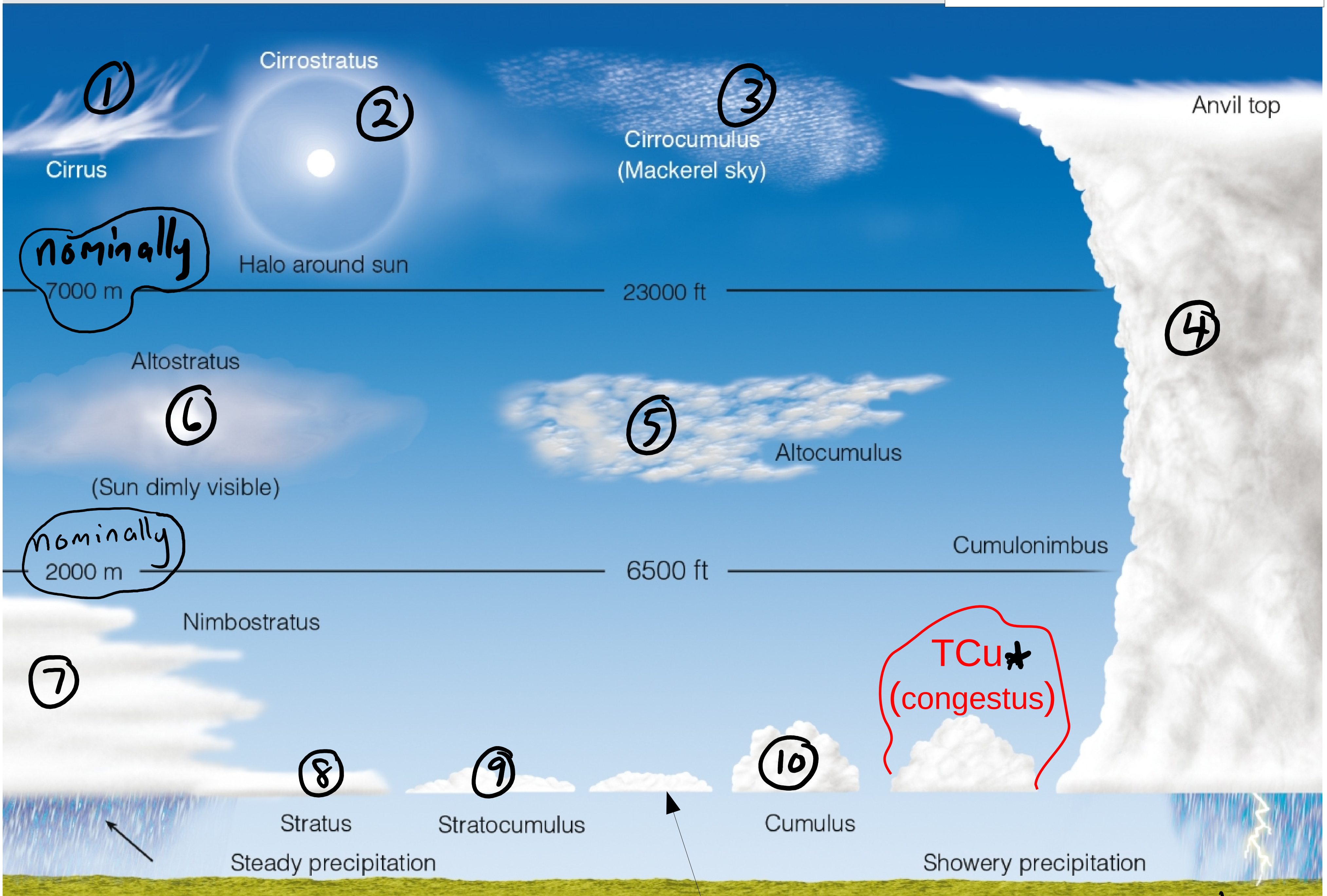
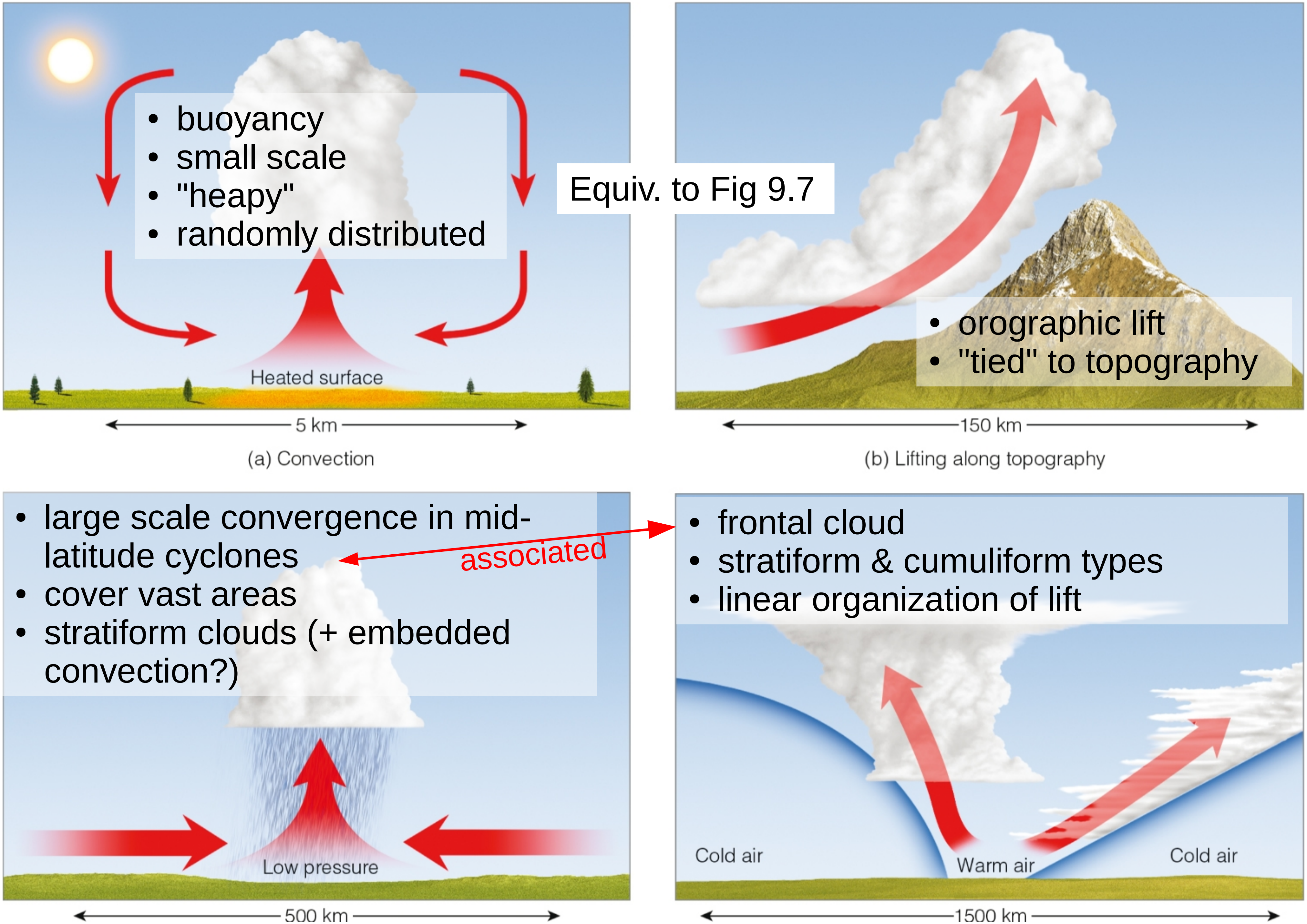
Ch9. Condensation B. Cloud & fog – mechanisms/types/classification.



fairweather Cu (humilis)

* towering cumulus

Sec 9.3. Cloud formation : must have moisture + lift



BASIS for Classification:

① Form

② Base height

There are 10 basic cloud types

Fig 9.14

TABLE 9.1 | Cloud classification.[a]

Low-Level Clouds (0–2 km above [redacted] ground level	
Stratus (St)	• a featureless sheet of cloud, often with ragged edges • similar to fog, but not at the ground • can be deep enough to produce drizzle or light snow (in which case, "nimbostratus")
Stratocumulus (Sc)	• an almost continuous sheet of cloud, with a well-defined base cloud and can show strong variations in tone • can produce light precipitation "broken" SCu
Cumulus (Cu)	• detached heaps of cloud with mounded tops and flat bottoms • usually scattered across the sky more developed forms "congestus", TCu, Cb
Cumulonimbus (Cb) (extends through all three levels)	• large heaped cloud that usually extends from low altitudes to the tropospause, where it normally forms an anvil top resembling cirriform cloud • usually produces heavy precipitation, often in the form of hail, combined with thunder and lightning

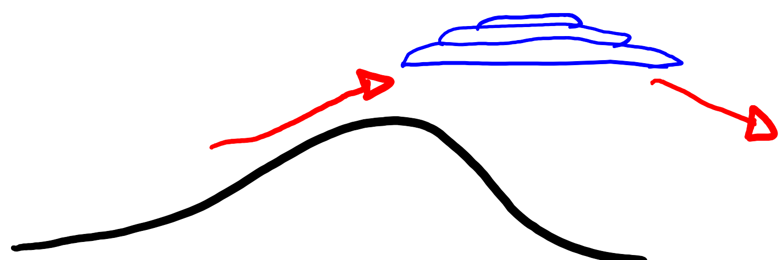
Middle-Level Clouds (2–4 km in polar regions, 2–7 km in temperate regions, and 2–8 km in tropical regions)	
Altocumulus (Ac)	• a sheet of cloud broken up into individual clumps or rolls that are normally regularly arranged • the individual cloud elements are larger than for cirrocumulus clouds and smaller than for stratocumulus clouds
Altostratus (As)	• a featureless sheet of cloud • can make the sun appear to be shining through frosted glass • can occasionally produce light precipitation
Nimbostratus (Ns) (can extend through more than one level)	• a featureless sheet of cloud thick enough to block out the sun and moon • usually produces steady precipitation of moderate intensity that can cause the base of the cloud to appear diffuse

Fig 9.18

Aside on orographic cloud

- tied to landscape
- forms on upwind side of cloud, evaporates on downwind side

lenticular form



- forced ascent of a stable layer

High-Level Clouds (3–8 km in polar regions, 5–14 km in temperate regions, and 6–18 km in tropical regions)	
Cirrus (Ci)	• isolated fibrous clouds that appear as streaks scattered across the sky
Cirrocumulus (Cc)	• a sheet of cloud broken up into tiny individual clumps that are normally regularly arranged • the individual cloud elements are smaller than for altocumulus cloud
Cirrostratus (Cs)	• a featureless sheet of cloud resembling a veil over the sky, can produce a halo around the sun or moon • thin enough to clearly see the sun and moon

Fig 9.8

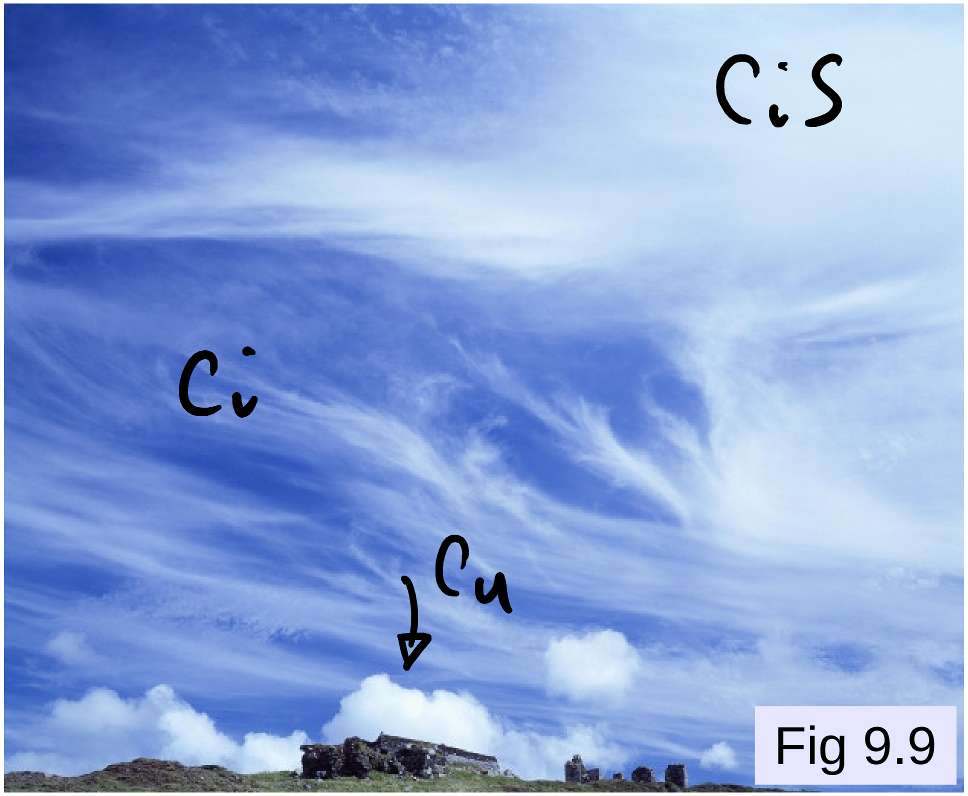
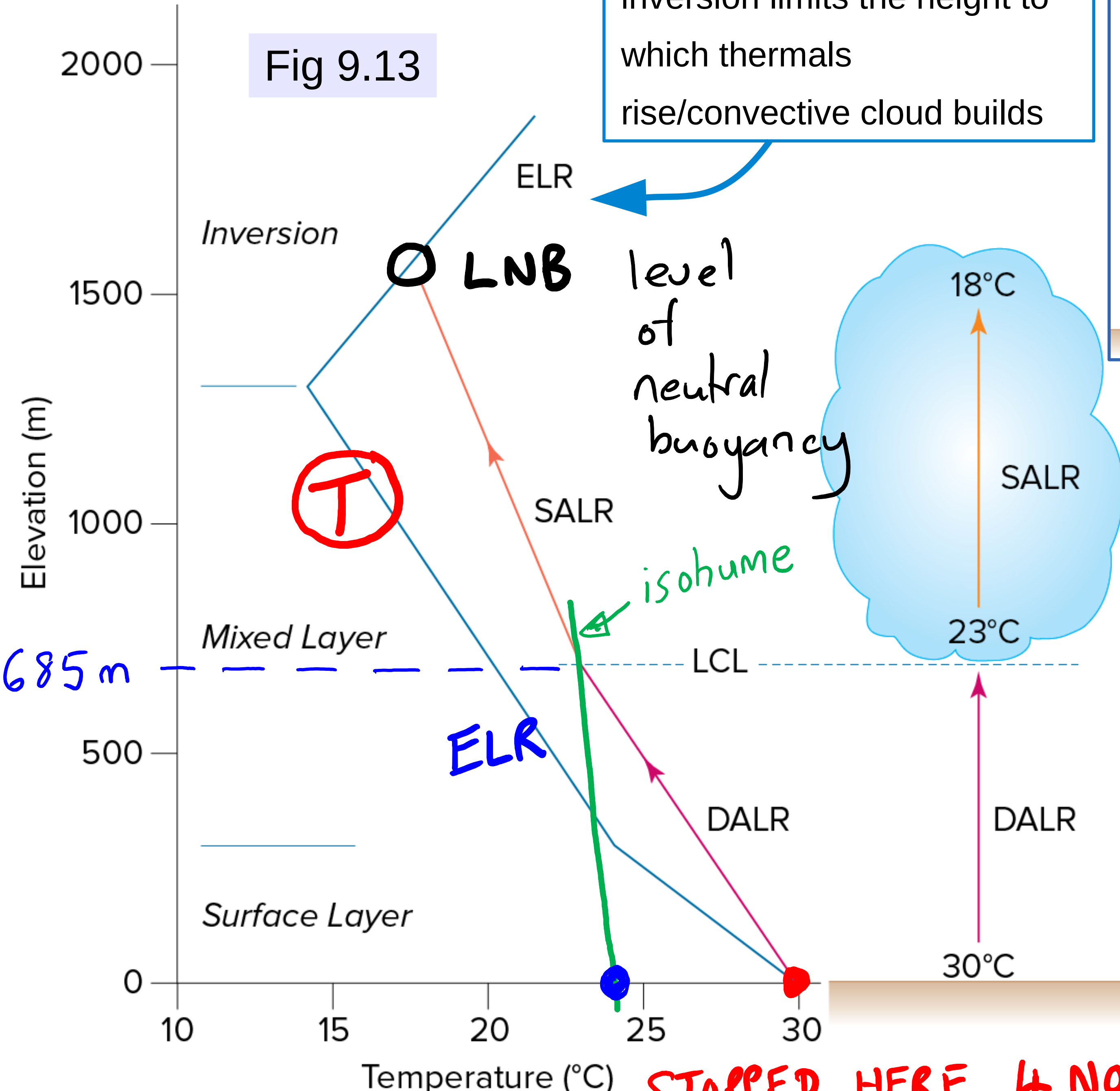


Fig 9.9

In this case a capping inversion limits the height to which thermals rise/convective cloud builds

Fig 9.13



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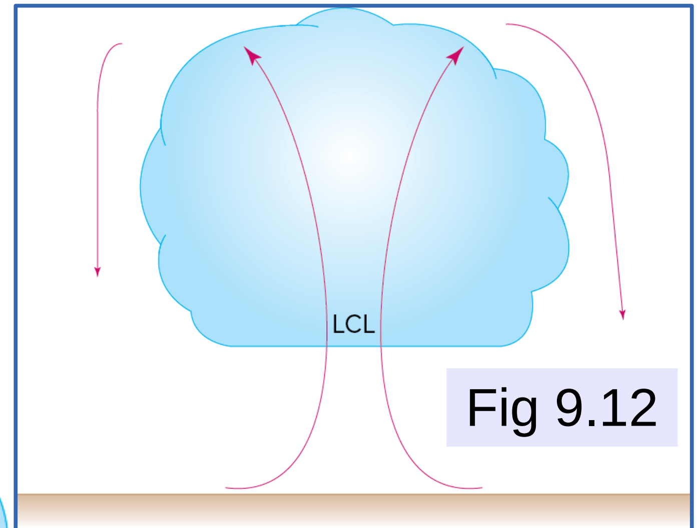


Fig 9.12

Recall the LCL can be estimated from surface T, T_d by formula (Eq 8.5) or on the skew-T chart

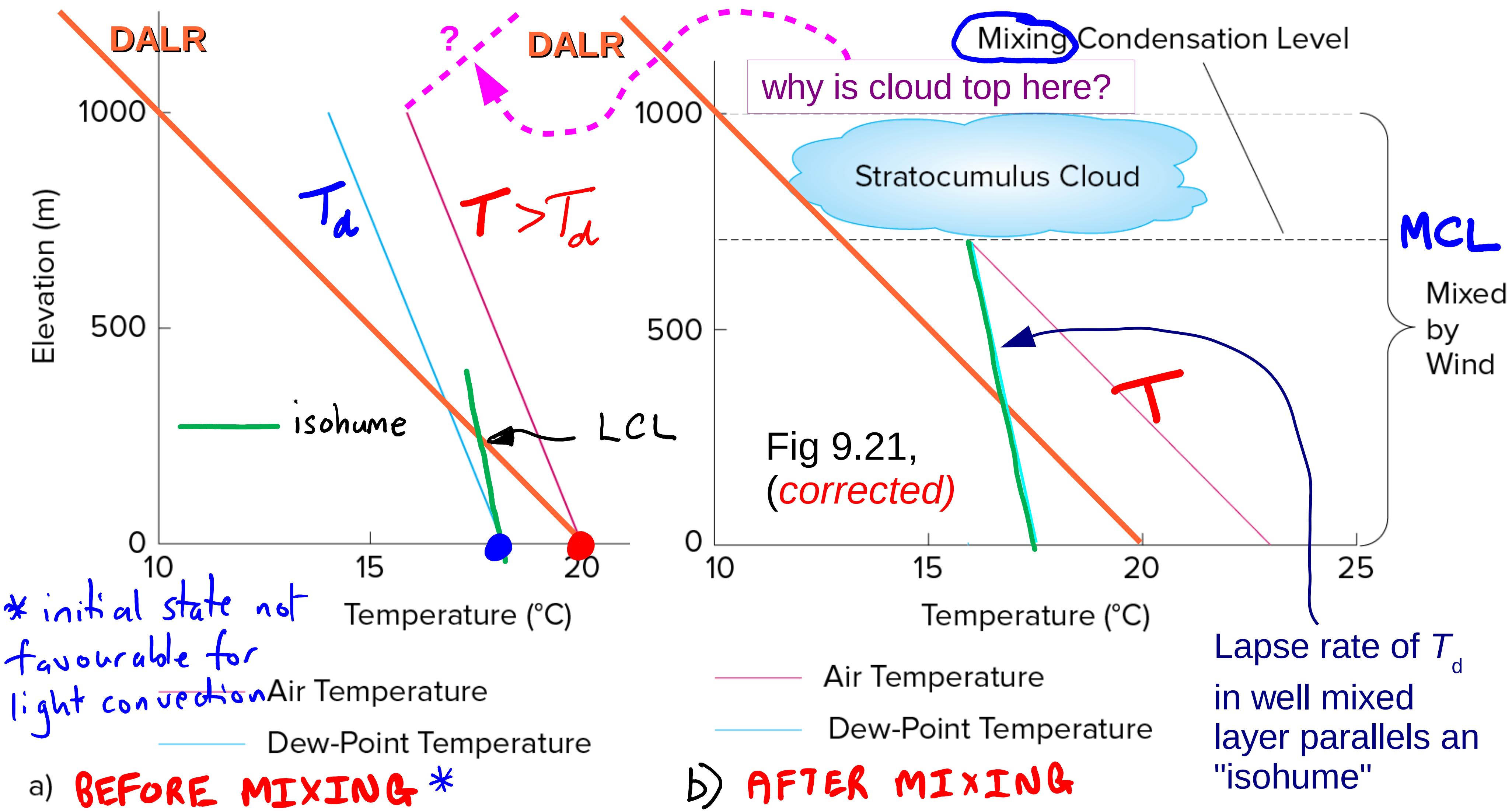
$$Z_{LCL} = 685 = 125(30 - T_d)$$

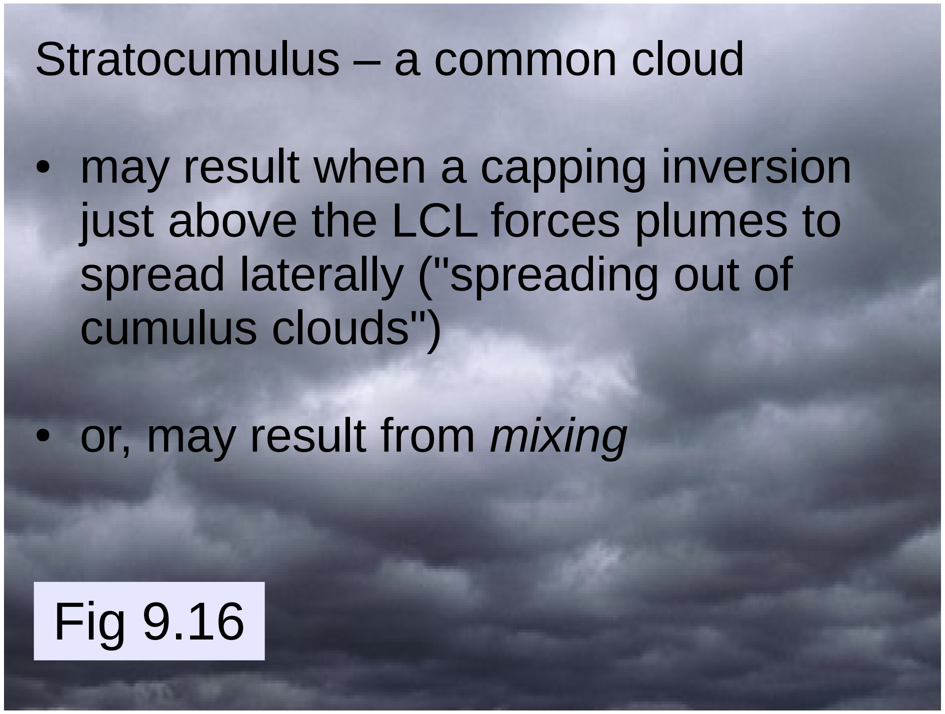
$$T_d = 24.5\,°C$$

Initially the layer is abs. or condit. stable, and close to saturation

Wind results in vertical mixing: cooling aloft and warming near ground

ELR goes to the DALR, dewpoint lapse rate → isohume } below MCL





Stratocumulus – a common cloud

- may result when a capping inversion just above the LCL forces plumes to spread laterally ("spreading out of cumulus clouds")
- or, may result from *mixing*

Fig 9.16

- base of layer heated by upwelling longwave radiation
- top of layer cooled by longwave emission
- this destabilization permits small scale convection
- sinking parcels are warmed, cloud evaporates

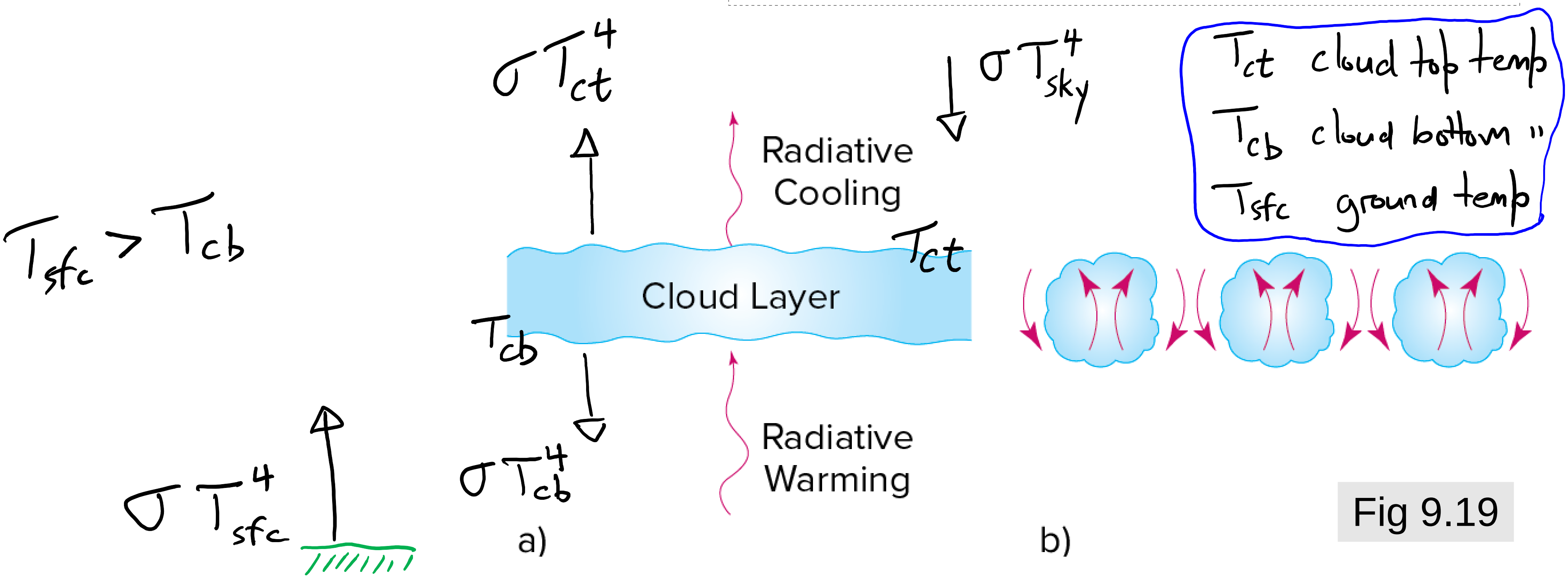
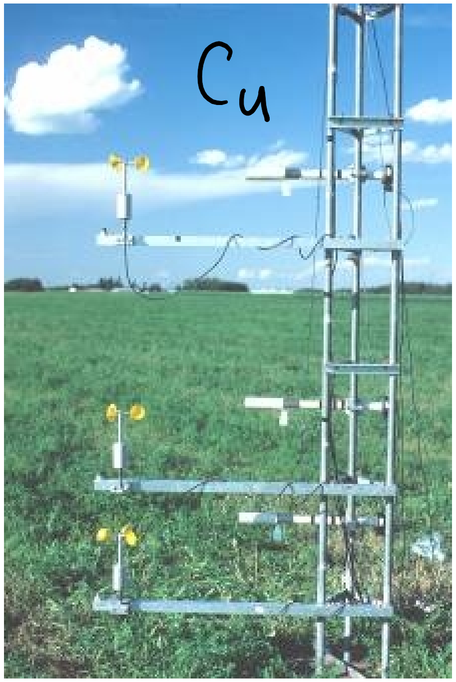
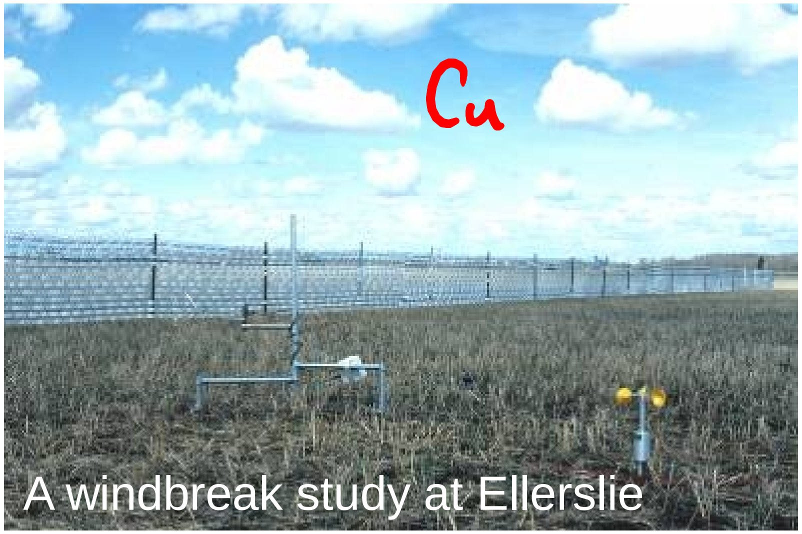


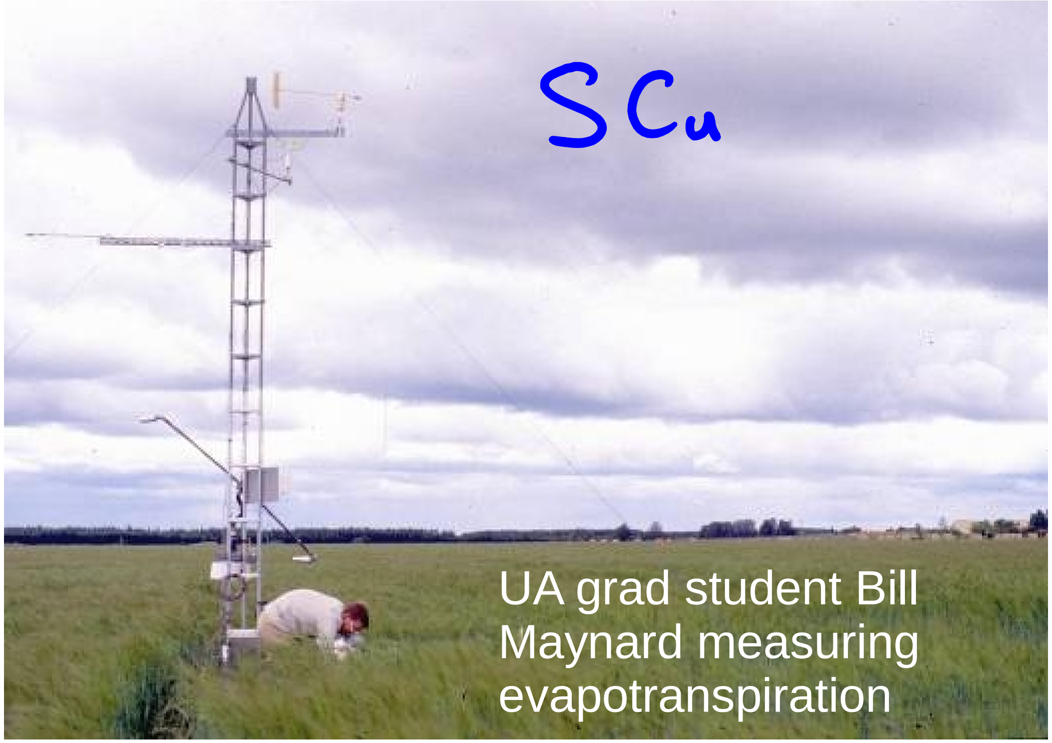
Fig 9.19



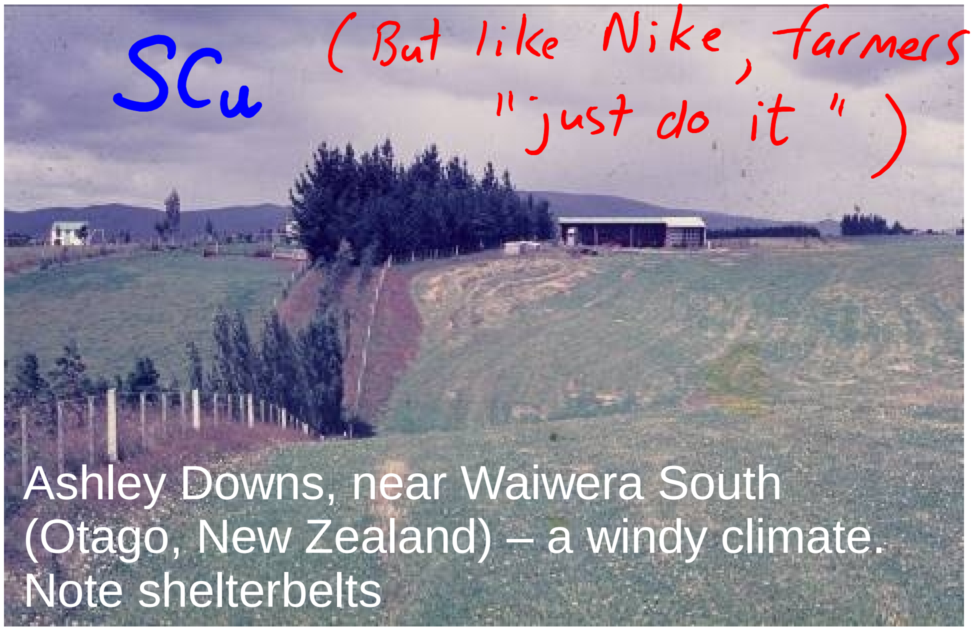


A windbreak study at Ellerslie

Windbreak/shelterbelt theory and design an element of micro-meteorology and wind engineering disciplines.



UA grad student Bill Maynard measuring evapotranspiration



Ashley Downs, near Waiwera South (Otago, New Zealand) – a windy climate. Note shelterbelts

- **cooling**

** Ground cools radiatively ($Q^* = L^* < 0$), and air in contact cools by conduction + convection $Q_H < 0$

  - “radiation fog” (“ground fog”) – due to radiational cooling**
  - “advection fog,” eg. warm moist air advected over a cold surface
  - “upslope fog” (adiabatic expansion -> cooling)

- **vapour addition** (evaporation-mixing fog)
  - eg. “steam fog,” **cold** air moving over **warm** water

- **mixing fog**

$\boxed{Q^* = Q_H + Q_E + \Delta Q_S}$ surface energy budget

Typically when $Q^* < 0$ we also have $Q_H < 0$

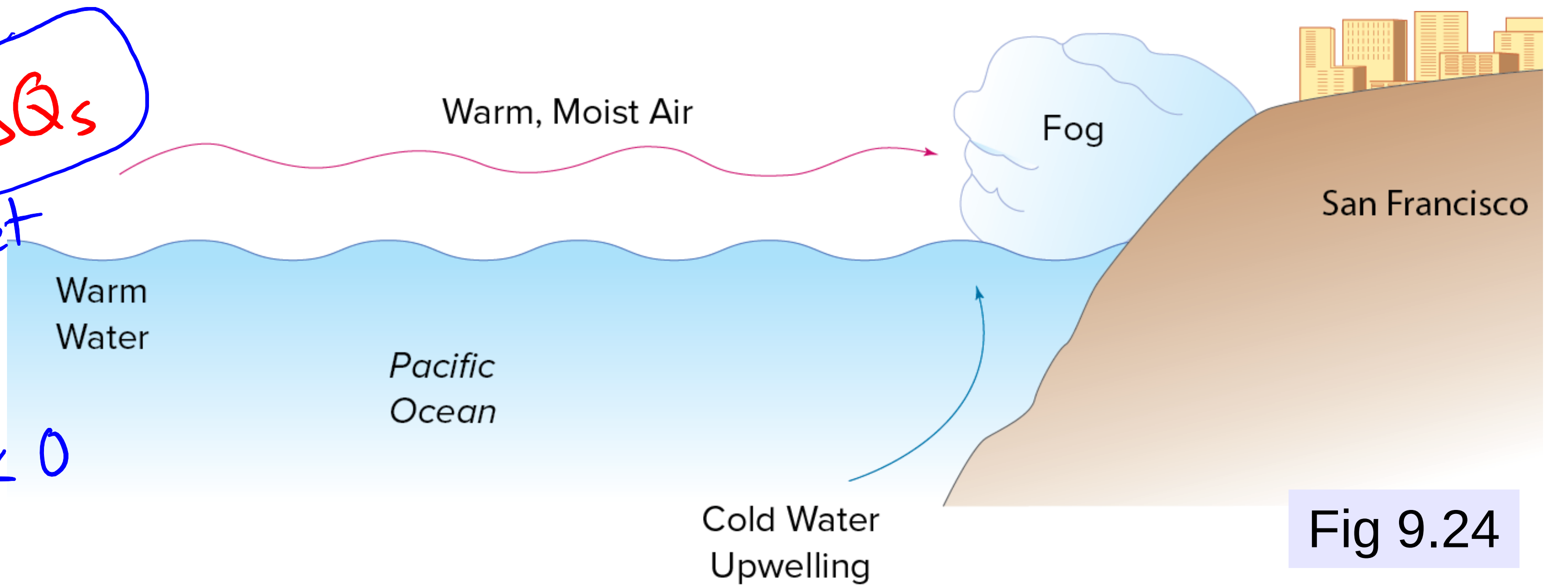
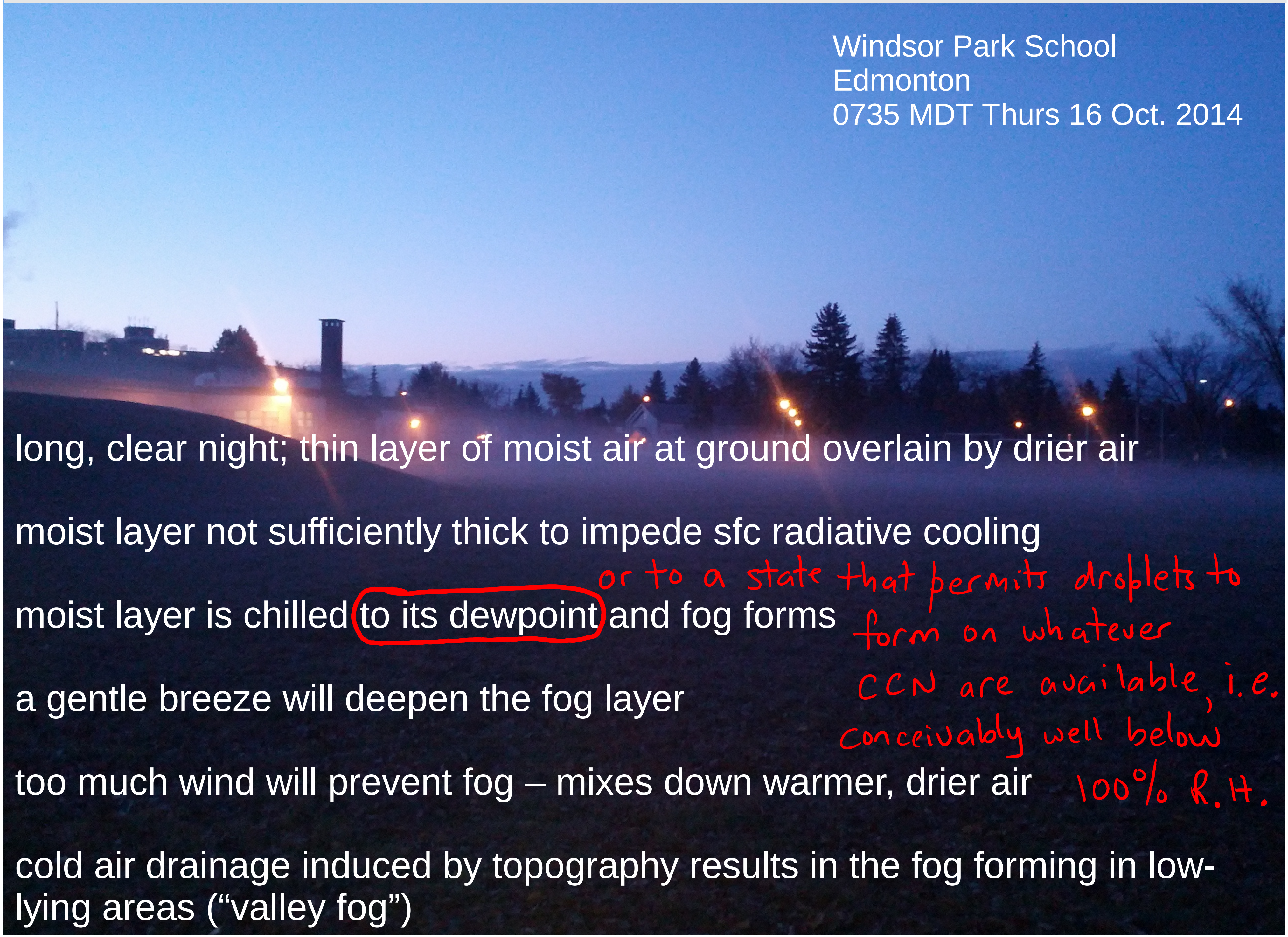


Fig 9.24



Windsor Park School
Edmonton
0735 MDT Thurs 16 Oct. 2014

long, clear night; thin layer of moist air at ground overlain by drier air

moist layer not sufficiently thick to impede sfc radiative cooling

moist layer is chilled to its dewpoint and fog forms

or to a state that permits droplets to form on whatever CCN are available, i.e., conceivably well below 100% R.H.

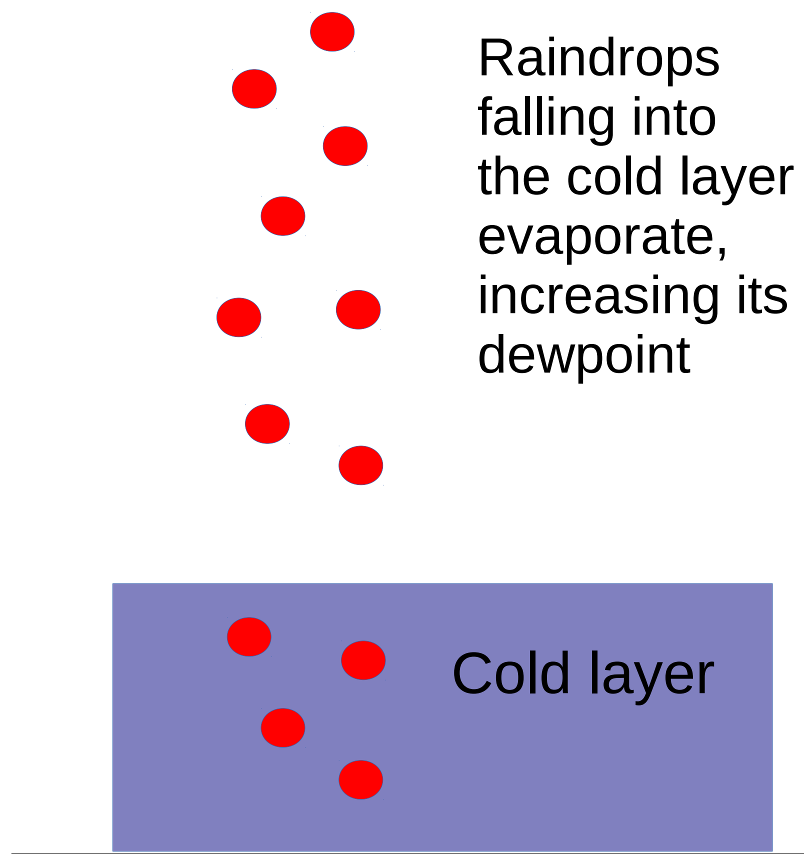
a gentle breeze will deepen the fog layer

too much wind will prevent fog – mixes down warmer, drier air

cold air drainage induced by topography results in the fog forming in low-lying areas (“valley fog”)

Precipitation fog

Fig 9.27



- two unsaturated parcels having equal mass

- after mixing, the temperature of the resulting parcel is the average of the two

- and so is the mixing ratio

- *but* the resulting average mixing ratio is such that the corresponding vapour pressure exceeds *exceeds* the saturation ~~mixing~~ vapour ~~ratio~~ pressure (blue curve) – condensation results

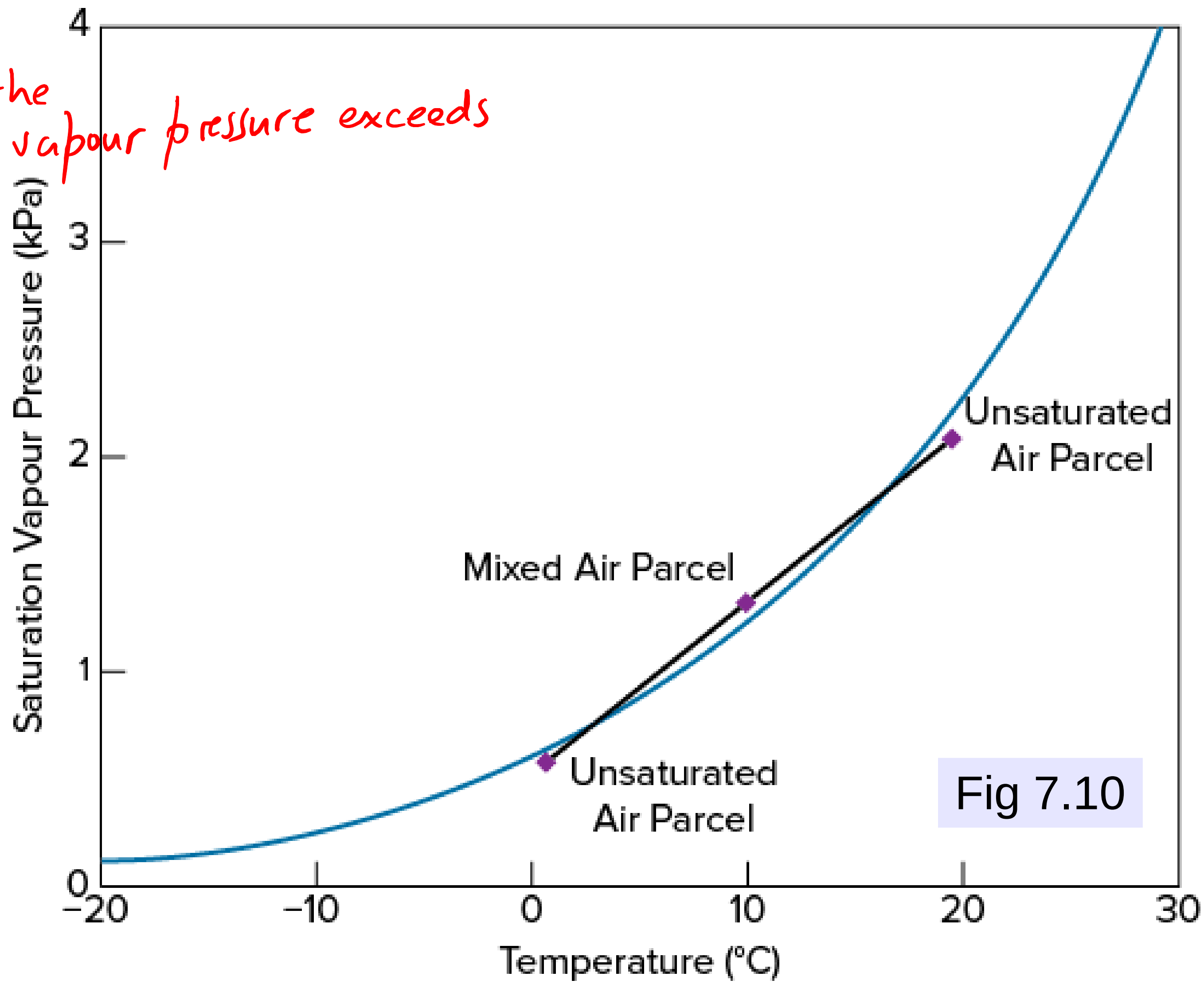
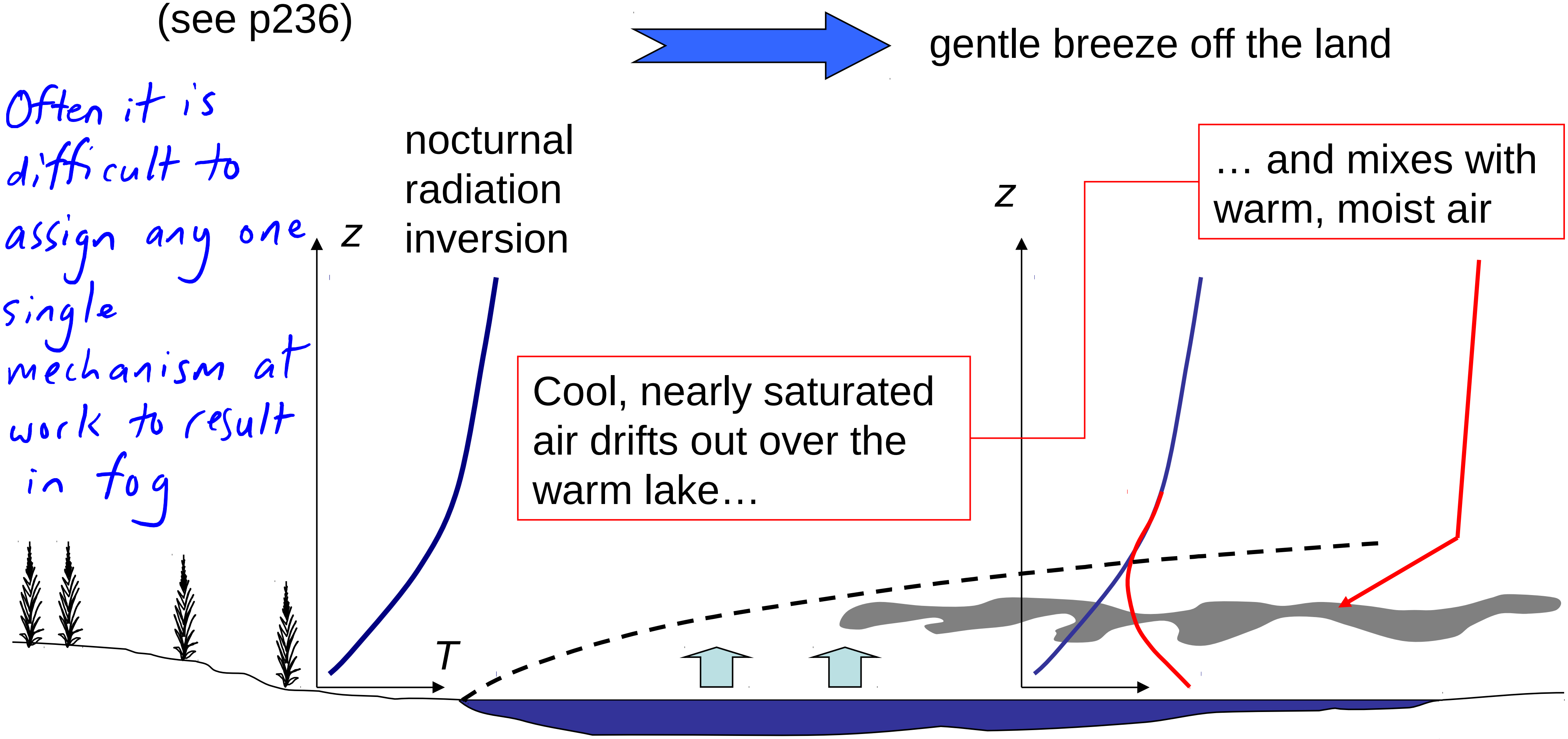


Fig 7.10

Complexity of fog formation – here a "steam fog" observed at dawn after a clear night over Pidgeon Lake, Sept. 96

(see p236)

Often it is difficult to assign any one single mechanism at work to result in fog



- land radiatively cooled
- air above cooled by convection
- then advects over lake
- is moistened by evaporation
- reaches the dewpoint within a shallow layer

Pidgeon Lake, due to its high heat capacity, is warmer on this autumn morning than the surrounding land that cooled rapidly overnight