

# Climate System II

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[https://paleodyn.uni-bremen.de/study/climate2020\\_21.html](https://paleodyn.uni-bremen.de/study/climate2020_21.html)

**Time: Tuesday 10:00-11:45**

Sometimes shorter, but with some exercises

# Climate System II

Today, November 3, 2020

- Goal and overview (45 min)
- Formalities (20 min)  
([https://paleodyn.uni-bremen.de/study/climate2020\\_21.html](https://paleodyn.uni-bremen.de/study/climate2020_21.html))
- Expectations and wishes from your side (20 min)

# Climate Trends at different Timescales

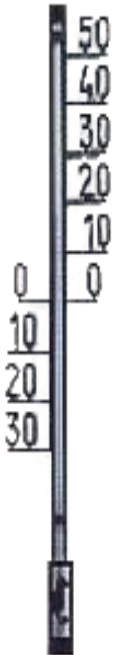
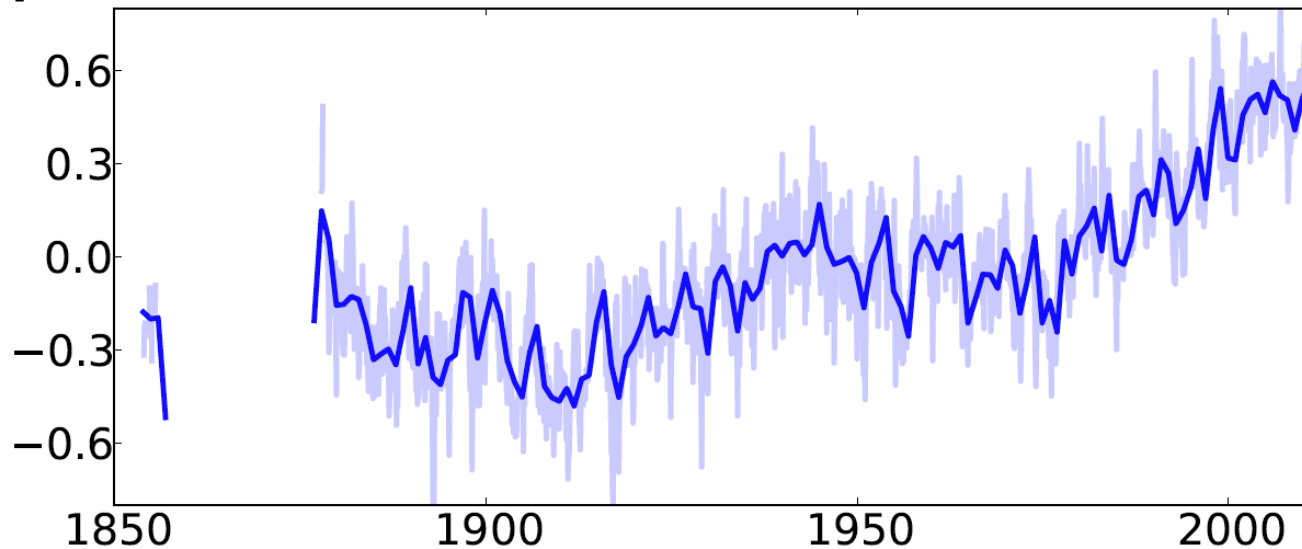
Temperature of the last **150 years** (instrumental data)

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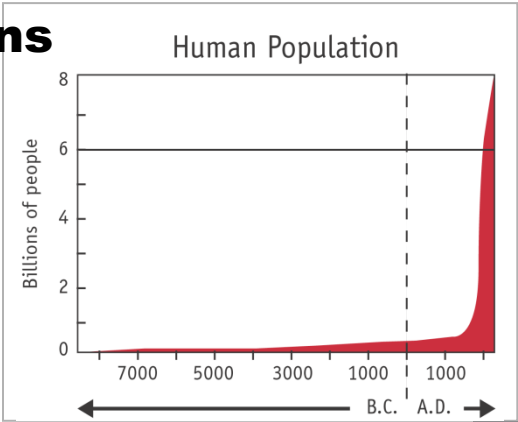
## Northern Hemisphere Temp. anomaly

HadCRU

[°C]



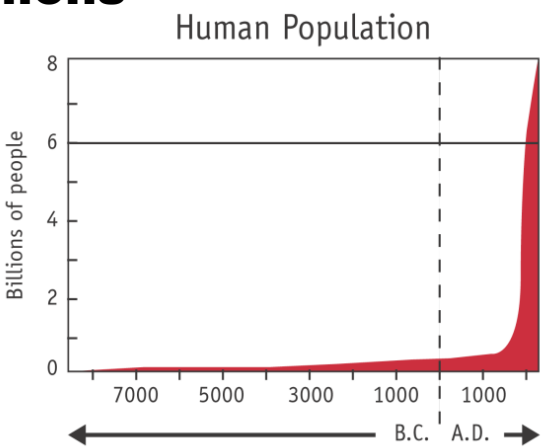
# Human Population: 7 billions



**The Challenge: Sustainable Management and Energy**



# Human Population: 7 billions

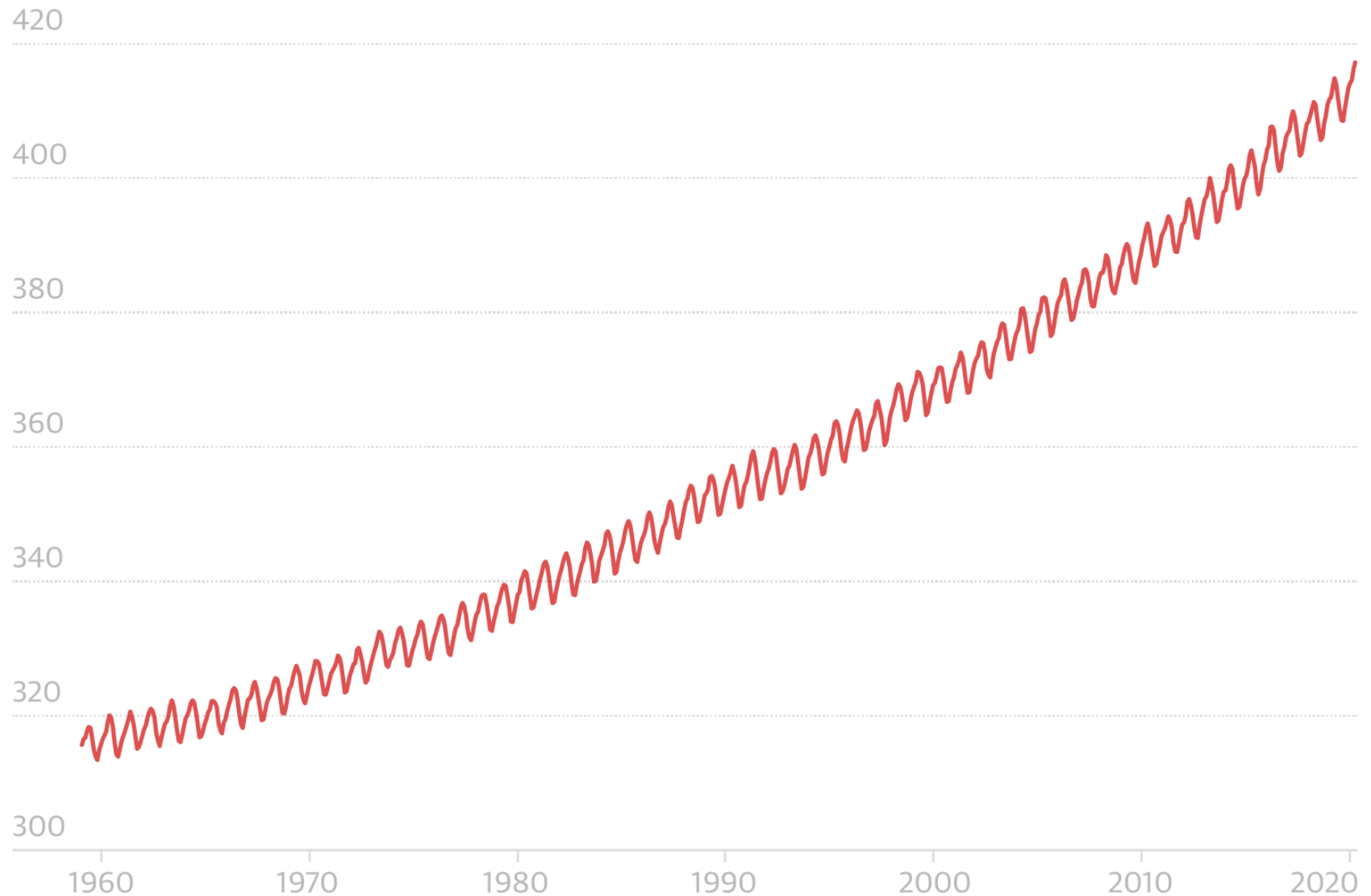


**CO<sub>2</sub> Increase:**  
**Land cover: 22%**  
**CO<sub>2</sub>-Emissions: 78%**



# Atmospheric CO2 has reached the highest level on record

Atmospheric CO2 concentration (parts per million)



Guardian graphic. Source: Scripps Institution of Oceanography, NOAA

# Atmospheric CO2 has reached the highest level on record

Atmospheric CO2 concentration (parts per million)

420

Without worldwide lockdowns intended to slow the spread of Covid-19, the rise might have reached +2.8ppm

400

380

360

340

320

300

1960

1970

1980

1990

2000

2010

2020

Reduction in emissions for 2020 is only between 4-7% compared with 2019. That will make no appreciable difference to the [world's ability to meet the goals of the Paris agreement](#), keeping the global warming below the threshold of 2°C.



Data: CDIAC/GCP/IPCC/Fuss et al 2014

Emissions from fossil fuels  
and cement (GtCO<sub>2</sub>/yr)

Scenario categories

>1000 ppm CO<sub>2</sub>eq

720–1000 ppm

580–720 ppm

480–580 ppm

430–480 ppm

2016 Estimate

Historical emissions

net-negative global emissions

**RCP8.5**  
3.2–5.4°C  
relative to 1850–1900

**RCP6**  
2.0–3.7°C

**RCP4.5**  
1.7–3.2°C

**RCP2.6**  
0.9–2.3°C

100

80

60

40

20

0

-20

1980

2000

2020

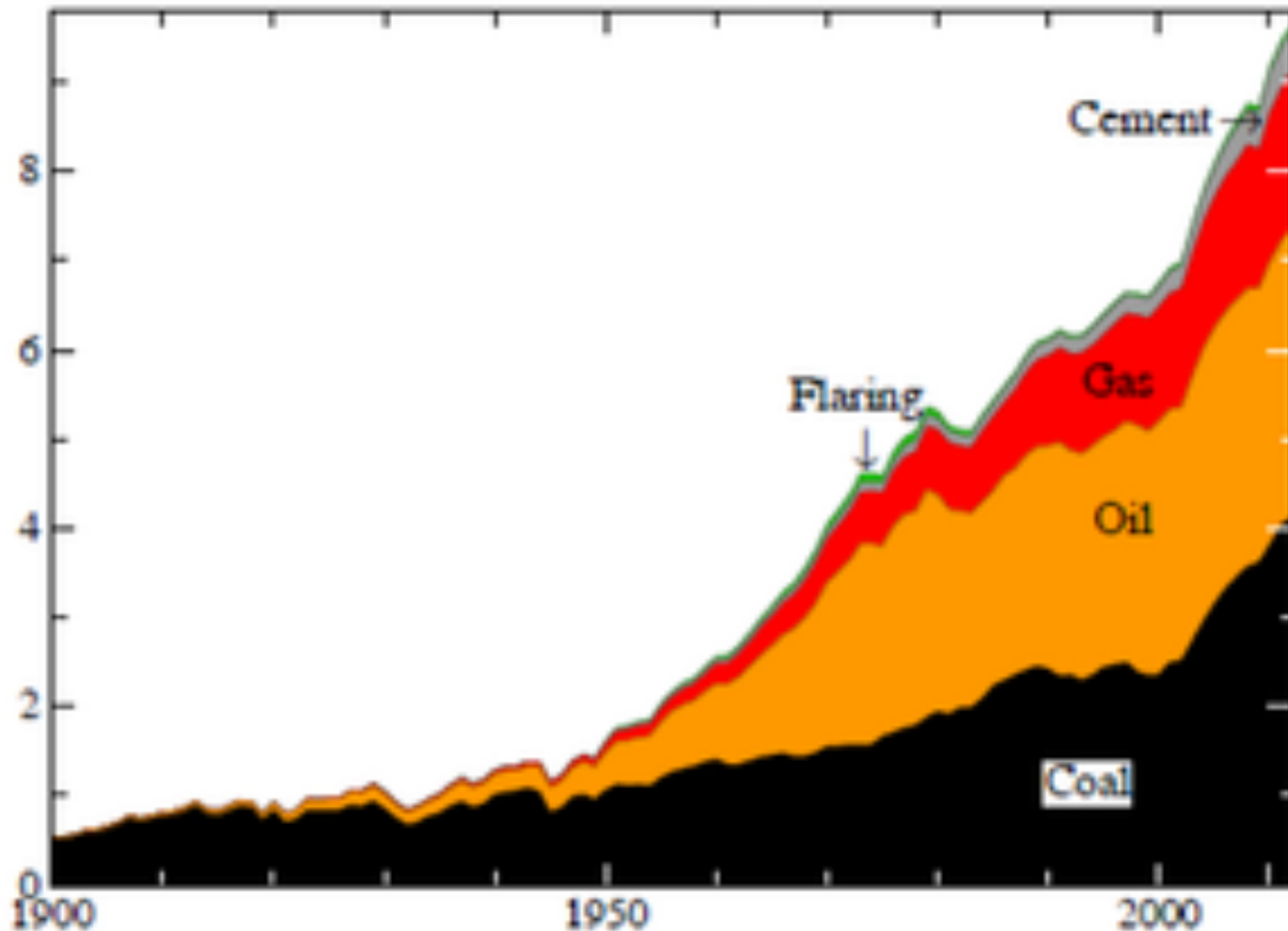
2040

2060

2080

2100

# Global Fossil-Fuel CO<sub>2</sub> annual emissions (Gt C/year)



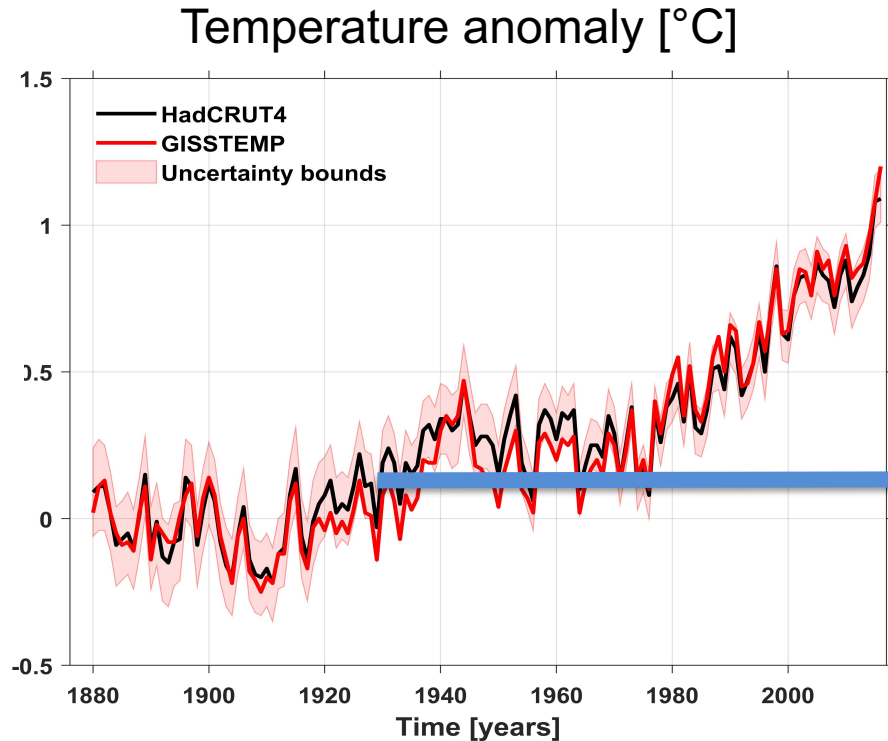
Hansen J, Kharecha P, Sato M, Masson-Delmotte V, Ackerman F, et al. (2013) Assessing “Dangerous Climate Change”: Required Reduction of Carbon Emissions to Protect Young People, Future Generations and Nature. PLOS ONE 8(12): e81648.

<https://doi.org/10.1371/journal.pone.0081648>

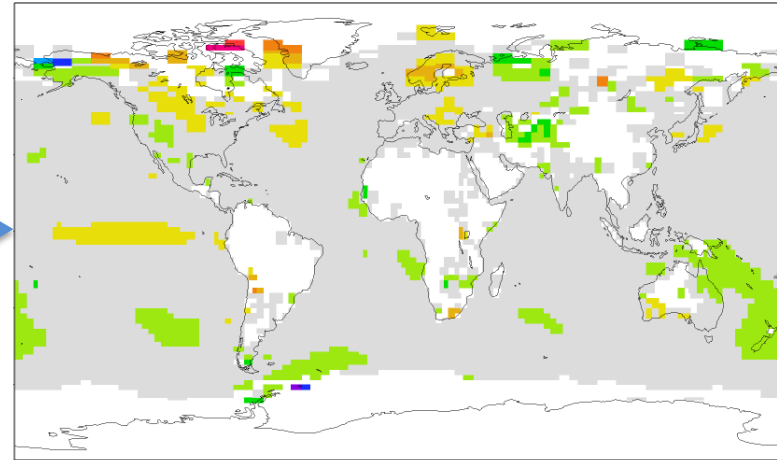
<https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0081648>



# Motivation: Observational Record

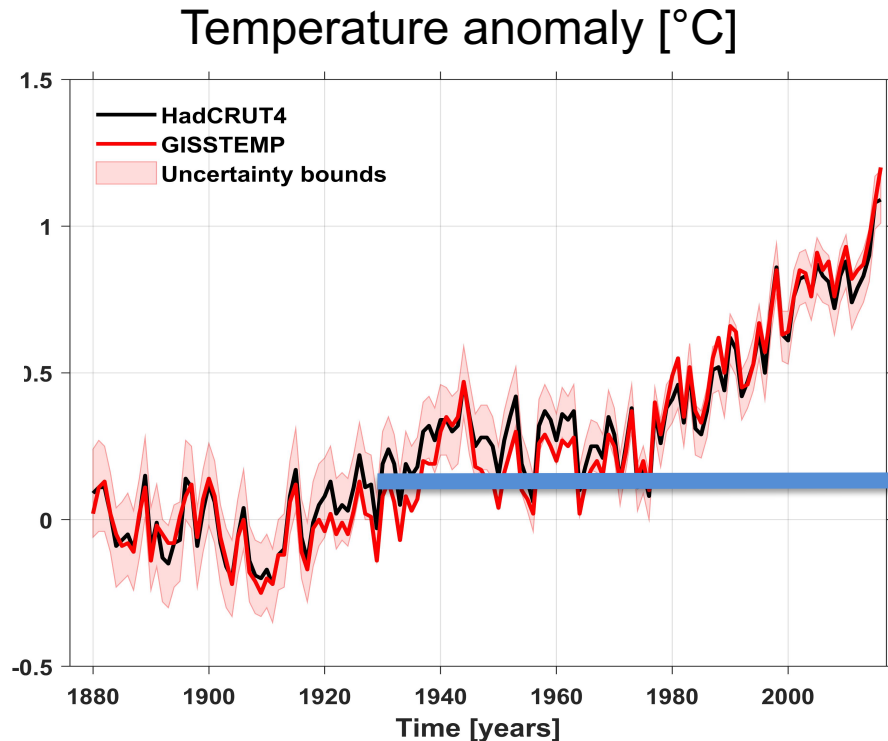


Uncertainty largely due to missing information at high latitudes

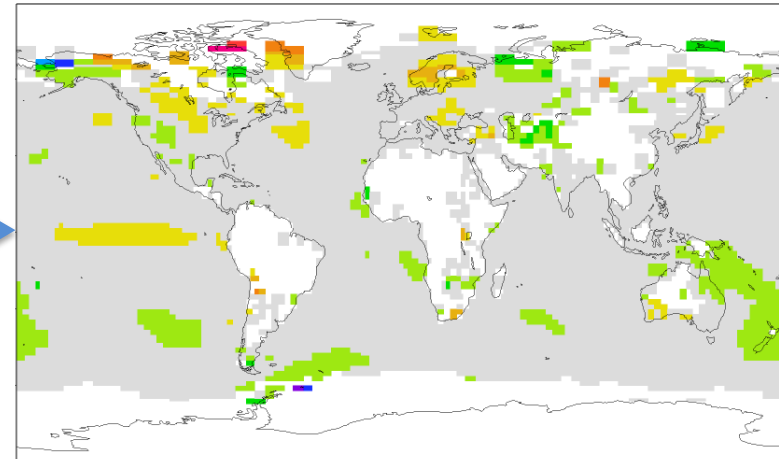


Temperature Anomaly 1930  
White areas: not enough data

# Motivation: Observational Record

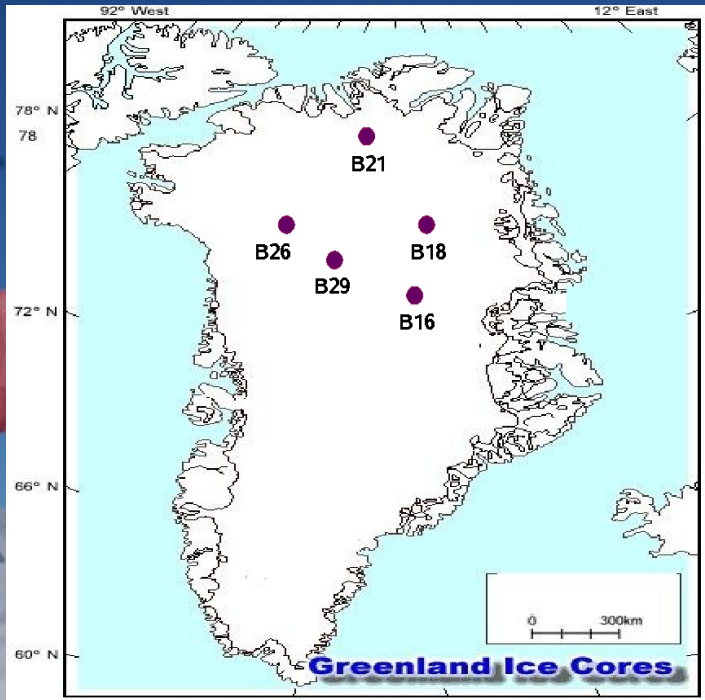


Uncertainty largely due to missing information at high latitudes

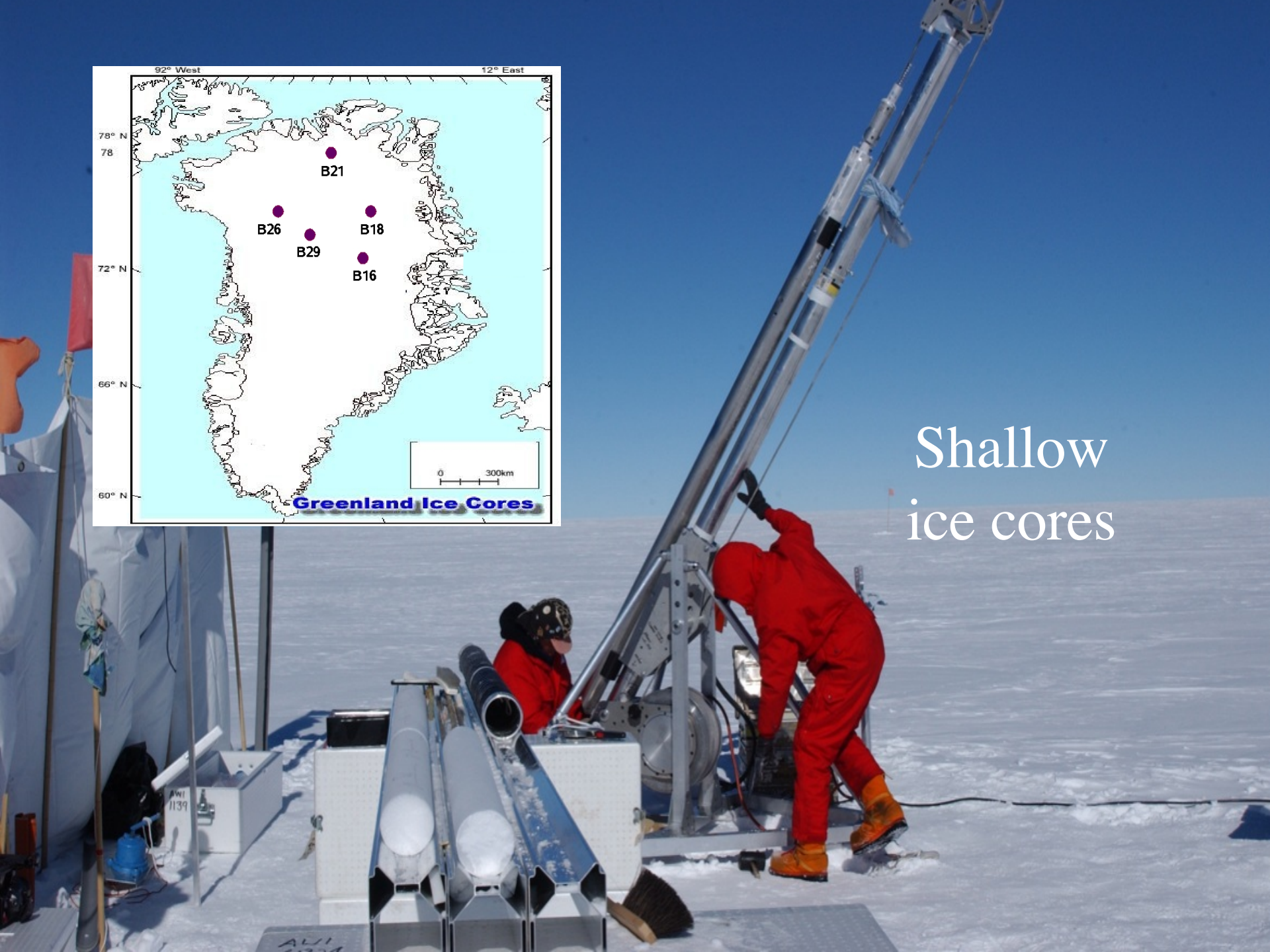


Temperature Anomaly 1930  
White areas: not enough data

**Climate variability beyond the instrumental record:  
Decadal, centennial, millennial**

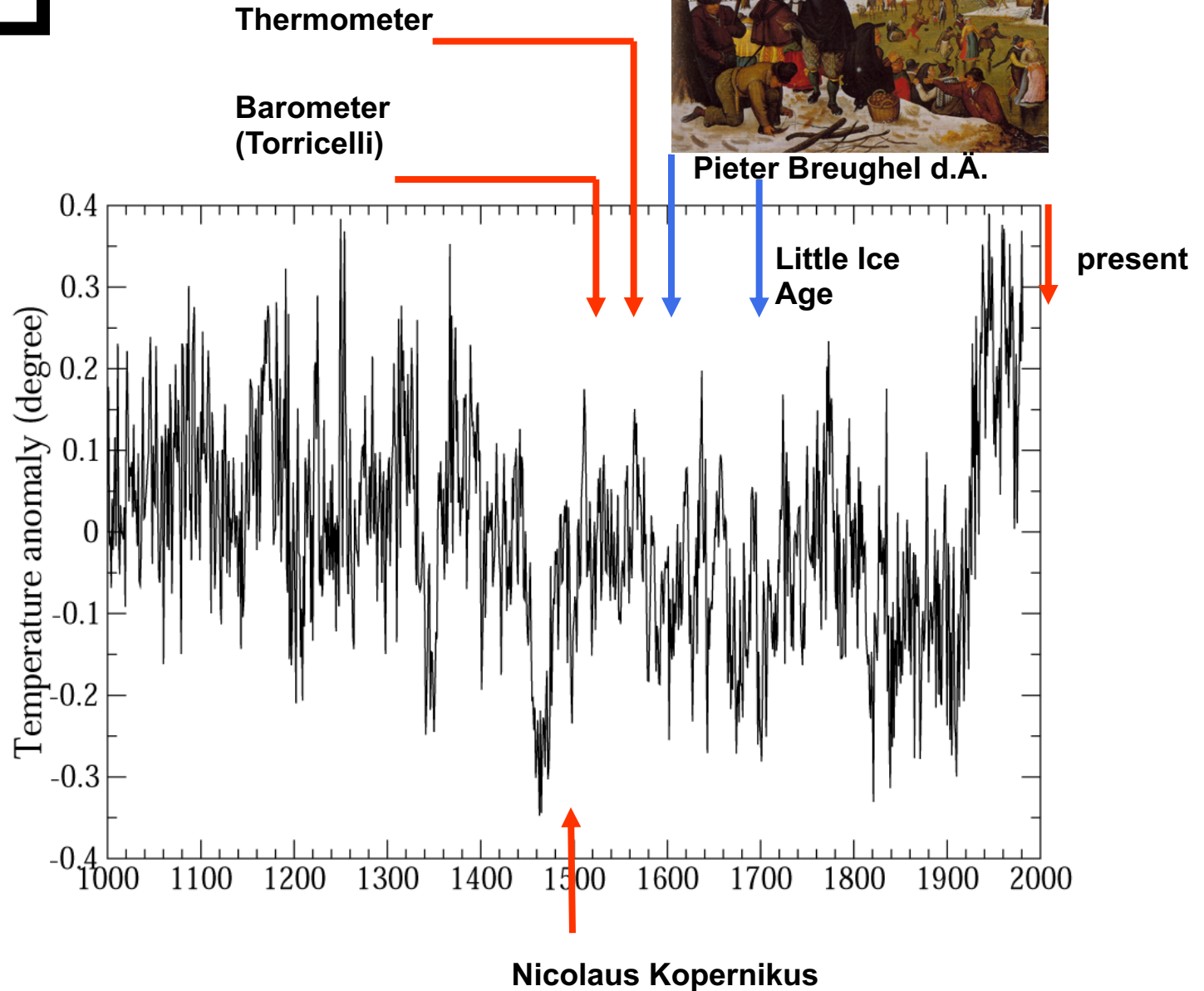


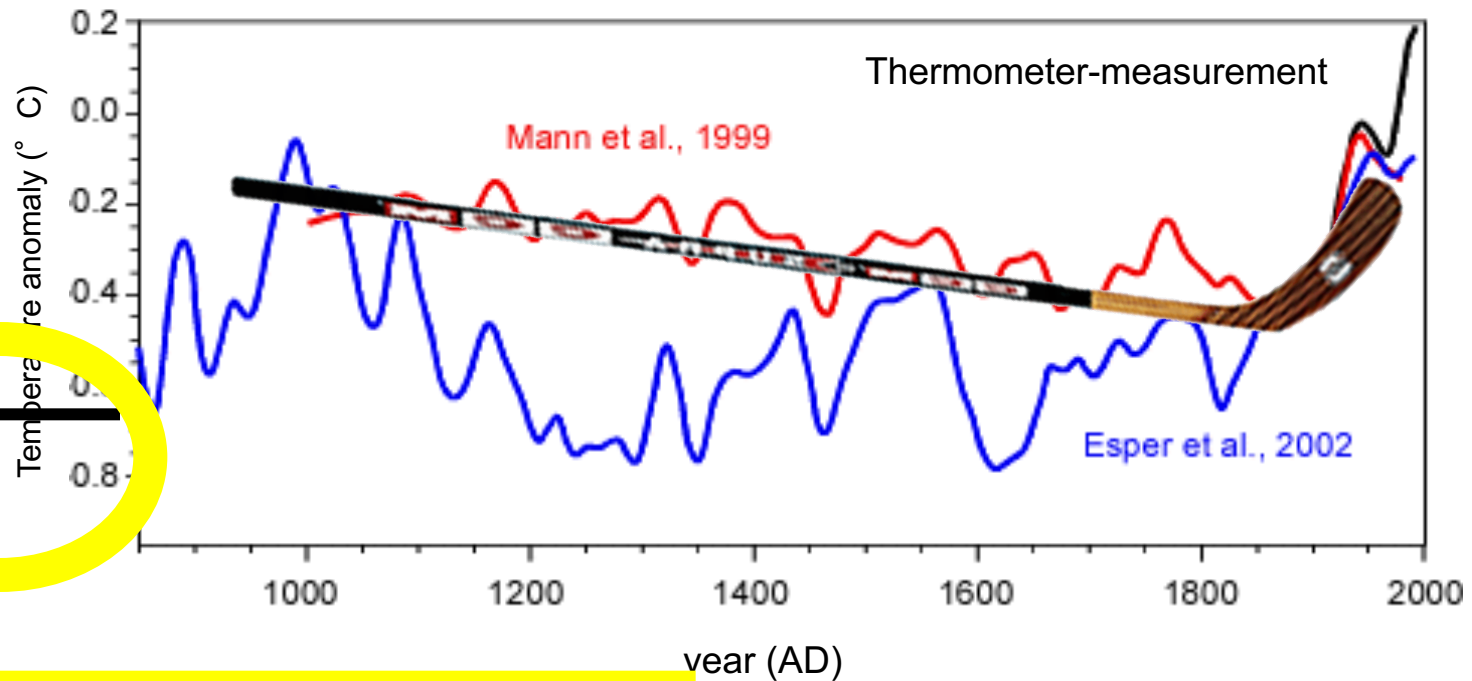
Shallow  
ice cores



# History

last 1000 Years





Further back in time?



# Proxy Data

- Indirect data, often qualitative
- Long time series from archives
- Information beyond the instrumental record



# Earth System: a polar perspective



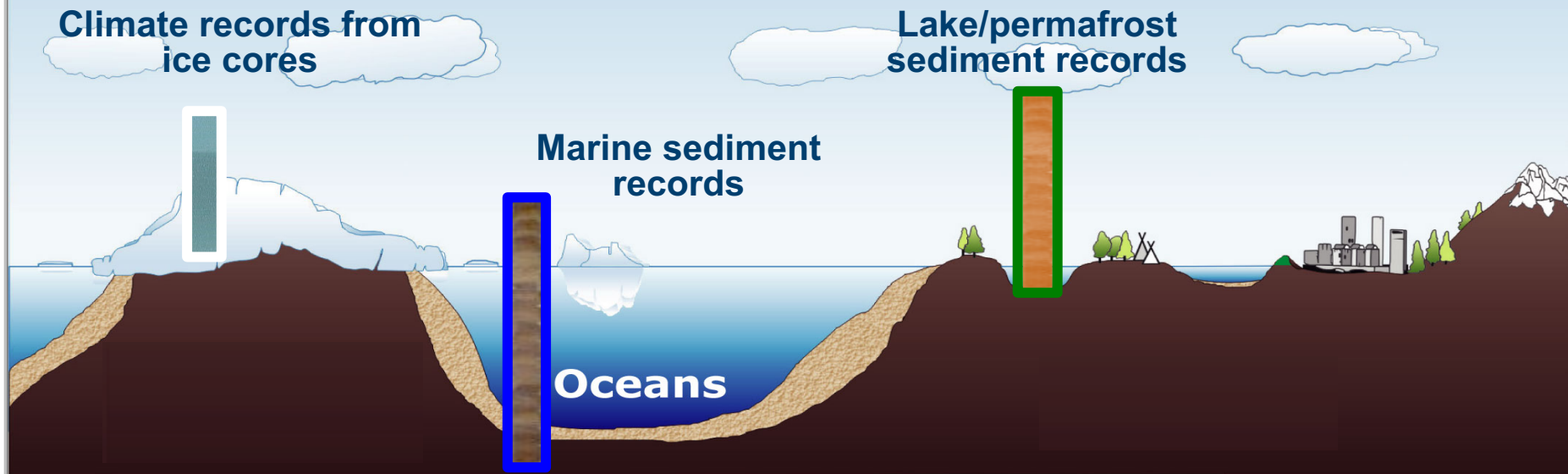
Ice drilling camp, 2009



Polarstern, marine sediments



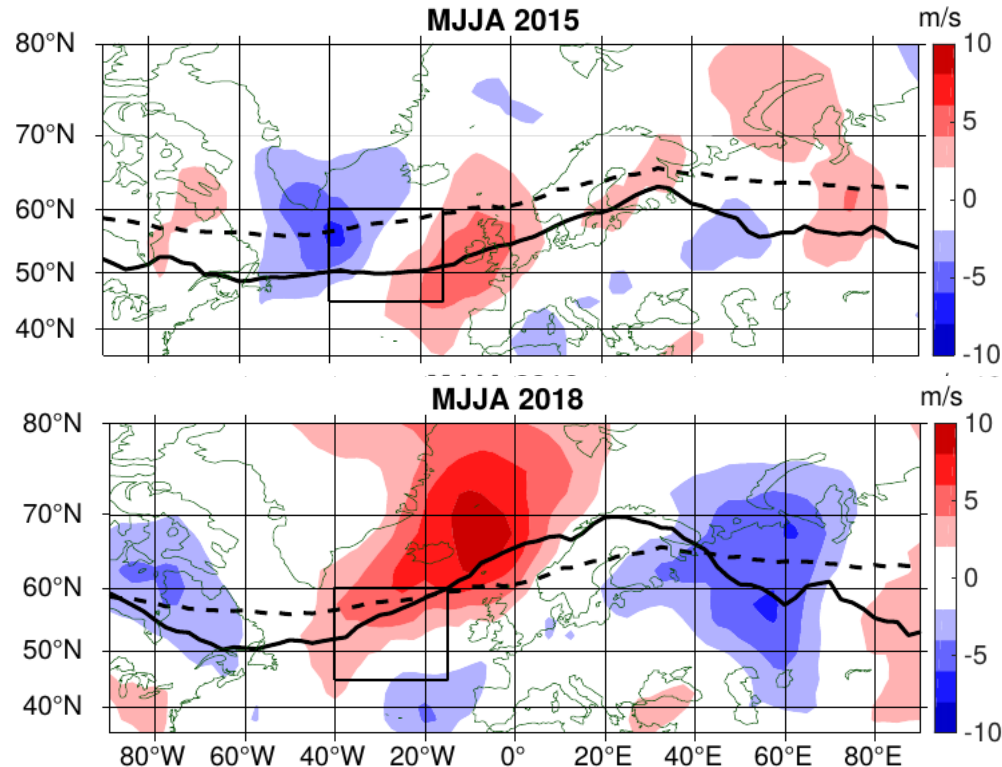
Lake/permafrost sediments



# Drivers of Jet Stream Anomalies

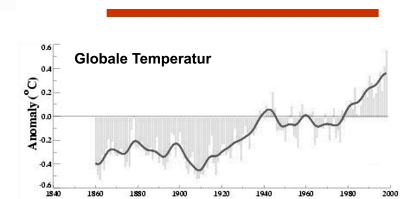
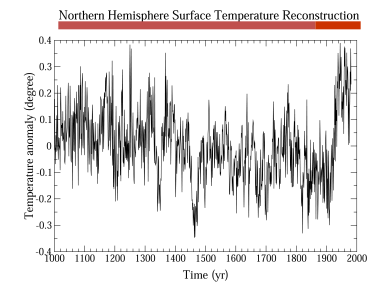
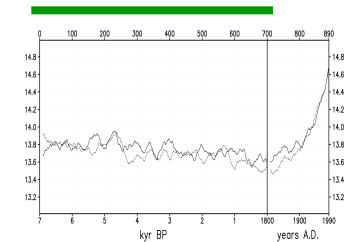
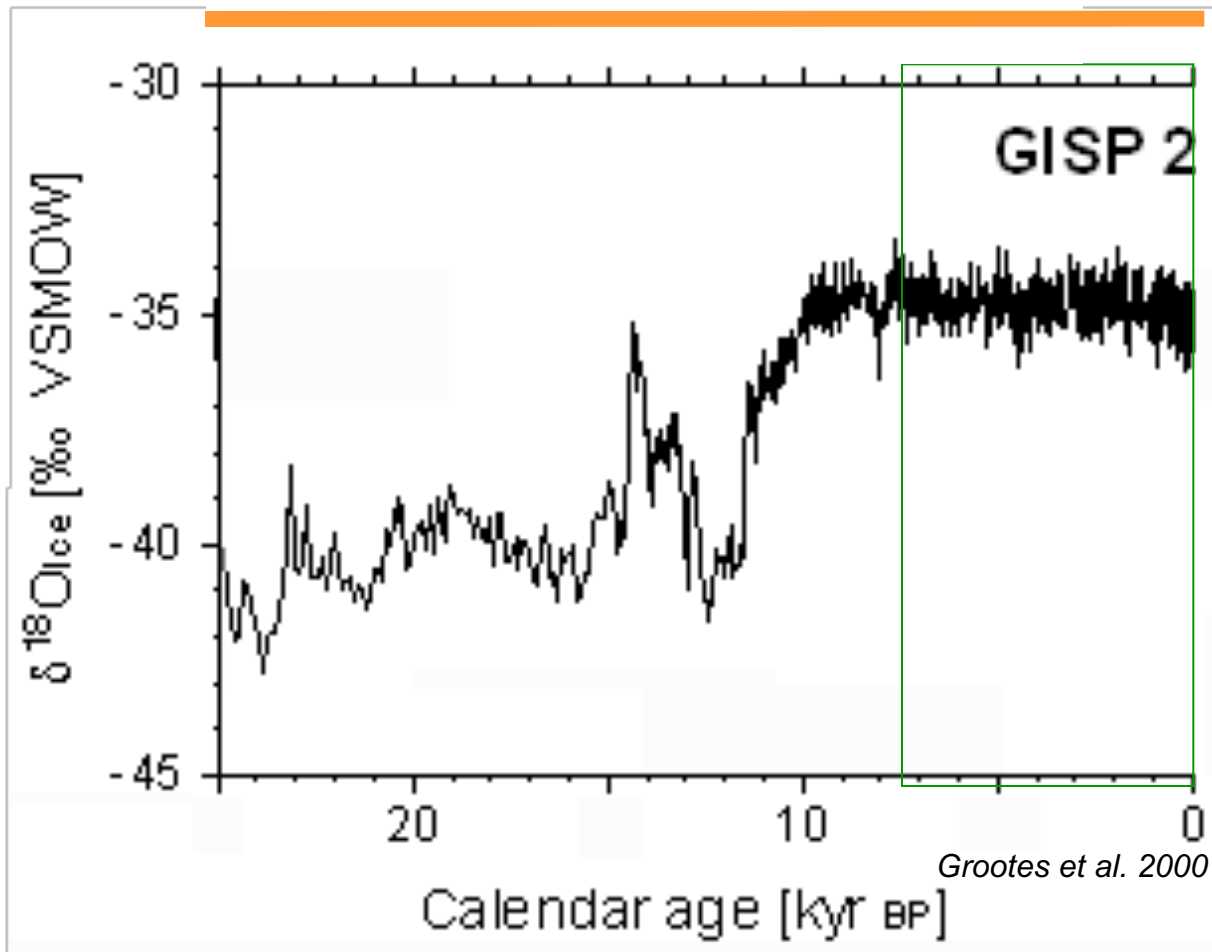
North Atlantic SSTs influence the jet stream waviness over the Euro-Atlantic sector.  
Shown by Duchez et al. 2016 for the 2015 summer heat wave.

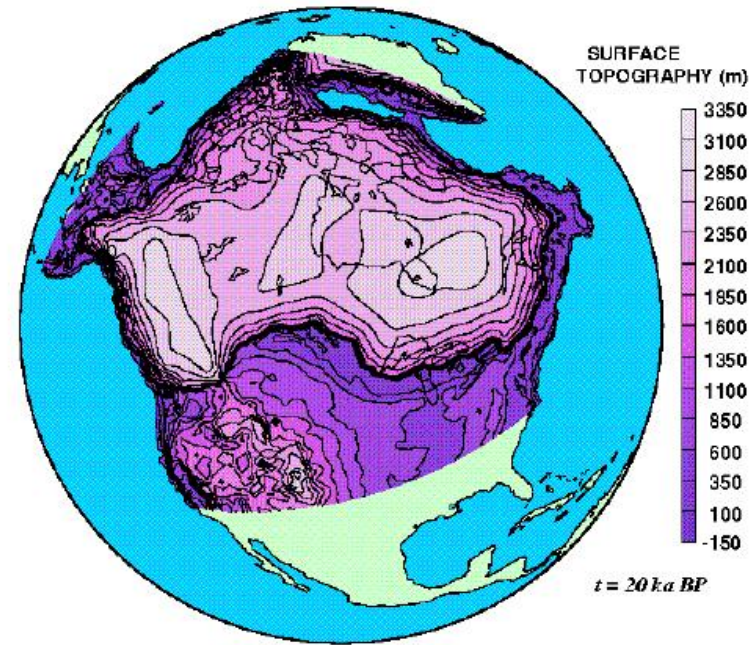
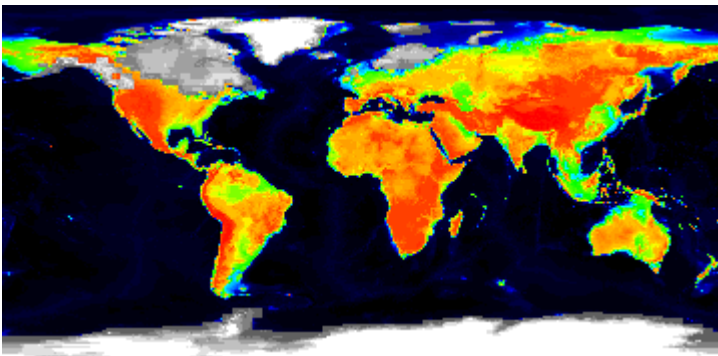
Summer meridional wind anomalies (shading) and mean jet stream position (contour)



# Climate Trends at different Timescales

## Deglaciation – Greenland ice core

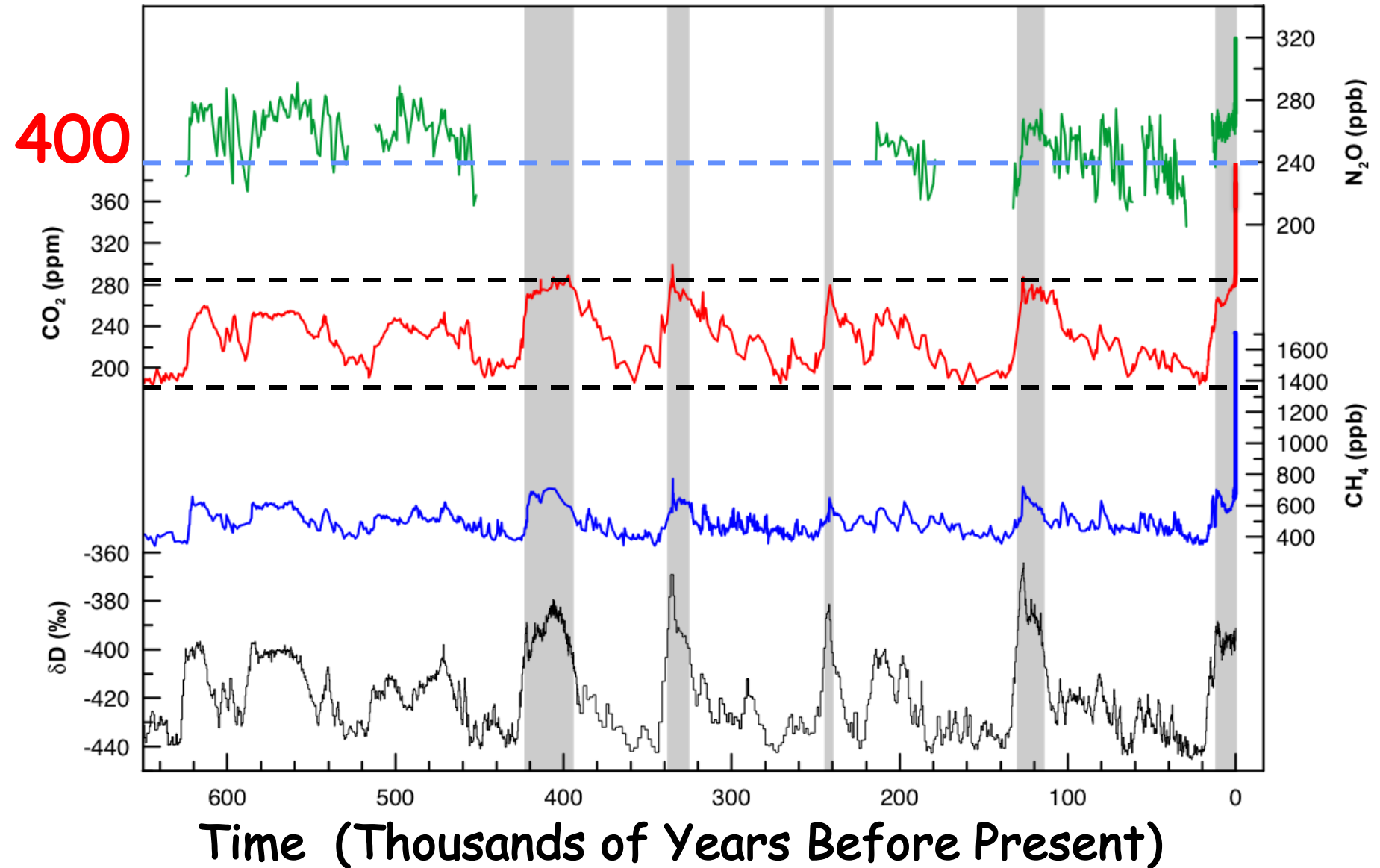


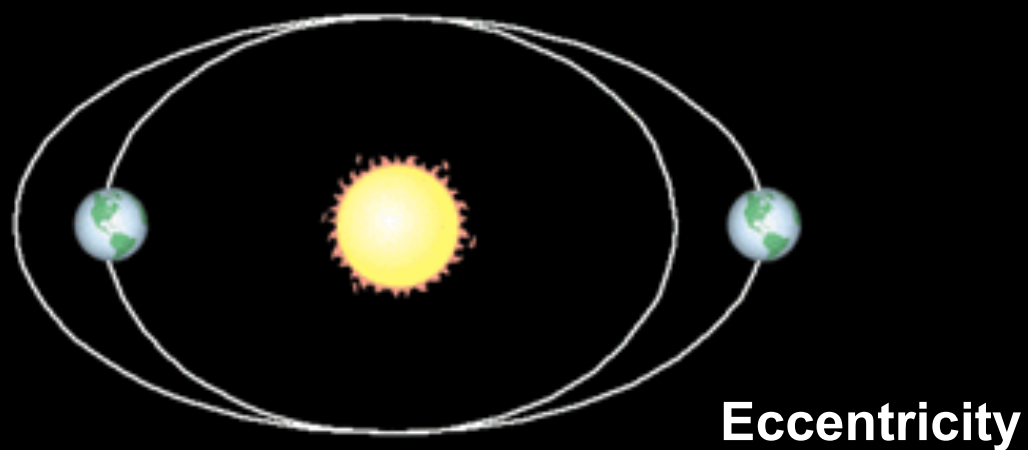
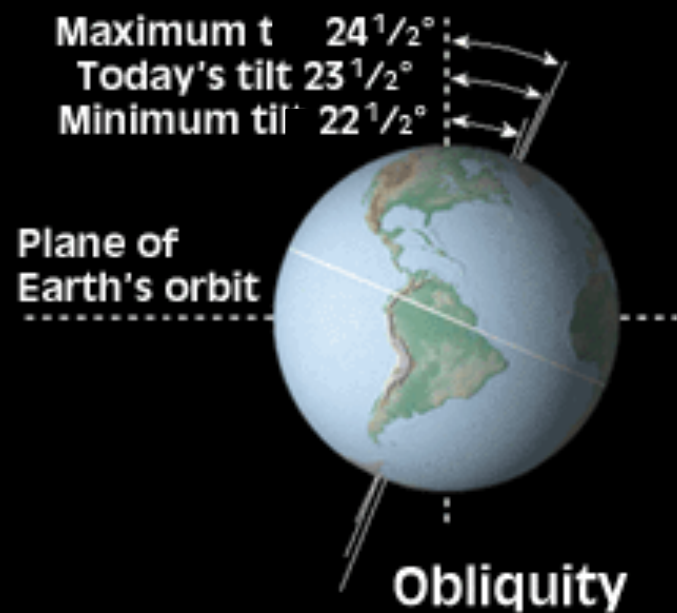
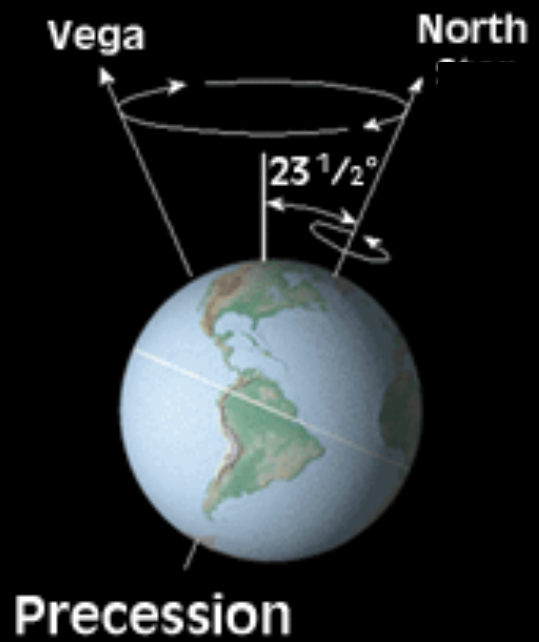


**Deglaciation**



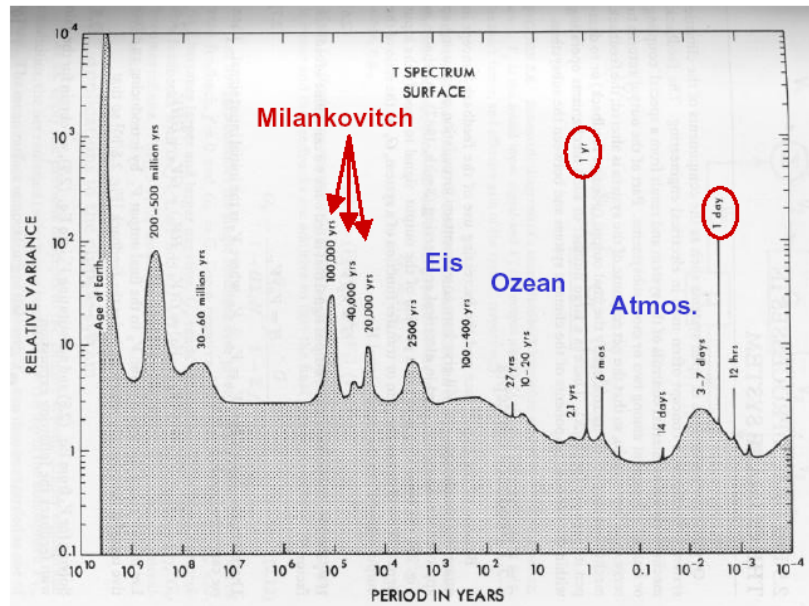
# Atmospheric Gas Concentrations from Ice Cores





# Orbital forcing

- ~20.000, ~40.000, ~100.000 years
- 0.5, 1 year
- Geometry of the Sun-Earth configuration



Quelle: Peixoto & Oort

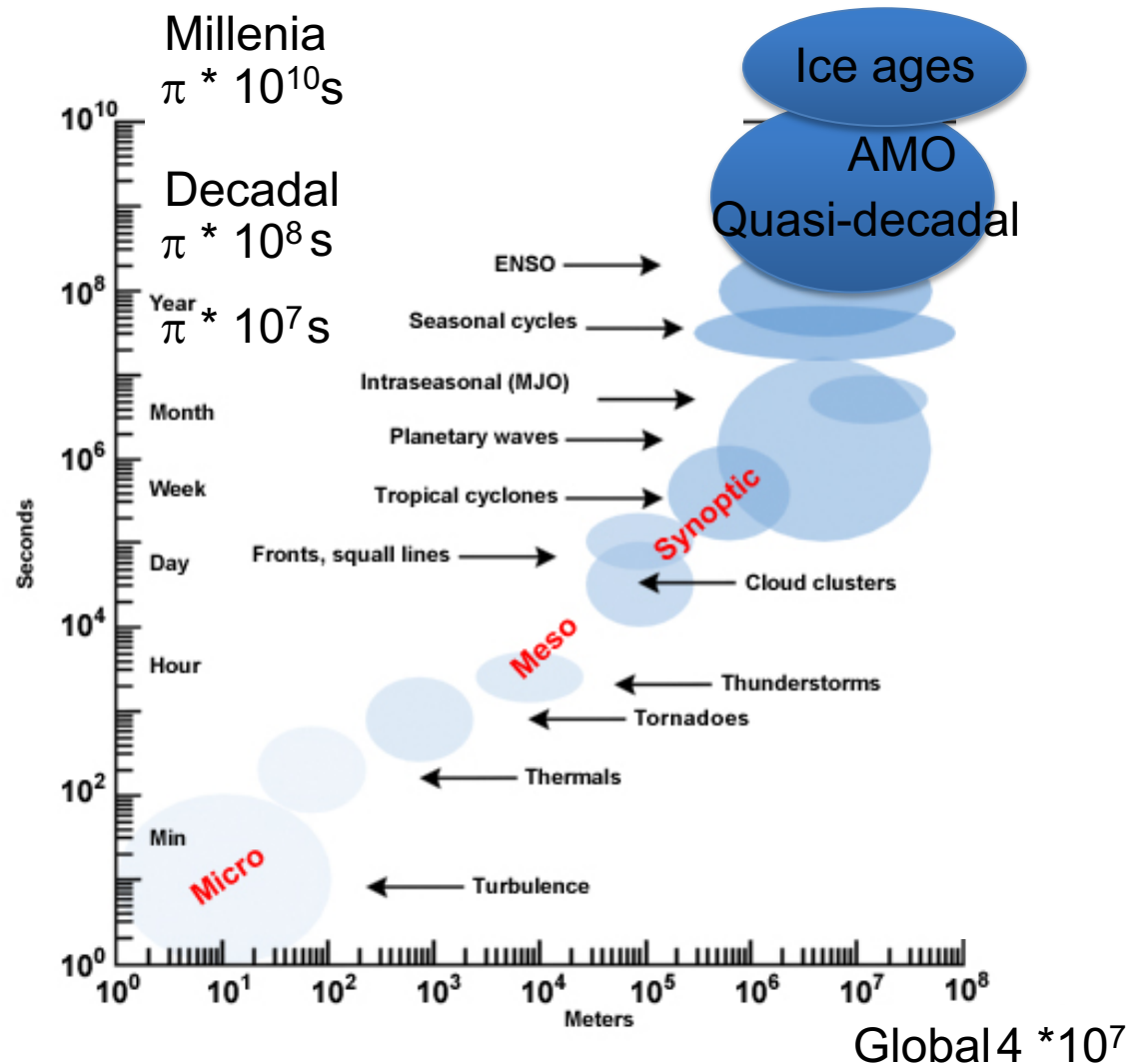


Sunspots

Photo: Nasa

# Spatio-Temporal Scales

Dissipative Systems (as atmosphere & ocean) cannot maintain large gradients on long time scales



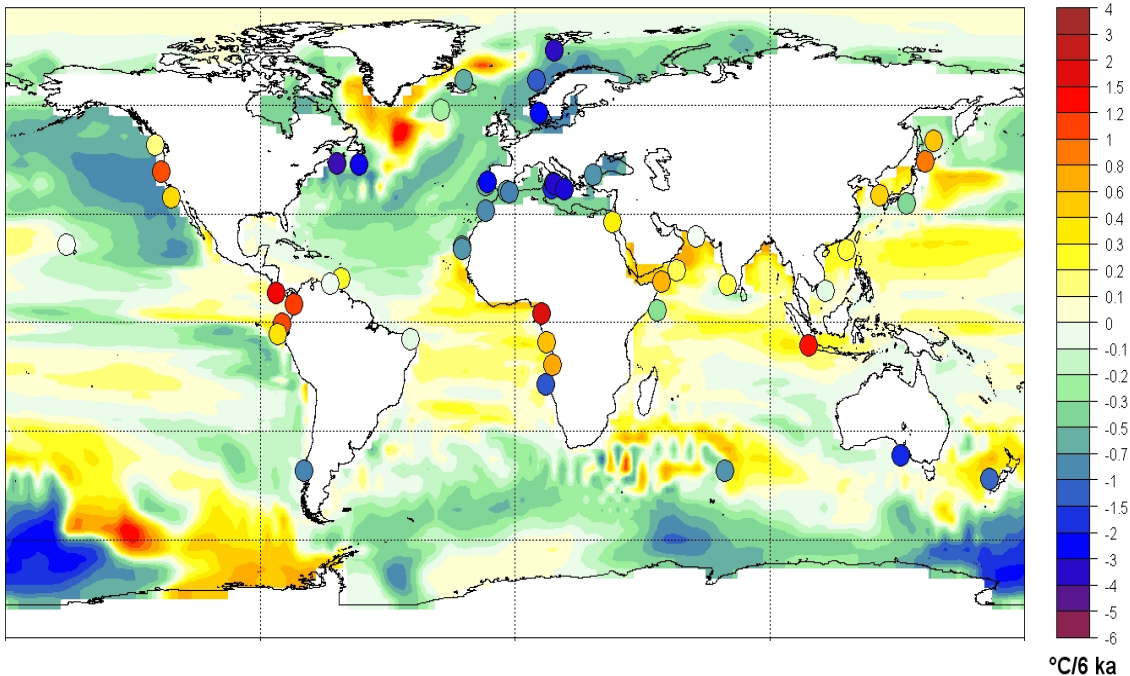
Spatial || temporal Scales



# Marine temperature trends (last 6000 years)



Annual mean sea surface temperature trends



Alkenone-based temperature trends

# Natural variability and perturbed climate

