Problem Set 6

1. Carbon footprint. John Average is a fairly typical American. Your job is to calculate his "carbon footprint" for him. His carbon footprint is the amount of greenhouse gases (in CO_2-eq) emitted every year as a result of his activities. John A provides you the following information:

- Home electricity use = 800 kWh/month. For simplicity assume half of this electricity comes from coal-fired power plants, one-quarter from natural gas, and one-quarter from non-emitting sources (hydro, nuclear, etc). Assume the power plants are 35% efficient.
- Home natural gas use for cooking and heating = 40 therm/month
- Driving = 1,000 miles per month; John's car has a fuel economy of 20 mpg
- Flying = 2 round trips each year, 2500 miles one-way; the plane uses jet fuel and gets 40 mpg per passenger
- Household garbage = 20 pounds of solid waste per week, sent to a landfill.

a) Make a table with two columns: (i) activity (ii) annual emissions in metric tons of CO_2-equivalent. For the first four items, calculate the CO_2 emissions. For the garbage, calculate the methane emissions and convert to CO_2-eq using a 100-year GWP. In your table, rank the activities in the order of emissions, highest first. What are John A's total emissions based on this information?

b) Compare John A's emissions to US per capita emissions.

c) Name two significant activities for GHG emissions that are (indirectly) part of everyone's carbon footprint but not mentioned in the list above.

Data you'll need:

(1) Find the emission factors (i.e. the mass of CO_2 produced per unit of energy, mass, or volume of fuel) for coal, natural gas, gasoline, and jet fuel at http://www.eia.doe.gov/oiaf/1605/coefficients.html. For coal, use the value for bituminous, and for natural gas, use the weighted national average for pipeline natural gas.

(2) Emission factor for solid waste = 0.05 g CH_4 per 1 g solid waste (very approximate – the actual factor varies widely depending on the organic content, the amount of recycling, whether there is landfill methane capture, and other factors)

(3) For US per capita, see

http://2010.census.gov/news/releases/operations/cb10-cn93.html

http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=90&pid=44&aid=8

2. Cloud effect on albedo: Read pages 89-91 in COW, and do Exercise 2 on page 92.

3. Sea level rise: This problem explores sea level rise due to anthropogenic global warming.

a. The IPCC mean estimate of global average surface temperature change (ΔT_S) for a doubling of pre-industrial CO_2 is 3 °C. Estimate the sea level rise due to thermal expansion of seawater that has an increase in temperature of 3 °C. Assume the *coefficient of thermal expansion* of seawater is 1.5×10^{-4} per °C (the density of seawater decreases by a factor of 1.5×10^{-4} for each °C of temperature change). You can assume that the area of the oceans remains constant.

b. Estimate the sea level rise that would result from the melting of 20% of the Greenland ice sheet. Greenland contains 10% of land ice. (Ignore any change in the area of the oceans). Compare this to the sea level rise from thermal expansion. Also: how much would sea level rise if all polar sea ice were to melt?