Name (1 point): **Section:** Monday Tuesday Wednesday
ID #: (circle one—1 point)

<u>AS 1 Homework #3</u>

The purpose of this homework is to help you understand how climate feedbacks such as water vapor feedback affect climate change. Show your work in the space provided and put your final answers in the boxes.

(a) (2 points) The global-mean surface temperature of the earth as seen from space is about 288 degrees Kelvin. Use the Stefan-Boltzman law to calculate the radiative flux corresponding to an object with this temperature.

Flux =

(b) (3 points) If CO_2 is instantaneously doubled, the greenhouse effect is enhanced, and the surface and troposphere receive about 4 W/m^2 of radiation. Use the Stefan-Boltzmann law again to calculate the temperature that earth's surface has to rise to (in degrees K) in order to balance this radiative forcing.

Temperature =

(c) (2 points) By looking at your answer to part (b), how much warming occurs when CO_2 is instantaneously doubled?

CO_2 Warming =

(d) (3 points) The warming you calculated in part (c) does not include any climate feedbacks. Let's see what happens if we include water vapor feedback. Due to the Clausius-Clapyeron relationship, water vapor increases in the atmosphere when the temperature rises. The increase in water vapor in the atmosphere enhances the greenhouse effect, with each degree K of surface warming increasing the radiation the surface and troposphere receives by 2.9 W/m^2. Calculate how much **<u>additional</u>** radiation (in W/m^2) the surface and troposphere would receive due to this effect assuming the warming you calculated in part (c).

Additional Radiation Flux=

(e) (2 points) Quantify the total enhancement (in W/m^2) of the greenhouse effect due to the increase in CO_2 and water vapor by adding 4 W/m^2 to you answer to part (d).

Total Enhancement Radiative Flux =

(f) (3 points) Now let's include the water vapor feedback effect in our calculation of the warming. Use the same method as in part (b) to calculate the temperature (in degrees K) that must occur to balance the radiative flux you found in part (e).

Temperature =

(g) (2 points) Calculate the warming that occurs because of the water vapor feedback by taking your answer to part (b) and subtracting it from part (f).

Warming =

(h) (3 points) One problem with our initial calculation of the strength of water vapor feedback in part (d) is that it does not reflect the additional warming the surface experienced due to water vapor feedback. Calculate the additional radiation flux (in W/m^2) the surface and troposphere would receive due to the water vapor feedback warming calculated in part (g). (Remember that 1 degree Kelvin of warming enhances the radiation flux by 2.9 W/m^2.)

Additional Radiation Flux =

(i) (2 points) Quantify again the total enhancement of the greenhouse effect due to the increase in CO2 and water vapor by adding your answer in part (h) to your answer in part (e).

Total Enhancement Flux =

(j) (3 points) Use the same method as in part (b) to calculate the temperature the surface must have to balance the radiative flux you found in part (i).

Temperature =

(k) (2 points) Calculate the total warming that occurs from the CO_2 doubling and the water vapor feedback loop by subtracting the original temperature of the planet from part (j).

Total Warming =

(l) (2 points) Use your answers from parts (k) and (c) to estimate how much water vapor feedback amplifies the equilibrium response to a doubling of CO_2. How much additional warming occurs because of the water vapor feedback loop?

Water Vapor Feedback Warming =