METEO 469 PROBLEM SET #3

NAME:

DUE:

ESTIMATING FUTURE WARMING

**1. *Worksheet successfully downloaded!***

**2. (a) Perform a dimensional analysis to show that the linearized equation for global surface temperature based on the zero-dimensional energy-balance model yields a value in degrees Celsius (oC), given that the solar constant has units W m-2, planetary albedo is unitless, the planetary longwave radiation constant (“A”) has units W m-2, and the temperature-dependent planetary longwave radiation constant (“B”) has units W m-2 oC-1. Start with the expression below, and use Microsoft Word’s Equation Editor to write your steps.**

**(b) Describe how to convert a temperature value expressed in degrees Celsius (oC) to one expressed in Kelvin (K); feel free to look this up using a resource of your choice. Explain why a change in temperature in oC is the same in K.**

**2. The next exercises use a toy zero-dimensional energy-balance model (0-D EBM) and will have you using an Excel spreadsheet file, which is provided, divided into two sheets named “Ex 2” and “Ex 3” whose tabs are given at the bottom left of the window. In each sheet, you will input values in the part of the sheet called “INPUT VALUES”, yielding “CALCULATED VALUES” in another part of the sheet.**

**a. Using the Ex 2 sheet, determine the planetary surface temperature for a blackbody Earth. For the input values, let “A” be 315 W m-2 and “B” be 4.6 W m-2 oC-1 and the solar constant be 1370 W m-2 and the planetary albedo value be 0.32, the “standard” values mentioned in Lesson 4. Round the result to two decimal places and express in both degrees Celsius and Kelvin.**

**b. Recall that the graybody assumption is that Earth’s atmosphere has a greenhouse effect, i.e., the atmosphere itself emits longwave radiation downward to the surface. We account for it by varying the values of terms “A” and “B”. Let “A” be 214.4 W m-2 and “B” be 1.25 W m-2 oC-1 and the solar constant be 1370 W m-2 and the planetary albedo value be 0.32. Use the Ex 2 sheet to calculate the planetary surface temperature for this conception of a graybody Earth. Round the result to two decimal places and express it in both degrees Celsius and Kelvin.**

**c. Using values of solar constant ranging from 0 to 2000 W m-2, incremented by 100 W m-2, and assuming that the planetary albedo value is 0.32 and that term “A” is 214.4 W m-2 and “B” is 1.25 W m-2 oC-1, calculate planetary surface temperature, displaying the results in a table, expressing them in Kelvin, and rounding them to two decimal places. Also, plot the results using Excel or other graphing utility, with the horizontal axis giving values of solar constant and the vertical axis giving values of planetary surface temperature.**

**d. Using values of planetary albedo ranging from 0 to 1, incremented by 0.05 W m-2, and assuming that the solar constant is 1370 W m-2 and that term “A” is 214.4 W m-2 and “B” is 1.25 W m-2 oC-1, calculate planetary surface temperature, displaying the results in a table, expressing them in Kelvin, and rounding them to two decimal places. Also, plot the results using Excel or other graphing utility, with the horizontal axis giving values of planetary albedo and the vertical axis giving values of planetary surface temperature.**

**e. Using values of term “A” ranging from 0 to 350 W m-2, incremented by 50 W m-2, and assuming that the solar constant is 1370 W m-2, planetary albedo value is 0.32, and term “B” is 1.25 W m-2 oC-1, calculate planetary surface temperature, displaying the results in a table, expressing them in Kelvin, and rounding them to two decimal places. Also, plot the results using Excel or other graphing utility, with the horizontal axis giving values of term “A” and the vertical axis giving values of planetary surface temperature.**

**f. Using values of term “B” ranging from 0 to 5.0 W m-2 oC-1, incremented by 0.5 W m-2 oC-1, and assuming that the solar constant is 1370 W m-2, planetary albedo value is 0.32, and term “A” is 214.4 W m-2, calculate planetary surface temperature, displaying the results in a table, expressing them in Kelvin, and rounding them to two decimal places. Also, plot the results using Excel or other graphing utility, with the horizontal axis giving values of term “B” and the vertical axis giving values of planetary surface temperature.**

**g. Discuss the results you found in parts a through f, giving a physical interpretation. Limit your response to a paragraph.**

**3. In this exercise, you will work with the idea of climate sensitivity and use the “Ex 3” sheet within the provided Excel spreadsheet file.**

**a. The European Union has defined 2oC warming relative to pre-industrial temperatures as the threshold for Dangerous Anthropogenic Interference (DAI) with the climate system. Use the Ex 3 sheet to estimate the concentration of carbon dioxide (in ppm) at which we would expect to breach the DAI amount of warming. Assume a “mid-range” gray body parameter setting, i.e., term “B” is 1.25 W m-2 oC-1. Also assume that the pre-industrial carbon-dioxide concentration is 280 ppm and that the pre-industrial average global temperature is 288 K.**

**b. The atmospheric carbon-dioxide concentration is currently at about 410 ppm and is increasing by about 2 ppm per year. If we continue to increase carbon-dioxide concentration at this rate, how many years will it take until we commit ourselves to DAI, based on the climate sensitivity (i.e., the gray body parameter setting) considered above? To answer this question, use your results from a. If you were advising policy makers, for how many years would you tell them we have to stabilize carbon-dioxide emissions and why?**

**c. Some scientists have argued that the threshold of 2oC is actually too high for DAI and that it should be a lower value. Re-work a and b assuming an alternative DAI of 1.5oC, and report the results. Is it too late to avoid DAI at this threshold?**