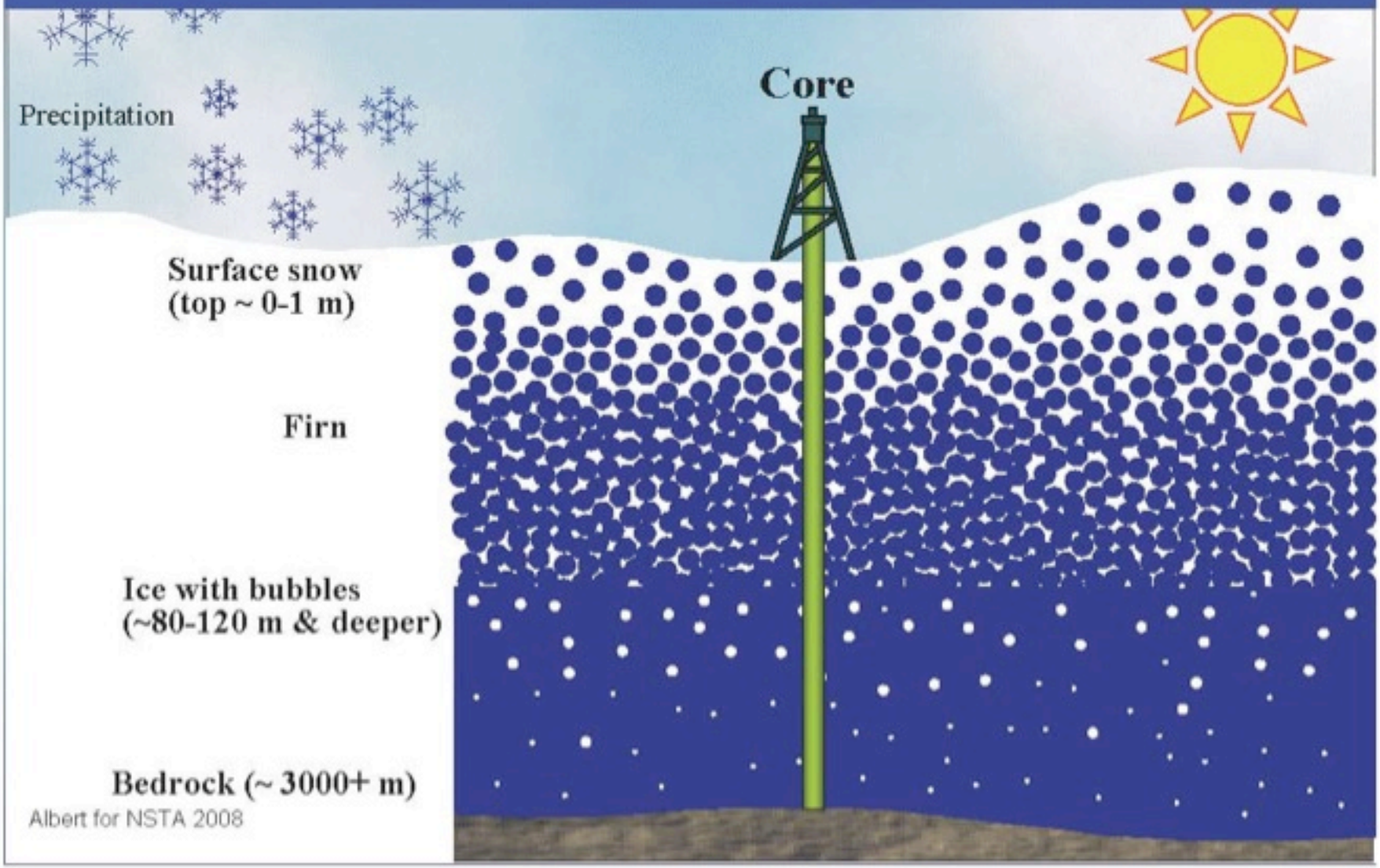
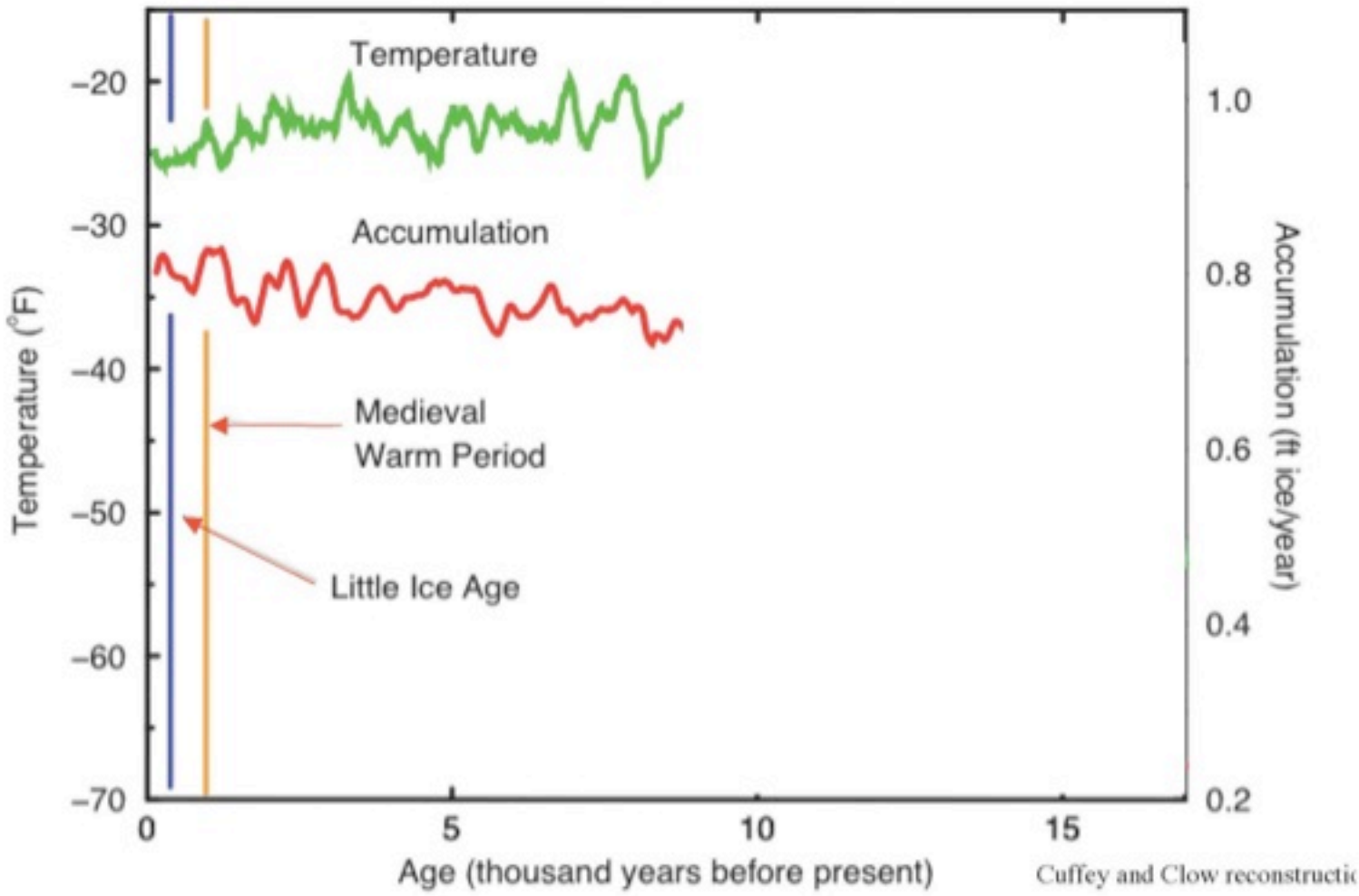
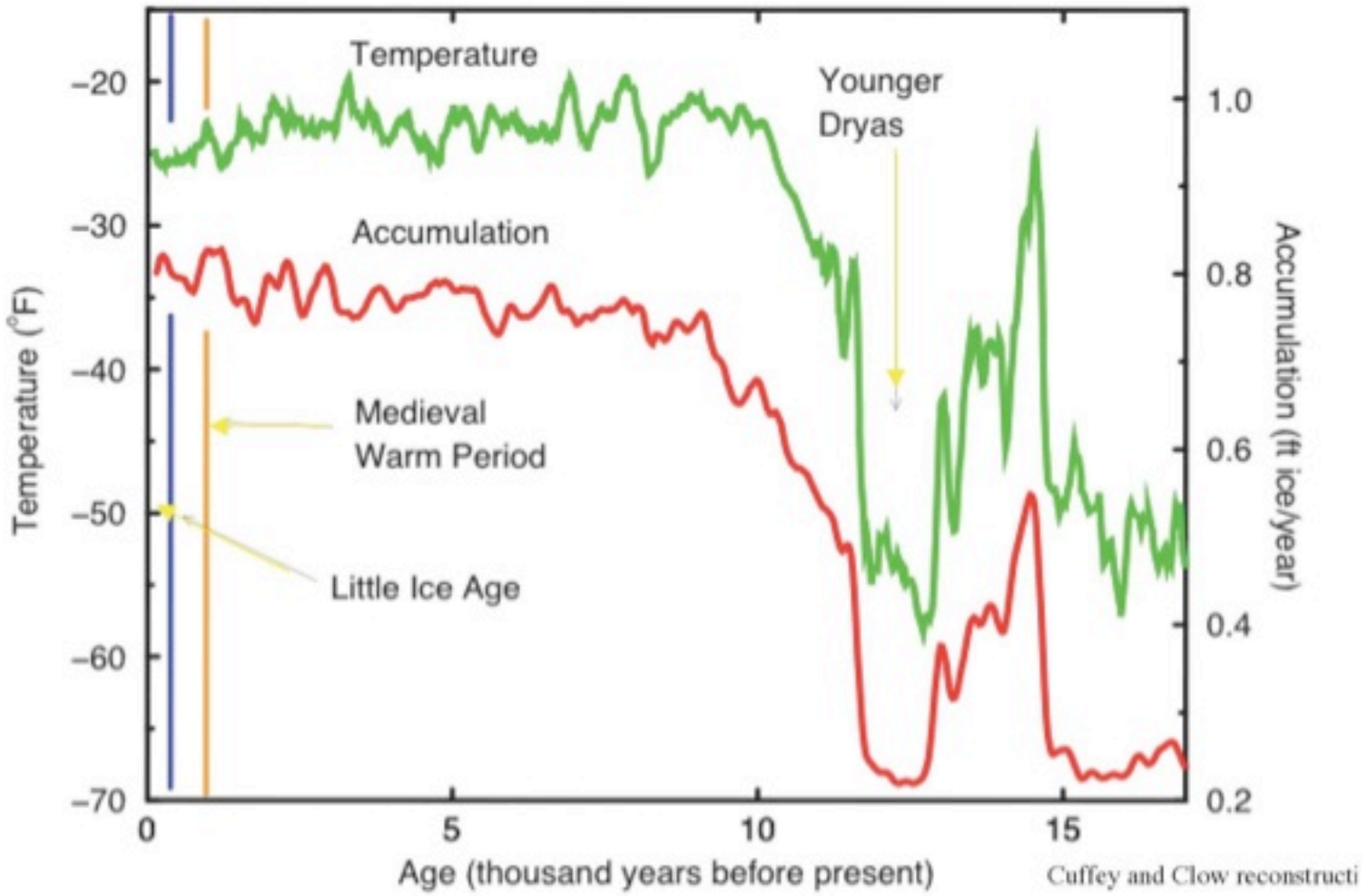
Ice cores show us how fast climate can change



Evidence from ice cores show temperature chang that we know impacted human lifestyles …



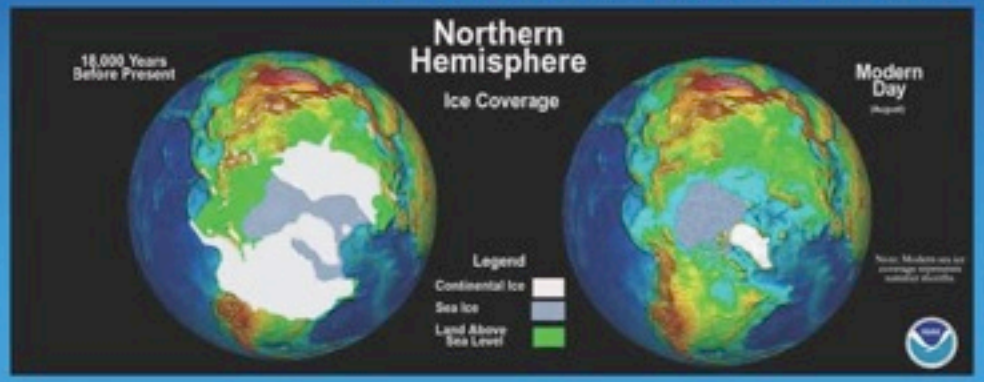
But those changes were small compared to the climate chang
before that! Climate change can occur abruptly, in less than
years!!

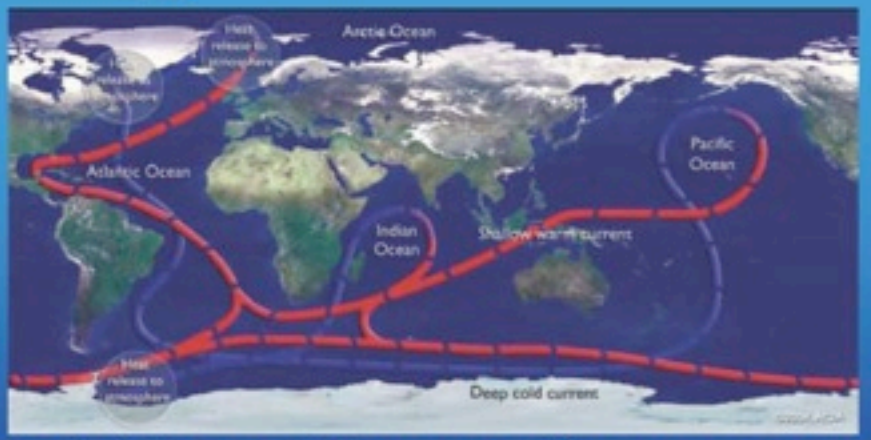


Cuffey and Clow reconstructi

Melting of the Laurentide ice sheet stopped global ocean circulation 13,000 years ago.

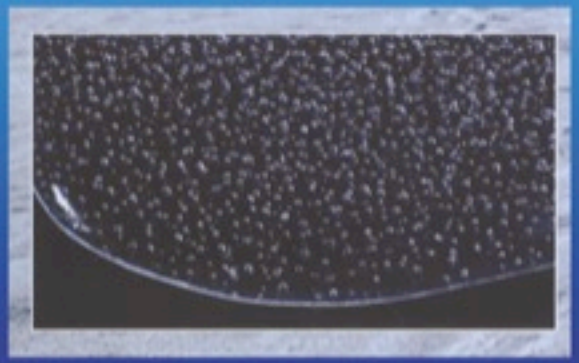
It took more than 1,000 years to start up again

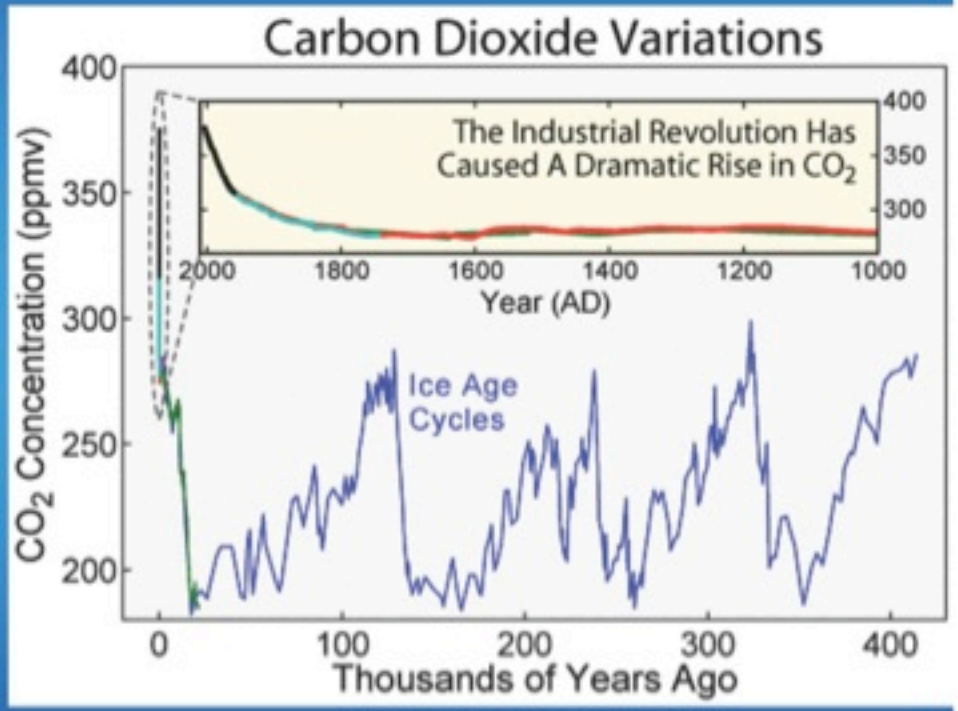




Slowing ocean circulation yields colder north, warmer equator, & changing weather patterns in between

CO_2 in the atmosphere now is higher than ice core evidence over the last 800,000 years





Evidence from the past enables preparation for the future

Polar science taught us that we need to think about climate change on timescales of decades or less, rather than millennia, when contemplating our future.

M Albert for PolarTrec 2009

Summary

- The Earth is a system of systems; changes in one part affect another
- The polar regions are important for global climate
- Polar science has taught us a lot, including
  - climate can change abruptly in less than 10 years
  - Feedbacks & nonlinearities in the sea ice & ice sheet systems can make change occur faster than expected
  - current levels of CO_2 are higher than evidence from the past 800,000 years

There is ample reason now for us to stop provoking climate change with emissions from burning, and move quickly toward new technology for sustainable energy.

Thank you

Thanks to the National Science Foundation for funding me for polar science

Thanks to PolarTrec for enabling teacher involvement in polar science

Thank you, teachers, for using evidence-based science when teaching the scientists and engineers of tomorrow!

Dr. Carl Leuschen

Professor at University of Kansas at Center for Remote Sensing of Ice Sheets (CReSIS)

Research interests: MARSIS sounding radar, MARS EXPRESS Satellite and the SHARAD sounding radar aboard the NASA Mars Reconnaissance Orbiter. JHU/APL airborne Ku-Band Delay-Doppler Phase-Monopulse (D2P) radar altimeter over glaciers, ice sheets, and sea ice in support of Cryosat pre-launch validation and AMSR-E calibration.

Center for Remote Sensing of Ice Sheets

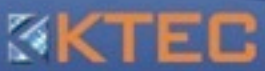
S. Gogineni

C. Leuschen

NATIONAL SCIENCE FOUNDATION :: KANSAS TECHNOLOGY ENTERPRISE CORPORATION :: NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

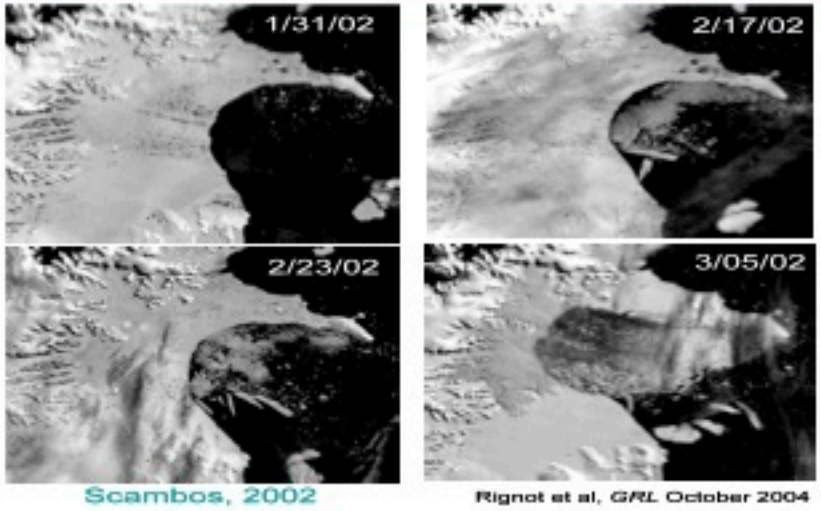
The University of Kansas | The Ohio State University | Pennsylvania State University
The University of Maine | Elizabeth City State University | Haskell Indian Nations University

Centre for Polar Observation and Modelling | University of Copenhagen
Technical University of Denmark | Antarctic Climate & Ecosystems CRC



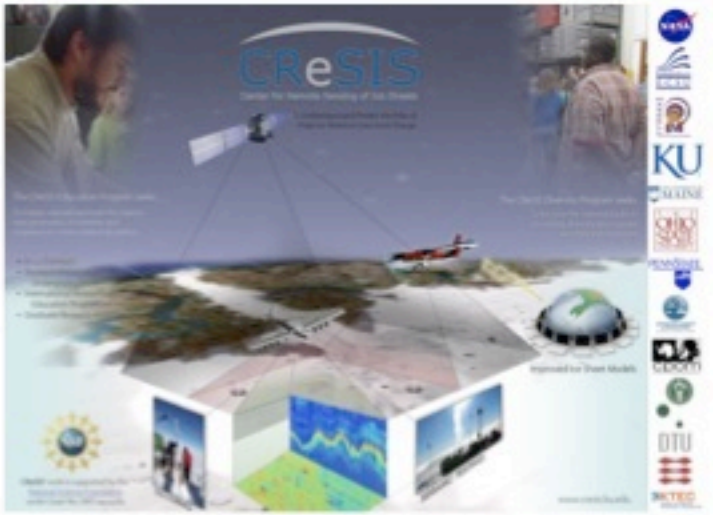
CReSIS

Introduction— Rapid changes



Scambos, 2002

Rignot et al, *GRL* October 2004



- Satellites are revolutionizing the study of ice sheets
- Rapid changes
  - Breakup of floating tongues
  - Changing basal conditions
- 3-D view of the ice sheet
- Fine resolution in transition areas

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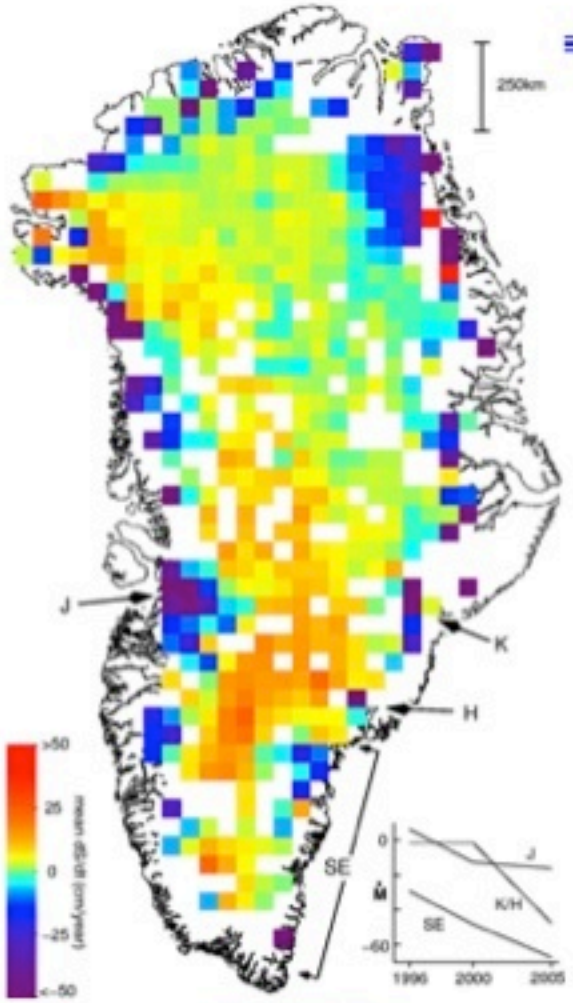
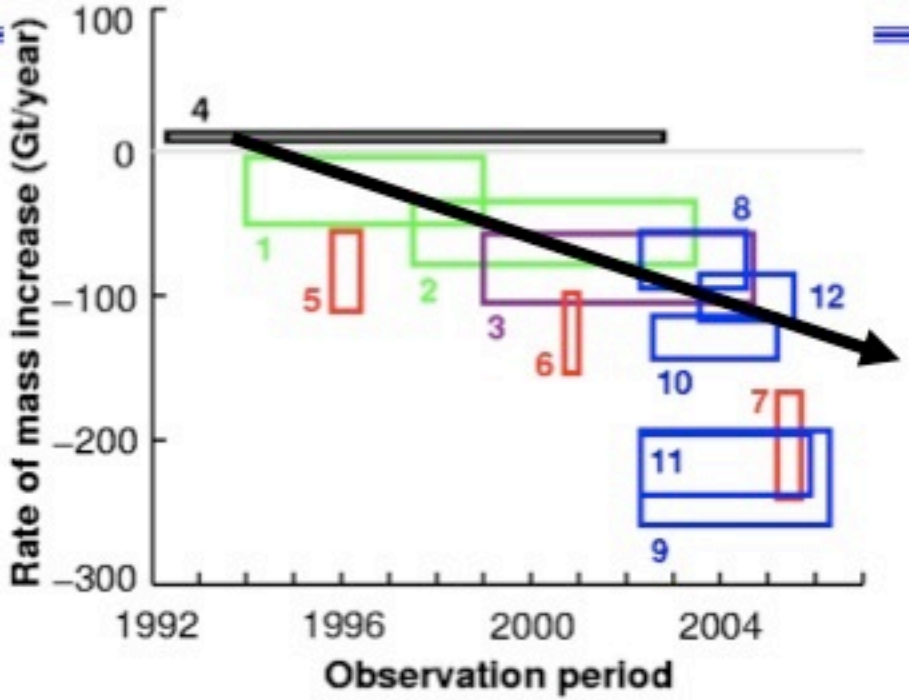
Greenland mass balance



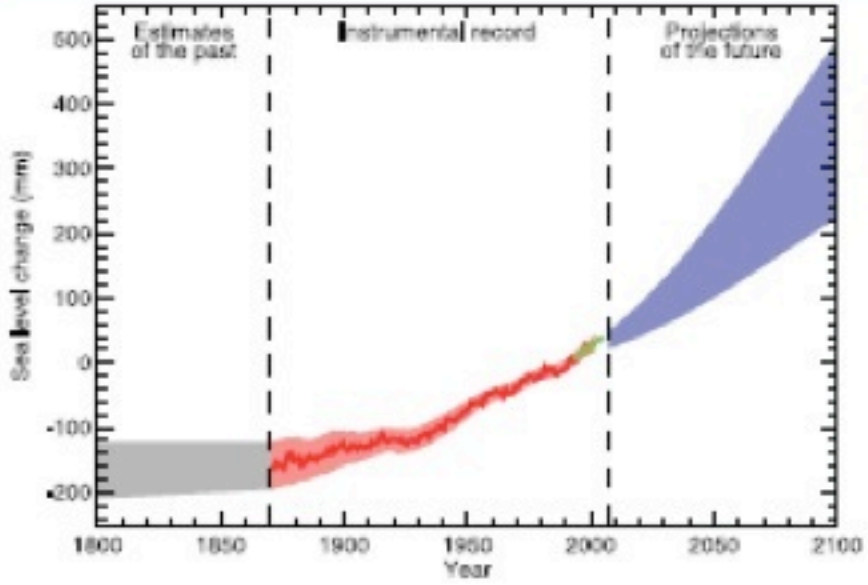


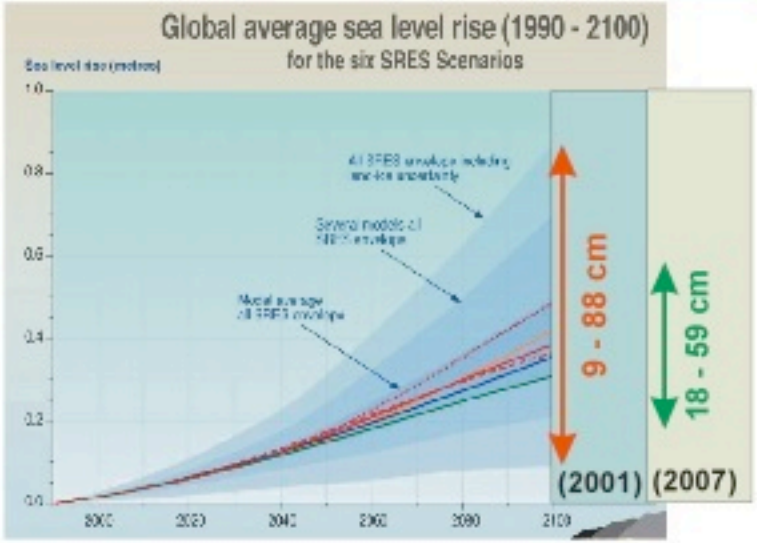
Black: ERS radar altimeter data
Green: ATM laser-altimeter surveys
Purple: ATM/ICESat comparisons
Red: Mass-budget estimates
Blue: GRACE gravity estimates

Thomas(2008)

CReSIS

Sea Level Rise





"Dynamical processes related to ice flow not included in current models but suggested by recent observations could increase the vulnerability of the ice sheets to warming, increasing future sea level rise. Understanding of these processes is limited and there is no consensus on their magnitude." *IPCC Summary For Policy Makers (2007)*

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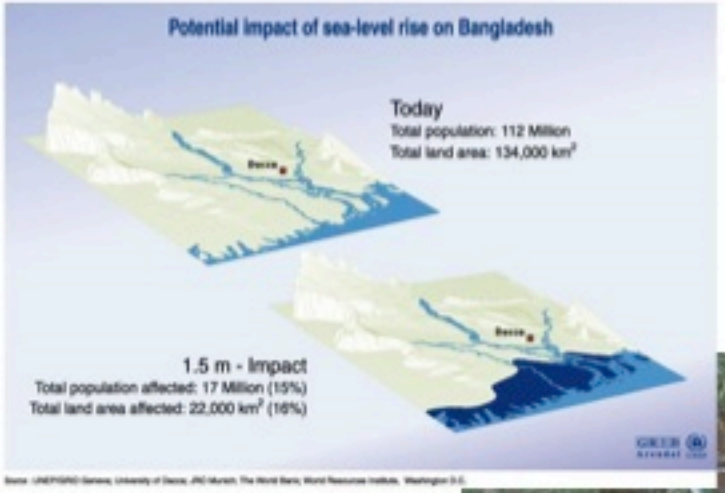
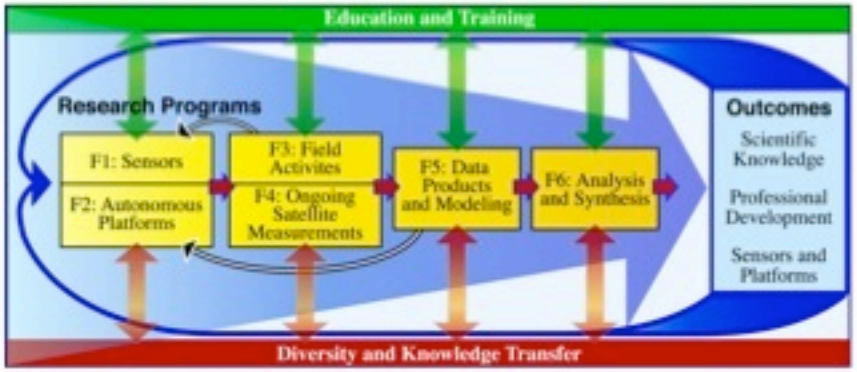
Sea Level Rise Impacts



CReSIS

Background— CReSIS

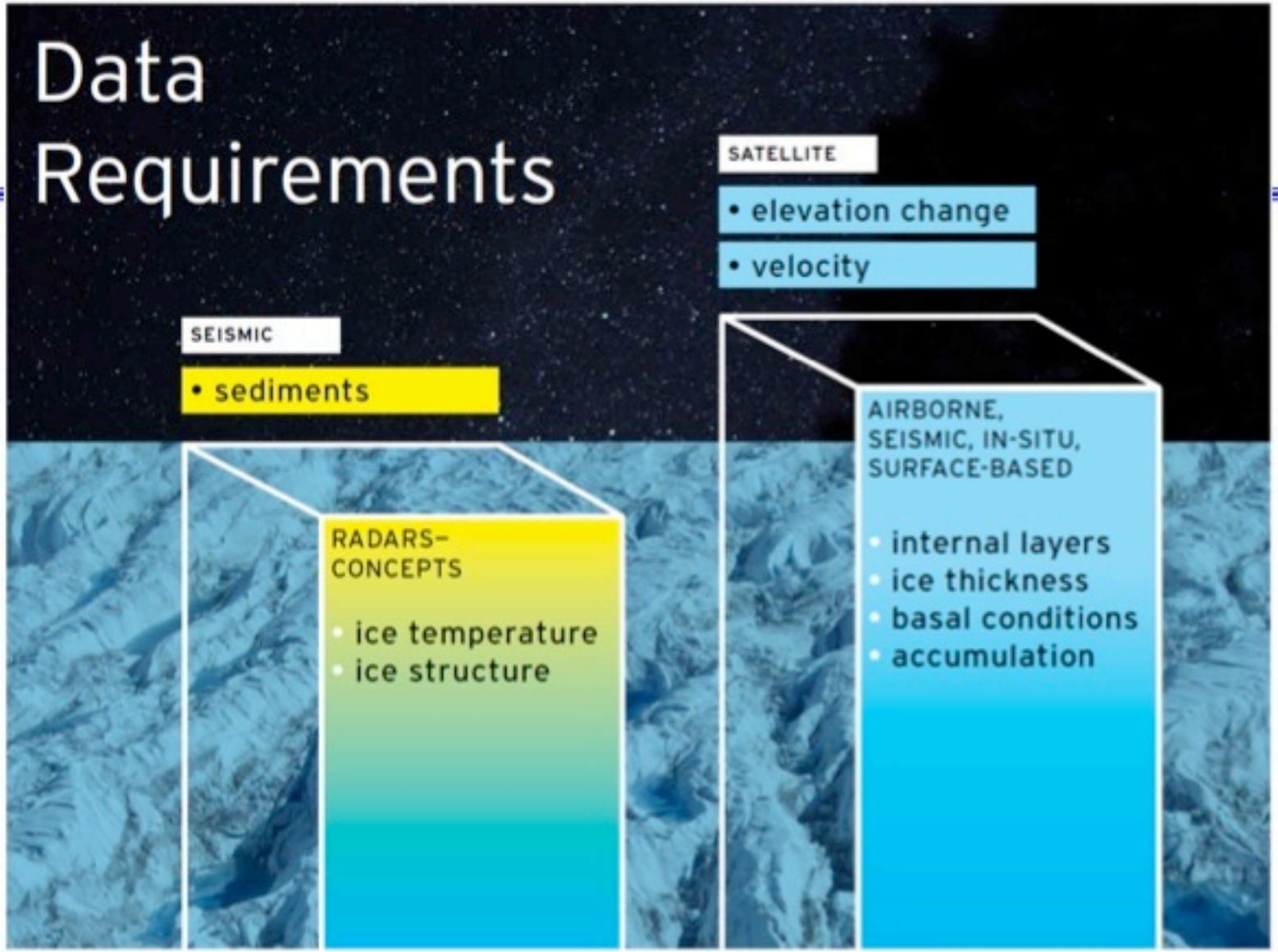
- Integrated research, education & diversity, and knowledge transfer program
- 6 US and 4 International Institutions
- Research
  - Technology and tools
  - Field programs
  - Data Products
  - Models
- Education & Diversity
  - K-12 to Post-doctoral
- Knowledge Transfer
  - Scientific and technical community
  - Public and policy makers



Program	Concept	Demonstration	Operational
LEOS	1958	1960-1968	1970
GEOS	1962	1966-1974	1975
UAVs, Sensors and Rovers	2002-2004	2005-2012	2013-2015

CReSIS

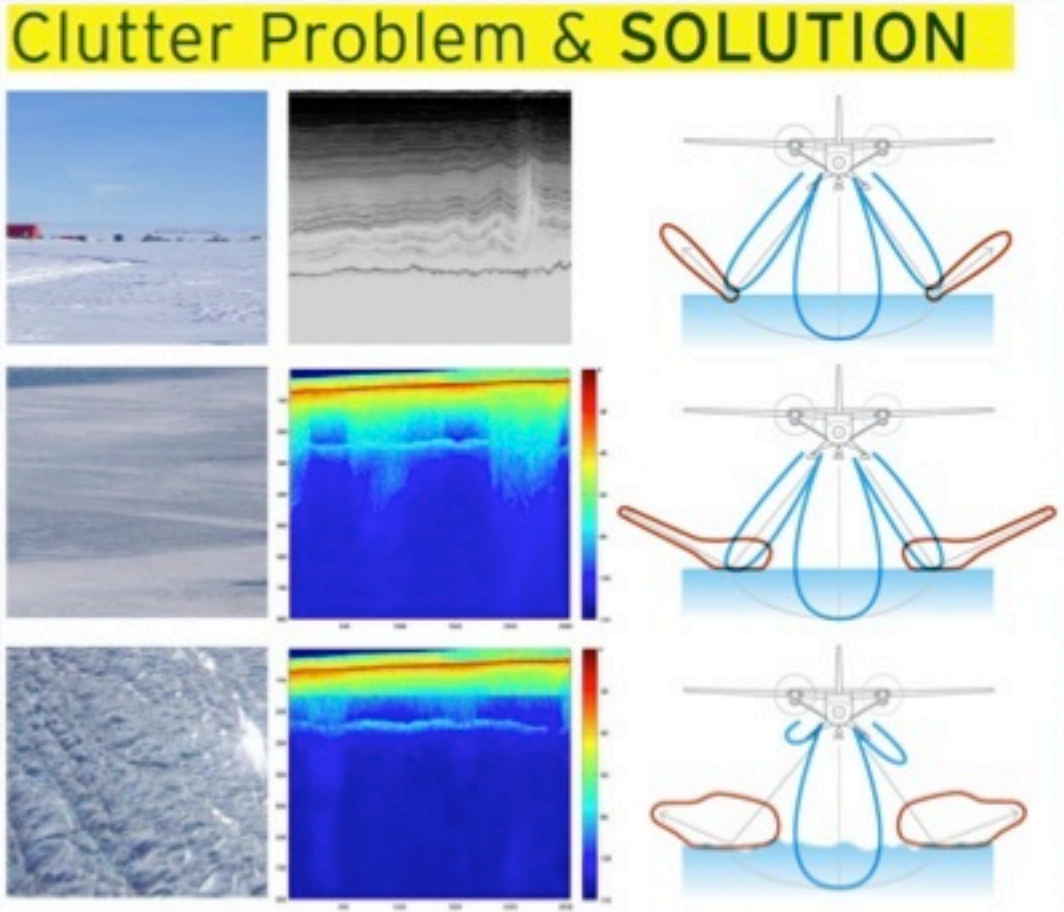
Data Requirements



CReSIS

Ice Thickness

- Radar Sounding of glaciers is well established.
- A major challenge is to obtain ice thickness data over fast-flowing glaciers
  - Ice thickness is a key to developing models to predict future sea level rise
- Imaging of ice-bed interface
  - Basal conditions
- Array processing to reduce clutter
  - Sound ice
  - Image ice-bed interface



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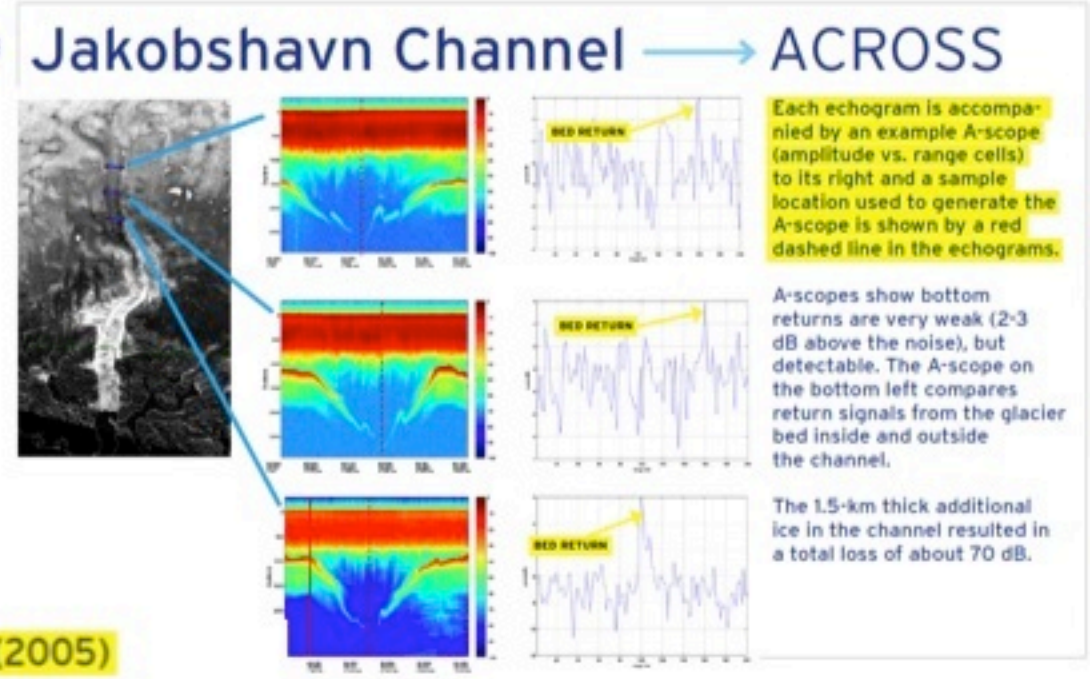
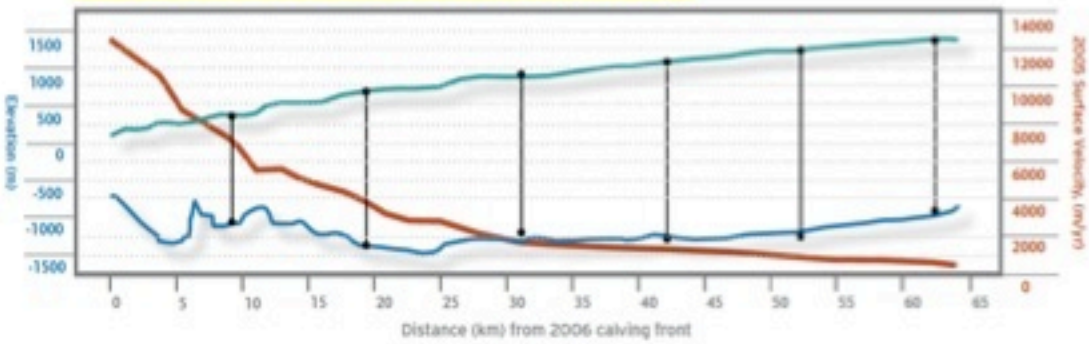
Radar Sounder/Imager

- SAR imaging of ice-bed
- Sounding of fast-flowing glaciers
  - A major challenge in radio glaciology
- Extremely low-range sidelobes





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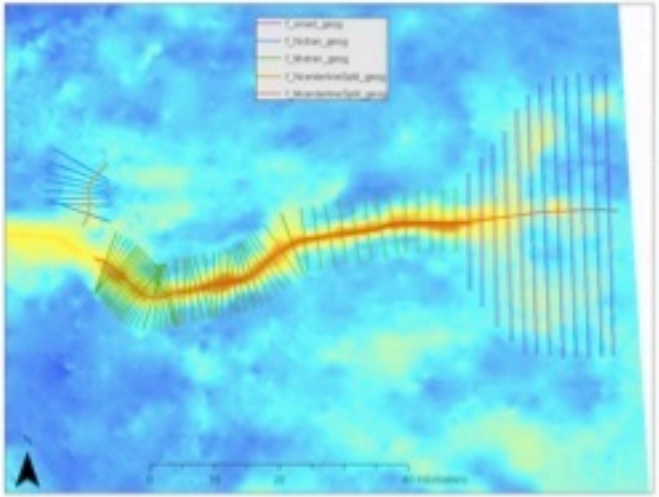
Large Errors in Flux Estimation km^3/yr

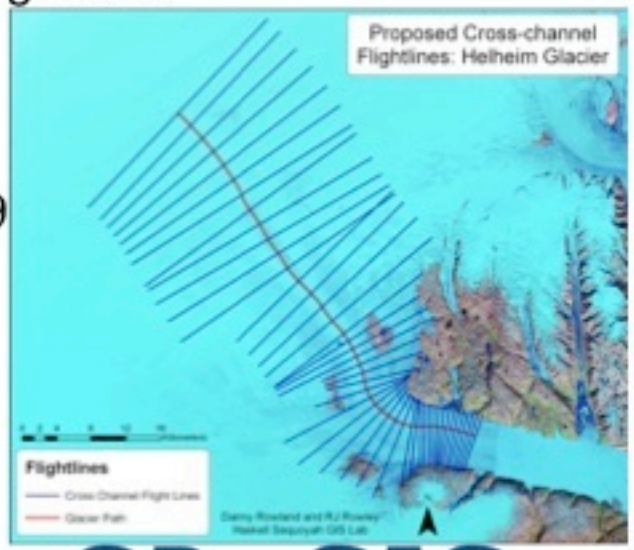
Year	South	North	Total
1985	25.3 ± 3.5	2.7 ± 0.5	28.0 ± 4.0
1995	25.3 ± 3.1	2.6 ± 0.5	27.9 ± 3.6
2000	32.7 ± 4.1	4.6 ± 0.9	37.3 ±5.0
2005	34.2 ± 4.7	6.2 ± 1.4	40.4 ± 6.0

Accurate ice thickness and bed topography information are required

Dense grid over three key glaciers

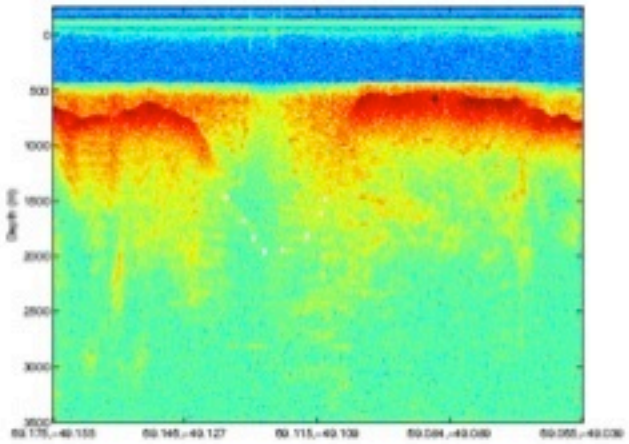


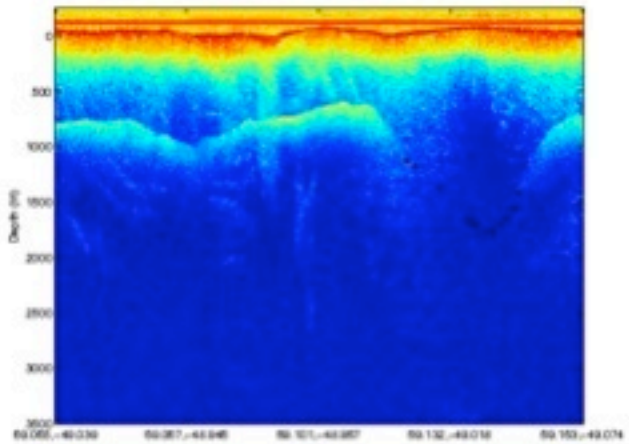
March-April 09



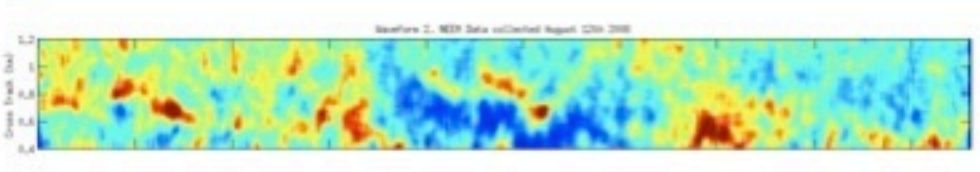
CReSIS

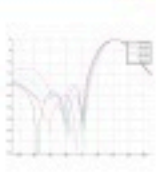
Results from April 2009

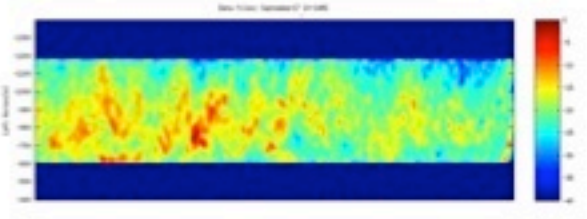


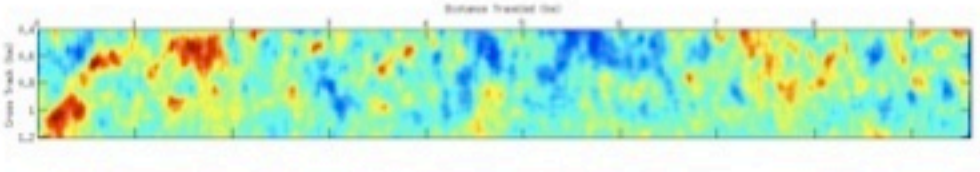


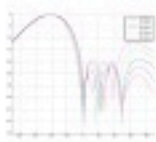
SAR Imaging of Ice Bed

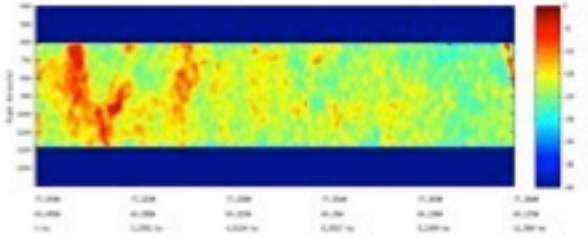


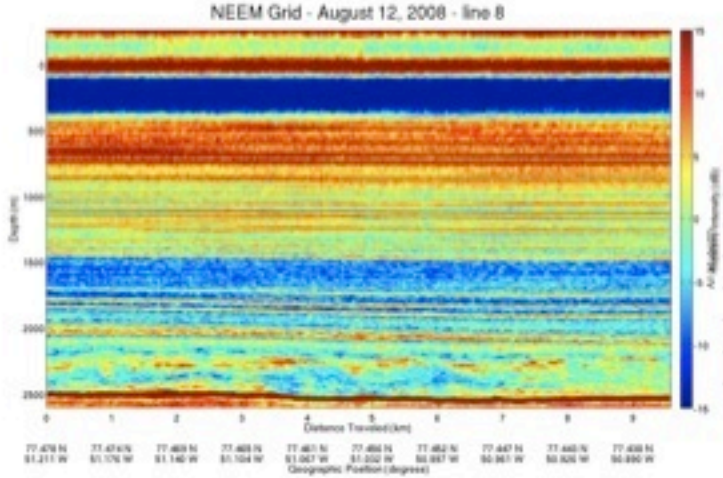


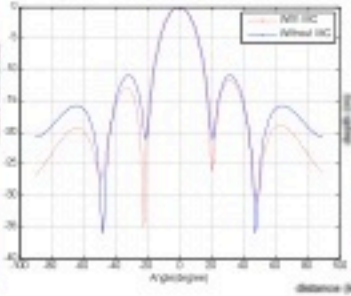


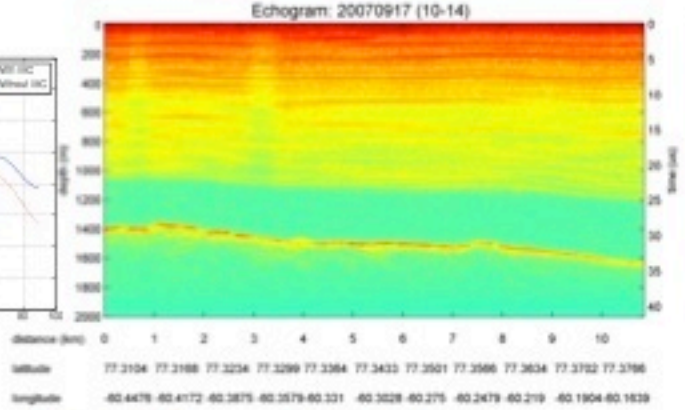








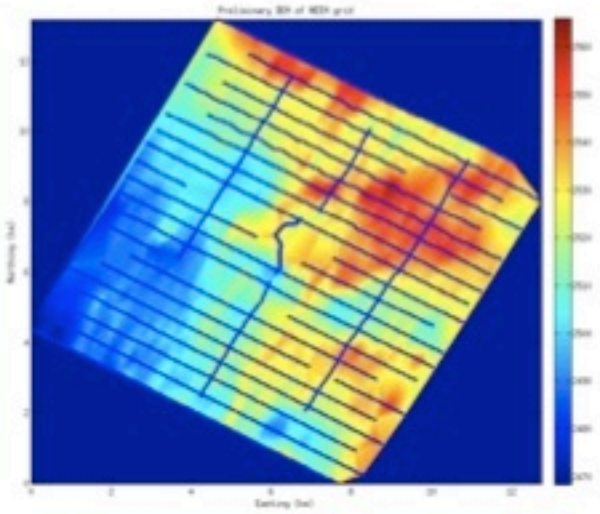


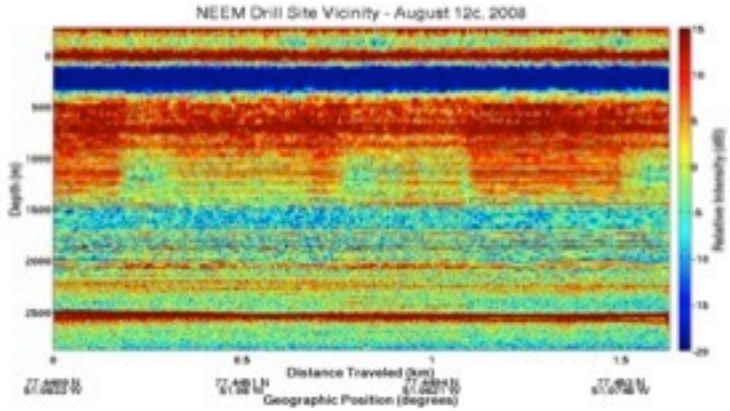


CReSIS

NEEM


U.S. AIR FORCE




NEEM Drill Site Vicinity - August 12c, 2008
Depth (m)
Relative Intensity (dB)
Distance Traveled (km)
Geographic Position (degrees)

CReSIS

UAVs

Parameter	Units	Value
Weights		
Takeoff Weight	lbs	1,100
Empty Weight	lbs	791
Payload Weight	lbs	165
Fuel Weight	lbs	120
Performance		
Cruise Speed	kts	130
Range	nm	950
Endurance	hrs	12
L/D_{Cr}	~	13.9
Powerplant		
Engine	~	TAE Centurion 2.0
Power	hp	135

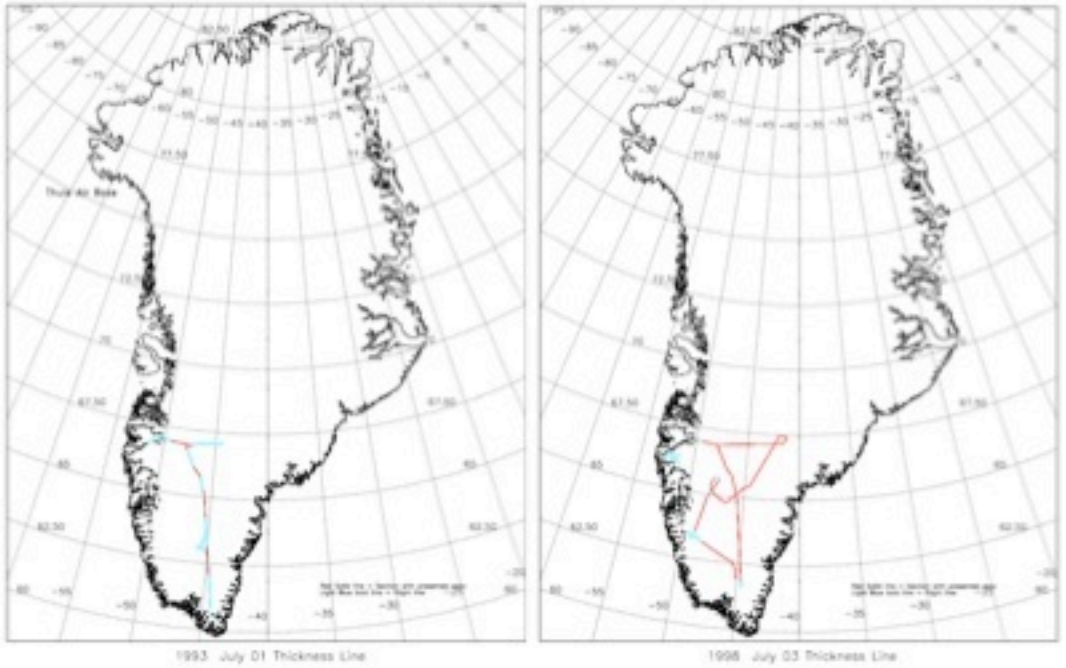
- Polar-capable UAV
- Flight trials
  - Kansas
    - April –June 09
  - Polar Regions
    - Dec 09-Jan 10

CReSIS

Integration of Research Into Courses

2009

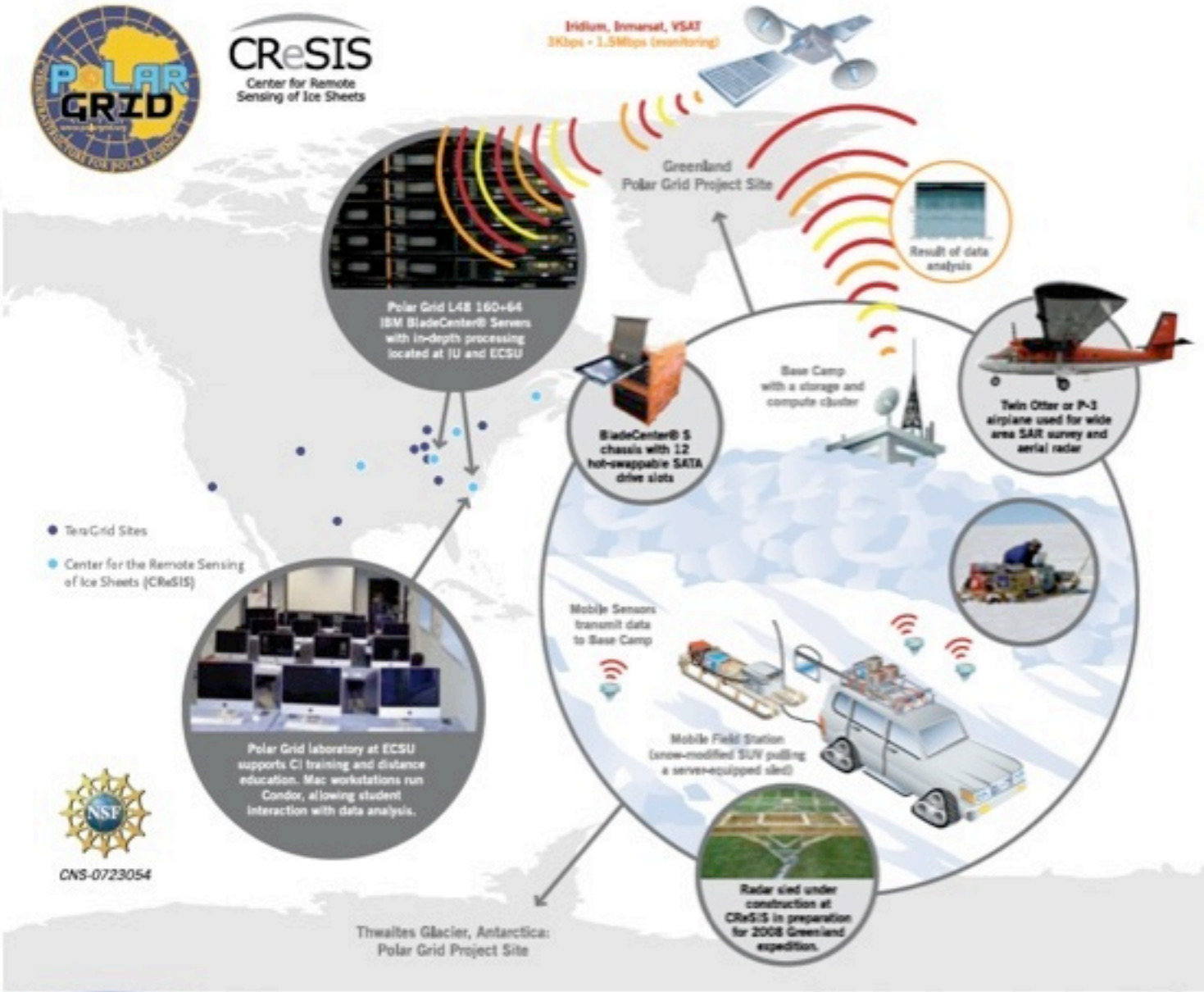
1993 1998



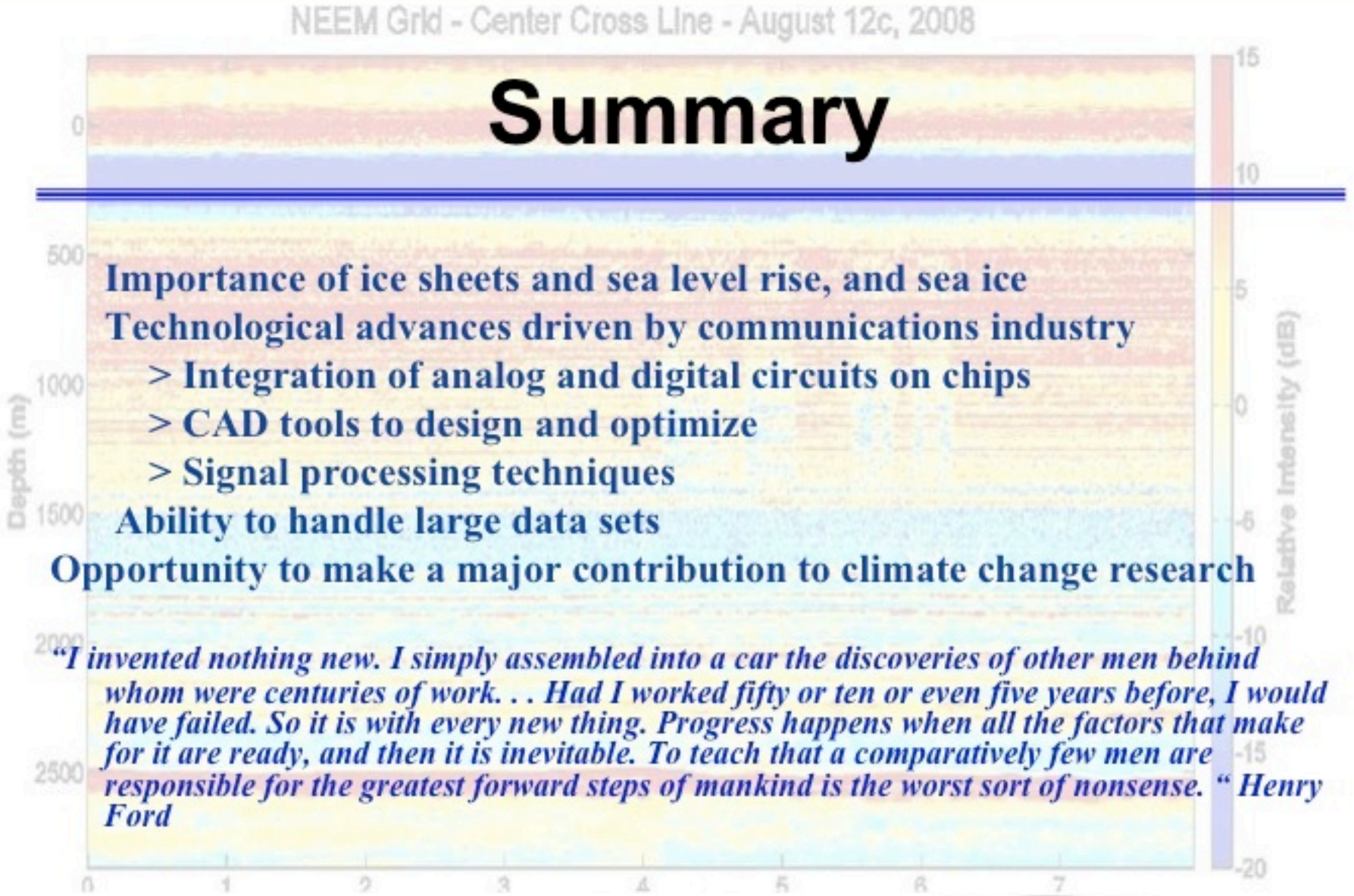
1993 July 01 Thickness Line

1998 July 03 Thickness Line

CReSIS


POLAR GRID
CReSIS
Center for Remote Sensing of Ice Sheets
Iridium, Inmarsat, VSAT
3Kbps - 1.5Mbps (monitoring)
Greenland Polar Grid Project Site
Result of data analysis
Polar Grid L48 160+64 IBM BladeCenter® Servers with in-depth processing located at IU and ECSU
BladeCenter® S chassis with 12 hot-swappable SATA drive slots
Base Camp with a storage and compute cluster
Twin Otter or P-3 airplane used for wide area SAR survey and aerial radar
TeraGrid Sites
Center for the Remote Sensing of Ice Sheets (CReSIS)
Mobile Sensors transmit data to Base Camp
Mobile Field Station (snow-modified SUV pulling a server-equipped sled)
Polar Grid laboratory at ECSU supports CI training and distance education. Mac workstations run Condor, allowing student interaction with data analysis.
Radar sled under construction at CReSIS in preparation for 2008 Greenland expedition.
Thwaites Glacier, Antarctica: Polar Grid Project Site
NSF
CNS-0723054

CReSIS



Summary

Importance of ice sheets and sea level rise, and sea ice

Technological advances driven by communications industry

- > Integration of analog and digital circuits on chips
- > CAD tools to design and optimize
- > Signal processing techniques

Ability to handle large data sets

Opportunity to make a major contribution to climate change research

"I invented nothing new. I simply assembled into a car the discoveries of other men behind whom were centuries of work. . . Had I worked fifty or ten or even five years before, I would have failed. So it is with every new thing. Progress happens when all the factors that make for it are ready, and then it is inevitable. To teach that a comparatively few men are responsible for the greatest forward steps of mankind is the worst sort of nonsense. " Henry Ford

CReSIS

National Science Foundation

WHERE DISCOVERIES BEGIN

CReSIS

Dr. Guðfinna Aðalgeirsdóttir

Danish Climate Centre

Danish Meteorological Institute

Research Interests: ice sheet dynamics, response of ice sheets and glaciers to climate change, and modeling of climate and ice sheet systems.

Greenland Ice Sheet in a climate system: The model world

Guðfinna Aðalgeirsdóttir
Danish Climate Centre
Danish Meteorological Institute
gua@dmi.dk

Melting ice affects the sea-level

IPCC 2007 Summary for Policymakers:

Table SPM-1. Observed rate of sea level rise and estimated contributions from different sources. {5.5, Table 5.3}

	Rate of sea level rise (mm per year)	
Source of sea level rise	**1961 – 2003**	**1993 – 2003**
Thermal expansion	0.42 ± 0.12	1.6 ± 0.5
Glaciers and ice caps	0.50 ± 0.18	0.77 ± 0.22
Greenland ice sheet	0.05 ± 0.12	0.21 ± 0.07
Antarctic ice sheet	0.14 ± 0.41	0.21 ± 0.35
Sum of individual climate contributions to sea level rise	1.1 ± 0.5	2.8 ± 0.7
Observed total sea level rise	1.8 ± 0.5[a]	3.1 ± 0.7[a]
Difference (Observed minus sum of estimated climate contributions)	0.7 ± 0.7	0.3 ± 1.0

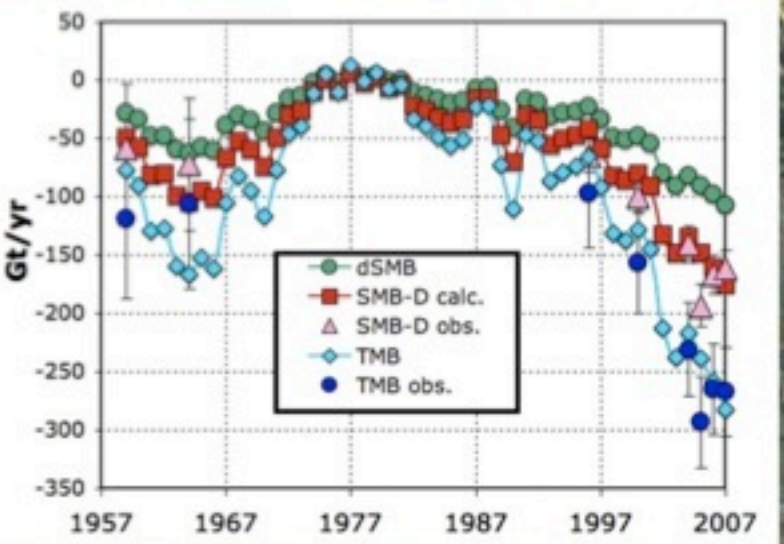
Table note:

[a] Data prior to 1993 are from tide gauges and after 1993 are from satellite altimetry.

Mass Balance Model of Greenland Ice Sh

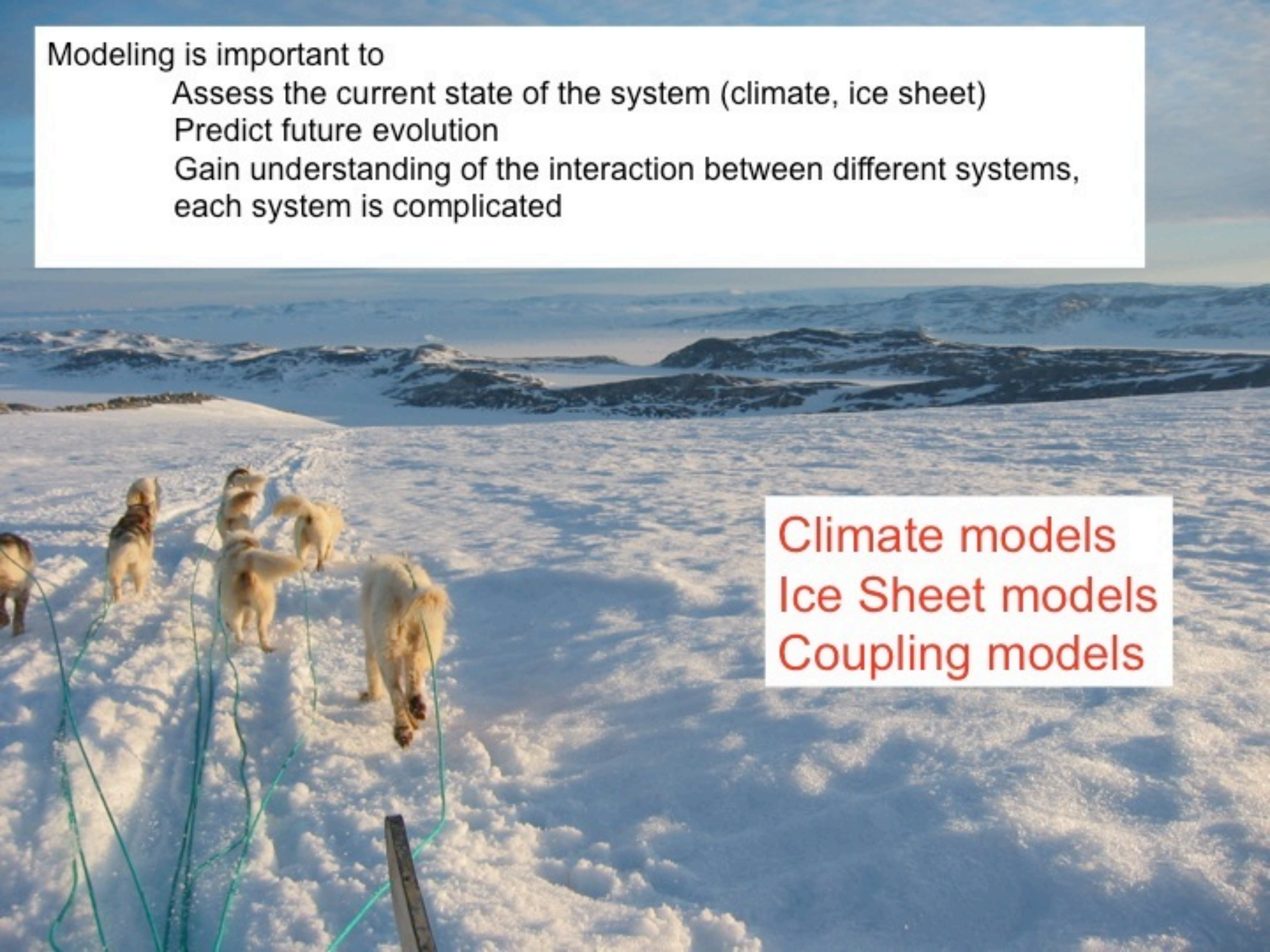
1960s:	-110 +/- 70 GT a^{-1}
1970s-1980s:	-30 +/- 50 GT a^{-1}
1996:	-97 +/- 47 GT a^{-1}
2007:	-267 +/- 38 GT a^{-1}

(Rignot et al., 2008)



5° N 54°48'55.50" W

Streaming 100%

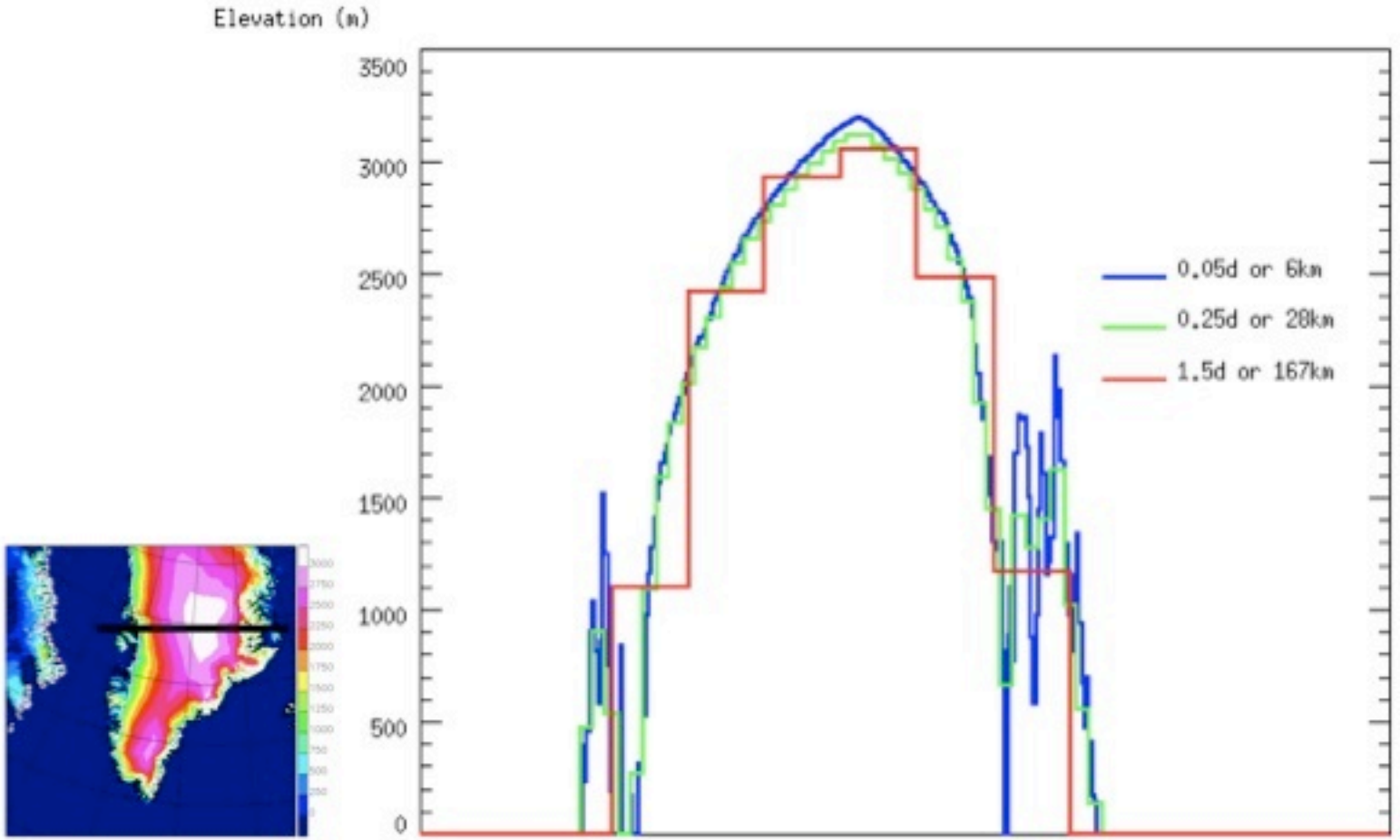


Modeling is important to

- Assess the current state of the system (climate, ice sheet)
- Predict future evolution
- Gain understanding of the interaction between different systems, each system is complicated

Climate models
Ice Sheet models
Coupling models

Horizontal resolution is important

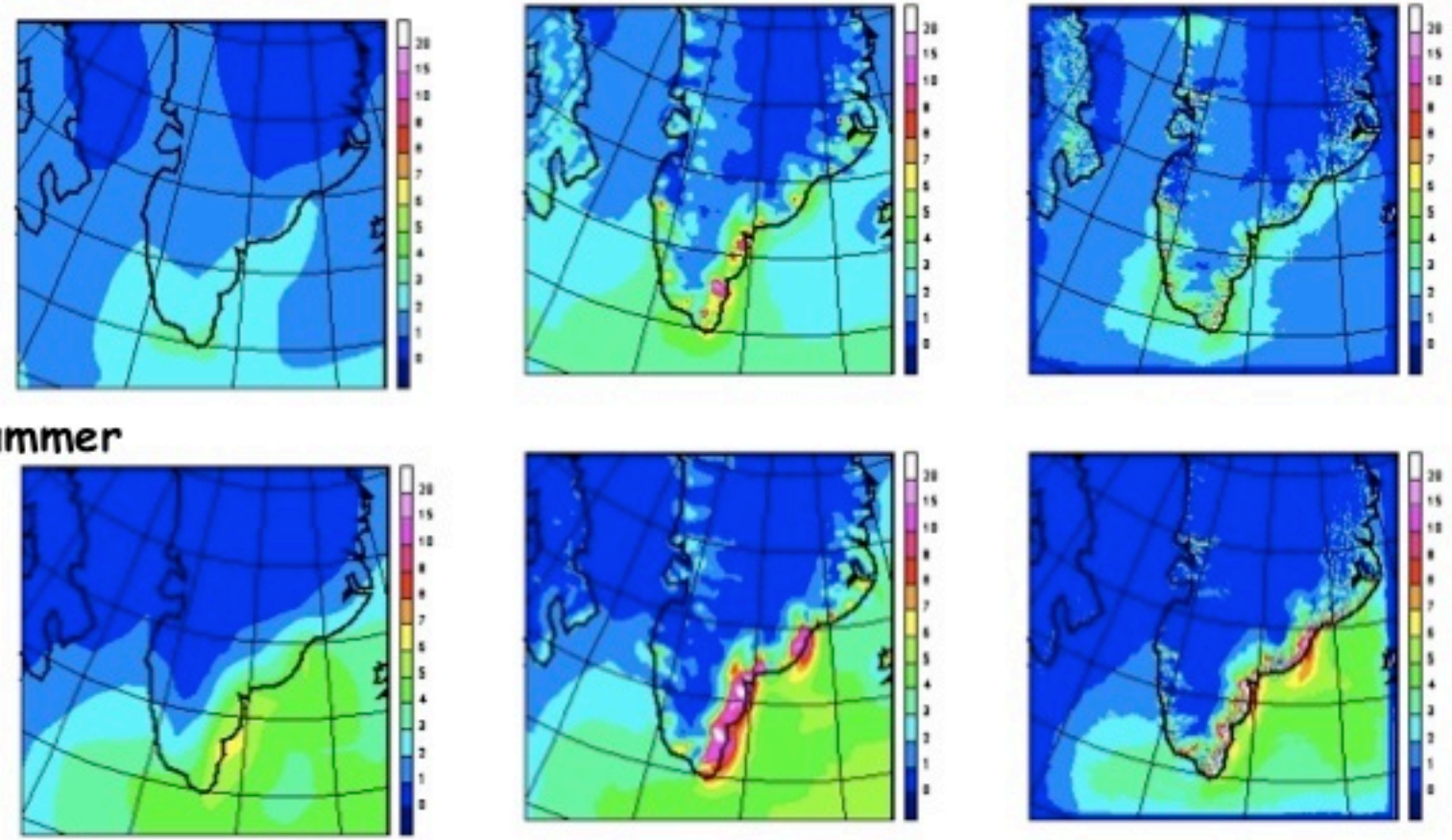


Resolution impacts precipitation pattern (mm/day)

ERA40
~150km
61-90

HIRHAM 25km
GCM 61-90

HIRHAM
5km ERAI
91-95

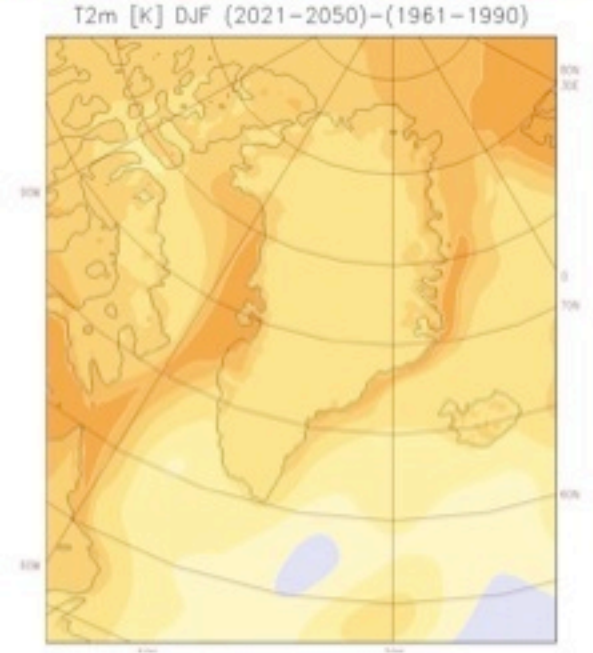


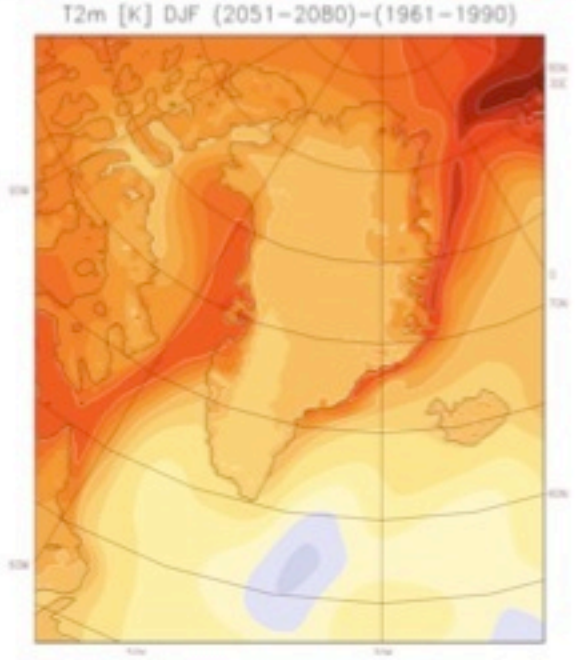
Summer

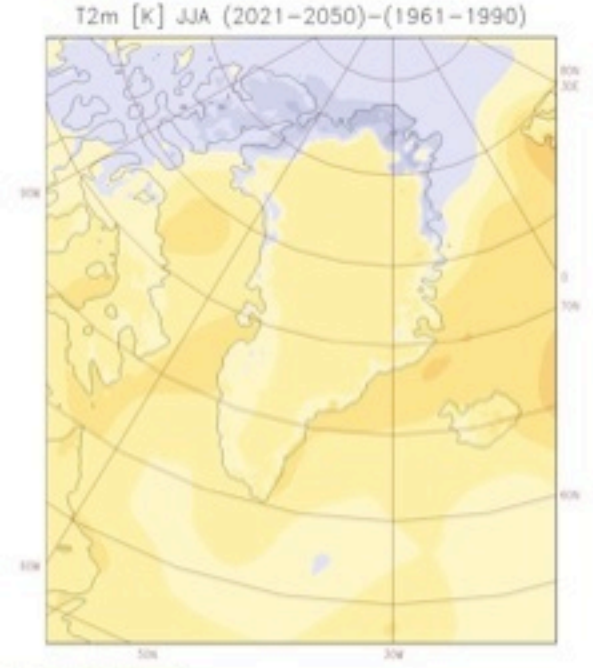
Winter

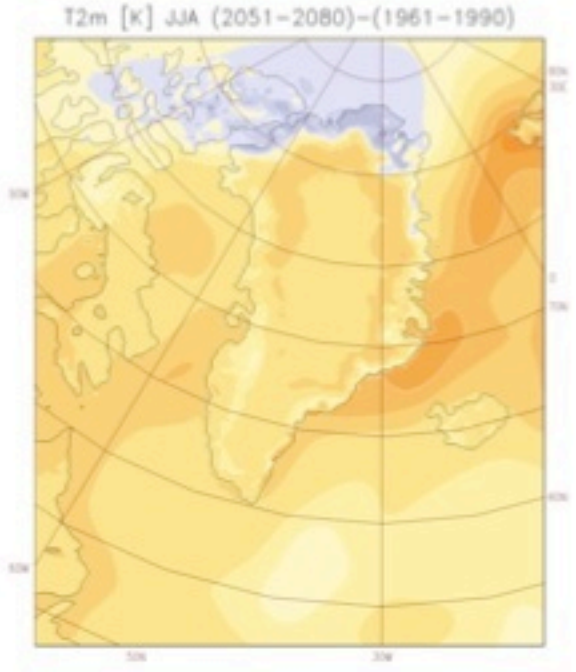
DMI

Change in 2m temperature (2051-2080) - (1961-1990)









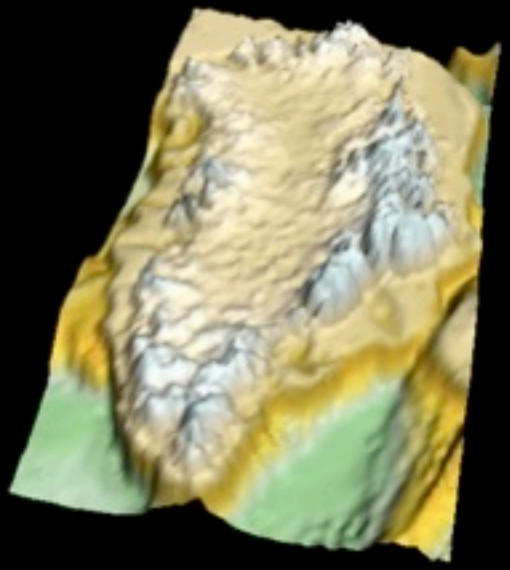
Example of a
Climate Model
Run at 25 km resolution
For period 1950-2080

Comparison of two
30 years period

One at ”present”

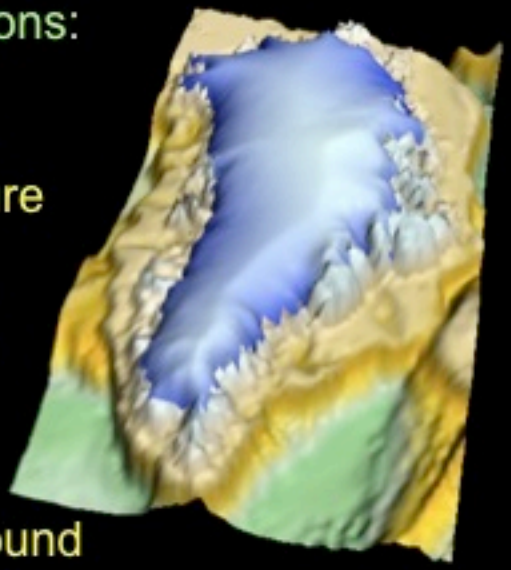
One in the modelled
future

Ice sheet model: Ingredients



Basal conditions:

Temperature
Water pressure
Basal melt
Basal sliding
Hydrology
Geothermal
heat flux
Isostatic rebound



At surface:

Atmospheric
Forcing

Mass balance
model

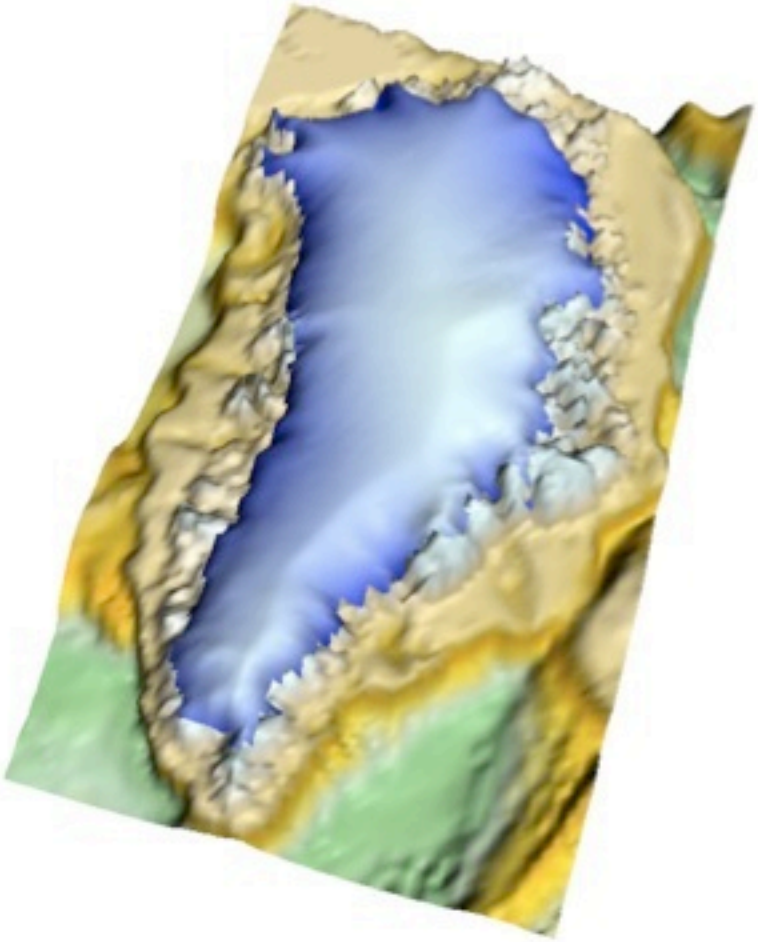
Ice dynamics: Shallow Ice approx. Polythermal Ice

Numerical solution of the approximated system

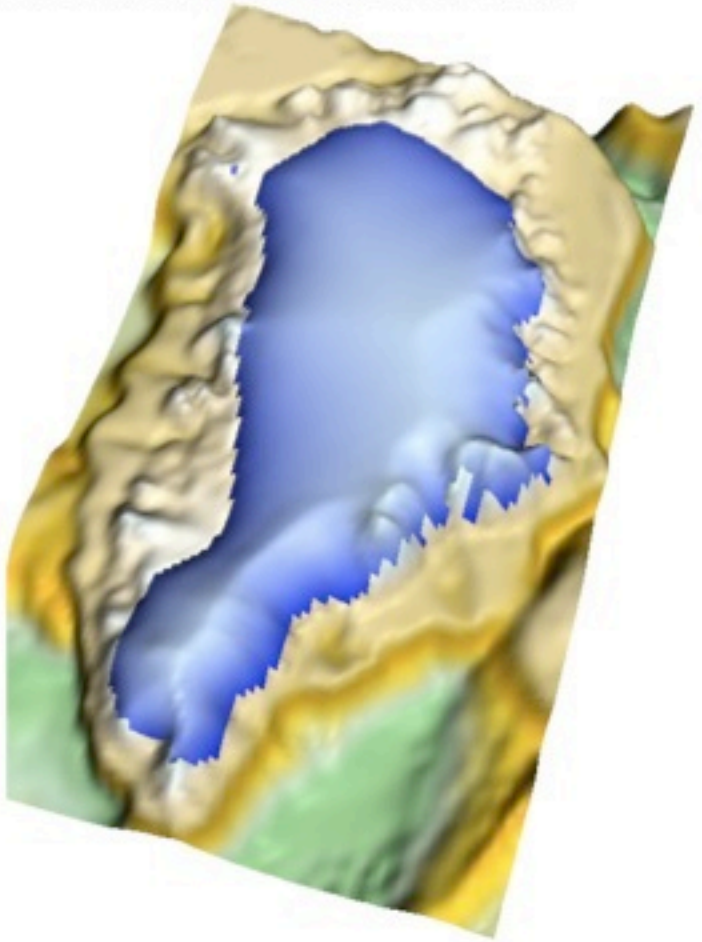
DMI

Result from a coupled climate and ice sheet model

Measured ice sheet



Modeled present ice sheet forced with HIRHAM



DMI

Model predictions are subject to large uncertainties

Gregory and Huybrechts, 2006 modelled ice sheet contribution to sea level rise

They applied 18 Different Climate models
and 3 Different Scenarios

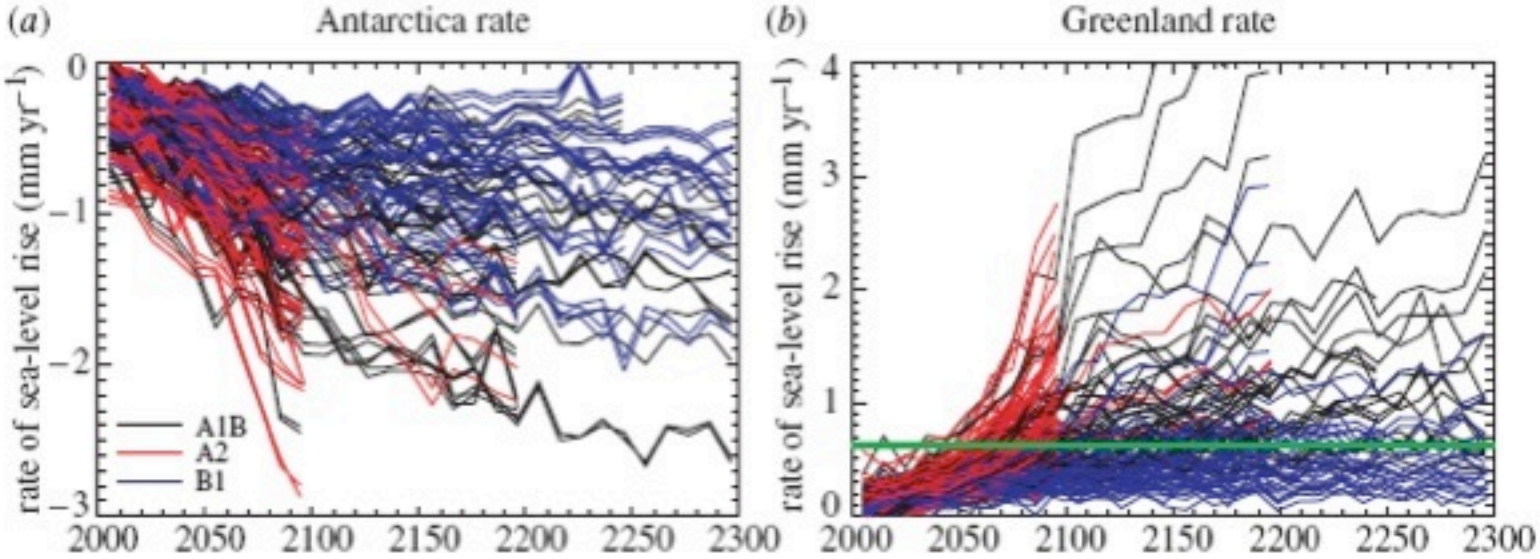
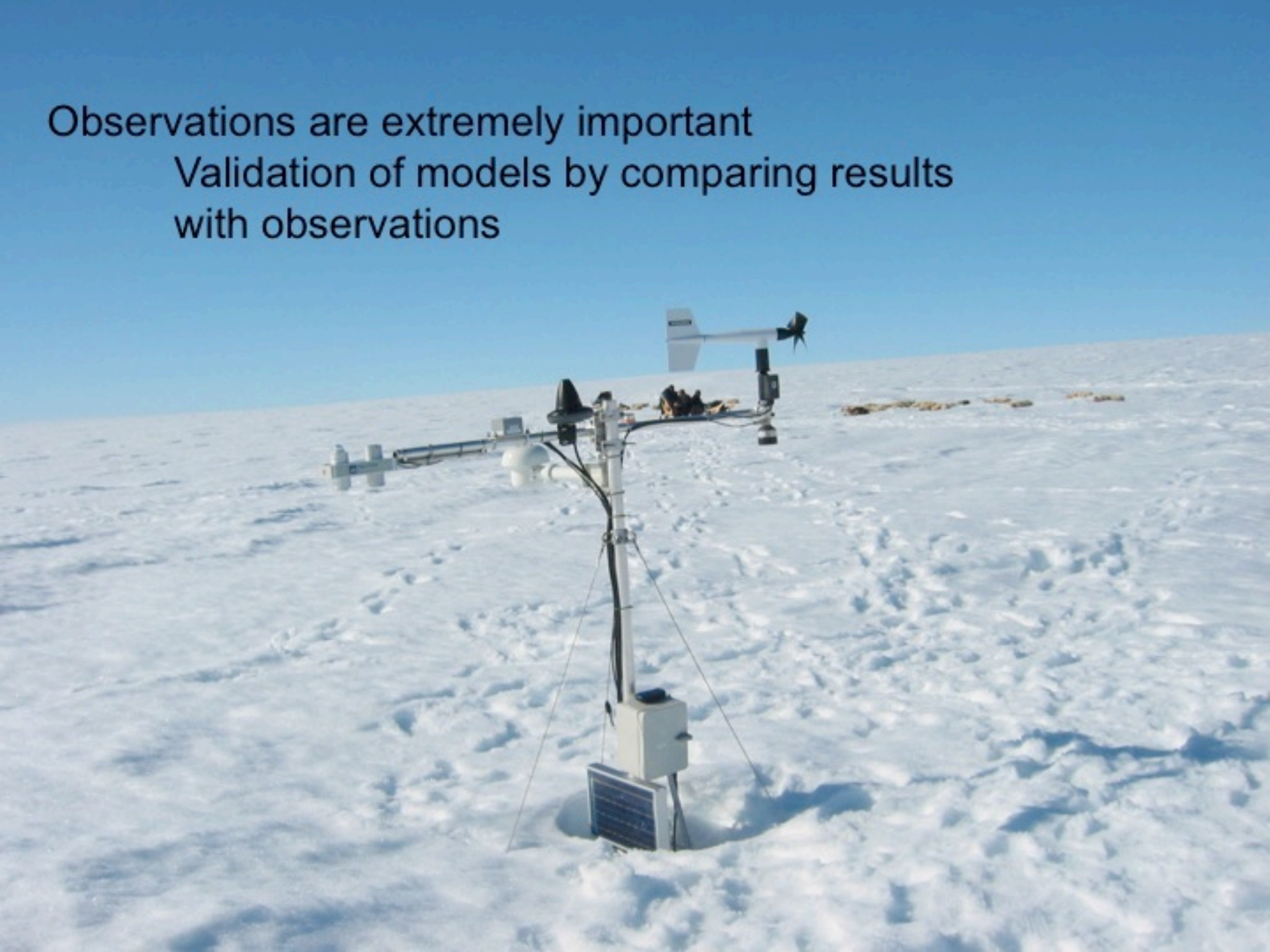


Figure 4. Rates of contribution to sea level (mm yr^{-1}) from ice sheets due to surface mass-balance change. Results are calculated for all available combinations of AOGCM, high-resolution model and emissions scenario (distinguished by line colour), and expressed as sea-level equivalent. The horizontal green line in (*b*) indicates the magnitude $|B_0|$ of the present-day surface mass balance of the Greenland ice sheet.

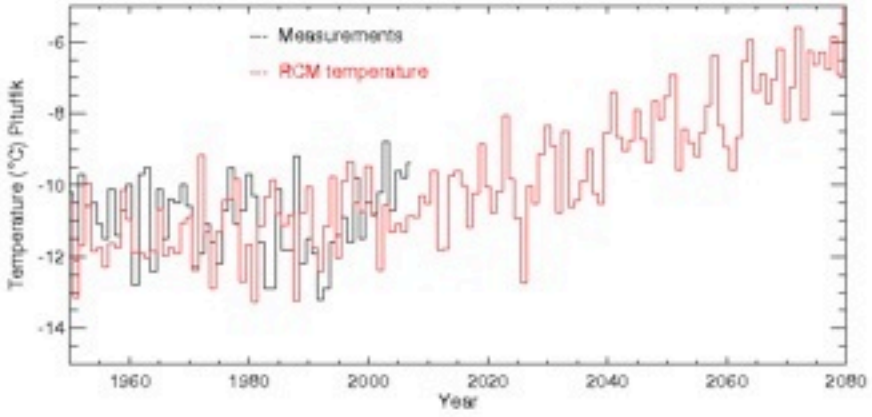
DMI

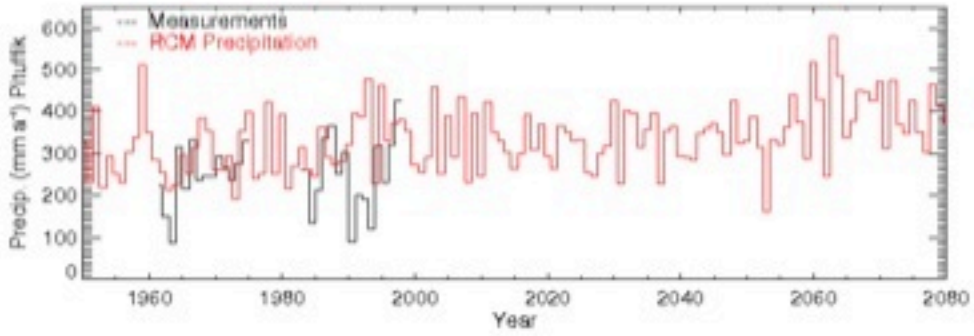
Observations are extremely important

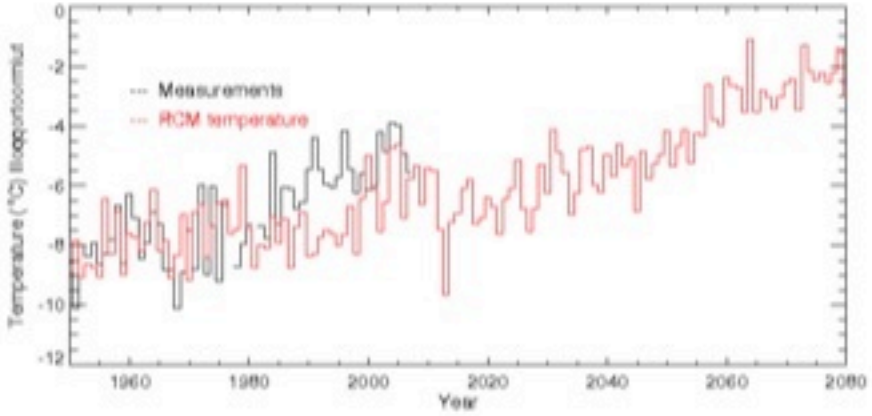
Validation of models by comparing results with observations

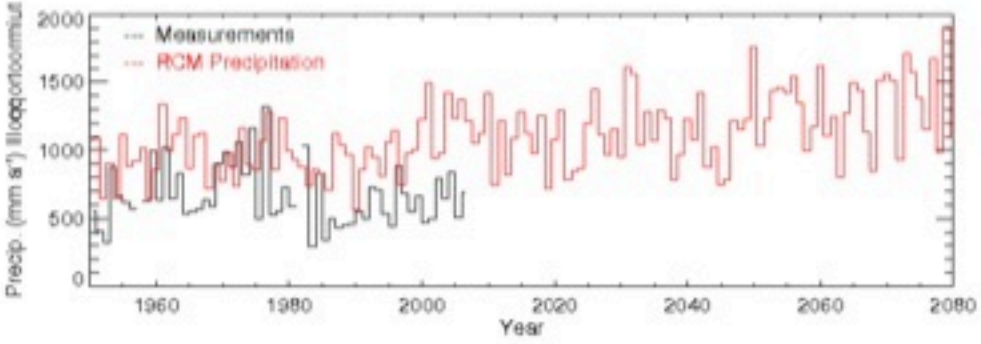


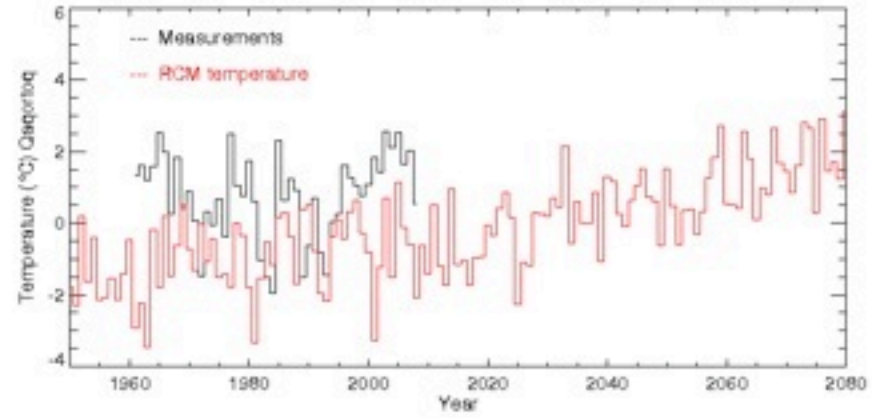
Comparison of temperature and precipitation data with model results

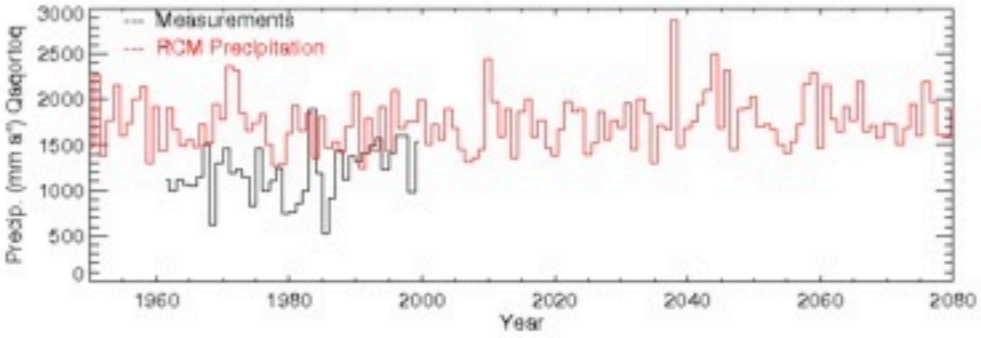


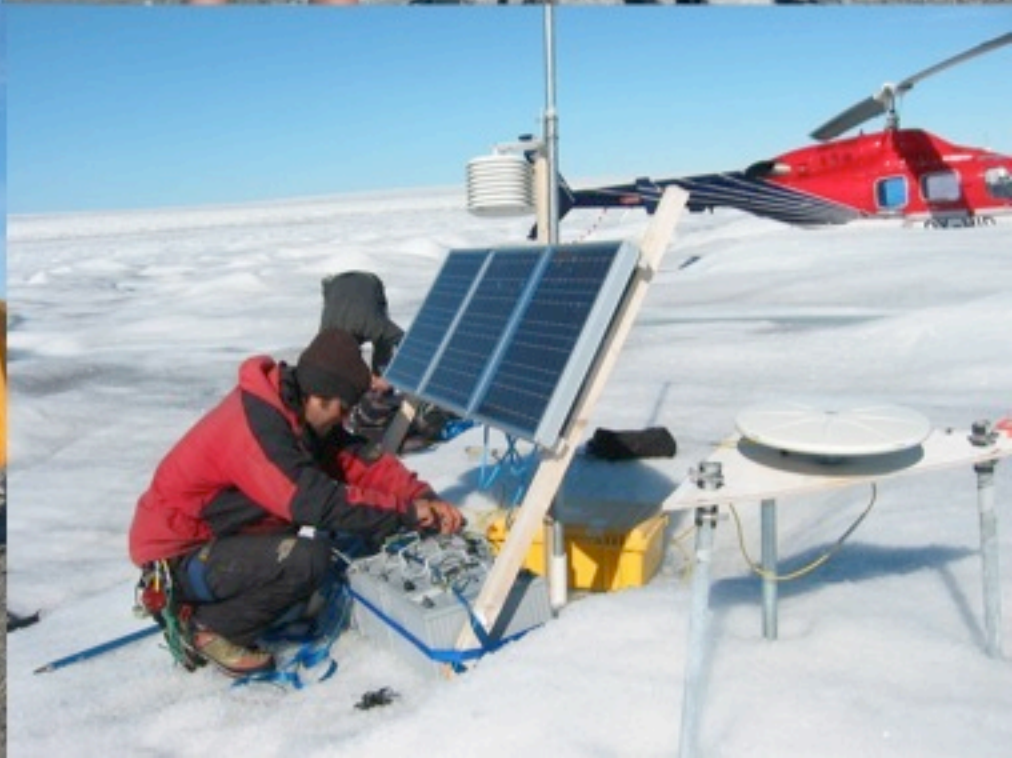












Joel Harper

Associate Professor,
Department of Geosciences, University of Montana

Research Interests:
Glaciology, Climate Change

Melt water infiltration on the Greenland Ice Sheet

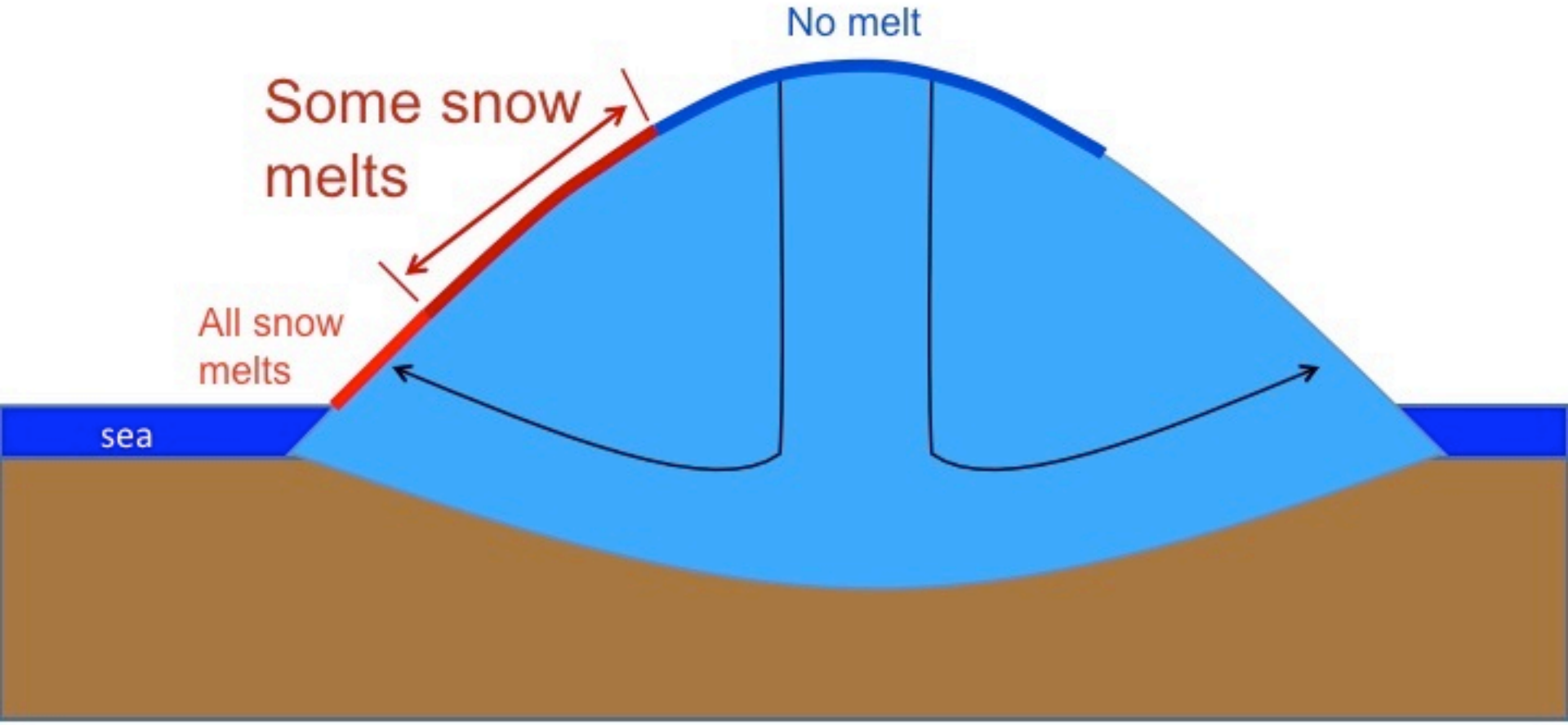
Joel Harper, University of Montana

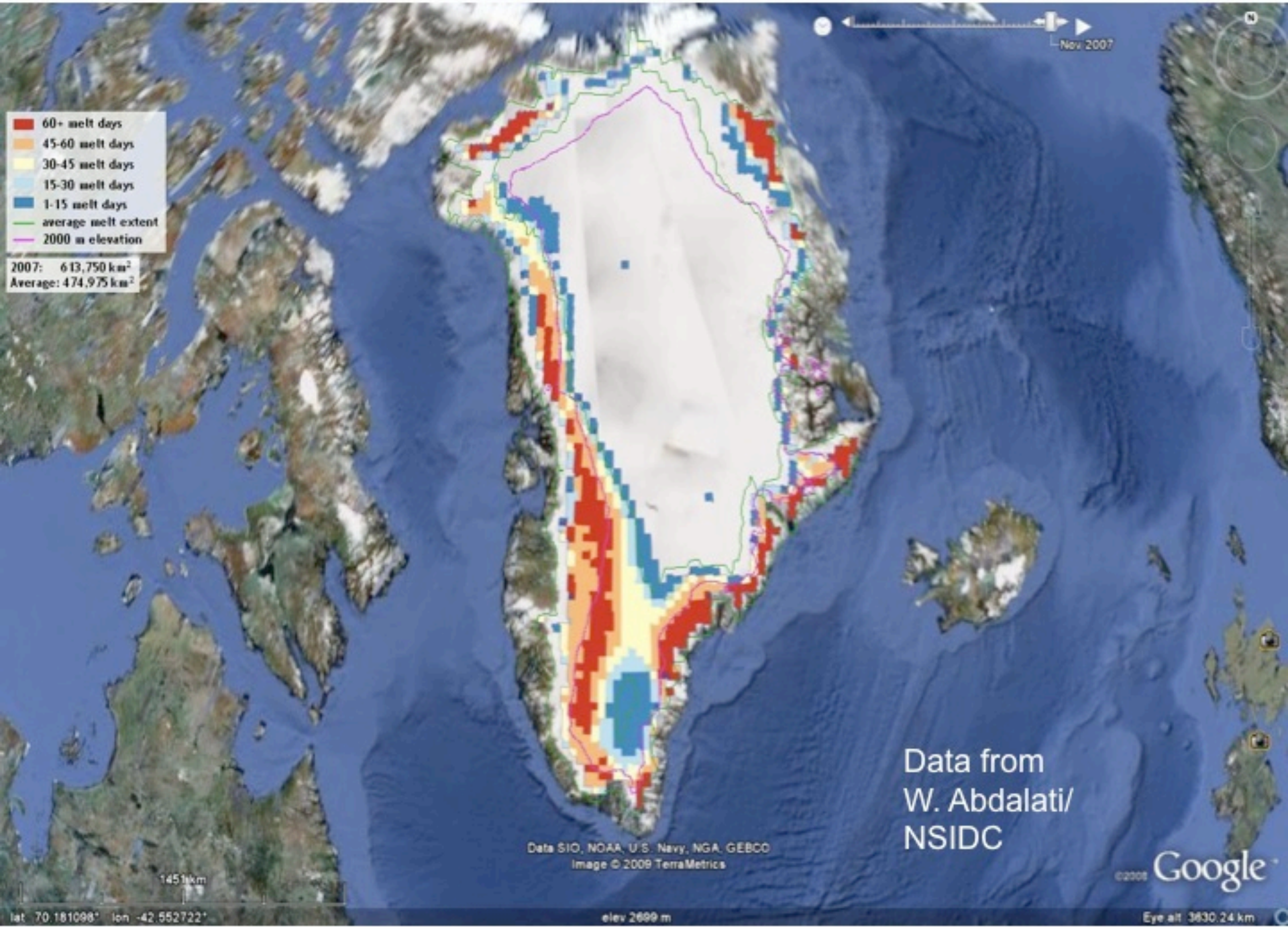
Neil Humphrey, University of Wyoming

Tad Pfeffer, University of Colorado

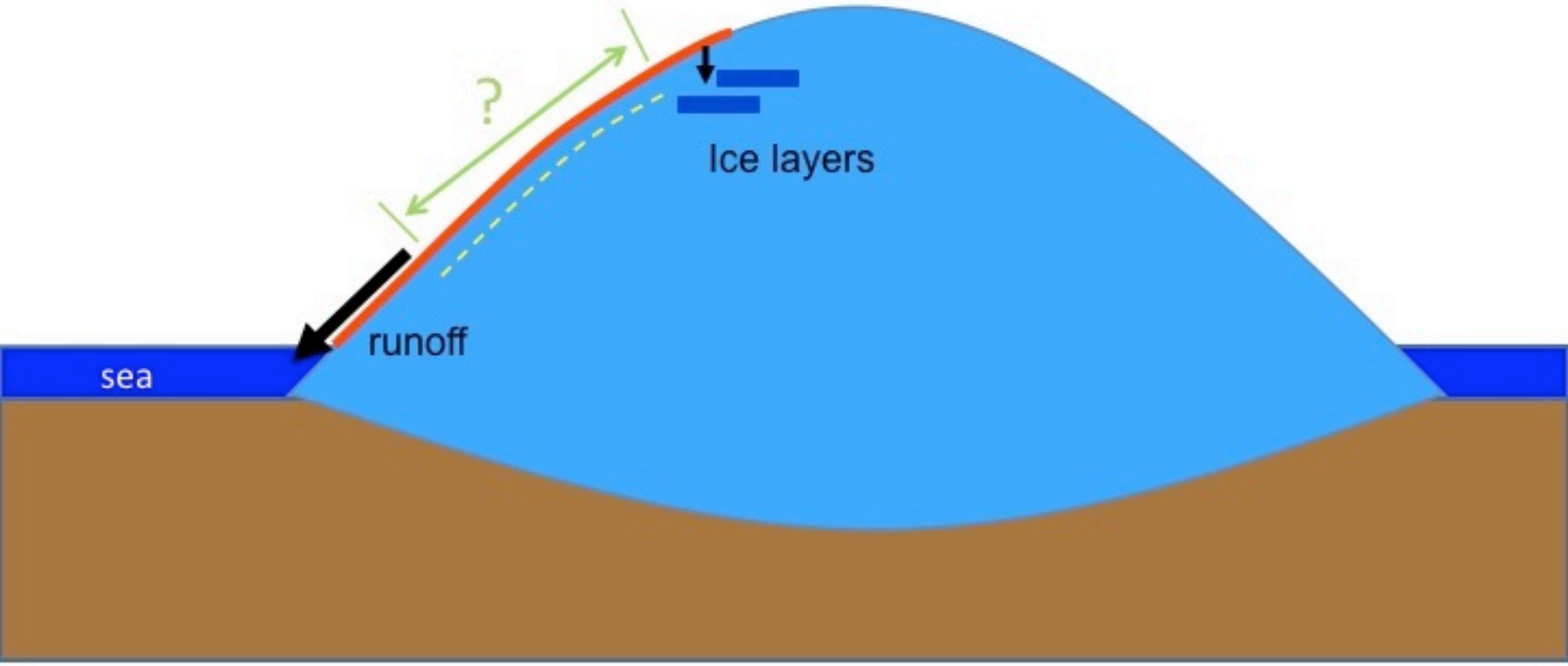
And students, Joel Brown, Dan Sturgis, Dan West, David Schuler

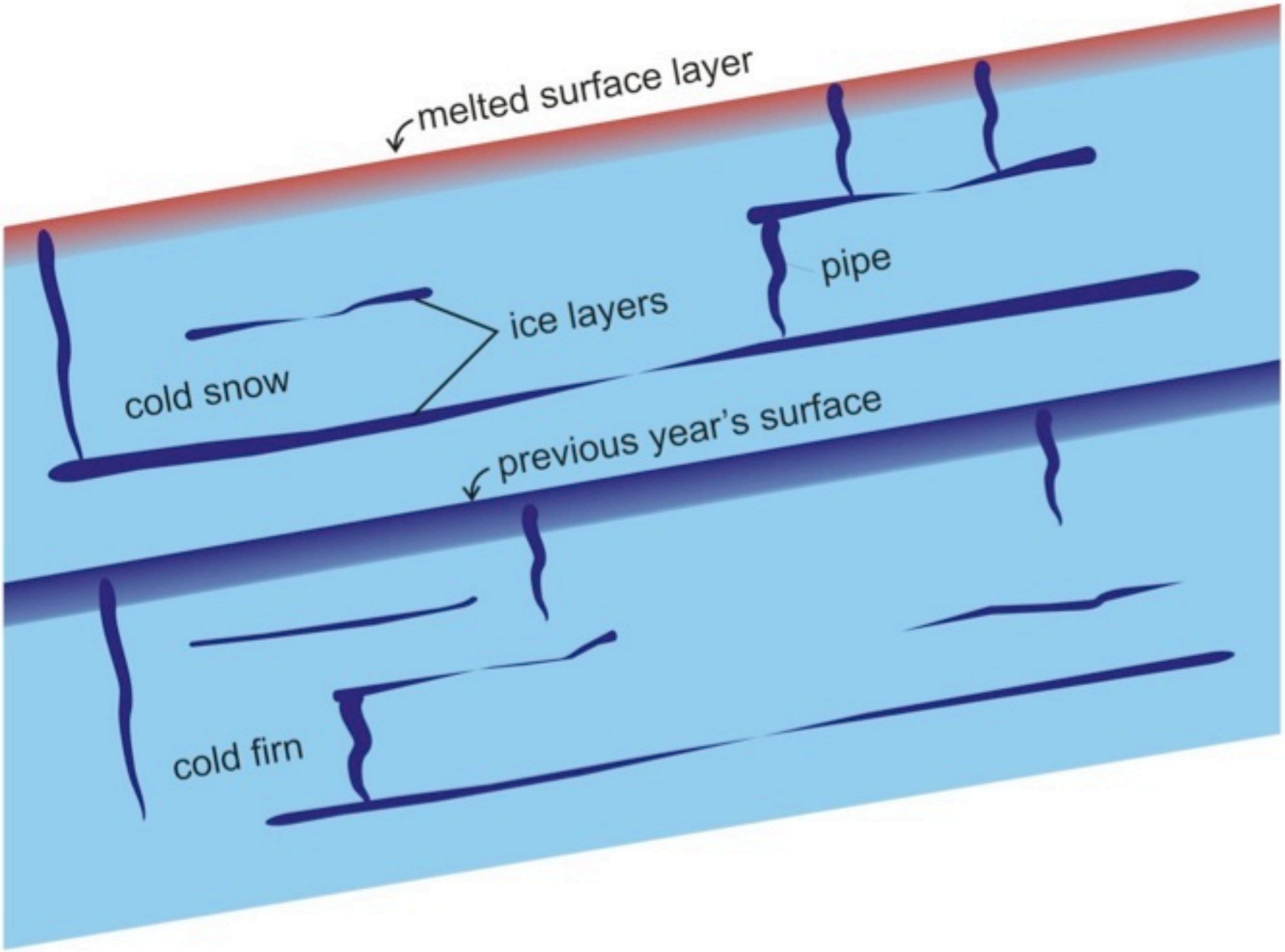
The percolation zone




60+ melt days
45-60 melt days
30-45 melt days
15-30 melt days
1-15 melt days
average melt extent
2000 m elevation
2007: 613,750 km²
Average: 474,975 km²
Nov 2007
Data from
W. Abdalati/
NSIDC
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2009 TerraMetrics
Google

Uncertain Runoff Limit




melted surface layer
pipe
ice layers
cold snow
previous year's surface
cold firn

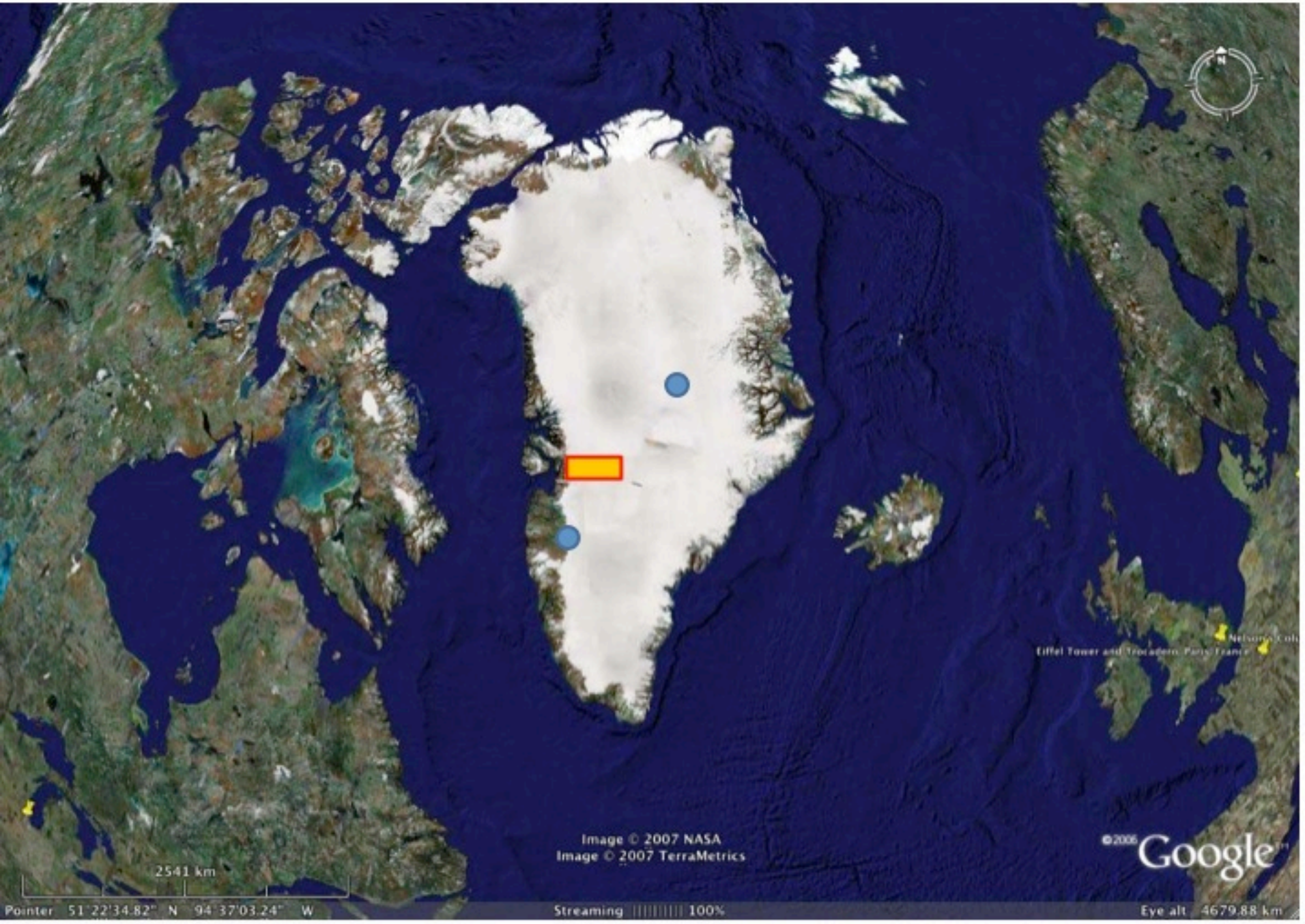
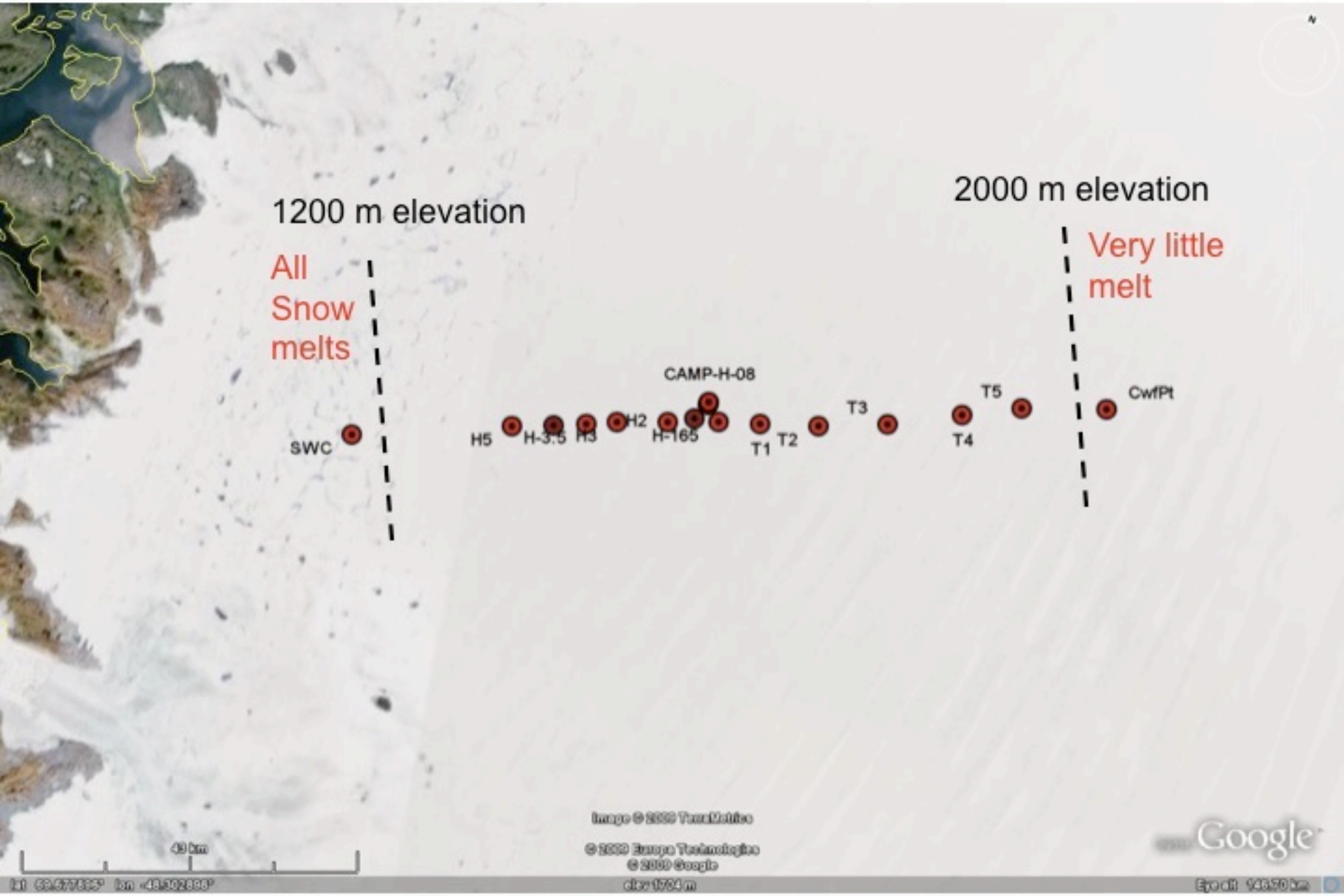
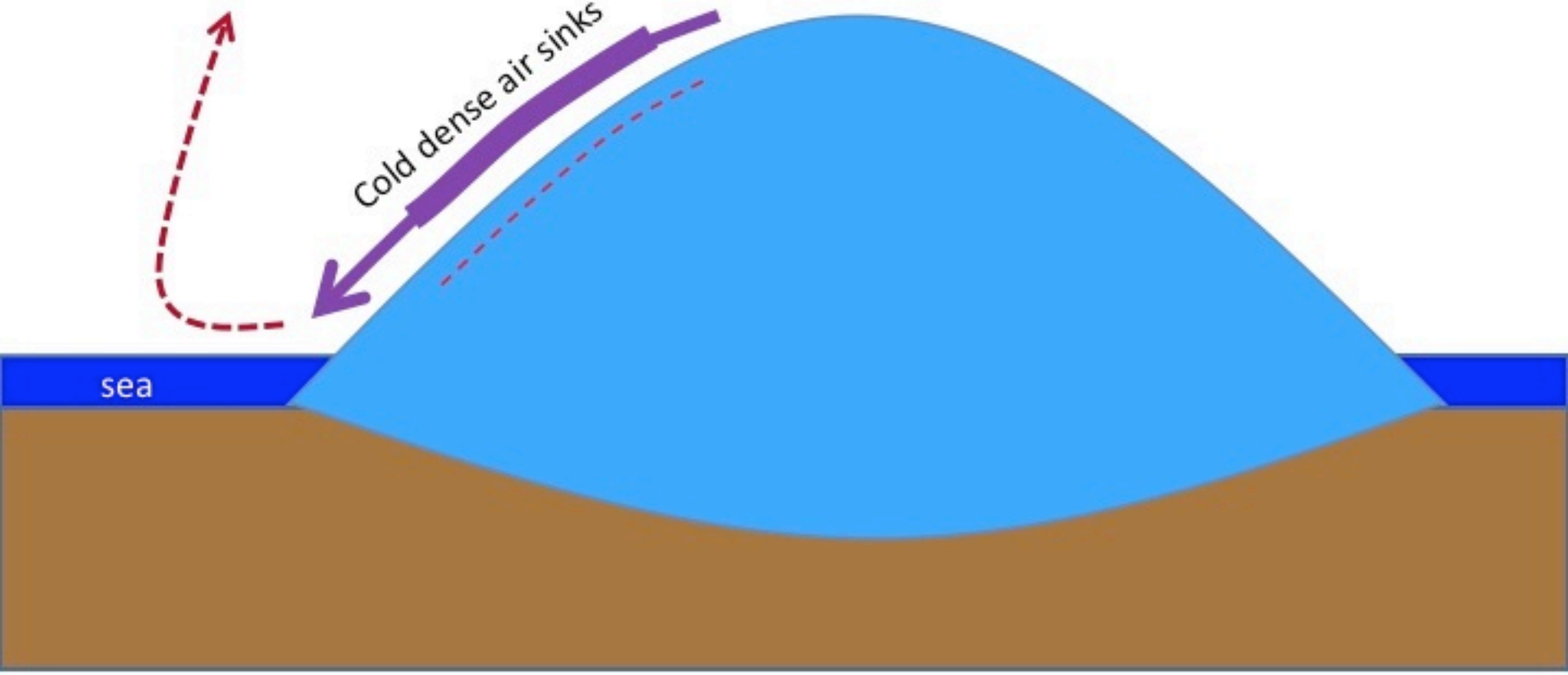


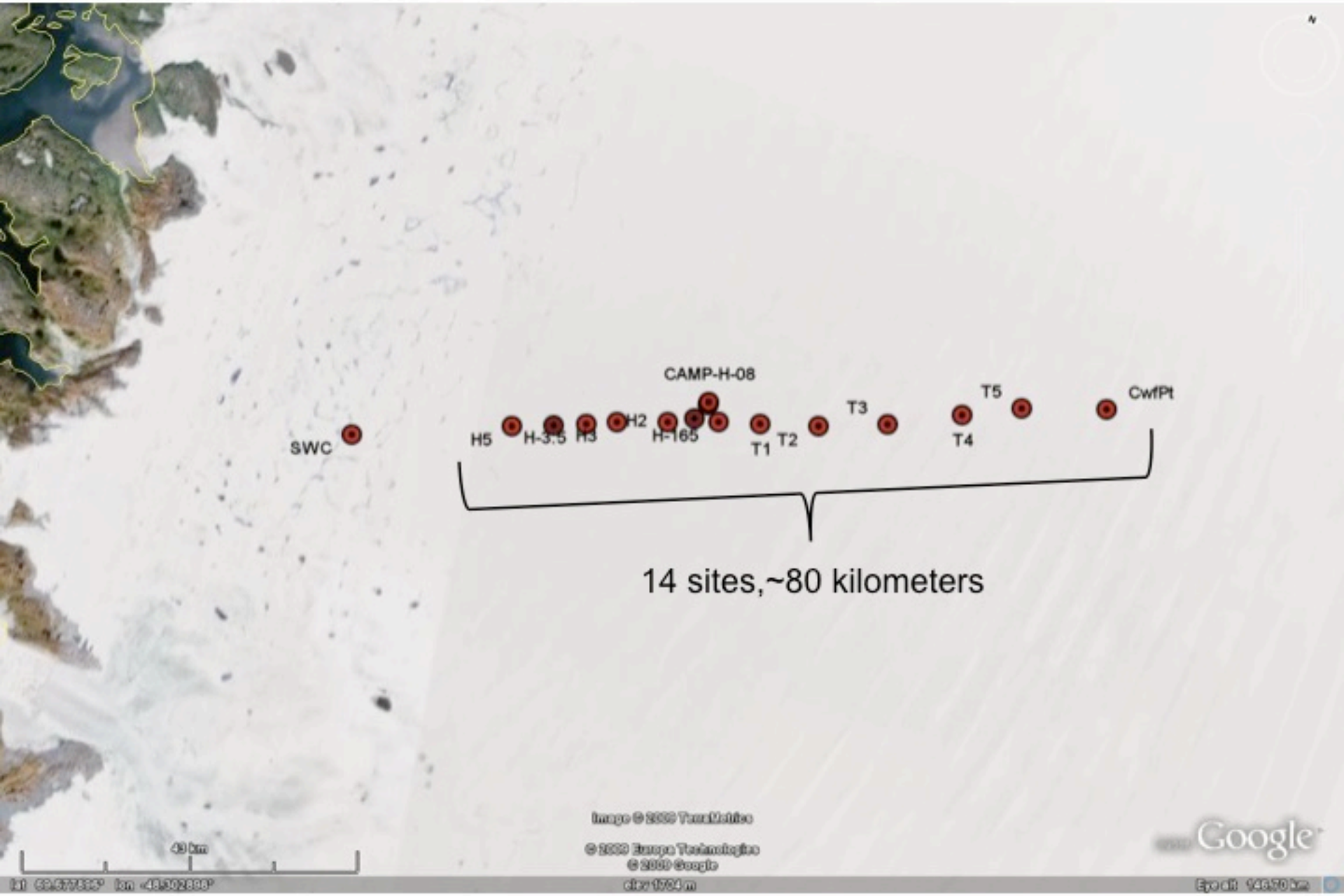
Image © 2007 NASA
Image © 2007 TerraMetrics
2541 km
Google
Pointer 51°22'34.82" N 94°37'03.24" W
Streaming 100%
Eye alt 4679.88 km


1200 m elevation
All Snow melts
2000 m elevation
Very little melt
SWC
H5
H-3.5
H3
H2
CAMP-H-08
H-165
T1
T2
T3
T4
T5
CwfPt
49 km


air greenland

Katabatic winds



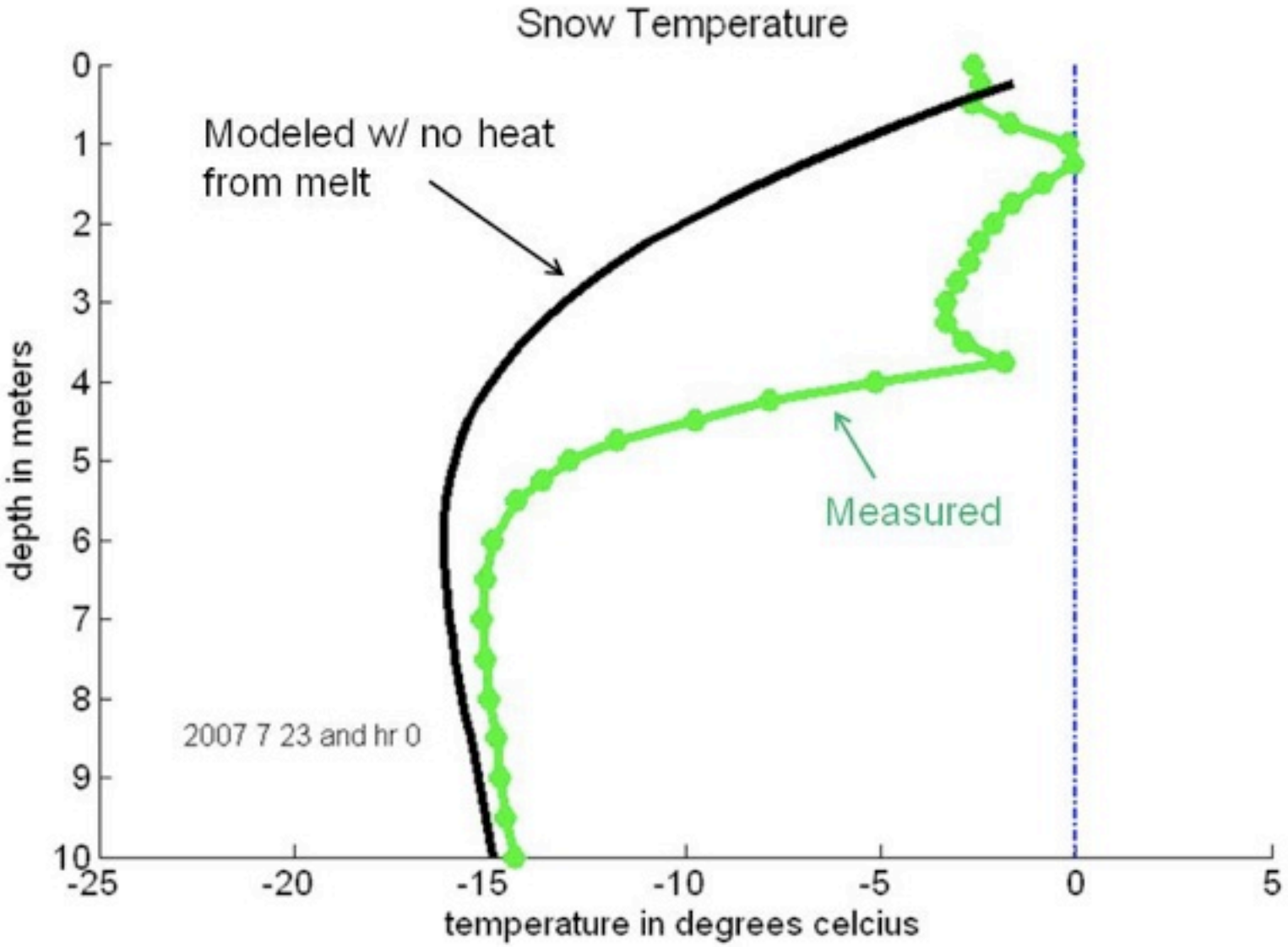

CAMP-H-08
SWC
H5
H-3.5
H3
H2
H-165
T1
T2
T3
T4
T5
CwfPt
14 sites,~80 kilometers
Image © 2009 TerraMetrics
© 2009 Europa Technologies
© 2009 Google
Google

Ground Radar

Shallow Ice Cores

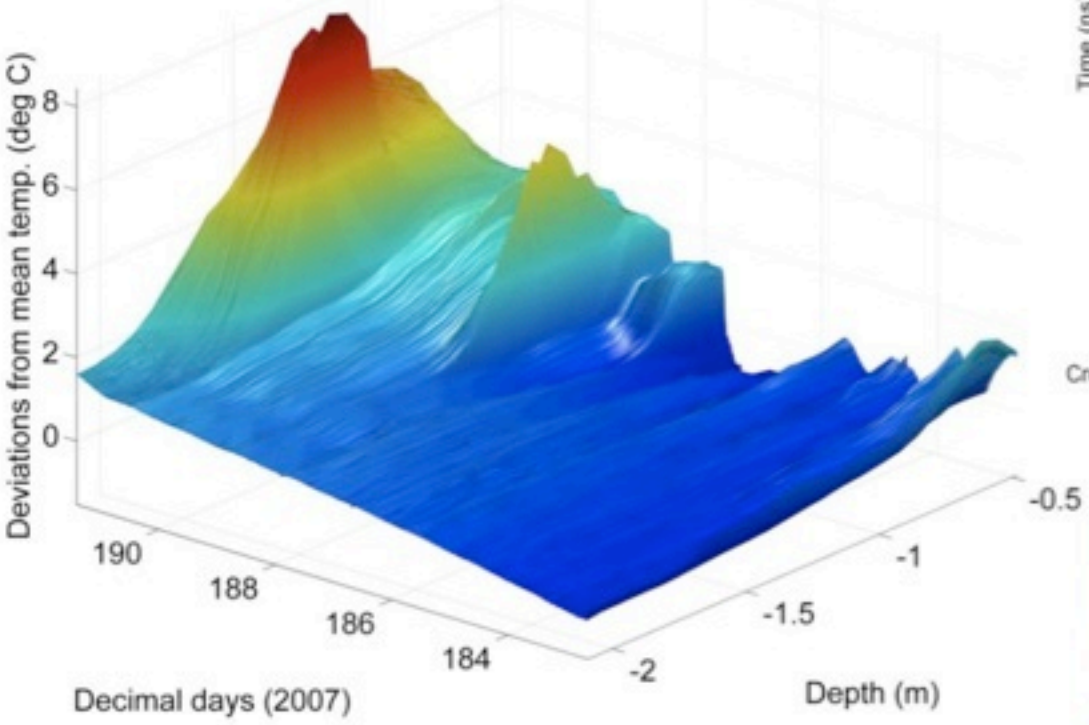
Ice permeability

Heat flow

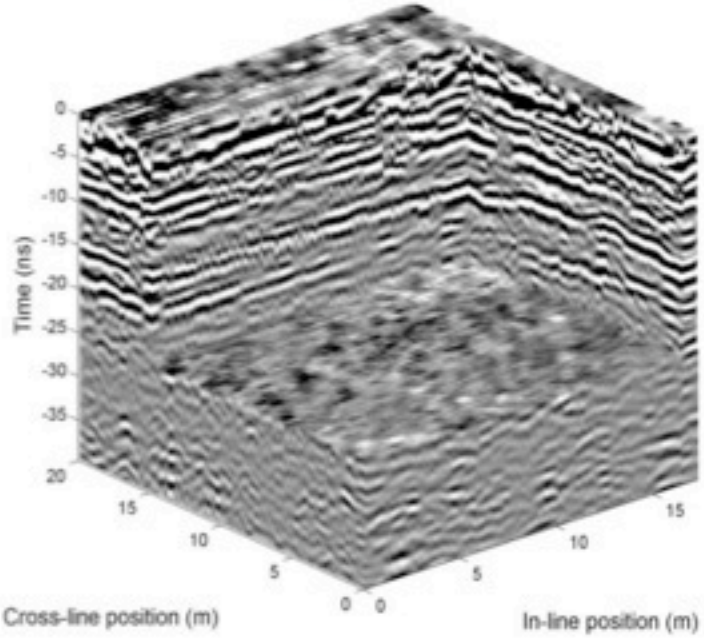

Snow Temperature
Modeled w/ no heat
from melt
Measured
2007 7 23 and hr 0
depth in meters
temperature in degrees celcius
0
1
2
3
4
5
6
7
8
9
10
-25
-20
-15
-10
-5
0
5

Putting it all together

Heat flow

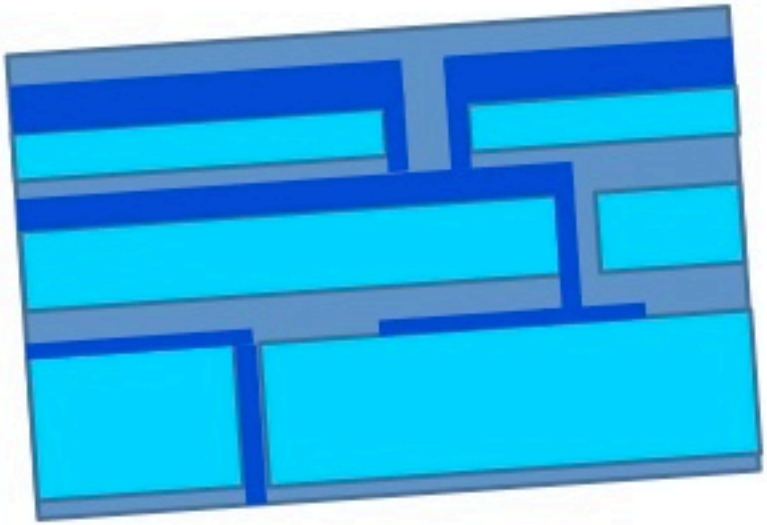


Radar

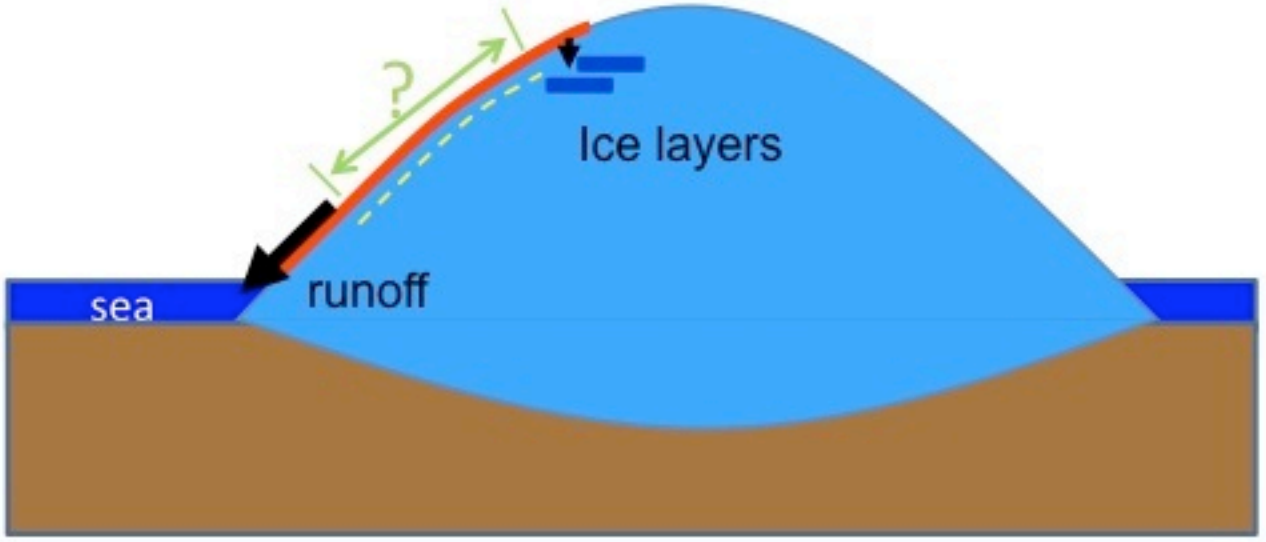


Ice/firn cores

1) Melt water infiltrates deep



2) Space for melt filling-up quickly?



Dr. Shari Gearheard

National Snow and Ice Data Center - Cooperative Institute for Research in Environmental Sciences- University of Colorado at Boulder

Based full time in Clyde River, Nunavut, Canada

Research interests: Human-environment relationships, Inuit culture, indigenous knowledge, collaborative research, Arctic environment, sea ice, weather, climate, Greenland, Inuktitut language, dogsledding

Siku-Inuit-Hila Project
Sea Ice change in Greenland

Dr. Shari Gearheard

Greenland Science Seminar, 8 July 2009

Sea ice and Arctic communities

- Platform for travel, hunting, fishing
- Habitat for key food resources and wildlife
- Integral part of Arctic landscape, climate, ecosystem
- Home and identity

Photo: Stephen Leafloor

Siku-Inuit-Hila Project

- Collaborative team of Inuit and scientists
- Knowledge exchange re. sea ice and sea ice use
- Iñupiat from Barrow, Alaska, Inuit from Clyde River, Nunavut, Inughuit from Qaanaaq, Greenland, researchers from Nuuk, Colorado, Alaska
- Expert working groups, community visits, sea ice monitoring
- Sea ice as the common denominator

Photo: Henry Huntington

Sea ice at Qaanaaq, Greenland

- Travel to hunting grounds, other communities, fishing camps
- Icebergs for fresh water
- Home and identity


Photo: Shari Gearheard

Photo: Shari Gearheard

Sea ice change and impacts at Qaanaaq, Greenland

- Earlier break up
- Later freeze up
- Thinner sea ice
- Shifting and more hazardous trails
- Sea ice hazards


Photo: Lars Poort

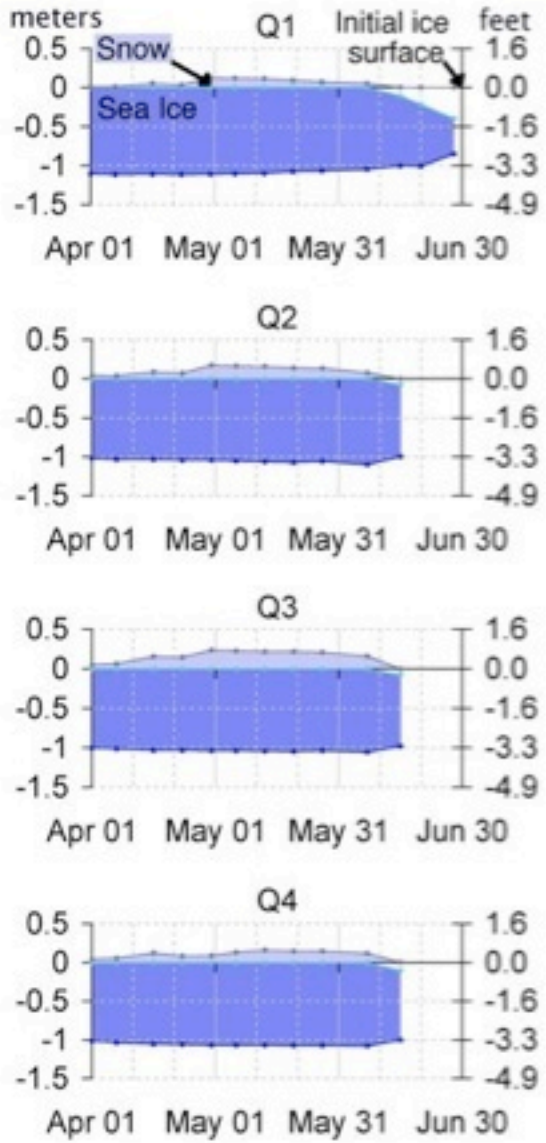

Photo: Shari Gearheard

Qaanaarmiut-led sea ice research

- *Sea ice monitoring
- Sikulirijiit – local sea ice expert working group
- Mapping
- Collaboration
- *Writing Qaanaaq's story

Qaanaaq sea ice monitoring

- 4 stations across fjord
- Stations installed and monitored each year locally
- User-friendly technology, robust results
- Information on local sea ice characteristics, e.g. heat flux in spring that leads to thinning



Q# = Qaanaaq monitoring station

Ilannguaq Qaerngaaq travels by dog team to check Qaanaaq sea ice stations

Writing Qaanaaq's sea ice story

- Local sea ice working group creating Qaanaaq contributions to Siku-Inuit-Hila project book due out 2010
- Stories, knowledge sharing, photos, maps, illustrations
- Knowledge preservation and practice

Photo: Shari Gearheard

Acknowledgements

- Siku-Inuit-Hila project team
- Qaanaaq project team: Toku Oshima, Mamarut Kristiansen, Qaerngaaq Nielsen, Uusaqqak Qujaukitsoq, Taliilannguaq Peary, Ilannguaq Qaerngaaq, Otto Simigaq, Ole Petersen, Qaaviganngnuaq Qissuk
- Communities of Qaanaaq, Clyde River, Barrow
- National Science Foundation
- Inuit Circumpolar Council – Greenland
- Lene Kielsen Holm (ICC)
- Health Canada
- ARCUS

Photo: Shari Gearheard

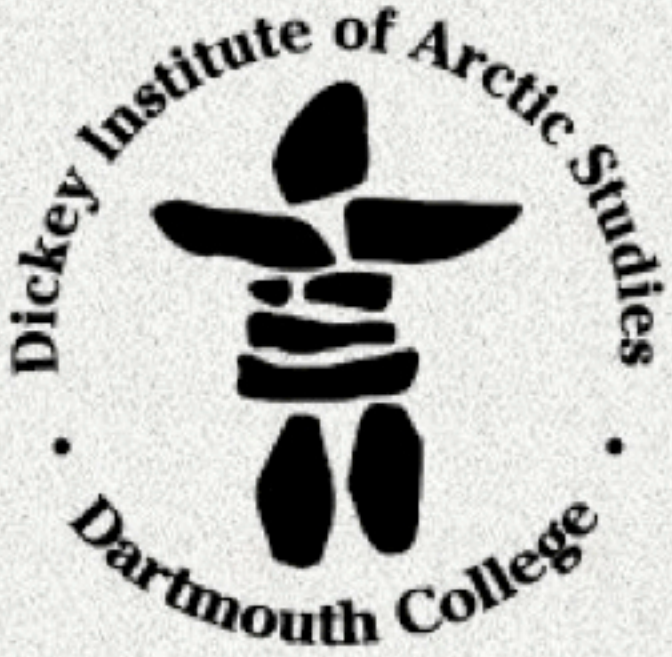
Dr. Ross Virginia

Dartmouth College

Myers Family Professor of Environmental Science

Director, Institute of Arctic Studies at the Dickey Center for International Understanding

Research Interests: developing an interdisciplinary science training program to look at polar environmental change, polar deserts of Antarctica and how climate and soil factors influence the establishment, distribution and function of microscopic organisms in the soil



Ross A. Virginia
Director, Institute of Arctic Studies
at the Dickey Center for International Understanding
Myers Family Professor of Environmental Science
Dartmouth College

Rapid Environmental Change

©2004, ACIA / Map ©Clifford Grabhorn

Overview of Native Concerns

- Global Warming
- Abnormalities in Subsistence Foods
- Human Health
- Impact of Commercial and Sports Fishing

Overview of Native Concerns

- Local Sources of Contaminants
- Outside Sources of Contaminants
- Changes in the Ecosystem
- Perpetuation of Culture

Involving Native Communities

- Polar scientists studying in Greenland may never meet Native Greenlanders or talk with them about their findings, never learn what science Greenlanders want, or form partnerships to involve these communities in the work.

Dickey Institute of Arctic Studies
Dartmouth College

The Challenge

- To train the next generation of polar scientists to "understand and respect the experience-based knowledge of indigenous cultures."

Aqqaluk Lynge, ICC-Greenland


IGERT: Polar Environmental Change
a new partnership with Greenland
www.dartmouth.edu/~igert/

IGERT

Integrative **G**raduate **E**ducation and
Research **T**raineeship (**IGERT**) Program

- Graduate Education Initiative from the National Science Foundation
- IGERT provides grants to transform graduate training in the sciences and engineering

IGERT Goals

- Train students in polar science and engineering
- Teach the ethics of conducting research in partnership with Arctic residents

- Gain understanding of the relationships between science and policy
- Develop skills in communicating science to policy makers, young students, and cross-culturally

Dickey Institute of Arctic Studies
Dartmouth College

What is Traditional Ecological Knowledge (TEK)?

- Traditional Ecological Knowledge is established through years of learning and is passed down from generation to generation. For example:
  - Agricultural techniques
  - Sustainable hunting and fishing
  - Land ethics
  - Weather observations

- Traditional Ecological Knowledge and Western science both contribute to our understanding of climate change

Dickey Institute of Arctic Studies
Dartmouth College

The Greenland Field Seminar



- Northern Peoples in Transition
- Changing Greenland: Scientific Evidence
- Political Ecology and Resource Management

Dickey Institute of Arctic Studies
Dartmouth College


Copenhagen 4 hrs 15 min
Los Angeles 6 hrs 45 min
Moscow 5 hrs 20 min
Rome 5 hrs 40 min
Tokyo 10 hrs 35 min
Paris 4 hrs 25 min
Frankfurt 4 hrs 40 min
London 3 hrs 35 min
Kangerlussuaq


Nuuk


Summit Camp

IGERT Polar Environmental Change Partners

- Ilisimatusarfik (Univ. of Greenland)
- Inuit Circumpolar Council (ICC) Greenland
- U.S. Cold Regions Research and Engineering Lab (CRREL)


“Climate change is not just a theory to us”
Aqqaluk Lynge

Dr. Morten Rasch

- Scientific Coordinator of the Greenland Ecosystem Monitoring program at Zackenberg and Nuuk Ecological Research Operations
- National Environmental Research Institute in Roskilde, Denmark
- Research interests include cross-disciplinary science focusing on climate change in marine and terrestrial ecosystems in the polar regions.

Greenland Ecosystem Monitoring

Morten Rasch
Scientific Leader

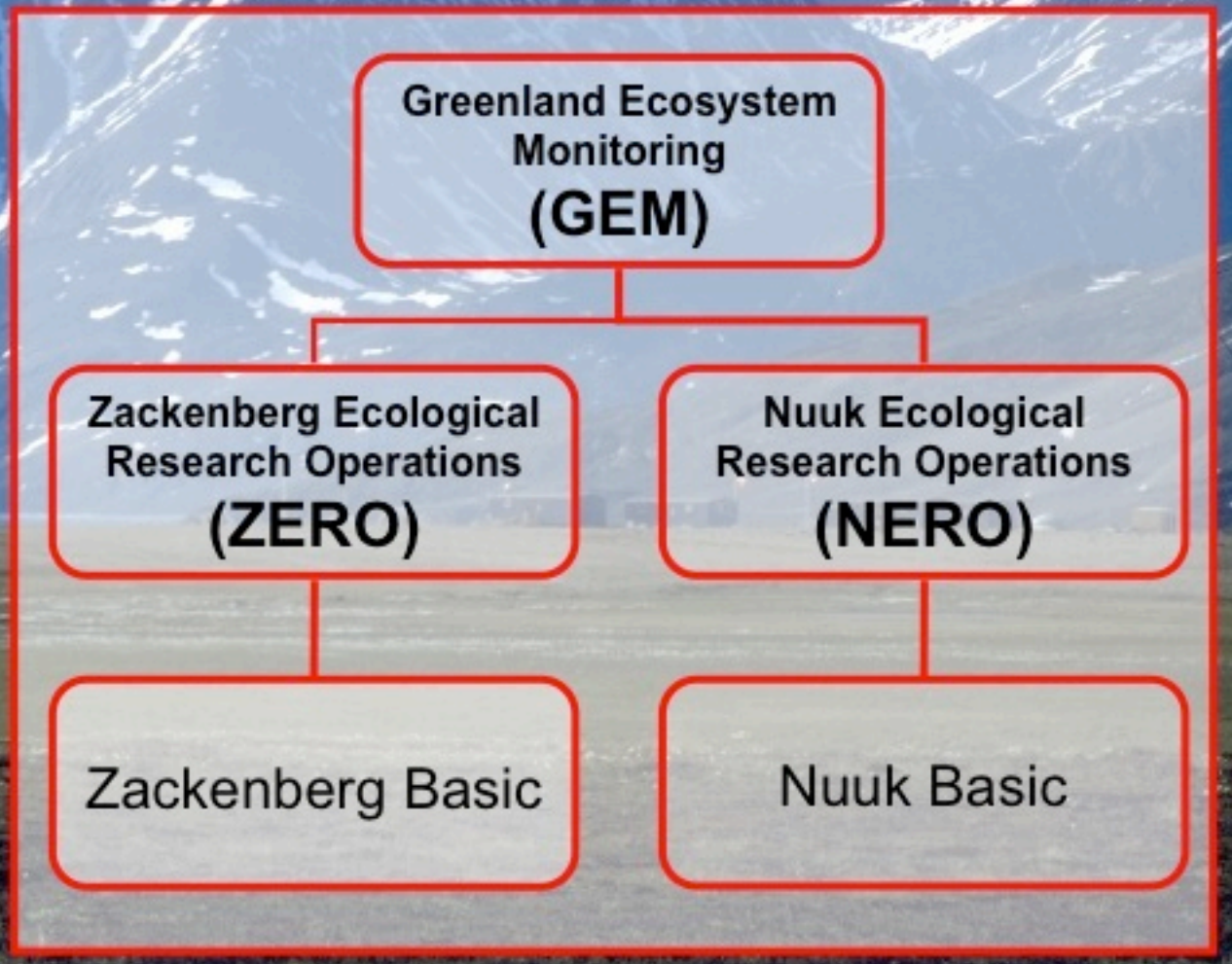
Greenland Ecosystem Monitoring
Zackenberg Ecological Research Operations
Nuuk Ecological Research Operations

Scientific Seminar
Joint Science Education Tour in Greenland
8 July 2009

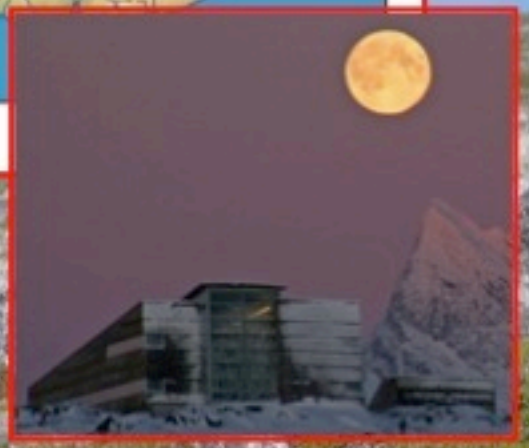
National Environmental Research Institute
University of Aarhus

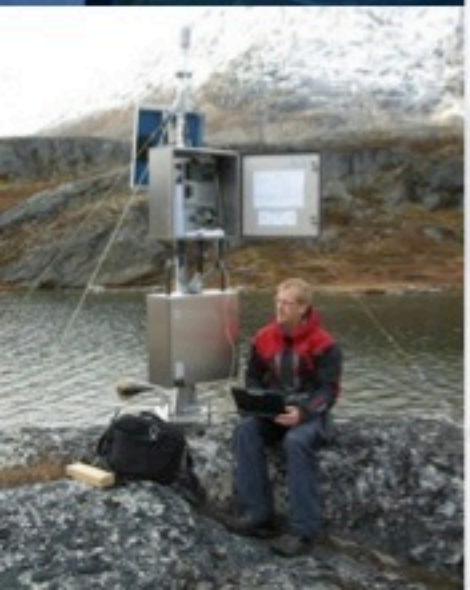
Greenland Ecosystem Monitoring

Zackenberg Ecological Research Operations
Nuuk Ecological Research Operations



Nuuk Ecological Research Operations (NERO)
Nuuk Basic

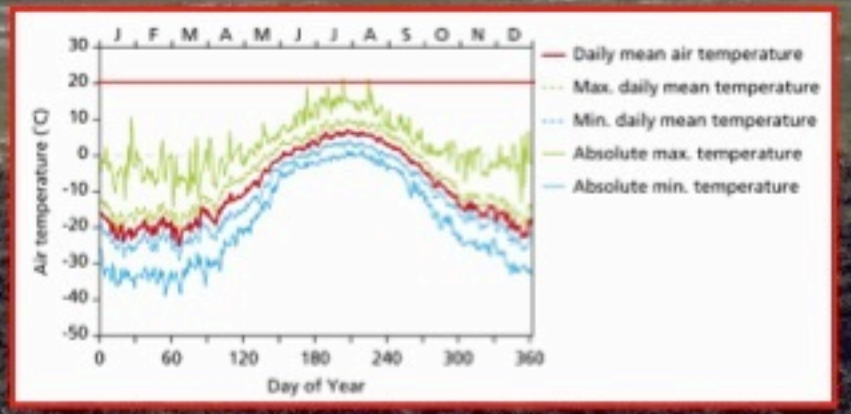




NERO and Nuuk Basic:

- Established in 2007
- Low arctic setting
- No permafrost
- Study area 25 km from Nuuk, the Capital of Greenland
- Four subprogrammes: Climate Basis, GeoBasis, BioBasis and MarineBasis
- Approximately 3,500 parameters measured once every year
- Run by Greenland Institute of Natural Ressources, Asiaq, University of Aarhus and University of Copenhagen
- Funded by The Ministry of Energy and Climate, The Ministry of Technology and Innovation, The Ministry of the Environment and The Greenland Home Rule
- Annual budget: c. 0.8 mio. EURO
- A Climate Research Center will be established in Nuuk in 2009, and staffed with ten scientists. It is the plan to establish strong synergies between the Climate Research Center, NERO and Nuuk Basic

Zackenberg Ecological Research Operations (ZERO)
Zackenberg Basic



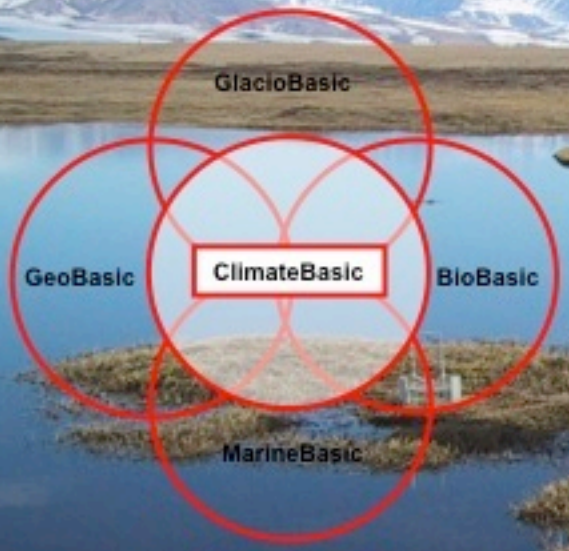
ZERO and Zackenberg Basic:

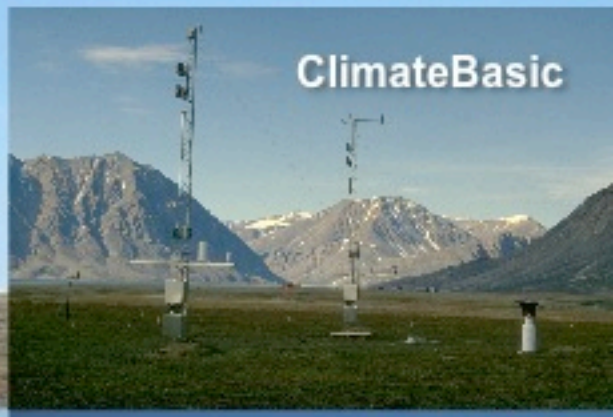
- Established in 1995
- High arctic
- Permafrost
- Study area 450 km from nearest town, Scoresby-sund
- Five subprogrammes: Climate Basis, GeoBasis, BioBasis, MarineBasis and GlacioBasis
- 3.500 parameters measured once every year
- Run by Greenland Institute of Natural Ressources, Asiaq, University of Aarhus, University of Copenhagen and Geological Survey of Denmark and Greenland
- Funded by The Ministry of Energy and Climate, The Ministry of Technology and Innovation, The Ministry of the Environment and The Greenland Home Rule
- Annual budget: c. 1.2 mio. EURO
- Besides being the observatory for ZERO and Zackenberg Basic, Zackenberg Research Station also hosts c. 15 other research projects each year

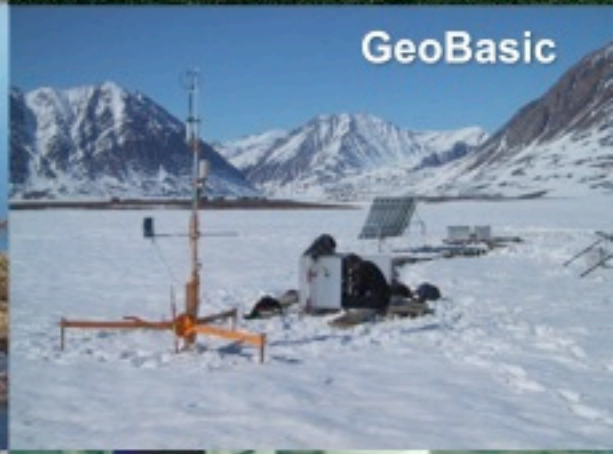
Greenland Ecosystem Monitoring

Major questions

1. How and why does climate variability influence the dynamics of high arctic ecosystems?
2. How do high arctic ecosystems affect climate?

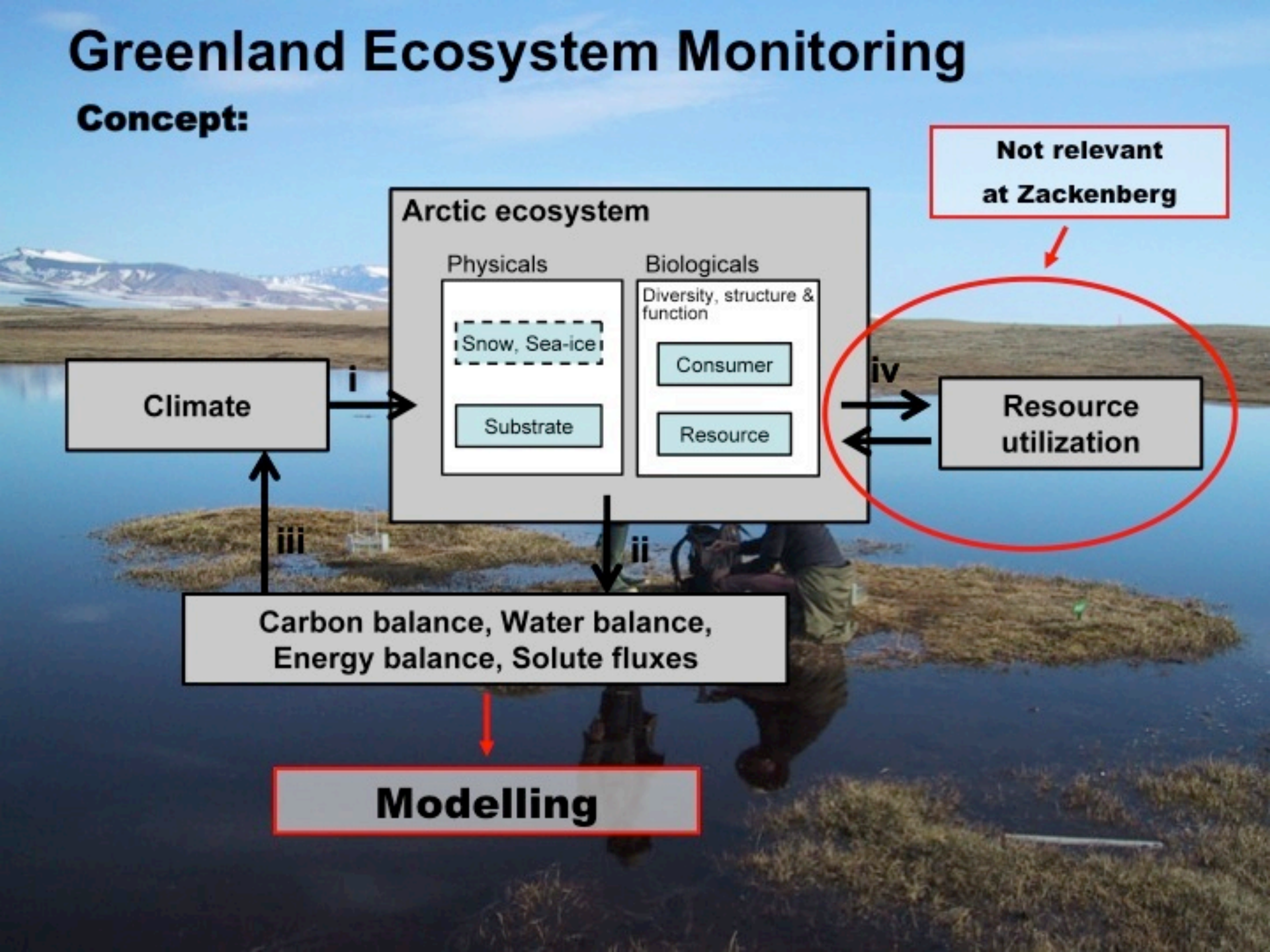






Greenland Ecosystem Monitoring

Concept:



Greenland Ecosystem Monitoring

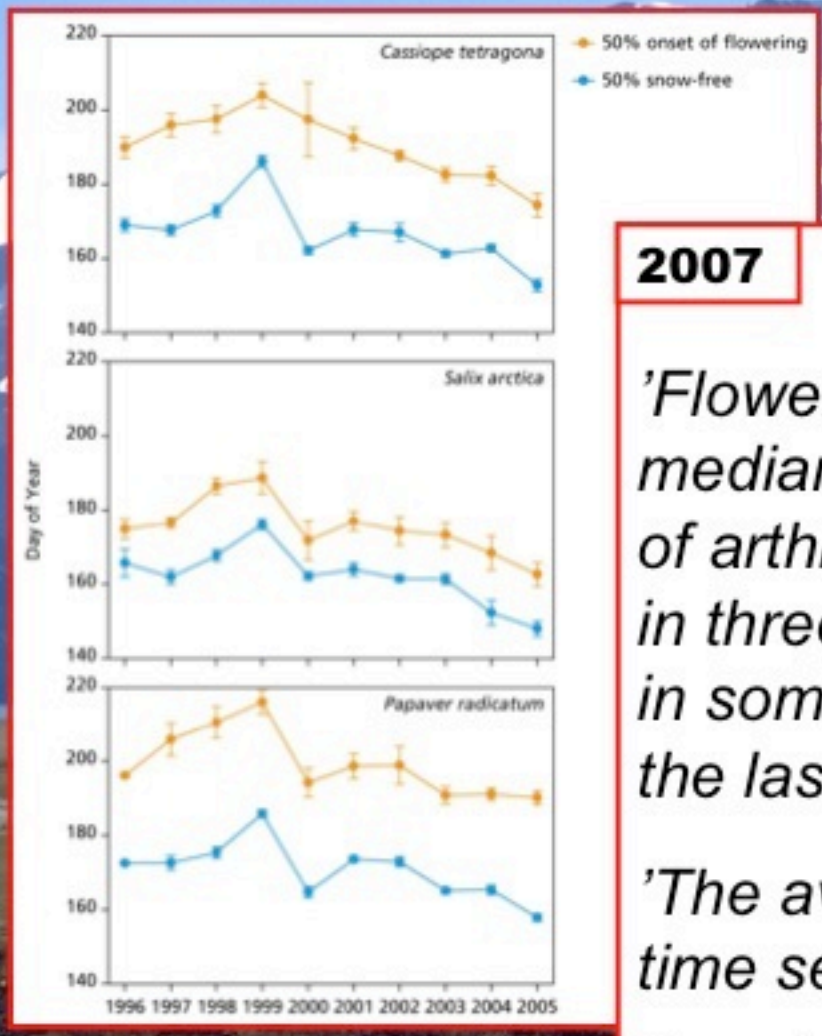
Measurements, data and publication:

- Greenland Ecosystem Monitoring focus on thirteen scientific themes being monitored in cooperation between the five monitoring sub-programmes
- A total of c. 3,500 parameters are measured at each locality each year at different time intervals (from several per second to one per year)
- All measurements are collected in common databases which are avialable on-line at www.zackenberg.dk and www.nuuk-basic.dk
- Data are provided free-of-charge to anyone being interested in using the data
- Data from Zackenberg and Nuuk are thoroughly reported each year to the ZERO and NERO Annual Report's
- A reporting of the first ten years of monitoring and research at Zackenberg was published by Academic Press (*Advances in Ecological Research 40*) in 2008.

Scientific theme	Description
Climate	Temperature (air, surface and soil), wind, humidity, precipitation
Snow	Cover, thickness, distribution
Hydrology	Water balance, nutrient cycling
Glacier ice	Iceberg export to Godthåbsfjorden
Sea ice	Cover, thickness, distribution
UV radiation	Strength, seasonal,interannual variations and ecosystem effects
Soil	Water balance, chemistry, soil arthropods, decomposition
Vegetation	Species diversity, growth, reproduction, phenology, parasitism, distribution of vegetation types, UV radiation effects
Gas flux	Carbon dioxide, methane, interactions with structure and function of herbivore-plant interactions
Lakes	Chemistry, Carbon balance, abundance and production of plankton and fish
Athropods	Insect abundance, reproduction and phenology
Mammals & Birds	Selected terrestrial, freshwater and marine species, species diversity, Abundance, distribution, reproduction, phenology
Water phase	Temperature, salinity, currents, chemistry, carbon balance, plankton, crustacean, fish.
Sea bottom	Chemistry, carbon balance, growth, abundance and distribution of benthic animals

Zackenberg Ecological Research Operations

Some results



2007

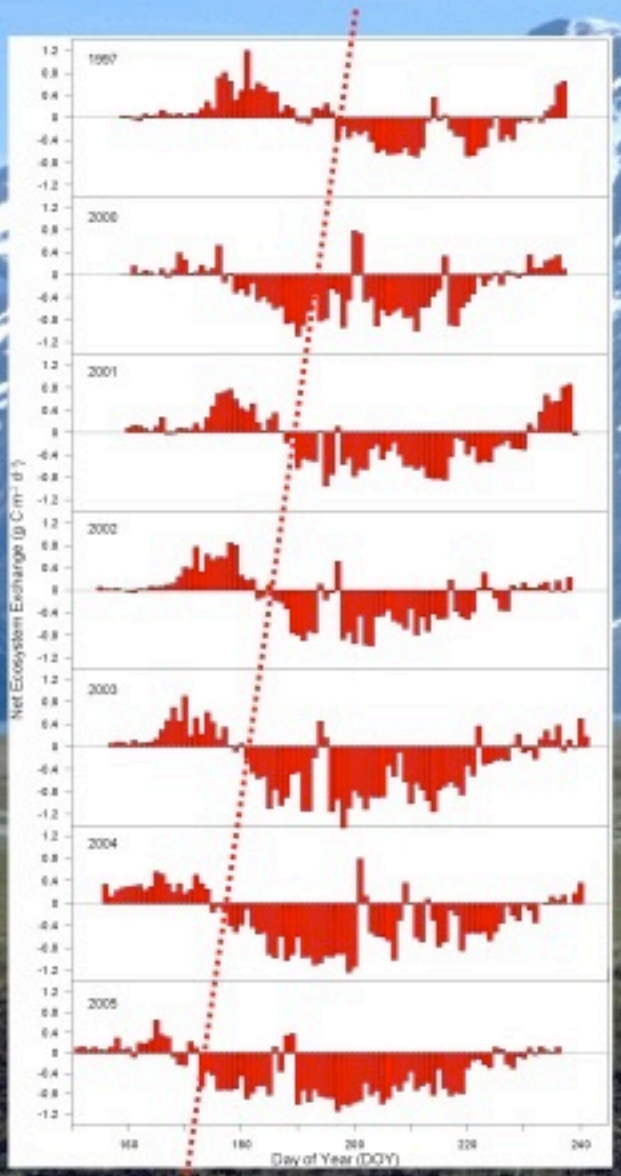
'Flowering dates in six plant species, median emergence dates of twelve taxa of arthropods, and clutch initiation dates in three species of birds have advanced, in some cases by over 30 days during the last decade'

'The average advancement across all time series was 14.5 days per decade'

Hoye et al. 2007: *Current Biology 17(12)*, 449-51.

Zackenberg Ecological Research Operations

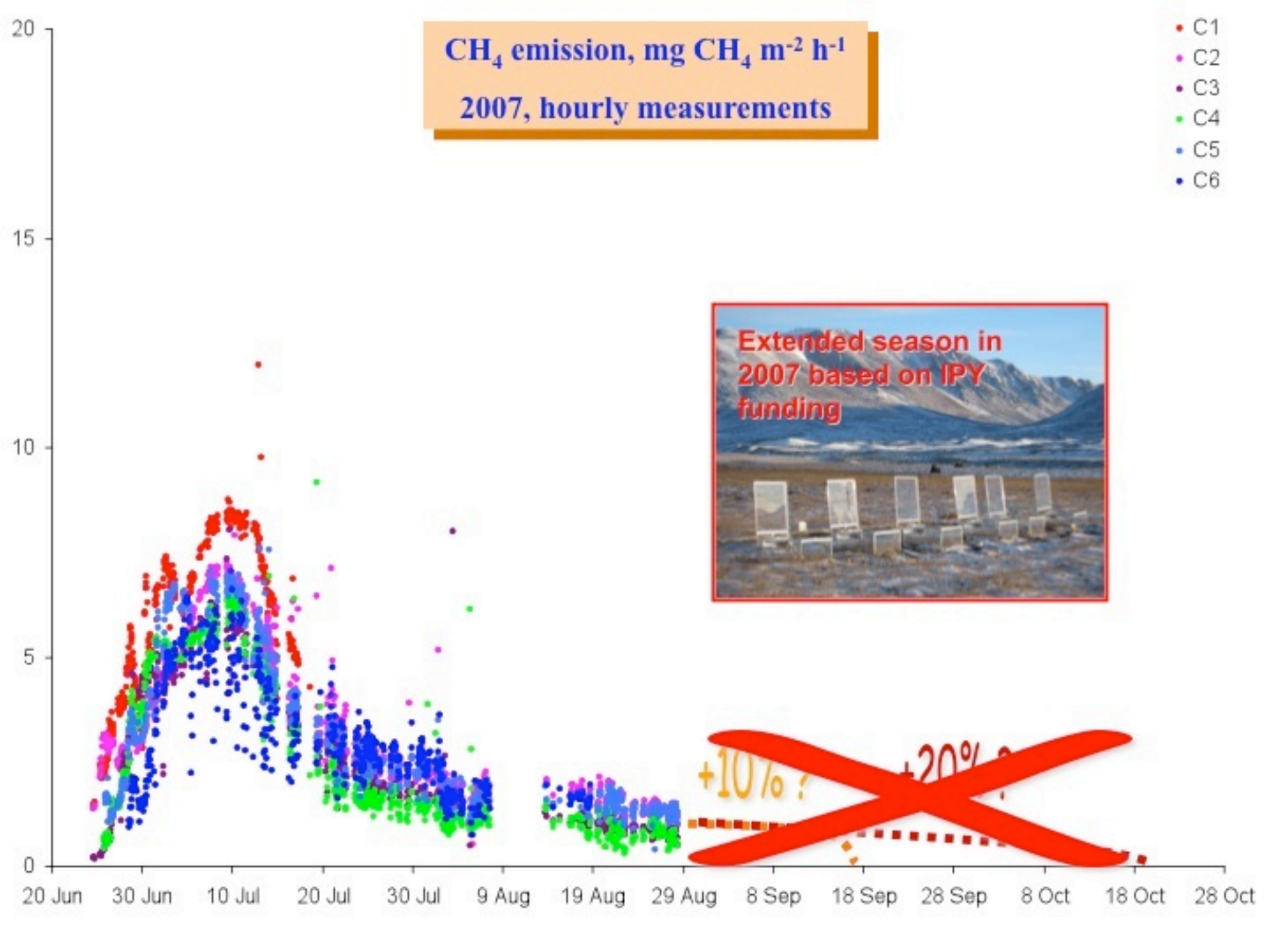
Some results

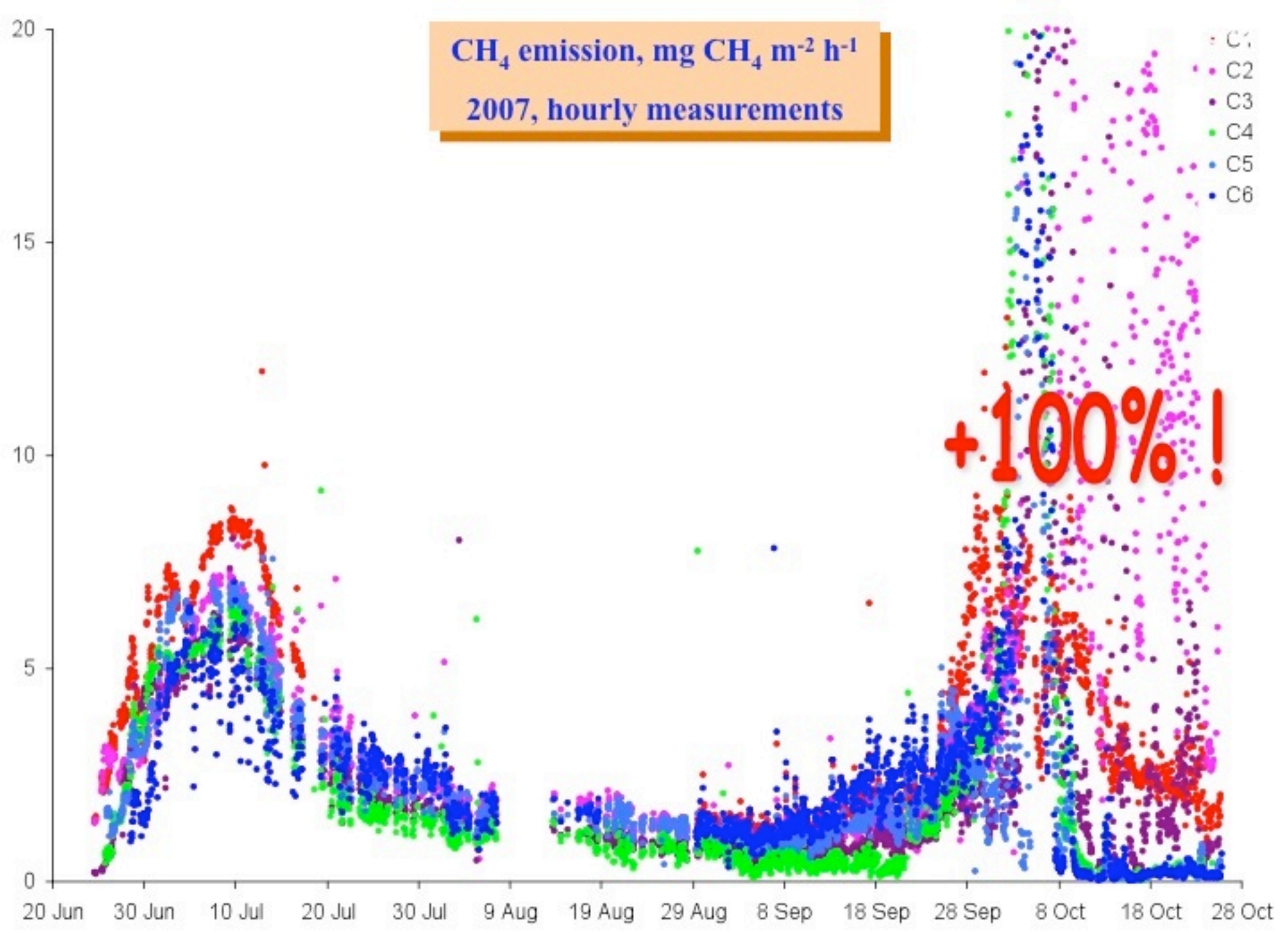


Carbon dioxide exchange from the tundra to the atmosphere has been measured almost continuously at Zackenberg since 1997.

In general the start of growing season has occurred earlier and earlier at Zackenberg since 1997.

Meltofte et al. (eds.) 2008: *Advances in Ecological Research 40*, 563 p.


CH_4 emission, mg CH_4 m^{-2} h^{-1}
2007, hourly measurements
C1
C2
C3
C4
C5
C6
Extended season in 2007 based on IPY funding
+10% ?
20
15
10
5
0
20 Jun
30 Jun
10 Jul
20 Jul
30 Jul
9 Aug
19 Aug
29 Aug
8 Sep
18 Sep
28 Sep
8 Oct
18 Oct
28 Oct


CH4 emission, mg CH4 m-2 h-1
2007, hourly measurements
C1
C2
C3
C4
C5
C6
+100% !
20
15
10
5
0
20 Jun
30 Jun
10 Jul
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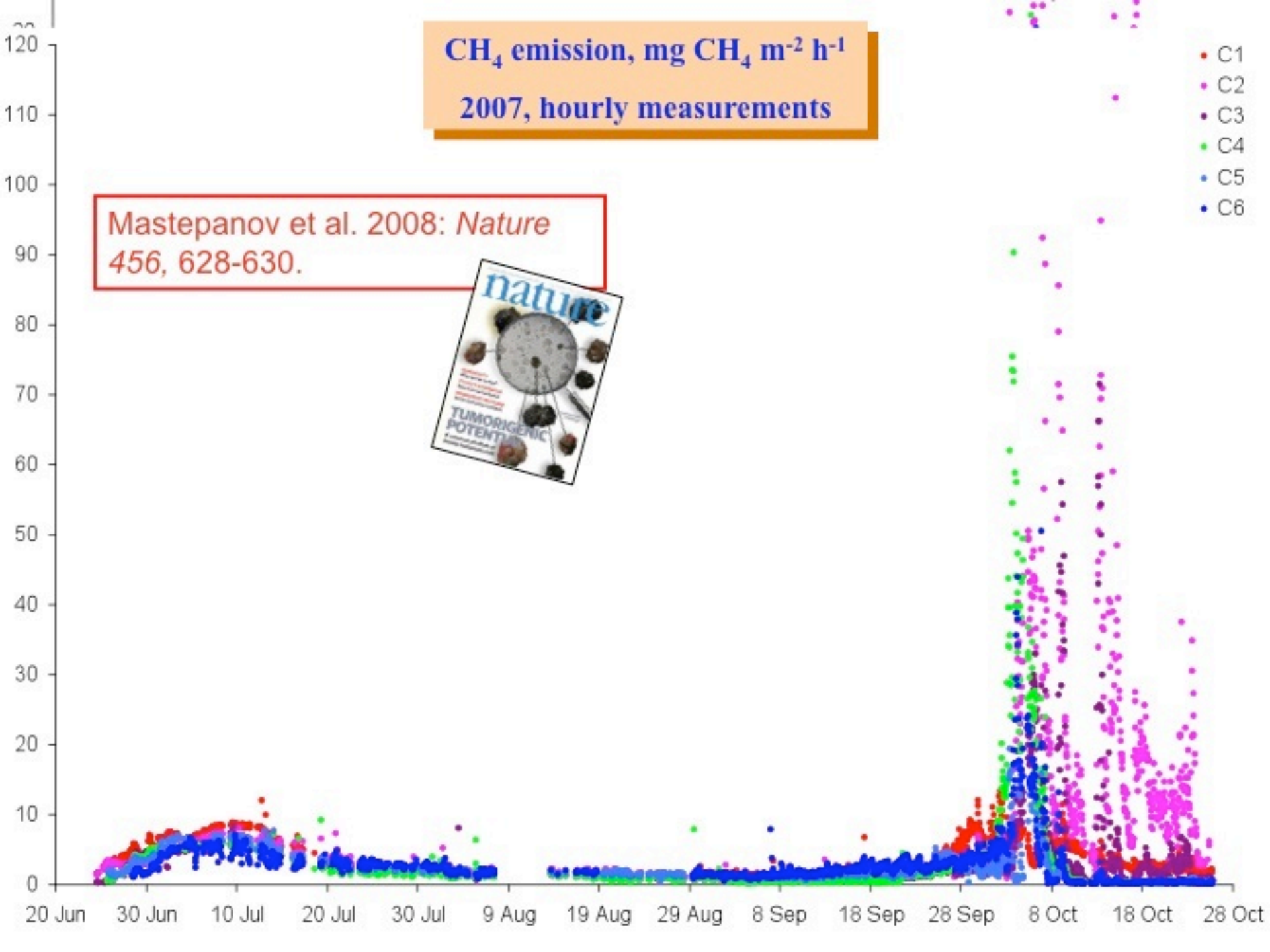
29 Aug
8 Sep
18 Sep
28 Sep
8 Oct
18 Oct
28 Oct


CH_4 emission, mg CH_4 m^{-2} h^{-1}
2007, hourly measurements
Mastepanov et al. 2008: *Nature 456*, 628-630.
nature
TUMORIGENIC POTENTIAL
C1
C2
C3
C4
C5
C6
120
110
100
90
80
70
60
50
40
30
20
10
0
20 Jun
30 Jun
10 Jul
20 Jul
30 Jul
9 Aug
19 Aug
29 Aug
8 Sep
18 Sep
28 Sep
8 Oct
18 Oct
28 Oct

Greenland Ecosystem Monitoring

Future plans:

1. Much more cooperation with other 'observatories', as forexample Svalbard Integrated Arctic Earth Observing System, Abisko Scientific Research Station, Toolik Research Station, Cheerski Research Station and the new arctic station in Canada. This could be in SAON, CEON, SCANNET or something else.
2. Permanent extension of the field seasons at both sites
3. Extension of carbon balance and biodiversity components
4. More comparative studies between low arctic (Nuuk) and high arctic (Zackenberg) sites
5. Increase educational component
6. Increase 'Greenlandic' involvement


We are looking forward to
cooperating with you
Further information: www.zackenberg.dk
www.nuuk-basic.dk
www.g-e-m.dk

Questions?




When asking a question, please state clearly:

- ✓ Your Name
- ✓ Your School/Organization
- ✓ Your State or City and Country
- ✓ Who the question is addressed to
- ✓ Your Question

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The archive of this event will be available shortly at:

www.polartrec.com!

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info@polartrec.com or call 1-907-474-1600