Royal Netherlands Institute for Sea Research

Aridity changes in the Sahel and their relation to Atlantic-Ocean circulation during the last 57 kyr: inferences from marine sediments off Senegal

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AWI Alfred-Wegener-Institut für Polar- und Meeresforschung

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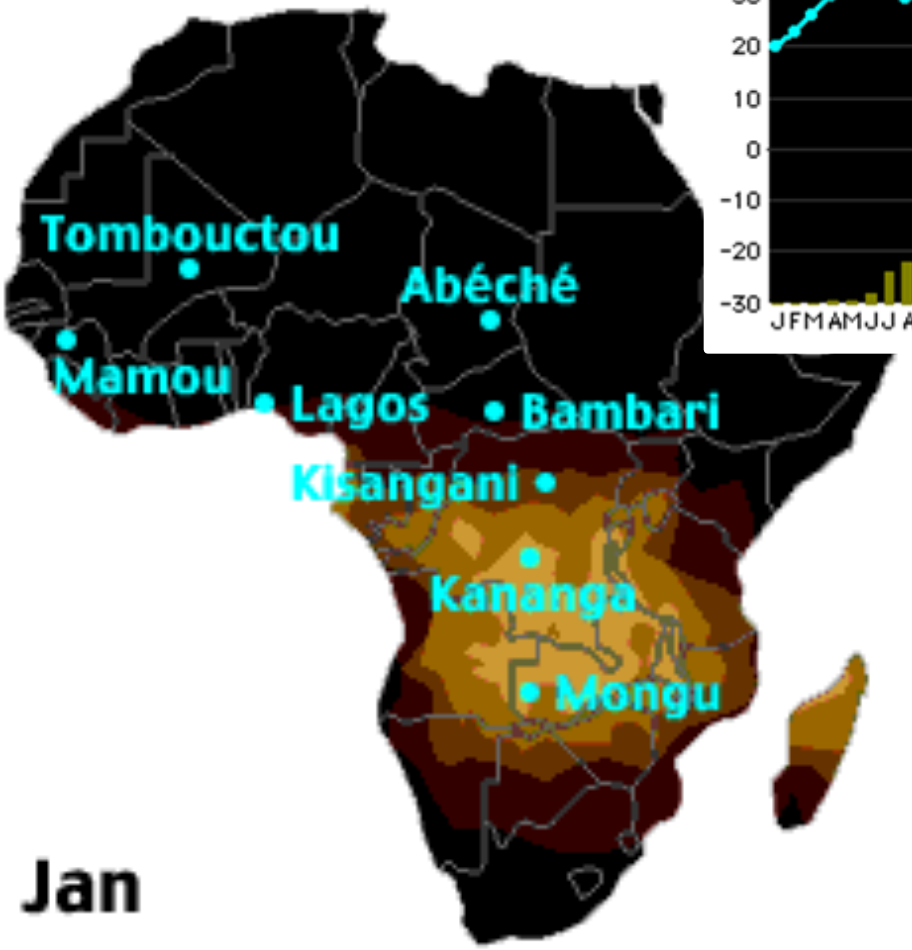
Why Sahel-climate reconstructions?

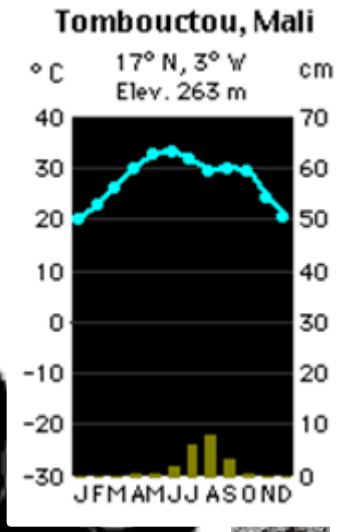
- Desert dust has many relations with global climate
  - e.g., back scattering of sun light,
  - changes in Earth's albedo,
  - fertilisation of terrestrial & marine life
- The Sahara Desert is the largest dust source in the world
- The Sahel is very vulnerable to droughts
- The past the future
- "Lucky shots" high-sedimentation marine archive

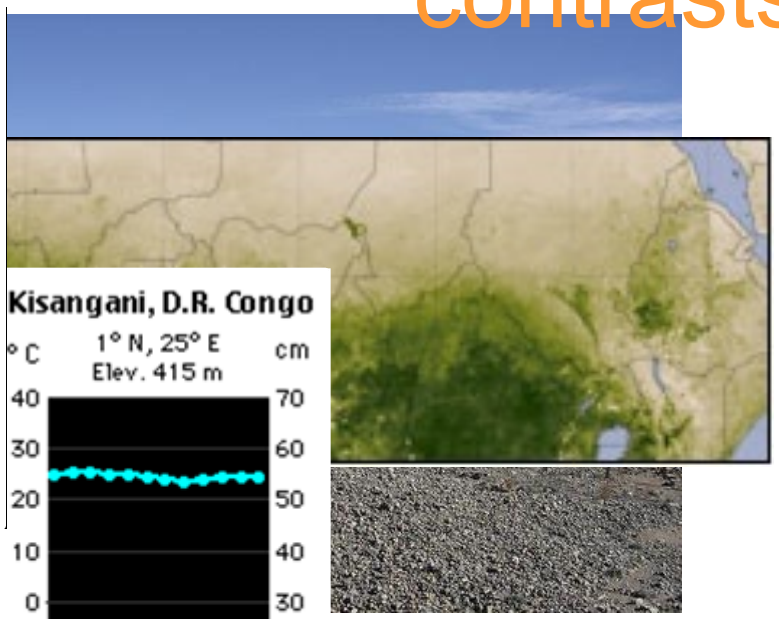
  → allows coupling of instrumental- & proxy records

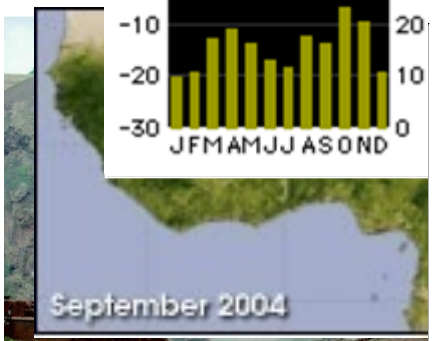
Sahel: strong seasonal contrasts

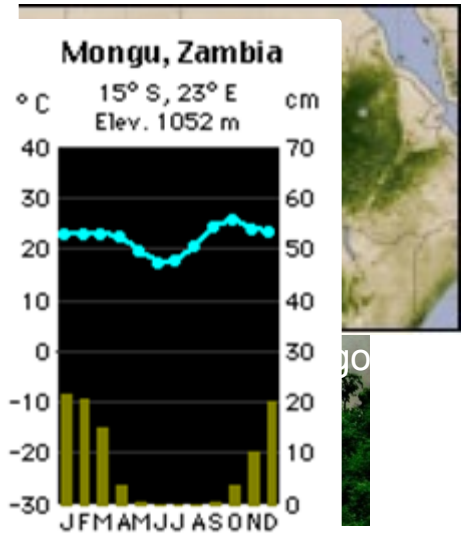
Precipitation



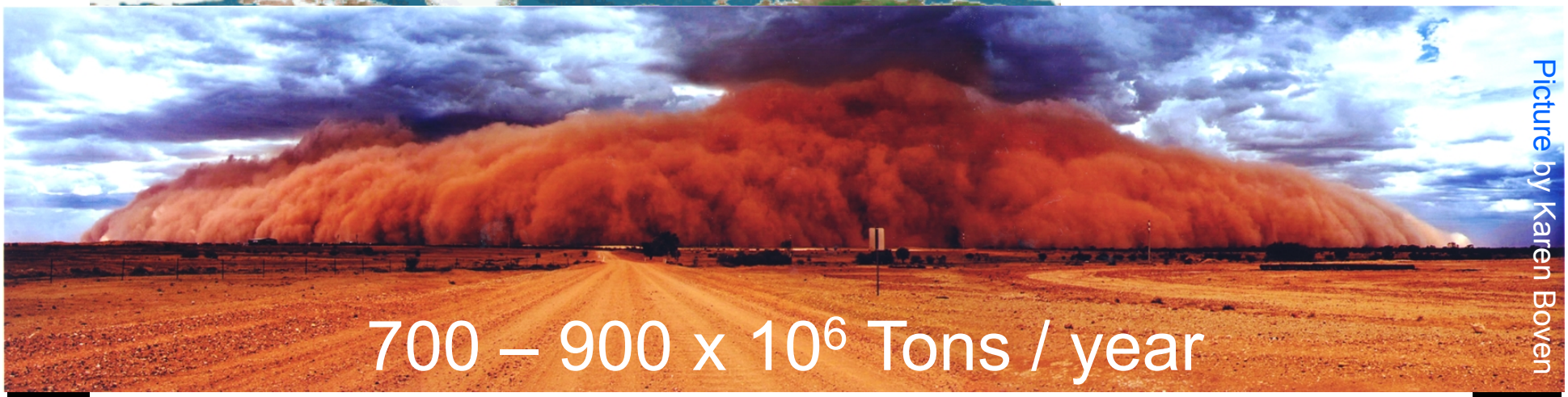






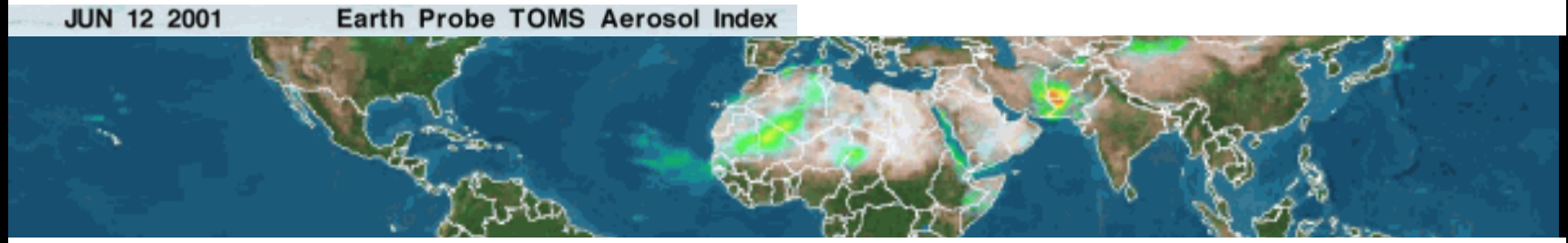


(http://people.cas.sc.edu)

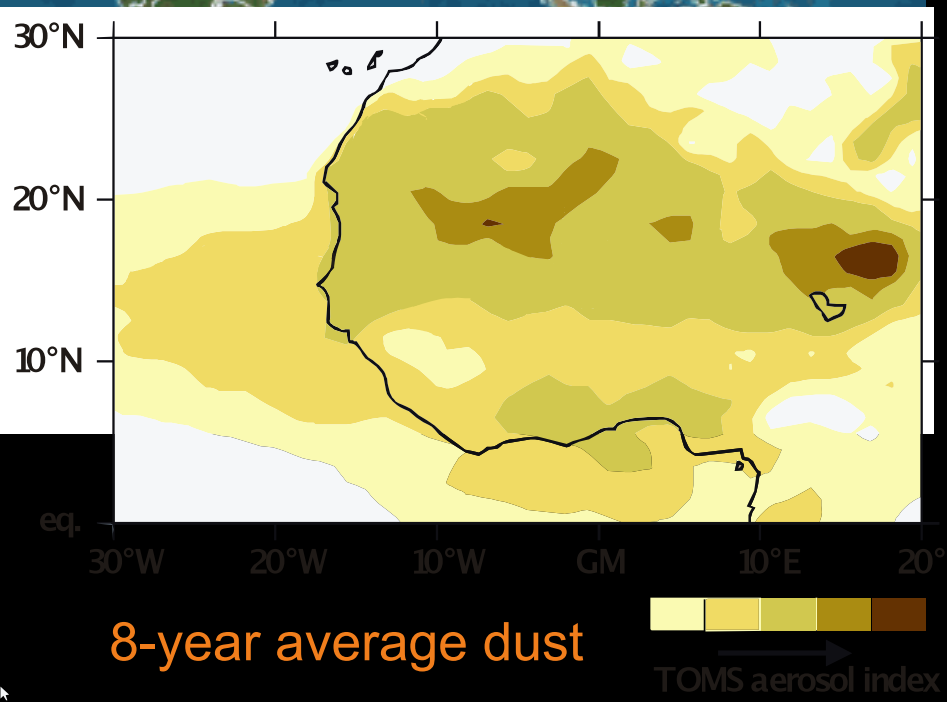


700 – 900 x 10^6 Tons / year

Picture by Karen Boven



Good chances for a paleo-dust record off NW Africa



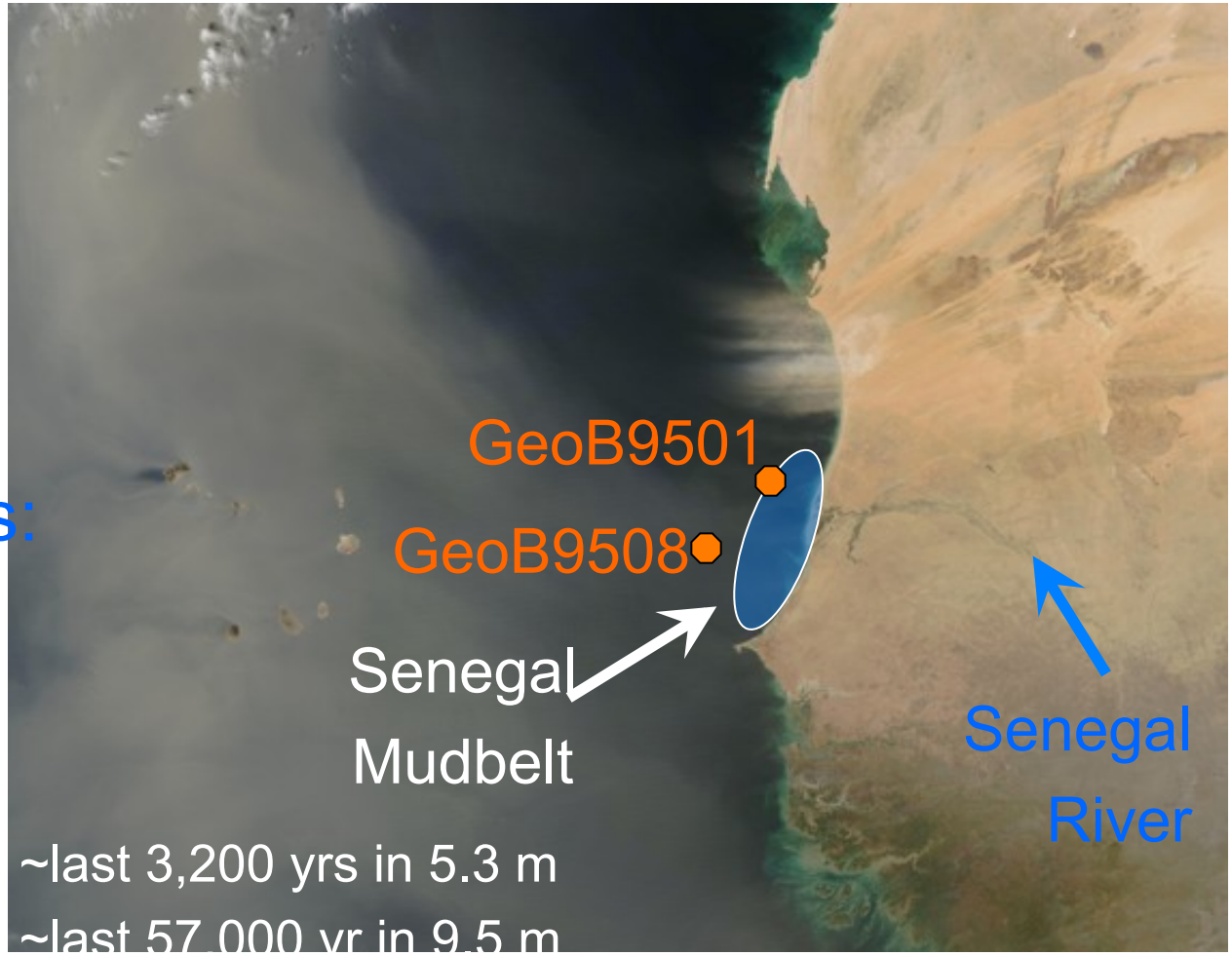
8-year average dust

Dust data from: http://toms.gsfc.nasa.gov/

Paleo dust from the Sahel

Two sediment types:

- Fluvial mud
- Wind-blown dust

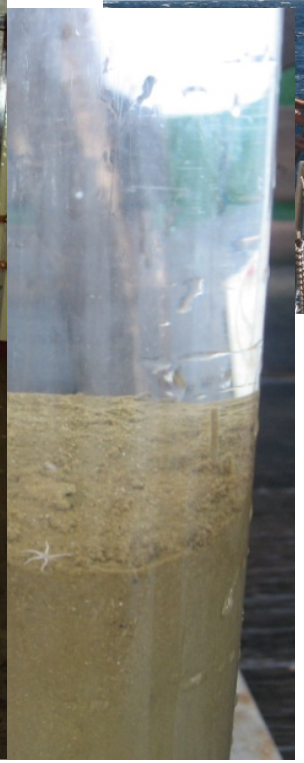


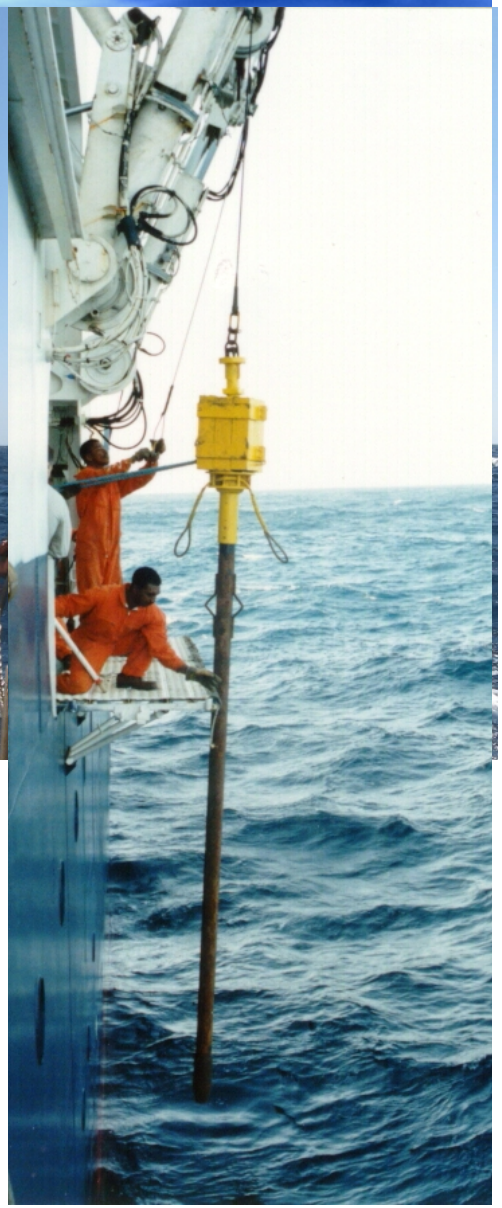
Sediment-core characteristics

Core GeoB 9501-4 (multi core): 42 cm; ~1(

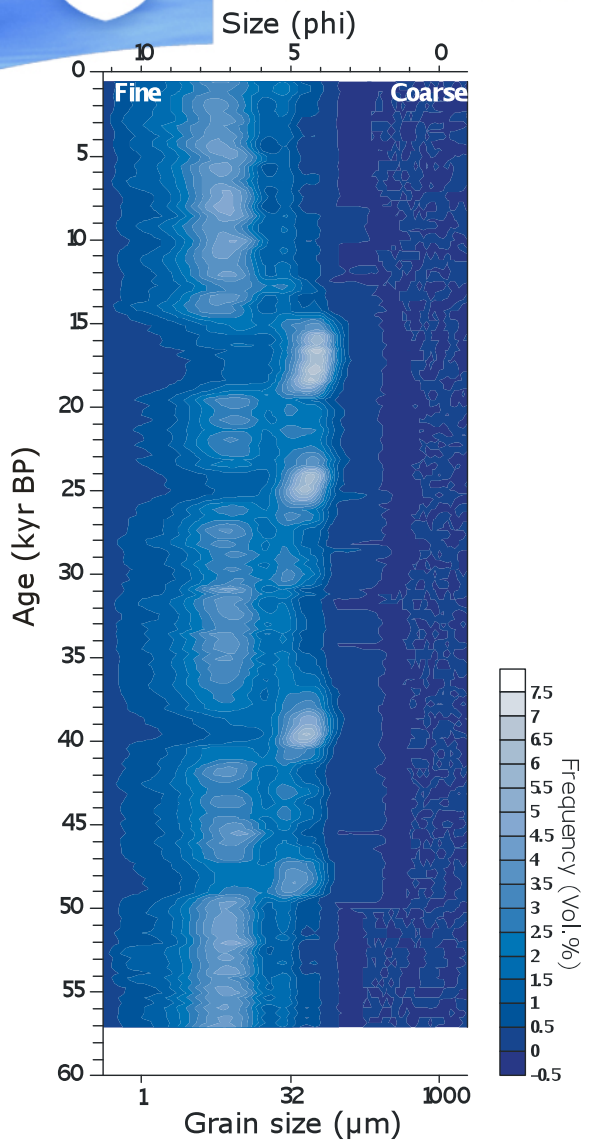
Core GeoB 9501-5 (gravity core): 532 cm;

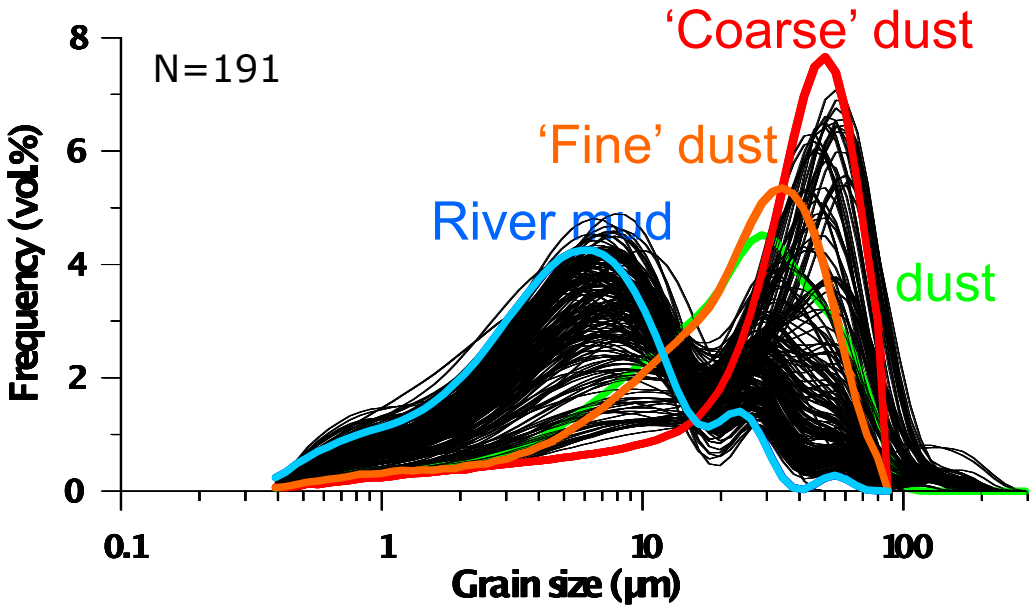
Core GeoB 9508-5 (gravity core): 953 cm;





Late Quaternary climate swings

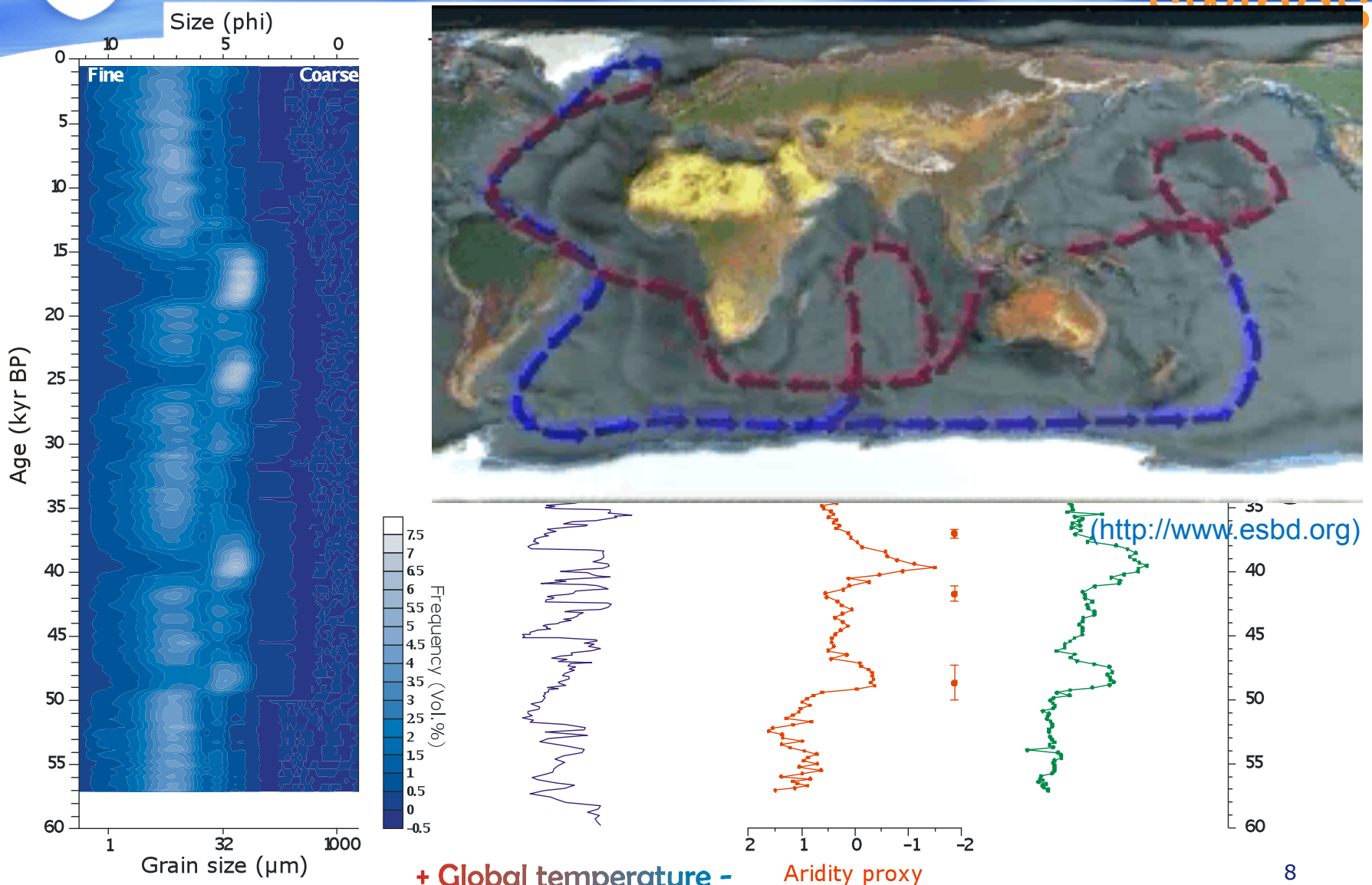




Present-day Senegal suspension load 95% < 10µm (Gac & Kane 1986)

End-member model: Weltje 1997

Late Quaternary climate swings



(http://www.esbd.org)

Climate in Sahel linked to AMOC

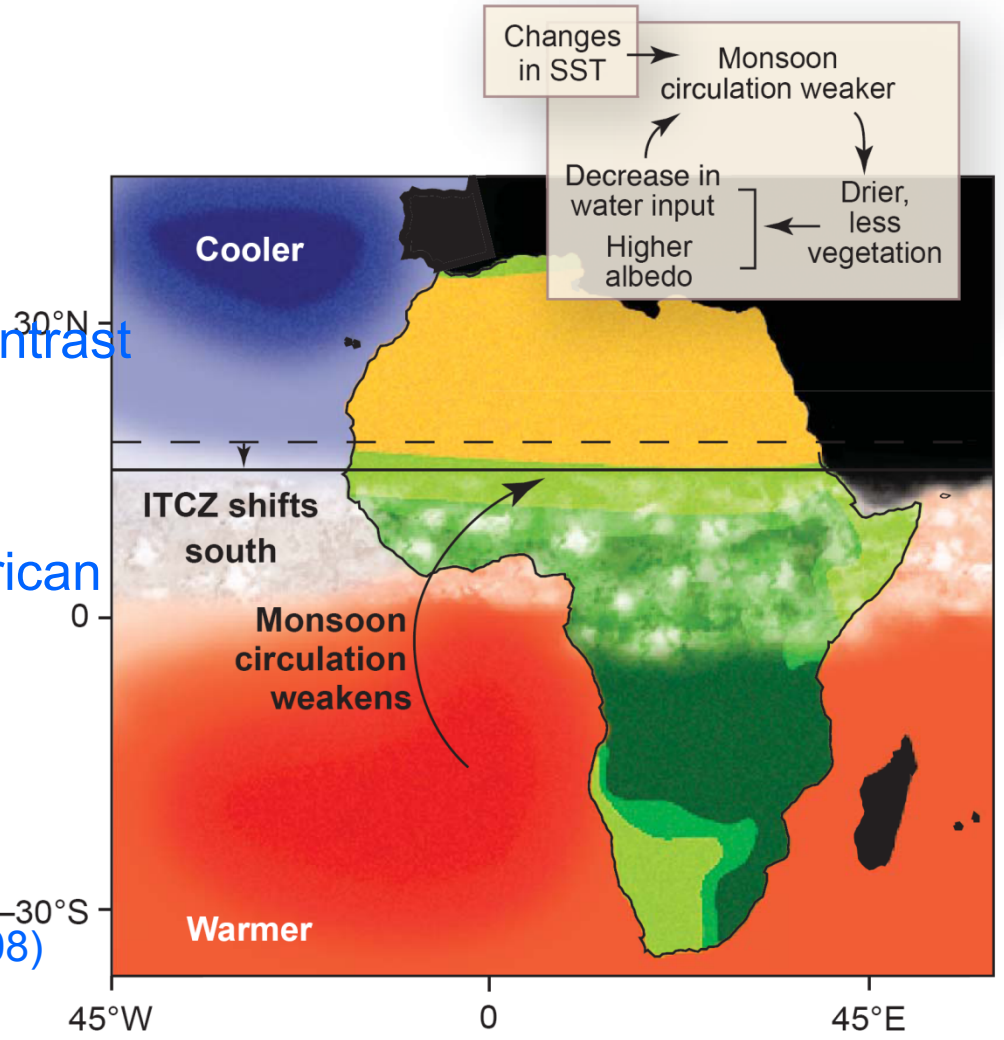
Freshwater pulses into North Atlantic

lead to larger temperature contrast across the equator

and southward shift of the African rainbelt

→drought in the Sahel

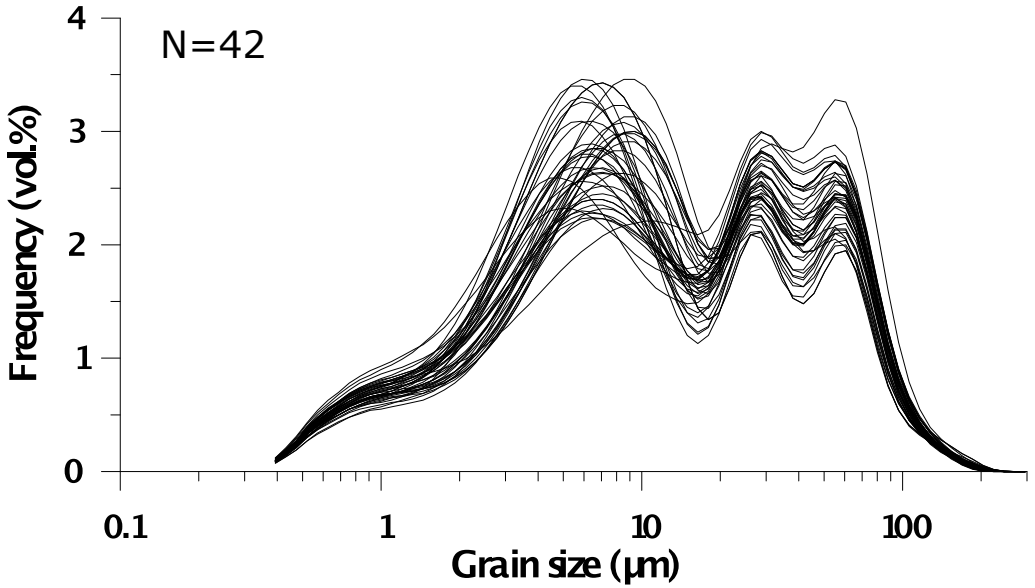
(Mulitza et al., 2008)

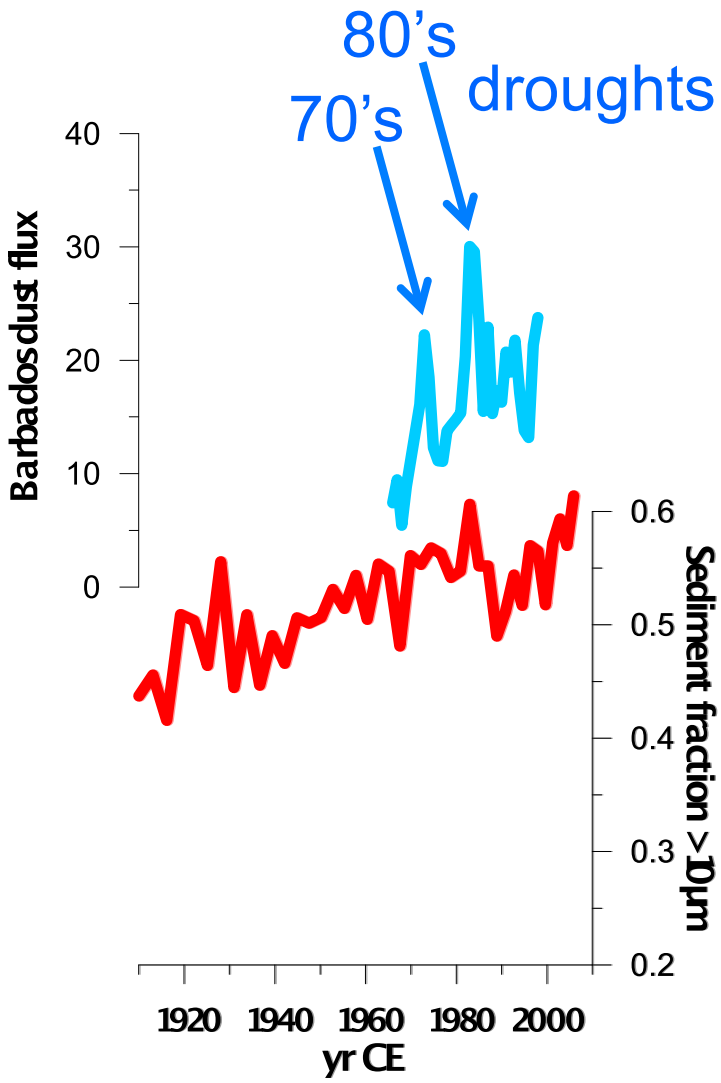


(Zen 2003)

Paleo-dust records
(last century)

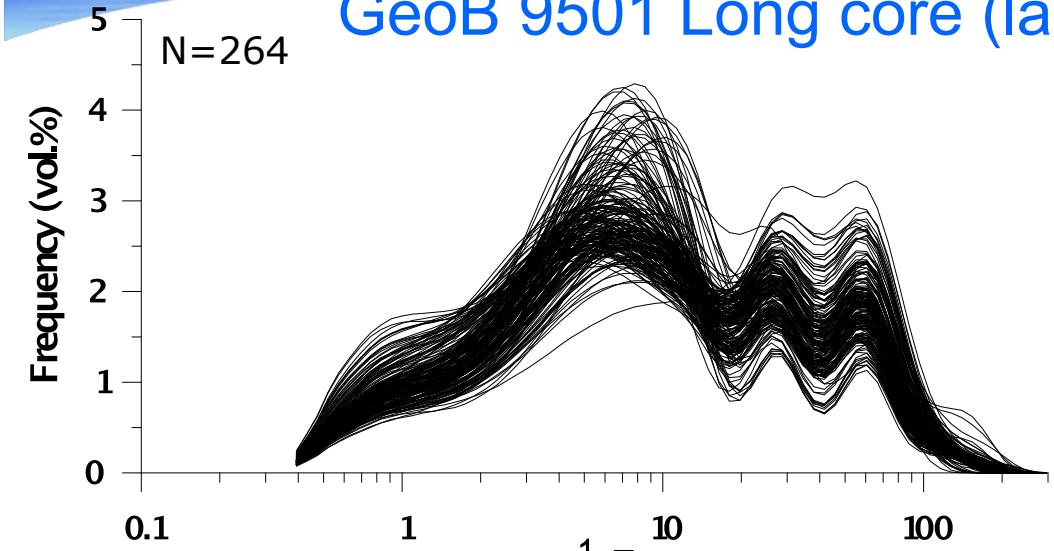
GeoB 9501 Short core (last 100 yrs)

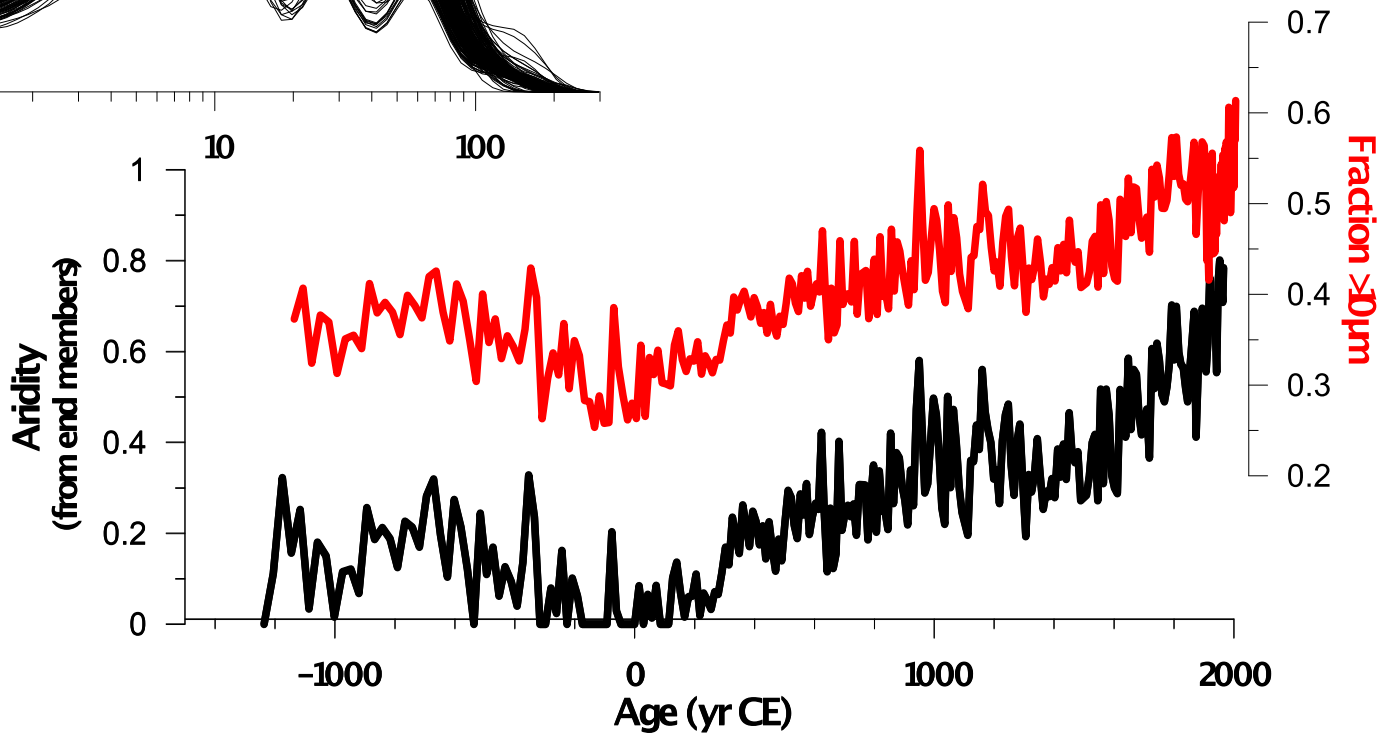




Late Holocene Sahel climate record

GeoB 9501 Long core (last 3,200 yrs)

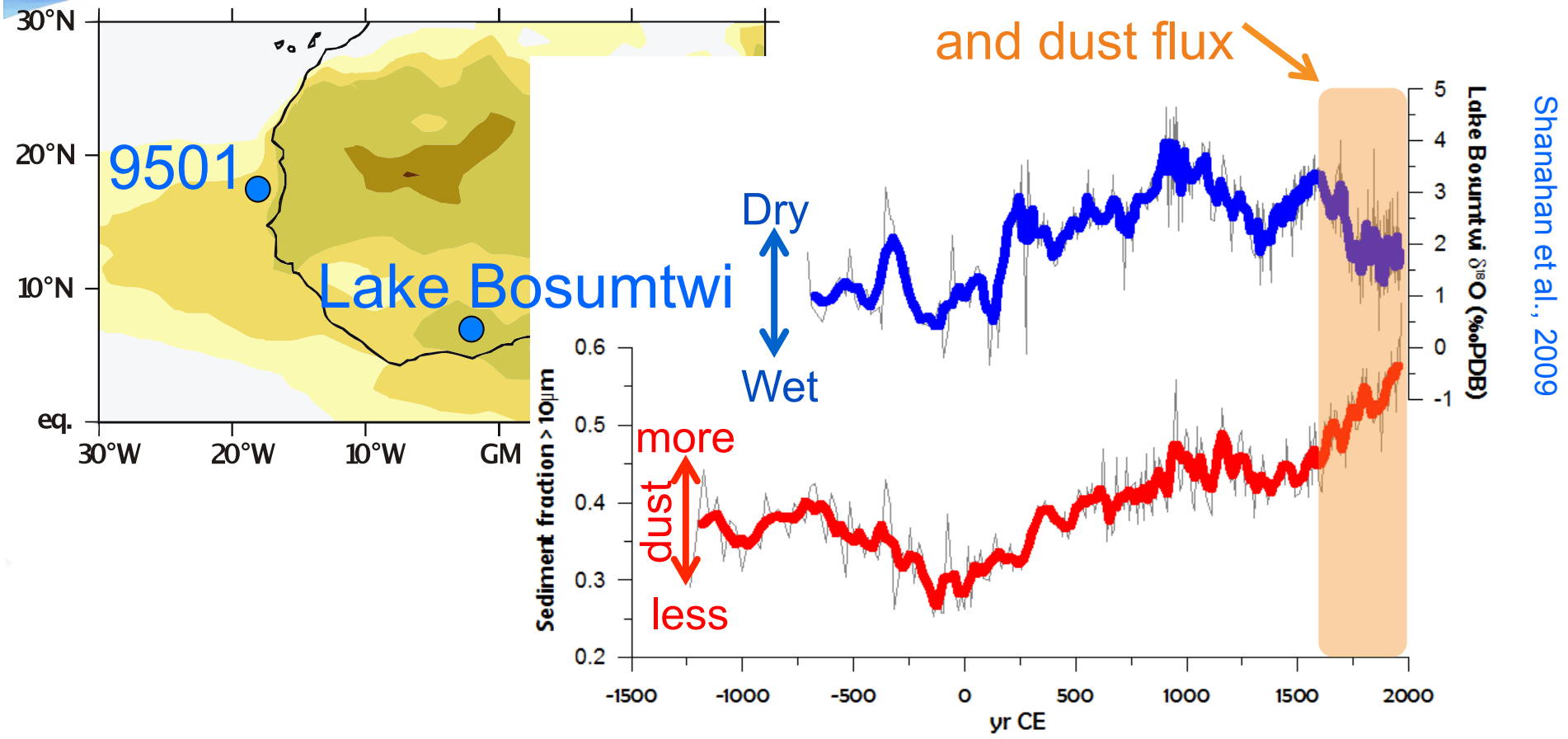




Paleo-dust records

(last three millennia)

Decoupling of precipitation and dust flux



Shanahan et al., 2009

Until ~1700 CE dust flux parallel with precipitation in Sahel

Last 300 yrs precip/dust decoupled → something else...

Natural vs Anthropogenic variability

Human agricultural activity caused increased dust mobilisation

early 18th century: Portuguese colonists

e.g., maize / millet / sorghum

(J.L.A. Webb, 1995)

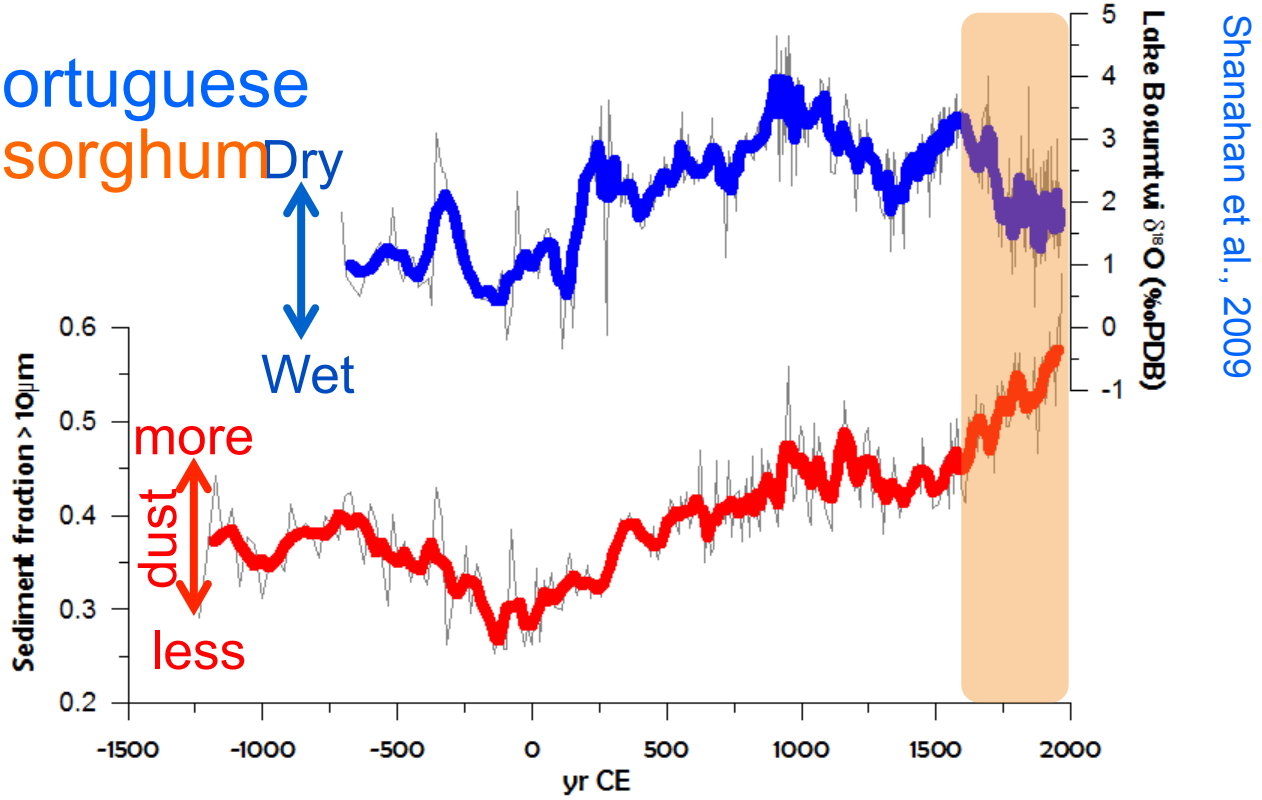
mid 19th century: "cash crop revolution"

e.g., peanuts

(G. Austin, 2009)

early 20th century: "agricultural export economies"

(G. Austin, 2009)

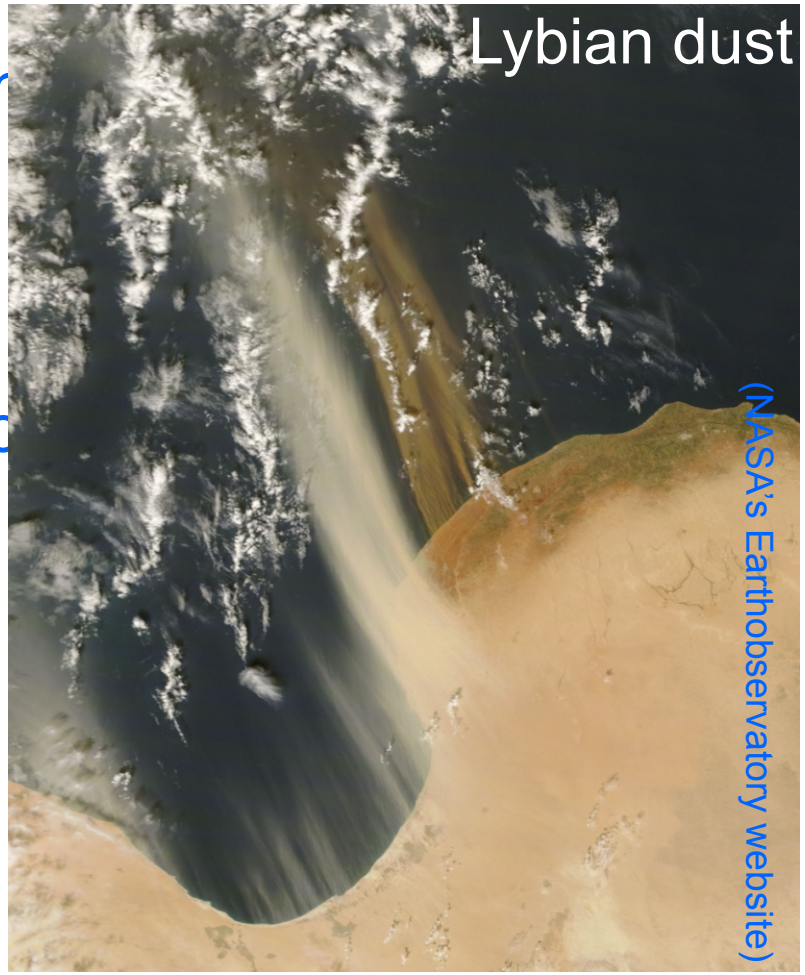


Shanahan et al., 2009

Summary

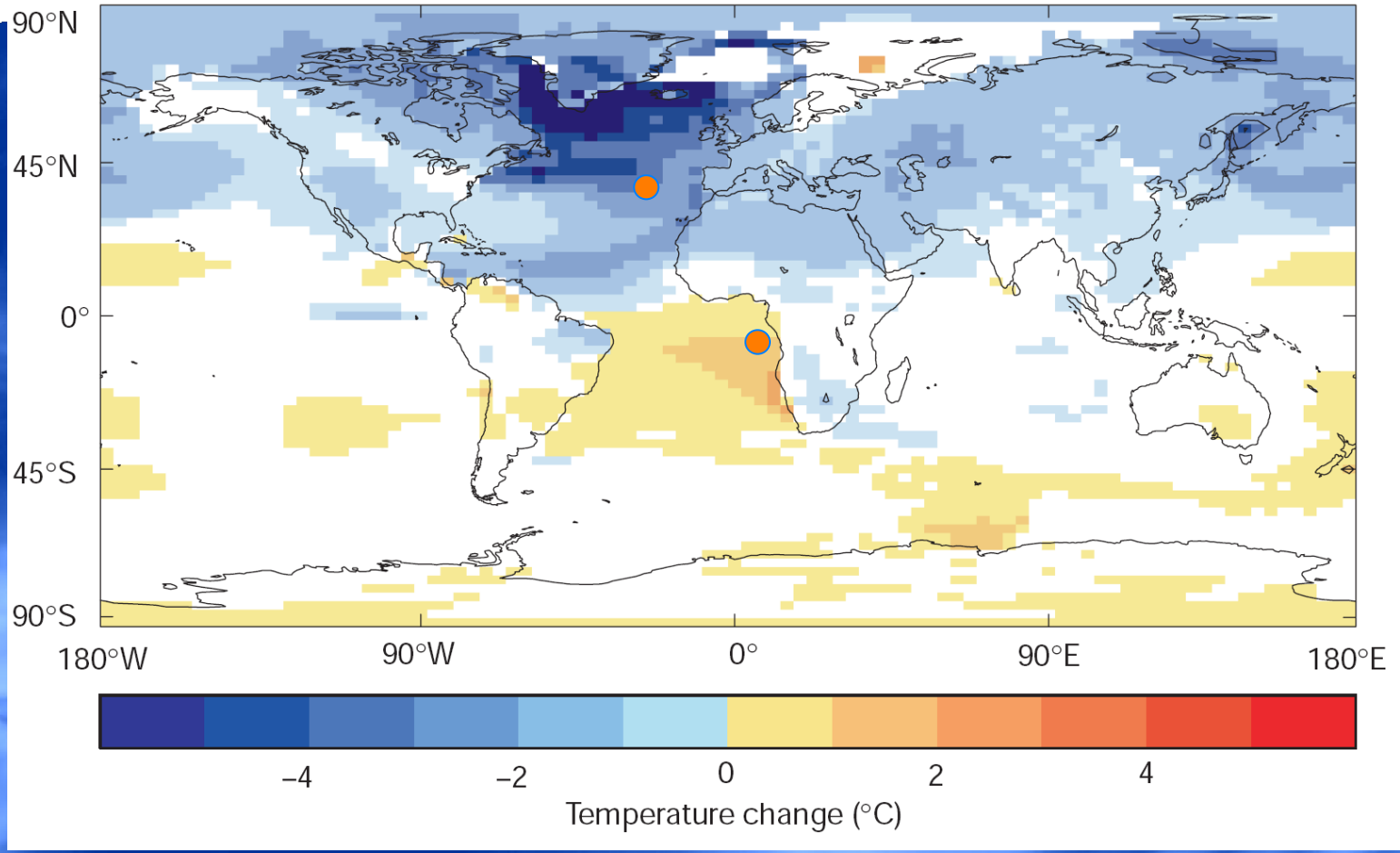
Late Quaternary sediment records offshore Senegal show:

- Sahel dust production mostly driver by precipitation, related to AMOC
- On shorter run (3.2 kyr) also link between precip. and dust productio
- natural variability overprinted by human (agricultural) activity during last 300 yr



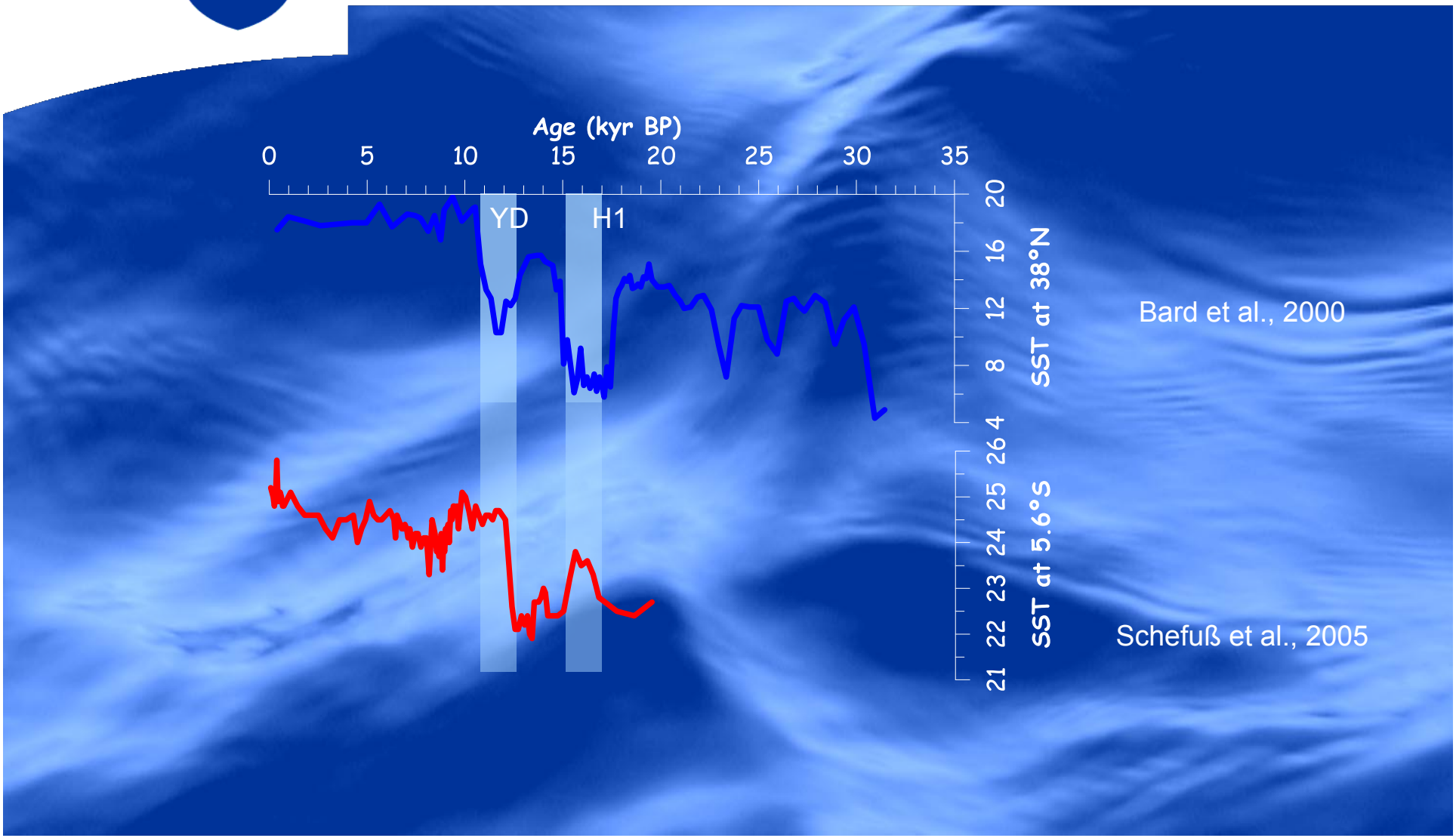
Thanks for your attention

Modelled response of surface temperature to reduced overturning

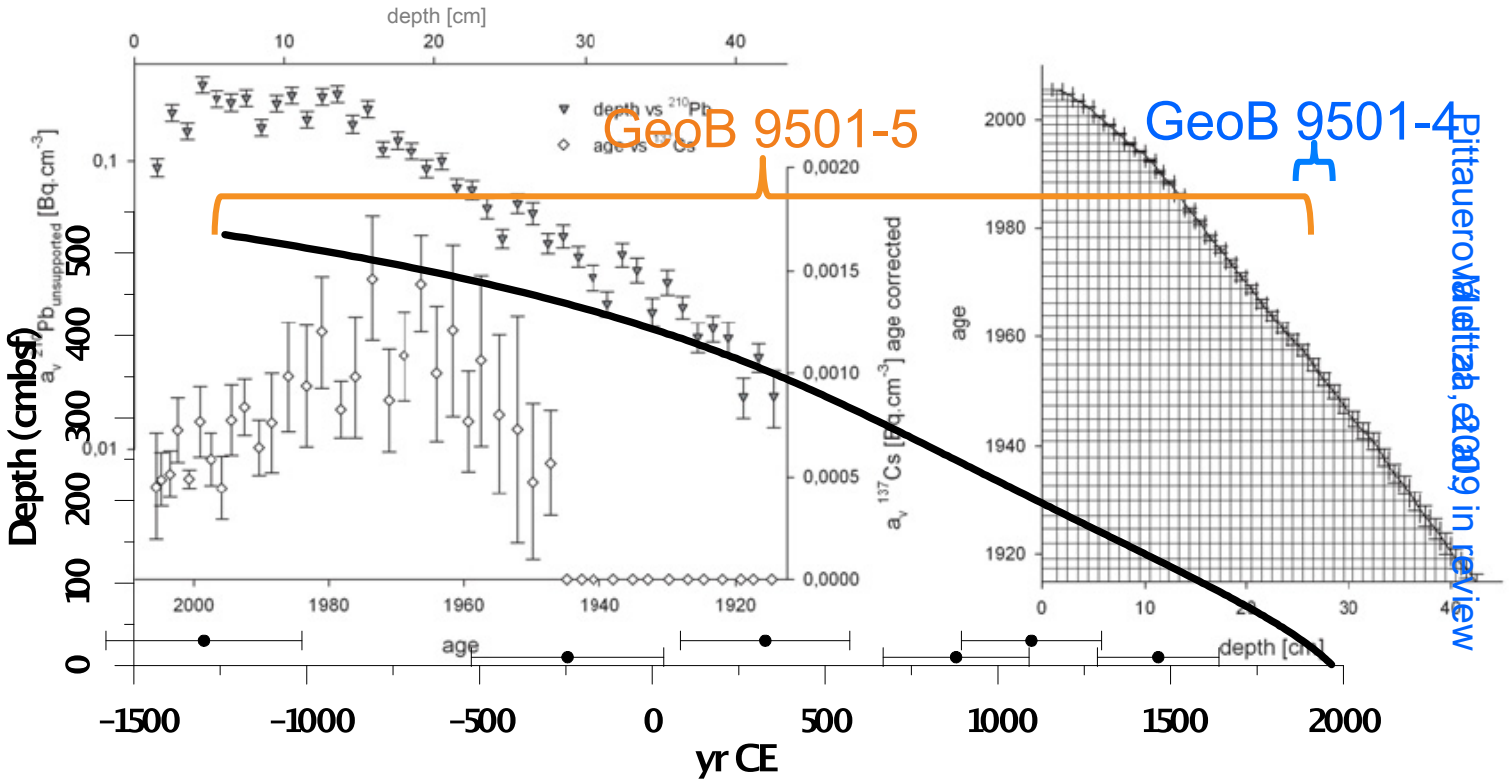


Vellinga and Wood, 2002

Reconstructed response of surface temperature to reduced overturning



Sediment-core age model



Core GeoB 9501-4 (42 cm) ^{210}Pb, ^{14}C, ^{137}Cs: 1913 – 2005 CE

Combination ^{210}Pb and ^{14}C → local reservoir age (541 yr)

Core GeoB 9501-5 (532 cm) ^{14}C, 4th order p.f.: 1230 BC – 1965 CE