Tentamen NS255B,

Jan 31, 2012

Exercise 1:

General questions/short exercises:

a) Are the following loss processes first-order?

A. Uptake of CO2 by the biosphere

B. Photolysis of gases in the stratosphere

C. Scavenging of aerosol particles by precipitation

b) Consider a 2-box model with the two boxes being the troposphere (1000-150 hPa) and the stratosphere (150-1 hPa). The lifetime of air in the stratosphere is 2 years. What is roughly the lifetime of air in the troposphere?

Exercise 2:

Briefly comment on following statements: (true, not true, explain why?)

a). The equilibrium temperature of Venus is lower than that of Earth, even though Venus is nearer to the sun.

b) Concentrations of CO2, krypton-85, and other gases emitted mainly in the northern hemisphere DECREASE with altitude in the northern hemisphere but INCREASE with altitude in the southern hemisphere.

c) The presence of a cloud cover tends to favor lower daytime temperatures and higher nighttime temperatures.

Exercise 3:

Consider a simplified planet-atmosphere system where a thin atmospheric layer is at some distance from the surface of the planet. The albedo of the planet's surface is A. The surface perfectly absorbs infrared radiation; i.e. it can be considered a blackbody in this wavelength region. There is no scattering of sunlight in the atmosphere, so the albedo of the atmosphere by itself is 0. The transmissivity of the atmosphere is τ_s for sunlight and τ_i for infrared radiation. The average incident solar radiation per surface area of the planet is Q. (For clarification: of the incident radiation Q the fraction $\tau_s Q$ is transmitted through the atmosphere, and the fraction $(1-\tau_s)Q$ is absorbed.)

a) Show that the surface temperature T_0 of the planet is given by following relation:

$$\sigma T_0^4 = Q\left[\frac{1+\tau_s}{1+\tau_i}\right](1-\tau_s A)$$

b) Using the relation above show that for some choices of τ_s, τ_i, and A the surface temperature is lower than the equilibrium temperature T_E of the planet. (This would be a sort of negative greenhouse effect).

Exercise 4:
It has been suggested hat hydrogen in the Earth's primitive atmosphere led to the production of CH_4 by the reaction

$$CO_2(g) + 4H_2(g) \xleftrightarrow{k_{eq}} CH_4(g) + 2H_2O(g)$$

a) The equilibrium constants k_{eq} for this reaction at 300 and 400 K are 5.2 x 10^{19} and 2.7 x 10^{12} bar^{-2}, respectively. If the partial pressures of H_2O, CO_2, and H_2 in the primitive atmosphere were taken to be 3.0 x 10^{-2}, 3 x 10^{-4}, and 5.0 x 10^{-5} bar, respectively, what are the equilibrium pressures of CH_4 at 300 and 400 K?
b) The equilibrium constants $k_{eq}=k_{forward}/k_{backward}$. At 400 K $k_{forward}$ is large, but at 300 K it is immeasurably small. Is it likely that this reaction was responsible for the conversion of much H_2 into CH_4 in the primitive atmosphere? Why, or why not?

Exercise 5:
In the year 2000 a total amount of 3.0x10^{13} kg of fossil fuels has been burned. Assuming that 50% of the emitted CO_2 accumulates in the atmosphere, what is the averaged increase of the CO_2 mixing ratio (in ppm) in the atmosphere? Assume that 80% of the weight of fossil fuels is carbon; the molecular weights of C, O, and air are 12, 16, and 29 g/mol respectively. (Mass of atmosphere: 5.2E18 kg)

Exercise 6 (please on a separate sheet!):
a) Leg kwalitatief uit wat voor stralingsforcering ontstaat aan het aardoppervlak, in de atmosfeer en aan de top van de atmosfeer als gevolg van aerosol dat zowel zonlicht terugkaatst als absorbeert.

b) Leg kort uit hoe de aanwezigheid van roet in de atmosfeer het regionale klimaat kan veranderen. Denk hierbij ook aan neerslag.

c) Beschouw een wolk met een dikte van 200 m, een wolkendruppelconcentratie van 75 cm^{-3} en een druppelstraal van 12.5 μm. Bereken het albedo A, met $A = \tau/(\tau+6.7)$ en τ de optische dikte.

d) Nu heeft de wolk uit c) een druppelconcentratie van 225 cm^{-3}. Bereken de forcering ΔF ten opzichte van de wolk uit c). De zonneconstante S is 1360 W m^{-2}.