Jordens klima og livets udvikling

"Earth rise"
– from Apollo 8 (1968)

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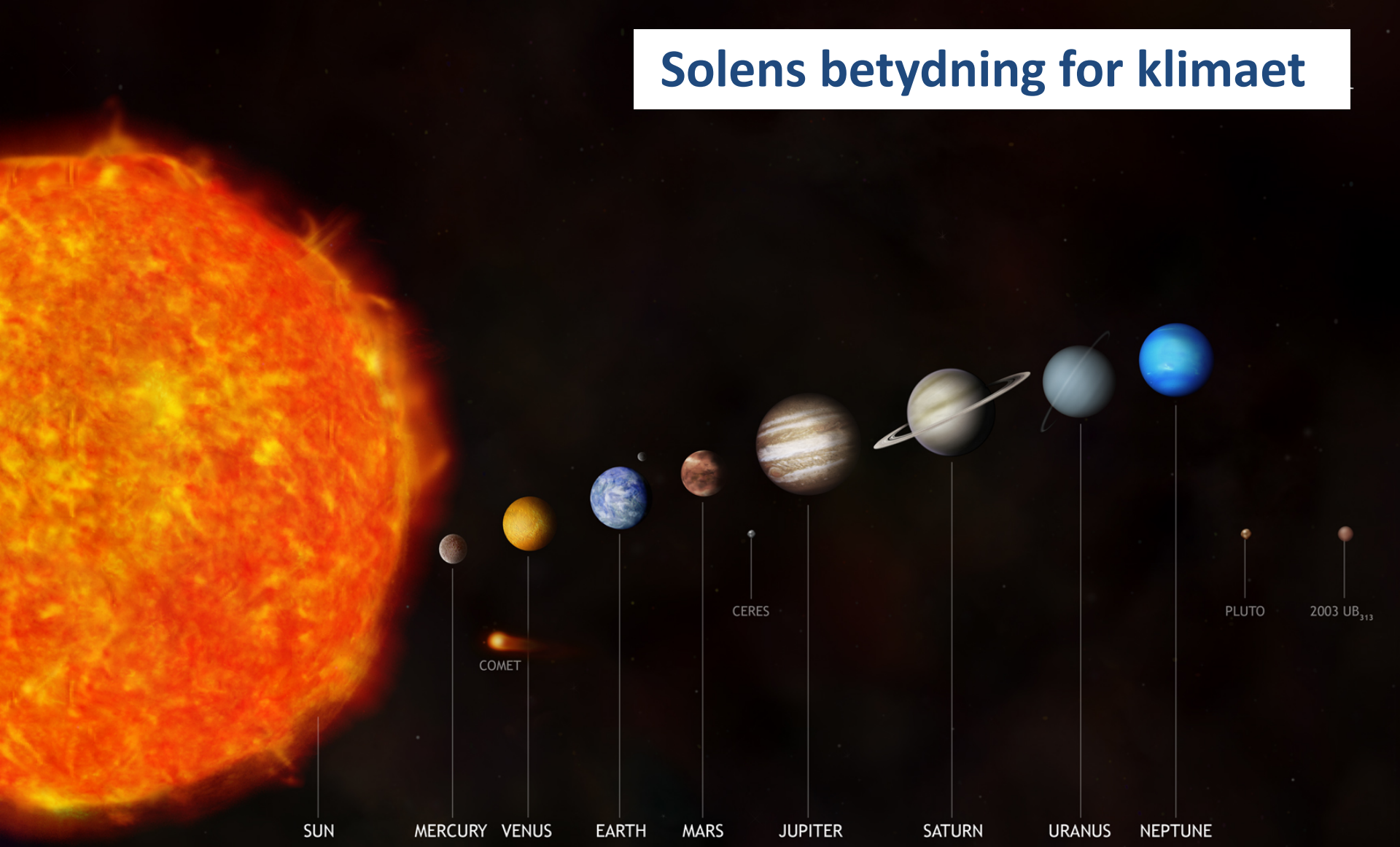
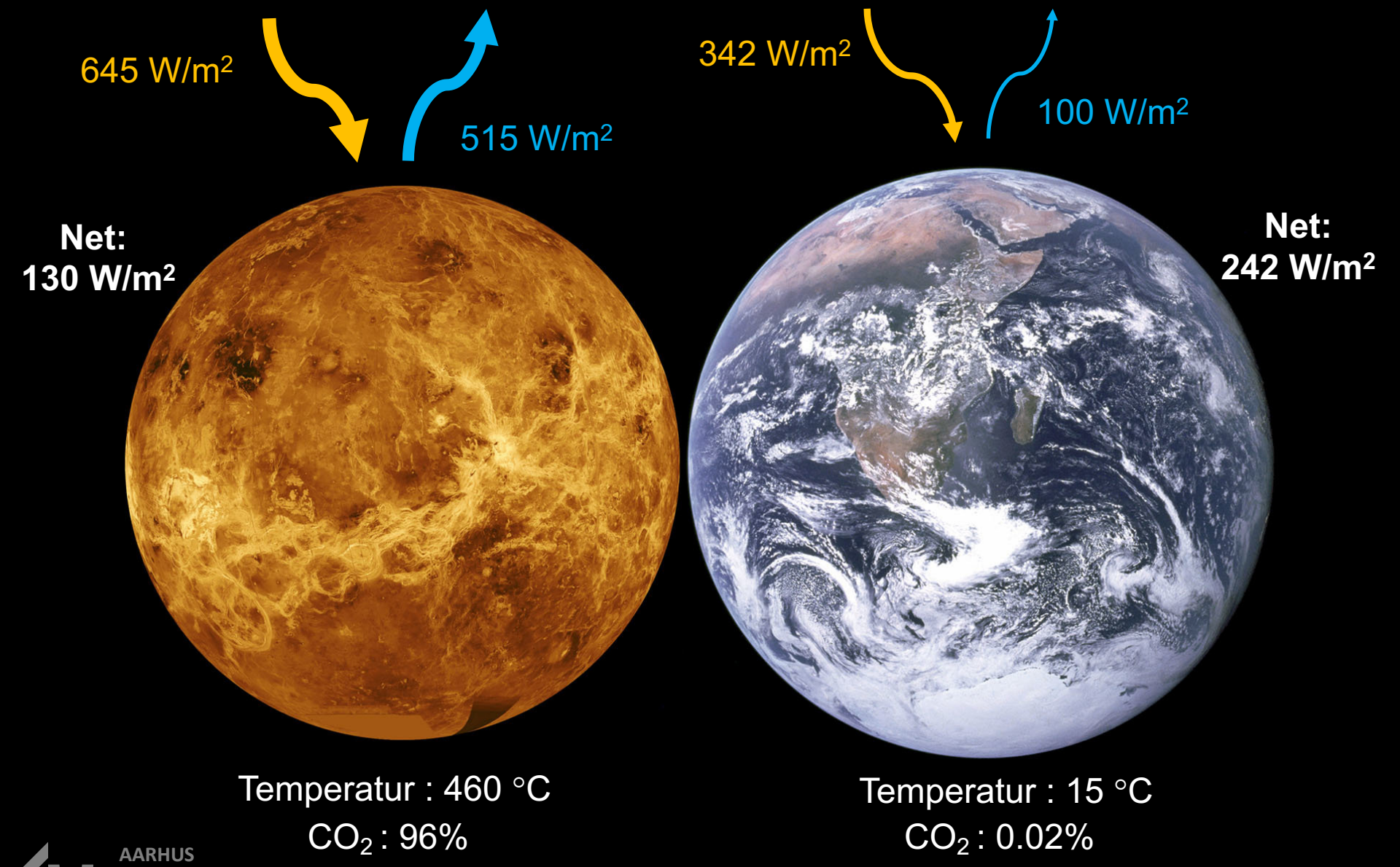
9. august, 2019

Solens betydning for klimaet



Solens energi : $1/d^2$

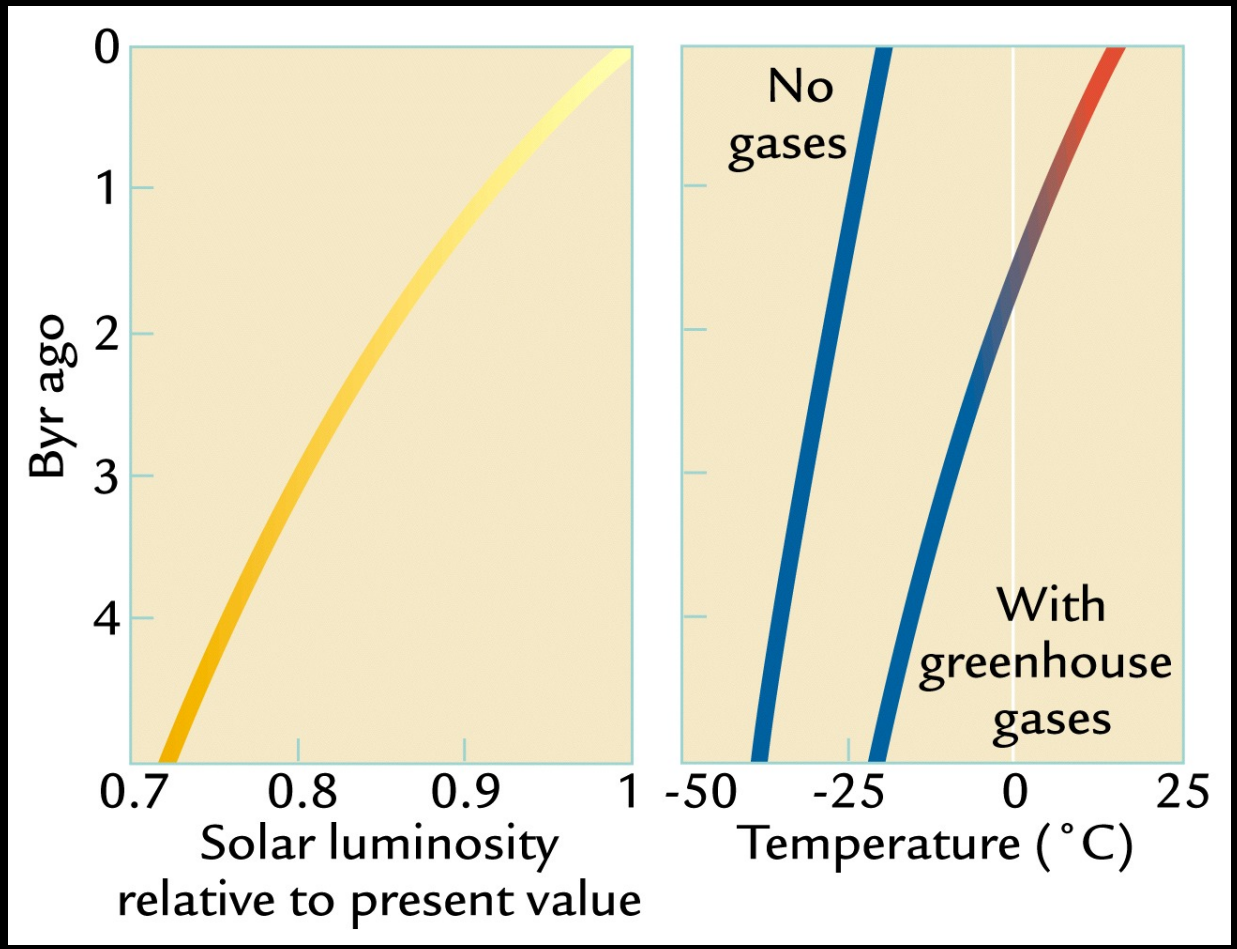
Klimaet på Venus og Jorden



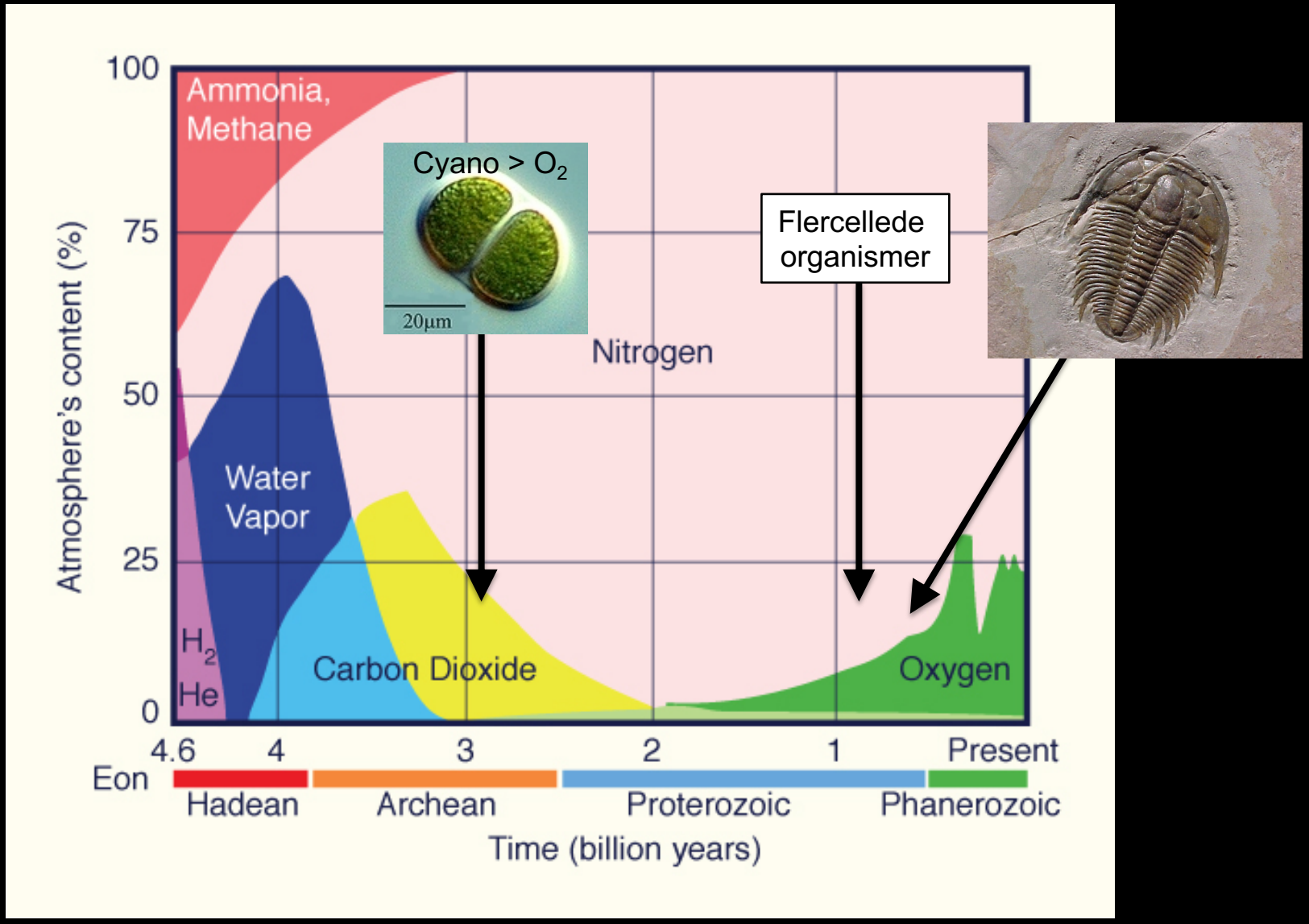
Jordens tidlige klima – flydende vand tilstede for 3.8 mia. år siden

Spor af flydende vand

"Faint Young Sun Paradox"



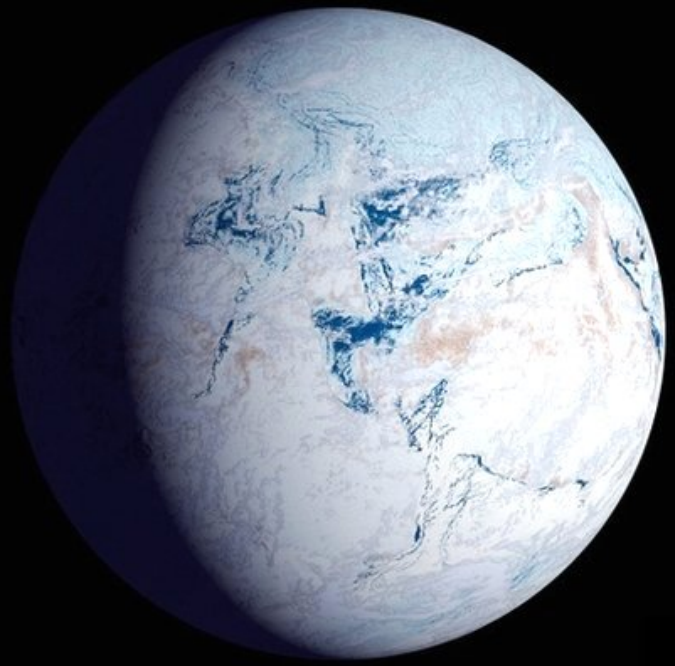
Atmosfærens sammensætning gennem Jordens historie



“Snowball Earth” – globalt isdække for 1000 - 650 mio. år siden ?

Is-aflejringer i Namibia

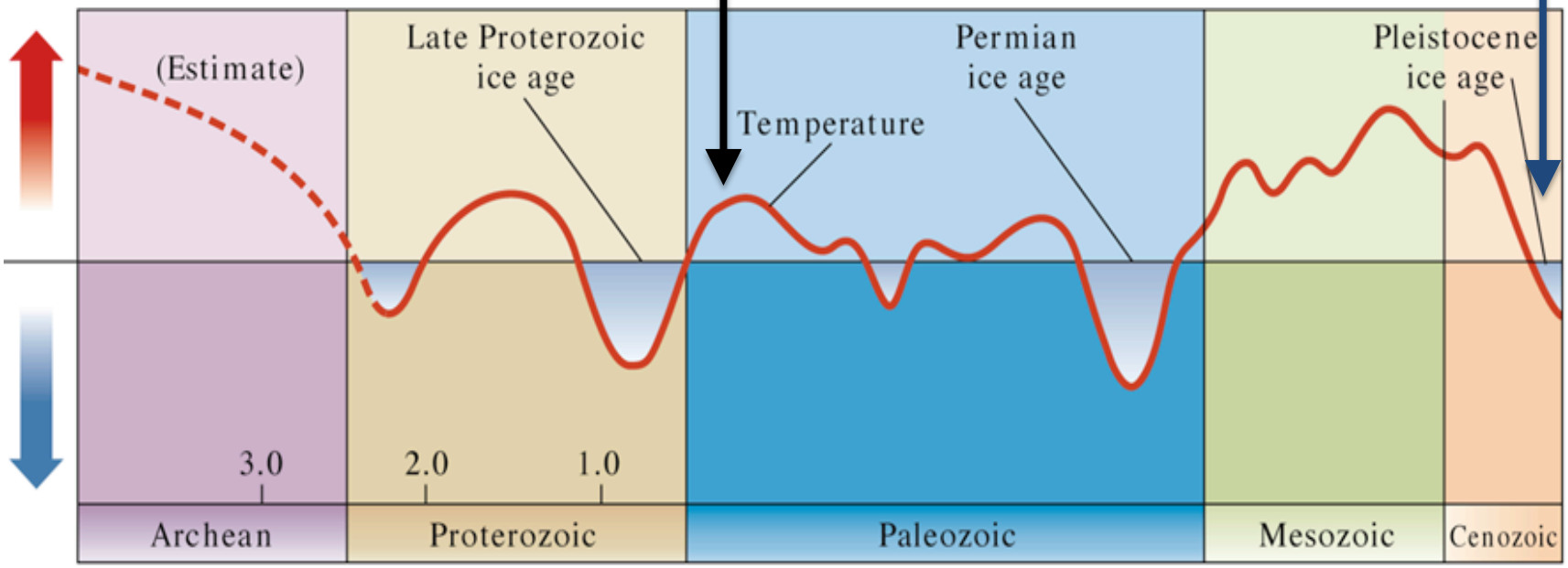
Snowball Earth



Klimaet gennem Jordens historie – en variabel størrelse

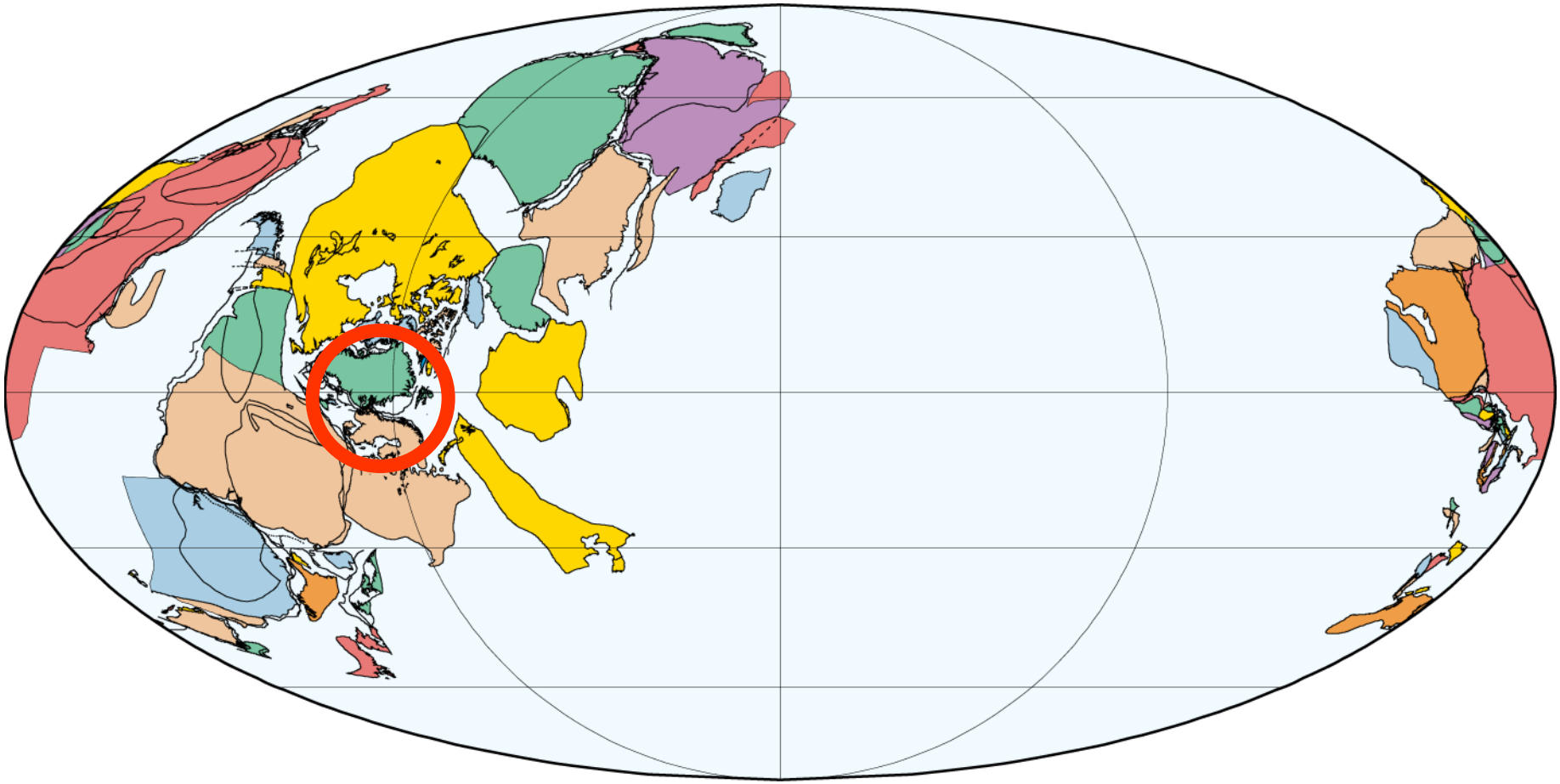
Den kambriske eksplosion af liv

"Modern ice house"

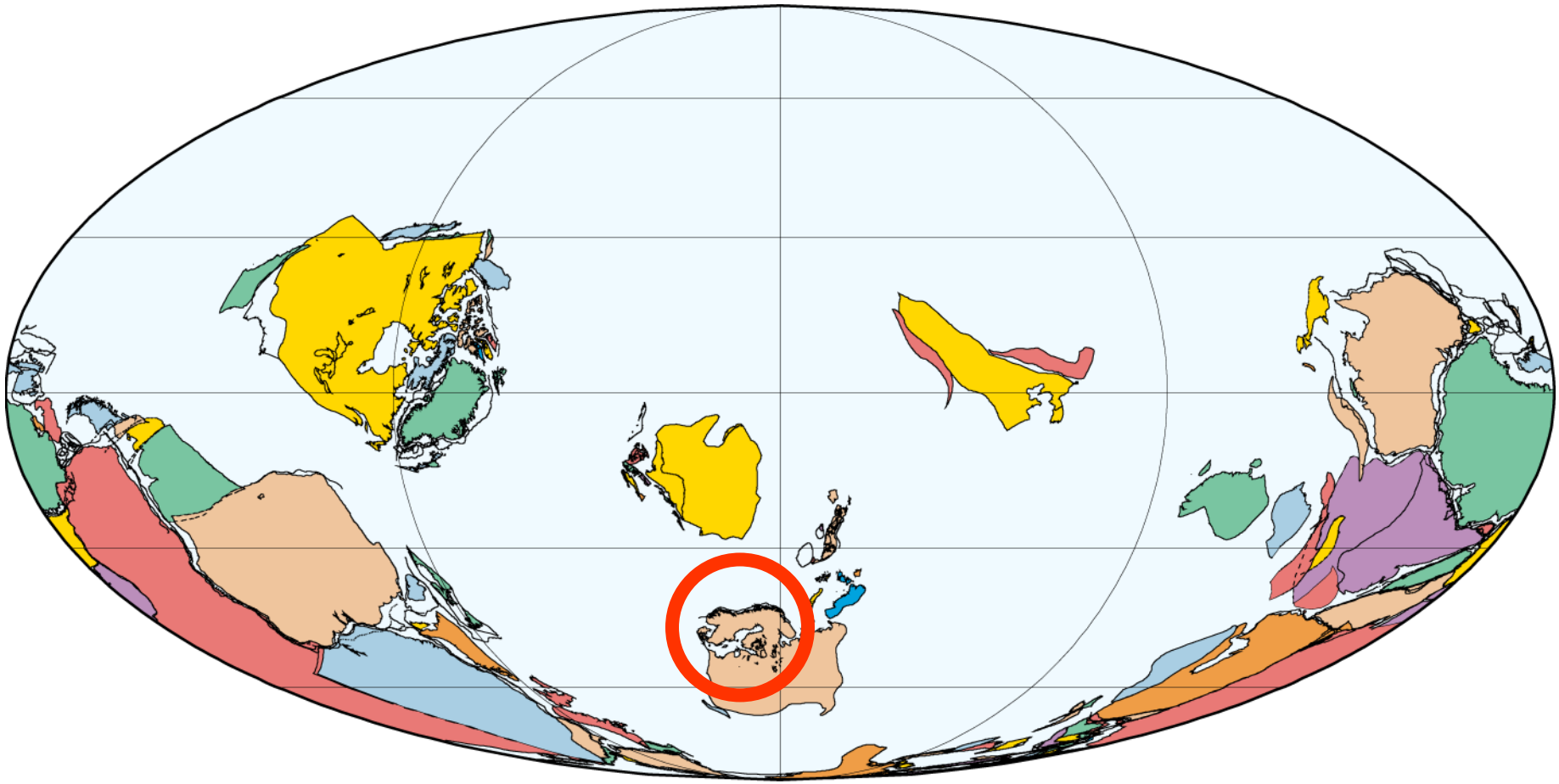


2,5 Mia. år 545 Mio. år 245 Mio. år

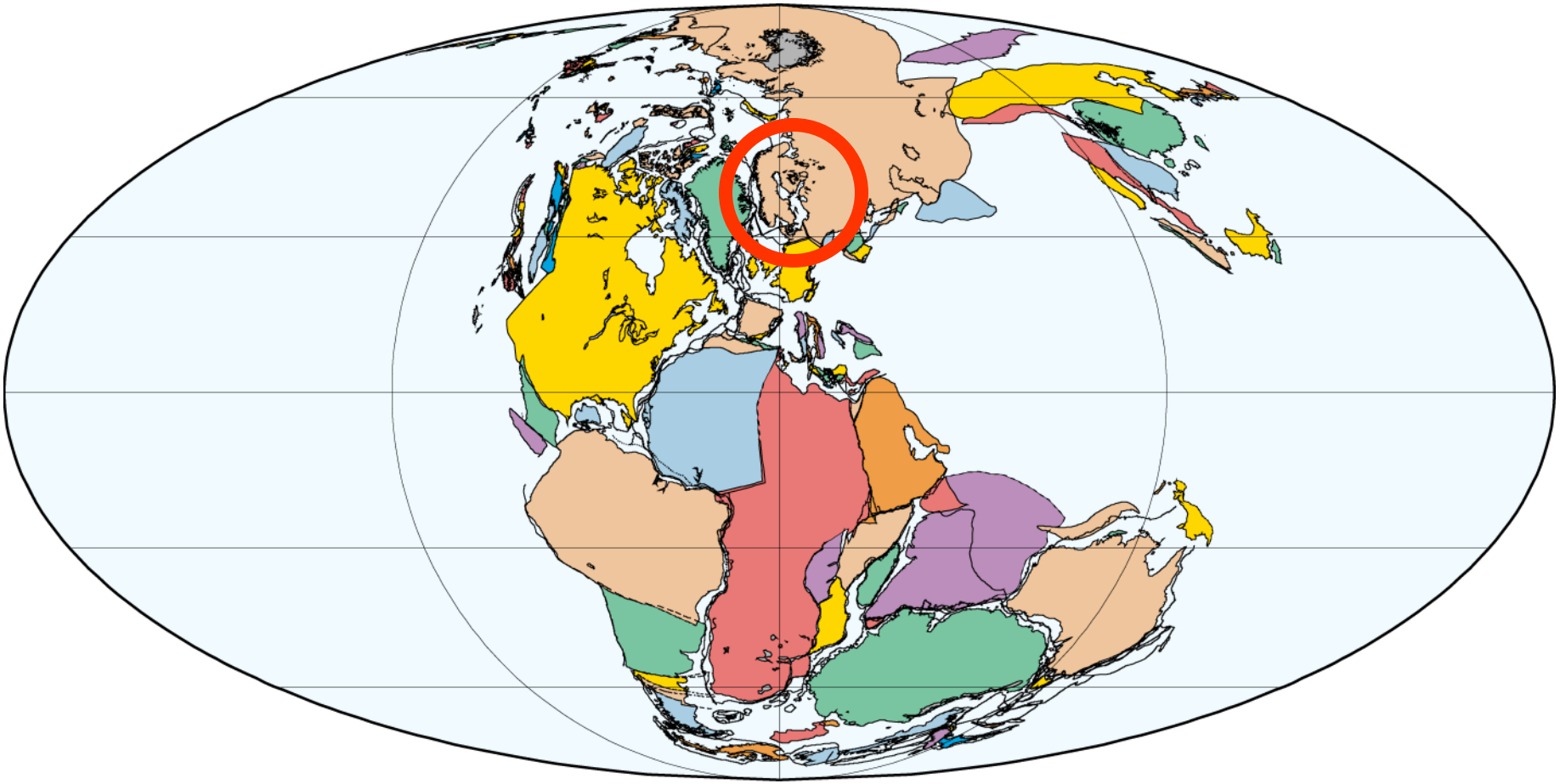
Rekonstruktion af Jordens kontinenter – 750 mio. år siden



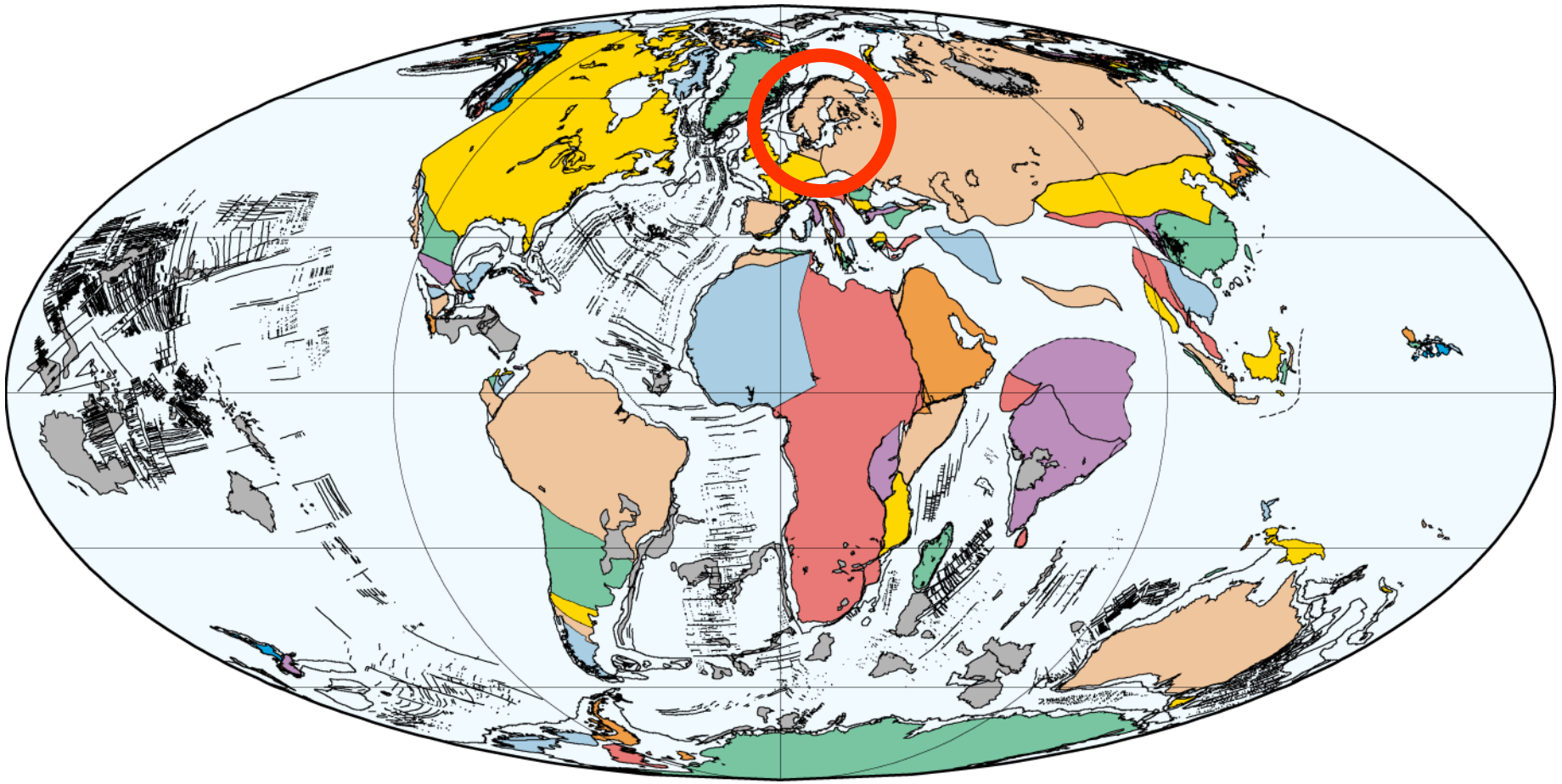
Rekonstruktion af Jordens kontinenter – 480 mio. år siden



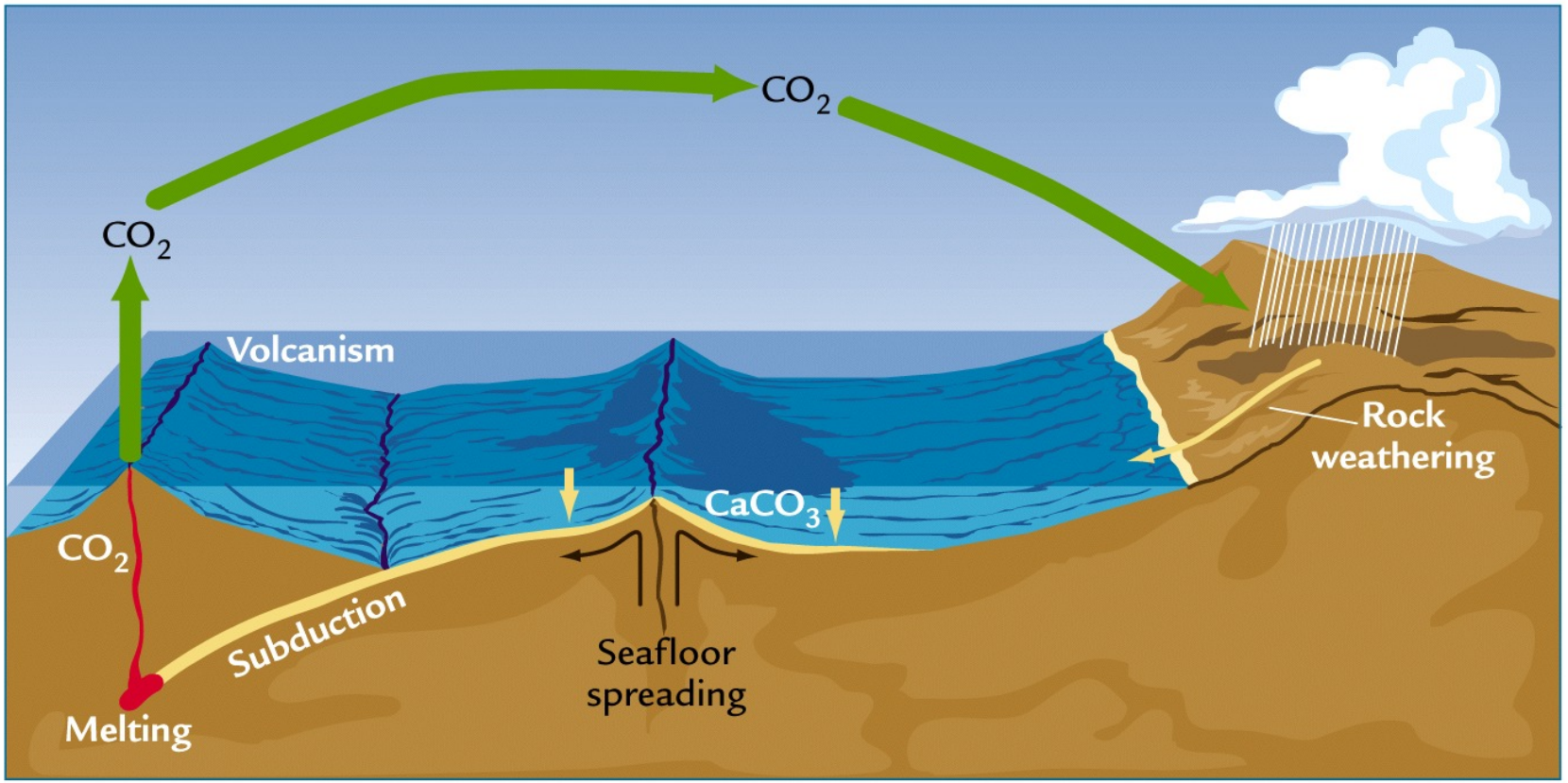
Rekonstruktion af Jordens kontinenter – 180 mio. år siden



Rekonstruktion af Jordens kontinenter – 60 mio. år siden



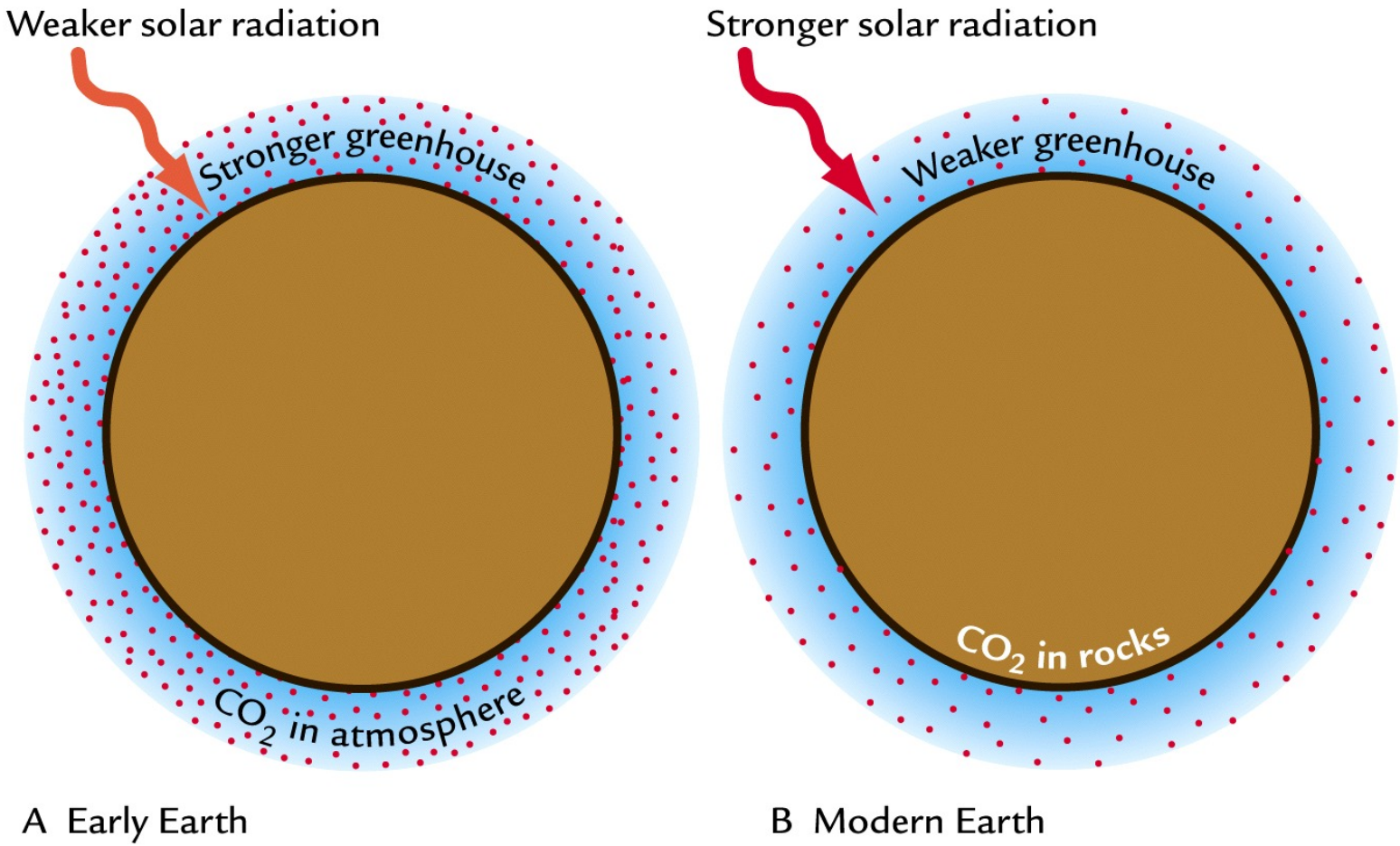
Pladetektonik - CO_2 - Klima



Varmere: Øget spredning => Kraftigere vulkanisme => Mere CO_2 i atmosfæren

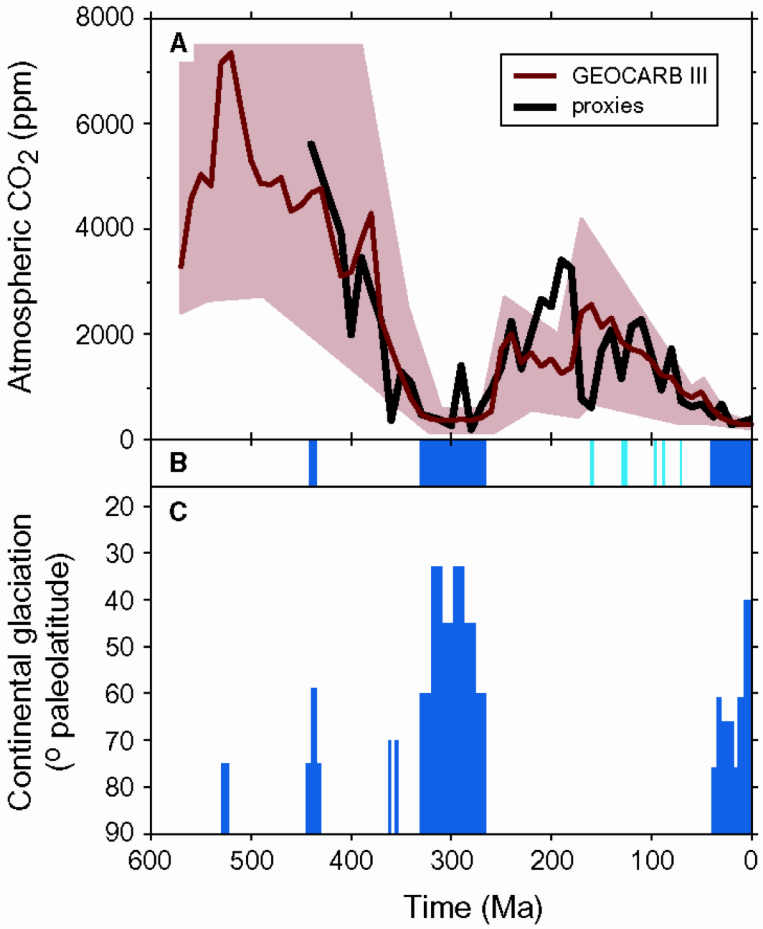
Koldere: Kollision af kontinenter => Hævning og forvitring => Mindre CO_2 i atmosfæren

”Faint Young Sun paradox” – CO_2 i atmosfæren vs. på havbunden



CO_2 og ændringer i Jordens klima

CO_2 i atmosfæren ~
Udbredelsen af iskapper



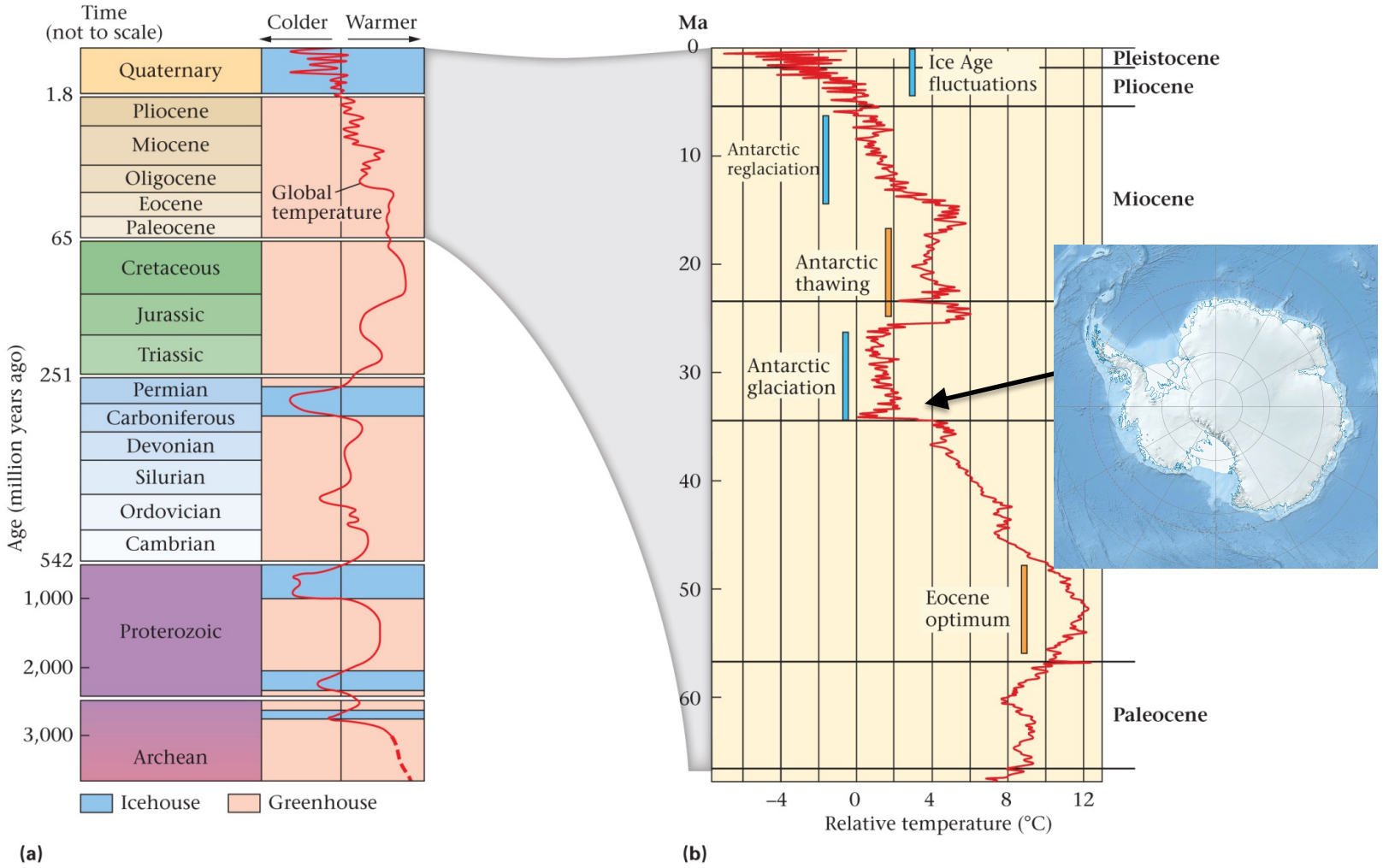
Kritisk tærskel ved 500 ppm (?)

CO_2 < 500 ppm
=> Udbredelse af iskapper og gletschere

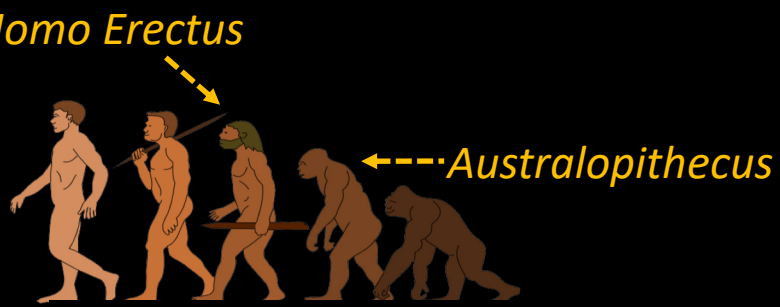
CO_2 > 500 ppm
=> Jorden mere eller mindre fri for is

Klimasensitivitet over 500 mio. år = 2.8 °C

Klimaet gennem Kænozoikum (sidste 65 mio. år)

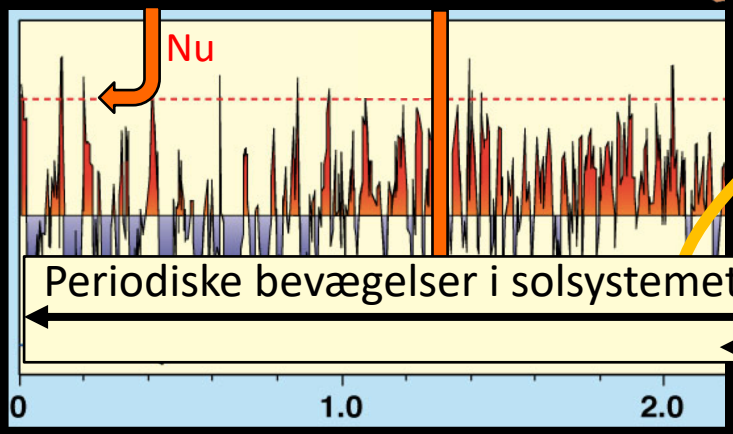


Klimaet gennem de sidste 5 mio. år



Varmt
= lidt is

Koldt
= meget is

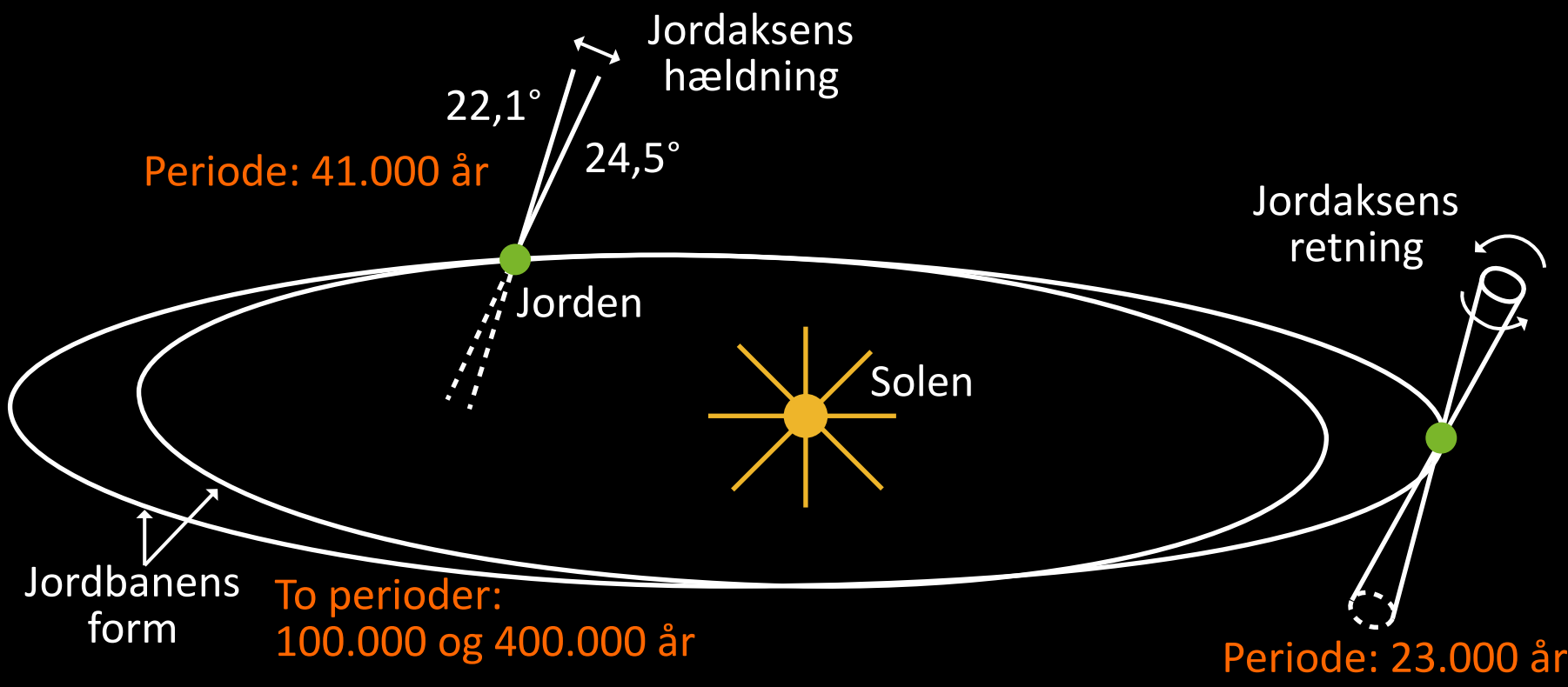


Millioner år før nu

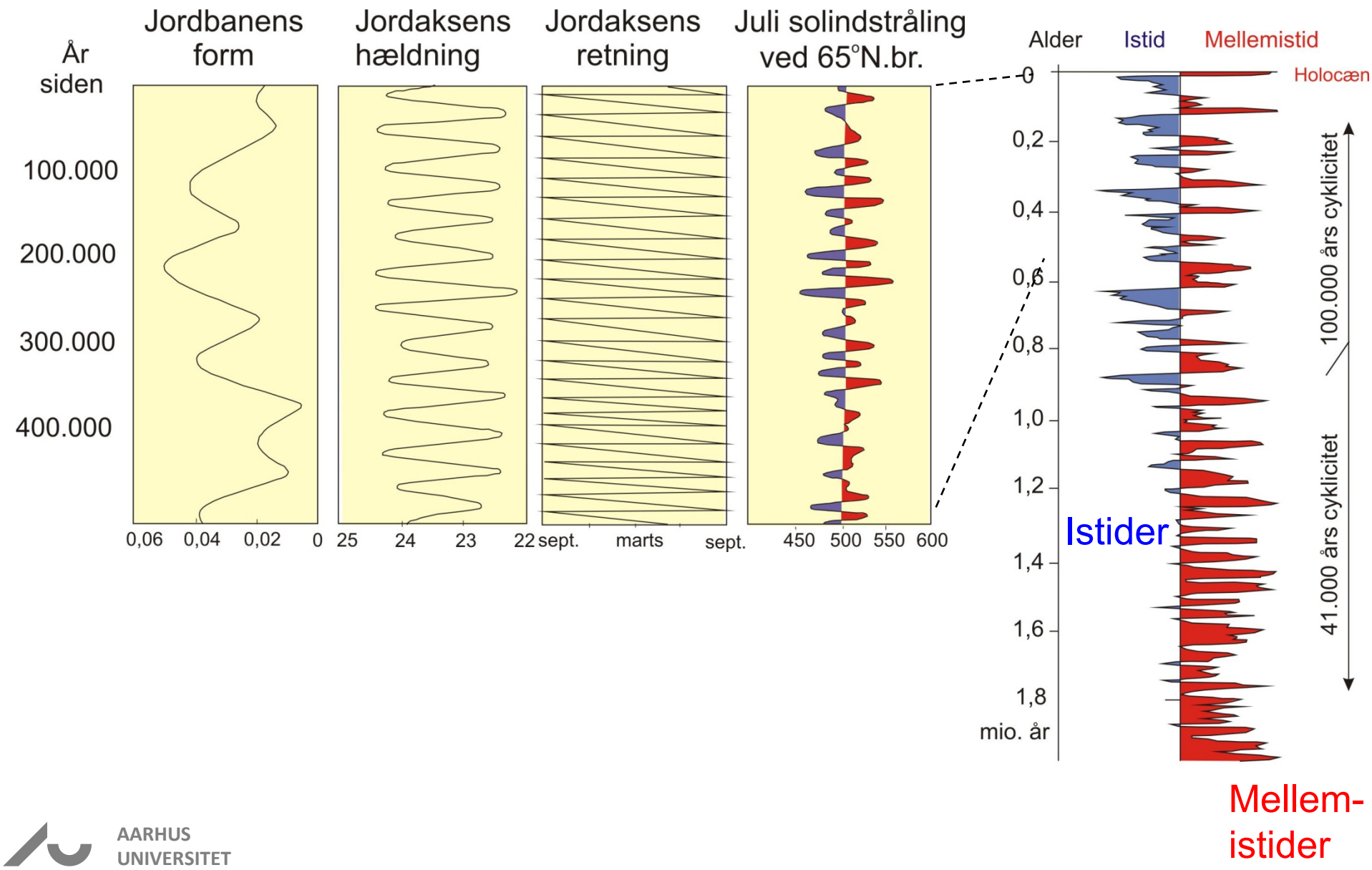
Periodiske bevægelser i solsystemet

Pladetektonik

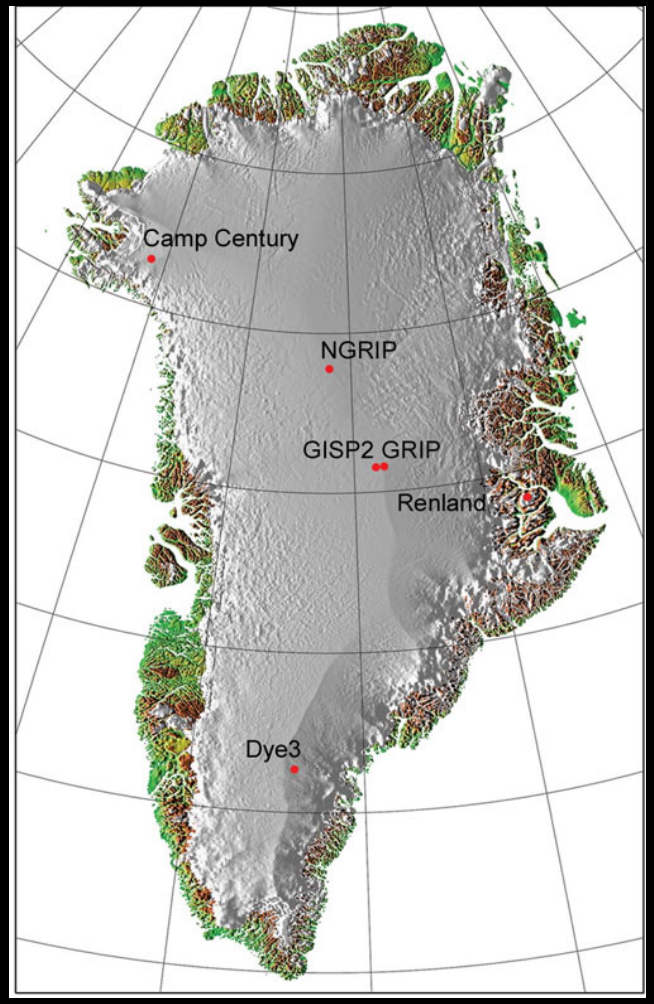
Periodiske bevægelser i Solsystemet



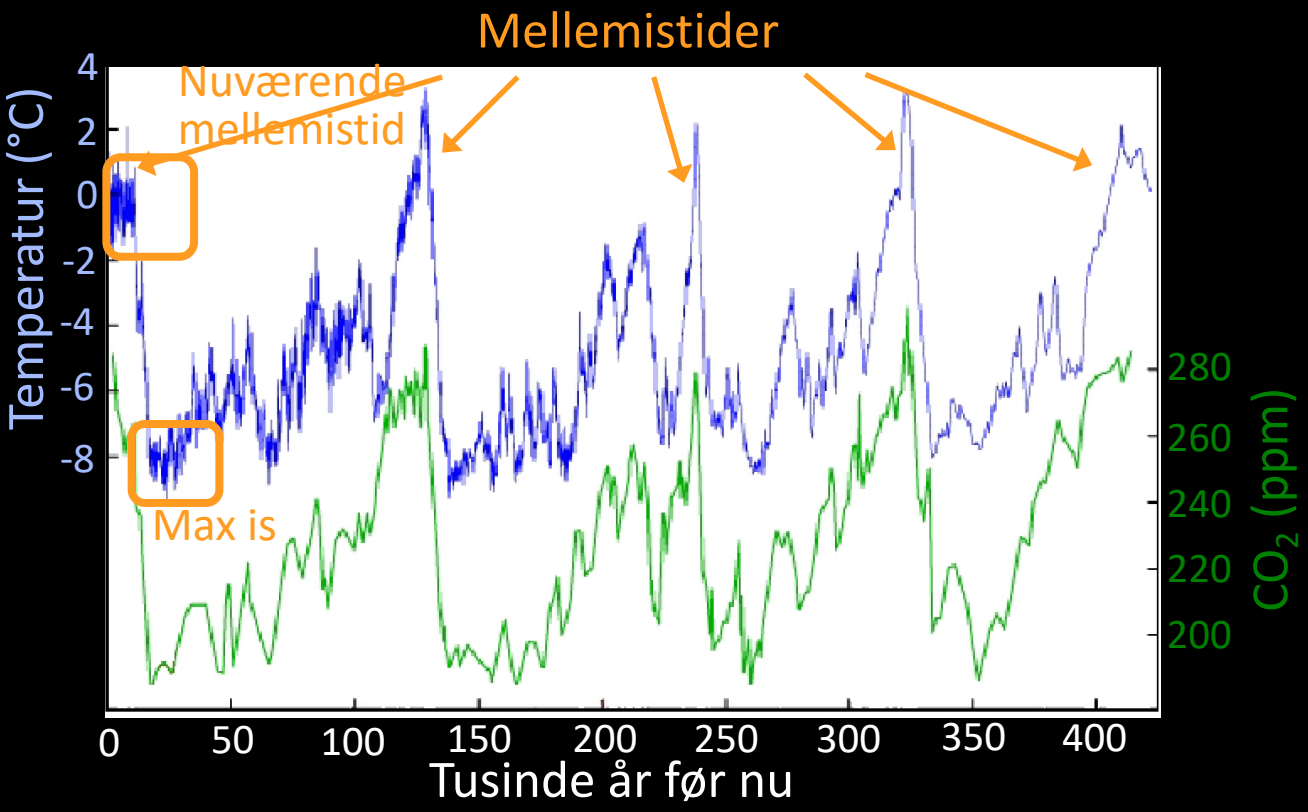
Periodiske bevægelser i Solsystemet giver istider og mellemistider

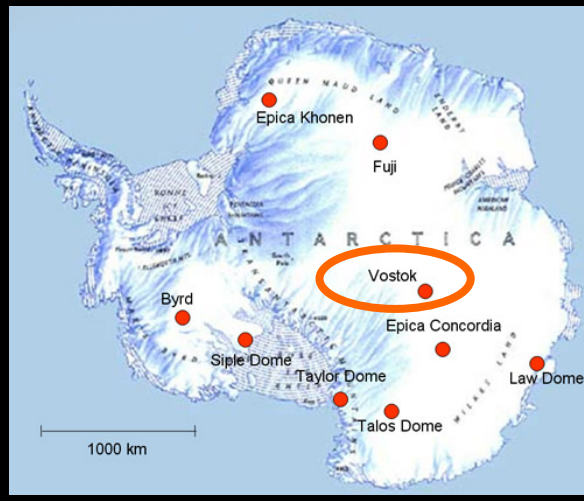


Isboringer fra Grønland og Antarktis

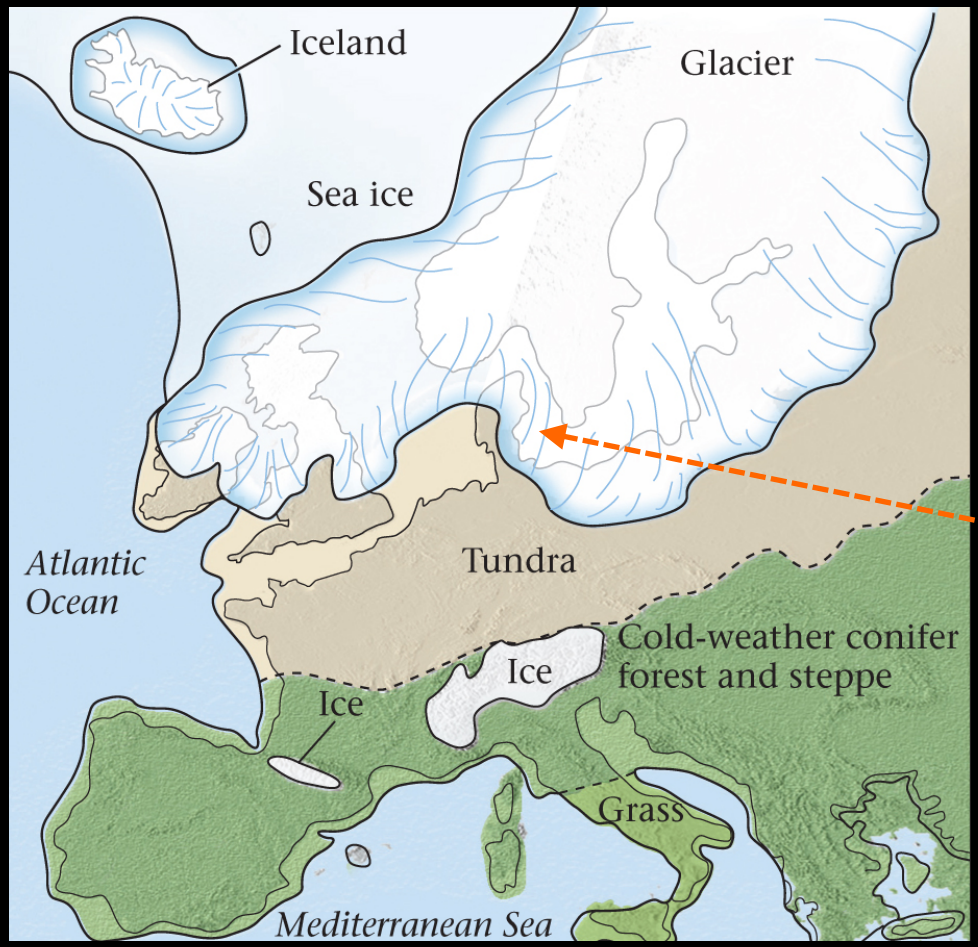


Temperatur og CO_2 fra Antarktis

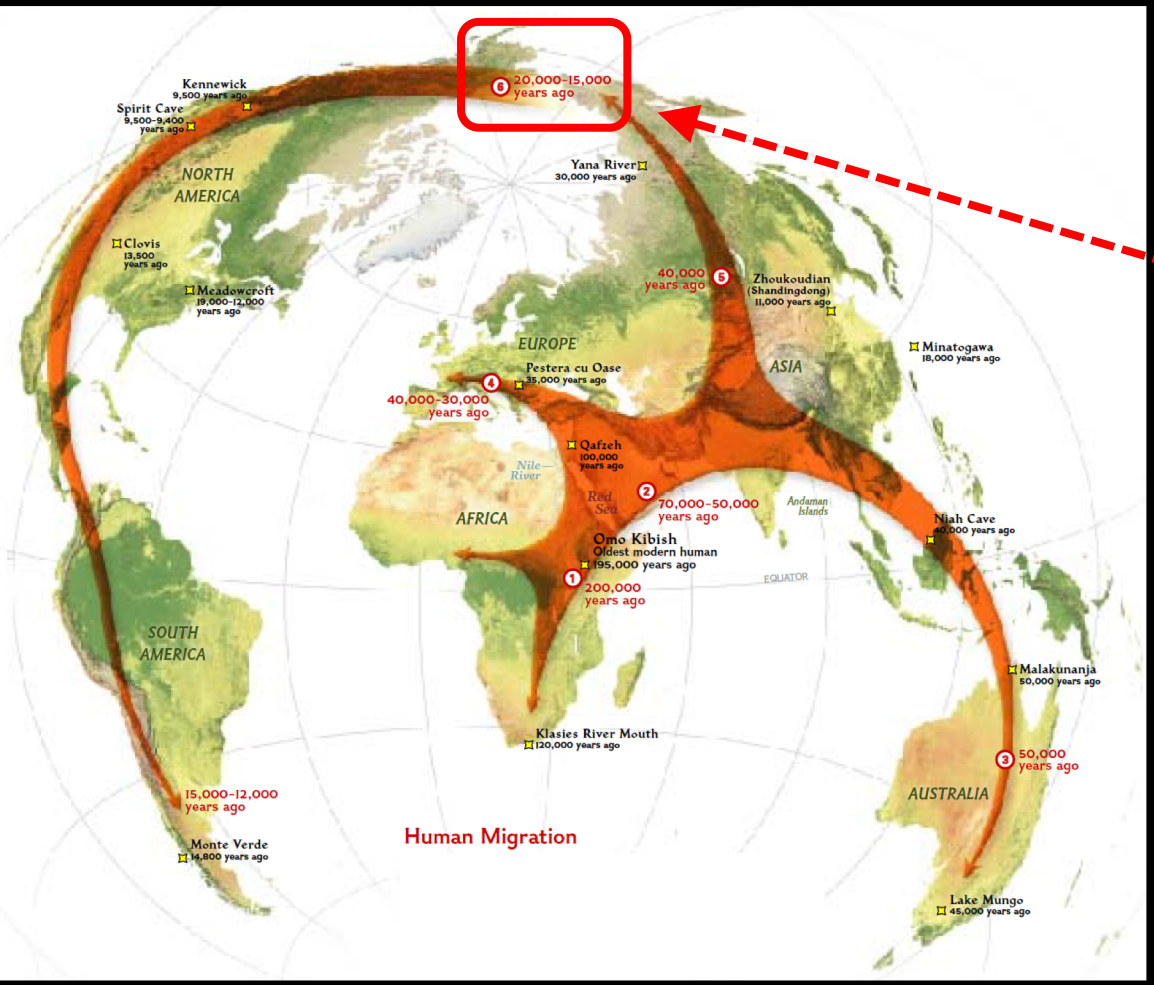




Et koldt Europa under sidste istids maksimum

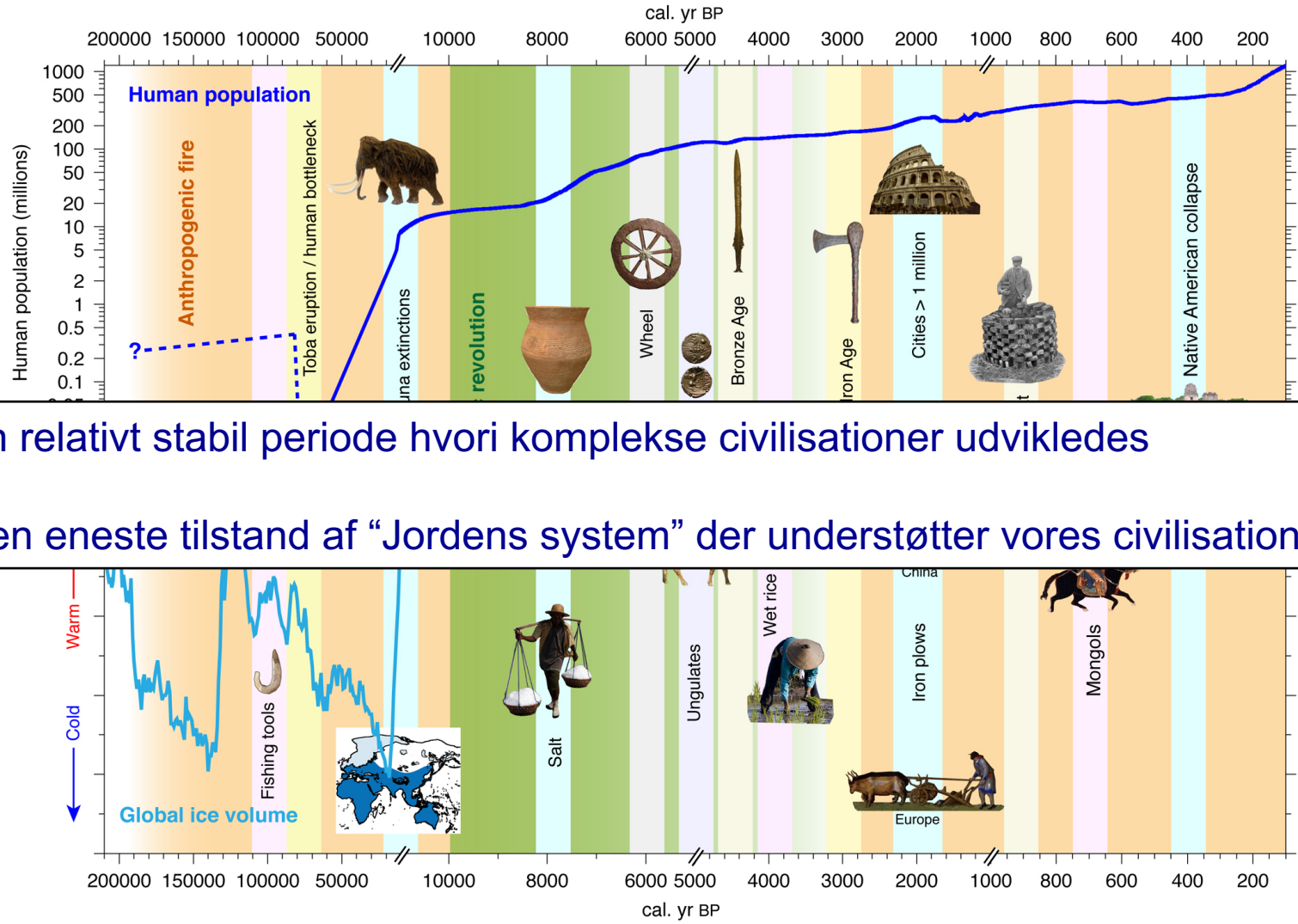


Istiderne og spredningen af det moderne menneske



Nuværende mellemistid (sidste 11.700 år) – en klimatisk rolig periode

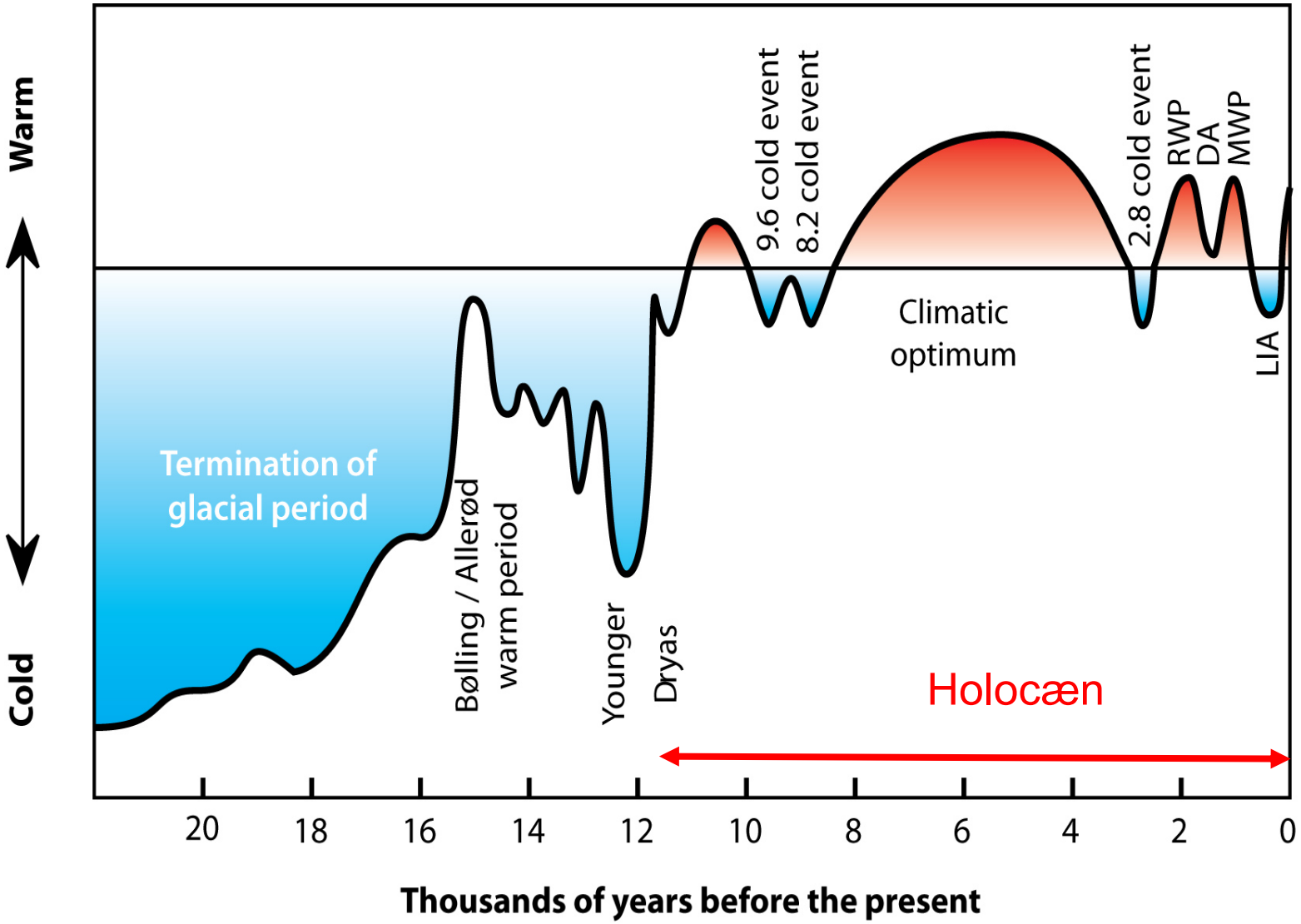
- men nu alligevel ganske begivenhedsrig…



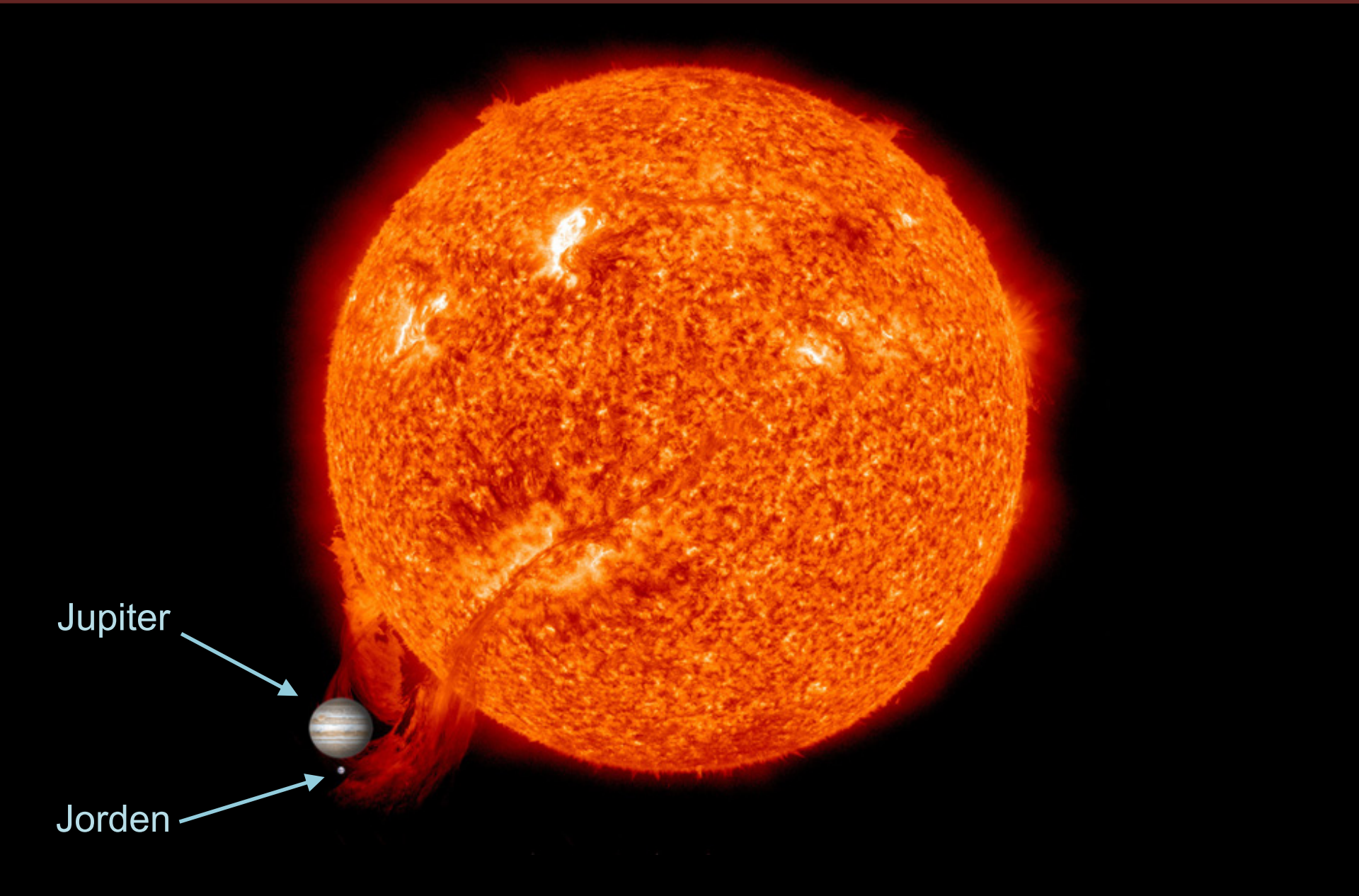
- En relativt stabil periode hvori komplekse civilisationer udvikledes

- Den eneste tilstand af "Jordens system" der understøtter vores civilisation

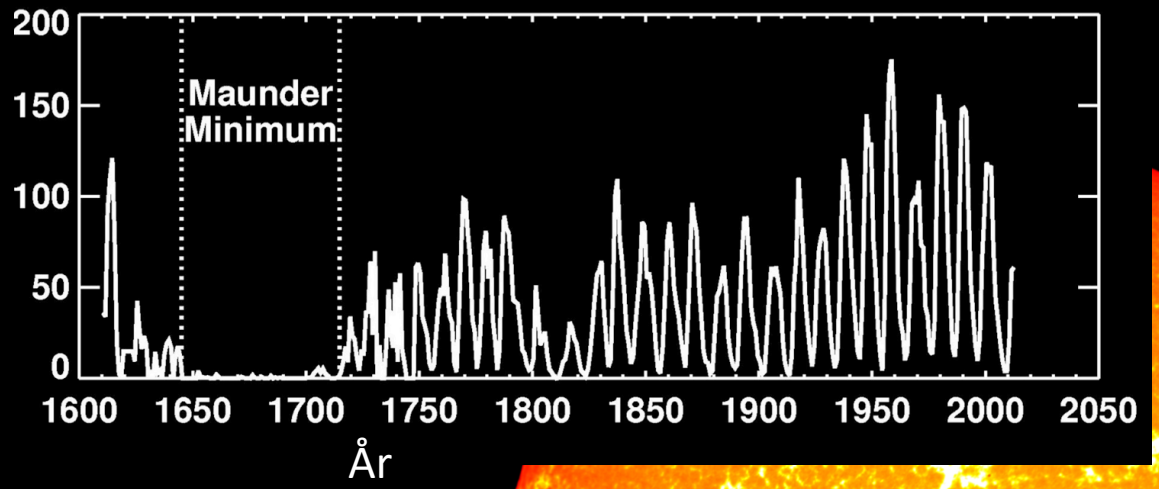
Det Holocæne klima ved nordlige breddegrader



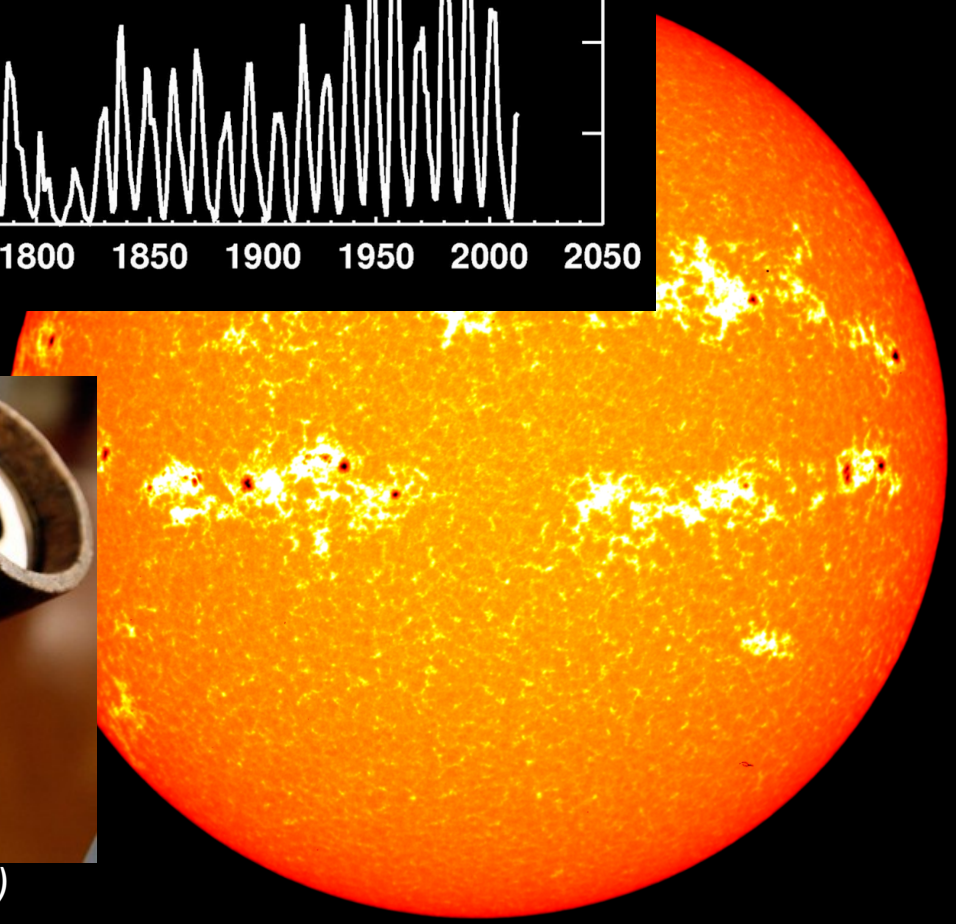
Solen er en aktiv nabo



Observation af solpletter – et mål for Solens aktivitet

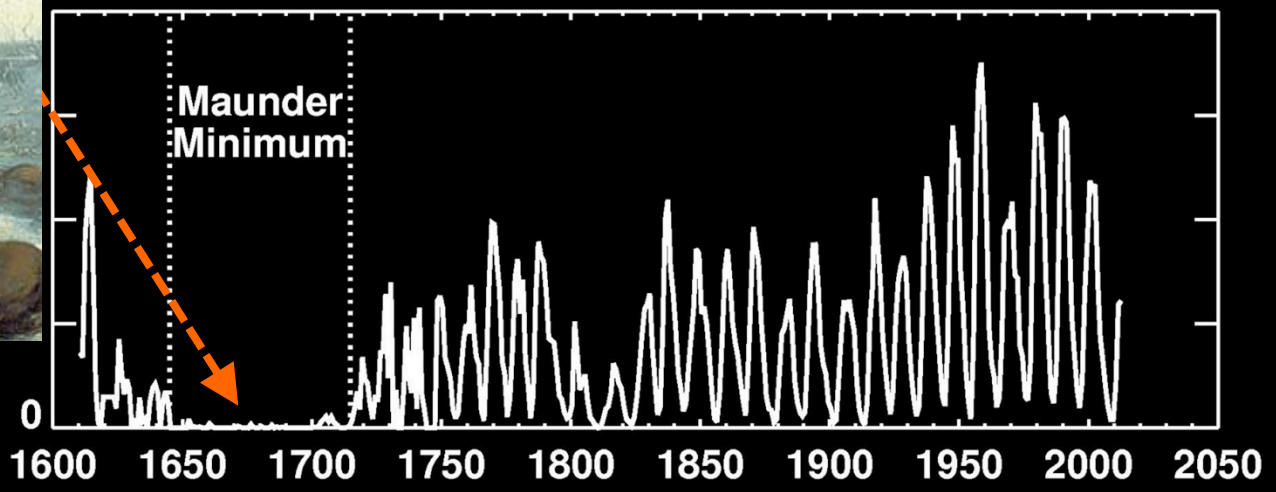


Galileo Galilei (1564-1642)



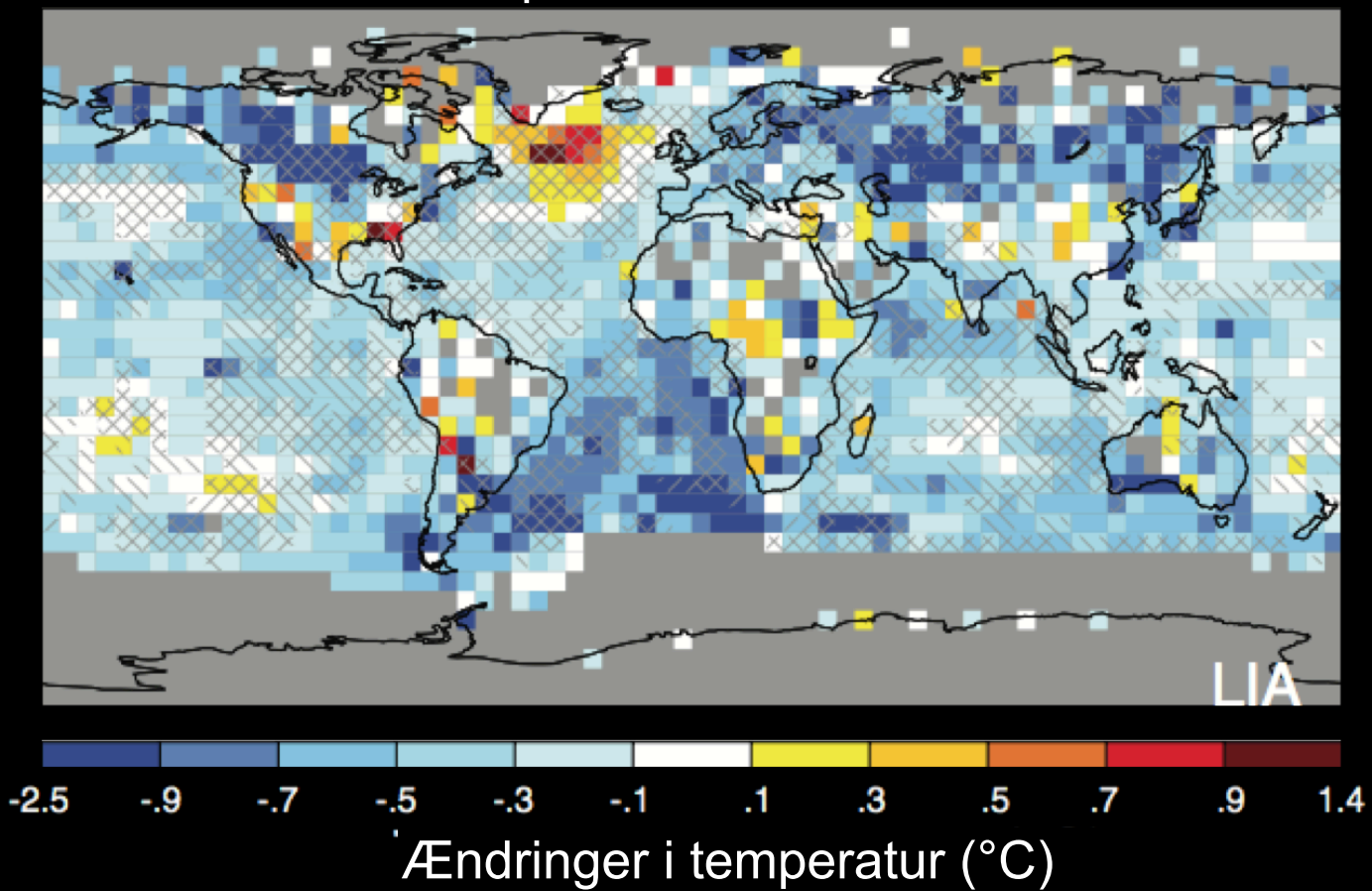
Solens aktivitet og klimaet omkring år 1658

Karl Gustav X ved Langelandsbælt



Klimaet omkring Maunder Minimum (AD 1645-1715)

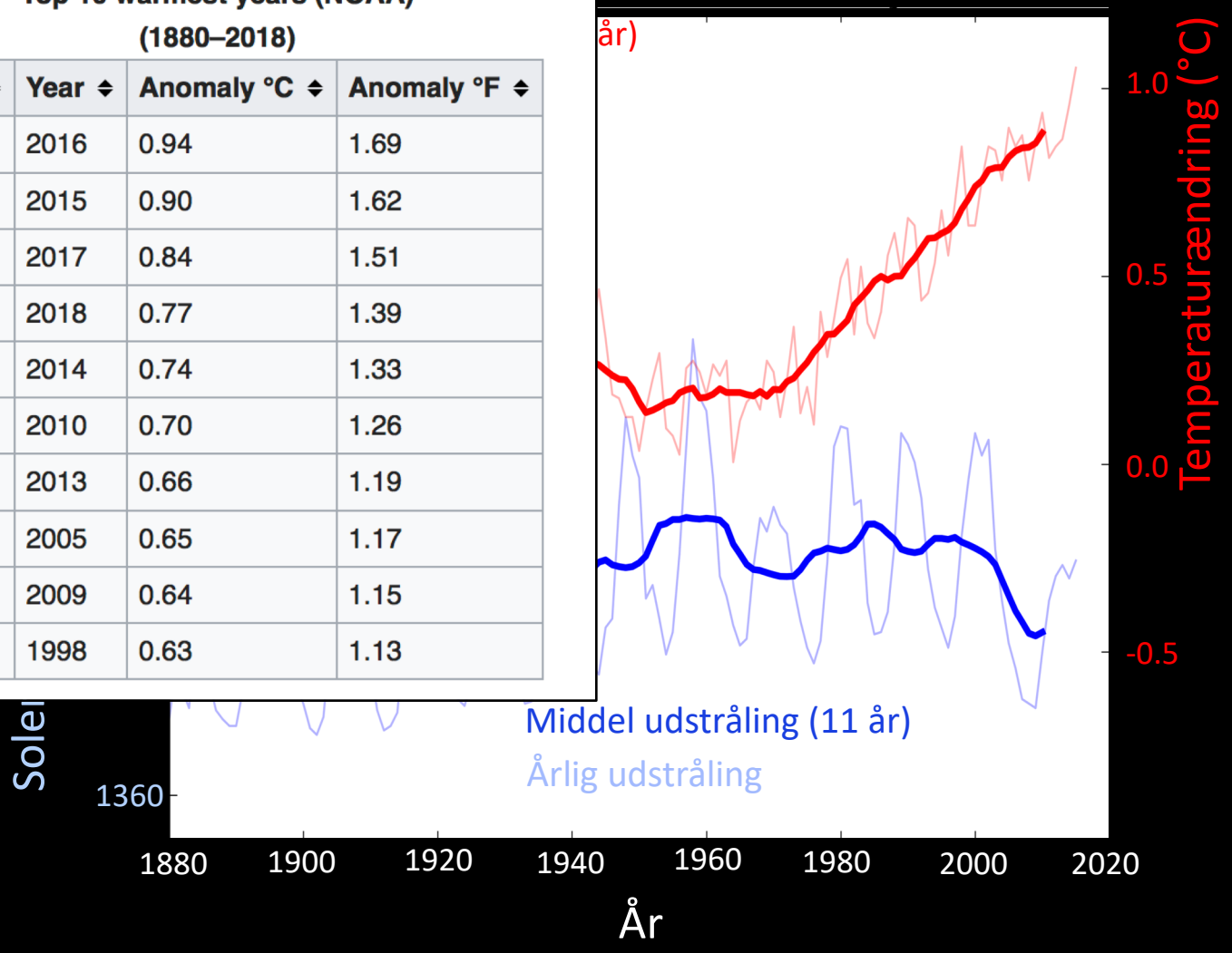
Et mere komplekst billede træder frem



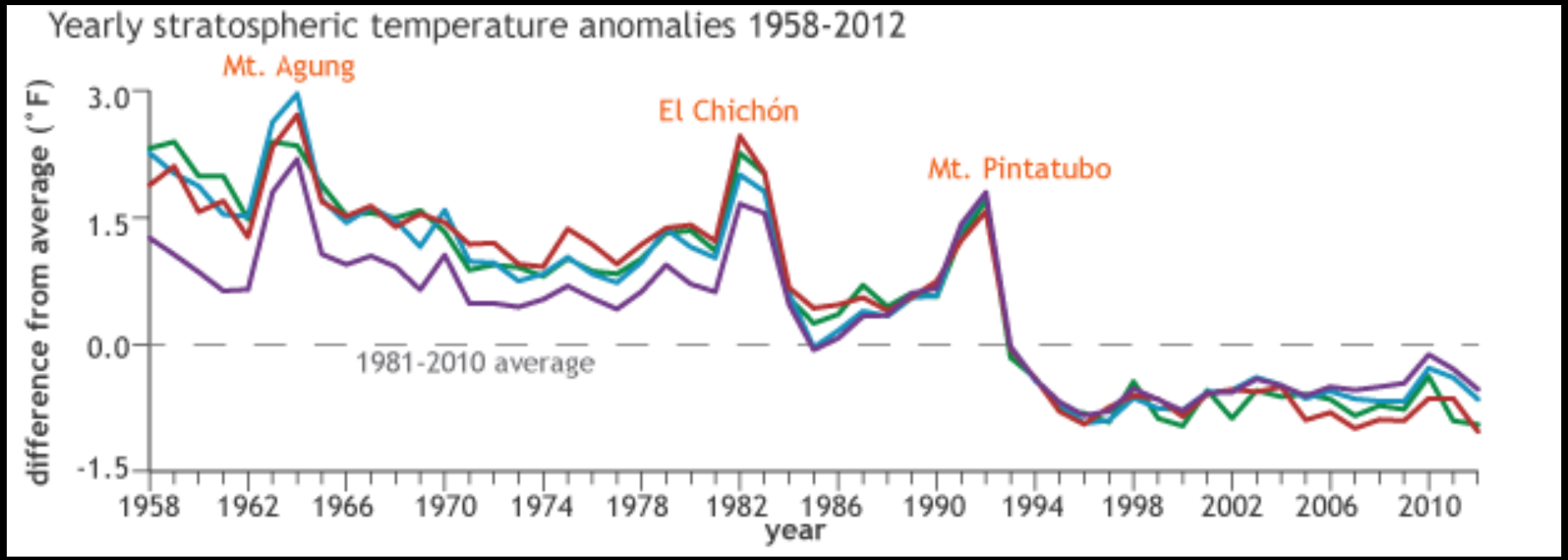
Jordens temperatur og Solens aktivitet de sidste 130 år

Top 10 warmest years (NOAA)
(1880–2018)

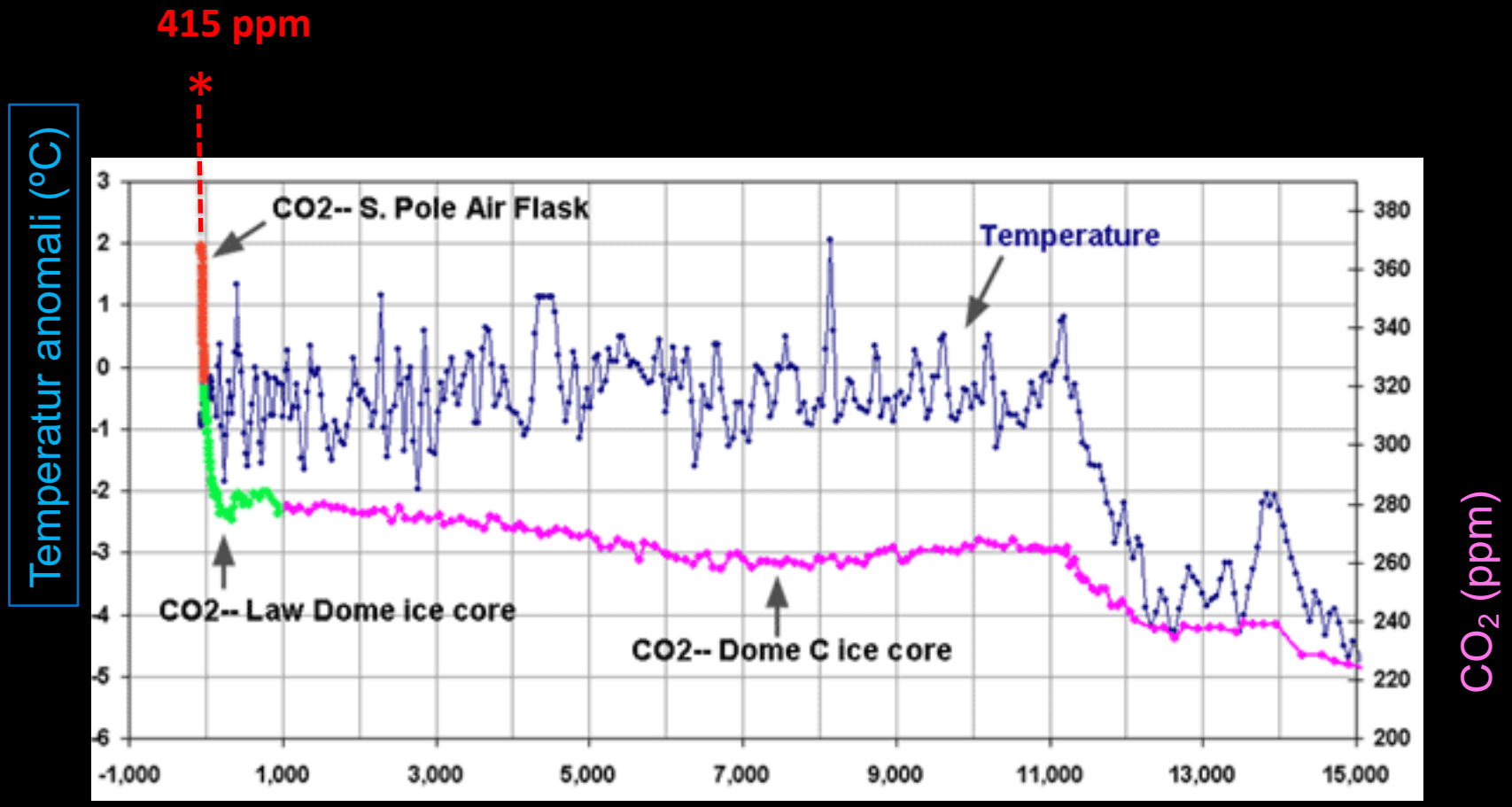
Rank	Year	Anomaly °C	Anomaly °F
1	2016	0.94	1.69
2	2015	0.90	1.62
3	2017	0.84	1.51
4	2018	0.77	1.39
5	2014	0.74	1.33
6	2010	0.70	1.26
7	2013	0.66	1.19
8	2005	0.65	1.17
9	2009	0.64	1.15
10	1998	0.63	1.13



Afkøling af stratosfæren > global opvarmning skyldes drivhusgasser



CO_2 gennem den nuværende mellemistid (sidste 11.700 år)



Antropocæn – ”The human age” ?

The human age

Momentum is building to establish a new geological epoch that recognizes humanity's impact on the planet. But there is fierce debate behind the scenes.

BY RICHARD MONASTERSKY

Almost all the dinosaurs have vanished from the National Museum of Natural History in Washington DC. The fossil hall is now mostly empty and painted in deep shadows as palaeobiologist Scott Wing wanders through the cavernous room.

Wing is part of a team carrying out a radical, US$45-million redesign of the exhibition space, which is part of the Smithsonian Institution. And when it opens again in 2019, the hall will do more than revisit Earth's distant past. Alongside the typical displays of *Tyrannosaurus rex* and *Triceratops*, there will be a new section that forces visitors to consider the species that is currently dominating the planet.

"We want to help people imagine their role in the world, which is maybe more important than many of them realize," says Wing.

This provocative exhibit will focus on the Anthropocene — the slice of Earth's history during which people have become a major geological force. Through mining activities alone, humans move more sediment than all the world's rivers combined. *Homo sapiens* has also warmed the planet, raised sea levels, eroded the ozone layer and acidified the oceans.

Given the magnitude of these changes, many researchers propose that the Anthropocene represents a new division of geological time. The concept has gained traction, especially in the past few years — and not just among geoscientists. The word has been invoked by archaeologists, historians and even gender-studies researchers, several museums

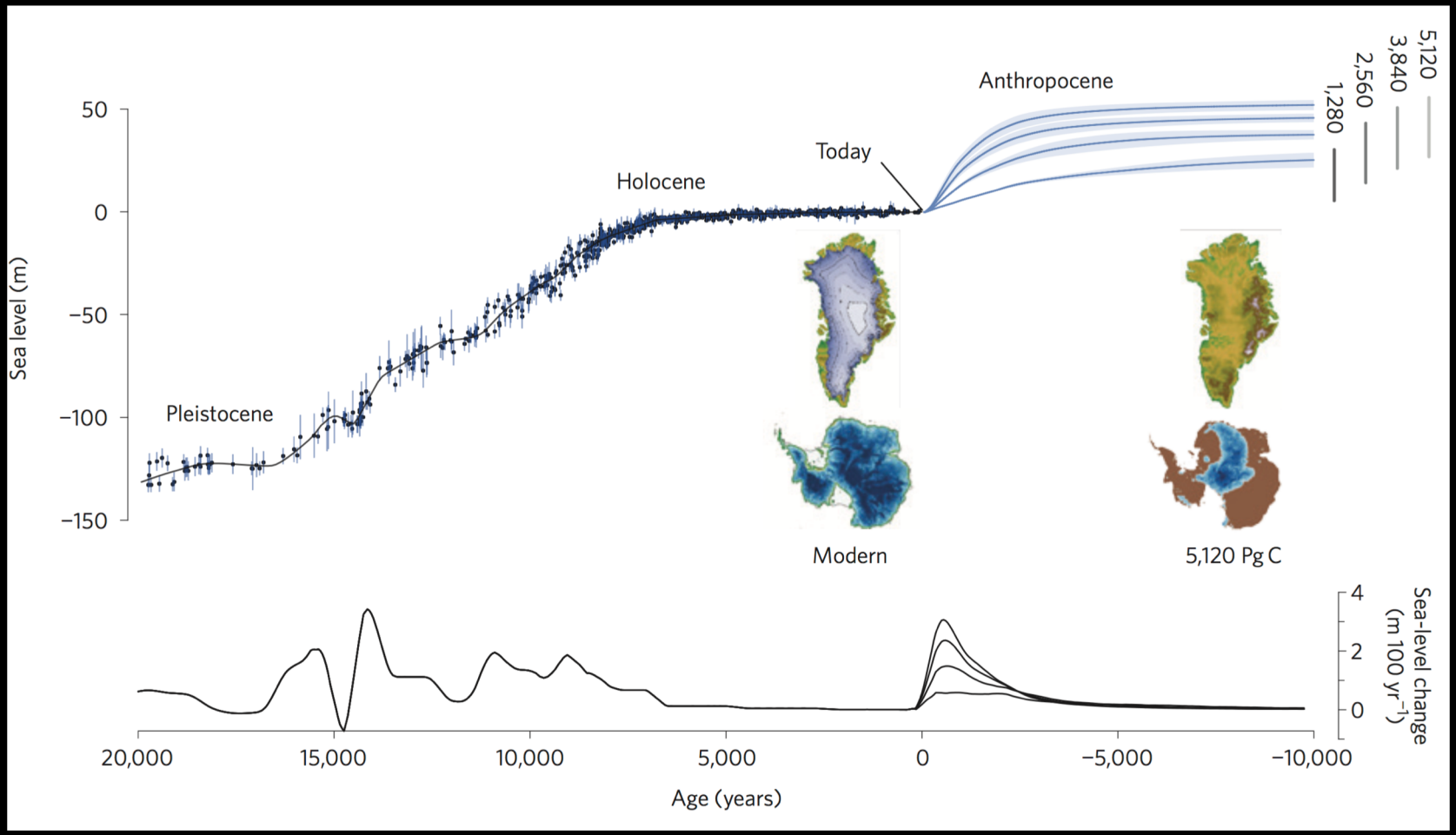
ILLUSTRATION BY JESSICA PANTHER

Den geologiske tommelfingerregel:
Jorden isfri indtil CO_2 > 500 ppm

Vil Jordens iskapper forsvinde helt ?
(vi er nu ved 415 ppm)

Vil Jordens iskapper forsvinde igen ?

- Indlandsisen på Grønland kan forsvinde om 3-5000 år



Tak

Østgrønland, 2018

Kilde til klimaet gennem Jordens historie:

W. F. Ruddiman (2013). Earth's climate: Past and Future (Third edition). W.H. Freeman, 464 pages.