

ANALYSIS OF SOUNDINGS

1. Location of Stable layers – inversions
 Frontal zones
 Tropopause
 Jet Streams
 Cloud layers

2. Determination of Unreported Quantities (use of Thermodynamic diagram)
 e.g., T_w , θ , θ_e , RH, T_v , h, precipitation water, etc.

3. Stability Analysis
 e.g., LCL, CCL, LFC, Lifted Indices, CAPE, etc.

4. Forecasting Max and min temperatures
 Thunderstorms and their severity
 Rain versus no rain
 Rain versus snow versus freezing versus ice pellets
 Cloud cover, ceilings, visibility

5. Cross-Section Analysis
 Vertical cross-section from sounding data
 Show structure of fronts and jets
 Isentropic analysis

Stable Layers

We shall define stable layers in soundings in terms of temperature:

- | | | |
|---|-------------------------------|--|
| (i) <u>inversion</u> – Temperature increases with height. | $\partial T / \partial z > 0$ | $\left. \vphantom{\begin{matrix} \partial T / \partial z > 0 \\ \partial T / \partial z = 0 \end{matrix}} \right\} \partial \theta / \partial z \gg 0$ |
| (ii) <u>isothermal</u> layer – Temperature is constant. | $\partial T / \partial z = 0$ | |
| (iii) nearly isothermal - $\partial T / \partial z$ is small ($\partial \theta / \partial z$ remains large). | | |

Examples

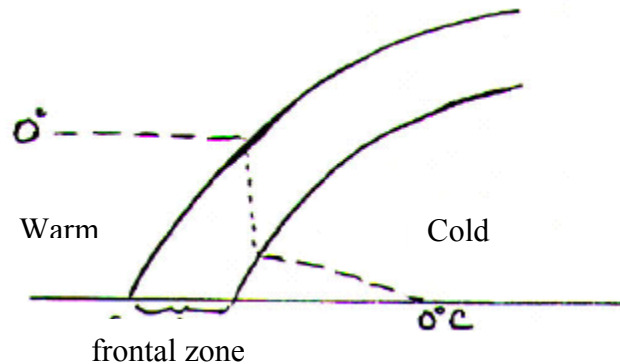
(a) surface inversion – due to radiative cooling

(b) subsidence inversion – caused by sinking layer of air above a layer that is not sinking as rapidly. The layer above this inversion should be dry and have a near dry-adiabatic lapse rate.

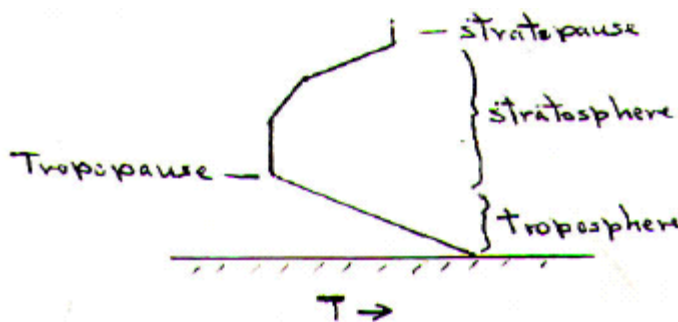
(c) frontal zones

Why is a front a stable layer?

Fronts slope back over cold air. For example, consider the 0°C isotherm: Connecting the isotherm through the frontal layer indicates an isothermal or inversion layer.



(d) stratosphere – large stable layer since temperature first becomes isothermal. At higher heights, the temperature increases with height. Location of the lower boundary (tropopause) of the stratospheric inversion is important.



How do stable layers look in terms of potential temperature?

Using equation (1): $\theta = T (p_0/p)^{R/c_p}$ (1)

is a “normalized” temperature such that when $\partial \theta / \partial z > 0$ (i.e., “warm” air above “cold” air) the atmosphere is stable, and when $\partial \theta / \partial z < 0$ (warm air below cold

air), the atmosphere is unstable. Note: This is for a dry atmosphere; for a saturated atmosphere, equivalent potential temperature, θ_e , has the same role.

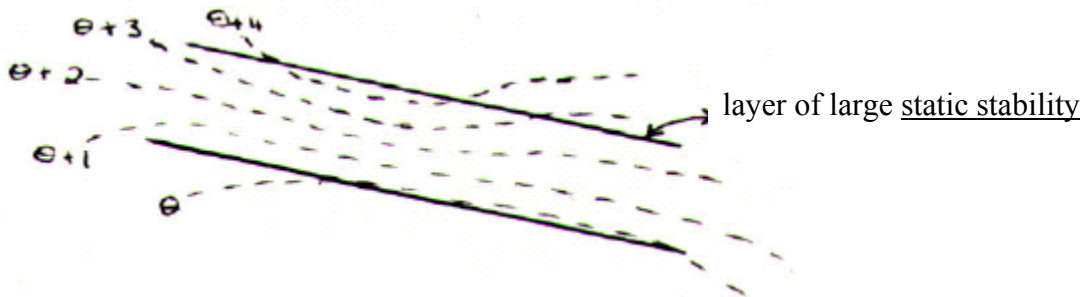
Recall
$$\frac{d\theta}{dt} = \frac{\theta}{c_p T} \dot{q} \quad (2)$$

Which is a statement of the First Law of Thermodynamics where \dot{q} is diabatic heating (e.g., latent heat release, radiation, friction). \dot{q} causes θ to change following the motion.

If $\dot{q} = 0$ (or is small), then $d\theta/dt = 0$, θ is conserved following the motion and air travels along isentropic (constant θ) surfaces. *This is a very important concept.*

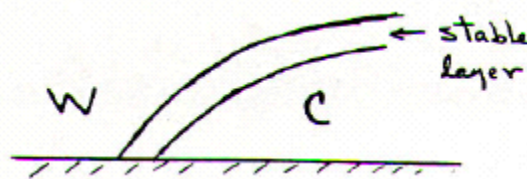
Since θ normally increases with height (i.e., the Standard Atmosphere is stable despite a decrease of T with height), we see from (1) that if T increases with height in a stable layer, θ really increases with height.

Therefore, $\partial\theta/\partial z$ is large in stable layers: $\partial\theta/\partial z \gg 0$; $\partial\theta/\partial p \ll 0$

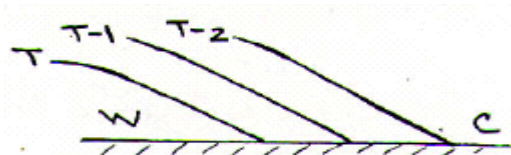


Analysis of Stable Layers

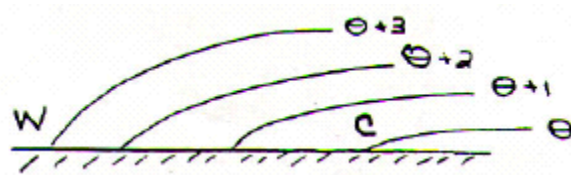
Stable layers slope up over colder air.



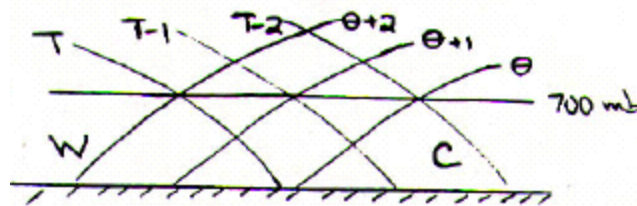
Isotherms (on average) slope downward toward cold air.



Isentropes (lines of constant θ) slope upward toward cold air.

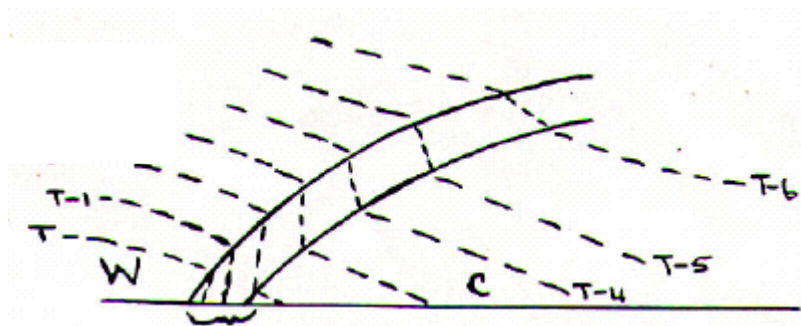


On a constant pressure surface, $\nabla_p T \equiv \nabla_p \theta$
(i.e., both T and θ decrease toward poles)



Isotherms in a stable layer:

Slope is more sharply downward in a frontal zone (may change sign of slope if inversion present). *Surface fronts usually weaken with height.*



Strongest surface temperature gradient

Isentropes in stable layer:

Slope is upward from warm to cold air and is steeper in a frontal zone.

They are packed closer together in the frontal zone so that $\partial\theta/\partial z$ is large. θ is approximately conserved along frontal boundaries. This rule can be used as a guideline to connect stable layers on sounding charts.

