EPSS C113/C213 Biological and Environmental Chemistry
Global Carbon cycles
Reading: Schlesinger & Bernhardt "Global carbon cycle"

Ch. 11. The modern carbon cycle

1. Fig. 11.1
    a. Whole Earth: ~*n*x10^23 g C
    b. Major crustal pools
        i. $CaCO_3$ 6.5x10^22 g
        ii. Buried organic matter 1.6x10^22 g
    c. Surface (active) pools
        *i*. *Atmosphere* *7.5x10^17* g
        ii. Ocean 3.8x10^19 g
        iii. Soil 1.5x10^18 g
        iv. Land Plants 5.6x10^17 g
2. Anthropogenic Fluxes
        i. Fossil-fuel burning 9x10^15 g/yr
        ii. Deforestation 9x10^14 g/yr
3. Total addition of ~1x10^14 g/yr should increase atmospheric concentration by 10/750 ≈ 1% per year. But only appears to be increasing by only ~0.5%/year. Remaining 0.5% must be "sunk" somewhere.

4. Probably most important: Oceans (CO2 dissolution).
    a. Temporal evolution of d13C in CO2
        i. 13C/12C in photosynthesized C roughly the same as fossil fuel/biomass. So sink to photosynthesis should minimize rate of change of d13C in air.
        ii. Dissolution of CO2 in the ocean does not discriminate 13C from 12C. Air CO2 d13C will drop as biomass CO2 added.
        iii. However, 13C/12C of photosynthesis variable, sinks to soil carbon, sources from cement manufacture complicate inversion.
    b. Loss of atmospheric O2 (Keeling et al., 1995)
5. Land/biotic uptake, ~1/2 of sink(?)
    a. CO2 fertilization
        i. CO2 may increase NPP, reduce water stress
        ii. Seasonal oscillation in atmospheric CO2, d13C of CO2 increasing – greater photosynthetic cycling?
        iii. However, field experiments generally not supportive – NPP may increase but decomposition rates also increase.
    b. Human-induced atmospheric NO3, P deposition
        i. Low-level acid rain pollution may fertilize nutrient-limited soils.
        ii. Probably modest player in global budget (?)

**Table 1.** Values of the quantities used in this study. Uncertainties in $d(O_2/N_2)/dt$ are due to standard drift and choice of fit (19), respectively. The latter is given for an average of data from two sites. The "values" of the measured trends in $O_2$ and $CO_2$ are illustrative only, because our results are calculated from related quantities [see (19)].

| Quantity | Value | Source |
|---|---|---|
| $f_{fuel}$ | −6.21 ± 0.37 GtC/year | (1) |
| $f_{cement}$ | −0.184 ± 0.011 GtC/year | (1) |
| Combustion stoichiometry | 1.43 ± 0.02 | (16) |
| Photosynthetic stoichiometry | 1.1 ± 0.06 | (17) |
| $d(O_2/N_2)/dt$ | −16 ± 0.8 ± 0.35 per meg/year | This study |
| $d(CO_2)/dt$ | 1.24 ± 0.05 ppm/year | This study |
| $CO_2$ (in 1995) | 760 ± 1 GtC | This study |
| $d/dt\ \delta_{atm}{}^{13}$ | −0.013 ± 0.008 ‰/year | This study |
| $\delta_{fuel}{}^{13}$ (in 1995) | −29.4 ± 1.8 ‰ | (32) |
| $\delta_{atm}{}^{13}$ (in 1995) | −7.86 ± 0.015 ‰ | This study |
| $\epsilon_{air-land}$ | −18 ± 1 ‰ | This study |
| $\epsilon_{air-sea}$ | −2 ± 1 ‰ | (33, 34) |

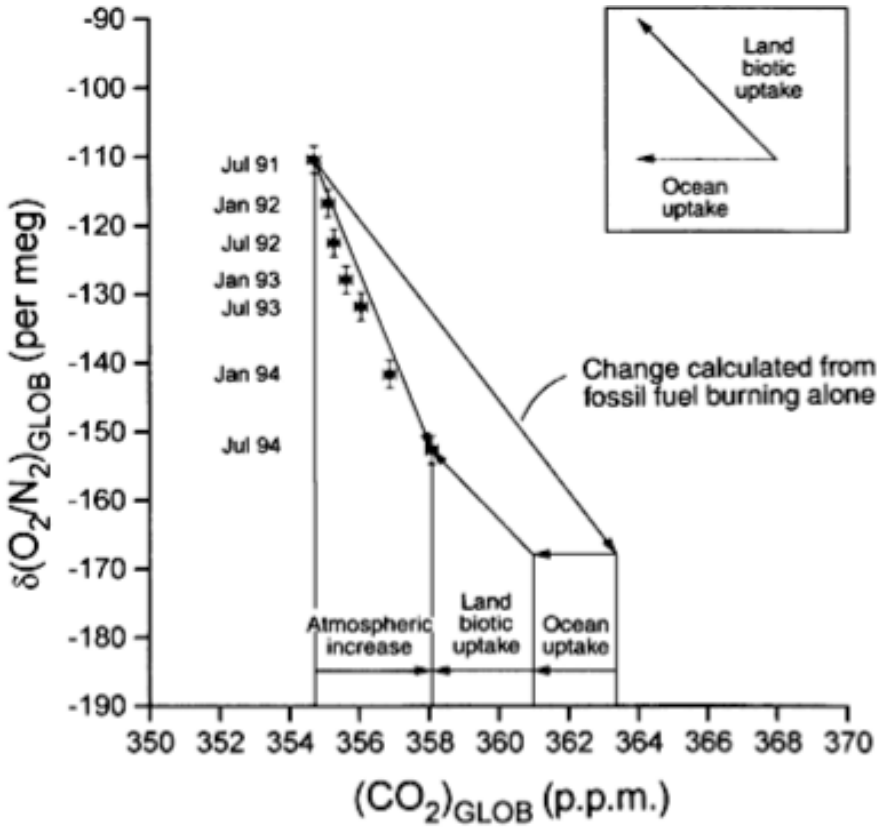


FIG. 2 Globally and annually averaged $\delta(O_2/N_2)$ versus $CO_2$. Annual means are computed by first fitting the data to the sum of a stiff spline plus a four-harmonic annual cycle. The harmonic fit is then used to adjust data to the 15th of each month, and monthly means are computed. Twelve consecutive monthly means are averaged to compute annual means. Months with missing data are filled in using the complete fitted curve. Also shown are the trends in $CO_2$ and $O_2/N_2$ computed from fossil-fuel burning and cement manufacture[32,27], and the unique combination of oceanic and land biotic $CO_2$ uptake required to account for the observations. Oceanic uptake of $CO_2$ is assumed to have no effect on $O_2$ concentration[9], while land biotic uptake is assumed to occur with $O_2/CO_2$ ratios of $-1.1{:}1$ (ref. 33). The error bars indicate the estimated standard errors of the globally and annually averaged values. In computing global oceanic and land biotic uptake, we additionally allow for uncertainty of $\pm 6$ per meg and $\pm 0.1$ p.p.m. in the overall trends in $O_2/N_2$ and $CO_2$, respectively, due to uncertainty in long-term calibration.