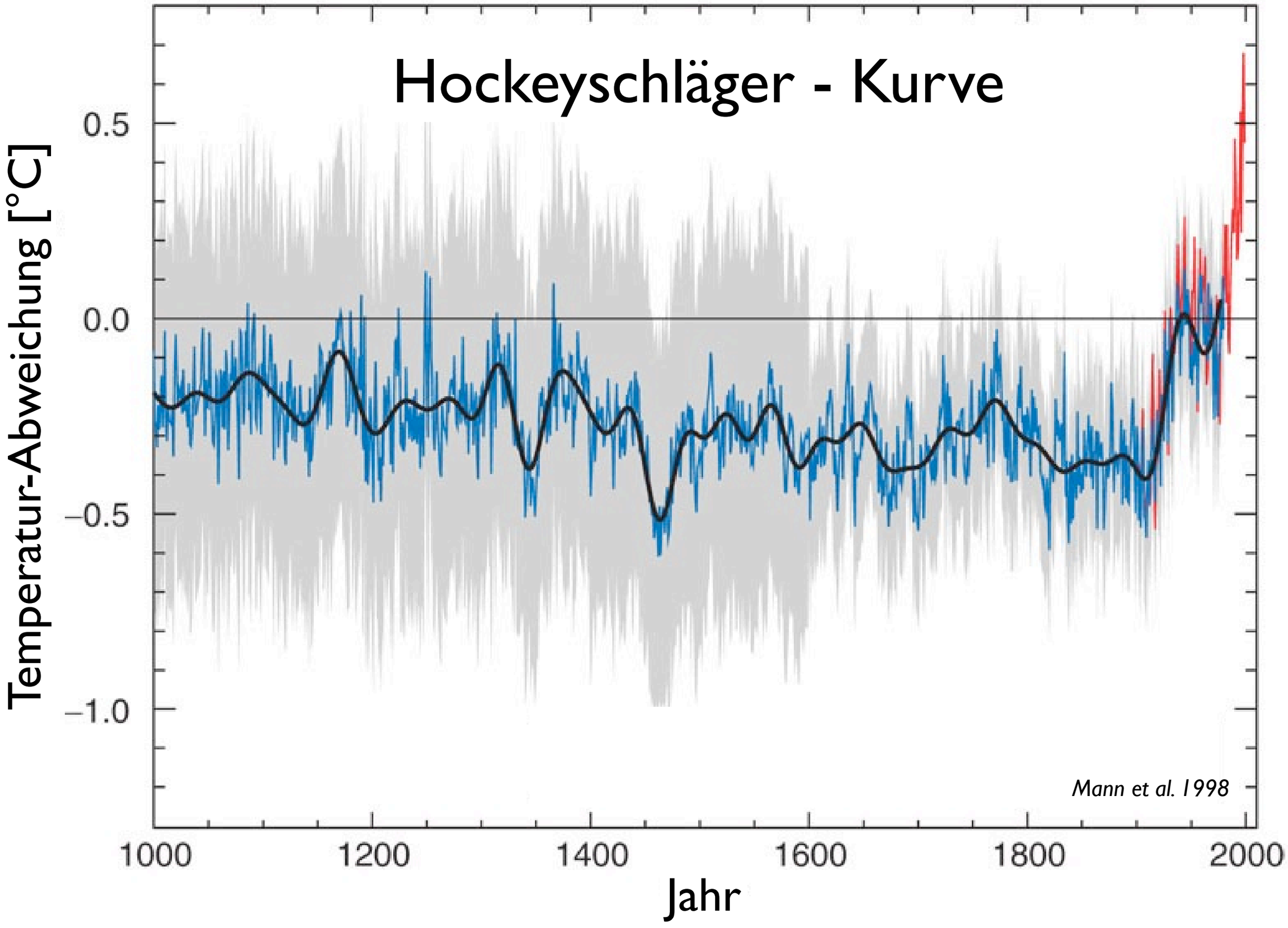
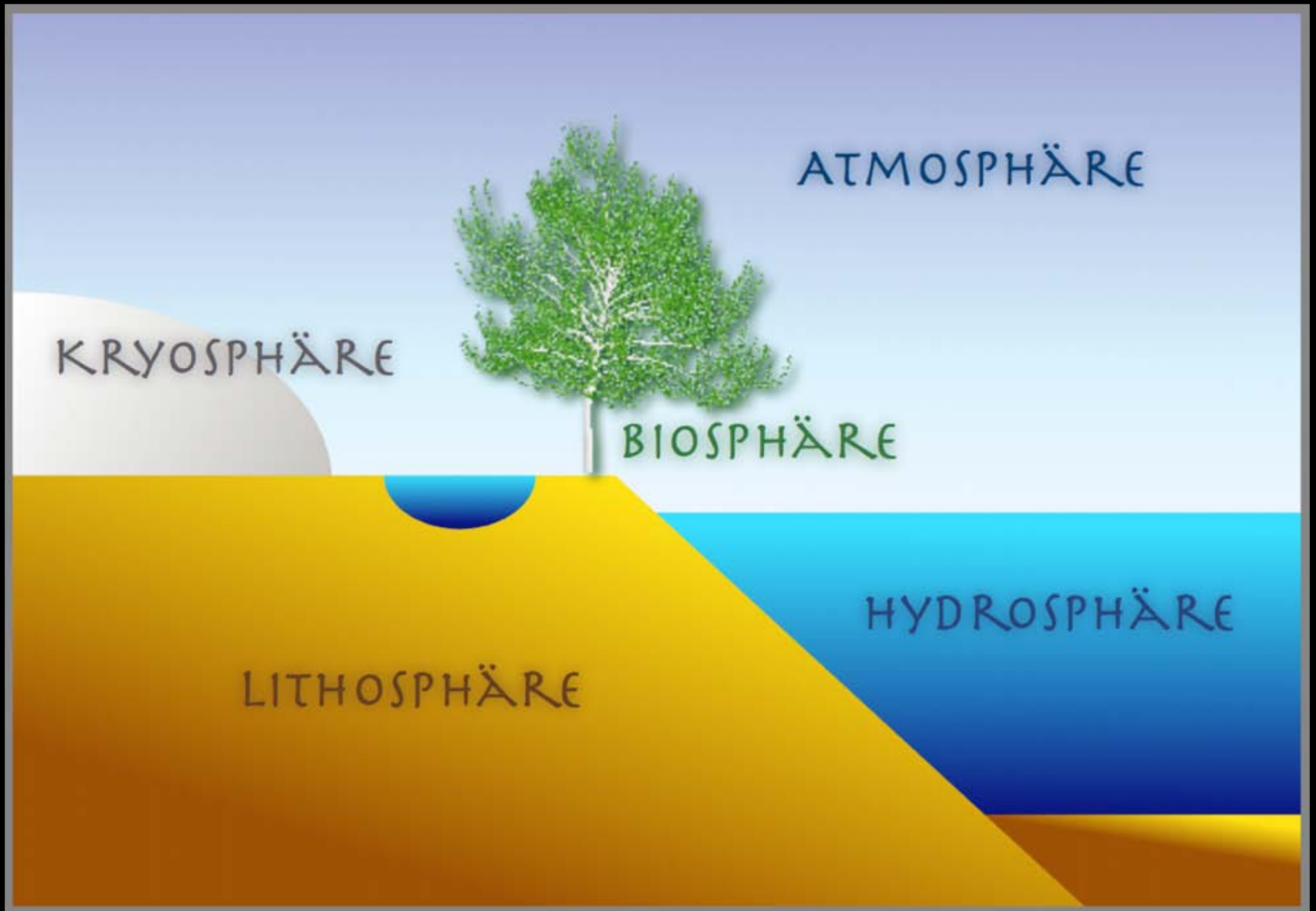
Die komplexe Erde

die Sphären des Erd- und Sonnensystems und ihr Spiel mit dem **Klima**

Hannes Grobe
Alfred-Wegener-Institut für Polar- und Meereesforschung

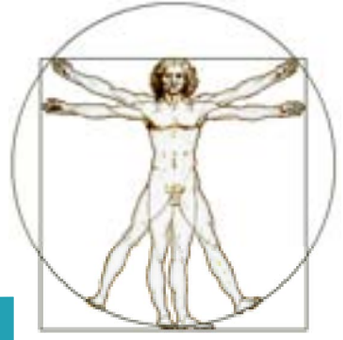
Hockeyschläger - Kurve




ATMOSPHÄRE
KRYOSPHÄRE
BIOSPHÄRE
HYDROSPHÄRE
LITHOSPHÄRE

?

Mensch

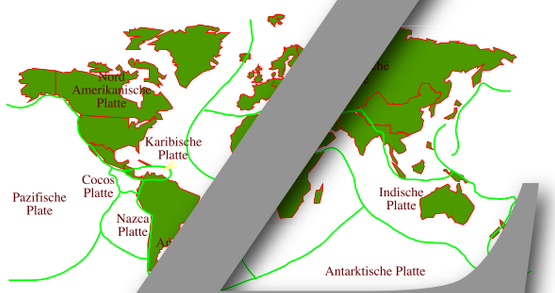


Meeresströmungen

ZEIT

Meteorit

Sonne



Kontinental-
verschiebung

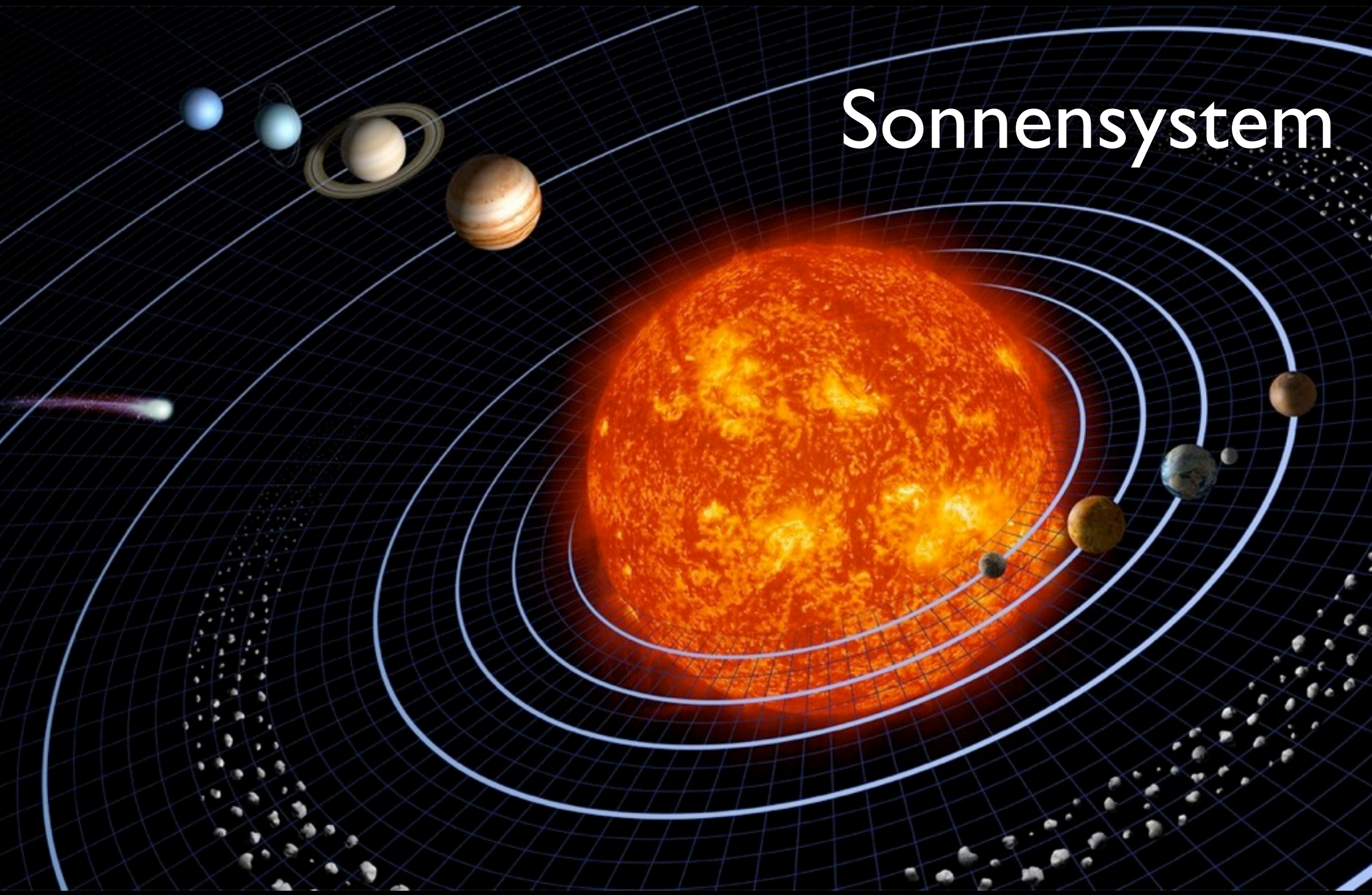
Erdbahn

Vulkane

1000 Mio | 100 Mio | 10 Mio | 1 Mio | 100 000 | 10 000 | 1000 | 100 | 10 | 1 Jahr | 1 Tag

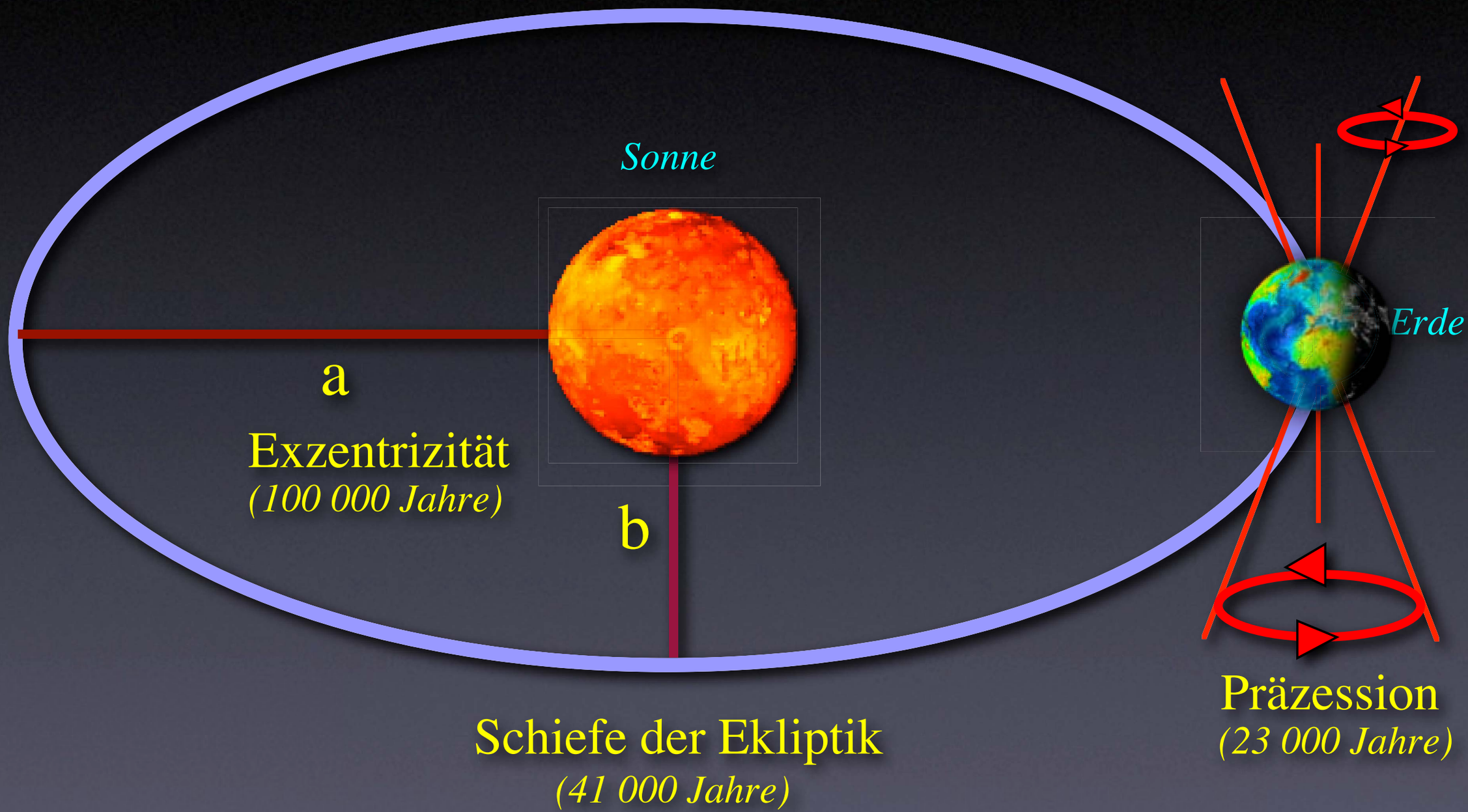
Zeitraum eines Klimawandels

Sonnensystem

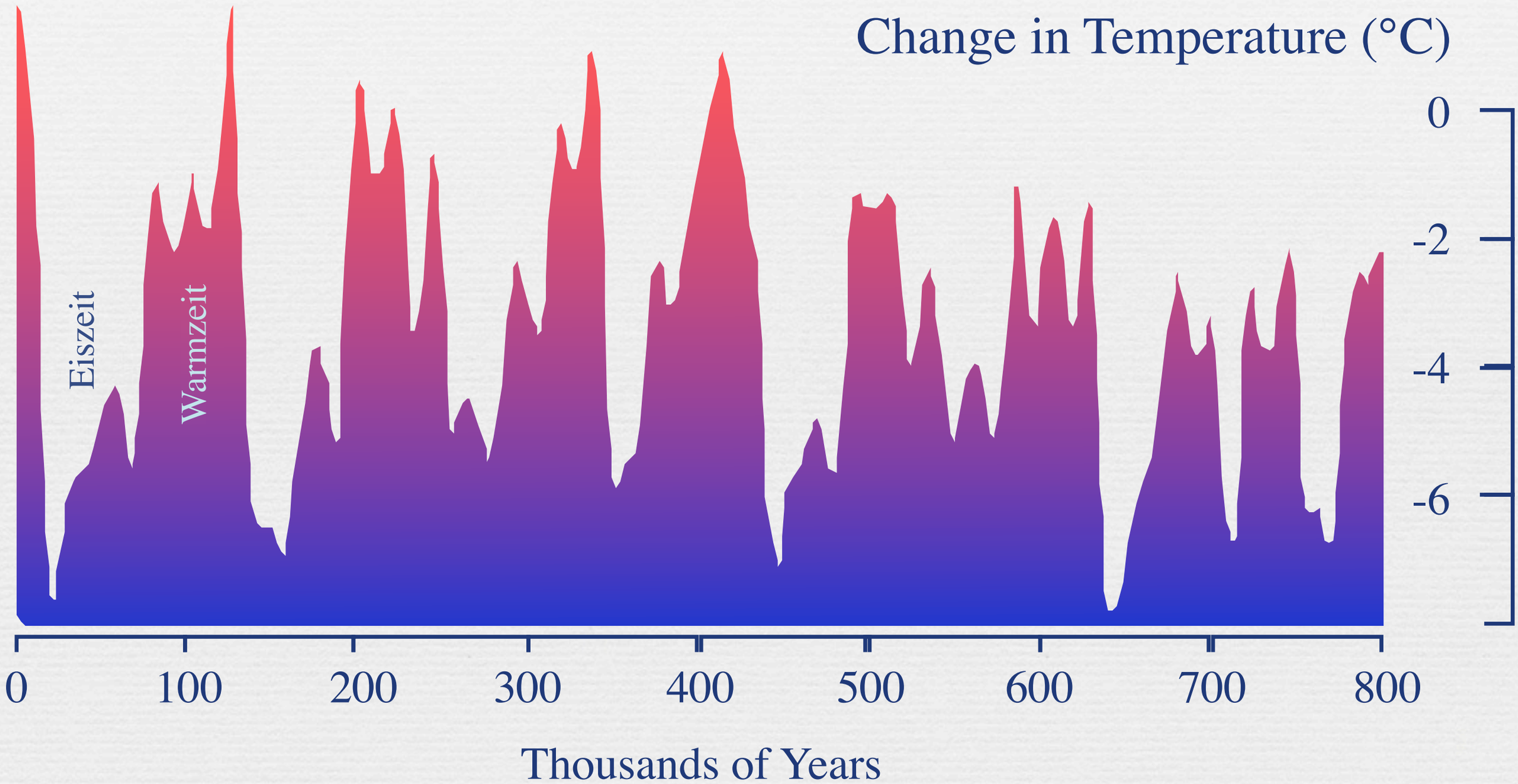


Harman Smith & Laura Generosa, NASA

Klimafaktor Erdbahn

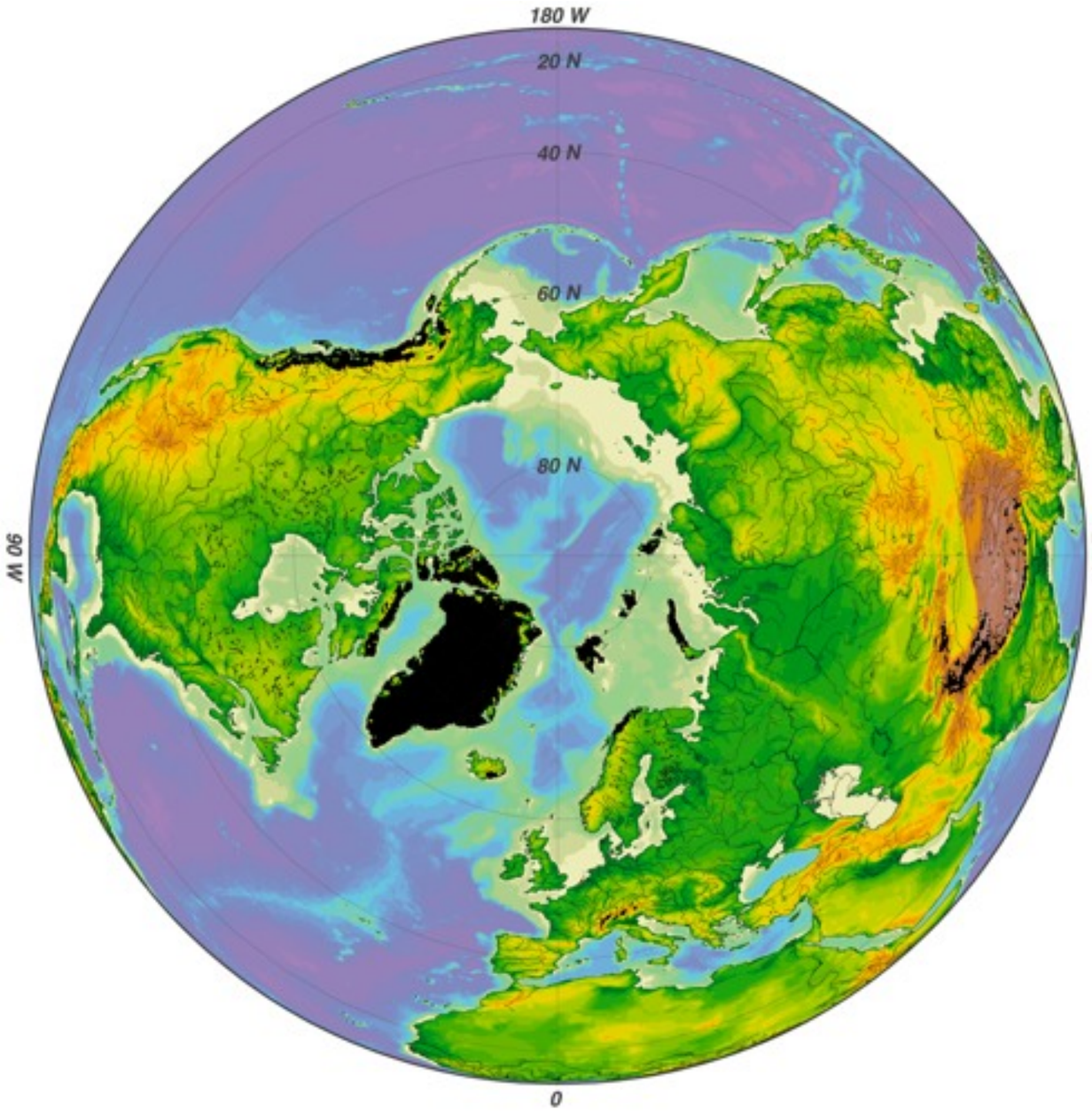


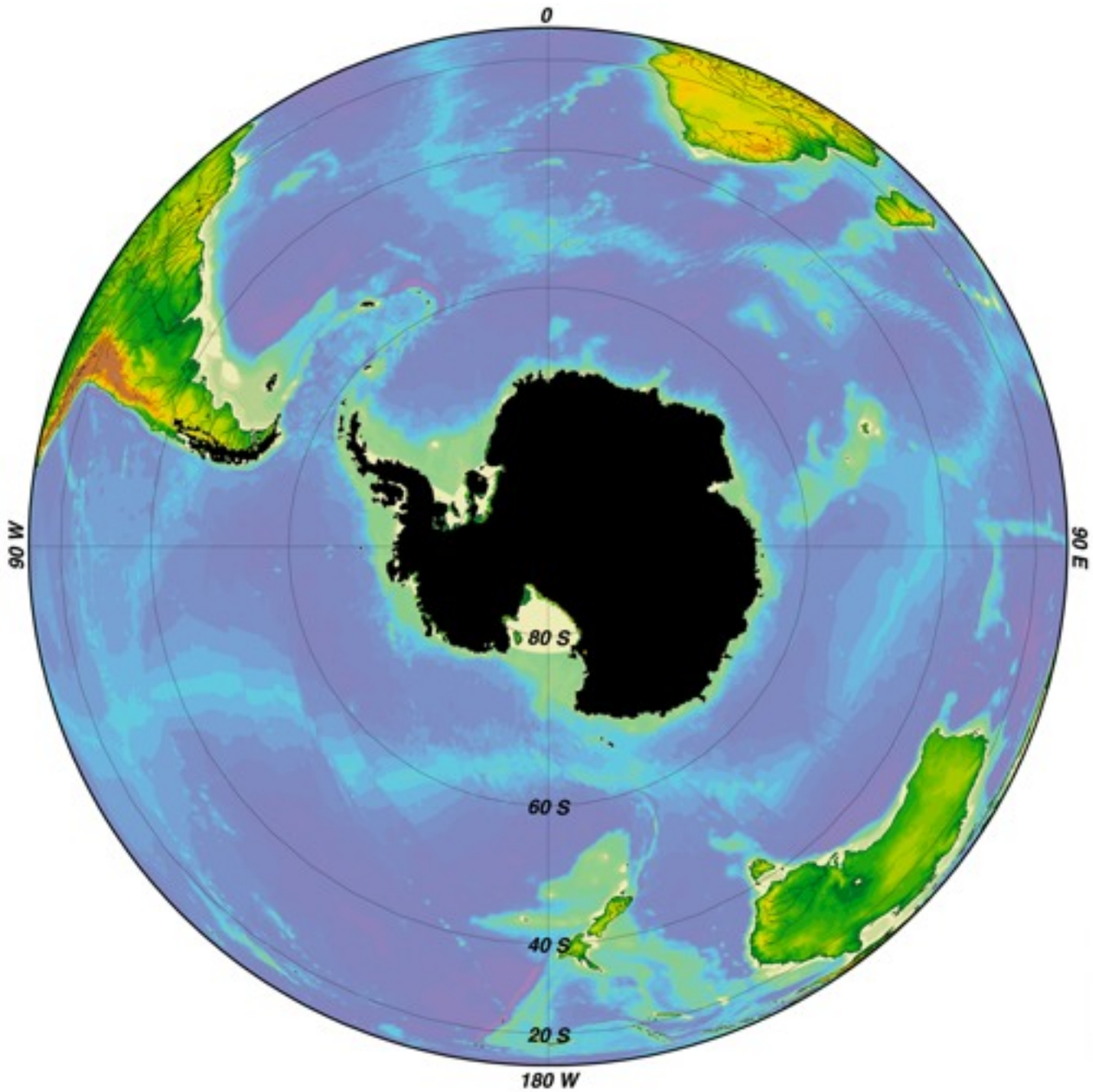
Quaternary

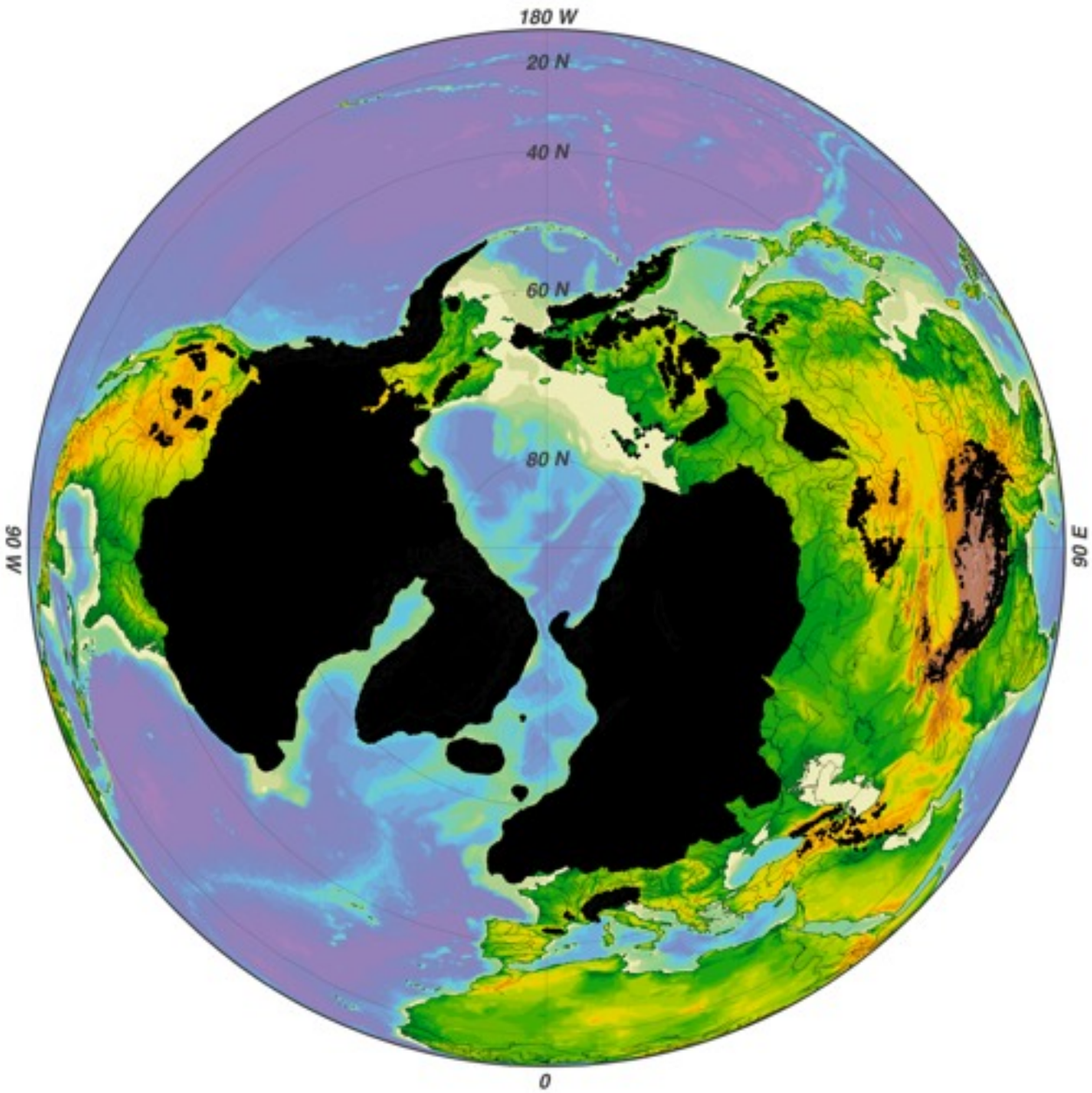

Change in Temperature (°C)
0
-2
-4
-6
Eiszeit
Warmzeit
0
100
200
300
400
500
600
700
800
Thousands of Years

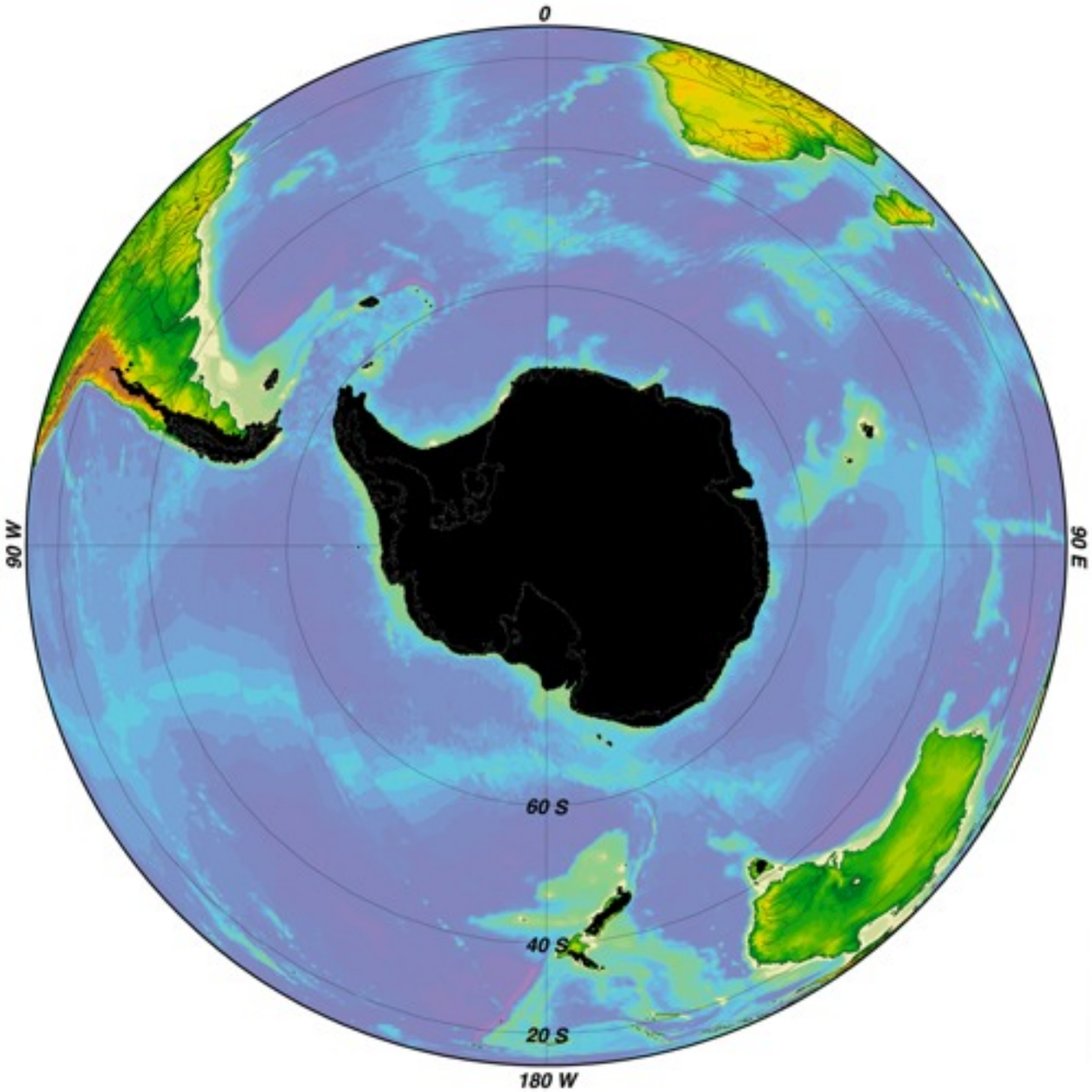
NUNATAK

Eiszeitalter seit 1,8 Millionen Jahren


180 W
20 N
40 N
60 N
80 N
90 W
90 E
0


0
90 W
90 E
80 S
60 S
40 S
20 S
180 W


180 W
20 N
40 N
60 N
80 N
90 W
90 E
0


0
90 W
90 E
60 S
40 S
20 S
180 W

Niederschlag

Verdunstung

Eiszeitlicher
Eisschild

Antarktis

Grönland

überhöht
nicht maßstabsgerecht

Gletscher 0.15~0.37 m

Grönland 7 m

Antarktis 57 m

Warmzeit 120 m

Eiszeit

Schelf

Schmelzwasser

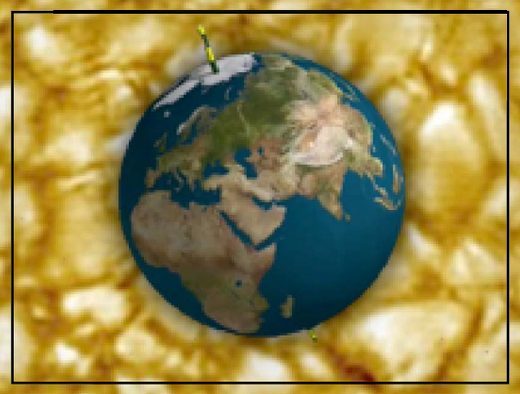
Kontinentalhang

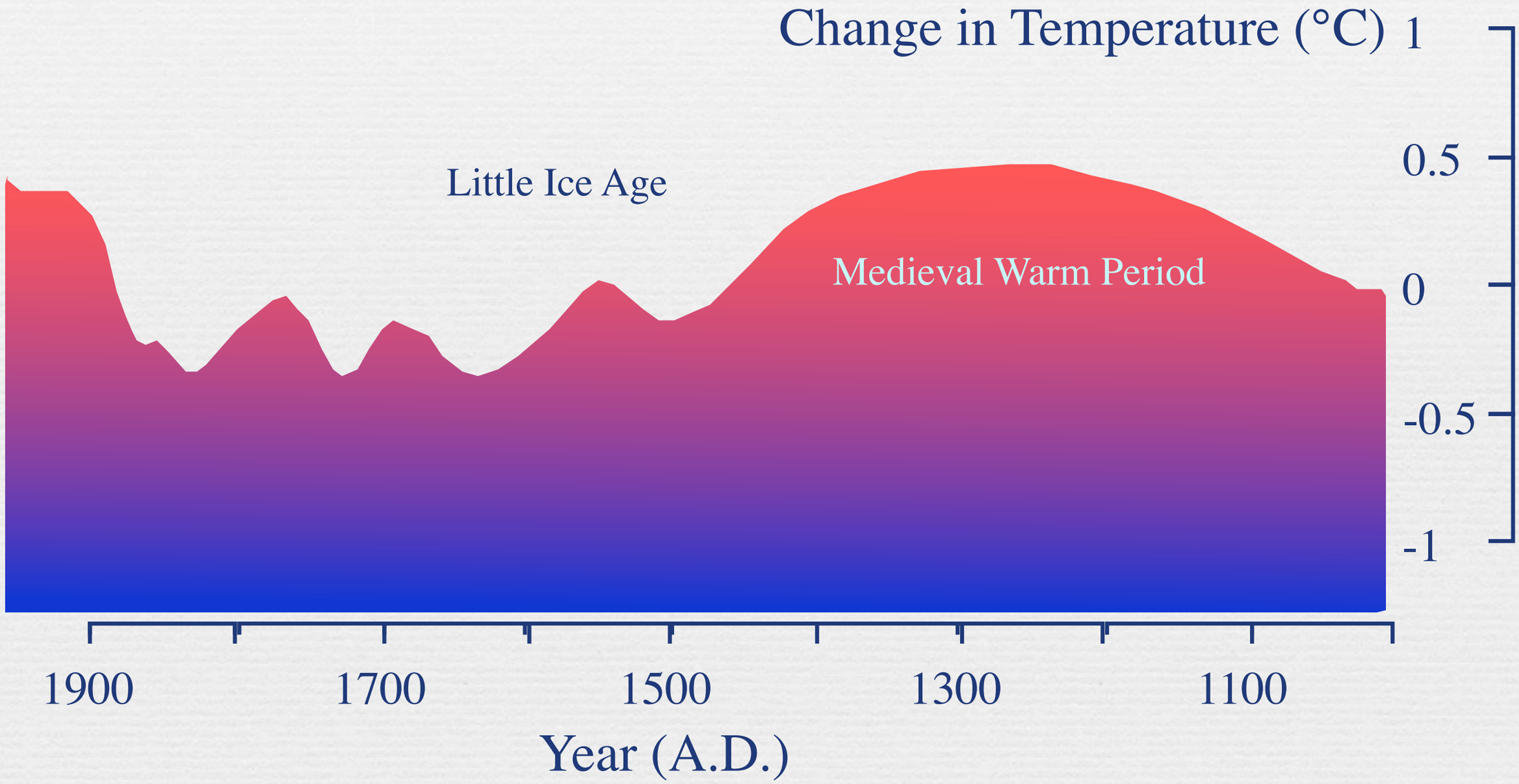
Tiefsee

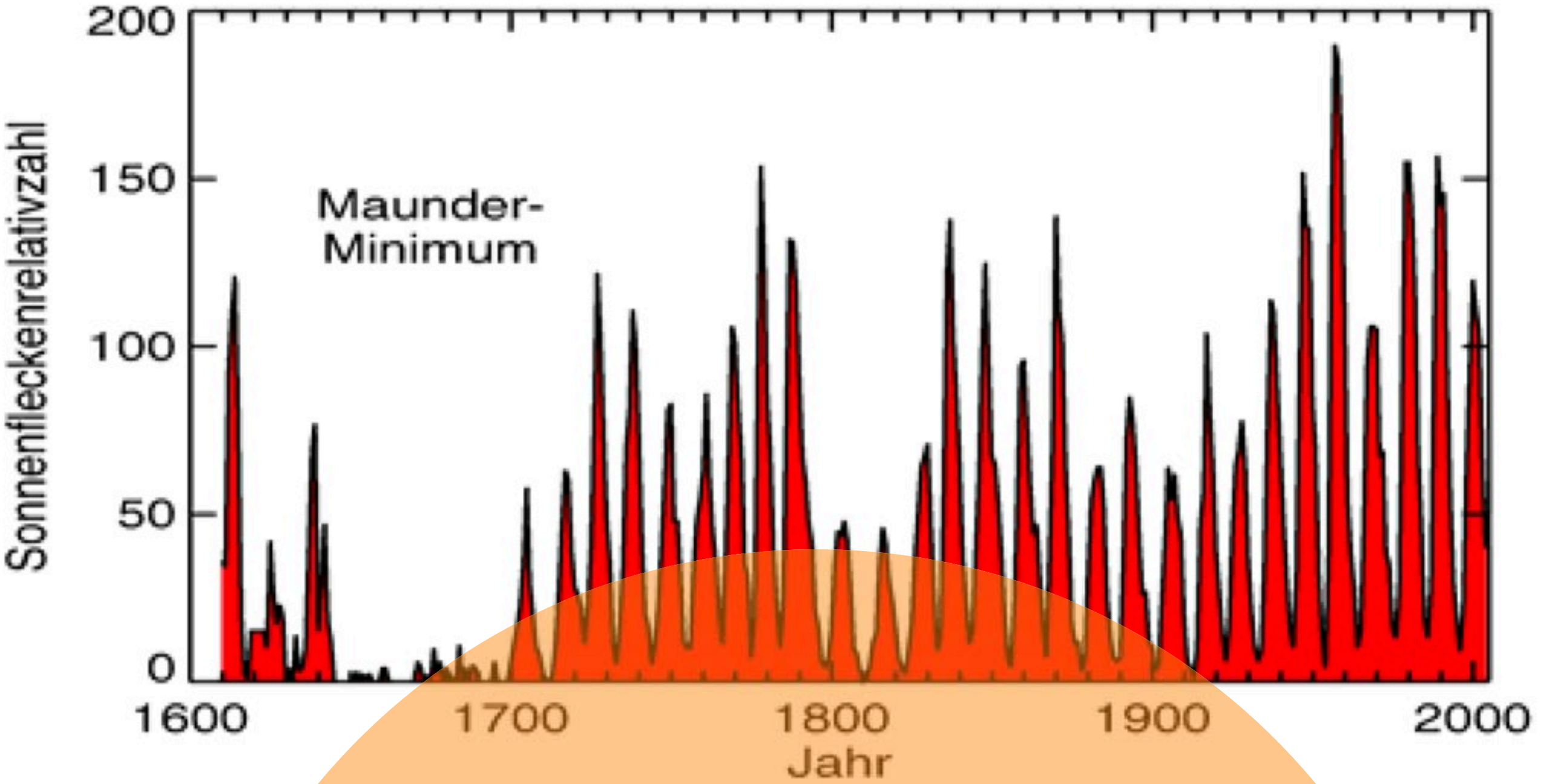
Anstieg des Meeresspiegels

Klimafaktor SONNE

Erde

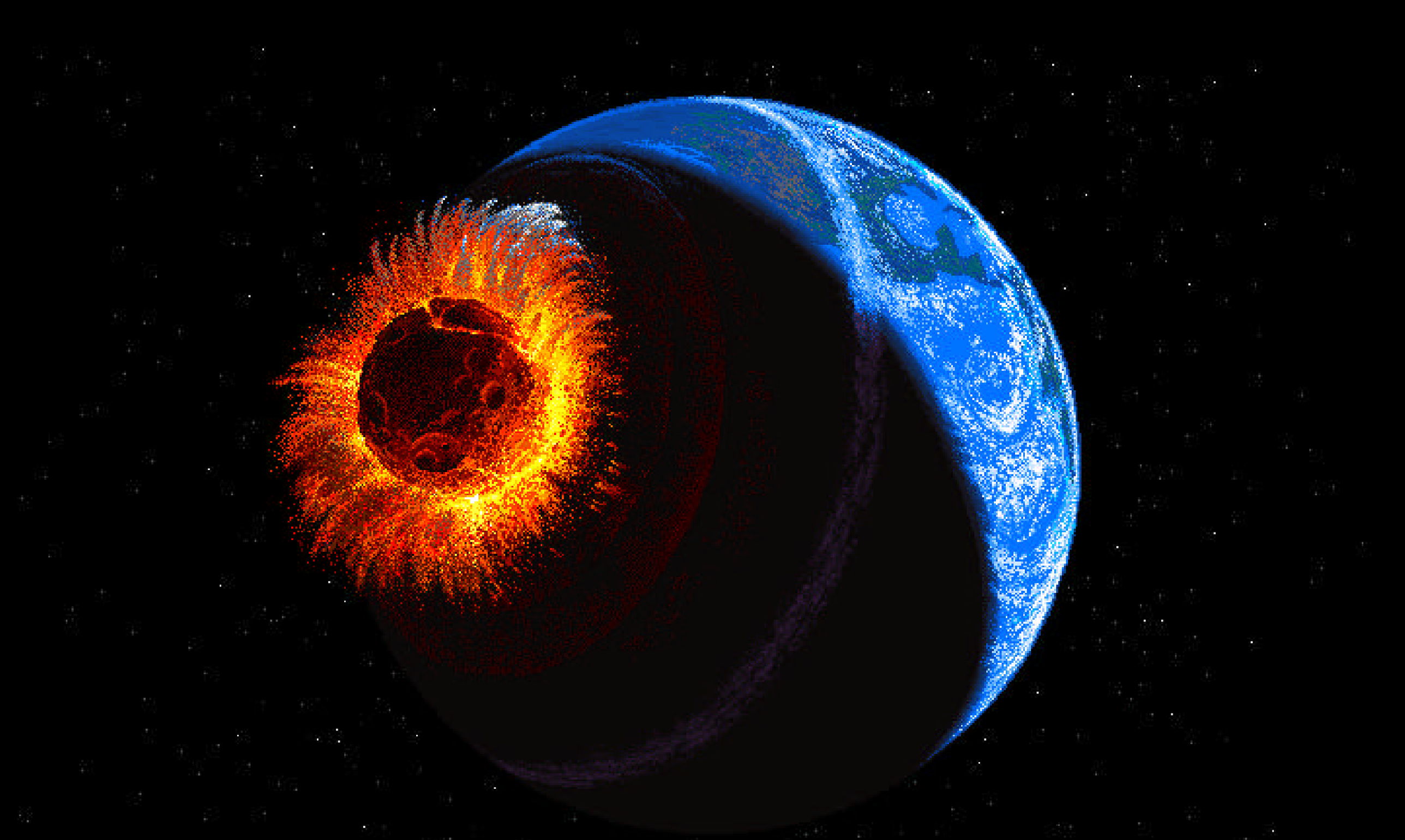



Change in Temperature (°C)
1
0.5
0
-0.5
-1
Little Ice Age
Medieval Warm Period
1900
1700
1500
1300
1100
Year (A.D.)



Sonnenflecken

Hendrick Avercamp (1585-1634) *Winterlandschaft* (ca.1608)



klimafaktor IMPAKT

Meteoriteneinschlag

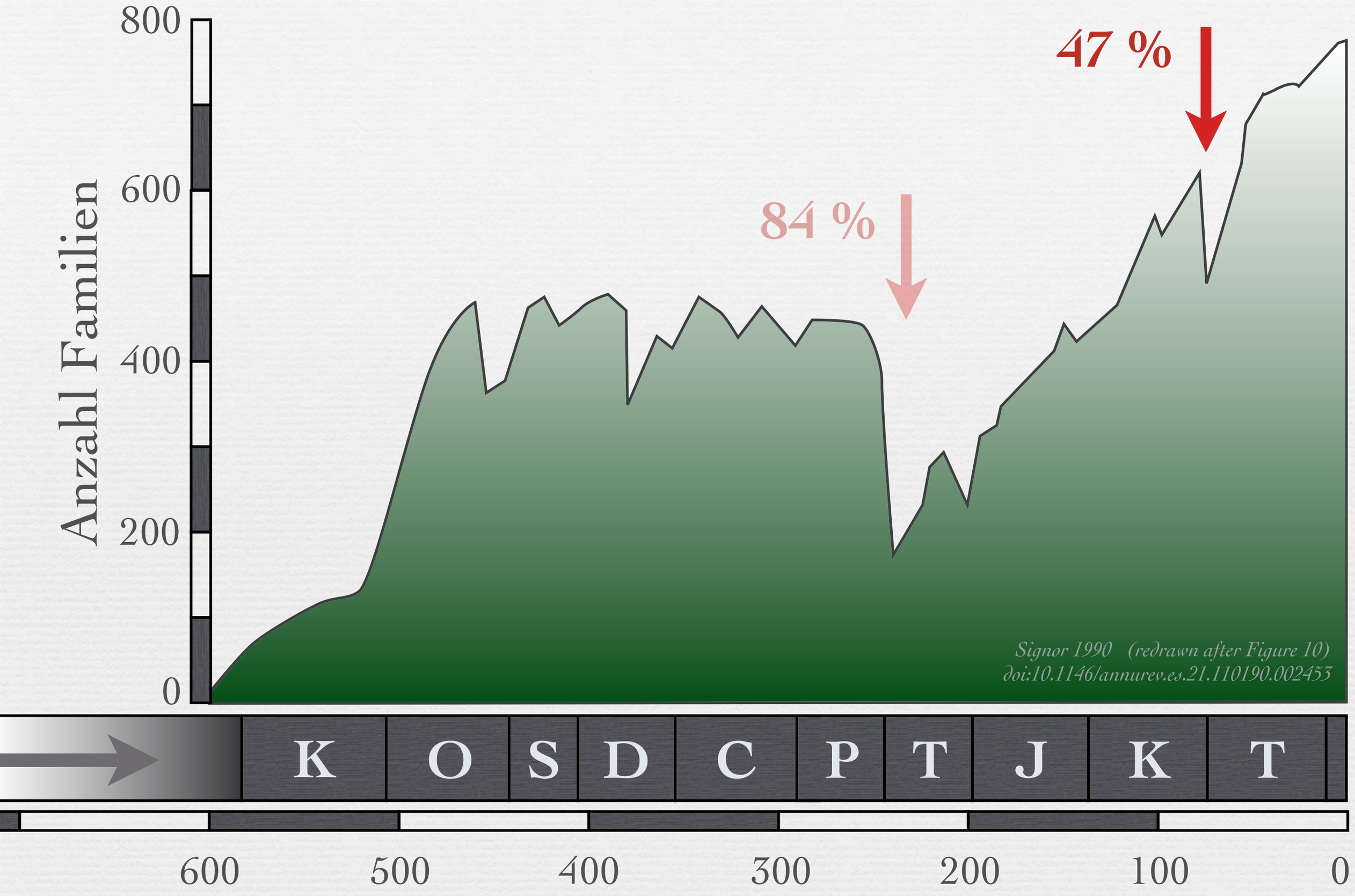
vor 65 Millionen Jahren (Kreide/Tertiär)

12 km Ø - 30 km/sec

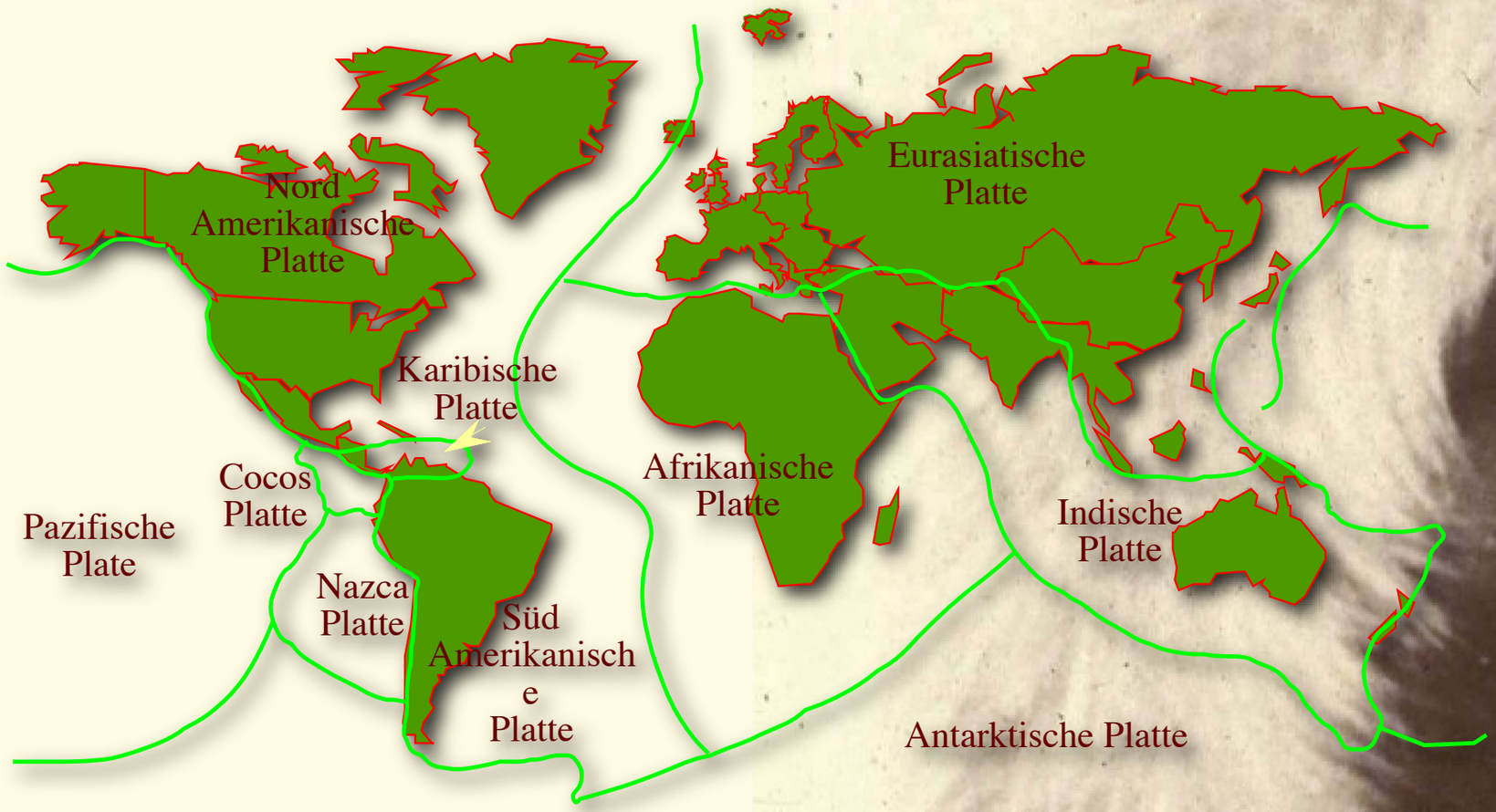
eq. 100 Mio Wasserstoffbomben

200 km Ø Krater

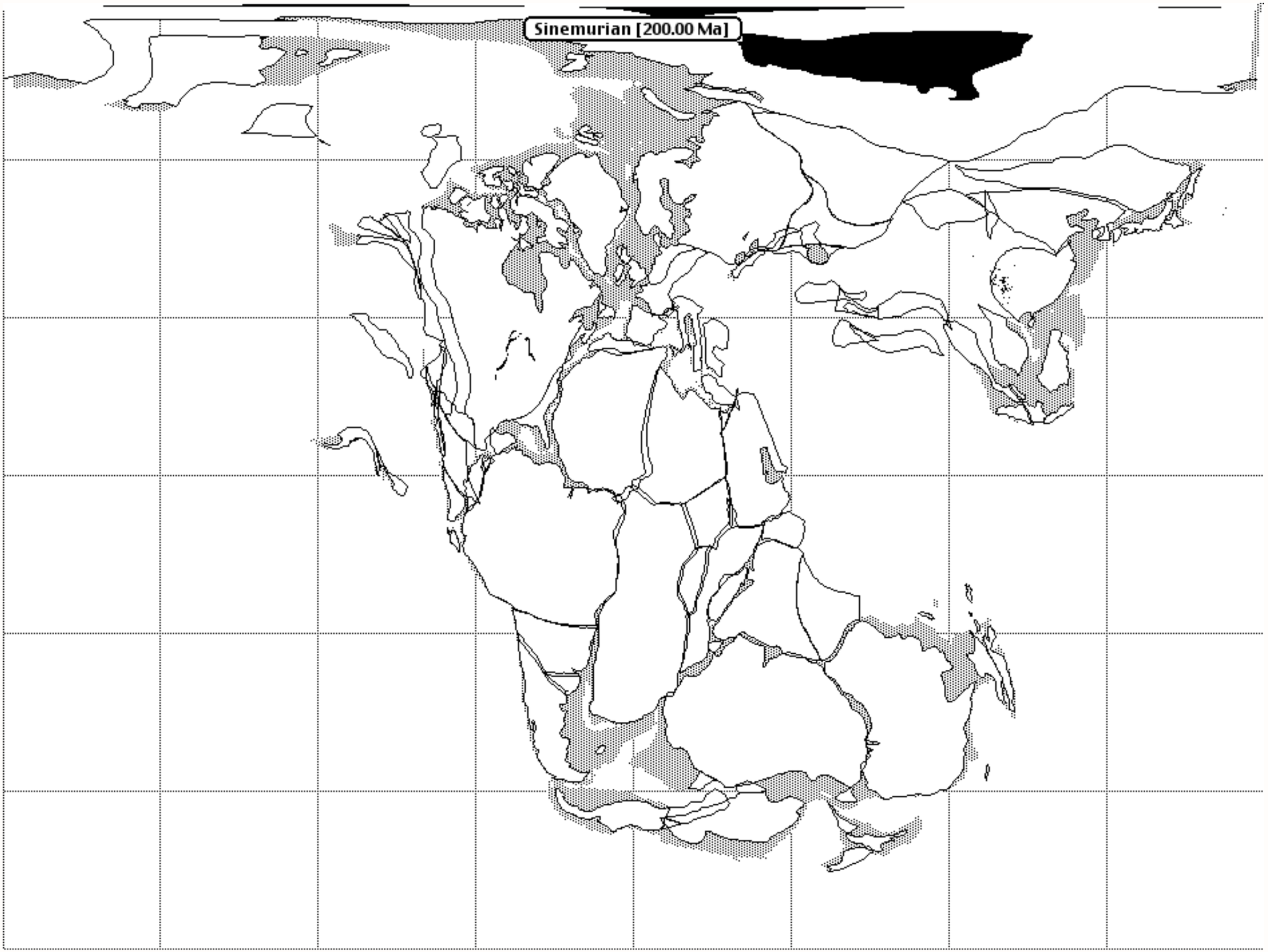
> Impaktwinter


Anzahl Familien
800
600
400
200
0
84 %
47 %
Signor 1990 (redrawn after Figure 10)
doi:10.1146/annurev.es.21.110190.002453
K
O
S
D
C
P
T
J
K
T
600
500
400
300
200
100
0
Geologisches Alter [Millionen Jahre]

Lithosphäre



Klimafaktor Plattentektonik



PALEOMAP Project - Christopher R. Scotese

Joseph M.W. Turner (1817) *Eruption of Vesuvius*

Tambora

Sunda-Inseln, Indonesien

10. April 1815

entspr. 150 000 Atombomben

1816 > *Jahr ohne Sommer*

NASA - EarthObservatory

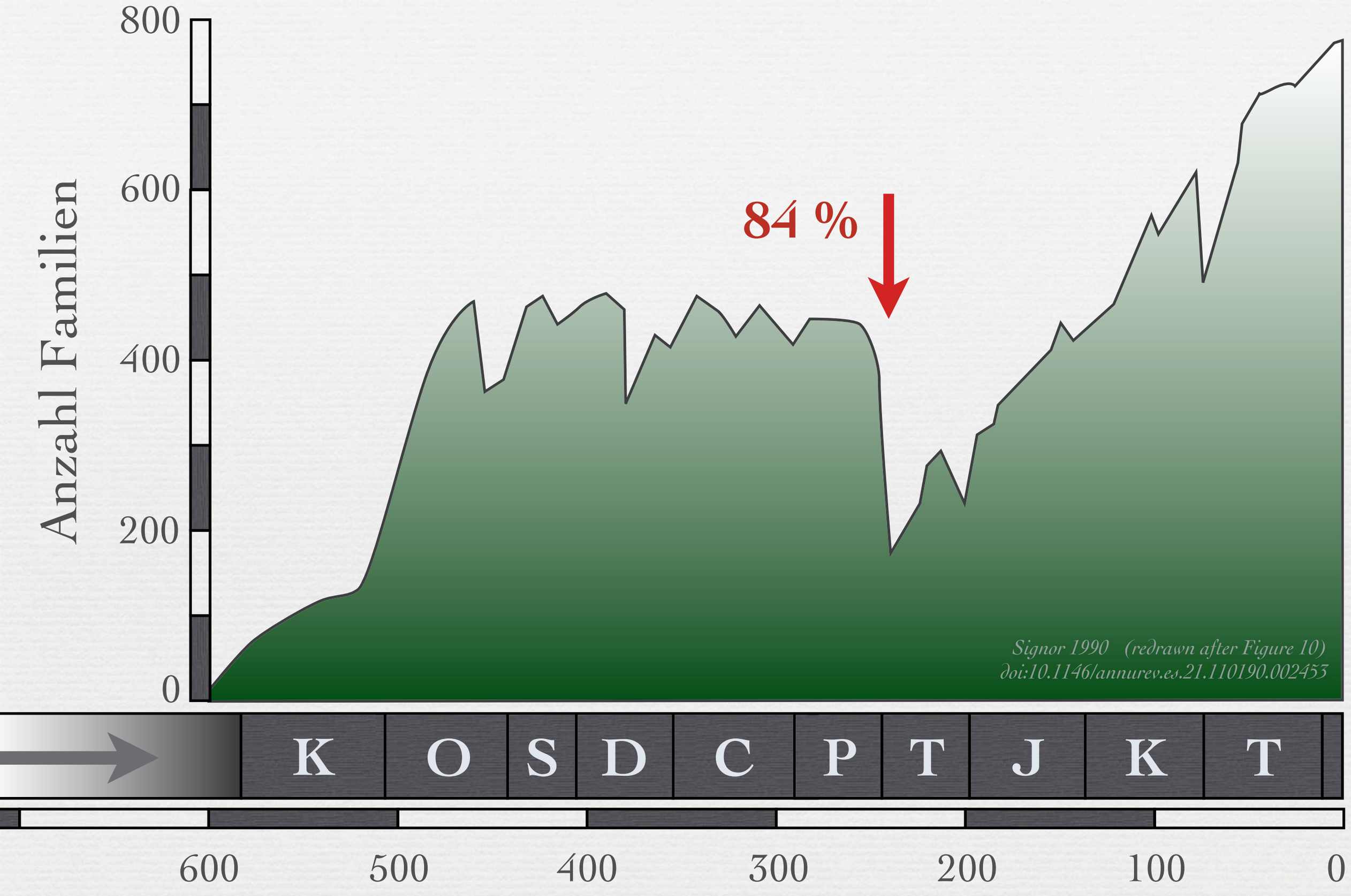
Joseph M.W. Turner (1838) *Flint Castle*

Plateau-Basalt

Plateaubasalte vor 250 Mio. Jahren (*Sibirischer Trapp*)

CO_2-Gehalt +700 ppm

Wikipedia (Jo Weber)


Anzahl Familien
800
600
400
200
0
84 %
Signor 1990 (redrawn after Figure 10)
doi:10.1146/annurev.es.21.110190.002453
K
O
S
D
C
P
T
J
K
T
600
500
400
300
200
100
0
Geologisches Alter [Millionen Jahre]

Hydrosphäre

vor 3 Millionen Jahre

vor 35 Millionen Jahre

Oberflächenströmung

Tiefenströmung

Bodenströmung

Tiefenwasserbildung

Salinität > 36 ‰

Salinität < 34 ‰

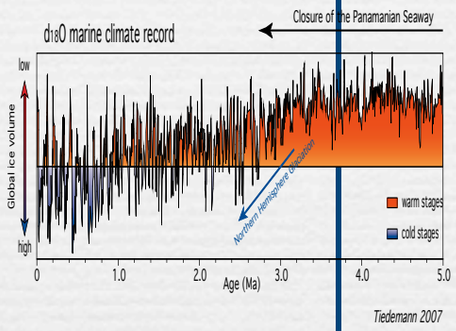
Klimafaktor Meeresströmung

(nach Rahmstorf 2002)

Quaternary

Tertiary

Mesozoic



Eiszeitalter

warm

cold

Mean Global Temperature

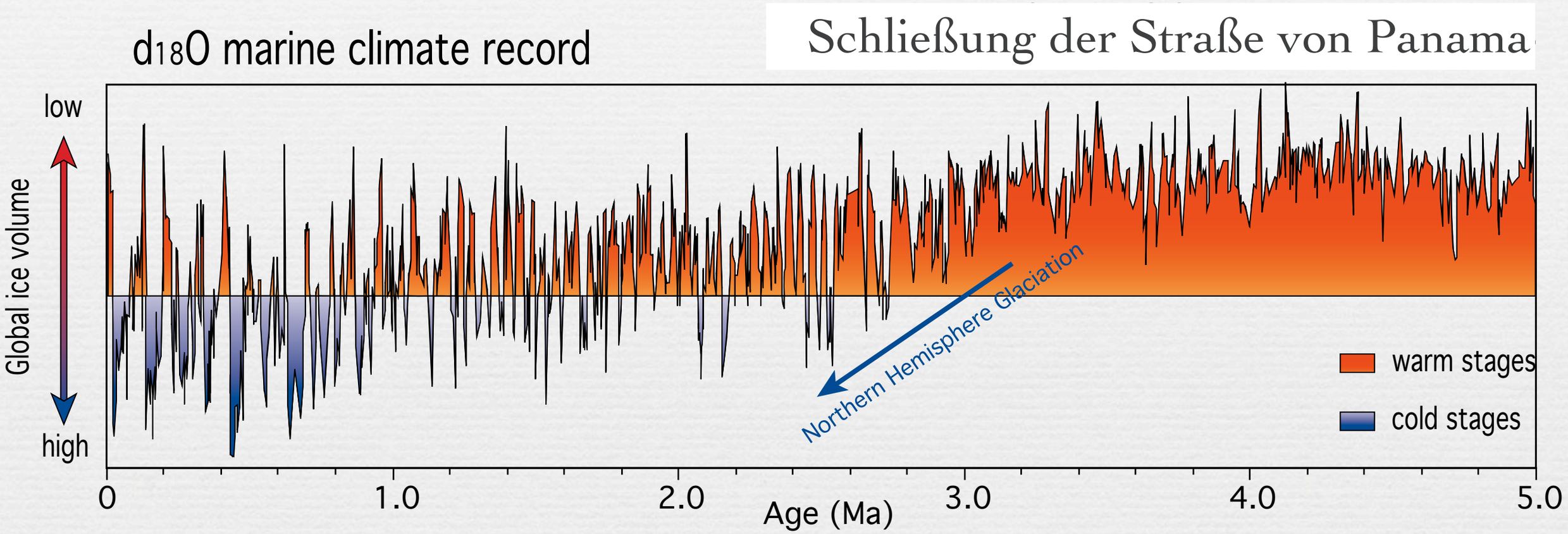
1.8

65

180

Millions of Years (B.P.)

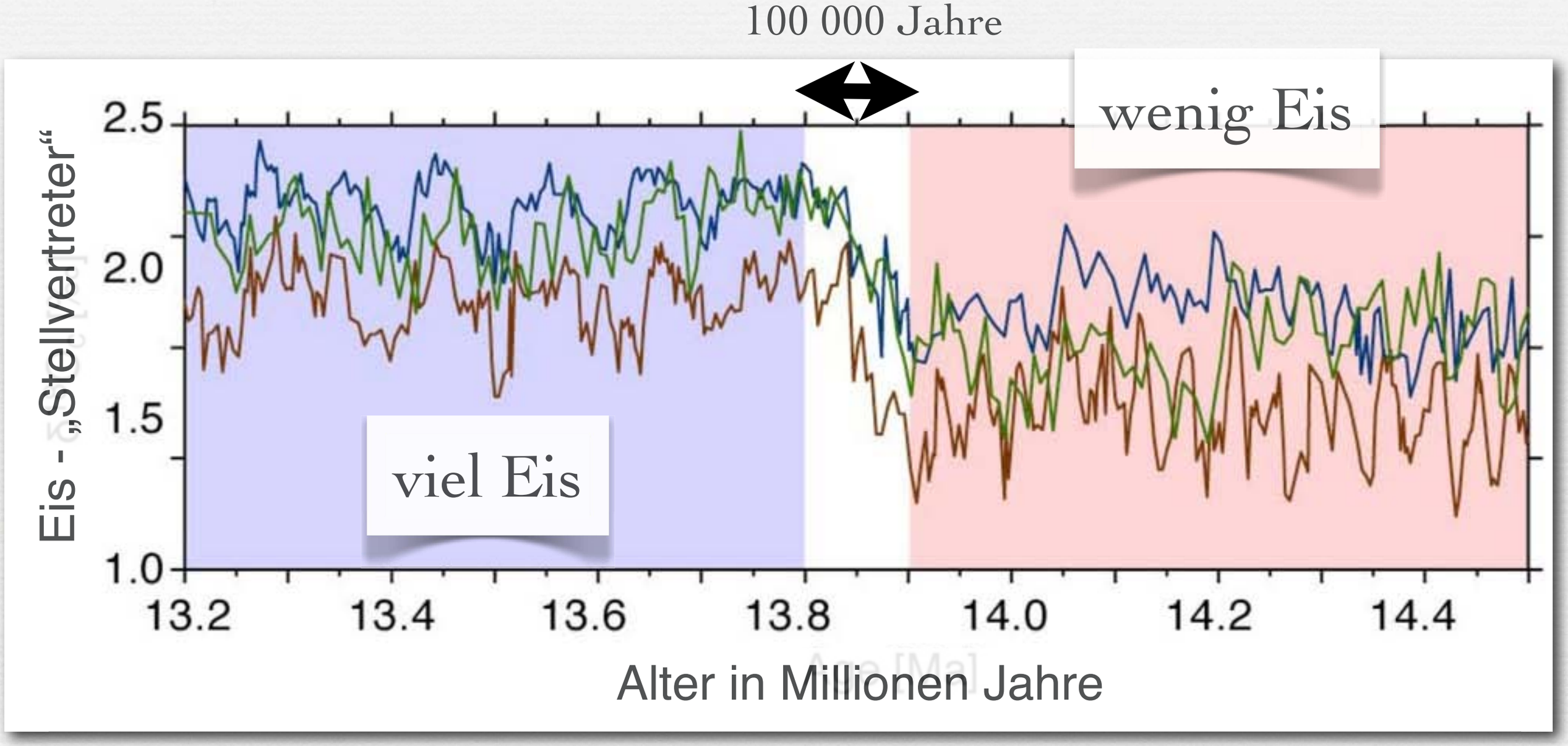
Schließung der Straße von Panama



Tiedemann 2007

Albedo

Abkühlung im Miozän



Data from Holburn et al. 2005, Shevenell et al. 2004; Grafic after Langebroek et al. 2009

Kalkstein


McMURDO STATION 3 km
(UNITED STATES)
SCOTT BASE
(NEW ZEALAND)
AA
AA
CANTERBURY

Olivin

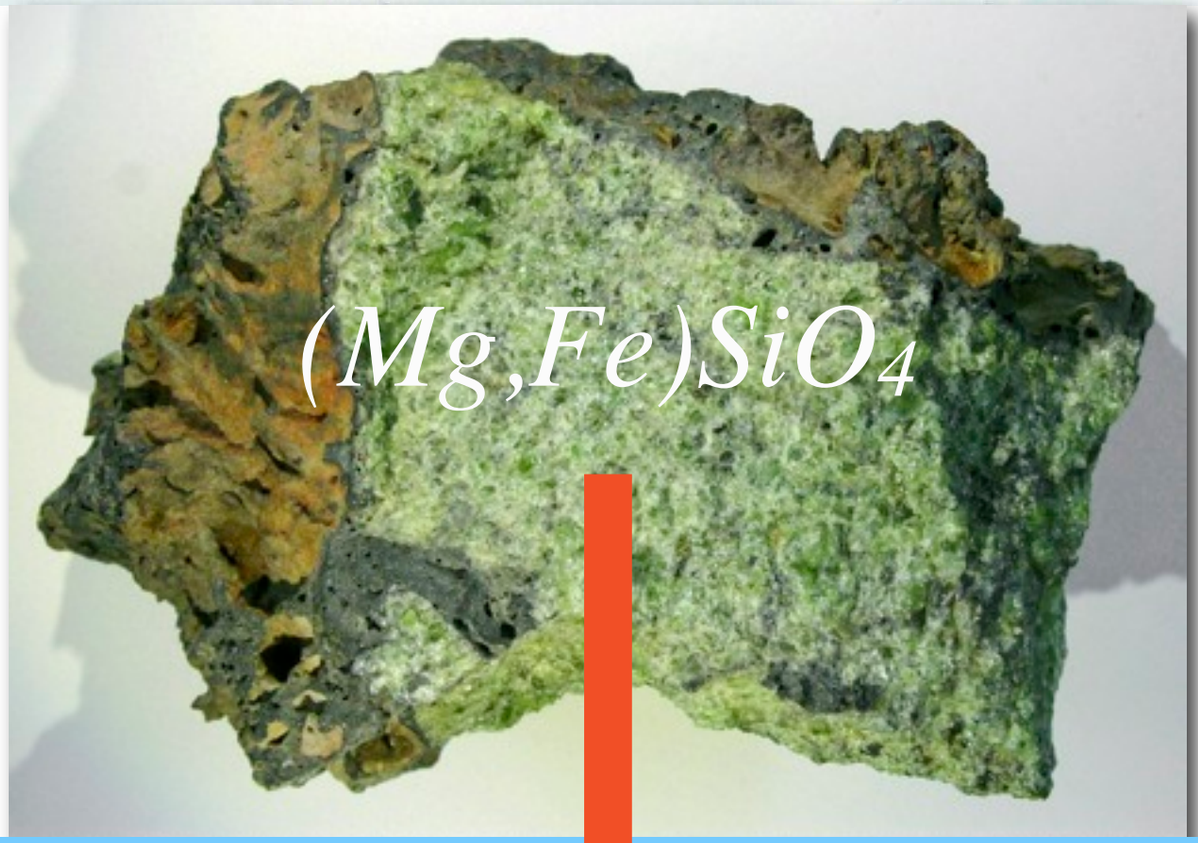
AWI Alfre… für Po…

Startseite | Aktuelles

- Kurzmeldungen
- Pressemitteilungen
- Pressearchiv

9. November 2010: **Wie viel Kohlendioxid kann der Atmosphäre entzogen werden, wenn das Mineral Olivin an Land vermehrt aufgelöst wird?**

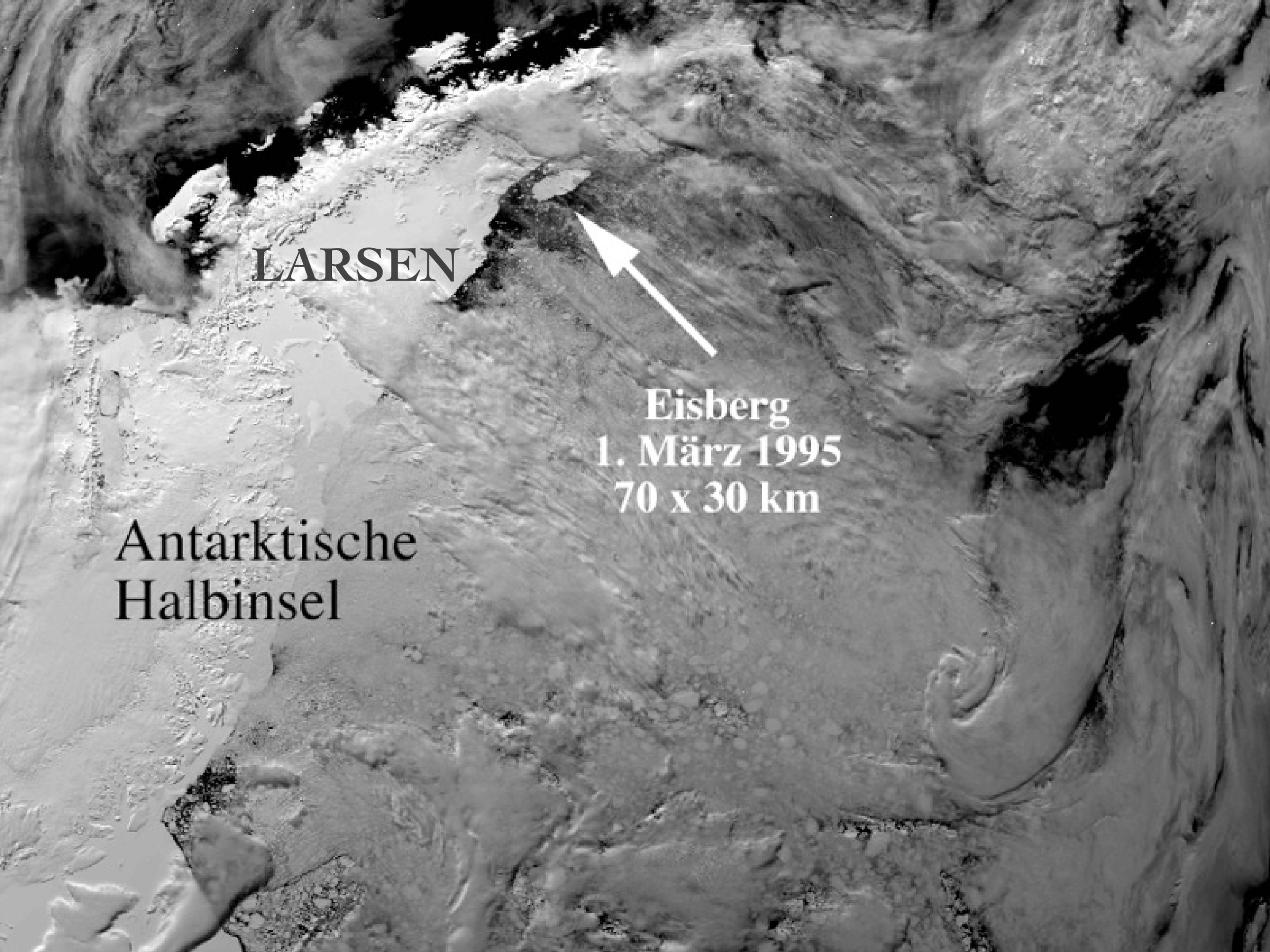
Regenwasser (H_2O) + Kohlendioxid (CO_2)

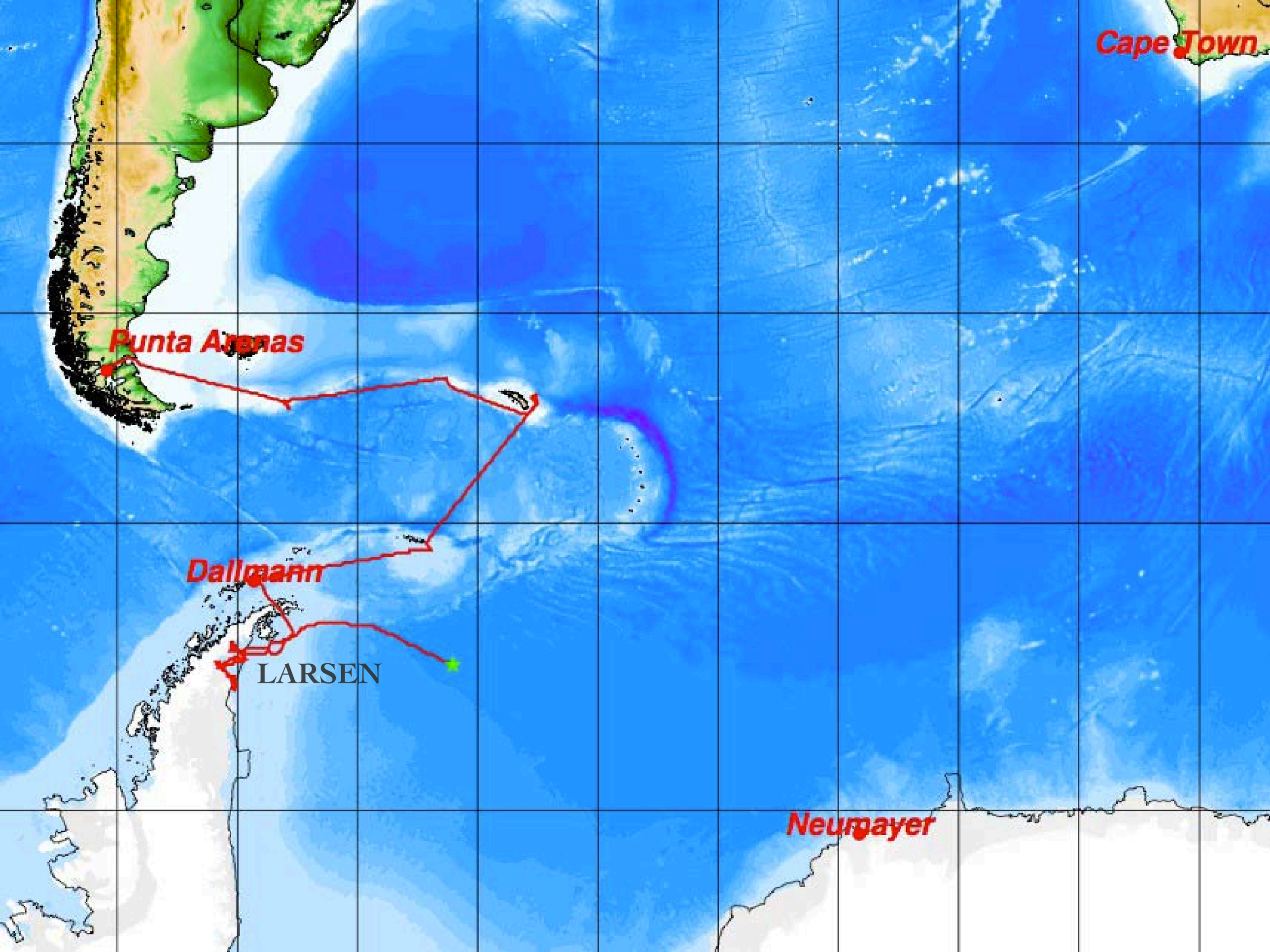


Verwitterung

*Flüsse -> Ozean -> **Sedimente***

Kryosphäre


LARSEN
Eisberg
1. März 1995
70 x 30 km
Antarktische
Halbinsel

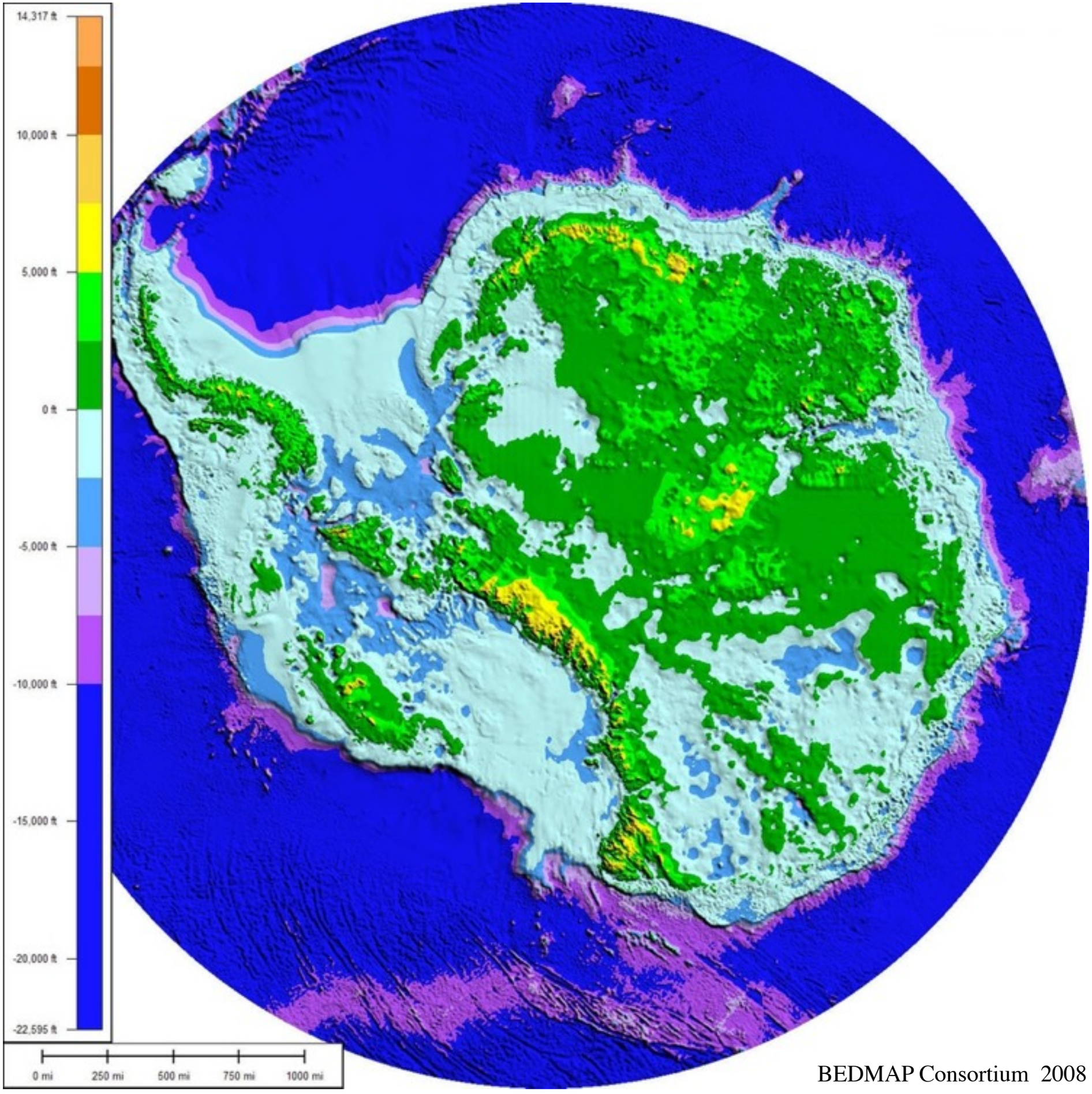

Cape Town
Punta Arenas
Dallmann
LARSEN
Neumayer

„unter“ Larsen

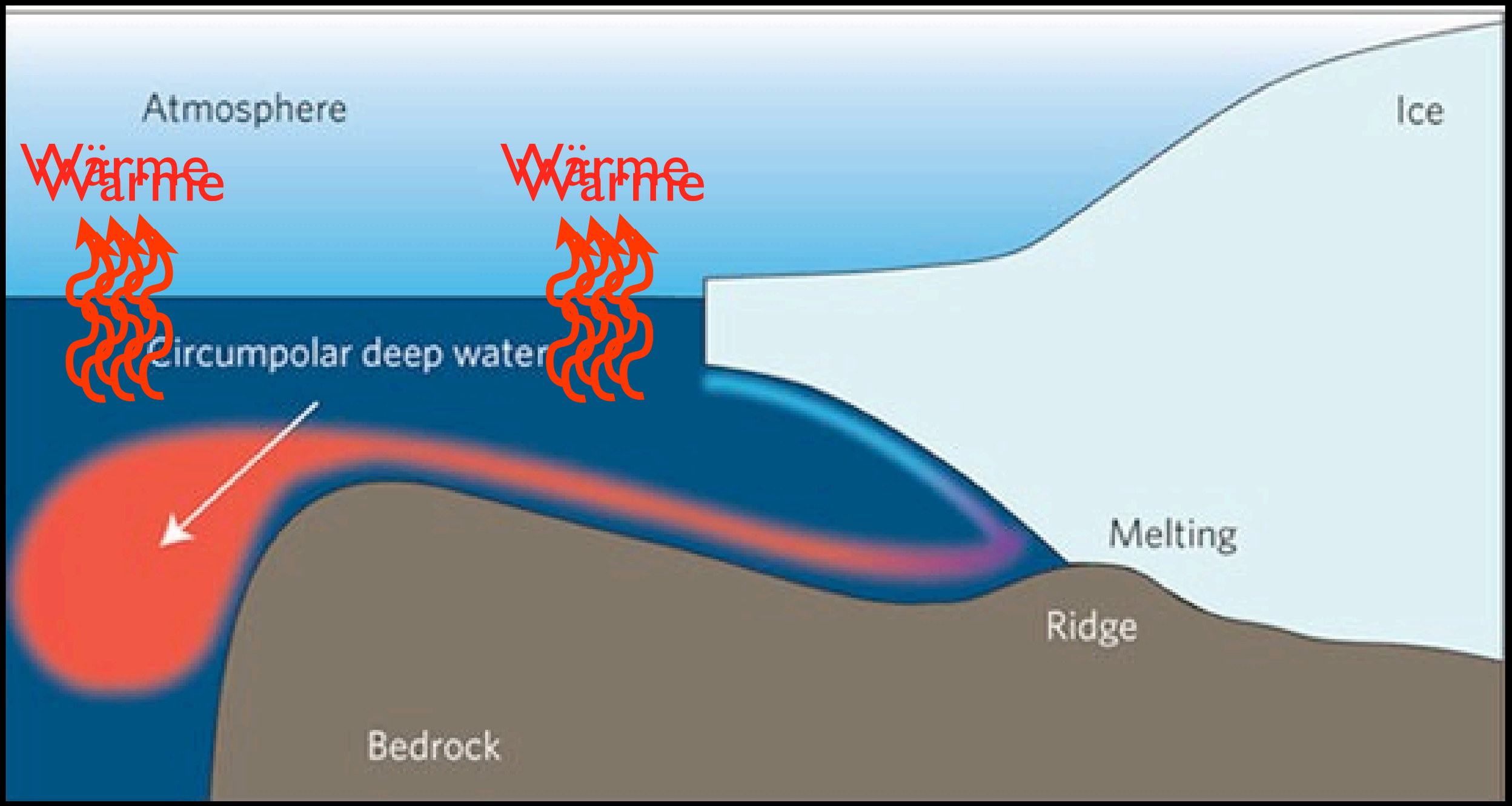
Foto: T. Lundälv, Polarstern 2011-03-03

„über“ Larsen

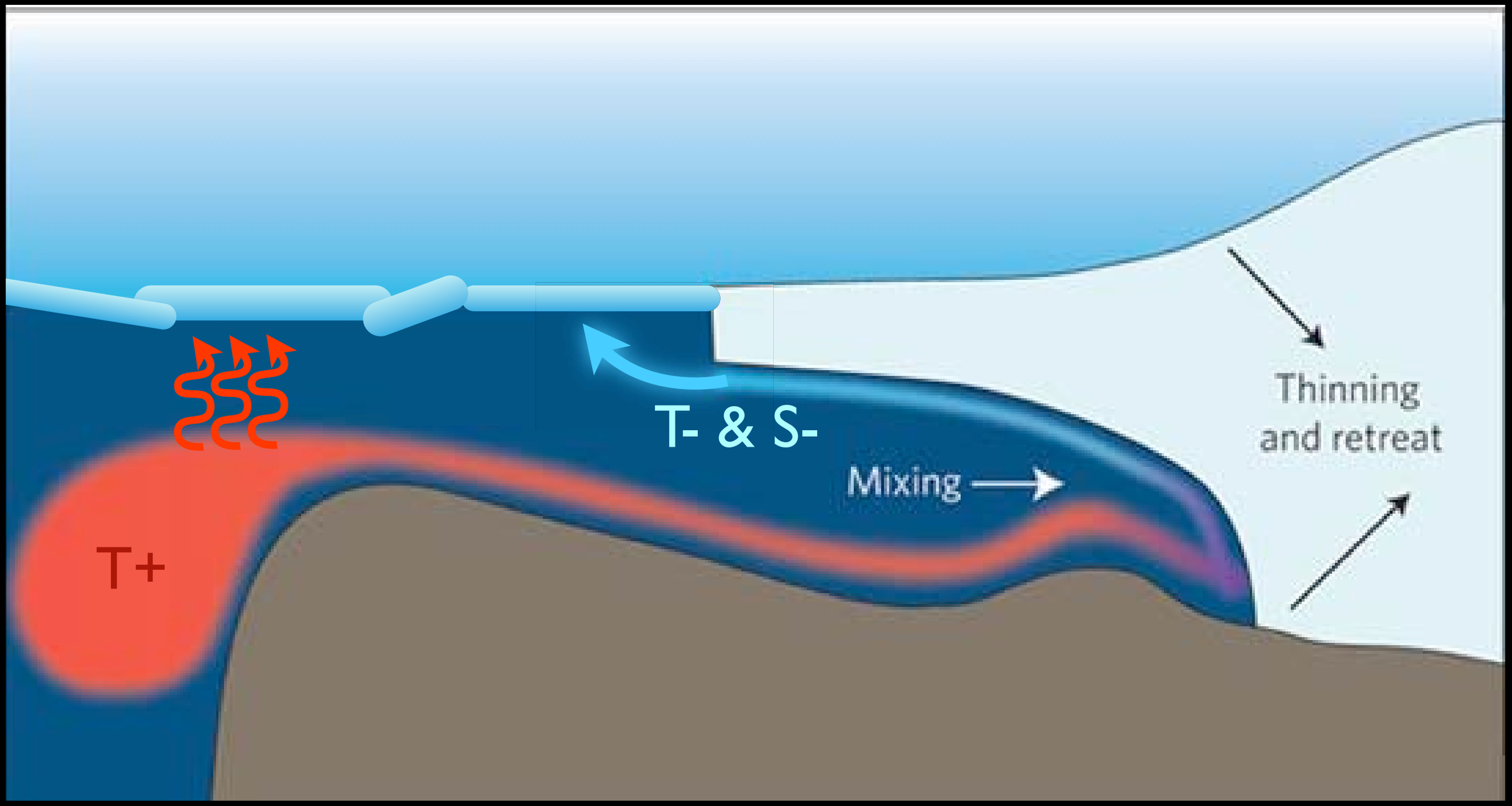
Foto: R. Knust, Polarstern 2011-03-03



BEDMAP Consortium 2008



modified after Schoof (2010) doi:10.1038/ngeo895



modified after Schoof (2010) doi:10.1038/ngeo895

Atmosphäre

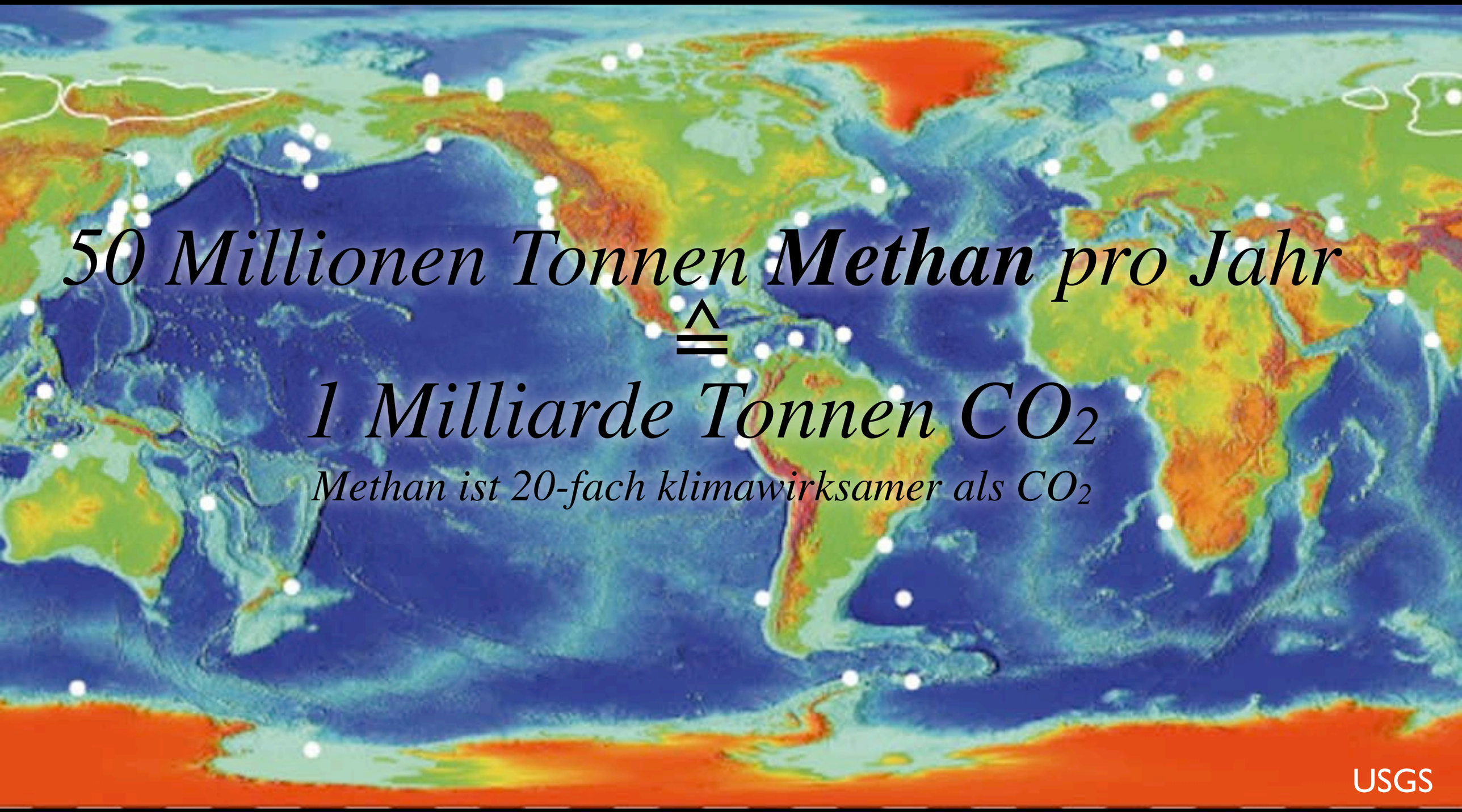
Permafrost

Permafrost

Source: International Permafrost Association, 1998.
Circumpolar Active-Layer Permafrost System (CAPS), version 1.0.

Carla Browning, University of Alaska Fairbanks 2007

Gashydrate



*50 Millionen Tonnen **Methan** pro Jahr*

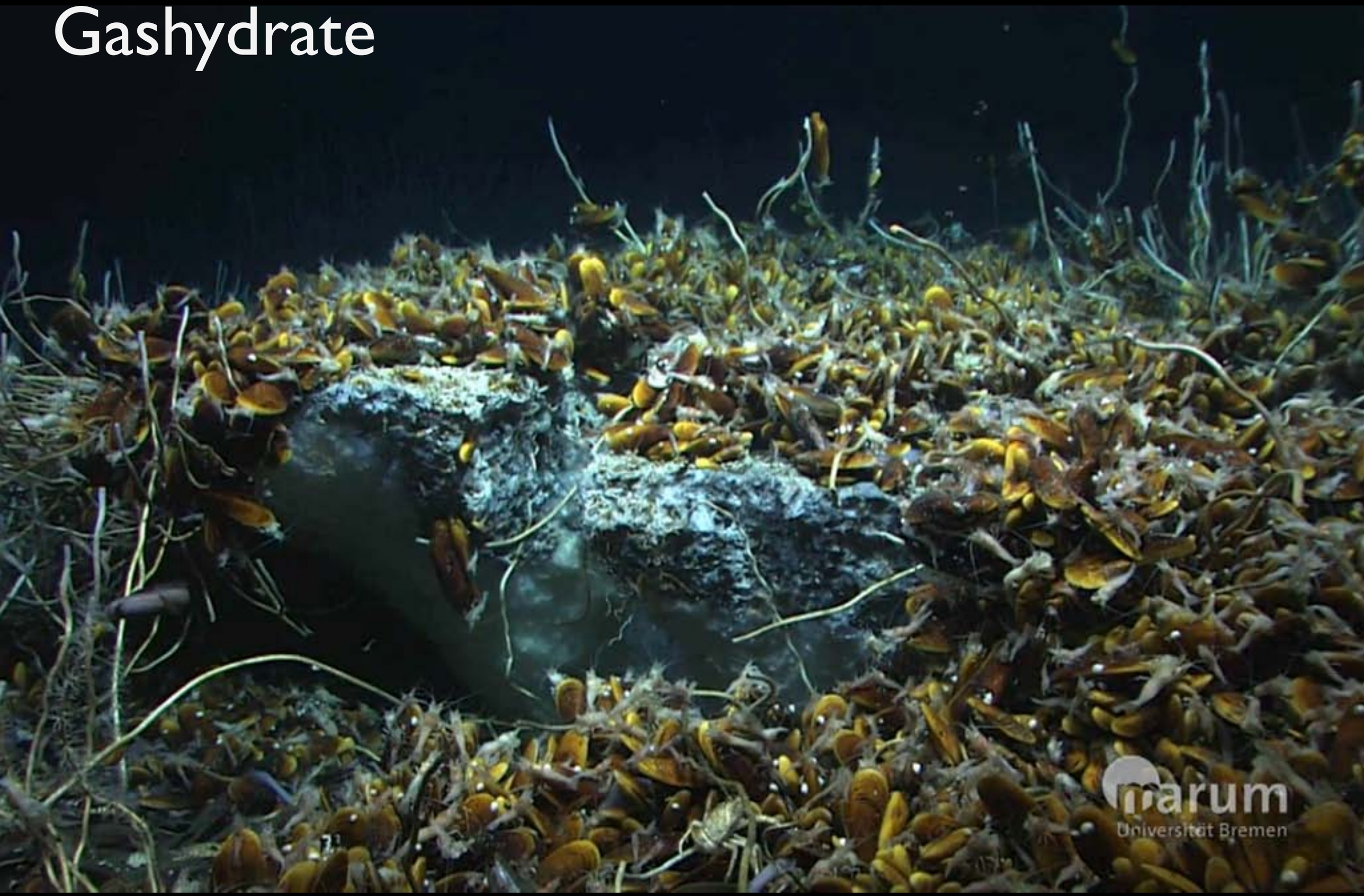
≙

1 Milliarde Tonnen CO_2

Methan ist 20-fach klimawirksamer als CO_2

USGS

Gashydrate



TEMPERATUR [°C]

0 2 4 6 8 10 12 14 16 18 20

TIEFE [M]

0 200 400 600 800 1000

MEERESOBERFLÄCHE

TEMPERATURPROFIL

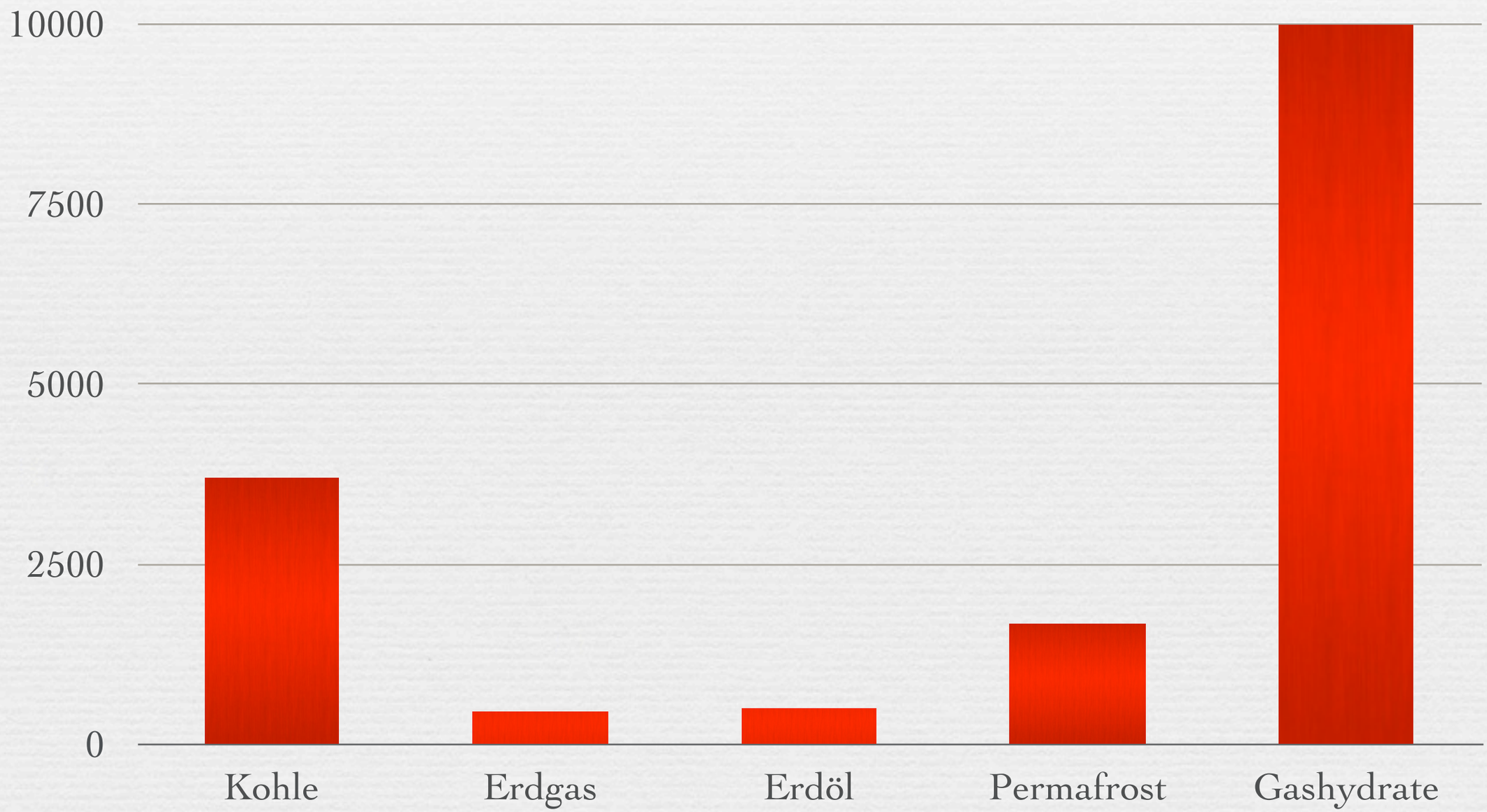
PHASEN-
GRENZE

BODENWASSER-TEMPERATUR
IN DER KREIDE (100-65 MIO JAHRE)
Huber et al. 2002

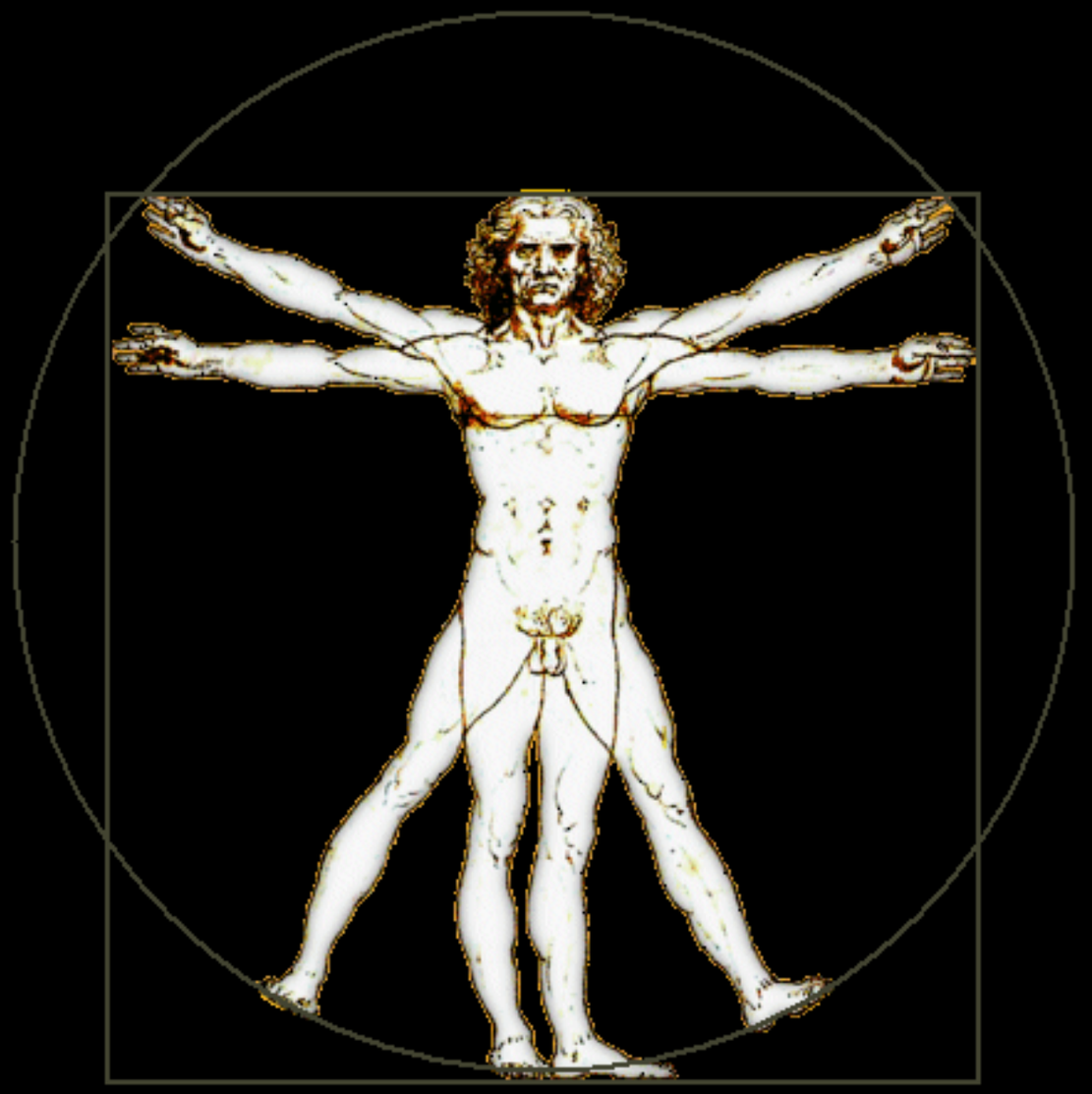
MEERESBODEN

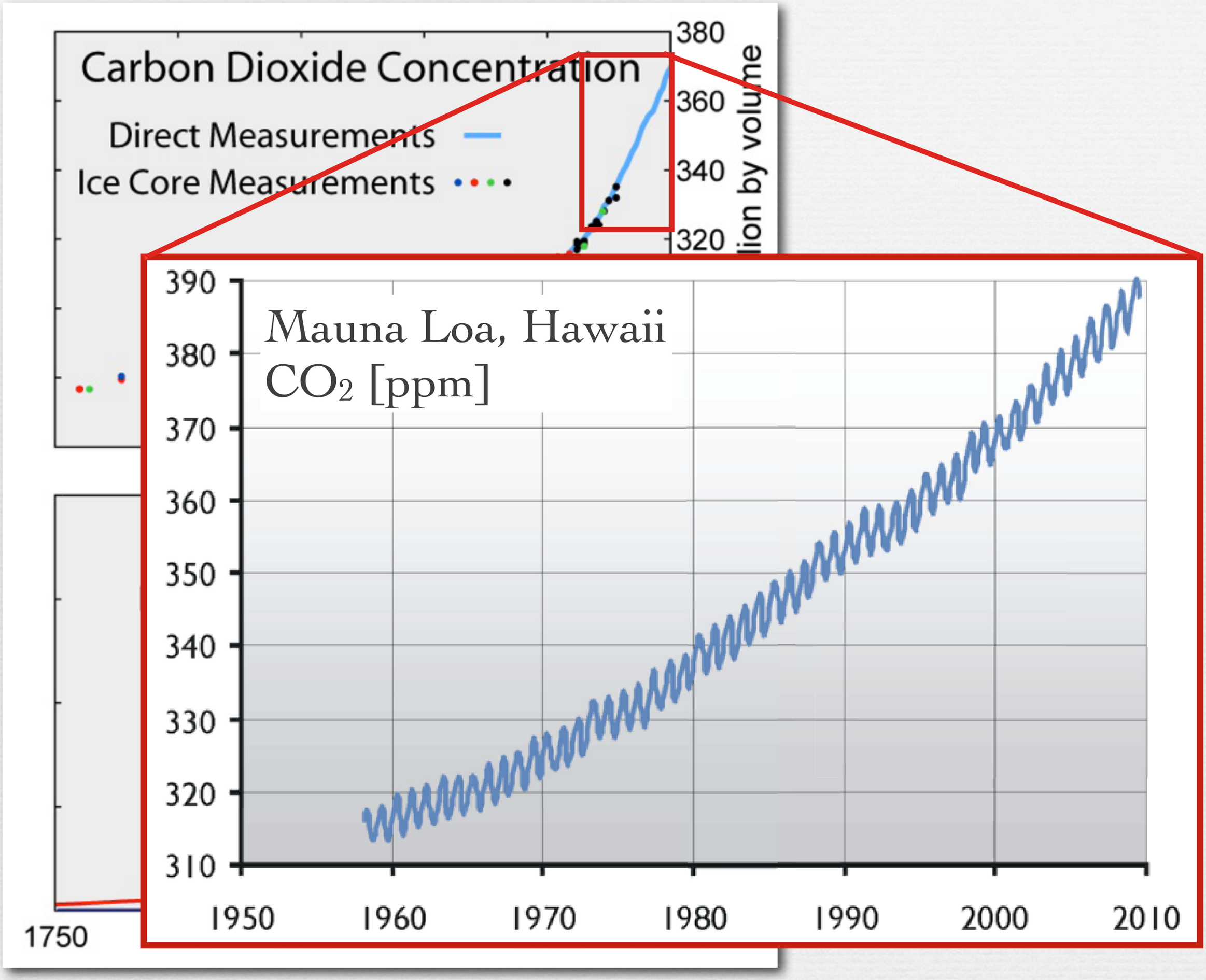
GASHYDRATE

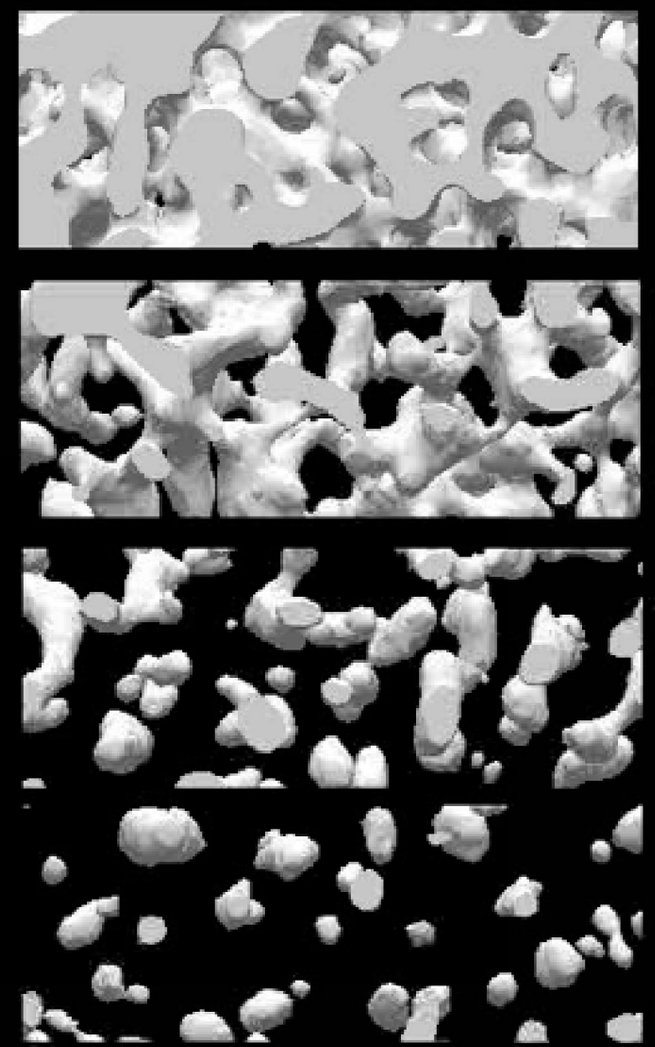
Kohlenstoff -Reservoir [GT]

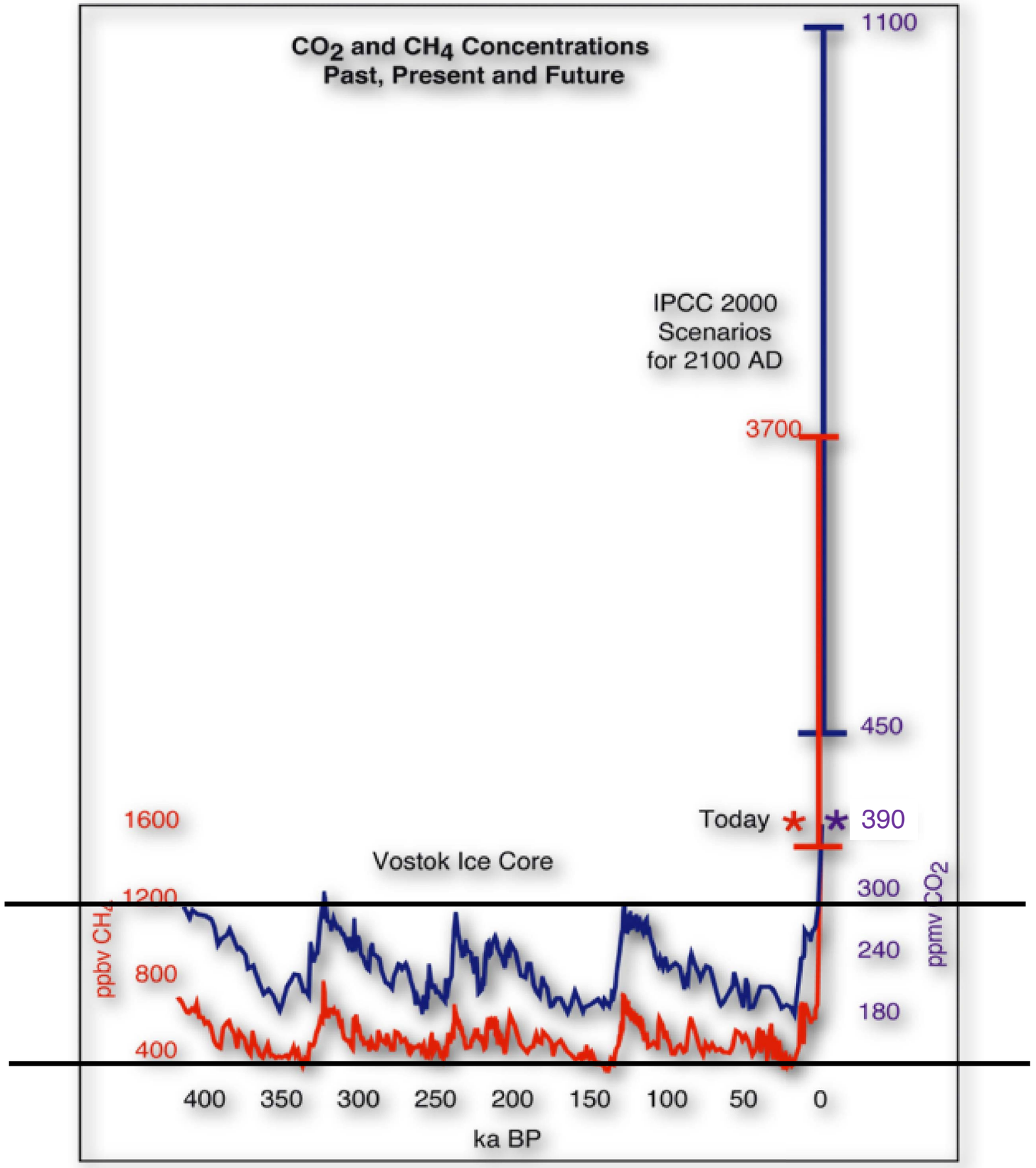


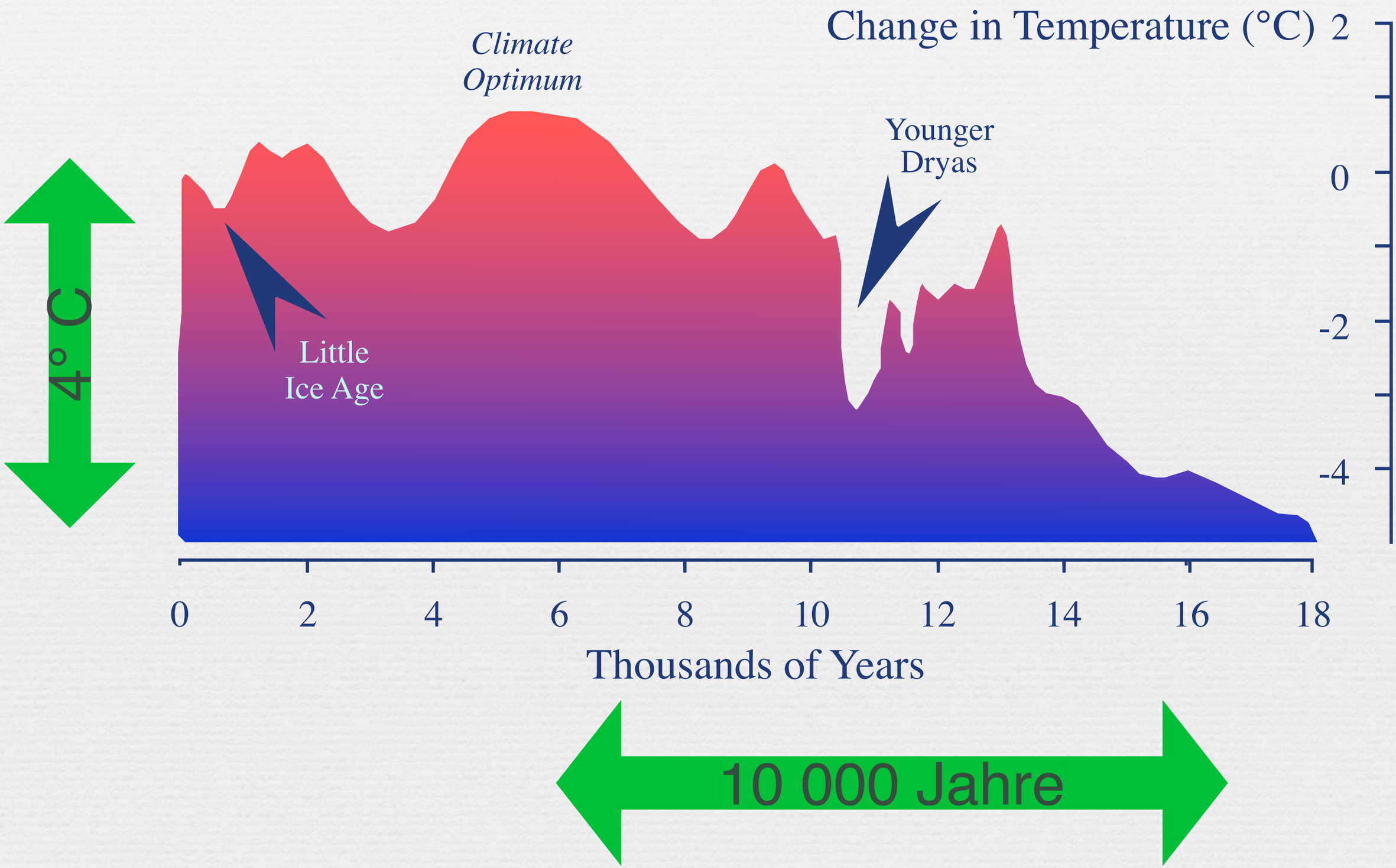
Anthroposphäre

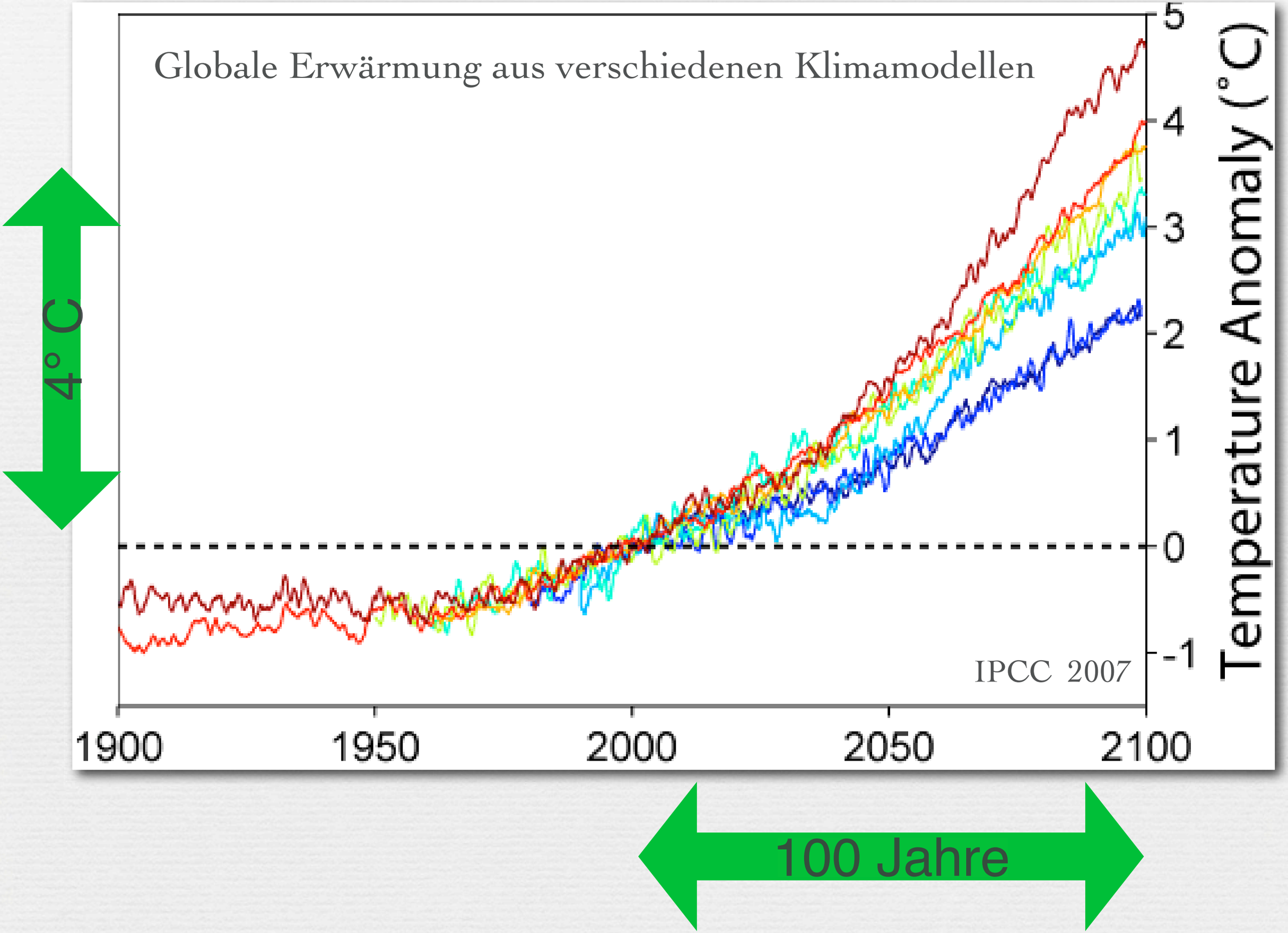



Carbon Dioxide Concentration
Direct Measurements
Ice Core Measurements
380
360
340
320
ion by volume
1750
Mauna Loa, Hawaii
CO2 [ppm]
390
380
370
360
350
340
330
320
310
1950
1960
1970
1980
1990
2000
2010

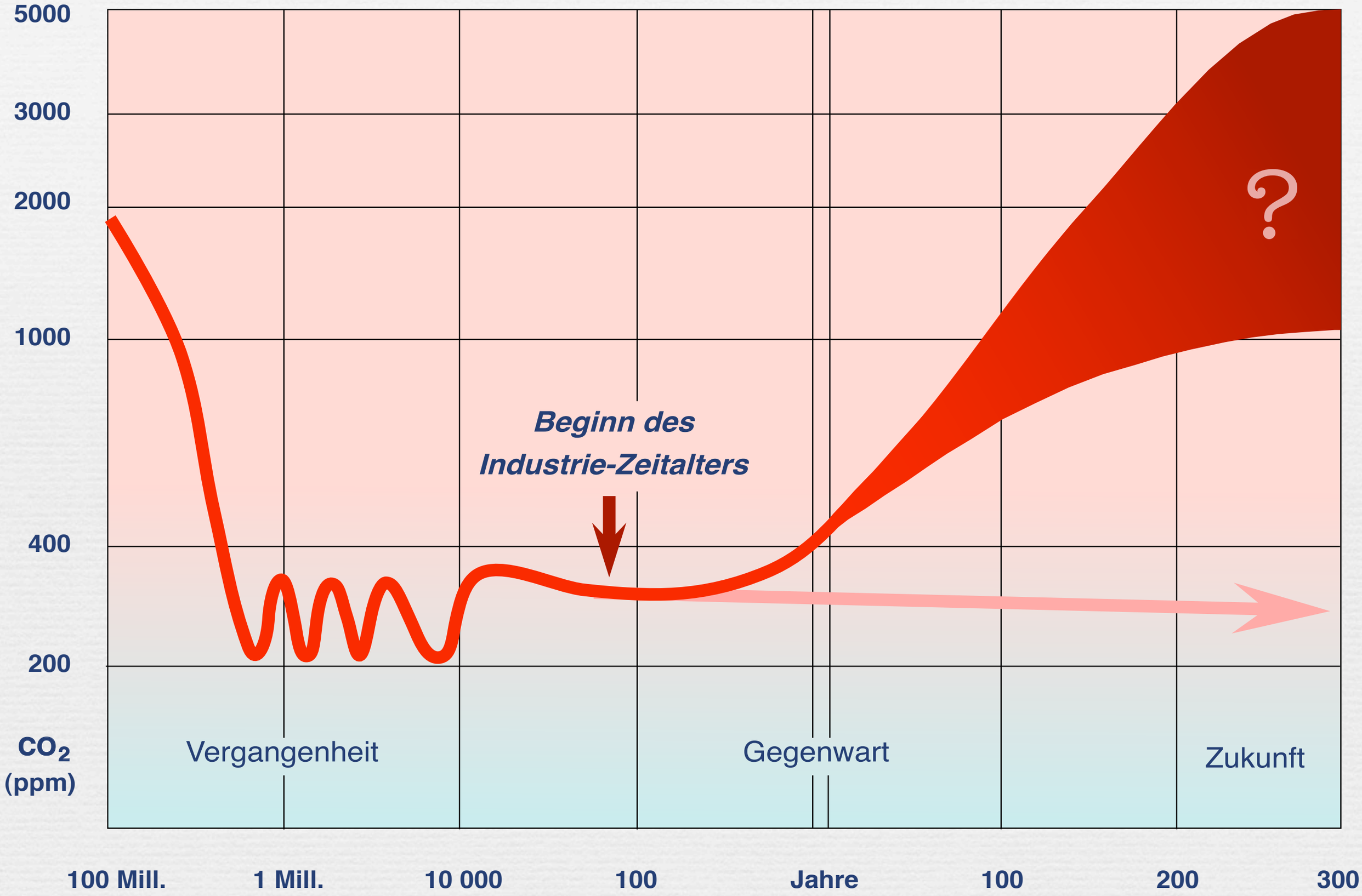



CO_2 and CH_4 Concentrations
Past, Present and Future
1100
IPCC 2000
Scenarios
for 2100 AD
3700
450
Today
390
1600
1200
800
400
Vostok Ice Core
ppbv CH_4
300
240
180
ppmv CO_2
400
350
300
250
200
150
100
50
0
ka BP


Change in Temperature (°C)
2
0
-2
-4
Climate
Optimum
Younger
Dryas
Little
Ice Age
4° C
0
2
4
6
8
10
12
14
16
18
Thousands of Years
10 000 Jahre


Globale Erwärmung aus verschiedenen Klimamodellen
4° C
5
4
3
2
1
0
-1
Temperature Anomaly (°C)
IPCC 2007
1900
1950
2000
2050
2100
100 Jahre

Entwicklung des CO_2-Gehaltes in der Atmosphäre



Entwicklung des CO_2-Gehaltes in der Atmosphäre

5000

1000

400

CO_2 (ppm)

eisfreie Erde

CO_2 Rate -0,0001 ppm/a

Beginn des Industrie-Zeitalters

CO_2 Rate +2 ppm/a

CO_2<450 ppm Eis Antarktis

CO_2 390 ppm

Vergangenheit

Gegenwart

Zukunft

100 Mill. 1 Mill. 10 000 100 Jahre 100 200 300

Die nächste Eiszeit kommt bestimmt ?