12. Air Masses and Frontal Zones

12.1 Air mass characteristics

An air mass is huge body of air throughout which the *temperature* and *humidity* characteristics are uniform.

Air masses are classified in the following ways:

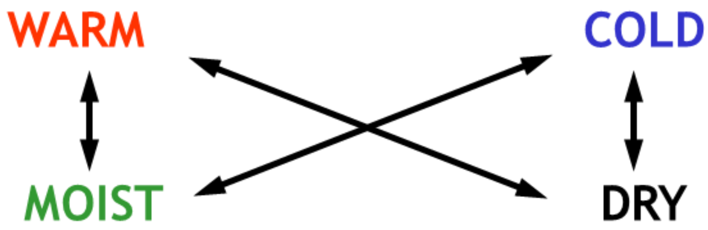


Fig. 12.1 - Classification of air masses.

Lower levels of the atmosphere will assume the characteristics of the underlying surface.

Air masses form in *source regions*.

Typical source regions are large anticyclonic (high pressure) areas. In such regions air movement is slow thus allowing the surface characteristics to penetrate upwards through the air mass.

The correct classification of air masses is as follows and depends upon the latitude of the source region:

Warm = *Tropical air*

Cold = *Polar air*

Very cold = *Arctic* or *Antarctic air*.

They are further categorised depending on whether the source region is over:

Land = *Continental air*

Water (sea) = *Maritime air*.

Almost any area of the world can act as a source region provided that the air remains in one place for long enough to acquire uniform properties (e.g. in a high-pressure system), however the table below shows the general classification and abbreviations used.

Classification of Air Masses		
Type	**Abbreviation**	**Source Region**
Arctic Maritime Air	Am or mA	Over sea
		Arctic or Antarctic regions
Arctic Continental Air	Ac or cA	Over land
Polar Maritime Air	Pm or mP	Over sea
		Sub-Polar regions
Polar Continental Air	Pc or cP	Over land
Tropical Maritime Air	Tm or mT	Over sea
		Sub-tropical regions
Tropical Continental Air	Tc or cT	Over land
Equatorial Air	E	Very low latitudes between the Trade Wind belts.

Table 12.1 - Classification of air masses.

When air moves away from its source region its original characteristics are modified by the nature of the surface over which it travels, so the air mass characteristics as it arrives in a particular region will be governed by:

Origin: *dictated by temperature and humidity of the source region;*

Path: *how the air becomes modified on its route, and;*

Age: *which will dictate the height to which the underlying source region surface characteristics will penetrate.*

12.2 Air mass movement

The movement of air from a source region is determined by the relative positions of high- and low-pressure systems.

In a *depression (LOW)* the winds circulate *anticlockwise* and *inward* in the Northern Hemisphere.

In an *anticyclone (HIGH)* the winds circulate *clockwise* and *outward* in the Northern Hemisphere.

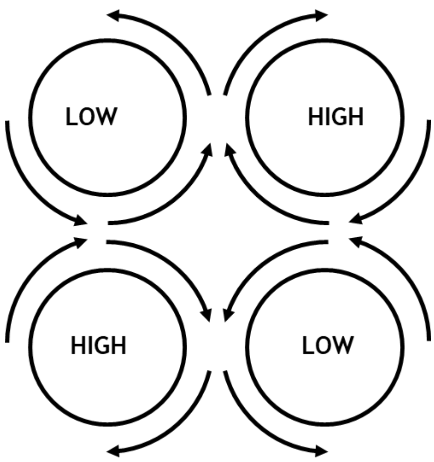


Fig. 12.2 - Movement of air in the NORTHERN HEMISPHERE.

12.3 Air mass weather

The following *general* rules can be applied:

(1) Warm air is capable of holding more moisture than cold air.

(2) In winter the land is relatively cold and the sea relatively warm.

(3) In summer the land is relatively warm and the sea is relatively cold.

The following simple situations can be considered:

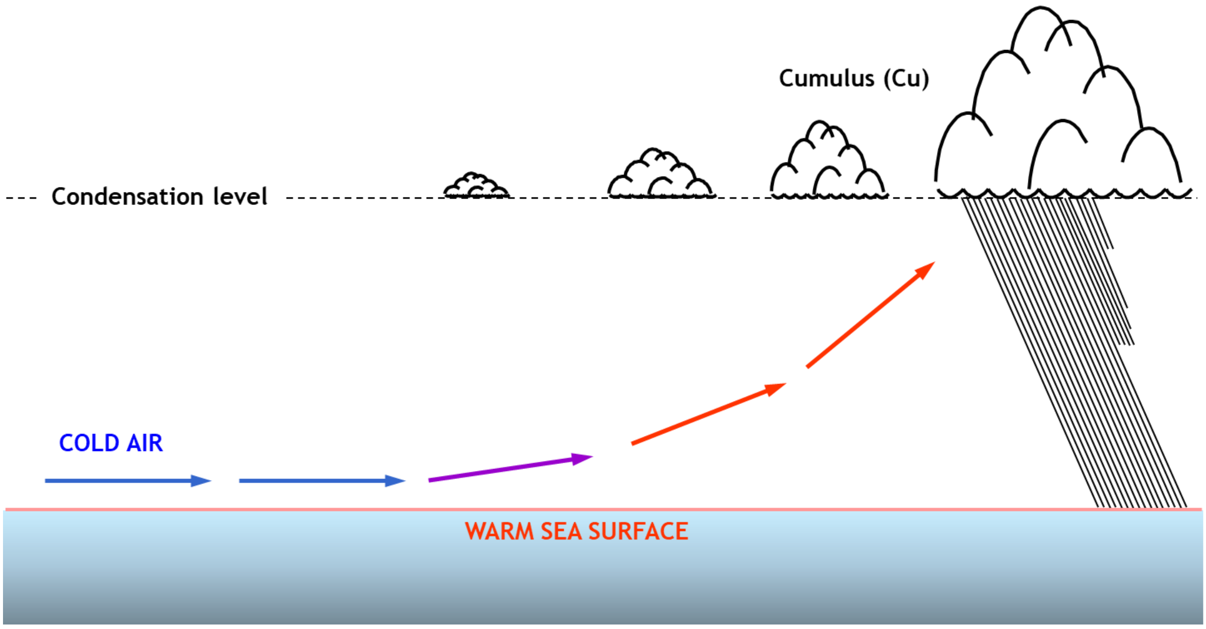
Cold air moving over a warmer surface.

Warm air moving over a colder surface.

12.3.1 Cold Air moving over a relatively warm surface

- Air is heated at the surface by contact.
- The warmed (less dense) air rises (convection).
- The greater the temperature difference between the air mass and the underlying surface, the more vigorous the convection.
- As the air rises it cools adiabatically causing the relative humidity (RH) increase.
- If the rising air is cooled beyond its *dew point* temperature, condensation will take place and *cumuliform* clouds will develop.
- This situation is described as being *unstable* since the air has risen spontaneously.
- These unstable conditions are associated with: *Cumulus type clouds;* *Very good visibility;* *Showers.*

Cold air moving over a warmer surface



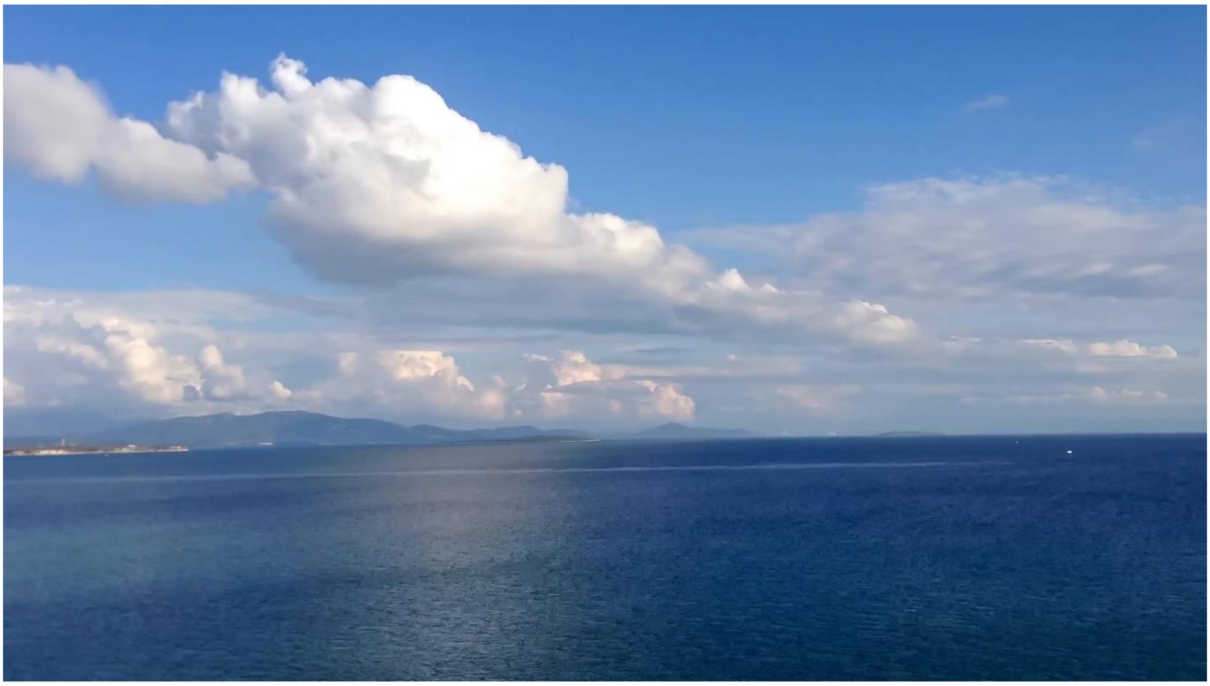


Fig. 12.3 - Cold air moving over a warm sea surface.
[*https://www.videoblocks.com/video/timelapse-of-white-cumulus-clouds-over-the-sea-with-boat-in-a-sunny-day-4k-bp34dnoqiovn8q70*](https://www.videoblocks.com/video/timelapse-of-white-cumulus-clouds-over-the-sea-with-boat-in-a-sunny-day-4k-bp34dnoqiovn8q70)

12.3.2 Warm Air moving over a relatively cold surface

- Air is cooled at the surface by contact making it denser.

- The now colder (more dense air) tends to resist upward movement and the atmosphere is said to be *stable*.

- Surface roughness/friction causes turbulence and will cause the cooled air to rise.

- As the air rises it cools adiabatically causing the relative humidity (RH) increase.

- If the rising air is cooled beyond its *dew point* temperature, condensation will take place and *stratus* (layer) type clouds will develop.

- A *stable* atmosphere is associated with: *Stratus (layer) type clouds;*
Poor visibility;
Rain/drizzle and/or fog.

Warm air moving over a colder surface

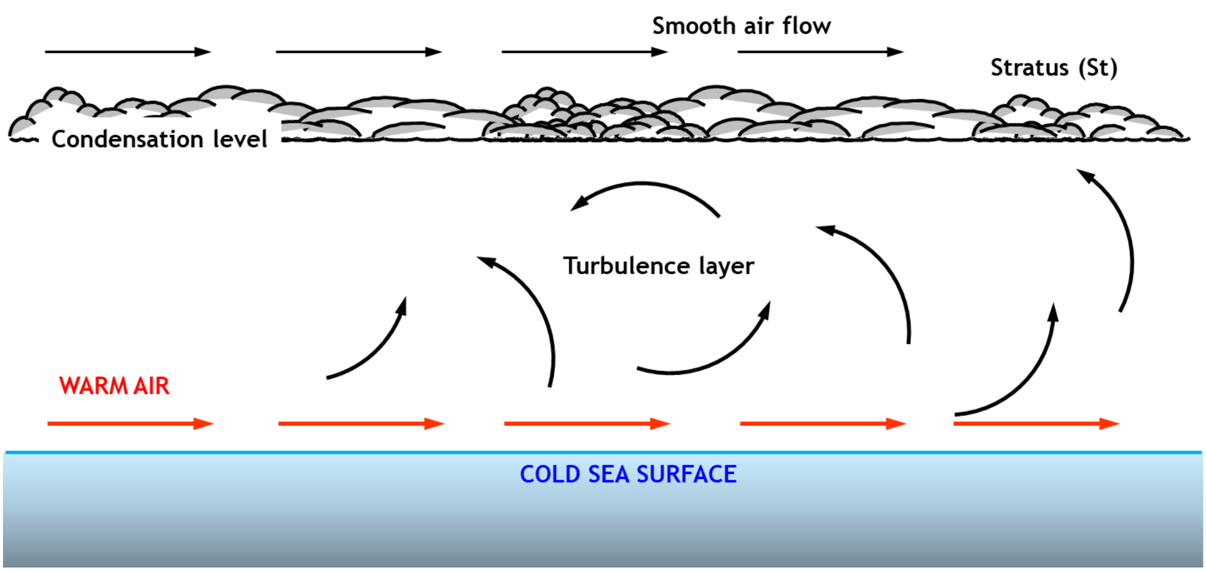


Fig. 12.4 - Warm air moving over a cold sea surface.

Remember these simple rules; with practice you will soon be able to make basic forecasts if you compare a received weather forecast with the synoptic chart!

12.4 Fronts and frontal zones

A *front* is the intersection of a frontal zone with the ground.

A *frontal zone* is the boundary between two adjacent air masses extending into three dimensions. Each of the air masses display distinct properties, mainly temperature and humidity, hence the boundary of each will be clearly defined.

Mixing of air across the boundary takes place rather slowly, so a particular property used to distinguish an air mass will also indicate the front. Temperature is commonly used for this purpose.

A Frontal zone is, therefore, a zone with a large temperature gradient, when compared with the gradient within the air masses.

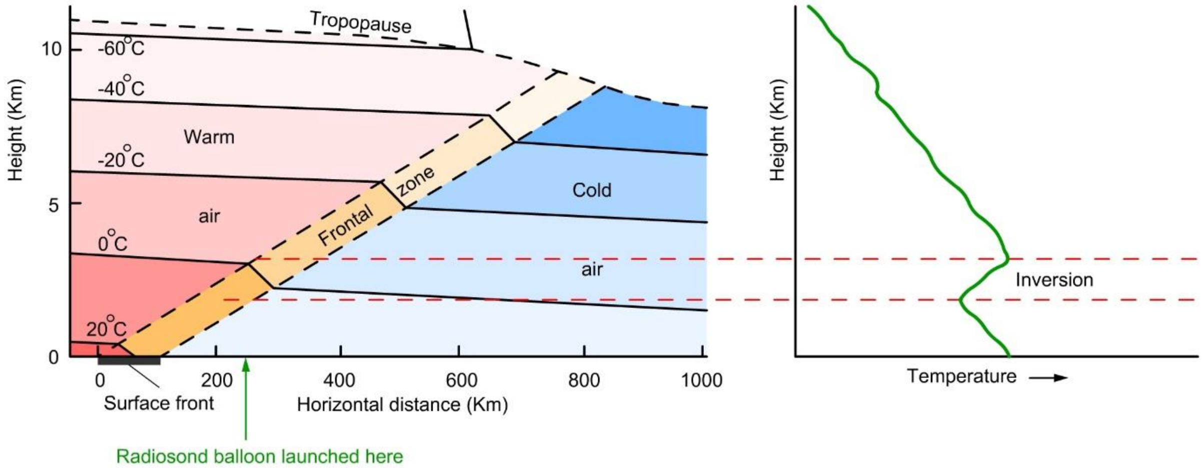


Fig. 12.5 - Frontal zone.

A frontal zone, as shown in the above figure, slopes upwards above the colder air mass which thus lies in the form of a thin wedge below the warmer air. The slope of this wedge is small, about 1/100, so a frontal zone which extends up to the tropopause will extend some 1000 km on the cold side of the front. The vertical depth of the frontal zone is usually 1-2 km and its horizontal width is 100-200 km.

If a radiosond balloon ascent were made as indicated the two air masses would be indicated quite clearly by the vertical distribution of temperature. The cold air mass is surmounted by the warm air mass, and between them over a depth of 1-2 km is the zone of transition - a frontal zone is shown as an *inversion*, in less extreme cases, by a sudden change in lapse rate.

An inversion layer is where the temperature increases with height instead of reducing with height. Radiosond instruments are used to obtain a temperature-height profile of the atmosphere.

12.4.1 Frontogenesis

This is the term applied to the formation of a new front or the strengthening of an existing front.

Frontogenesis occurs in regions where the air motion brings different air masses into close proximity. Convergence is essential for the formation and maintenance of active fronts.

The most important place that fronts are likely to form is near developing depressions.

Frontogenesis is influenced by the absorption of heat from the underlying surface. It is accompanied by vertical motion in the atmosphere and the release of latent heat.

Fronts are most active where the air has a high moisture content and there is strong convergence.

12.4.2 Frontolysis

This is the process of weakening or dissipation of an active front. It is associated with divergence and therefore often occurs near developing anticyclones.

12.5 The principal frontal zones

The principal frontal zones of the world are shown for both January and July for the Atlantic Ocean. These frontal positions are much generalised; the greatest range in positions and movement occur in temperate latitudes.

Similar seasonal variations occur in the Pacific and Indian Oceans too.

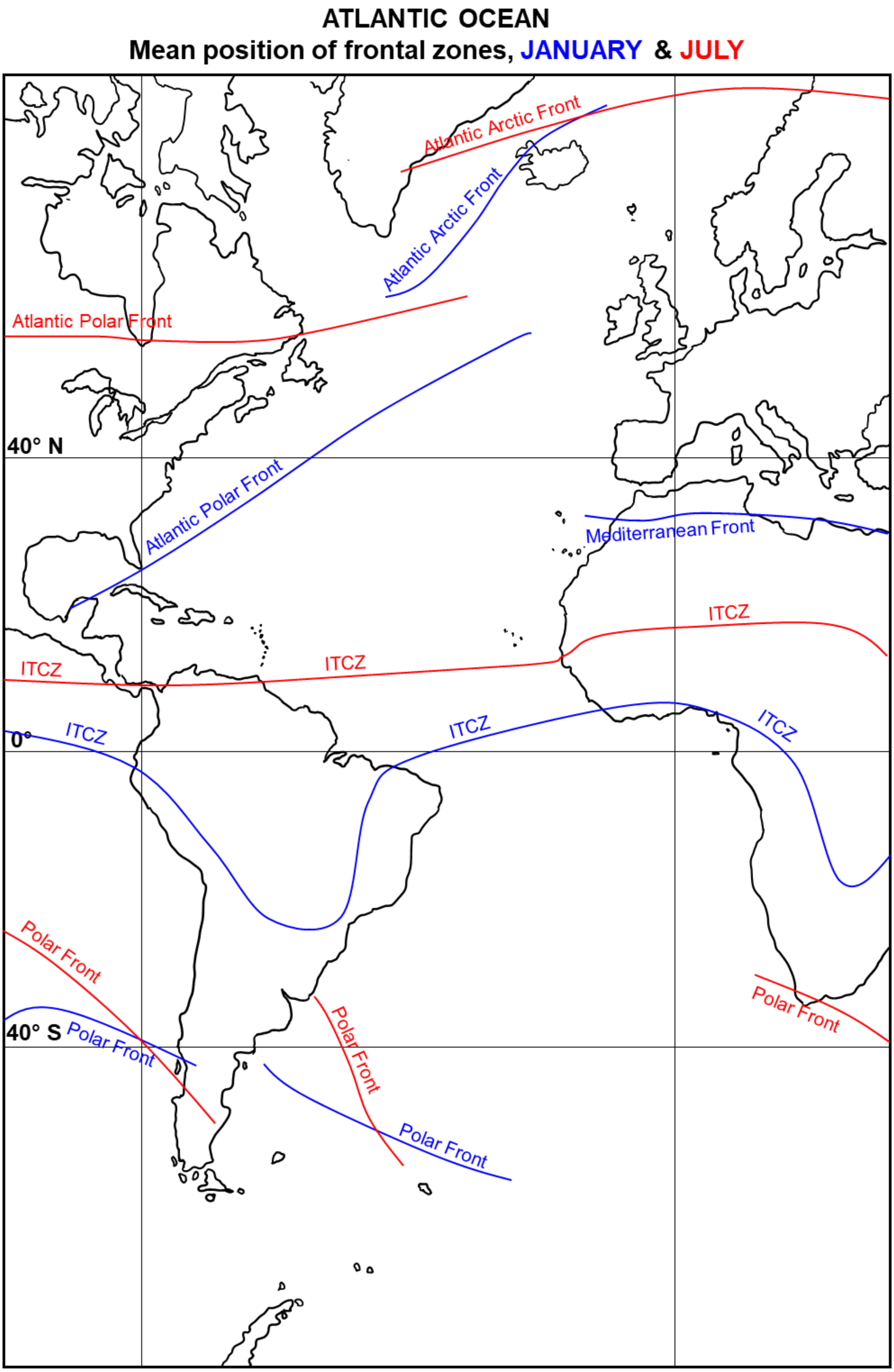


Fig. 12.6 – Principal frontal zones in the Atlantic Ocean.

A brief description of each is given below.

Arctic Fronts - These separate arctic air masses from polar maritime air masses.

Polar Fronts - These separate polar continental air or polar maritime air from tropical maritime air. In winter the polar fronts move to lower latitudes than in summer. The polar fronts are of importance due to the formation of depressions.

Mediterranean Front - During the winter months the Mediterranean front is persistent. It separates the cold air masses over Europe from the warmer air masses over North Africa. It is not evident during the summer months.

ITCZ - Inter-Tropical Convergence Zone - This is not a true front because the temperature and moisture characteristics on either side of the ITCZ are the same. It is defined as the meeting place of the converging trade-wind belts of the northern and southern hemispheres.