

Climate & Sustainability

PHYS 189

Fall 2017

Problem Assignment # 1

due 09-01-17

1. (a) Define climate, climate variability, and weather.
(b) Is climate variability the same as weather? Explain.
2. What are the 4 primary components of the “climate system” Give an example of how each influences the climate.
3. Atmospheric composition: CO₂. For parts b-d use the very simple climate model at <https://spark.ucar.edu/simple-climate-model>.
 - (a) List at least 3 sources and 3 sinks of CO₂. Please include some natural and some anthropogenic examples.
 - (b) In the very simple model, the default CO₂ emissions is 10.5 Gigatons per year. If you step the model forward without changing the emissions, how much does the temperature increase from now until 2050? 2100?
 - (c) How much does the temperature increase by 2050 if you increase the CO₂ emissions to 16.4 Gigatons per year? By 2100?
 - (d) Now set the CO₂ emissions to zero. How long does it take the temperature to return to what it was in 1980? Why doesn't the CO₂ concentration immediately fall to pre-industrial levels?
4. Atmospheric composition: Ozone
 - (a) In which atmospheric layer are we concerned about ozone depletion?
 - (b) Why is it being depleted?
 - (c) What are some implications of depletion?
 - (d) Why is ozone considered “good” and “bad”? (Hint: think about layers in the atmosphere where ozone is found).
5. Atmospheric composition: aerosols
 - (a) What are aerosols?
 - (b) Give 3 examples of human sources of aerosols and 3 examples of natural sources.
6. Pressure
 - (a) Pressure is defined as force per unit area. What is the source of pressure in the atmosphere?
 - (b) What is a line of constant pressure called?
 - (c) How does pressure change with altitude in the atmosphere?
7. Hydrostatic balance
 - (a) Draw an air parcel (as a box is fine).

- (b) Draw vectors (arrows) representing the vertical forces acting on the parcel. Label the vectors with the names of the forces.
- (c) If the parcel is in hydrostatic balance, what forces are in balance? What is the vertical acceleration of a parcel in hydrostatic balance?
- (d) Write down the hydrostatic equation and indicate which terms represent the forces on your diagram.

8. Temperature

- (a) Convert the following Celsius temperatures to Fahrenheit and Kelvin: -20°C , 10°C , 40°C . Show your work for full credit.
- (b) Draw a diagram to illustrate the vertical change in temperature away from the Earth's surface. Label each of the layers.
- (c) Explain why the temperature changes the way it does in the troposphere. Include what the main source of heating is for this layer.
- (d) Repeat part c. for the stratosphere.
- (e) What thermal layer of the atmosphere do we live in? What is the top of this layer called? Why does the height of this layer vary?
- (f) At the top of the atmosphere is a layer called the thermosphere. It has extremely high temperatures, but a person exposed to the thermosphere would rapidly freeze. Explain the apparent contradiction in terms of what you know about heat and temperature.

9. Simulations for gas properties. Go to the following website and answer the following questions: <http://phet.colorado.edu/en/simulation/gas-properties>

- (a) What 4 things can you do to increase pressure in the simulation?
- (b) What happens to the density of the gas when you turn gravity on? Based on this, what would happen to our atmosphere if we turned off earth's gravity? (Hint, turn up gravity, and observe what happens when you turn it back to zero).
- (c) Suppose you restart the simulation and you add both heavy and light species. Now turn on gravity. Do the light species act the same as the heavy species? Explain. How is this relevant to our atmosphere?