Atmospheric Pollution

Lecture 3

Sahraei
Physics Department
Razi university

http://www.razi.ac.ir/sahraei

PBL height (several tens of meters to several kilometers)

Depend on:

1. rate of heating or cooling of the surface

2. strength of winds

3. the roughness and topographical characteristics of the surface

4. large-scale vertical motions

5. horizontal advections of heat and moisture

Daytime: PBL height on the order of 1 km (0.2-5 km)

Nighttime: PBL height on the order of 100 m (20-500 m)

A strong diurnal variation in meteorological variables can be found within the PBL.

Large diurnal temperature variations (relative to the free troposphere above).

Kinds of atmospheric boundary layers

Marine	Continental
Little diurnal variability	Strong diurnal variability
1-2 km (3 max, maybe)	Up to 5 km over deserts
Wave state important	Surface shape fixed, but important

Difference between boundary layer and free atmosphere

The boundary layer is:

- More turbulent
- With stronger friction
- With more rapid dispersion of pollutants
- With non-geostrophic winds while the free atmosphere is often with geostrophic winds

Significance of the boundary layer (BL)

1) People spend most of their lives in the BL.

2) Daily weather forecasts of dew, frost, and maximum and minimum temperatures are really BL forecasts.

3) Pollution is trapped in the BL.

4) Fog occurs within the BL.

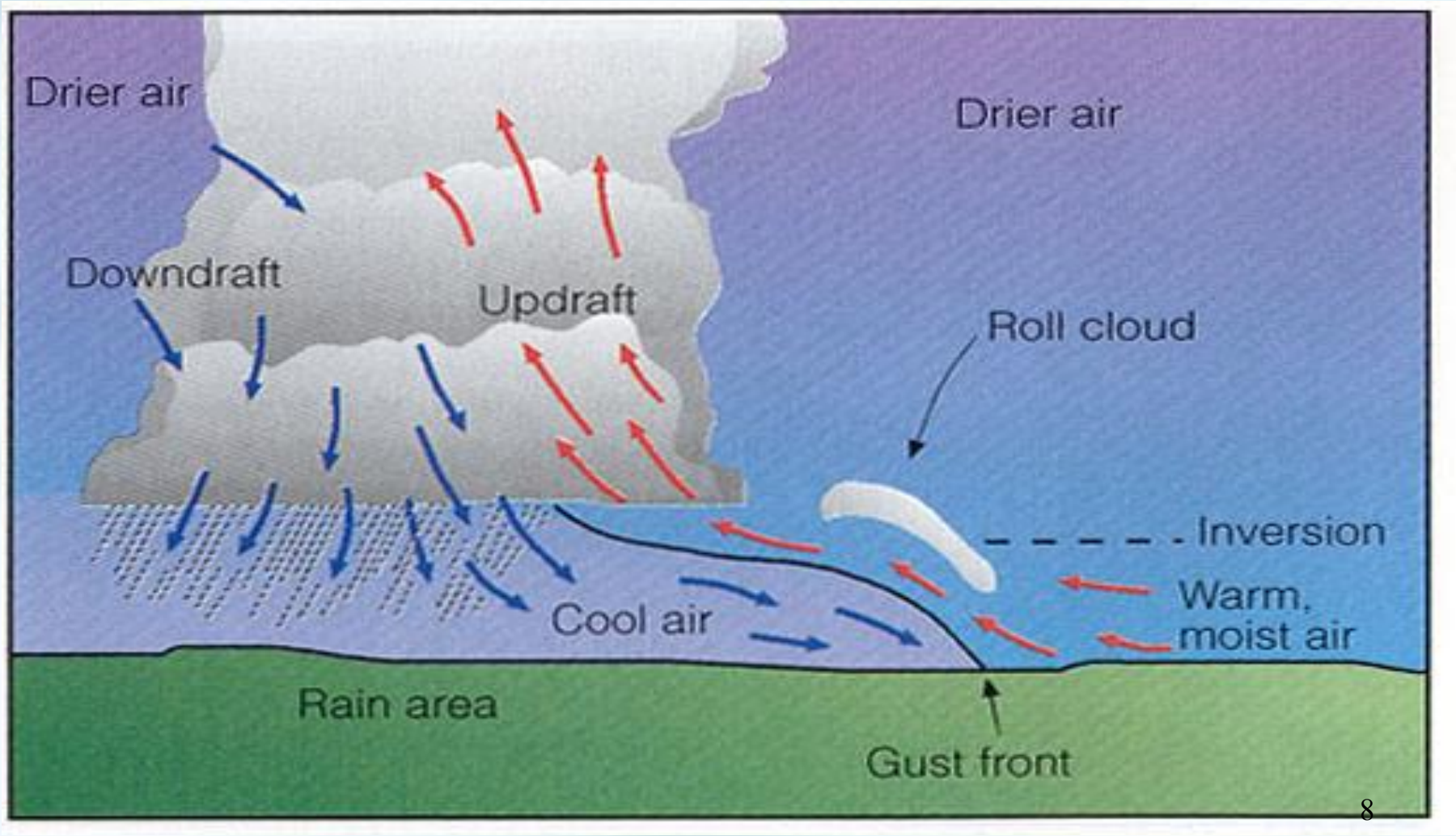
5) The primary energy source for the whole atmosphere is solar radiation, which for the most part is absorbed at the ground and transmitted to the rest of the atmosphere by BL processes.

6) Crops are grown in the BL. Pollen is distributed by boundary layer circulations.

7) Cloud nuclei are stirred into the air from the surface by BL processes.

8) Virtually all water vapor that reaches the FA is first transported through the BL by turbulent and advective processes.

9) Thunderstorm and hurricane evolution are tied to the inflow of moist BL air.

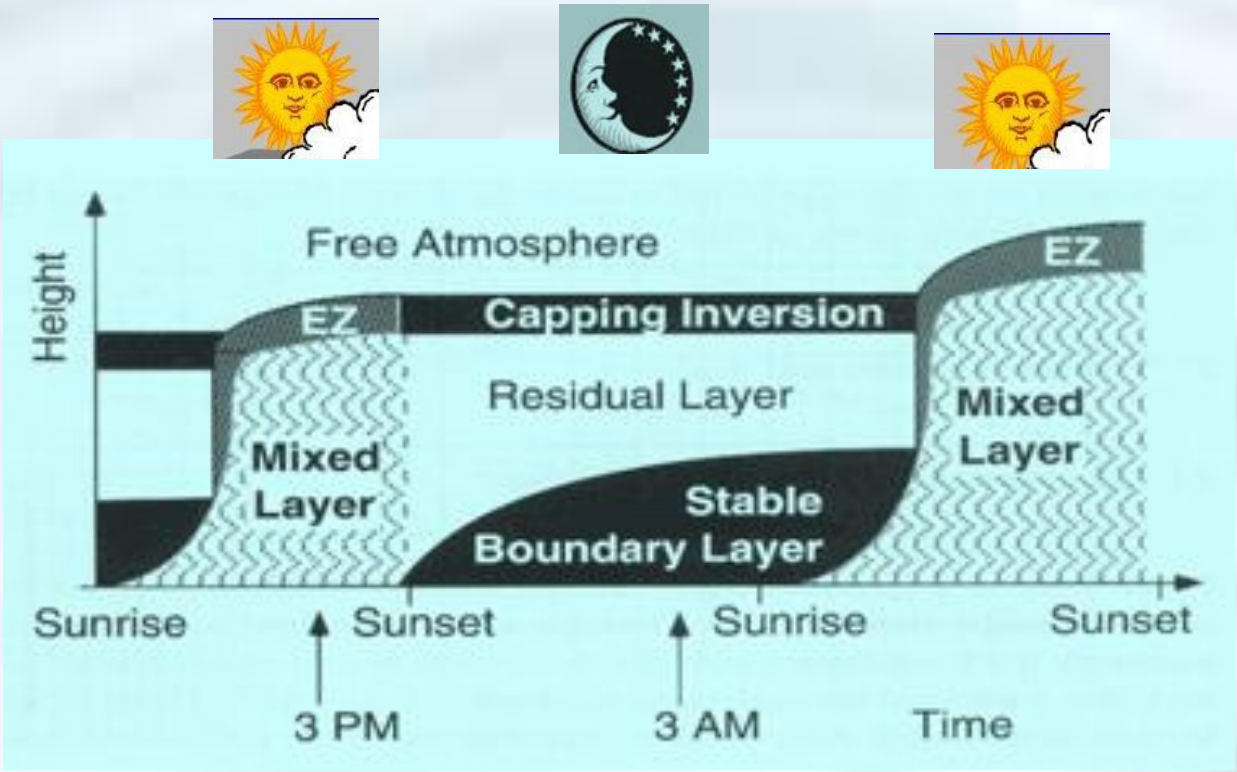


10) About 50% of the atmosphere's kinetic energy is dissipated in the BL.

11) Wind stress on the sea surface is the primary energy source for ocean currents.

PBL structure & evolution

Component of the boundary layer during fair weather



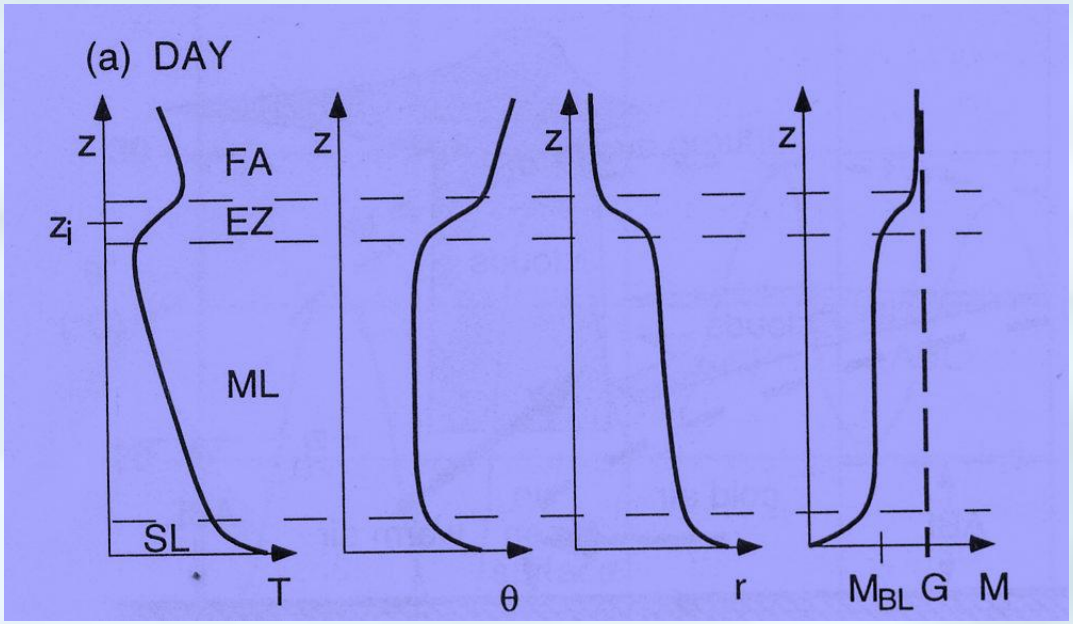
The stable boundary layer over land in the diurnal cycle .
An important scientific challenge is to develop a turbulent mixing scheme which covers all three regimes (Stull, 1988)

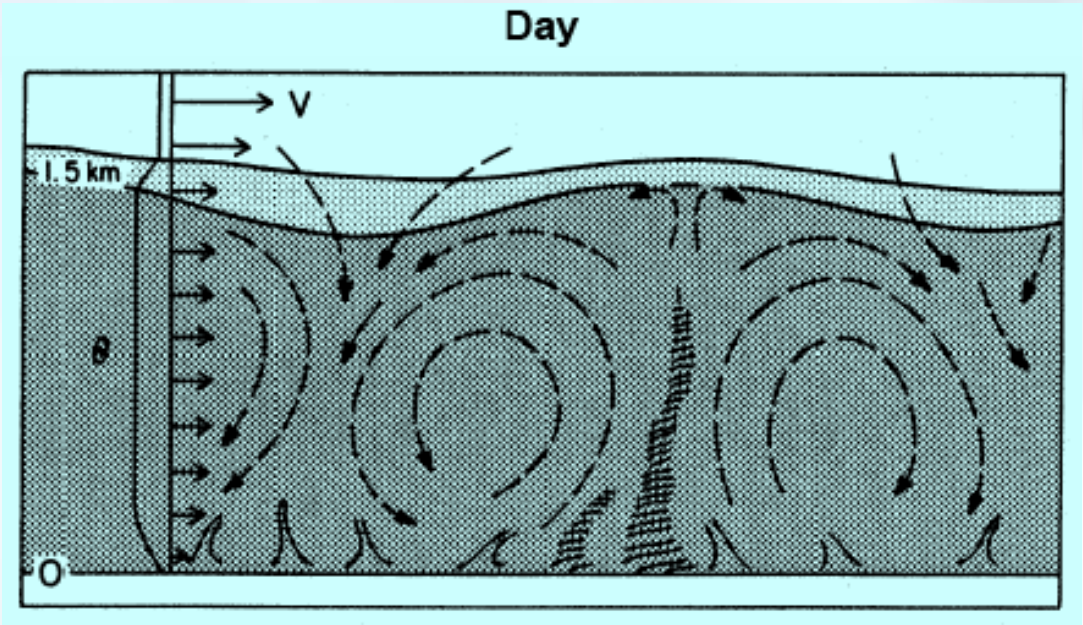
Typical profiles of potential temperature, wind and humidity over land in midlatitudes during cloudless conditions.

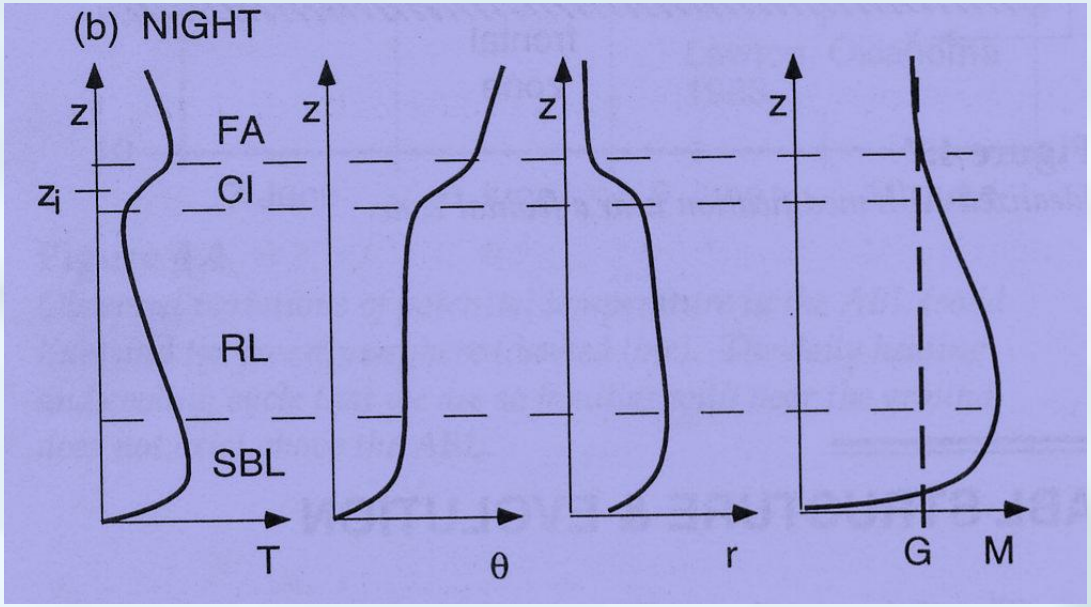
$$\theta = T\left(\frac{P_0}{P}\right)^{R/c_p}$$

$$q_v = \frac{m_v}{m_d + m_v}$$

$$r = \frac{m_v}{m_d}$$



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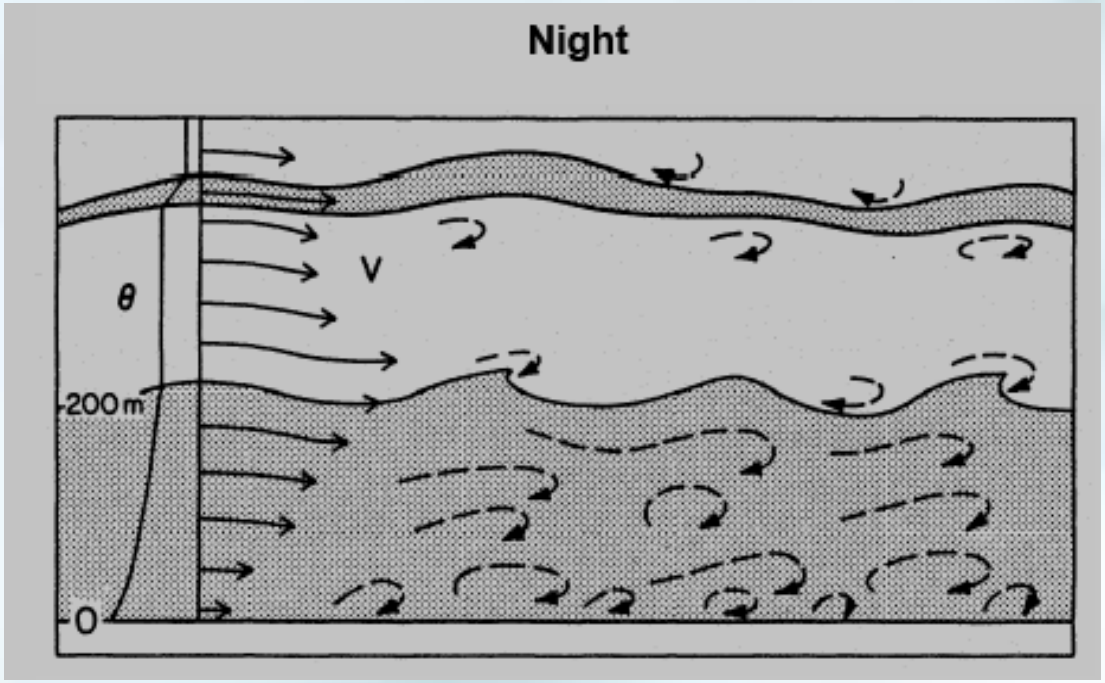
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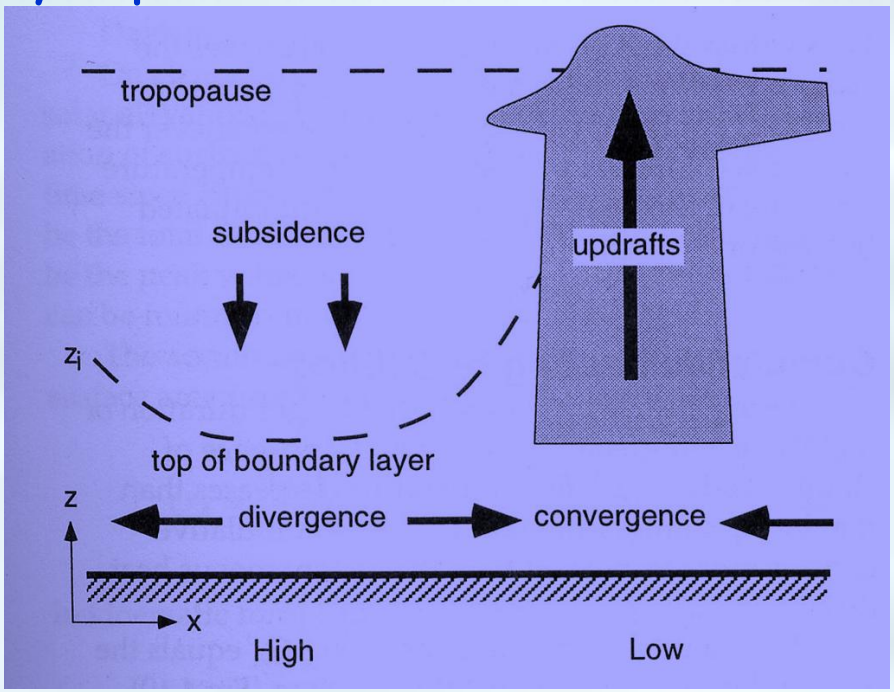
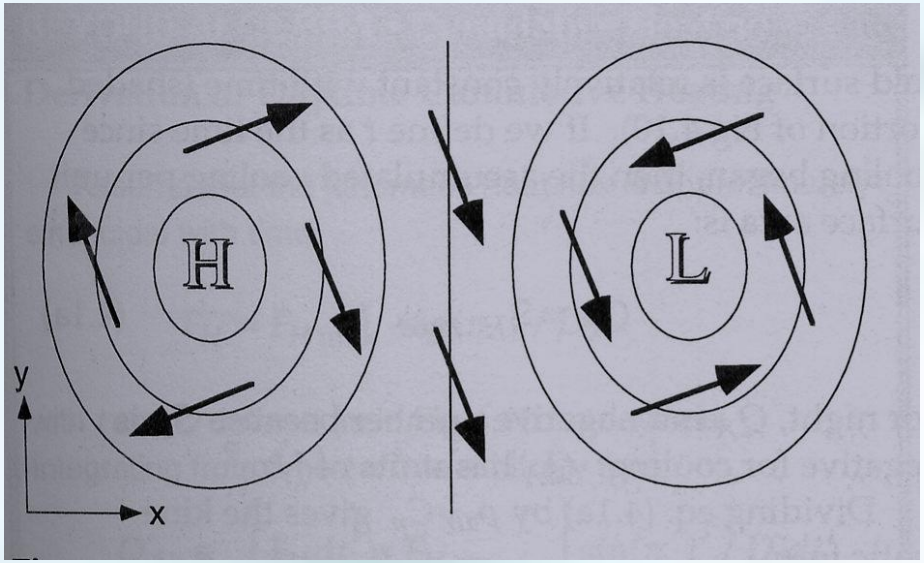
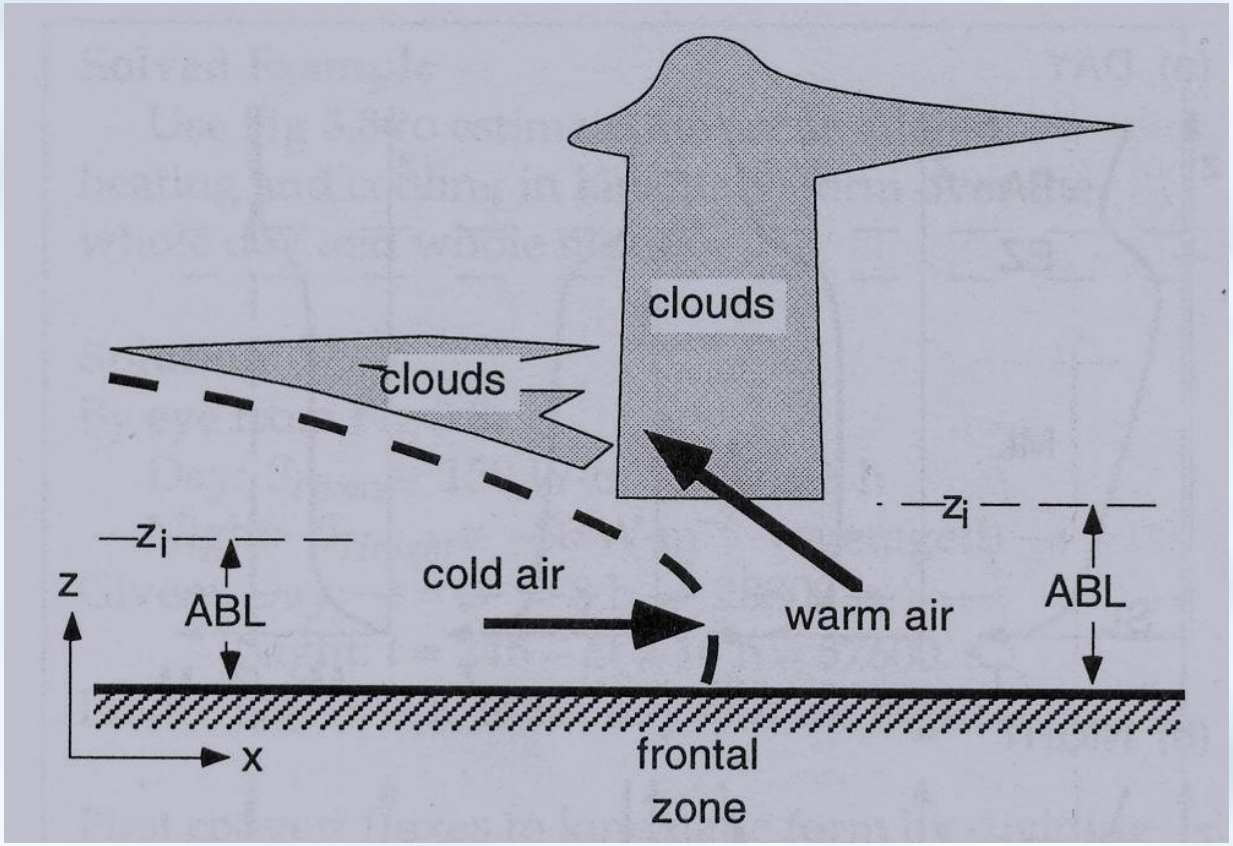
Influence of synoptic scale vertical circulation on the PBL





Idealized PBL modification near a frontal zone

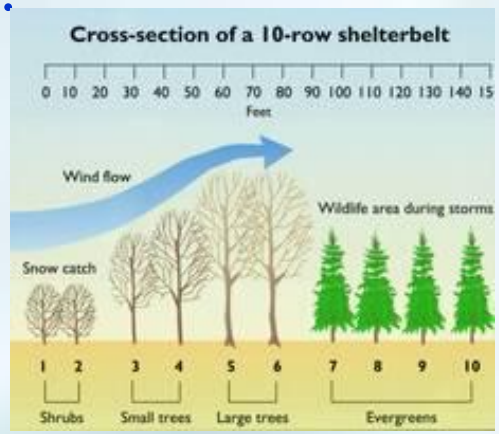


Micrometeorology versus Microclimatology

Micrometeorology is the study of the meteorology in PBL.

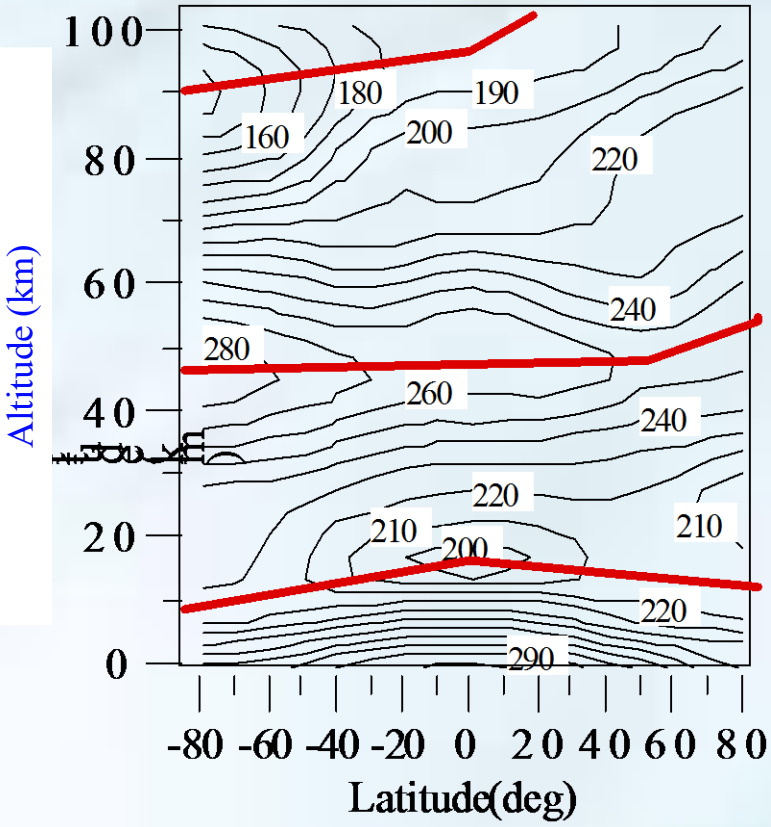
Microclimatology the study of climate and its characteristics in a small area.

The study of a microclimate, including the study of profiles of temperature, moisture and wind in the lowest stratum of air, the effect of the vegetation and of shelterbelts, and the modifying effect of towns and buildings.



Zonally-Averaged Temperatures

January



July