

Time travel through climate

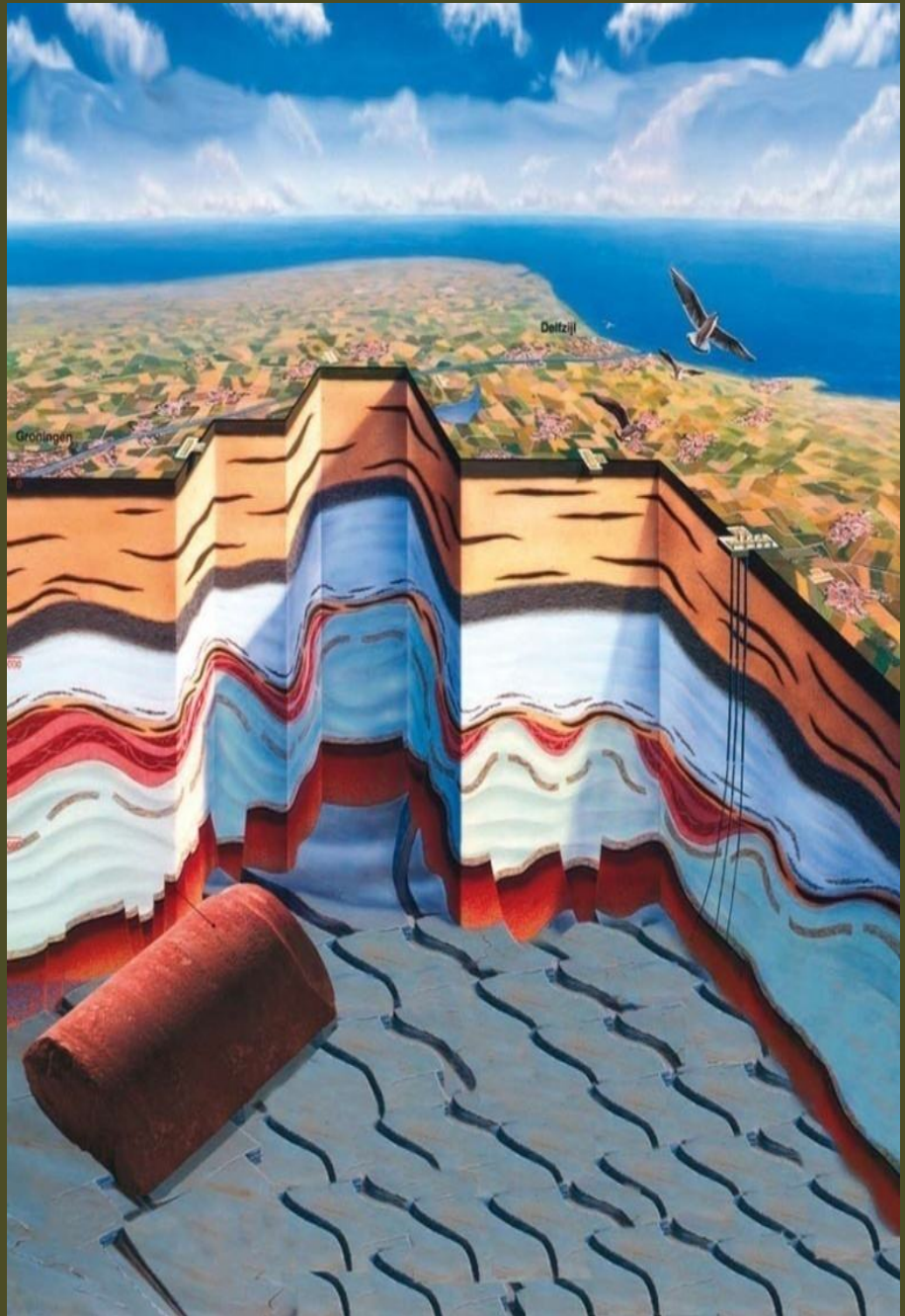
A chilly story

Joop Marquenie

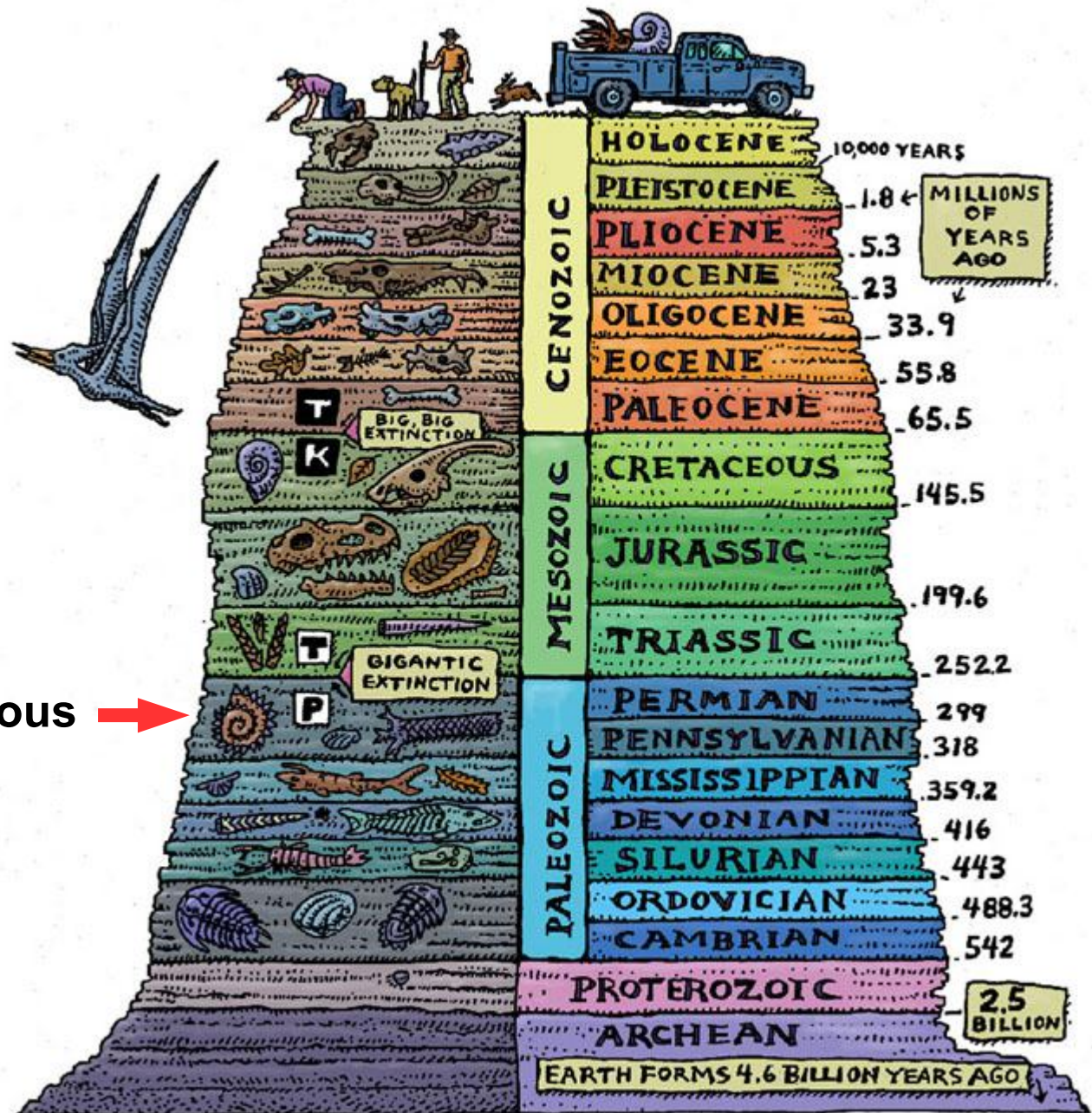
Detailed information about geology in the Netherlands starts with Carboniferous

Coal mines in Limburg
Gas from Groningen

Start of terrestrial speciation
Important start to
demonstrate climate change



Carboniferous →



What is Carboniferous?

Geological period: 350 million years ago

First occurrence of extended forests

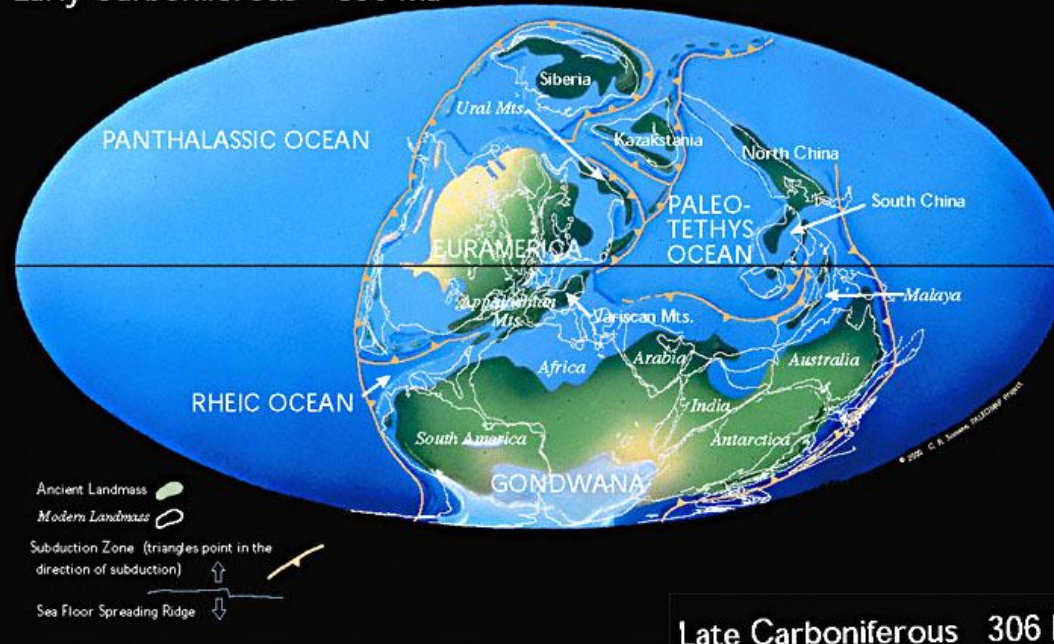
Formation of coal

Where, when and how?

Where were the Netherlands?

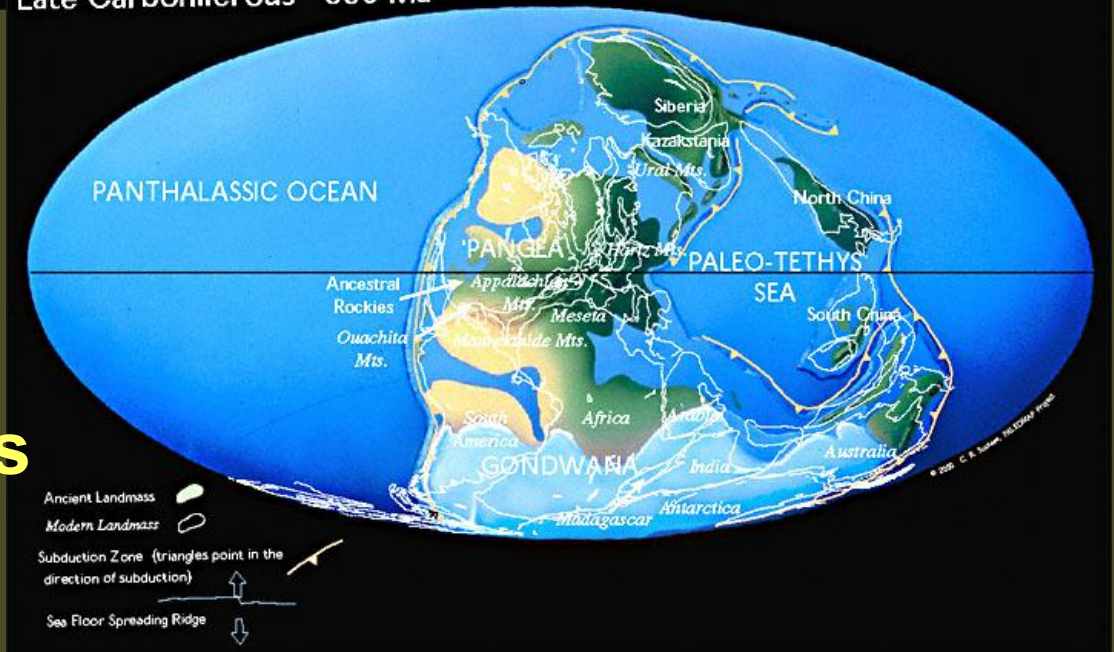
What was the climate?

Early Carboniferous 356 Ma



Early Carboniferous
350 million years

Late Carboniferous 306 Ma



Late Carboniferous
300 million year ago

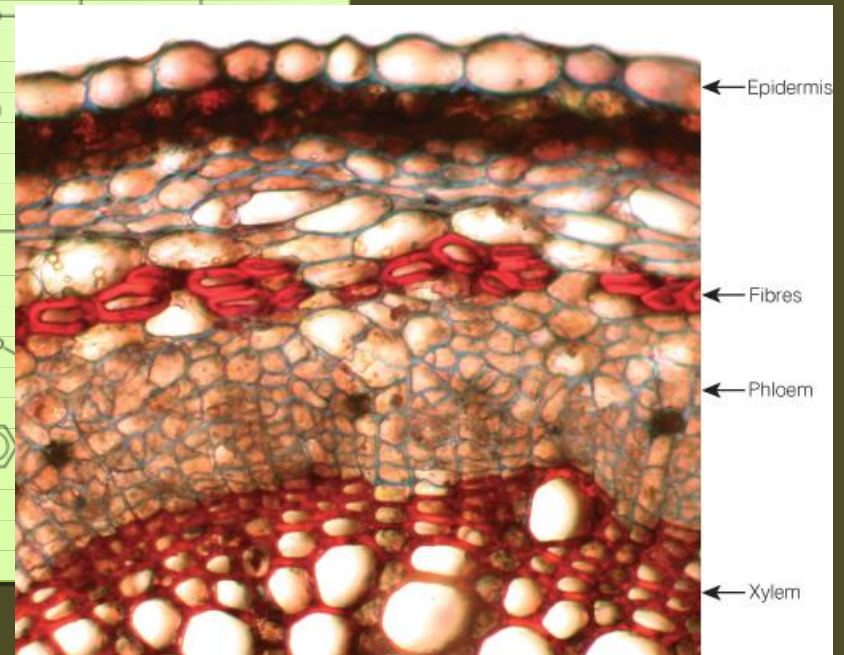
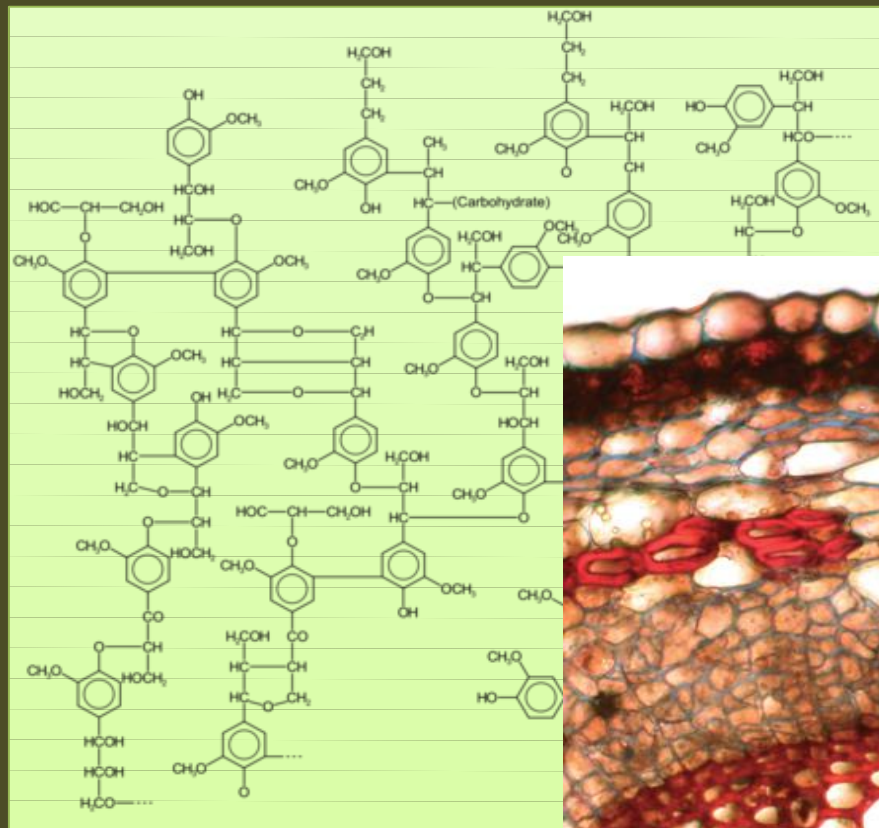
Artist-impression Carboniferous

No large grazers



The large invention of the era: the biopolymer **LIGNINE**

WOOD



Extremely durable

From a 2-dimensional ecosystem
to multi-dimensional

Piling of waste (dead wood)
For millions of years

The new invention: decomposition of wood

The end of the Carboniferous



Heimans groeve, Geul in Limburg (NL)



Following Carboniferous: Perm

forming Pangea 250 million year ago

Scarces still visible

Ural mountains (city of Perm)

Norwegians and
Greenland mountains

Appalachians

Super-continent PANGEA



**Perm ends with mass
extinction
90% of all known species**

Comets hit Siberia,
Vulcanic eruptions

And a new invention:
Methane producing bacteria

End of Perm: break-up of Pangea

After sand deserts the drying seas



Triassic, Jurassic and Cretaceous

Earth heats up

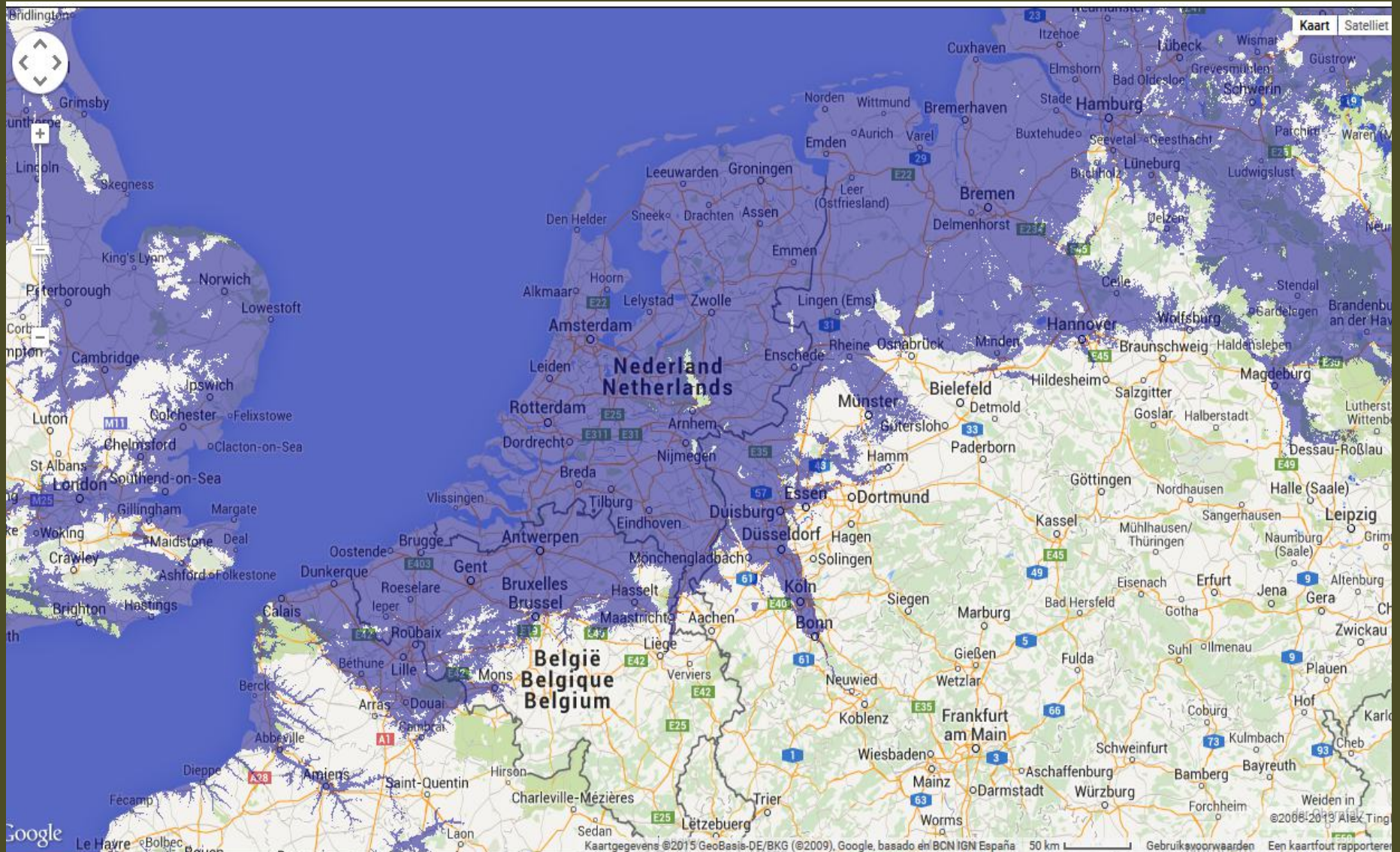
Sea level rises with about 60 m

Development of the Dinosaurs

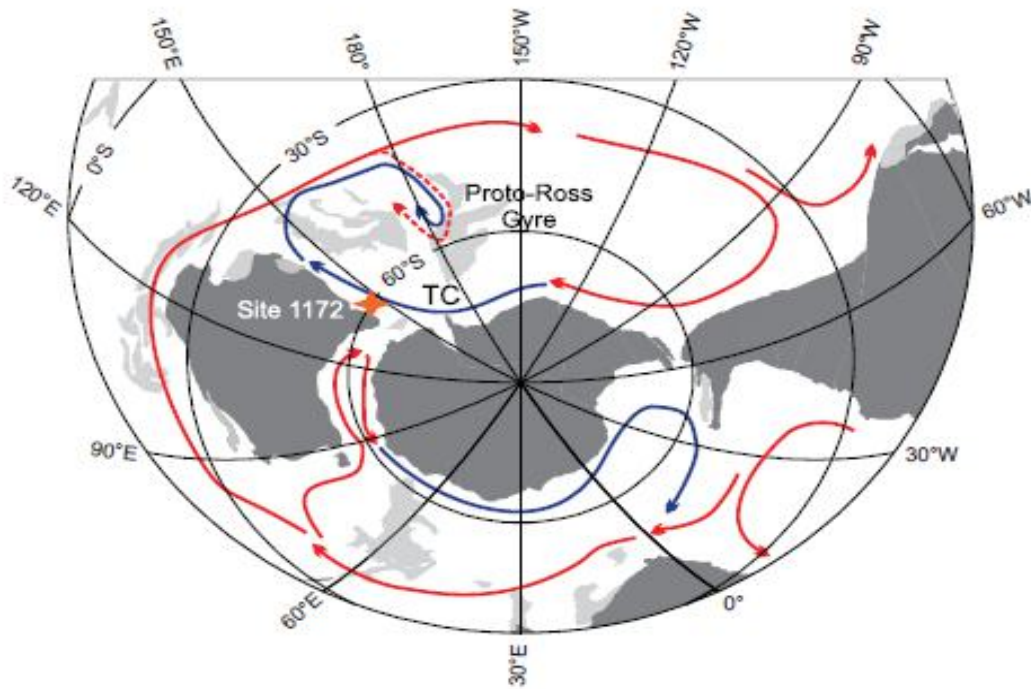
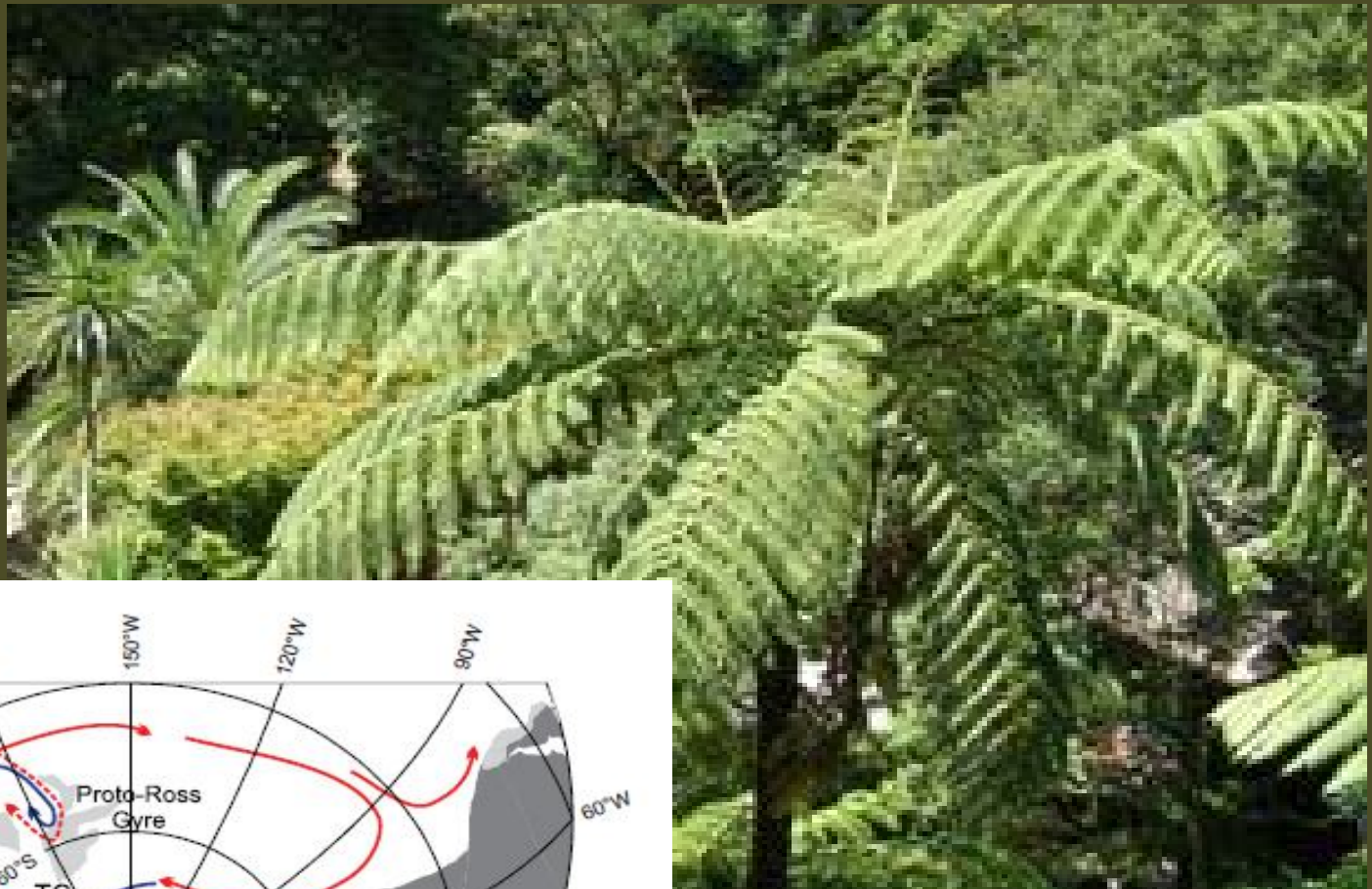
Mammals hidden existence

Reconstruction of the skeleton of *Mosasaurus hoffmannii* Natural history Museum in Maastricht





**Antarctica
covered
with
woods**



**Arctic ocean
is
open water**

Sea level falls

**Temperatures
drop world-wide**



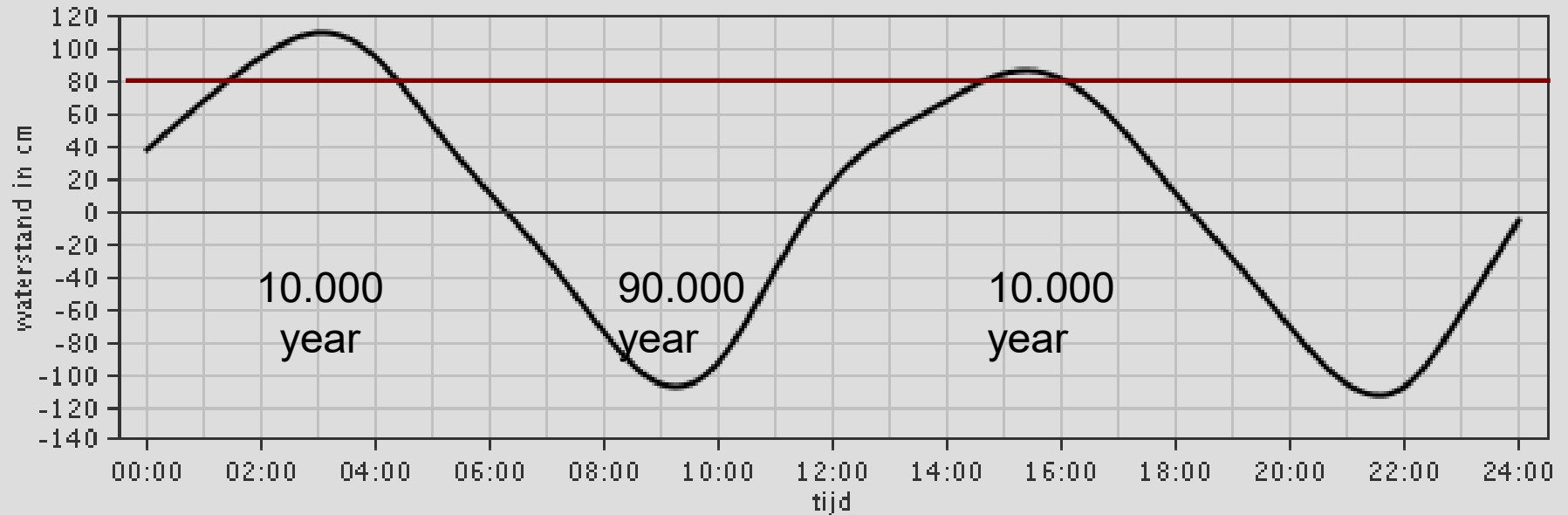
The last 2-5 million years

Continents move further north

Cyclic cold and warm periods

**Sea level drops and rises with 120
meters**

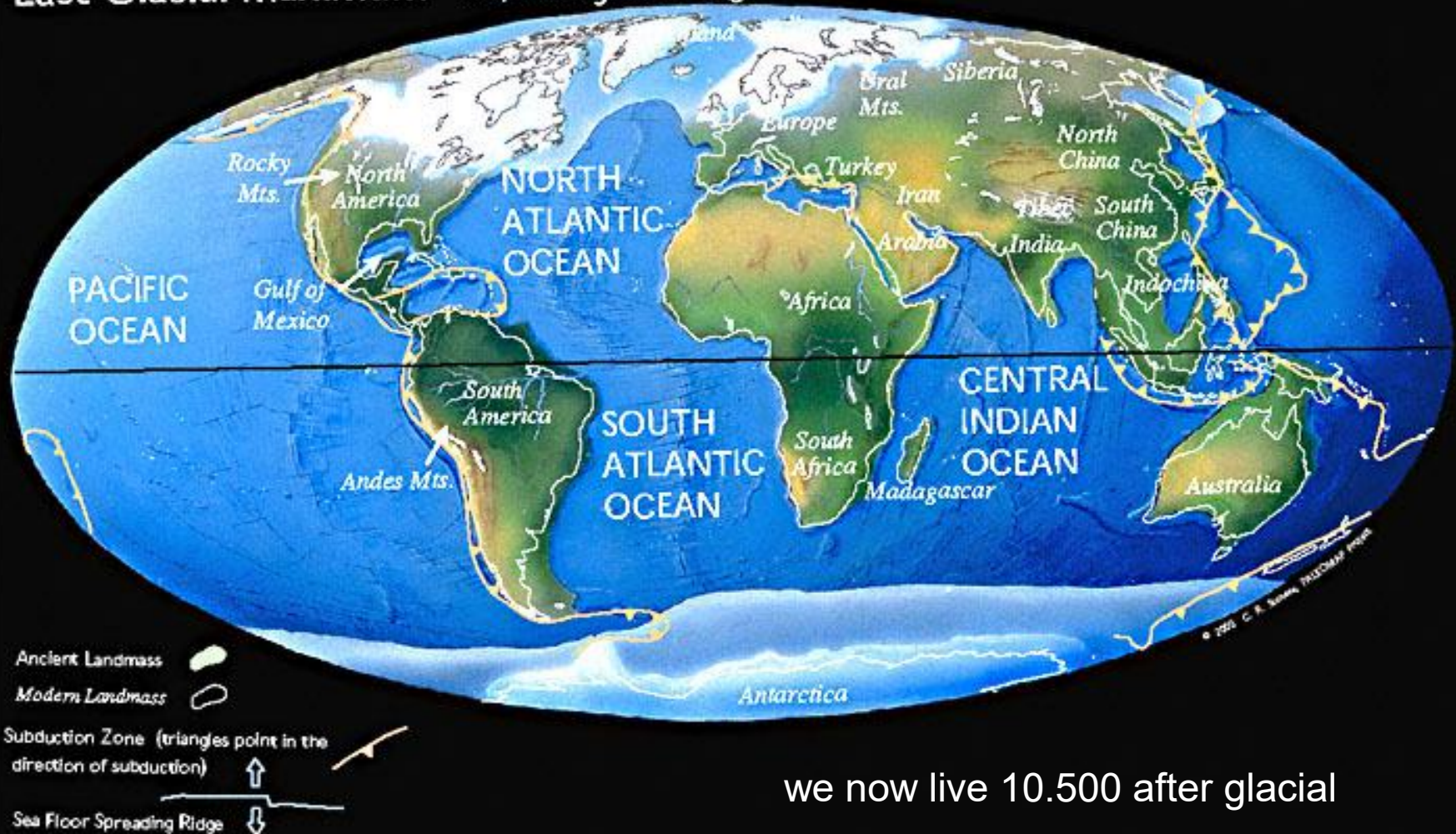
Ebb and flood



But also climate

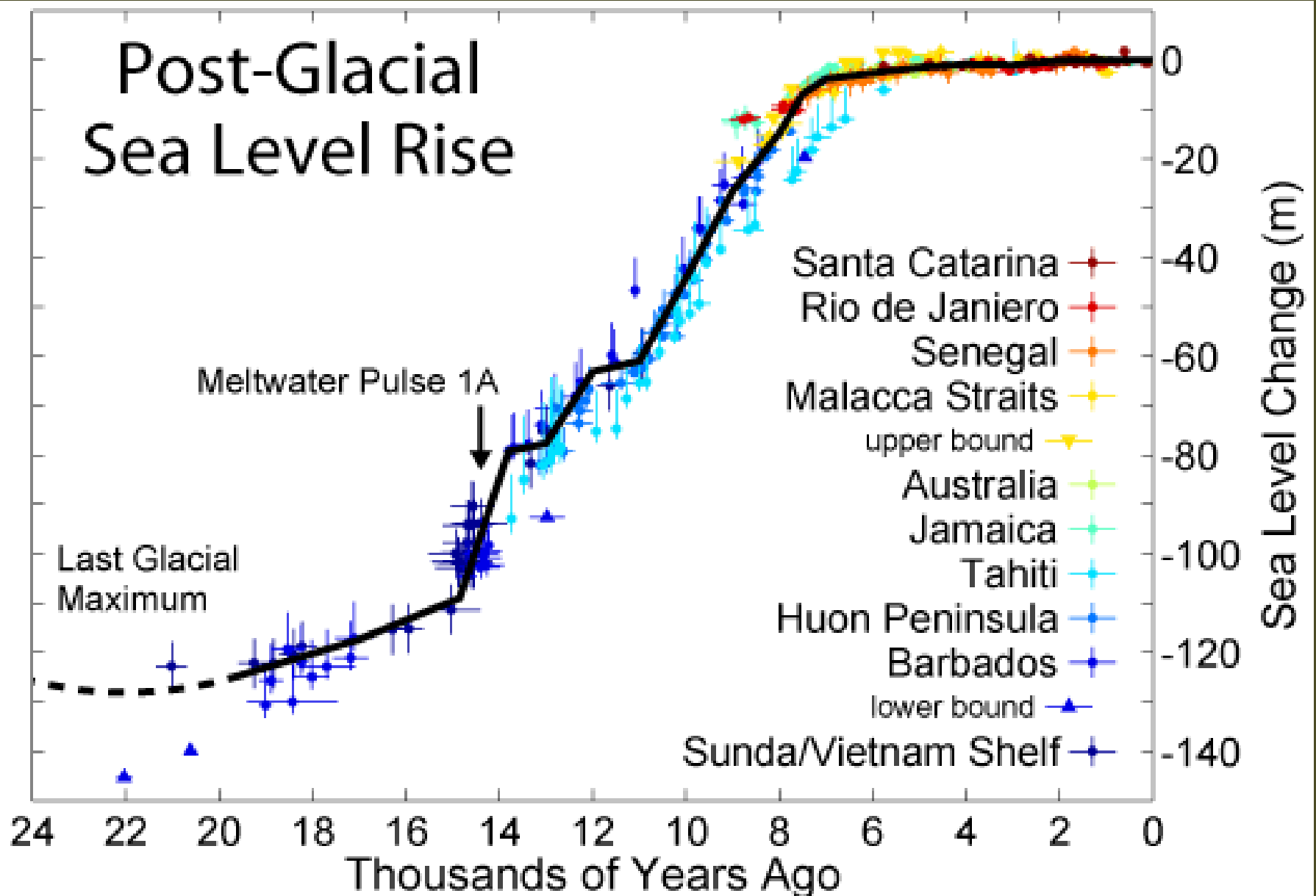
Cyclic patron

Last Glacial Maximum 18,000 years ago



we now live 10.500 after glacial

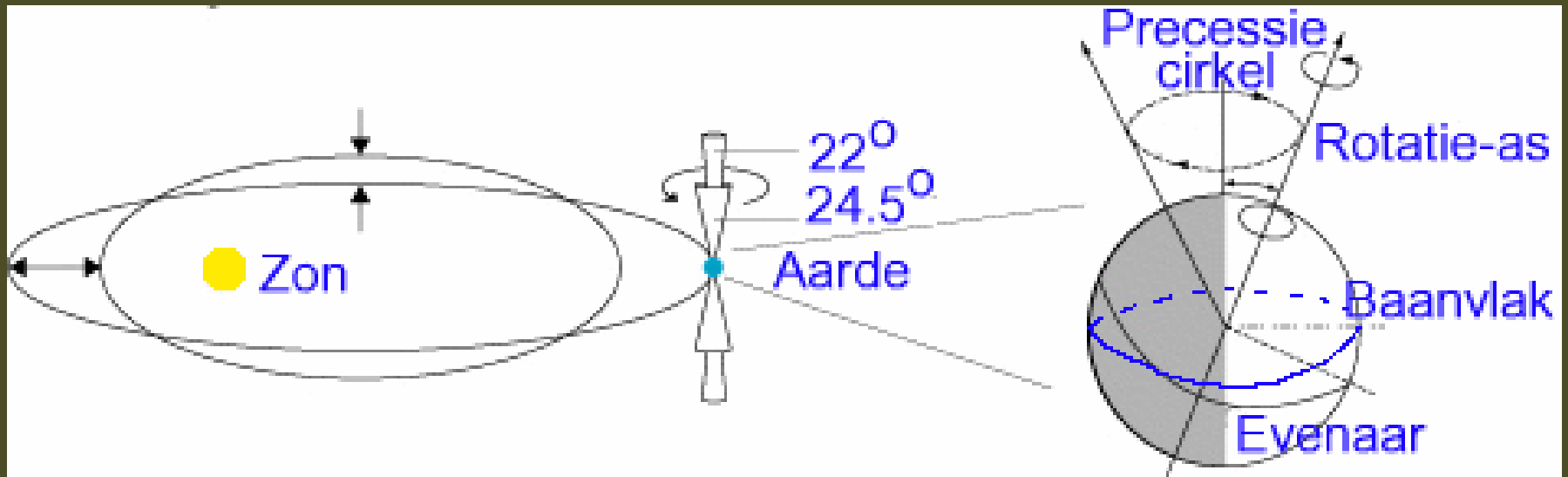
Post-Glacial Sea Level Rise



Why ice ages?

Because continents moved north!

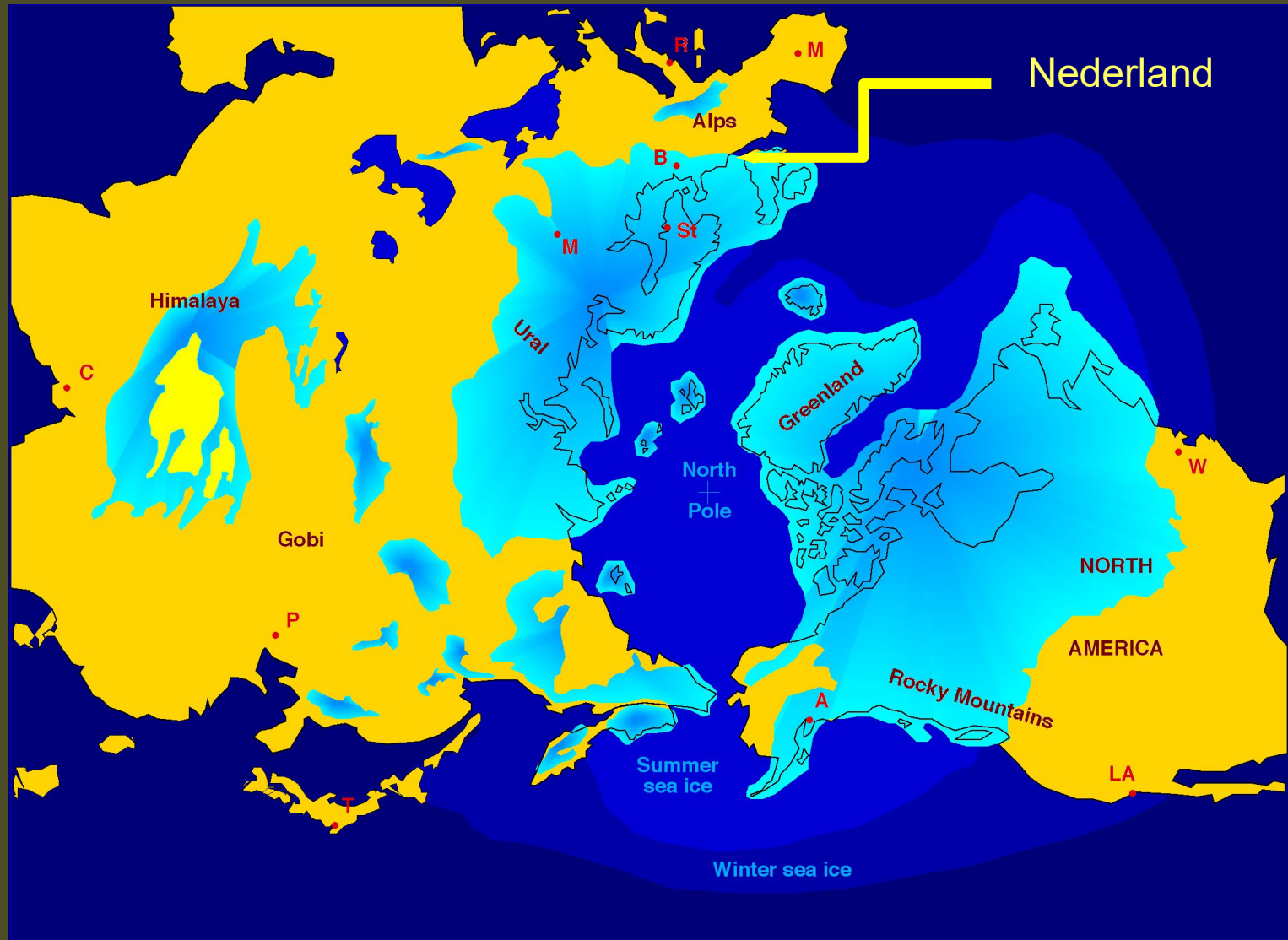
20.000 year



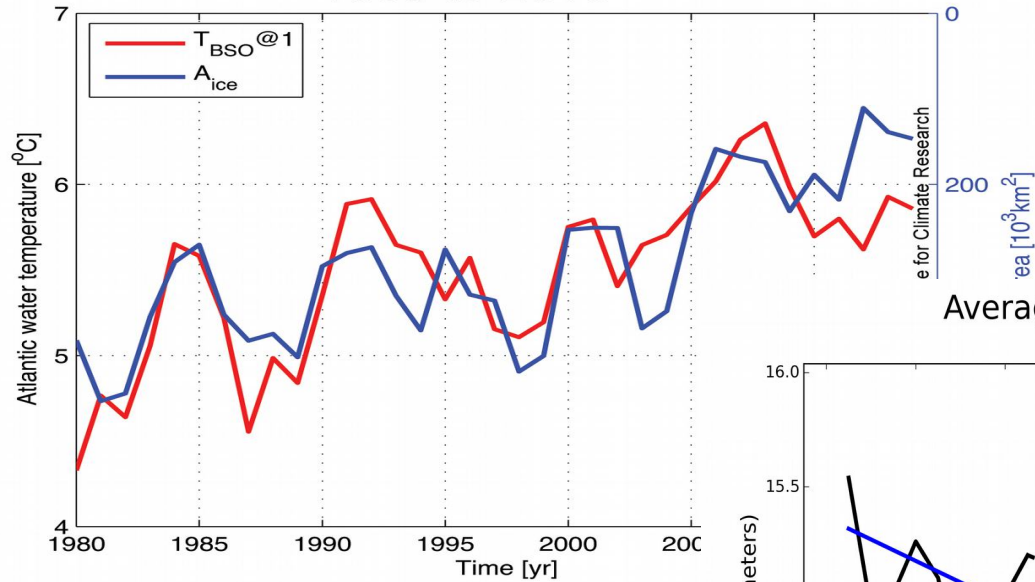
100.000 year

40.000 year

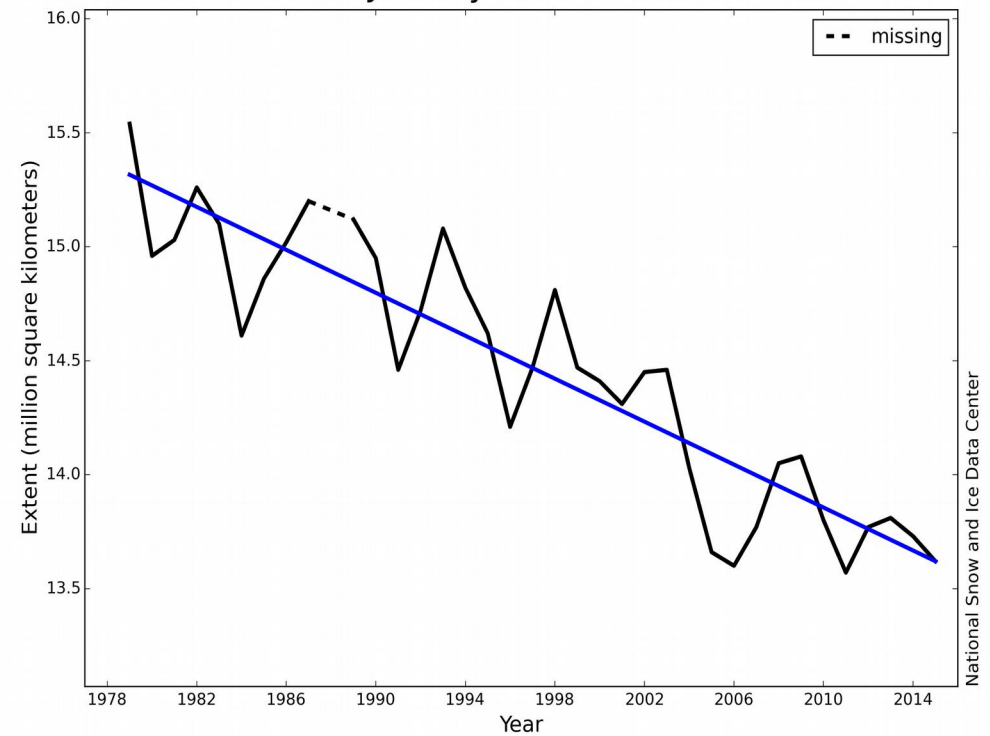
40.000 years ago



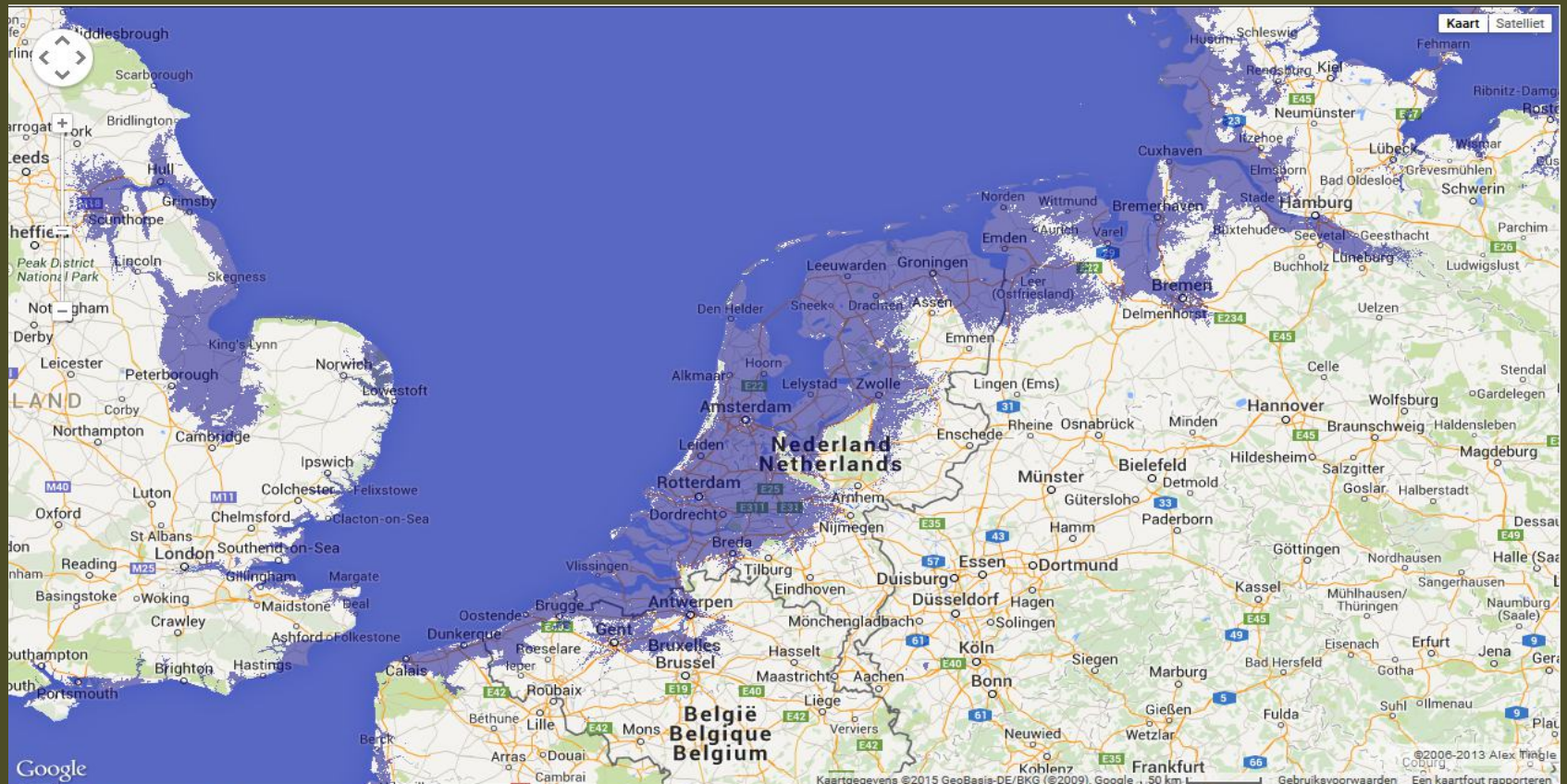
Barents Sea Ice Area and Ocean Temperature 1980 to 2015



Average Monthly Arctic Sea Ice Extent January 1979 - 2015



6 Meter sea level rise



Of wordt het koud en gaat de zeespiegel nu weer dalen?

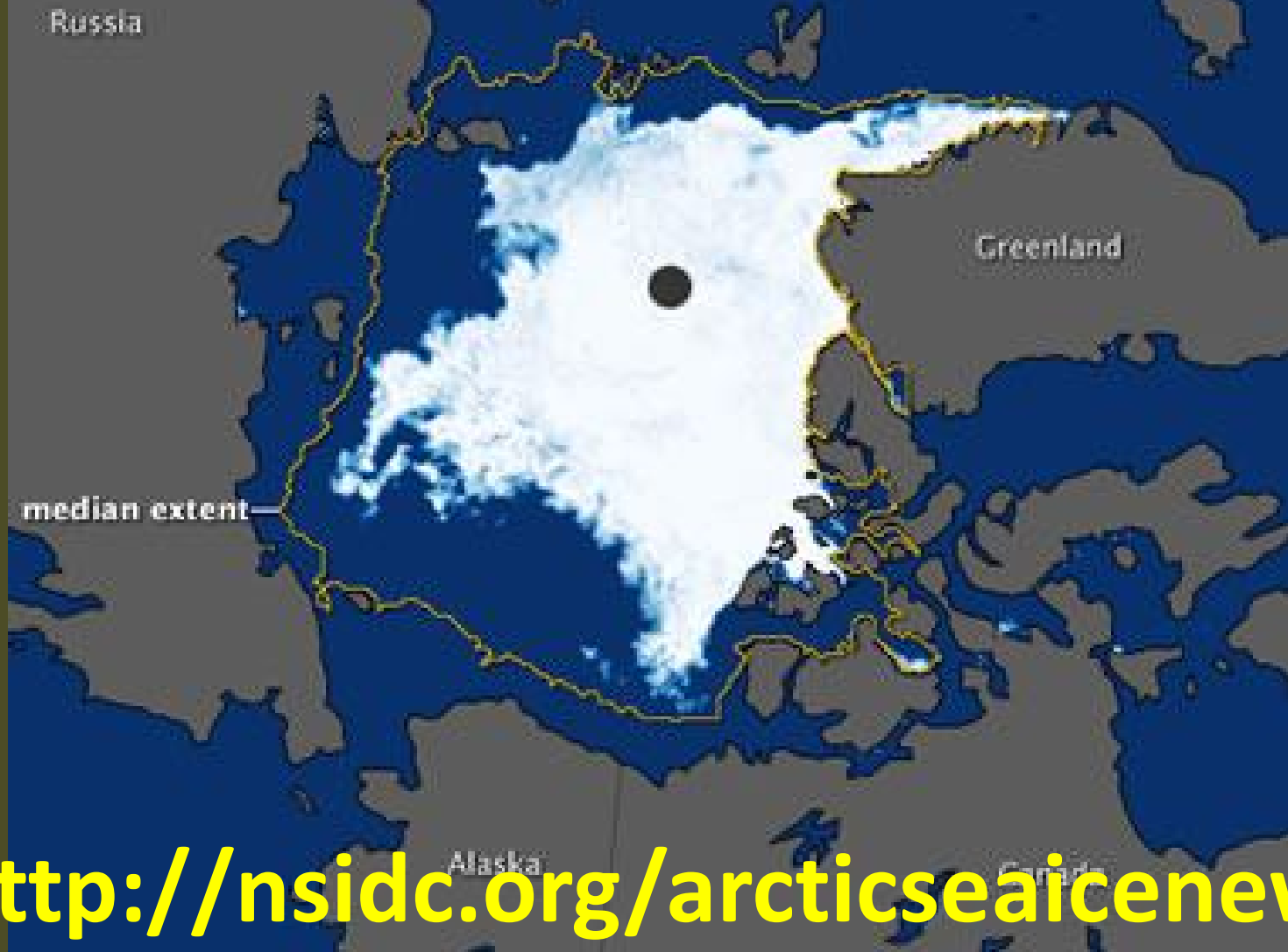
**Predictions are difficult,
especially about the future!**

Yogi Bear

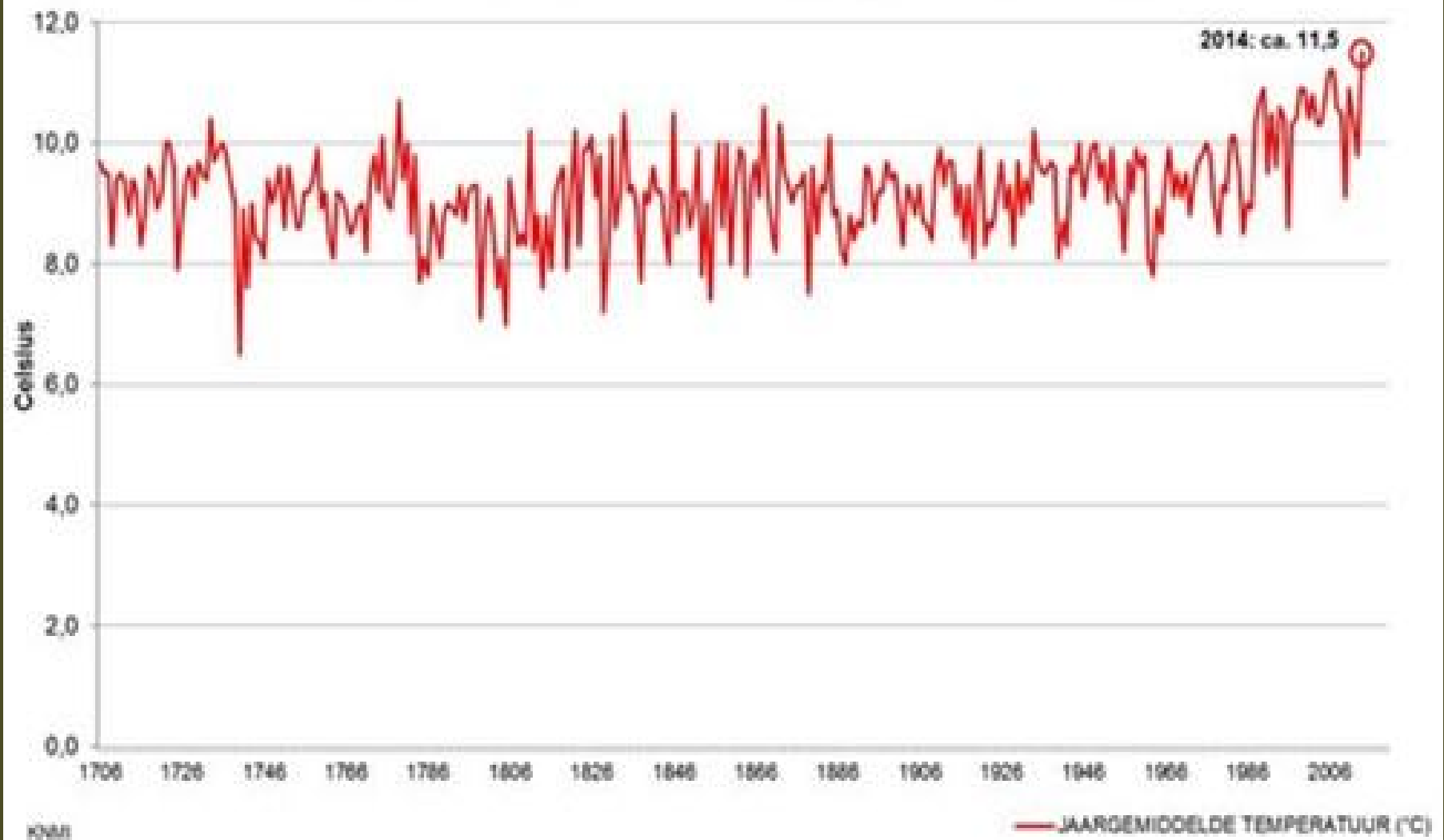
Little Ice Age 1600-1800



August 2012



JAARGEMIDDELDE TEMPERATUUR, De Bilt 1706-2014



What were the temperatures

Around 800

**When Vikings colonised
Greenland to seed barley**

How cold was the Little Ice Age

**When again we can seed Barley
on Greenland?**

THE Middle Ages were unusually warm in northern Europe, and it was during that period that the Vikings settled in Greenland. They cultivated land, growing mostly barley. The climate then cooled down, which made the place too chilly for arable farming. These days Greenland's 56,000 people rely largely on sheep farming in the south, hunting in the north and fishing in the west.

Or at least they did until the world started warming up again.

Average temperatures in Greenland have risen by 1.5°C over the past 30 years. The barley is back.

Kenneth Hoeth has been growing it, but only as an experiment. Several farmers in southern Greenland are now farming potatoes, turnips and iceberg lettuces commercially. Mr Hoeth is trying out other crops: he is pleased with his Chinese cabbage, which he says is particularly crispy.



Boston, 2014