



# Clouds

## Part 2

### Textbooks and web sites references for this lecture:

- Joseph M. Moran e Michael D. Morgan, Meteorology, The Atmosphere and the Science of Weather, Mc Millan College Publishing Company, 1994, ISBN 0-02-383341-6 (§ 7)
- <https://cloudatlas.wmo.int/en/clouds.html>



# Middle Clouds

## ■ Altocumulus

- <1 km thick
- mostly water drops
- Gray, puffy
- Differences from cirrocumulus
  - » Larger puffs
  - » More dark/light contrast



## ■ Altostratus

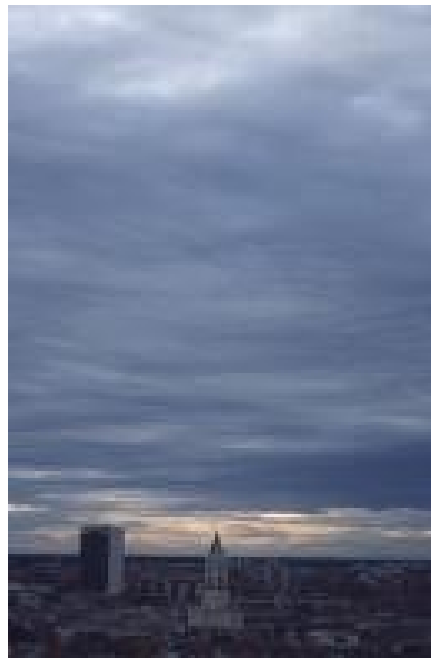
- Gray, blue-gray
- Often covers entire sky
- Sun or moon may show through dimly
  - » Usually no shadows





# Altostratus

- Altostratus (As) uniformed -gray layers that can cover all the sky, with such thickness can totally darken the Sun or create halos; they can give light rains.





# Altostratus

*Altostratus*  
PSC Cloud Photo







# Altostratus

Alto Stratus Castellanus





# Alto cumulus

- Alto cumulus (Ac) spots or puff sometimes waved or bands parallels (due to wave also no orographic), of dimensions  $> Cc$ , with net contours (water vapor), sometimes disposed contours in more layers





# Alto cumulus

- Mid level cumulus clouds







# Alto cumulus







# Alto cumulus

Alto Cumulus Radiatus





# Alto cumulus



Alto Cumulus Undulatus



# Low Clouds

## ■ Stratus

- Uniform, gray
- Resembles fog that does not reach the ground
- Usually no precipitation, but light mist/drizzle possible

## ■ Stratocumulus

- Low lumpy clouds
- Breaks (usually) between cloud elements
- Lower base and larger elements than altostratus

## ■ Nimbostratus

- Dark gray
- Continuous light to moderate rain or snow
- Evaporating rain below can form *stratus fractus*







# Nimbostratus

Nimbostratus (Ns) between middle clouds and those lower parts, extended jagged darkgray (between Sc and St) because of moderately thick, sometimes it is associated with Cb which provokes shower, alternating rainfall more weak but persistent.



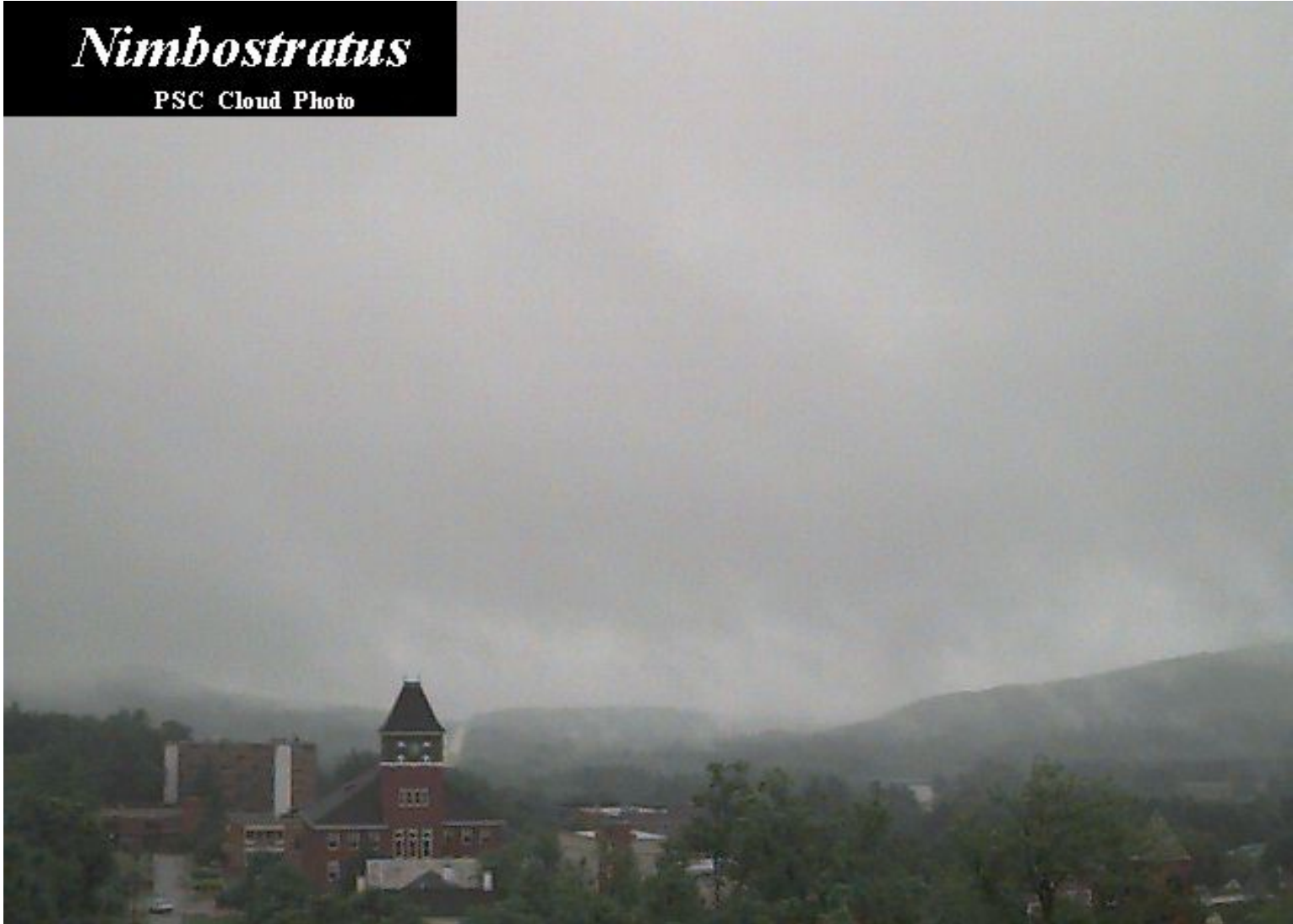


# Nimbostratus

- Stratus clouds that are precipitating

*Nimbostratus*

PSC Cloud Photo





# Stratocumulus

- Stratocumulus (Sc) shape of large puffy or coils separated by serene sky, sometimes it is disposed undulates in the presence of atmospheric wave , rarely brings rains





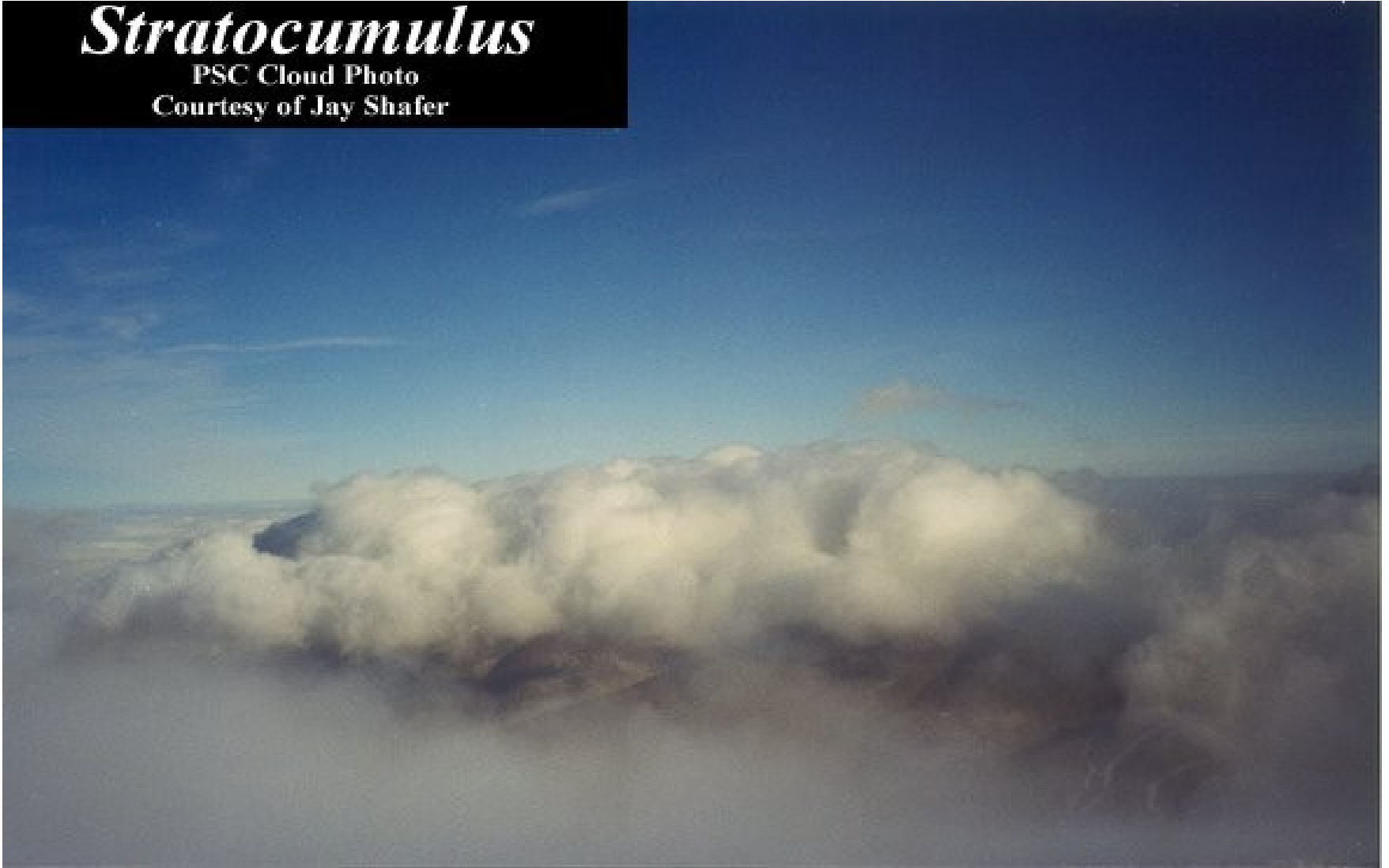


# Stratocumulus

- Cross between stratus and cumulus

## *Stratocumulus*

PSC Cloud Photo  
Courtesy of Jay Shafer





# Stratocumulus

A Layer of Stratocumulus  
Cloud viewed from above





# Stratocumulus cloud streets



Stratocumulus undulatus





# Stratus

- extended grey-uniformed covering all the horizon and also the peaks of hills (high fog), sometimes can “come down” until earth (fog), produces only drizzles





# Stratus

- Stratus clouds are usually the lowest of the low clouds.
- Often appear as an overcast deck (as shown in next slide), but can be scattered.
- The individual cloud elements have very ill-defined edges compared to cumulus
- Fog is just stratus clouds on the surface





# Stratus fractus







# Stratus on Ground (fog)





# Stratiform cloud layers





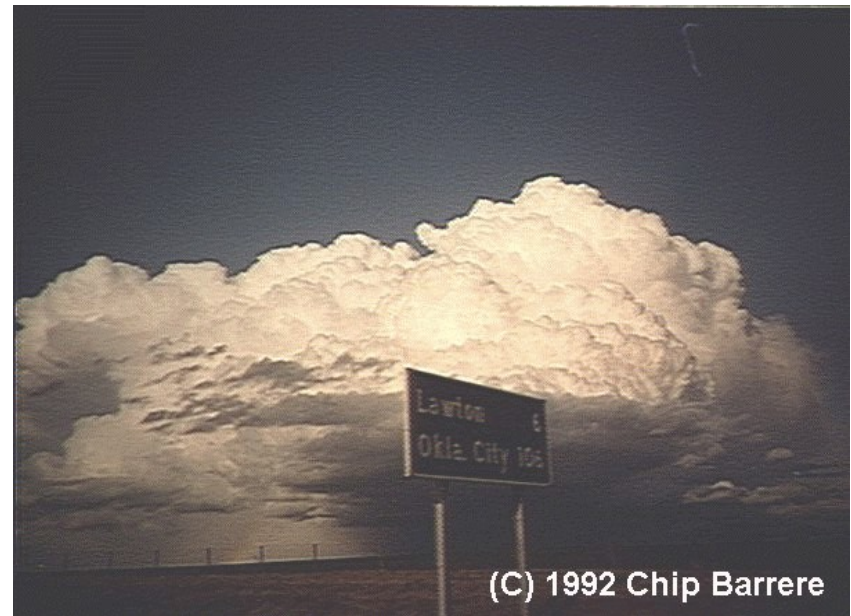
# Vertically developed clouds

## ■ Cumulus

- Puffy “cotton”
- Flat base, rounded top
- More space between cloud elements than stratocumulus

## ■ Cumulonimbus

- Thunderstorm cloud
- Very tall, often reaching tropopause
- Individual or grouped
- Large energy release from water vapor condensation





# Cumulus Clouds

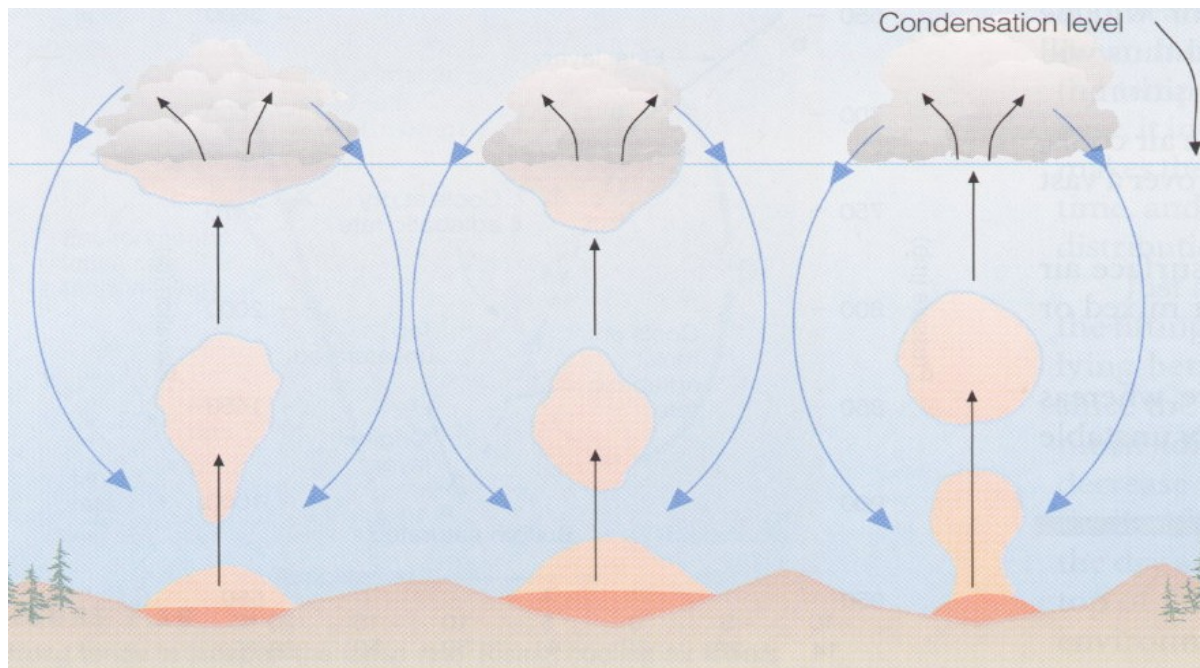
- Cumulus clouds are puffy (like popcorn, cauliflower)
- Often have noticeable vertical development
- Cells can be rather isolated or they can be grouped together in clusters as shown
- The base of a cumulus cloud can look like a stratus cloud if it is overhead.
- Thick cumulus can make skies dark (filters out sun's rays)





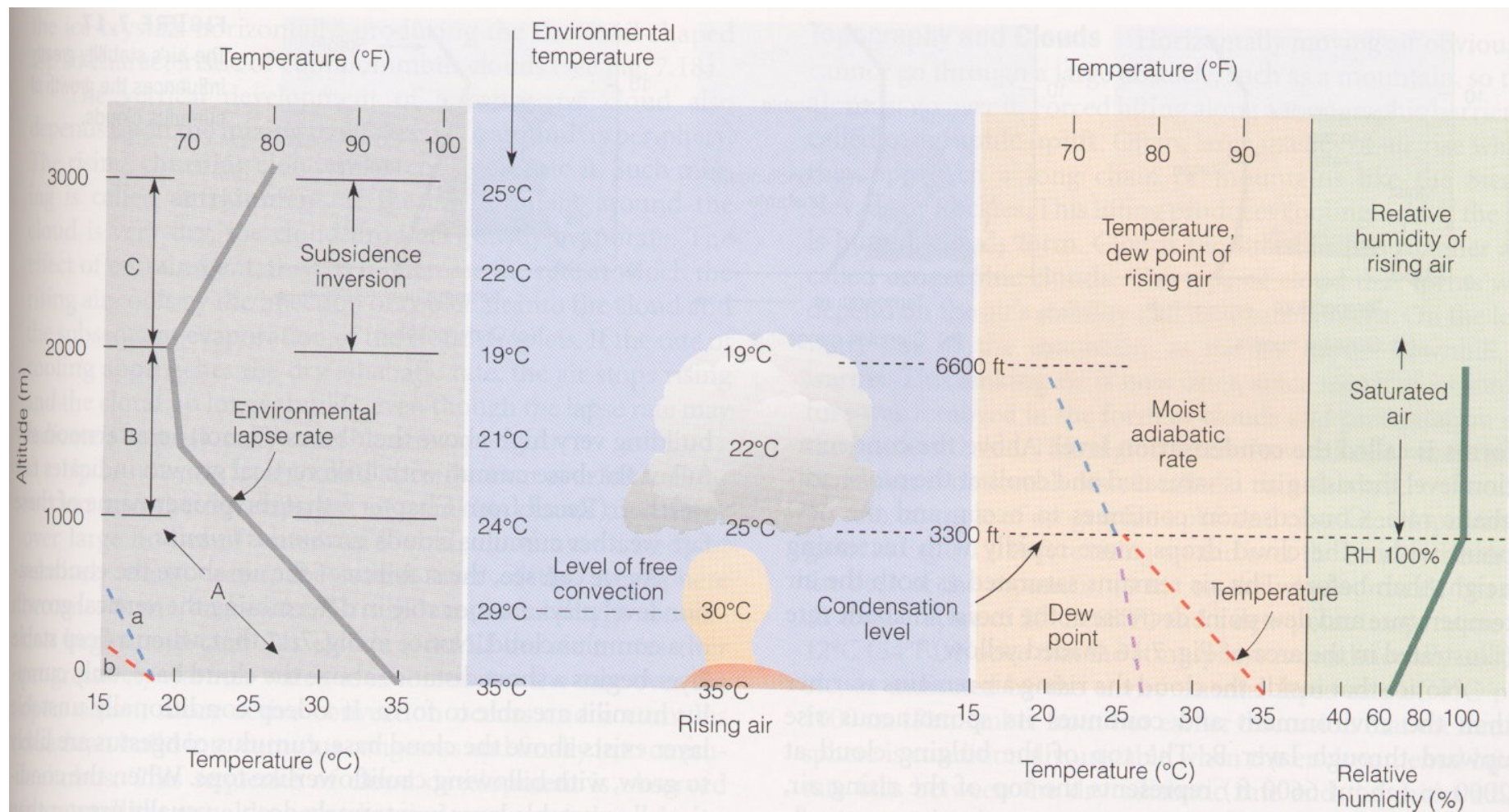
# Fair weather cumulus cloud development

- Air rises due to surface heating
- RH rises as rising parcel cools
- Cloud forms at  $RH \sim 100\%$
- Rising is strongly suppressed at base of subsidence inversion produced from sinking motion associated with high pressure system
- Sinking air is found between cloud elements
  - Why?





# Fair weather cumulus cloud development schematic







# Cumulus

- Cumulus (Cu) resembles to puffy of cotton that punctuates the sky; their thickness follow the cycle of the solar radiation, with great cover in afternoon and dissolution towards evening; it does not give rain; since LCL depends on RH ★ humidity of the ground, their distribution and thickness depends on the surface (less frequent on sea, snow,...)







# Cumulus imponentis

- Cumulus congestus ( $T_c$ ) when the atmosphere is a little bit unstable, the vertical extension of the Cu tends to be grow and the cloud assumes the typical aspect of cauliflower; it can cause an isolated shower.





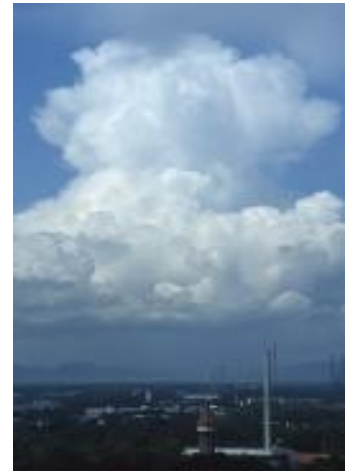
# Cumulus congestus (castellanus)





# Cumulonimbus

Cumulonimbus(Cb)when the ascending currents in the Tc catch up the tropopause and invert their way, they form the Cb; the strong descendent currents generate precipitations much intense (but short), also snow or hailstorm; sometimes it appears the anvil for distension of the air on climb in tropopausa and/or the stratosphere



- Cumulus clouds with precipitation and thunder/lightning activity





# Cumulonimbus



## Cumulonimbus with anvil

*Cumulonimbus*

PSC Cloud Photo  
Courtesy of Bill Schmitz





# Cumulonimbus with anvil



# Cumulonimbus with Pileus cap



-- Photograph by Geoff Manikin --  
-- U. of Illinois Cloud Catalog --





# Cumulonimbus with tornado





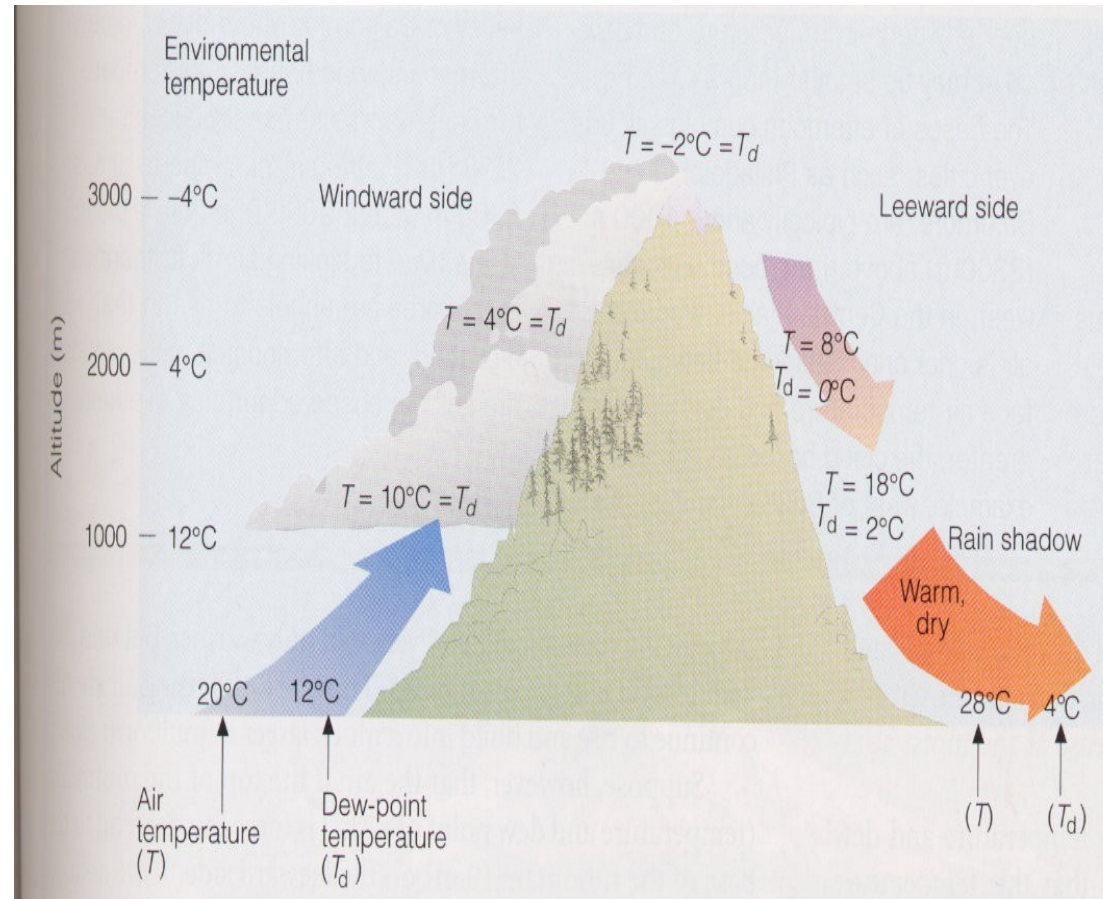


# Cumulonimbus mammatus



# Orographic clouds

- Clouds can also be caused by mountains or hills
- Result to air flowing up and over mountains which causes condensation to occur and clouds to form
- Forced lifting along a topographic barrier causes air parcel expansion and cooling
- Clouds and precipitation often develop on upwind side of obstacle
- Air dries further during descent on downwind side





# Cap Clouds

- Air containing water vapor lifted until it is saturated, producing liquid water cloud droplets which can "cap" the summit

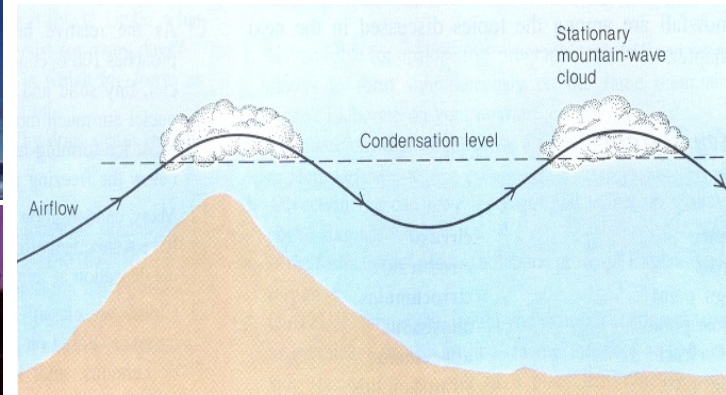






# Lenticular and flag clouds

- **Lenticular clouds** or orographic waves clouds: created by the waved currents crossing the mountains when, in the crest of the wave, the LCL is reached or exceeded; they have a lens shape and remain nearly stationary because the generating waves are stationary; they enter in the category of Ac; usually present downwind to large mountain ranges (e.g. Alps during foehn conditions ). Sometimes these clouds are formed only near the peak, extending leeward (**flag clouds**)

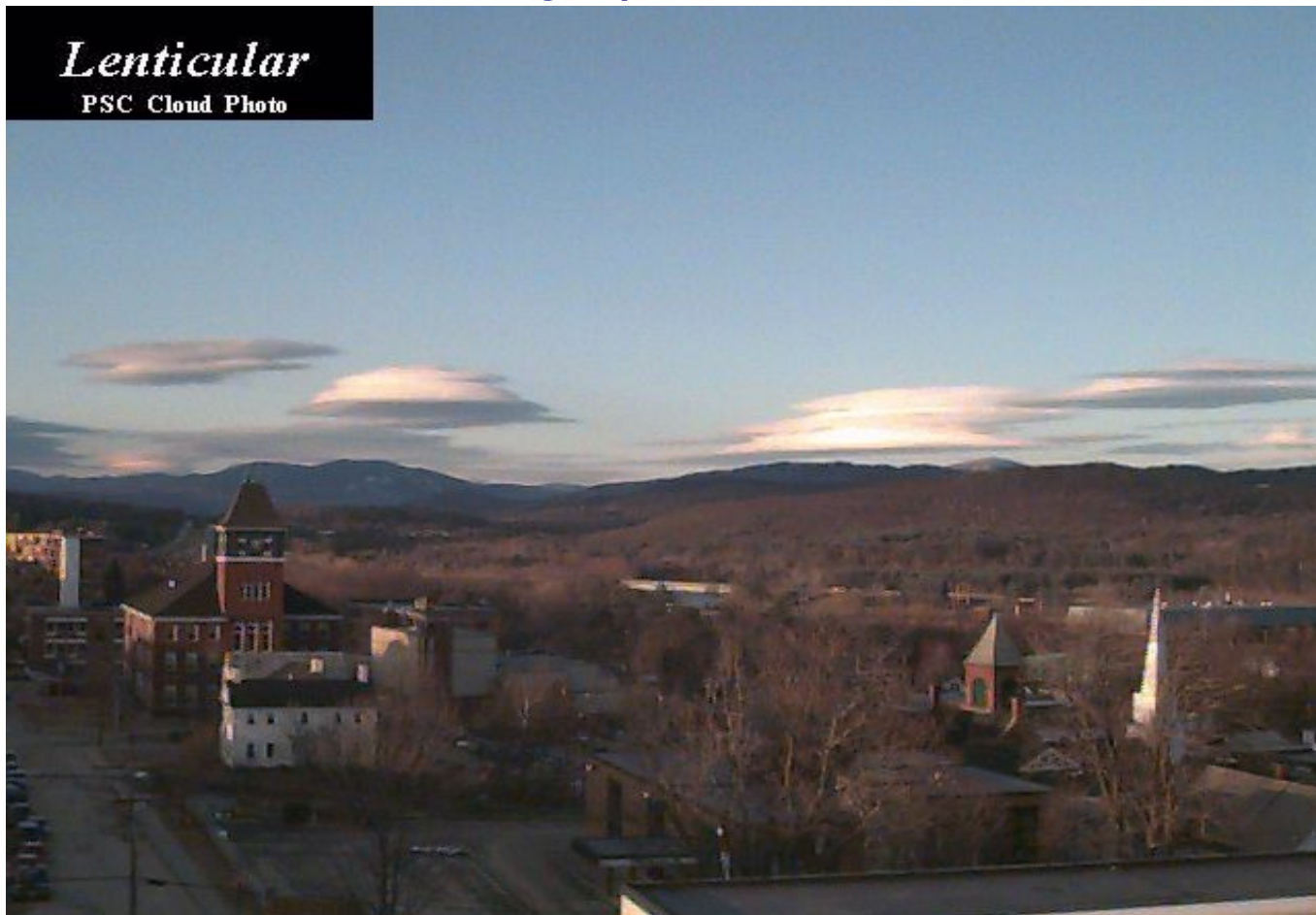






# Lenticular Clouds

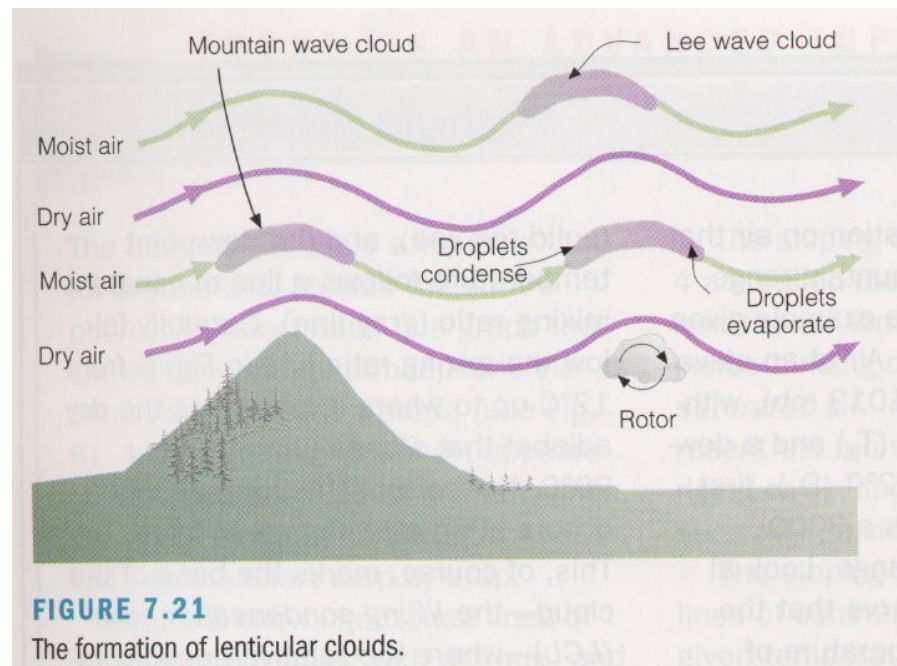
- Lenticular means “like a lens”
- Looks like flying saucers
- Forms from air rising up a mountain





# Lenticular clouds

- Stable air flowing over a mountain range often forms a series of waves
  - Think of water waves formed downstream of a submerged boulder
- Air cools during rising portion of wave and warms during descent
- Clouds form near peaks of waves
- A large swirling eddy forms beneath the lee wave cloud
  - Observed in formation of rotor cloud
  - Very dangerous for aircraft





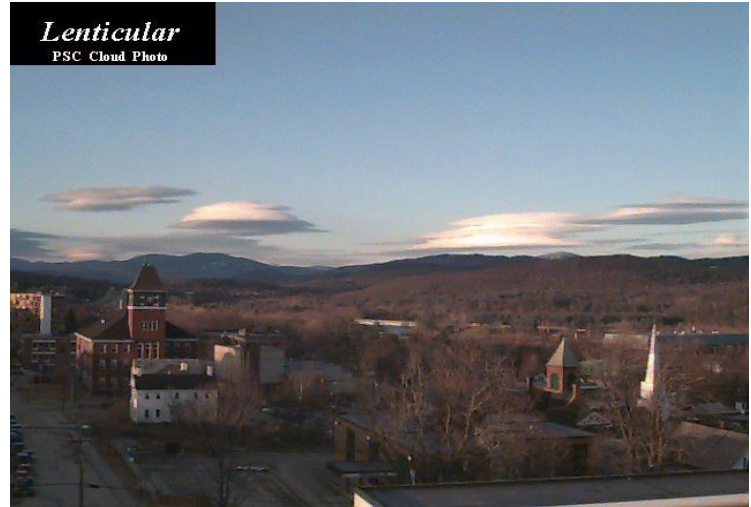


# Lenticular clouds

**Lenticular**  
PSC Cloud Photo  
Courtesy of James D. Rufo



**Lenticular**  
PSC Cloud Photo





# Kelvin-Helmholtz Billows

- Occurs in regions of strong density and velocity changes. (dynamics class)







# Non-tropospheric clouds



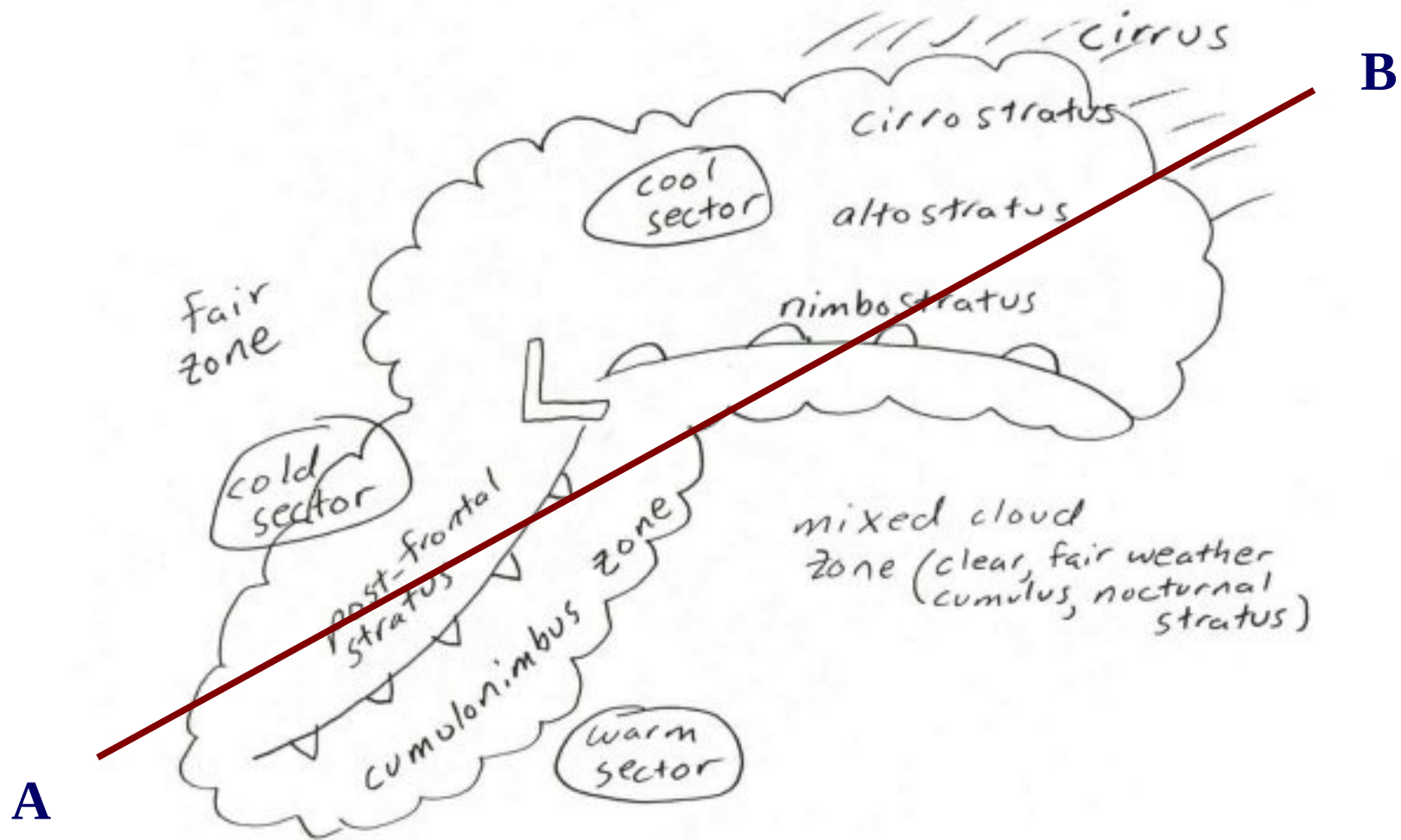
• **Nacreous clouds**, quite coloured, present in the high stratosphere (where  $T \cong 0^\circ\text{C} \rightarrow$  soild or supercooled water vapor); with shape of Ci, and veiled; usually visible at high latitudes in winter, better at the sunset; their genesis and evolution is mysterious



**Noctilucent clouds**, waved, shaped like Ci, are located in the high mesosphere ( $T < -50^\circ\text{C}$ ), composed by ice deposited on aerosols (by meteorites?); very rare, visible only at high latitudes immediately before or after the sunset



# Clouds and fronts





# Cloud and extra-tropical cyclones

