Unit 2 Global air circulation

1 Air circulation in response to unequal heating of the atmosphere

Global air circulation systems move thermal energy, air and water from equatorial regions with energy surpluses to polar regions with energy deficits.

2 World pressure belts

- The global air circulation patterns control our weather and climate. These patterns are caused by shifting zones of high or low pressure in summer and winter.
- They move seasonally with the varying intensity of the Sun's direct rays.
- Atmospheric pressure is shown on maps by isobars which are lines joining places with equal pressure.

2.1 Where are the pressure belts found in each hemisphere?

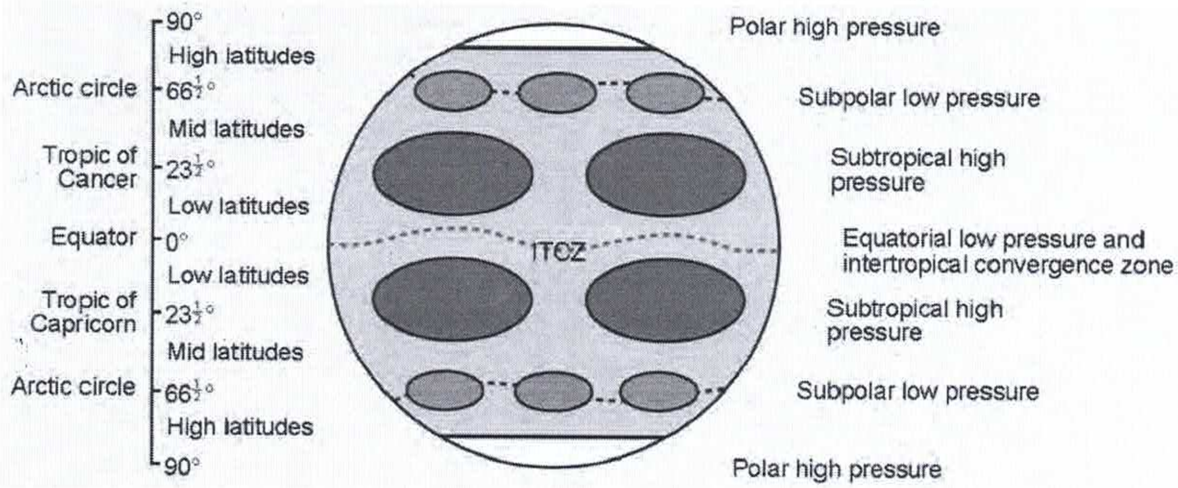

FIGURE 28 Location of the global atmospheric pressure belts

- In January the low pressure Intertropical Convergence Zone (ITCZ) is situated mostly south of the equator.
- In July the ITCZ shifts north of the equator.

TABLE 7 Summary of causes and characteristics of global pressure belts

Name	Location	Cause(s)	Air characteristics
Equatorial low pressure	10° N to 10° S	Thermal: • Intense heating due to constant high sun altitude and consistent daytime (12 hours) • Warming creates less dense, lighter, rising air.	Warm and wet air. When moist air rises, it may condense and result in clouds and rain.
Subtropical high pressure	Between 20–35 °N and 20–35 °S	Dynamic: • Air above region is pushed downwards. • Air heats by compression as it descends to Earth's surface.	Hot and dry air. Cloudless, especially over desert areas.
Subpolar low pressure	In the region of 60° and 70° to the north and south of the equator	Dynamic: • As a result of the Earth's rotation, at these latitudes air is spun away from the Earth's surface by centrifugal forces.	Cool and wet air. Contrasting air masses meet along polar front – cold, dry air from high latitudes and warm, wet air from lower latitudes.
Polar high pressure	Around the poles (90° north and south)	Thermal: • Low temperatures as areas receive little solar energy • Air becomes more dense, heavier and sinks.	Cold and dry air. Air is so cold that it contains little moisture; convection and precipitation are limited.

3 The relationship between air temperature, air pressure and wind

3.1 High and low pressure cell formation

- During daytime, land surfaces heat up more rapidly than water. The air above the land is heated, it becomes less dense, expands and rises. This lowers the air pressure over the land.
- Over the adjacent water surface, the air is cooler. It becomes more dense, contracts and descends.

TABLE 8 The characteristics of high pressure and low pressure cells in the southern hemisphere

High pressure	Low pressure
Air sinking anti-clockwise.	Air rising clockwise.
At Earth's surface air moves outwards to areas of lower pressure – outward-blowing surface winds.	At Earth's surface air moves inwards from areas of higher pressure – inward-blowing surface winds.
As it descends, cool air is heated by compression.	As it rises, warm is cooled by expansion.
Associated with calm, fair and dry/hot weather.	Associated with cloudy, rainy and stormy weather.

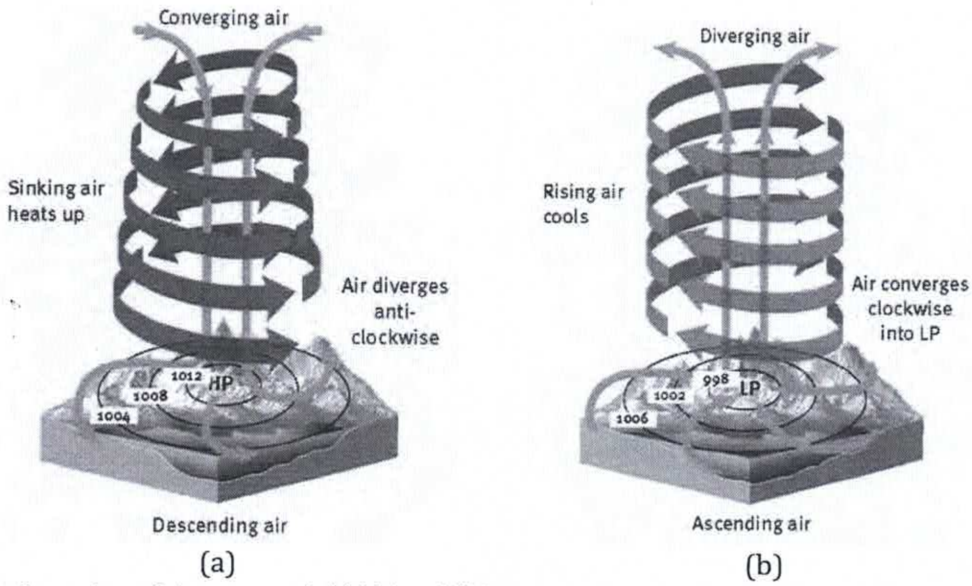

FIGURE 29 Comparison of air movement in (a) high and (b) low pressure cells in the southern hemisphere. In high pressure cells the air sinks anti-clockwise. In low pressure cells the air rises clockwise. In the northern hemisphere the air rotation is the other way around.

3.2 What is the relationship between atmospheric pressure and wind?

Atmospheric pressure differences are caused by uneven heating of the Earth's surface. **Figure 30** shows the relationship between pressure and wind. To start, there are three columns of air all at the same temperature and air pressure.

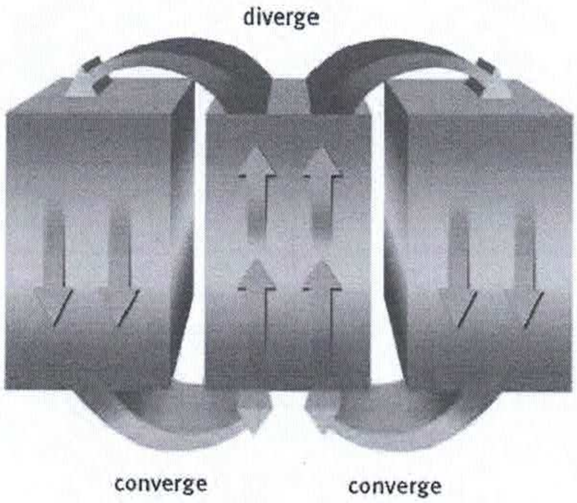

FIGURE 30Model showing the relationship between temperature, atmospheric pressure and wind

- The air at the bottom of the central column is heated. It expands and rises to the top of the column.
- Now there is less air at the bottom of the central column so the pressure is lower. At the top of the central column there is more air so there is higher pressure.
- Now there is a pressure gradient between the columns.
- Air will flow from the side columns to the lower pressure at the bottom of the central column and is called is called convergence.
- Air will flow from the high pressure at the top of the central column to the lower pressures at the top of the side columns. This outward flow from high pressure is called divergence.

4 The tri-cellular model of global air circulation

4.1 Hadley cell

- The high temperatures at the equator cause the warm moist to rise and move towards in the upper atmosphere causing a belt of low pressure at the equator resulting in heavy rainfall.
- Close to the ground air flows from the subtropical high pressure from about 30° N and S to the equatorial low pressure zone.
- Cool air in the upper atmosphere above approximately 30° N and S descends forming high pressure cells preventing clouds and rain from forming.
- The zone between the tropics where trade winds from the subtropical high pressure belts converge is called the Intertropical Convergence Zone or the ITCZ.

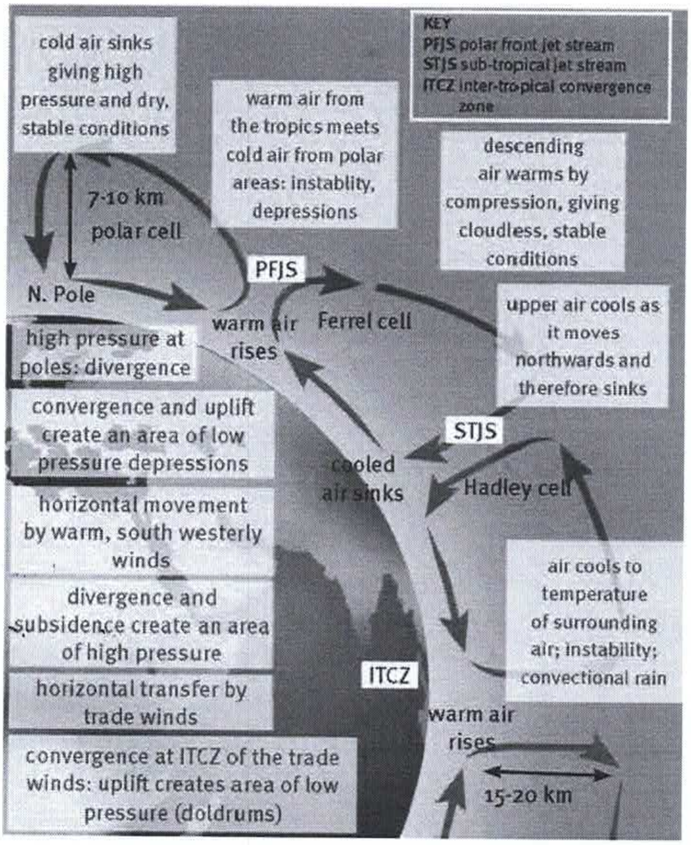

FIGURE 31 The tri-cell model of atmospheric circulation consists of the Hadley cell, the Ferrel cell and the polar cell.

4.2 Ferrel cell

- At latitudes 30° N and S, some of the air in the high pressure zones moves towards the equator as part of the Hadley circulation.
- The rest of the air moves along the surface to the higher latitudes of 60° N and S, where the air pressure is mainly low.
- Along the polar front, at 60° N and S, warm air from the subtropical high pressure belts meets cold air from the polar high pressure zones.

4.3 Polar cell

- Over the poles, the air sinks, forming the polar high pressure zones.
- At the surface, air diverges outward from the polar highs.
- It then flows as easterly surface winds in the Polar cell, towards the sub-polar low pressure belts at 60° N and S.