

2e Toets Klimaatdynamica 28 Juni 2010 9-12

1. Stable isotopes in paleoclimatology

- a. Explain which stable isotopes are used in paleoclimatology and what fractionation is.
- b. Explain whether an increase in the marine benthic record implies a cooling or a warming of the climate system.
- c. Provide an estimate of the change in $\delta^{18}\text{O}$ in a marine benthic record and for an ice core from Greenland over the transition from the Last Glacial Maximum to the Holocene.
- d. Calculate the change in marine benthic oxygen concentration from a glacial to an interglacial assuming an average ocean depth of 3800 m nowadays and a sea level rise over this period of 120 m. Explain the assumption made in your calculation.

2. Dating

Ice cores are sometimes dated based on ice flow considerations. A standard model is the Nye model.

- a. What are the physical assumptions made to derive an equation between time and depth in the Nye model?
- b. Derive an age scale for an ice core based on a Nye model for a linearly decreasing vertical velocity.

- c. Discuss three different dating techniques for ice cores and marine cores.

3. Climate history

- a. What are the main forcing mechanisms for climate change on geological time scales?
- b. Sketch global CO₂, temperature, ice volume, and benthic marine isotopes over the last 60 Myrs and explain your sketch.
- c. Explain the Milankovitch theory qualitatively and indicate dominant periodicities, discuss in addition the spectral paradox during the Pleistocene.

4. Sea Level Rise

The change in melt (ΔAbl) on a circular Greenland ice sheet depends strongly on the temperature (T) via the following equation:

$$\Delta Abl = aT^2 + bT + c$$

We also know that the change in accumulation (ΔAcc) increases if the temperature increases. An approximation is given by

$$\Delta Acc = c + T^b$$

If we assume that the ice sheet is perfectly plastic we can approximate the surface profile (H) as a function of radial position (r) by:

$$H = \gamma\sqrt{r}$$

You may use the following constants:

$$a = 1 \text{ (m}^3\text{/K}^2\text{)}, b = 2.41 \cdot 10^{11} \text{ m}^3\text{/K}, c = 10^{10} \text{ m}^3, \beta = 2, \gamma = 0.44 \text{ m}^{0.5},$$

$$A_{\text{ocean}} = 3.62 \cdot 10^{14} \text{ m}^2$$

- a. Calculate the contribution to sea level rise over a period of 100 years if the temperature increases linearly by 3K.
- b. Calculate the change in radius of the ice sheet if the initial ice sheet equals 7 m of equivalent sea level rise.
- c. Estimate the sea level rise at the Dutch coast and explain your answer.