14 Oct., 2011

• Dr. Wilson will post Quiz 2 correct answers and scores over the weekend

• Today we begin Ch. 6 Cloud Development and Forms

Vertical motion is key in relation to cloud development, and vertical motion is to a great extent controlled by the "static stability" of the atmosphere, i.e. the environmental lapse rate

lec14.odp
JDWilson vers 6 Oct. 2011

Cloud development and forms (Ch6) – "Processes and conditions associated with the formation of clouds due to upward motion"

We've learned that parcels cool as they rise, and that if parcels rise far enough they will saturate. But ***why*** are some days cloudy, and not others? And what accounts for the variety of cloud types?

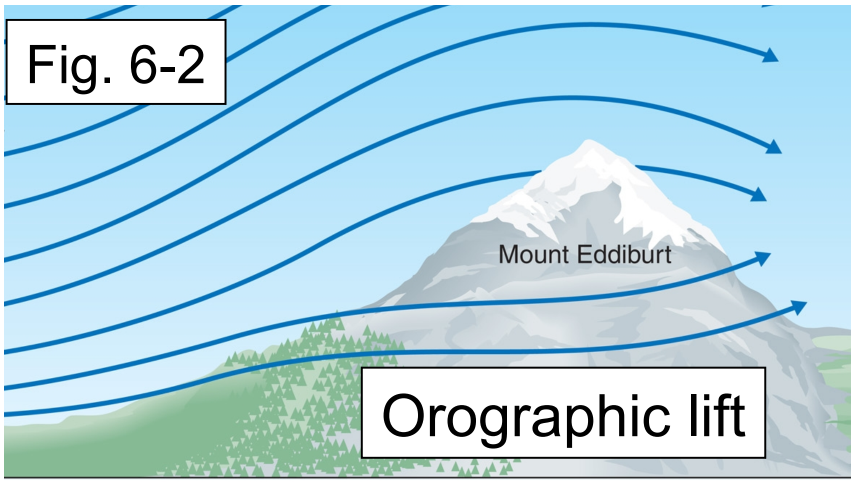
These questions can be explored by considering (i) the causal origin of the lift

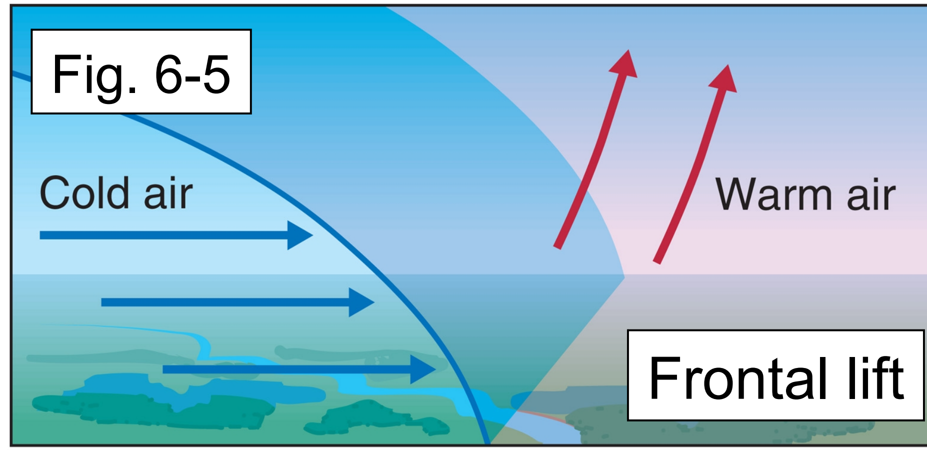
- ***spontaneous?***, eg. Cumulus clouds due to thermals in an unstable boundary layer

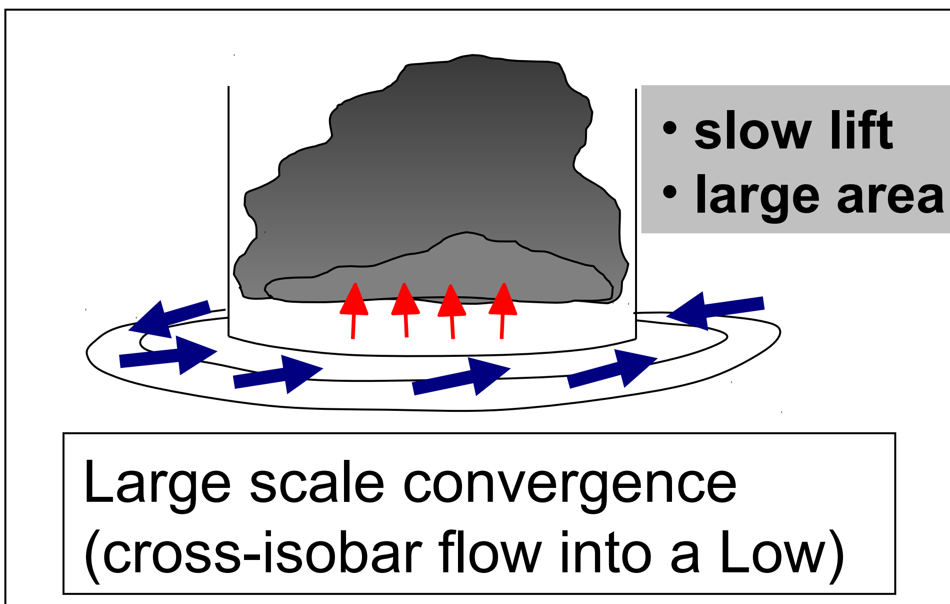
- ***forced?***, eg. wind forced to blow over a mountain

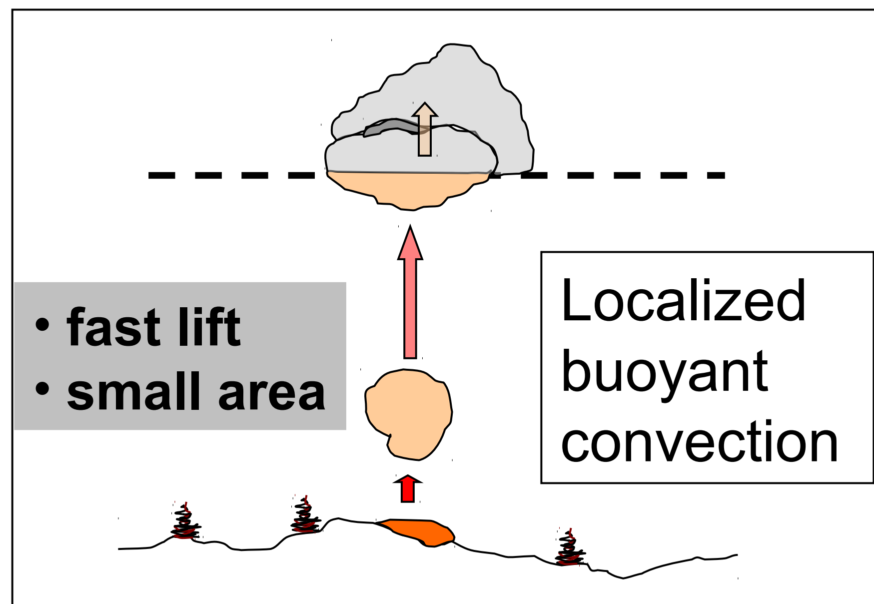
and (ii) the inherent susceptibility of the atmosphere to permit (or limit/attenuate/inhibit/forbid) ascent of parcels

The four mechanisms that cause lift:









Assessing Static Stability of the Atmosphere

We compare the **ELR** (environmental lapse rate) against “benchmark” lapse rates (**DALR**, **SALR**) that are defined by appeal to an idealized conceptual process of the adiabatic lift of a parcel.

ie. the dry adiabatic lapse rate (DALR) is an idealized "benchmark" process - we vizualize the vertical motion (upward or downward) of an intact "parcel" of unsaturated air, contained in an imaginary flexible skin that freely permits the parcel to expand or contract so as to remain at the local pressure, but, which prevents heat exchange with the outside atmosphere. The thermodynamic process undergone by such an idealized parcel as it ascends (or descends) is said to be "adiabatic expansion" (adiabatic compression, if descending).

by comparing the **ELR** with the “benchmarks” (**DALR, SALR**) we can assign a stability class to any layer

Assessing Static Stability of the Atmosphere

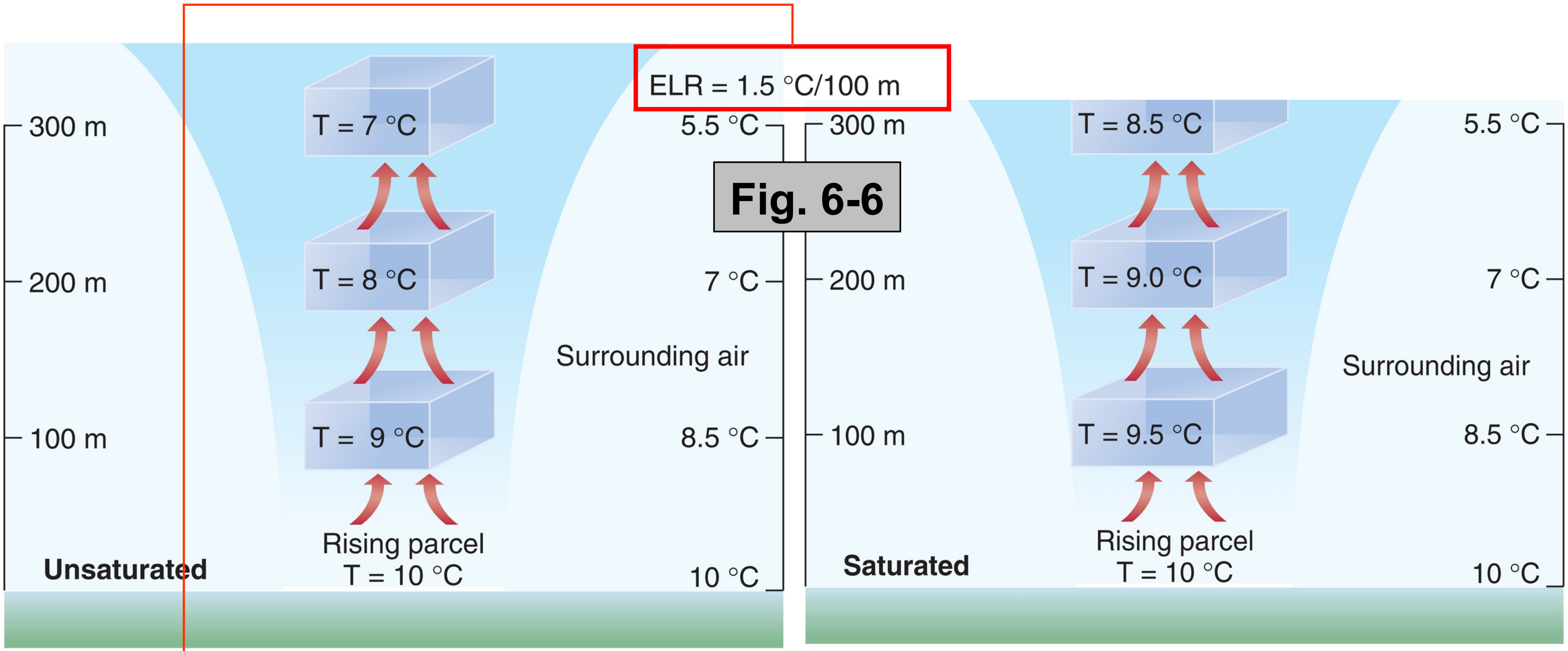
Will an “air parcel” that has been dislodged (for whatever reason) on the vertical axis experience:

- a restoring buoyancy force (statically stable)

- no buoyancy force (“statically neutral”)

- a buoyancy force exacerbating (reinforcing) the original disturbance (“statically unstable”)

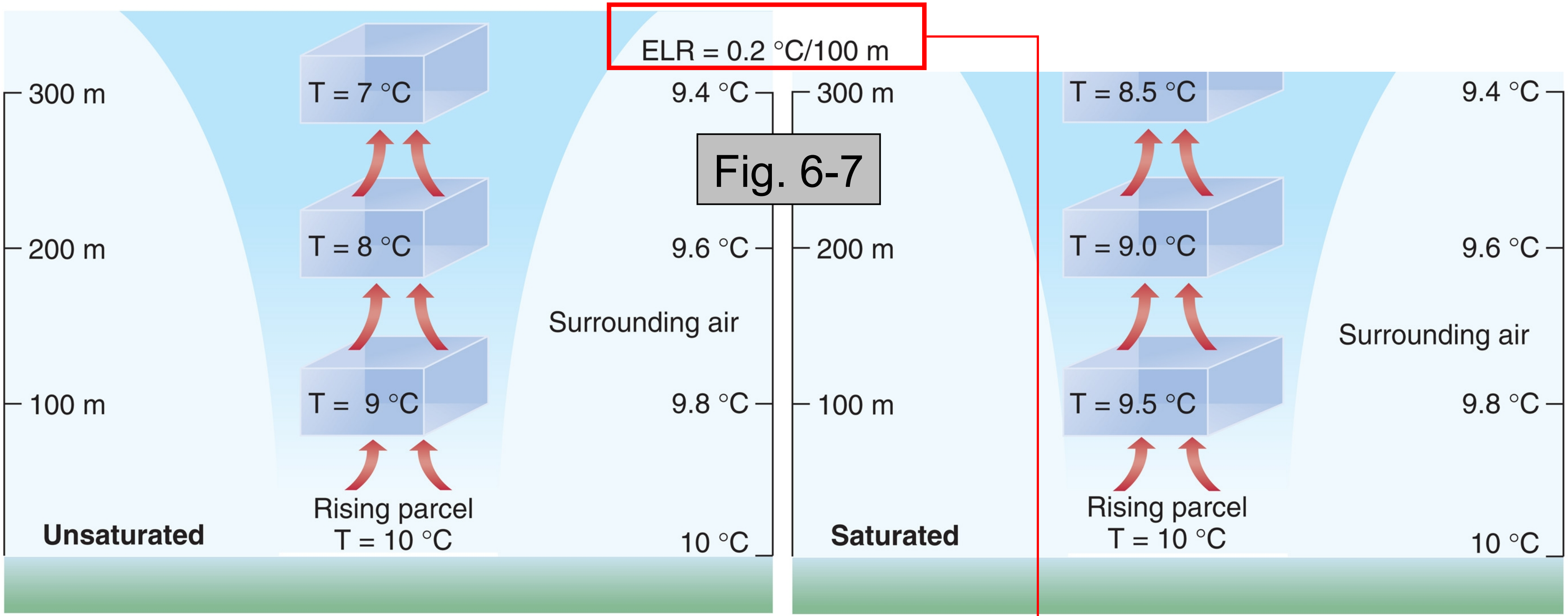
"Absolutely** unstable atmospheric layer" - air parcel rising becomes warmer than surrounding ("environmental") air



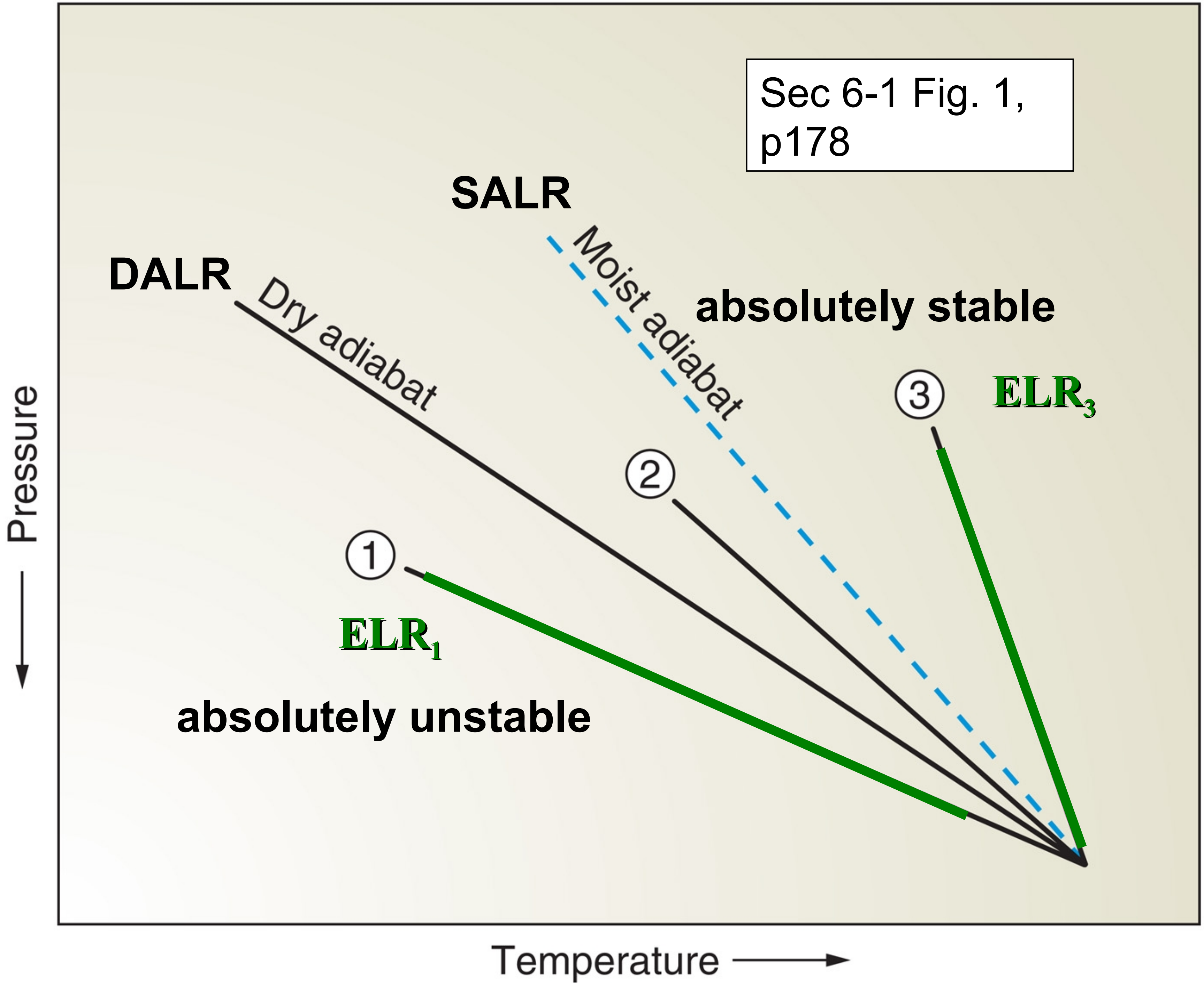
- **ELR exceeds both DALR (0.01 K m^{-1}) and SALR (0.005 K m^{-1})**

** absolute stability (instability) is also named "unconditional" stability (instability)

"Absolutely** stable atmospheric layer" - air parcel rising becomes cooler than surrounding ("environmental") air



- **both DALR and SALR exceed the ELR**


Sec 6-1 Fig. 1, p178
SALR
Moist adiabat
DALR
Dry adiabat
absolutely stable
3
ELR3
2
1
ELR1
absolutely unstable
Pressure
Temperature

Conditionally unstable atmospheric layer**

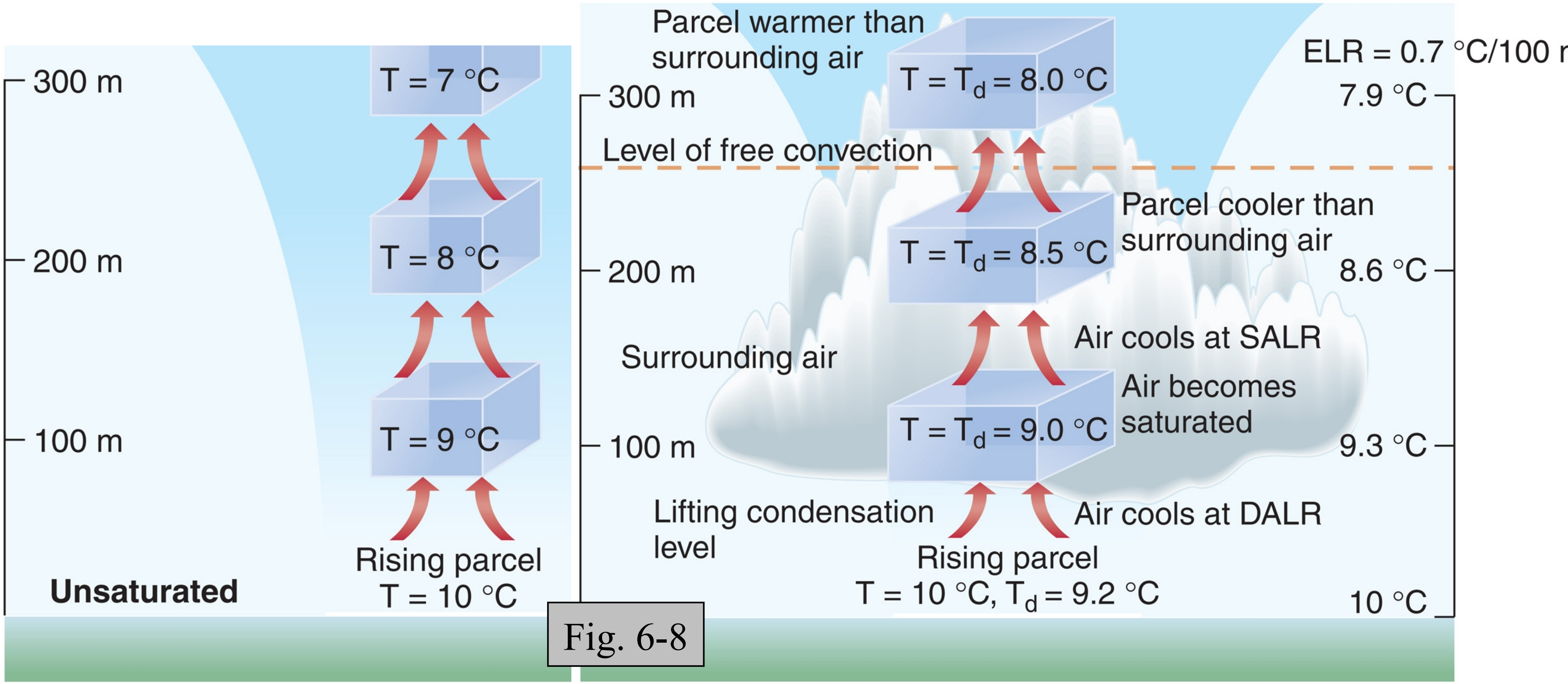
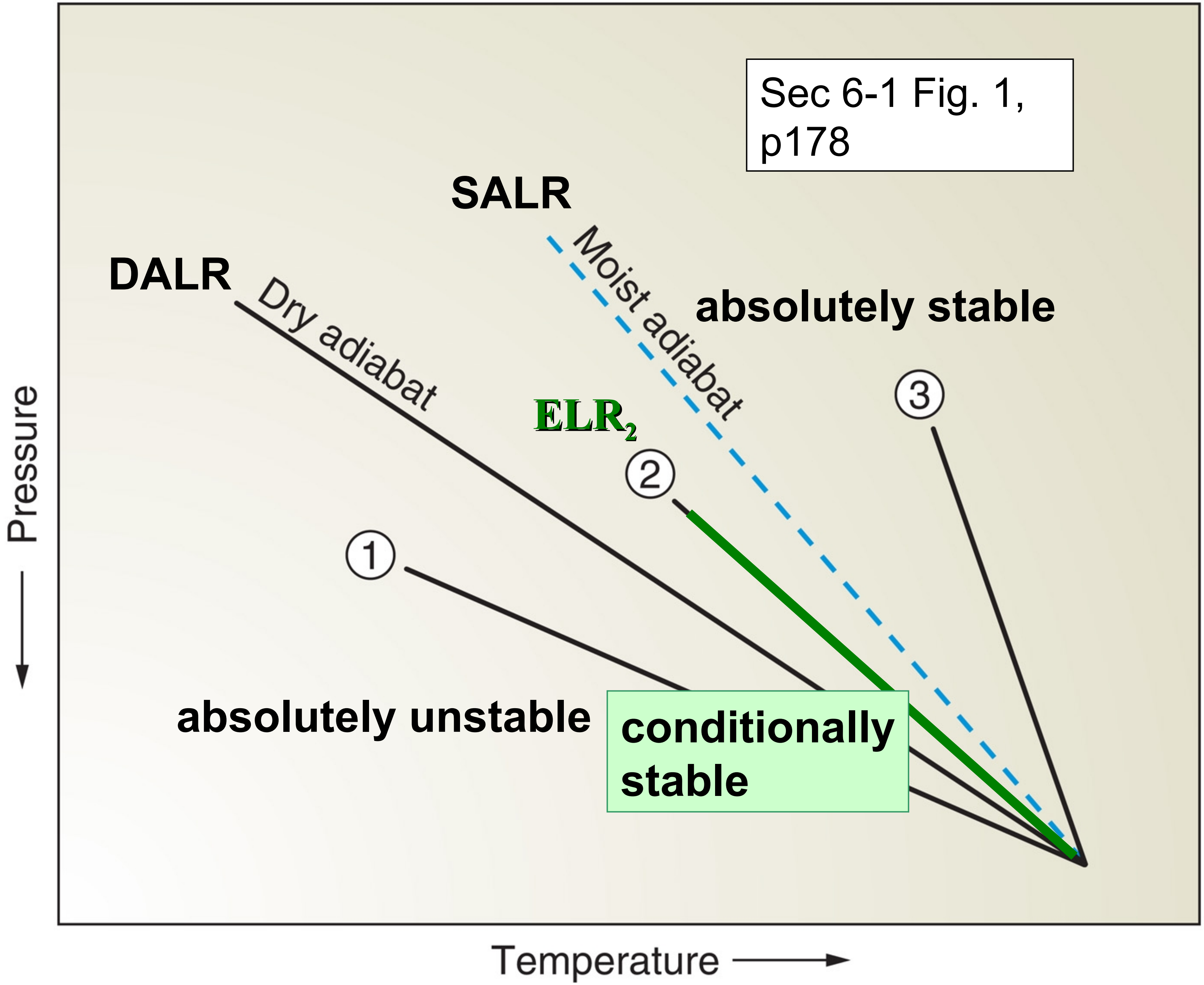


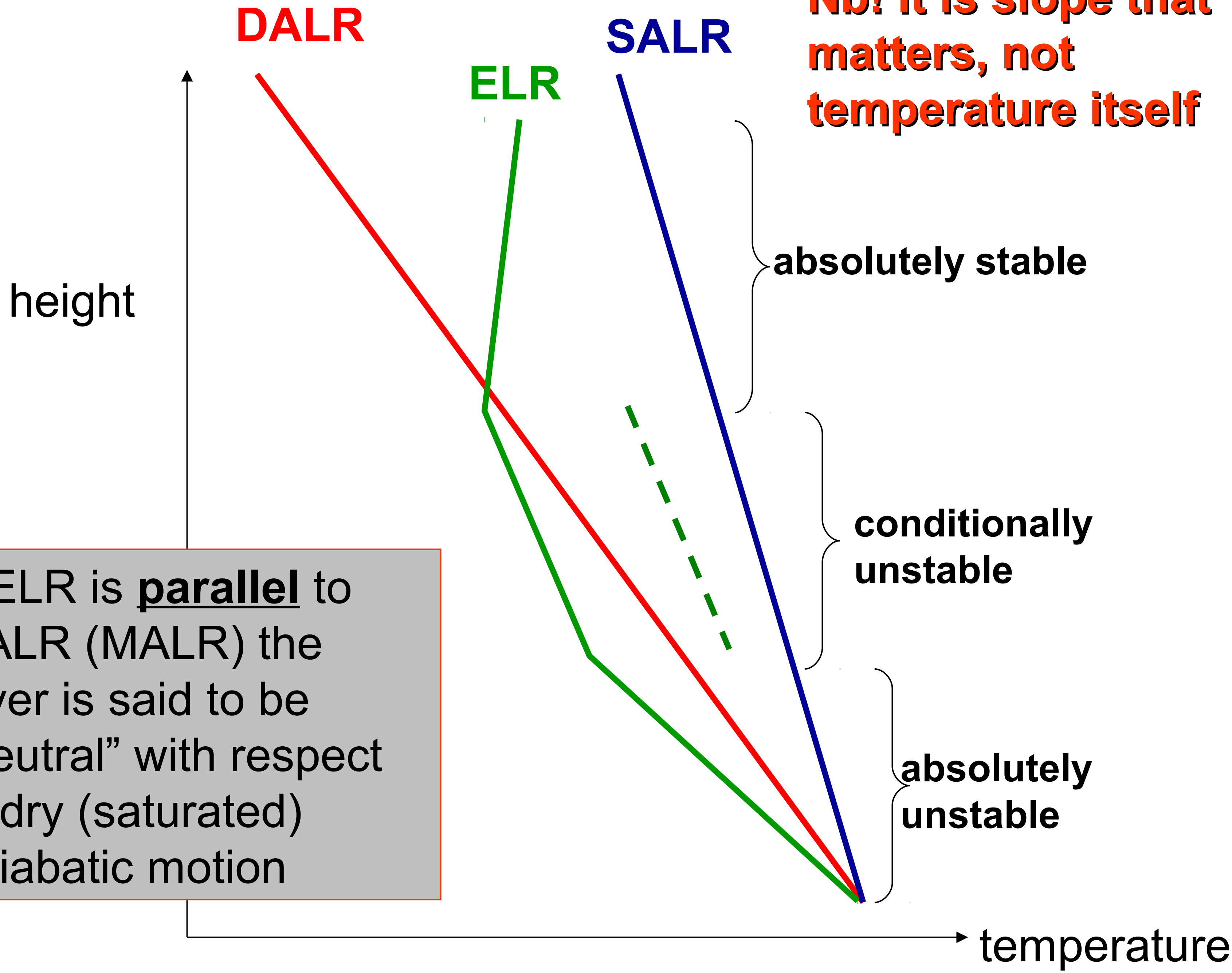
Fig. 6-8

"If the atmosphere is conditionally unstable, an air parcel becomes buoyant if lifted above some critical altitude… the level of free convection" (p175)

** same as conditionally stable


Sec 6-1 Fig. 1, p178
SALR
Moist adiabat
DALR
Dry adiabat
absolutely stable
ELR2
3
2
1
absolutely unstable
conditionally stable
Pressure
Temperature

Nb! It is slope that matters, not temperature itself



If ELR is **parallel** to DALR (MALR) the layer is said to be "neutral" with respect to dry (saturated) adiabatic motion

… deep layers of the atmosphere are seldom absolutely **unstable** … Why? Because any transient instability will result in vertical motion that mixes heat and so reduces or removes the instability (the layer in question returning spontaneously towards **neutral** stratification).

… since a **stably**-stratified layer strongly resists the upward motion of parcels, those parcels that, ***due to being forced to do so, do rise***, will tend to spread horizontally in thin layers… flat tops and bases… "stratiform" clouds