Introduction to Weather
Moisture in the Air – Vapor Pressure and Dew Point

No study of weather would be complete without a discussion of precipitation. Here in Seattle it seems like it can rain for days on end. Where does all that water come from? What makes it rain? (And how can we make it stop!) You’re out of luck if you want an answer to that last question, but understanding why it rains is not all that difficult.

When we talk about moisture in the atmosphere we are talking about the presence of water molecules. The water may be present as a solid (snow or ice) as a liquid (rain) or as a gas. When water is in its gaseous state, we don’t detect its presence. The properties that we associate with water (ex. wetness) are only noticeable when water is a liquid. So how can we be sure that there is actually water present in the atmosphere?

➢ Think of all the “evidence” you have for the fact that there is water vapor in the air. You should be thinking of physical evidence or observations – not something like “because I read it in the paper”. List as many as you can in the space below.

This is a photo of Castle Geyser in Yellowstone National Park. Is the column of “steam” above the geyser water vapor?
Well, yes and no. There is probably some water vapor there, but we cannot see water vapor in the air. We can only see it when it is in a liquid or solid state! So, what are we seeing? The vapor in the air above the geyser is turning into droplets of liquid water and that why we see the column of water vapor.

Here are a few important ideas about water vapor in the atmosphere

- There is water present in the atmosphere, even though we can’t see it or feel it.
- We only “notice” water when it is in the liquid or solid state.

**What determines the amount of water vapor in the air?**

You've probably observed that some days feel wetter than others. If you have curly hair, you might have noticed that your hair is curlier on "wetter" days. As you’ll see later, this perception actually has more to do with the relative humidity than with the total amount of water in the air, but the two are related.

The amount of water in the air varies from day to day and is affected primarily by the temperature. When it gets hotter, there is more water vapor in the air. Why is that? We will talk about this idea as a whole class.

A good way to see the relationship between vapor pressure and temperature is to look at the relationship graphically. The table below shows the vapor pressure of water at a series of temperatures. These vapor pressures represent the maximum amount of water vapor that can be present in the air at a given temperature. Use the graph paper on the next page to prepare a graph of vapor pressure as a function of temperature, then use your graph to answer the questions which follow.

<table>
<thead>
<tr>
<th>Temp (°C)</th>
<th>Vapor Pressure (mbar)</th>
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<tbody>
<tr>
<td>5</td>
<td>8.7</td>
</tr>
<tr>
<td>10</td>
<td>12.3</td>
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<td>15</td>
<td>17.0</td>
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<td>20</td>
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<td>30</td>
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<td>73.8</td>
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<td>50</td>
<td>123.3</td>
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<td>80</td>
<td>473.4</td>
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1. Imagine a sample of air at 50 °C in which the vapor pressure of water is 40 mbar. Mark this point on the graph with the letter A. Is the air above or below its capacity for water vapor at this point? Explain your reasoning.

2. Now imagine that the sample of air cools down to 20 °C. Draw a line on your graph to represent this cooling, marking the final point with the letter B. Is the air above or below its capacity for water vapor at this point? What, if anything, will happen to the sample of air as it cools?
Vapor Pressure and Relative Humidity
An important concept from the above discussion is that warmer air contains more moisture than colder air. Does this mean that warm air is always more humid than cold air? What exactly is meant by the term humidity?

When we hear the term humidity in a weather forecast, it is the relative humidity. Relative humidity refers to the amount of water present in the air relative to the maximum amount that could be present at that temperature. Here's an example.

Imagine a sample of air at 40 °C. If you refer to your graph or data table, you will see that the maximum vapor pressure at this temperature is about 74 mbar. (Don’t just take my word for it - go check for yourself!). Suppose, however, that the measured vapor pressure was only 30 mbar. Even though the air can contain up to 74 mbar of water vapor, only 30 mbar is actually present. We use the following formula to calculate the relative humidity.

\[
\text{Relative Humidity} = \frac{\text{measured vapor pressure}}{\text{maximum possible vapor pressure}} \times 100
\]

In the example above, the relative humidity is:

\[
r.h. = \frac{30}{74} \times 100 = 40.5\%
\]

Now consider another sample of air. This sample of air has a measured vapor pressure of 25 mbar and is at 25 °C.

- This second sample of air contains less total moisture than the first sample (25 mbar compared to 30 mbar). Does that mean that it is less humid? Explain your thinking.

- Calculate the relative humidity for this second sample of air. Show your work below. You will need to use the data table or graph.

In the second case, the relative humidity is higher, even though the amount of moisture in the air is actually less. That's because in the second case, the air was closer to its maximum "capacity". Our perception of dampness is related more to the relative humidity than to the actual amount of water vapor in the air. Thus, even though warm air might contain more water vapor than cold air, cool days can often be more humid than warm days.
Here are a few more problems for practice.

- If the measured vapor pressure in Auburn is 15 mbar and it is 20 $^\circ$C, what is the relative humidity?

- If you have a forced air furnace in your dwelling, the furnace probably pulls cold air in from outside. Imagine that your furnace pulls air that is 60% in humidity at 5 $^\circ$C and heats that same air to 25 $^\circ$C. What is the relative humidity of the air in your house? (Assume that the amount of water vapor (grams of water vapor per cubic meter of air) in the air stays the same through the heating process).

**Dew Point**
The dew point is another measure of the humidity of the air. The dew point is the temperature at which moisture will begin to condense from the atmosphere. You may notice that during late summer and early fall, there is dew on the ground when you wake up in the morning. This happens because cool air has a lower capacity for moisture than warm air. As the air cools down overnight, some of the moisture in the air condenses.

- Imagine a sample of air at 30 $^\circ$C and 57% relative humidity. Find this point on your graph and mark it with an X. Imagine that the sample of air cools. At what temperature will the moisture in the air begin to condense? Use your graph to find the answer. Explain your thinking.

We can do a quick experiment to measure the dew point of the air in the room today. Gather the following equipment before beginning.

**Equipment**
A can 1/2 to 2/3 full with room temperature water
A thermometer
A cup full of ice
Procedure
Make sure that the outside of the can is dry before beginning. Put the thermometer in the can and note the temperature. Begin adding ice to the can a few cubes at a time. Use the thermometer to stir, and monitor the temperature of the water. Watch the outside of the can carefully. The air immediately surrounding the can will cool down as the can cools down. At some point, the air will cool to its dew point, and drops of water will begin to form on the can. Record this temperature. Summarize your results in the space below.

➢ From the results of your experiment, you should be able to make a rough estimate of the relative humidity in the room today. Ask an instructor if you need help with this part.

➢ Let’s use another example to test our understanding of the dew point concept. Where is there more moisture in the air?

   a) at Snoqualmie Pass in the winter (temperature 1 °C; dew point 2 °C) or
   b) at Hanford in the summer (eastern Washington) (temperature 35 °C, dew point 8 °C)

   Explain your logic.

When you reach this point, find a computer in SMT 233 or in ST 21 and go to the following web site:

http://www.pals.iastate.edu/simulations/Mtnsim/

This simulation will help you understand why the western slopes of the Cascade Mountains are wetter than the eastern slopes. Do as many of the questions on the page as possible given the time we have. Answer those questions on your paper. Let us know when you have questions.