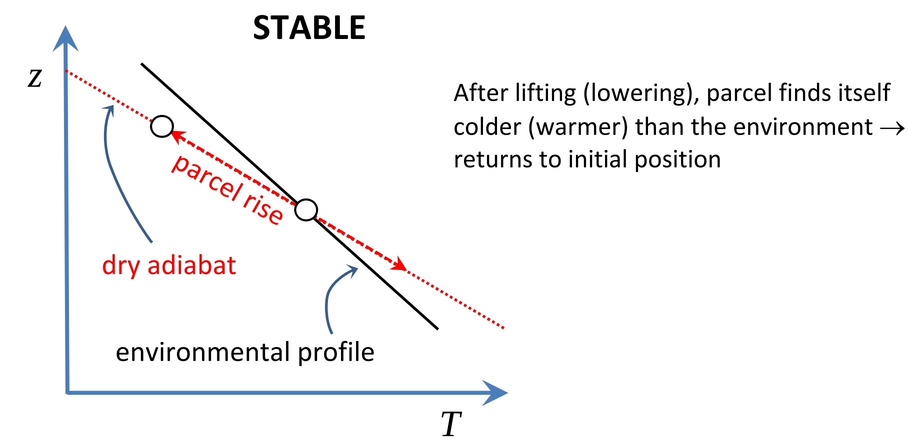
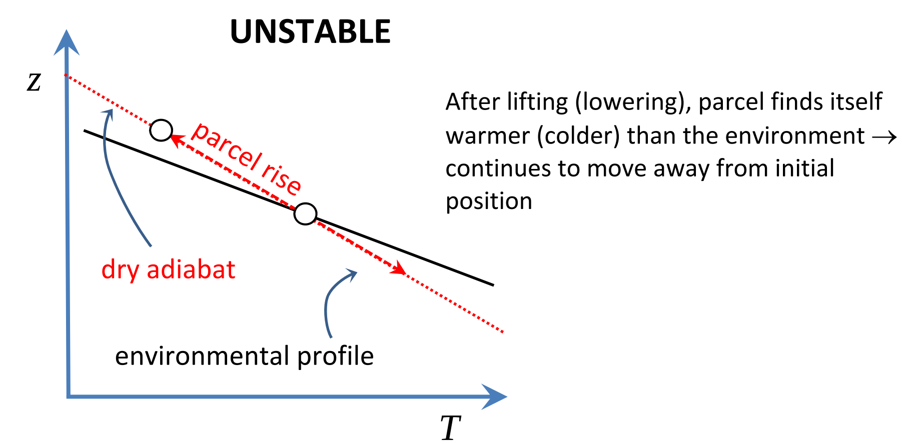
Stability Review

The stability of the atmosphere to perturbations is an important topic. There are numerous types of stability. Here, we will review static (buoyant) stability concepts. The term "static" is used here to indicate that this form of stability does not require a prior flow.

For unsaturated air, we examine the environmental profile, and compare this to the temperature that an adiabatic parcel of air would have if lifted/lowered from an initial point on the environmental profile:





STABILITY CRITERIA for UNSATURATED AIR

$\left|\frac{dT}{dz}\right| < \Gamma_d$ or $\frac{d\theta}{dz} > 0$ STABLE

$\left|\frac{dT}{dz}\right| > \Gamma_d$ or $\frac{d\theta}{dz} < 0$ UNSTABLE

$\left|\frac{dT}{dz}\right| = \Gamma_d$ or $\frac{d\theta}{dz} = 0$ NEUTRAL

Strictly speaking, we should be using virtual temperature (or virtual potential temperature) rather than simply temperature, to account for the impact of moisture variations on buoyancy.

If the air is saturated, the latent heat release upon lifting (cooling upon lowering) changes the stability criteria because the temperature of the lifted parcel no longer changes at the dry adiabatic lapse rate but with the moist adiabatic lapse rate Γ_m, which is less steep than the dry adiabat ($\Gamma_m < \Gamma_d$).

There are now a total of five possibilities. Defining the environmental lapse rate as $\Gamma = -dT/dz$, we can write the five stability criteria as:

$\Gamma < \Gamma_m$	ABSOLUTELY STABLE
$\Gamma = \Gamma_m$	SATURATED NEUTRAL
$\Gamma_m < \Gamma < \Gamma_d$	MOIST UNSTABLE BUT DRY STABLE (CONDITIONALLY UNSTABLE)
$\Gamma = \Gamma_d$	DRY NEUTRAL
$\Gamma > \Gamma_d$	ABSOLUTELY UNSTABLE