GEOL1100 2013, HW 3

Use Matlab to help with the number crunching! You need almost exactly the same formula for each subquestion!

1 Heating it up!

Hints: $4.718J = 1cal$, $1W = 1J/s$, $1day = 86400s$

1.1 How many W of power does it take to heat up 1 m^3 of seawater (with density of 1035 kg/m^3, $c_p = 1cal/g/K$) at a rate of 1K/day?

1.2 How many W of power does it take to heat up 1 m^3 of sea ice (with density of 990 kg/m^3, $c_p = 0.5cal/g/K$) at a rate of 1K/day?

1.3 How many W of power does it take to heat up 1 m^3 of dry air (with density of 1.25 kg/m^3, $c_p = 0.25cal/g/K$) at a rate of 1K/day?

1.4 How many W of power does it take to heat up 1 m^3 of moist air ($40\% = 0.5kg/m^3$ is water vapor with $c_p = 0.5cal/g/K$, $60\% = 0.75kg/m^3$ is dry air with $c_p = 0.25cal/g/K$ and they have the same temperature) at a rate of 1K/day?

2 Global Warming of the Atmosphere vs. the Surface Ocean

The excess energy associated with global warming is taken to be approximately 1.5 W/m^2, on global average. Let us assume that this is the number, and find out what happens if all of that energy goes into only one reservoir.

2.1 How many Kelvin would a dry atmosphere heat in a year of global warming, assuming all of the $1.5W/m^2$ were to apply to the atmosphere?

(Hint, you will need to figure out how much mass per unit area kg/m^2 the atmosphere has–recall that hydrostatic pressure is the weight/area above you, so 1 bar= of pressure is equivalent to the weight (weight is mg) per square meter of the whole atmosphere.)

2.2 How many Kelvin would the upper 50m of the ocean heat in a year of global warming, assuming all of the $1.5W/m^2$ were to apply equally across this 50m mixed layer?

(Hint, don't worry about the fact that the ocean only covers 72% of the Earth, that is only a small correction.)

2.3 How many Kelvin would the whole 4km of the ocean heat in a year of global warming, assuming all of the $1.5W/m^2$ were to apply equally across this 4km depth?

3 About $6 \cdot 10^{15} W = 6$ petawatts of energy is transported by the atmosphere & ocean poleward to redistribute the sun's unequal heating of the equator and poles.

Assume 2 petawatts is carried by sensible atmospheric heating, 2 petawatts is carried by latent heat, and 2 petawatts is carried by the ocean.

3.1 Suppose the ocean heat transport can be divided into two layers. The upper layer has a potential temperature of $20°$C and travels poleward, the lower layer has a potential temp of $2°$C and travels equatorward. How many Sverdrups ($10^9 kg/s$) need to be flowing to carry the 2 petawatts of net poleward energy?

Hints: The poleward flow rate in Sverdrups must equal the equator ward flow rate.

3.2 Calculate the mass of water vapor traveling poleward and returning as liquid water to carry this latent heat energy. You may neglect any sensible heating from the difference in temperature between the vapor and liquid (i.e., use 540 cal/g latent heat of fusion).