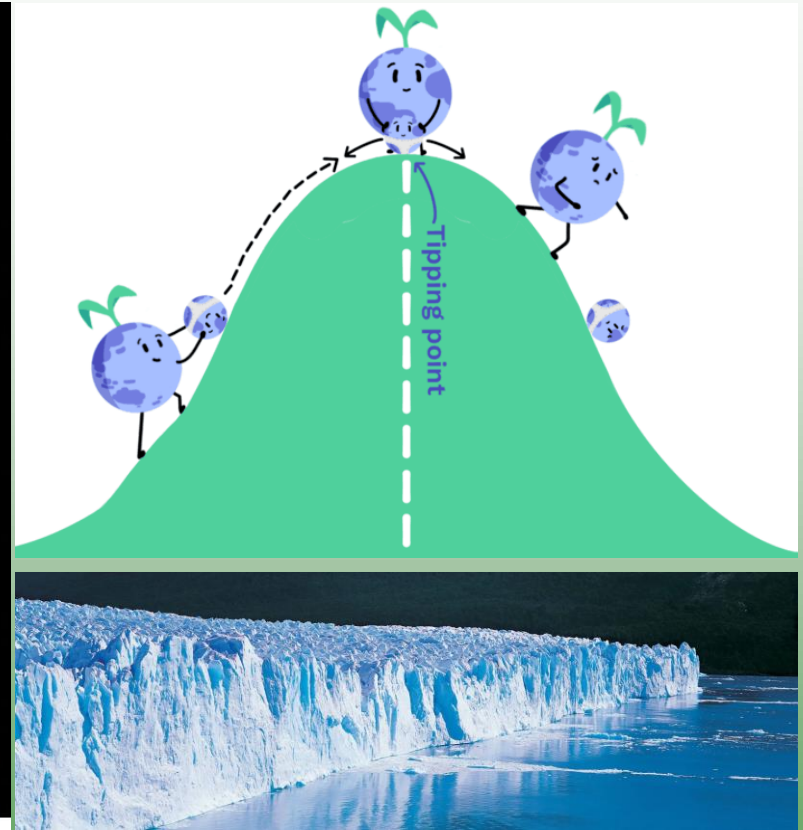


Climate Change Tipping Points: The Untold Story of William Dansgaard



© 2007 Thomson Higher Education



MULTNOMAH



UNIVERSITY

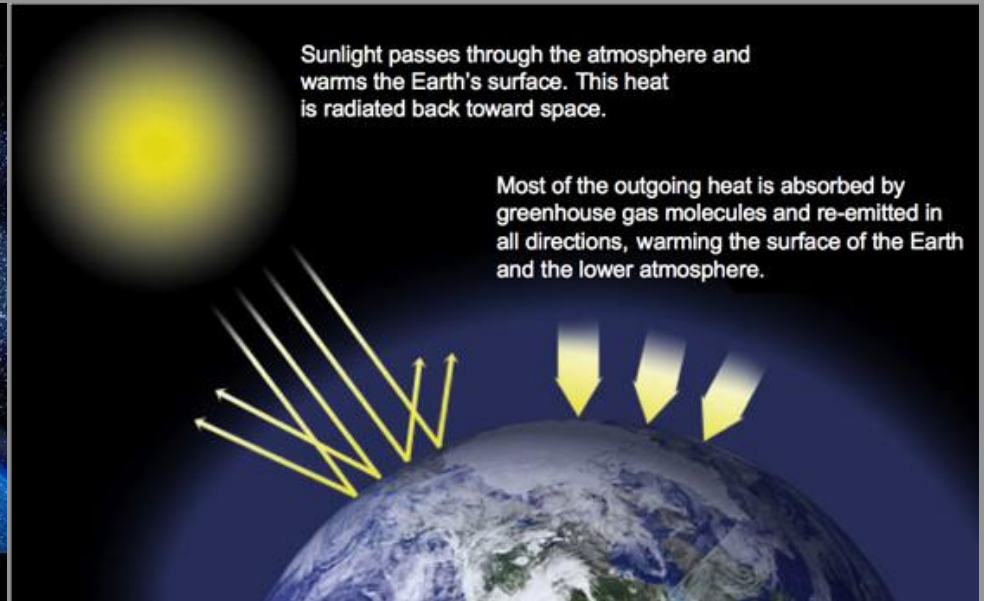
Kyle Dittmer, PH (AIH 07-1699)

CRITFC Hydrologist-Meteorologist

MU Professor, Dept. Natural Sciences

Oregon AMS,
Nov. 7, 2023

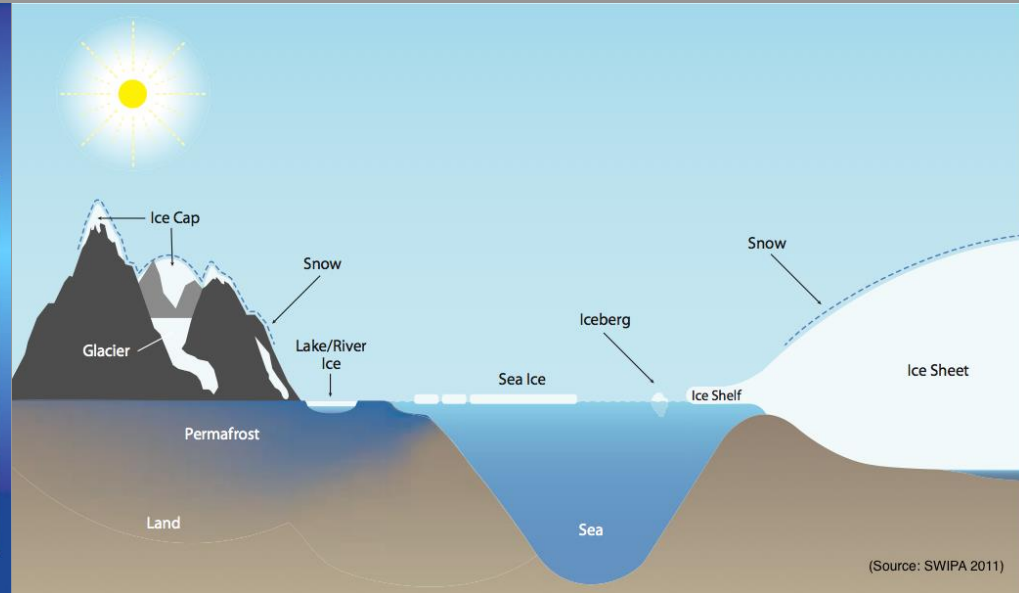
CLIMATE BASICS: THE ATMOSPHERE



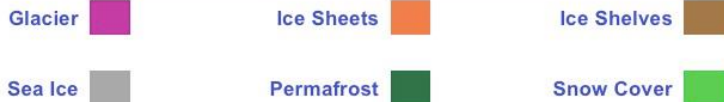
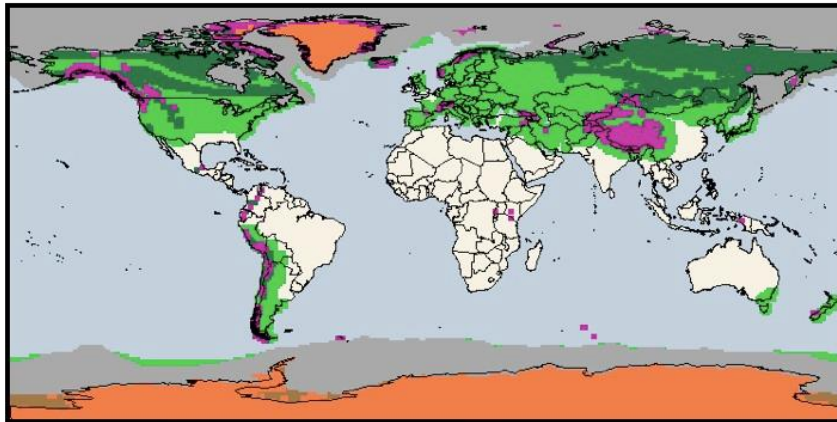
CLIMATE BASICS: THE CRYOSPHERE

Cryosphere

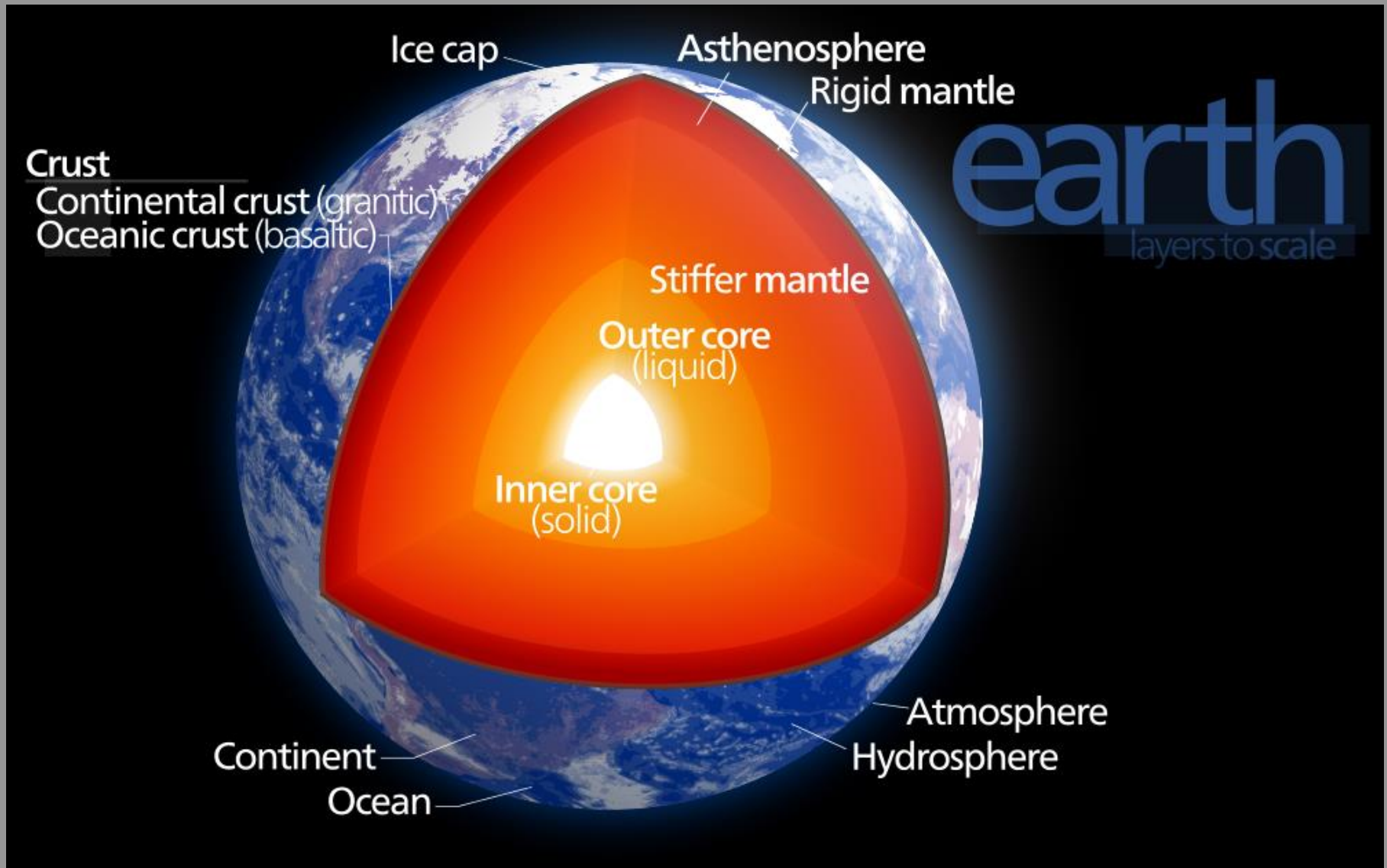
- The portion of the Earth's surface where water is in a solid form
- Snow or ice: includes glaciers, ice shelves, snow, icebergs, and arctic climatology



Global Cryosphere by Type

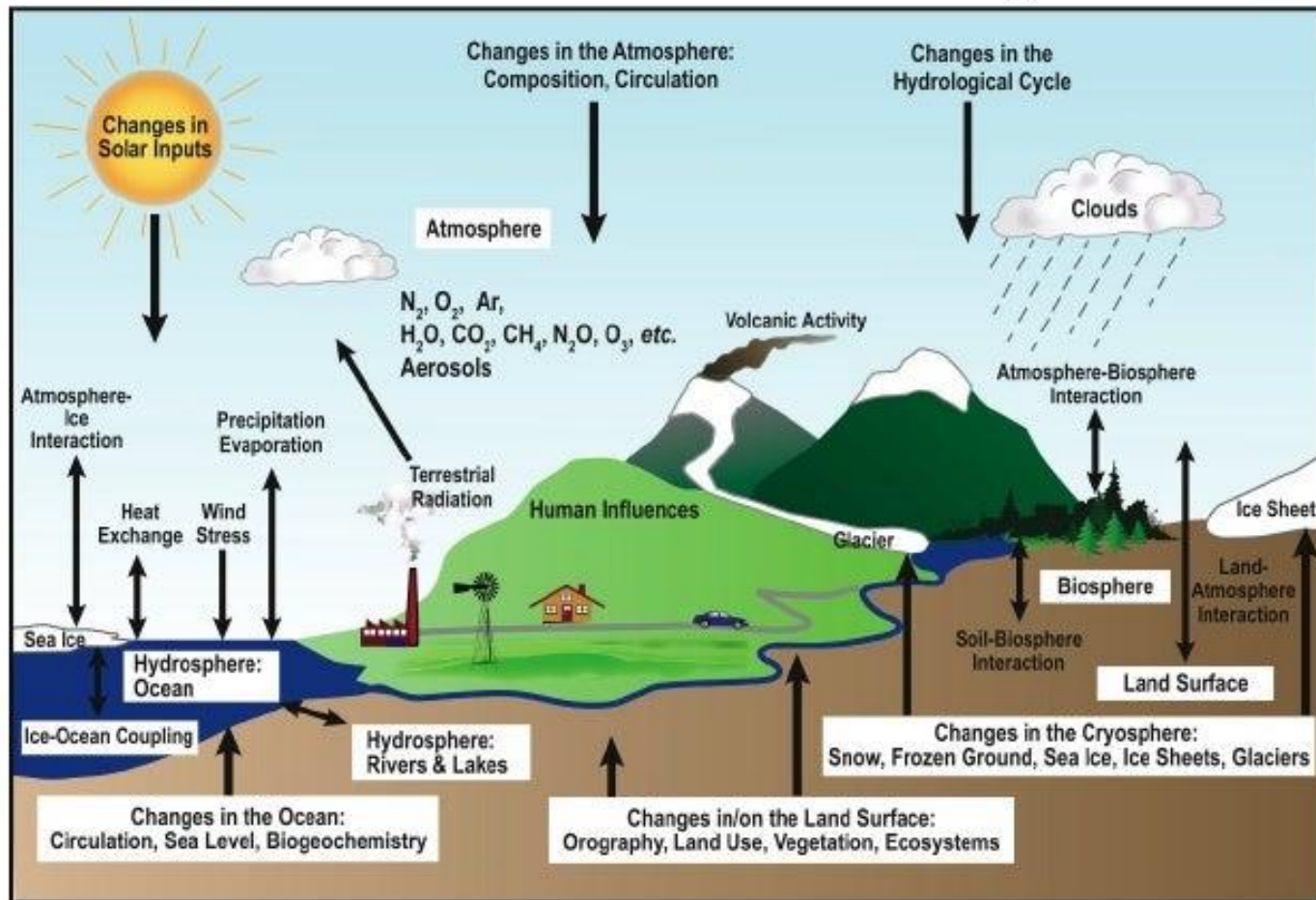


EARTH...AN *INTEGRATED* SYSTEM



EARTH'S CLIMATE...*INTEGRATED* SYSTEM

The Earth's Climate System



WHAT IS CLIMATE CHANGE?

HOW IS CLIMATE CHANGE DEFINED?

#1 – Long-term (decades) significant trend of temperature & precipitation.

#2 – Change in the seasonal timing of precipitation and/or snow events.

#3 – Increased variability in the weather (i.e., more extreme weather).

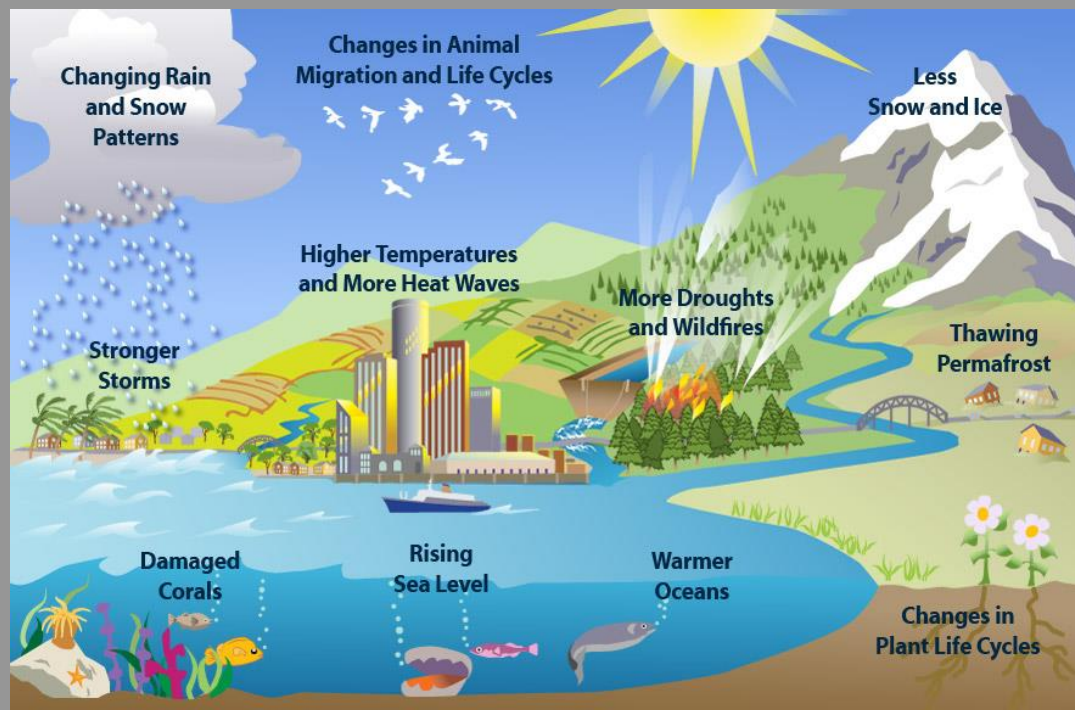
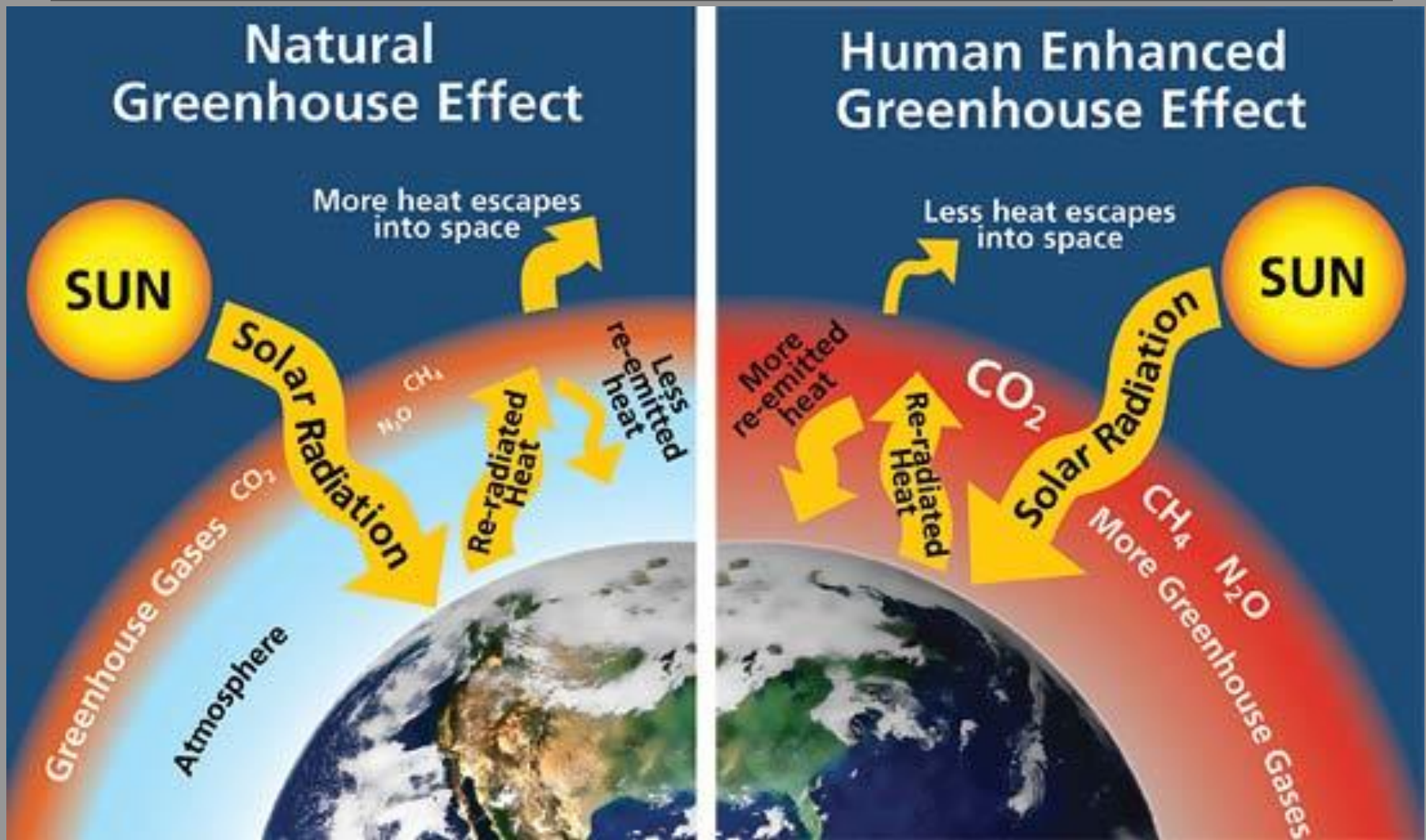


Figure source: (<http://www.epa.gov/>)...exact link now gone

THE \$1 MILLION QUESTION:

"WHAT IS THE CAUSE OF CLIMATE CHANGE?"

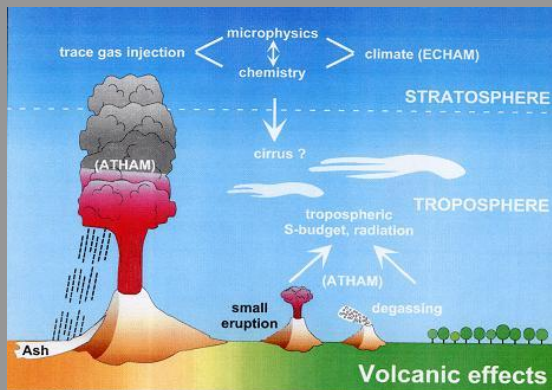
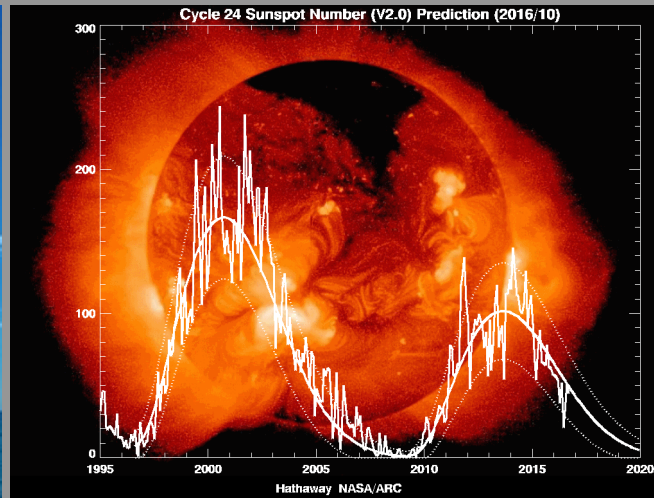
Cause #1 – Greenhouse Gas or **GHG** (man-made – industry, energy)



THE \$1 MILLION QUESTION:

"WHAT IS THE CAUSE OF CLIMATE CHANGE?"

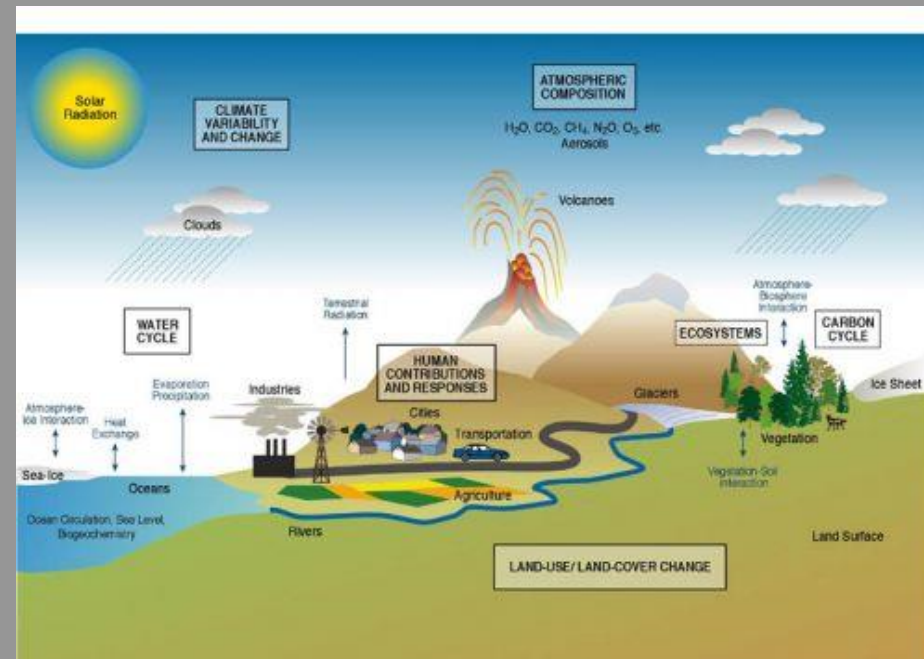
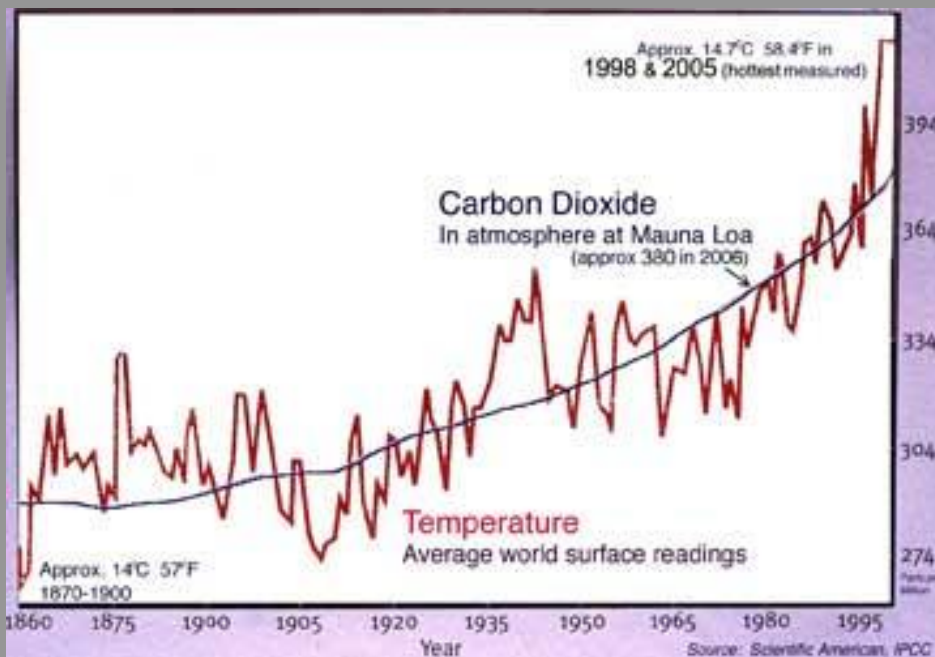
Cause #2 – Natural Cycle (Earth orbit, solar cycle, ocean current, volcanism)



THE \$1 MILLION QUESTION:

"WHAT IS THE CAUSE OF CLIMATE CHANGE?"

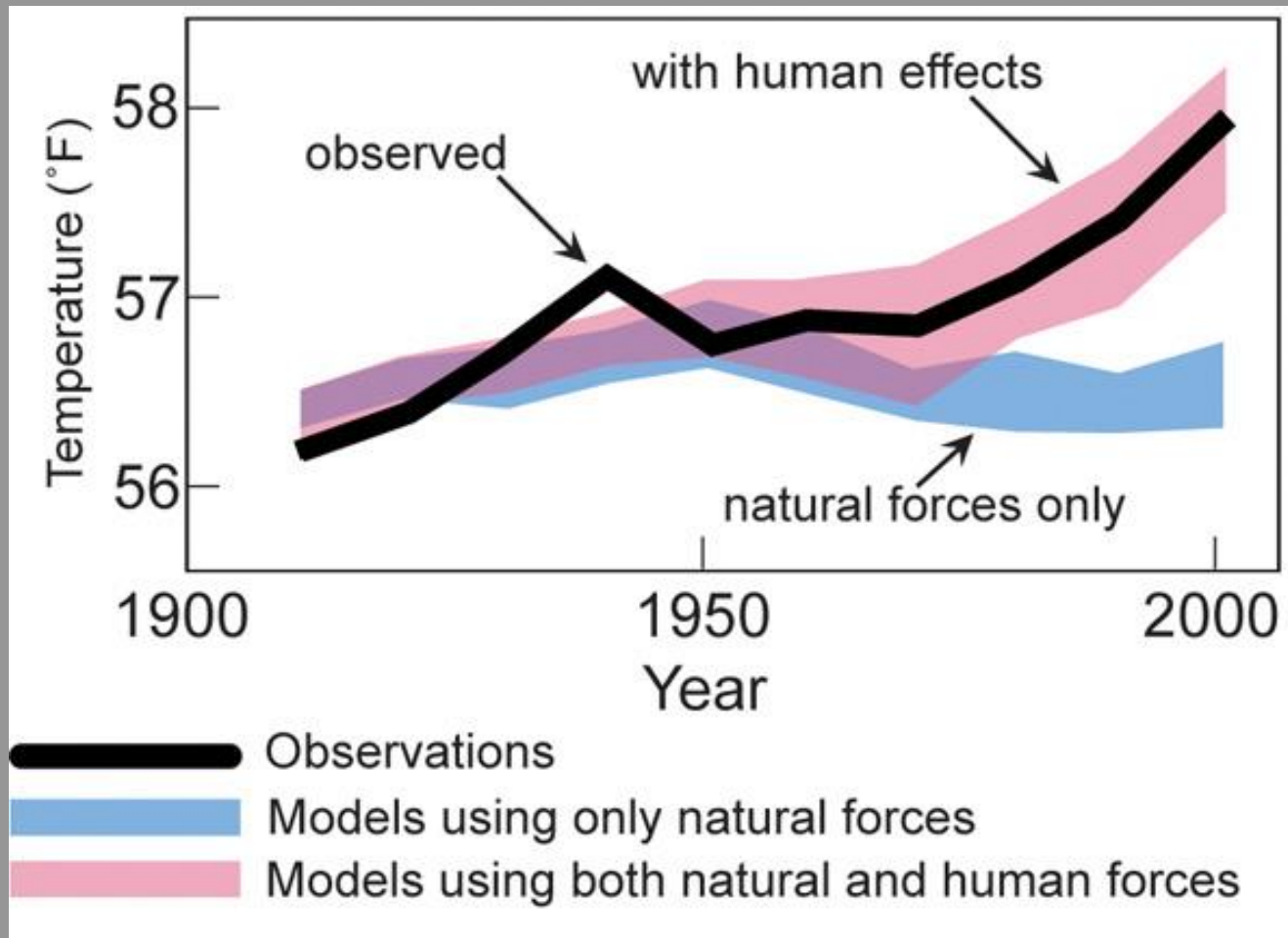
Cause #3 – Blended-view (GHG/man-made and Natural Cycle)



THE \$1 MILLION QUESTION:

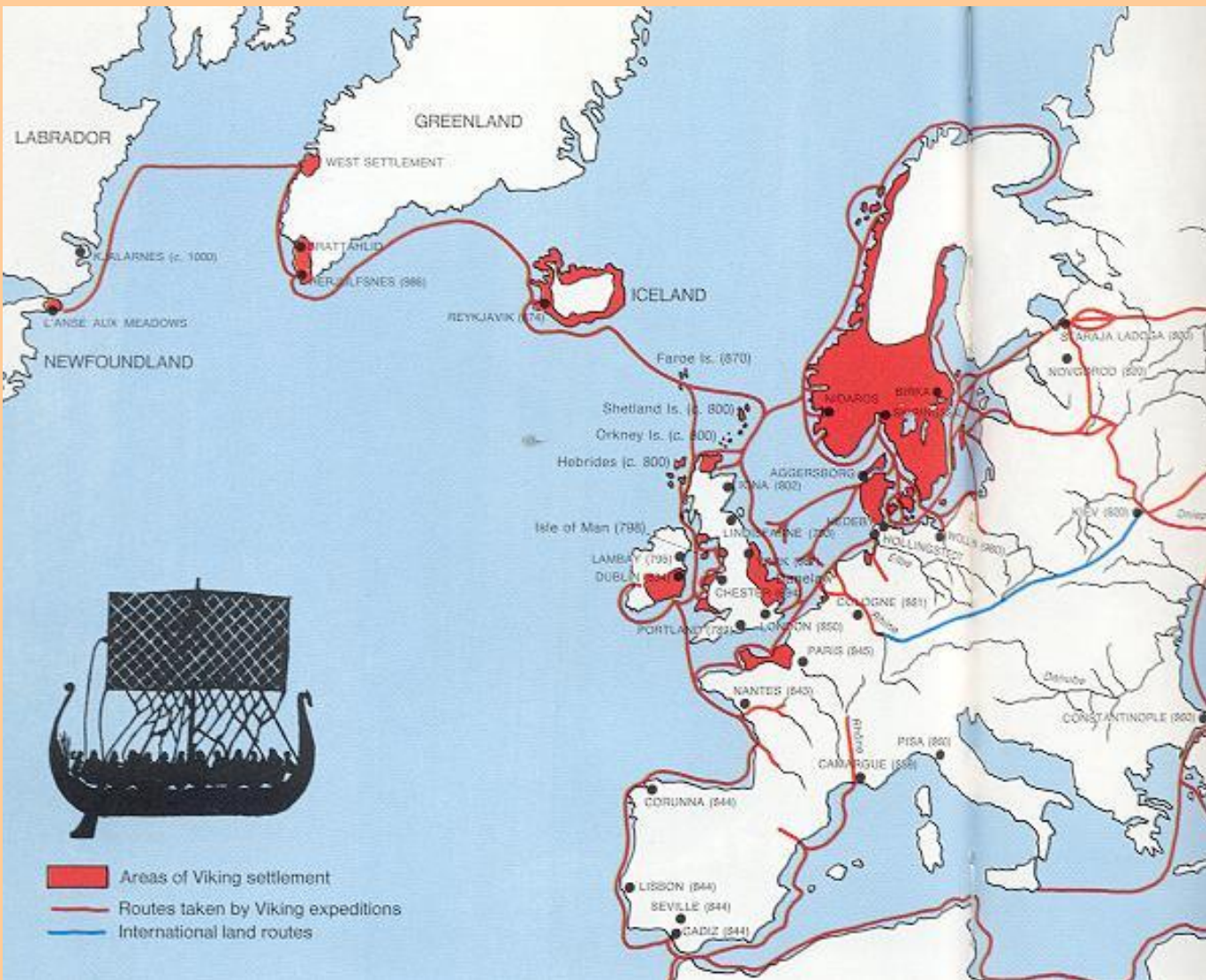
"WHAT IS THE CAUSE OF CLIMATE CHANGE?"

Cause #3 – Blended-view (GHG/man-made *and* Natural Cycle)



Source: Stott, et.al. (Science, 2000)

Viking Journeys to Greenland



The Climate System and Climate Variations

33

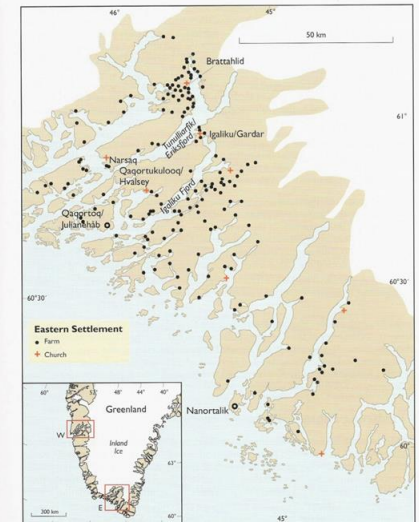


Figure 6 Descendants of the Nordic Vikings established the two Norse communities in Greenland, the Eastern Settlement (E) and the Western Settlement (W) during the Medieval Climatic Optimum around AD 1000. The Norse settlers built farms and churches, but they lived on the edge of sustainability and at the end of the fourteenth century they vanished from Greenland. Why the Norse culture flourished is still one of the mysteries of medieval history but may at least partly be ascribed to the influence of climate change.

Greenland 2006



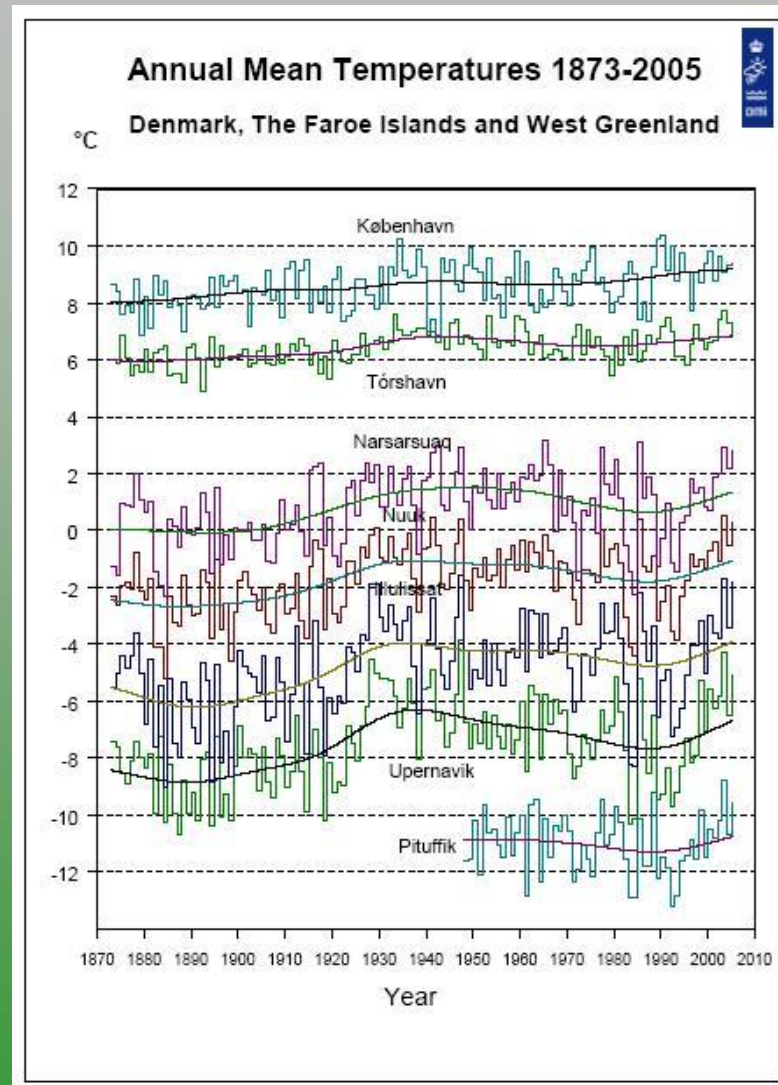
Photo courtesy of Torben Hansen (<http://www.th-randers.dk>)

Greenland 2006



Photo courtesy of Torben Hansen (<http://www.th-randers.dk>)

Trends of Greenland temperature



Source: Denmark Meteorological Institute (<http://www.dmi.dk/dmi/tr06-08.pdf>)

Greenland – ZERO project

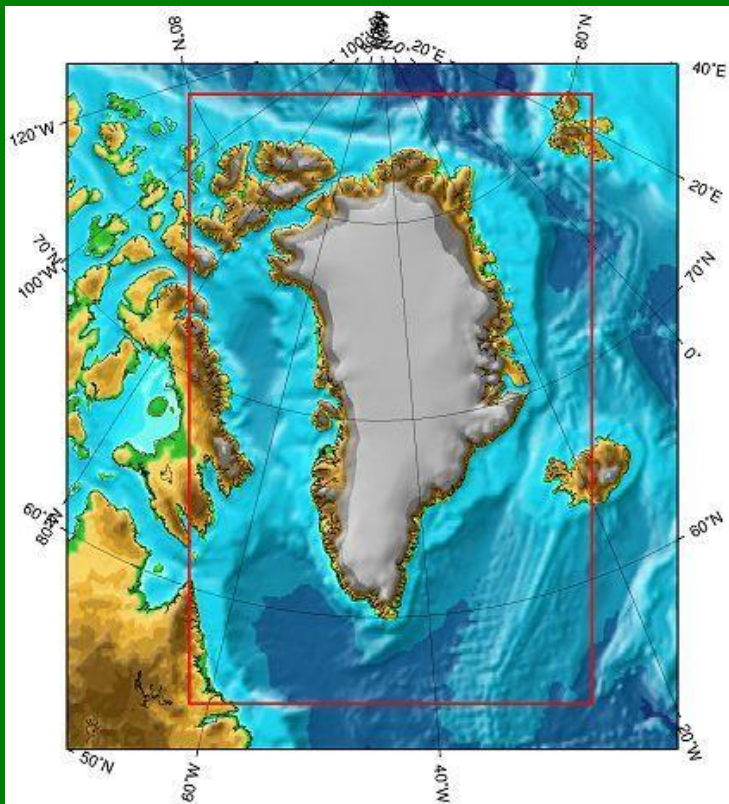
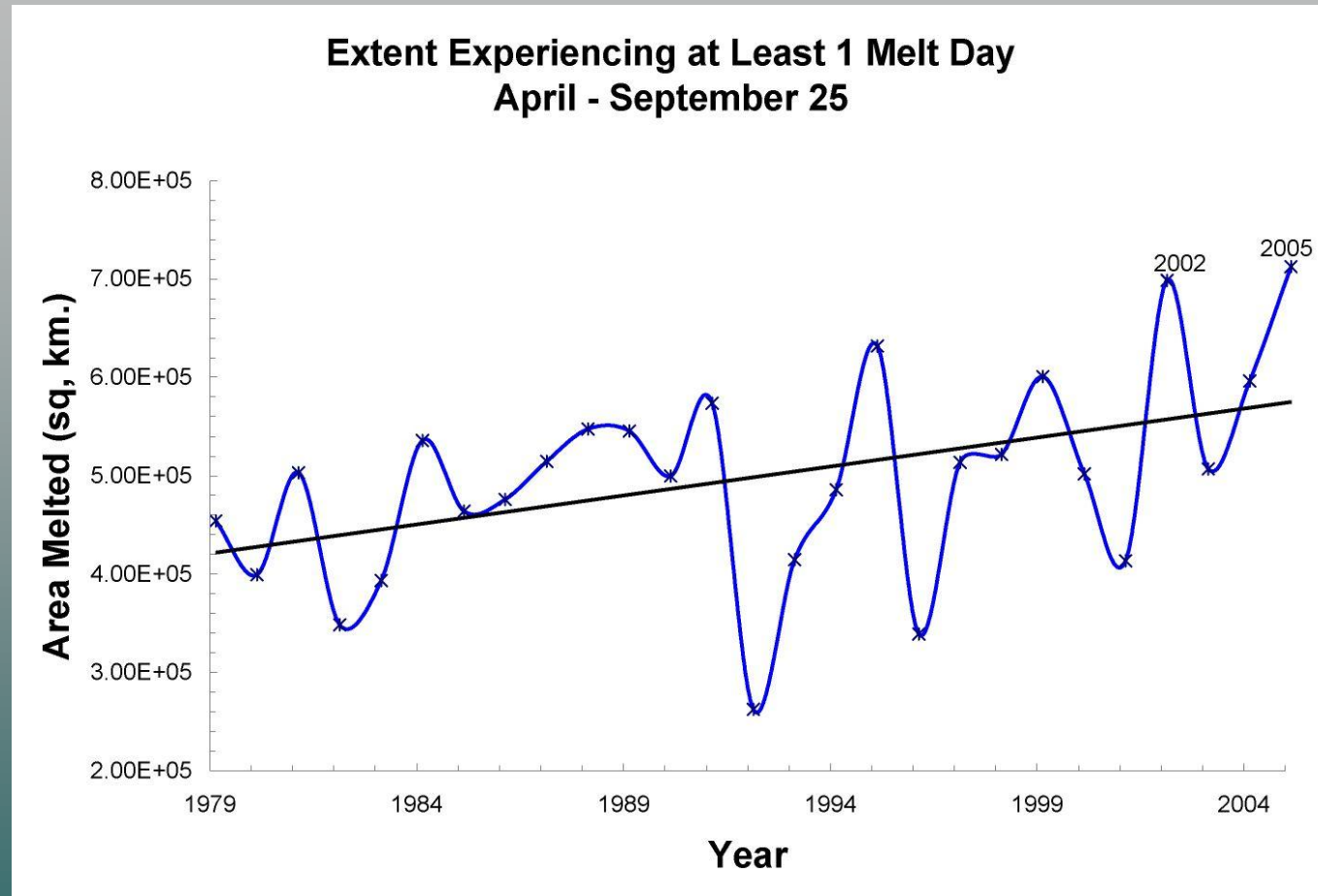


Figure 1 The Zackenberg Research Station seen from south-west in late August 1996.
(Photo: Hans Meltofte)



Source: Climate Change Research – Danish Contributions
Map courtesy of the DMI (<http://klimagroenland.dmi.dk>)

Trend of Greenland glacial melt?

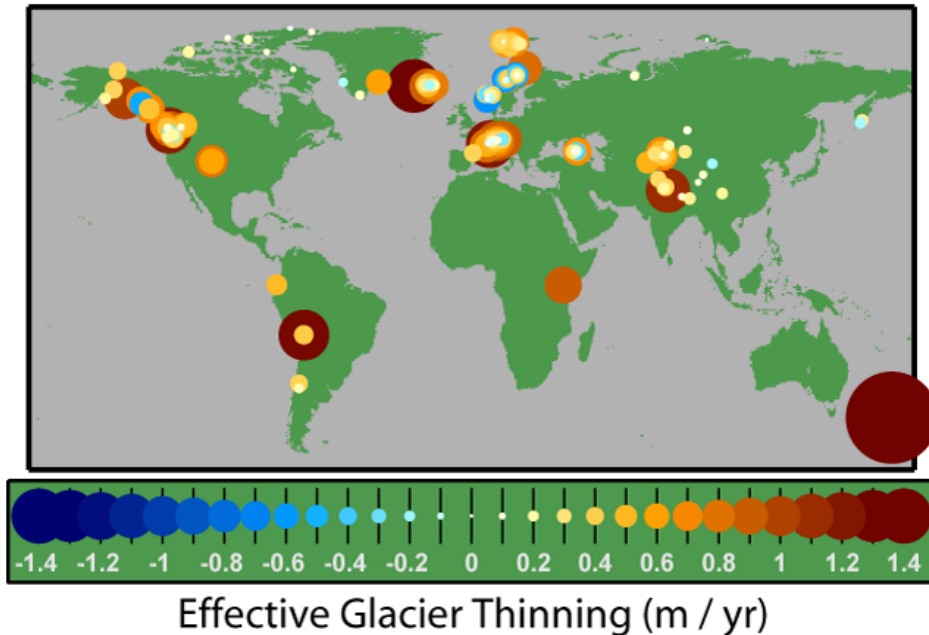


Video clip: time-lapsed Greenland glacial melt 2002-2016:

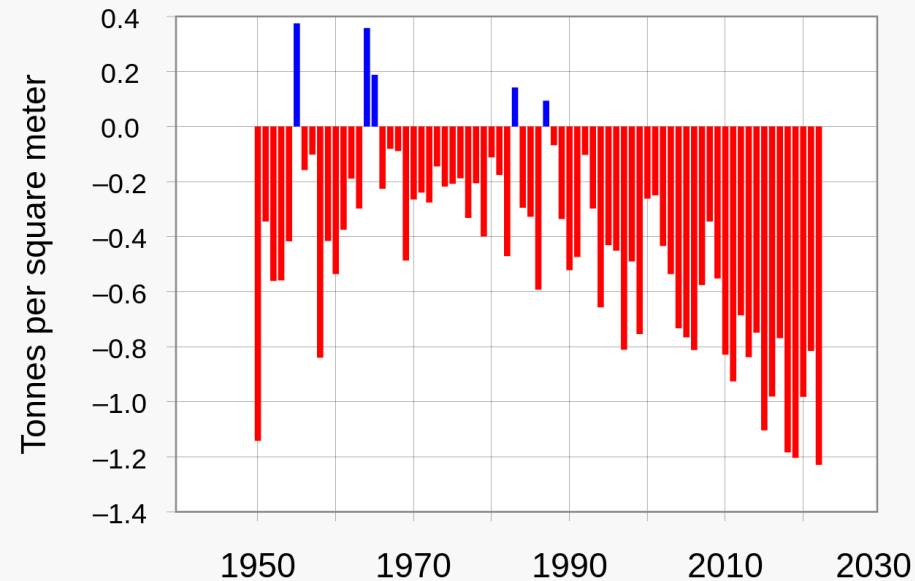
https://www.youtube.com/watch?v=ZVWXC_j7Dqs

Evidence for Climate Change: Global Glacial Retreat

Mountain Glacier Changes Since 1970

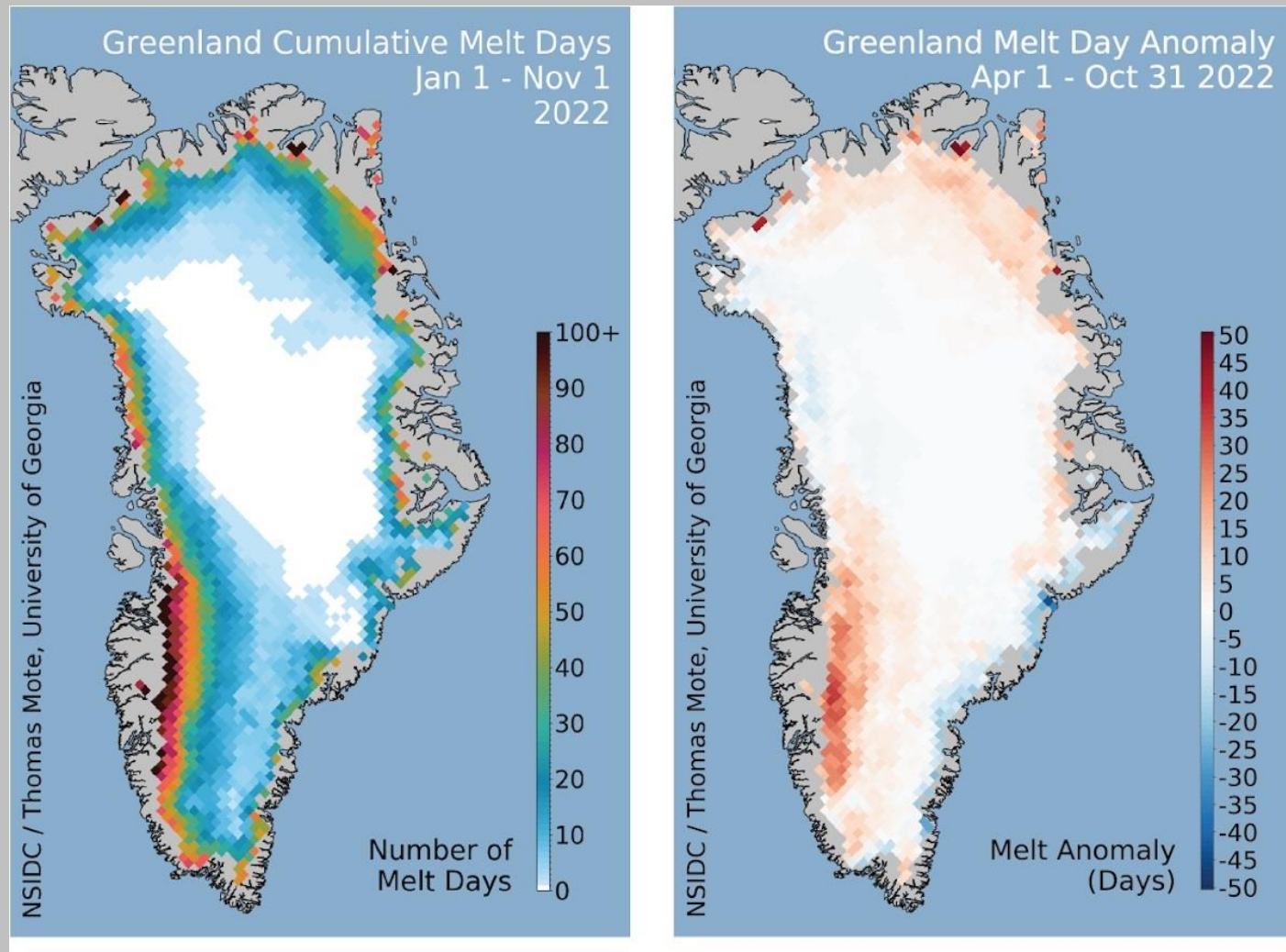


Global mass change of reference glaciers



Source: (http://en.wikipedia.org/wiki/Retreat_of_glaciers_since_1850)

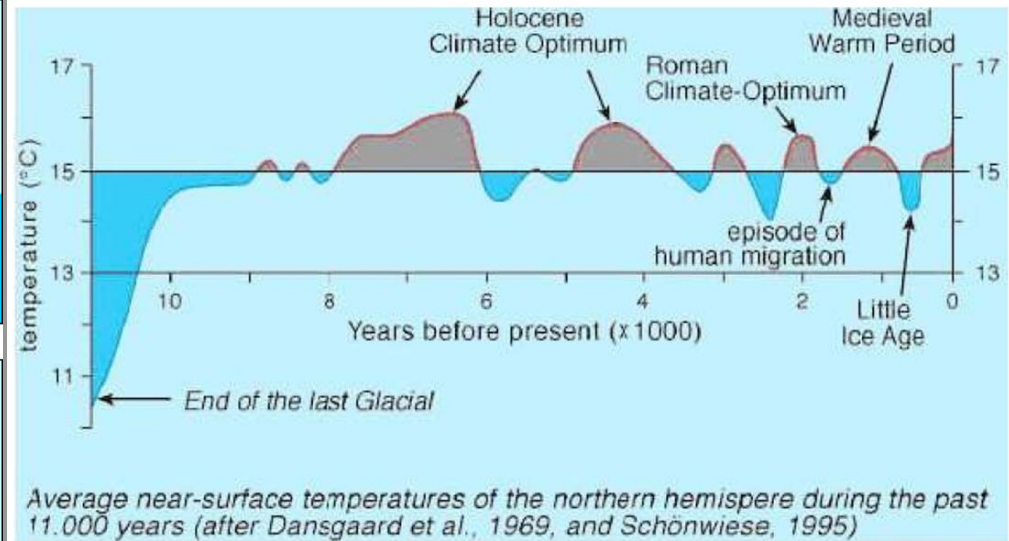
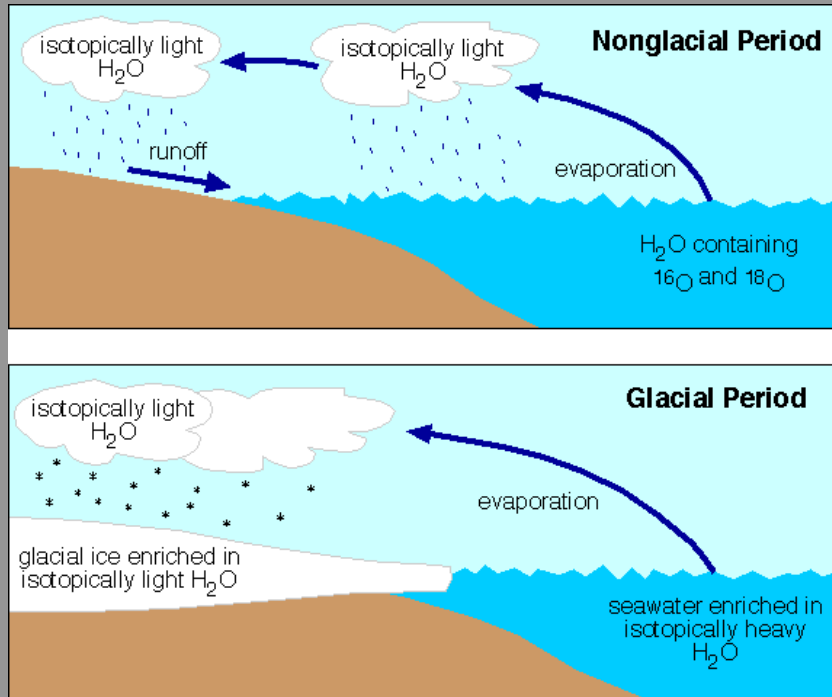
Evidence for Climate Change: Impacts to Greenland Glaciers



Source: (<https://www.universetoday.com/158589/greenlands-ice-loss-is-worse-than-we-thought/>)

PALEO-CLIMATE METHODS

Oxygen-isotopes (temperature proxy)



ROYAL
MUSEUMS
GREENWICH

What is an
ice core?



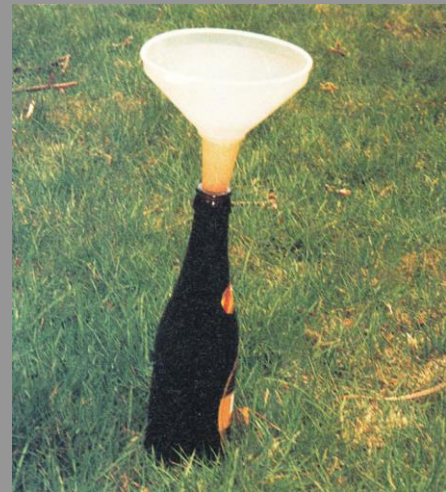
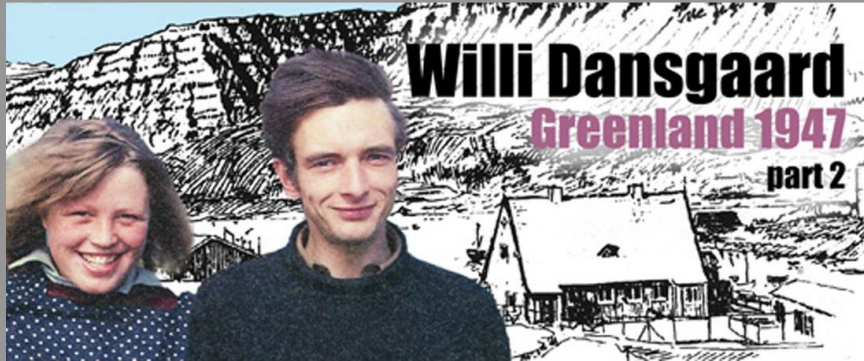
WHO IS WILLIAM DANSGAARD?

- 1) Danish Paleoclimatologist – U. of Copenhagen, Dept. of Geophysics
- 2) Member, Royal Danish Academy of Science (plus three other societies)
- 3) Won five international awards for his scientific work
- 4) 40+ years of Greenland field and lab work investigations
- 5) Many peer-reviewed science papers/books published (1970s-1990s)
- 6) Founding Father of the field of Stable Isotope Meteorology



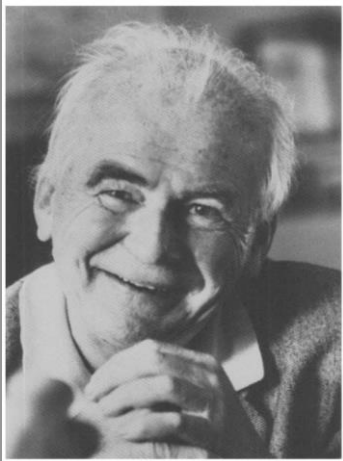
WILLI DANSGAARD – THE EARLY YEARS

- 1) First job: Denmark's Meteorological Institute (like NOAA), Greenland.
- 2) He help set up a Mass Spectrometer, UC's Biophysical/Isotope Lab.
- 3) June 1952: experiment to measure the isotope composition of rainwater.
- 4) Casual experiment continues with airplane - air samples inside a cloud.



WILLI DANSGAARD – THE FIELD YEARS

- 1) Further tested O-18 variations in rainwater, river, and Greenland ice.
- 2) Collaborated with Scholander (1956), U-Oslo: chemistry of air bubbles in ice.
- 3) EGIG project (1959-60): Greenland geodetic survey, auger firn/ice-cores.
- 4) First analysis of ice O-18 vs. temperature at many sampling sites.



Source: Frozen Annals (Dansgaard, 2005)

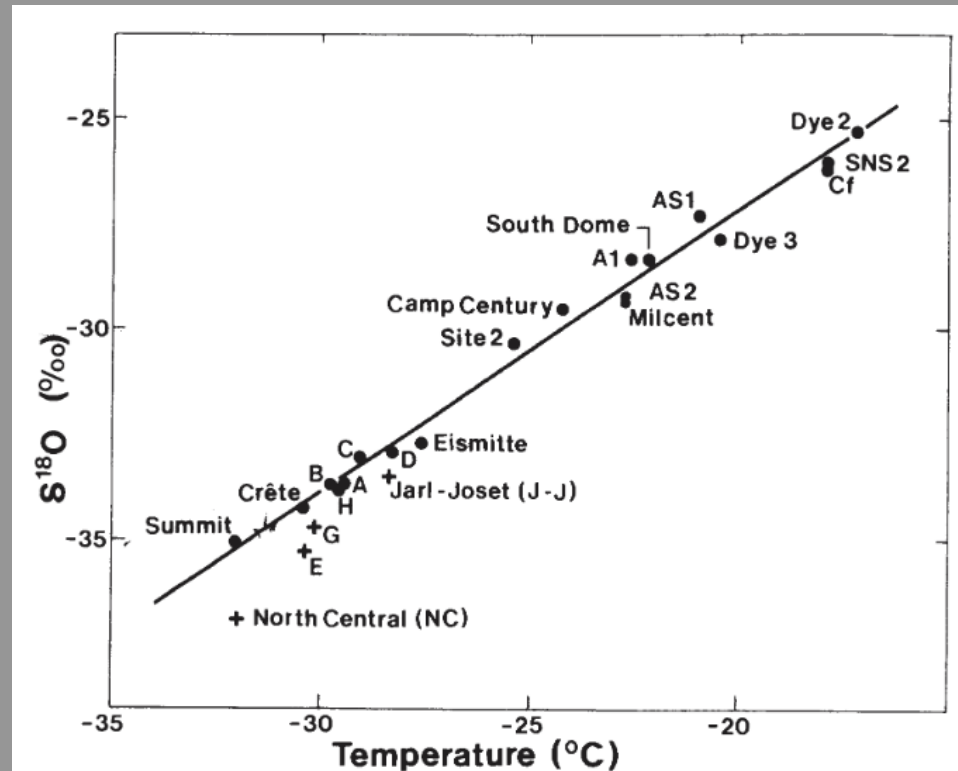


Fig. 3.8 Mean annual δ of snow versus temperature at EGIG and other stations visited later.

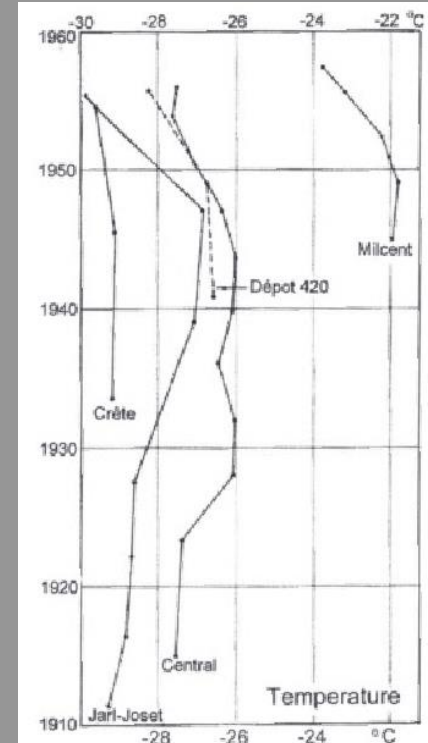
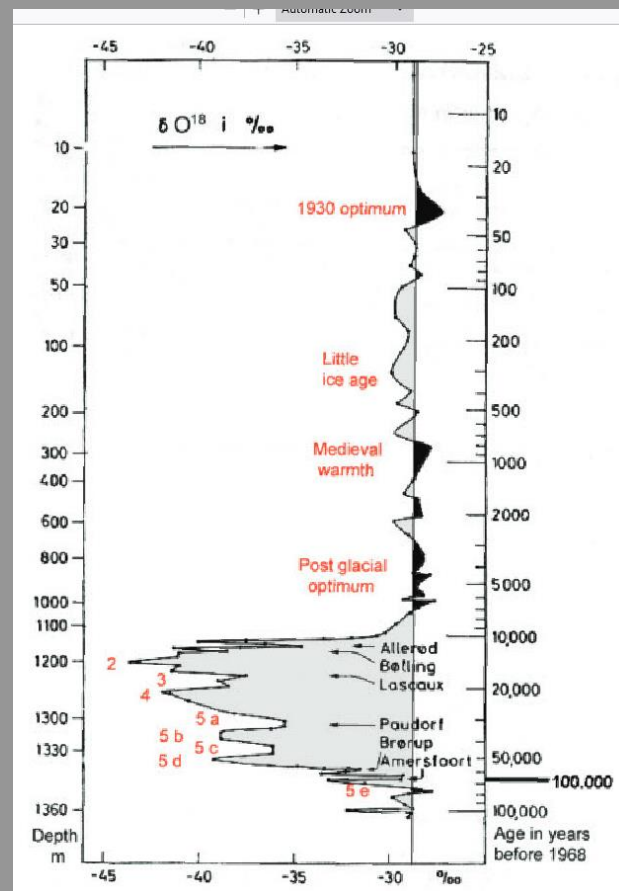
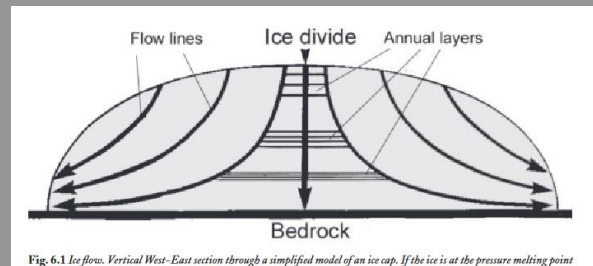
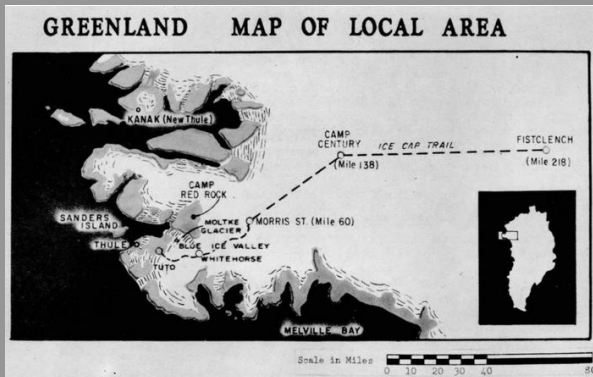


Fig. 3.9 Climate records based on the H_2O^{18} concentration (δ) in snow and firn layers deposited at five EGIG stations on the inland ice (cf. Fig. 3.3, p. 31). Two of the records reach more than 50 years back showing the warming trend in the first half of the 20th century, and they all suggest a subsequent cooling.

WILLI DANSGAARD – THE FIELD YEARS

- 1) Camp Century (1963-1966): ice-coring reached to bedrock (~1400-m).
- 2) Chemistry of air bubbles: O-18, Deuterium, CO₂, Methane, volcanic dust.
- 3) International symposium ISAGE (1968) – CC ancient ice/isotope record.



Source: Frozen Annals (Dansgaard, 2005); EGU blog/Camp Century Revisited (2022)

WILLI DANSGAARD – THE FIELD YEARS

- 1) GISP Drilling Project (1972); ISTUK (1981): ice-coring went to ~2000-m.
- 2) Noticed *abrupt shifts* in O-18, and temperature, ~25-30,000 years ago.
- 3) Hans Oeschger, Wally Broecker – N-Atlantic Gulf Stream switched on/off.

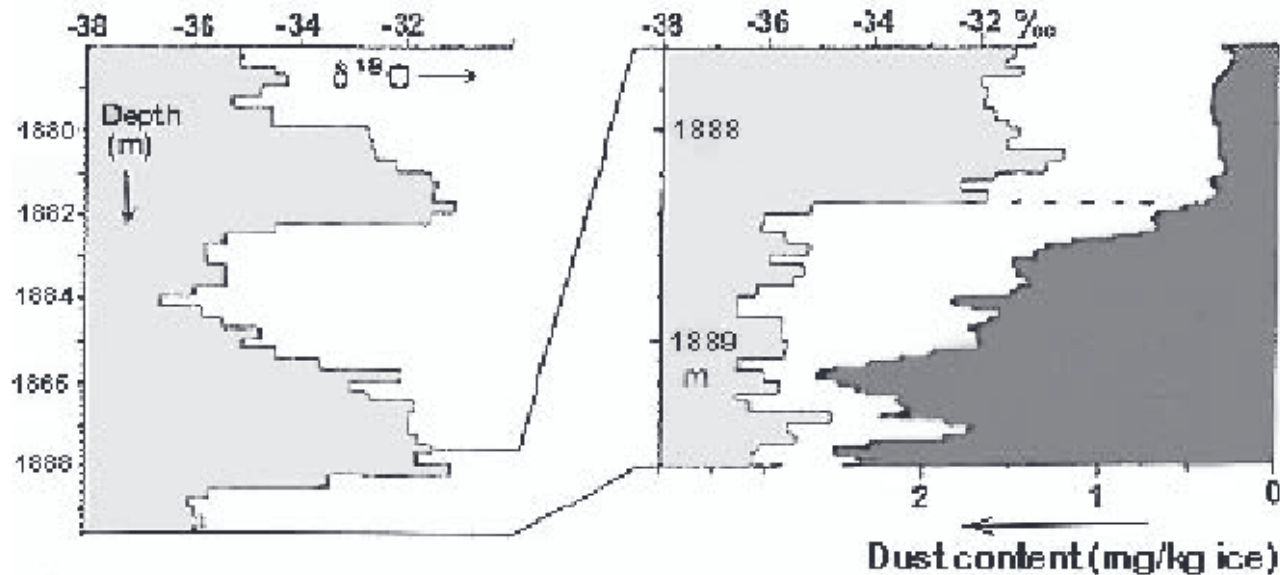
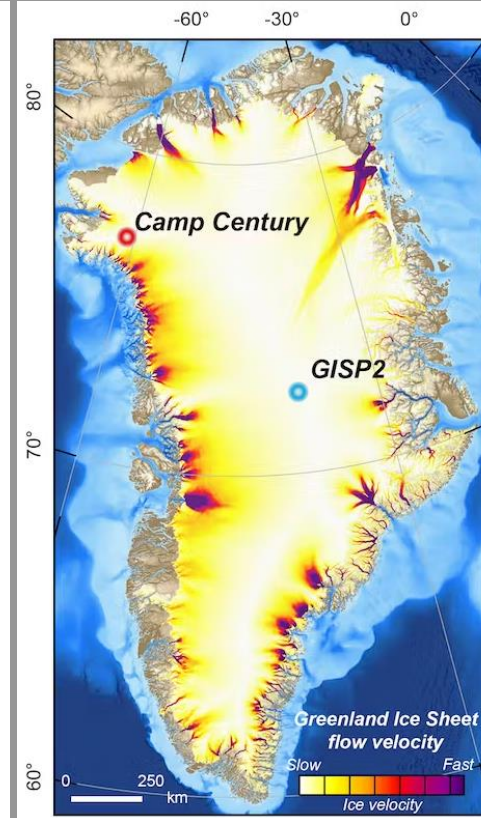


Fig. 11.4 δ and dust concentration in the ice deposited during some of the great climatic shifts that characterized the coldest part of the glaciation. **On the left:** Two violent δ -oscillations measured along 11½ m ice core corresponding to 4000 years around 25 to 30,000 years ago. Each of the two abrupt δ -shifts correspond to 10–12°C warming within less than a century. **On the right:** The eldest of the two is shown in detail and compared with the dust concentration changes in the same two metres of ice.



WILLI DANSGAARD – THE FIELD YEARS

- 1) GRIP Drilling Project (1987) – expanded sampling efforts; GRIP2 - USA.
- 2) Ice-core record now extends ~150,000 years ago (next to last glaciation).
- 3) Found **24** great/violent abrupt climate change events (131-117,000 yr B.P.).

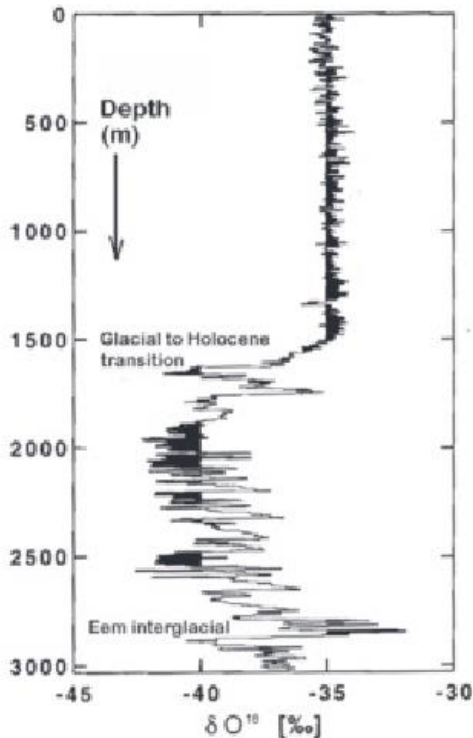


Fig. 13.1. $\delta^{18}\text{O}$ -profile along the GRIP ice core. The wildly oscillating record from 1500 to c.2750 m depth reflects the turbulent glacial climate.

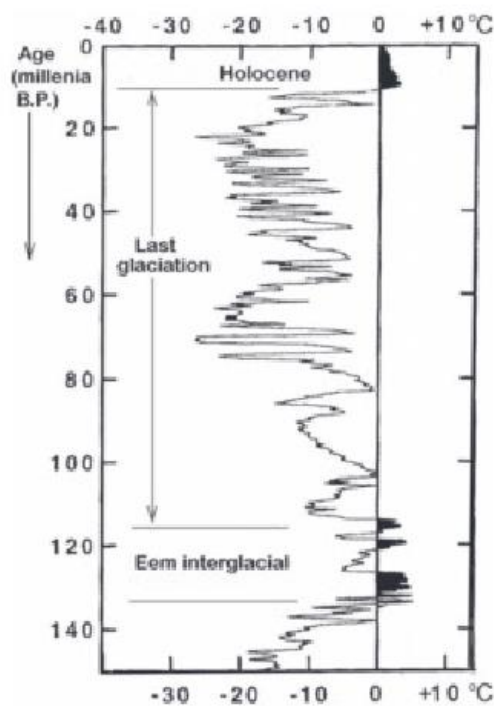


Fig. 13.2. Calculated Greenland temperature deviations from present values through the last 150,000 years.



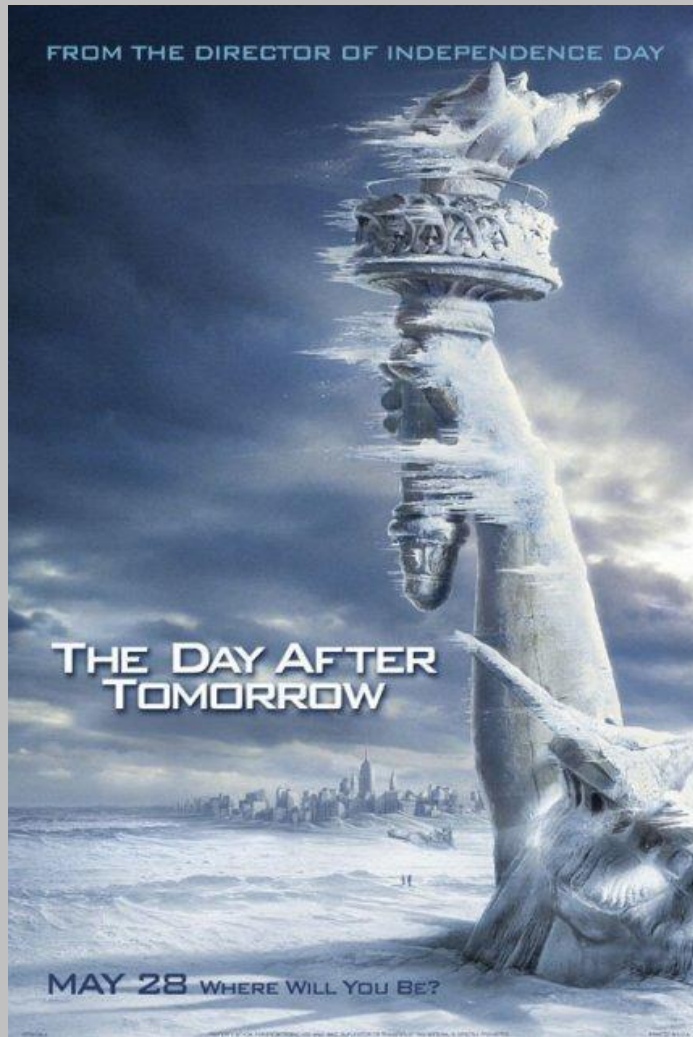
Fig. 12.4 GRIP's headquarters in windy weather. Photo: Toars Sifis.



Fig. 14.7 The entire NorthGRIP crew celebrating the big moment in the drill ball

Rapid Climate Change?

Climate Change Judgement Day?

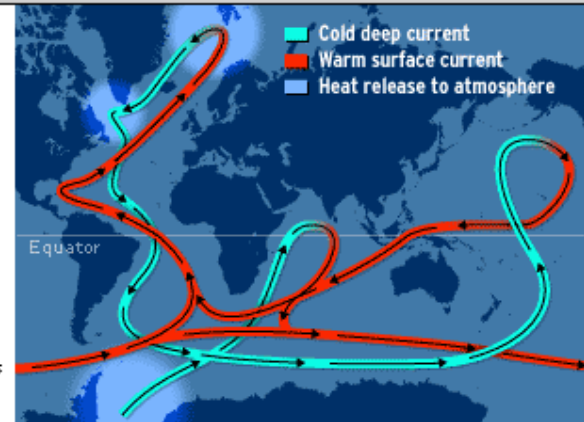


FACT FILE Climate conveyor belts

Driven by changes in temperature and salinity, large ocean currents are in constant motion, moving heat from the equator to the upper latitudes and then moving cold back toward the equator.

Known as 'thermohaline circulation,' this phenomenon includes the Gulf Stream, which moderates northern Europe's climate.

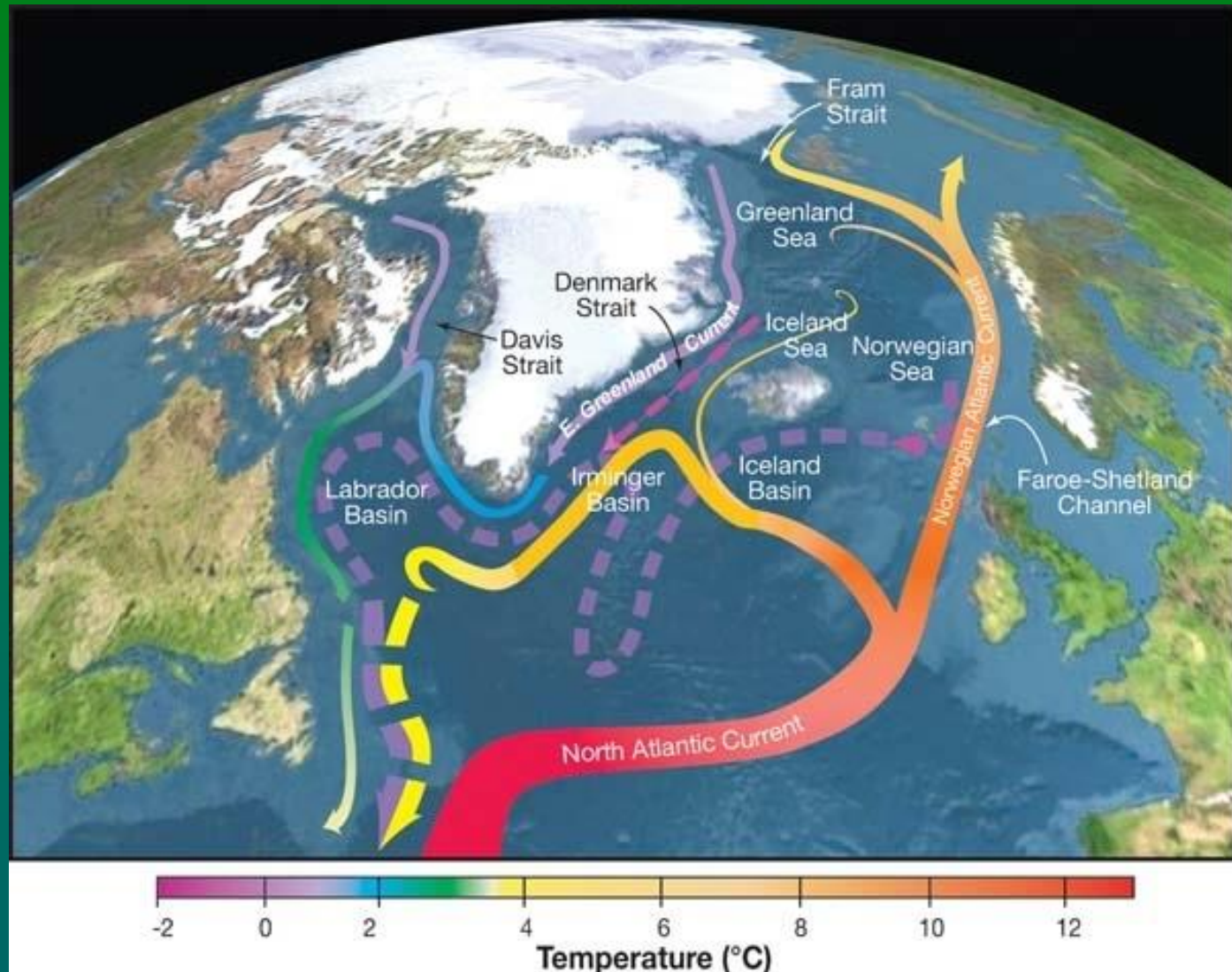
Some scientists speculate that global warming could weaken this circulation and leave some regions relatively cooler.



SOURCES: National Center for Atmospheric Research, Intergovernmental Panel on Climate Change

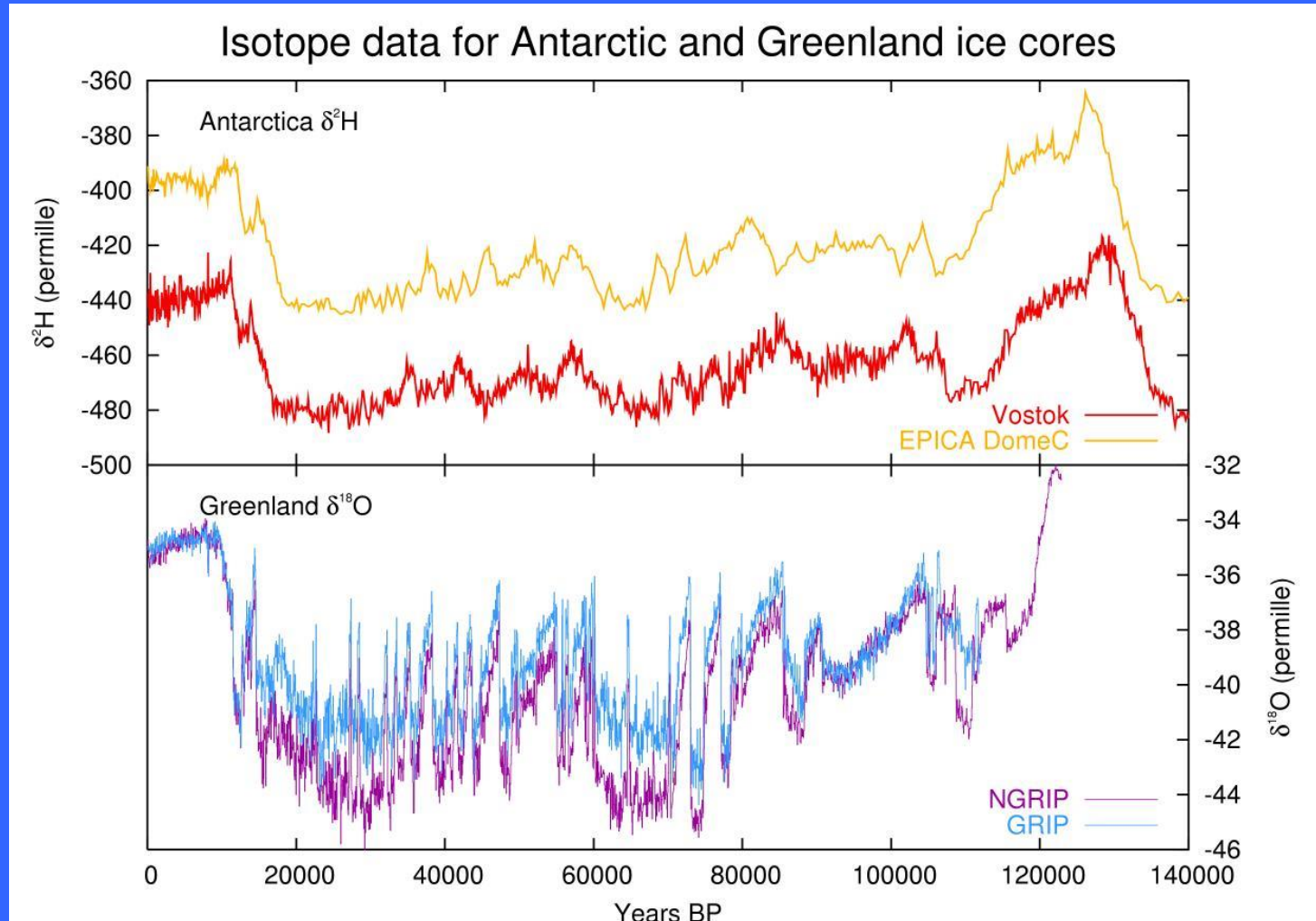
MSNBC

Atlantic Meridional Overturning Circulation



Source: https://en.wikipedia.org/wiki/Atlantic_meridional_overturning_circulation

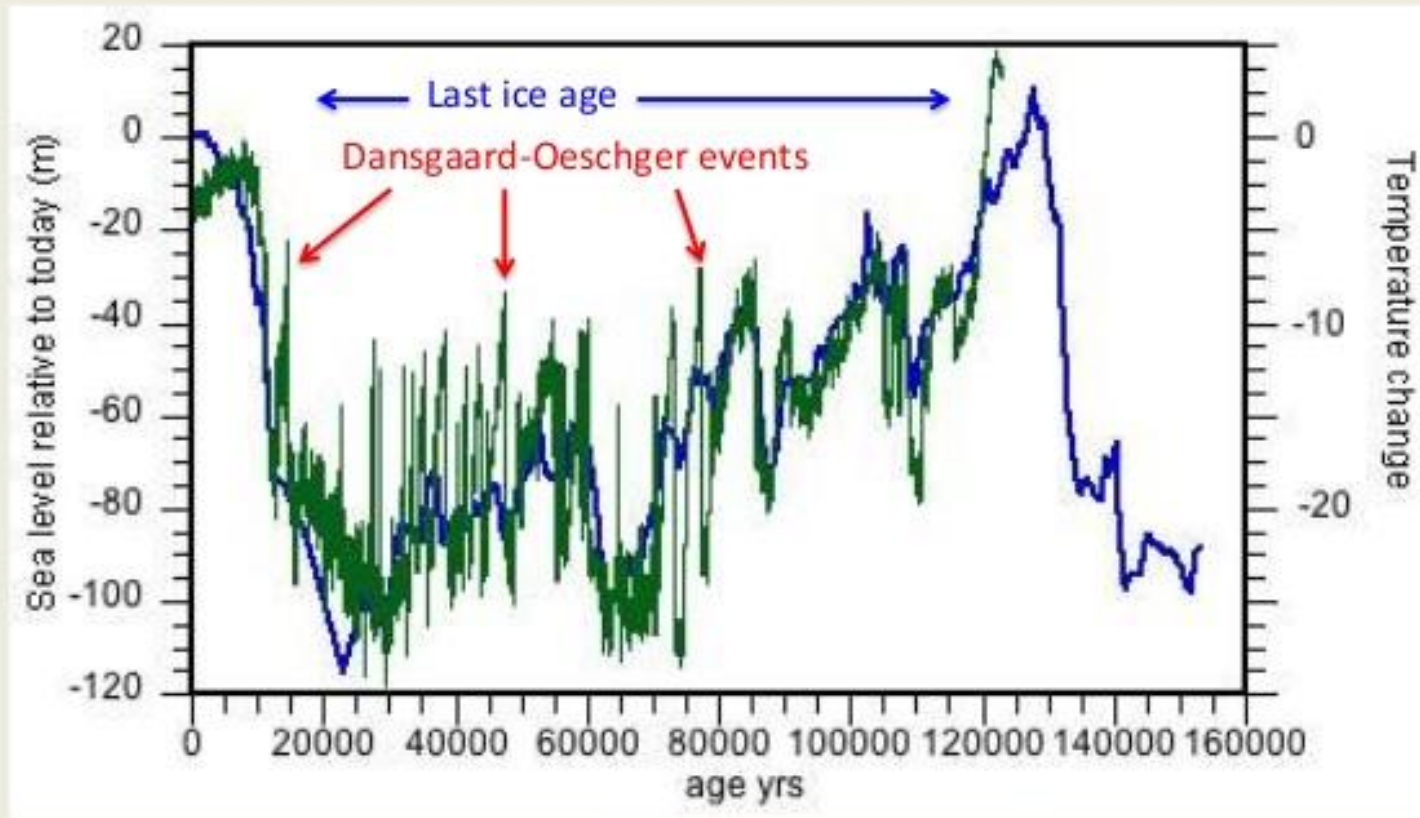
A *Dansgaard-Oeschger* event: Climate Change “Tipping Point” event



Source: http://en.wikipedia.org/wiki/Dansgaard-Oeschger_events

A *Dansgaard-Oeschger* event: Abrupt Climate Change

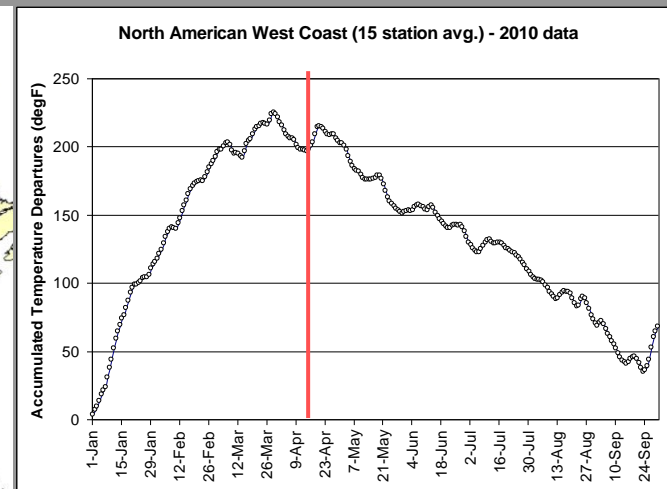
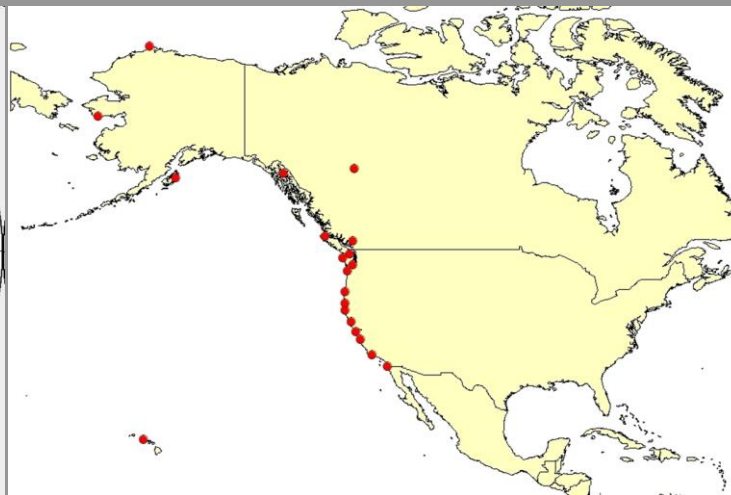
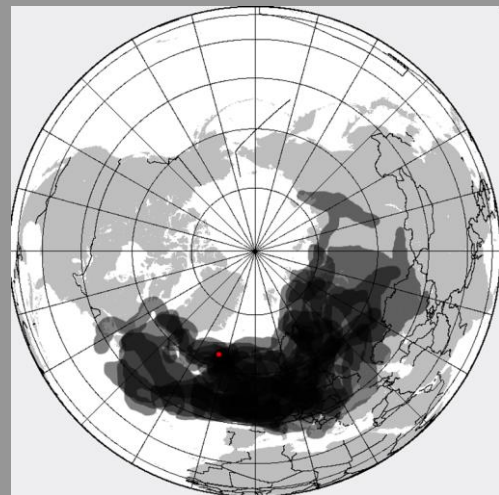
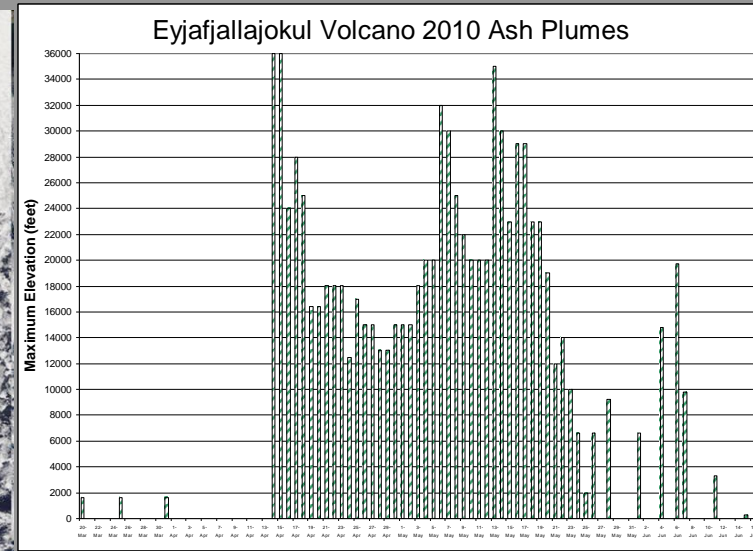
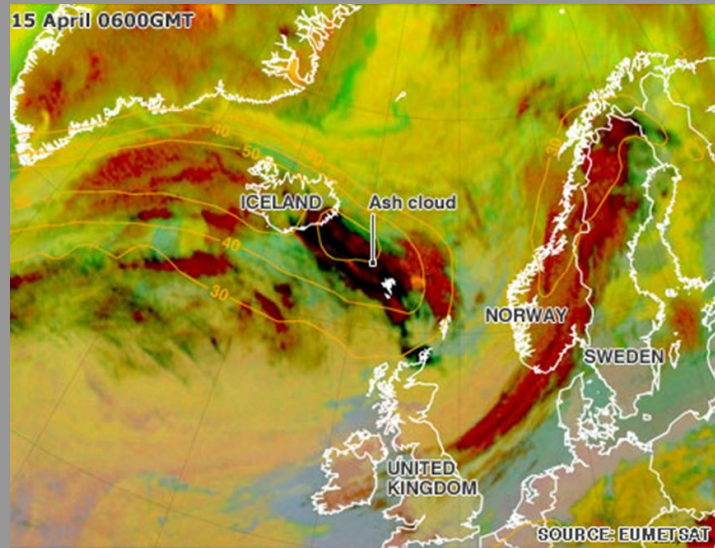
Abrupt events: the ice core view



Green is Greenland temperature

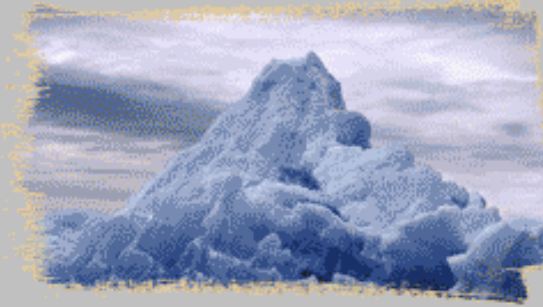
Blue is sea level

A *Dansgaard-Oeschger* event: Impacts to PNW?



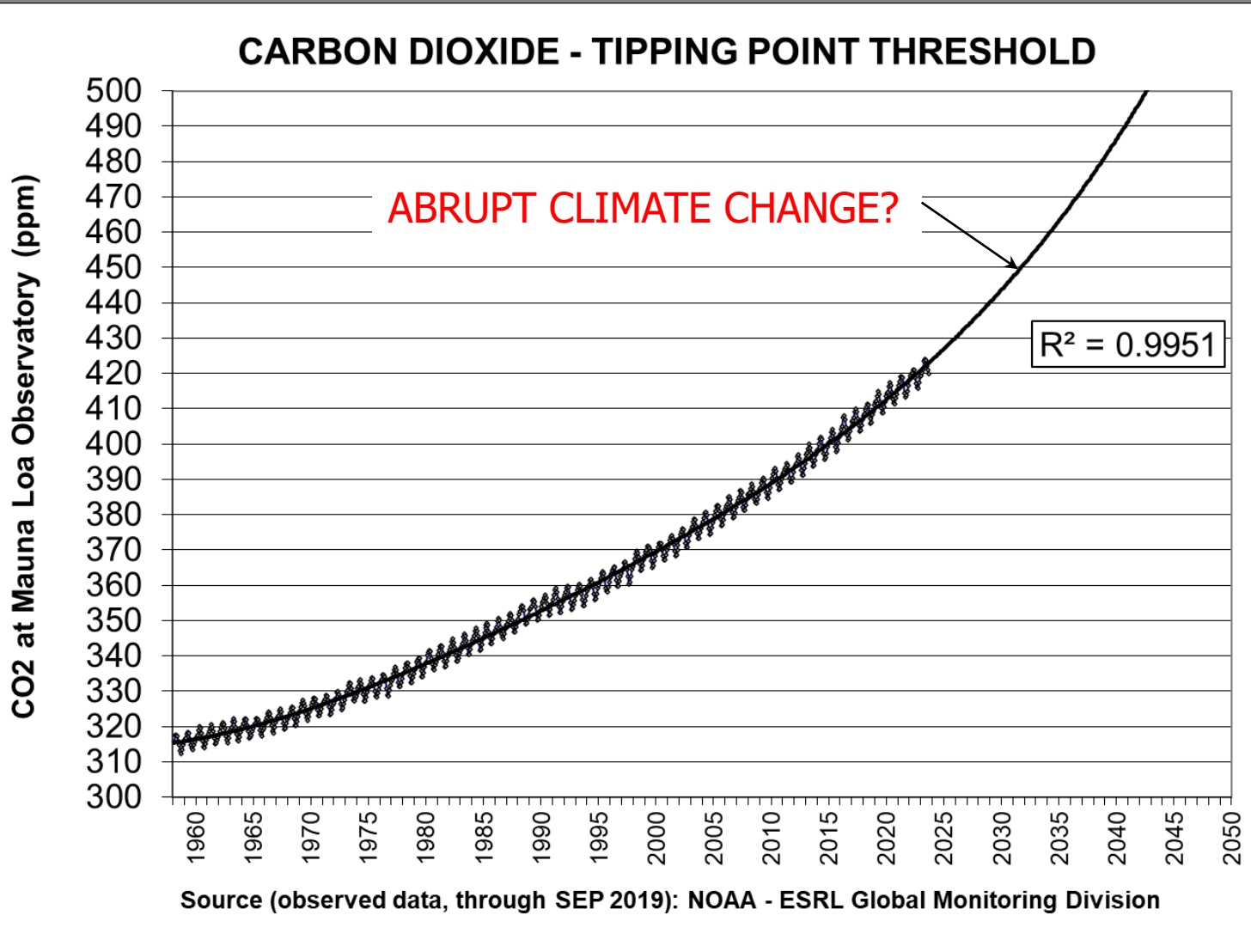
Analogue: Iceland Volcano, Eyjafjallajökull
Dittmer (2011), unpublished study

A. Lyberth - Greenland Inuit Elder



"The Eskimo-Kalaallit people have a prophecy that *when the once rock-hard glaciers become so soft that you could leave a handprint on them*, this would be a sign that Mother Earth is in profound turmoil. I never thought I would witness the prophecy taking place in my lifetime."

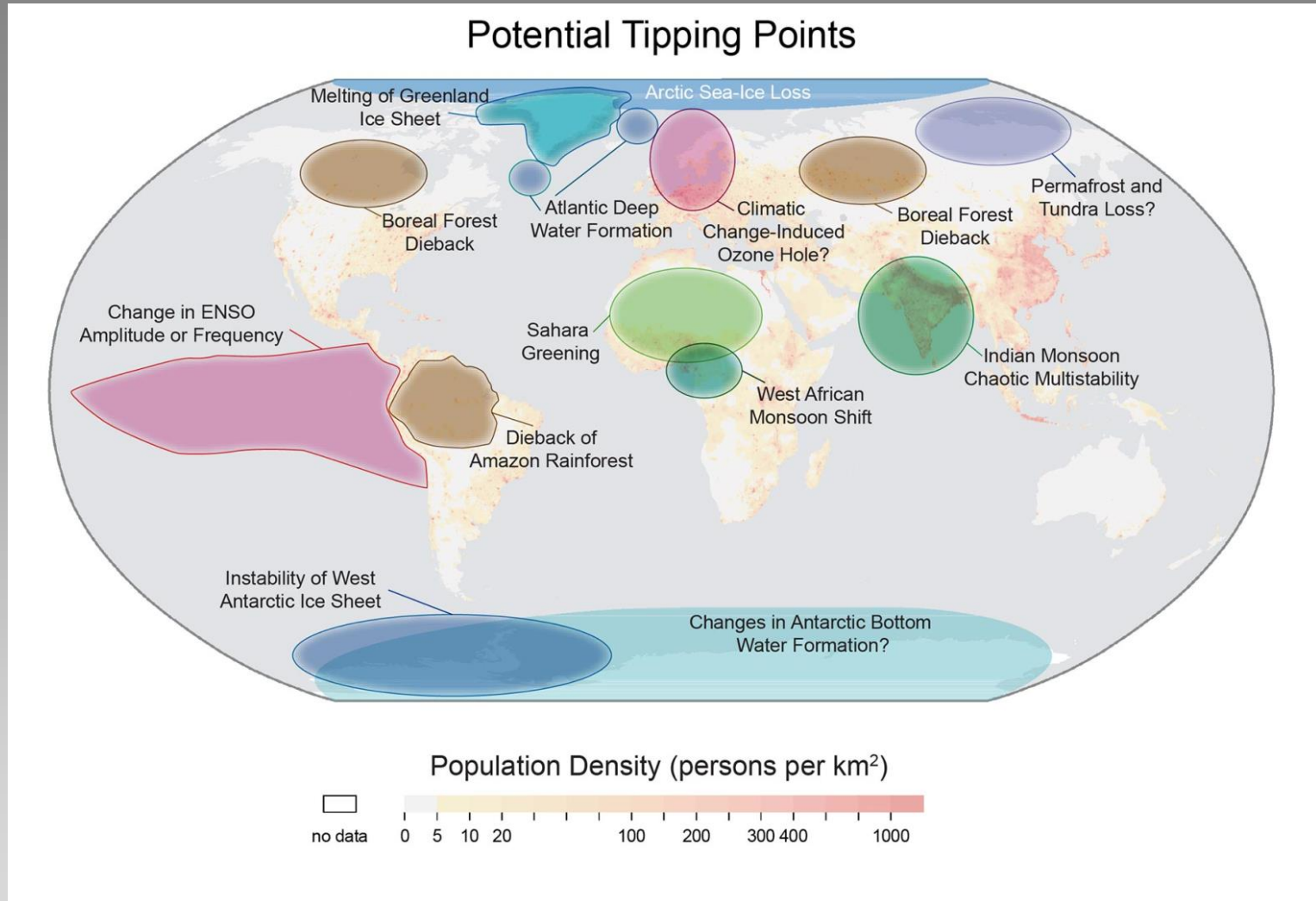
Countdown to CO2 Tipping Point?



Dr. James Hansen, NASA: <https://pubs.giss.nasa.gov/abs/ha02210k.html>

<https://www.wired.com/2007/12/nasas-james-han/>

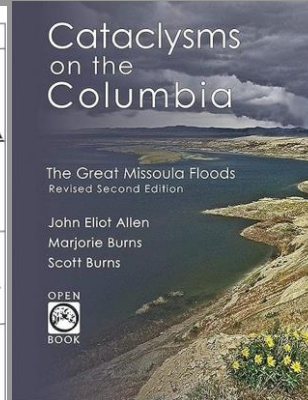
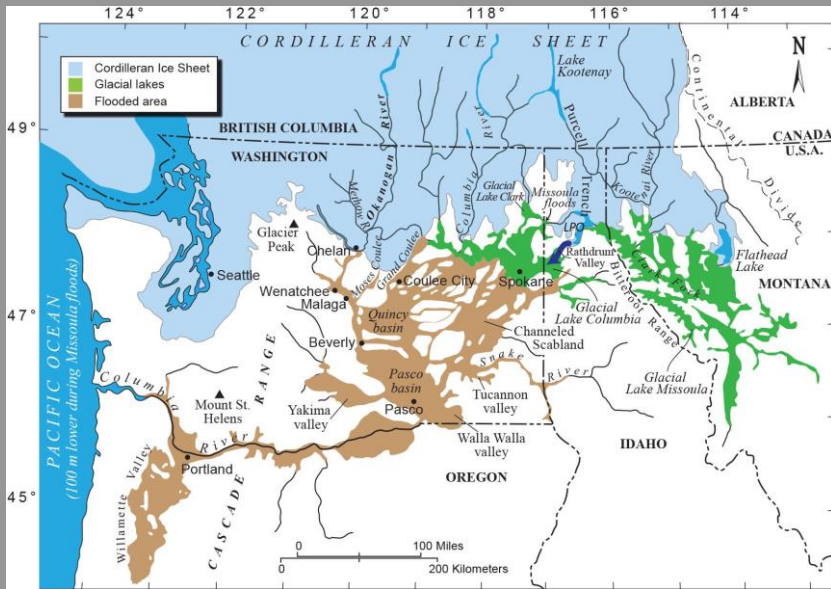
OTHER CC TIPPING POINTS?



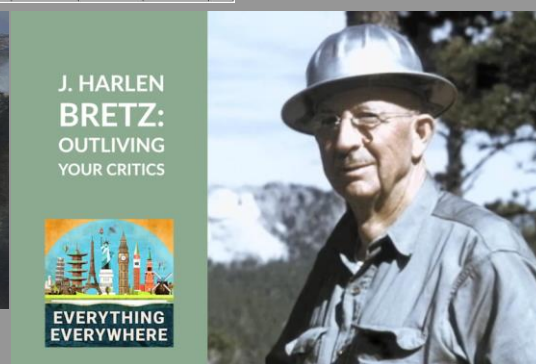
Source: <https://nca2014.globalchange.gov/report/appendices/faqs>

https://en.wikipedia.org/wiki/Tipping_points_in_the_climate_system

OTHER CATASTROPHIC EVENTS - LMF

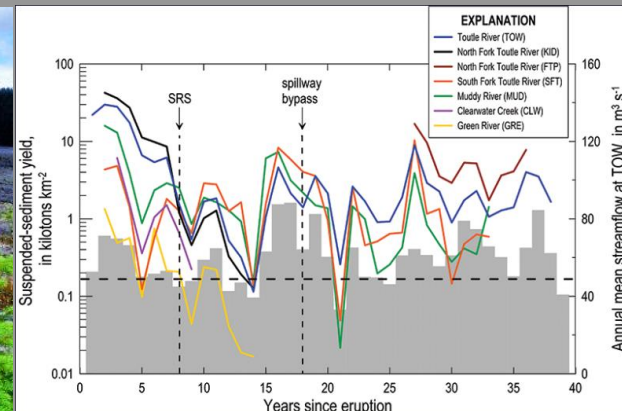
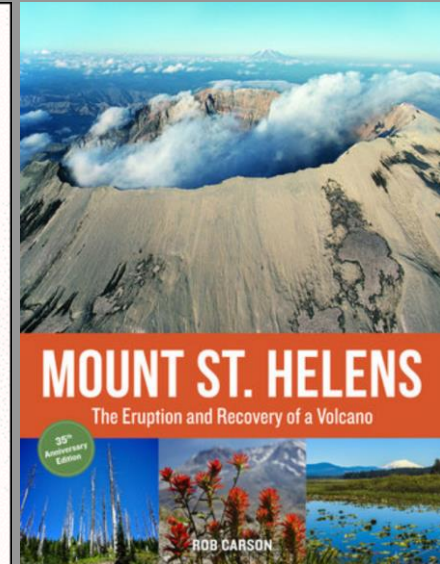
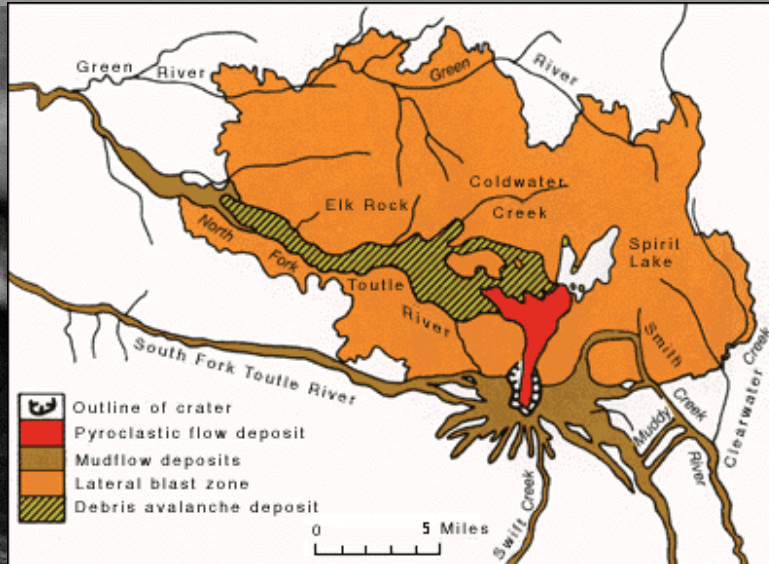


Lake Missoula Flood Path in Panorama Photos by Rick Thompson



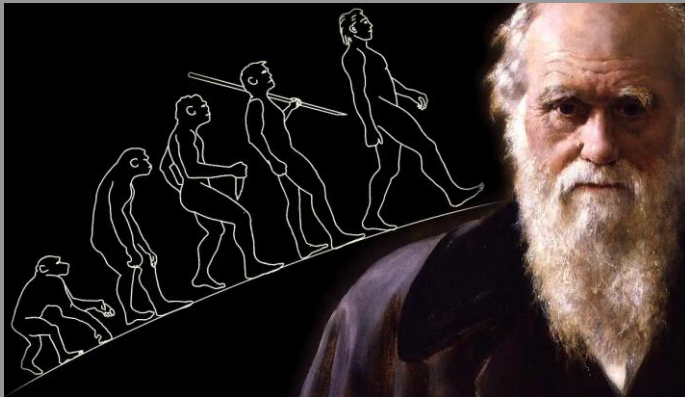
J. Harlen Bretz: He seriously challenged the idea of **Uniformitarianism** with his major field evidence of gigantic Ice-Age floods. *"Ideas without precedent are generally looked upon with disfavor and men are shocked if their conceptions of an orderly world are challenged."*

OTHER CATASTROPHIC EVENTS - MSH

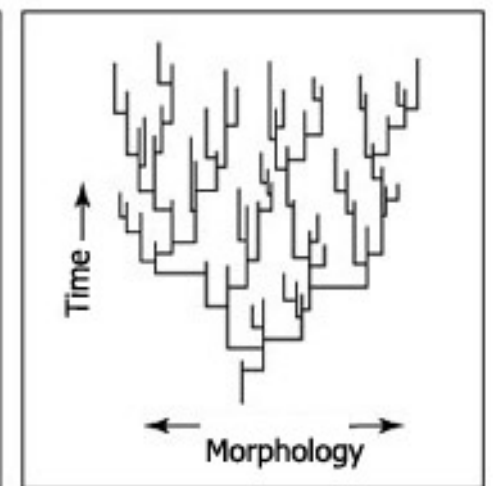
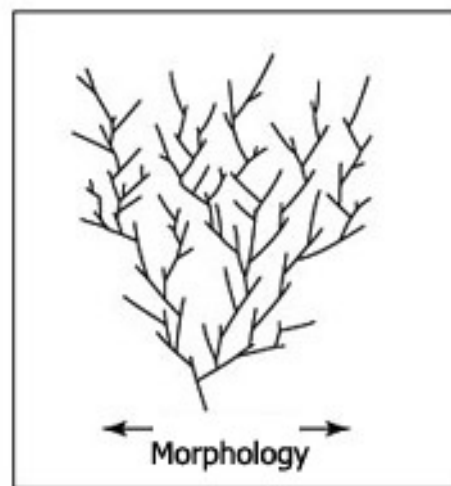
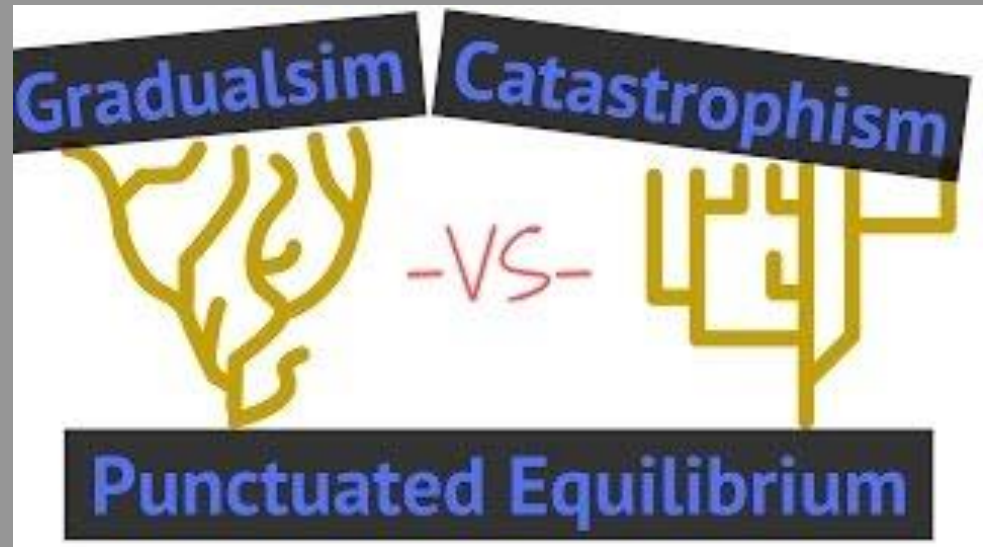
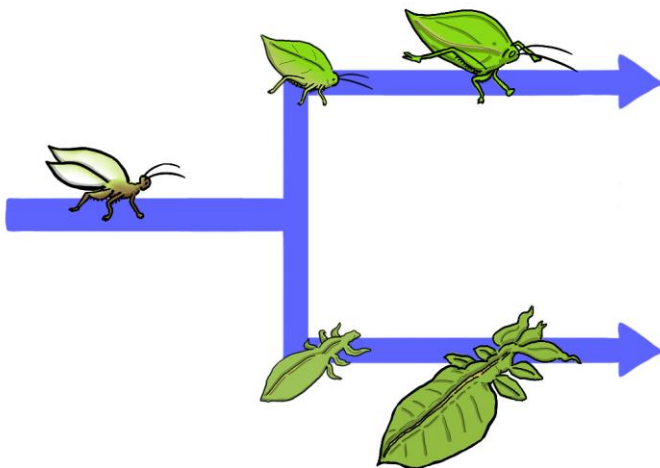


Most of the area Salmon were destroyed by the eruption. The river waters were so heavily choked with sediment that Biologists estimated that it would take 10-15 years before the Salmon would return to the rivers.

OTHER CATASTROPHIC EVENTS - EVOLUTION



Punctuated Equilibrium



How does Darwin's original idea of gradual Evolution pathway differ from a Punctuated Equilibrium pathway?

REMEMBERING WILLIAM DANSGAARD

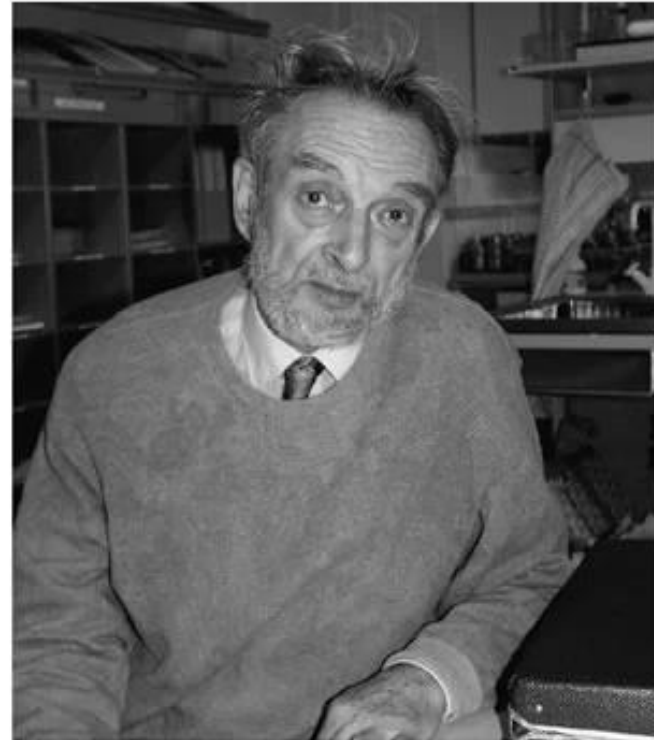
ARCTIC

VOL. 64, NO. 3 (SEPTEMBER 2011) P. 365–387

WILLI DANSGAARD (1922–2011)

Willi Dansgaard, distinguished professor emeritus at the Niels Bohr Institute and head of the Geophysical Isotope Laboratory at the University of Copenhagen, Denmark, died in Copenhagen on January 8, 2011 at the age of 88. He is recognized as one of the world's foremost authorities on past climate change as revealed in polar ice cores.

Dansgaard will be remembered best for his considerable contributions in the field of the Earth's past climate and its abrupt climate changes (with H. Oeschger, University of Bern) and by his students and co-workers whom he trained and inspired. His groundbreaking discovery of the seasonal variations and rapid changes in climate over short time intervals was established by measuring variations in the stable oxygen isotope ratio data (O^{18}/O^{16}) in the 1390 m deep core recovered at Camp Century, Greenland. This core, the first to bedrock, was obtained in 1966 by the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL) in Hanover, New Hampshire. Dansgaard's climate record of the deep core reflected annual accumulation layers dating back to 8300 years BP, and additional accumulation years back to the bottom at 115 000 years BP, with less accuracy.



Willi Dansgaard at age 75 in 1997. Photo: Sigfus Johnson.

"His style of leadership in the group was marked by his hot temper, his very short patience with 'details' and his strong focus on the scientific goals. He was very good at including everybody, senior as well as very junior, in important decisions and this created a very strong team spirit."

RESEARCH CITATIONS

https://www.iceandclimate.nbi.ku.dk/publications/frozen_annals/

<http://www.sciencepoles.org/article/willi-dansgaard-pioneer-of-paleoclimate-research>

<https://nbi.ku.dk/english/www/willi/dansgaard/>

<https://www.science.org/doi/abs/10.1126/science.166.3903.377?sid=28e20f18-e1a4-4e4d-b8f1-b794c5b2688a>

<https://www.latimes.com/science/la-me-willi-dansgaard-20110207-story.html>

<https://www.cambridge.org/core/journals/polar-record/article/willi-dansgaard/16626A5BA1F8F35488630C56CFE8575>

<https://theconversation.com/ancient-leaves-preserved-under-a-mile-of-greenlands-ice-and-lost-in-a-freezer-for-years-hold-lessons-about-climate-change-157105>

https://en.wikipedia.org/wiki/Dansgaard%E2%80%93Oeschger_event

<https://www.ncei.noaa.gov/sites/default/files/2021-11/2%20Heinrich%20and%20Dansgaard%E2%80%93Oeschger%20Events%20-%20Final-OCT%202021.pdf>

<https://www.sciencedirect.com/science/article/abs/pii/S0033589413000215>

<http://www.nasonline.org/publications/biographical-memoirs/memoir-pdfs/scholander-per.pdf>

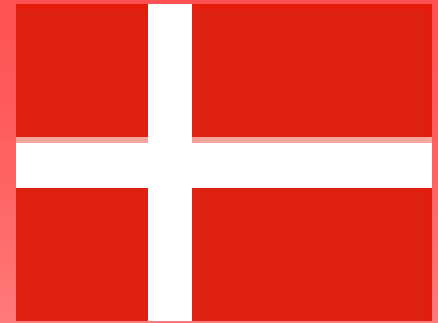
<https://blogs.egu.eu/divisions/cr/2022/01/28/camp-century-bottom-ice/>

<https://oceanservice.noaa.gov/facts/amoc.html>

https://en.wikipedia.org/wiki/Atlantic_meridional_overturning_circulation

https://www.google.com/books/edition/Climate_Change_Research/chgrtAEACAAJ?hl=en

Acknowledgements and Thank You to...



- Dr. Annette Guldberg, Danish Met. Inst. (<http://www.dmi.dk>)
- Dr. Martin Drews, Denmark's Technical U. (<https://www.dtu.dk/english>)
- Jan Besson, Danish-American journalist (Copenhagen)
- Sonja Kromann, Northwest Danish Association (Seattle),
Danish American Cultural Retreat Coordinator
- Mrs. Lili Gregerson, Mrs. Bodil Muller, Prof. Inger Olsen —
Portland Danish language instructors
- Honorable Torben Hansen, Member, Danish Parliament

What are your questions?

Mange tak! 😊

(Thank you very much!)

