Air Mass

1. Definition:

An air mass is defined as an extensive portion of atmosphere whose physical properties, especially temperature, moisture content and 1apse rate are homogenous horizontally and vertically for hundreds of kilometres. Thus, an air mass has two basic characteristics-

(i) Vertical temperature distribution, lapse rate, a measure of warmth or coldness which affects its stability; and

(ii) Homogenous moisture content, which is an indication of latent heat.

2. Characteristics:

- However, as the air mass extends through many latitudes and covers hundreds of thousands to millions of square kilometres, the horizontal homogeneity is far from achieved and small differences in the physical properties, such as temperature and humidity exist from one point to another at the same level.
- These internal differences are quite small in comparison with the much more rapid rates of change that are experienced across the boundaries between different air masses.
- The nature and degree of uniformity of an air mass is determined by the nature of the source area (from which the air mass obtains its original qualities) and the direction of movement.
- The physical properties of all air masses are classified according to the way in which they compare with the corresponding properties of the underlying surface region or with those of adjacent air masses; (i) changes that occur in the constitution of an air mass as it moves over long distances; and (ii) the age of the air mass.

3. **Origin**

In order to acquire these properties, the air mass must stagnate for a time on the source region, which itself should have-

(a) fairly homogenous surface condition (for example, large land or water area with evenly distributed insolation) over a very large area.

(ii) light divergent winds. The light winds ensure that the air will stay over the source region long enough to come approximately to equilibrium with it. The spreading and stretching associated with divergence causes the contrasts to diminish. Thus, the most notable centres for its development are semi-permanent high pressure areas at the outer limits of the Hadley cell and in winter, the thermally induced high pressure regions over the poleward continental margins. LOW-pressure zones are not suitable for the origin of air masses as they accentuate unevenneSS of temperature by bringing air of different temperature characteristic.

4. Source Region

4.1. Definition: The extensive areas over which air masses originate or form are called source regions whose nature and properties largely determine the temperature and moisture characteristics of air masses. An air mass originates when atmospheric conditions remain stable and uniform over an extensive area for fairly long period so that the air lying over that area attains the temperature and moisture characteristics of the ground surface. Once formed, an air mass is seldom stationary over the source region, rather it moves to other areas.

4.2. Characteristics:

An ideal source region of air mass must possess the following essential

(i) There must be extensive and homogeneous earth's surface so that it may possess uniform temperature and moisture conditions.

(ii)The source region should be either land surface or ocean surface because irregular topography and surface comprised of both land and water cannot have uniform temperature and moisture conditions.

(iii) There should not be convergence of air, rather there should be divergence of air flow so that the air may stay over the region for longer period of time and thus the air may attain the physical properties of the region. It is, thus, apparent that anticyclonic areas characterised by high barometric pressure and low pressure gradients are most ideal regions for the development of air masses.

(iii) Atmospheric conditions should be stable for considerable long period of time so that the air may attain the characteristics of the surface.

4.3. Classification:

The air mass source regions are divided into two categories

(1) **Primary source regions:** The primary source regions are extensive where air mass lies for fairly long period. Such source regions are tropical warm sea surfaces and hot desert land surfaces, and Arctic cold region.

(2) **Secondary source regions.** The secondary source regions are characterized by extensive uniform surfaces where the air mass does not stay for longer period, rather the air mass moves away after its origin. In other words, the secondary source regions are those where air masses are transformed (modified) and attain unique characteristic features. It may be mentioned that air mass source region cannot be convergence zone of air, rather it should be divergent zone.

4.4. Different Source Regions:

There are 6 major (primary) source regions of air masses on the earth's surface

(1) Polar oceanic areas (North Atlantic Ocean between Canada and Northern Europe, and North Pacific Ocean between Siberia and Canada-during winter season),

(2) Polar and arctic continental areas (snow-converted areas of Eurasia and North America, and Arctic region during winter season),

(3) Tropical oceanic areas (anticyclonic areas- throughout the year),

(4) Tropical continental areas (North Africa-Sahara, Asia, Mississippi Valley zone of the USA-most developed in sumnmers),

(5) Equatorial regions (zone located between trade winds-active throughout the year), and (6) monsoon lands of S.E. Asia.

Source regions are also classified on the basis of

(A) Nature of surface into (1) continental source region and (2) maritime (oceanic) source region, and

(B) on the **basis of latitudes** into (1) equatiorial source region, (2) tropical source region, (3) polar source region, and (4) arctic Source region.

5. Modification

As the air masses move away from their source region, they are affected by different heat and moisture exchanges with the ground surface and by dynamic processes in the atmosphere. Thus, an initially barotropic air mass is gradually changed into a moderately baroclinic air stream in which isometric and isobaric surfaces intersect each other (see chapter 8, Humidity) The presence of horizontal temperature gradient means that air cannot travel as a solid block without changing its internal structure. Also the actual path followed by an air parcel in the middle and upper troposphere will be very much different from the path taken at the surface because the westerly wind velocity increases with height in the troposphere. Even despite these changes the air mass concept is quite valid and remains of practical value.

There are two mechanisms by which air masses can be modified- thermodynamic and dynamic, although this rigid distinction is not justified in practice.

A. Thermodynamic modification-

a) Thermodynamic modifications are caused by the transfer of heat between the base of an air mass and the surface over which it flows.
b) The degree of modification is determined by the nature of underlying surface the path of movement of the air mass, the duration of travel, and the addition of moisture.
c) An air mass may be heated from below either by passing from a cold to a warm surface or by solar heating of the ground over which the air is located. Alternatively, the air can be cooled from below.
d) Heating from below increases the air mass instability and the effect is spread rapidly through a considerable thickness of air whereas surface cooling produces temperature inversion, which greatly limits the vertical extent of cooling. For this reason, cooling occurs largely through radiative heat loss by air.

e) Evaporation also causes changes in the air, the moisture being supplied either from the underlying surface or by precipitation from an overlying air mass.
f) Abstraction of moisture by condensation or precipitation can also cause changes. A parallel and most important change is the respective addition or loss of latent heat that accompanies evaporation and condensation.
g) Thermodynamic modifications also depend to a large degree on the temperature of air mass. Warm air masses in passing over water bodies develop potential instability.

B. Mechanical Modification- Dynamic (mechanical) changes involves mixing pressure changes associated with the actual movement of air masses either by turbulence, high level convergence and divergence. Prolonged period of turbulent mixing causes substantial change in the 'physical properties of air masses. Dynamic changes may be brought about by a combination of one or more factors-

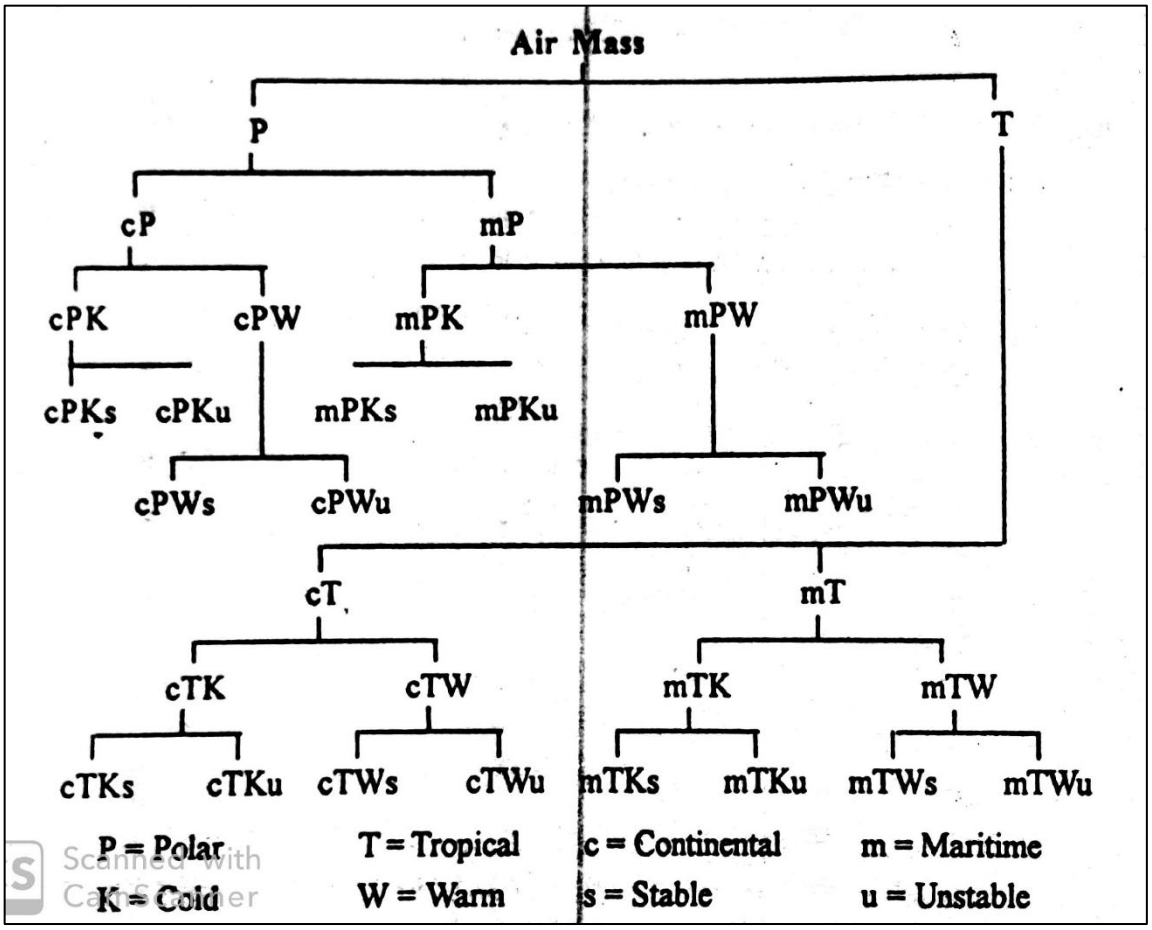
- Turbulent mixing at a lower level, where natural friction provides a ready mechanism for the upward transfer of the effects of thermodynamic effects by eddy formation.
- Large scale lifting resulting from forced ascent by mountain barrier or by air stream convergence
- Sinking caused by high level convergence or by descent of air in the lee of high ground caused by pressure gradient.
- Lifting caused by horizontal convergence at low level.
- Advection.

Turbulence causes thorough mixing, sometimes up to a considerable height and transfers heat and moisture up to a considerable height. Subsidence causes stable stratification in the atmosphere while lifting and ascent causes steepening lapse rate and therefore, promotes instability.

6. Classification

Based on thermodynamic and mechanical modifications and some other consideration air masses are divided into 16 categories.

Thus, thermodynamic modification causes air mass to become cold or warm represented by letters W for warm and K (from German "Kalt", meaning) for cold. While mechanical or dynamic modification causes it to become stable (s) and unstable (u). Although it must be strictly borne in mind that the effects of dynamic and thermodynamic modifications are clearly inseparable.



Characteristics of major air masses:

1. Continental Polar (cP)

a) As cP moves equatorward over warmer ground it gets heated in its lowest layers causing the lapse rate in the lowest km or two of the atmosphere, unstable making the air gusty.
b) There is general suppression of clouds since the air is usually quite dry.
c) Moreover, the instability is only for a smaller form, they are usually near the ground.
d) Whatever clouds do depth stratocumulus or small cumulus and they provide only occasional and brief showers.

2. Maritime Polar (mP)

a) Maritime Polar (mP) air consists of deep layer of cool moist air with steep lapse rate.
b) The sea level temperature of this air is generally several degrees above freezing point. Places, such as Seattle and London, especially, during winter half of the year.
c) The mP never gets too cold since the ocean surface below keeps the air falling far below freezing point.
d) From one of its source mP moves from over North America, it ascends causes cloudiness and precipitation.
e) Since the convective instability that precipitation.

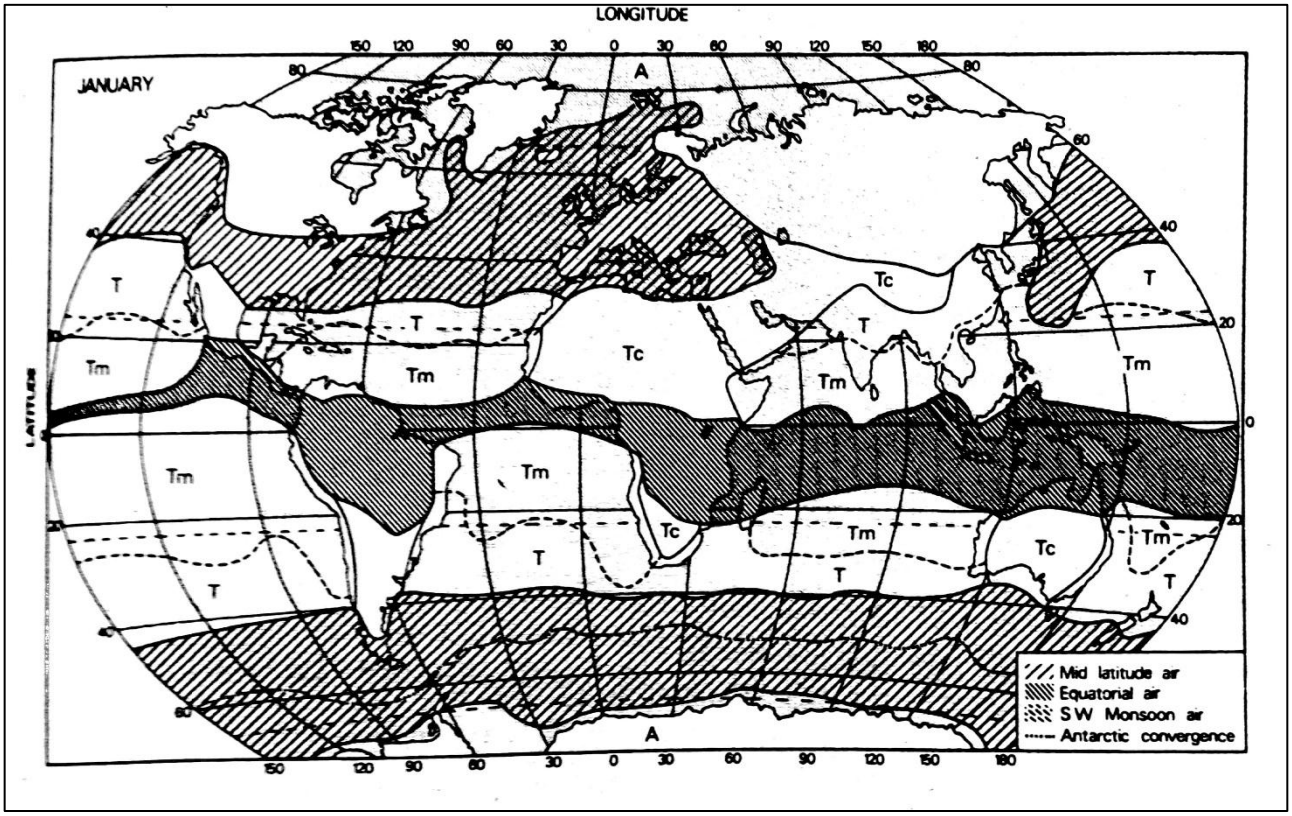
3. Continental Tropical (cT)

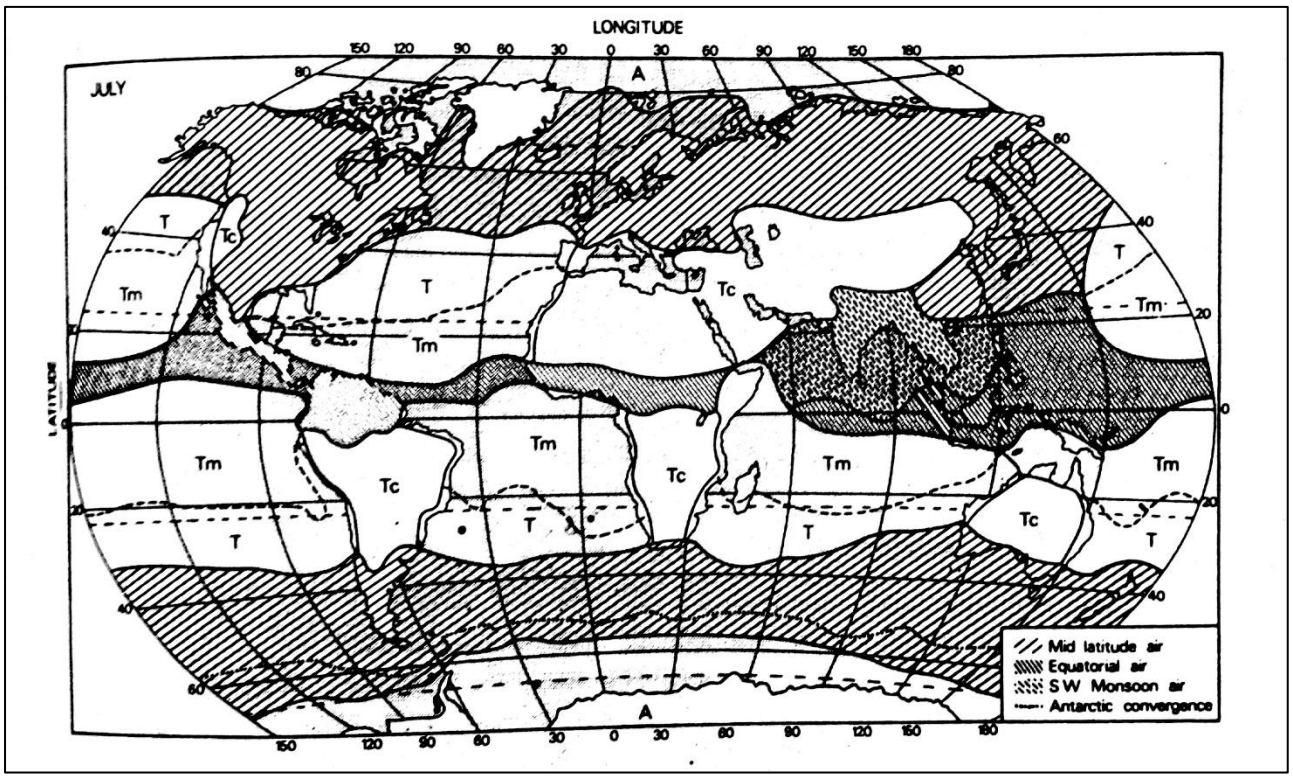
a) Continental tropical forms over the subtropical deserts of the world,
b) It is the hottest air mass at thee surface with temperatures over 40°C in summer.

c) The lapse rate of this air is quite steep in the lowest one kilometre or two but because of the trade wind motion and cloud formation are largely suppressed.
d) Source regions in the deserts it rapidly picks up moisture and changes to m air mass. Of all the air masses, cT before losing its identity.

4. Maritime Tropical (mT)

a) The mT air is found throughout the Tropics, and particularly, over subtropical Oceans.
b) The air mass is associated with cumulus and cumulonimbus clouds.
c) When mT air mass moves poleward over cooler ground or water it is rendered stable as it is cooled from below.
d) During autumn and winter cooling below dew point leads to formation of fog and stratus clouds.
e) Temperature inversion is responsible for making the air mass stable. It also leads to trapping of pollutants.




LONGITUDE
JULY
LATITUDE
A
D
T
Tc
Tm
Mid latitude air
Equatorial air
S W Monsoon air
Antarctic convergence