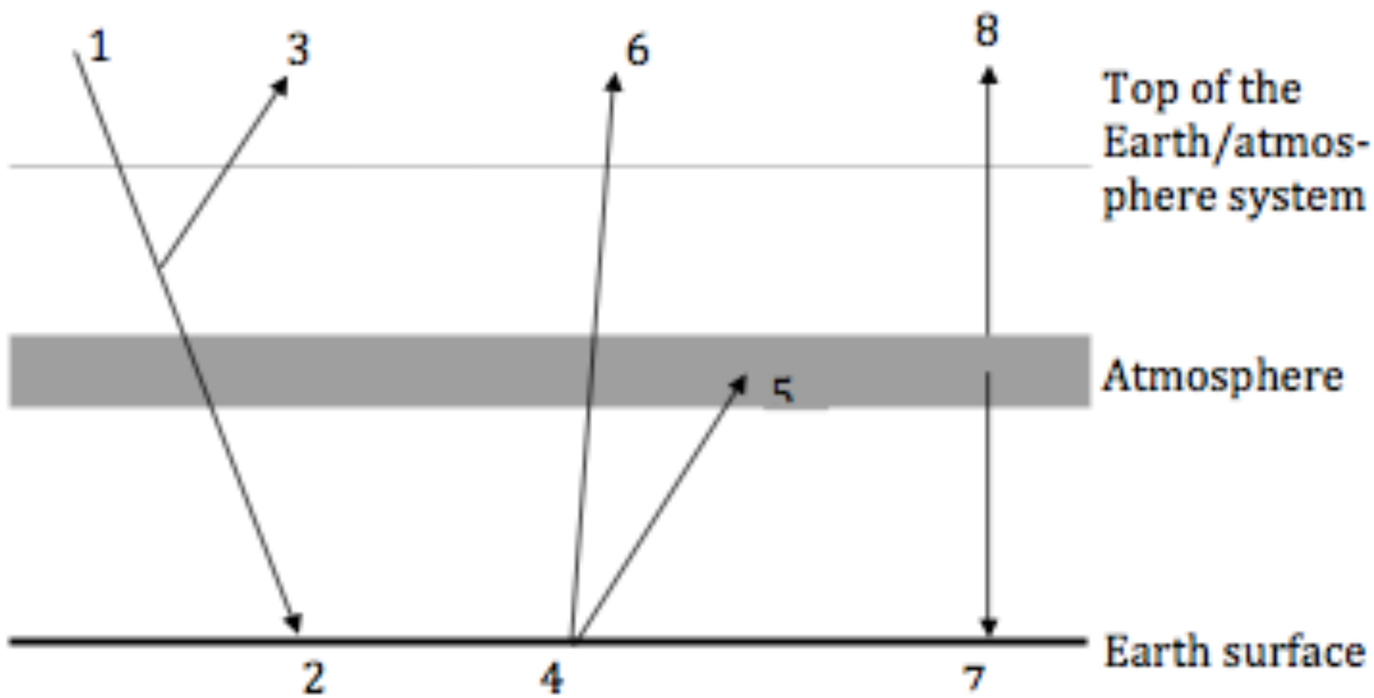
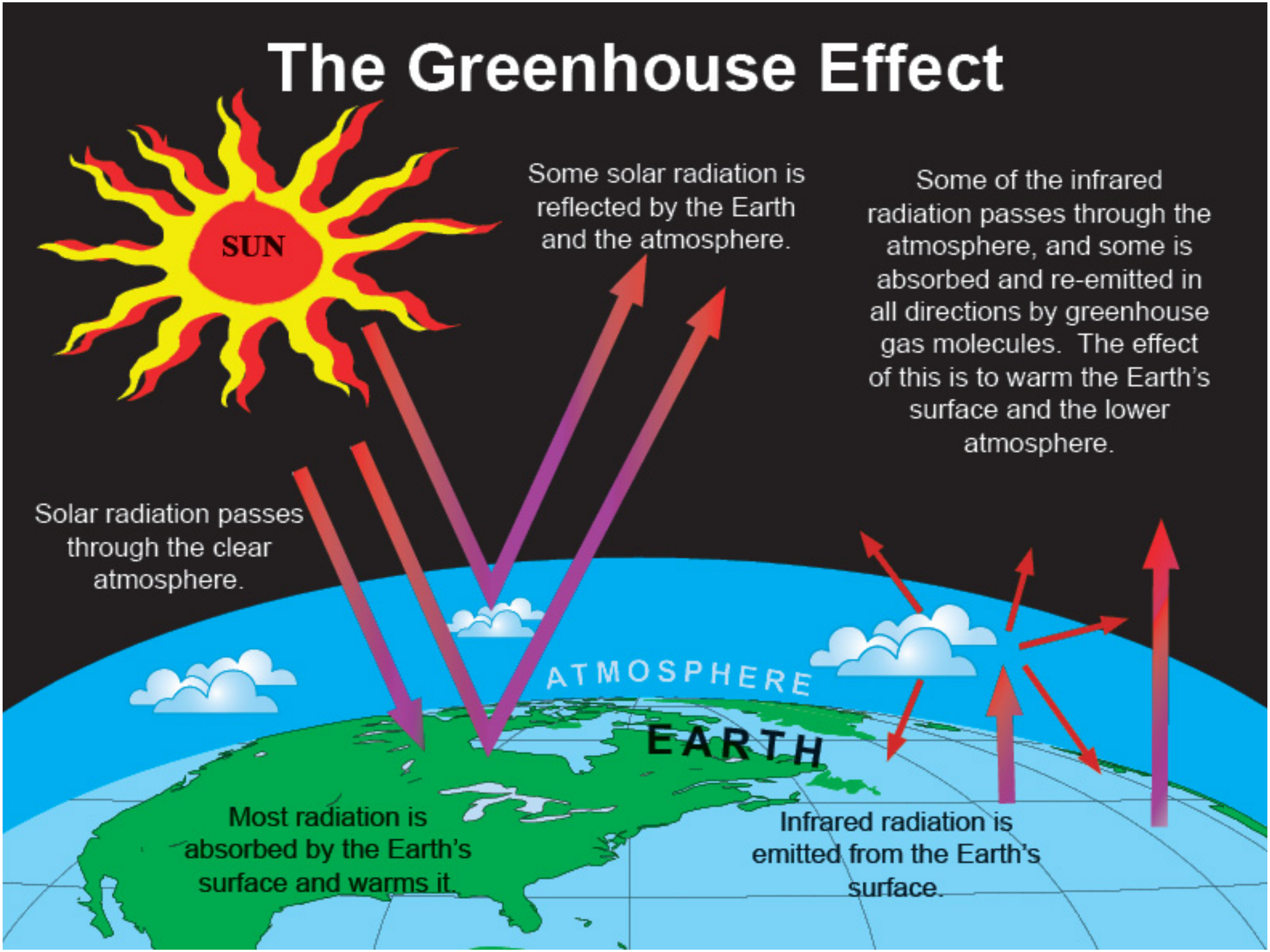
Lecture for Labs 4-6

GEOL 1147: Introduction To Meteorology Lab

Lab 4



1. Incoming solar radiation
2. Solar radiation absorbed at the surface
3. Reflected solar radiation
4. Emitted longwave radiation from the surface
5. Longwave radiation absorbed by the atmosphere
6. Longwave radiation emitted from the surface to space
7. Longwave radiation emitted from the atmosphere to the surface
8. Longwave radiation emitted from the atmosphere to space



The Greenhouse Effect
SUN
Some solar radiation is reflected by the Earth and the atmosphere.
Some of the infrared radiation passes through the atmosphere, and some is absorbed and re-emitted in all directions by greenhouse gas molecules. The effect of this is to warm the Earth's surface and the lower atmosphere.
Solar radiation passes through the clear atmosphere.
ATMOSPHERE
EARTH
Most radiation is absorbed by the Earth's surface and warms it.
Infrared radiation is emitted from the Earth's surface.

Greenhouse Gases

Name of the gas	Molecular weight		Percentage
• Water vapor	H_2O	18.02	< 4.%
• Carbon dioxide	CO_2	44.01	0.038%
• Methane	CH_4	16.04	0.00017%
• Nitrous oxide	N_2O	44.01	0.00003%
• Ozone	O_3	48.00	0.000004%

Lab 5

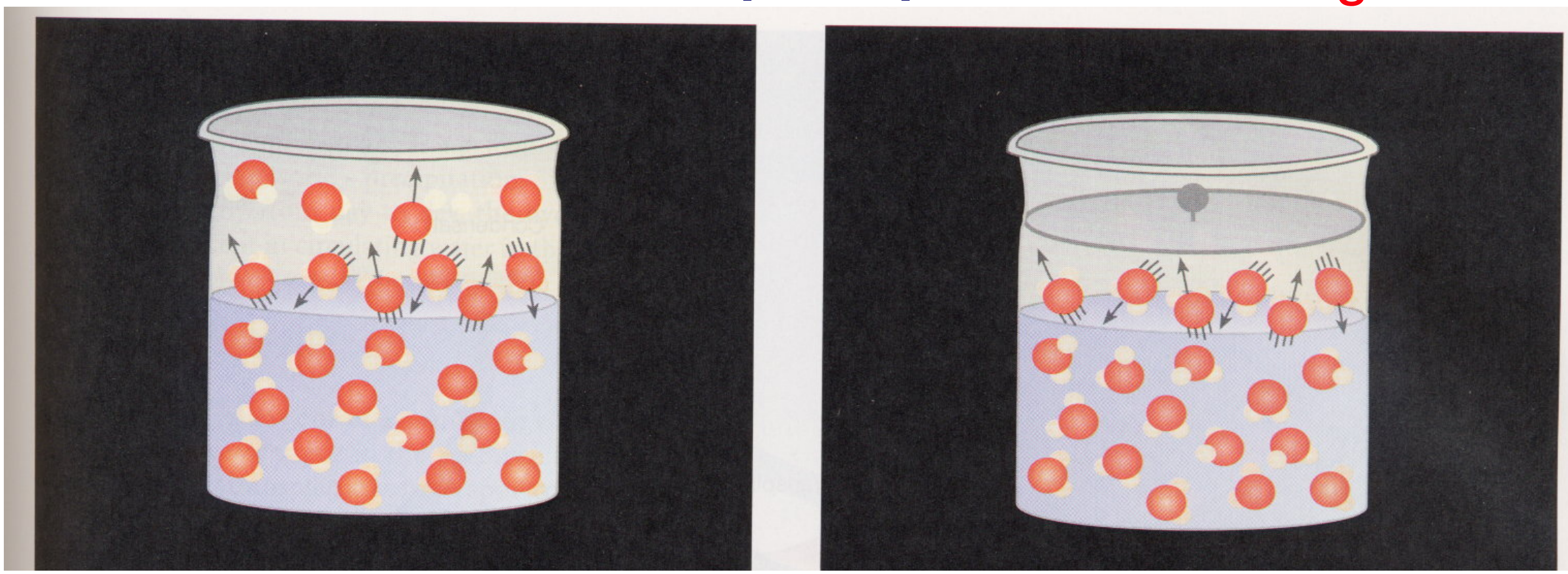
Measures of Water Vapor in the atmosphere

• Vapor pressure	e
• Mixing ratio	r
• Relative humidity	RH
• Dew point temperature	T_d
• Wet-bulb temperature	T_w

Vapor pressure - e

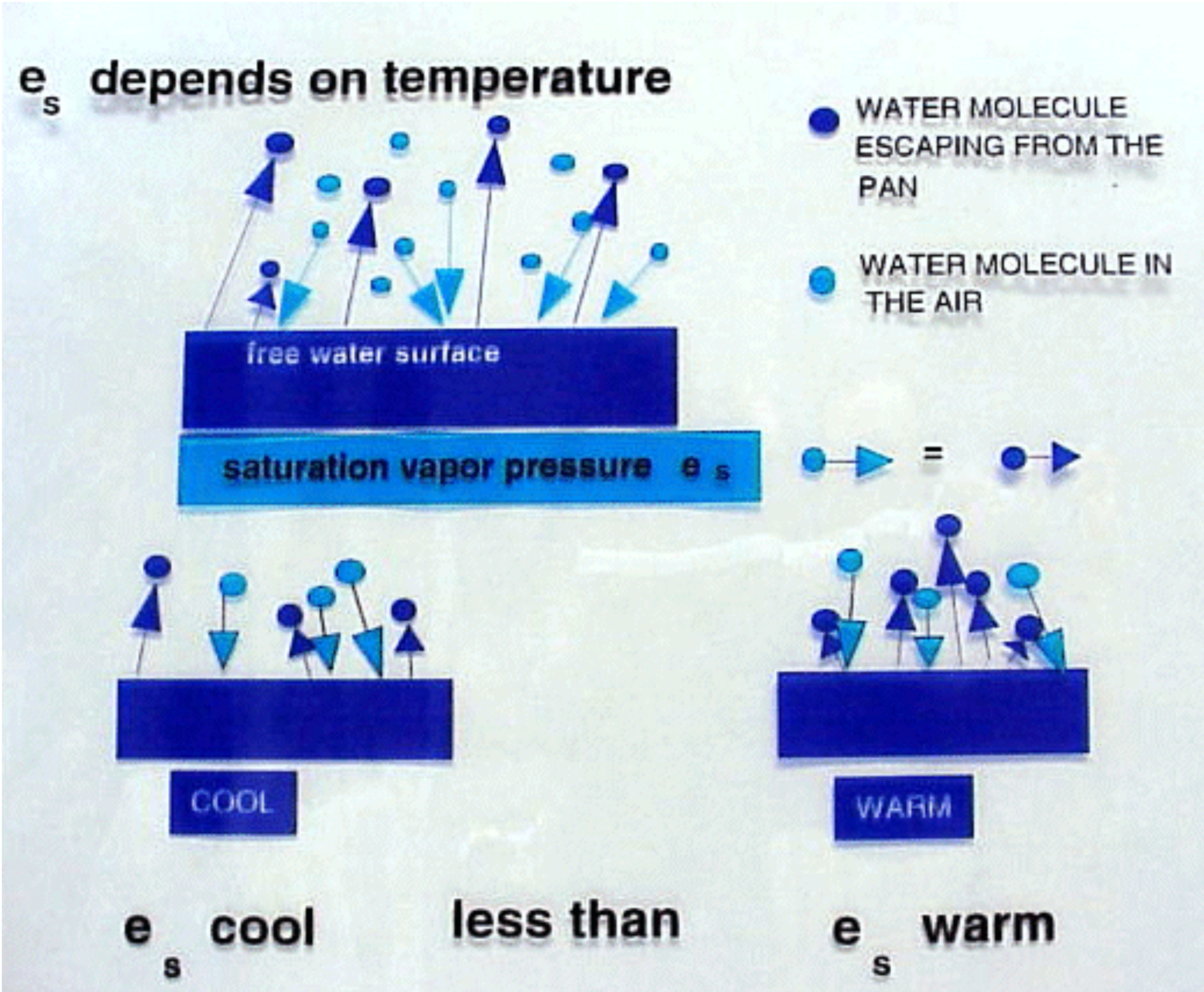
- Air molecules all contribute to pressure p
- Each subset of molecules (e.g., N_2, O_2, H_2O) exerts a partial pressure
- The vapor pressure, e, is the pressure exerted by water vapor molecules in the air
  - similar to atmospheric pressure, but due only to the water vapor molecules
  - 2-30 mb common at surface
  - the larger the vapor pressure is, the more water vapor molecules in the atmosphere

Saturation vapor pressure e_s



- Water molecules move between the liquid and gas phases
- When the rate of water molecules entering the liquid equals the rate leaving the liquid, equilibrium is reached
  - The air is said to be saturated with water vapor at this point
  - *Equilibrium does not mean no exchange occurs*

Saturation vapor pressure e_s depends upon temperature
higher temperature, higher e_s,
more water vapor that the air can hold



Mixing Ratio - r

- Ratio of mass of water to mass of <u>dry</u> air in a unit volume
- Invariant to change in volume

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

Relative Humidity – R.H.

The ratio of the amount of water vapor in the air compared to the amount required for saturation.

R.H. = water vapor content / water vapor capacity

$$\text{R.H.} = \frac{e}{e_s(T)} = \frac{\tilde{n}_v}{\tilde{n}_{vs}(T)} = \frac{q}{q_s(T)} = \frac{r}{r_s(T)}$$

Higher relative humidity does not necessarily mean more water vapor in the air

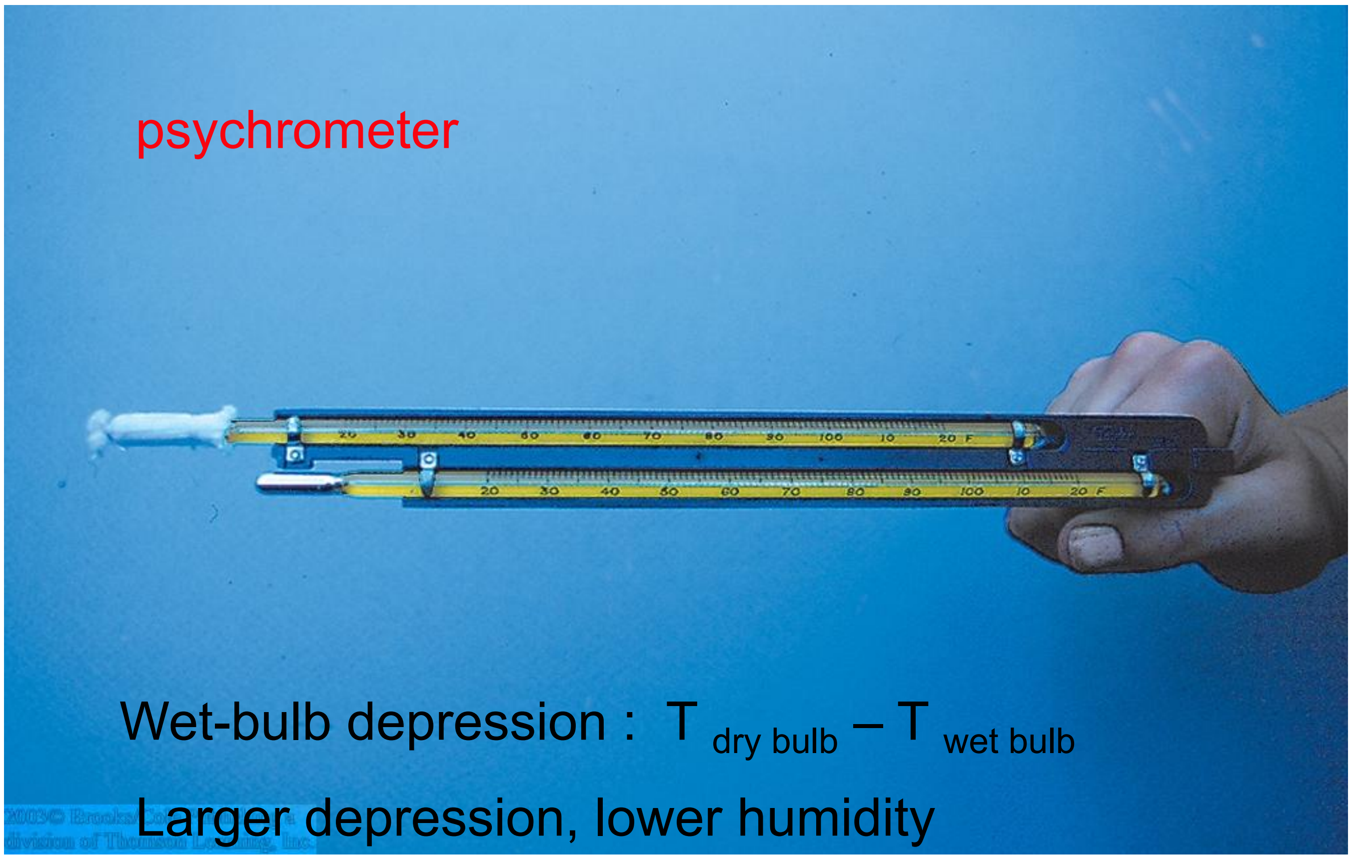
Dew Point Temperature - T_d

- Temperature to which air must be cooled (at constant pressure and constant water vapor content) to become saturated.
- When $T=T_d$, $e_s(T_d) = e$, $q_s(T_d) = q$, $r_s(T_d) = r$
- $T_d \leq T$
- Unlike relative humidity which is a measure of how near the air is to being saturated, dew point temperature is a measure of its actual moisture content. *The higher the dew point, the more water vapor in the air.*

- Dew point depression: $T - T_d$
- The larger the dew point depression is, the drier the air is, or the air is farther away from saturation

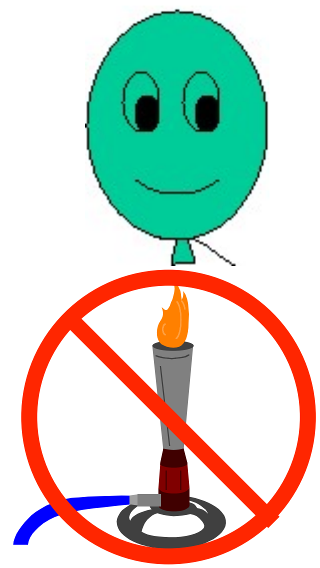
Wet-bulb temperature - W_b

The lowest temperature that can be obtained by evaporating water into the air.



Adiabatic Processes

- Adiabatic process is a thermodynamic process in which no heat is transferred to or from the system.



$$\cancel{dq} = 0$$

(courtesy F. Remer)

Lapse Rate

- The rate of temperature decrease with height is known as *lapse rate,* $(\Gamma = - \Delta T / \Delta z)$

Dry adiabatic lapse rate – the rate of temperature decrease of a rising *unsaturated* air parcel

$$\Gamma_d = -\Delta T / \Delta z = 9.8\ ^{o}C\ km^{-1} \approx 10\ ^{o}C\ km^{-1}$$

Lifting a moist parcel

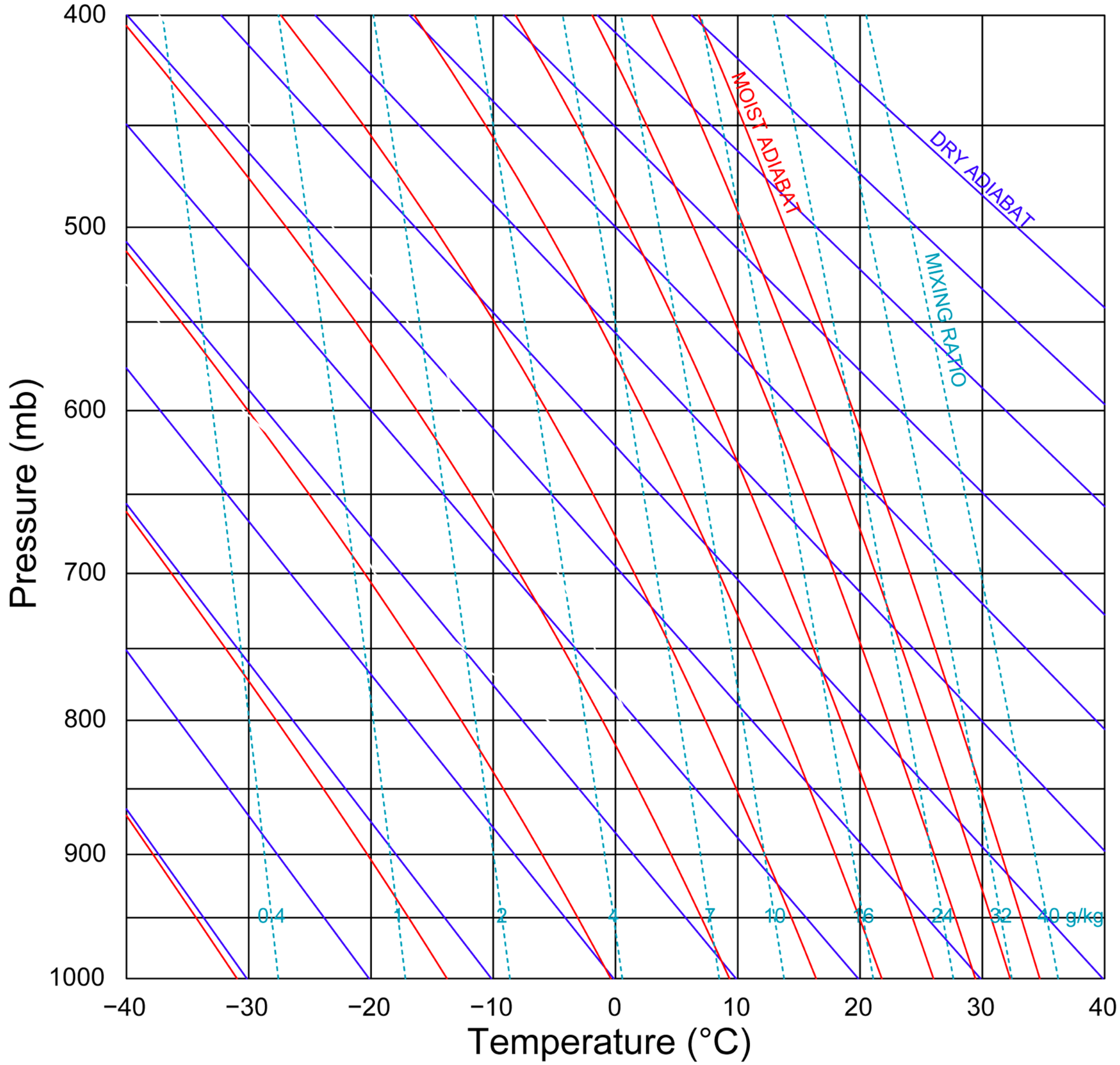
- If a rising air parcel becomes saturated condensation occurs
- Condensation warms the air parcel due to the release of latent heat
- So, a rising saturated parcel cools less than unsaturated air parcel
- The cooling rate for a lifted saturated air parcel is called moist adiabatic lapse rate

Moist adiabatic lapse rate

Decrease of temperature with height for saturated air

Γ_s always < Γ_d

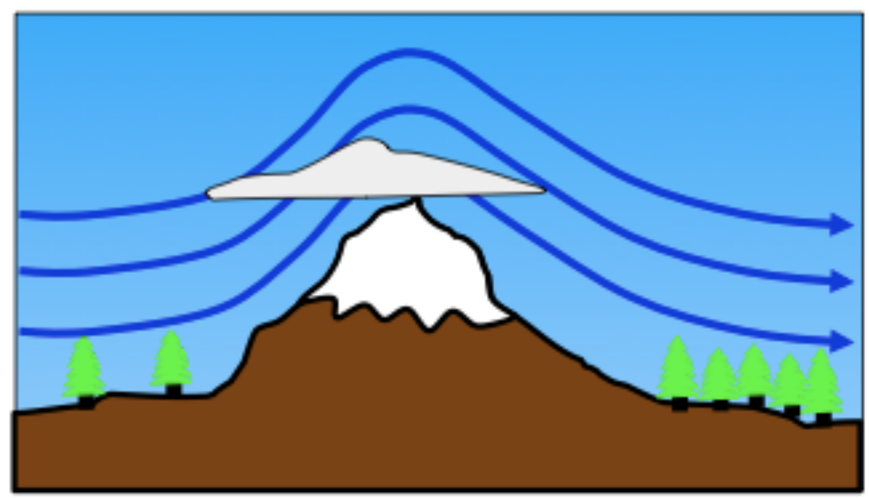
STUVE THERMODYNAMIC DIAGRAM



Lab 6

Condensation Level (CL)

- The height at which the air parcel just reaches saturation is known as the condensation level (CL) (sometimes referred to as the Lifting (or Lifted) Condensation Level (LCL)).



1. Locate the points that describe the following air parcel state (mark these points on your thermodynamic diagram):
$T = 30°C$, $T_d = 13°C$, and $p = 1000$ mb

1a. Start with the air parcel described above. Lift this air parcel from its initial pressure of 1000 mb to a pressure of 900 mb. Mark the new temperature, dewpoint, and pressure as well as the lines used to get to these points on your thermodynamic diagram. Label these points.

1i. Now continue lifting the air parcel until it reaches its CL. Mark the point representing the condensation level on the diagram.

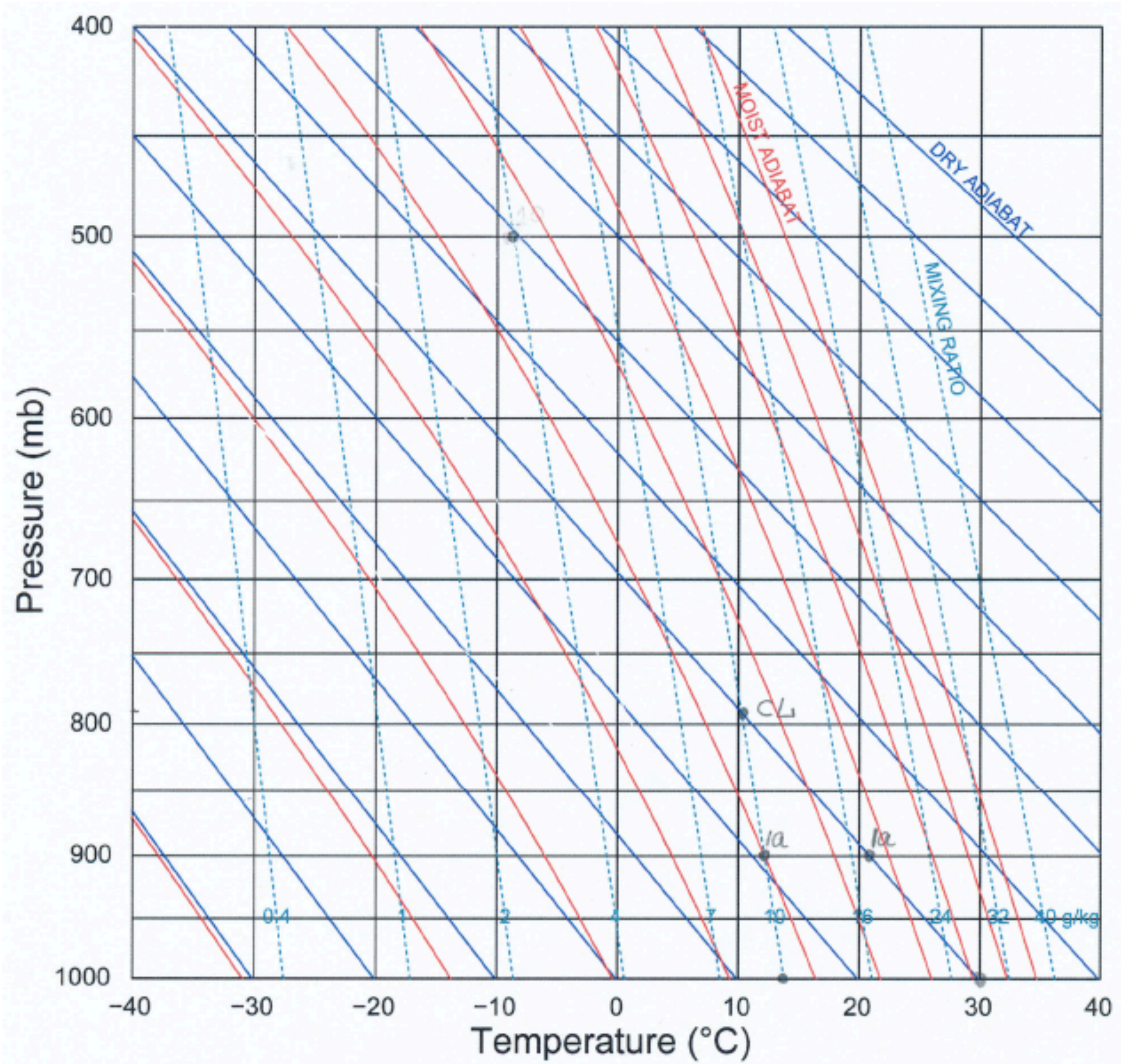


Figure 1: Thermodynamic chart for Problem 1 in Lab 6.