

# Climate and Human History

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Thursdays, 2:00-4:00pm

Slides and other materials at:  
<http://www.stephan-matthiesen.de/en>

# Climate and Human History

1. Climate and climate history
2. The Ice Age
3. Farming and City States
4. Rise and Fall of the Roman Empire
5. Tang and Maya in the 10th century
6. Mediaeval Optimum and Little Ice Age
7. El Niño through the ages
8. Miscellaneous topics
9. Current and future changes
10. Summary and re-cap



# About me



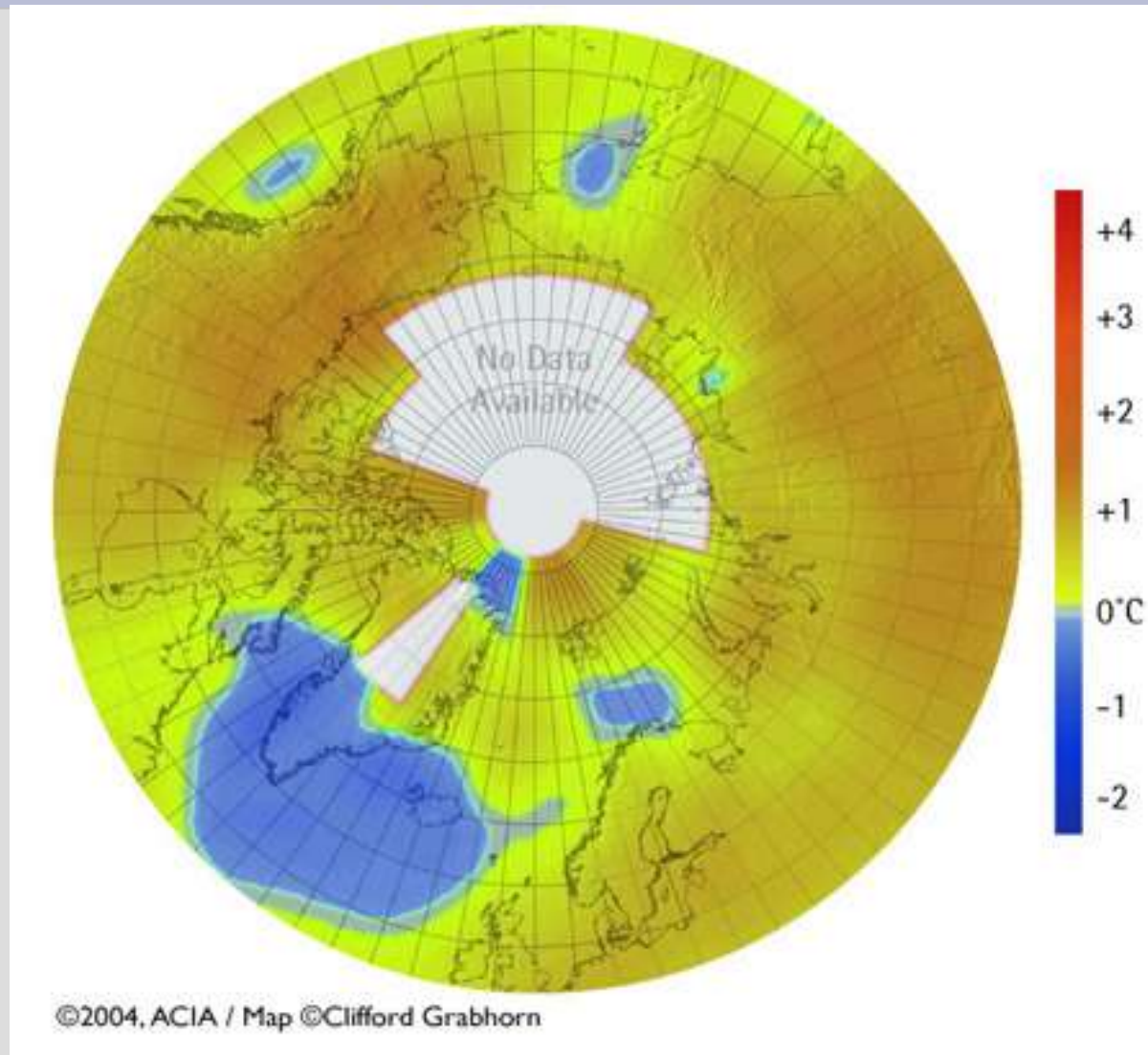
Fieldwork in Sweden, Aug 2007



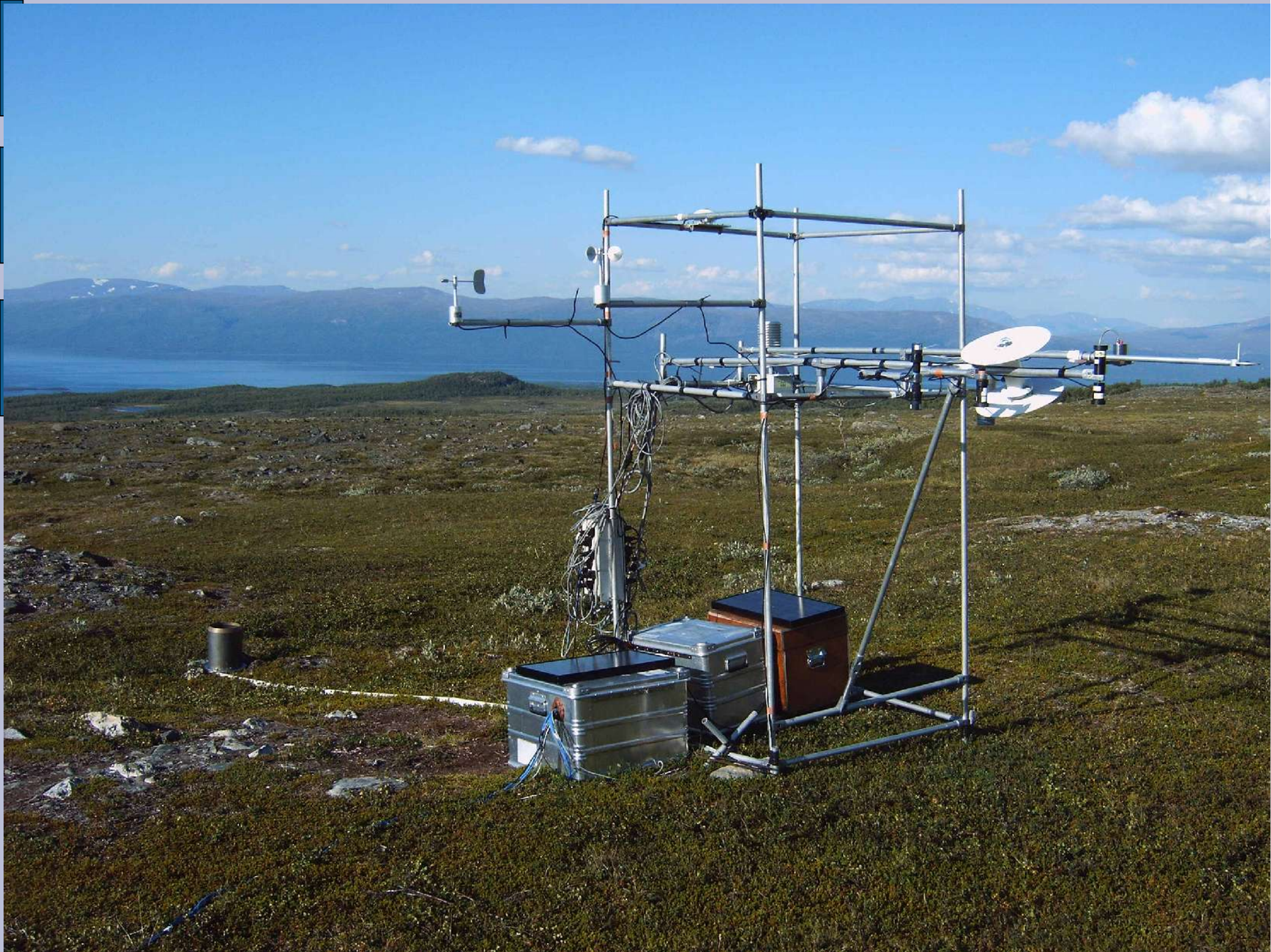




# Arctic Change Observed 1954-2003





















# About you

- Why did you decide to come to this course?
- Are there any civilisations or periods that you are particularly interested in?



# Climate and Climate History

## Outline:

- The Climate System
- Methods for Reconstructing Past Climates
- Climate History



# What is Climate?

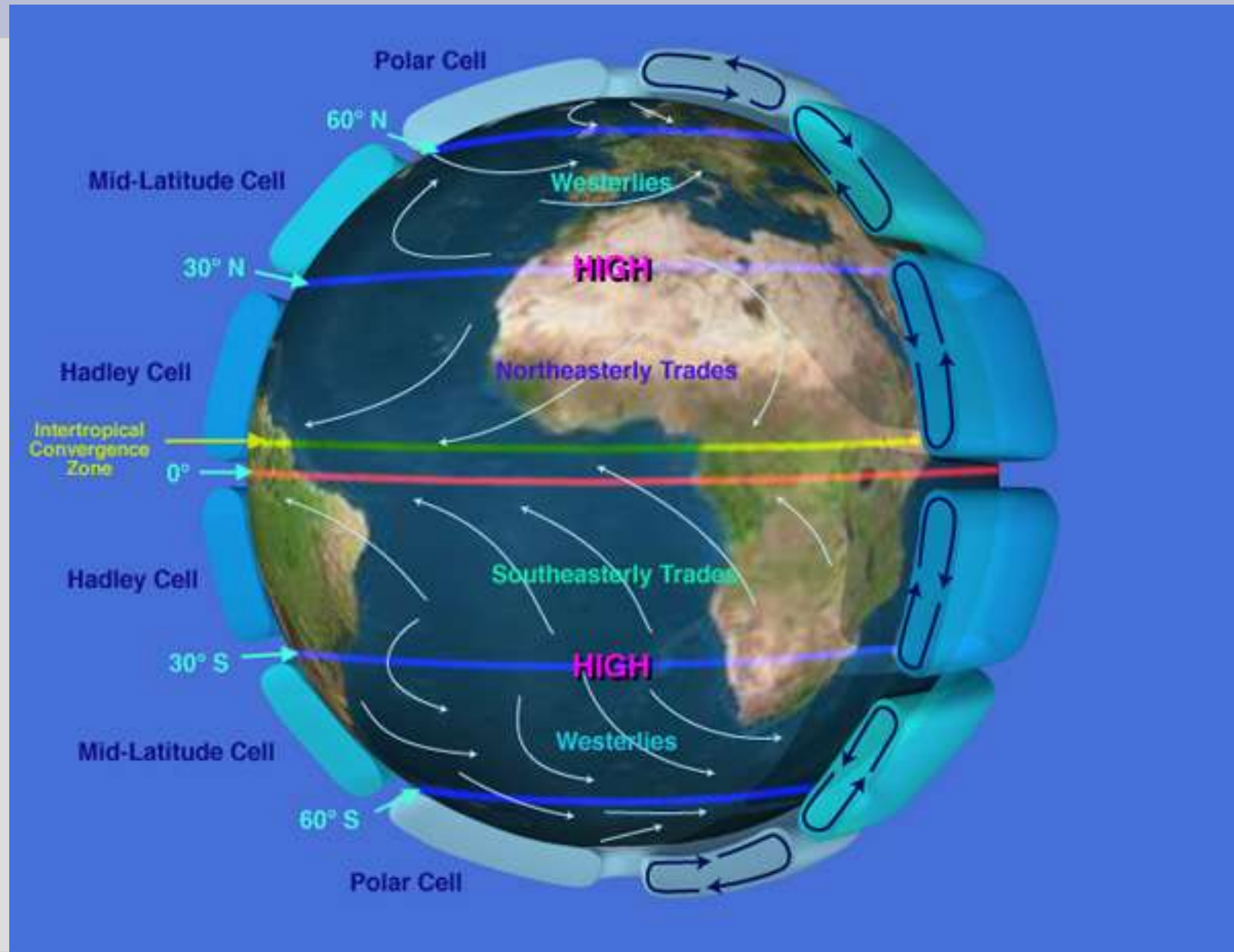
“average weather”:

“Climate represents (...) the accumulation of daily and seasonal weather events (the average range of weather) over a long period of time.”

[Ahrens (2002): Meteorology Today]

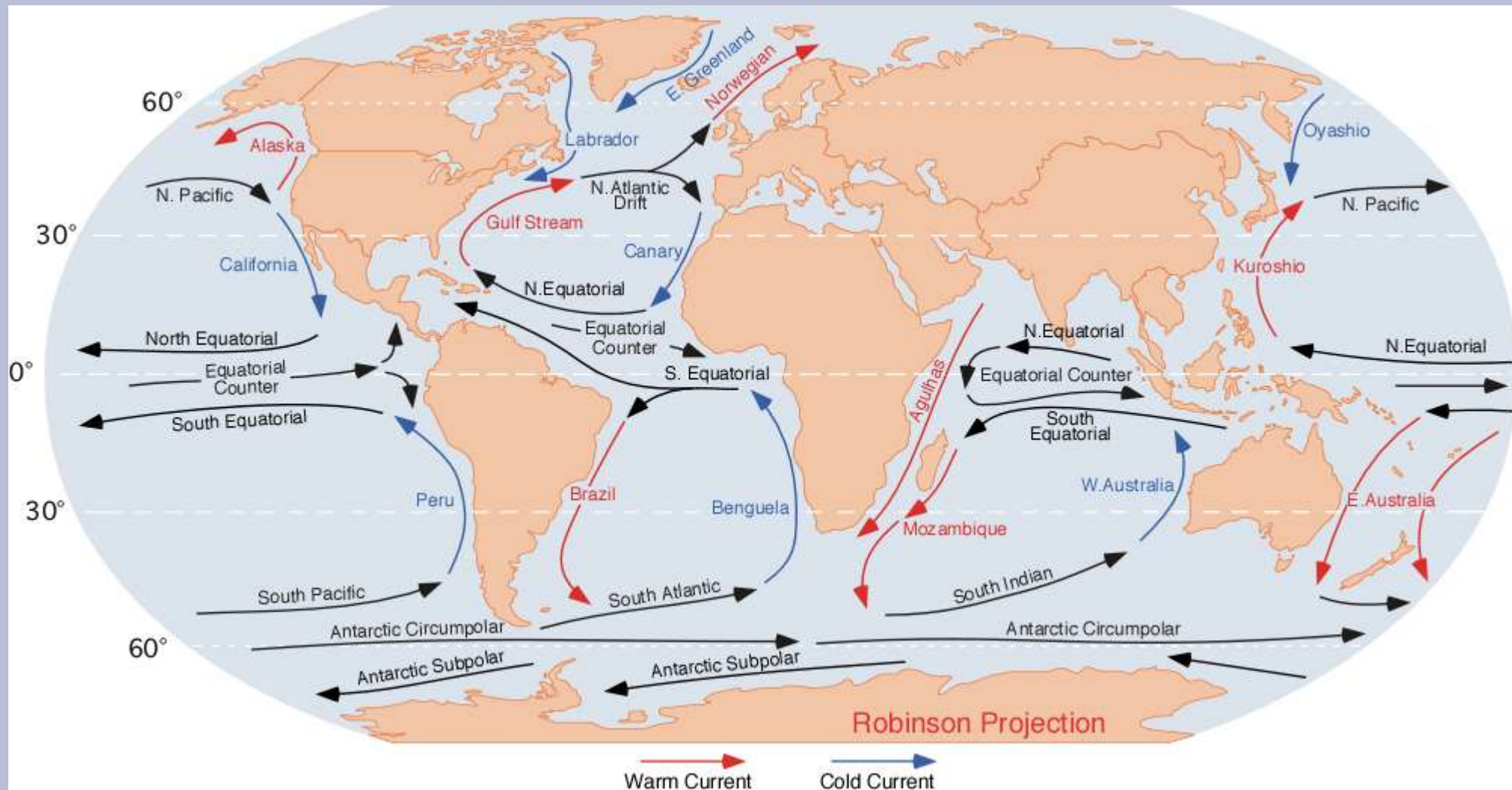


# Atmospheric Circulation



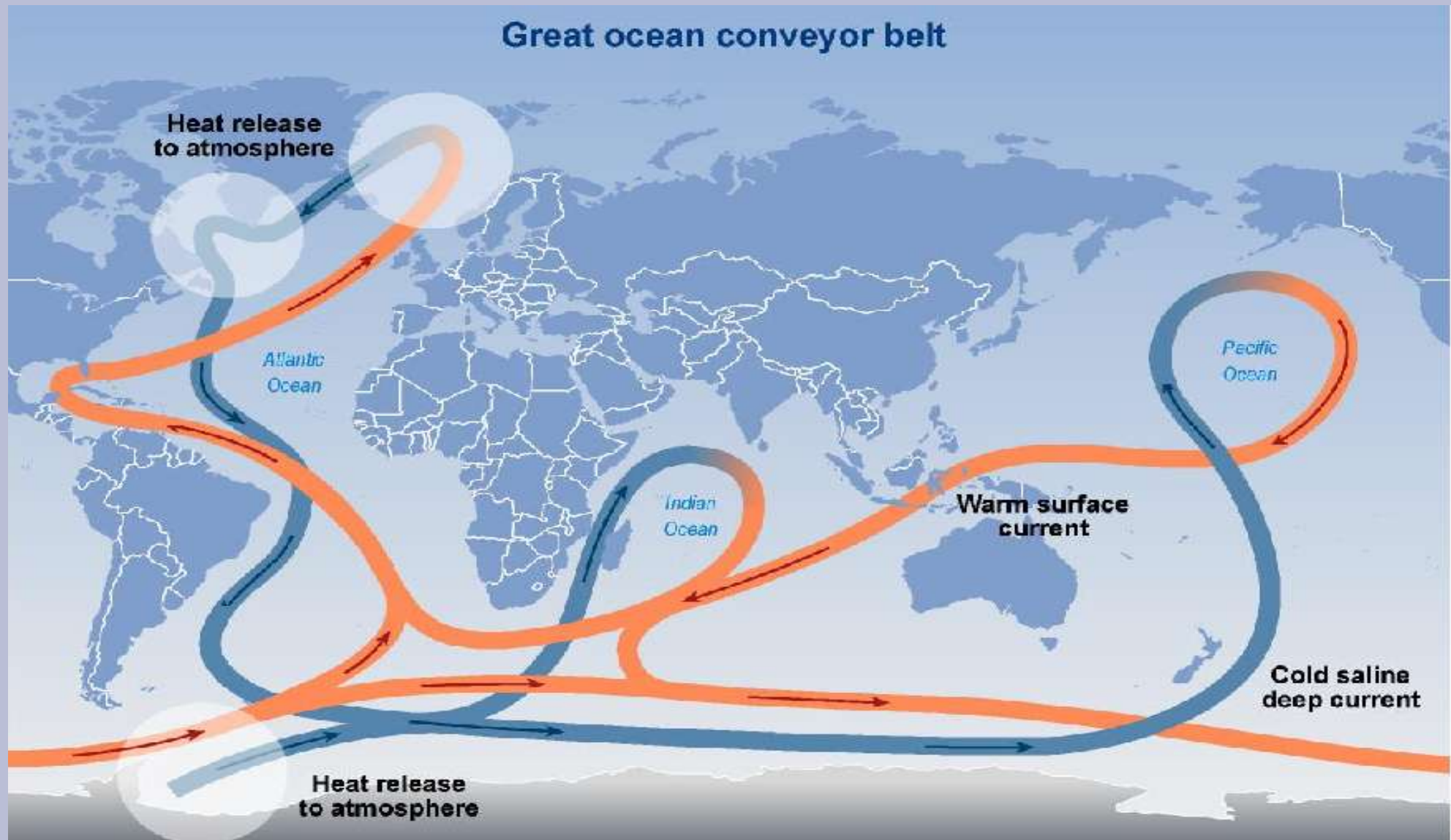


# Ocean currents



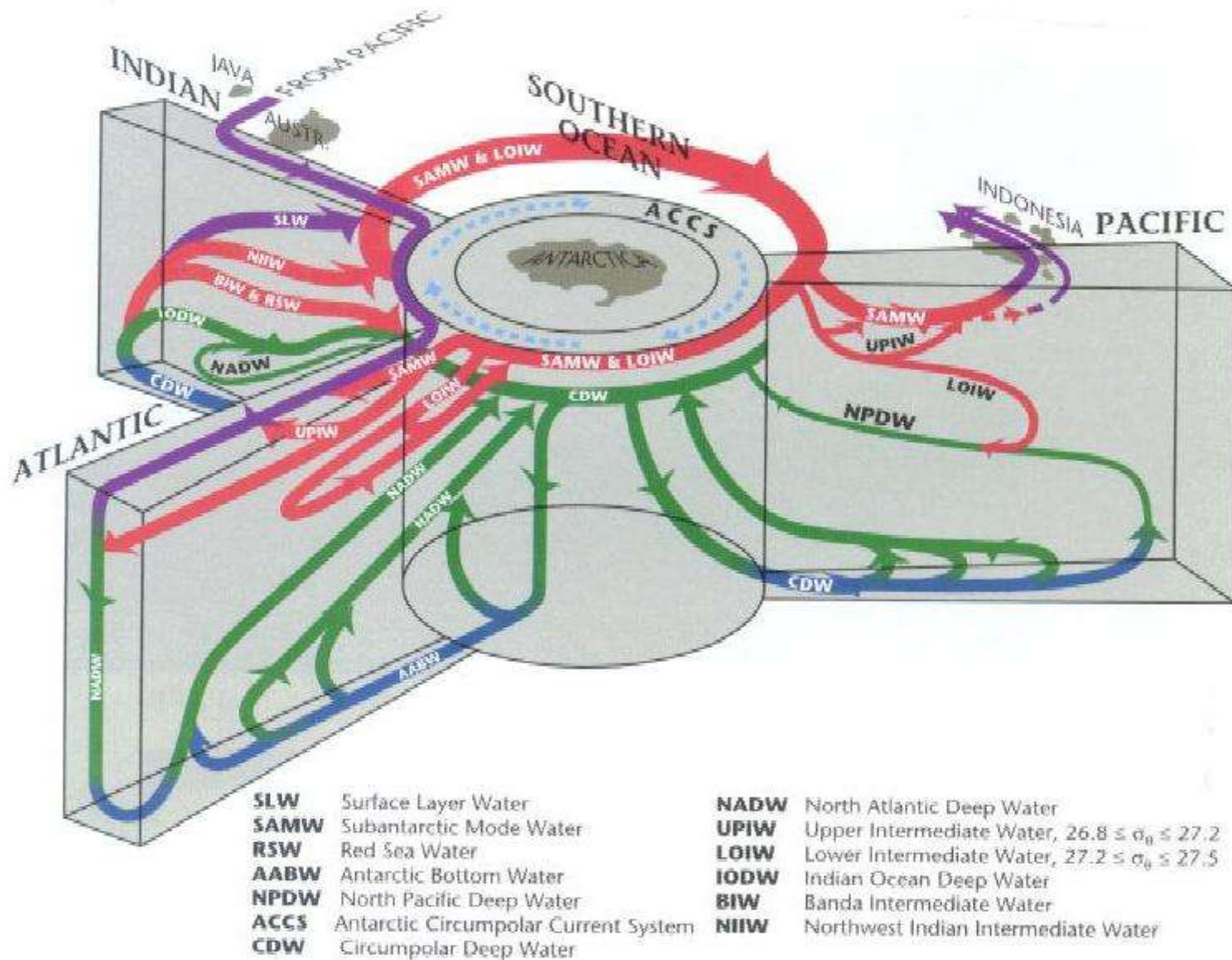


# Thermohaline Circulation





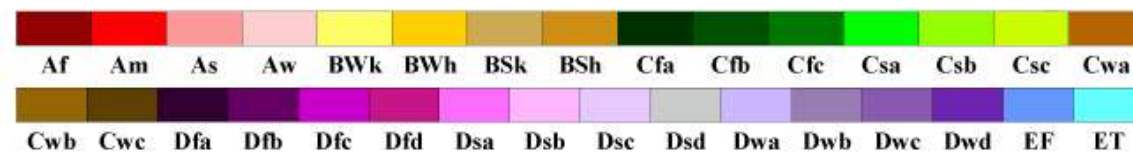
# A different view of the thermohaline circulation





# World Map of Köppen–Geiger Climate Classification

updated with CRU TS 2.1 temperature and VASCLimO v1.1 precipitation data 1951 to 2000



## Main climates

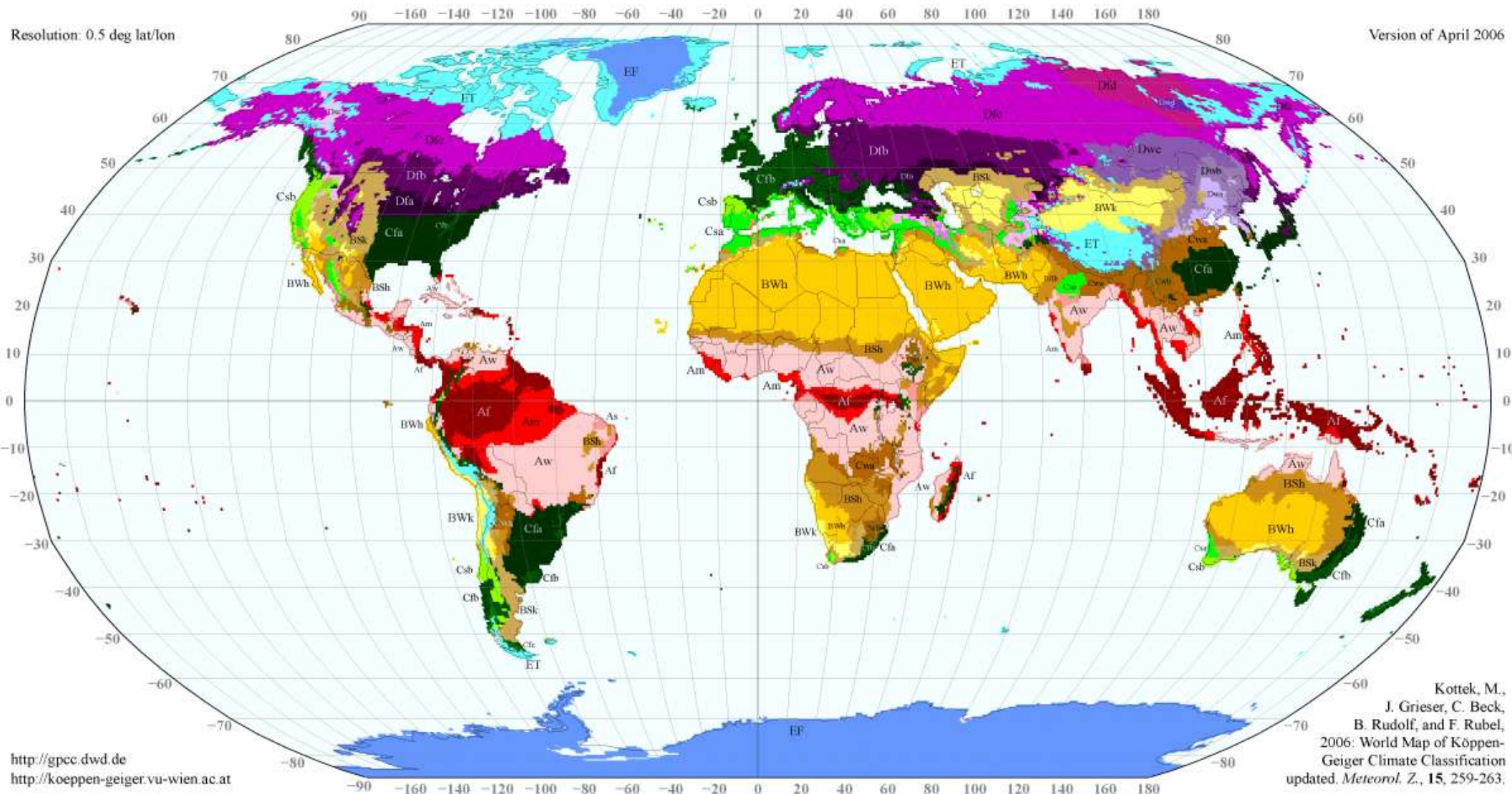
A: equatorial  
B: arid  
C: warm temperate  
D: snow  
E: polar

## Precipitation

W: desert  
S: steppe  
f: fully humid  
s: summer dry  
w: winter dry  
m: monsoonal

## Temperature

h: hot arid  
k: cold arid  
a: hot summer  
b: warm summer  
c: cool summer  
d: extremely continental  
F: polar frost  
T: polar tundra



<http://gpcc.dwd.de>  
<http://koeppen-geiger.vu-wien.ac.at>

Kottek, M.,  
J. Grieser, C. Beck,  
B. Rudolf, and F. Rubel,  
2006: World Map of Köppen-  
Geiger Climate Classification  
updated, *Meteorol. Z.*, 15, 259-263.

<http://koeppen-geiger.vu-wien.ac.at/>

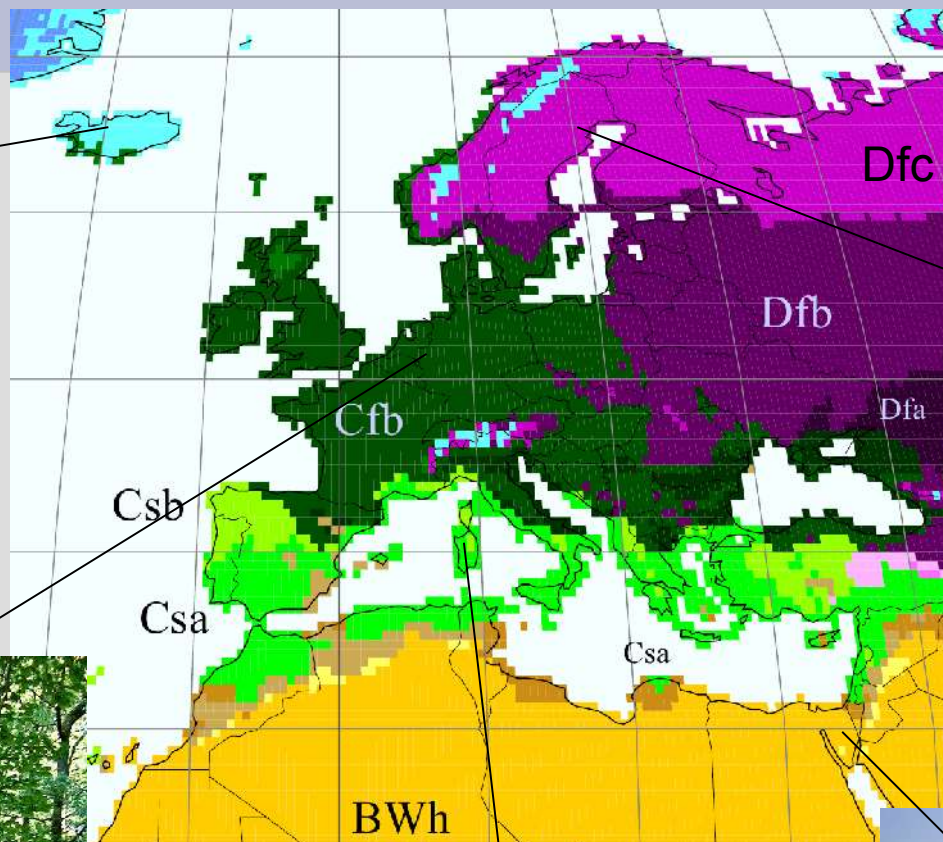


A: **equatorial**: all months above 18°C  
 B: **arid**  
 C: **warm temperate**: coldest month > -3°C  
 D: **snow**: coldest month < -3°, warmest > 10°C  
 E: **polar**: warmest month < 10°C

W: desert  
 S: steppe  
 f: fully humid  
 s: summer dry  
 w: winter dry

h: hot arid  
 k: cold arid  
 a: hot summer  
 b: warm summer  
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 T: polar tundra

ET: tundra



Dfc: boreal



Cfb



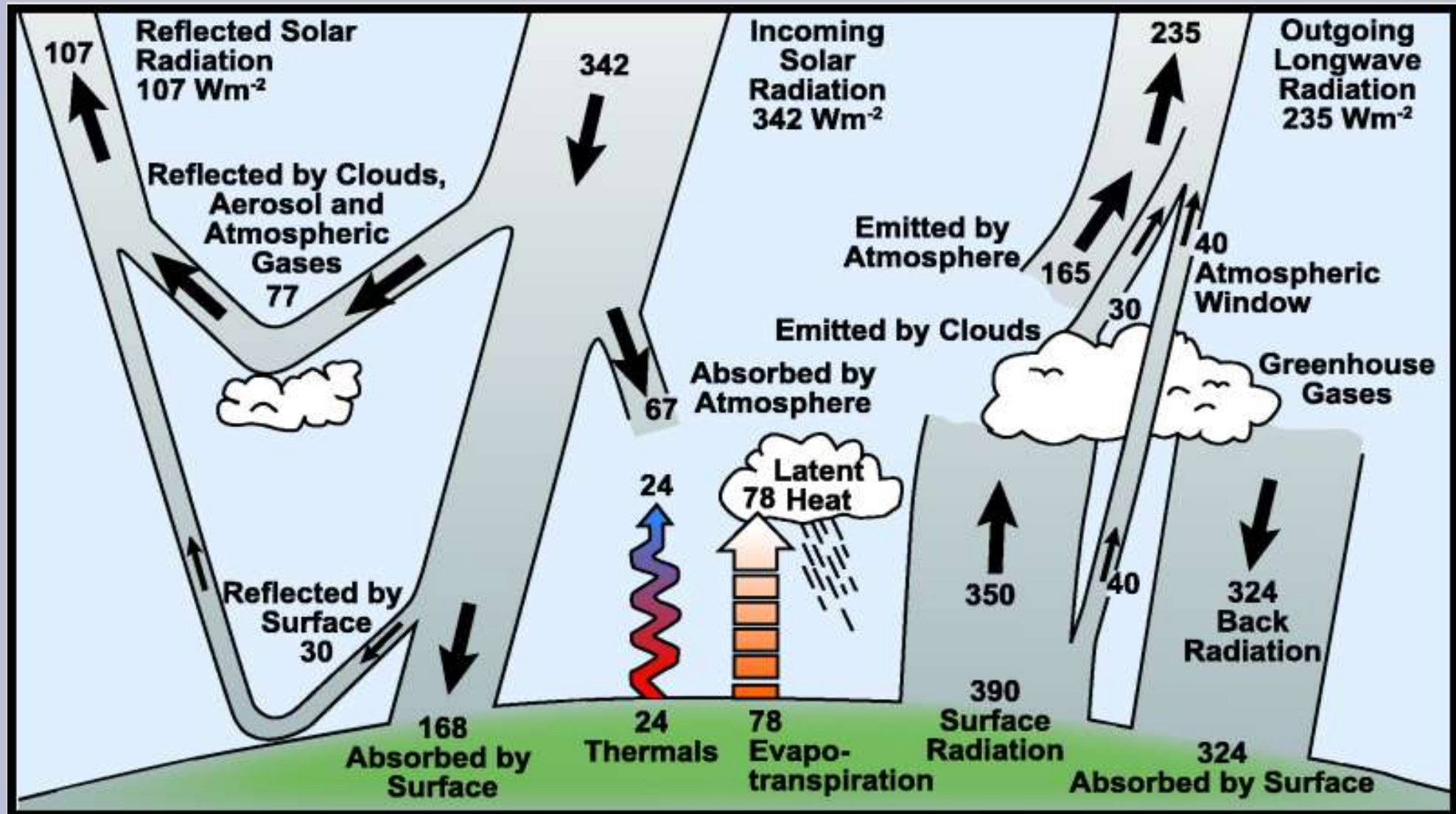
Csa: mediterranean



BWh: desert

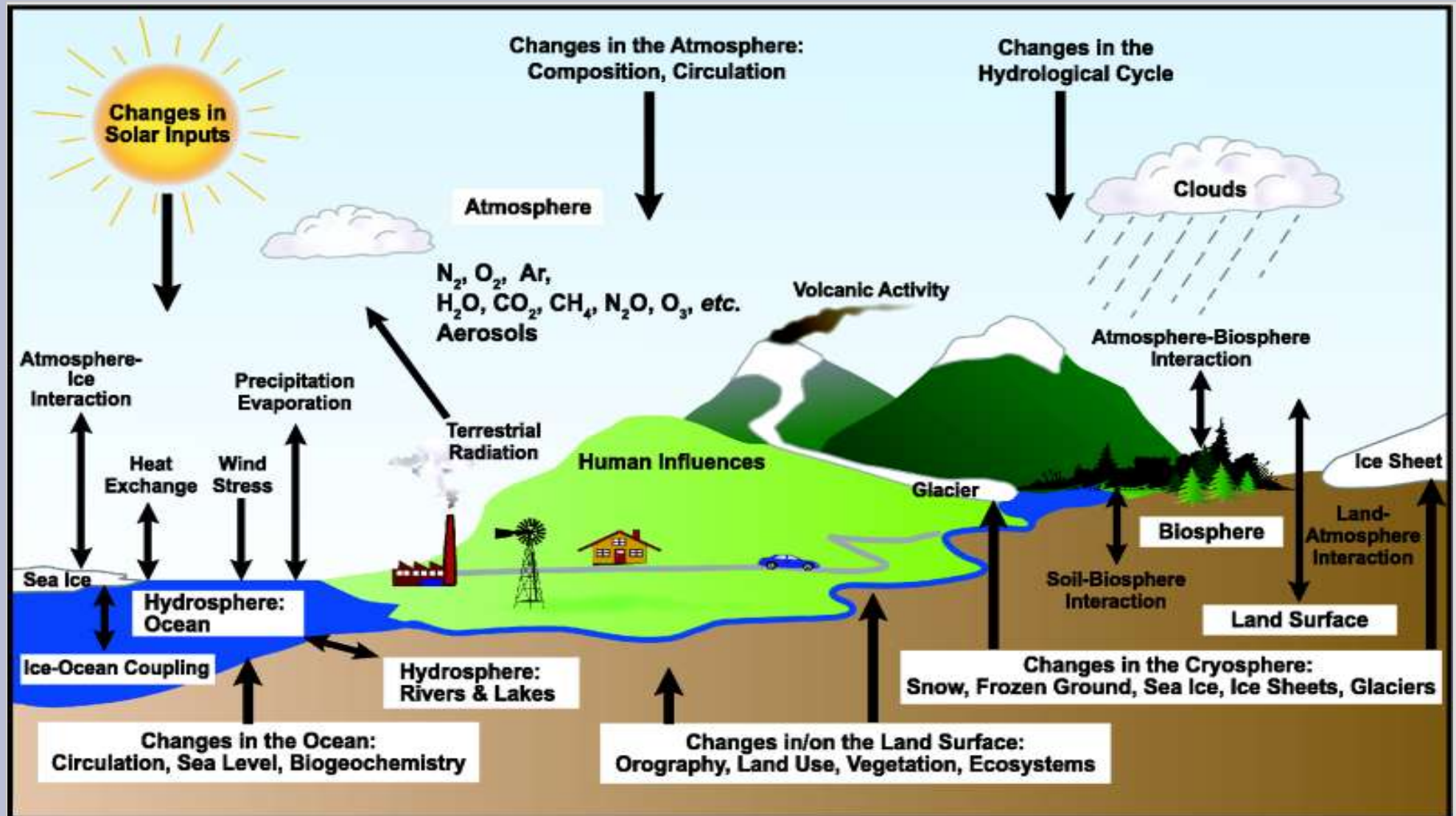


# Energy Balance in the Atmosphere





# Factors affecting climate





# Methods for Climate Reconstruction

- Can you think of a method to reconstruct the climate of the past?
- What is the temporal range? How far back in time does this method work?
- What are assumptions and uncertainties?



# Methods for Climate Reconstruction I

- Instrumental Records
  - Weather stations
  - Ship logs
- Historical Records
- Geomorphological and lithological evidence
  - glacial landforms
  - lake sediments
- Borehole temperature

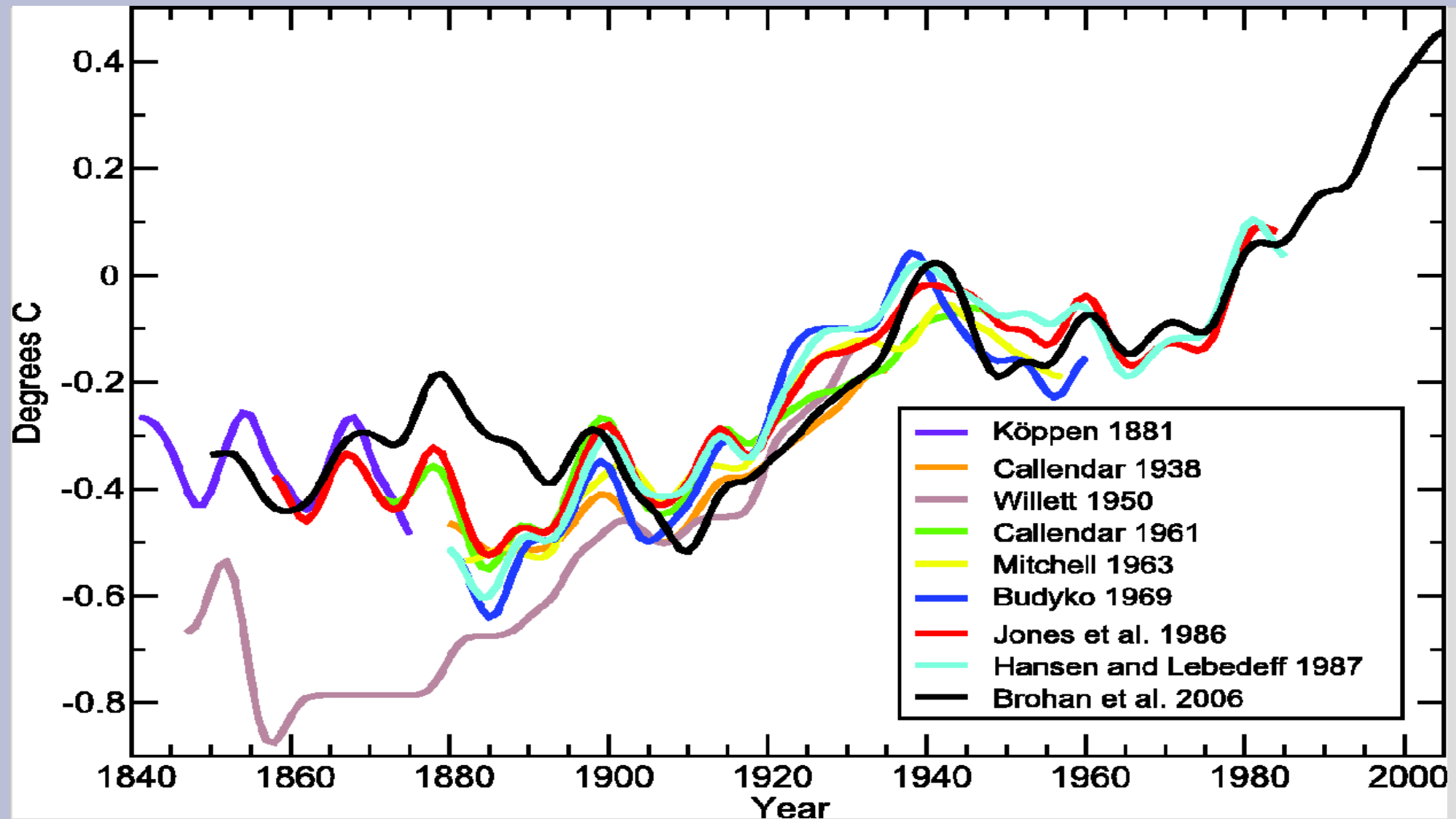


# Methods for Climate Reconstruction II

- Biological evidence
  - Tree rings
  - Pollen
  - Macrofossils (also rodents)
  - Insects (particularly in lake sediments)
  - Marine Plankton assemblages (diatoms, foraminifera)
- Geochemistry
  - Isotope methods (oxygen isotope)
  - from ice cores and (marine) sediment cores

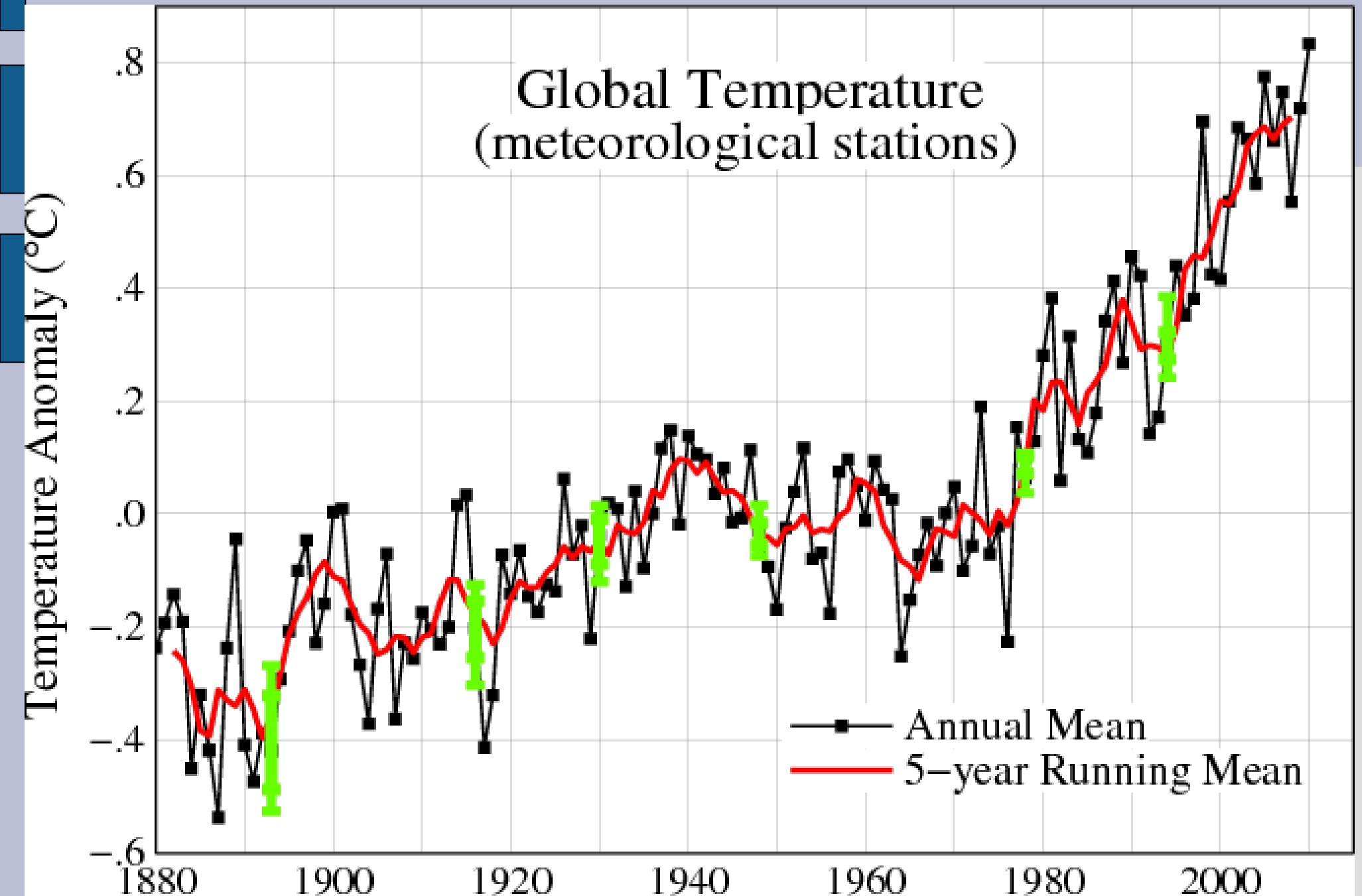


# Instrumental Records





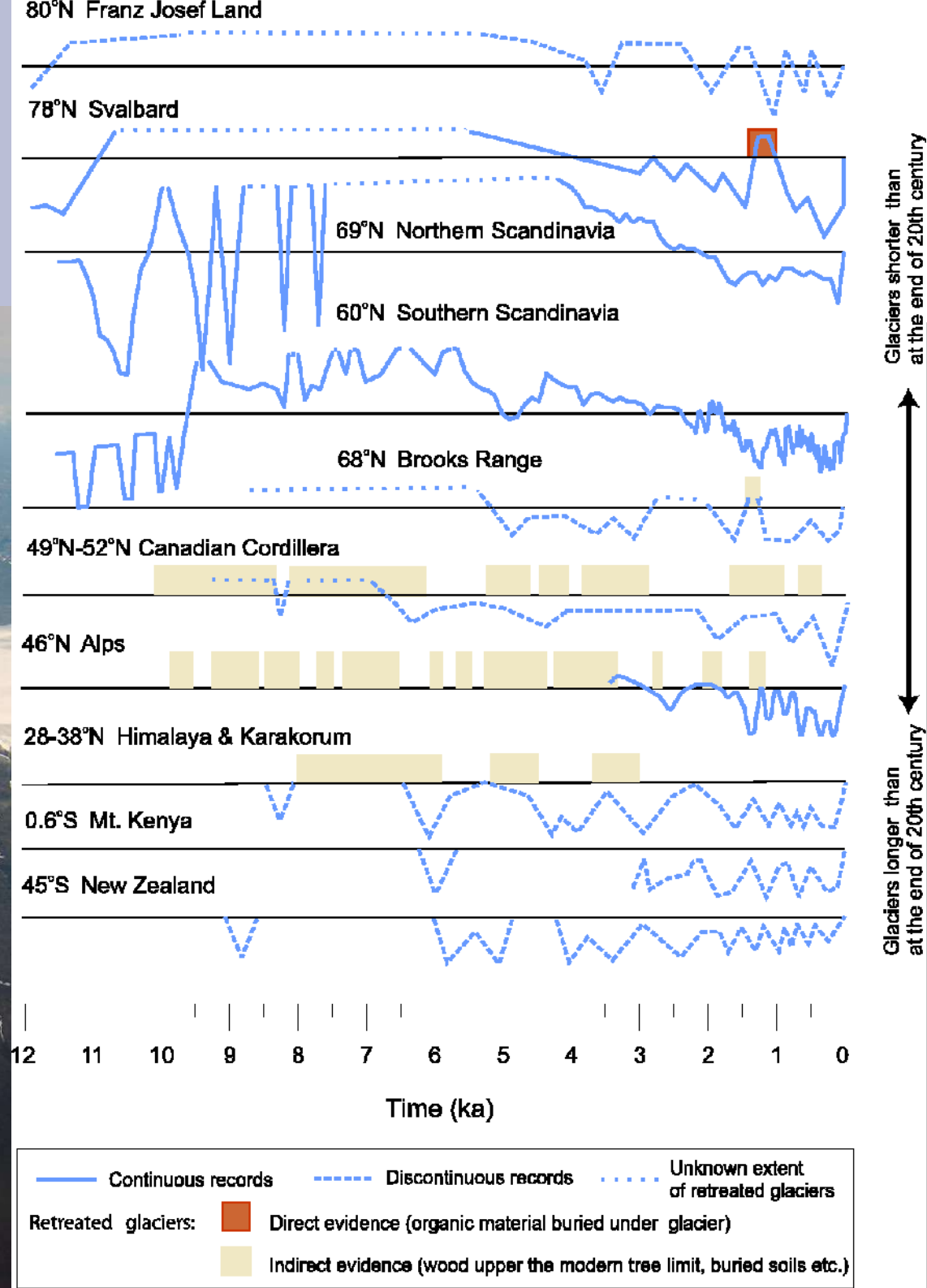
# Instrumental Records





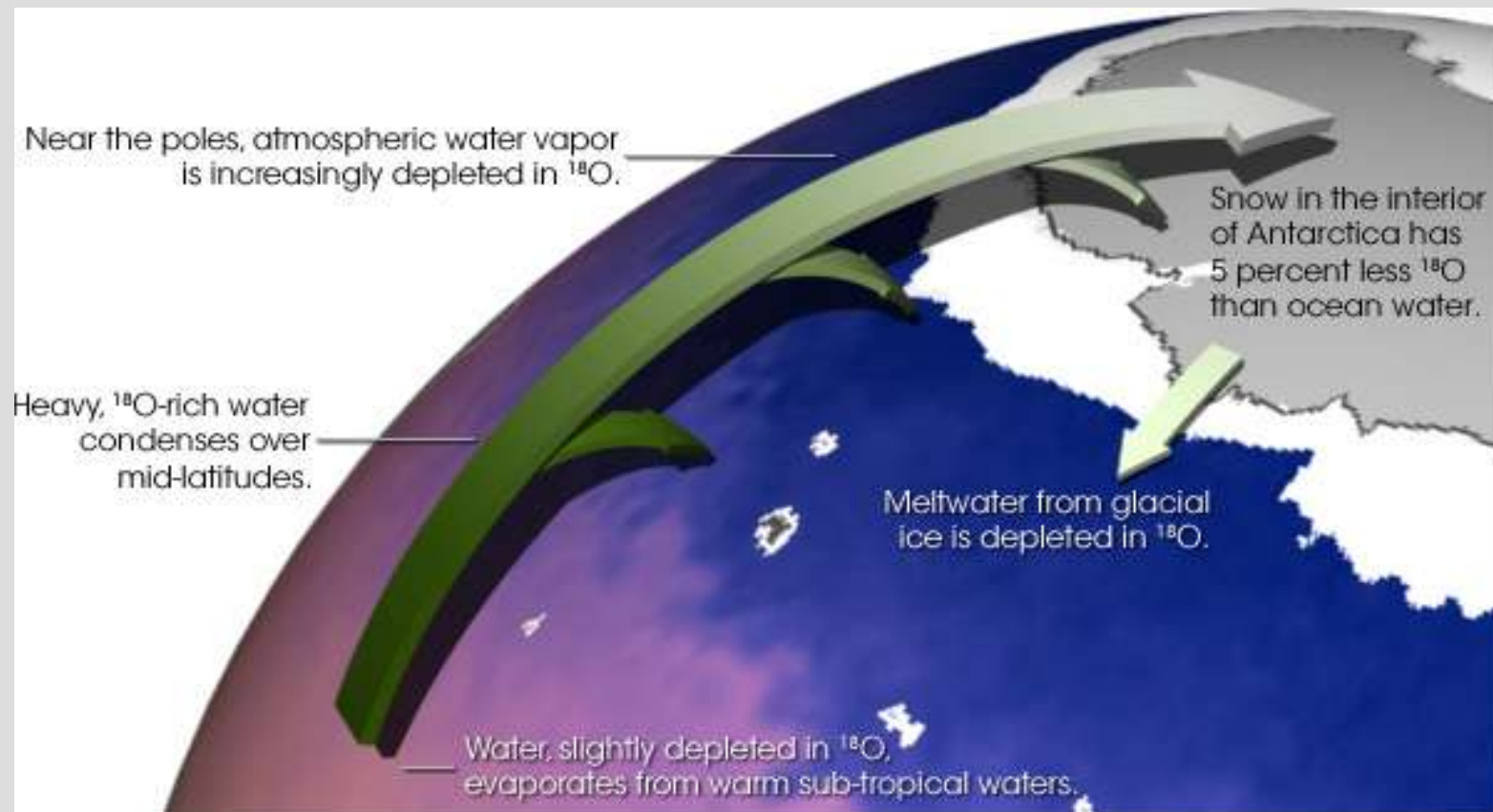


# Glaciers



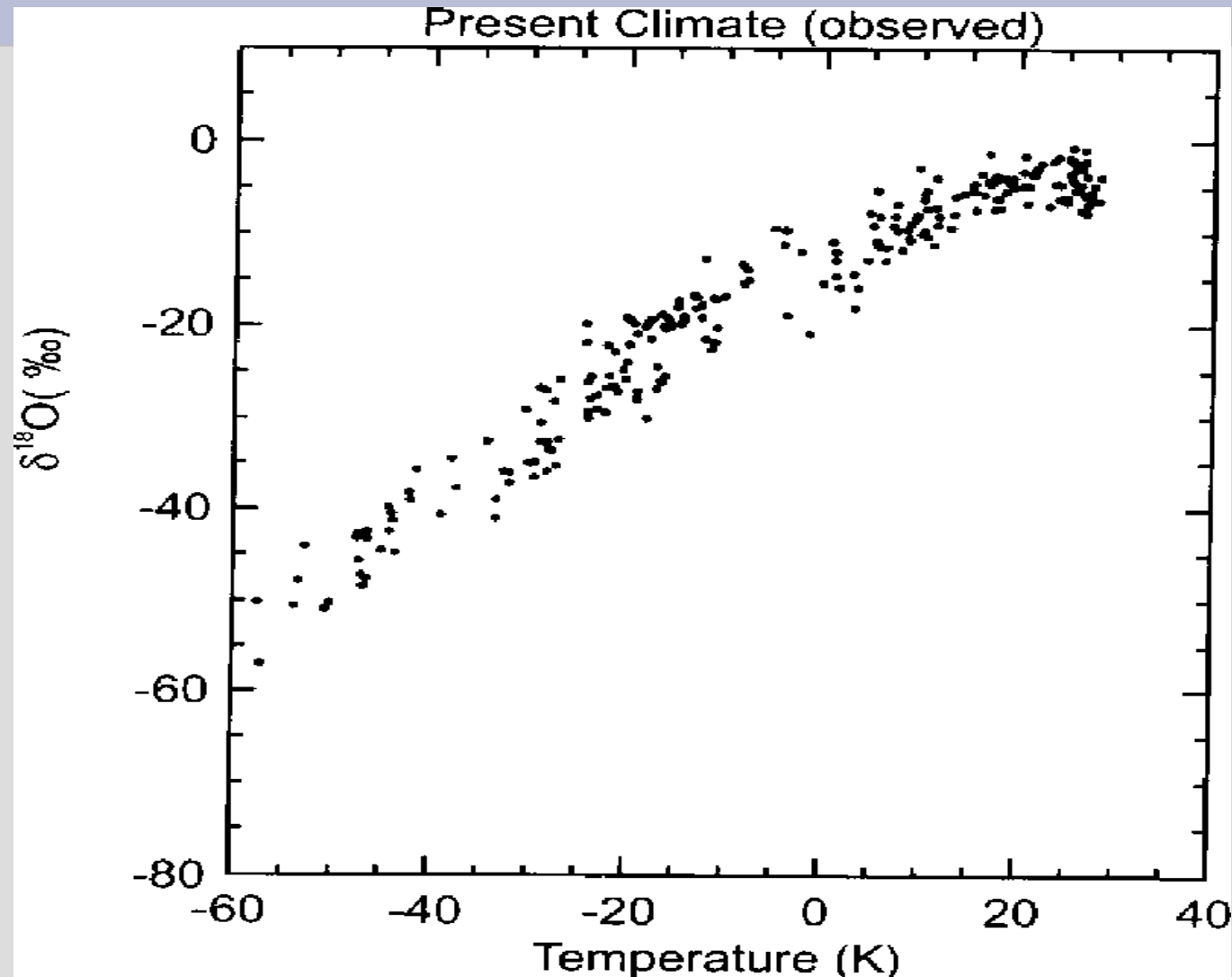
# Oxygen isotope method

- Fractionation (temperature dependent: more fractionation at lower temperatures)
- Isotopes bound in ice sheets change global distribution



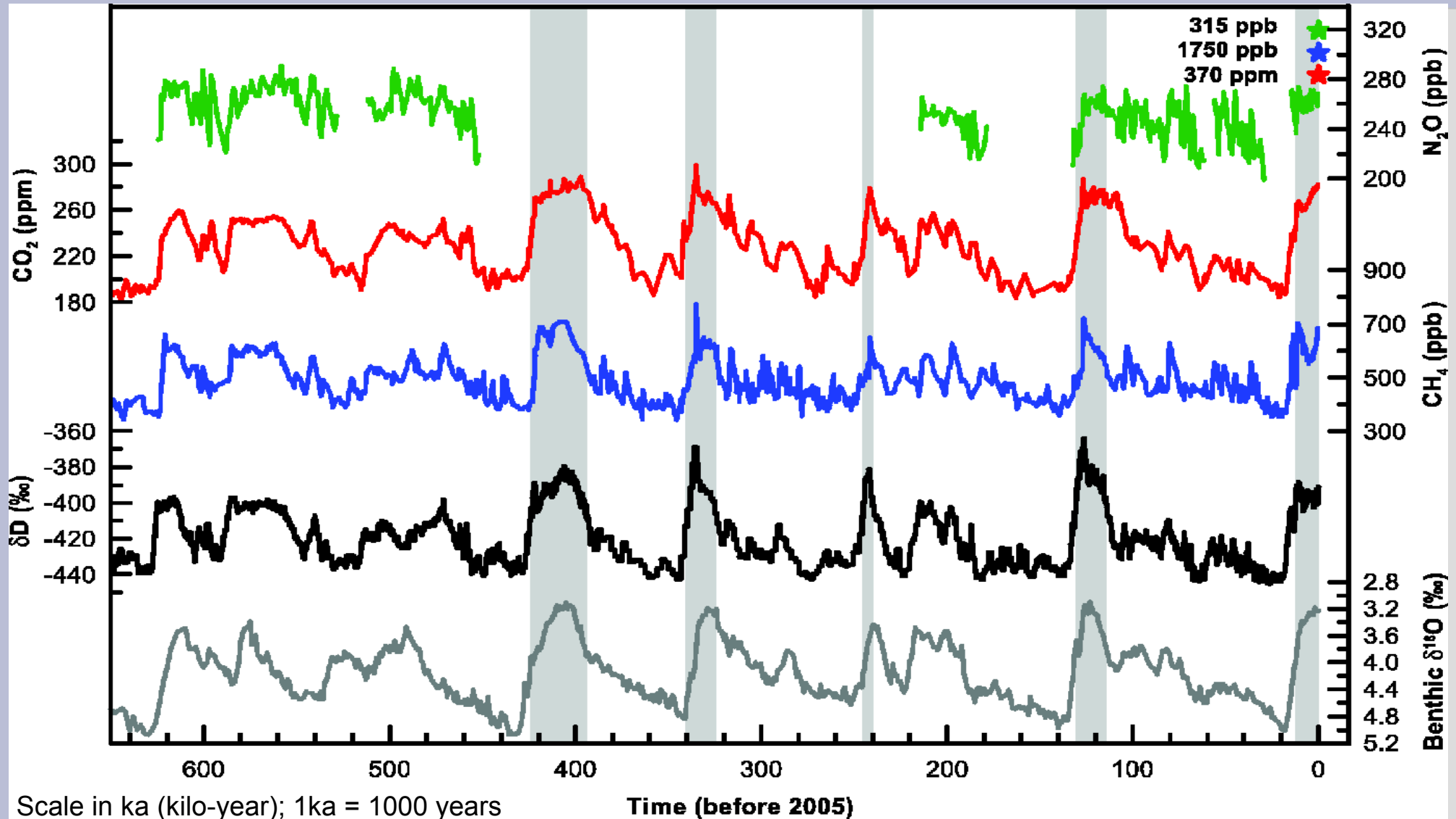


# Oxygen isotope method



Relation between oxygen isotope ratio in snow and mean annual temperature at the same site (from Bradley 1999, p. 134)

# Ice Cores

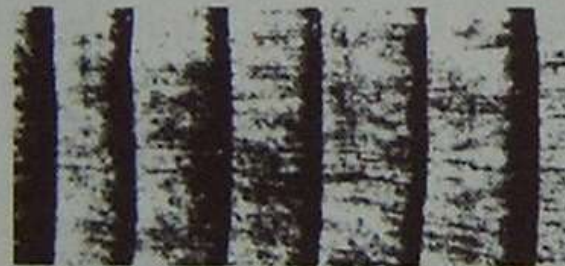




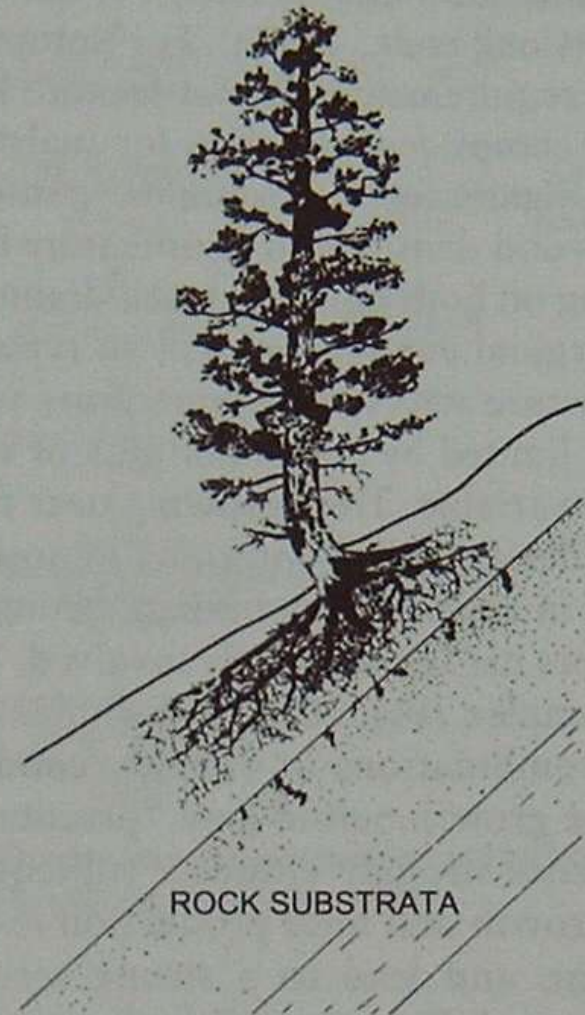
# Tree ring (Dendro- climatology)



WATER TABLE



Rings of uniform width provide little or no record of variations in climate.



ROCK SUBSTRATA



Rings of varying width provide a record of variations in climate.

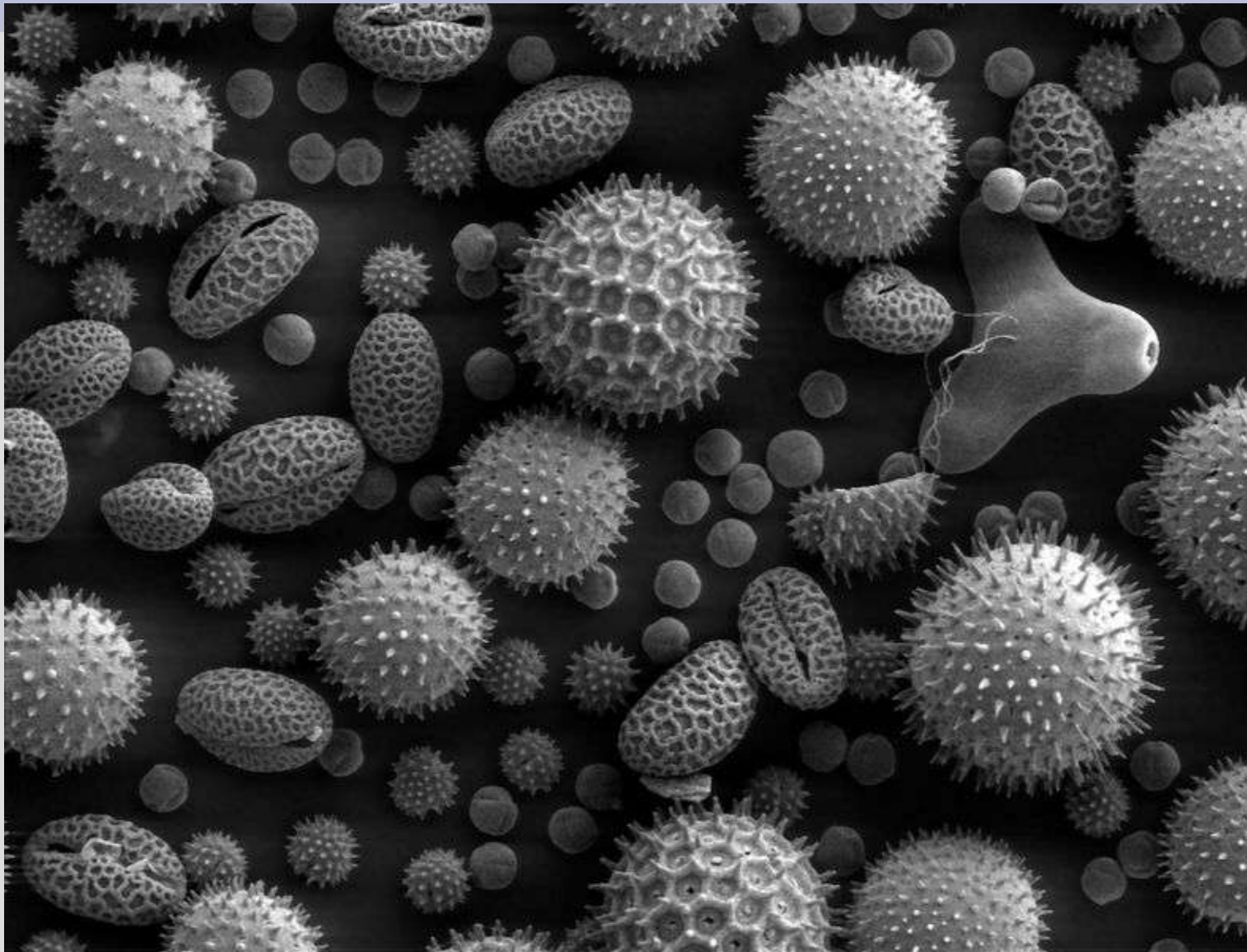
# Tree ring data (Dendroclimatology)

Confounding factors:

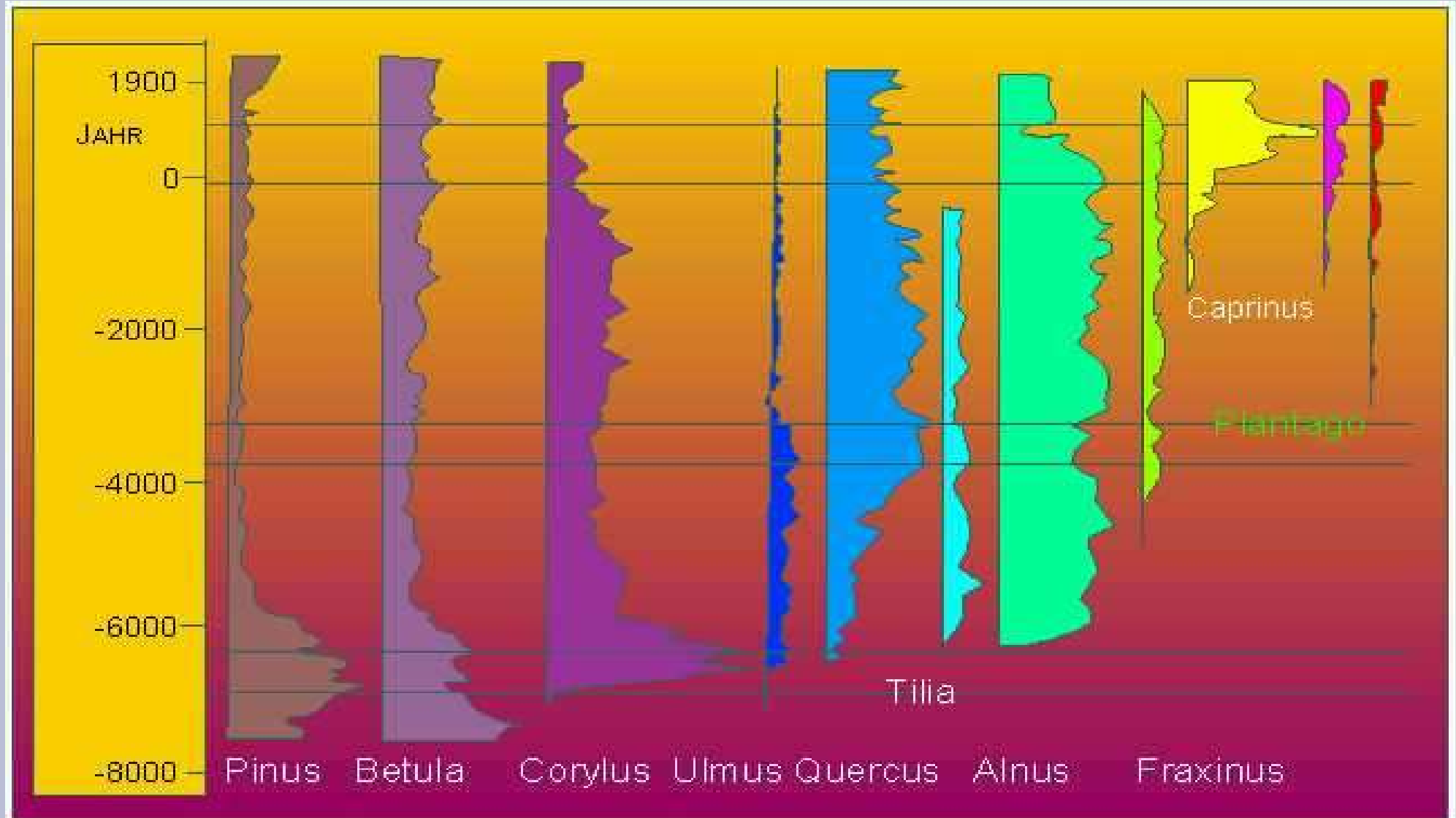
- Climate factors
  - Temperature
  - Precipitation
  - Sunlight
  - Wind
- Soil
- Tree age
- Disease, Disturbances, herbivore impact



# Palynology (pollen analysis)

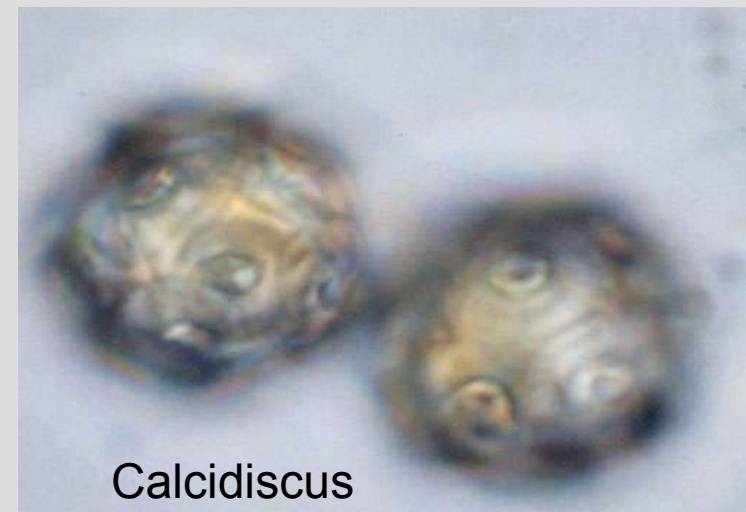
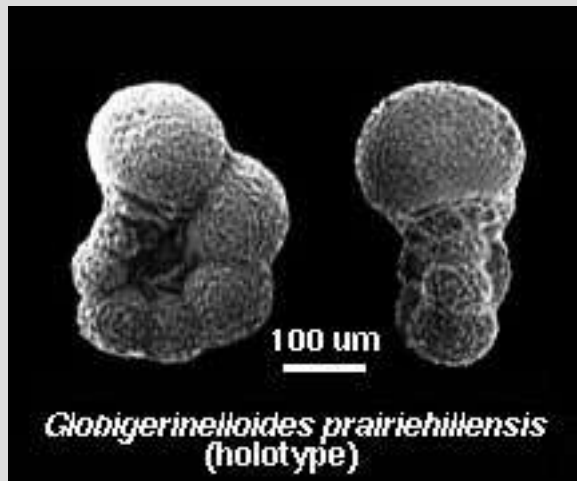
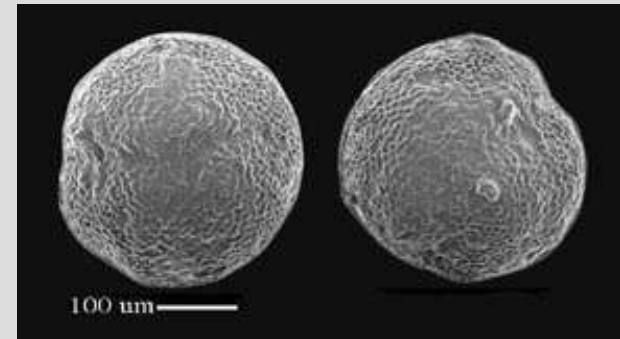


# Palynology (pollen analysis)

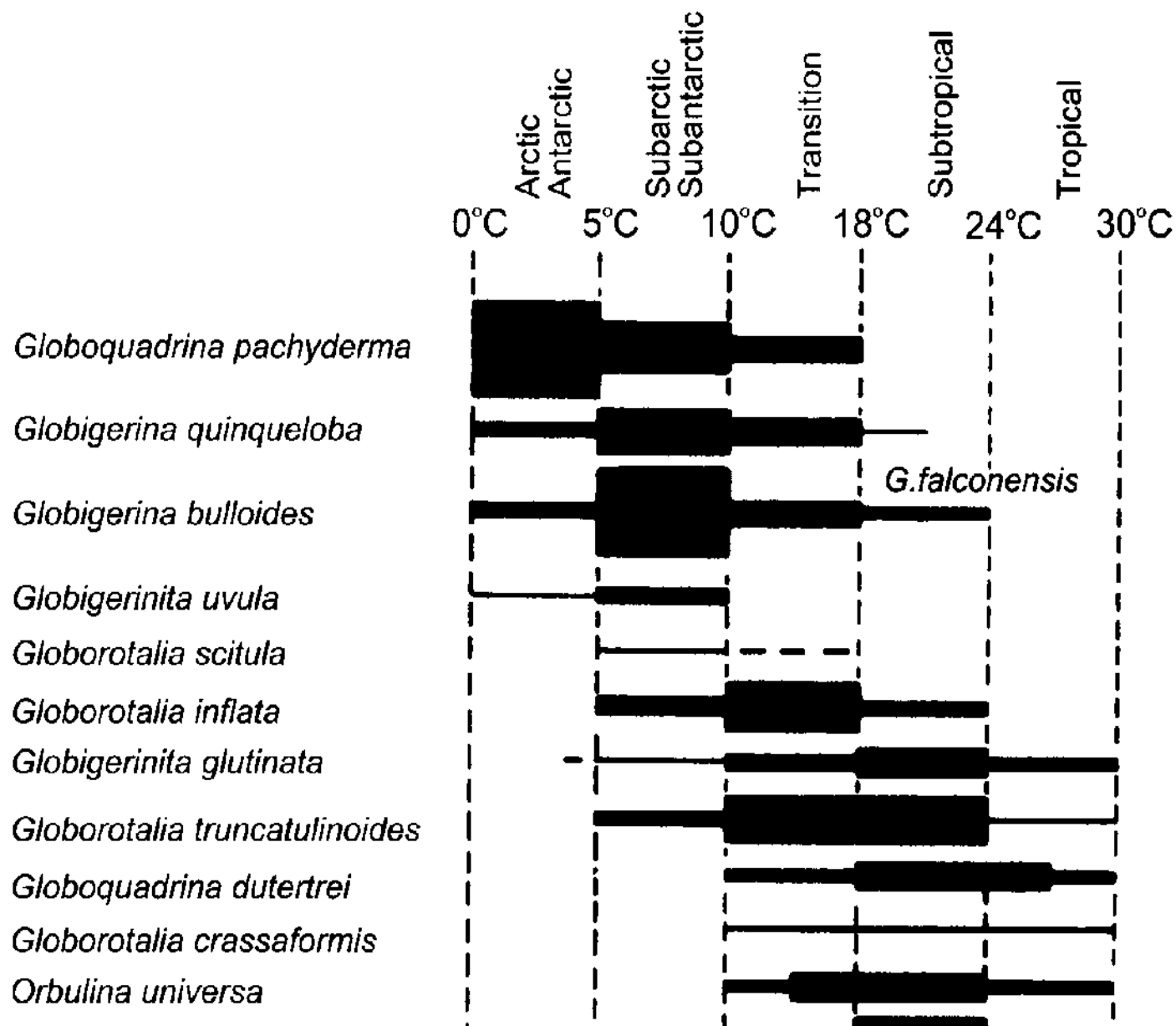




# Plankton faunal assemblages



# Plancton assemblages





# Ocean drilling



# Drilling for sediment cores





# Sediment cores



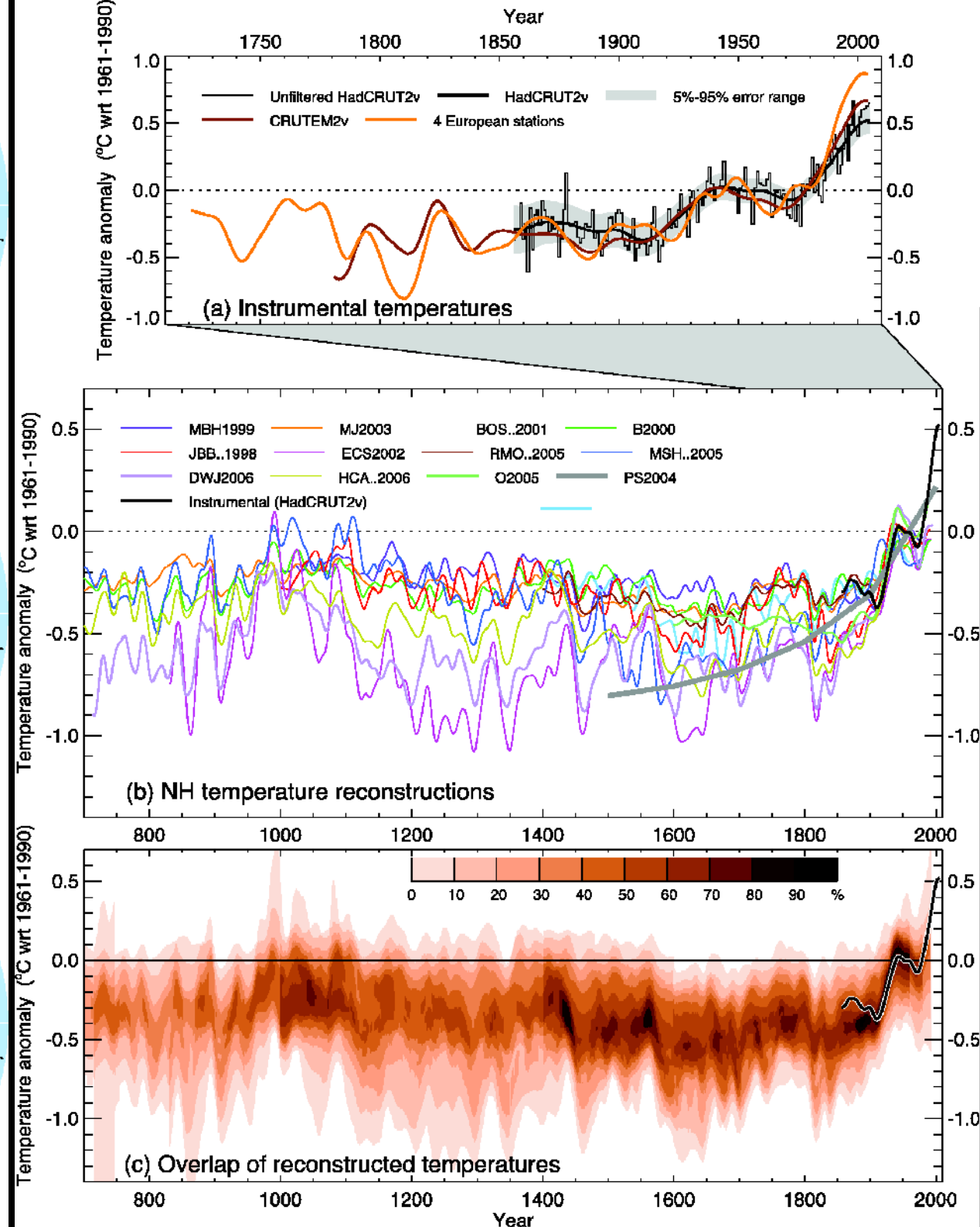
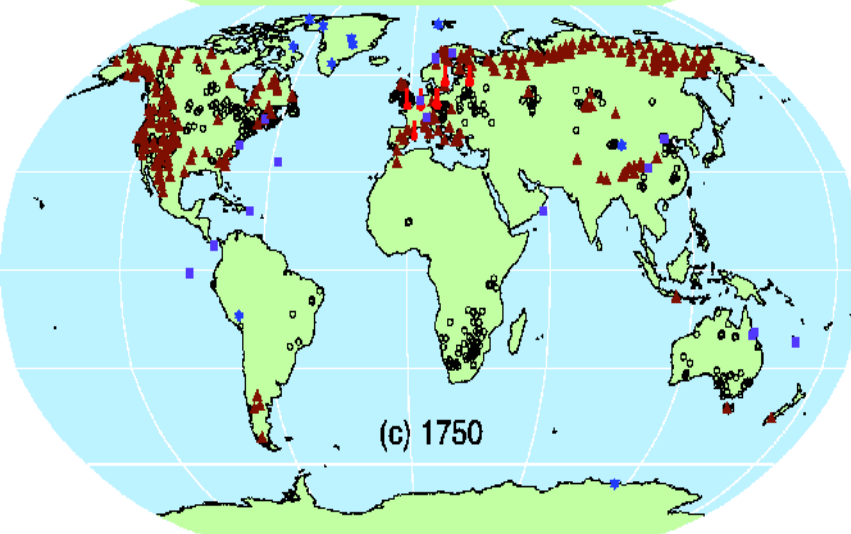
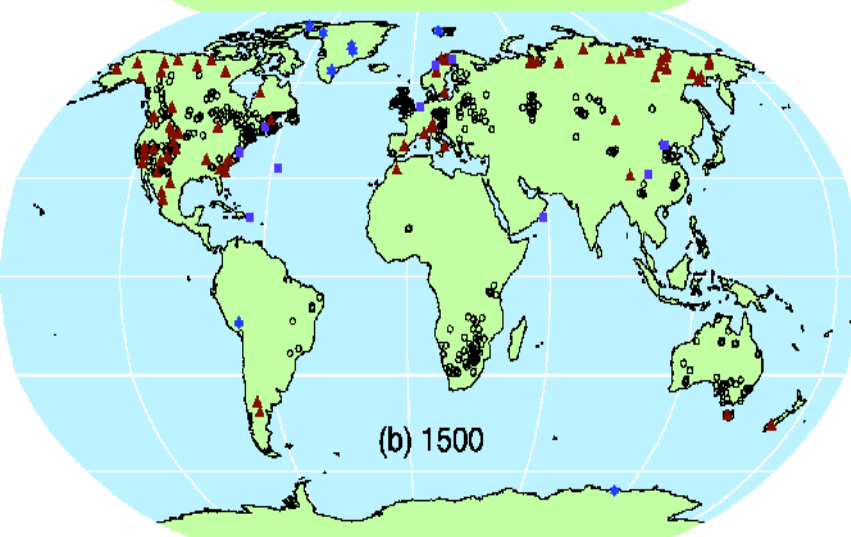
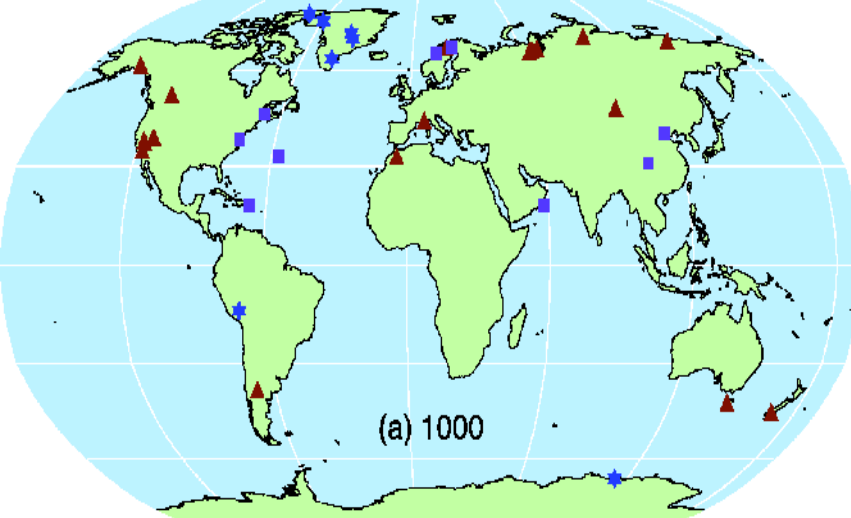
# Analysing the sediment core





# Climate Reconstruction

- 1000 years
- Multi-proxy:
  - Instrumental (red)
  - Tree rings (brown triangles)
  - Ice cores (blue stars)
  - Boreholes (black circles)
  - Other (purple squares)





# Literature

- IPCC (2007): Fourth Assessment Report. (available at <http://www.ipcc.ch/>)
- Bradley (1999): Paleoclimatology. Academic Press.
- Lowe, Walker (1997): Reconstructing Quaternary Environments. Longman.
- General reading on weather and climate: Eyewitness companion “Weather”, Dorling-Kindersley, 2008.