Lifting Condensation Level (LCL) overview

The Lifting Condensation Level (LCL) is the height at which a parcel of air lifted dry-adiabatically would become saturated.

On a thermodynamic diagram it is located at the point of intersection of the dry adiabat through the point representing the parcel's original pressure and temperature, and the mixing ratio line value at the original level. The intersection point on the diagram represents where saturation occurs and a cloud forms.

There is some other obscure terminology you may see in the literature. The pressure and temperature at the LCL are sometimes called condensation pressure and condensation temperature, respectively, and the corresponding point on a thermodynamic diagram is called either the characteristic point, adiabatic saturation point, or adiabatic condensation point. The LCL is also called the isentropic condensation level.

SkewT exercise

Initial parcel: p=980 mb; T=27°C, T_D=11°C

What is q and q_s at 980 mb?

What temperature is the LCL?

What pressure is the LCL?

Calculations

Initial parcel: p=980 mb; T=27°C, T_D=11°C

What is e and e_s 980 mb?

What is q and q_s at 980 mb?

What temperature is the LCL?

What pressure is the LCL?

What is q at the LCL?

What is q_s at the LCL?

What is the relative humidity at p=980?

What is the relative humidity at the LCL?

Convert T and T_D to Kelvins. T=27+273.15=300.15°K, T_D=11+273.15=284.15°K

Use Bolton's vapor pressure equation to get $e(T_D)$ and $e_s(T)$

$$e = 6.11exp\left[\frac{17.67(T_D-273.15)}{T_D-29.65}\right]=13.1 \text{ mb}$$

$$e_s = 6.11exp\left[\frac{17.67(T-273.15)}{T-29.65}\right]=35.6 \text{ mb}$$

$q = \frac{0.622e}{p-e} \times 1000$=8.4 g/kg

$q_s = \frac{0.622e_s}{p-e_s} \times 1000$=23.5 g/kg

Note that if e and e_s are dropped in the denominator for q and q_s, the values become 8.3 g/kg and 22.6 g/kg.

$T_{LCL} = \frac{2840}{3.5 \ln T - \ln e - 4.805} + 55$=280°K. This corresponds to 7.5°C (for comparison to SkewT). However, equations must use temperature in degrees Kelvins.

$p_{LCL} = p\left[\frac{T_{LCL}}{T}\right]^{c_p/R}$=775 mb

Relative humidity at the surface is RH=e/e_sX100=36.8%. If we approximate as RH=q/q_sX100=35.9%.

What is the relative humidity at the LCL? 100% of course! The air is saturated at the LCL. This makes sense, since q stays the same during adiabatic ascent, but q_s is decreasing as the air is lifted at lower pressure.