Saturated (Moist) Adiabatic Rate

Saturated air parcels that are lofted still experience expansion and adiabatic cooling. But this cooling is offset by the latent heat of condensaiton. Unfortunately, the latent heat of condensation is not constant and decreases with decreasing temperature.

$$\Gamma_s = \Gamma_a \cdot \frac{\left(1+\frac{m_s L_v}{R_d T}\right)}{\left(1+k\frac{m_s {L_v}^2}{R_d T^2}\right)} \qquad (1)$$

The expression for the saturated adiabatic rate can be viewed as the dry adiabatic rate modulated by a correction factor. The correction factor is smaller fraction with higher latent heat “release”. In concept, a rising air parcel cools by expansion at the rate of 1^0C $100m^{-1}$ but as the air parcel is cooling sensible heat will be added that offsets the adiabatic cooling. Typically, in the lower atmosphere and in F^0, the adiabatic rate of 5.5^0F/1000 ft will be offset by a warming effect of about 2^oF/1000 ft, leading to net cooling of around 3.5^0F/1000 ft.

Equation (1) can be solved for every temperature that appears on a thermodynamic chart, resulting in a family of lines called moist adiabats. Since the moist adiabatic rate given by (1) is not constant, these lines are curves whose mean slope is much greater at higher temperatures and saturation mixing ratios. These curves can be labeled with the temperature at their intersection with the 1000 mb level, which is known as the wet bulb potential temperature. The wet bulb temperature is the temperature of an object from whose surface continuous evaporation is occurring. An example of this would be your skin surface when you are perspiring.

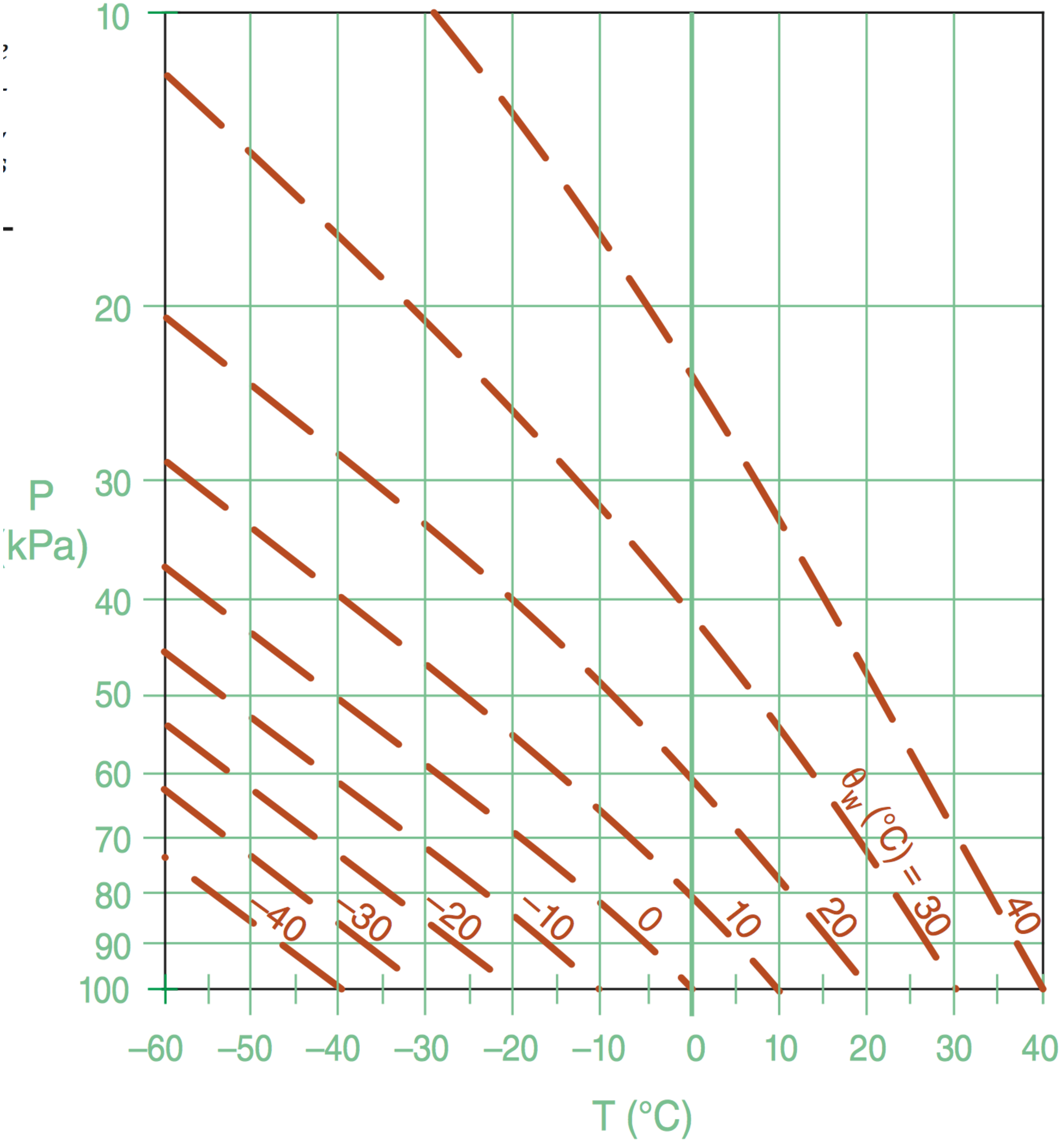

Figure 1: Wet adiabats labeled in wet bulb potential temperature on a Stüve diagram. A saturated air parcel would cool along these lines instead of along adiabats.