Visibility
Visibility is the transparency of the atmosphere and is defined as the maximum distance at which an object can be clearly seen and distinguished in normal daylight.
Visibility can be reduced by liquid or solid particles in the air as in the following cases:
(a) Mist or fog (b) Precipitation (c) Spray (d) Smoke (e) Dust, etc.

Mist/Fog
Mist is said to exist when visibility is reduced by water particles that have condensed on dust, minute particles of salt, etc., but are so small that they remain suspended in the air. If mist becomes dense and reduces visibility to 1 km or less, it is called fog. Mist can occur when relative humidity is a low as 80%
Mist is always experienced before and after fog.
Haze
If visibility is reduced by solid particles such as dust, sand, volcanic ash, etc., in suspension in the air, Haze is said to exist. Haze can, in rare cases, reduce visibility to 200 meters or less.
Spray
Spray is the name given to small droplets of water driven by the wind, from the tops of waves. Spray Affects visibility when the wind force is 9 or more (wind speed of over 40 knots)

TYPES OF FOG

1. Radiation fog

Also called land fog because it forms only over land, not over sea. During the night, land gives off its heat very quickly. On clear nights, the radiation of heat from the land surface into space is quicker as it is unobstructed by clouds. The air in contact with the ground thus gets cooled and if cooled below its dew point, a large quantity of dew is deposited. If, however, a light breeze is blowing, turbulence causes the cold from the land surface to be communicated to the air a couple of meters above the ground and shallow fog called 'ground fog' results. The visibility at eye level above this ground fog may be good but, in the fog, it may be only a couple of hundred meters or less. If the wind is a bit stronger, radiation fog may extend up to a height of about 150 meters or so above the ground. Strong winds cause too much turbulence, resulting in low clouds (stratus type) and no fog.

Radiation fog, which can form over land only, may drift on to rivers, harbors, lakes and other coastal regions. For example: fog on the Thames River, Dover Straits, the Sand heads of the Hooghly, etc. Radiation fog forms over land because of the large diurnal range of air temperature over land. It does not form over sea because of the very small diurnal range of air temperature over sea. Radiation fog reaches its maximum about half hour after sunrise because air temperature is at its lowest at that time. It generally dissipates after the sun has shone for a few hours and the land surface has warmed up.

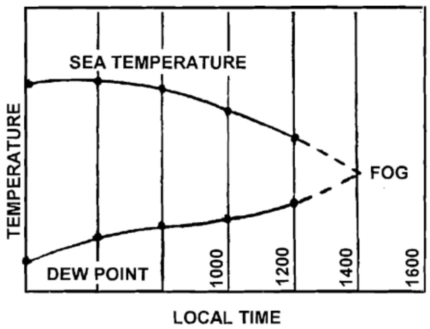
Conditions favorable for radiation fog are:

- Large moisture content in the lower layers of air.
- Little or no cloud at night.
- Light breeze at the surface.
- Cold wet surface of land.

2. Advection fog.
Is also called sea fog because it is mostly found over sea. It can, however, form over land also. It is formed when a moist wind blows over a relatively cold surface of sea or land. When the most air is cooled below its dew point, the excess water vapor condenses into small droplets of water on dust or minute particles of salt, resulting in advection fog.
Wind causes advection fog to form and also to spread. If the wind is quite strong, turbulence causes advection fog to form to considerable depth. However, very strong winds carry the moisture too high, resulting in low clouds (Stratus type) and no fog

The possible time of occurrence of advection fog can sometimes be predicted by plotting the Temperature of the sea surface and the dew point temperature of the air as two separate curves against ship's time as shown in the following figure

In the case illustrated, it is observed that the two curves appear to converge. By extending the two lines as shown in dotted lines, it is noticed that the curves would intersect at about 1400 hours. We can then expect to experience advection fog at about 1400 hours.



3. **Sea smoke:**

When very cold, dry air passes over a relatively warm sea surface, the water vapor, evaporating from the sea surface, is quickly condensed into water-droplets and it appears as if vertical streaks of smoke are rising from the sea surface. This is called steam fog or sea
Smoke .it is commonly seen in the Arctic Ocean.

4. **Smog** is radiation fog mixed with smoke.
Smoke + Fog =Smog

It is a thick, black, oppressive blanket, which not only wets all exposed surfaces but also
Makes them black due to carbon particles in the smoke

5. Hill fog or orographic fog: When a wind comes against a mountain range and begins
To climb over it, it progressively cools adiabatically. After dew point is reached, any
Further cooling causes the excess moisture to condense into water droplets forming hill fog
Or orographic fog.

Buys Ballot's law, the relation of wind direction with the horizontal pressure distribution named for the Dutch meteorologist C.H.D. Buys Ballot, who first stated it in 1857. He derived the law empirically, unaware that it already had been deduced theoretically by the U.S. meteorologist William Ferrel, whose priority Buys Ballot later acknowledged. The relationship states

that in the Northern Hemisphere a person who stands facing away from the wind has high pressure on the right and low pressure on the left; in the Southern Hemisphere, the reverse would be true. Theoretically, the relationship states that the angle between the wind and the pressure gradient is a right angle. This is almost exactly true in the free atmosphere, but not near the surface. Near the ground, the angle is usually less than 90° because of friction between the air and the surface and the turning of the wind toward areas of lower atmospheric pressure at the same altitude. Because of the weakness of the Coriolis effect (produced by the Earth's rotation) in equatorial regions, the law is not applicable there.
Face the true wind and the low-pressure area will be on your right in the Northern Hemisphere, left in the Southern Hemisphere.

Beaufort weather code

Weather	Beaufort letter	Weather	Beaufort letter
Blue sky (0 - 1/8 clouded)	b	Overcast sky (whole sky covered – unbroken cloud)	o
Sky partly clouded (1/8 - 3/8)	bc	Passing showers	p
Cloudy (> 3/8 clouded)	c	Squally weather	q
Drizzle	d	Rain	r
Wet air (without precipitation)	e	Sleet	rs
Fog	f	Snow	s
Gale*	g	Thunder	t
Storm#	G	Thunderstorm with rain	tlr
Hail	h	Thunderstorm with snow	tls
Precipitation in sight of ship	jp	Ugly threatening sky	u
Line squall	kq	Unusually good visibility	v
Storm of drifting snow	ks	Dew	w
Sandstorm or dust storm	kz	Hoarfrost	x
Lightning	l	Dry air	y
Mist	m	Haze	z

True and Apparent Wind

The direction and force of wind experienced on a moving ship is the apparent wind. This is the resultant of true wind and ship's *reversed* movement. For making log entries and weather reports, it is true wind that is required, not apparent wind.

Important note: Wind is named by the direction from which it comes.

Imagine a vessel steaming 000 (T) at 20 knots:

1. If there was no true wind at all (calm), the observer on the vessel would feel the apparent wind coming **from** North at 20 knots. Actually, the air is still but the ship's movement causes this apparent wind to be experienced.

2. If the true wind was coming from North at 10 knots, the apparent wind, to an observer on the vessel, would be from North at 30 knots.

3. If the true wind was coming from South at 12 knots, the apparent wind, to an observer on the vessel, would be from North at 8 knots.

4. If the true wind was coming from South at 20 knots, the apparent wind, to an observer on the vessel, would be nil (calm).

5. If the true wind was coming from South at 24 knots, the apparent wind, to an observer on the vessel, would be from South at 4 knots.

Out in open sea, the direction and force of true wind can be judged easily. The direction of true wind would be at right angles to the line of waves.

Note:

(1) A shipboard anemometer measures speed of apparent wind.

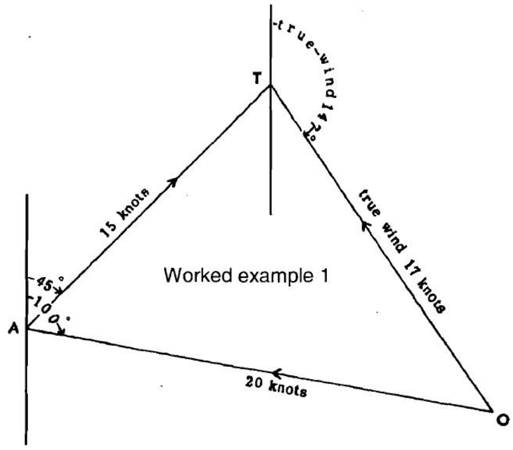
(2) The direction of wind obtained by observing the line of waves is the direction of true Wind

(3) Direction of smoke from the funnel on a moving vessel is direction of relative wind

Worked example 1:

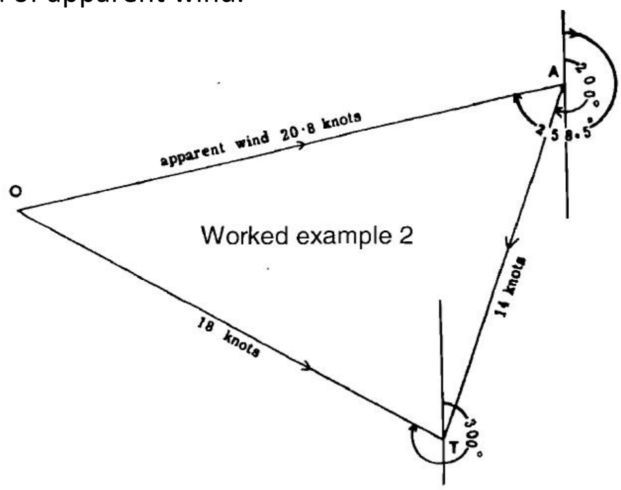
Course 045° speed 15 knots, Apparent wind 100° At 20 knots. Find the direction and speed of true wind.

Consider a triangle OA T where,
AT is the course and speed of the vessel
OT is the direction and speed of true wind
OA is the direction & speed of apparent wind.



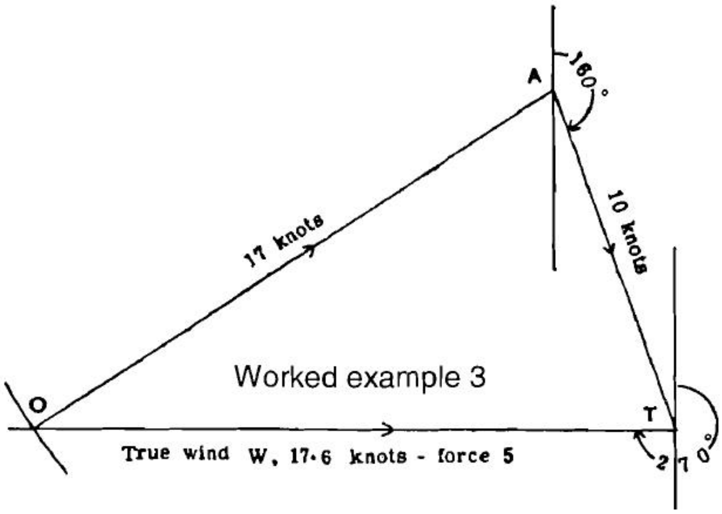
Draw a line representing North-South and take any point A on it. At "A", draw an angle equal to the course and cut off "AT" equal to ship's speed, using any convenient scale.
"AT" represents the course and speed of the vessel.
At "A", draw an angle equal to the apparent wind and cut off "AO" equal to the apparent wind speed, using the same scale.
"OA" now represents the apparent wind.
Join OT and this represents the true wind. Using the same scale as before, convert distance "OT" into knots
To obtain the direction of true wind, draw a North-South line through "T" and read off the angle between it and "OT".
In the example, the true wind in this case is 147° at 17 knots.

Worked example 2:
Course 200° speed 14 knots. True wind 300° at 18 knots
Find the direction and speed of apparent wind.



Draw a North-South line and take any point A on it. Draw AT equal to course and speed of vessel (200° at 14 knots), using any convenient scale. At T draw a North-South line and insert the true wind OT (300° at 18 knots), using the same scale.
Join OA, which now represents the apparent wind.
Using same scale, · convert distance OA into knots. The angle that OA makes with the North-South line at A is the direction of the apparent wind. Apparent wind in this case is 258.5° at 20.8 knots.

Worked example 3:
Course 160° speed 10 knots. Direction of wind (obtained by observing line of waves) was 270°. Wind speed by shipboard anemometer was 17 knots. What direction and force of wind is to be entered into the ship's logbook?



Draw AT = Course & speed = 160° at 10 knots. At T, draw a North-South line and insert direction of true wind, 270°. Centre A, radius =apparent wind speed of 17 knots, cut off the arc AO. OA now represents the apparent wind and OT, the true wind. Distance OT Converted into knots is the speed of true wind.

Examples for exercise

1. On a vessel steaming 346° at 15 knots, the apparent wind was observed to be NW at 22 Knots. Find the direction and speed of the true wind. (Answer 275° at 12 knots).

2. From a vessel on a course of 243° at 12 knots, the apparent wind was observed to be 120° at 15 knots. Find the direction and speed of the true wind. (Answer 095° at 23.8 knots).

3. On the monkey island of a ship doing 117 at 16 knots, an anemometer and wind vane Showed 15 knots and 036°
Find the direction and speed of wind required to be mentioned in the weather report. (Answer 344.5° - 20 knots).

4. A vessel is steaming 267 at 14 knots through a true wind blowing from SE at 11 knots. Find The direction and speed of the apparent wind experienced. (Answer 216° at 10.5 knots)

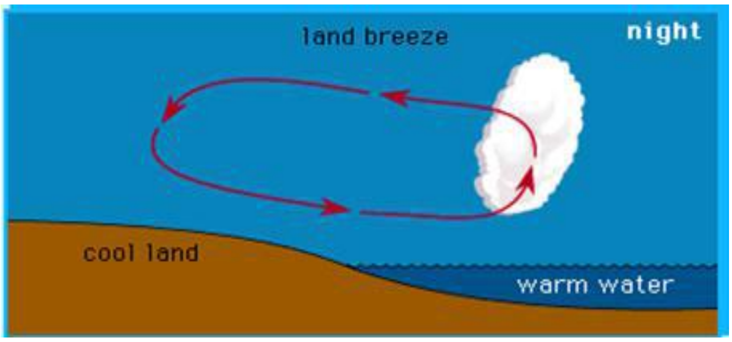
PERIODIC AND LOCAL WINDS

Land breeze:

During the night, the land gives off its heat very quickly and the air in contact with it also cools rapidly resulting in a high pressure over the land. The temperature of the sea surface, and hence the temperature of the air in contact with it, remains fairly constant resulting in a relatively low pressure over the sea.

The isobars run roughly parallel to the coast. Since the distance between the HP over land and the LP over sea is small, the wind blows directly across the isobars "from the land towards the sea".

The land breeze sets in a couple of hours after sunset and blows until about half-hour after sunrise



Sea breeze:

During the day, the land gets extremely hot and the air in contact with it gets heated, resulting in a low pressure over land. The temperature of the sea surface, and hence the temperature of the air over it, remains fairly constant resulting in a relatively high

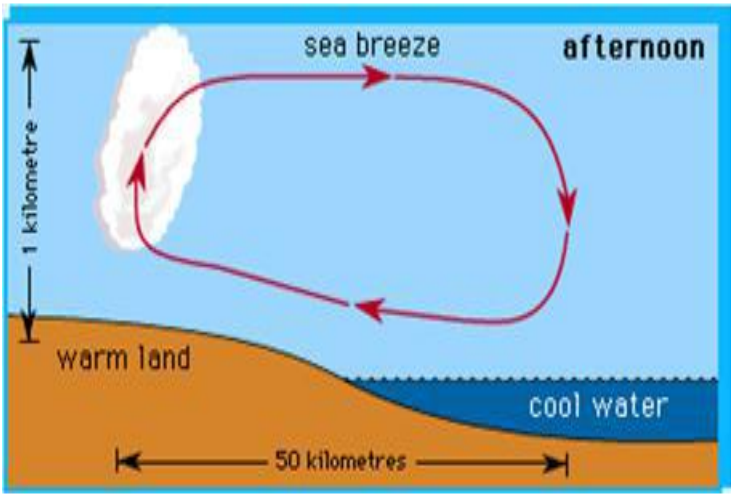
Pressure over sea

The isobars run roughly parallel to the coast. Since the distance between the high and

The low pressure areas is quite small and the pressure gradient is fairly high, the wind blows directly across the isobars from the HP over the sea, towards the LP over land.

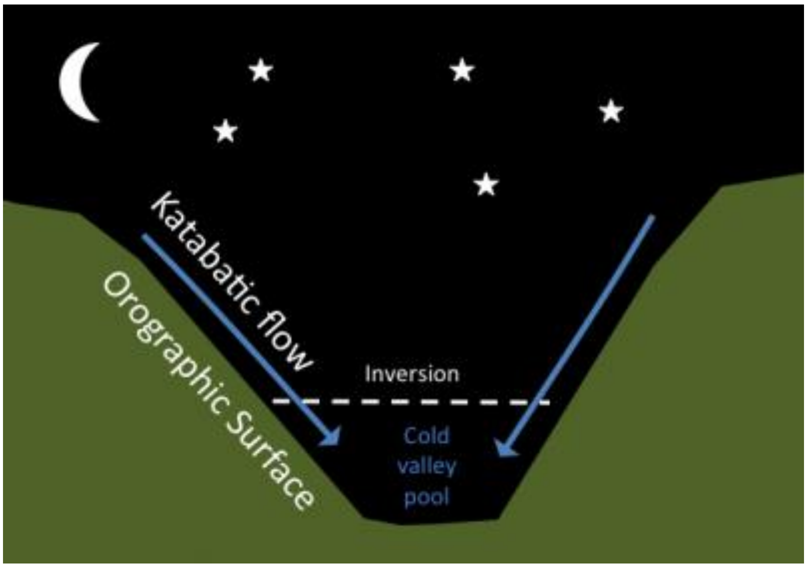
The sea breeze usually sets in by about 1000 or 1100 hours local time, reaches a maximum

Force of 3 to 4 by about 1400 hours and dies down about sunset. In rare cases, sea breezes have been detected as far away as 100 miles from the coast.

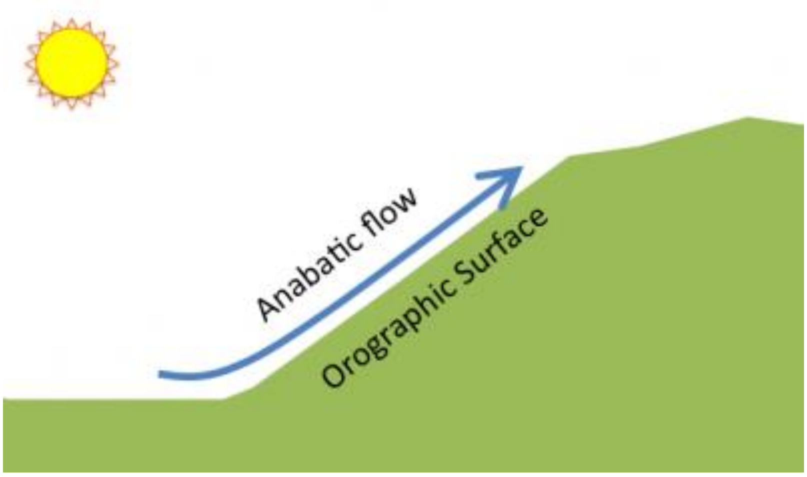


Katabatic wind:

On clear nights, the land surface radiates its heat into space very quickly resulting in a cold layer of air next to the land surface. If the ground is sloping, the air on top of mountain is colder and hence denser than at valley .Air at the top of the hill starts sliding down due to gravitational force and is called a 'Katabatic wind' (in Greek 'Kata' means 'down')
If the mountain is high and the slope is steep, katabatic winds can reach sea level with force 7 or more in a very short while.



Anabatic wind:
During daytime, the land surface gets heated quickly, resulting in a layer of warm air next to the land surface. The air on top of the hill is warmer and hence less dense than at the valley. The relatively colder air moves upward, thus displaced from the valley, slides gently up the mountain side. This is called an Anabatic wind (in Greek 'Ana' means 'up')



Fohn wind effect

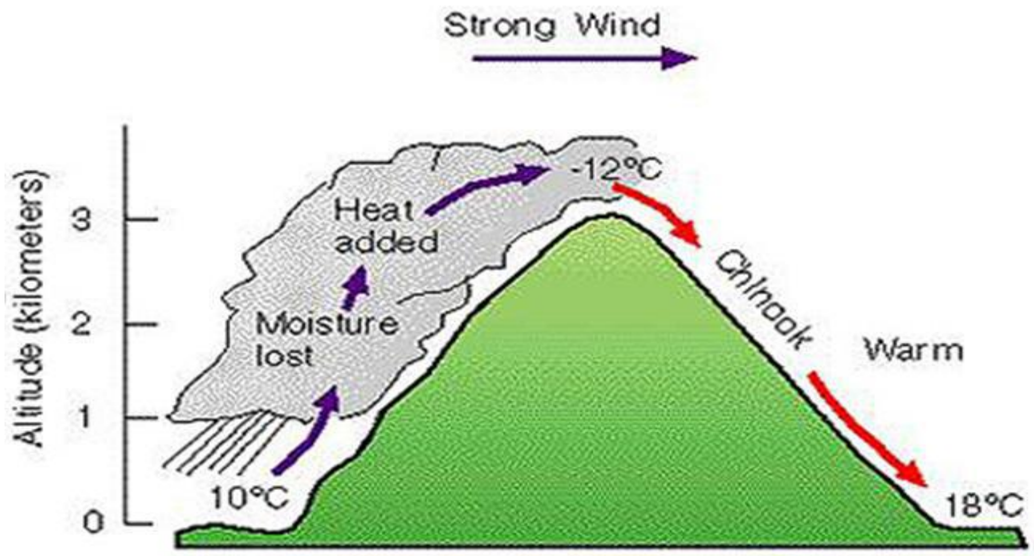
Fohn Wind Effect is an effect whereby the leeward side of a mountain range is drier and warmer than the windward side. This would be more pronounced if the wind was blowing from sea towards a coastal mountain range, as the air would then be moist. Fohn wind effect is the direct result of the difference between the DALR and the SALR of air as illustrated Below:

When moist air blowing against a mountain, it begins to ascend and its temperature drops by 5° C per km height (SALR). As the air temperature reduces, the relative humidity will increase. On reaching a certain height, the air will be saturated and condensed out

The excess moisture in the air is given off as orographic cloud and then heavy rain falls on the windward side

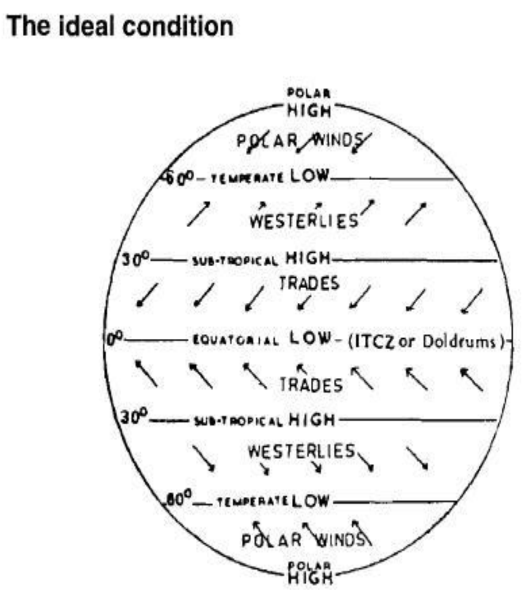
While descending on the leeward side, the temperature of the air would increase at 10°C per km (DALR). This is because; the air has lost its humidity and now is dry

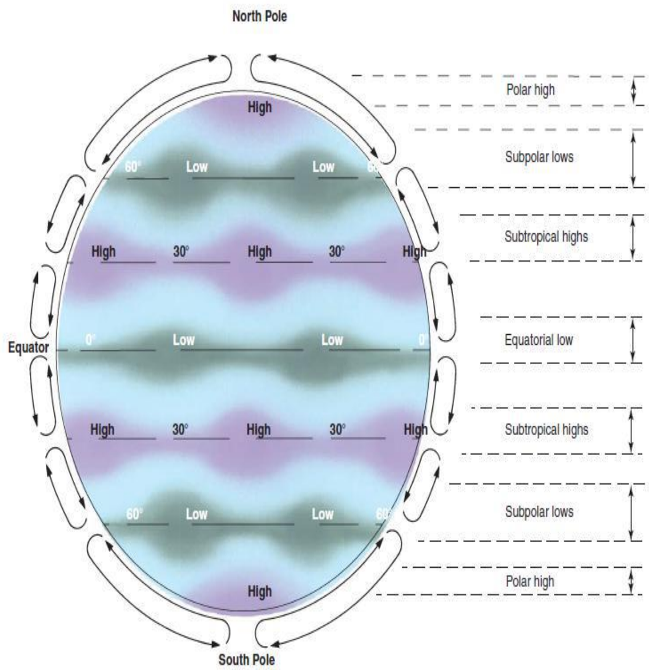
The result will be so that on the leeward side of the mountain, the air will be drier and warmer than the windward side



GENERAL PRESSURE AND WIND DISTRIBUTION

The figure gives the general pressure and wind systems which would exist if the entire surface of the earth was water only. Since such is not the case, variation of the above conditions occurs over large areas of land.





The following pressure belts oscillate with the apparent movement of sun. In northern hemisphere in winter, they move southwards and in summers northwards.

- **Equatorial low** – It occurs near the equator the sea level pressure is low.
- **Subtropical high** – Along the 30 degrees North and 30 degrees South, there are high pressure areas.
- **Sub-polar Lows** – Along 60 degrees North and 60 degrees South, low pressure belts.
- **Polar Highs** – It occurs near poles, the pressure is high.

-

Trade Winds

Definition

Trade Winds is defined as steady and persistent winds which blow on the Equatorial side of the subtropical high pressure systems in both Hemispheres.

Description

When air moves, the Coriolis force deflects air either to the right of air motion in the Northern Hemisphere and to the left of air motion in the Southern Hemisphere.

Where the Trade Winds from each hemisphere approach each other, the rising air creates instability which, depending on the strength of the winds, results in a line of cumulonimbus clouds. This line of weather is known as the Inter Tropical Convergence Zone (ITCZ). The Inter Tropical Convergence Zone (ITCZ) is generally located near the Equator year-round, except in the Indian Ocean and central Asian landmass in the Northern Hemisphere Summer.

Considering the air which moves from the subtropical high pressure systems at around 30 degrees latitude towards the ITCZ which is located near the Equator, and considering the effect of the Coriolis Force::

In the northern hemisphere the Trade Winds generally blow from the north east while in the southern hemisphere they blow from the south east. The direction of the winds is influenced by land masses so the Trade Winds tend to be more uniform over the oceans.

The weather associated with Trade Winds is generally fine for flying operations; scattered small cumulus and stratocumulus with a base of around three thousand feet . However, as the trade winds progress across the ocean, they gather moisture and the cloud become more developed, and so the western side of the tropical oceans is more cloudy than the eastern side. Where the Trade Winds pass over land, for example the Hawaiian Islands, showers may form as a result of orographic lift and instability caused by surface heating over the land.

The term “Trade Winds” is marine. Therefore the Trade Winds blow near the surface of the Earth. The winds in upper levels (circa 20000 – 30000 feet) over the Trade Wind level are generally called “Anti-Trade Winds”. These winds blow opposite to their surface-level counterparts (eg. NE trades → SW anti-trades)

The principle of the Monsoon stems in part from the effect of trade wind movement over land from water or water from land, and the location and displacement of the ITCZ.

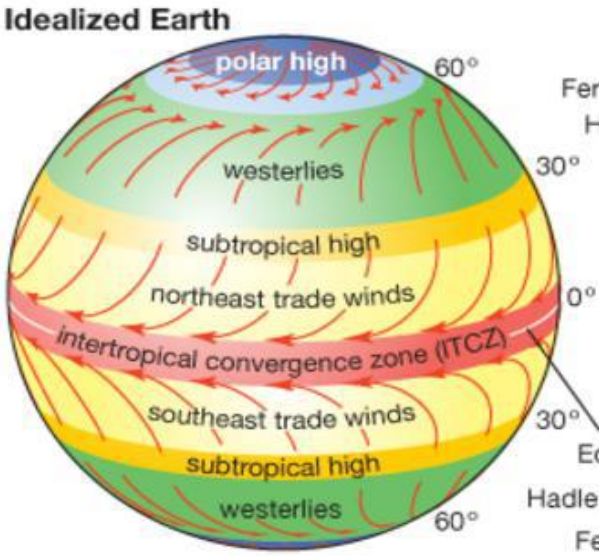
Doldrum: (ITCZ=intertropical convergence zoon)

The Intertropical Convergence Zone is a band of low pressure around the Earth which generally lies near to the equator.

The Intertropical Convergence Zone, or ITCZ, is a band of low pressure around the Earth which generally lies near to the equator. The trade winds of the northern and southern hemispheres come together here, which leads to the development of frequent thunderstorms and heavy rain. These thunderstorms can reach, and sometimes exceed, 16 kilometers, 55,000 feet or 10 miles in height above the surface.

The air that is forced to rise along the ITCZ moves towards the poles and slowly descends leading to large areas of high pressure in the sub-tropics, sometimes known as the horse latitudes, and bring largely benign weather conditions to places like the Azores. The resulting circulation that forms with air converging near the surface around the equator and diverging above is known as the Hadley Cell.

The ITCZ moves throughout the year and follows the migration of the Sun’s overhead position typically with a delay of around 1-2 months. As the ocean heats up more slowly than land, the ITCZ tends to move further north and south over land areas than that over water. In July and August, the ITCZ lies well to the north of the equator over Africa, Asia and Central America before moving south into South America, central Africa and Australia by January and February.Another term for the ITCZ, used historically in seafaring circles, is the 'doldrums' since the winds along the band of low pressure are typically calm, trapping ships for days or even weeks at time leaving them stranded.



Definition of monsoon

Monsoon is traditionally defined as seasonal changes in atmospheric circulation and precipitation associated with the asymmetric heating of land and sea.

However, because of the winds and weather usually associated with the monsoons in India and Southeast Asia, the word monsoon is often used to mean the prevailing wind and associated weather of these regions.

The Monsoon Process

Continental land masses warm up considerably in summer and cool down in winter. The biggest temperature variations are found in the land masses of North America and Asia.

Monsoons are caused by the larger amplitude of the seasonal cycle of land temperature compared to that of nearby oceans. This differential warming happens because heat in the ocean is mixed vertically through a "mixed layer" that may be fifty meters deep, through the action of wind and buoyancy-generated turbulence, whereas the land surface conducts heat slowly, with the seasonal signal penetrating perhaps a meter or so. Additionally, the specific heat capacity of liquid water is significantly higher than that of most materials that make up land. Together, these factors mean that the heat capacity of the layer participating in the seasonal cycle is much larger over the oceans than over land, with the consequence that the air over the land warms faster and reaches a higher temperature than the air over the ocean.

The hot air over the land tends to rise, creating an area of low pressure. This creates a steady wind blowing toward the land, bringing the moist near-surface air over the oceans with it. Rainfall is caused by the moist ocean air being lifted upwards by mountains (Orographic Lift), surface heating, convergence at the surface, divergence aloft, or from storm-produced outflows at the surface.

However the lifting occurs, the air cools due to expansion in lower pressure, which in turn produces condensation and precipitation as the air becomes saturated.

Monsoon Climates

Monsoon climates have clearly marked seasons, each with a specific type of weather and wind from a certain direction. Monsoon climates are found in many parts of the world: West Africa, Ethiopia, northwest Australia, northwest corner of South Africa and the biggest areas of east and south Asia (including East Indies and Philippines).

Over Asia the mountain ranges run mainly east to west and this, together with the fact that the land mass of Asia is the largest in the world, limits the transposition of warm and cold air masses and makes seasonal contrasts much greater.

In winter: In January, in the northern hemisphere, low temperatures over Asia in winter give rise to an intense anticyclone (called Siberian high) which extends its influence over most of Europe and Asia. Because of the intense cold in the heart of Siberia in winter (average of minus 40 degrees Celsius) the pressure in the anticyclone reaches very high values (sometimes even 1070 hPa). Air flows out from the high pressure region and gives rise to the winter monsoon, with north westerly winds in northern China. Further south the winds become northerly and finally north easterly as they take up the trade wind flow to become the northeast monsoon of Southeast Asia and Indonesia.

India is cut off from the Siberian anticyclone by the barrier of the Himalayas, but it develops its own high pressure system, centered in northwest India and northern Pakistan and, as a result, there is an eastward flow of air out along the Ganges valley area which eventually joins the northeast monsoon over the Bay of Bengal.

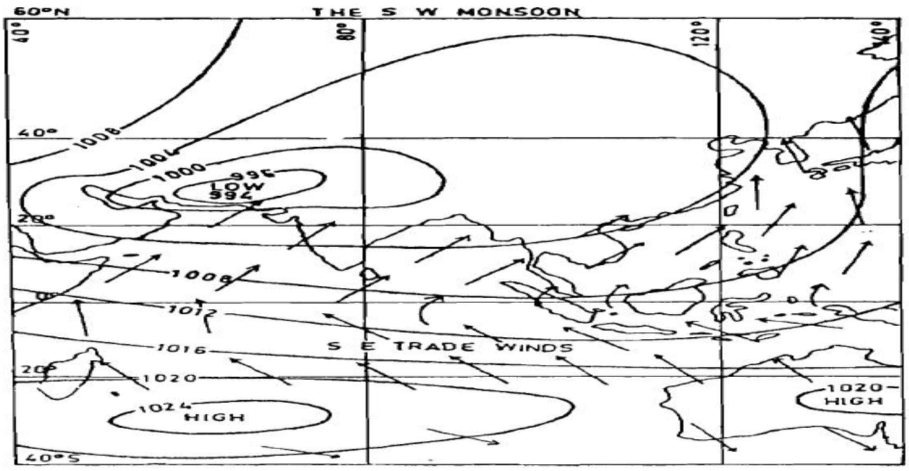
Over China, Japan and eastern Asia, the air is generally very cold and warms up as it moves towards the equator. The flow from India is not as cold. Over the land the air remains dry, over the sea the monsoon becomes moist. The weather created by the monsoon depends on whether a land or sea track is followed and how much instability has developed.

In summer: The pressure distribution is completely changed because the high land temperatures lead to low pressure systems over the areas of southern Asia which are subject to the most heating and high pressure over the oceans. The flow is then from the sea to the land and the air in many cases actually comes from the southern hemisphere as the southeast trade winds which are then turned by the coriolis force on crossing the equator to form the southwest monsoon. The southwest monsoon has its direction changed again as it reaches the land masses of Asia (for example being diverted to flow from the southeast up the Ganges valley towards the low pressure area over northwest India).

Whilst the descriptions above have focused on the Asia monsoons, other parts of the world are subject to similar seasonal changes. The climatology of West Africa for example includes reference to the southwest monsoon and that of Australia, the northwest monsoon.

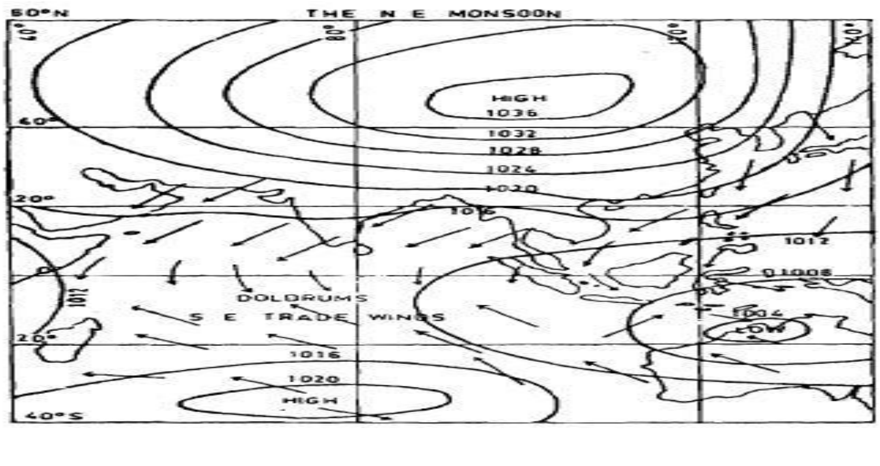
Monsoons of the Indian Ocean (South West Monsoon)

During northern summer, the continent of Asia gets very warm and the resultant low pressure over with a pressure of about 994 mb. This low is considerably lower than the equatorial low of 1012 mb and hence a pressure gradient exists from the equator towards NW India. The SE Trade winds, blowing from the oceanic high of 30° S towards the equatorial low, cross over the equator and blow, as a strong SW wind called the SW Monsoon, towards the Low over NW India The SW direction is the result of gradient force and Coriolis force. The SW Monsoon blows from June to October and brings heavy rain to The West Coast of India, West Bengal, Bangladesh and Myanmar. The wind force is about 7 or 8 in the Arabian Sea and about 6 or 7 in the Bay of Bengal. The same SW Monsoon is also experienced in the China Sea (and all over the world but its effect is greatest in Arabian Sea, that is why, SW monsoon is mainly named for Arabian Sea and Indian Ocean)



The North East Monsoon

During northern winter, the continent of Asia gets cold and the resultant high pressure over it centers over Siberia with a pressure of about 1036 mb.
The equatorial low of 1012 mb. Remains practically unaffected by the change of season. The anticyclonic winds, around the Siberian high, reach the Bay of Bengal and Arabian Sea as the NE Monsoon with a force of 3 to 4. Heavy rain falls on the East Coast of India. The NE Monsoon blows from December to April.
In the China Sea the pressure gradient is larger, resulting in wind force between 5 and 7. The wind direction in this region is between north and northeast.



The hygrometer

The hygrometer is an instrument for obtaining the relative humidity and/or dew point temperature of air.
The type in use at sea on merchant ships is called the Mason's hygrometer or wet-and-dry-bulb hygrometer or psychrometer.

Description
The hygrometer consists of two identical Celsius thermometers, one called the dry bulb thermometer and the other, the wet bulb thermometer.
The wet bulb thermometer has a thin, single layer of muslin or cotton tied around the bulb by a few strands of cotton wick. The extra length of the strands of wick is immersed in a bottle of distilled water. Both the thermometers are enclosed in a special, ventilated, wooden box called the Stevenson screen.

Principle
Because of capillary action, the muslin always remains damp - water is drawn upwards, from the Bottle through the strands of wick
If the atmosphere is dry, rapid evaporation takes place from the muslin. Since evaporation causes cooling, the wet bulb thermometer will show a much lower reading than the dry bulb thermometer.
If the atmosphere is humid, evaporation from the muslin will be slow, and less cooling of the wet bulb will take place. The reading of the wet bulb thermometer will then be not much lower than that of the dry bulb thermometer.
In other words, the difference between the readings of the wet bulb and the dry bulb Thermometers (called the depression of the wet bulb), gives an indication of the relative humidity of the air
The greater the difference, the lower the relative humidity and vice versa

To find relative humidity and dew point

Meteorological tables, entered with dry bulb reading on one axis and the depression of the wet bulb on the other axis, give the relative humidity or the dew point of the air. Separate tables are provided for relative humidity and for dew point. Separate tables are provided for use with the hygrometer and with the whirling psycrlrometer.

Precautions when using a hygrometer

-The Stevenson's screen should be on the windward side, in open air, away from artificial Sources of heat (heaters or blowers)
-It should be about 1.5 m above the deck for the convenience of the observer.
-Sunlight falling on the Stevenson's screen is permitted but not directly on thermometers.
-It should be far away from metal bulkheads ,etc., Which will cause heat radiations that can Affect the readings.
-In any case, the muslin and strands of wick must be changed once a week. This is because solid particles are left behind by the evaporating water. These particles subsequently Prevent free evaporation and the wet bulb reading will be higher than the correct reading.
That is why distilled water is used. Even then, the distilled water available is rarely as pure as We would like it to be.

-The muslin should be only just damp. Too much water on it, or too little, will cause error in wet Bulb reading. This can easily be rectified by adjusting the number of strands of wick leading into the water bottle.
-The water bottle should be washed and the distilled water in it renewed once a week.
-The dry bulb should be clean and clear of drops of condensed water.

Wet bulb reading higher than dry bulb

This can happen only under the following circumstances:

-Insufficient evaporation taking place from the wet bulb due to dust, salt or other impurities on the muslin, or due to no water on the muslin.

-Insufficient time interval allowed after shifting of Stevenson's screen to windward, addition of distilled water, renewal of wick or water, etc.

-Difference in the sensitivity of the thermometers whereby one of them is slow in recording sudden changes of temperature.

-Faculty or broken thermometers.

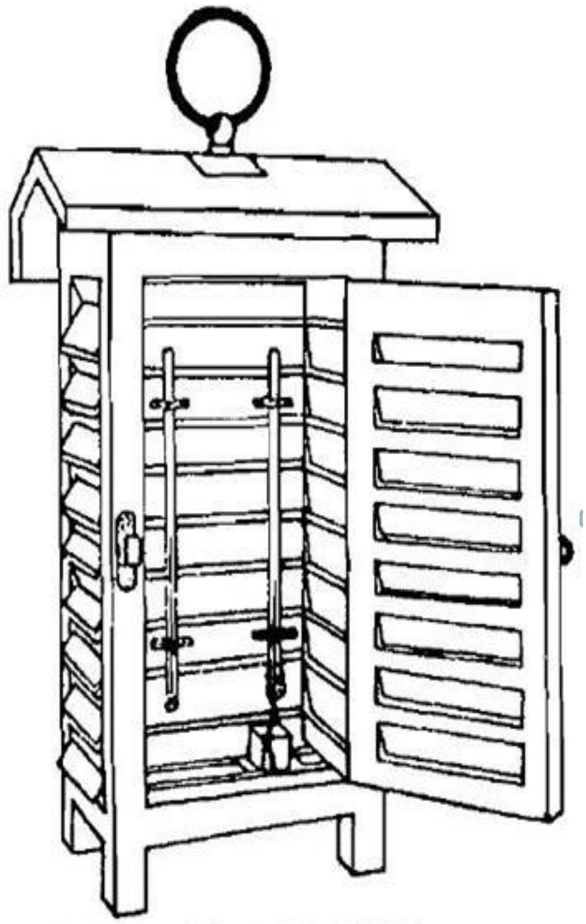
The Stevenson screen

This is a wooden box specially constructed to house a hygrometer. It was invented by Thomas Stevenson
It is a wooden cupboard with a hinged door. The door, the back and the two sides, are all fitted with slats which let air circulate freely without letting in direct solar radiation or re-radiated heat from ship's structure. The slats also keep out rain and spray. There are various types of Stevenson's screens. The type found on ships is the portable type.
If sunlight is allowed to fall directly on the thermometer it will get very hot and the reading Shown by it will be the temperature of the instrument itself, not that of the atmosphere.
Inside the screen, the thermometer will show the temperature of the atmosphere because of The shade and the free circulation of air

During the night, if the thermometer was out in the open, its bulb would radiate out its Heat very quickly, much quicker than the air and would thus show a lower than true reading of atmospheric temperature. The thermometer will then show the temperature of the Instrument itself, not that of the atmosphere.

The whirling psychrometer
This is a very efficient type of hygrometer. Hence its basic principle is the same as hygrometer
Description and use
It consists of a light wooden frame, pivoted to revolve smoothly around a handle. The frame has two identical Celsius thermometers mounted on it. One of them has a layer of thin muslin tied firmly around its bulb, and is called the wet bulb thermometer.
When required, the frame is held horizontal and, using a dropper, one drop of distilled water is made to fall on the muslin to make it damp.
The frame is then whirled around in open air for at least two minutes before reading off the wet and dry bulb temperatures.

By entering meteorological tables with the dry bulb reading on one axis and the depression Of the wet bulb on the other axis, the dew point and/or the relative humidity are obtained. Different tables are used for the whirling psychrometer and for the hygrometer in the Stevenson's screen because of their different rates of evaporation



THE STEVENSON SCREEN

Dry Bulb (°C)	Number of degrees difference between the wet- and dry-bulb readings (°C)									
	1	2	3	4	5	6	7	8	9	10
10	88%	77	66	56	45	35	26	16	7	--
11	89	78	67	57	47	38	28	19	11	2
12	89	79	68	59	49	40	31	22	14	5
13	89	79	69	60	51	42	33	25	16	9
14	90	80	70	61	52	43	35	27	19	11
15	90	80	71	62	54	45	37	29	22	14
16	90	81	72	63	55	47	39	31	24	17
17	91	82	73	64	56	48	41	33	26	19
18	91	82	73	65	57	50	42	35	28	21
19	91	82	74	66	58	51	44	37	30	24
20	91	83	75	67	59	52	45	38	32	26
21	91	83	75	68	60	53	47	40	34	27
22	92	84	76	69	61	54	48	41	35	29
23	92	84	77	69	62	56	49	43	37	31
24	92	84	77	70	63	57	50	44	38	32
25	92	85	77	71	64	57	51	45	40	34
26	92	85	78	71	65	58	52	46	41	35
27	93	85	78	72	65	59	53	47	42	37
28	93	86	79	72	66	60	54	49	43	38
29	93	86	79	73	67	61	55	50	44	39
30	93	86	80	73	67	61	56	50	45	40
31	93	86	80	74	68	62	57	51	46	41
32	93	87	80	74	68	63	57	52	47	42
33	93	87	81	75	69	63	58	53	48	43
34	93	87	81	75	69	64	59	54	49	44

What are Air Masses?

Air mass is an extremely large body of air in the atmosphere whose properties – temperature, humidity and lapse rate, which is the decrease of an atmospheric temperature with height, are largely uniform over an area which can be several hundred kilometers across the surface of the earth. Climate science defines air mass as a relatively huge bulk of air that is distinctive by its homogeneity of temperature and moisture content. Air Mass is a voluminous body of air found in the lower regions of the atmosphere. Air masses are identifiable particularly for their unvarying qualities of moistness and heat at any specific altitude. Air Masses persist as distinct and discernible even when they become mobile. "*An air mass is a large body of air with generally uniform temperature and humidity. The area over which an air mass originates is what provides it's characteristics. The longer the air mass stays over its source region, the more likely it will acquire the properties of the surface below. As such, air masses are associated with high pressure systems.*"

Two different air masses can be separated and the line of distinction is called a front. It is along these fonts that weather formation occurs.

When we refer to air masses we are indicating at those massive air packages that can spread over an area approximately 1,600 kilometers. They exercise a considerable influence on the climatic conditions of the region over which they lodge and carry with them distinctive climatic features of their source region.

Formation of Air Masses

Air Masses are most common in the tropics, subtropics and high latitudes. The zones from which air masses grow are called "source regions." These are generally tracts of ocean, desert or snow-covered plains. The large surfaces with uniform temperatures and humidity, where air masses originate are called source regions. Uneven warming and cooling of the earth's surface by the Sun gives rise to air masses.

Warm air masses

The warm air masses form over the equator or desert areas where the solar radiation is maximum. In clear, almost cloudless days, the heat is reflected back to the atmosphere. The air becomes light and spreads.

Cold air masses

Cold air masses form near the poles where solar radiation is at a minimum. On cloudless days, the snow cover near the Poles, reflect sunlight away, preventing the earth to warm up. When this persists for a long period of time, cold air masses form over a large area.

Movement of Air Masses

Warm wind is light and tend to rise. Cold air is heavy. Areas with warm light wind have a low pressure zone. Cold wind is heavy and creates high pressure. Wind flows from high pressure air masses to low pressure areas.

When wind speed is low the air remains stationary over a particular landscape and in the process gathers the natural climatic conditions of that region-heat or cold. When the winds move air masses, they carry the weather conditions along to a new region. An air mass on the move begins to transform as it passes over new landscapes, although retaining enough of its original qualities that alter local weather.

When this air mass reaches a new area, it often clashes with another air mass with a different temperature and humidity. This can create a severe storm.

Classification of Air Masses

The source regions and their climatic specifications classify the world's major air masses. An air mass is named by the combination of its humidity and temperature specificity. The type of temperature that an air mass acquires, is derived from the latitude of origin; temperatures generally decrease pole ward.

Air masses originating near the equator are Equatorial. These are considered hot air masses. At a higher latitude the air masses are called tropical air masses. These are considered warm air masses. The Polar air masses are at a still higher latitude. These range from cool to cold, depending on the position of the sun.

1- **Arctic**

The Arctic is the highest latitude of origin of any air mass. This air mass is considered very cold. Their source of origin is Arctic Ocean, Siberia, Northern Canada, Southern Ocean.

2- **Maritime Polar**

Maritime Polar air masses have their source region over cold ocean currents or high latitude ocean waters. This air mass can produce widespread rain or snow, fog, drizzle, cloudy weather and long lasting light to moderate rain.

3- **Continental Polar**

Continental Polar air masses are cold to cool and dry. Continental Polar air masses form over Canada and Siberia. These air masses bring cold air during the winter and cool, relatively clear, rather pleasant weather in the summer.

The air mass is stable and usually obstructs cloud formation. Air masses can also prevent the vertical movement and may cause high pollution levels, especially near and downstream from large industrial areas. As the Continental Polar air move south across the warmer land, the lower portion of the air mass may become sufficiently light by warming to cause formation of clouds within the air mass.

4- Maritime Tropical

Maritime Tropical air mass results from the warm waters of the Gulf of Mexico and Gulf Stream. This air mass is characterized by hot, humid conditions. These air masses form in almost all seasons across the south, south eastern and eastern United States. It is associated with cloudiness and precipitation. Maritime tropical air masses are also known as trade air masses.

5- Continental Tropical

These are the hot, dry air masses which originate over northern Mexico and the southwestern United States. This air mass moves into the United States through New Mexico, Arizona and western Texas and frequently migrates eastward to north-eastward making Texas climate hot and dry.

6- Effect of Air Masses on Weather

In a particular area, the occurrence of particular air masses helps to ascertain the climate of that region.

This in turn affects the types of vegetation, that can be found there and what can be cultivated successfully there.

Droughts are the result of hot, dry air mass. This can destroy natural vegetation and kill trees. These regions have the increase risk of devastating wildfires.

At the boundaries between air masses, the clash of masses of air with different characteristics can lead to dynamic weather like hail, tornadoes, high winds or ice storms.

Air masses are important natural occurrence which may have the following features:-

- It is within the transition zones that surface low pressure and fronts are most often found.
- Dry air is more dense than moist air. So, cold and dry air masses are stable because they have a higher density and higher average molecular bulk.

- Warm moist air masses are drifting due to their low density. They expand because they have a lower molecular weight.
- Low pressure forces air mass movement because it is light and contains less moisture. These are generally sourced in land areas.
- The mid-latitude zones are unique. They can experience several different air mass types over the course of a year.
- Tropical and Polar areas tend to have more uniform weather throughout the year, although the tropics can experience a wet rainy season, a dry season and mild winters. The temperature around the poles depend almost completely on the angle of the sun which varies from season to season.
- Latitude, altitude, types of ocean currents, sunshine hours, sunshine angle, natural vegetation, temperature of the soil, snow cover, prevailing wind, determine the character of an air mass.

Fronts: Formation, Characteristics and Classification of Fronts

When two air masses with different physical properties (temperature, humidity, density etc.) meet, due to the effect of the converging atmospheric circulation, they do not merge readily.

The transition zone or the layer of discontinuity so formed between two air masses is a three-dimensional surface and is called a front.

Front Formation:

The ideal conditions for a front to occur are temperature contrast and converging air which should be strong enough to move one air mass towards another along with the Coriolis force. Just as frontogenesis or front-formation is caused by converging air (for instance, along sub-polar low pressure belt), frontolysis or dissipation of front is caused by divergent air (for instance, fronts passing through sub-tropical high pressure belt tend to dissipate).

General Characteristics:

The temperature contrast influences the thickness of frontal zone in an inversely proportional manner. With a sudden change in temperature through a front, there is a change in pressure also, which is reflected in bending of isobars towards the low pressure. These isobars are otherwise smooth curves. The fronts mostly lie in low pressure troughs. Also, a front experiences wind shift, since the wind motion is a function of pressure gradient and Coriolis force.

For instance, south-west wind of Tropical Maritime air-masses may give way to the northwest wind of polar air-mass across the front. The frontal activity is invariably associated with cloudiness and precipitation because of ascent of warm air which cools down adiabatically, condenses and causes rainfall. The intensity of precipitation depends on the slope of ascent and amount of water vapor present in ascending air.

Classification of Fronts:

Based on the mechanism of frontogenesis and the associated weather, the fronts can be studied under the following types:

1. Cold Front:

Such a front is formed when a cold air mass replaces a warm air mass by advancing into it, and lifting it up, or when the pressure gradient is such that the warm air mass retreats and cold air mass advances. In such a situation, the transition zone between the two is a cold front.

The weather along such a front depends on vertical structure of the uplifted air mass, but is generally associated with a narrow band of cloudiness and precipitation. The approach of a cold front is marked by increased wind activity in warm sector and the appearance of cirrus clouds, followed by lower, denser alto-cumulous and altostratus. At actual front, dark nimbus clouds cause heavy showers. A cold front passes off rapidly, but the weather along it is violent. (Fig. 2.20)

2. Warm Front:

This is actually a sloping frontal surface, with a slope gradient between 1:100 and 1:200, along which active movement of warm air over cold air takes place. As the warm air moves up the slope, it condenses and causes precipitation but, unlike a cold front, the temperature and wind direction changes are gradual. With the approach, the hierarchy of clouds is—cirrus, stratus and nimbus.

Cirrostratus clouds ahead of the warm front create a halo around sun and moon. Such, fronts cause moderate to gentle precipitation over a large area, over several hours. The passage of warm front is marked by rise in temperature, pressure and change in weather. (Fig. 2.20)

3. Occluded Front:

Such a front is formed when a cold air mass overtakes a warm air mass and goes underneath it. The warm sector diminishes and the cold air mass completely undertakes the warm sector on ground.

Thus, a long and backward swinging occluded front is formed which could be a warm front type or cold front type occlusion. (Fig. 2.20) Weather along an occluded front is complex—a mixture of cold front type and warm front type weather. Such fronts are common in west Europe.

4. Stationary Front:

When the surface position of a front does not change, a stationary front is formed. In this case, the wind motion on both sides of the front is parallel to the front. Overrunning of warm air, along such a front causes frontal precipitation.

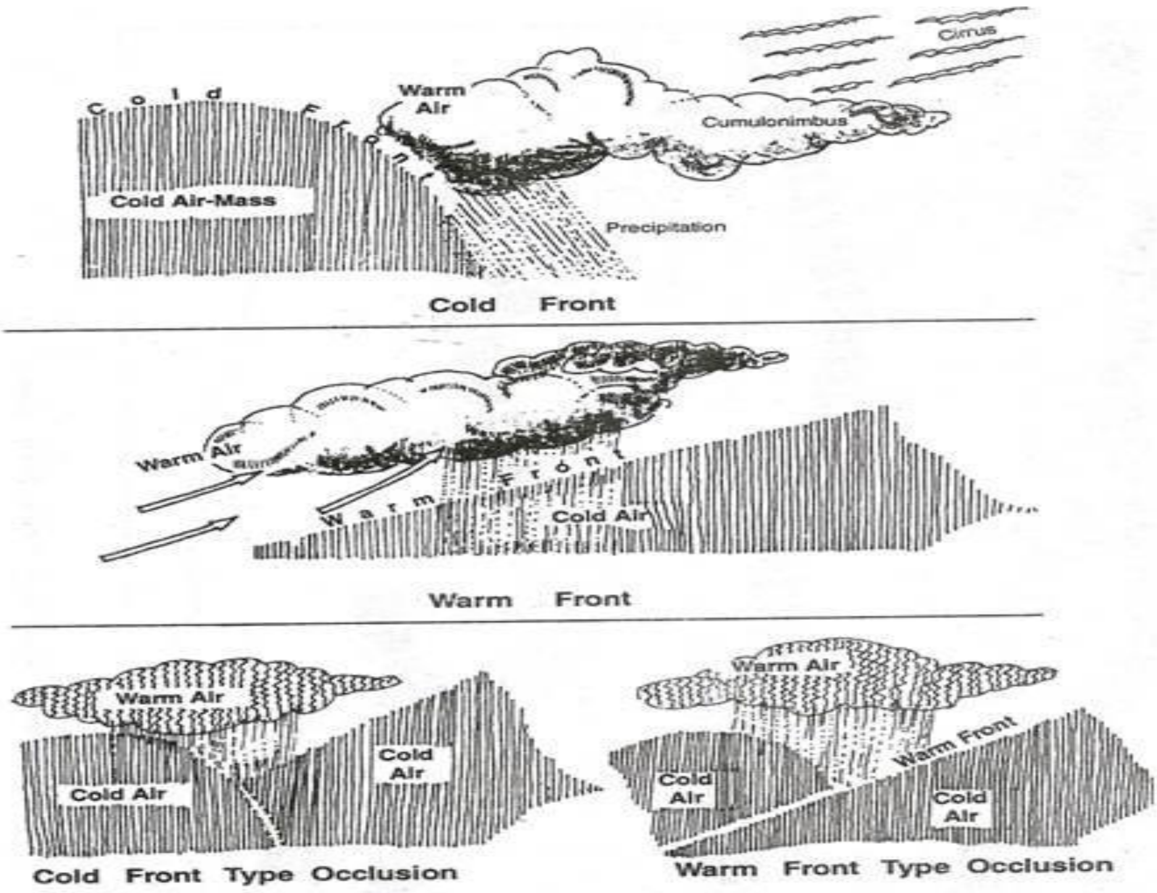


Fig. 2.20 Various types of fronts.

Some of these are discussed below:

The Atlantic Polar Front is formed when maritime tropical air masses meet continental polar air masses. Full development of this front takes place during winter.

The Atlantic Arctic Front is formed when the maritime polar air masses meet the air masses developed along the boundary of Arctic source- region. The Mediterranean Front is formed when the cold polar air masses of Europe meet the winter air masses of Africa. Pacific Arctic Fronts are formed along the Rockies-Great Lakes region. These fronts change with seasons (Figs. 2.21, 2.22).

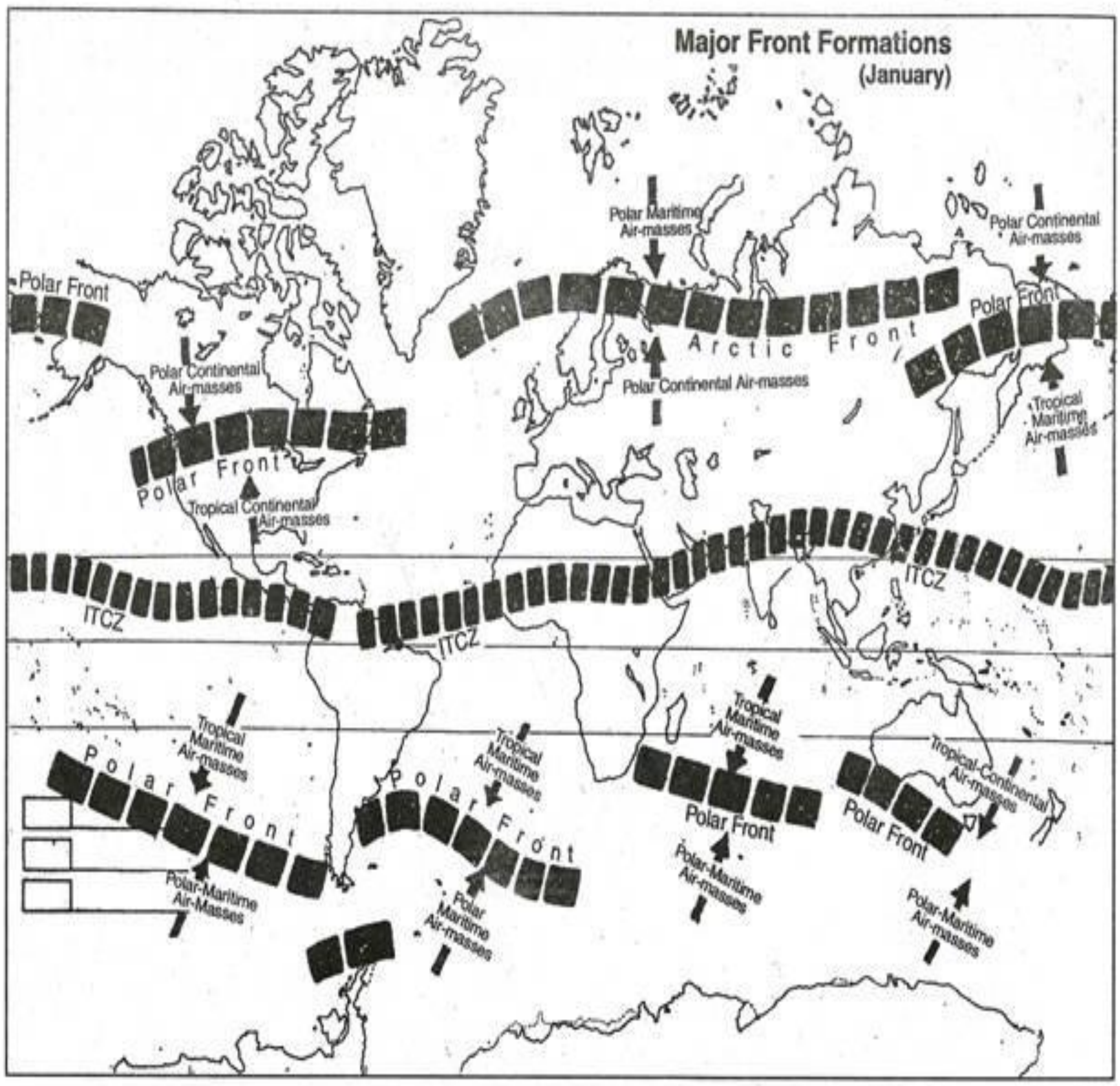


Fig. 2.21 Map showing various fronts formed during January.

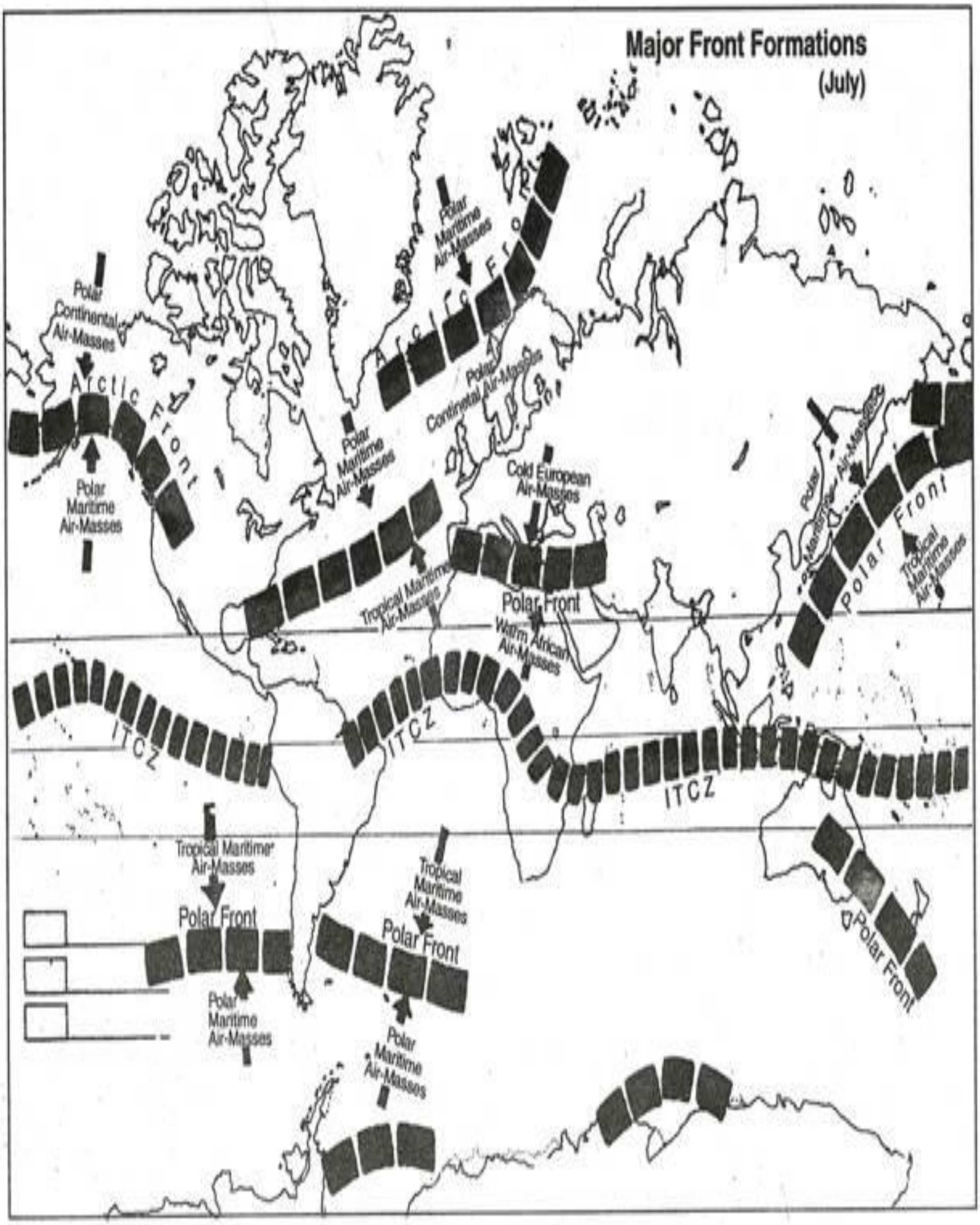


Fig. 2.22 Map showing various fronts formed during July.