Examination Climate Dynamics
15-04-15 (9.00 – 12.00)

1 Paleo Climate

a. Where do you find the lowest $\delta^{18}O$ concentration on Earth? and explain why this is the case.

b. Explain the standard way of dating marine sediment cores and discuss the limitations.

c. Explain the four key mechanisms of climate change on geological time scales

d. Provide two possible explanations for the jump in the marine benthic isotope record 33.8 Myr ago.

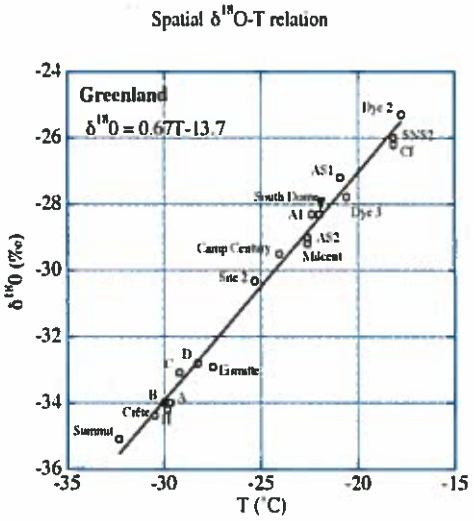
e. Explain the spectral test

2. Ice Cores

a. Explain how results from ice cores from the Northern and Southern Hemisphere are synchronized in time

b. Explain how CO_2, temperature and precipitation can be retrieved from an ice core.

c. Explain why there is an age difference between the CO_2 concentration in the air bubbles and the $\delta^{18}O$ concentration of the ice at the same depth in an ice core.



d. Explain based on the figure above the concept of a transfer function. Why is there a linear relation between both quantities. What assumption should hold for the interpretation of the results.

e. Derive an equation for the age as a function of depth for an ice sheet in steady state. Explain which assumptions you have to make.

f. Explain the importance of $\delta^{13}C$ measurements on the CO_2 and CH_4 in ice cores

3. Climate sensitivity

a. Explain why the climate sensitivity is state dependent?

b. Provide an explanation why the climate sensitivity is smaller for a much warmer climate than the present climate

c. What is the importance of paleo studies with respect to our knowledge on climate sensitivity for the present-day climate?

4. Ice in the climate system

a. What is the importance of the thermodynamics of ice for the flow of ice?

b. Explain which assumptions are needed to arrive at the Robin solution for the vertical temperature profile in the center of an ice sheet

c. Sketch the vertical temperature profile in the center of an ice sheet for different values of the mass balance.

d. Why is the vertical temperature profile nearly linearly near the equilibrium line of a cold-based glacier?

e. Why is the equilibrium line position for a glacier in steady state closer to the tongue of the glacier than to the head of the glacier?

5. Climate change

a. Explain the importance of a reduced air borne fraction

One of the key points of the summary for policy makers of the IPCC AR5 report discusses emission rates of CO_2 and temperature change. A simplification of this discussion is the following.

Assume that the total cumulative emission (C_∞) can be formulated as:

$$C_\infty = C_0 + E_0\left(\frac{1}{r} + \frac{1}{s}\right)e^{r(t-t_0)} - \frac{1}{r}E_0$$

In which C_0 is the cumulative anthropogenic emission in 2009 (t_0) , E_0 the rate in 2009, r the rate of emission increase until t_1, s the emission reduction after t_1

b. How can this concept be used to calculate the temperature change and why is this justified to do?

c. Derive an equation for the minimum peak warming.

d. Sketch contour lines of emission reduction rates as a function of time and climate target based on the equation derived above.

6. Sea level

a. Which terms determine the relative sea level in the sea level equation and explain those terms.

b. Explain why relative sea level changes influence the rate of retreat of a marine based ice sheet

c. Explain whether relative sea level rise for the Dutch coast in the coming century is larger for a volume equal to 0.5 m eustatic sea level rise from Antarctica or from small glaciers.

d. Explain the difference between mass changes and volume changes for the relative sea level change projections for the next century.