# Paleoclimatology & Paleoecology

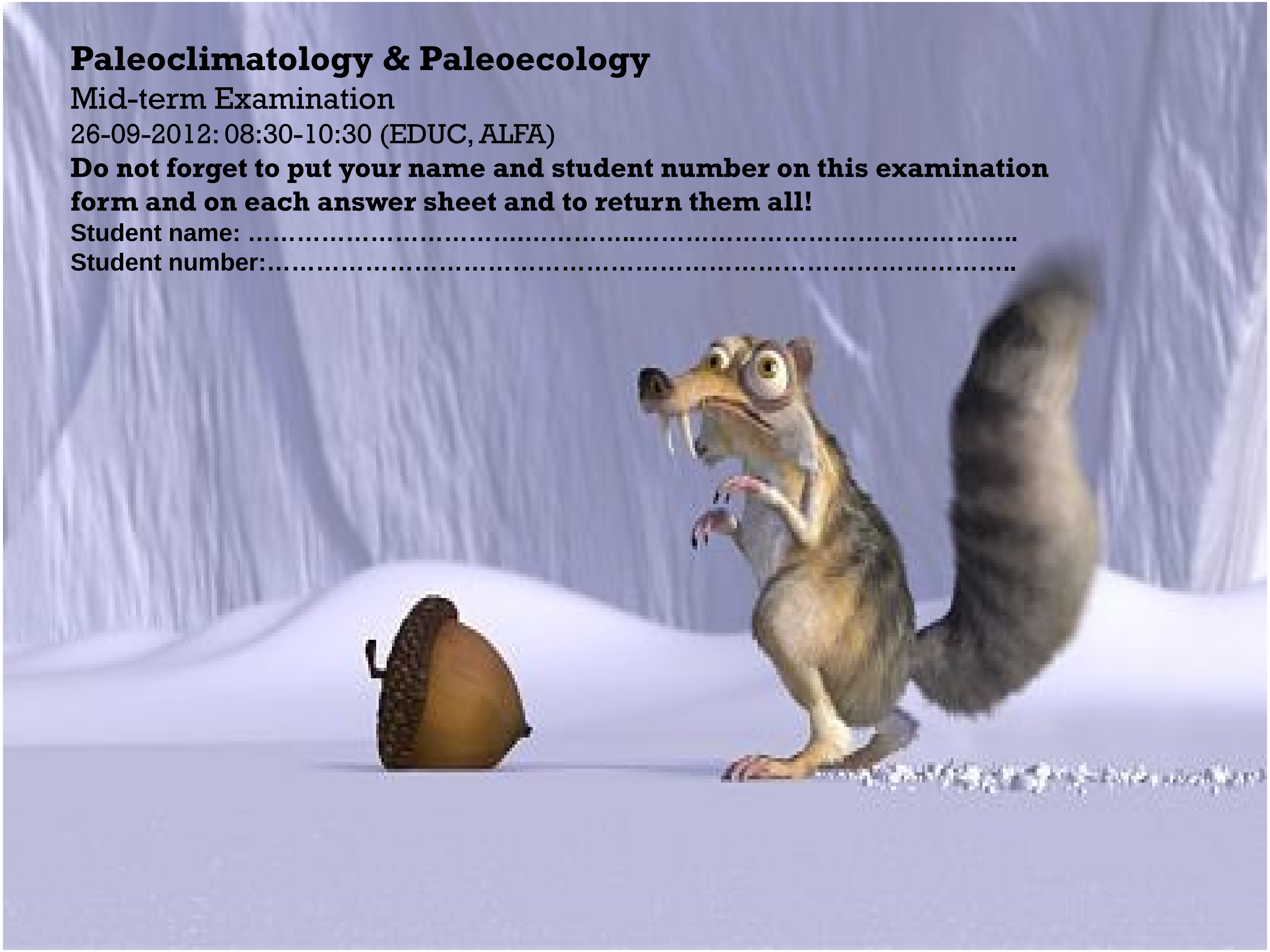
Mid-term Examination

26-09-2012: 08:30-10:30 (EDUC, ALFA)

**Do not forget to put your name and student number on this examination form and on each answer sheet and to return them all!**

**Student name: ……………………………..……..……………………………………..**

**Student number:……………………………………………………………………………..**



**Question 1. (22pt)**

**a.** Give three reasons why annual temperatures are lower at the polar regions than in the tropics: (6pt)

1. Angle of incoming radiation: less insolation
2. High reflectivity and thus less absorbed energy
3. High albedo (ice)

**b.** What is the difference between sensible and latent heat transport: (4 pt)

Sensible heat: The product of the temperature of the air and its specific heat by moving air .

Latent heat: The heat stored in water vapor during initial evaporation, which is released during condensation and precipitation.

**c.** What are the three main lithological components of deep sea sediments? (6pt)

1. Calcareous ($CaCO_3$) ooze
2. Siliceous ($SiO_2$) ooze
3. Clay

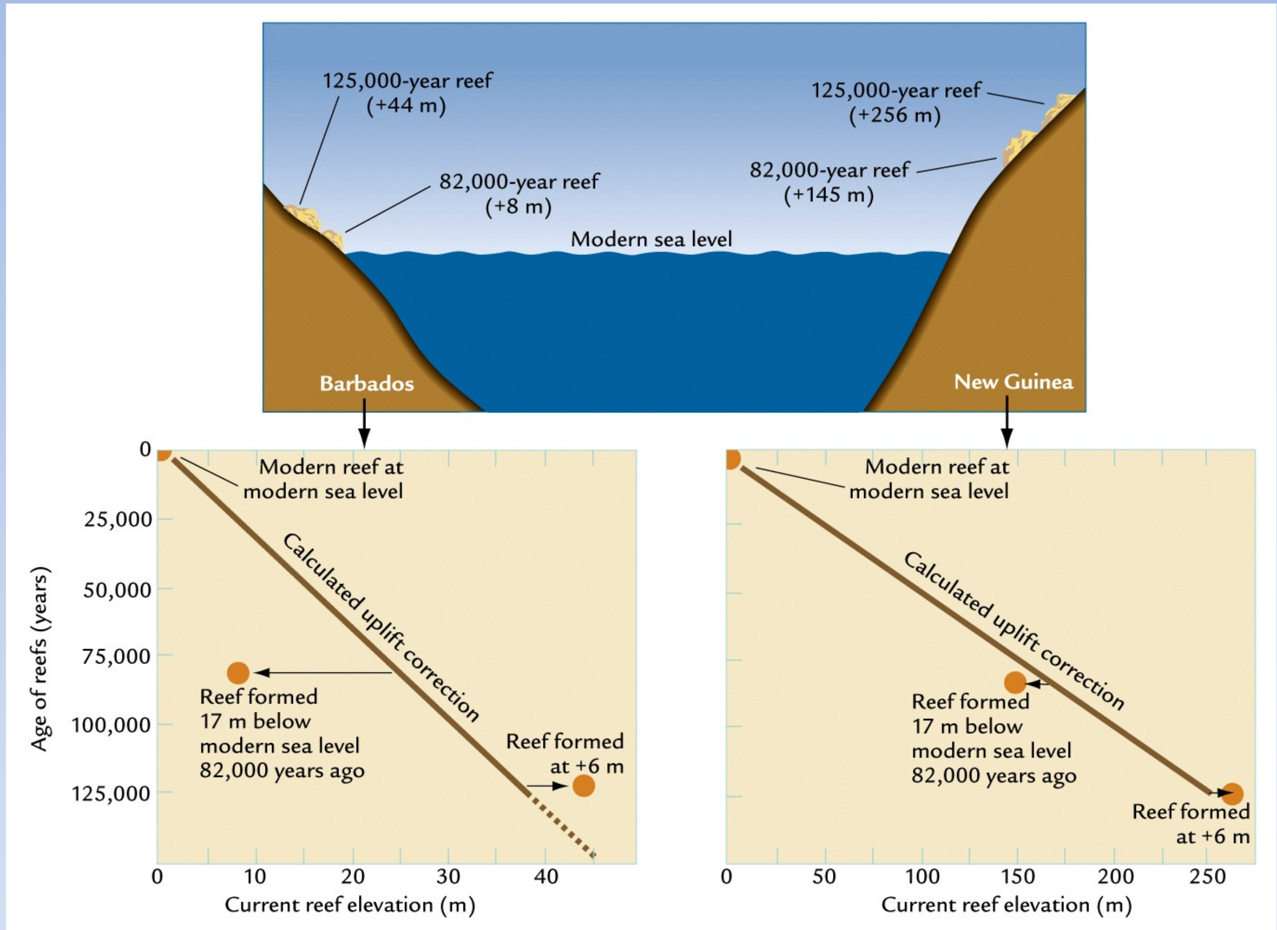
**d.** What is meant by the Response Time and give two examples of slow and two examples of fast response time components in the climate system? (6pt)

Response time is a measure of the rate at which a medium changes towards equilibrium with the imposed forcing.

Slow response: Mountain glaciers, deep ocean, ice sheets

Fast response: Atmosphere, land surface, ocean surface, vegetation, sea ice

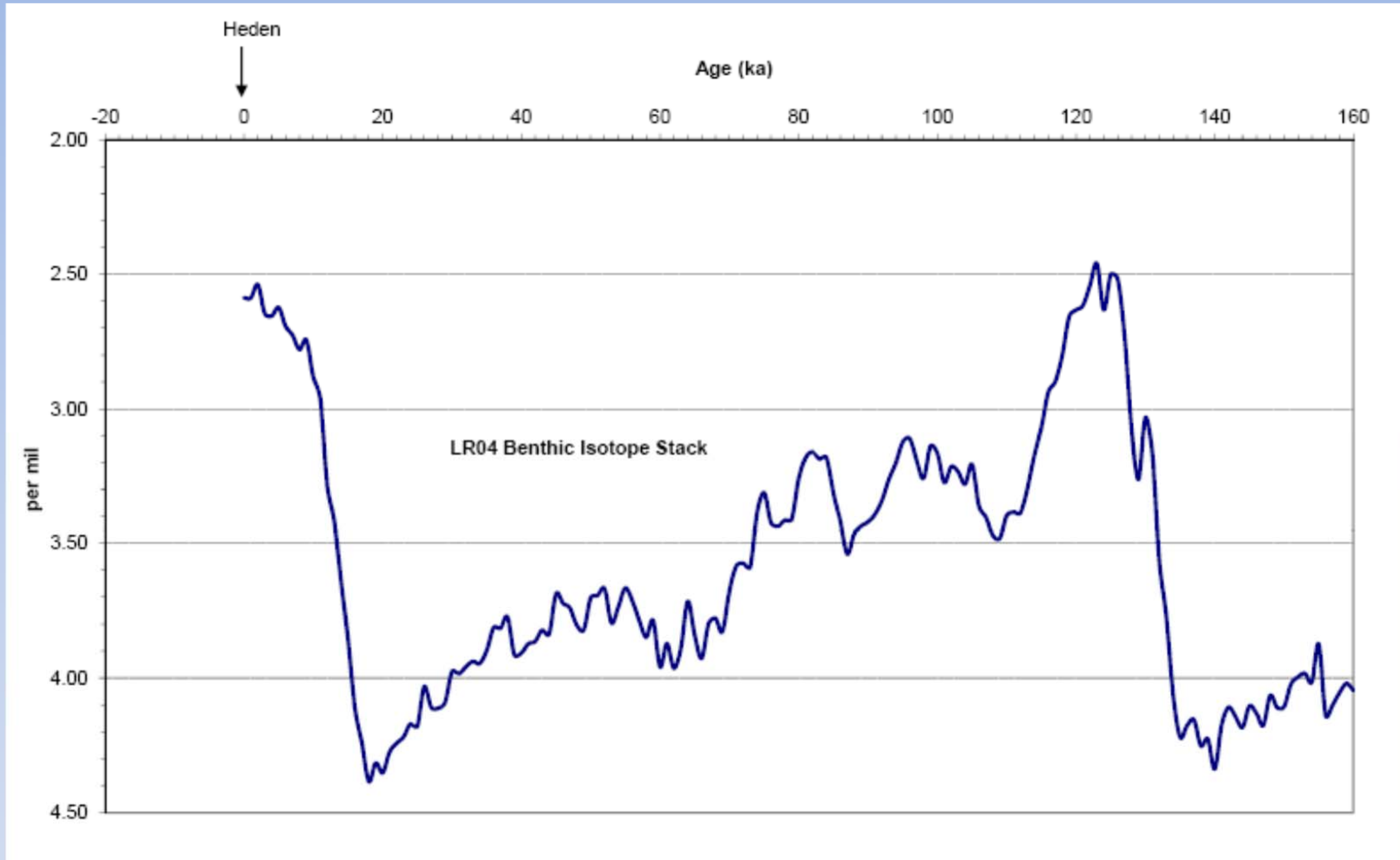
## Question 2. Stable isotopes, sea level and deep sea temperatures (48pt)




a. (5pt) Explain how coral reefs can be used to reconstruct past sea level, using the information from the cartoon above

(1) Radiometric dating, (2) close to sea level, (3) uplift correction

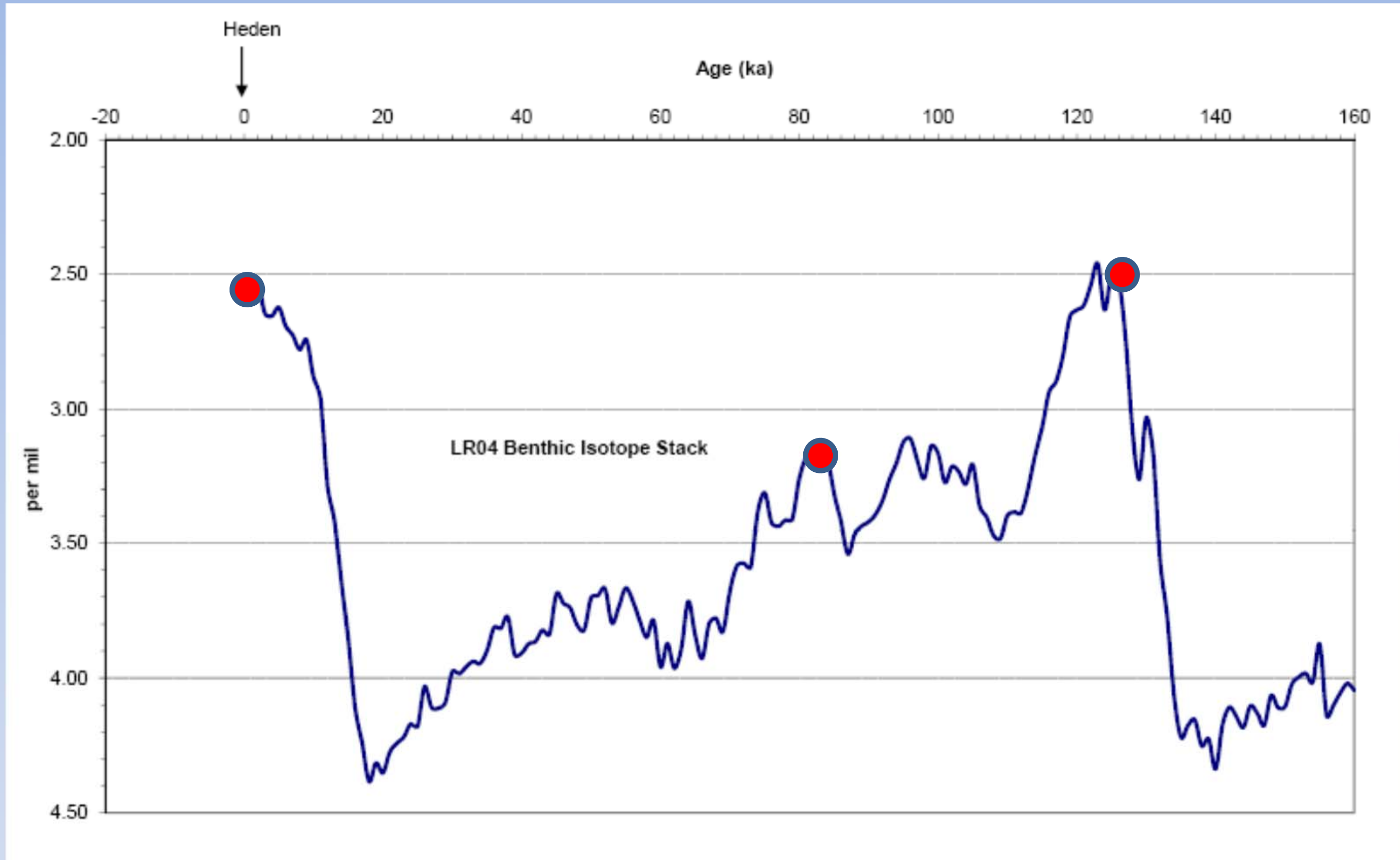
**Question 2. (continued)**




Above you see a plot of the global stacked benthic foraminiferal d18O changes for the past 160,000 years by Lisiecky and Raymo (2004).

**b.** (1pt) What is the scale on which the $\delta^{18}O$ values are plotted? VPDB

## Question 2. (continued)




**c.** (2pt) Plot the position of the three coral reefs of Q2a in the plot above and give the approximate d18O values of the benthic foraminiferal record at these times: 2.6, 3.2 & 2.5 ‰

**d.** (5pt) Calculate the (average) deep sea temperature for the present-day by taking into account the following equations:

$$T = 16.9 - 4.2 \, (\delta^{18}O_{CaCO3} - \delta^{18}O_{water})$$

$$\delta^{18}O_{water} \; [VSMOW] = 1.00027 * \delta^{18}O_{CaCO3} \; [VPDB] + 0.27 \quad (‰)$$

$$T = 16.9 - 4.2 \, (2.6 – (0-0.27))$$

$$T = 4.85 \; °C$$

**e. (10pt)** Consider that the average depth of the present-day ocean is 3800 and the following $\delta^{18}O$ ice volume balance holds:

**$\delta^{18}O_{present\text{-}day\ ocean}$ * Present-day Ocean Volume =**
**$\delta^{18}O_{ice}$ * Ice Volume + $\delta^{18}O_{past\ ocean}$ * Past Ocean Volume.**

Calculate the $\delta^{18}O_{past\ ocean}$ value during formation of the two ancient coral reefs mentioned in Q2a and explain the assumption(s) you have made.

At 82 ka: 0*3800=-40*17+x*(3800-17) -> x=0.18 ‰ (SMOW)

At 125 ka: 0*3800=-40*-6+x*(3800+6) -> x=-0.06 ‰ (SMOW)

**f.** (10pt) Calculate the (average) deep sea temperature for the two periods mentioned in Q2e, using the equations of Q2d.

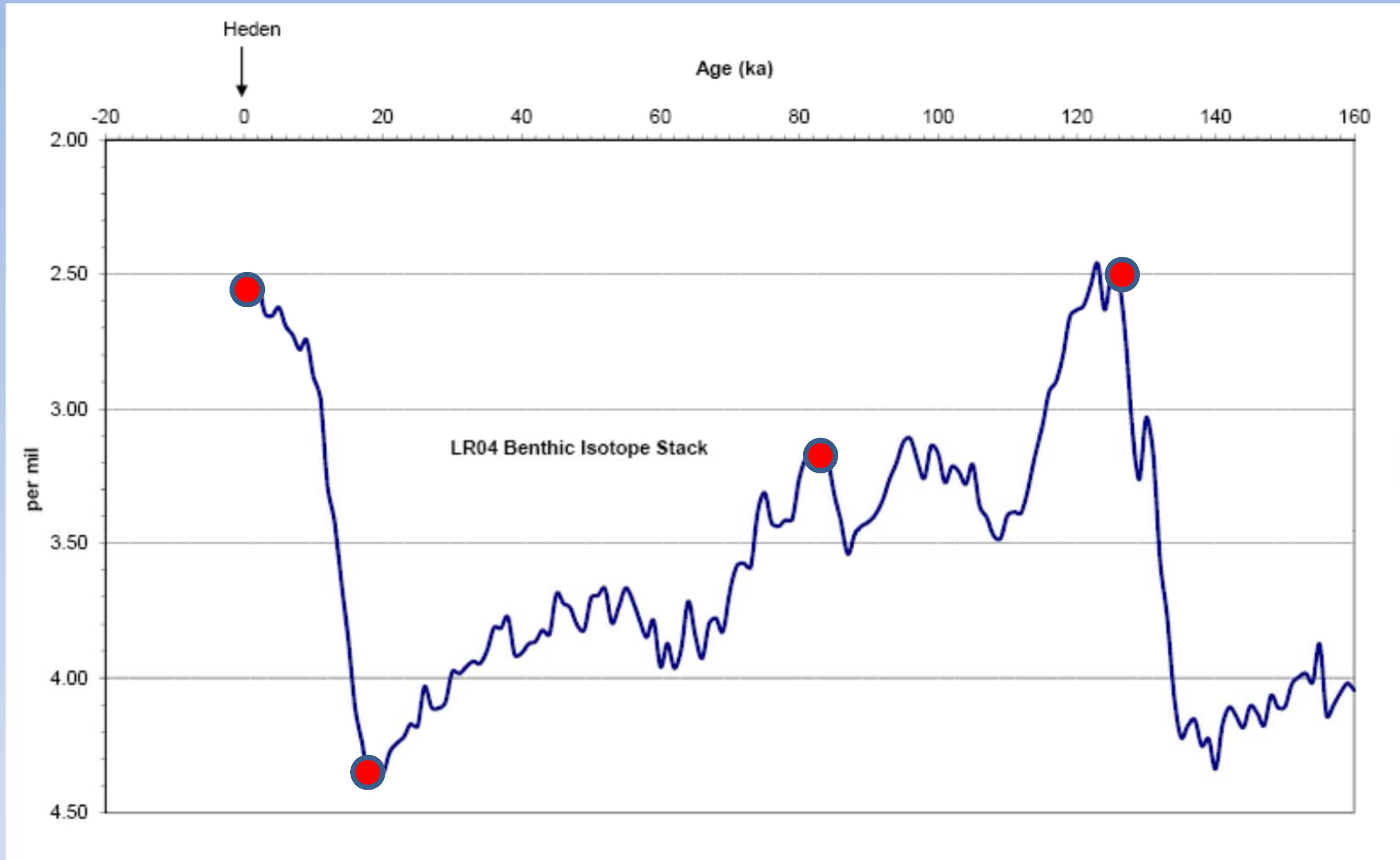
$T = 16.9 - 4.2\ (\delta^{18}O_{CaCO3} - \delta^{18}O_{water})$

$\delta^{18}O_{water}$ [VSMOW] = 1.00027 * $\delta^{18}O_{CaCO3}$ [VPDB] + 0.27 (‰)

$T_{82ka} = 16.9 - 4.2\ (3.2 – (0.18-0.27)) = 3.1\ °C$

$T_{125ka} = 16.9 - 4.2\ (2.5 – (-0.06-0.27)) = 5.0\ °C$

## Question 2. (continued)




**g.** (5pt) In addition, calculate the (average) deep sea temperature for the last glacial maximum (LGM), considering a sea level drop during the LGM of 120 meters with respect to the present. LGM: 4.4 ‰

**g. (continued)** Consider that the average depth of the present-day ocean is 3800 and the following $\delta^{18}O$ ice volume balance holds:

$\boldsymbol{\delta^{18}O_{present\text{-}day\ ocean}}$ *** Present-day Ocean Volume** =
$\boldsymbol{\delta^{18}O_{ice}}$ *** Ice Volume** + $\boldsymbol{\delta^{18}O_{past\ ocean}}$ *** Past Ocean Volume**.

At LGM: 0*3800=-40*120+x*(3800-120) -> x=1.3 ‰ (SMOW)

At 125 ka: 0*3800=-40*-6+x*(3800+6) -> x=-0.06 ‰ (SMOW)

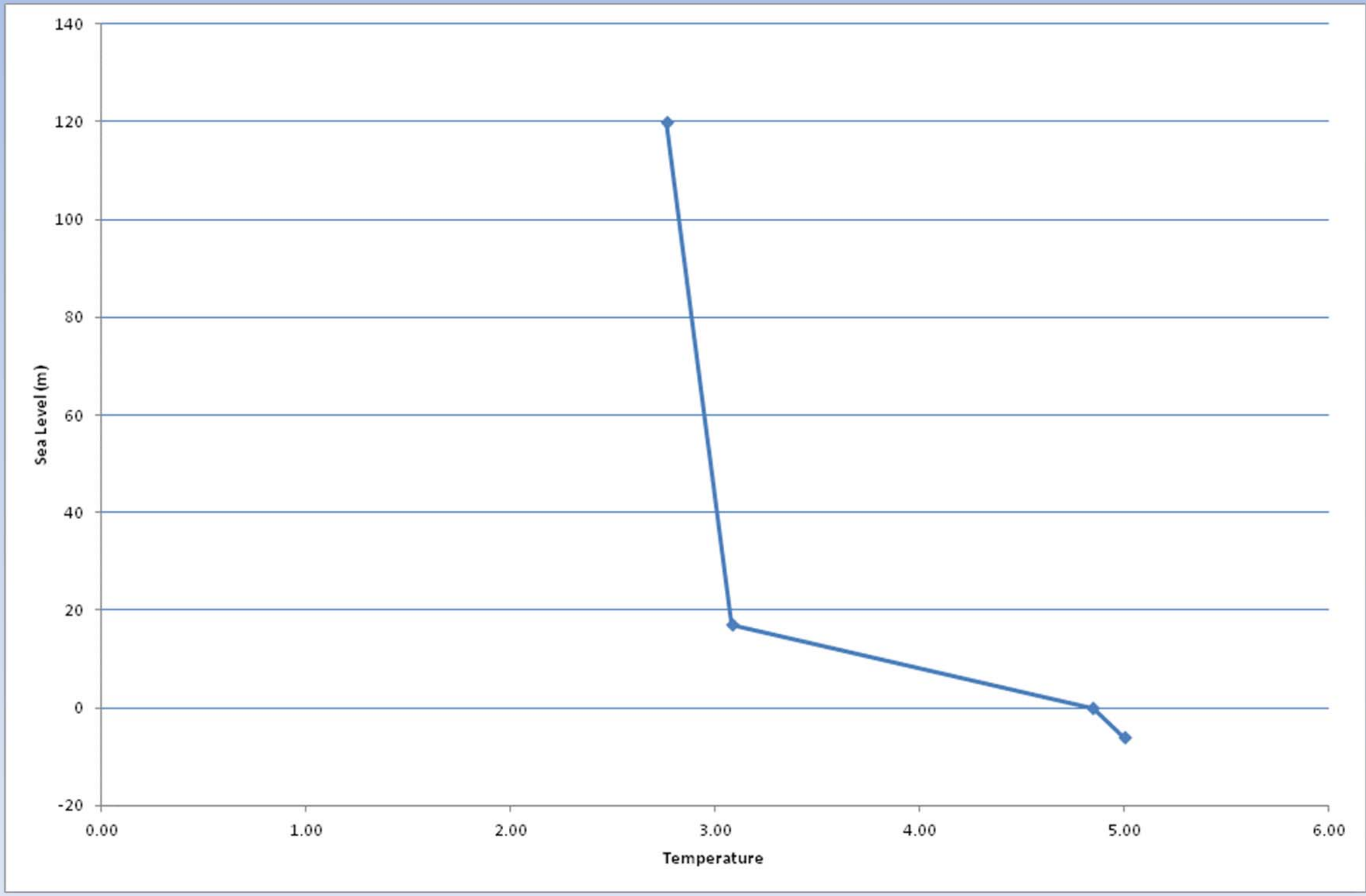
**g.** (continued)

$T = 16.9 - 4.2\ (\delta^{18}O_{CaCO3} - \delta^{18}O_{water})$

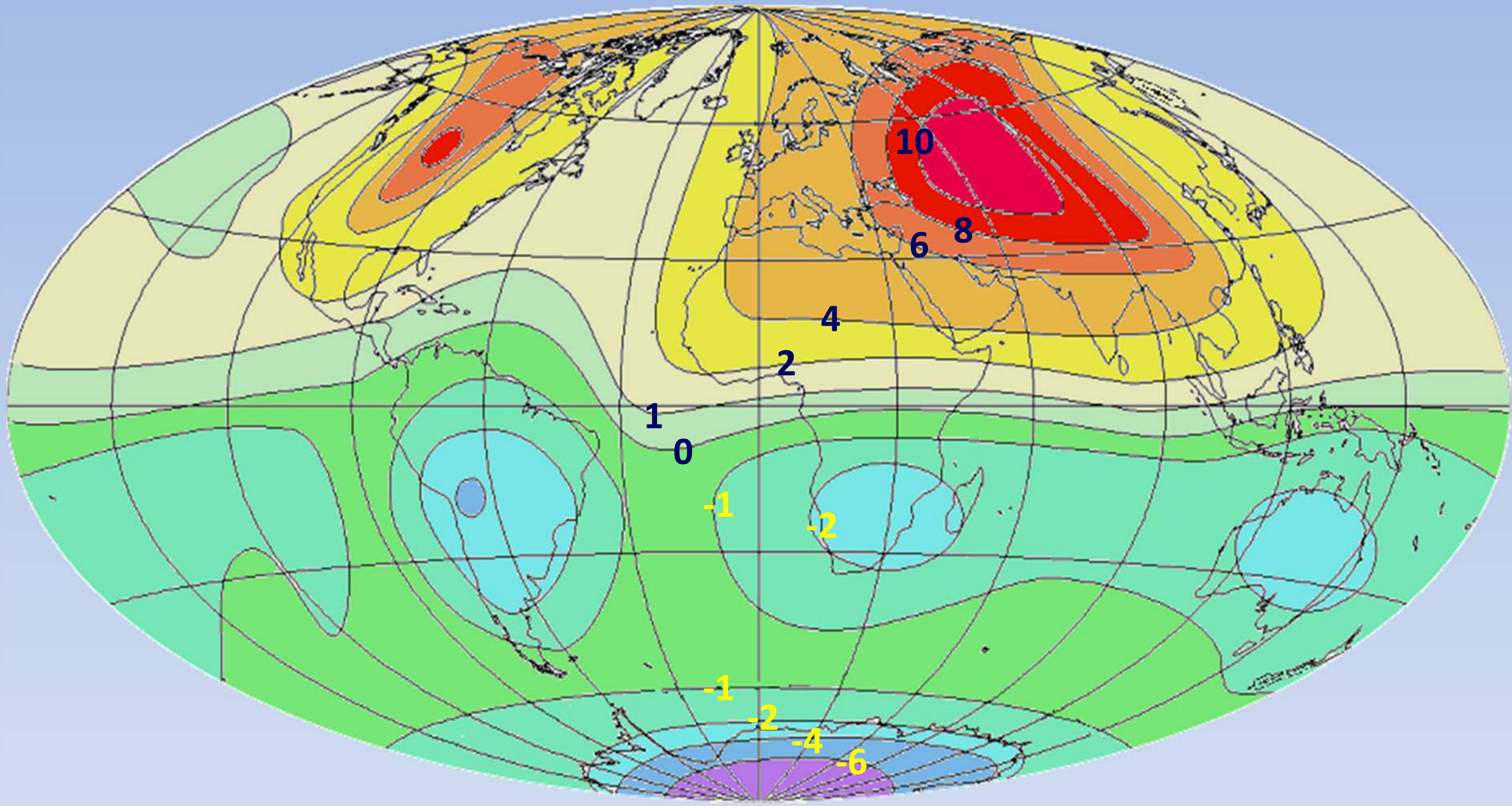
$\delta^{18}O_{water}$ [VSMOW] = 1.00027 * $\delta^{18}O_{CaCO3}$ [VPDB] + 0.27 (‰)

$T_{LGM} = 16.9 - 4.2\ (4.4 - (1.3 - 0.27)) = 2.8\ °C$

**h.** (10pt) Explain if the changes in deep sea temperature and ice volume are proportional over glacial – interglacial times.  NO



## Question 4. Orbital and Insolation (30pt)




**a. (5 pt)** The figure above displays the modeled changes (Δ) in maximum temperatures (T) between:

a. Precession minimum – Precession maximum

b. Precession maximum – Precession minimum

c. Obliquity minimum – Obliquity maximum

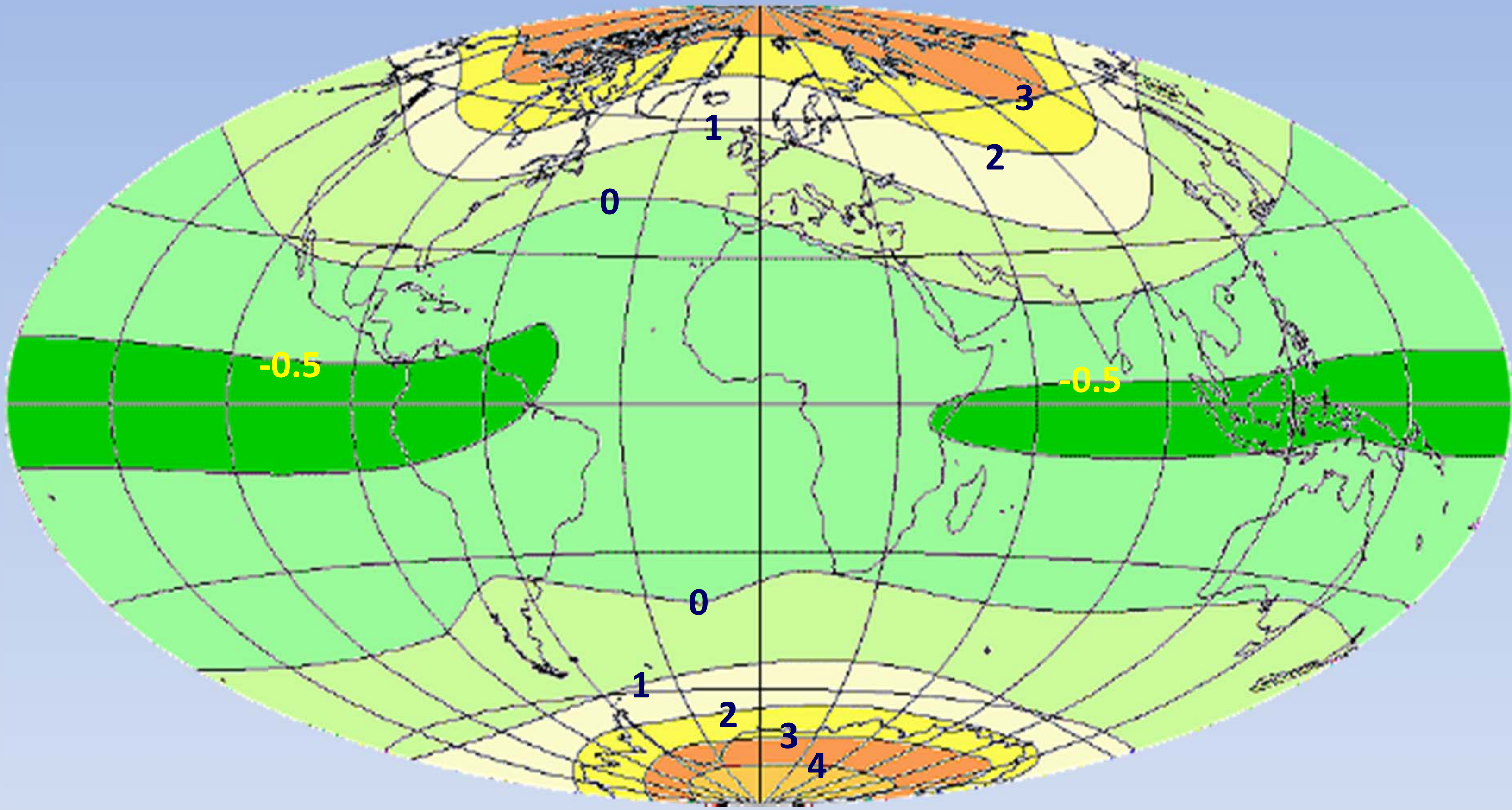
d. Obliquity maximum – Obliquity minimum

**b. (5 pt)** Explain your answer of Q3a:

Precession, because both hemispheres have an opposite signal; NH increase in maximum (summer) temperature during Precession Minimum (Perihelion), while SH summer is at a minimum (Aphelion).

Precession minimum – Precession maximum. During a precession minimum NH summer are in perihelion, so maximum insolation. Because the maximum temperature differences are at the NH, this means that we are looking at the difference between a precession minimum – a precession maximum configuration.

## Question 4. Orbital and Insolation (30pt)




**c. (5 pt)** The figure above displays the modeled changes (Δ) in maximum temperatures (T) between:

a. Precession minimum – Precession maximum

b. Precession maximum – Precession minimum

c. Obliquity minimum – Obliquity maximum

d. Obliquity maximum – Obliquity minimum

**d. (5 pt)** Explain your answer of Q3c:

Obliquity, because both hemispheres show a similar increase in maximum temperature at high latitudes and a decline in the tropical regions. Maximum summer insolation at both NH and SH high latitudes  during Obliquity maximum.

Obliquity maximum – Obliquity minimum. During an obliquity maximum NH and SH summer are characterized by increased insolation at high latitudes, whereas minimum insolation is reached at high latitudes during summer during minimum obliquity. This means that we are looking at the difference between an obliquity maximum – an obliquity minimum configuration.

**e.** (10 pt) What is the eccentricity cycle and how does it effect insolation changes at the earth's surface?

Eccentricity describes the change in the elliptical shape of the earth's orbit. During an eccentricity maximum, the earth receives slightly more insolation. In addition, it modulates the influence of precession.