AIR MASSES & FRONTS

"An air mass is a vast pool of air having similar temperature and moisture characteristics over its horizontal extent."

An air mass occupies thousands of square miles of the Earth's surface. Air masses are born in a source region where they take on their characteristic temperature and moisture content. **Source regions** are often regions of low relief and calm wind that prevent turbulent mixing and allow the air to take on the conditions of the surface over which it forms. High pressure enables the air to move outward from the source region.

Air masses are classified according to two categories of generalized source regions:

1. **Latitudinal position** of the globe which primarily determines thermal properties, &
2. **Underlying surface** – continents or oceans – determining the moisture content.

With respect to "Latitudinal Positions", five types of air masses are as follows:

Air Mass	Symbol	Source Regions
Arctic	A	Arctic Ocean and fringing (bordering) lands
Antarctic	AA	Antarctica
Polar	P	Continents and oceans (50° – 60° North and South)
Tropical	T	Continents and oceans (20° – 35° North and South)
Equatorial	E	Oceans close to equator

With respect to "**Underlying Surface**", two further sub-divisions are imposed on the preceding type as follows:

Air Mass	Symbol	Source Regions
Maritime	M	Oceans
Continental	C	Continents

By combining types based on "Latitudinal Positions" with those based on "Underlying Surface", a list of six important air masses results. These are:

Air Mass	Symbol	Properties
Continental Arctic	cA	Very cold, very dry (winter)
Continental Antarctic	cAA	Very cold, very dry (winter)
Continental Polar	cP	Cold, dry (winter)
Maritime Polar	mP	Cold, moist (winter)

Continental Tropical	cT	Warm, dry
Maritime Tropical	mT	Warm, moist
Maritime Equatorial	mE	Warm, very moist

1. Continental Arctic and Antarctic (cA&cAA)

Source Areas

Ice-and snow-covered surface in Greenland, Antarctica, Hudson Bay, Mackenzie Basin (River), Mongolia Lake, (Lake) Baikal Region, Scandinavia.

Typical Characteristics

Low water vapour content; temperature inversions above surface cooling zone (2000-3000 ft.); subsidence (decline) above generally stable.

Associated Weather

Clear skies except when modified; low temperatures at night; strong winter storms (blizzards) along leading edges (Arctic Front).

2. Continental Polar (cP)

Source Areas

In winter, the cold continent surfaces mostly free of ice and snow; in summer, cool surfaces in Canada and ex-USSR; rare summer south of ex-USSR.

Typical Characteristics

Found only in North Hemisphere; often modified continental Arctic air mass; clear skies at night; scattered cumulus clouds during the day; some subsidence above.

Associated Weather

Clear air; frost hazard in late spring and early fall; summer convectional showers near water bodies; involved in most frontal activity in mid-latitudes.

3. Maritime Polar (mP)

Source Areas

Ocean areas, latitudes 40° – 60° north and south.

Typical Characteristics

In winter, mainly modified continental Arctic and continental Polar air brought into ocean areas, resulting instability – Maritime Polar Cold Air; surface temperatures rarely sub-freezing; summer air generally stable – Maritime Polar Warm Air.

Associated Weather

Fog and overcast skies, when passing over a cold surface; cyclonic and orographic conditions produce heavy precipitation; fronts with Maritime Polar Warm Air produce drizzly rain.

4. Continental Tropical (cT)

Source Areas

High planes with sub-tropical anti-cyclones (mainly in winter); Sahara, South Africa, Central Australia, South-west China, North India, Andean Planes.

Typical Characteristics

Extremely low humidity; hot dusty turbulent air; subsidence of warm air aloft.

Associated Weather

Hot, dry weather; much haze; sometimes associated aloft with tornadoes.

5. MARITIME TROPICAL (mT)

Source Areas

Warm tropical and sub-tropical ocean areas beneath sub-tropical anti-cyclones.

Typical Characteristics

Usually subsidence and low lapse rate above; generally fairly stable; some low-level instability; often an inversion aloft.

Associated Weather

Hazy air; scattered cumulus clouds; passage over cold land results in broad overcasts; produces most continental snowfall in mid-latitudes; convectional rain with Maritime Tropical Cold Air in summer.

6. MARITIME EQUATORIAL (mE)

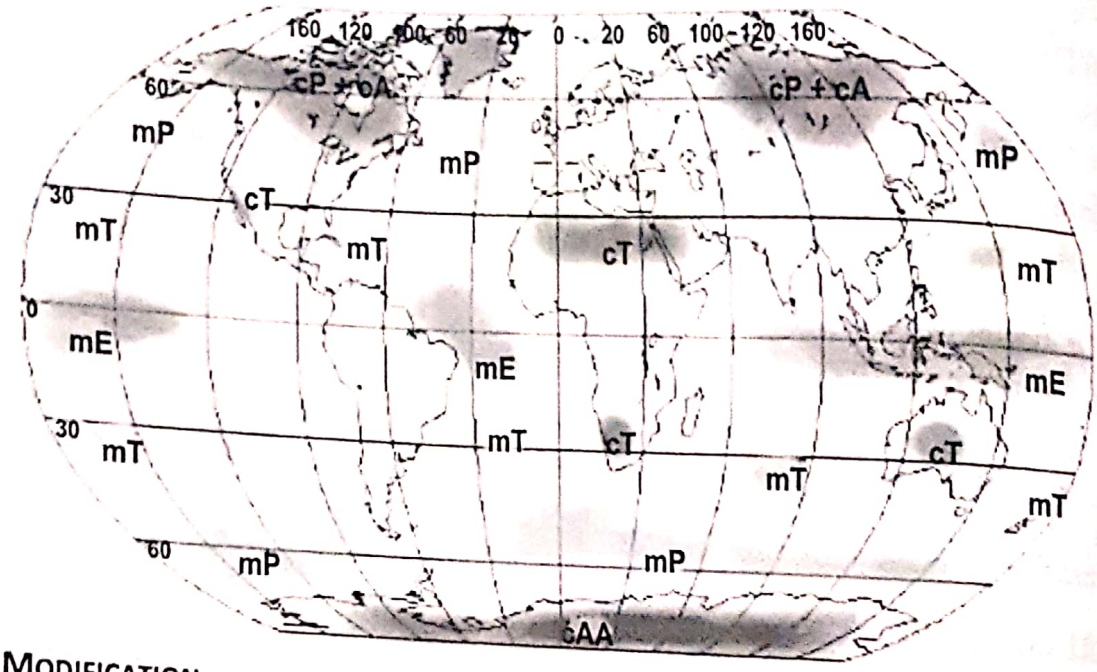
The name maritime equatorial is sometimes applied to very moist and warm air masses, originating within a few degrees of equator. These are a pronounced form of maritime tropical air masses. This air mass holds about 200 times as much water vapour as the extremely cold Arctic and Antarctic air mass.

GLOBAL AIR MASSES

Figure below shows the location of the air mass source regions that affect Earth's climate. Continental arctic air (cA) is typically described as extremely cold and dry. Record-setting temperatures in the middle and high latitudes are due to the invasion of this very cold mass of air. At about the same latitude in the Southern Hemisphere is found the continental Antarctic (cAA) air mass. This too is an exceedingly cold air mass and is drier than its arctic counterpart as the source region is the continent of Antarctica. Continental polar (cP) air is considered a cold and dry air mass that is warmer than the arctic air mass located to the north. Continental polar air is typically a stable or conditionally stable mass of air. Maritime polar (mP) air is cool and moist air that brings mild weather to coastal locations. Maritime polar air is warmer than continental polar air in the winter as the surface temperature of the ocean is higher. Similarly, mP air masses are typically cooler than cP air masses during the summer as the continents warm more than the ocean at these latitudes. Maritime polar air masses that enter the west coast are forced to rise up coastal mountain chains causing significant orographic uplift and precipitation. In Europe, mP air masses penetrate further inland due to the east–west orientation of the mountains. Thus smaller temperature ranges and higher humidity typical of maritime climate are found further inland in Europe than in the North America.

Maritime tropical (mT) air masses are warm and moist air masses that are responsible for much of the precipitation east of the Rocky Mountains in the United States. Precipitation occurs when mT air collides with cP air causing the warmer and less dense mT air to rise, cool, and condense into clouds. In the southeast portion of the United States, convective uplift of air also occurs to create precipitation. Over subtropical and tropical continents, the source region for the

hot and dry continental tropical (cT) air mass is found. Major source regions are the great deserts of the Earth such as the Sahara, Arabian, and Australian. The extremely low humidity is due to the lack of available water for evaporation as well as the subsidence of the subtropical high. The southwest desert of the United States serves as a source region for cT air too, but only during the summer. Surface temperatures in the winter are too cold to create a continental tropical air mass there. Near the equator the exceedingly warm and humid maritime equatorial air masses form. Convection and convergence of this air mass in the Inter-tropical Convergence Zone is one of the reasons for the heavy rainfall experienced in the rainforests of this region.



Air Mass Modification

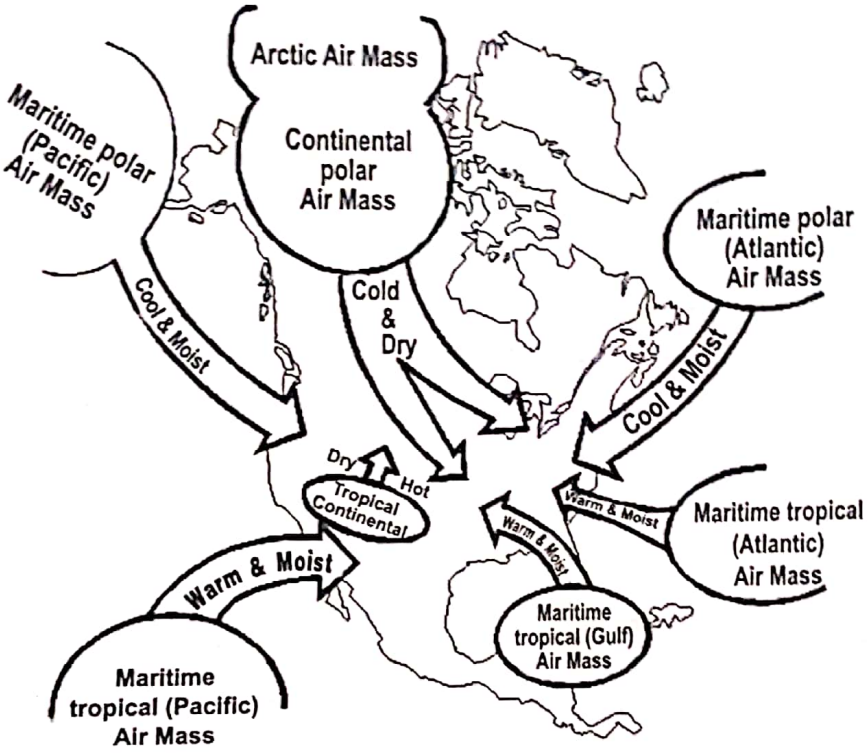
The characteristics of air masses are derived first from the source areas where they originate and second from the areas they cross once they leave their source areas. The modifications in route may take many forms, but generally the lower portions of the invading air masses are the first to be altered. The great air streams that form the circulation systems at the Earth's surface thus are continually undergoing some alterations outside their source areas. The extent of modifications frequently can be observed by examining the vertical profiles of air masses.

The principle modifications that take place in surface air masses may be summarized as follows:

1. **Thermodynamic Modifications**
   - i. Heating at the Earth's surface
   - ii. Cooling at the Earth's surface
   - iii. Cooling above the Earth's surface by loss of radiation
   - iv. Addition of water vapour at the surface
2. **Mechanical Modifications**
   - i. Mixing by passage over rough terrain
   - ii. Orographic, convergent and convectional lifting
   - iii. Subsidence (decline) from above

AIR MASSES OF NORTH AMERICA

The arrows in Figure indicate the trajectory that air masses affecting North America take as they move out of their source regions. As they traverse the surface, the temperature and moisture content of air masses are modified. Continental air masses, travelling south out of central Canada, move over warmer surfaces. To indicate that the air mass is colder than the surface over which it is travelling a "k" is added (cPk). Heat transfer into the air mass from the underlying surface creates unstable conditions. In the late fall and early winter, cP air masses moving over the open water of the Great Lakes gain heat and moisture. As the air mass strikes the land, the air can be uplifted by topographic barriers causing the lake-effect snows.



Off the southwest coast of North America lies a source region for maritime tropical air. This air mass is typically unstable at its source. As it moves toward land the air passes over the cold California Current. As the air mass traverses the cold ocean current, heat is transferred out of the air mass near the surface. In addition, the subsidence of the air aloft due to the presence of the subtropical high in this region causes adiabatic warming of the air at higher elevations. As a result, the environmental lapse rate of temperature decreases or sometimes inverts, making the air stable. To show that the air mass has become stable an "s" is added to its abbreviation, e.g. mTs. Stable conditions inhibit uplift and reduce the possibility for precipitation. Conversely, off the east coast of the United States, the warm Gulf Stream enhances the instability of the maritime air mass and precipitation becomes more likely. In this case, a "u" is added to indicate that the air mass is unstable, e.g. mTu.

WHAT IS A FRONT?

A given air mass may have a rather sharply defined boundary between itself and a neighbouring air mass. This discontinuity is termed as a 'front'. Simply, we can say that the line

of contact along the separation plane between air masses and the surface is termed as a Front.

CHARACTERISTICS OF FRONTS

Fronts may be near vertical, as in the case of air masses having little motion relative to another; or they may be inclined at an angle not far from the horizontal, in cases where an mass is sliding over another. A front may be most stationary with respect to the Earth's surf but nevertheless, the adjacent air masses may be in relatively rapid motion with respect to e other along the front.

SYNOPTIC SCALE FRONTS

At a smaller or synoptic scale are the "weather" fronts e.g., cold, warm, occluded, stationary.

1. Cold Front

A frontal contact zone in which cold air is invading warm air zone is termed as a "c front". The cold air mass, being heavier, remains in contact with ground and forces the warm air mass to rise over it. The slope of the cold front is being actually of the order of slope of 1 in to 1 in 80. Cold fronts are often associated with strong atmospheric disturbances, the warm thus listed often breaks out in violent thunderstorms. These may also occur along a line well advance of the cold front, a "squall line". Thunderstorms can be seen on the radar screen.

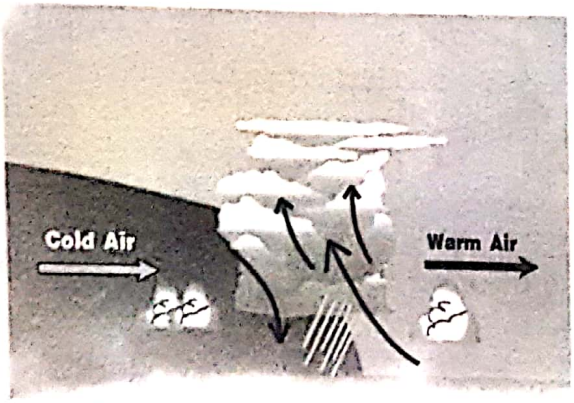


Figure: Profile view of cold front

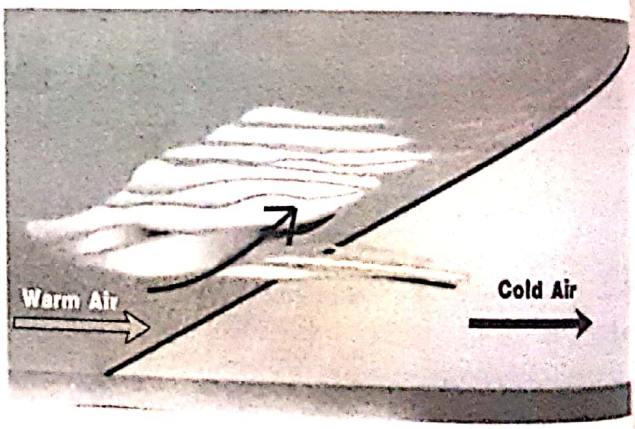


Figure: Profile view of warm front

2. Warm Front

A warm front is that in which warm air is moving into a region of colder air. Here, aga the cold air mass remains in contact with the ground, and the warm air mass is forced to rise a ascending a long ramp. Warm fronts have lower slopes than cold fronts, being of the order of 1 80 to as low as 1 in 200. Warm fronts are attended by stable atmospheric conditions and lack turbulent air motions of the cold front. Of course, if the warm air is unstable, it will devel convection cells and there will be heavy showers and thunderstorms.

3. Occluded Front

Cold fronts normally move along the ground at a faster rate than warm fronts. Hence, wh both types are in the neighbourhood, as they are in the cyclonic storms, the cold front m overtake the warm front. An "occluded front" then results. The colder air of the fast-moving co front remains next to the ground, forcing both the warm air and the less cold air to rise over The warm air mass is lifted completely free of the ground.

4. Stationary Fronts

A **stationary front** is a collection of air masses, neither of which is strong enough to replace the other. On a weather map, this is shown by an inter-playing series of blue spikes pointing one direction and red domes pointing the other.

EXPECTED QUESTIONS

1. Attempt a classification of air masses and describe the weather associated with warm and cold fronts.
2. How are the air masses classified and designated? Discuss the characteristics of some typical air masses at the source region, their paths of movement and the associated weather.
3. Explain original concept of air masses and present principal air masses.
4. Differentiate between air masses and fronts. Also discuss their salient features