ESS / OCEAN / ATMOS 589 -- 2005
Problem Set 1.

Oxygen-18, ice volume, and temperature.

Notes:

1. The calcium carbonate in a foraminifer shell were formed at 25°C in today's ocean ($\delta^{18}O_{SMOW}$ = 0 ‰), what is the $\delta^{18}O$ of the shell on the SMOW scale? Also, *estimate* its $\delta^{18}O$ value on the PBD scale.

Assume that the fractionation factor between carbonate and water is given by $1000*\ln(\alpha_{cc\text{-}water}) = 2.78*10^6/T^2 - 2.89$ (T in K; valid between 0 and 500 °C).

Reminder: by definition:

$\alpha_{cc\text{-}water} = (^{18}O/^{16}O)_{carbonate}/(^{18}O/^{16}O)_{water}$

$\delta^{18}O_x / 1000 = (^{18}O/^{16}O)_x / (^{18}O/^{16}O)_{SMOW} - 1$ on the SMOW scale

where x is any substance.

2. Show that the simple mass balance equation below is valid (where M = mass)

$$(M_{ice}*(\delta^{18}O_{ice}+1000))_{LGM} + (M_{ocean}*(\delta^{18}O_{ocean}+1000))_{LGM} = (Mass_{ocean} * (\delta^{18}O_{ocean}+1000))_{TODAY}$$

This is straightforward algebra with the approximations that 1) there is a negligible amount of ice present today and 2) the mass of water is approximately equal to the mass of pure $H_2{}^{16}O$ water [that is, $M_{waterr}$ = number of $H_2{}^{16}O$ molecules times the molecular weight of $H_2{}^{16}O$ (~ 18 g/mol)].

3. Adkins et al. (2000) used pore water measurements from marine sediments to determine that the last glacial maximum (LGM ~the time of the most recent high $\delta^{18}O$ value in the benthic forams), the $\delta^{18}O$ of the deep ocean was +1‰ compared with today. Assuming that this value is representative of the entire ocean at the LGM:

a) calculate the deep ocean temperature change at the LGM compared with today, if the $\delta^{18}O$ of benthic formas was 1.13 ‰ greater than today.
b) use this to calculate the average $\delta^{18}O$ of the ice sheets at the LGM, assuming average ocean depth is 4000 m and that sea level at the LGM was 150 m lower.
c) use this information to estimate and plot the sea level variation and surface ocean temperature throughout the last 780,000 years, using the data in forams.txt on the class web site (under "assignments"). For simplicity, assume that the relative contributions of sea level and temperature to the benthic $\delta^{18}O$ value remain constant).

4. Read CLIMAP and Denton papers and come prepared with questions for Tuesday (emailed to faculty and the discussion leaders by Monday).