# Air mass: Typology, origin, characteristics and modification

**Part II (1+1+1 System) Geography Hons.**
**Paper: IV**
**Module: V**
**Topic: 3.3**



**Introduction and definition of an air mass**

The term air mass, as used by meteorologists denotes a large volume of air which is mostly homogeneous in temperature and humidity and extends to a large area often covering over thousands of kilometres and reaching upto the top of the troposphere.

An air mass may consist of several layers lying horizontally one above the other with each layer having uniformity of temperature and humidity. Thus the uniformity of temperature and humidity is not confined merely to the air in contact with the earth's surface but exists even in upper air up a height of several kilometres.

**Air Mass-Important Definitions**

1. "A body of air in which the upward gradients of temperature and moisture are fairly uniform over a large area is known as an air mass." - *Strahler and Strahler*
2. "An air mass is defined as a large body of air whose physical properties (temperature, moisture content and lapse rate) are more or less uniform horizontally for hundreds of kilometres." - *Barry and Chorley*

**Origin of an Air Mass**

An air mass originates over a period of time when a large volume of relatively stationary air remains in contact with a vast land or ocean surface which has nearly uniform characteristics of temperature and moisture.

Following two conditions are essential for the development of an air mass.

(i) An extensive land or water surface with homogeneous conditions of temperature and humidity.

(ii) A large, relatively stationery, volume of air over the surface with no divergent winds. Light winds ensure that the air stays over the source region for a sufficiently long time so that it acquires the temperature and humidity of the surface over which it stays. The spreading and stretching associated with divergence causes the contrasts to diminish.

**Source Regions of Air Masses**

A source region is a vast area of land or ocean over which there is great homogeneity of important characteristics likes temperature and humidity. It is important that air should descent on a large scale over the source area so that there are sufficient opportunities for air mass formation as it helps the entire air of the air mass to acquire the qualities of temperature and humidity of the region over which it lies.

The main source regions for air mass development are:

(i) the polar regions with their uniformly cold expanse of ice and low wind speed, and

(ii) hot tropical regions. Air masses generally do not develop over mid-latitudes where cold winds from polar areas meet with hot winds from tropical areas and uniformity of temperature and humidity is not maintained over large areas. Taking these facts into account, Strahler and Strahler have given a global scheme of source regions (Fig. 1).

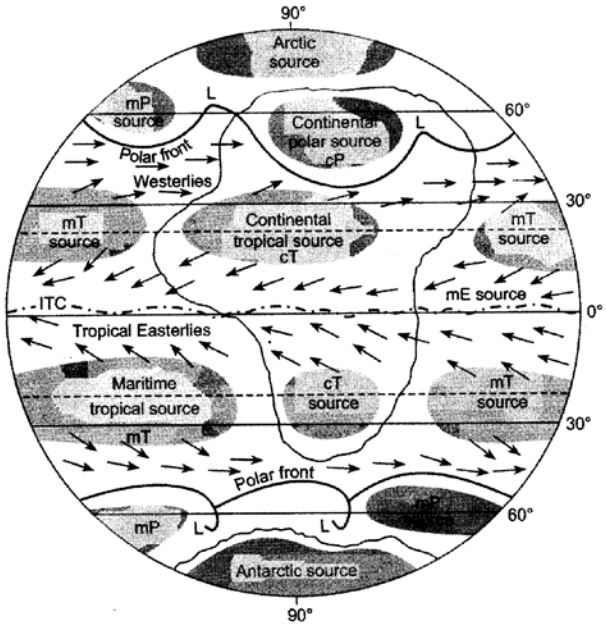


Fig.1. A schematic global diagram showing the source regions of air masses in relation to the polar front and the intertropical convergence zone (ITC). (After Strahler and Strahler, 1984)

Following are the main source regions:

1. **Arctic and Antarctic Source Regions.** These source regions surround north pole and south pole respectively and represent extremely cold conditions. Obviously, very cold air masses originate in these source regions.
2. **Continental Polar Source Region (cP).** The northern parts of continents in the northern hemisphere are very close to the Article source and are almost permanently covered by snow and ice. These are very cold areas where cyclonic conditions prevail. As such this source region offers good opportunities for air mass formation.
3. **Maritime Polar Source Region (mP).** The maritime polar sources are found over the oceans at about 60°N and S. The northern part of the Atlantic Ocean and the eastern part of the Pacific Ocean provide suitable conditions for air mass formation.
4. **Continental Tropical Source Region (cT).** Source regions on the continent in the tropical zone are known as continental tropical source regions. These source regions specially develop in Asia and North Africa. They are confined to N. Africa only in winter but spread over vast areas in Africa, Asia and southern Europe in summer.
5. **Maritime Tropical Source Region (mT).** These source regions are found over oceans in the tropical zone. The anticyclonic conditions, both in summer and winter provide suitable opportunities for development of air mass source regions.
6. **Maritime Equatorial Source Region (mE).** Trade winds from the north and the south converge over the oceans at the equator and give rise to maritime equatorial sources region. Here, air masses keep on developing throughout the year.
7. **Monsoon Source Region.** In addition to the above mentioned source regions, there is monsoon source region which is centred over the Indian Ocean. It strengthens the summer monsoons and helps in bringing summer rainfall. This region is the source of warm, moist air masses in summer and cold, dry air masses in winter.

**Characteristics of Air Masses**

1. Air masses originate over vast flat surfaces having uniform temperature and humidity.
2. Air masses travel slowly over hundreds of kilometres from their source regions.
3. As the air masses move away from source regions their chief characteristics of temperature and humidity undergo large scale changes.
4. They affect the weather conditions of the areas visited by them.
5. When two air masses of different temperature and humidity approach each other, they do not intermingle but a front is formed between them. Weather conditions change abruptly at the front. The front keeps two approaching air masses separate from each other.

**Classification of Air Masses**

Air masses can be classified on the basis of their source regions and amount of humidity present in them.

A. **Classification Based on Source Regions**

The primary air mass source regions are those of high latitudes or polar regions, or those of low latitudes, or tropical regions. Thus air masses are divided into following two broad classes.

1. **Polar Air Masses (P)** originate in polar areas and are denoted by the letter 'F'. Air masses of Canada are of this type. Arctic air mass is also considered to be another form of polar air masses and is denoted by the letter 'A'.
2. **Tropical Air Masses (T)** originate in the tropical areas and are denoted by the letter 'T'. Since they originate in the tropical zone, they are warm air masses. The air masses originating near the equator are known as equatorial air masses and are represented by the letter 'E'.

B. **Classification of Air Masses based on Humidity**

1. **Maritime Air Masses** originate over ocean surfaces and carry more humidity. They are represented by the letter 'm'. Maritime air masses originating in polar areas are represented by mP whereas those originating in tropical area are denoted by mT. Maritime air masses of the North Atlantic Ocean are mP air masses while those originating in the Gulf of Mexico are mT air masses.
2. **Continental Air Masses** originate over the continents and are denoted by the letter 'C'. These air masses lack in humidity. Continental air masses originating in the polar areas are called continental polar air masses and are denoted by cP. Air masses originating in Eurasia present good examples of cP air masses. Similarly continental air masses originating in the tropical zone are known as tropical continental air masses and are represent by cP.

Chief characteristics of some of the major air masses are given in Table 1.

Table 1. Some Typical Characteristics of Air Masses at Their Source Region

| Air Mass | Temperature (°C) | Specific Humidity *(g/kg)* | Stability | Source Regions |
|---|---|---|---|---|
| 1. Maritime tropical (*m*T) | 22 to 30 | 15-20 | Conditionally stable | Tropical and subtropical oceans, tropical rain forests of Amazon and Congo Basins and portions of Southeast Asia. |
| 2. Continental tropical (*c*T) | 30 to 42 | 5-10 | Conditionally stable; during the day the lapse rate is nearly adiabatic from surface to 3 km or more | Subtropical deserts, especially Sahara and Australia (poorly developed in winter) |
| 3. Maritime polar (mP) | | | | |
| Winter | 0 to 10 | 3 - 8 | Conditionally stable | Ocean, poleward of about latitude 45° to 50° |
| Summer | 2 to 14 | 5 - 10 | | |
| 4. Continental Arctic (cA) | | | | |
| Winter | -55 to -35 | 0.05-0.22 | Very stable; inversion from surface to 2 km is common | Antarctica, Arctic Basin, Greenland, interior portions of Eurasia and North America roughly north of (Summer - found only in deep interior of Antarctica and possibly Greenland) |
| 5. Continental polar (cP) | | | | |
| Winter | -30 to -20 | 0.06-0.2 | Very stable; surface inversion | Interior of continents, between about latitudes 45° and 55° |
| Summer | 5 to 15 | 4-9 | Stable or conditionally stable | Northern portions of North America and Eurasia (generally north of 55° or 60° latitude) |

**Modifications of Air Masses**

As mentioned earlier, air masses originate from specific source regions and are almost homogeneous with respect to their two basic characteristics of temperature and humidity. Stagnant air is one of the basic pre-requisites for the development of an air mass. However, these ideal conditions do not prevail for a much longer period. The general circulation of air pulls air mass from its source region and carries it to other locations. Uneven heating of the earth's surface, irregularities in relief etc. also contribute to the migration of air masses from their source regions to other areas. As the air masses leave their source regions and move to other areas, they undergo modifications, the degree of which depends upon the following factors:

(a) The original character of the air mass.
(b) The path followed by the air mass in moving from its source region to its present position.
(c) The temperature and humidity of the surface over which it moves.
(d) The length of time during which the process of modification takes place.

Modification of the status of an air mass is the result of following two developments:

(a) Exchange of heat and/or moisture between the air mass and the surface it comes in contact with.
(b) Large scale ascent or descent of air in the air mass.

Two principal types of air mass modifications are recognised:

(i) Those which are thermodynamic in nature and
(ii) Those which are mechanical in origin. Actually these modifications do not occur separately but usually in combination.

**I. Thermodynamic Modifications.** Modification of an air mass resulting from the transfer of heat between the bottom of an air mass and the surface over which it moves is known as thermodynamic modification. The degree of modification depends upon the nature of the underlying surface, the trajectory or path of the air mass as it leaves its source region, and the number or days it has travelled in arriving at the observation point.' Such a modification takes place in two different ways: (a) when air mass is heated from below and (b) when air mass is cooled from below.

(a) **When air mass is heated from below.** When an air mass moves over a surface which is warmer than its own air, there will be warming of the lower layers of the air mass. This will result in an increased lapse rate with associated instability. This condition favours the ascent of heated lower air with possibility of condensation, formation of clouds and precipitation. There is differential rate of heating with maximum change occurring in the lower layers. Such an air mass is denoted by the letter 'K' (cold or Kalt). This means that the concerned air mass is cooler than the surface over which it moves. For example, if a polar air mass moves towards the tropical zone, it is cooler than the surface over which it moves and letter 'K' is attached with the concerned air mass. Thus cP and mP become cPK and mPK respectively which means that continental polar (cP) and maritime polar (mP) air masses are moving towards warmer tropical areas.

(b) **When air mass is cooled from below.** When an air mass moves over a surface which is colder than the lower layer of the air mass, there is a chilling of the surface air and inversion of temperature takes place. This situation Increases the stability of the air which is opposed to the ascent of air and consequently, the condensation of the air, formation of clouds and precipitation. This type of air mass is denoted by the letter 'W' (warm). This means that the concerned air mass is warmer than the surface over which it moves. For example, if a tropical air mass moves towards the polar region, it is warmer, than the surface over which it moves and letter 'W' is attached with the concerned air mass. The cT and mT become cTW and mTW respectively which means that continental tropical (cT) and maritime tropical (mT air masses are moving towards the cold polar areas).

**II. Dynamic or Mechanical Modification.** This is a type of modification in which no transfer of heat from the air mass to the surface and vice versa takes place; rather it happens due to movement of the air. It happens in cyclones, anticyclones, surface friction or due to meeting of different air masses. Greater importance is attached to the modifications of an air mass resulting from large scale horizontal convergences and divergences which occur well above the earth's surface. Such circulations produce ascending and descending movements of air thereby affecting the air mass stratification. Horizontal divergence is associated with subsidence in the free atmosphere. This results in increased stability which does not encourage condensation and precipitation. Such a situation is associated with an anticyclone. In contrast to this, horizontal convergence is associated with ascent

of air which increases instability and the possibility of condensation and precipitation. This type of condition prevails in a cyclone.

When an air mass flows over the surface, the friction between air and the ground surface brings about changes in the lower layers of the air mass and there is a mixing of heat and moisture at certain height and the air mass becomes either cold or warm for which letters K (Kalt or cold) and W (warm) are used.

If an air mass descends along the leeward side of a mountain, its temperature increases and its humidity decrease. Thus there is a condition of stability in a descending air mass and it becomes unsaturated. Similarly, if an air mass becomes a part of a cyclone, it starts descending and becomes stable. Letter 's' is attached to a descending air mass to indicate its stability. For example PKs means that the polar cold (PK) air mass is stable.

Conversely, when an air mass ascends along a hill slope, it becomes unstable and is indicated by 'u'. For example, PKu means that the polar cold (PK) air mass unstable.

Thus, there are 16 types of air masses, as indicated below: