ATM 211	Climate and Climate Change	Fall, 2003

Homework 2 assigned: Mon Oct 13 due: Thur Oct 23

Readings:

Earth System Science and Daisyworld: KKC Chap 2 (all)
Global Energy Balance: KKC Chap 3 (begin)

KKC Chap 2:

1. *Daisyworld:* Imagine four "Daisyworld" cases. (a) white daisies/cool climate, (b) white daisies/warm climate, (c) black daisies/cool climate, and (d) black daisies/warm climate. White daisies cause planetary albedo to increase. Black daisies cause planetary albedo to decrease. (Note: each case has either white or black daisies, but not both.) For the cool climate, an increase in temperature causes more daisies to grow. For the warm climate, an increase in temperature causes fewer daisies to grow. Draw a three-component system diagram for each of these cases. The three components should be daisy coverage (C), planetary albedo (A), and average surface temperature (T). Give the sign of the feedback loop in each case and state whether the equilibrium point would be stable or unstable. [16 pts]

2. *Daisyworld:* Look at Figure 2-14 from the text. This shows how daisy coverage (panel a) and surface temperature (panel b) change as a function of solar luminosity for the case of white daisies. (Part I) Draw a third panel showing how planetary albedo changes as a function of solar luminosity. Include the "lifeless case" as a dashed line for reference (as in panel b). (Part II) Now redraw all three panels for the case of a world with black daisies (where an increase in daisy coverage causes a decrease in planetary albedo). The figures do not need to be precise, but should show the form of each curve. Include the "lifeless case" as a dashed line in the plots that show temperature and planetary albedo. Hand-drawn figures are fine. The x-axes should be labeled "Solar luminosity" for all plots. The y-axes should be labeled "C" (on the percent daisy coverage plot), "T" (on the average surface temperature plot) and "A" (on the planetary albedo plot). You can omit the numbers from the x- and y-axes. (A plot without numbers on either axis is called a conceptual plot or, sometimes, a "Cal Tech" plot.) [16 pts]

3. *Radiation and matter:* State the four ways that radiation and matter interact. [8 pts]

4. *Radiation and albedo:* A lamp shining on a table delivers 100 Watts (W) of energy to the surface. The table has an albedo of 0.8 and a surface area of 2 m^2. (a) How much energy per unit area is coming directly from the lamp and being absorbed by the table? Express your answer in W/m^2. [4 pts] (b) Assume that the lamp and the table are inside a room with no windows and are the only objects in that room. Name two other sources of radiation energy to the surface of the table. [8 pts]

5. *Applying the planetary energy balance equation.* The solar constants for Venus, Earth, and Mars are 2643, 1370, and 593 W/m^2, respectively. The albedos are 0.8, 0.3, and 0.22, respectively. (a) Compute E_{IN} for each planet (the flux of solar energy absorbed, in W/m^2.) [6 pts] (b) Compute T_e for each planet (the effective radiating temperature, K.) [6

pts]. (c) The surface temperatures of Venus, Earth and Mars are 450, 15, and –55 °C, respectively. Convert these temperatures to degrees Kelvin, K, and then compute the greenhouse effect, ΔT_g, for each planet. [6 pts]

6. *Climate change theory:* The conceptual model that underlies concern about global warming is expressed in the equation: $\Delta T = \lambda \, \Delta F$. State which one of these three terms is most directly associated with the following: (a) climate models, (b) increase of CO_2 in the atmosphere, (c) ice-albedo feedback, (d) urban heat-island effect. [2 pts each]

7. *Define the following terms in the context of this course [2 pts each]:* (a) albedo, (b) positive feedback loop, (c) infrared radiation, (d) unstable equilibrium

Extra credit: Do Critical-Thinking Problems 2 and 4 at the end of Chap 2 (p 32-33). Up to 10 extra credit points if you do both (equivalent to attending a lecture).

NOTE on problem 4: The equation for parabola was given incorrectly in the text. It should have been: $y = o - c(a - x)^2$

where o, a, and c are constants. o is the value of y when y is maximum, a is the value of x when y is maximum, and c describes the flatness or steepness of the curvature. Once you establish the values of x and y on the graph for key points (like where y is maximum and where y is zero), you can solve for o, a, and c.