Topic: Inversion of Temperature

B.A HONOURS IN GEOGRAPHY: 3rd SEMESTER

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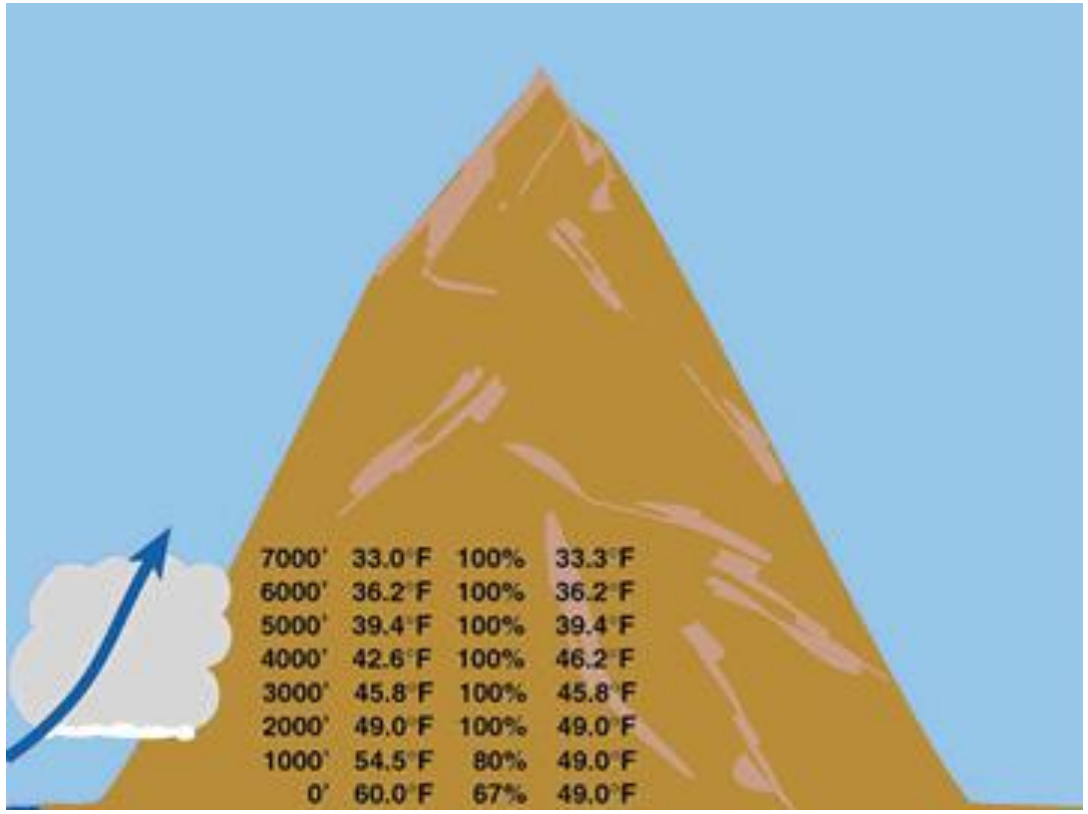
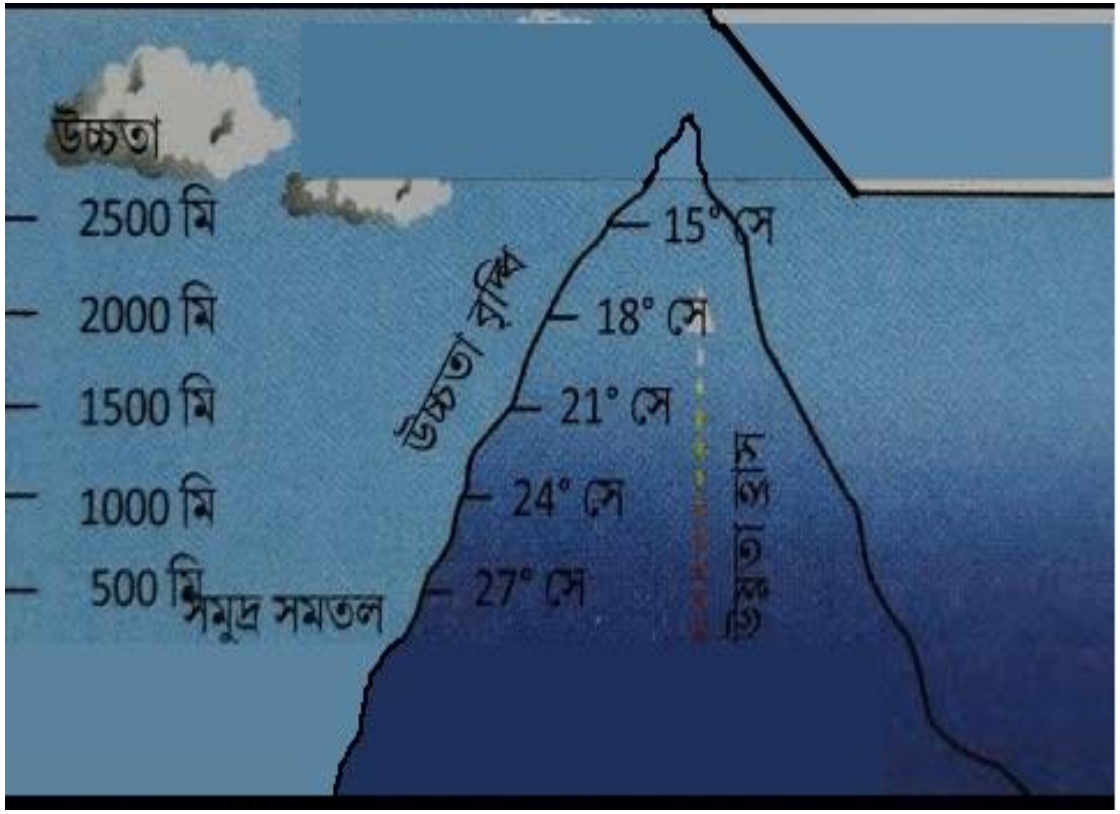




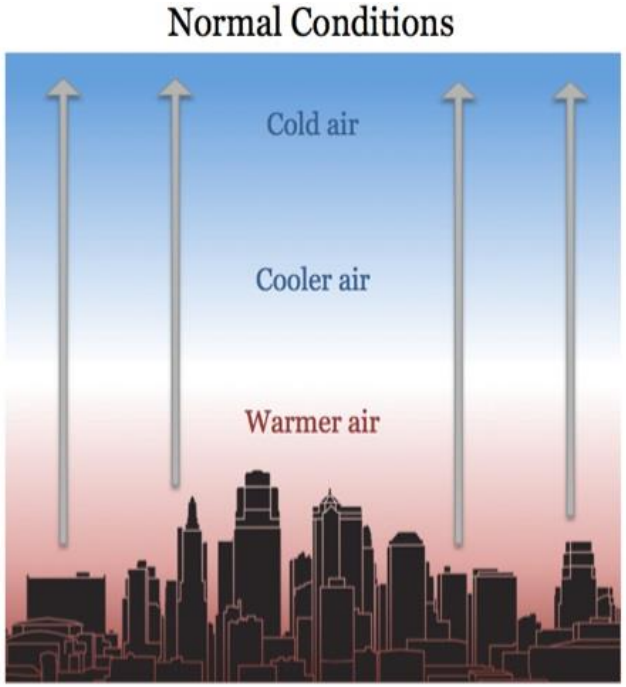
- ✓ Under normal conditions, temperature usually decreases with increase in altitude in the troposphere at a rate of 6.5 degree centigrade for every 1 Kilometer. This is called **normal lapse rate**.

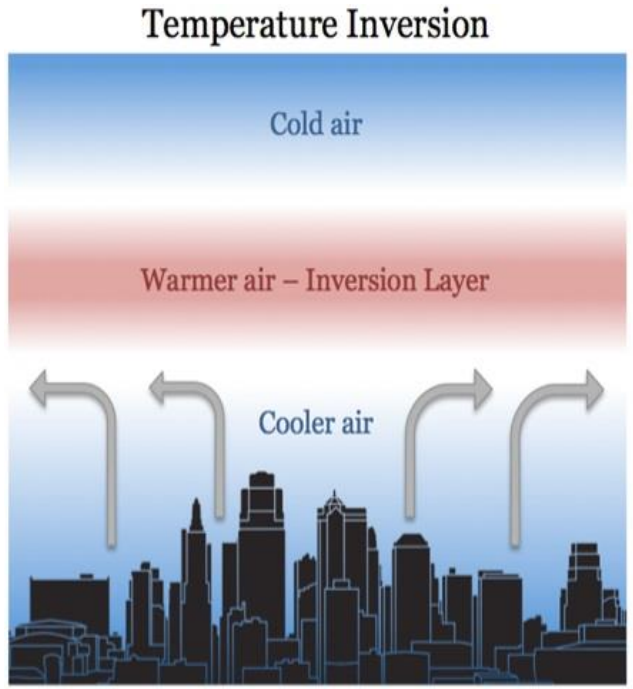
- ✓ But on some occasions, the situations get reversed and temperature starts increasing with height rather than decreasing. This is called **temperature inversion**.

Concept of Temperature inversion

It is a reversal of the normal behavior of temperature in the troposphere. Under this meteorological phenomenon a layer of warm air lies over the cold air layer.

- Thus, warm air layer lies over cold air layer. This phenomenon may occur near the earth's surface or at greater height in the troposphere.
- The inversion of temperature near the earth's surface is of very short duration because the radiation of heat from the earth's surface during daytime warms up the cold air layer which soon disappears and temperature inversion also disappears.
- On the other hand, upper air temperature inversion lasts for longer duration because the warming of cold air layer aloft through terrestrial radiation takes relatively longer period of hours.





Favorable Conditions for Temperature Inversion

Long winter nights

Loss of heat by terrestrial radiation from the ground surface during night may exceed the amount of incoming solar radiation.

Cloudless and clear sky

Loss of heat through terrestrial radiation proceeds more rapidly without any obstruction.

Dry air near the ground surface

It limits the absorption of the radiated heat from the Earth's surface.

Slow movement of air

It results in no transfer or mixing of heat in the lower layers of the atmosphere.

Snow covered ground surface

It results in maximum loss of heat through reflection of incoming solar radiation.

Types of Temperature Inversion

Temperature inversion is classified into the following types on the basis of **relative heights from the earth's surface** at which it occurs and the **type of air circulation**:

(1) Non-advectional Inversion

(i) Ground / surface inversion / radiation inversion

(ii) Upper air inversion

(2) Advectional Inversion

(i) Frontal inversion or cyclonic inversion

(ii) Valley inversion due to vertical air movement

(iii) Surface inversion due to horizontal air movement

(3) Mechanical Inversion

(i) Subsidence inversion

(ii) Turbulence and convective inversion

Ground / Surface Inversion

Ground or surface inversion, also called as radiation inversion, occurs near the earth's surface due to radiation mechanism. This is also called as non-advectional inversion because it occurs in stable atmospheric condition characterized by almost no movement of horizontal or vertical air.

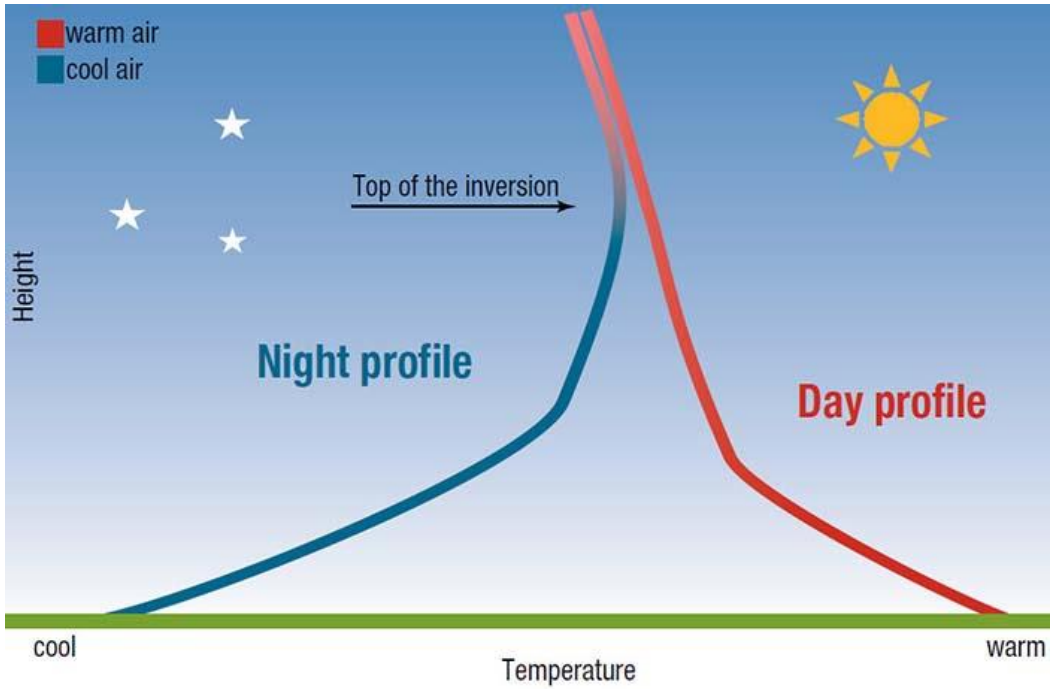
Such inversion normally occurs during the long cold winter nights in the snow-covered regions of the middle and high latitudes. In the low latitude areas (tropical and subtropical areas) it occurs during winter nights only and the inversion generally disappears with sunrise but sometimes it persists up to noon.

The duration and height of surface inversion increase pole-ward. The inversion occurs up to the height of 30-40 feet in the low latitudes, a few hundred feet in the middle latitudes and half a mile in the high latitudes.

Mechanism

a) Surface inversion is caused due to excessive nocturnal cooling of the ground surface due to rapid rate of loss of heat from the ground through outgoing long-wave terrestrial radiation.

b) The air coming in contact with the cool ground surface also becomes cold while the air layer lying above is relatively warm. Consequently, temperature inversion develops because of cold air layer below and warm air layer above.



Suitable Conditions

The ground or surface inversion occurs under the following conditions -

1. Long winter nights - so that the loss of heat by terrestrial radiation from the ground surface during night may exceed the amount of insolation received from the sun through incoming shortwave electromagnetic radiation waves and thus the ground surface becomes too cold.

2. Cloudless and clear sky - so that the loss of heat through terrestrial radiation proceeds more rapidly without any obstruction. Clouds absorb terrestrial radiation and hence retard loss of heat from the earth's surface.

3. Presence of dry air near the ground surface - so that it may not absorb much heat radiated from the earth's surface as moist air is capable of absorbing much of the radiant heat from the earth's surface.

4. Slow movement of air - so that there is no transfer and mixing of heat in the lower layers of the atmosphere.

5. **Snow-covered ground surface** - so that there is maximum reflection of incoming solar radiation. Snow is a bad conductor of heat which retards the flow of heat from the ground surface lying below the snow- layers to the lower atmosphere.

As this inversion of temperature occurs in the calm atmospheric condition (very little movement of air) and hence it is also called static or non-advectional inversion.

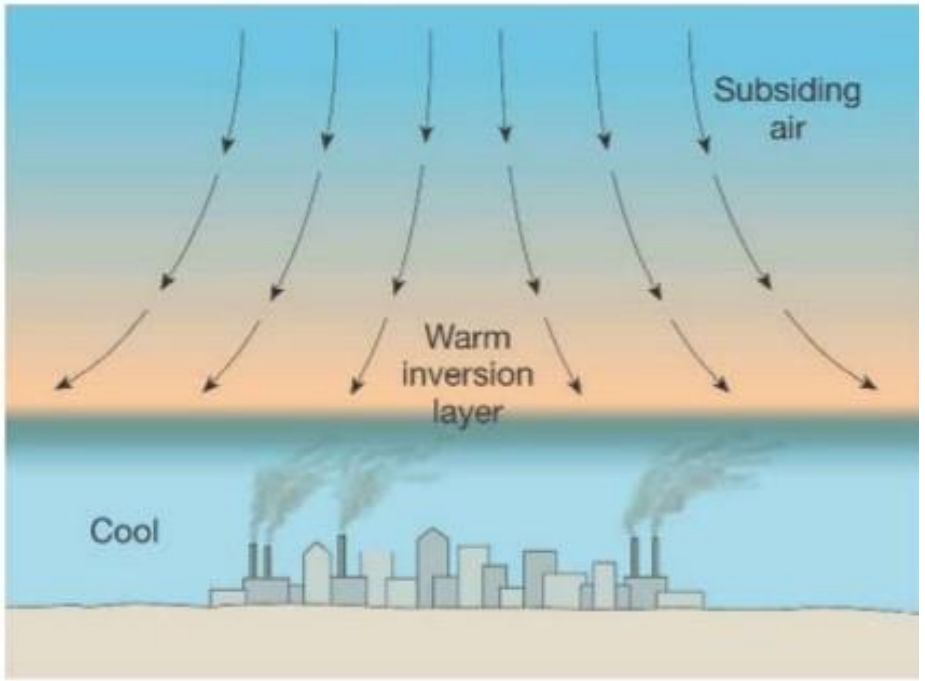
Upper Air Inversion

Upper air inversion is of two types -(i) thermal upper air inversion and (ii) mechanical upper air inversion.

Thermal upper air inversion is caused by the presence of ozone layer lying between the height of 15 to 35 km (even up to 80km) in the stratosphere. The ozone layer absorbs most of the ultraviolet rays radiated from the sun and thus the temperature of this layer becomes much higher than the air layers lying above and below ozone layer.

Mechanical inversion of temperature is caused at higher heights in the atmosphere due to subsidence of air and turbulence and convective mechanism. It may occurs in a number of ways -

a) Sometimes, warm air is suddenly transported upward (due to eddies formed by frictional forces) to the zone of cold air and thus cold air being denser lies under the warm air and inversion of temperature is formed.
b) When a parcel of air descends, it is warmed at the dry adiabatic rate of 10°C per 1000m because of compression. Thus, a zone of warm air formed above the cold layer of air and inversion is happened. Such mechanical inversion is generally associated with the anticyclonic conditions. So, it is very commonly occurred in the middle latitudes where high pressures are characterized by sinking air.

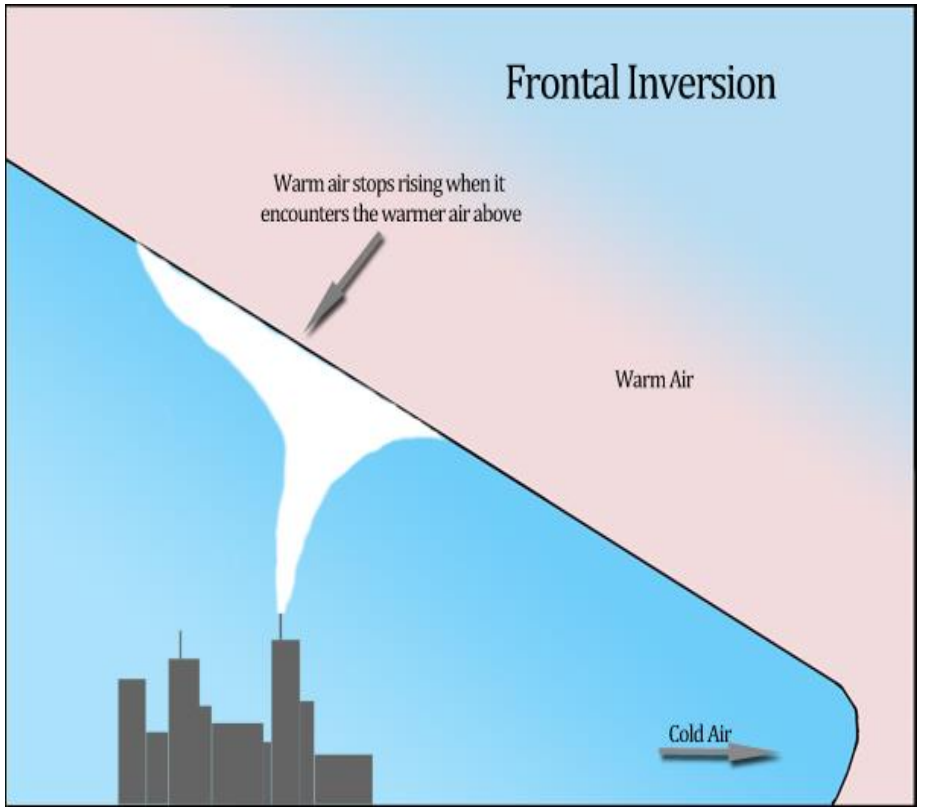


Advectional Inversion

Advectional inversion of temperature is also called as dynamic inversion because it is always caused due to either horizontal or vertical movements of air. Strong wind movement and unstable conditions of the atmosphere are prerequisite conditions for advectional inversion of temperature. This is further divided into 3 sub-types on the basis of the nature of air movements -

Frontal or cyclonic inversion

Frontal or cyclonic inversion is caused in the temperate zones due to temperate cyclones which are formed due to the convergence of warm westerlies and cold polar winds in the northern hemisphere. The warm air is pushed up by the cold polar air and thus the warm air overlies the cold air because it is lighter than the cold air. Thus, the existence of warm air above and cold air below reverses the normal lapse rate (decrease of temperature with increasing height) and inversion of temperature occurs.



The inversion layer associated with frontal or cyclonic inversion is always sloping because the boundary zone (front) between the warm westerlies and cold polar air masses become slopy. It is also interesting to note that air moisture increases upward in frontal inversion of temperature while it decreases upward in other types of temperature inversion.

Surface inversion

Surface inversion of temperature caused by horizontal movement of air occurs in several situations. Such inversion is caused when warm air moves to the area of cold air or cold air moves into the area of warm air. As warm air being lighter is pushed upward by relatively denser cold air and inversion takes place.

Surface inversion occurs generally in the low latitudes. When the warm air moves, such inversion is caused over the continents during winter and over the oceans during summer but when the cold air becomes active and invades the areas of warm air, such inversion occurs over the continents during summer and over the oceans during winter.

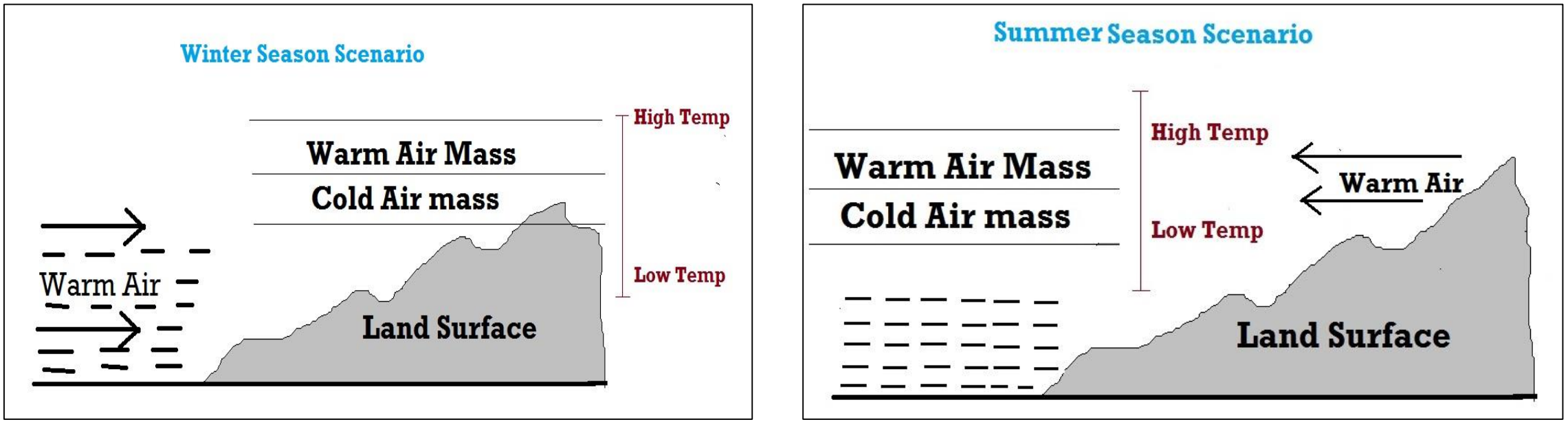
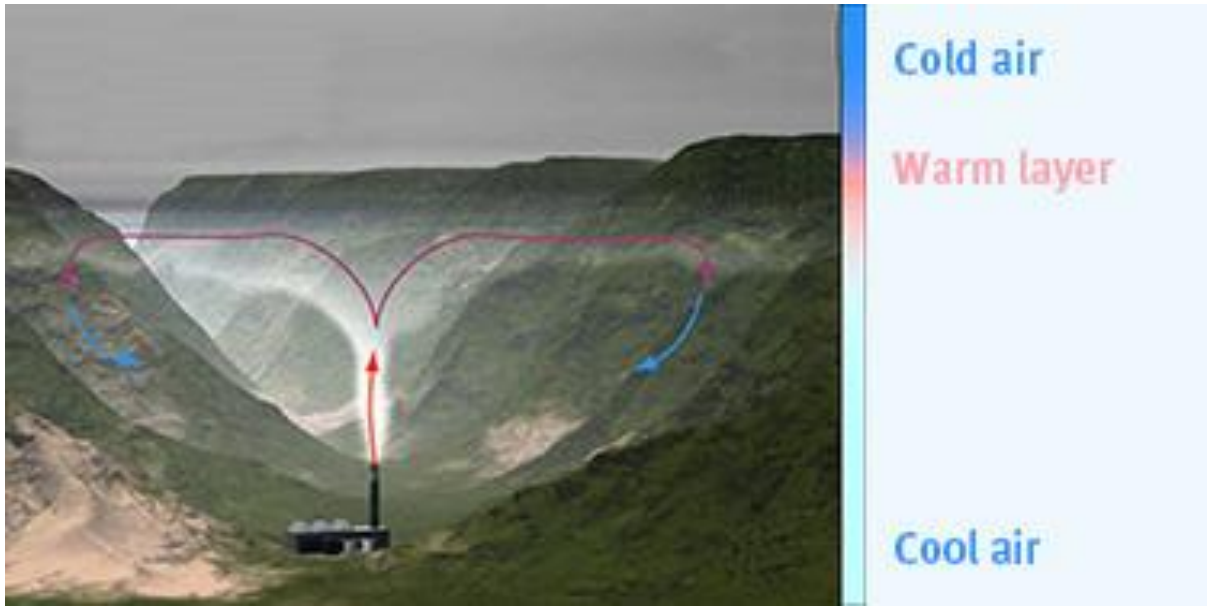


Fig: Surface inversion scenarios in low latitudes

Valley inversion

Valley inversion generally occurs in the mountainous valleys due to radiation and vertical movement of air. The temperature of the upper parts of the valleys in mountainous areas becomes exceedingly low during winter nights because of rapid rate of loss of heat from the surface through terrestrial radiation. Consequently, the air coming in contact with the cool surface also becomes cool. On the other hand, the temperature of the valley floor does not fall considerably because of comparatively low rate of loss of heat through terrestrial radiation. Thus, the air remains warmer than the air aloft and hence the warm and light air of the valley floor is pushed upward by the descending cold and heavier air of the upper part of the valley. Thus, there is warm air aloft and cold air in the valley floor and inversion of temperature is caused.

This situation is responsible for severe frost in the valley floors causing great damage to fruit orchards and vegetables and agricultural crops whereas the upper parts of the valleys are free from frost. This is why the valley floors are avoided for human settlements while the upper parts are inhabited in the mountainous valleys of middle latitudes.



Significance of Temperature Inversion

Though inversion of temperature denotes local and temporary conditions of the atmosphere but there are several climatic effects of inversion which are of great significance to man and his economic activities. Temperature inversion determines the precipitation, forms of clouds, and also causes frost due to condensation of warm air due to its cooling.

- **Dust particles hanging in the air:** Due to inversion of temperature, air pollutants such as dust particles and smoke do not disperse on the surface.
- **Stops the movement of air:** It causes the stability of the atmosphere that stops the downward and upward movement of air.
- **Less rainfall:** Convection clouds can not move high upwards so there is less rainfall and no showers. So, it causes a problem for agricultural productivity.
- **Lower visibility:** Fog is formed due to the situation of warm air above and cold air below, and hence visibility is reduced which causes disturbance in transportation.
- **Thunderstorms and tornadoes:** Intense thunderstorms and tornadoes are also associated with inversion of temperature because of the intense energy that is released after an inversion blocks an area's normal convention patterns.
- Diurnal variations in temperature tend to be very **small.**

1. When the air above is warmer than the air below, it is called a

a) Temperature shift
b) Temperature change
c) Temperature inversion
d) Temperature reversal

2. How does a temperature inversion break?

a) the air mixes
b) it doesn't
c) it breaks the next day
d) it stays the same

3. Read the following conditions:

I. Cloudy Sky
II. Cold dry air
III. Strong winds
IV. Long winter nights

Which of the above conditions promotes the inversion of temperature?

(a) 1, 2 and 3 (b) 1, 2, 3 and 4

(c) 1 and 4 (d) 2 and 4

4. Which is not a type of inversion of temperature?

a) Ground inversion
b) Frontal inversion
c) Valley inversion
d) Hill inversion

5. Which of the following is not correct for inversion?

a) It causes the stability of the atmosphere
b) It reduces visibility which causes disturbance in transportation
c) Make destruction of fruit orchards in the lower parts of valleys due to severe frost caused by inversion
d) It results higher amount of precipitation