SIO217B 2nd Keeling Problem Set Due: March 3

Problem 1. This problem explores the O_2 method for estimating the various terms in the global carbon budget:

$$M_{air} \cdot \frac{dX_{CO2}}{dt} = F - O - B + LU$$

Here M_{air} is the total moles of dry air in the atmosphere, X_{CO2} is the CO_2 mole fraction (ppm), F is fossil-fuel emissions, O is the ocean sink, B is the land biospheric sink, and LU is emissions from land-use. All terms are in units of mol C yr^{-1}. The calculation starts with the following inputs, estimated for the decade from Jan 2000 to Jan 2010:

Average atmospheric CO_2 mole fraction in Jan 2000:	369.1 ppm
Average atmospheric CO_2 mole fraction in Jan 2010:	388.5 ppm
Total moles M_{air} of dry air in the atmosphere:	1.77×10^{20} mol
Average decrease atmospheric O_2 from Jan 2000 to Jan 2010:	7.64×10^{14} mol O_2/yr
O_2:C molar combustion ratio for fossil-fuels:	1.40 (mol O_2/mol C)
O_2:C molar exchange ratio for land biospheric carbon*:	1.10 (mol O_2/mol C)
F: Average fossil-fuel emissions for the decade 2000-2010:	7.81 Pg C/yr
LU: Average land-use emissions for the decade 2000-2010:	1.10 Pg C/yr

*This ratio applies to both the land-use (LU) and land sink (B) terms.

A. Using this information, calculate the magnitude of the $M_{air}dX_{CO2}/dt$, B and O terms in the carbon budget. Give your answer in units of Pg C/yr.

B. Calculate the uncertainty in your estimates for B and O, allowing for ±2.4% ($\pm0.18\times10^{14}$ mol) uncertainty in the measured O_2 loss, ±6% (±0.46 Pg C/yr) uncertainty in fossil fuel burning, and ±70% (±0.77 Pg C/yr) uncertainty in land use emissions. You can neglect other sources of uncertainty. Beware that, depending on how you do the algebra, the fossil-fuel term may appear twice in your calculation, and you need to allow these terms to co-vary in order to compute the uncertainty correctly. You can avoid this co-variation problem by making sure that you combine the fossil-fuel terms into one single term.

Problem 2. This problem examines the impact of different CO_2 emission scenarios on the future loading of CO_2 in the atmosphere. It uses the spreadsheet:

Future_atmospheric_CO2_calculator.xls

As input, the spreadsheet requires emissions in Pg C per decade ("CO2 calculator" worksheet, cells AA3 to AL3), and it provides as output the CO_2 concentrations also by decade ("CO_2 calculator" worksheet, column C).

As provided, the spreadsheet is carrying out a calculation for the highest emissions scenario of the 2007 IPCC report, the so-called A2 Scenario. You will notice that the CO_2 levels predicted by this scenario rise to roughly 750ppm by century end.

(a) Reading from the spreadsheet, in what decade does the CO_2 level rise above 450 ppm in the A2 Scenario?

(b) Modify the emissions for the A2 scenario so that CO_2 rises only to 450 ppm and stays at that level after that (i.e. until 2100, the last year of interest here). This will require modifying the emissions for all decades after (and possibly including) the decade from (A) above. Provide a plot of the emissions by decade and the CO_2 concentrations predicted. Discuss how and why the emissions must vary with time to keep the CO_2 levels at 450 ppm.