Assignment III, PHYS 459 (Cloud and Precipitation Physics)
Fall 2019 Due Tuesday, September 10th, 2019 at Beginning of Class

1. Assume that 1% of all molecules in the Earth's atmosphere are water, and recall our estimate (from HW2) of how many molecules are in the Earth's atmosphere.

   a) If all that atmospheric water vapor was deposited in liquid form on the Earth's surface, what would be the depth of the resulting water layer above the current surface? (Assume you deposit it on land and water in equal proportion to the surface area of the Earth that is land and water and don't worry about surface orography; for sake of this problem assume Earth is a perfectly smooth sphere).

   b) If the (mass weighted) average raindrop has a 1.5 mm diameter, how many total drops would have to fall in each square meter of the surface to reach the depth computed in part (a)?

   c) Assume that the Earth has a surface temperature of 15 Celcius everywhere (close to the global average). What would be the globally averaged relative humidity if 1% of all molecules in the Earth's atmosphere are water?

   d) Repeat the calculation in part (c) except assume that 2% of all molecules in the Earth's atmosphere are water.

2. Water molecules are about 18 grams per mole, or have a molecular weight of nominally 3×10^{-26} kg. Air has a molecular mass of about 30 grams per mole, meaning that the average air molecule has a mass of nominally 5×10^{-26} kg. Thus, your average water molecule is lighter than your average air molecule. That being said, most people will argue that humid air "feels" heavy. Comment on this. Are people wrong? How can one scientifically make sense of this feeling?

3. What is larger, dew point temperature or frost point temperature? Explain.

4. In class, I stated that it is estimated that $10^{18} - 10^{20}$ bubbles burst each second on the Earth's oceans. Assume that the bubble burst rate is constant in space and time and consistent with 10^{20} bursts total each second on the surface of all Earth's oceans. Choose some point P on the surface of the ocean and some time origin $t_\circ$. On average, how long would you have to wait until a bubble would burst within 1 meter of P? Clearly state your assumptions and reasoning.

5. Same as the above question, but assume there are only 10^{18} bursts total each second on the surface of all Earth's oceans, and find how long you would have to wait (on average) until a bubble would burst within 1 millimeter of P.

6. It seems odd that we only have the global bubble-burst rate known to within a factor of 100; given your results to the above two problems, it seems like a relatively simple experiment (count bubble burst rates in a specified area in a bunch of different locations at a bunch of different times) could nail down that value much more precisely. Why isn't it as easy as I'm making it out to be?