Exercises

A. In the blackbody model, how much would the Earth's surface temperature change if the surface albedo was 0.40 instead of 0.31?

B. What is the relative GWP (Global Warming Potential) of CO_2?

C. Explain what causes the annual rise and fall of [CO_2] shown in Figure 22.3 of the 2nd and 3rd editions of the textbook?

D. How many kg of CO_2 does a person's driving produce in one year, if they drive 12,000 miles/year at 25 miles/gallon. Treat gasoline as C_8H_{18} with $\rho =$ 0.7 g/ml.

E. List two feedback mechanisms related to CO_2 concentration.

F. What is the mechanism by which some particles exert a direct negative radiative forcing? What is the mechanism by which some particles exert a direct positive radiative forcing? What is the mechanism by which particles may exert an indirect radiative forcing?

G. Consider the statement "The climate in Syracuse today is warm for this time of year." From your reading of Section 1.2 of the text, explain what is wrong with the statement.

H. Consider Species A absorbs at λ_1 in the IR with a cross-section of 1×10^{-19} cm^2/molecule. Species B absorbs at λ_1 with a cross-section of 4×10^{-18} cm^2/molecule.
Compute the %Transmittance (aka %T) **and** %Absorbed (%A = 100-%T) at λ_1 for a path-length of 10 km for the following conditions:
a) an atmosphere with only species A, and [A] =2.5×10^{13} molecules/cm^3
b) an atmosphere with [A] =2.5×10^{13} molecules/cm^3 **and** [B] = 2.5×10^{11} molecules/cm^3

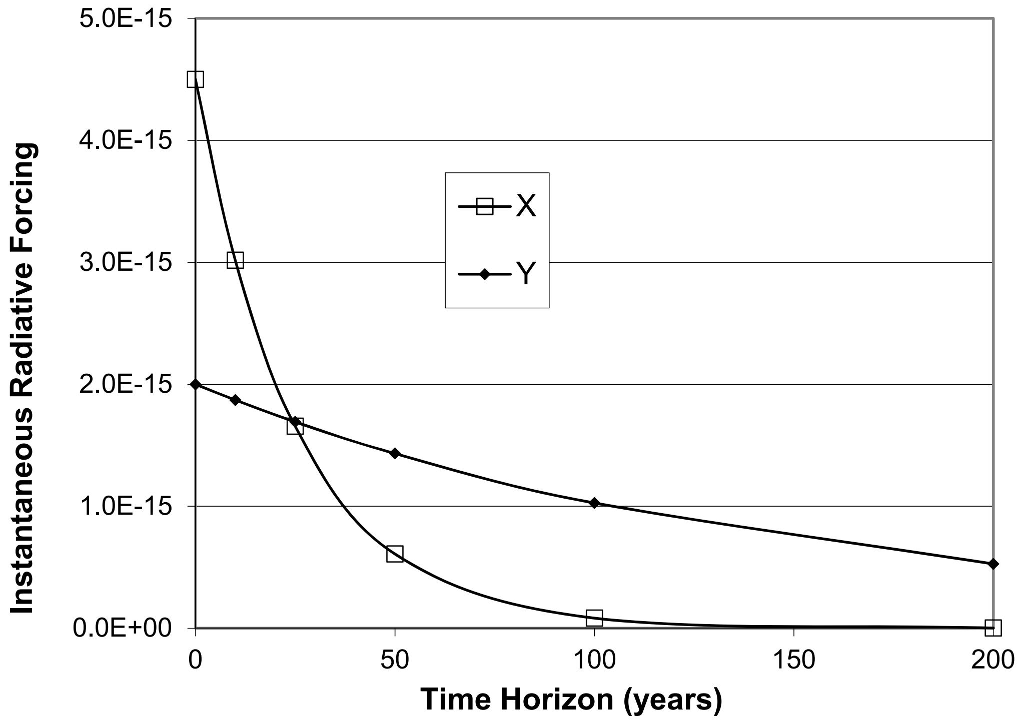
I. On the graph on the next page:
i) what is the instantaneous radiative forcing of compound Y at t=10 years (the first data point)
ii) what is the AGWP of compound Y for a time horizon of 10 years? (in W years m^{-2} kg^{-1})

J. In the handout I gave you on energy balances, what energy flux of IR emitted from the Earth's surface passes the atmosphere to escape into space?

Problems

1. The figure on the next page shows the instantaneous radiative forcing (IRF) for substances X and Y. The units of IRF are W m^{-2} kg^{-1}.
A) Calculate (approximately) the GWP of X relative to Y for a time horizon of 200 years.
B) Estimate the time at which the relative GWP of X equals 1.0 (relative to Y)

HINT: Start by calculating the lifetime, τ, of each species from the data in the graph and the equation $\ln([X]_t/[X]_0) = -t/\tau_X$ and then using the equations for AGWP and relative GWP. Use the calculus formula employed in lecture. Alternatively, you can get the AGWP of X and Y by adding up the areas of a bunch of polygons to get the area under each curve.



2. Does the GWP of CFC-115 increase or decrease with increasing time horizon? Why?

Does the GWP of CFC-11 increase or decrease with increasing time horizon? Why?

<u>Type of Answers</u>: Quantitative reasoning. Use Table 21.4 from the 2nd edition of the textbook, which is also posted to Blackboard as the second page of the file with the curves of IRF, AGWP, and GWP versus time horizon.

3. <u>Given</u> the molecules and results from Exercise H, and:
Species B also absorbs at λ_2 in the IR with a cross-section of 1×10^{-18} cm^2/molecule

<u>Question:</u> Does this addition of species B to an atmosphere <u>already containing A</u> have a greater effect on the amount of energy of the Earth's IR emission by the atmosphere at λ_1 or at λ_2?

(Assume the emission power, I_0, from the Earth's surface is the same at λ_1 and λ_2, and that these are the only absorbers one need account for.)

Prompt a) Which quantity in Exercise H is proportional to the radiative forcing of these compounds at λ_1 and λ_2: Absorbance, %T, or %A ?

Prompt b) What is the baseline at λ_1 to determine the effect of adding compound A? At λ_2?

<u>Type of Answer</u>: Calculation. Note: this is really a question about window regions!