Climate System II

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https://paleodyn.uni-bremen.de/study/climate2021_22.html

Time: Tuesday 10-12

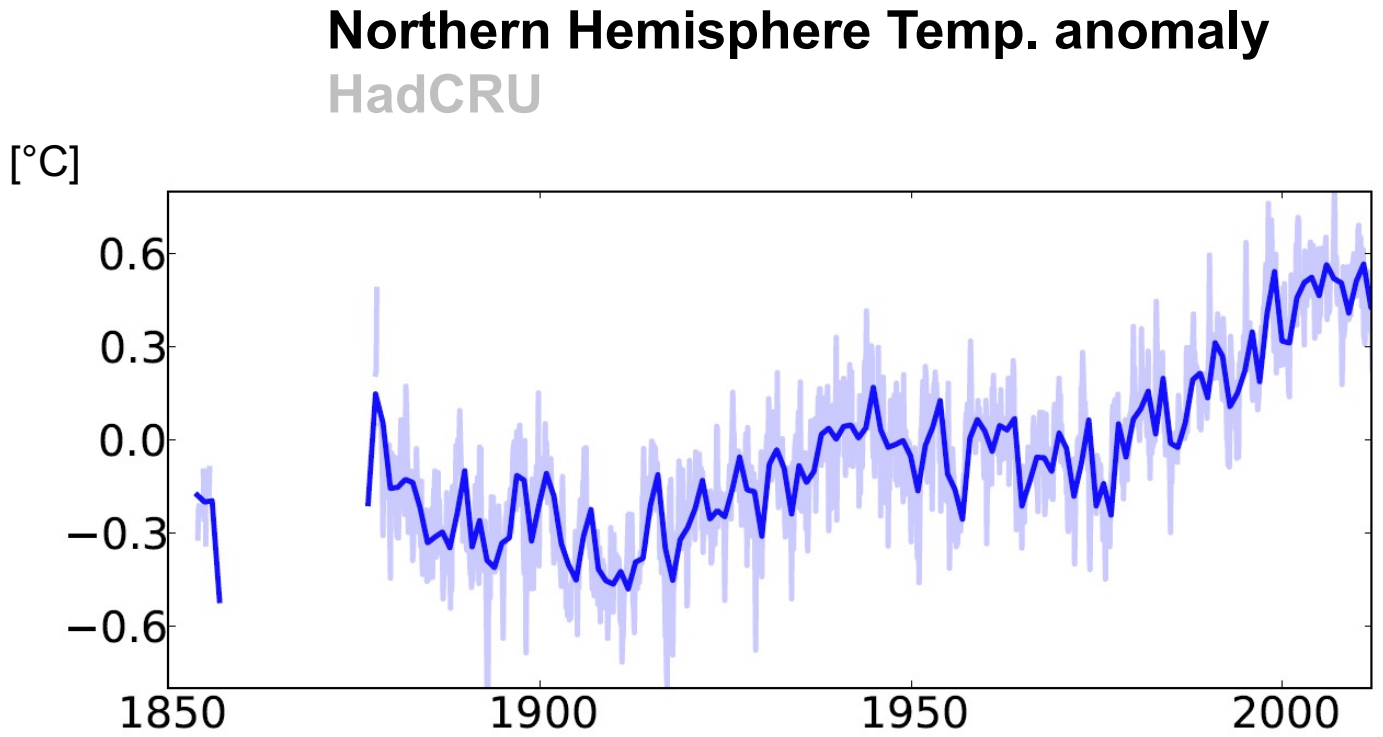
Sometimes shorter, but then with some exercises

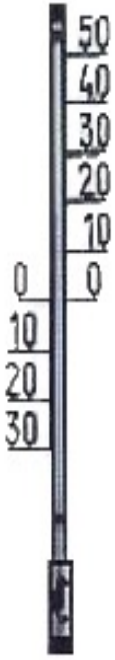
1-2 going into the field -> plan

Just for orientation

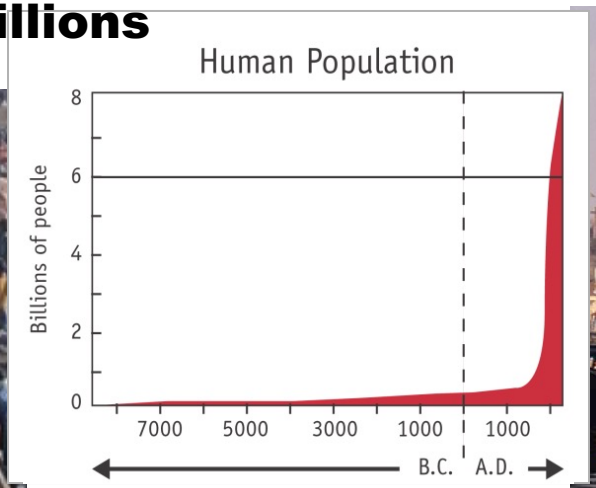
Climate Trends at different Timescales

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





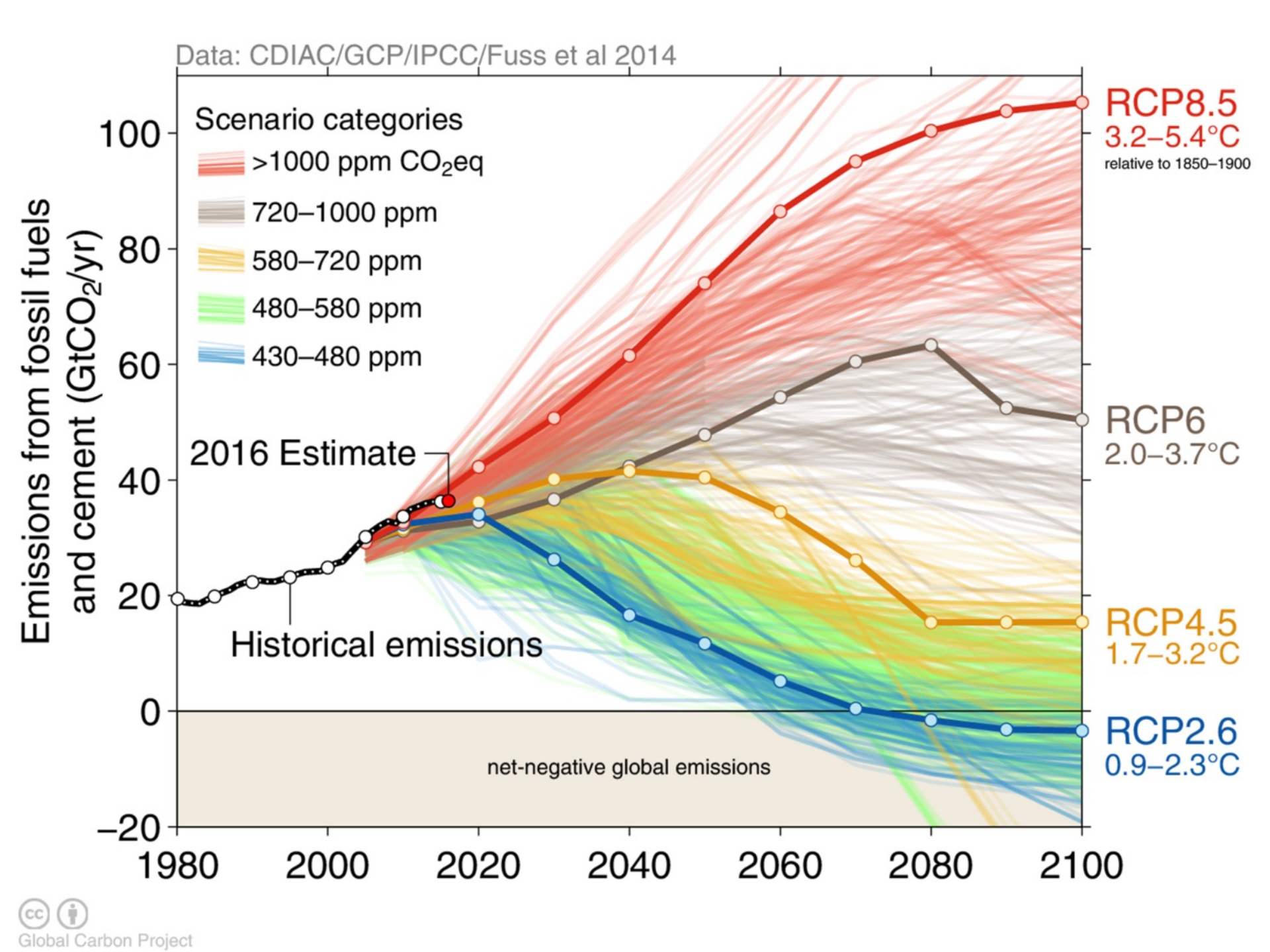
Human Population: 7 billions



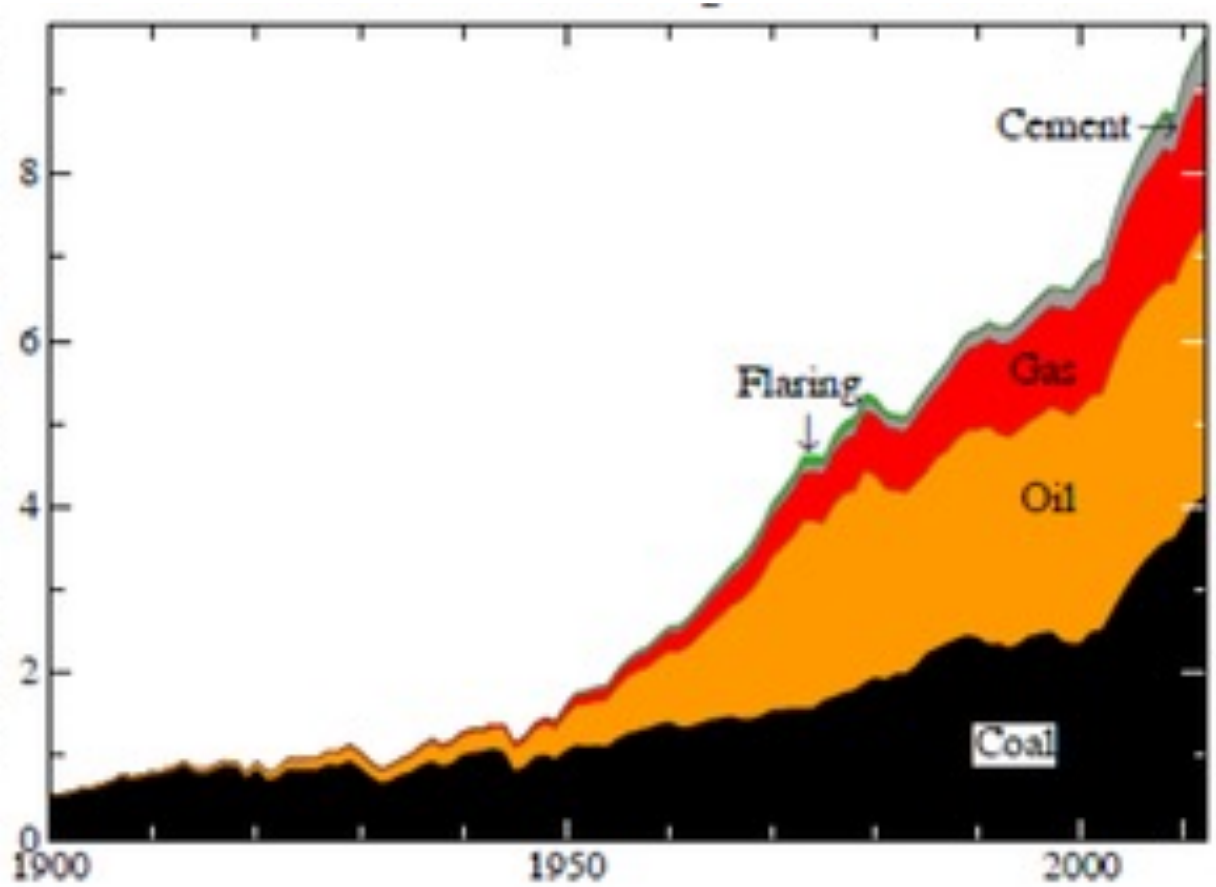
CO_2 Increase:

Land cover: 22%

CO_2-Emissions: 78%

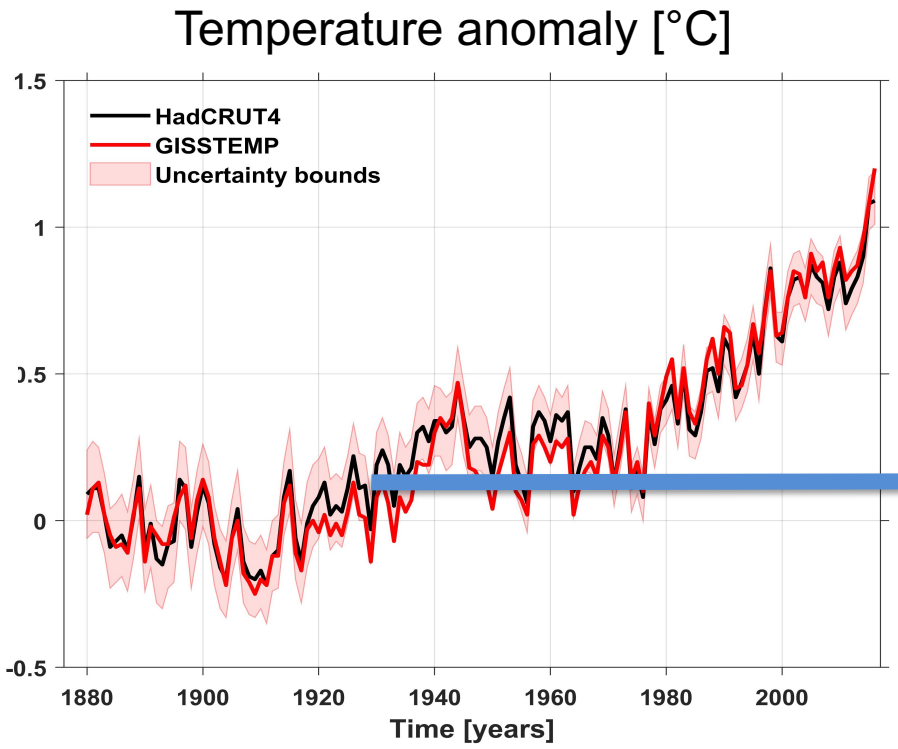

Data: CDIAC/GCP/IPCC/Fuss et al 2014
Scenario categories
>1000 ppm CO_2eq
720–1000 ppm
580–720 ppm
480–580 ppm
430–480 ppm
2016 Estimate
Historical emissions
net-negative global emissions
RCP8.5
3.2–5.4°C
relative to 1850–1900
RCP6
2.0–3.7°C
RCP4.5
1.7–3.2°C
RCP2.6
0.9–2.3°C
Emissions from fossil fuels and cement ($GtCO_2$/yr)
100
80
60
40
20
0
–20
1980
2000
2020
2040
2060
2080
2100
Global Carbon Project

Global Fossil-Fuel CO2 annual emissions (Gt C/year)

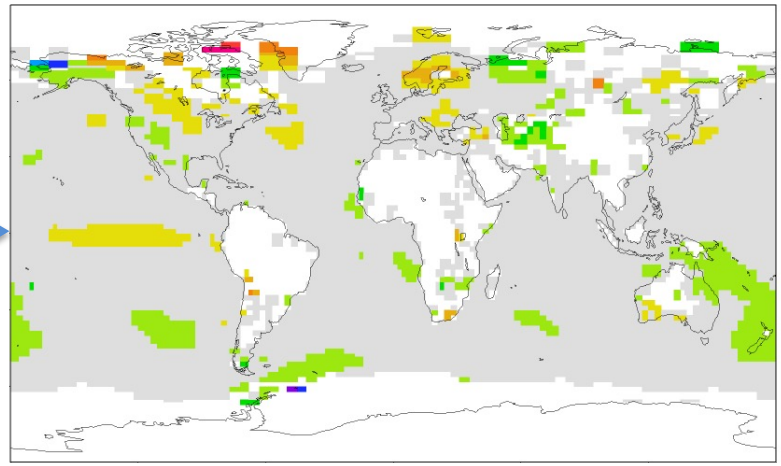


Hansen J, Kharecha P, Sato M, Masson-Delmotte V, Ackerman F, et al. (2013) Assessing "Dangerous Climate Change": Required Reduction of Carbon Emissions to Protect Young People, Future Generations and Nature. PLOS ONE 8(12): e81648. https://doi.org/10.1371/journal.pone.0081648
https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0081648

Motivation: Observational Record



Uncertainty largely due to missing information at high latitudes

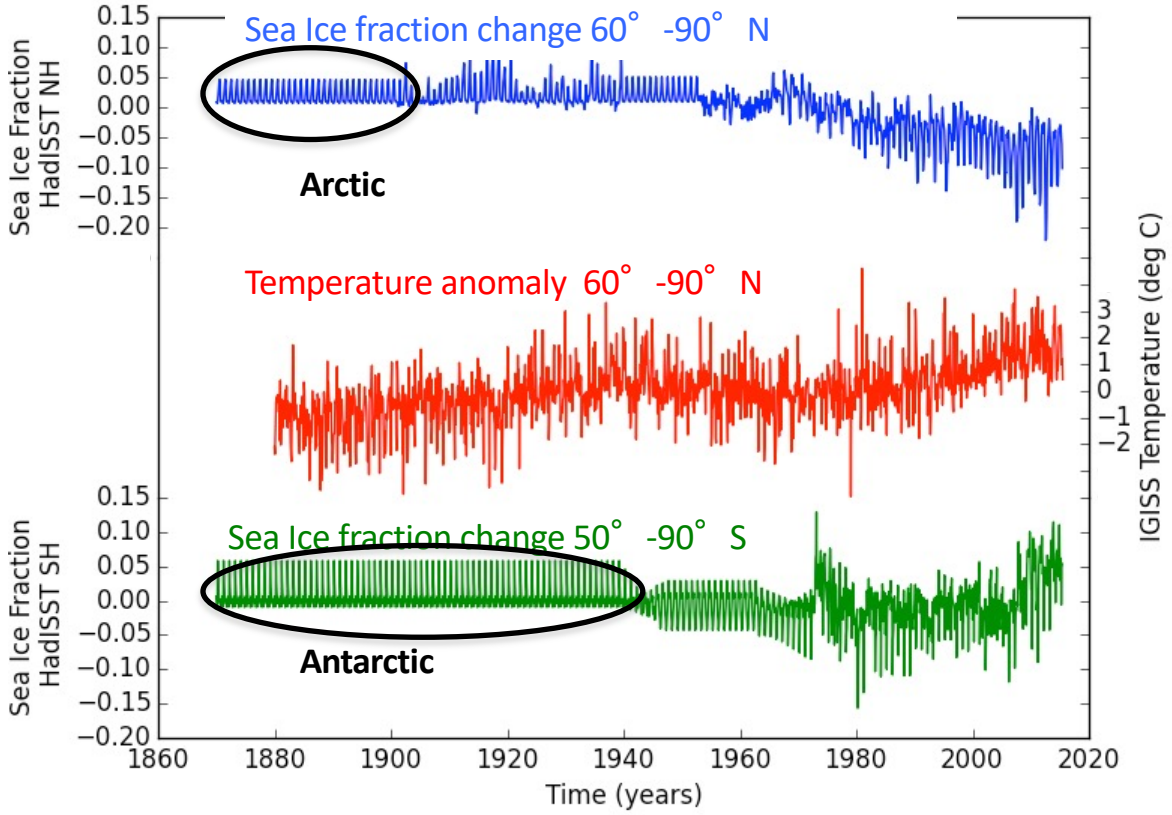


Temperature Anomaly 1930
White areas: not enough data

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

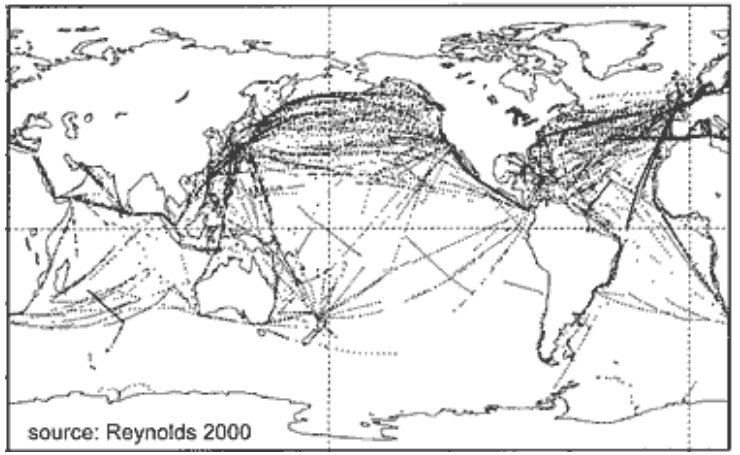
Arctic Sea Ice retreat

Missing Information about Sea Ice

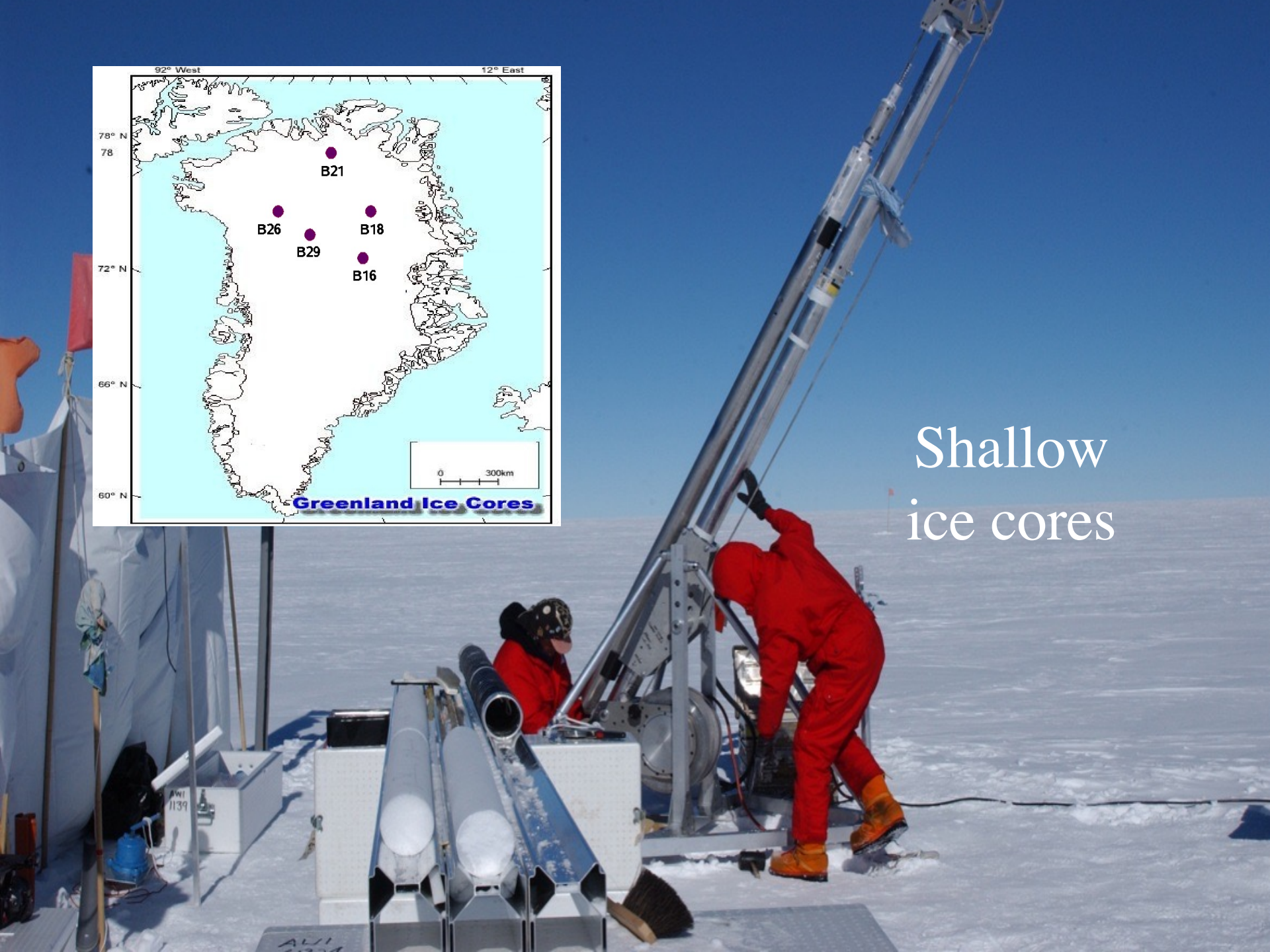


The “Climate dilemma“

- The records of direct temperature measurements are short and already fall in the phase of strong human influence.
- Instrumental data are sparce



- For the time before instrumental records, one has to rely on information from proxy data and modeling.



Shallow ice cores

History

last **1000 Years**

Pieter Breughel d.Ä.

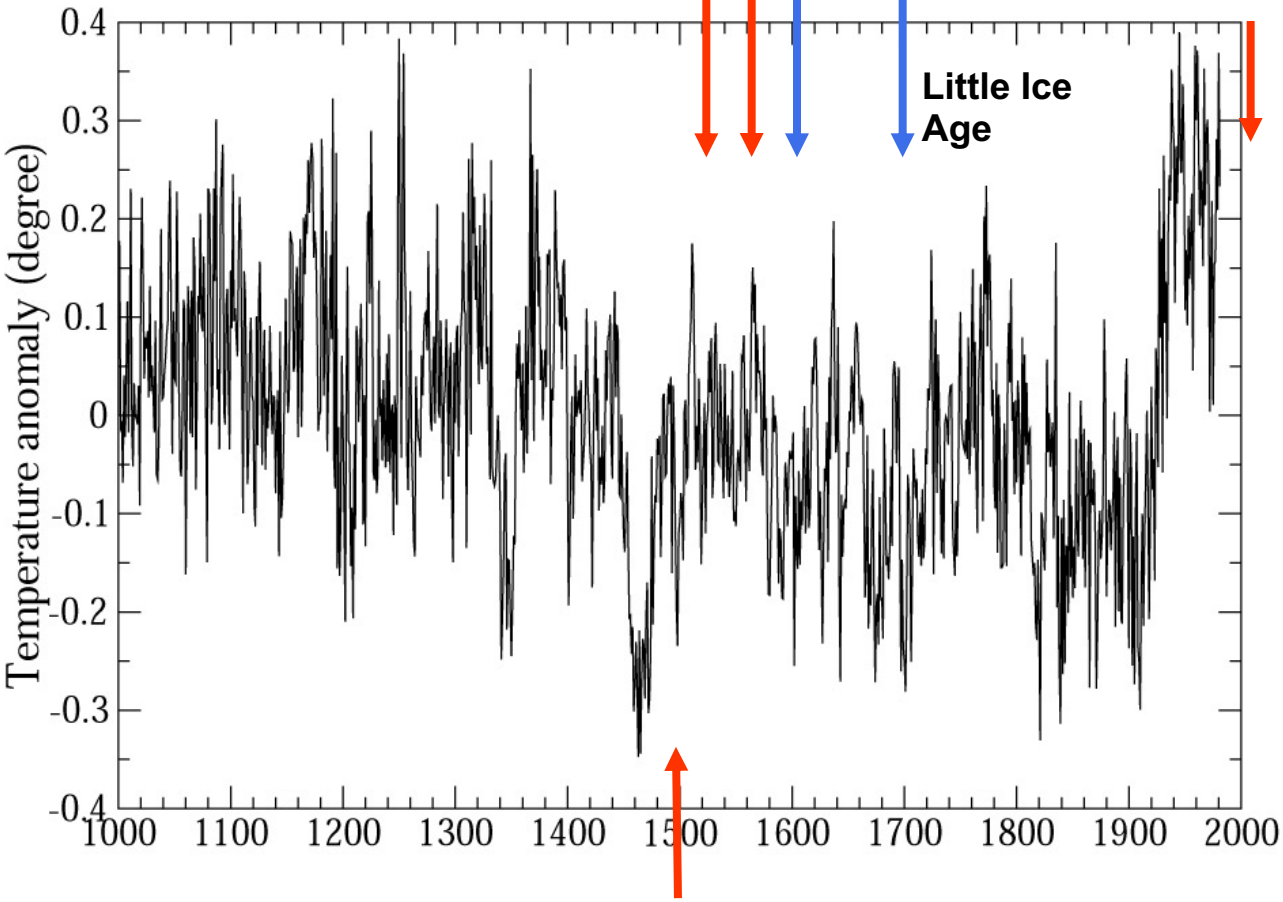
Thermometer

Barometer
(Torricelli)

Little Ice
Age

present

Nicolaus Kopernikus



Proxy Data

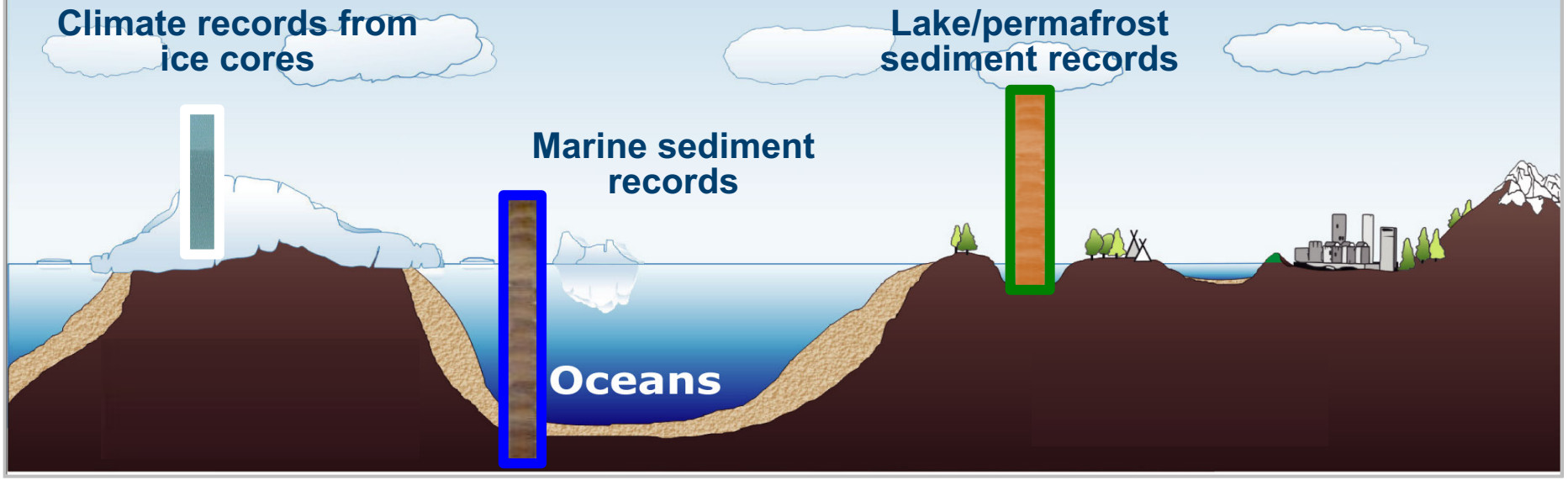
- Indirect data, often qualitative
- Long time series from archives
- Information beyond the instrumental record

Earth System:reconstructions

Ice drilling camp, 2009

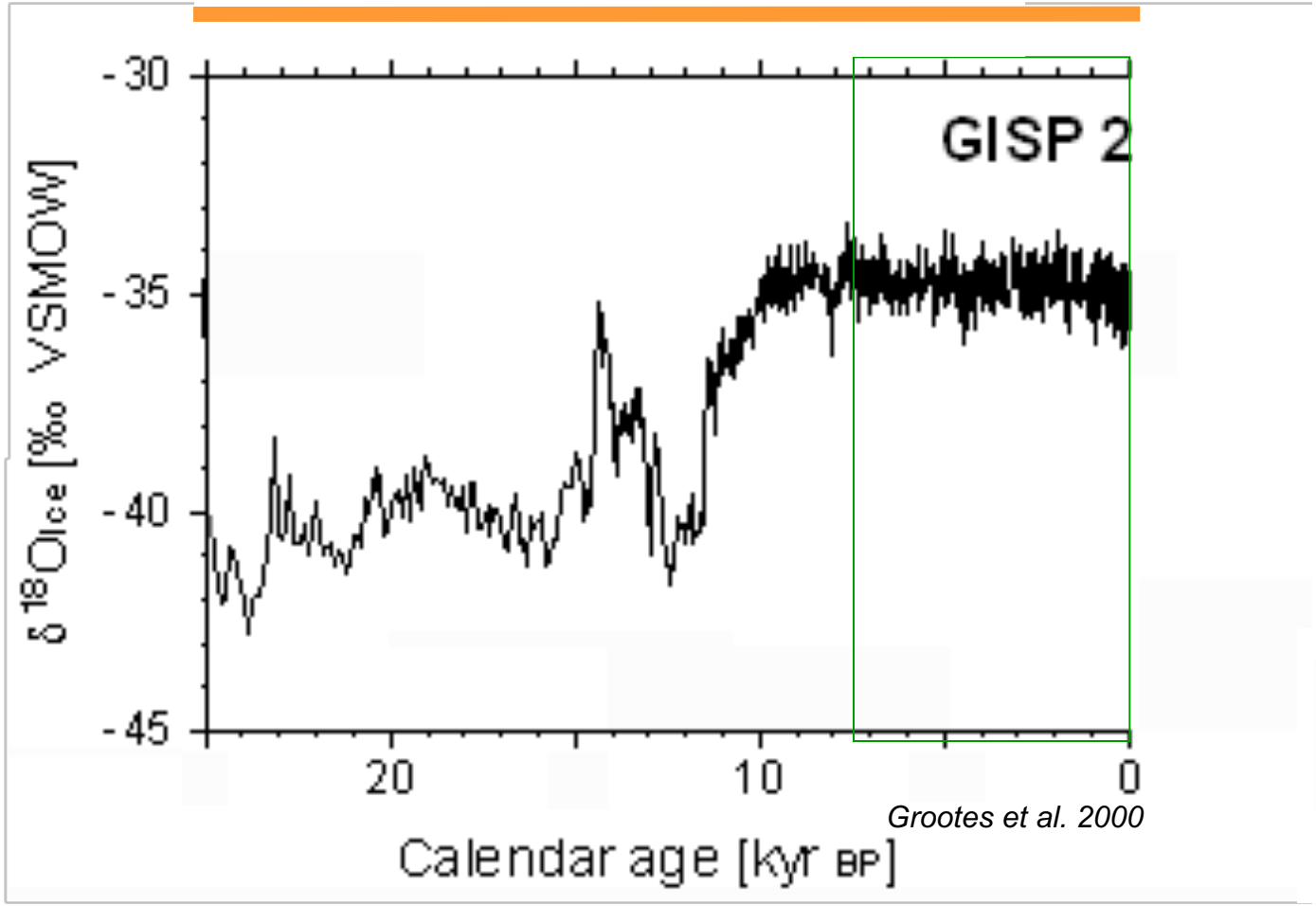
Polarstern, marine sediments

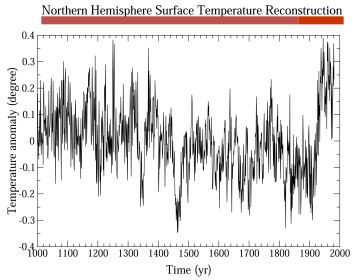
Lake/permafrost sediments

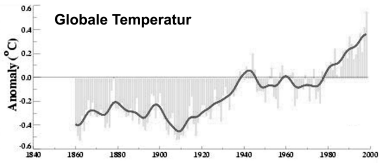


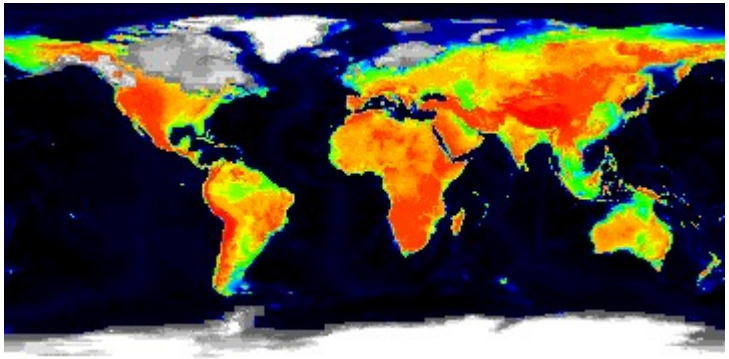
Climate Trends at different Timescales

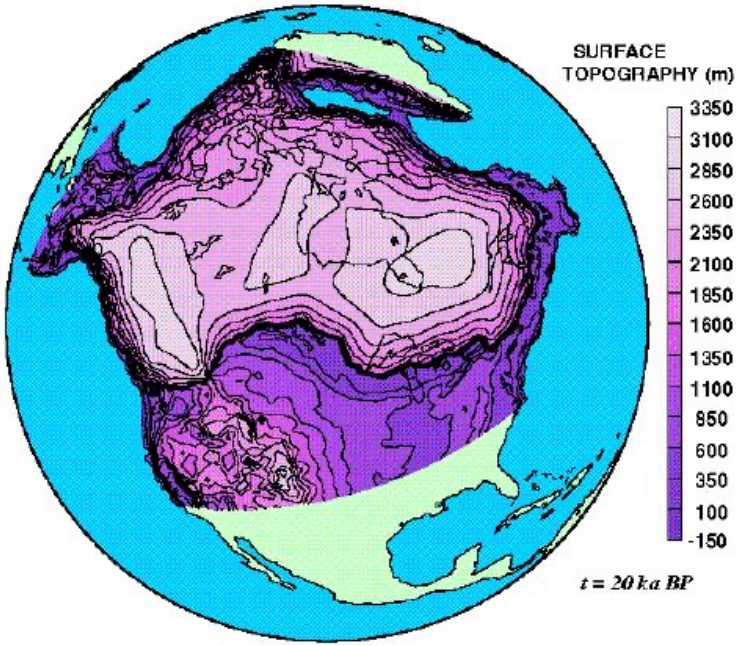
Deglaciation – Greenland ice core





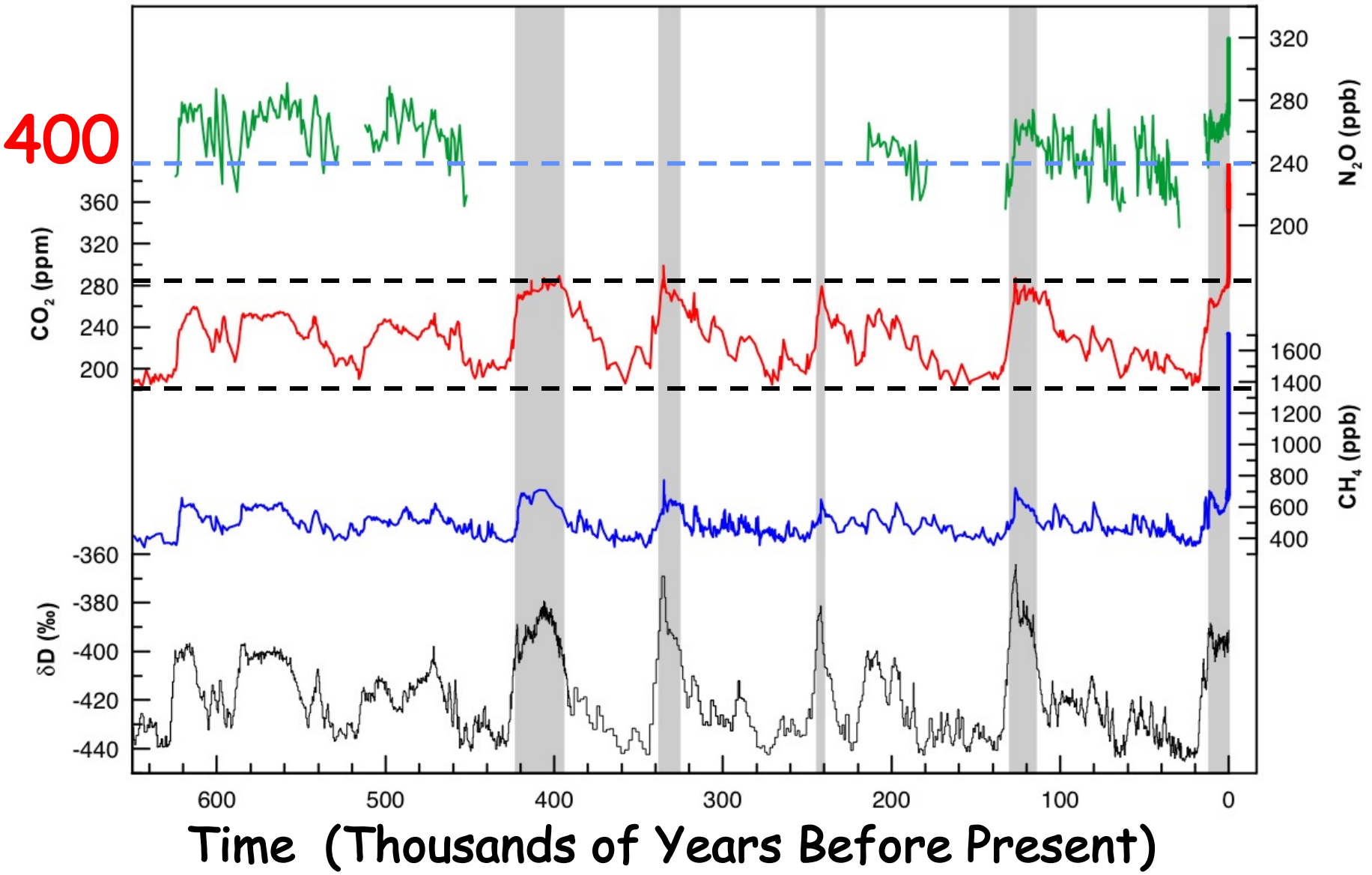




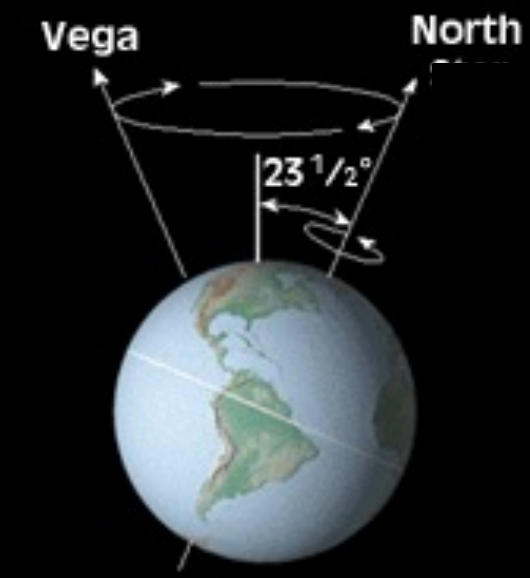


Deglaciation

Atmospheric Gas Concentrations from Ice Cores



EPICA 2008



Precession

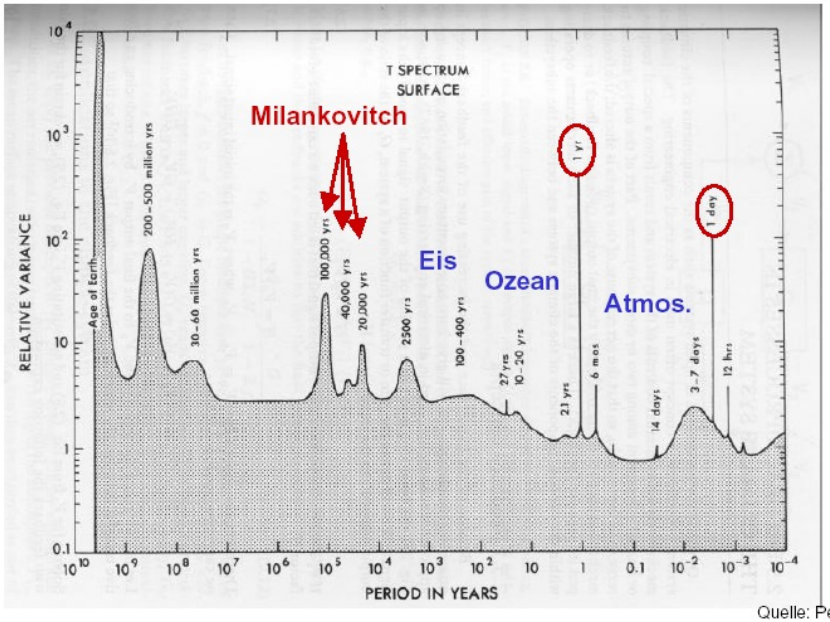
Obliquity

Eccentricity

Orbital focing

- ~20.000, ~40.000, ~100.000 years
- 0.5, 1 year

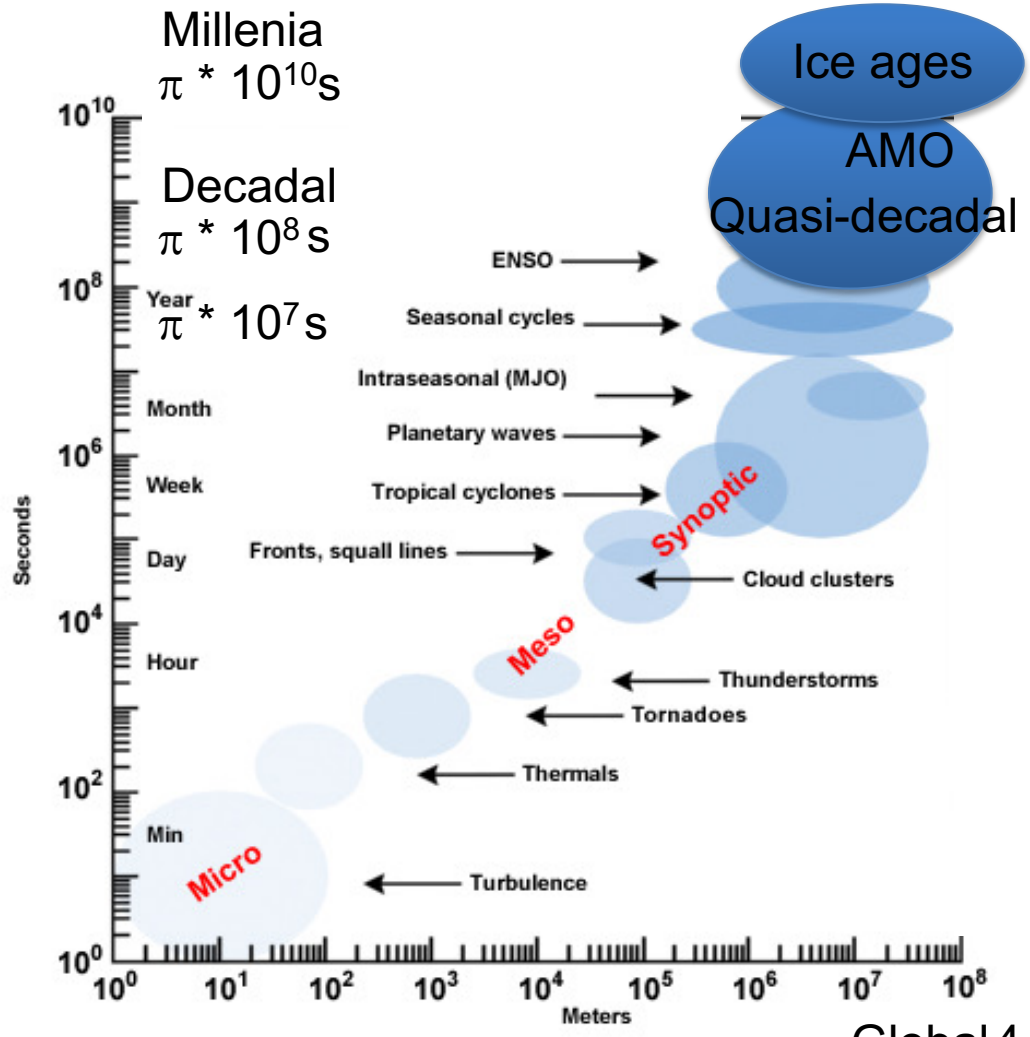
- Geometry of the Sun-Earth configuration



Quelle: Peixoto & Oort

Spatio-Temporal Scales

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

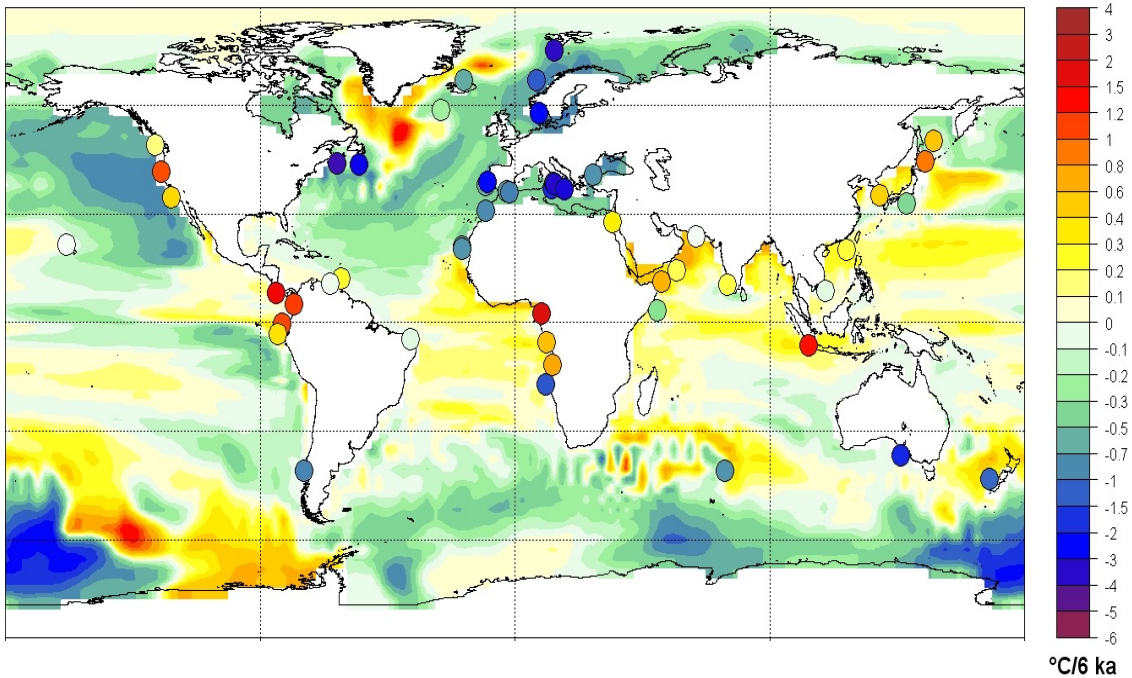


Spatial || temporal Scales

Global $4 * 10^7$

Marine temperature trends (last 6000 years)

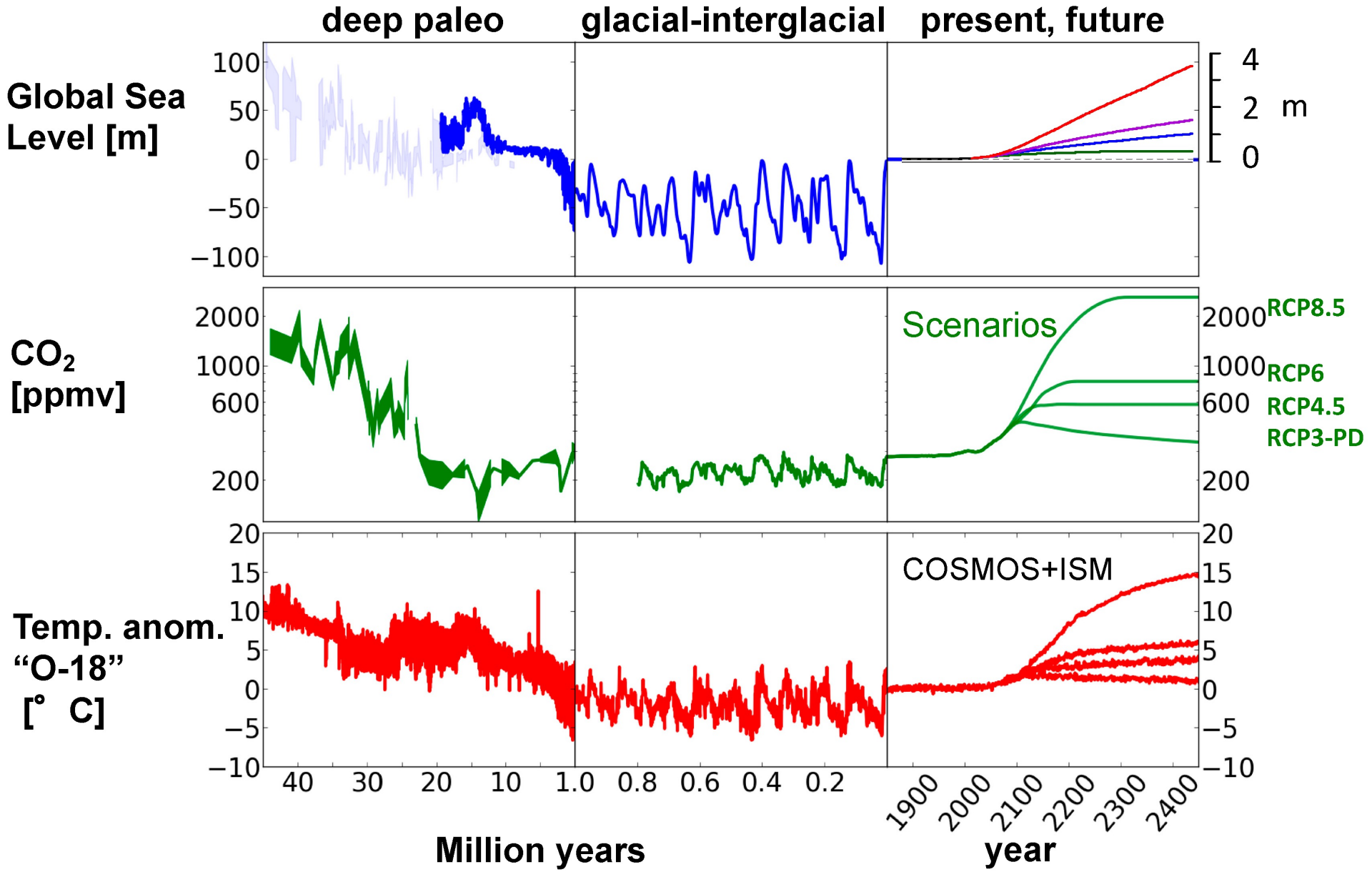
Annual mean sea surface temperature trends



Alkenone-based temperature trends

Lohmann et al., 2013, CP

Natural variability and perturbed climate



Feedback etc.

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