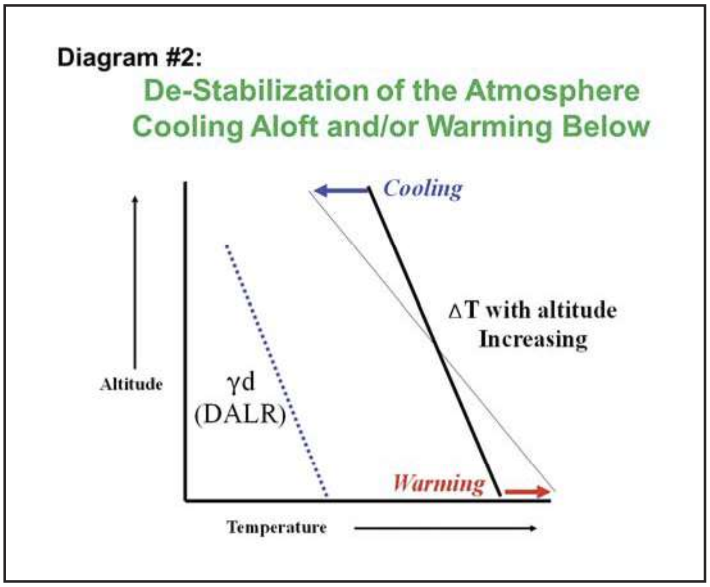

Diagram #2: De-Stabilization of the Atmosphere

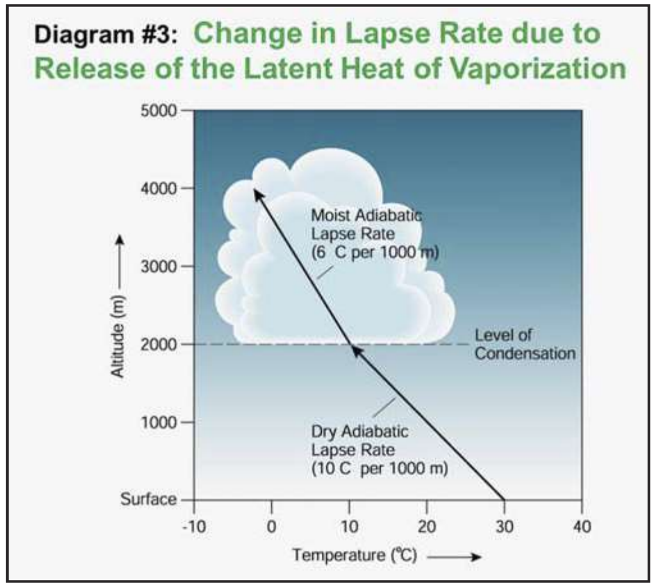

Diagram #3: Change in the Lapse Rate due to the Release of the Latent Heat of Vaporization

at that particular pressure level. At DRT the temperature and dewpoint closed and thus cloud layers were detected by the fast-rising rawinsonde at approximately one kilometer of altitude (3,300 feet mean sea level) and another at approximately four kilometers (13,100 feet mean sea level). In pre-flight weather analysis, the soaring pilot can get an idea of cloud layers that could hinder initial surface heating for purposes of thermal flight from the 'observed' morning temperature and dewpoint temperature plots on the rawinsonde sounding, or forecast cloud layers that could develop during his/her projected flight by looking at the temperature and dewpoints aloft progged by numerical model soundings.

Water present within or on the surface of the ground is detrimental to the rise of the sensible temperature of the surface due to the high specific heat of water (See the August Issue of *"Soaring,"* "*Weather to Fly*"). The presence of standing water, a

Upper Air Sounding Labeled Parameters

Environmental sounding – This bold, red line represents the actual measured temperatures in the atmosphere (Label: 1). The temperature sounding is the jagged line running from bottom to top on the diagram. The sounding line is always to the right of the dewpoint temperature line.

Dewpoint plot – This bold, green, jagged line runs from the bottom to the top of the diagram and it is the vertical plot of dewpoint temperature (Label: 2). The dewpoint line is always to the left of the environmental temperature sounding. The dewpoint is the temperature to which a given parcel of air must be cooled at constant pressure and constant water-vapor content in order for saturation (condensation) to occur.

Dry Adiabatic Lapse Rate (DALR) – The DALR is a rate of cooling (9.8 degrees Celsius per kilometer) due to an adiabatic expansion of a rising, unsaturated parcel of air. These slightly curved, light red, dashed lines on the Skew-T Log-P diagram arc to the right from the lower right upward with increasing height. Weather articles often reference the DALR as it pertains to thermals (Label: 3).

Moist Adiabatic Lapse Rate (MALR) – The MALR is a rate of cooling that depends on the moisture content of the air of a rising, saturated parcel of air. Owing to the release of latent heat, the MALR is less than the DALR. However, the MALR does increase with an increase in height since cold air has less moisture content than warm air. With the higher altitude and less water content available in that colder air, the MALR begins to approach that of the DALR. The MALR is indicated by dashed, light green lines that start to run vertical from the lowest portion of the chart but then curve to the left with increasing altitude (Label: 4).

Saturation mixing ratio lines – Saturation mixing ratio is the dimensionless ratio of the mass of water vapor to the mass of dry air. On the energy diagram, it is expressed in a value of grams-per-kilogram. These light green-brownish, dashed lines run from just left of vertical upward to just right of vertical (Label: 5). The mixing ratio line values are labeled on the bottom of the diagram.

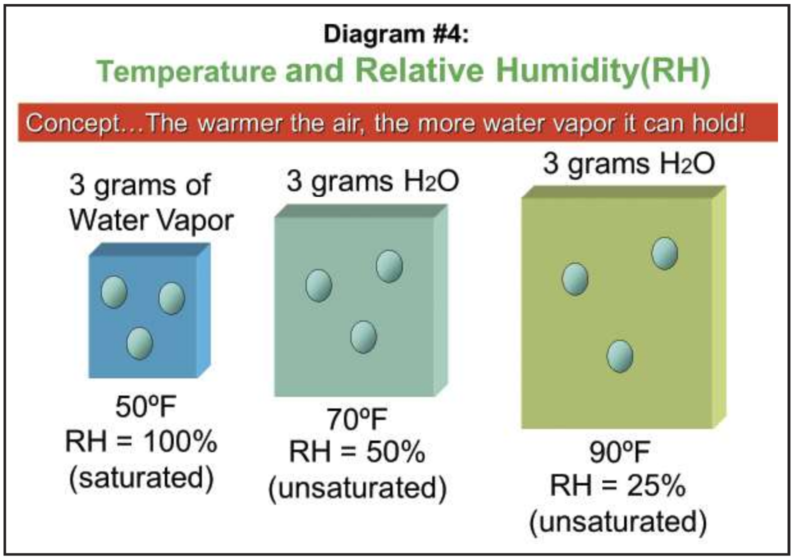

Diagram #4: Temperature and Relative Humidity (RH)

very moist soil, or a large amount of green vegetation will slow the sensible rise of the surface temperature and subsequently the heating of the lower atmosphere from surface interaction.

What about atmospheric moisture and its influence on the temperature lapse rate in the upper air? Previously discussed the Dry Adiabatic Lapse Rate (DALR) is a constant rate-of-cooling due to decreasing air pressure of an air parcel that is rising in the atmosphere ***(DRT Raob Label: 3)***. This is true only if the rising air parcel remains dry, i.e., no condensation or change of state of the parcel's water vapor occurs. So what happens if the rising air parcel cools to its dewpoint temperature and, therefore, the air parcel has reached its water vapor saturation temperature? The water vapor within the rising air parcel begins to condense into suspended water droplets (visible moisture/cloud formation). The energy that was needed to change the state of water into its gas vapor form, the latent heat of vaporization, is released into the parcel and the parcel warms ***(See Diagram #3: Change in Lapse Rate due to Release of the Latent Heat of Vaporization)***. The rising air parcel, i.e., buoyant because of its lower air density/higher temperature than the surrounding air will become even more buoyant as the parcel warms from this water condensation process. If buoyancy of a dry, rising air parcel (thermal) was beginning to decrease and weaken due to a smaller temperature difference between the rising air parcel and the surrounding air, the condensation process of the water vapor warms the air parcel and increases rising air parcel/ambient air temperature differential. Therefore, atmospheric high water vapor content provides a potential for de-stabilizing the atmosphere, i.e., an encouragement for upward vertical motion. The upper air observed soundings or forecast soundings quantify atmospheric moisture content by the dewpoint temperature values.

Remember that the water vapor saturation value of warm air is much higher than that of cold air ***(See Diagram #4: Temperature and Relative Humidity, RH)***. The amount of warmth added to a rising air parcel from the condensation process at lower altitudes and at a relatively higher temperature is much larger than that at higher altitudes where average temperatures are cooler, the water vapor content is subsequently less, and the resulting warming from the condensation process is therefore smaller. Furthermore, the Moist Adiabatic Lapse Rate (MALR) or Wet Adiabat on a Skew-T/Log-P Diagram ***(DRT Raob Label: 4)*** also reflects a pseudo-adiabatic process meaning that the condensed moisture is assumed to precipitate out of the air parcel as it continues its ascent. In looking at the Skew-T/Log-P example diagram, note that the MALR is *not* a constant. [The DALR is constant temperature rate-of-loss of 3 degrees Celsius (5.4 degrees Fahrenheit per thousand foot/10 degrees Celsius per kilometer gain of altitude). Over the lowest 10,000 feet of the atmosphere, the MALR averages a temperature loss of 2 degrees Celsius/3.5 degrees Fahrenheit per thousand feet gain of altitude or 6 degrees Celsius per kilometer. An atmosphere high in water vapor content and initiating the condensation process is able to maintain upward vertical motion (buoyancy) with threshold temperature decreases of only 2 degrees Celsius per thousand feet in the MALR instead of the higher value of the DALR at 3 degrees Celsius per thousand feet. Our example upper air sounding provides a visible picture to underscore the fact that cooler air holds less moisture before reaching saturation than warmer air. Note how the slope of the MALR lines begin to bend toward that of the DALR at high altitudes, particularly as they approach the 200-millibar pressure level (approximately 40,000 feet mean sea level). With the saturation water vapor pressure much less in air that averages -40 degrees Celsius, the water vapor available to release its latent heat of vaporization when it condenses (or sublimates directly to ice crystals at this altitude) does not appreciably warm the rising air parcel. Therefore, the slope of the MALR and DALR is not that much different at such cold temperatures and altitudes.

With high values of atmospheric water vapor content, the condensation process releases explosive amounts of energy to warm rising air. With significant warming due to high water vapor condensation, large amounts of air parcel warming enables the rising air parcel to boost its temperature higher than any previously blocking atmospheric stable layer or temperature inversion to a rising dry air parcel under a dry adiabatic ascent. Thus, large amounts of atmospheric water vapor are considered the "fuel" for convective (thunderstorm) development. In a less unstable environment, thermals that ascend enough for its dry adiabatically cooling air to reach its dewpoint temperature provide more benign but useful conditions for the soaring pilot in the form of visible thermal markers we know as cumulus clouds!

In consideration of our discussion on atmospheric moisture, along with upper air sounding analysis, atmospheric stability indices provide clues to meteorologists and pilots about the fine line that separates benign cumulus development from the dangerous presence of thunderstorms….and leaves room for future discussion in "Weather to Fly."

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