

**Assignment #6 (40 pts)**

Due Wed 4 June, 2008, in class or online via collect it.

**1. Milankovitch Cycles**

a. What are the primary orbital variations and the periodicities of each?

Precession – 19-23 ky (also listed as 26 ky in fig 14-5)  
Obliquity/Tilt – 41 ky  
Eccentricity – 100 ky

b. Why are these thought to be the primary drivers of glacial-interglacial cycles?

The frequencies for the periodicities given above match the primary frequencies of the oxygen isotope records of glacial-interglacial cycles. (e.g. Vostok ice core, from Antarctica)

c. What happens if the Earth has no tilt?

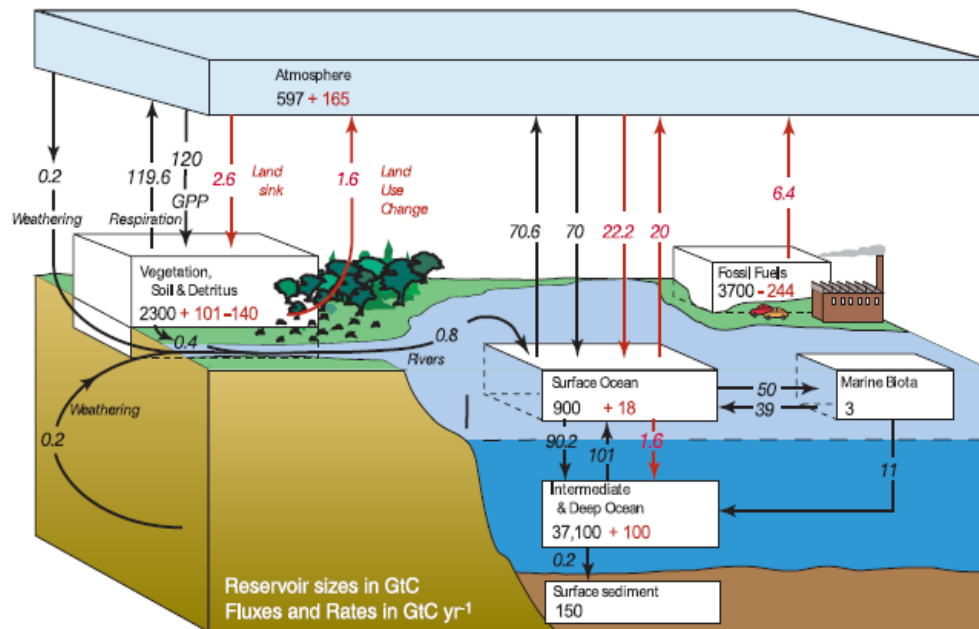
The seasonal cycle is nearly eliminated – i.e. each latitude receives about the same insolation year-round, as if it were continually at spring or fall equinox. (The only seasonality would occur as a result of the eccentricity of the orbit.)

d. What happens if the Earth's axis of rotation points directly toward the sun (ie the axis is in the plane of the ecliptic)? What happens to seasonality?

This would be the other extreme in seasonality. The polar regions would go from having very intense, direct insolation for the summer months (as if at the equator, except with insolation all day long), to having no insolation at all during the winter months. The equator would vary as well – from intense overhead insolation at the equinoxes, to very low angles at the summer and winter solstices.

**2. Carbon Cycle**

Given the following diagram of the carbon cycle from IPCC AR4 (2007), which shows estimates of carbon reservoirs and fluxes for preindustrial (black) and anthropogenic (red) contributions to the cycle.



a. Is the marine biota reservoir of carbon in equilibrium? What is the lifetime of carbon in this reservoir in years?

In days?

The marine biota reservoir is in equilibrium or steady state. The flux in of 50 Gt/yr is balanced by the flux out of 39 to Surface Ocn and 11 to Intermediate and Deep Ocean. The lifetime the burden/sink (see carbon cycle notes – 5/14), or the reservoir size/sink. Burden or reservoir is 3 Gt. Sink is 50 Gt/yr. Lifetime =  $3 \text{ Gt}/50\text{Gt/yr} = 0.06 \text{ yr}$ .  $0.06 \text{ yr} \times 365 \text{ days/yr} = 21.9 \text{ days}$ .

b. Is the intermediate and deep ocean reservoir of carbon in balance? If not, what is the flux change per year? Does it act then as a net source or a net sink of carbon from other reservoirs?

We need to consider all fluxes into the reservoir, and all fluxes out of the reservoir.

$$\text{Flux}_{\text{in}} = 90.2 + 1.6 + 11 = 102.8 \text{ GtC/yr}$$

$$\text{Flux}_{\text{out}} = 101 + .2 = 101.2 \text{ GtC/yr}$$

$$\text{Flux}_{\text{net}} = \text{Flux}_{\text{in}} - \text{Flux}_{\text{out}} = 102.8 - 101.2 = 1.6 \text{ GtC/yr}$$

It is **not** in balance, the flux change per year is 1.6 GtC coming in that is not going out, so it is a net sink for carbon from other reservoirs.

c. Is the surface ocean reservoir of carbon in balance? If not, what is the flux change per year? Does it act as a source or net sink of carbon? For which reservoir?

Need to consider all fluxes into the reservoir, and all fluxes out of the reservoir, as above.

$$\text{Flux}_{\text{in}} = .8 + 70 + 22.2 + 39 + 101 = 233 \text{ GtC/yr}$$

$$\text{Flux}_{\text{out}} = 70.6 + 20 + 50 + 1.6 + 90.2 = 232.4 \text{ GtC/yr}$$

$$\text{Flux}_{\text{net}} = \text{Flux}_{\text{in}} - \text{Flux}_{\text{out}} = 233 - 232.4 \text{ GtC/yr} = 0.6 \text{ GtC/yr}$$

It is not in balance, there is 0.6 GtC/yr coming in that is not going out, so it is a net sink for carbon.

Attribution for this reservoir is difficult to pinpoint – and so it may not be a fair question.

Here is one way to think about it: The net flux from the atmosphere to the surface ocean is 1.6 GtC/yr (into reservoir). The net flux from the intermediate/deep ocean, river runoff and the marine biota reservoir to the surface ocean is -1.0 GtC/yr (i.e. out of the reservoir), and so we might consider that the net sink is primarily for the atmosphere.

**3. Younger-Dryas** Describe the Younger-Dryas and explain briefly how it might have been caused by changes in the thermo-haline circulation. Be sure to include effects of stratification of the water column, deep water formation. Why is the evidence for the Y-D found most prominently in Europe?

The Younger Dryas Event is a period of rapid cooling around 10,500 years ago, in the midst of the warming that was occurring after the last glacial maximum. It is thought that the Younger Dryas could have been caused by a slowdown of the formation of North Atlantic deep water, which drives the thermo-haline circulation in the North Atlantic. Meltwater from retreating ice sheets in North America might have been forced into the North Atlantic. The fresh water is less dense than salty ocean water, and therefore would have stabilized the water column and allowed formation of sea ice further southward. This low density, stable layer would have prevented sinking and formation of North Atlantic deep water, and the northward warm ocean flow would have been slowed. Climate in Europe is heavily influenced by the warmer sea surface temperatures of the Gulf Stream and North Atlantic Drift. Evidence for the Younger Dryas is found most prominently in Europe because changes to those currents would heavily influence the otherwise mild conditions found in Europe.