Monday, October 25, 2010

Week 10 Assessment – available thru Friday, Oct. 29, 5 pm

Topic - The Carbon Cycle (Chapter 8)

Residence Time (p 154)
Oxidized and reduced carbon (p 154)
Short-term organic carbon cycle (p154-156)

Next time:
Marine organic carbon cycle (p 157)
Nutrient limitation (p 158-159)
Steady State and Residence Time

Residence Time – average amount of time spent in a reservoir that is in steady state.

Residence time = Reservoir size / inflow (outflow) rate

Residence time related to response time

Long residence time → Long response time

Short residence time → Short response time
What is the residence time of CO$_2$ in the atmosphere if the atmosphere contains 760 Gtons of carbon and the output due to photosynthesis is 60 Gton/yr?

(a) 60 years

(b) $1/60$ year

(c) 12.67 years

(d) $1/12.67$ years (about 1 month)
What is the residence time of CO$_2$ in the atmosphere if the atmosphere contains 760 Gtons of carbon and the output due to photosynthesis is 60 Gton/yr?

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(d) 1/12.67 years (about 1 month)
Is atmospheric CO$_2$ in steady state?

Yes

... and No!

Steady state a matter of time-scale
Seasonal time scale -> No
Annual time scale -> Steady state
100 year scale -> No
Natural Cycle -> Yes
The Mauna Loa CO₂ record

“Keeling Curve”
Land/Atmosphere Short-term Organic Carbon Cycle

Respiration:
\[ CH_2O + O_2 \rightarrow CO_2 + H_2O \]

Decomposition:
\[ 2CH_2O \rightarrow CO_2 + CH_4 \]

Photosynthesis --
\[ CO_2 + H_2O \rightarrow CH_2O + O_2 \]
Oxidized vs. Reduced Carbon

The oxidation state of carbon refers to the nature of the atoms bonded to that carbon.

The more hydrogens atoms that are attached to carbon the more “reduced” it is.

The more oxygen atoms that are attached to carbon the more oxidized it is.

$\text{CO}_2$ is a highly oxidized form of carbon

$\text{CH}_4$ is a highly reduced form of carbon

To oxidize carbon, one typically only has to add oxygen and burn it (e.g., combustion or respiration)
Land/Atmosphere Short-term Organic Carbon Cycle

Respiration:
\[ CH_2O + O_2 \rightarrow CO_2 + H_2O \]

Decomposition:
\[ 2CH_2O \rightarrow CO_2 + CH_4 \]

Photosynthesis --
\[ CO_2 + H_2O \rightarrow CH_2O + O_2 \]
Respiration and aerobic decomposition:
\[ \text{CH}_2\text{O} + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O} \]

Photosynthesis
\[ \text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{CH}_2\text{O} + \text{O}_2 \]
In summer, plants and trees take up CO$_2$

In winter, plants and trees lose their leaves, and those leaves that have fallen off in previous years become buried and decay, reforming CO$_2$

We expect to see an annual cycle in CO$_2$ – decreasing values in summer and rising values in winter

But we also expect the value at the end of the year to return to the same value as the previous year – that is, if the system is in steady state.
Which hemisphere dominates the annual CO₂ cycle?
$\text{CO}_2$ decreases in summer $\quad$ $\text{CO}_2$ increases in winter