Meteorology – Lecture 10

Robert Fovell
rfovell@albany.edu

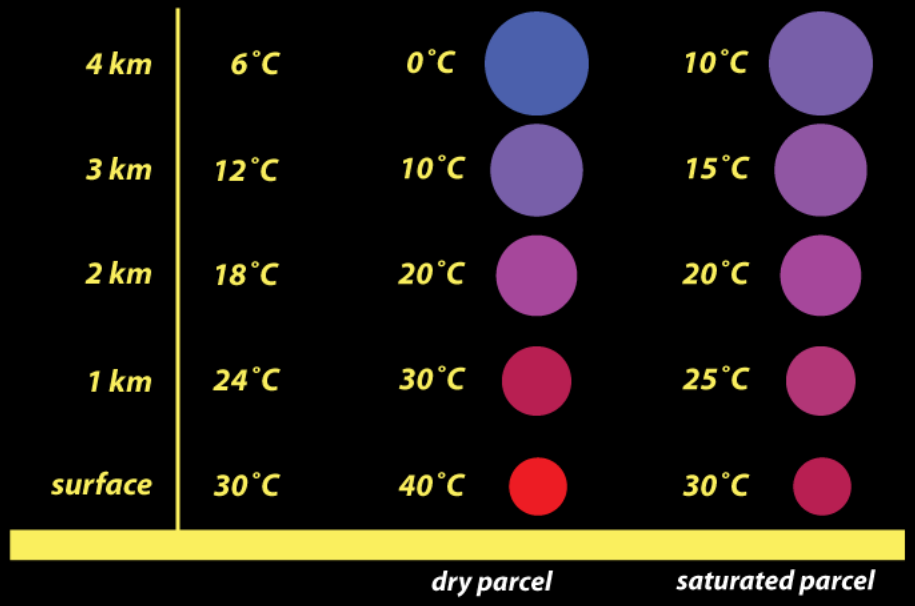
Important notes

- These slides show some figures and videos prepared by Robert G. Fovell (RGF) for his “Meteorology” course, published by The Great Courses (TGC). Unless otherwise identified, they were created by RGF.
- In some cases, the figures employed in the course video are different from what I present here, but these were the figures I provided to TGC at the time the course was taped.
- These figures are intended to supplement the videos, in order to facilitate understanding of the concepts discussed in the course. *These slide shows cannot, and are not intended to, replace the course itself and are not expected to be understandable in isolation.*
- Accordingly, these presentations do not represent a summary of each lecture, and neither do they contain each lecture’s full content.

Animations linked in the PowerPoint version of these slides may also be found here:

http://people.atmos.ucla.edu/fovell/meteo/

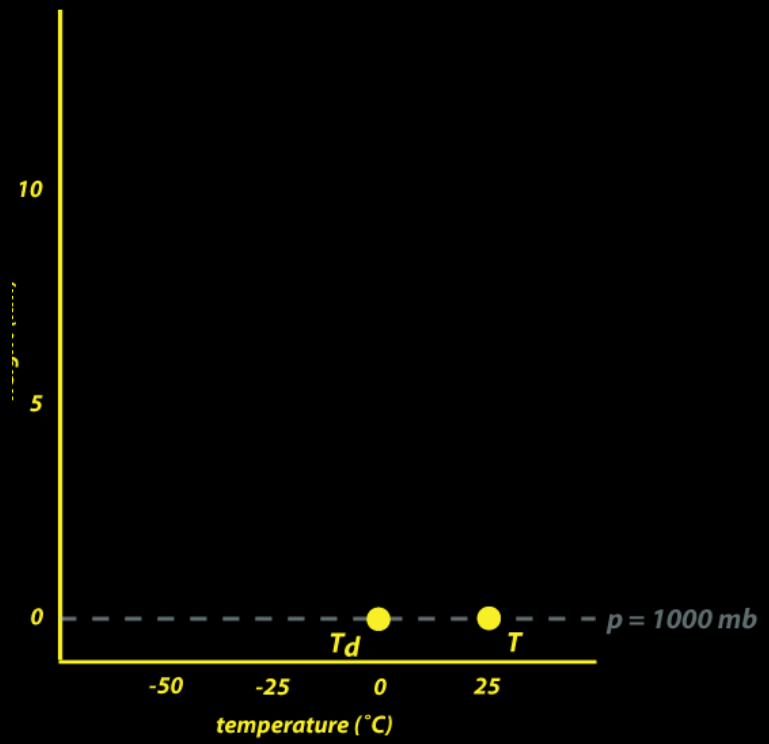
Beach example with moisture (again)



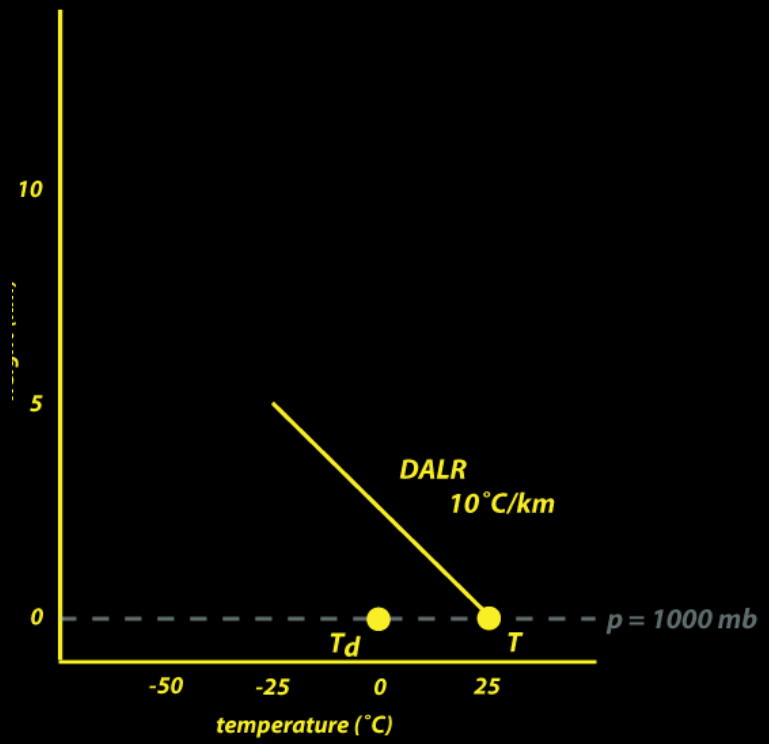
At 4 km, dry parcel is colder than environment but saturated parcel is *warmer*

Lifting a parcel to saturation

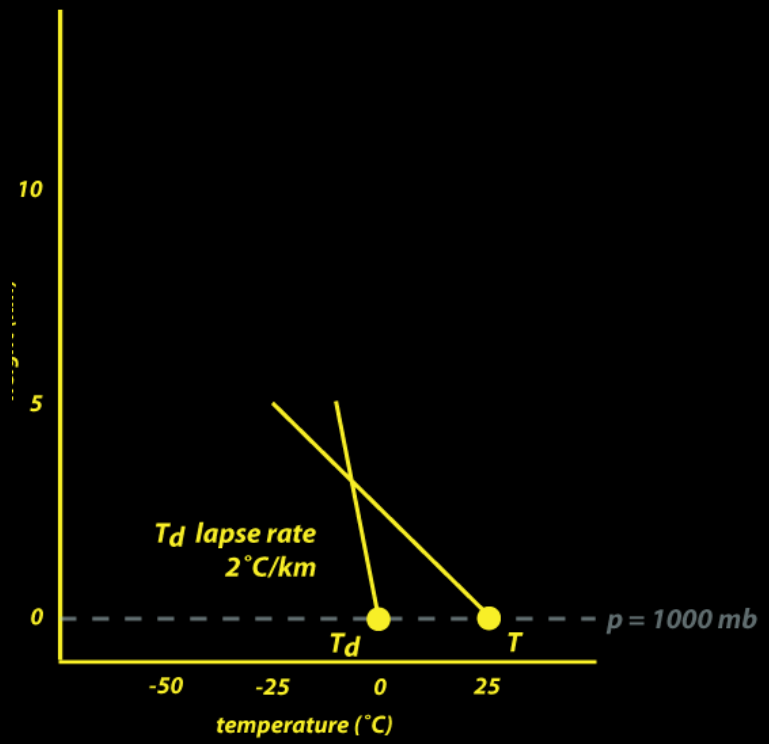
Lift a surface parcel



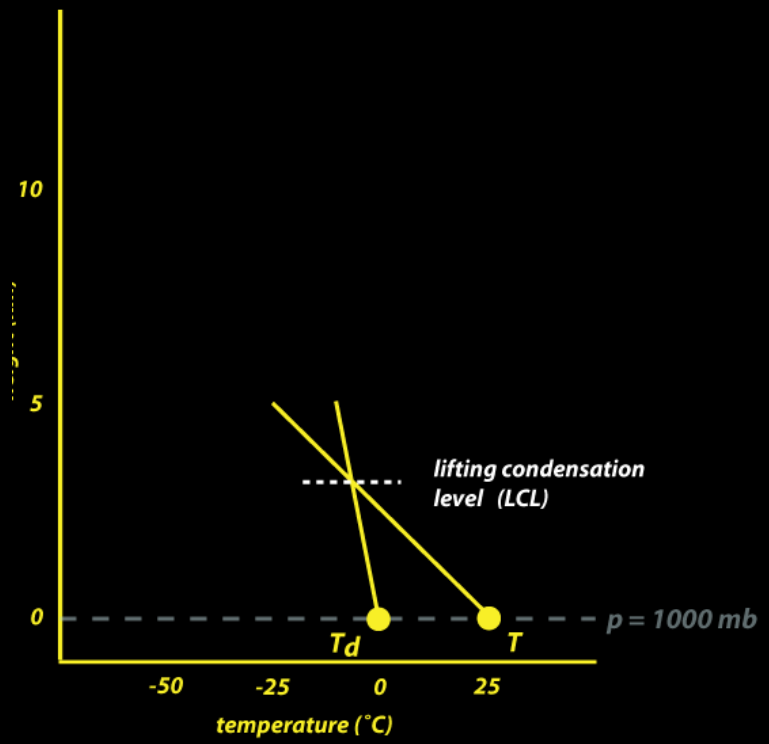
Lift a surface parcel



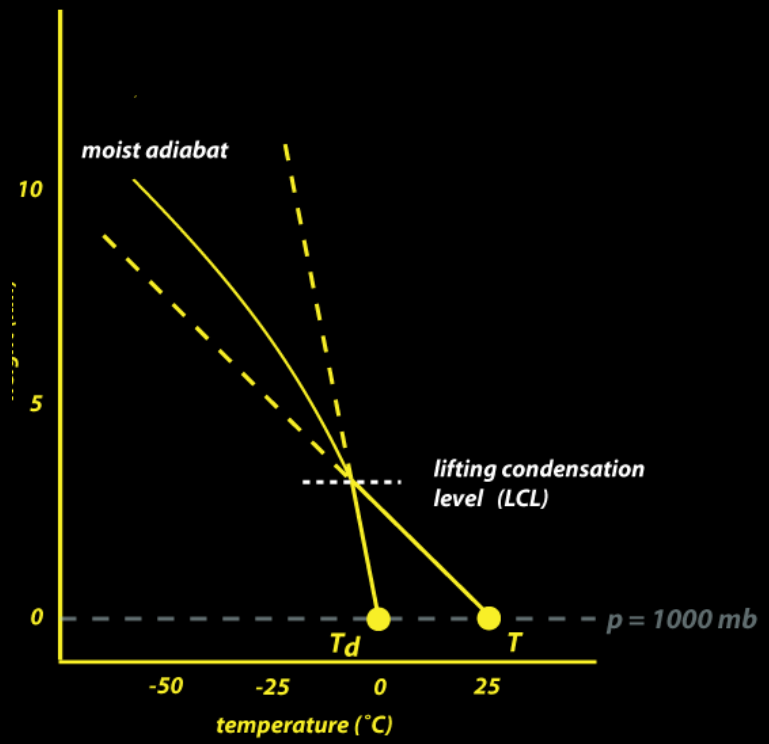
Lift a surface parcel



Lift a surface parcel

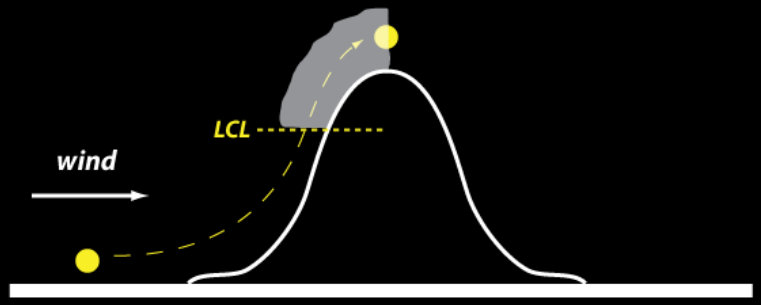


Lift a surface parcel



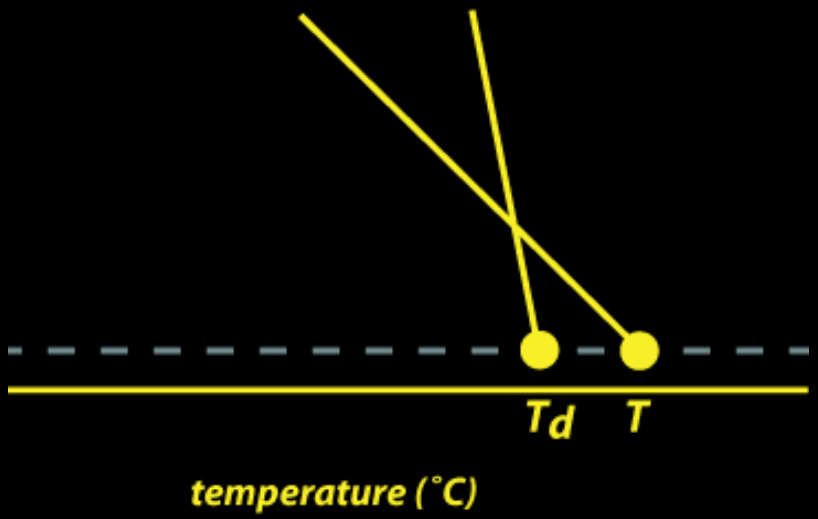
Lifting a parcel over a mountain

Parcel reaches mountain top

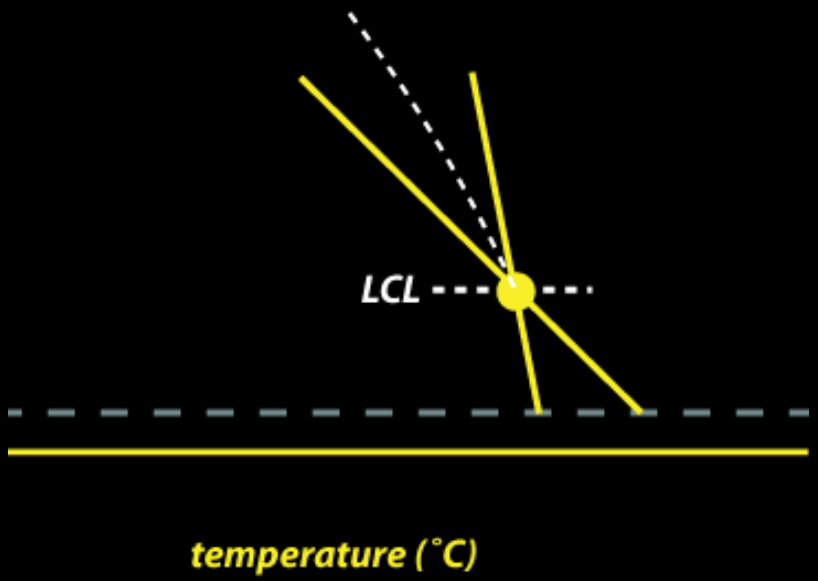


Say this parcel was pushed up a mountainside.
It has saturated on the way up, forming a cloud.
It has reached the mountain top.
Now what does it do?

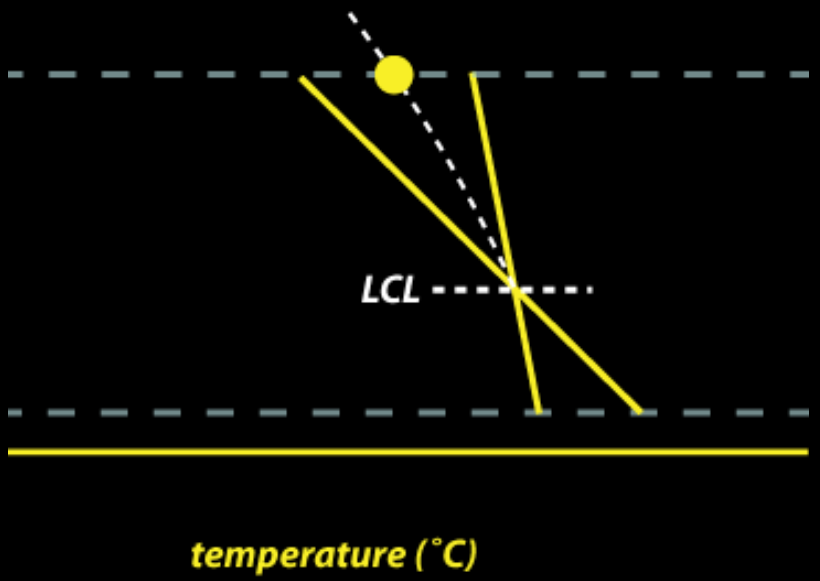
Lift a subsaturated parcel



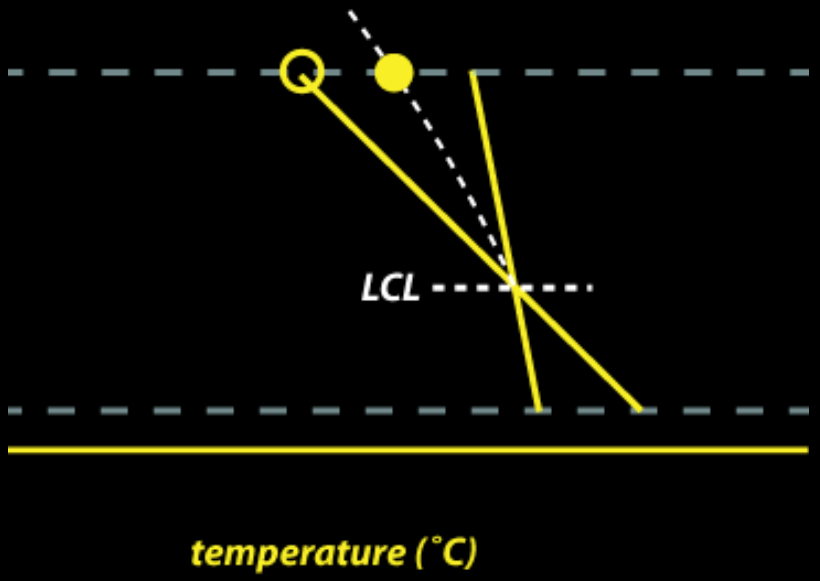
Lift a subsaturated parcel



Lift a subsaturated parcel

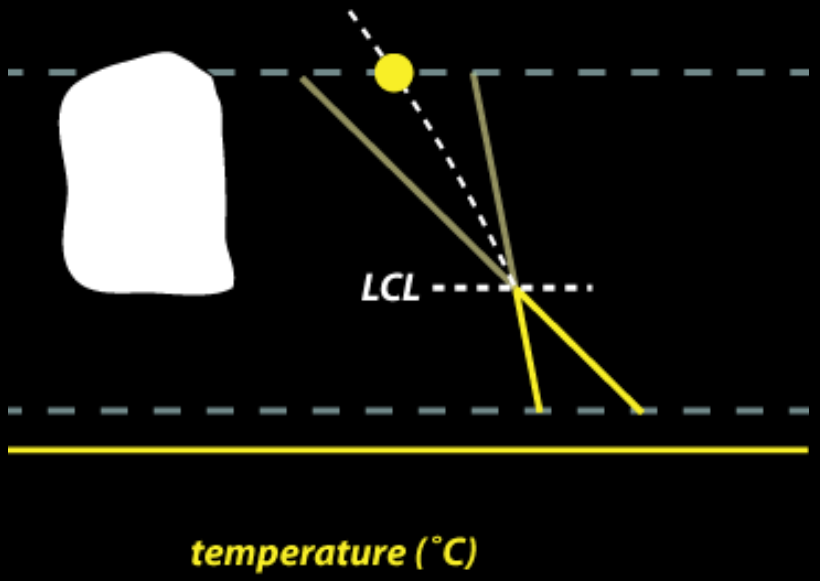


Lift a subsaturated parcel

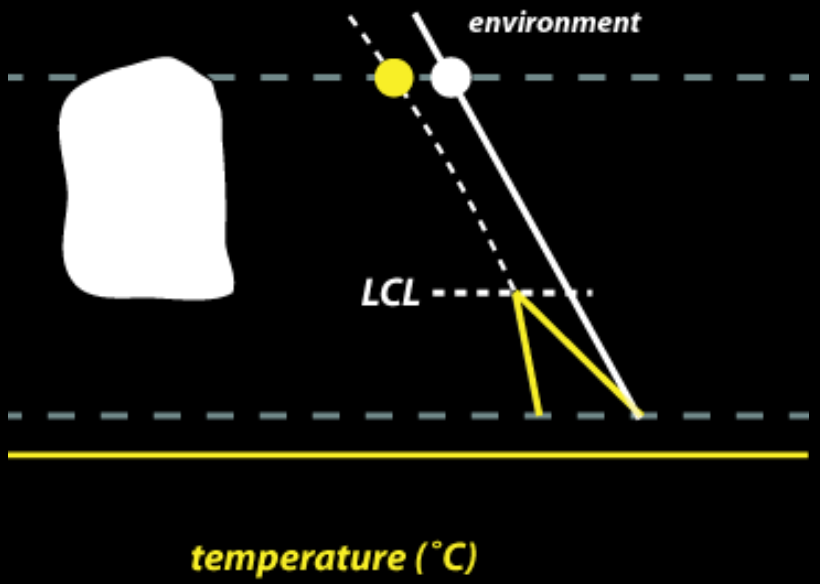


The parcel is warmer than it would have been had it remained subsaturated.

Lift a subsaturated parcel

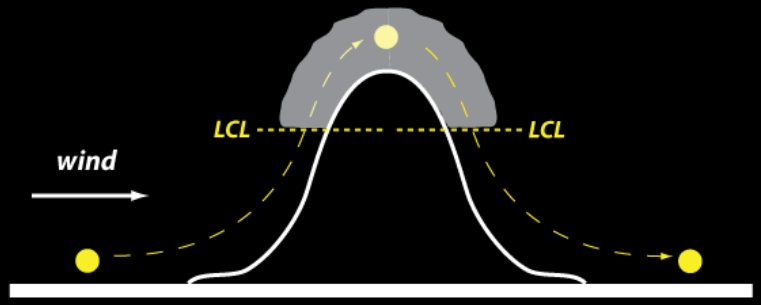


Lift a subsaturated parcel



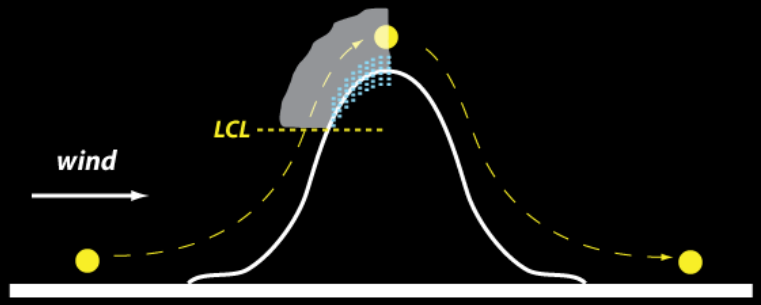
Now we compare the parcel to its surrounding environment.

Lift a subsaturated parcel



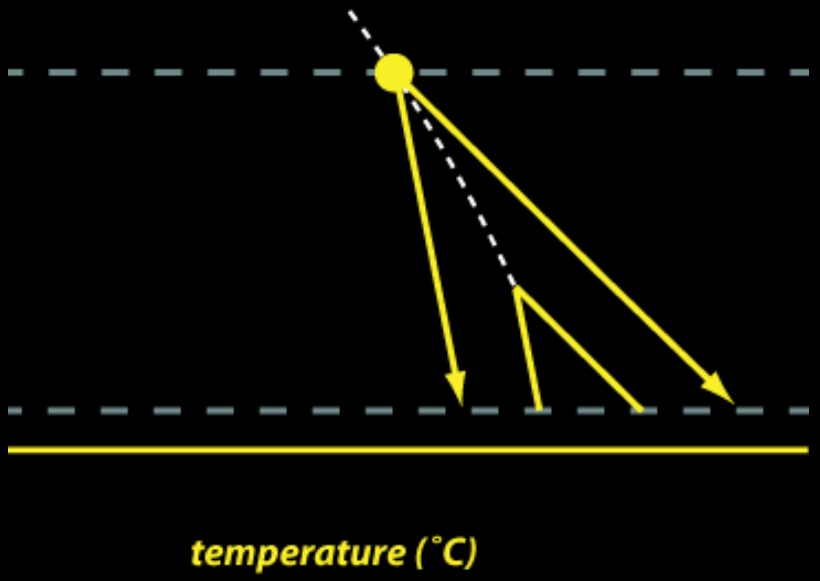
The parcel is colder (more dense), so it falls back down the lee side.

All rain, no cloud



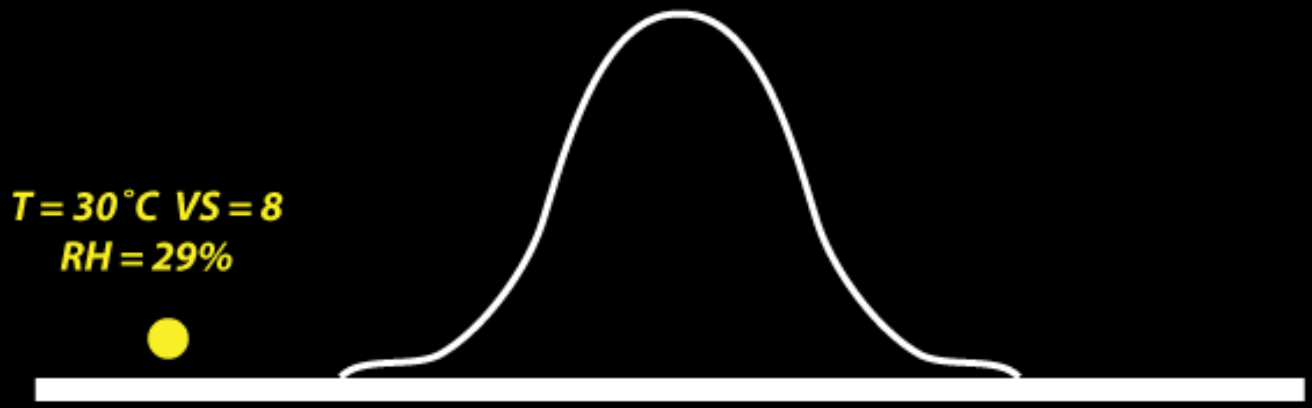
What if we lost all the condensation that former?
(All rain, no cloud)

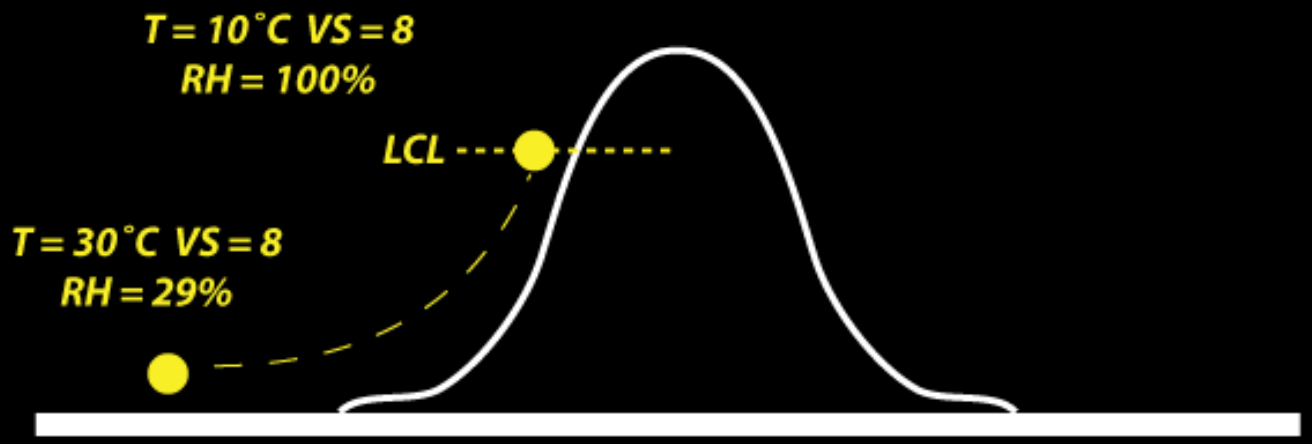
All rain, no cloud

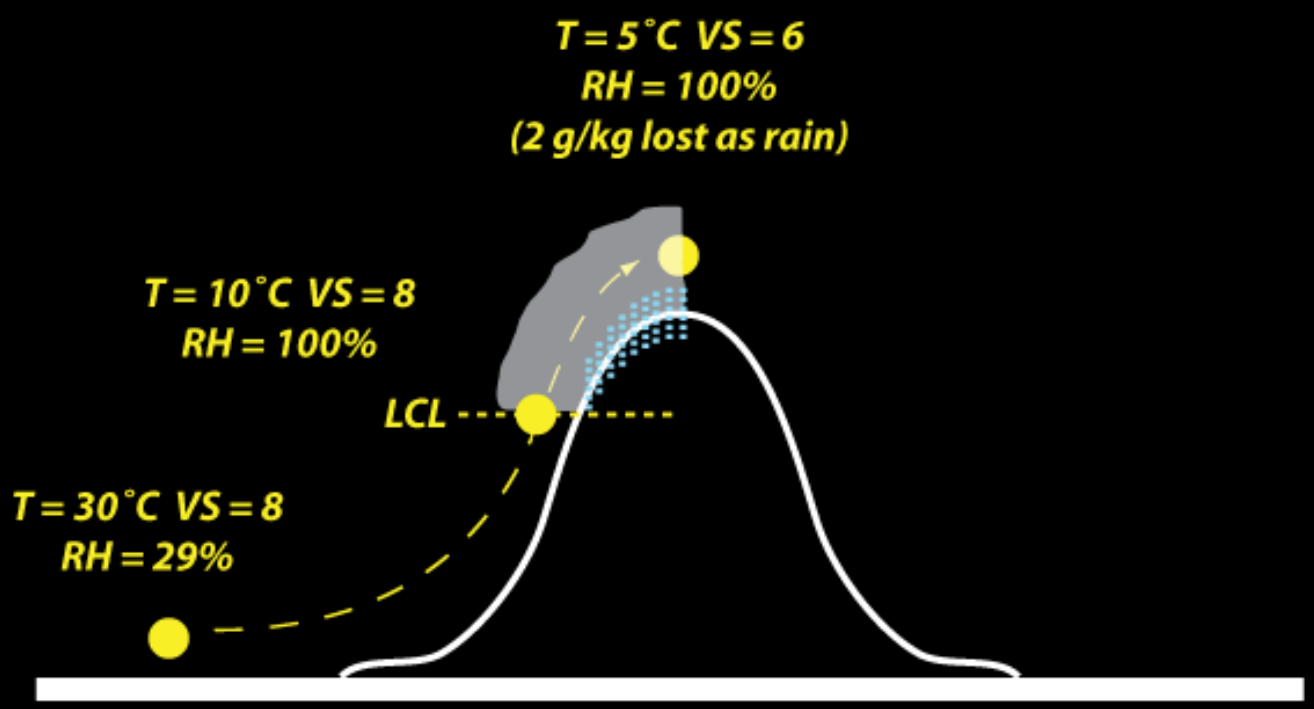


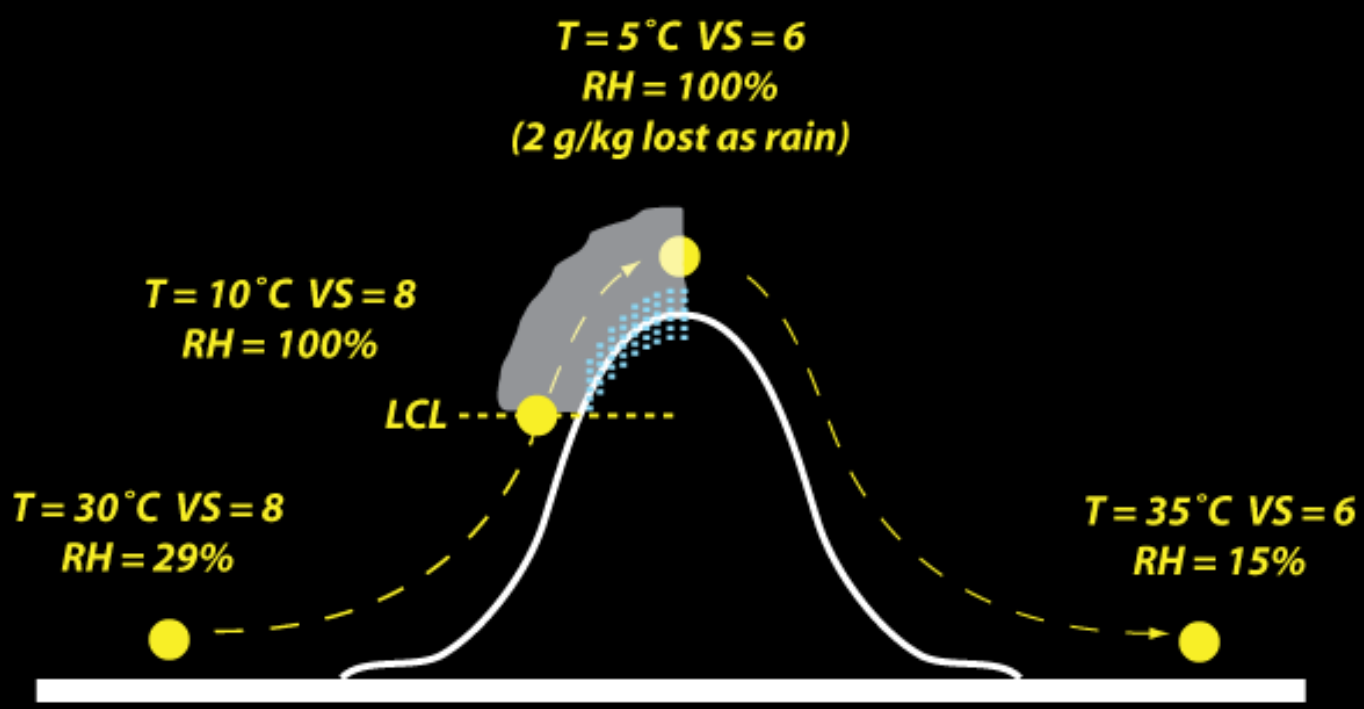
The parcel descends as subsaturated, becoming hotter and drier on the lee side

An example using numbers


T = 30˚C VS = 8
RH = 29%

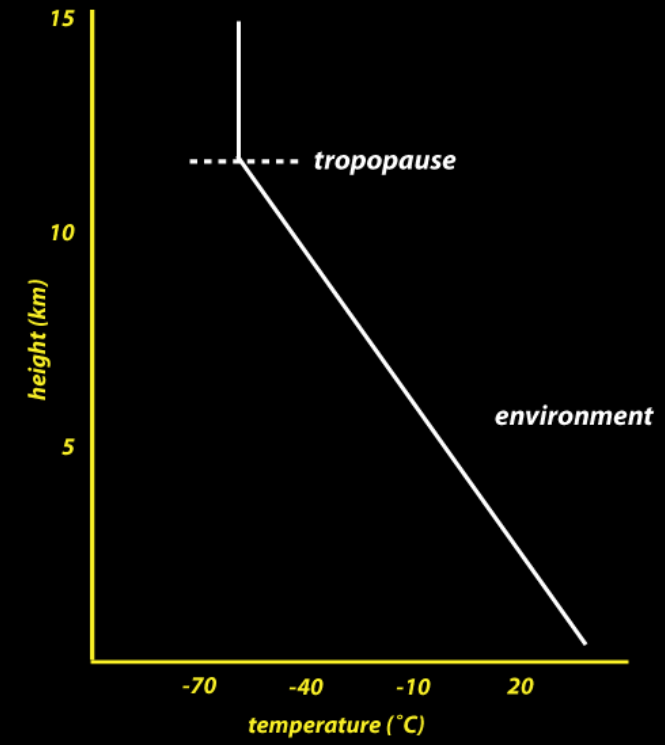

T = 10˚C VS = 8
RH = 100%
LCL
T = 30˚C VS = 8
RH = 29%


T = 5˚C VS = 6
RH = 100%
(2 g/kg lost as rain)
T = 10˚C VS = 8
RH = 100%
LCL
T = 30˚C VS = 8
RH = 29%


T = 5˚C VS = 6
RH = 100%
(2 g/kg lost as rain)
T = 10˚C VS = 8
RH = 100%
LCL
T = 30˚C VS = 8
RH = 29%
T = 35˚C VS = 6
RH = 15%

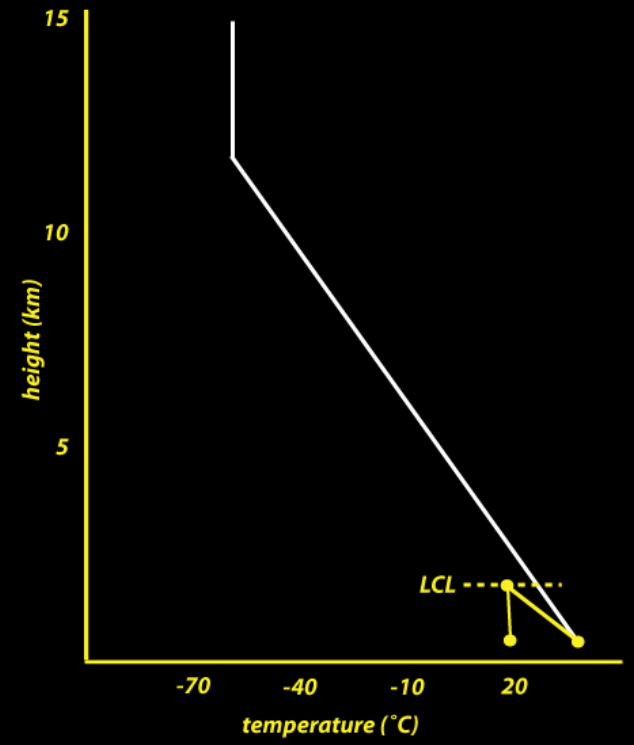
Instability

A “sounding” with potential instability



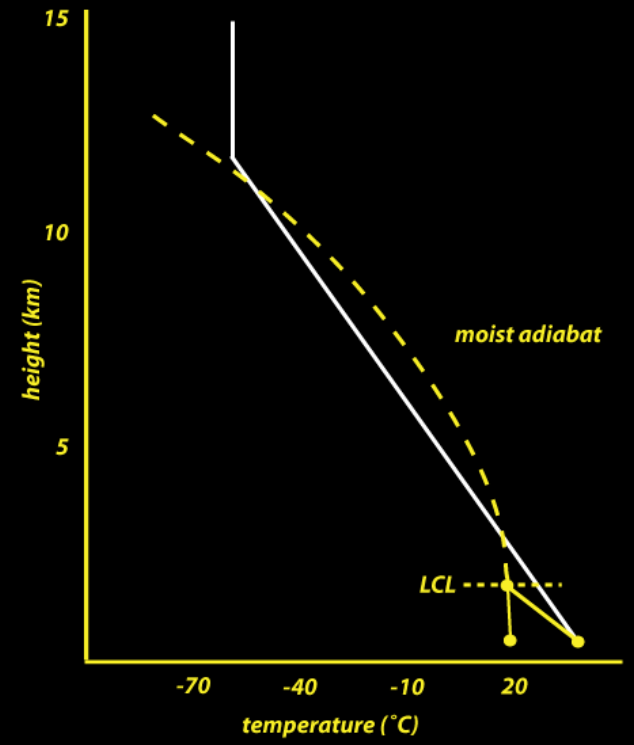
- A thunderstorm sounding (vertical profile of T, TD and other properties)
- Despite starting off subsaturated & struggling, a surface parcel can become positively buoyant given sufficient lifting…

A “sounding” with potential instability



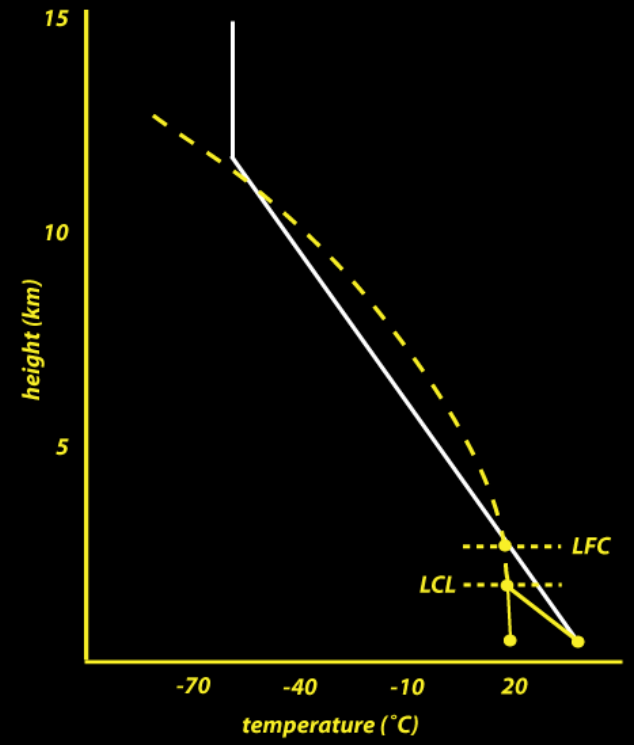
- Lift a surface parcel to saturation
- It’s COLDER than its surrounding environment
- It’s negatively buoyant

A “sounding” with potential instability



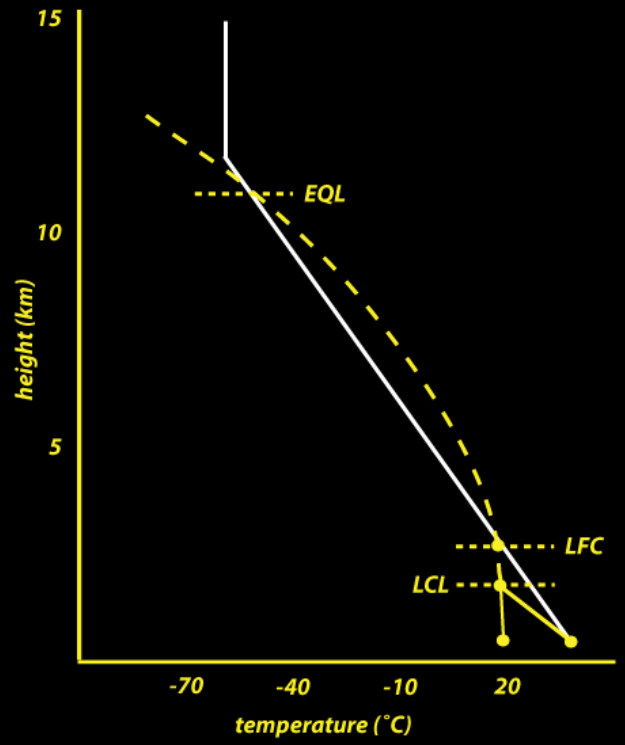
- Once saturated,, the parcel follows the moist adiabat
- Look at its new path
- It’s catching up to the environmental temperature…
- Despite its initial disadvantage, this parcel actually manages to become WARMER than its surroundings!

A “sounding” with potential instability



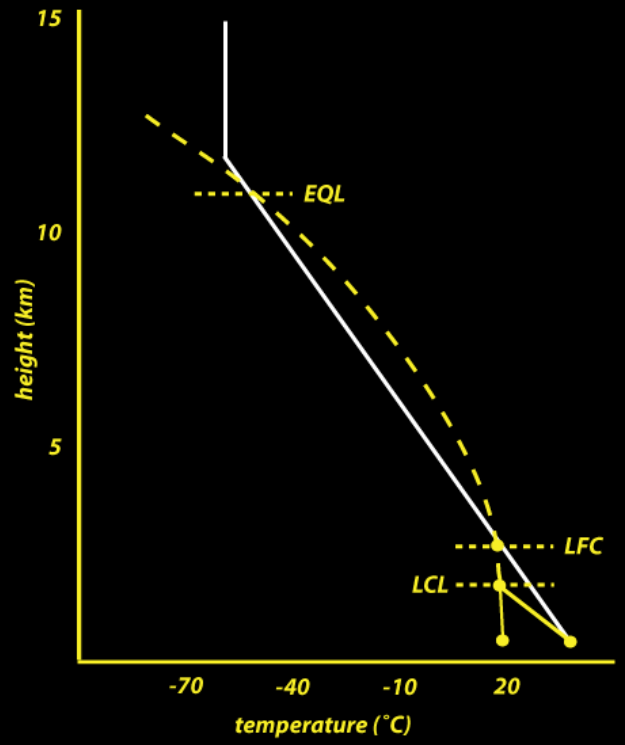
- Where the parcel becomes the same temperature as its new surroudnings is called its **LFC = level of free convection**
- Beyond this point, it’s warmer than its environment and *convecting freely*
- It does not need an external push anymore
- The parcel is **positively buoyant**

A “sounding” with potential instability



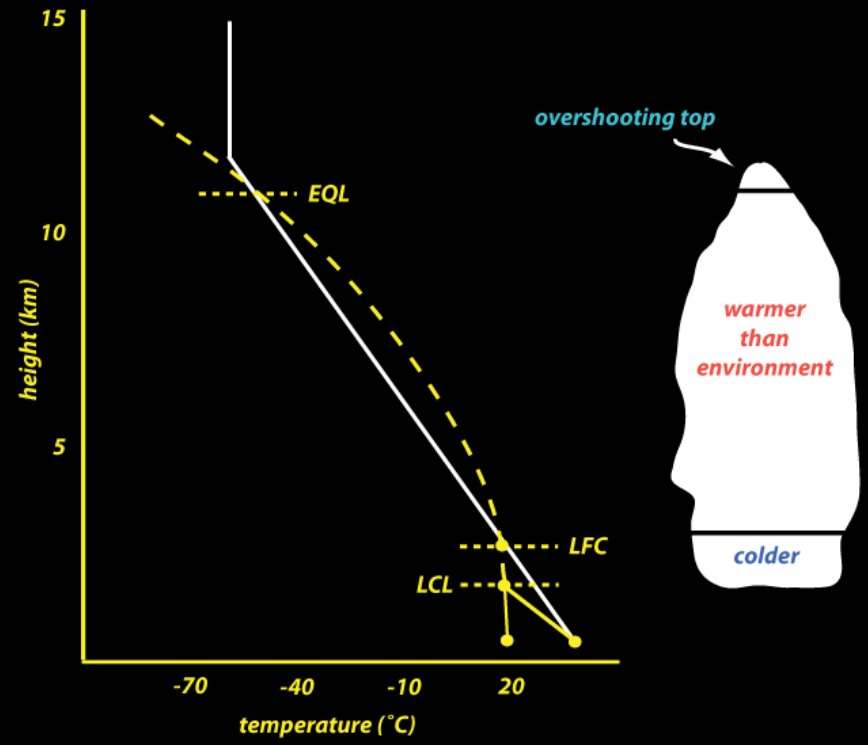
- From here, the sky’s the limit!
- Or the *tropopause*, which usually comes first
- The rising parcel eventually exhausts its supply of water vapor…
- It also approaches the stratosphere, a region of high stability
- Eventually it becomes the same temperature as its surroundings again, its **EQL or equilibrium level**

A “sounding” with potential instability



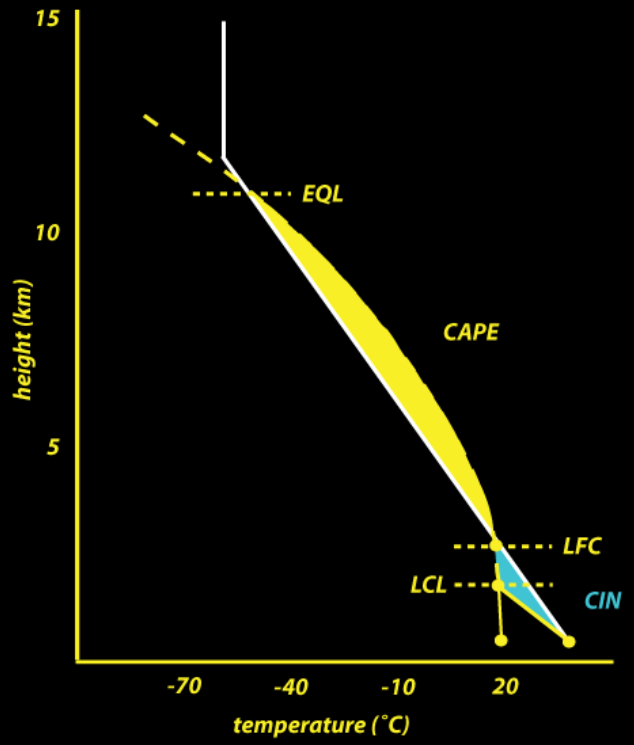
- Another term for EQL is **cloud top**
- It’s our first guess at cloud top
- I’ve drawn cloud top at a little above the EQL, since the rising parcel can overshoot it a little

Summary figure

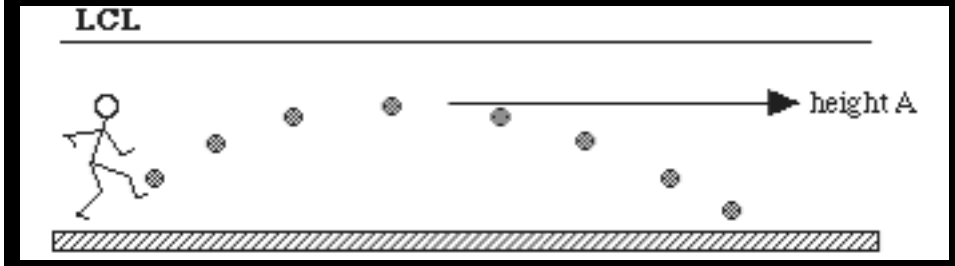


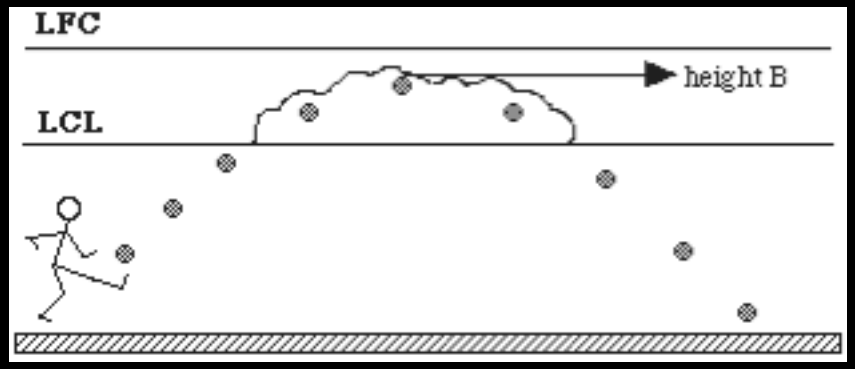
CAPE and CIN

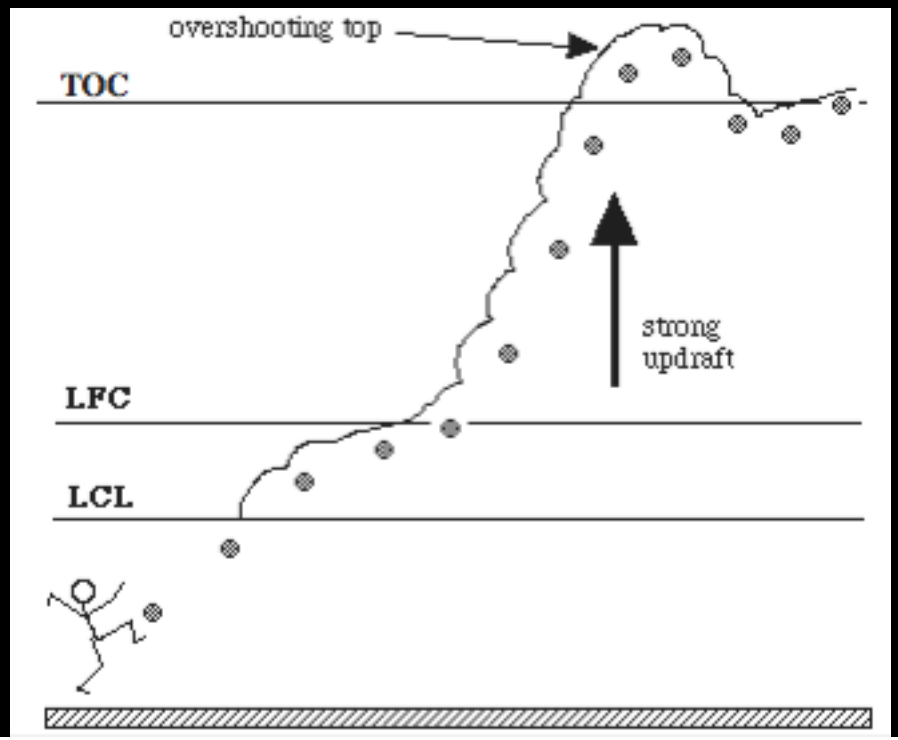
CAPE and CIN



CAPE = convective available potential energy = where parcel is warmer
CIN = convective inhibition = where parcel is colder on initial ascent



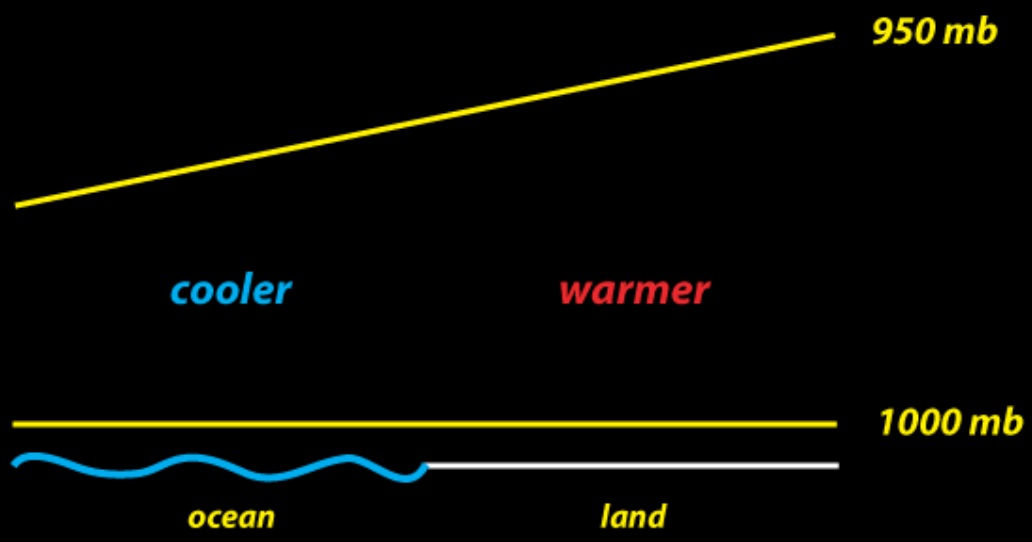




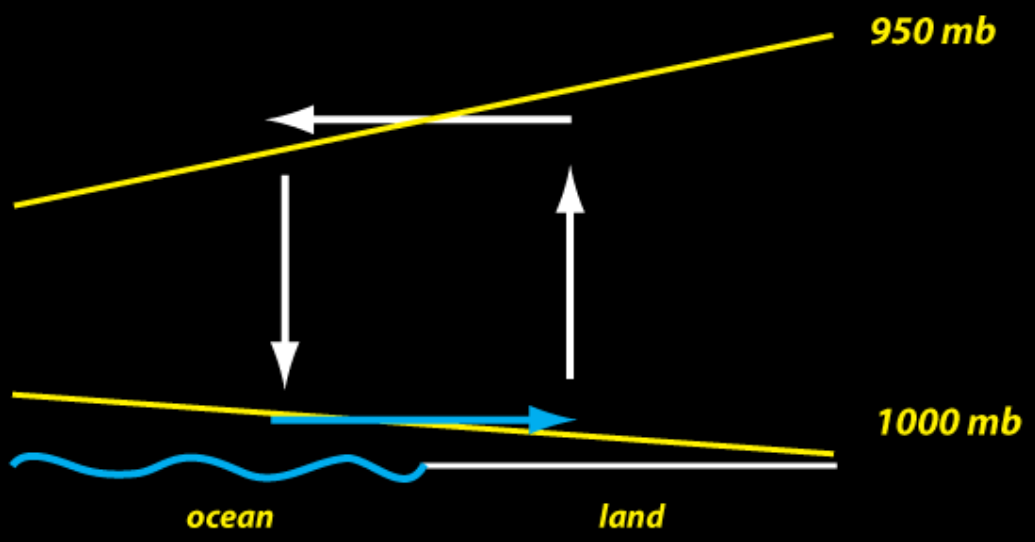
- The amount of lifting available can make an enormous difference in the weather that happens on a given day

Sea-breeze thunderstorms

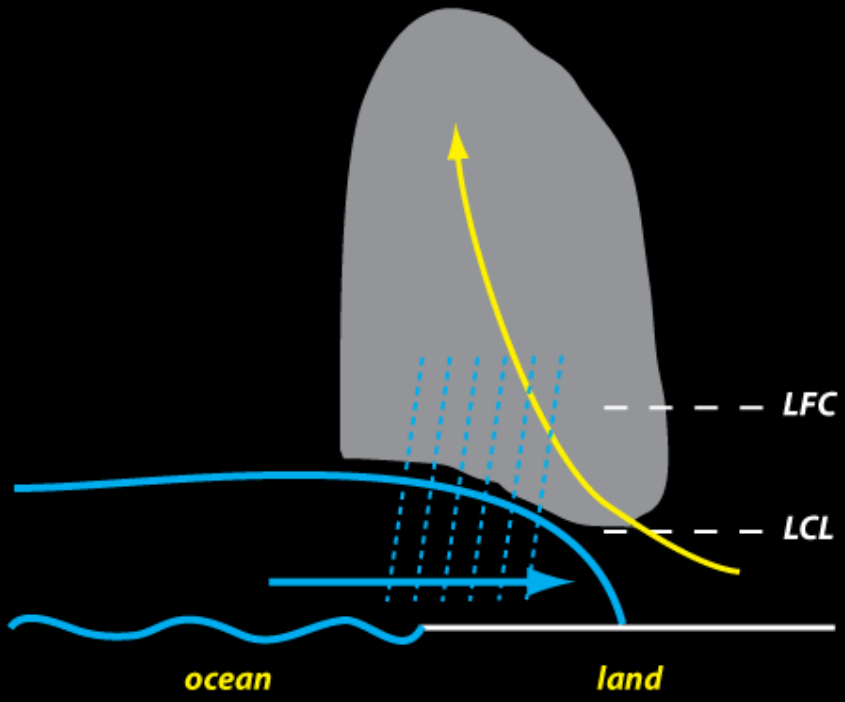
The land surface is being heated on a sunny day



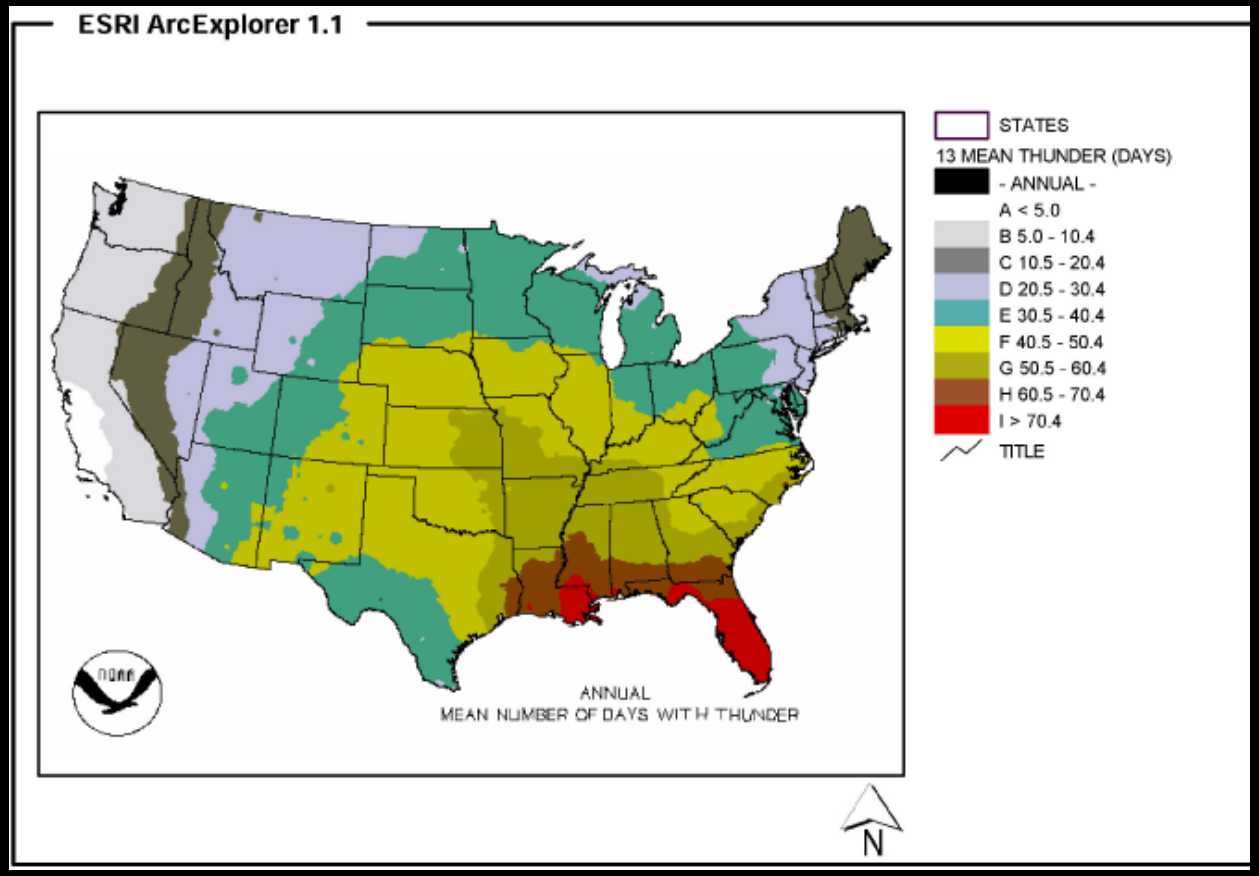
A circulation starts, and cool marine air starts pushing inland



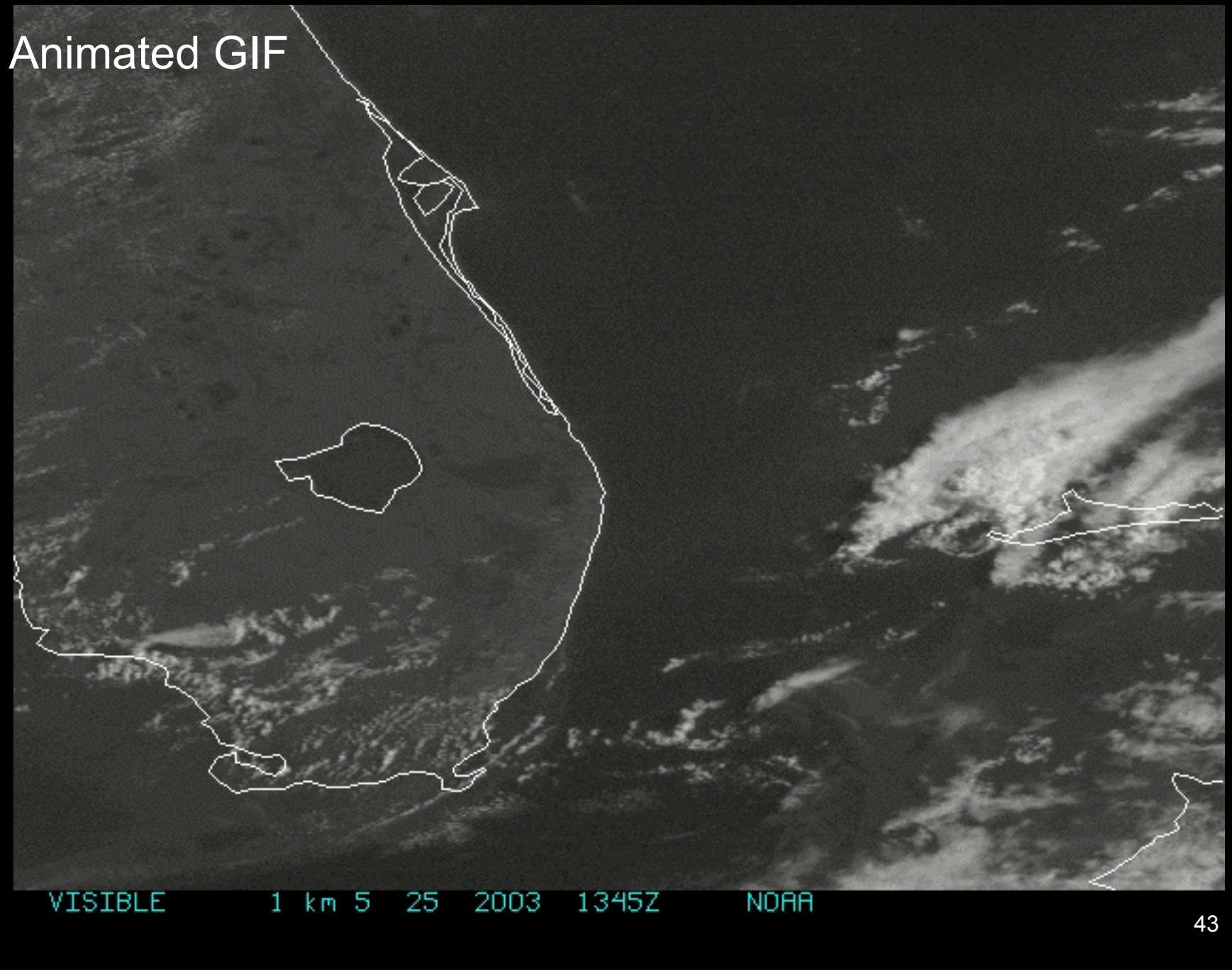
Air with different densities resist mixing, and may result in lifting the less dense air to saturation, perhaps creating thunderstorms



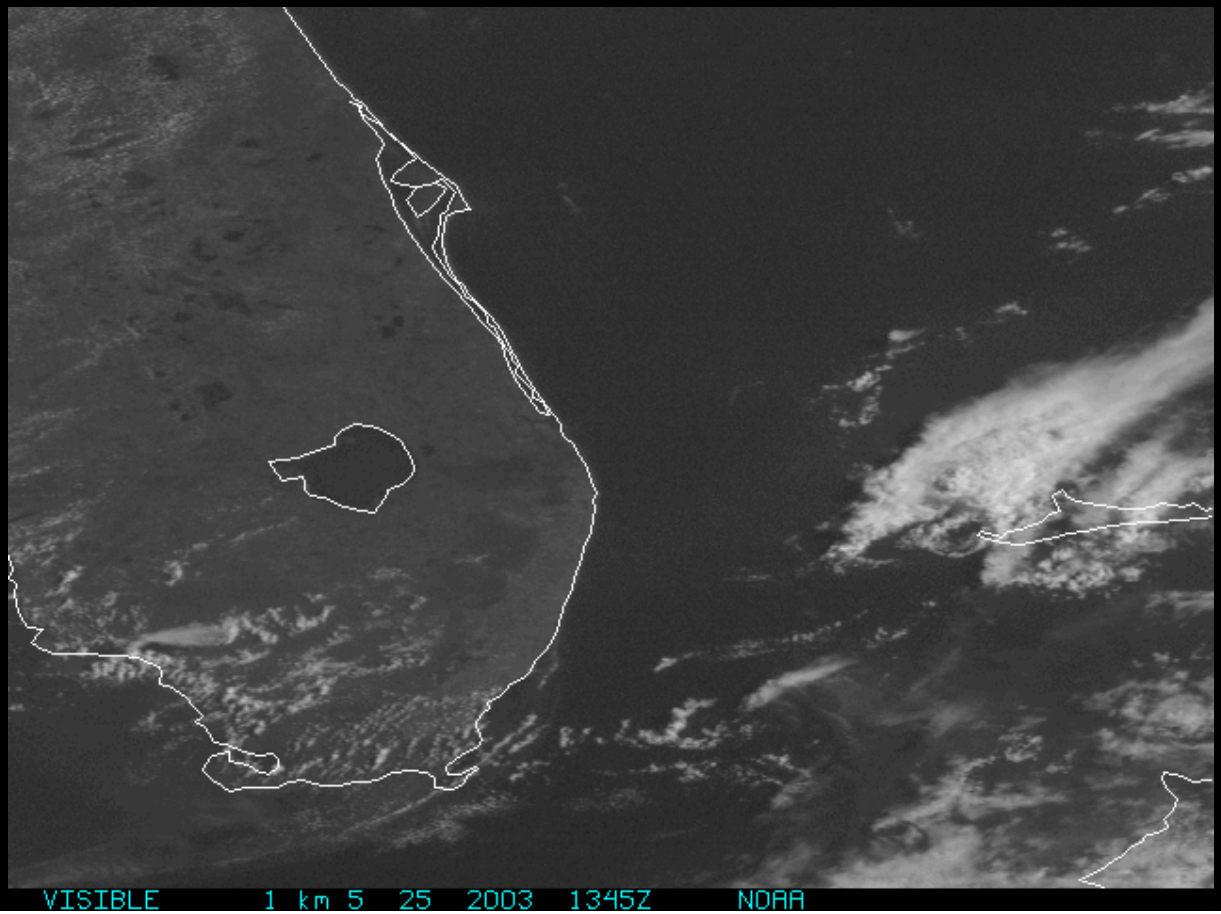
Thunderstorm frequency



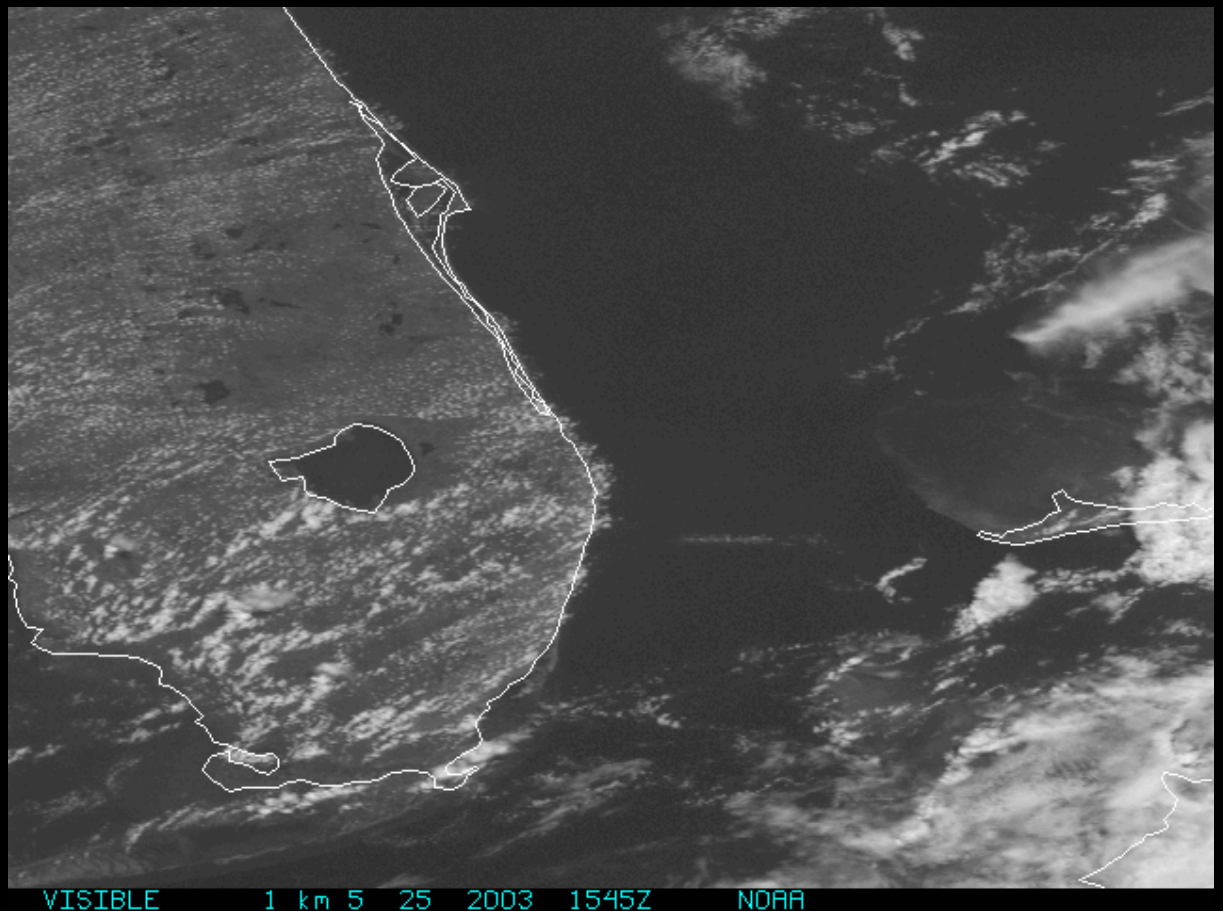
Origin of this map: http://cdo.ncdc.noaa.gov/cgi-bin/climaps/climaps.pl


Animated GIF
VISIBLE 1 km 5 25 2003 1345Z NOAA

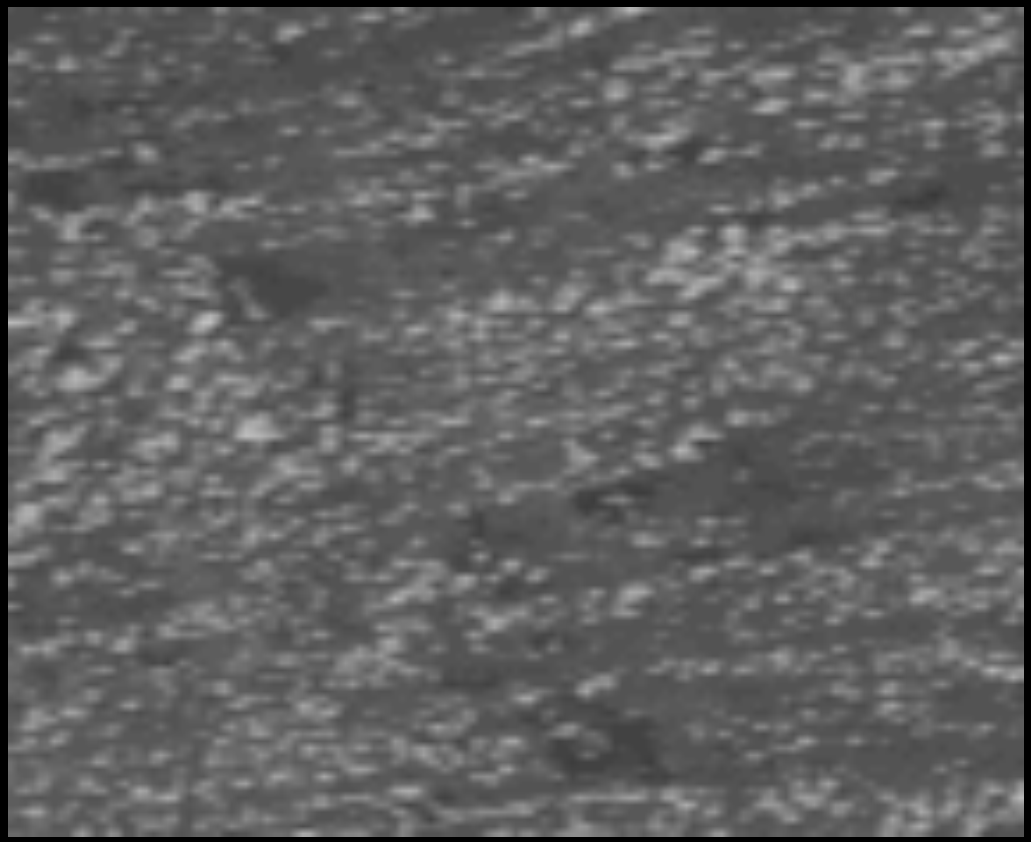
This is the image for 9:45 AM Eastern Daylight Time.
Remember, meteorologists use London time, that's why the image is Marked 1345Z. It's 1:45 PM London Standard Time.



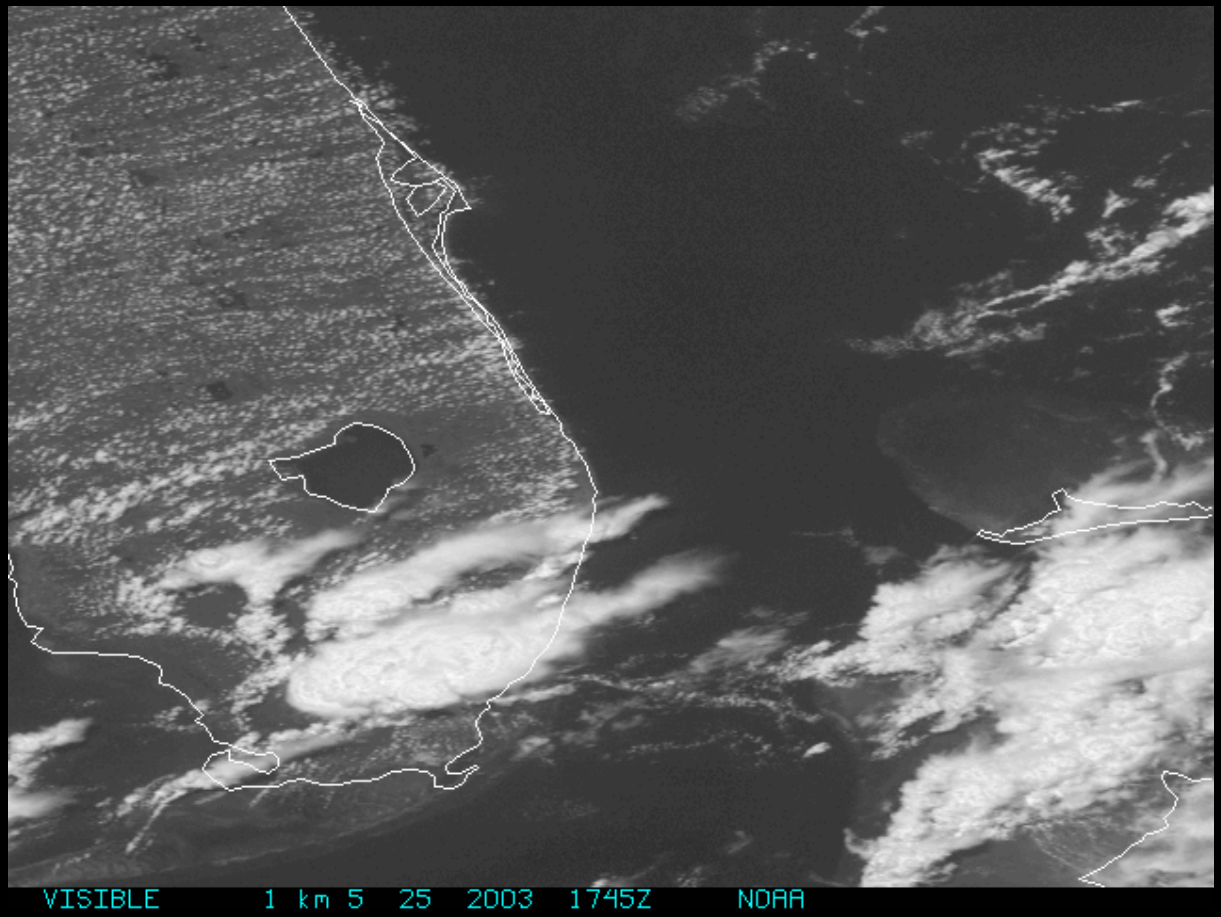
By two hours later, at 1545Z or 11:45 AM, clouds now appear over much of the land surface, being best developed near the SW shoreline. The land's getting HOT. The land air is rising as part of the sea-breeze circulation. Some of that rising land air has found its LCL. A sea-breeze front has also formed.



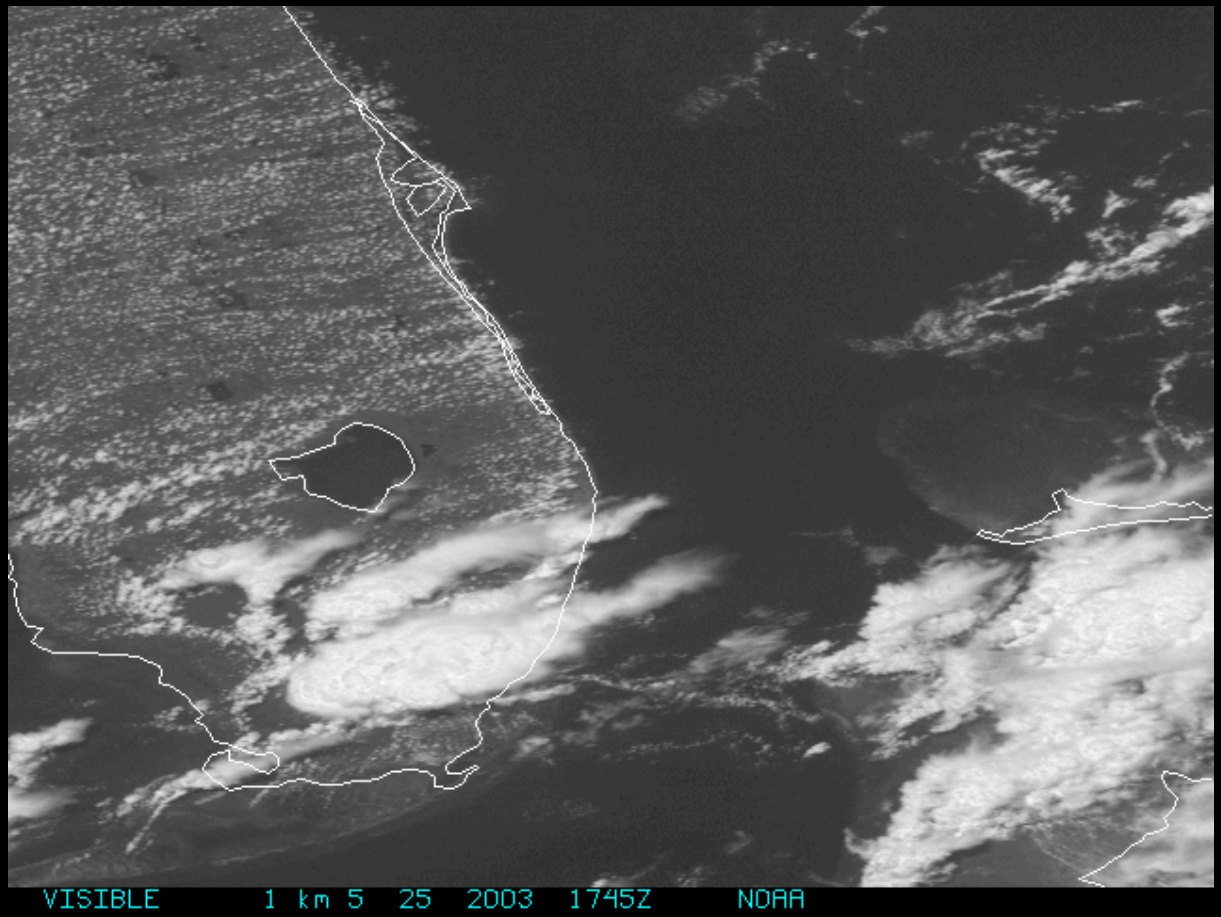
Close up of the clouds over land. “Roll clouds”.



By 1745Z, or 145 PM local time, thunderstorms have erupted over South Florida. These storms formed as the marine air pushed inland, lifting the moist air over the land. Note now the SW coast is clear. You are seeing the cooler air behind the sea-breeze front and the descending motion behind the front that makes for clear skies.



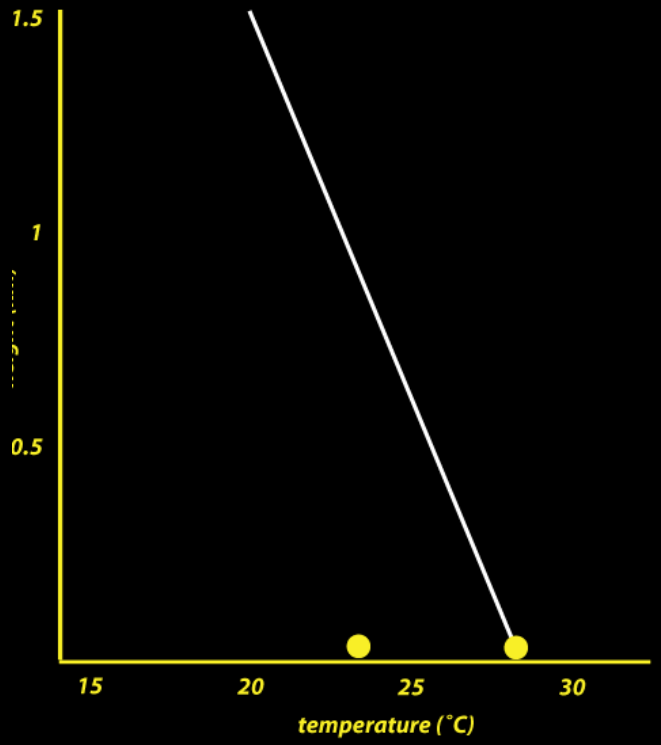
Note the roll clouds over Central Florida are now better developed.
Second, notice the roll clouds everywhere
except over Lake Okeechobee. The lake is not as strongly heated.



Roll clouds

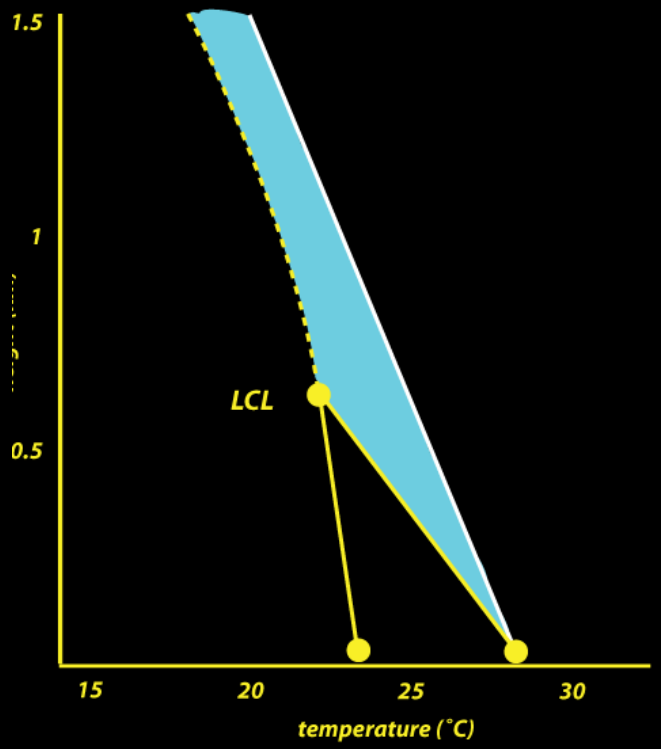
(Includes some material I didn't get to in this lecture)

Roll cloud development



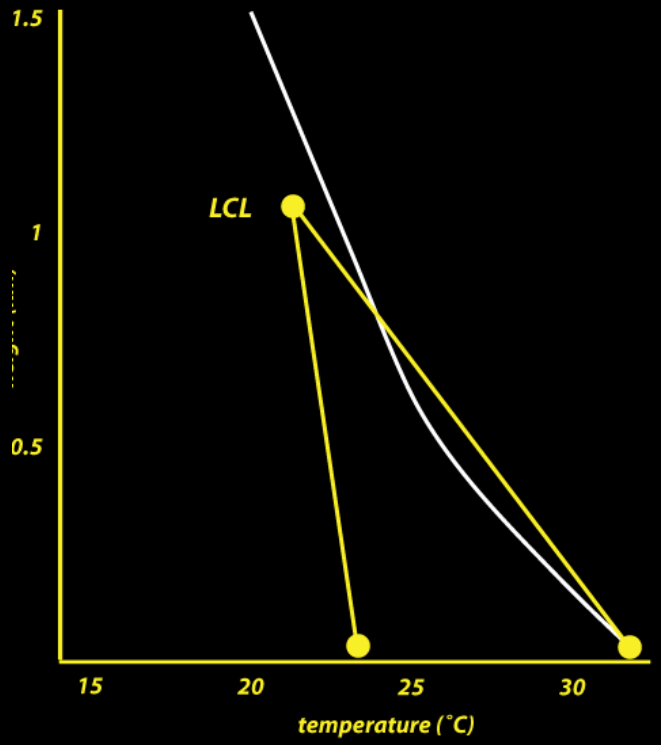
- Our environmental temperature profile at some time in the morning.
- Note we're only looking at the lowest 1.5 km or 1 mi above the surface
- Make a subsaturated parcel of surface air.

Roll cloud development

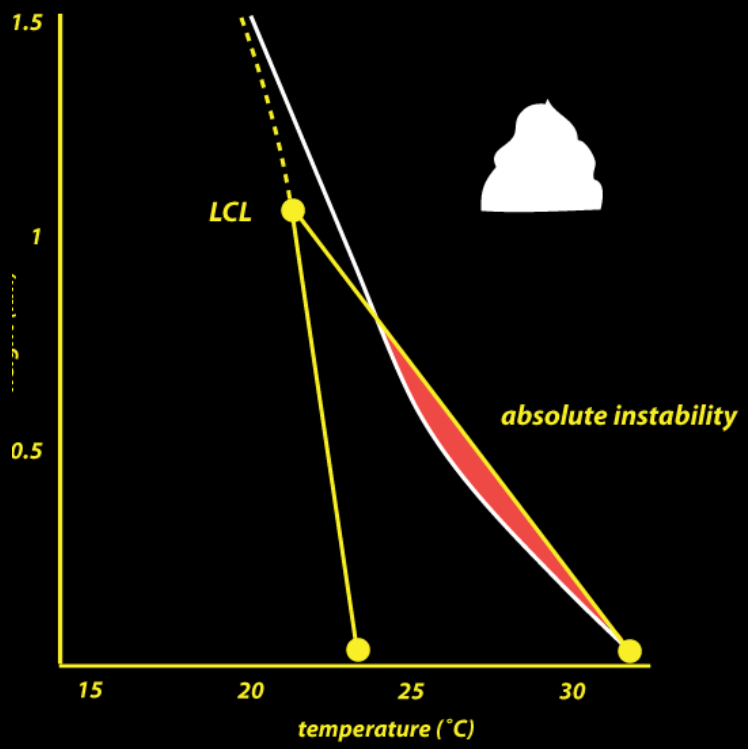


- This parcel saturates after a vertical push of about 600 m or 2000 ft, but it's always colder than its surroundings.
- We may not have sufficient lift available to get it to its LCL
- Likely weather at this point: clear sky, no clouds.

Roll cloud development

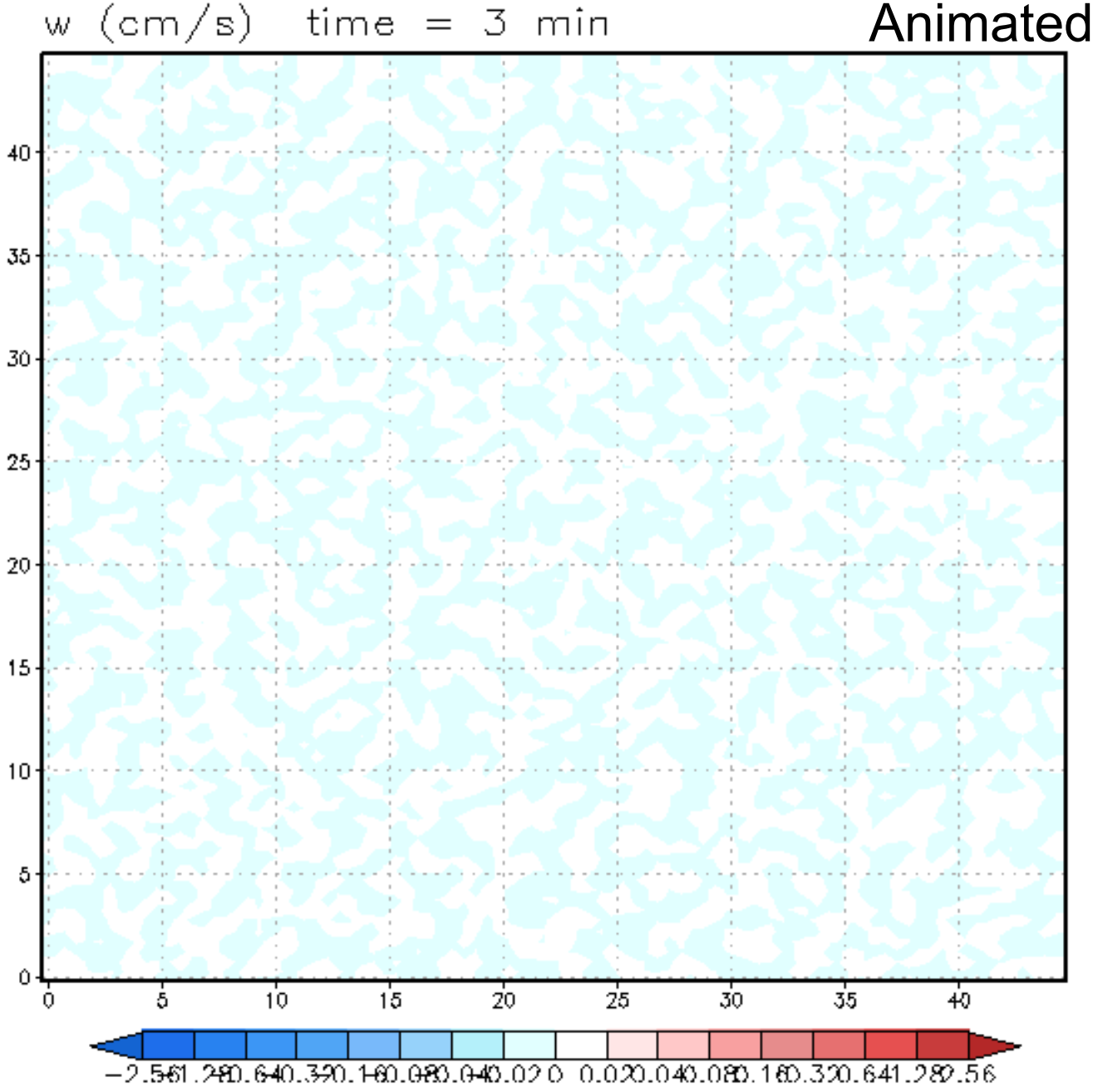


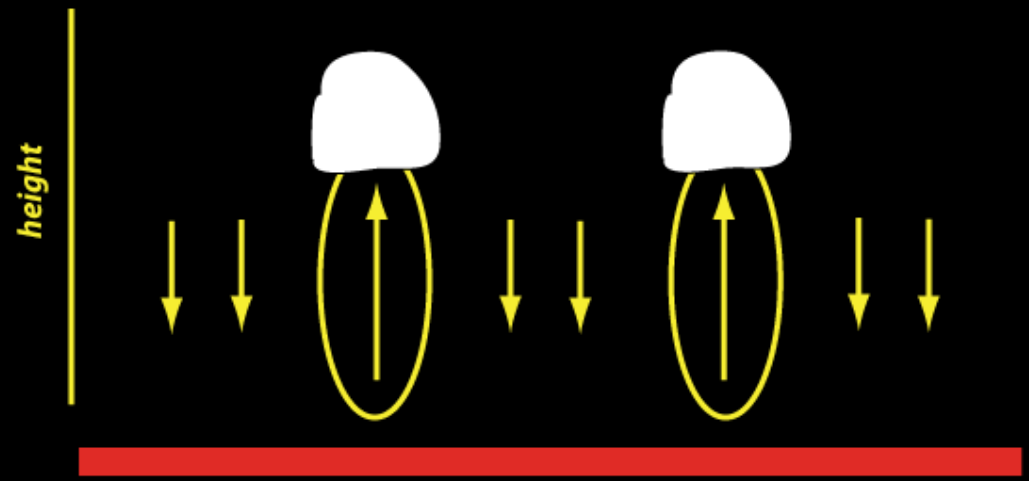
- By afternoon, however, surface heating has made the land (and air just above it) warmer, although the dew point hasn't changed
- Note the LCL (cloud base) is higher, but the parcel will get there more easily…



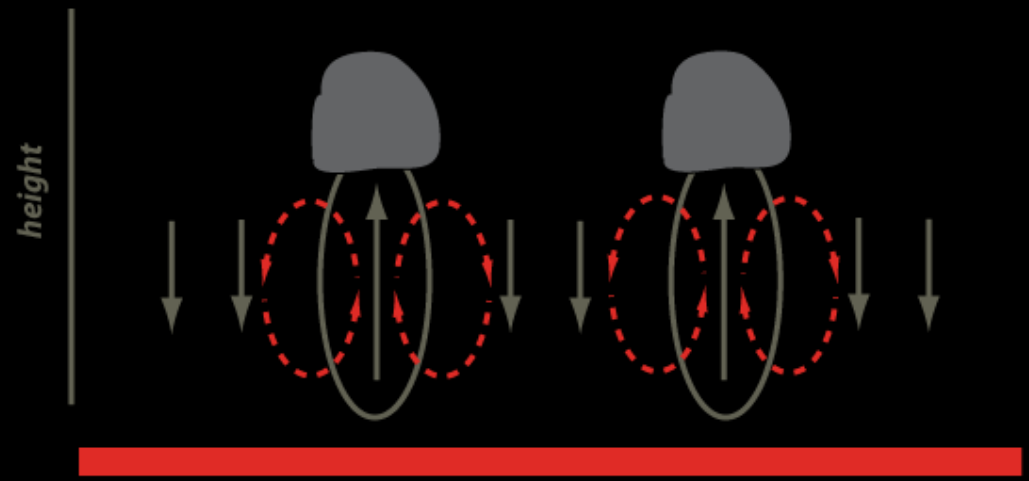
- The atmosphere near the ground is absolutely unstable, but the parcel quickly becomes colder than its surroundings again
- Overshooting is likely, and results in a shallow cloud
- Likely weather: shallow disorganized clouds or shallow roll clouds

Animated GIF





A vertical cross-section taken across the rolls would look something like this. The rolls have organized into zones of ascent and descent. Where the air is rising, it has a chance of becoming saturated. The downdraft regions are clear.



The rolls represent counter-rotating circulations in the vertical plane. Watch for their development on warm, sunny afternoons…Over your head or on satellite pictures. But be careful… not all bands of clouds are rolls or represent the manifestation of instability.

[end]