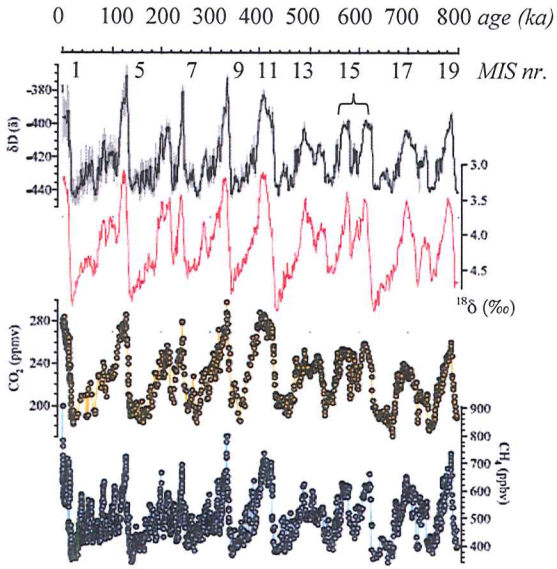
Tentamen Global Change 6 april 2010 9-12 hr 13.0202
Please write name and student number on each paper you hand in !

1.
The figure shows a variety of environmental records from polar ice.
top of the figure (black curve)
a) From which pole is this record - explain (2 answers).
b) What is the main mechanism causing the climate variations shown in this record?
c) How many glacial cycles are visible? Explain your answer.
d) What can one conclude from the shape (amplitude, width) of the MIS (Marine Isotope Stage) peaks; in general, and in particular for MIS-5 and 11.
second plot from top (red curve)
e) This is the only plot not obtained from polar ice. What kind of record is plotted here? Explain your answer.
third and fourth plot from top
f) The CO_2 and CH_4 concentrations in the ice varied between ca. 200-280 ppm and 400-800 ppb, respectively. What are their values today?



2.
Consider 2 reservoirs of a certain compound. The number of molecules for reservoir 1 is N_1; the isotope ratio is R_1; the delta-value δ_1. For reservoir 2, this is N_2, R_2 and δ_2, respectively.
Both reservoirs will be mixed into one, characterized by N, R, δ respectively.
a) Write down the balance of rare isotopes.
b) Derive the δ value of the mixed reservoir. Use approximations where applicable.
c) Consider 2 reservoirs of water and the ^{18}O isotope. One reservoir (the largest) has a δ value of $^{18}\delta = -12‰$. The other reservoir (the smallest) has a δ value of $^{18}\delta = -8‰$. The $^{18}\delta$ value for the mixed reservoir is -11‰. What is the relative size of the original reservoirs (before mixing)?
d) Discuss how this can be used to trace the origin of water in the river Rhine.
e) Consider 2 reservoirs of atmospheric CO_2 and the ^{13}C isotope. One reservoir (the largest, 95%) has a δ value of $^{13}\delta = -8‰$. The other reservoir (the smallest, 5%) has a δ value of $^{13}\delta = -40‰$. Calculate the $^{13}\delta$ value for the mixed reservoir.
f) Can you think of a practical application (relevant for modern society) of the latter?

3.
a) What is meant by the term "isotope disequilibrium"? For which aim is the knowledge of the istope equilibrium necessary?
Name two materials from the carbon cycle that we could sample now in order to observe an isotope disequilibrium for ^{13}C. How did the disequilibrium evolve? Support your explanation with a sketch drawing of $\delta^{13}C$ vs. time.
Give one example each for a positive and a negative ^{14}C isotope disequilibrium.
b) We want to measure the magnitude of the Suess-effect in the modern atmosphere. What is different between ^{13}C and ^{14}C?
c) Explain the diurnal rectifier effect of atmospheric CO_2. Why is it named rectifier effect? If photosynthesis and CO_2-release by soil and plants of a certain biome are balanced over the day, explain which of both would seem to be higher according to atmospheric measurements, when not taking into account the rectifier effect.

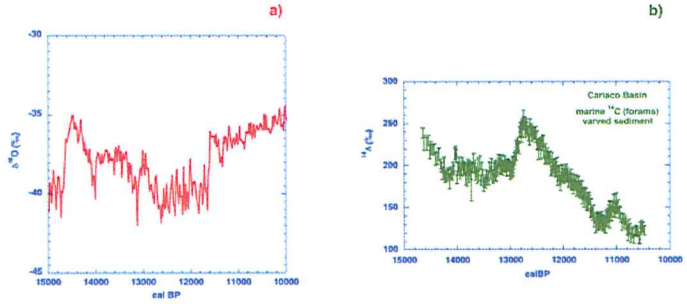
4.

In the figures below, 2 paleoclimate records are shown from about 10-15 millennia ago. The red curve (a) is from an ice core; the green curve (b) is from an (atmospheric) ^{14}C record.

a) What is meant by cal BP, and what by $^{14}\Delta$?

b) In figure a), a cold phase is visible between 12900 and 11600 cal BP. What is the cause of this cold phase, and how is it named?

c) Explain the shape of the $^{14}\Delta$ signal (figure b) during this cold phase.



5.

Assume that the atmosphere has the following Carbon isotopic contents: $^{13}\delta = -8‰$ for ^{13}C, and $^{14}a_N = 103.4$ for ^{14}C%.

a) What is the $^{14}a_N$ for terrestrial plants, taking for their $^{13}\delta$ value $^{13}\delta = -25‰$.

b) What is the $^{14}a_N$ for marine plants, taking for their $^{13}\delta$ value $^{13}\delta = 0$.

c) By upwelling of deep and old water, marine plants show an apparent age. How large is this "reservoir effect"? What is the $^{14}a_N$ of such plants?

d) We measure for a marine plant $^{13}\delta = 0‰$, and $^{14}a_N = 25\%$. Calculate the conventional ^{14}C age of this plant.

e) Suppose that we do not correct for isotopic fractionation using $^{13}\delta$. What would then the ^{14}C age be?

f) Discuss the relation between questions d) and e).