RESEARCH PROCESS

BL KINEMATIC VARIABLES

- Gust Factor
  - Also used to convert between different averaging times → "Durst Curve"

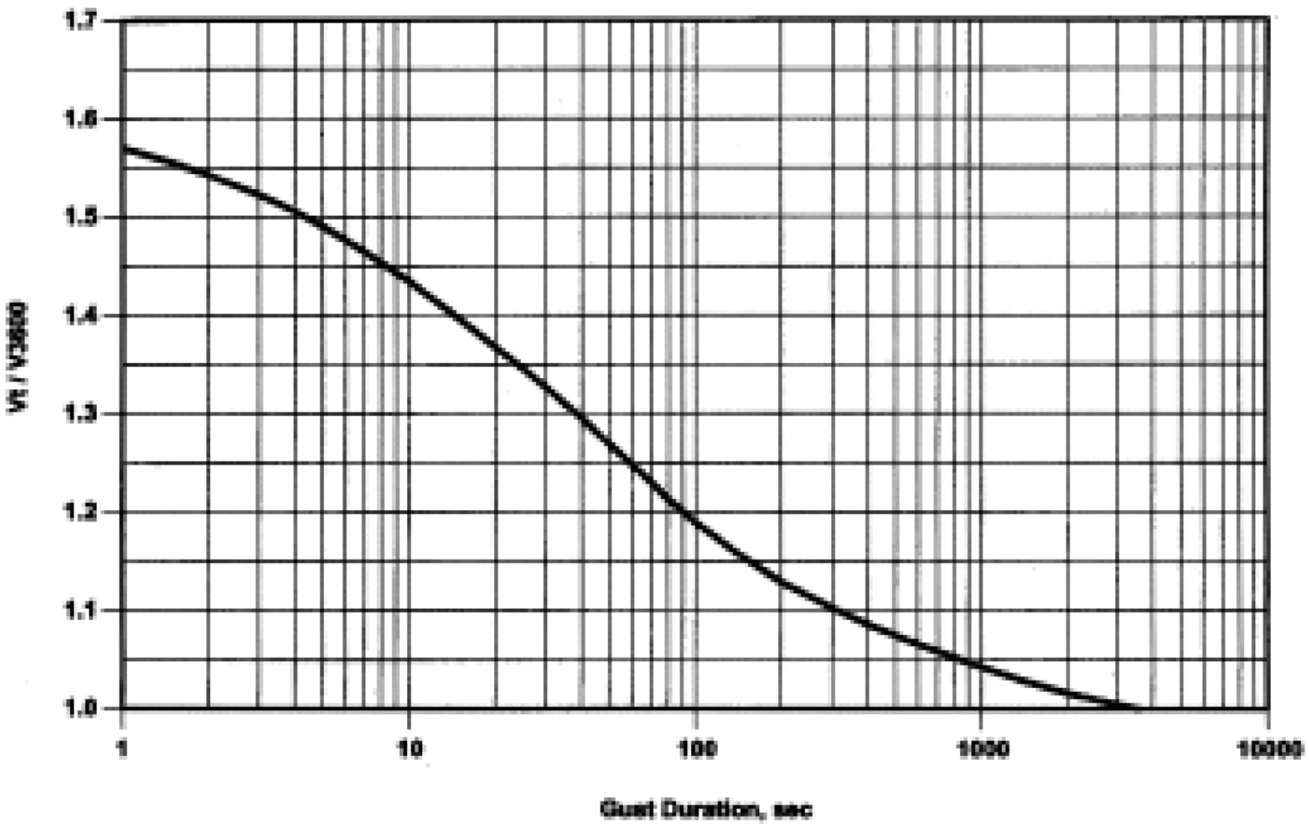

FIGURE C6-4 MAXIMUM SPEED AVERAGED OVER t_s TO HOURLY MEANS SPEED

THE RESEARCH PROCESS

- Develop research question (s)
  - "Science Leads."
  - For instance, " Why do some thunderstorms produce tornadoes, while others do not?
- Narrow down your questions and develop *TESTABLE* hypotheses
  - Example: " Thunderstorms need strong low level winds to produce a tornado."
- Determine what data you need and how you will collect it
  - The data will dictate what tools you need. Our focus is on wind, <u>so what tools allow us to collect wind data?</u>

THE RESEARCH PROCESS

- You know what tools you need and what kind of data you will collect, but how will you collect it?

  - Field Projects
  - Example: Project SCOUT

- Data collection must be carefully designed and must take into account personnel and equipment safety.

- Important:
  - Instrument characteristics
  - Data
  - Biases

THE RESEARCH PROCESS

- Data collection is over…now what?
- DATA PROCESSING
- The ultimate goal of research is to share your answers with the scientific community
  - Publications
  - Conference Presentations
  - Lectures

ORIGINAL RESEARCH article
Front. Built Environ., 15 October 2019 | https://doi.org/10.3389/fbuil.2019.00119

Exploring the Feasibility of Using Commercially Available Vertically Pointing Wind Profiling Lidars to Acquire Thunderstorm Wind Profiles

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Five Scales of Airflow Associated with a Series of Downbursts on 16 July 1980

T. THEODORE FUJITA AND ROGER M. WAKIMOTO
The University of Chicago, Chicago, IL 60637

(Manuscript received 5 September 1980, in final form 17 March 1981)

ABSTRACT

A series of destructive windstorms on 16 July 1980 in a 50 km (30 mi) wide zone from Chicago to Detroit was surveyed both from the air and the ground. In spite of the initial suspicion of 10–20 tornadoes in the area, the nature of the windstorms was confirmed to be downbursts and microbursts characterized by multiple scales of airflows with their horizontal dimensions extending tens of meters to hundreds of kilometers.

An attempt was made to estimate the wind speed based on three types of airborne objects: a 180 kg (390 lb) chimney, a 1000 kg (one ton) corn storage bin, and lumber from damaged roofs found inside downburst areas, obtaining the maximum wind speed of 63 ± 10 m s^{-1} (140 ± 25 mph). A total of $500 million damage reported was caused by thunderstorm-induced non-tornadic storms which affected very large areas.

SMS/GOES pictures showed that the parent cloud was oval-shaped with its lifetime in excess of 12 h. The overshooting areas enclosed by the −66°C isotherms shrunk rapidly at the onset of the Chicago-area downbursts, indicating that the downbursts began when overshooting activities subsided. This variation of the overshooting features, however, does not necessarily imply a direct physical link between the collapsing top and the downbursts at the surface. This paper presents cloud-top features and wind effects on the ground with no attempt to relate them on the basis of conceptual models currently available.

1. Introduction

Suckstorff (1938) postulated that precipitation cooling within thunderstorms causes an outflow of cold air which results in strong surface winds. As air traffic increased in the late 1930's, squall-line related accidents occurred in various parts of the world, resulting in the operation of fact-finding projects of thunderstorms and squall-line circulations.

Results of the Japanese Thunderstorm Observa-

one related the localized wind with the foot of a strong downdraft which could spread out violently and result in uprooted trees and damaged houses.

There are numerous reports of uprooted trees in NOAA's *Storm Data* in which types of damaging winds are classified as tornado or straight-line winds. Straight-line winds are assumed to be those which rush out of thunderstorms behind advancing gust fronts which are tens of kilometers in length.

EARTH'S CLIMATE HISTORY (AND PRESENT)

EARTH'S CLIMATE HISTORY

- Based on dating of Uranium isotopes, Earth has been around for about 4.6 billion years.

- Most of the paleo-climatological methods (proxies) only give us information from ~ the last million years.
  - Dendroclimatology / Dendrochronology
  - Ice Cores

GOOD QUOTE

- Data from before the instrument record are called proxy data.

- Proxy Data – " *…long-lived geological, chemical, or biological systems that have the climate imprinted on them"* -- Dessler (2016)

- Goal: Reconstruct past climates and analyze the results

PALEOCLIMATOLOGY

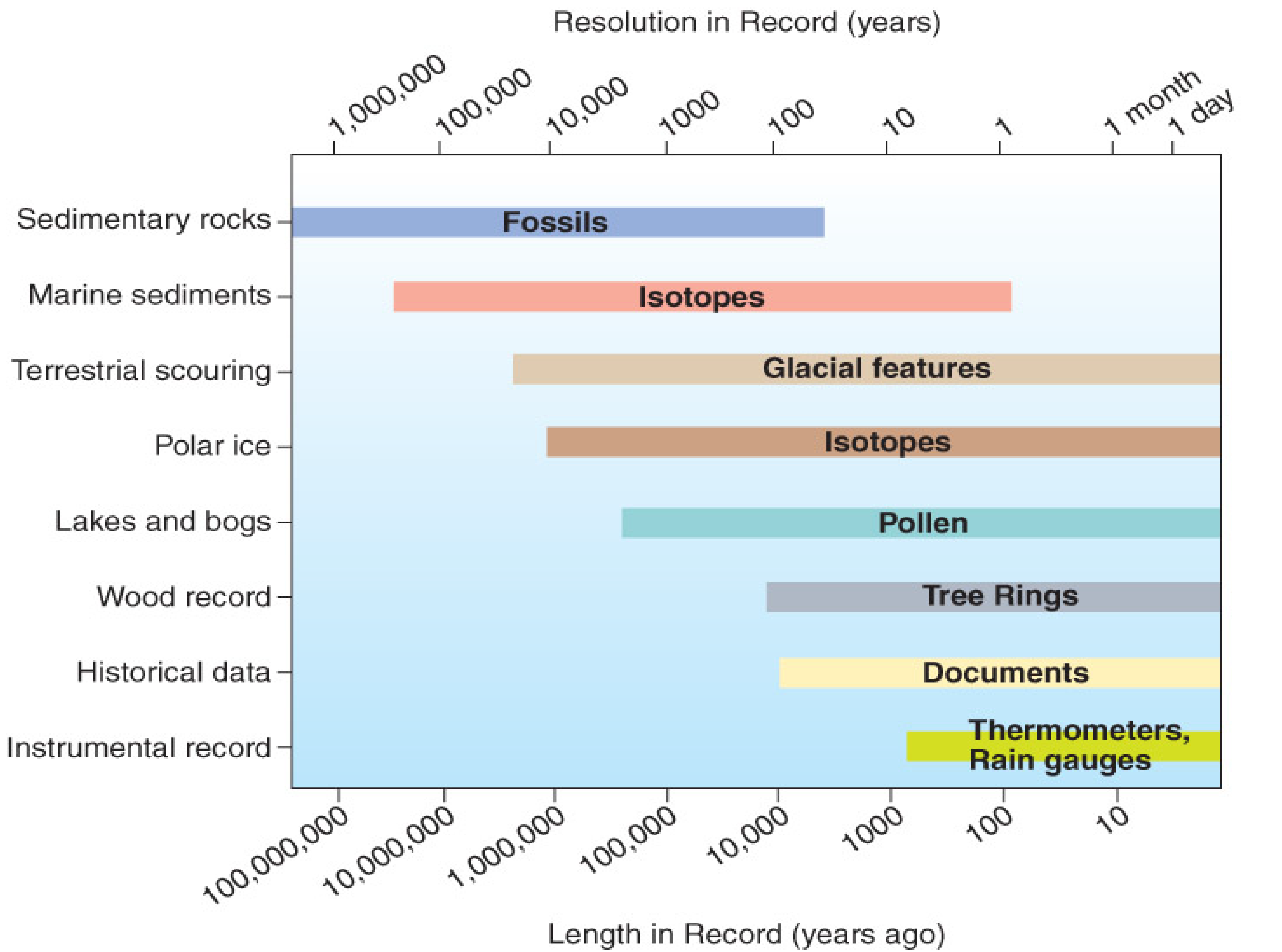
- Proxy Data:
  - Accuracy declines with increasing time before present.
    - Declining Resolution
    - Fragmented records
    - Correlating proxy variables to physical quantities.
    - Lack of benchmarks

PALEO-CLIMATOLOGY

- **Biological**
  - Tree Rings
  - Coral
  - Pollen
- **Cryological**
  - Ice Cores
- **Geological**
  - Sediment Cores
  - Fossils
  - Speleothems
- **Historical**
  - Old records
  - Art

Good for the Holocene

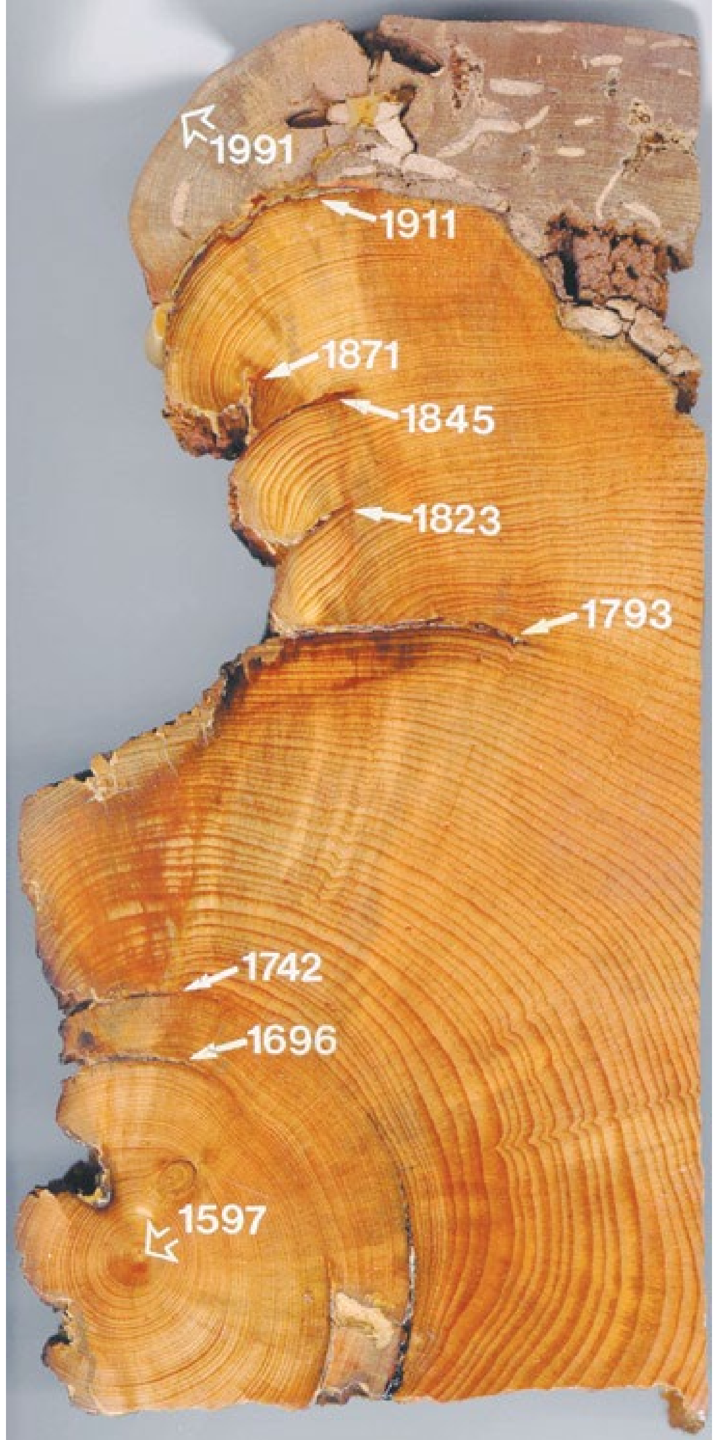
Can get much older



Resolution in Record (years)
1,000,000
100,000
10,000
1000
100
10
1
1 month
1 day
Sedimentary rocks
Fossils
Marine sediments
Isotopes
Terrestrial scouring
Glacial features
Polar ice
Isotopes
Lakes and bogs
Pollen
Wood record
Tree Rings
Historical data
Documents
Instrumental record
Thermometers, Rain gauges
100,000,000
10,000,000
1,000,000
100,000
10,000
1000
100
10
Length in Record (years ago)

DENDRO-

- -chronology: the use of tree rings for dating.
- -climatology: the use of tree rings as a proxy indicator of climate.
- Both based on analyzing the thickness and density of annual growth rings of certain tree species.

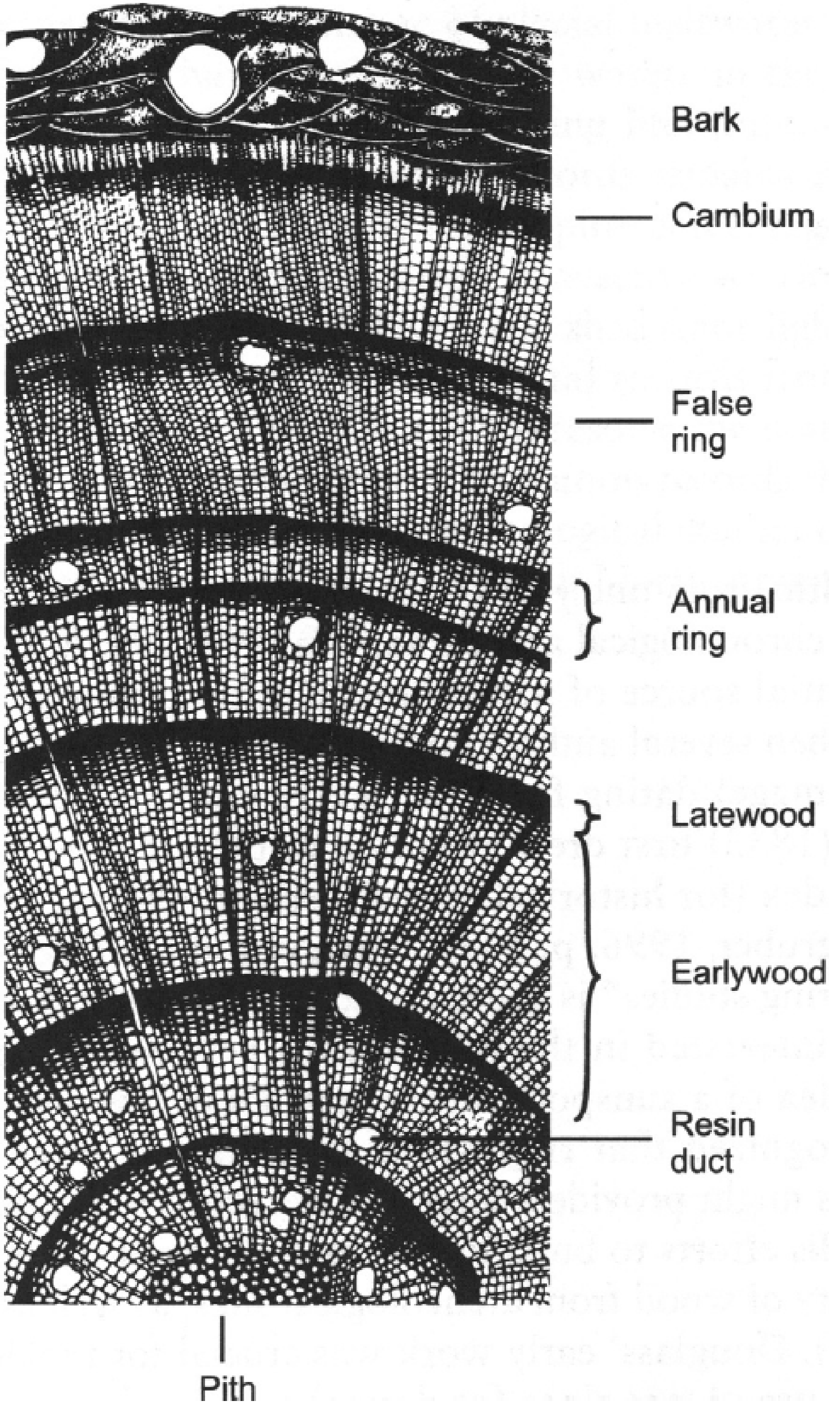

1991
1911
1871
1845
1823
1793
1742
1696
1597

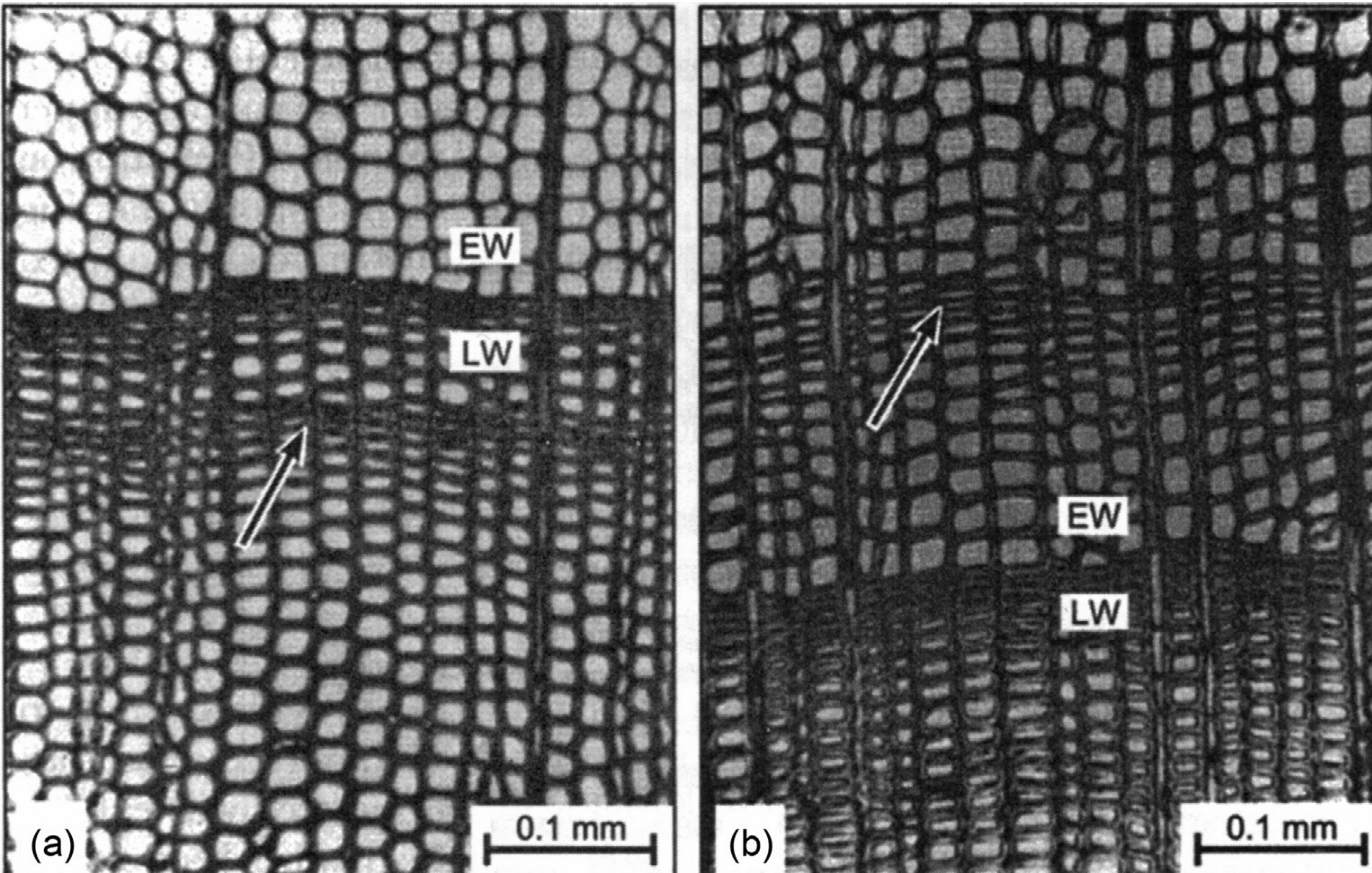
TREE RINGS: LIGHT AND DARK

- Color based on cell type:
  - Spring growth cells are lighter in color
  - Late growth cells are smaller, thick-walled, and more dense

- Abrupt changes in cell type mark the boundary between annual growth rings.

- Can get "false rings" when conditions get rough before end of growing season.


Bark
Cambium
False
ring
Annual
ring
Latewood
Earlywood
Resin
duct
Pith


EW
LW
(a)
0.1 mm
EW
LW
(b)
0.1 mm

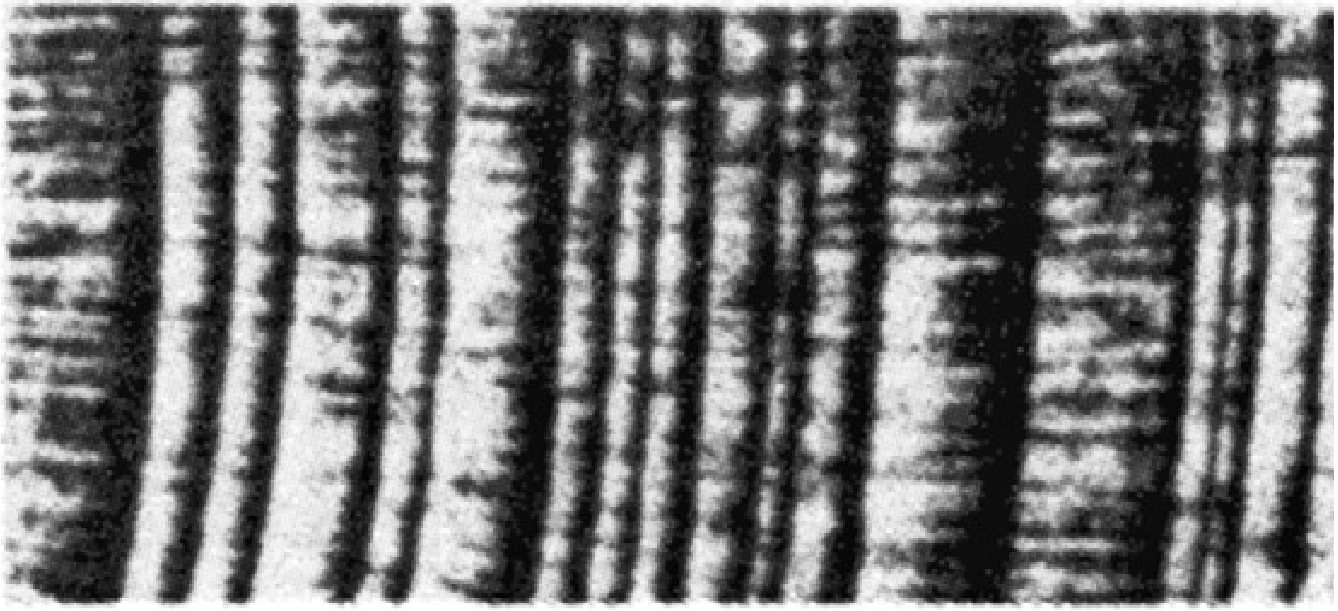
TREE RINGS

- The width of the rings is controlled by multiple factors:
  - Age of the tree
  - Tree species
  - Food storage / soil quality
  - Climate factors
    - Sunshine
    - Temperature
    - Precipitation
    - Humidity
    - Wind speed

- Account for non-climate signals through the tree-growth index: ratio of width to expected width based on age

ISOLATING A CLIMATE SIGNAL: SITE CONSIDERATIONS

- Need a location where trees are under some stress:
  - Temp stress: trees @ altitudinal or latitudinal tree line
  - Precipitation stress: trees in semi-arid regions
- Example: Proximity to the water table can reduce the climate signal.



ISOLATING A CLIMATE SIGNAL: SITE CONSIDERATIONS

- Need a location where trees are under some stress:
  - Temp stress: trees @ altitudinal or latitudinal tree line
  - Precipitation stress: trees in semi-arid regions
- Example: Proximity to the water table can reduce the climate signal.
- Location with a proper sample size:
  - 2 to 3 cores from each tree
  - ~20 trees from each site.

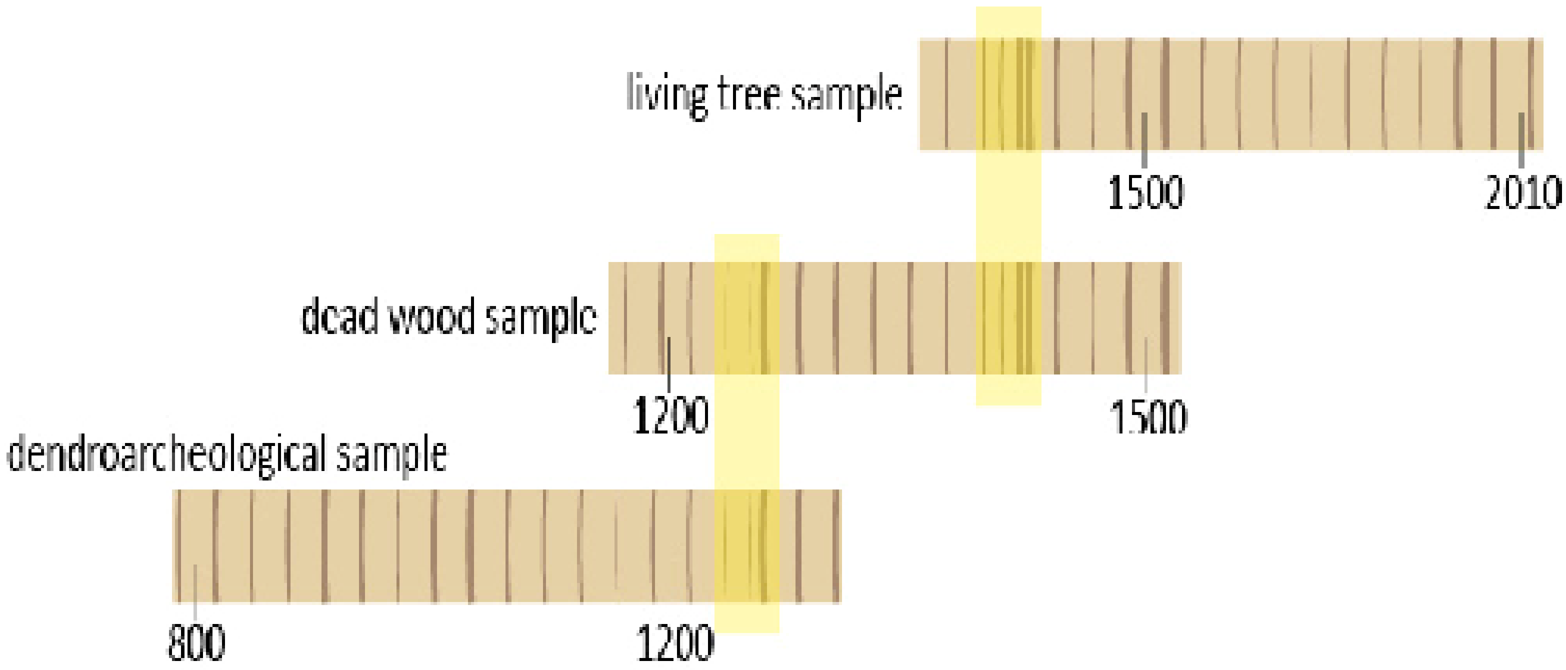
ISOLATING A CLIMATE SIGNAL: SITE CONSIDERATIONS

- Primary Tree species used are:
  - Ponderosa Pine
  - Douglas Fir
  - Bristlecone Pine

- Oldest living individual tree is ~ 5,000 years old.

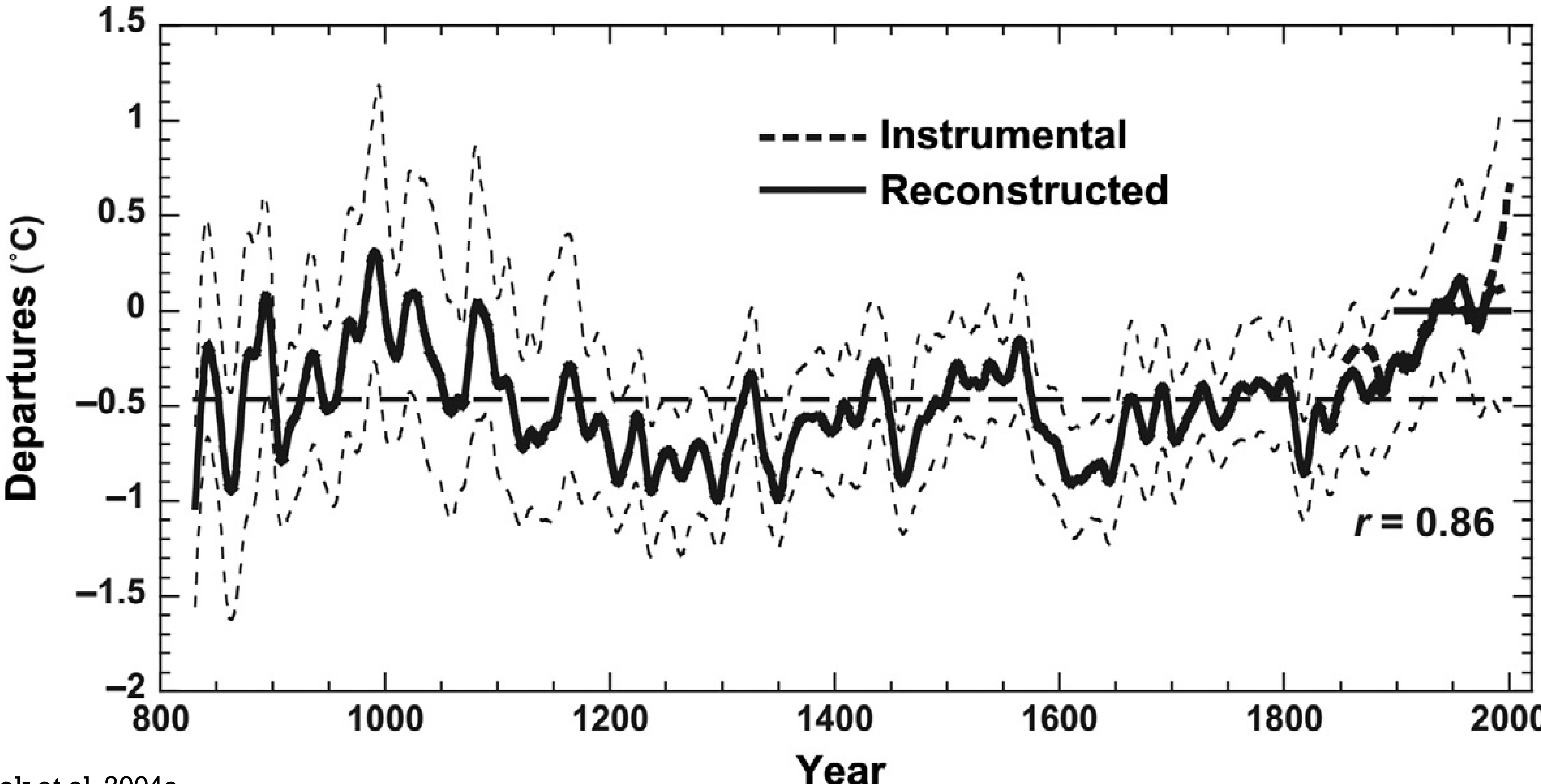
TREE CORE RECORDS

- Records are typically limited to 500-700 years.
- Can use "cross dating" to extend the record back ~ 10,000 years.



WHAT DO WE GET?

- Reconstructions can yield
  - Temperature time histories



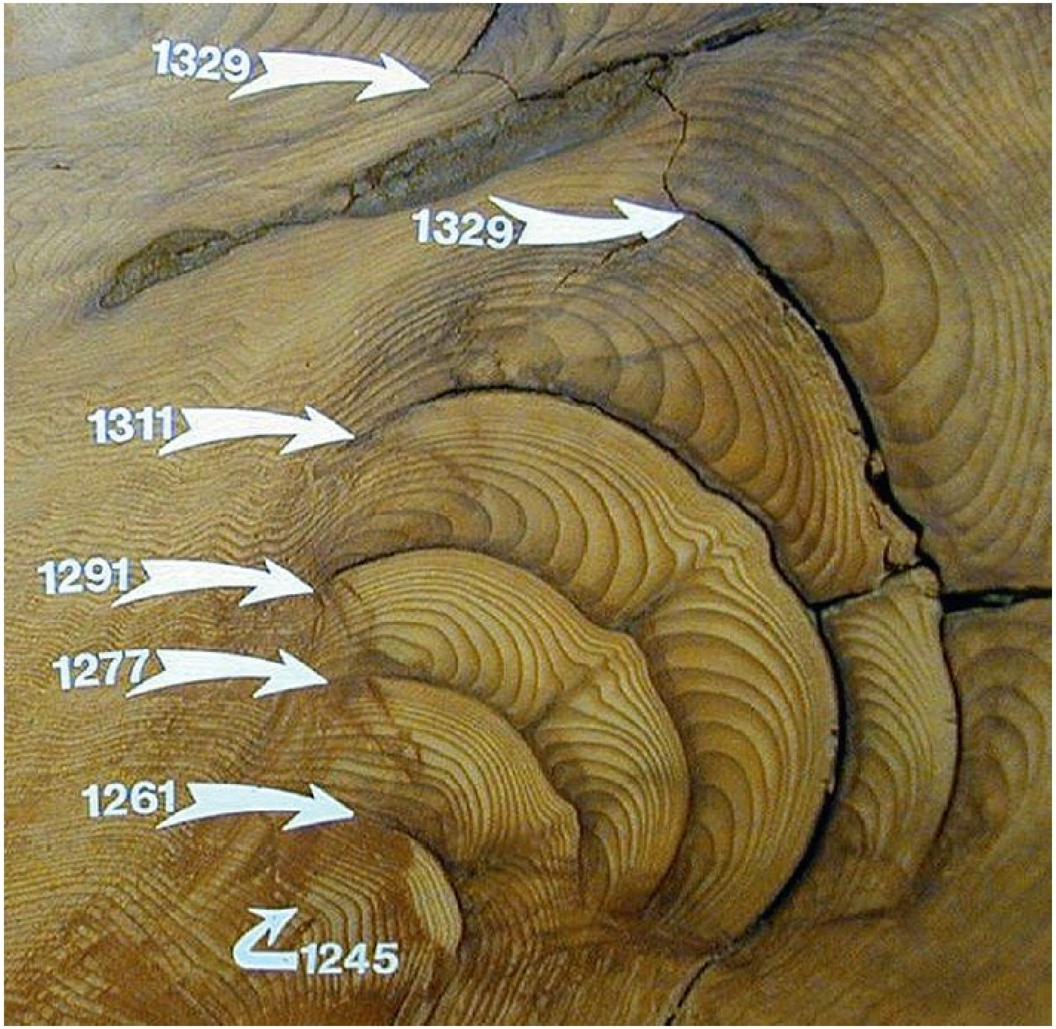
Cook et al. 2004a

WHAT DO WE GET?

- Drought information:

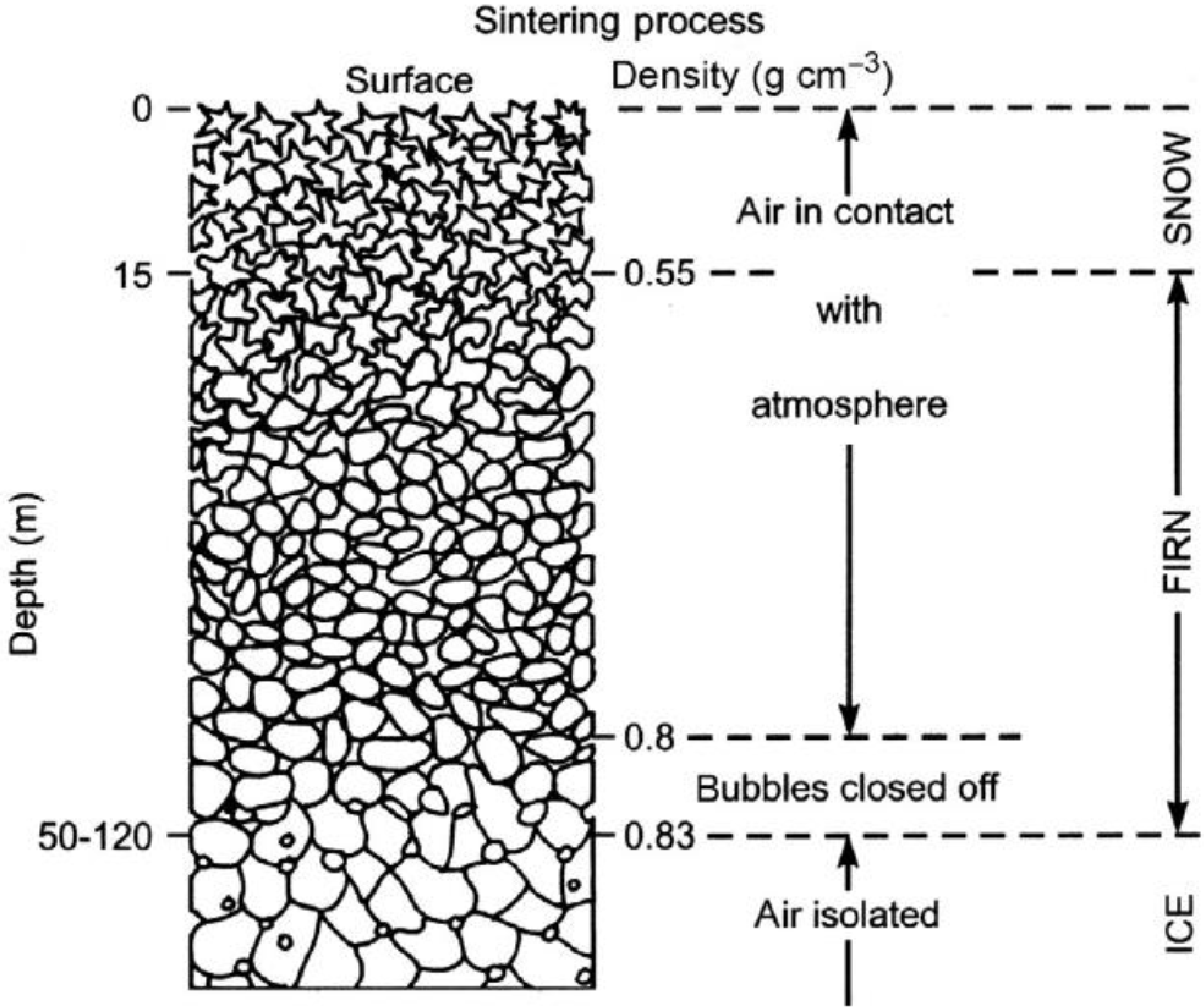
WHAT DO WE GET?

- Wildfire information.
- Which we can relate to other atmospheric variables.



ICE CORE BASICS

- Starts as snowfall.
- Snow accumulates … slowly.
  - Interior regions of Antarctica receive only about 2 inches of snow a year.
- Weight of accumulated snow causes underlying crystals to settle, deform, and recrystallize, which removes the air spaces between the crystals.
  - Taking air out → increase in density
  - "Densification"


Sintering process
Surface
Density (g cm⁻³)
0
15
50-120
Depth (m)
0.55
0.8
0.83
Air in contact
with
atmosphere
Bubbles closed off
Air isolated
SNOW
FIRN
ICE

https://climate.nasa.gov/news/2616/core-questions-an-introduction-to-ice-cores/

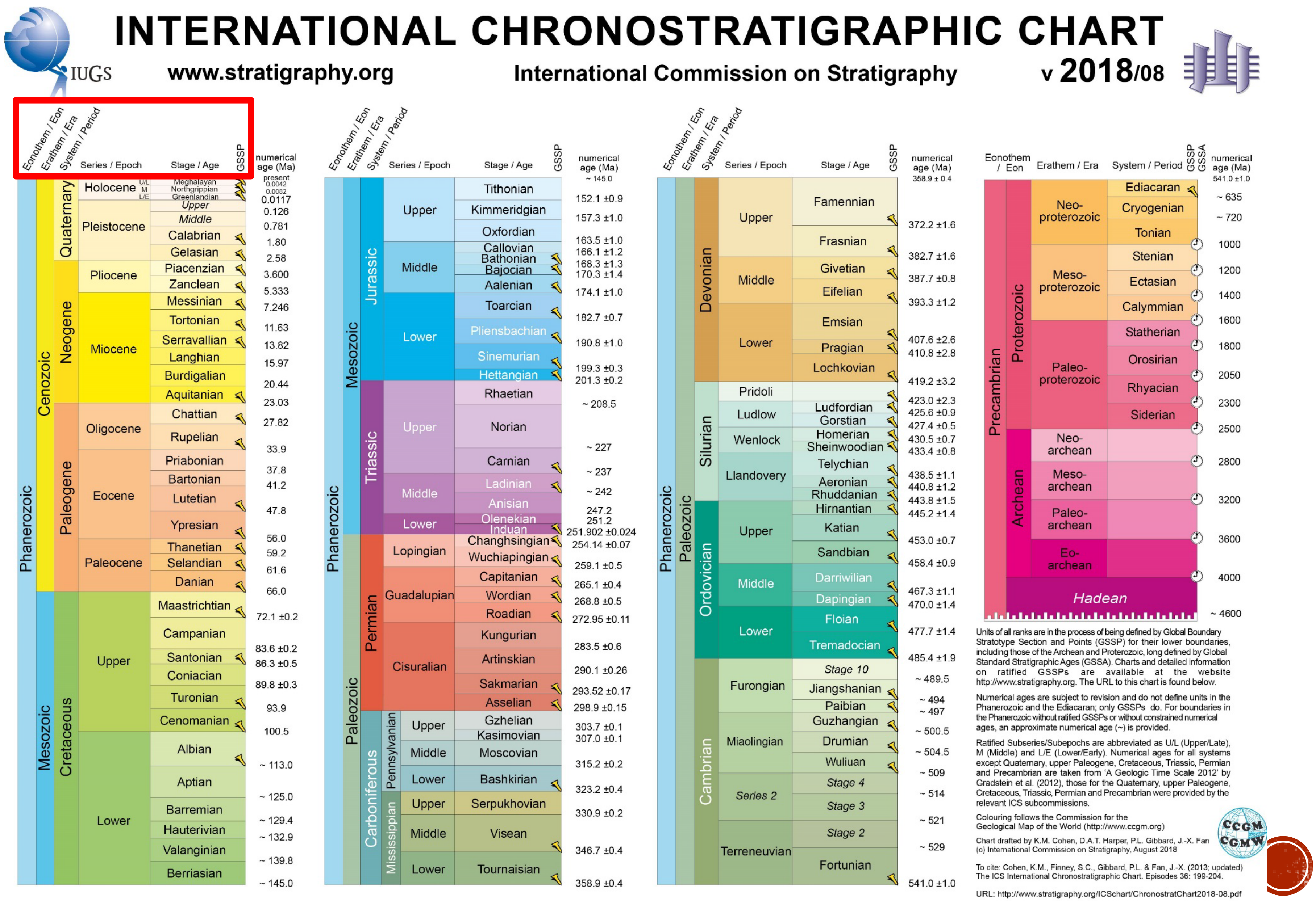
http://www.sciencepoles.org/interview/climate-cycles-and-million-year-old-ice

WHAT CAN WE GET FROM ICE CORES?

TABLE 5.1 Principal Sources of Paleoclimatic Information from Ice Cores

Parameter	Analysis
Temperature	
Summer	Melt layers
Annual	δD, $\delta^{18}O$ (ice), Ar, N_2 (diffusion)
Source region temperature/humidity	Deuterium excess (*d*)
Accumulation (net)	Seasonal signals
Volcanic activity	Conductivity, non-sea salt (nss.) SO_4^{2-}, glaciochemistry
Tropospheric turbidity	ECM, microparticle content, trace elements
Wind speed	Particle size, concentration
Atmospheric composition	Trace gases (CO_2, CH_4, and N_2O)
Sea ice extent	Glaciochemistry (Br^-, I^-, and Na^+)
Atmospheric circulation	Glaciochemistry (major ions)
Solar activity and geomagnetic field changes	^{10}Be
Forest fire history	Levoglucosan and other biomarkers

GEOLOGIC TIME SCALE



EARTH'S CLIMATE HISTORY

- We are currently in the:
  - Phanerozoic Eon
  - The Cenozoic Era
  - Quaternary Period
  - Holocene Epoch
- The previous Epoch, the Pleistocene, was characterized by the Ice Age

EARTH'S CLIMATE HISTORY: THE ICE AGE

- Ice Age: A series (cycle) of glacial and interglacial periods that occurred during a ~1.7 million year period of the Pleistocene

- Climate was extremely variable. A major player on the Norther American Continent was the Laurentide Ice Sheet


18,000 YEARS AGO
Greenland ice sheet
Mountain glaciers
Laurentide ice sheet

ICE AGE

- Each glacial advance erases evidence of the previous advance.
- Thus, our most reliable evidence extends only back to the last glacial maximum (LGM)
- The LGM began about 27K ya and peaked ~18K ya.

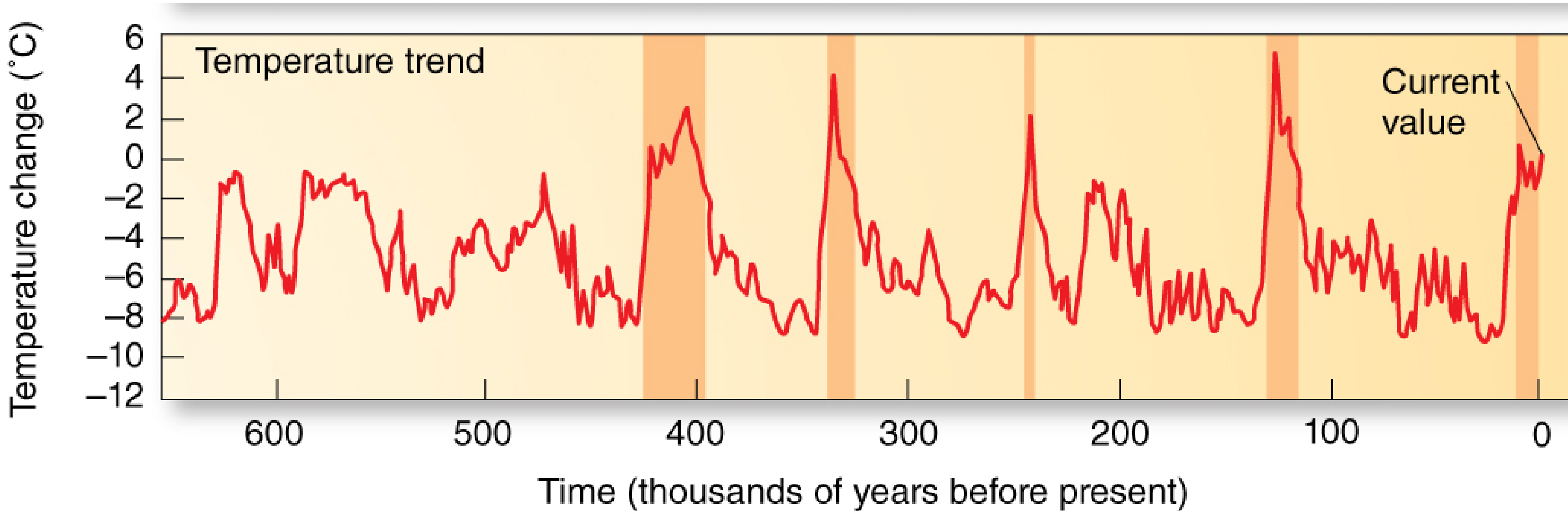
ICE AGE CYCLE

- The end of the LGM was marked by a temp increase to the present interglacial:

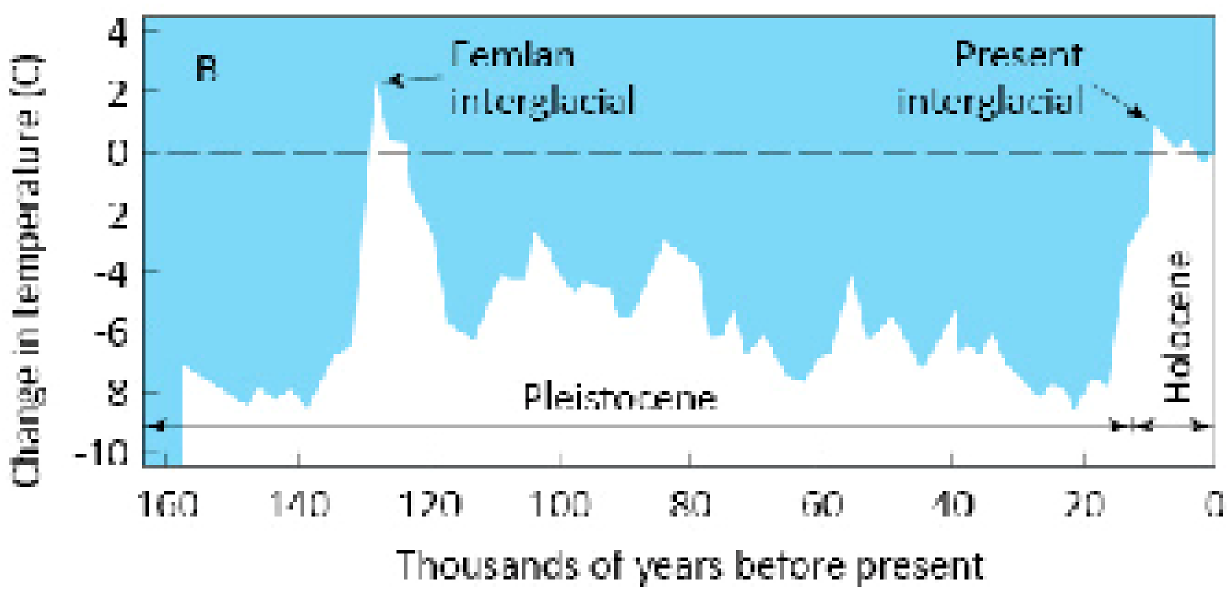
- Laurentide Ice Sheet began to melt.

- Melting occurred with only:
  - 5 Deg C temp increase in tropics
  - 6-8 Deg C temp increase in the mid-lats
  - 10 Deg C temp increase at the poles

- One of multiple cycles. Glacial period ~ every 100,000 years separated by ~11,000 year interglacial period.



Temperature change (°C)
6
4
2
0
−2
−4
−6
−8
−10
−12
Temperature trend
Current value
600
500
400
300
200
100
0
Time (thousands of years before present)



Change in temperature (C)
4
2
0
-2
-4
-6
-8
-10
B
Eemian interglacial
Present interglacial
Pleistocene
Holocene
160
140
120
100
80
60
40
20
0
Thousands of years before present

ICE AGE CYCLES

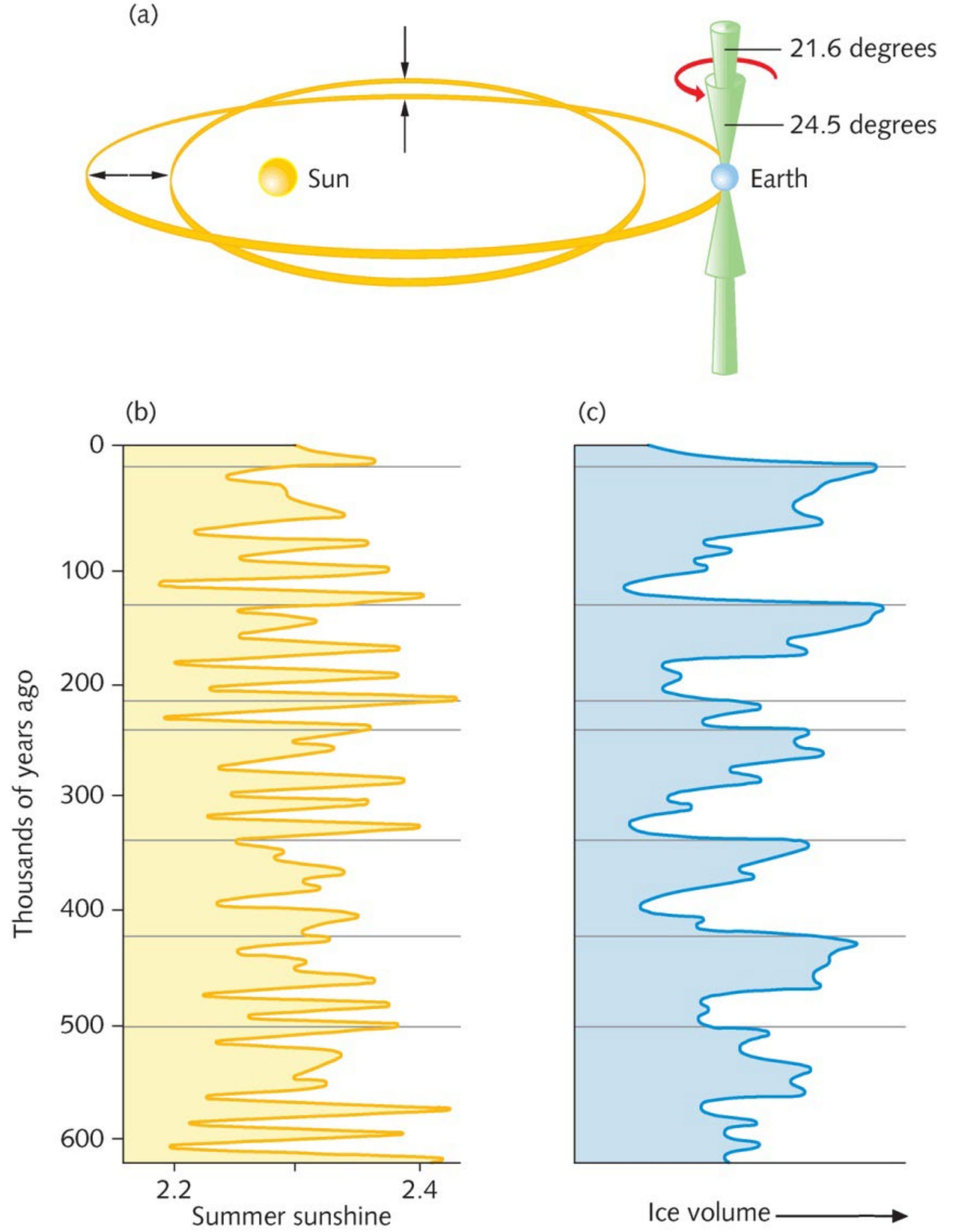
- Why were these period so repetitive?

- The 100,000 year fluctuation can be attributed to Milankovitch Theory: slight changes in earth's orbit alter the sun-earth geometry.

MILANKOVITCH THEORY

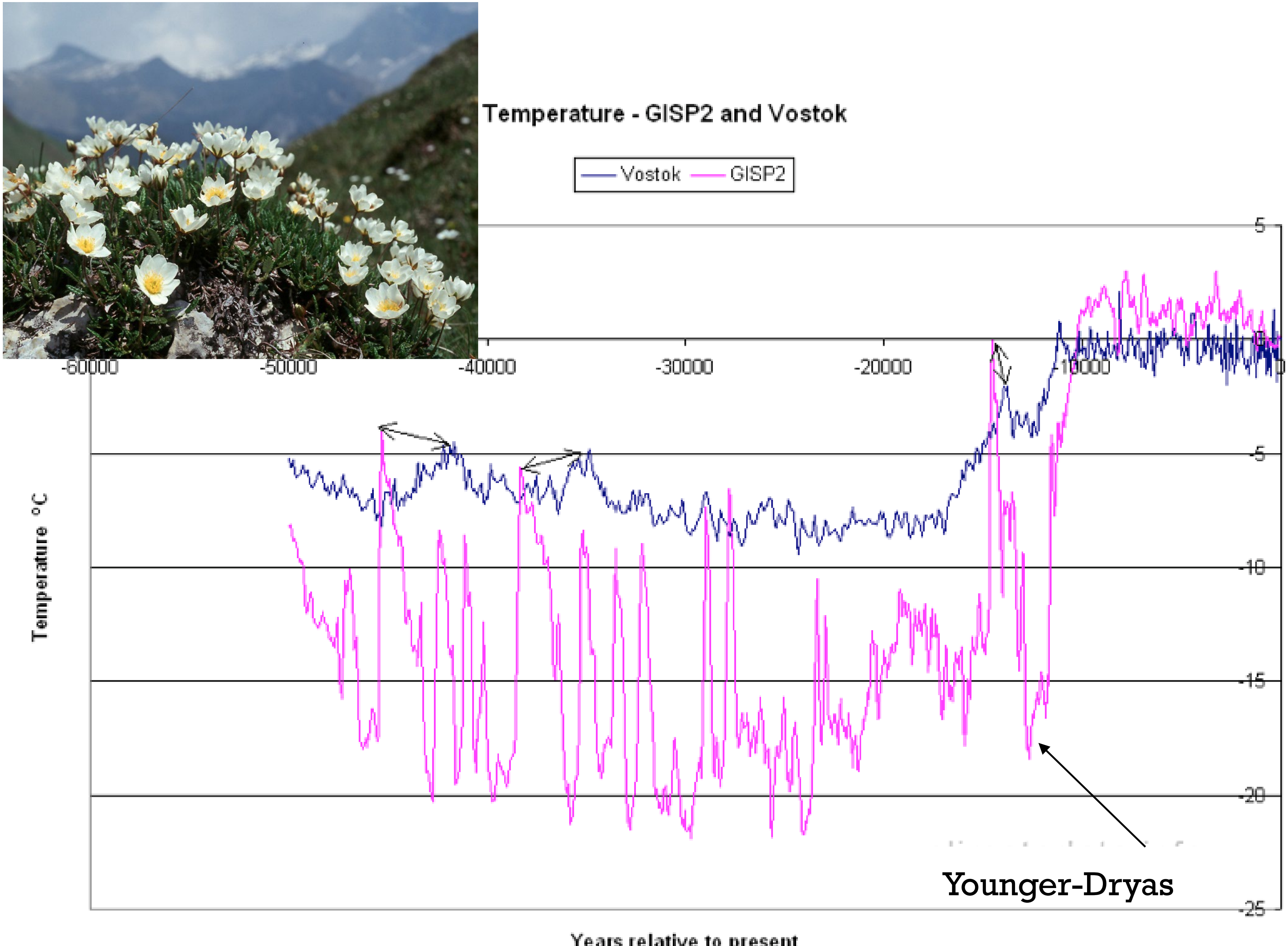
- Three modes:
  - Changes in the eccentricity of Earth's Orbit
    - How close to a perfect circle is Earth's orbit around the sun?
    - 100,000 year cycle
  - Changes in the obliquity of Earth's Orbit
    - Tracks changes in Earth's tilt
    - 41,000 year cycle
  - Precession
    - Which star is Earth's axis pointing to? Polaris right now.
    - 27,000 year cycle.

- Milankovitch modes explain about 60% of the variance in Earth's climate history.
- Effects greatest at high latitudes in summer where insolation can vary by 20%
- These changes (glacial vs interglacial) have been globally synchronous



GLOBAL / NON-GLOBAL CHANGES

- Despite glacial / interglacial periods being globally synchronous, ice core data show:
  - Southern Hemisphere climate been more stable
  - Time delays in most recent glacial cycle
  - Abrupt changes on the scale of 2-3K years and 7-12 K years.


Temperature - GISP2 and Vostok
Vostok
GISP2
Temperature °C
Years relative to present
5
0
-5
-10
-15
-20
-25
-60000
-50000
-40000
-30000
-20000
-10000
0
Younger-Dryas

YOUNGER-DRYAS

- Regional short-term climate fluctuation.
- Abrupt cooling
- Palynology data revealed the pollen of the Dryas Octopetala much further south than normal.
- Time scale too short to be Milankovitch…so what caused it?

YOUNGER DRYAS

- Related to the melting of the Laurentide Ice Sheet and the AMOC.

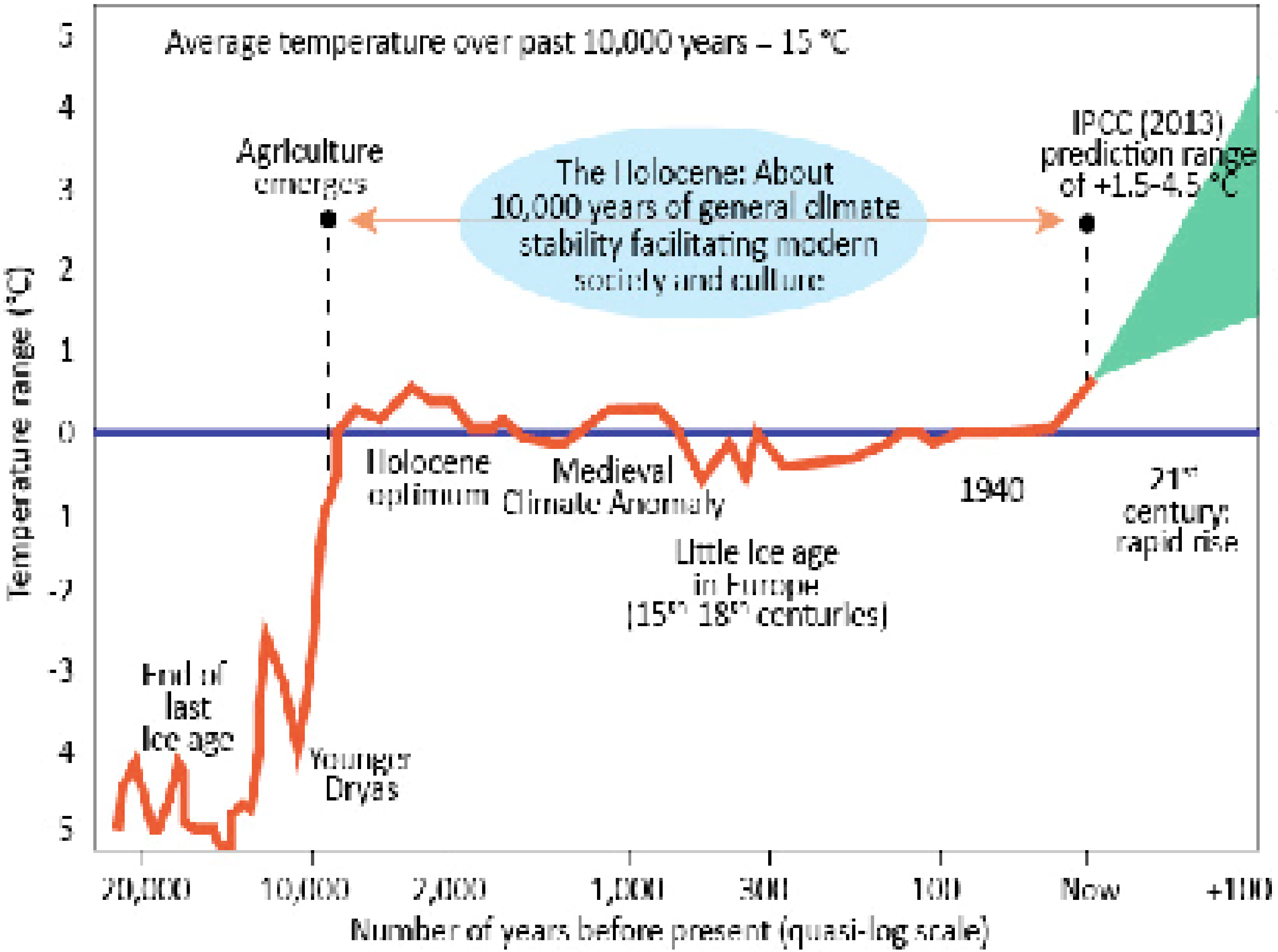
- When the AMOC resumed its normal pattern, warming continued
  - The arctic warmed by 7 °C over the course of 50 years .

THE HOLOCENE

- At the conclusion of the Younger-Dryas Period, Earth entered into the present interglacial period: The Holocene Epoch (~10,500 YBP)

- Characterized by:
  - Relatively stable climate (compared to the last Epoch)
  - Development of Agrarian Societies
  - Modern Civilization

Temperature stability during the Holocene

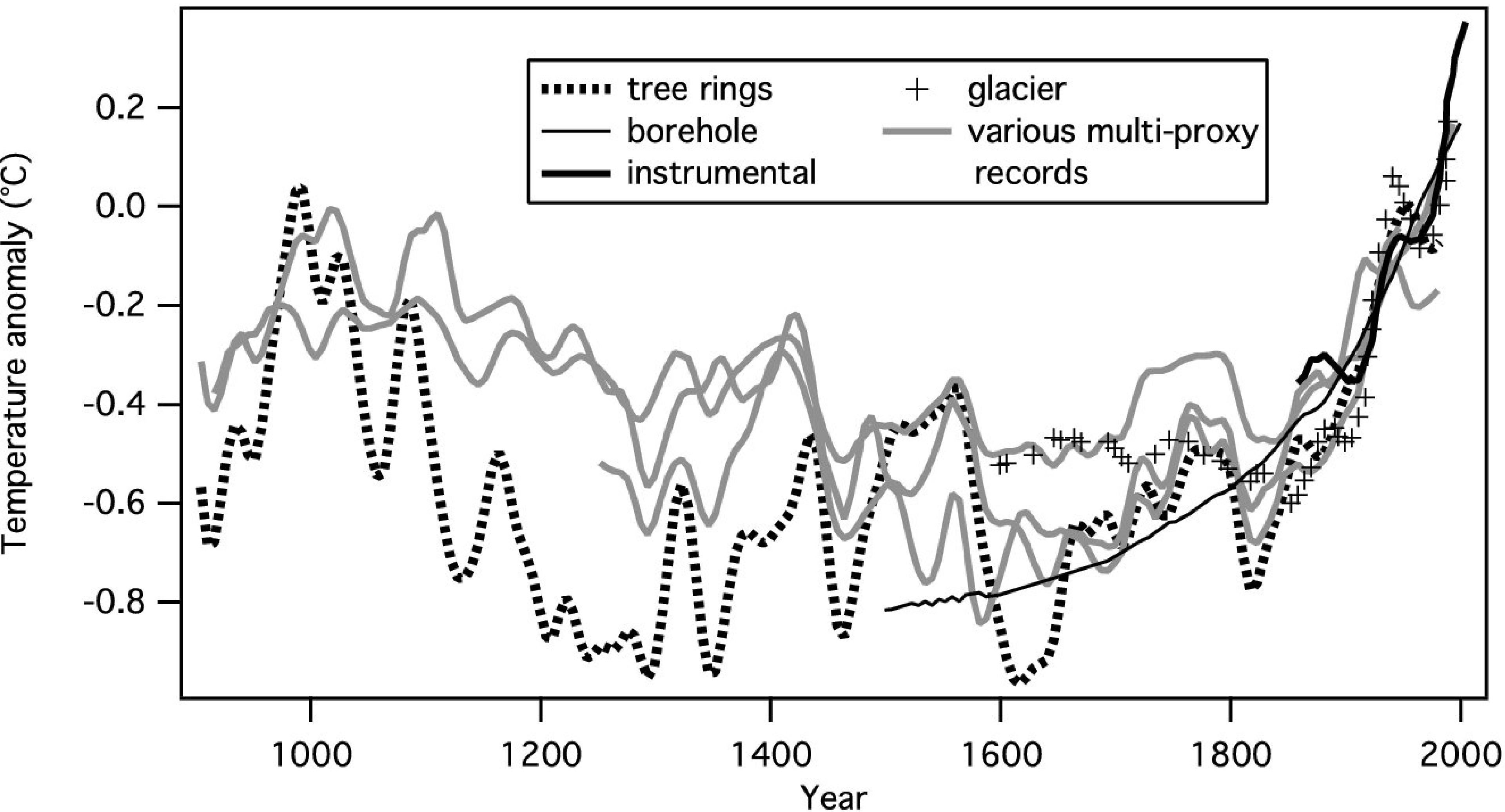


THE HOLOCENE

- There have also been several small scale climate fluctuations with in the Holocene (specifically over the last 1000 years):

  - Medieval Climate Anomaly (MCA)
    - Mild Winters; Growing Wine in England
    - Isolated to N.H. based on data
    - Vikings get adventurous…

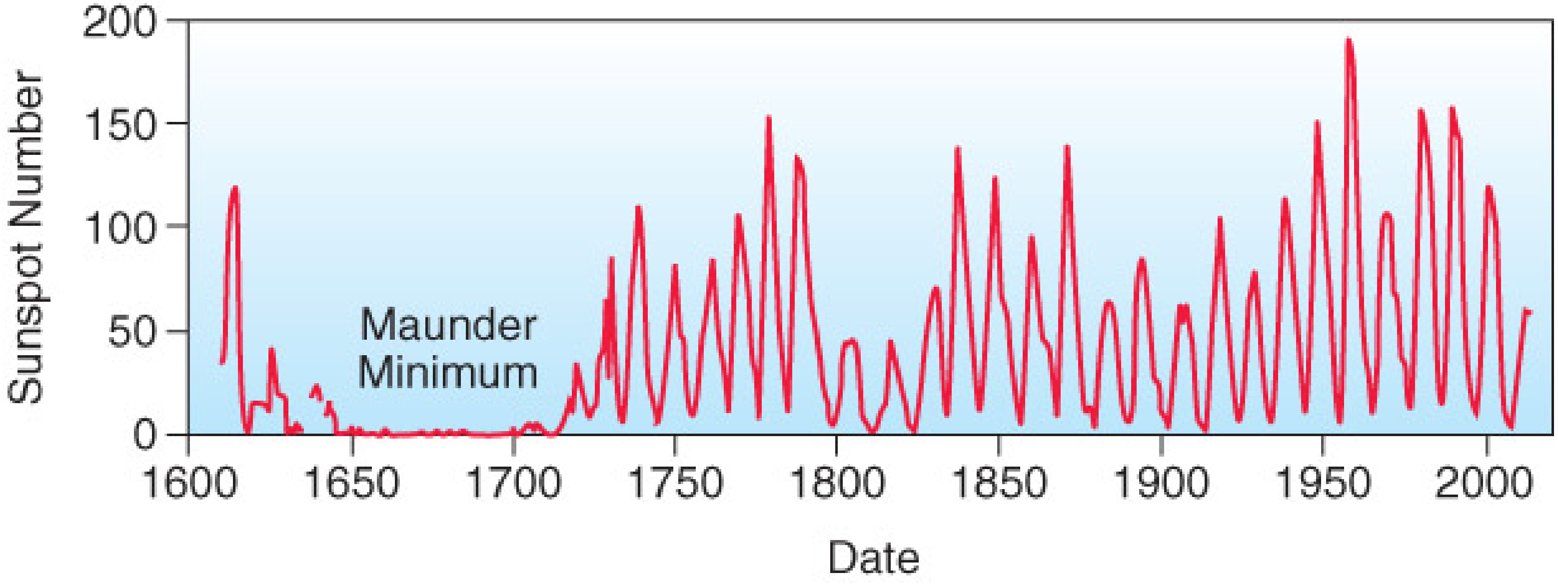
  - Little Ice Age (LIA)
    - Multi-century cool period
    - Global temp ~0.5 cooler.
    - Vikings give up; Food shortage; Societal Unrest.



tree rings
borehole
instrumental
glacier
various multi-proxy records
0.2
0.0
-0.2
-0.4
-0.6
-0.8
Temperature anomaly (°C)
1000
1200
1400
1600
1800
2000
Year

LITTLE ICE AGE

- What caused it?
  - Not Entirely sure
  - Sunspots?



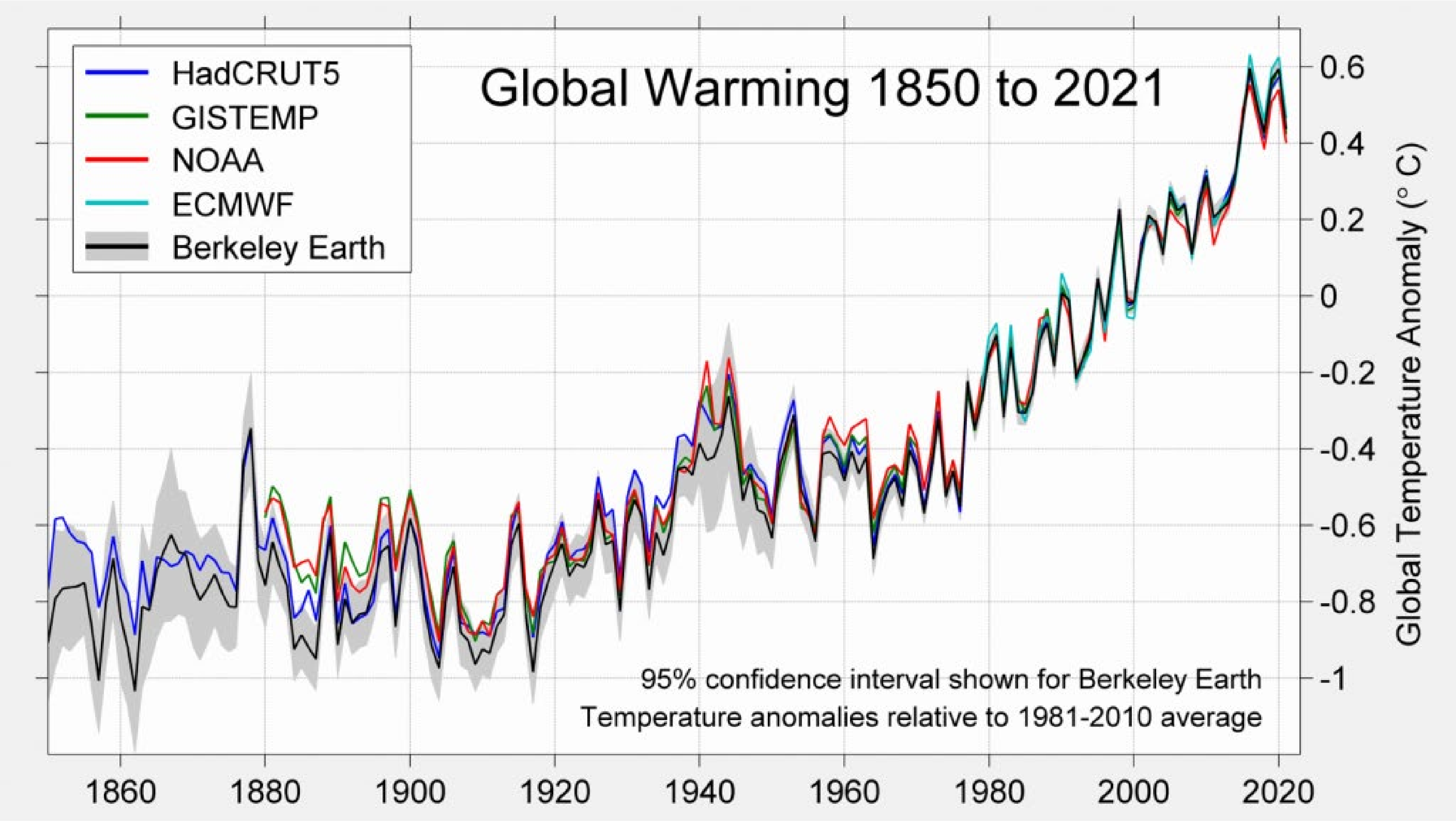
ANTHROPOCENE?

- Check out this article:

https://www.smithsonianmag.com/science-nature/what-is-the-anthropocene-and-are-we-in-it-164801414/

- Watch this clip:

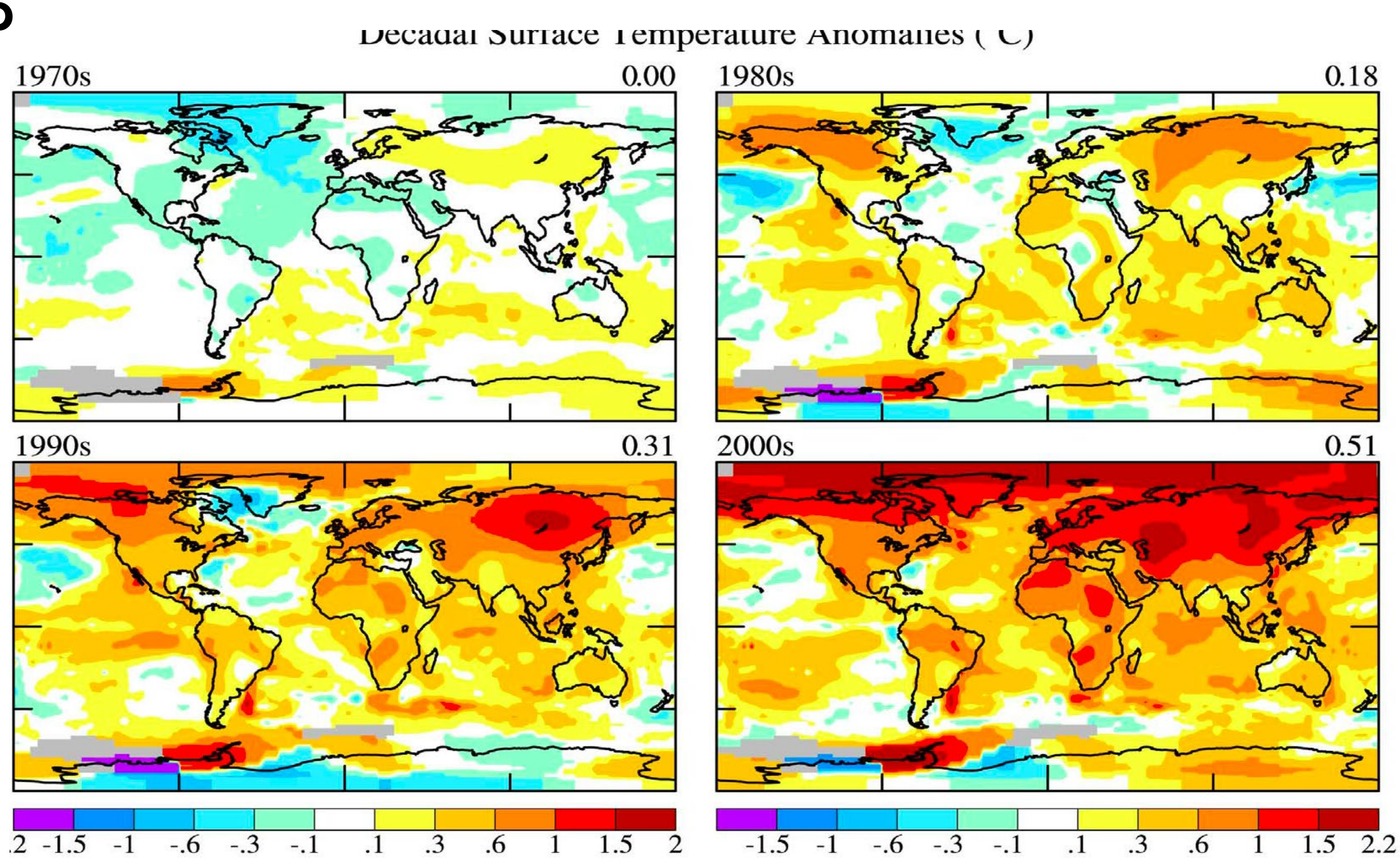
http://www.smithsonianmag.com/videos/category/science/what-is-the-anthropocene/?jwsource=cl



Global Warming 1850 to 2021
HadCRUT5
GISTEMP
NOAA
ECMWF
Berkeley Earth
95% confidence interval shown for Berkeley Earth
Temperature anomalies relative to 1981-2010 average
Global Temperature Anomaly (° C)
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
1860
1880
1900
1920
1940
1960
1980
2000
2020

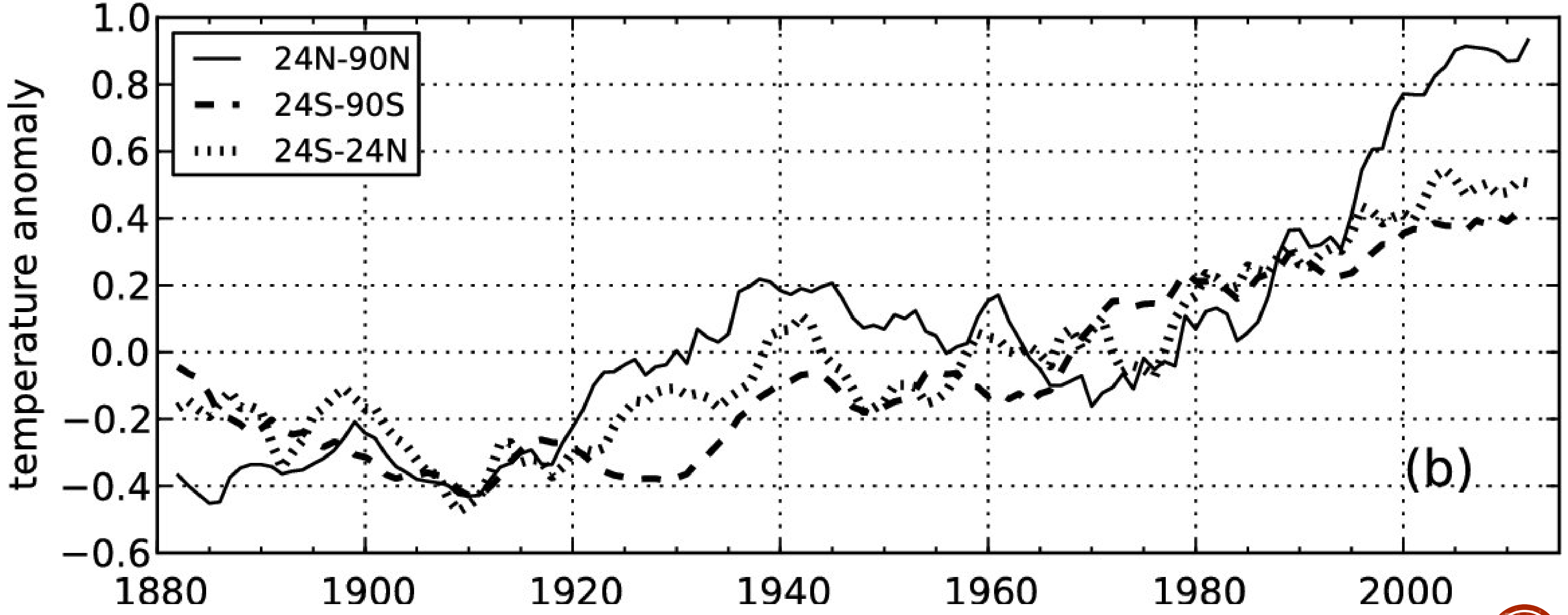
GLOBAL TEMPERATURE RECORD

- Additionally, land areas have warmed more than ocean
  - Why?



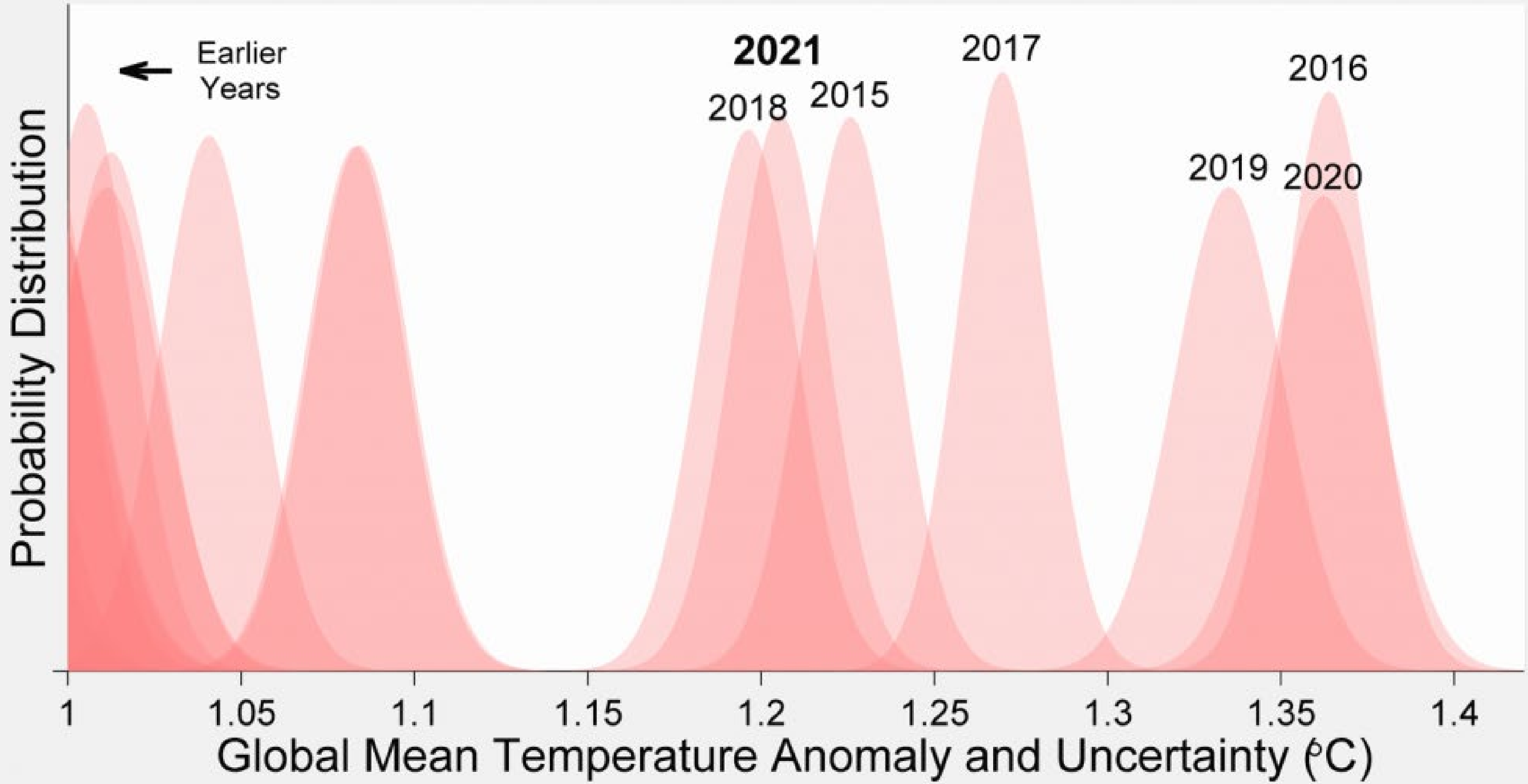
GLOBAL TEMPERATURE RECORD

- NH warmed more than Southern Hemisphere
  - Why?



RECENT DATA

Rank 1 = Warmest Period of Record: 1880–2021	Year	Anomaly °C	Anomaly °F
1	2016	0.99	1.78
2	2020	0.98	1.76
3	2019	0.95	1.71
4	2015	0.93	1.67
5	2017	0.91	1.64
6	2021	0.84	1.51
7	2018	0.82	1.48
8	2014	0.74	1.33
9	2010	0.72	1.30
10 (tied)	2013	0.67	1.21
10 (tied)	2005	0.67	1.21



Based on Berkeley Earth's estimates of the global annual average temperature increase relative to 1850-1900.