Supplement Part II : Estimations of CO_2 Distribution (GT/year) Amongst Atmosphere, Land Biomass, Ocean Biomass and Ocean Storage

The data collected for estimations of the CO_2 budget amongst the atmosphere, land biomass, ocean biomass and ocean storage and the method of estimations of CO_2 distribution in GT/year are summarized below.

1. One may convert Peta moles into mass units in GT/year knowing the molecular weights of species of interest.
2. Th energy released from fossil fuels (FF), E_{FF} =408.250 Exa J
3. Get data on energy from land use (E_{LU}). If E_{LU} is not available, estimate energy release from C emission data from land use (C_{LU}). For C data, C_{LU}= =1.418 GT/year in 2006 [23]. But C in GT per Exa J= 0.027 and hence ELU = 1.418/0.027=51.96 Exa J.
4. Total energy (E_{tot}) released due to both $E_{FF}+E_{LU}= E_{tot}$= 460.2 Exa J.
5. Estimate the O_2 consumed due to FF and LU, $O_{2\ sink,\ tot}$, Peta moles:

$$O_2\, Consumption\, rate (FF+LU), \frac{Peta\, mole}{year} = 2.232 * 10^{3} * Ann(FF+LU)\, Energy \left(\frac{Exa\, J}{year}\right),\ HHV_{O_2} = 0.448 x 10^{-13}\ Exa\, J\, per\, mole, \qquad \text{Equation 1}$$

With 2006 FFLU energy in Exa J per year =460.21, O_2 consumption rate =1.027 Peta moles/year in 2006

6. Make linear and quadratic curve fits to Keeling's data on CO_2 and O_2 in ppm vs year and obtain the constants a_1, b_1… d_1, d_2.
7. Estimate O_2 supplied by atm {$O_{2\ sink,\ atm}$}. Since $d[O_2]/dt$, ppm/year = b_1 (linear plot, negative) or d_2 *years since 1991+ d_1 (quadratic fit), $O_{2\ sink,atm}$, Peta moles of O_2 supplied by atm per year = 0.178*b_1 (linear fit) or d_2 * (2006-1991) + d_1 (quadratic fit) assuming atm air moles = $1.77x10^5$ Peta moles. With b_1= - 4.438 ppm/year (linear fit on O_2), $|O_{2\ sink,\ atm}|$, Peta moles of O_2/year = 0.789. While FF and LU require 1.027 Peta moles /year.
8. Estimate O_2 source from land ocean water biomass (LOWBM). The difference between moles consumed for energy release (FF+LU) and O_2 supplied by atm is the O_2 produced by land and ocean biomass. Thus, $O_{2\ LOWBM}$ (Peta moles/year)= 1.027-0.789= 0.238 Peta moles /year
9. Calculate x= O_2 moles produced/O_2 moles consumed for energy release = $O_{2\ LOWBM}$ produced / $O_{2\ sink,\ tot}$ =0.232 or 23.2% of O_2 required for energy release is produced by (LOWBM). See Table 2 for relations.
10. Estimate the CO_2 emission from FF using RQ_{FF}. For FF, RQ =1 if coal is used worldwide, =0.5 if natural gas is used worldwide, or determine RQ_{FFLU} if worldwide data on CO_2 and world FF energy consumption are known since CO_2 in GT/year per Exa J = 0.1* RQ_{FF}; thus RQ_{FF}=0.75.

11. For the RQ of LU, and if that energy from LU is mostly biomass, then RQ_{LU}=1. Then for RQ for FF+ LU is given as RQ_{FFLU}= RQ_{FF}* EF_{FF} + + RQ_{LU}* $EF_{LU,}$ where EF_{FF} = O_2 by FF/O2 total}. EF_{LU} = {O_2 by LU/O_2 total}, RQ_{FFLU} = 0.778
12. Estimate CO_2 release from FF and LU. $CO_{2\ FFLU,}$ Peta moles/year = 0.778*1.027=0.799
13. Estimate the RQ of LOWBM. RQ $_{LBM}$ =1. RQ_{OWBM}= 0.87 (Phytoplankton). For the RQ of LOWBM, splitting O_2 produced by ocean-based biomass and land-based biomass is required. The parameter "z" represents a fraction of O_2 produced from OWBM. RQ_{LOWBM}= RQLBM* {1-z) + RQ_{OWBM}* z. Since ocean covers 70% of earth's area, z≈ 0.7, RQ_{LOWBM}= 0. 909.
14. Estimate CO_2 sink from LOWBM. CO_2 sink with land and ocean biomasses = RQ_{LOWBM} * {O_2 production rate from biomass}, $CO_{2\ sink,\ LOWBM}$ = 0.909*0.238 =0.216 Peta mols/year
    or CO_2 sink via LBM and OWBM, GT/year = 44.01*RQ_{LOWBM} * x* O_2 in Peta mols by FFLU/year
15. Estimate the CO_2 stored by atm {$CO_{2\ st,\ atm}$}. Since d [CO_2]/dt, ppm/year = a_1 (linear plot, positive) or c_2 *years since 1991+ c_1 (quadratic fit), $CO_{2\ st,atm}$, Peta moles per year = 0.178*a_1 {linear fit} or c_2 * (2006-1991) + c_1 (quadratic fit) assuming atm air moles = $1.77x10^{20}$ moles. With a_1= 2.789 ppm/year (linear ft on O_2), $|CO_{2\ st,\ atm}|$, Peta moles/year = 0.370.
16. Calculate CO_2 stored by OW using CO_2 balance. CO_2 release from FF and LU=O_2 moles consumed* RQ_{FFLU} = 1.027*0.778=0.799 Peta moles/year, $CO_{2\ st\ atm}$ = 0.37, $CO_{2sink,\ LOWBM}$ = 0.216. Hence CO_2 stored in OW = 0.799-0.370-0.216=0.213 Peta moles/year. y=$CO_{2\ st,Ocn}$/O_2 by FF and LU = 0.213/1.027=0.207. The quadratic fit yields 0.19 Peta mole/year; CO_2 stored by ocean , GT/year = y* Peta mols O_2 by FFLU*44.01