GEOL/ENVS 3520, Homework 4 (due Tues., 7 April)

Part 1:"Choosing a prudent temperature and CO_2 cap"

Using the table of impacts from our last lecture (also available on p. 16 of the IPCC AR4 WGII "Summary for Policy Makers" at http://www.ipcc.ch/ipccreports/ar4-wg2.htm) or other resources, determine what the amount of allowable additional global warming should be (relative to 1980-99 average), if any. Describe the impact(s) that you consider to be most critical in setting your warming cap. What is the reason that this impact must be avoided?

Having chosen a temperature cap, use the diagram describing the probabilistic relationship between atmospheric CO_2 amount and warming from our most recent lecture (and reproduced below) to determine what the prudent CO_2 cap should be. In doing this, record the certainty with which you have decided not to exceed a certain temperature (in terms of % probability or the IPCC "likelihood" language adopted in the figure).

Note that the impacts table and CO_2 vs. T figure describe temperature change with respect to different reference periods. You can consider the warming from the pre-industrial period until 1980-1999 base period to be 0.75 °C for purposes of this exercise.

Part 2: "Evaluating the relationship between population growth, energy efficiency, stabilization CO_2 concentration and future requirements for carbon-free energy"

Point your browser to http://geodoc.uchicago.edu/Projects/kaya.doc.html , the web-based "Kaya Identity Model" maintained by your textbook author. The model couples estimates of future population, economic growth and energy use with a simple geochemical model of the carbon cycle in order to forecast future CO_2 emissions and concentrations. We will run the model in order to gain some understanding of the interplay of these factors and to begin to assess the scale of the carbon-free energy demand in the future.

Begin by running the model (hitting "do the math") using the default parameters given. This should produce graphical output in the lower part of your browser window. The individual graphs will generally contain continuous lines (fits to historic data and forecasts) and discrete symbols (historic data).

Convince your self that the historic data are correct by picking off yr-2000 values of "population", "per capita GDP", "energy intensity" and "carbon efficiency" to obtain their product which should be the yr-2000 CO_2 emission in GTC. Write out the calculation, making sure you have used the correct units and magnitudes (i.e. the correct "power of ten"). What do you get?

Now, seeing that the historic data look reasonable, note the fit of the model curves to the data of the past. The past fits are all based on simple "%/yr" approximations so they are not perfect- that is, the rates of growth or decline in certain quantities has been more variable than can be accommodated by these simple fits (the fit to the carbon emission data has a different control than the economic variables, so ignore the past fit of the carbon emission data for the moment). As you can see, the default values have been specified to fit the more recent data when it is not possible to fit all of the data well. Make a note of which of the economic variables are fit best.

Now note the emissions predicted for yr-2050 that result from the default assumptions. Assuming that we will wish to limit these emissions, choose and note a desired CO_2 stabilization level (i.e. a "prudent CO_2 cap" from **Part 1**). Now note the amount of carbon-free energy that will be required in yr-2050 in order to achieve that cap (you may have to interpolate if your CO_2 cap falls between represented levels).

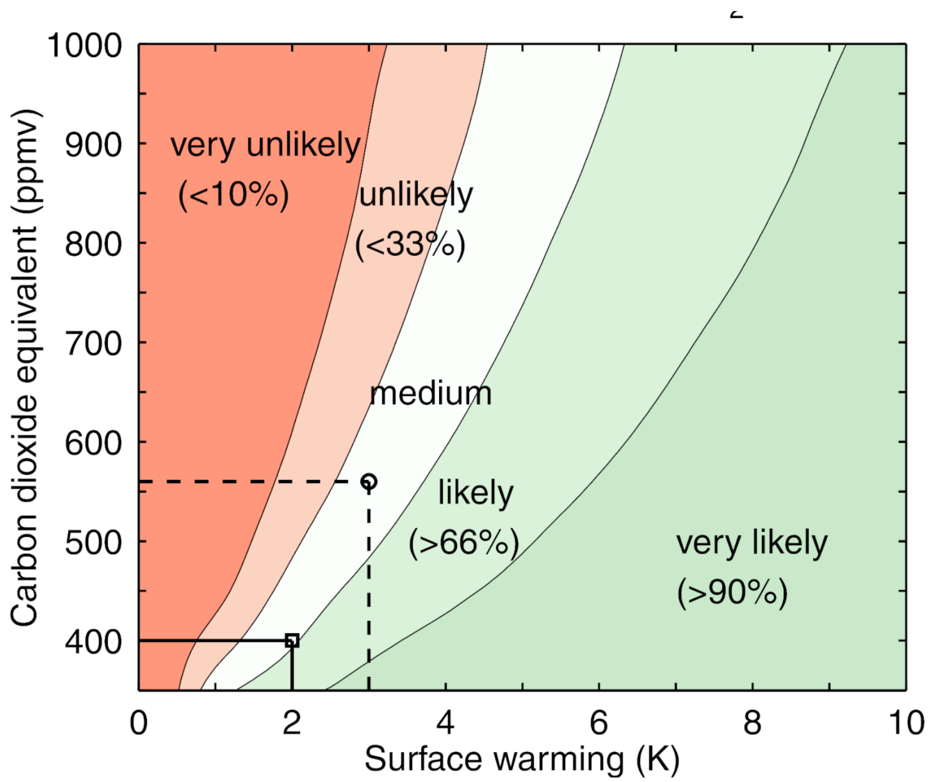
Next, let's look at the impact on our projections of changes in "energy intensity", which is a measure of how effectively we use energy to grow the economy. In order to obtain an independent estimate of "energy intensity" go to the Energy Information Administration (EIA) web site at http://www.eia.doe.gov/oiaf/ieo/index.html and navigate to Chapter I "World Energy Demand and Economic Outlook" (in html, not PDF). Near the bottom of the page under "Trends…" are some projections (in "%/yr") associated with different sets of economic assumptions. Choose an EAI projection and apply it to the Kaya Identity Model. Note that this should be entered in Kaya as a negative value, since (ideally) the trend is to run the global economy more efficiently over time (i.e. using less energy per $ GDP growth). Also be aware that the EAI projections are to 2030, but Kaya will use them out to 2100. Run the model and observe how the specified energy intensity fits the historic data. Does the fit seem conservative or optimistic? Note the new values for total emissions in 2050 and C-free energy needed in 2050 for your chosen CO_2 stabilization cap.

Keep in mind that for this exercise, we have assumed that the "carbon efficiency" (which is determined by the energy density of the mix of fuels running the economy) is unchanged. We could run our experiment differently and try to determine the rate at which "carbon efficiency" would have to increase in order to get to your chosen CO_2 cap. This would effectively incorporate the carbon-free energy into the "carbon efficiency" calculation. You do not need do this, but you should be aware of this alternative way of posing the problem.

Lastly, now search the web to obtain the total global energy consumption today in TW (and hope that you can find it without having to convert from quadrillion BTU/y). What is the present value and what is the present fraction of that value that is carbon-free? What is the multiple by which we will have to increase the C-free energy supply above todays in order to support the global economy in 2050 without exceeding your chosen CO_2 stabilization cap (using what you believe to be a realistic forecast for energy intensity)?

In preparing your work you should:

1) Print out the relevant model output for the 2 runs you have executed (One way to do this is to right click the individual graphs you want to save, then copy them to a document, trying to be space efficient. Alternately, you can take a screen shot and paste and crop it as necessary).
2) Append to the plots all values that I asked you to note or calculate, with neat and clear annotations.
3) Bring your work to the start of class on Tues., 7 April.



Probability of remaining below a global mean temperature level for a given CO_2 (equivalent) stabilization level, taking into account uncertainty in climate sensitivity and non-CO_2 radiative forcings. Likelihood terminology from IPCC