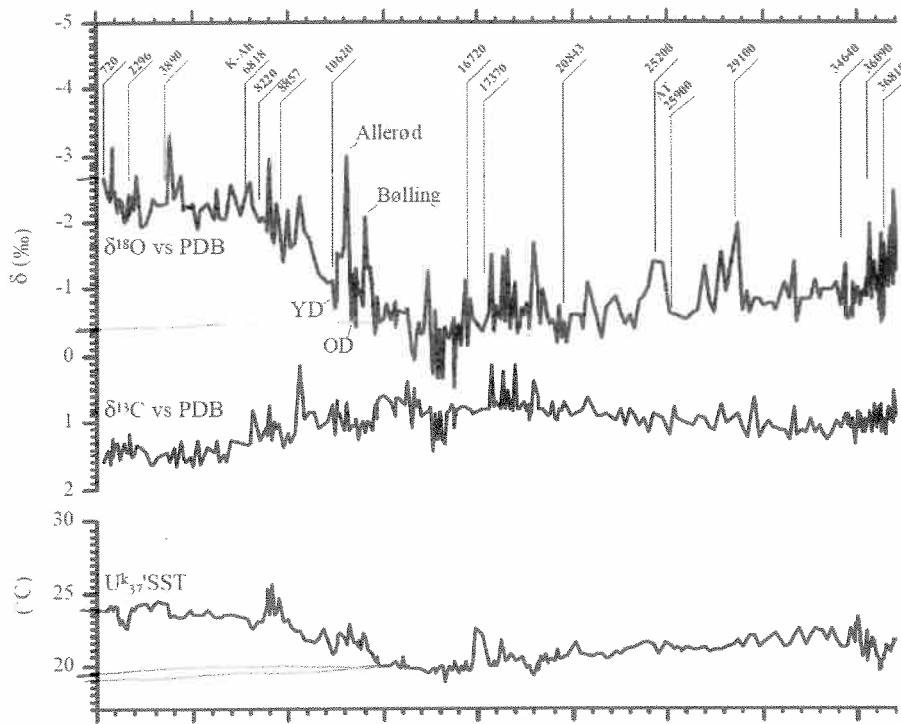


1. Foraminiferal stable isotopes

- a) Generally planktonic foraminiferal $\delta^{18}\text{O}$ depends on 3 main factors. What are these factors? Describe of each of them how they influence planktonic foraminiferal $\delta^{18}\text{O}$.

Figure 1 gives the $\delta^{18}\text{O}$ values for the mixed layer planktonic foraminifer *Globigerinoides ruber* in a sediment core from the East China Sea for the last 40 kyr. Also given is the sea surface temperature (SST) record for the same core based on the alkenone unsaturation index (Uk37')



Planktonic foraminiferal oxygen and carbon isotopic record from the East China Sea. The lower graph shows the reconstructed temperatures based on UK37. Ages are based on ^{14}C dating and corrected for reservoir age and offsets in initial ^{14}C .

- b) The last deglaciation can be seen in both the $\delta^{18}\text{O}$ and SST records. Calculate the rise in sea level (in meters) across the last deglaciation using the following data:

$$T = 16 - 4.14(dc-dw) + 0.13*(dc-dw)^2$$

Average depth of the ocean: 3800 m
 Average ice sheet composition: -38‰

Handwritten calculations:

$$\text{vol}_{ice} \cdot 30 = \text{vol}_{oc} \cdot (-0.47)$$

$$\text{vol}_{ice} \cdot \frac{30}{\text{gm}} = \text{vol}_{oc} \cdot \frac{1}{\text{gm}}$$

$$(3000 - \text{vol}_{ice}) \cdot \frac{30}{\text{gm}} = \text{vol}_{oc} \cdot \frac{1}{\text{gm}}$$

$$-307234 = \text{vol}_{ice} \cdot \frac{30}{\text{gm}} = \text{vol}_{oc} \cdot \frac{1}{\text{gm}}$$

- c) Based on coral records we know that during the last deglaciation the actual rise in sea level was 120m. What could be the reason for this offset between actual and calculated sea level rise?

20pt.

2) Dansgaard-Oeschger oscillations

- a) Name three proposed theories explaining the Dansgaard-Oeschger type of millennial scale climate variability observed during the last glacial. Thomas Stocker used methane concentrations of air trapped in bubbles in ice to correlate the Arctic and Antarctic temperature records and show that they are anti-phased during Dansgaard-Oeschger cycles.
- b) What does this imply for oceanic heat transport in the Atlantic Ocean and how are different areas (deep sea and surface waters) affected?
- c) An important role of thermo haline circulation (THC) in glacial Dansgaard-Oeschger cycles is also suggested when comparing ^{14}C and ^{10}Be records. What was noticed when these records were compared in the Cariacco basin and how is this linked to the THC?
- d) According to you, what theory explains the observed climatic changes during Dansgaard-Oeschger cycles best? Give arguments and explain.

20pt

3) El Niño-Southern Oscillation.

- a) Explain what a La Niña event is.
- Two different theories have been proposed for explaining the cyclicity in El-Niño
- b) What are these two theories? Please explain the sequence of events which would lead to an El Niño cyclicity.
 - c) What is the impact of El Niño on Australia/Indonesia, the central Pacific and the west coast of the Americas?
 - d) How would you test which of the two theories best describes the El Niño cycles using geological records?

10pt