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DOCUMENT TITLE

METEOROLOGY FOR AUSTRALIA

CHAPTER 27 – CLIMATOLOGY

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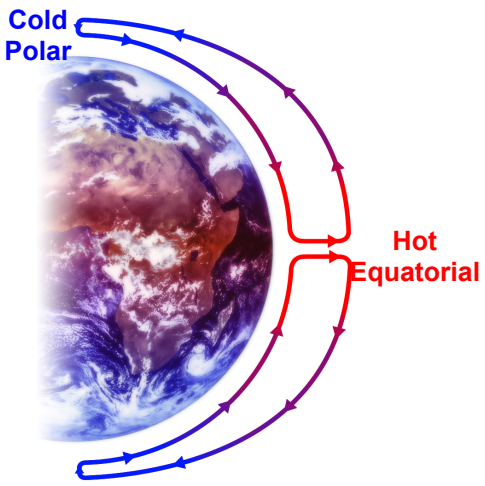
CLIMATOLOGY

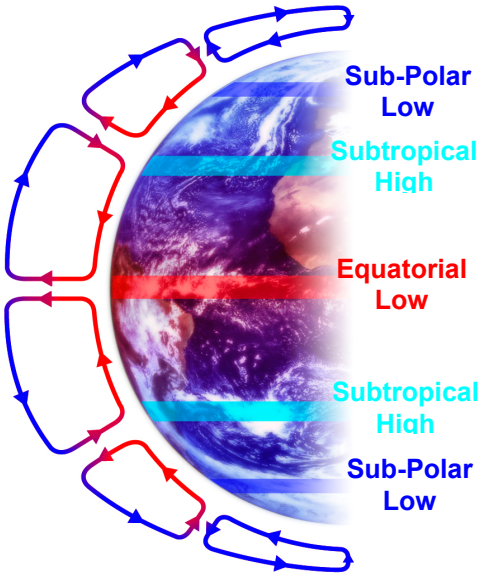
THE GENERAL ATMOSPHERIC CIRCULATION

If the Earth did not rotate and the Geostrophic force did not affect air circulation, there would be a surface flow of air from the high pressure systems over the cold polar regions towards the low pressure systems over the hot equatorial belt. The heated air near the equator would expand, become less dense and rise to flow back towards the poles in the upper atmosphere.

The polar high and equatorial low pressure areas exist on a rotating globe, but the Geostrophic effect leads to a disruption of the simple pattern of air circulation and results in the development of areas of relatively high pressure in the sub-tropics and areas of relatively low pressure in the sub-polar zones.



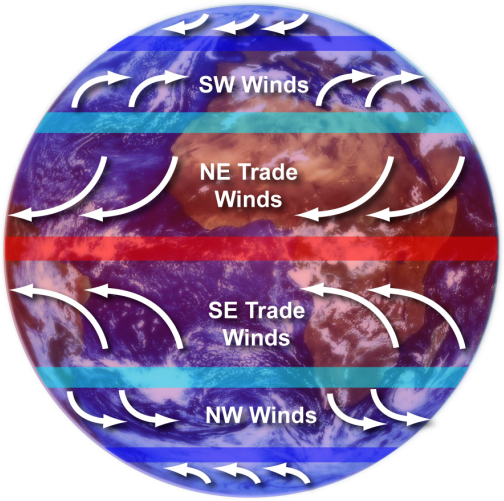
Circulation on a non-rotating



Circulation on a rotating earth

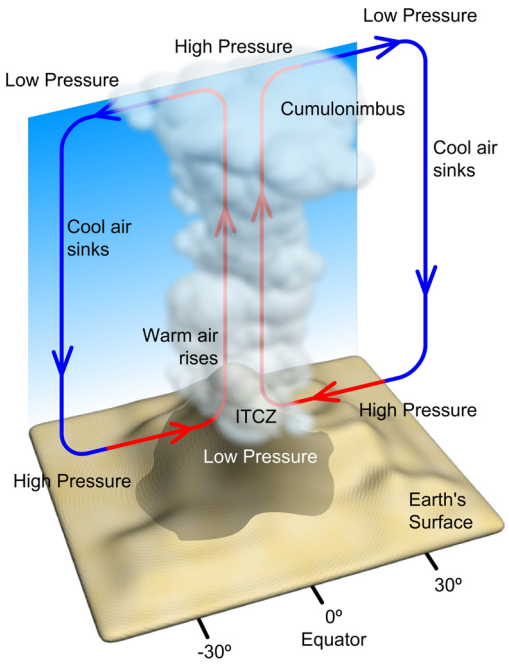
What actually tends to take place in the atmosphere is that air on either side of the equator moves towards the equatorial low pressures and, in doing so, is deflected to the right in the Northern Hemisphere and to the left in the Southern Hemisphere.

Both wind belts develop into easterly wind systems known as **trade winds.** As the air that rises over the equatorial belt moves back towards the poles, the same deflection occurs, and these upper level winds become westerly winds following the Earth's parallels of latitude.



Winds on a rotating earth

Continued circulation of the air tends to cause an accumulation of this westerly air above the sub-tropics and the air, in moving away from the equator, is converging onto a small area. The resulting tendency for air to bank up leads to the development of belts of relatively high pressure at approximately 30°North and South of the equator.



Moving to the Polar regions, consider what is likely to happen to the air moving outwards from the poles. In travelling towards the equator, deflection results in polar easterly winds, which tend to spread outwards from a small area to a much larger area. This air develops into a belt of relatively low pressure at about 60° north and south of the equator. To complete the cycle, air moves from the sub-tropical highs pole wards towards the sub-polar lows and, in doing so, deflection causes them to develop into westerly wind streams.

In the upper layers of the atmosphere, air returns to the Polar regions and it, too, becomes a westerly stream because of the deflection. The result is an idealised circulation and pressure system that results in :

Equatorial Lows

At the equator there is a belt of **equatorial low pressures** where air tends to converge and is forced to rise in convection currents. Inside these systems the air is quite calm. The belt is also known as the **doldrums**, the Inter-Tropical Convergence Zone (ITCZ), or the Inter-Tropical Front.

Sub-Tropical Highs

Subtropical high pressures prevail in the latitudes of approximately 30°N and 30°S. These anti-cyclones form spiralling zones of subsiding air, and the areas between them and the equatorial lows are usually referred to as tropical “cells”; air flows from the highs to the lows on the surface and back again in the upper layers of the troposphere. Subsidence is strongest in the eastern portions of these anti-cyclones, and it is here that the air is driest and most stable. Areas of calm occupy the centres of these high pressure systems and the belt was given the name **horse latitudes**.

Trade Winds

Trade winds, or tropical easterlies, are the prevailing winds between the sub-tropical high pressure belt and the equatorial lows.

Westerlies

Within the middle latitudes, the airstreams diverging from the sub-tropical anti-cyclones and extending pole-wards are known as the variable westerlies. In the Southern Hemisphere, they are often called the **"Roaring Forties",** because of their latitudinal position. With constant strength and changeable direction they blow towards the sub-polar cyclones which develop along the "polar front".

Sub-Polar Lows

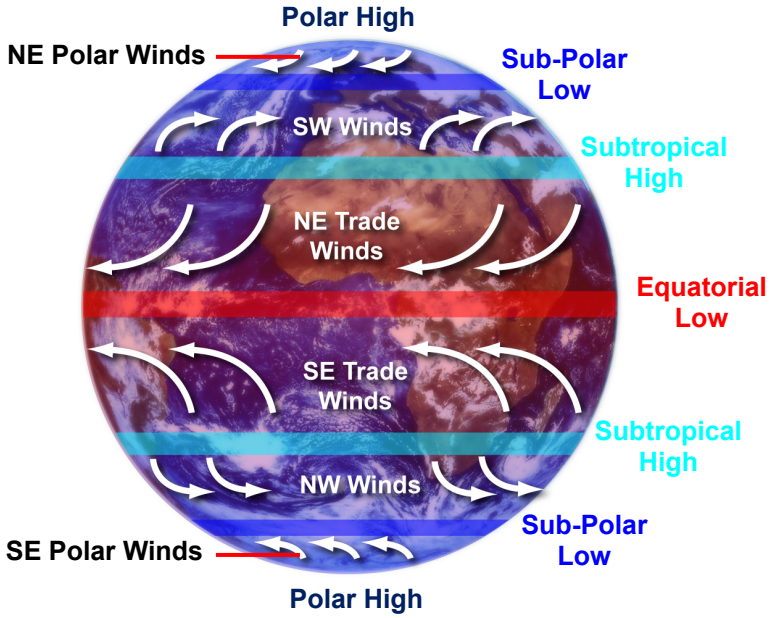
Sub-polar low pressures, or mid-latitude cyclones, form a very irregular belt. They may develop anywhere between the latitudes of 40° and 70° in both hemispheres, but their average position is at about 60°N and S. Like the equatorial zone, this is a belt of convergence, and it is called the **polar front.** Unlike the equatorial low pressure systems, air streams of vastly different temperatures are involved, as tropical air from the equator side converges with polar air from the pole-ward side.

Polar Easterlies

Polar easterlies are the winds blowing out from the Polar regions towards the sub-polar low pressure systems. They are cold, variable winds.

Polar Highs

Polar high pressures are dominant over the cold Polar regions. They consist of masses of dense air subsiding and moving outwards from the poles.



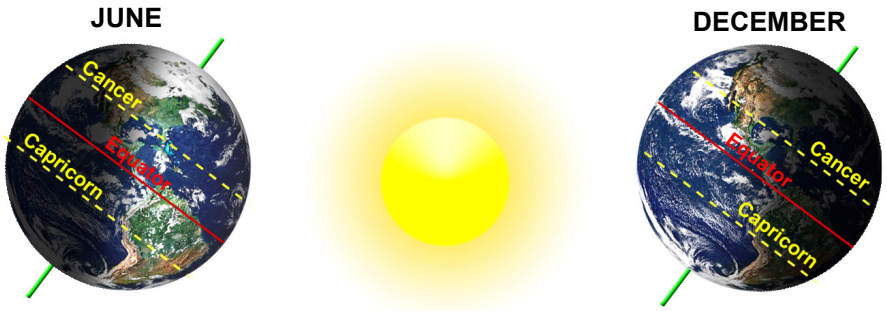
The Ideal Circulation of the earth

SEASONAL VARIATION IN THE ATMOSPHERIC CIRCULATION

Having seen how the Earth's spherical shape, size and rotation influence the atmospheric pressure and air circulation, the revolution of the Earth around the sun on a **tilted axis**, and the uneven distribution of the Earth's **land and sea masses** also affect the characteristics.

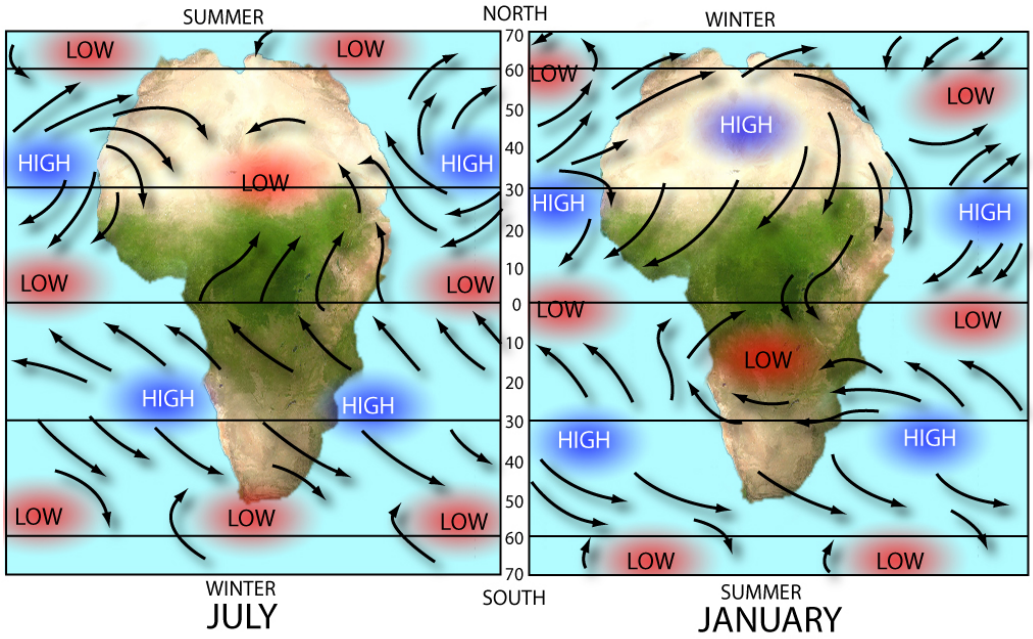
TILTED AXIS

Because of the Earth's **revolution around the sun on a tilted axis** every twelve months, the overhead sun swings from tropic to tropic, and the hottest part of the world, or Thermal Equator, tends to move likewise. The equatorial low pressure systems also move, but they tend to lag behind the apparent movement of the sun moving little more than 10° on either side of the equator. The seasonal movement of the equatorial belt results in a similar fluctuation north and south of each of the other pressure and wind belts. If the Earth did not have a tilted axis, there would be no seasonal fluctuations at all.



LAND AND SEA MASSES

If the Earth had a uniform surface, composed everywhere of ocean, the swing of the pressure and wind belts would be uniform everywhere. But **the uneven distribution of land and water masses** disrupts this neat pattern. The large land masses heat up and cool down much more than the oceans, and they may become centres of low or high pressure, out of alignment with the normal pressure belts. Because of its latitudinal extent, the African continent is a good example.



Effect of Land Masses on Ideal Circulation

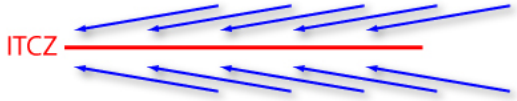
For example, the large land masses in the horse latitudes, where sub-tropical high pressure systems normally prevail, becomes so hot in summer that they develop low pressure systems. Secondly, these large land masses of the northern hemisphere become so cold in winter in the belt of prevailing sub-polar lows (at about 60°N) that they become centres of high pressure. Because of the larger land areas in the Northern Hemisphere, the most noticeable interruptions to the belts of pressures occur there. Only minor seasonal changes in pressure systems occur in the Southern Hemisphere, where the continents are so much narrower.

THE INTER-TROPICAL CONVERGENCE ZONE

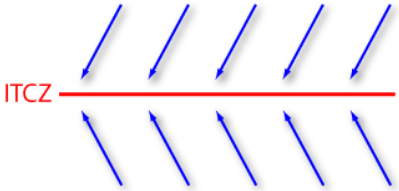
The Inter-Tropical Convergence Zone (ITCZ) is the region of the equatorial lows and the following facts should be noted:

- The ITCZ is made up of a series of thermal lows.
- The width of ITCZ **weather** varies between 30 to 300 miles.
- Over the ocean areas the ITCZ generally stays within about 15° of the equator.
- In the eastern Pacific and eastern Atlantic oceans, it stays in the **Northern** Hemisphere throughout the year.

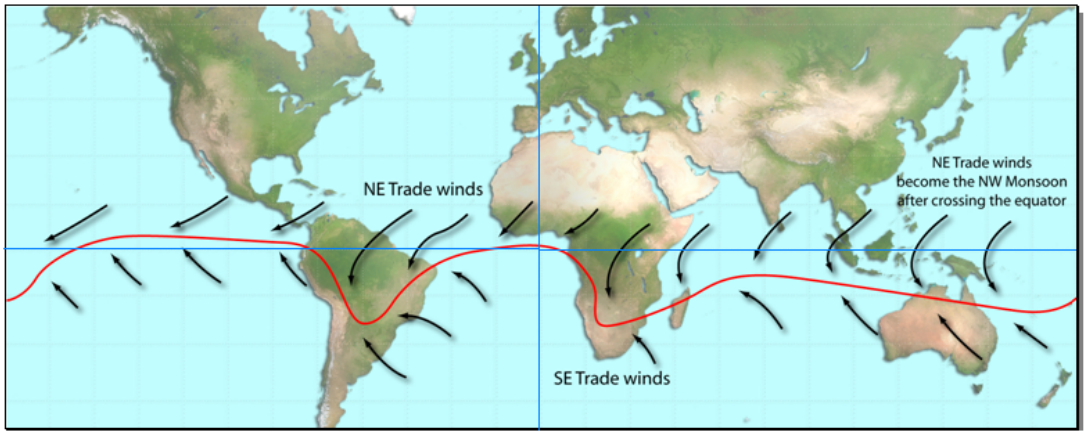
- Land mass heating in the summer causes major deflections of the ITCZ away from the equator.
- Its movement is usually predictable throughout the year except for its most northerly movement over Eastern Asia which varies considerably owing to changes in low pressure values over NE Russia.
- The ITCZ lags about eight weeks behind the sun so reaches its most northerly limit at about the end of August and its most southerly at the end of February.
- If the angle of the converging trade winds is very small, little weather results.



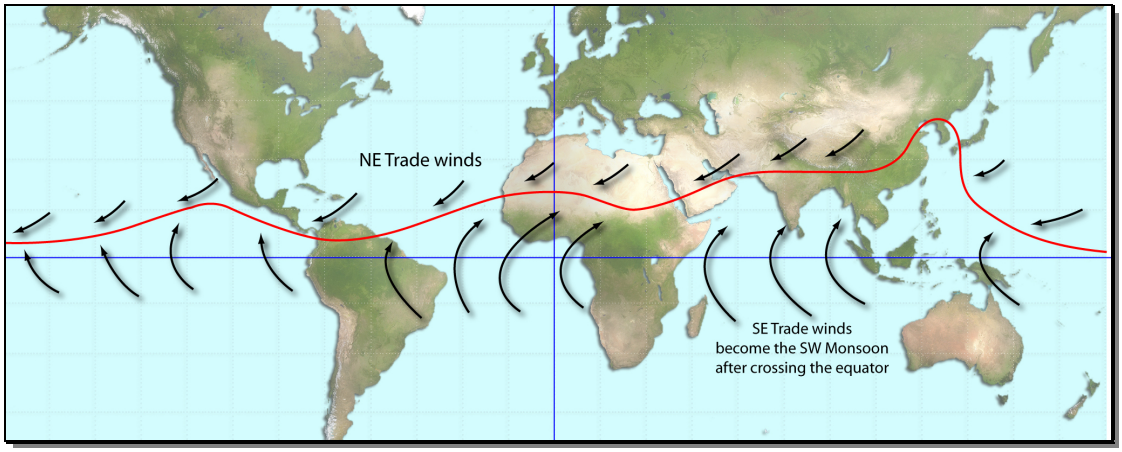
- If the angle of the converging trade winds is large Cu, Cb and showers result.



- The tops of clouds may reach the tropopause (50-55,000') and freezing level is about 17,000'



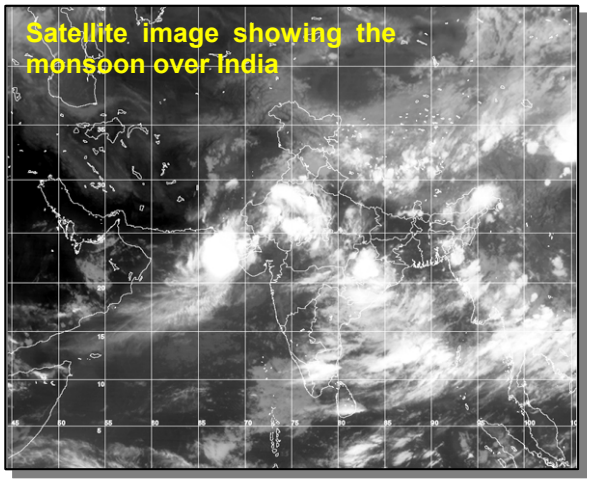
Position of the ITCZ in January



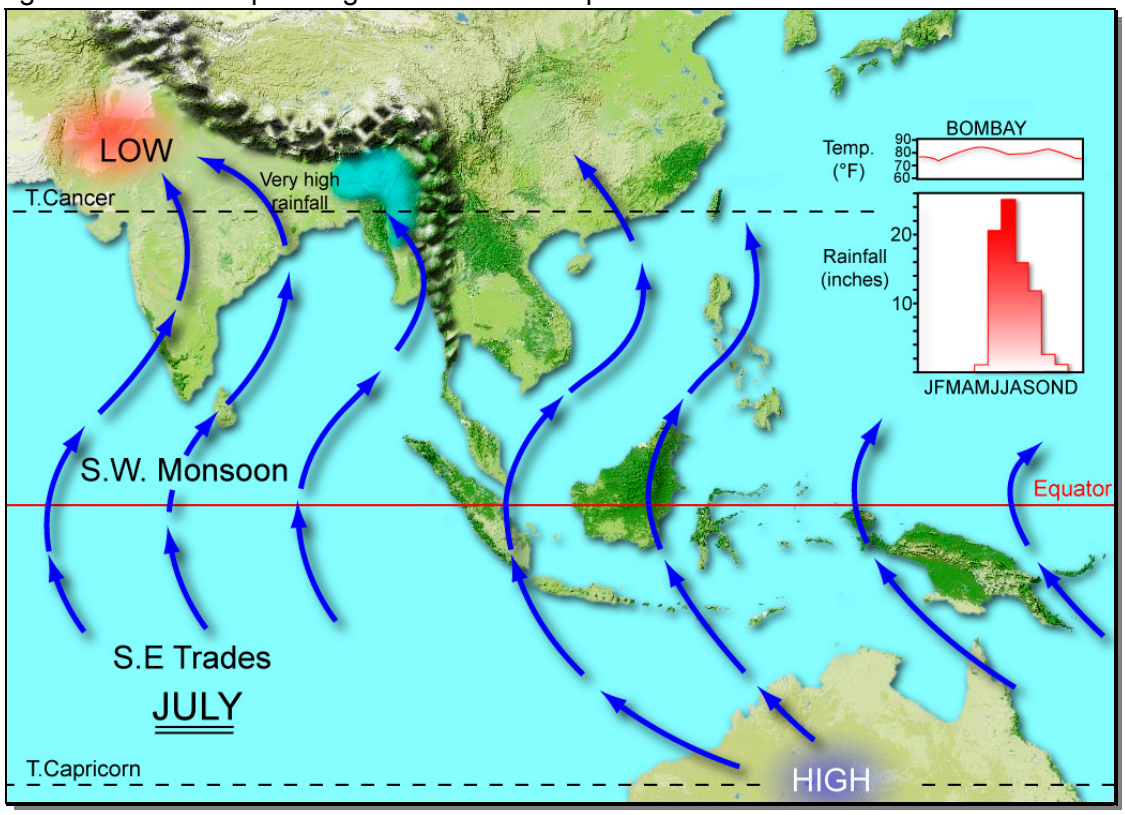
Position of the ITCZ in July

MONSOONS

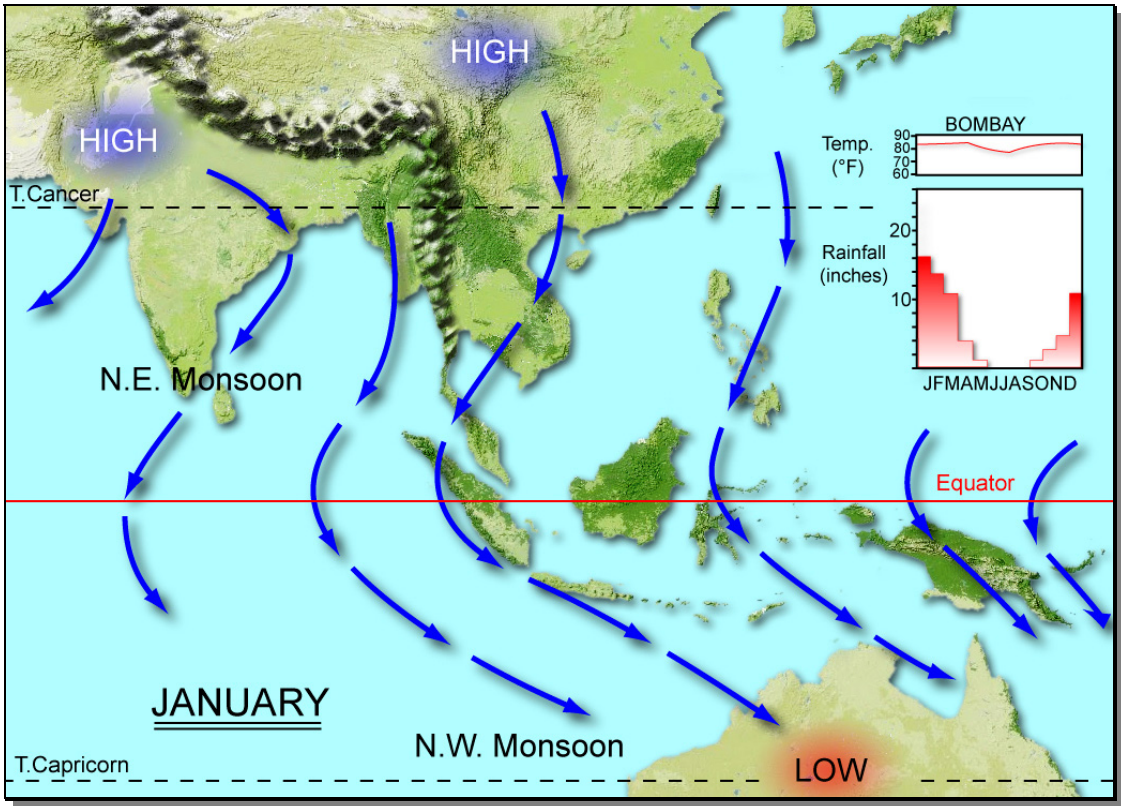
The development of the summer low and the winter high over large land masses results in a seasonal reversal of winds, air blowing into a continent in summer and out of it in winter. These seasonally reversing winds are called monsoon winds (from the Arabic *Mausim*, a season), and their development is similar to the land and sea breezes but on a much larger scale.



The greatest development of Monsoons occurs between Australia and Southern Asia. When it is summer in the Northern Hemisphere, the Asian land mass becomes very hot and develops into a centre of low air pressure. So intense is the low that air is drawn into Asia from the east and the south, spiralling into the cyclone in an anticlockwise direction (deflected to the right in the Northern Hemisphere). This is the opposite direction to the normal north-east trade winds blowing from the sub-tropical highs south of the equator.



In the winter season a strong high pressure system develops over Asia and air blows out of the interior in a clockwise direction to become the north-east trade winds to the south of the continent. At that time, however, the hot summer conditions over Australia produce low pressures and air blows into Northern Australia.



NORTH EAST MONSOON OF SOUTH EAST ASIA

The NE Monsoon blows from November to March. It starts as a very cold, dry continental air mass but it warms as it moves south. Following a long land track, it produces clear, cool and dry weather conditions but, when it swings across the China Sea and the Bay of Bengal, it is warmed and moistened from below to produce Cu/Cbs and moderate or heavy showers to eastward-facing areas of SE Asia, Malaysia, the Philippines and India. The cloud build-up is aided by orographic uplift. As the air tracks further south it crosses the equator behind the ITCZ and changes its direction to NW by Northern Australia (Darwin area).

SOUTH WEST MONSOON OF SOUTH EAST ASIA

In July a large thermal low forms over India. The SE trades flow from the H.P. and are deflected to become the SW trades on crossing the equator. After tracking for thousands of miles they have picked up vast quantities of moisture. On reaching the lands of SE Asia these air masses undergo surface heating and orographic uplift, further increasing their instability. Cu clouds develop into Cbs and TS with intense rainfall.