MOISTURE

The mixture of water vapor with the permanent gases of the atmosphere has occasioned a number of "Humidity Problems" over which the student is in danger of becoming more or less confused.

W. J. Humphreys
in "Physics of the Air"

Introduction

The amount of gaseous water vapor in the atmosphere varies from nearly zero to as much as four percent. This extreme variability is due to the fact that water can exist as a solid, a liquid or a gas at the temperatures normally found on our planet.

Meteorologists are interested in the amount of water vapor present in the atmosphere for several reasons: (1) the condensation of water vapor produces precipitation and (2) the release of *latent heat* during condensation and freezing of water is an important source of energy while the absorption and release of *radiation* by water vapor affects the earth's energy budget.

Moisture

The words "moist" and "moisture" most likely conjure up in your mind various degrees of wetness. Clearly, when speaking of atmospheric moisture something more precise and meaningful is needed other than phrases such as "slightly moist" or "moist" or even "dripping wet." Obviously, the problem is one of definition since all the possibilities of "moist" have different meanings to different people. But how can something as nebulous as "moisture" be quantified and described? Should it be measured with a ruler as, say, 2.7 inches or 0.89 cm? Or could it be weighed somehow to reveal data such as 14 gms, 22 gms, etc? Perhaps it could be thought of as an invisible force, in the same manner as air, and speak of how much of it is pressing down on your head at any given time?

The answer to these above questions is, oddly enough, "Yes, all of these can be used to measure and describe atmospheric moisture." But before we go into the details, let's review some material on molecular processes.

Water can exist in three states: solid, liquid, and gas. The gaseous state is invisible, as is air, and usually mixes readily with air. This invisible moisture will be referred to as water vapor. At any given temperature only a certain amount of water vapor can be present, the amount being dependent on the temperature. (The higher the temperature, the more water vapor can be present.) The liquid state of water in the atmosphere is commonly thought of as rain (when the water drops are large) and fog (when the water drops are small) and the solid state as snow and ice.

The processes that occur when water changes state are summarized in figure 2–1.

Molecular Motion

The temperature of a substance is proportional to the mean (average) kinetic energy (energy of motion) of the molecules that comprise the substance. For example, in a thermometer, an increase in

To: \ From:	Liquid	Solid	Gas
Liquid	* *	Melting	Condensation
Solid	Freezing	* *	Sublimation
Gas	Evaporation	Sublimation	* *

Figure 2–1

temperature causes the molecules that comprise the fluid to move faster. As a result, the fluid expands which can be seen by watching the rise of the fluid in the tube. Likewise, when there is a decrease in temperature, the fluid shrinks as the molecules within the fluid move more slowly.

Now, consider a container of water. The water has a certain temperature based on the motion of the water molecules. That is, there are fast moving molecules and slow moving molecules with the temperature based on the average motion of all the molecules. Since the molecules are constantly moving, there is no reason to believe that they must all stay in the container. It would seem reasonable to believe that the faster moving molecules could leave since they have the greatest energy and can therefore break away from the rest. But, if a fast moving molecule leaves, what happens to the mean molecular motion? It must decrease and therefore the temperature must decrease.

As an analogy to the above, consider ten cars moving on a freeway. Five cars move at 60 mph and five move at 40 mph. The mean speed is then $((5 \times 60) + (5 \times 40)) \div 10 = 50$ mph. Approaching an exit ramp, one of the cars moving at 60 mph darts off the freeway. Now the mean speed is $((4 \times 60) + (5 \times 40)) \div 9 = 48.8$ mph.

But what if the car that left immediately returned to the freeway on the next entrance ramp so that once again there are ten cars, 5 at 60 mph and 5 at 40 mph? Obviously in this situation the mean speed of the cars will remain 50 mph (except for the brief period when the car was off the road). If in the container of water, for each molecule that leaves one molecule returns, the mean molecular motion will not change, and therefore, neither will the temperature of the water. Obviously, in this instance, the water level will not change since there is no net departure of water molecules. This condition where the same number of molecules are reentering as are leaving is known as the equilibrium state.

However, what would happen if we heated the water? Molecules of water would escape rapidly because they gain energy. Therefore, if molecules are leaving, the water must be cooling. But how can cooling occur if we are heating the water?

Suppose we take the container of water, put a thermometer in it, seal it in an airtight box and apply heat so that the water begins to boil. The molecules of water will begin to escape very rapidly from the water into the open air inside the box. However, because the box is sealed, these molecules will also begin to warm. The temperature inside the box, then, can increase greatly as we apply more heat to the box. (This continued heating occurs *so long as the box is sealed.*)

Let's digress for a moment and see why it is so important to keep the box sealed. As an analogy, suppose you hiked up a high mountain. You come to your campsite, put a pot of water on to boil, and plan to wait five or six minutes before it's ready. Surprisingly, however, after only two or three minutes your pot of water is boiling, and ready to be poured. Why? Atmospheric pressure decreases with increasing altitude. The pressure, then, on top of the mountain is less than sea level pressure. This pressure decrease is the reason why the water boiled so rapidly (that is, at a lower temperature than if you were

at sea level). Actually, if you were up as high as 473 mb (about 20,000 ft), the water would boil at 176°F rather than at 212°F which is the boiling point at 1,013 mb (average sea level pressure), at 23 mb it would boil at room temperature (about 68°F) and at 6 mb, 32°F would be the boiling point.

Conversely, if you *increased* the atmospheric pressure water would boil at a much *higher* temperature: at 1,986 mb the boiling point is 248°F; at 6,171 mb water will boil at 320°F.

This brings us to the reason why the box must be sealed. By sealing off the box from the outside atmosphere and then applying heat, the pressure inside the box can increase far above the normal sea level pressure. This increase in pressure will allow the water to boil at higher and higher temperatures rather than 212°F.

Now let's take away the box. Water molecules are now rocketing out of the water into the free air. We look at the thermometer in the water and amazingly we see that the temperature has dropped to 212°F (100°C) and it will not budge above that point even though we have a fire roaring under the container. Clearly, cooling must be occurring in the water to prevent its temperature from rising further. In fact, with each additional amount of heat that is added to the water (in excess of the heat needed to bring the water to the boiling point) a certain amount of molecules escape the water causing it to cool. (This is something like pouring water into a glass with no bottom.) This excess heat, the heat that goes into transforming the liquid to a vapor (the molecules from being *in* the water to *outside* the water) is known as the *Latent Heat of Vaporization.*

Air does not hold water vapor in the same way that a sponge holds liquid water. In fact, the same number of water molecules would be present above a liquid water surface if there were no other gas molecules there at all. The amount of water present in the gaseous state depends on the energy of the molecules in the liquid. In other words, the higher the temperature, the more energetic the molecules and the faster the rate at which they leave the liquid.

The number of molecules falling back into the liquid is proportional to the number of molecules present in the gaseous state. When the number of molecules entering the liquid is equal to the number leaving, we say the system is saturated, and the pressure of the water molecules in the space above the liquid water is called the saturation vapor pressure.

Problem 2–1

Discuss, in terms of molecular movement, why you feel chilled when coming out of a pool on a sunny, dry day (or even stepping out of your shower).

Can the latent heat of evaporation be recovered? Suppose we return to our sealed container of water and attach a pipe to it which allows the steam to flow to another chamber (see figure 2–2). We allow cold water to flow past the chamber, thus cooling the inside. Looking inside the chamber, we see that the steam flowing into it does not remain steam for very long. Rather, water is collecting in the bottom of the chamber. We are, therefore, reversing the original process. If two thermometers are immersed in the water, one on each side of the box, we see that the water that has flowed past the chamber (T_2 in the picture) is warmer than the water that has not yet flowed past the chamber (T_1).

How can the water become warm if the box is being cooled? Because when the vapor returns to the liquid state (condensation) the same quantity of heat that went into evaporating the drops (in the first process) is returned to the system. This heat is known as the *Latent Heat of Condensation.*

Let's use the results from the above experiment and apply them to the atmosphere. You have no doubt experienced the refreshing coolness of the air after a summer rain shower. As the rain falls through the air, which, let us assume, is "unsaturated" (which means the actual vapor pressure is less than the

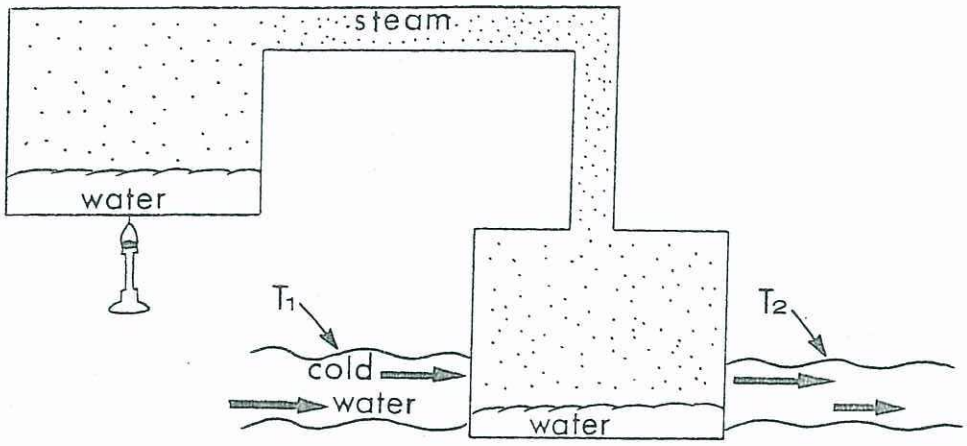


Figure 2–2

saturation vapor pressure) each individual rain drop acts as a container of water. Rather than receiving heat from a fire, the rain drop receives heat from the surrounding atmosphere. Cooling, then, occurs because the droplet evaporates and cools (due to the fact that it is losing faster moving molecules). It then passes this cooling on to the surrounding environment through a process known as conduction.

When condensation takes place, the moisture in the air is cooled not by a flowing stream of cold water, but by the cold air itself; and at the moment the vapor is transformed into a droplet, a quantity of heat is returned to the environment.

An example of the importance of this latent heat of condensation can be seen in the hurricane. As these storms, which are born over oceans, draw large quantities of moist air into them, the air cools and condenses. The latent heat of condensation that is released is a form of energy and it is this energy that drives the hurricane to destructive force.

Warm Air Vapor Pressure versus Cold Air Vapor Pressure

Suppose we again return to our box with the container of water in it. Attached to the box is a device for measuring the pressure exerted by the water vapor in the box. (All gases exert a pressure. That pressure exerted by water vapor is known as the vapor pressure.) The higher the reading on the vapor pressure meter, the more vapor there is in the box.

Initially, we take a vapor pressure reading and then apply heat to the water. Now we see that the vapor pressure reading has increased. While we continue to heat the water, the air in the box is also warming and the vapor pressure is continually rising. That is, the air inside the box contains more and more water vapor. What can you conclude from this experiment? Simply, that more water vapor can be present in warm air than cold air.

Problem 2–2

You have just moved into a new house and find that the previous owners left behind a humidifier and a dehumidifier. Which would you use in summer? Why? Which would you use in winter? Why? Would you ever use them both at the same time? Why or why not?

Moisture Variables

All of the variables used to quantify the amount of moisture in the atmosphere can be divided into two classes: (1) Those variables which depend *only* on the amount of water vapor in the air, and (2) those variables which depend not only on the amount of water vapor in the air, but also on the temperature of the air. The members of the first group are known as absolute measures and those of the second group are known as relative measures ("relative" measuring meaning "related" to temperature). No special order of presentation will be made as to absolute or relative measures.

Vapor Pressure (e) and Saturation Vapor Pressure (e_s)

The total atmospheric pressure at any time is actually the sum of many small pressures for each of the constituents of the earth's atmosphere contributes a pressure to that of the total atmospheric pressure. For example, there is a pressure exerted by oxygen, a pressure exerted by hydrogen, nitrogen, and all of the other gases which make up the air we breathe. The contribution to the total atmospheric pressure which is made by water vapor is known as the vapor pressure. Since the vapor pressure only changes when the amount of water vapor in the air changes, e is an absolute measure of the air's vapor content.

There is, however, a limit as to how much of the total pressure can be made up by water vapor. This limit is known as the saturation vapor pressure and it is defined to be the maximum pressure that water vapor can exert at any given temperature.

E_s is a relative measure of atmospheric moisture since temperature plays a direct role. As in the case of the dew point, when the temperature increases, the atmosphere allows more water vapor to be present, but the water vapor may or may not take advantage of the situation.

Dew Point (T_d)

Perhaps the most widely used measure of atmospheric moisture in meteorology is the dew point. The dew point is defined as the temperature, expressed in degrees centigrade or Fahrenheit, at which the moisture in the atmosphere will condense when cooled at constant pressure. As an example, think of what happens when you pour a cold drink into a glass. Before pouring, the outside of the glass is dry; but, moments after you pour, the glass becomes wet. What happened? The air around the glass had a certain amount of water vapor. When the cold drink was poured into the glass the air around the glass immediately began to cool and, when the air was cooled to the dew point, moisture began to condense onto the nearest object: the glass. (This is another important point: for condensation to occur, the water vapor in the air must have something to condense "onto.") Now, using these ideas and those presented in the temperature exercise, can you think of the events that take place in order for clouds to form?

Since warm air has a higher saturation vapor pressure than cold air, one would expect to see dew points, on the average, higher in summer than in winter. Though the temperature of the air is a limiting value as to how high the dew point can go, (that is, once the temperature equals the dew point condensation occurs), the temperature of the air does not directly affect the dew point. In other words, if the temperature of the air changes, the dew point does not have to change (the air's saturation vapor pressure changes, but the dew point can stay the same). However, if the amount of moisture present changes, then the dew point has to change. The dew point, then, is a measure of the absolute water vapor present in the volume of air.

Mixing Ratio (w) and Saturation Mixing Ratio (w_s)

Let us say that it is possible to extract a small quantity of the atmosphere and weigh it on a scale. This portion of the atmosphere is just a representative sample of the entire atmosphere and, therefore, we should expect it to be made up of the usual atmospheric gases, including water vapor. The mixing ratio is defined to be the weight (actually mass) of water vapor (M_v) in the sample divided by the weight

(mass) of dry air (M_d)in the sample: $w = \frac{M_v}{M_d}$. Note that the temperature does not appear in the equation. Therefore, since the mixing ratio does not depend on temperature, it is an absolute measure of the moisture in the atmosphere.

Again, there is a limit as to how much water vapor can be present in the volume of air. When discussing vapor pressure, this limit is known as the saturation vapor pressure. With mixing ratio, this limit is known as the saturation mixing ratio and it is directly related to temperature. It is defined to be the maximum amount of water vapor (in grams) that can be present in one kilogram of dry air at any given temperature. It is also defined to be the mixing ratio the air sample would have if it were saturated. Therefore, when the air is saturated, $w = w_s$. These mixing ratios are usually expressed inparts per thousand. $\frac{4 \text{ gms}}{1 \text{ kg}}$ (4 grams of water vapor to 1,000 grams of dry air) is a typical value for dry air while $\frac{30 \text{ gms}}{\text{kg}}$ to $\frac{40 \text{ gms}}{\text{kg}}$ are about the maximum value for very moist air.

Relative Humidity (RH)

The most common measure of atmospheric moisture used by the general public is relative humidity. No new concepts need be introduced since relative humidity is just the ratio of several of the variables already discussed.

Relative humidity can be defined as:

$$RH = \frac{\text{Amount of water vapor present}}{\text{Maximum amount of water vapor at the current temperature}}$$

That is, $RH = \frac{w}{w_s} \times 100$

Relative humidity can also be measured in terms of pressure:

$$RH = \frac{\text{The contribution made by water vapor to the total atmospheric pressure}}{\text{The maximum pressure that water vapor can exert at the current temperature}}$$

That is, $RH = \frac{e}{e_s} \times 100$

Both ratios are multiplied by 100 in order to allow RH to be expressed in "percent."

Relative humidity is the most common variable used to express atmospheric moisture (at least to the general public) and though it is not an inaccurate measure of moisture, it is not the most accurate. This is because relative humidity is a relative measure of moisture which means, again, that it is dependent on the air temperature. (Note the denominators of the above two equations are both dependent on temperature.)

As an example of the less desirable characteristics of RH, consider the second equation (though the first will do). Let us say that a particular air mass remains over an area for twenty-four hours. Therefore, the vapor pressure does not change for this period of time since the amount of moisture associated with this air mass does not change. Let us say that it is also an ordinary day, being warmer during the daylight hours than at night. Since warm air has a higher saturation vapor pressure than cold air, e_s will be higher during the day than at night. Since the denominator of the equation is greater during the day, RH is lower during the day than at night when the air cools and the denominator is smaller. If you did not know this fact, you might compare the relative humidity for day and night and conclude that the air is more moist at night. Actually, the absolute moisture content of the air has not changed, rather it is the decrease in temperature that caused the increase in the relative humidity.

Precipitable Water (W)

Precipitable water is the amount of liquid water that would result if all the water vapor in the atmosphere over a given area were to suddenly condense and fall out. This is analogous to squeezing a

wet sponge and having the liquid water fall out. Here, the liquid water is the water vapor in the atmosphere and the squeezing action is the condensing process.

Dew Point Depression ($T - T_d$) and Wet Bulb Depression ($T - T_w$)

Two other relative measures of the atmosphere's moisture content are the dew point depression $T - T_d$ and wet bulb depression $T - T_w$. This last will be explained later, but for now both are simply measures of the air's closeness to saturation. That is, large depressions indicate that the air is relatively (related to T) dry, small depressions indicate that the air is relatively moist and if $T - T_d$ or $T - T_w$ equal zero, the air is saturated.

Problem 2–3

Would you expect the relative humidity to be greater in the morning or afternoon? Explain. (Assume the air's absolute moisture content does not change.)

Problem 2–4

"Warm air always has a higher vapor pressure than cold air." Discuss the validity of this statement.

Problem 2–5

You take a hot shower and your bathroom fills up with steam. Does w increase or decrease? w_s? What about dew point depression?

Instrumentation

There are several instruments in common use for measuring atmospheric moisture.

Hair Hygrometer

This is the type of humidity instrument most often sold in gift shops grouped with barometers and thermometers. It is based on the fact that hair changes length according to the amount of moisture in the air and it is constructed simply by attaching a hair to a pointer and calibrating the pointer to a dial graduated in percentage of relative humidity. Then, as the air's moisture content changes, the hair changes length and the change in RH shows up on the dial. Hair hygrometers are not the most accurate instruments to measure relative humidity.

Dew Point Hygrometer

The dew point hygrometer makes use of physical principles in a more realistic manner than the hair hygrometer. The basis for its use is the latent heat of evaporation and the result that can be gained from it is the dew point. An example of a dew point hygrometer is shown in figure 2–3.

A liquid that evaporates easily (such as ether) is placed into the chamber and air is slowly pumped through the chamber to promote evaporation. As the liquid evaporates, the temperature decreases as can be seen on the thermometer. The mirrored surface is attached to the outside of the chamber. Now as the chamber cools, the mirror will cool by conduction which will then cool the air in front of the mirror. The cooling is continued until a fog forms on the mirror (condensation). At this point, the temperature is read and this temperature (by definition) is the dew point temperature. If done carefully, this yields good results, but obviously, the instrument is quite cumbersome.

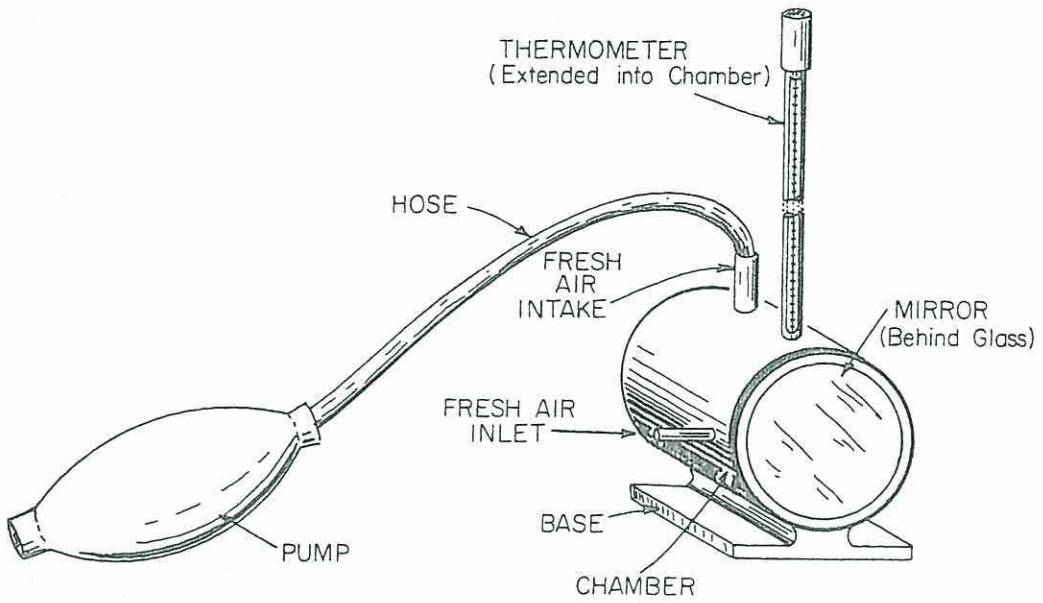


Figure 2–3. A dew point hygrometer.

Sling Psychrometer

The sling psychrometer is the most accurate of all the atmospheric moisture measuring instruments. It consists of two thermometers mounted side by side on a metal plaque. A handle is attached to enable the user to swing the instrument. One thermometer has a piece of clean cloth wrapped around the bulb. This bulb is known as the wet bulb. The other thermometer is the dry bulb. To use, dip the cloth in clean (preferably distilled) water. Swing the instrument in a circle for a minute or two. (This will cause evaporation and cooling, with the rate of cooling dependent on how much water vapor is present. The resulting temperature is known as T_w — the wet bulb temperature). Read T_w. Continue the process three or four times until two T_w readings are nearly equal. Note the dry bulb temperature (which is just the air temperature — T). From these two values, T and T_w, and tables, the RH and dew point can be ascertained. By using the equation $e = e_s^* - .35\frac{mb}{°F}(T - T_w)$ the vapor pressure can also be calculated (e_s^* is the saturation vapor pressure at the *wet bulb* temperature). In this equation, both T and T_w must be read in °F.

The sling psychrometer is bulky and requires tables; but, it is relatively easy to use and relies solely on basic physical principles and simple instruments thereby making it extremely accurate. Note that in the quantity $T - T_w$ is the wet bulb depression.

The Station Model

Introduced now is an extremely useful device used in one form or another on all weather maps. This is the station model which allows a great amount of meteorological information to be plotted on maps in a concise manner and a limited amount of space. Temperature, moisture, wind, pressure, sky cover, weather and precipitation data are contained on the model. All are presented in a specific form and a specific location which *must never be violated.*

The bare form of the station model is a circle. The data listed above are then plotted around, in or on the circle. Temperature and moisture, the two meteorological variables thus far discussed, are plotted on the model as shown below.

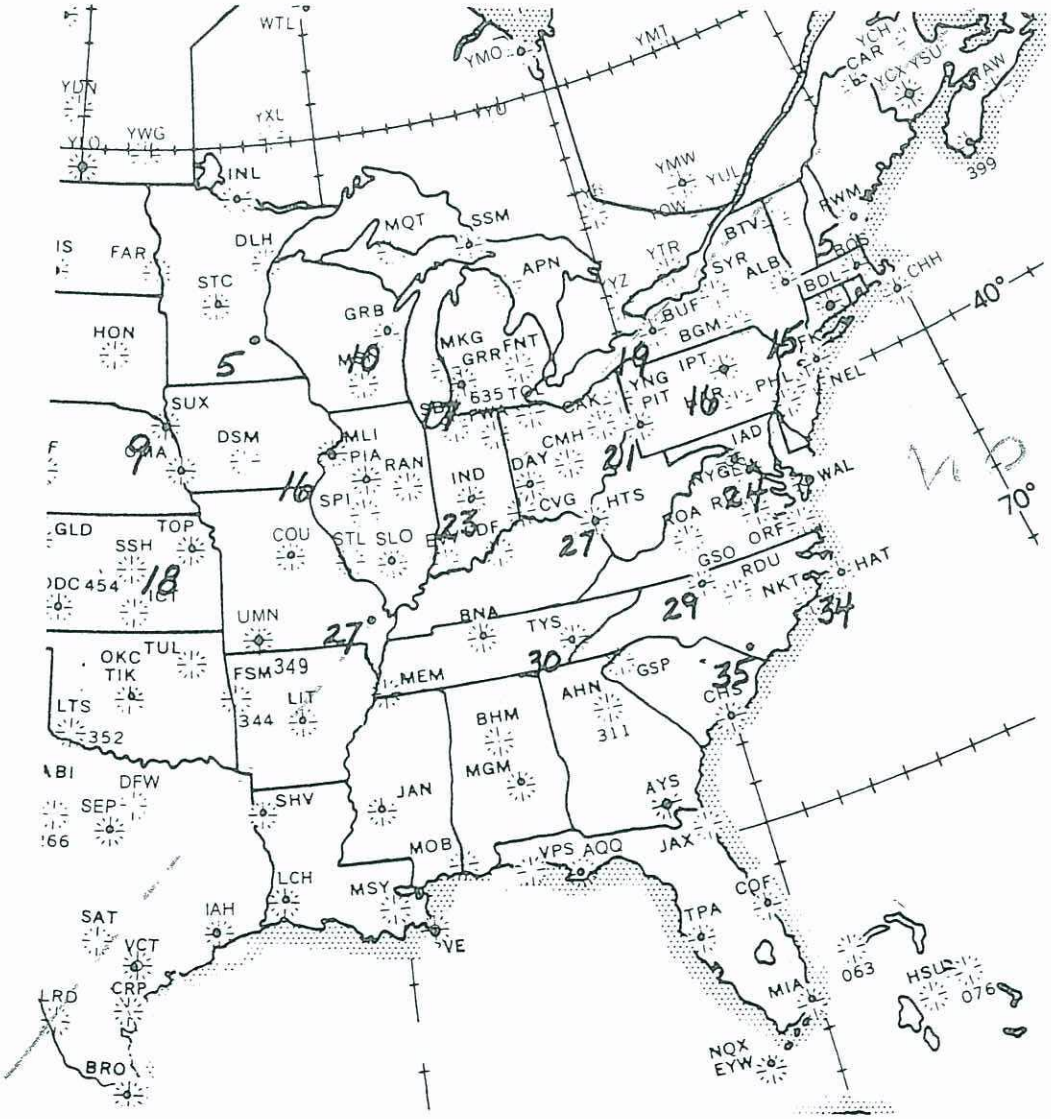
Here, 52 is the air temperature in degrees Fahrenheit and 47 is the dew point temperature, also in degrees Fahrenheit. Note that the degree symbols (°) are *not* included. (If you look back to the numerical field presented in the first lab, you will see that this is the manner in which the air temperature has been presented.)

On surface maps the air temperature and dew point temperature are in degrees Fahrenheit (though in the future temperatures may be plotted in degrees Celsius). On upper air maps, the air temperature is in degrees Celsius and, rather than the dew point temperature being plotted, the dew point depression is presented.

In future exercises you will see how the remaining pressure, wind, precipitation, etc., data are included on the model.

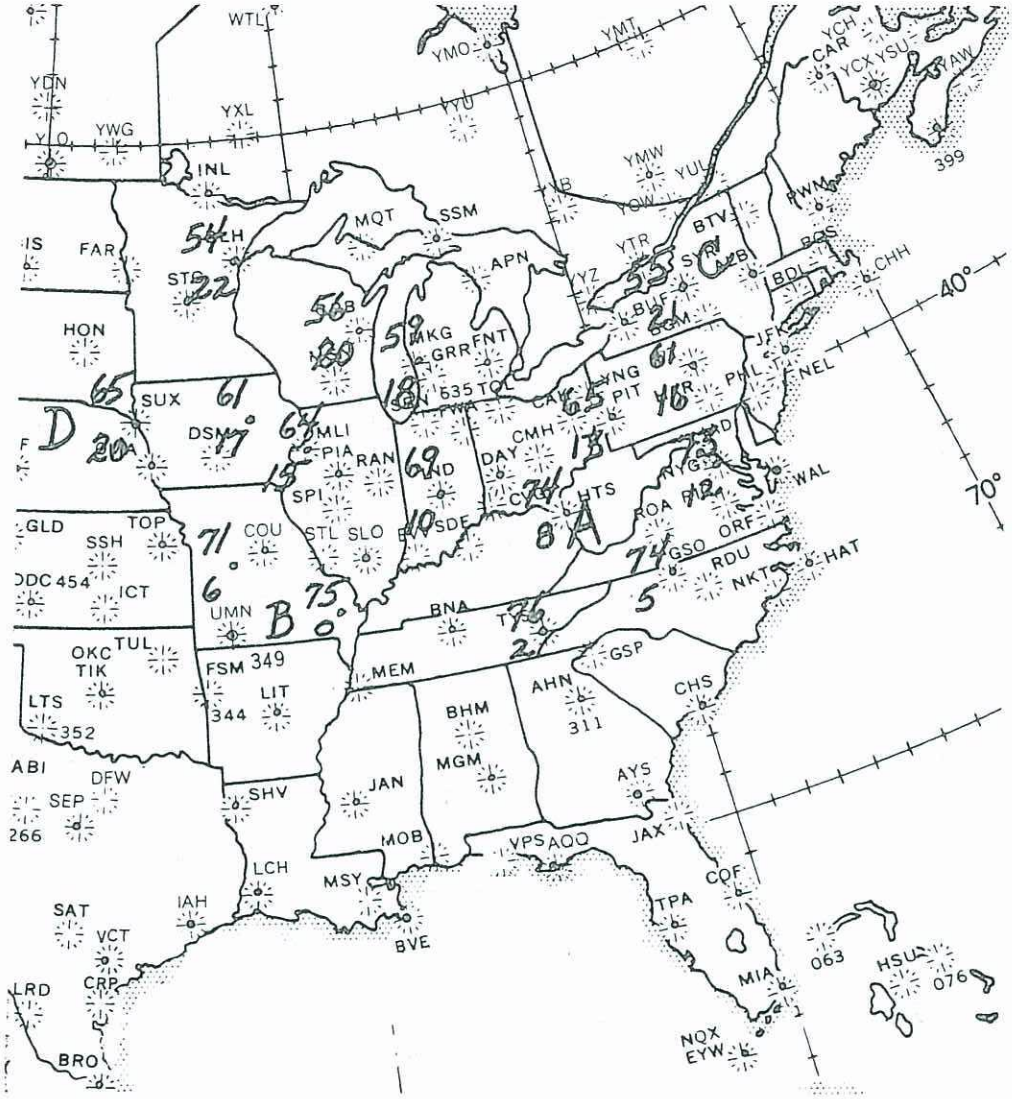
Problem 2–6

Analyze the dew point field below at 5° intervals. (Note that the numbers are on the lower left of the station)



Problem 2–7

Analyze the dew point depression field below at 5° intervals. The lower number in the plotted station model is the dew point depression. What are the dew points at stations A,B,C,D?



Computations

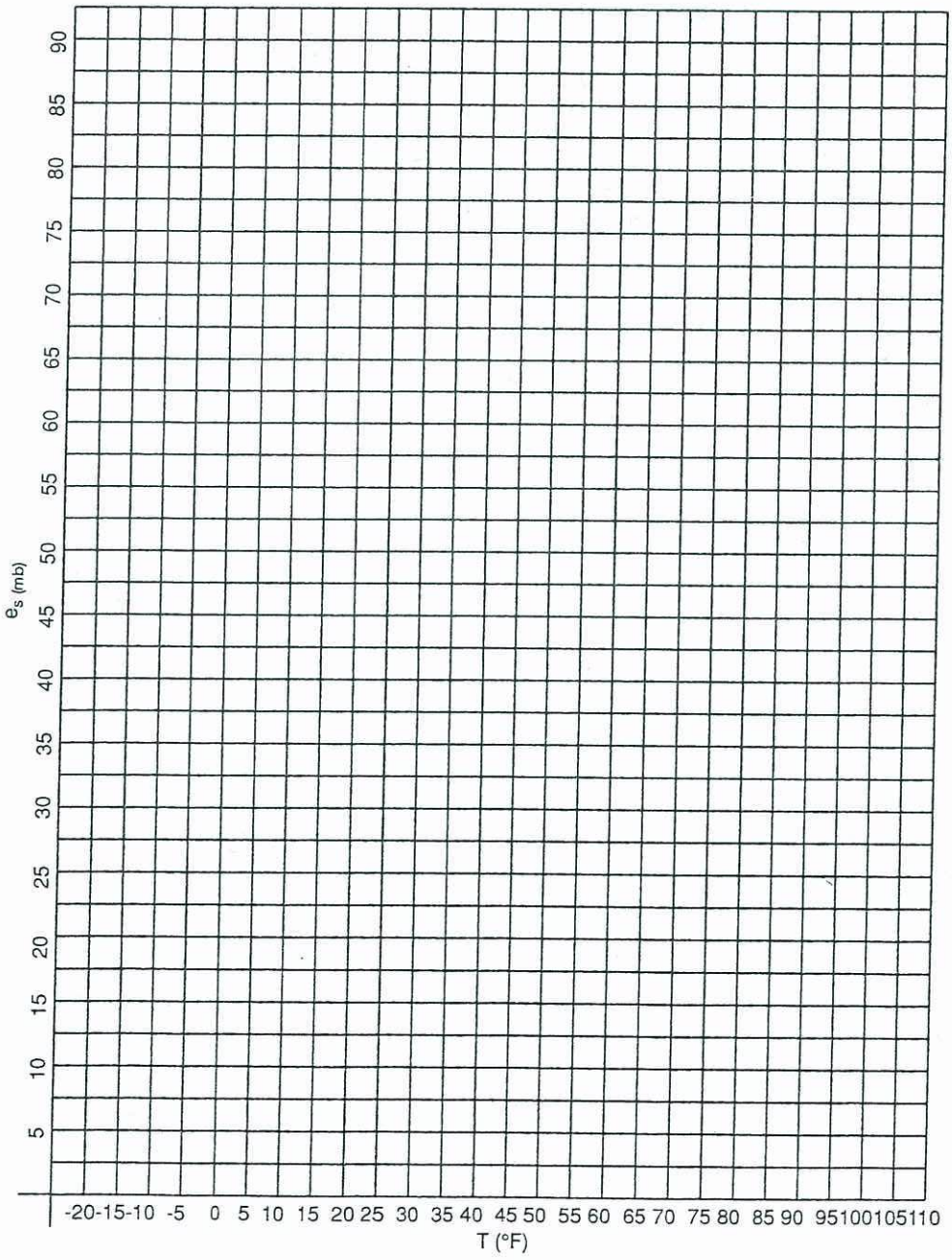
This section is devoted to example calculations to show you how to calculate unknown values of the moisture variables presented in the last section. For some of the calculations, you will need to refer to Table 2–1: "Vapor Pressures Corresponding to Various Temperatures." You may find it useful to think of this table as "The Contributions Made by Water Vapor to the Total Atmospheric Pressure for Various Temperatures." Care must be used here because: (1) If the temperature you have is a dew point temperature, then the corresponding pressure is the vapor pressure; that is, the actual pressure being exerted by water vapor at that moment; (2) If the temperature is the air temperature, then the corresponding pressure is the saturation vapor pressure which is the maximum amount of water vapor that the air can hold at that air temperature. Remember that e_s is dependent on air temperature, nothing more. (3) If the temperature is the wet bulb temperature, then the corresponding pressure is e_s^* the vapor pressure at the wet bulb temperature.

TABLE 2–1
Saturation Vapor Pressures Corresponding to Various Temperatures

°F	mb	°F	mb	°F	mb	°F	mb
−20	.43	15	2.74	45	10.09	80	34.6
−15	.57	20	3.47	50	12.19	85	40.7
−10	.75	25	4.40	55	14.63	90	47.7
− 5	.98	30	5.55	60	17.51	95	55.7
0	1.30	32	6.10	65	20.86	100	64.9
5	1.66	35	6.87	70	24.79	105	75.3
10	2.14	40	8.36	75	29.33	110	87.2

Problem 2–8

On the graph paper below plot e_s vs °F



Example 1

Given: $w = 7 \frac{g}{kg}$ and $w_s = 14 \frac{g}{kg}$

Find: RH

Solution: $RH = \frac{w}{w_s} \times 100$

$= \frac{7\ g/kg}{14\ g/kg} \times 100$

$= 0.5 \times 100 = 50\%$

Example 2

Given: $e = 8.36$ mb $e_s = 17.51$ mb

Find: RH, T, T_d

Solutions: $RH = \frac{e}{e_s} \times 100$

$= \frac{8.36\ mb}{17.51\ mb} \times 100$

$= 48\%$

To find T and T_d, simply refer to table 2–1. If $e = 8.36$ mb, the dew point must be 40° F. If $e_s = 17.51$, the air temperature must be 60° F.

Example 3

Given: $T = 80°F$ $T_w = 70°F$

Find: RH, T_d

Solution: Use table 2–1

$T = 80°$ therefore, $e_s = 34.6$ mb

$T_w = 70°$ therefore, $e_s^* = 24.79$ mb

Now, since $RH = \frac{e}{e_s} \times 100$, all you need is e, and

$e = e_s^* - .35\ mb/°F(T - T_w)°F$

$= 24.79\ mb - .35(80 - 70)\ mb$

$= 24.79\ mb - .35(10)\ mb$

$= 24.79\ mb - 3.5\ mb$

$= 21.29\ mb$

$RH = \frac{e}{e_s} \times 100$

$= \frac{21.29\ mb}{34.6\ mb} \times 100$

$= 61.5\%$

To find T_d, use table 2–1. Since $e = 21.29$ mb, $T_d = 66°F$ (or use the graph you created in problem 2–8)

Example 4

Given: RH = 70% e_s = 12.19 mb

Find: T_d

Solution: $RH = \frac{e}{e_s} \times 100$

$.7 = \frac{e}{e_s}$

$(.7)(e_s) = e$

$(.7)(12.19\ mb) = e$

therefore, if e = 8.53 mb, T_d must be 41°F

Example 5

Given: RH = 70% $w_s = 10\ \frac{g}{kg}$

Find: w

Solution: $RH = \frac{w}{w_s} \times 100$

$.7 = \frac{w}{10\ g/kg}$

$(.7)(10\ g/kg) = w$

$7\ \frac{g}{kg}$

Example 6

Given: RH = 50% e = 10.09 mb

Find: T

Solution: $RH = \frac{e}{e_s} \times 100$

$.5 = \frac{10.09\ mb}{e_s}$

$e_s = \frac{10.09\ mb}{.5}$

$= 20.18\ mb$

therefore, if e_s = 20.18 mb, T must be 64°F

Problem 2–9

Show all work and be sure to use proper units throughout.

a. Given: e = 2.74 mb and e_s = 4.40 mb

Find: RH, T_d, T

b. Given: $e_s = 20.86$ mb and $T_d = 50°F$

Find: RH

c. Given: $w = 8 \frac{g}{kg}$ and $RH = 62\%$

Find: w_s

d. Given: $T = 70°F$ and $T_w = 50°F$

Find: T_d, RH

e. Given: $RH = 50\%$ and $e_s = 8.36$ mb

Find: e

Plot: T, T_d on the station model

f. Given: RH = 80% and e = 29.33 mb

Find: T

g. Given: e = 10.09 mb and e_s = 10.09 mb

Find: RH

Problem 2–10

Can T_d ever equal T_w? Why or why not?

Can T_d ever exceed T_w? Why or why not?

Summary

In this exercise you have been introduced to many of the processes that govern the amount of moisture in the atmosphere. The moisture variables discussed are used everyday for weather forecasting.

All of the material discussed here is basic to a good understanding of meteorology. You will see many of these ideas in future exercises, especially in the exercise on "Clouds and Precipitation."