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Wx Watch

Dew Point Review

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The inside story behind saturated air and fog formation

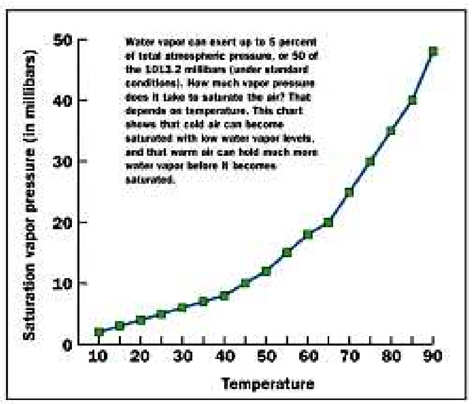
Here's an important pilot weather factoid we all learn: When the temperature-dew point spread is less than 5 degrees Fahrenheit (3 degrees Celsius), expect fog. This rule of thumb is important to remember, but there are other ways of looking at how dew point temperature (better known simply as *dew point*) and other moisture measurements influence aviation weather.

First things first. Warm air can hold more water vapor in suspension than cold air. Why? Think of warmer air as having faster-moving, higher-energy molecules. Now imagine water droplets, like those that make up fog. Increase the air temperature and, all other variables being equal, the droplets evaporate in the high-energy air. That is, water molecules leave the droplets.

Now take that higher-temperature air and cool it. Thanks to the cooler, lower-energy state of the air parcel, any moisture condenses back into a water droplet. The moisture in the air has gone from a liquid state (fog) to a gaseous state (water vapor) and back again. Again, you may ask, why?

There's a limit to how much water vapor can exist in a gaseous, invisible state. Reach that limit, and the air is said to be *saturated.* Add any more water vapor and the result is *super saturation,* then *condensation,* which in large amounts means precipitation — rain, snow, or sleet (ice pellets, IP in METAR code). Now get this: This limit, as you must have guessed by now, is a function of air temperature. You can also think of this limit as the maximum amount of pressure exerted by water vapor; any more pressure from more water vapor and — presto! — condensation, droplets, fog, and clouds. This limit is called *saturation vapor pressure.*

I've plotted the saturation vapor pressures for various temperatures (see the chart below) and just one look tells you why lower temperatures can mean fog trouble. The lower the temperature, the less water vapor is required to saturate the air.



Saturation relates to relative humidity. Most people think relative humidity is a measure of the actual moisture in the air. Not so. Relative humidity is the ratio between the moisture level in the air and the maximum possible moisture capacity (the saturation vapor pressure) of the air at a particular temperature. In other words, it's the ratio between what is and what could be, in moisture-speak. Relative humidity 50 percent? Then the air is only halfway to the saturation point.

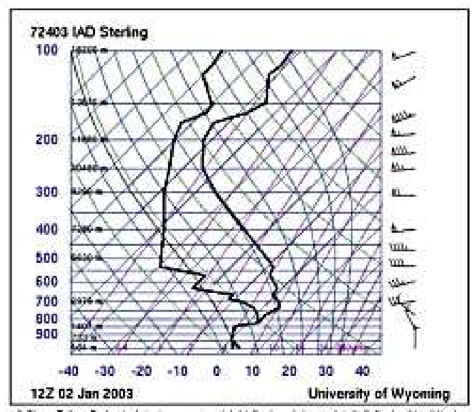
Where does dew point figure in? Unlike relative humidity, dew point *is* a measure of the actual water vapor in the air. This is the temperature to which air must be cooled in order to become saturated, and therefore reach 100-percent relative humidity. At this point, fog or clouds are almost certain to form. As we've seen from the chart, this can be any temperature. But for any given temperature the amount of water vapor needed to saturate the air varies. Low air temperature ? Then it won't take much water vapor to cause saturation. High air temperature ? Then lots more moisture will be needed to create fog or clouds.

These facts lead us to some significant truths, all of them worth bearing in mind as you plan your flights:

Temperatures rise during the day, then fall at night. If nighttime temperatures fall to the dew point, don't be surprised if fog occurs. Once the sun comes up, the temperature-dew point spread widens, relative humidity decreases, fog droplets evaporate, and visibility improves. This process can take several hours.

The higher the dew point, the more moisture in the air. As we move into the warmer months of the year, keep an eye on dew points. Dew points above, say, 60 degrees F (15.5 degrees C) mean that not much cooling is needed to create fog or clouds. Increasing dew point temperatures also can confirm that frontal passages are imminent, as fronts push moisture-laden air masses ahead of them. Conversely, low dew points indicate dry air masses.

High dew points correlate well with the probability and severity of thunderstorms. Once thermals, fronts, and other lifting forces go to work on air masses with high dew points, towering cumulus or cumulonimbus clouds can soon follow. Cooling takes place as moisture-laden air is lifted higher and higher in unstable air masses. Most severe thunderstorms (those with 50-plus-knot surface winds, three-quarter-inch hail, or tornadoes) happen in air masses with dew points above 70 degrees F (21 degrees C).



A Skew T- Log P chart plots temperature (right line) and dew point (left line) with altitude and can be used to locate clouds. At a glance, you can see that clouds top out at the 800-millibar level (just below 5,000 feet msl. That's where the temp-dew point spread widens.

The temperature/water vapor relationship constantly changes. Saturation of an air mass can occur via two mechanisms. Cooling to the dew point is one. Addition of moisture — through frontal activity or flows of humid air — is the other. As temperatures and moisture levels rise and fall, these variables influence each other and cause dew points to fluctuate.

Dew points below 32 degrees F (zero degrees C) indicate a chance of frost. If temperatures drop to these dew point values, you may be in for a lengthy preflight frost-removal exercise.

Dew point values can forecast nighttime low temperatures. Forecasters often use dew point as a quick and dirty indicator of the evening's lowest temperature. That's because temperature cannot be lower than dew point. This rule of thumb works best when there is no surface wind, and works especially well in the warmer months of the year. Another way to anticipate fog is to look at the difference between the air temperature and the soil temperature (soil temperatures are approximately 5 degrees F [3 degrees C] colder than surface temperatures). If the air temperature is 30 degrees F (17 degrees C) warmer than the soil temperature, then fog is likely to occur.

Close temperature-dew point spreads don't always mean fog. There are times when close temperature-dew point spreads do *not* presage a fog-, dew-, or frost-shrouded airport in the morning. Plunging nighttime temperatures often are the result of radiational cooling, the kind associated with high pressure and clear skies. But what if there are cloud layers that prevent low-level heat from escaping? Cloud layers can trap heat near the surface — and maybe even cause temperatures to warm up. This widens the temperature-dew point spread, and prevents the cooling necessary for fog formation. Fog also tends to rely on temperature inversions. That is, situations where the lowest layers of the atmosphere *increase* in temperature with altitude. When no inversion exists, and temperatures decrease with altitude, then low-level air and moisture is free to mix with drier, higher-altitude air. Surface winds higher than five knots or so can do the same thing. A fast check of surface reports and, if you're really interested, atmospheric soundings can give you an idea if the overnight weather is conducive to this kind of false-positive setup. Absent these conditions, however, you can pretty much count on lowered visibilities in fog or mist.