**CE/ABE/ENSCI 524B – Assignment #1 Solutions**

**Global Atmospheric Change**

8.1 Suppose the ratio of in standard ocean water is If another sample of ocean water has an ratio of what would be the value of Would the sample correspond to a warmer or colder climate?

The principle used is that less ice on Earth leads to more dilution with lighter water and therefore a warmer climate.

* The sample with a ratio of , would correspond to a warmer climate. A lower ratio means a lower amount of A lower amount of in ocean water means warmer temperatures.

8.2 A relationship between the mean annual surface temperature of Greenland and the value of of the snow pack on the Greenland ice sheet is given by

An ice core sample dating back to the last glaciations has a value of equal to What would the estimated surface temperature have been at that time?

8.5 The solar flux arriving at the outer edge of the atmosphere varies by as the earth moves in its orbit (reaching its greatest value in early January). By how many degrees would the effective temperature of the earth vary as a result?

* The solar flux arriving at the outer edge of the atmosphere, is represented by the solar constant of For this problem we are assuming that the solar flux varies by as the earth moves in its orbit. So,
* We also know that the energy absorbed by Earth is and the energy radiated back to space by earth is assuming that the earth is a blackbody and behaves according to the Stefan-Boltzmann Law.
* As we know that the energy absorbed by Earth equals the energy radiated back to space, we can set the two equations equal and solve for the effective blackbody temperature. This leads us to
* The average albedo for Earth constant, We also know that where is the Stefan-Boltzmann Constant. We also know, from previously, that
* Using these quantities and solving for we get The earth would vary from to

Any atmospheric heat retention has been ignored, but the 4K variation is correct.

8.8 In Figure 8.13, the average rate at which energy is used to evaporate water is given as Using as the latent heat of vaporization of water, along with the surface area of the earth, which is about estimate the total world annual precipitation in (which is equal to the total water evaporated). Averaged over the globe, what is the average annual precipitation in meters of water?

* + Assuming average conditions everywhere and also that there is enough water for evaporation everywhere, we can estimate what the total world annual precipitation in would be. This is not realistic, of course.
  + Using the average rate at which energy is used to evaporate water, and the surface area of the earth, we can solve for the total power used to evaporate water over the surface of the earth.
  + Using the total power used to evaporate water over the surface of the earth, we can solve for the total energy used to evaporate water over the surface of the earth in the course of a year.
  + Using the latent heat of vaporization of water, we can solve for the total mass water evaporated from the total energy used to evaporate water per year.
  + Using the density of water, we can solve for the total volume of water evaporated from the total mass of water evaporated = a rough estimate of the total volume of precipitation per year, worldwide is therefore
  + By dividing by the surface area of the earth, we can find the average annual precipitation in meters of water. , say 1m.

A better approach would have been to accept water for evaporation only available on 70% of the Earth’s surface, but that precipitation is spread over all of Earth. That would result in an average rainfall of 0.7m per year on average, which is close to reality.

8.14 The radiative forcing as a function of concentration for is modeled as a square root dependence:

Assuming it has been in that region since preindustrial times when the concentration was find an appropriate if the current concentration is and the forcing is estimated to be Estimate the added radiative forcing in if it reaches a concentration of

1. Find an appropriate if the current concentration is
   * Using the preindustrial concentration for nitrous oxide, listed on page 481, we know that
2. Estimate the added radiative forcing in 2100 if it reaches a concentration of
   * Using the that we calculated for nitrous oxide, we can solve for the added radiative forcing, if the concentration reaches The added forcing that results from an increase in concentration from in 2010 to in 2100 is

8.20 Compute the global warming potential for a greenhouse gas having atmospheric lifetime and relative forcing per unit mass that is times that of over the following time periods:

* To calculate the Global Warming Potential (GWP) of a gas we need to know the radiative forcing of the gas the exponential decay of that gas and the time period for cumulative effects and use them in the equation
* In this problem, we know the relative forcing as compared to carbon and we know the atmospheric lifetime, which gives us the exponential decay function of the gas Assuming an average lifetime of 100 years for CO2, and a decay function of The GWP for three different time periods are as follows.

1. 20 years
2. 100 years
3. 500 years