CIVE 3331

Meterology and Air Pollution

Stable air – tends to stay at one elevation.
Unstable air – tends to rise/fall depending on surrounding conditions.

<Scan and append handwritten notes>

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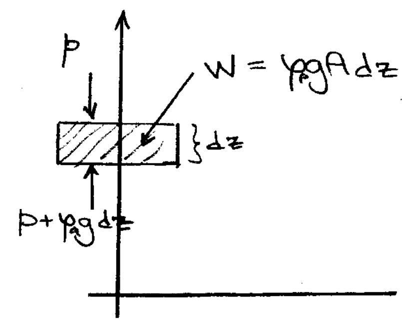
Unstable air – tends to rise/fall



Force Balance for air parcel

$$\Sigma F_z = -pA + (p + \rho_a g\,dz)A - \rho_p g A\,dz$$

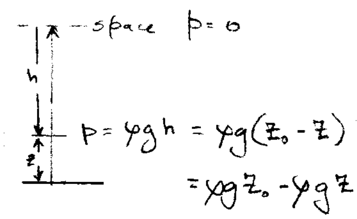
$$= (\rho_a g\,dz - \rho_p g\,dz)A$$

If $\rho_p > \rho_a$ then parcel will sink
$\rho_p < \rho_a$ then parcel will rise
$\rho_p = \rho_a$ then stable

From thermodynamics recall $\Delta H = C_p \Delta T - V\Delta P$
For constant enthalpy (zero heat transfer)

$$\frac{\Delta T}{\Delta P} = \frac{V}{C_p}$$

Now using a hydrostatic pressure distribution as a model for the atmosphere



$$p(z) = \rho g z_0 - \rho g z$$

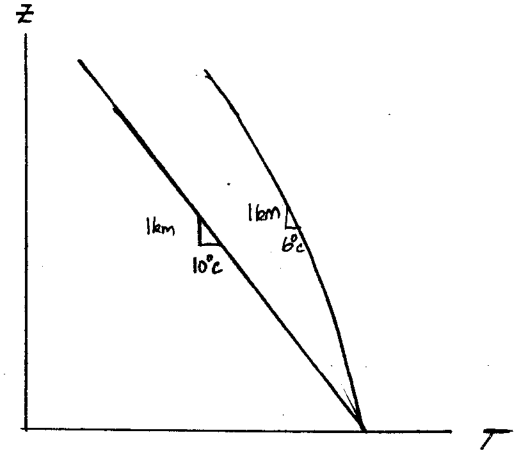
$$dp = -\rho g\,dz$$

$$\therefore \frac{\Delta T}{\Delta P} = \frac{\Delta T}{-\rho g \Delta z} = \frac{V}{C_p} \quad \therefore \frac{\Delta T}{\Delta z} = -\frac{\rho g V}{C_p} = \underbrace{-\frac{g}{C_p}}_{\text{adiabatic lapse rate}}$$

$$\frac{\Delta T}{\Delta z} = -0.00976\,K/m = -9.76\,°C/km = -5.4\,°F/1000\,ft \quad \text{(Dry rate)}$$

Assumed air is "dry"

If air has enough water vapor so that condensation occurs then we need to use a saturated adiabatic lapse rate.



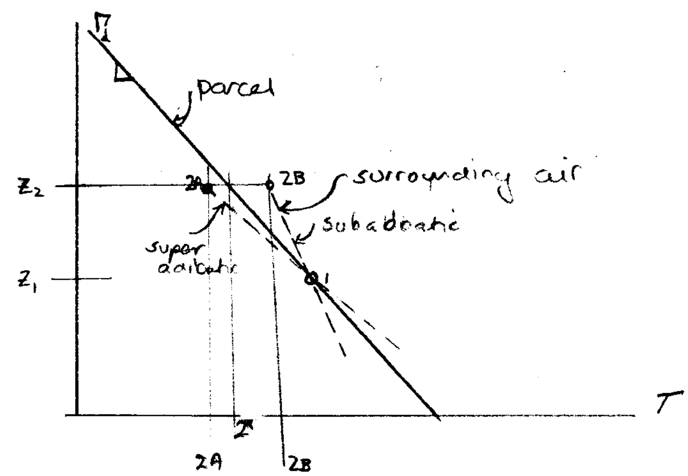
An average sat. lapse rate is 6°C/km or 3°F/1000 ft.

Lapse rates are used to understand atmospheric stability

Take parcel and cause it to rise,

$T_{2A} < T_{2*}$ $\therefore$ parcel will tend to rise further $\Rightarrow$ unstable

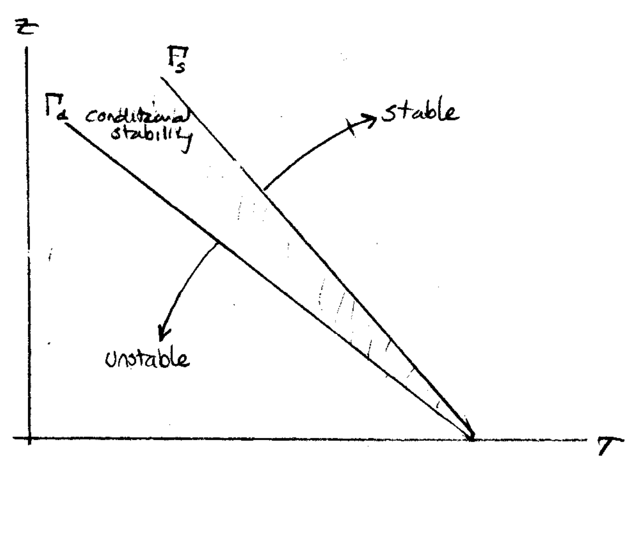
$T_{2B} > T_{2*}$ $\therefore$ parcel will tend to sink back $\Rightarrow$ stable.



One consequence of stability is that pollutants can concentrate.

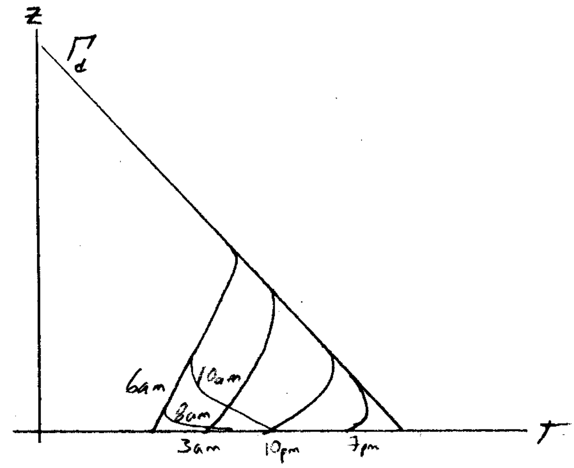
Unstable atmospheres mix pollutants (dilution) and are desirable

Neutral stability concentration can occur, but may change conditions enough to create unstable or stable conditions



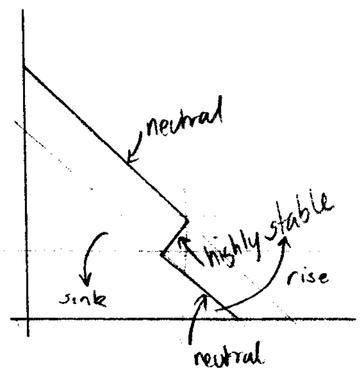
Temperature inversion

- extreme case of stability, shape of temperature profile has a kink



Radiation inversion - clear night, earths heat radiates outward and earth cools air near surface

In morning sun reheats surface and creates kinky profile



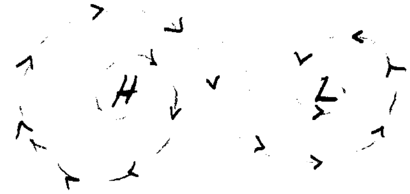
During morning before erosion compounds concentrated in air.

When erosion occurs, "fumigation" when the stable layer sinks as near surface heated air rises

Usually No PC smog, but CO and toxics can be significant

Subsidence Inversion

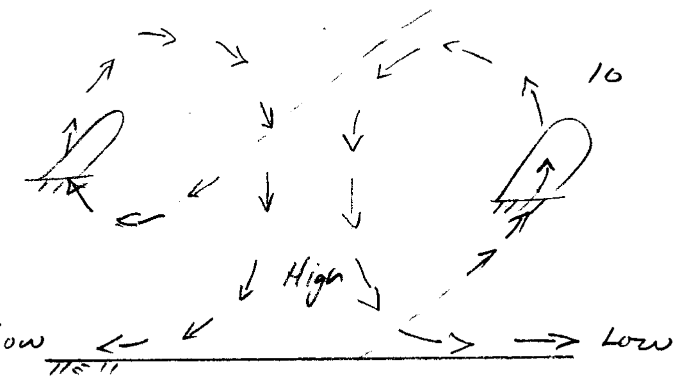
High pressure anticyclones



cyclonic pattern (N hemisphere)

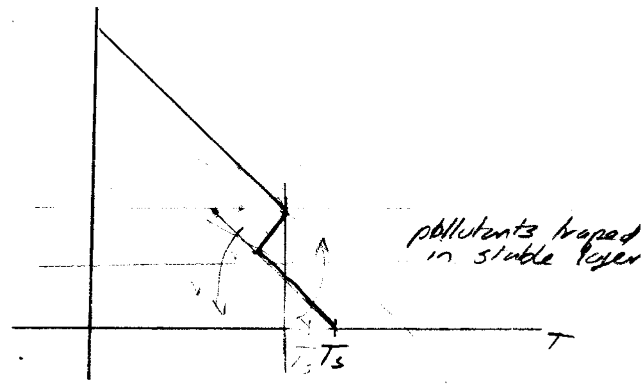
Can last for weeks/months

PC smog is significant



cells are expected at equator, 30°, 60°, 90° latitudes

At other latitudes coriolis driven winds reduce chance of set up.



anticyclones occur at 30° & 90° latitudes.

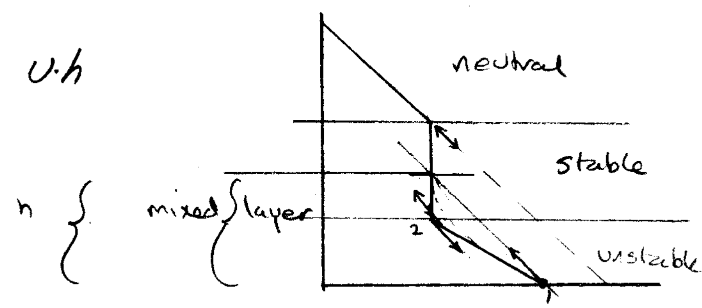
Stability and Mixing Depth

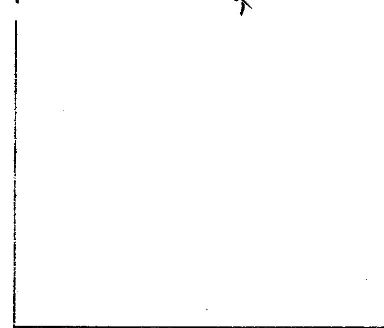
Stability and mixing concepts are used to estimate vertical dilution of pollutants

Ventilation coefficient = $U \cdot h$

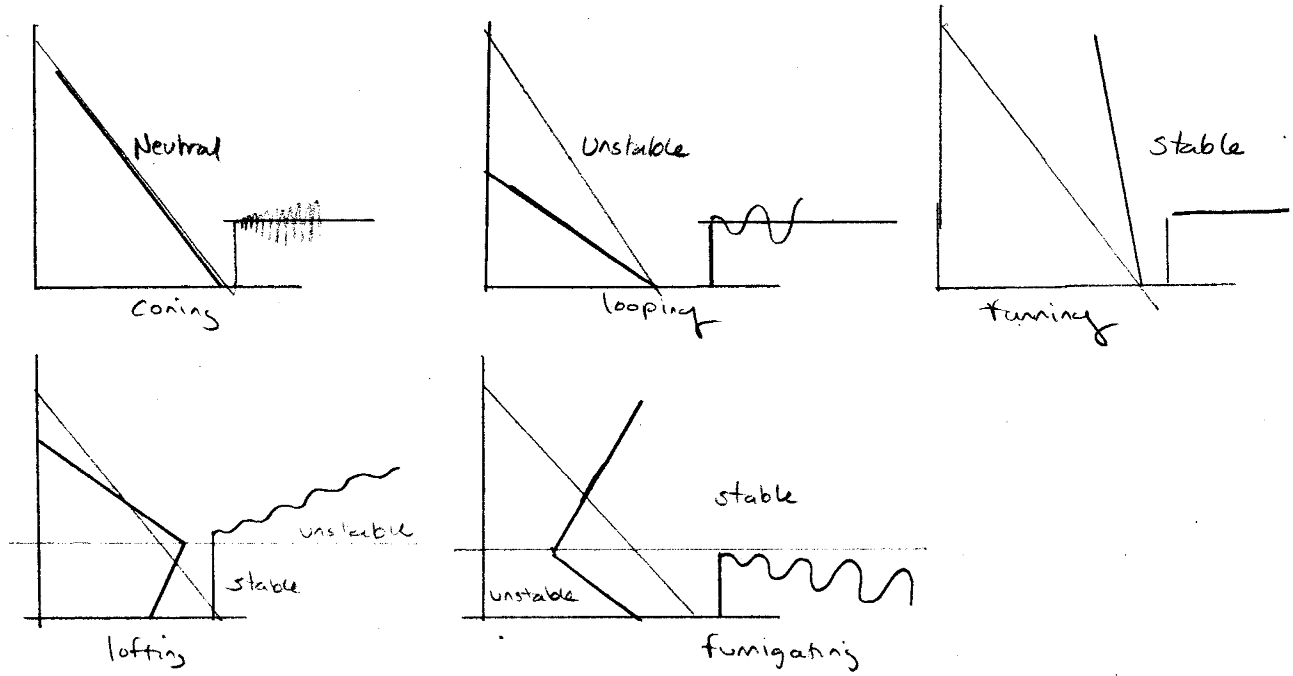
U = average windspeed

$vc < 6000 m^2/s$ are indicative of high air pollution potential.





Temperature profiles & stability play a big role in discharge placement



Plume Models