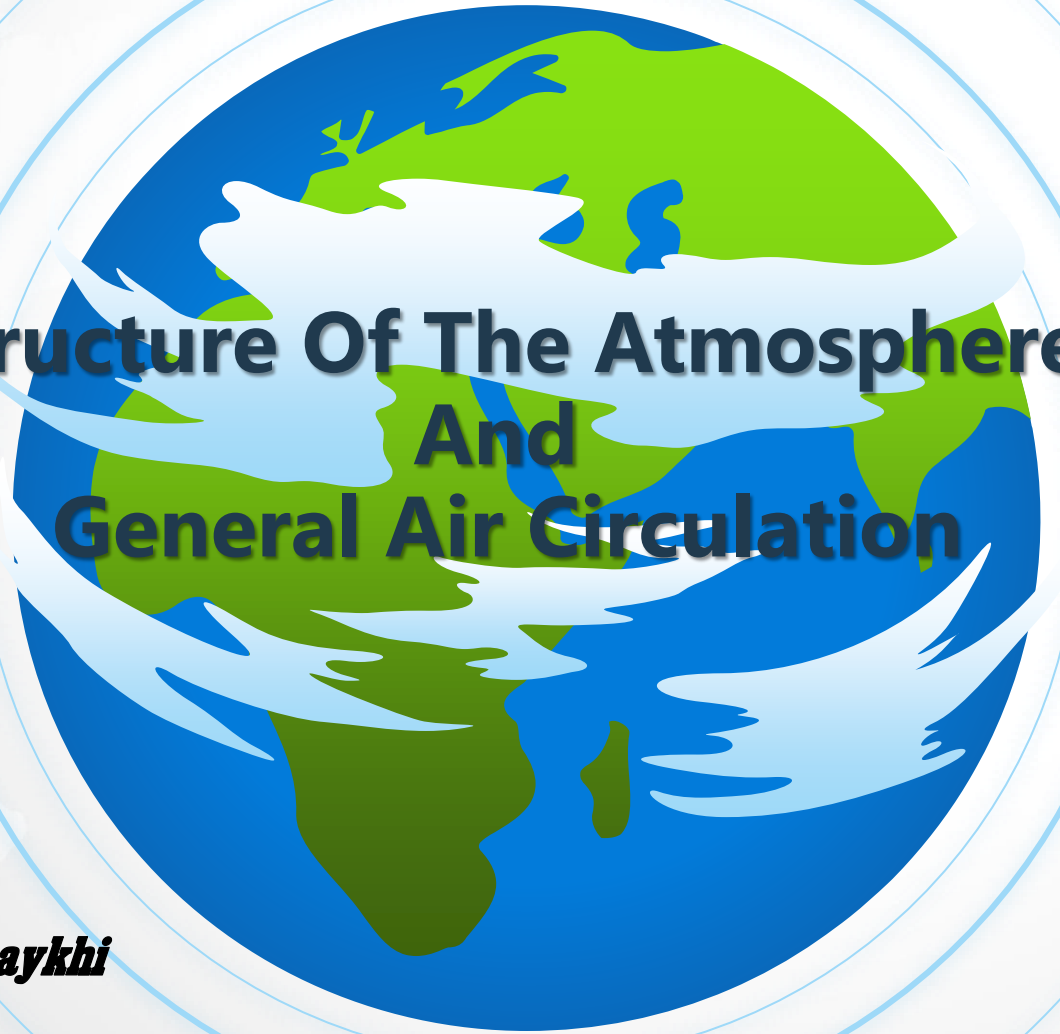

Structure Of The Atmosphere And General Air Circulation

Lecturer: ***Mohammed Al Mashaykhi***

29,9,2024

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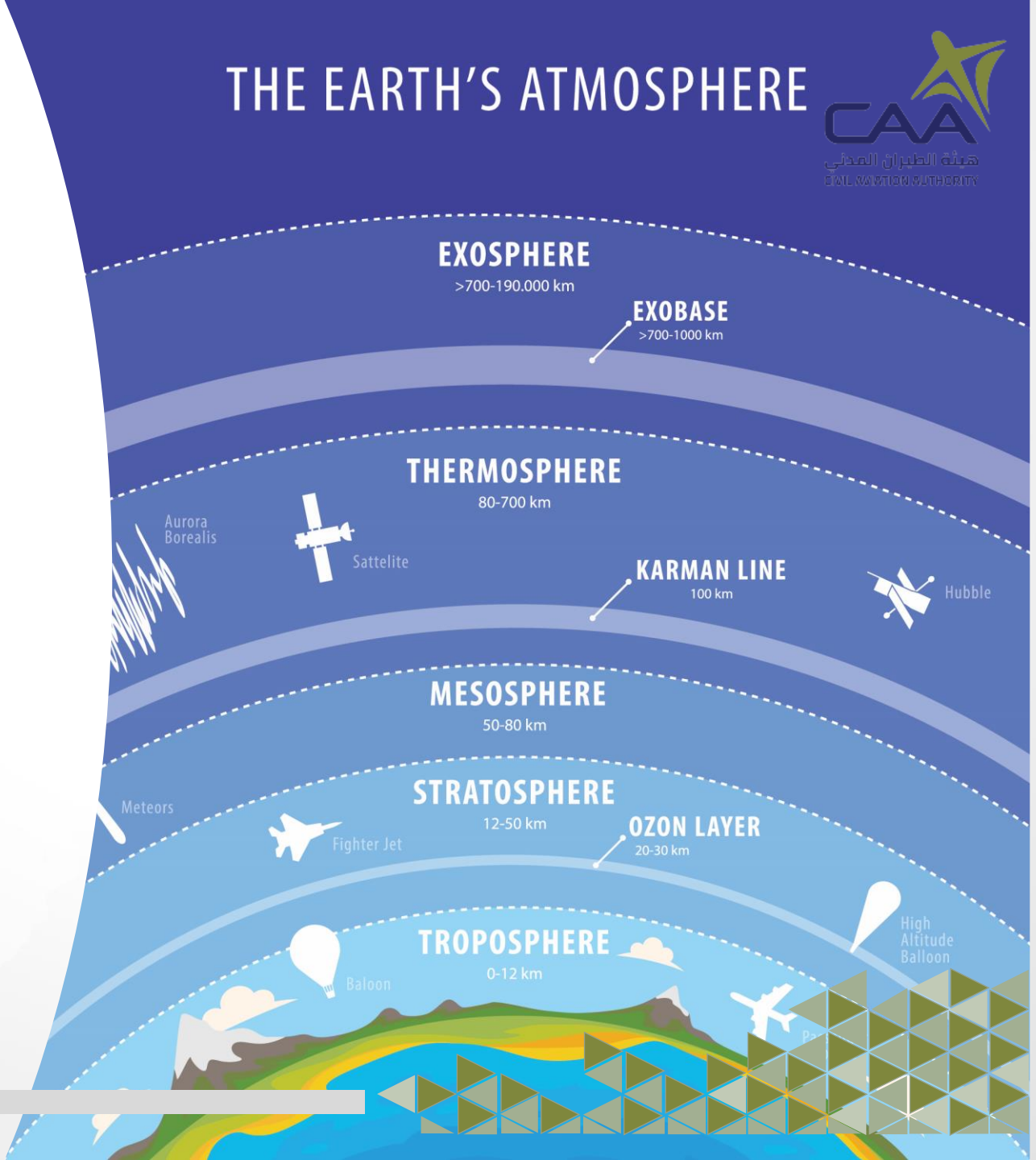
Introduction

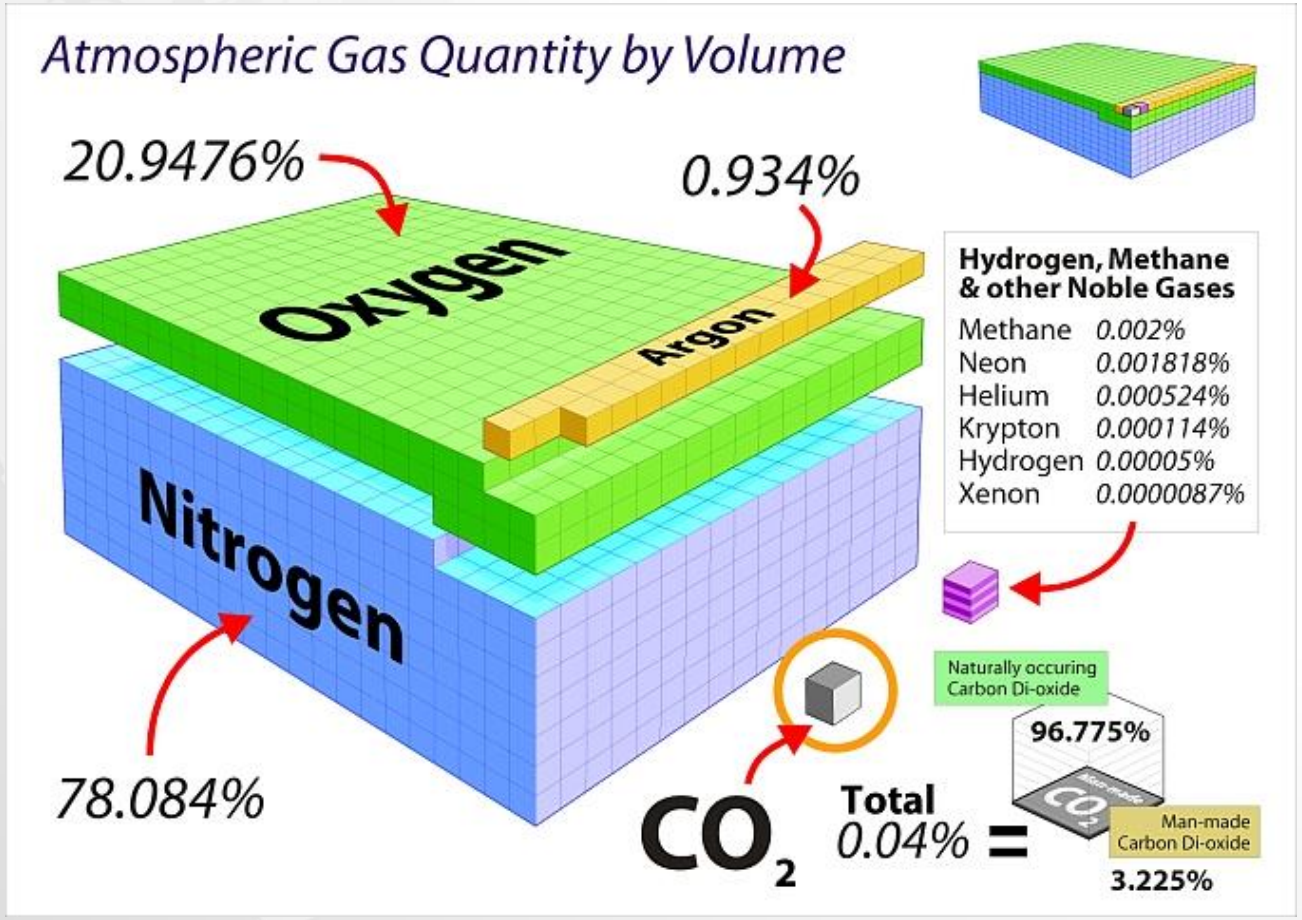
The Vertical Structure of the Atmosphere



Troposphere

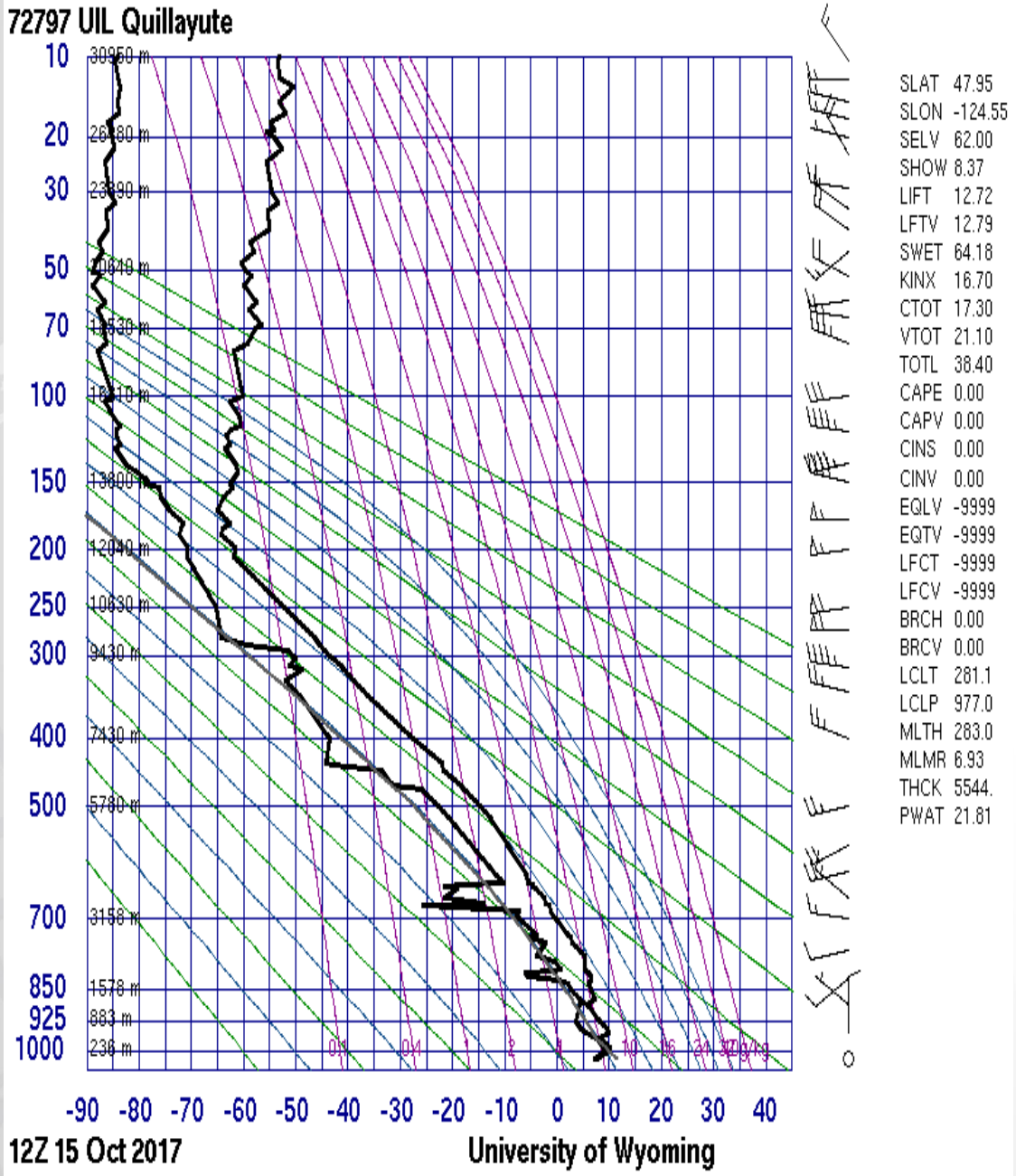
- lowest layer of Earth's atmosphere.
- ~3/4 of mass of atmosphere
- Most weather occurs in this layer
- The top of troposphere is called the **tropopause**.
- Midlatitude **jet stream** tends to be **strongest** near the **tropopause**.
- As the density of the gases in this layer **decrease** with height, the air becomes **thinner**. Therefore, the temperature in the troposphere also **decreases** with **height** (by ~6.5C per km, 3.6 F per 1000 ft)

Composition of Air



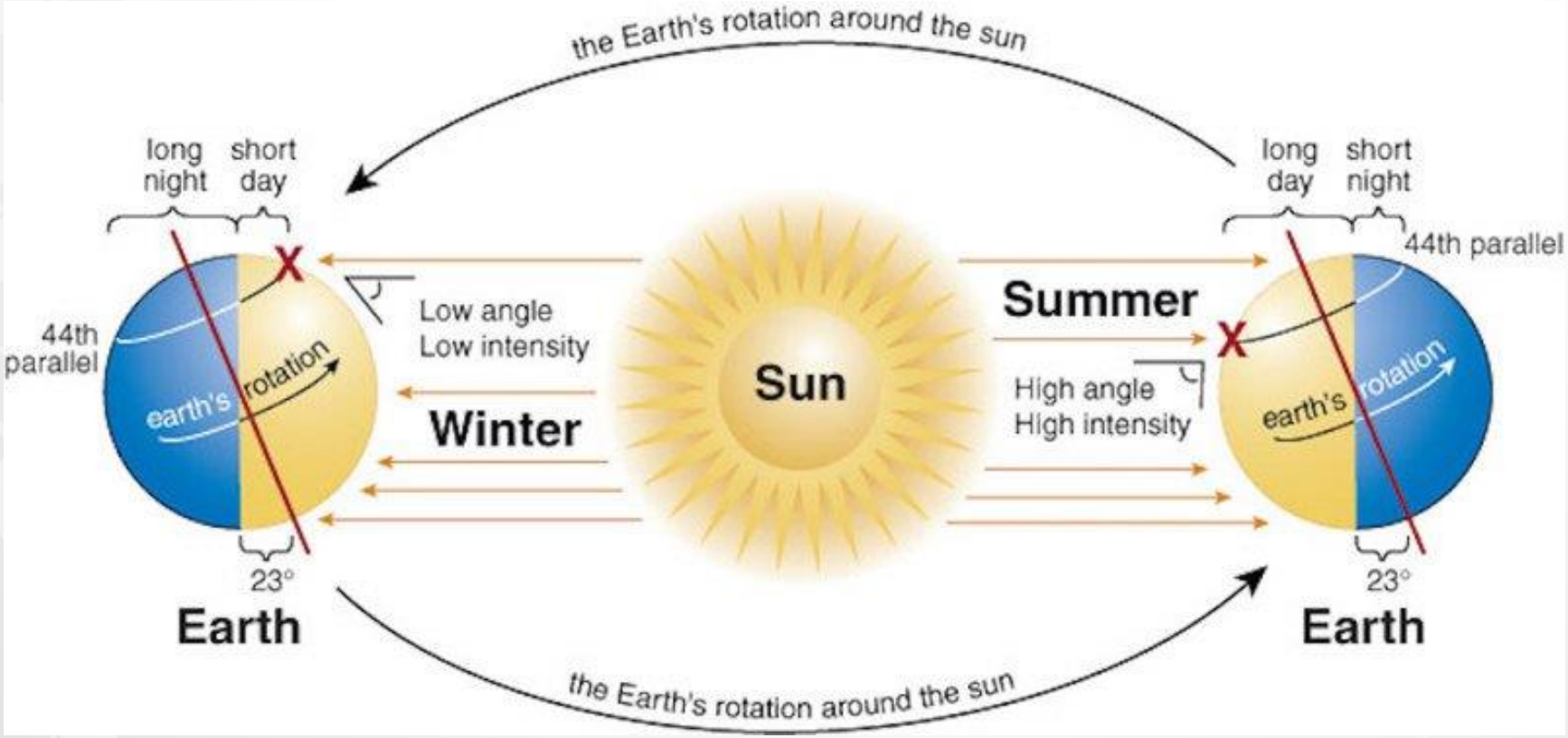
Stratosphere

- 19 **percent** of the **atmosphere's gases** but very little water vapor.
- The **temperature increases** with **height**.
- Heat is produced in the process of the formation of **Ozone**, and this heat is responsible for **temperature increases**.
- This increase in temperature with height means **warmer air is located above cooler air.** This prevents convection as there is no upward vertical movement of the gases.
- The transition boundary which separates the mesosphere from the stratosphere is called the stratopause.
- Objects Flying in this Layer:
  Weather Ballon (Radiosonde)
- Features:
  Ozone Layer

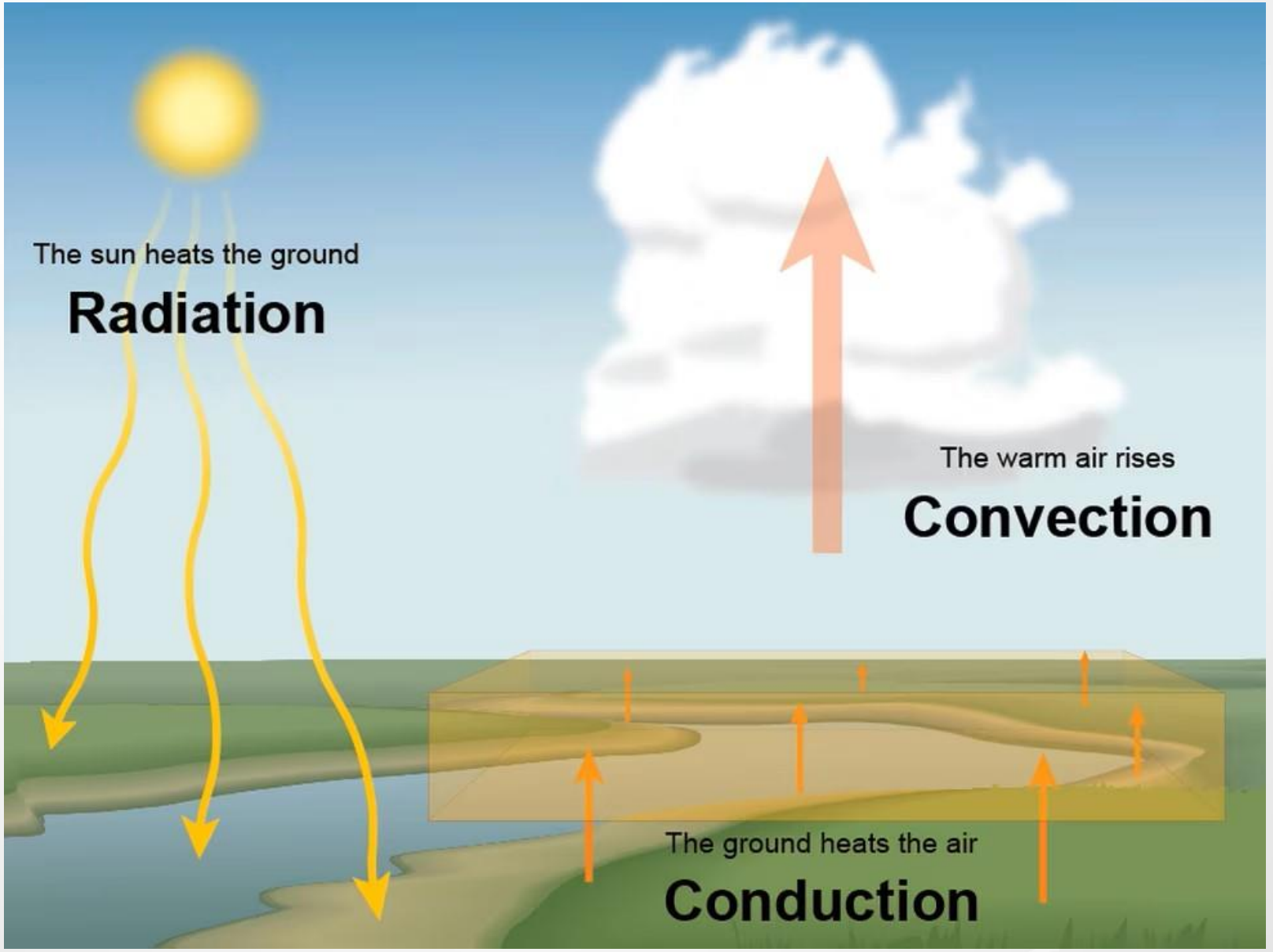


Weather Balloon (Radiosonde)

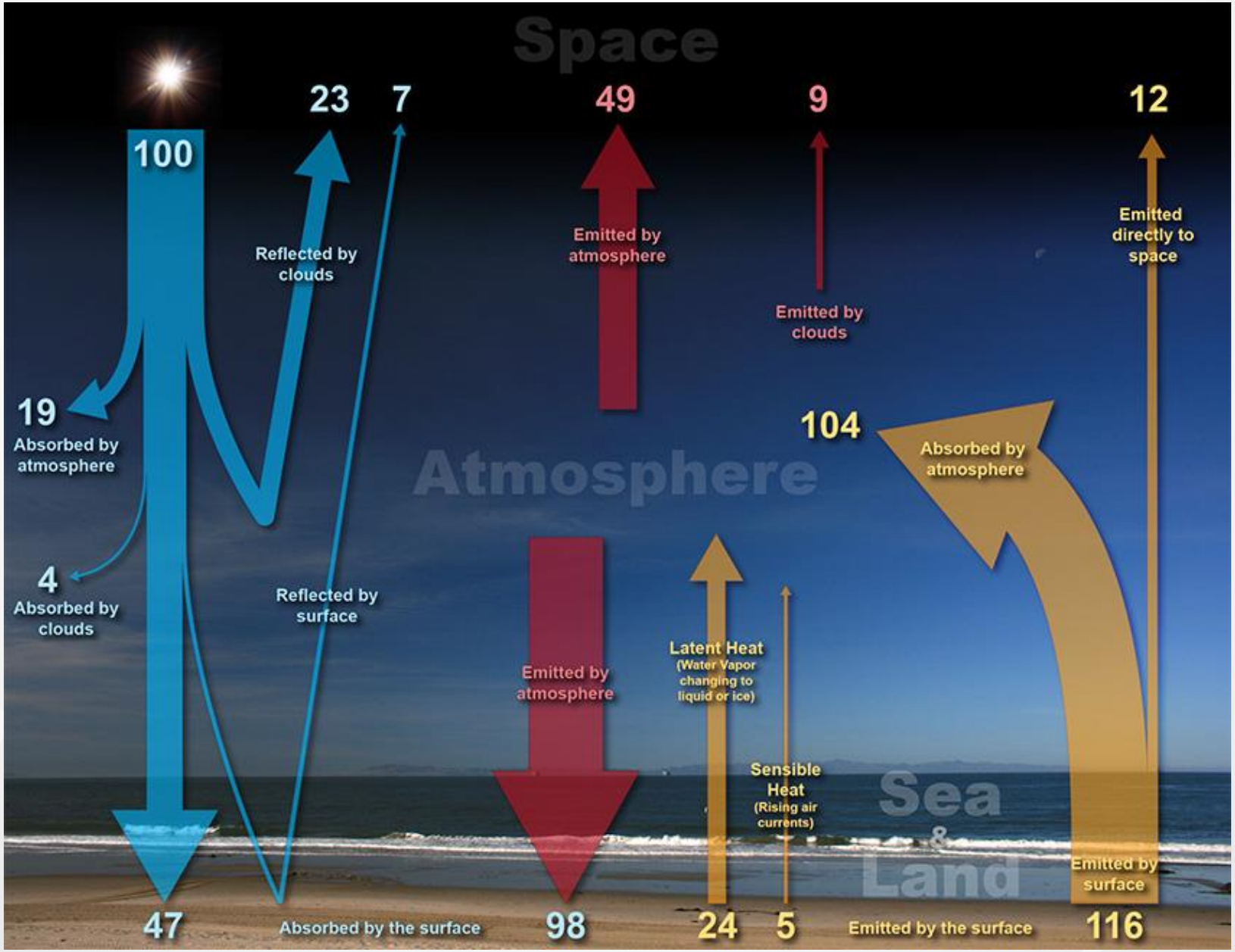
2 Radiation


the Earth's rotation around the sun
long night
short day
long day
short night
44th parallel
44th parallel
Low angle
Low intensity
Summer
Winter
Sun
High angle
High intensity
earth's rotation
earth's rotation
23°
23°
Earth
Earth
the Earth's rotation around the sun

The Transfer of Heat Energy



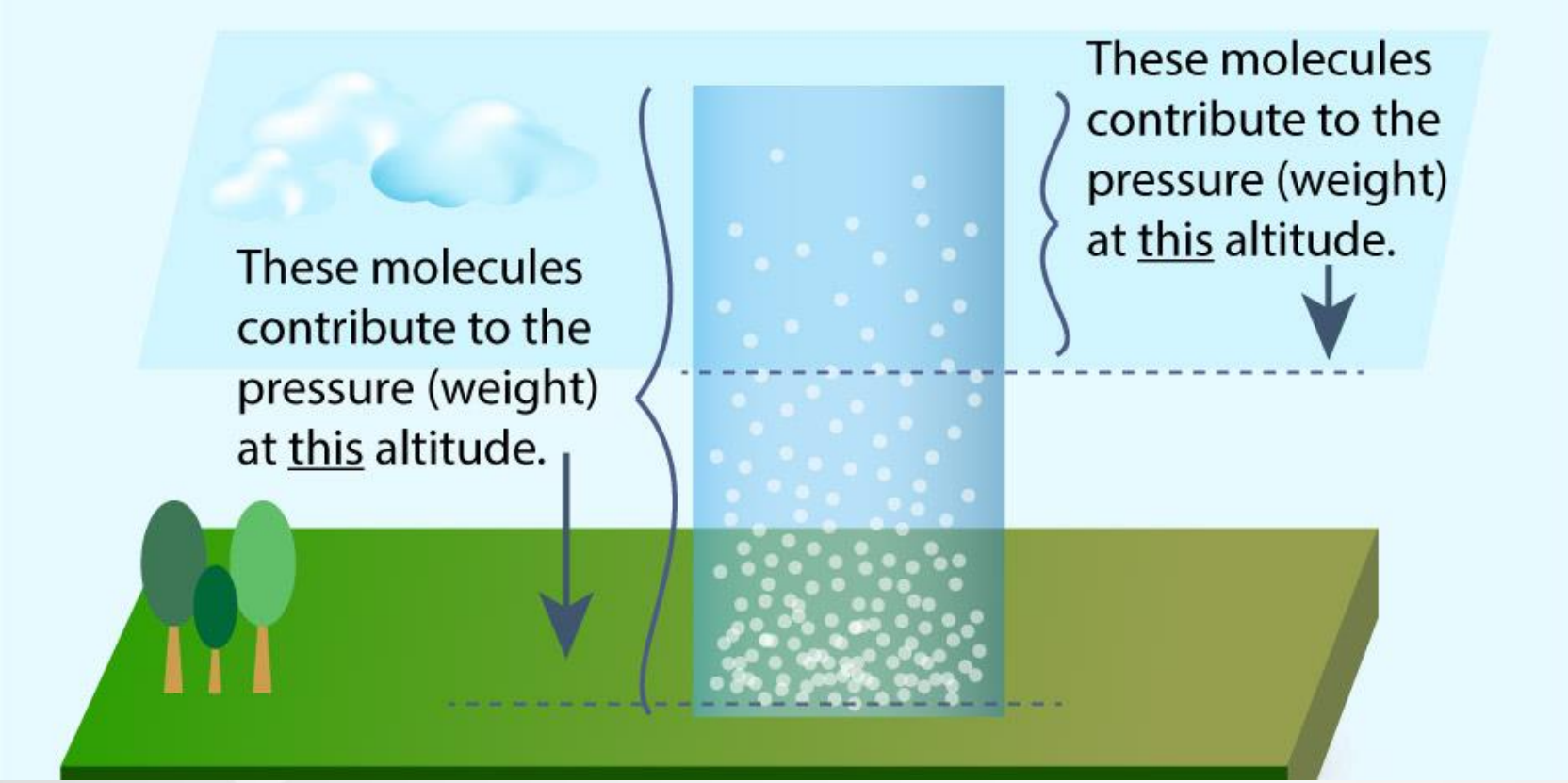
The earth-atmosphere energy balance



Air pressure

Air pressure

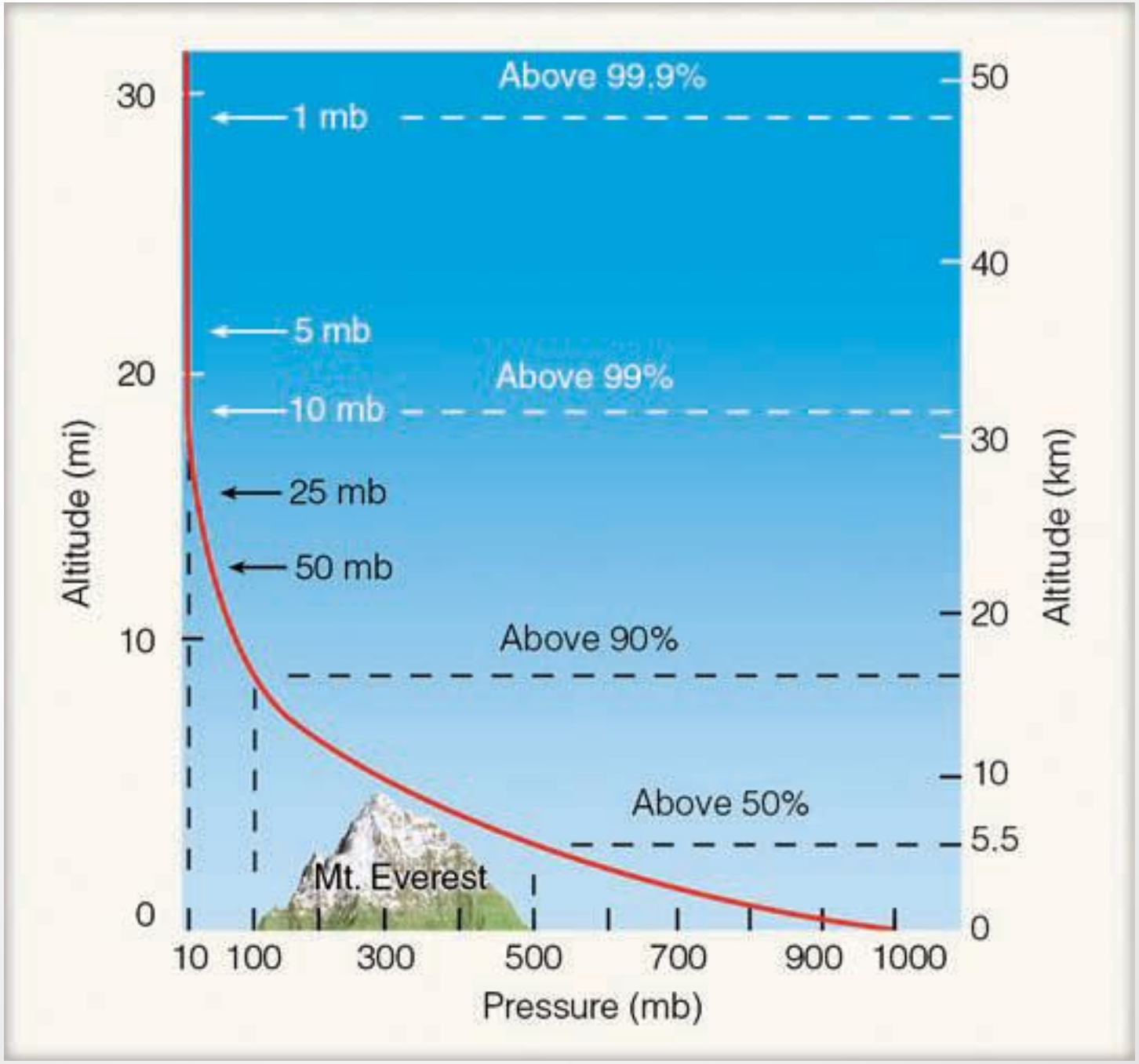
Air pressure ,or atmospheric pressure , is the force per unit area exerted on a surface by the **weight of air** above that surface.



Pressure and Density

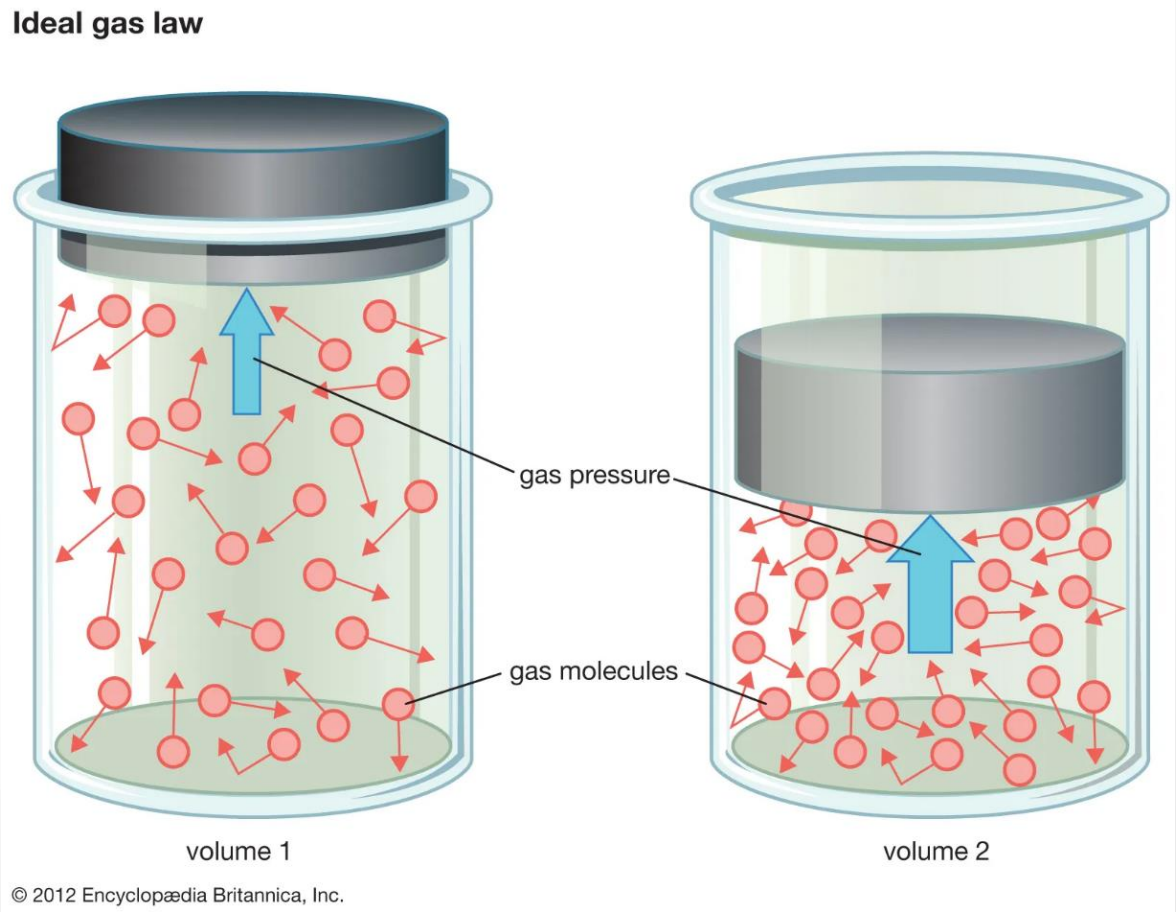
As the number of air molecules in column of air decreases, the air pressure decreases and vise versa

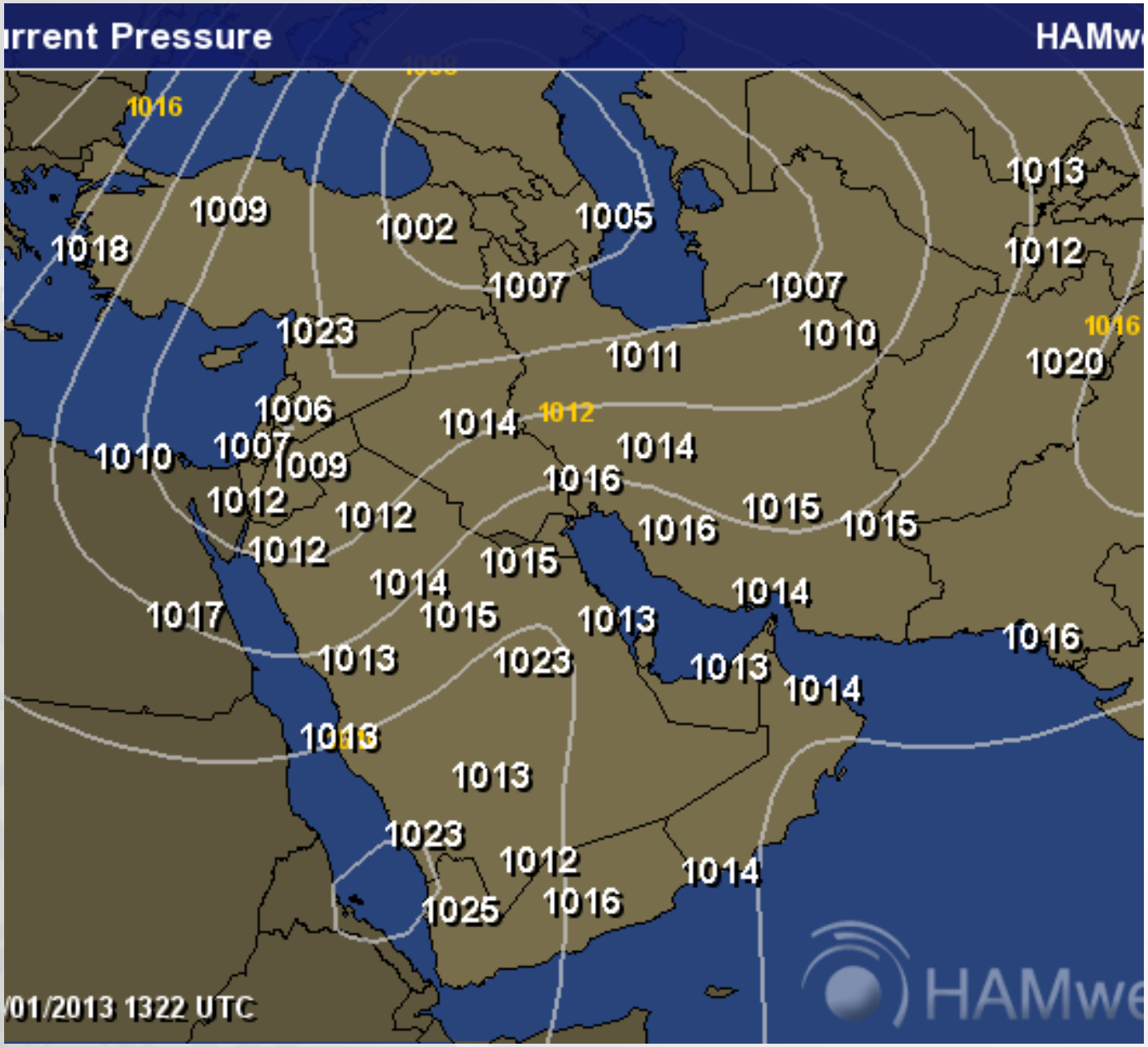
Pressure and Altitude (Height)



Pressure and Volume

- **A gas will expand to fill whatever space it is given.**
- **The decrease of volume mean increase in air pressure and vice versa.**

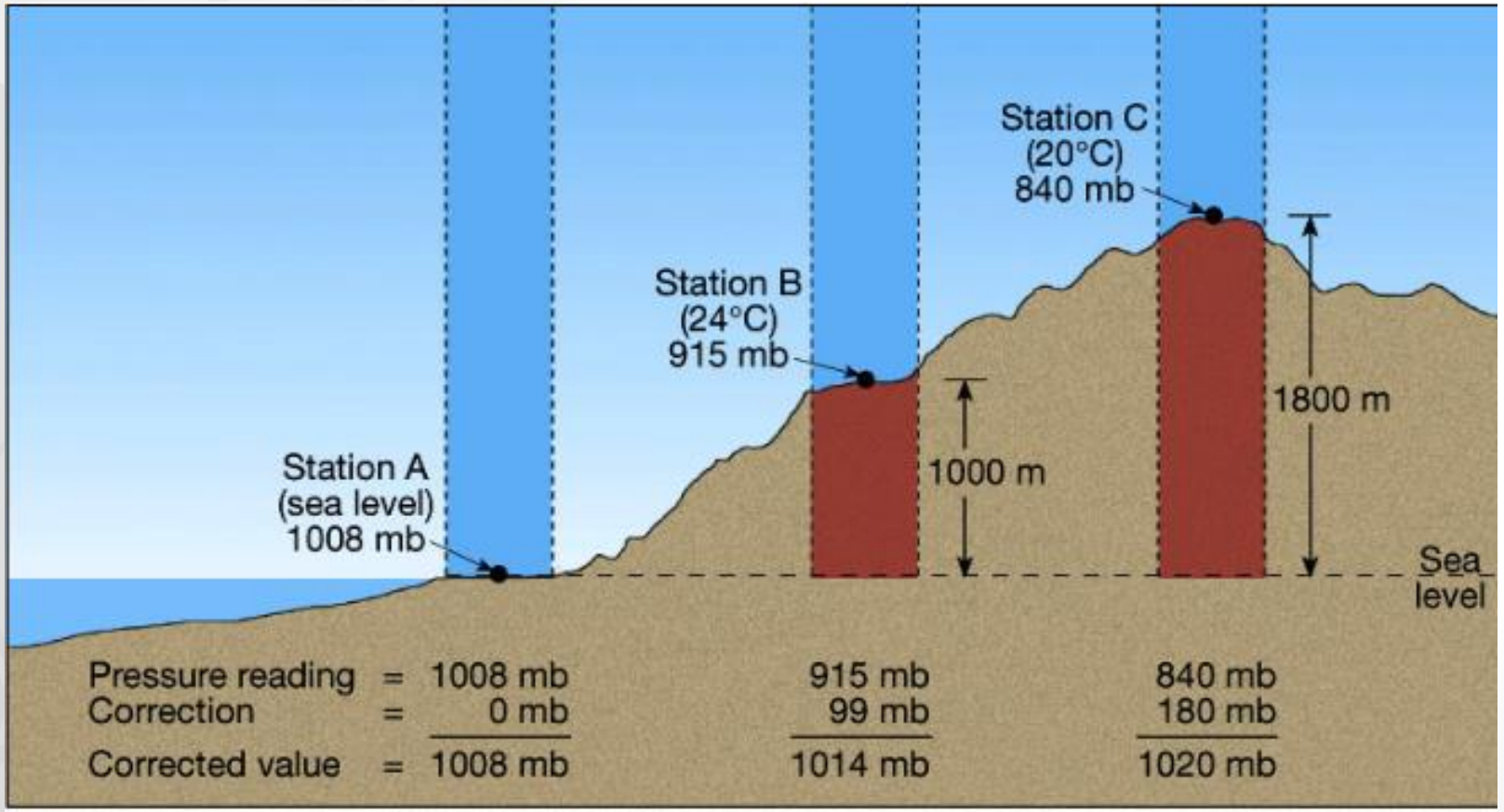




Pressure Charts

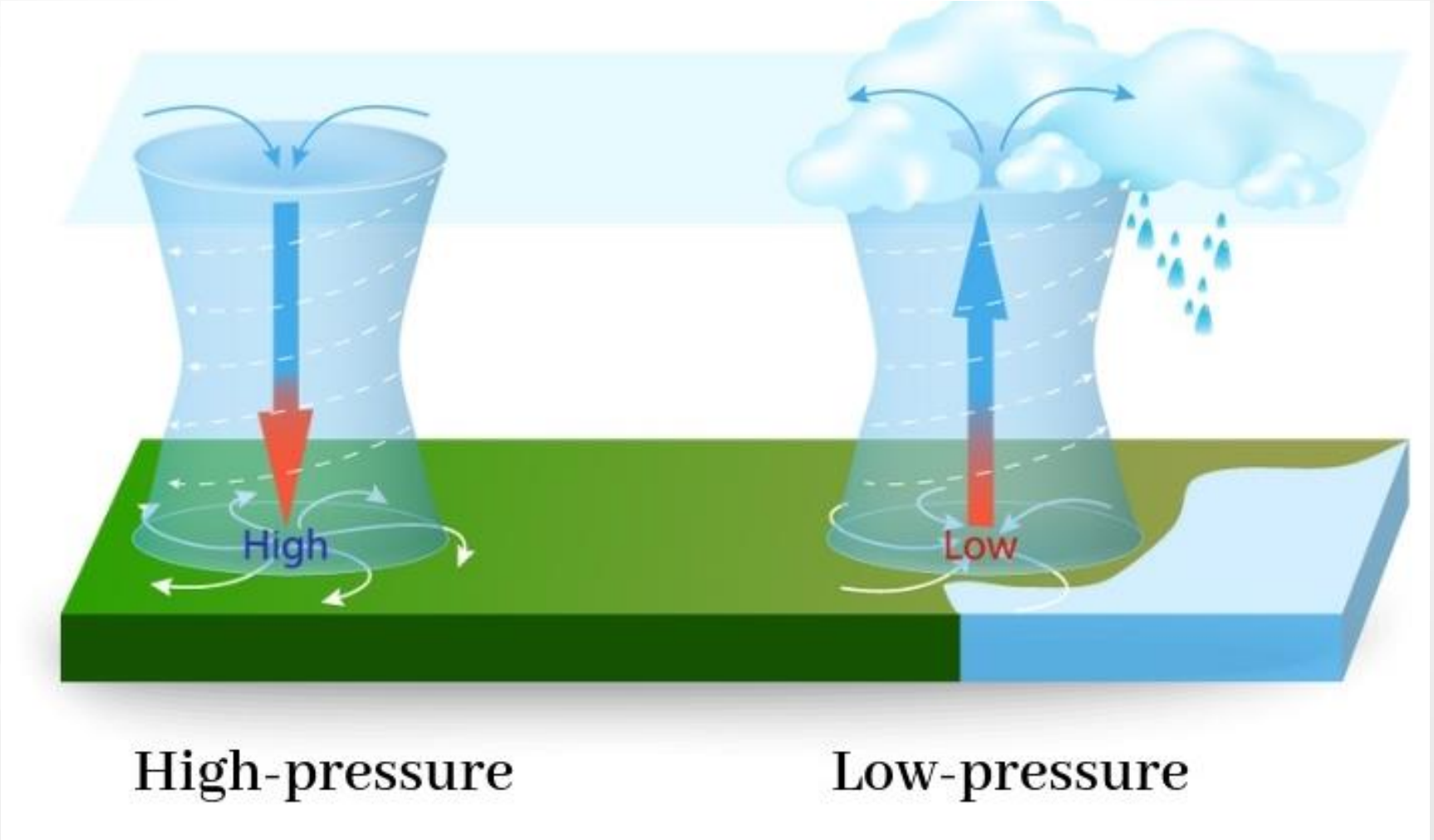
Pressure chart is drown in one atmospheric level

Pressure Correction



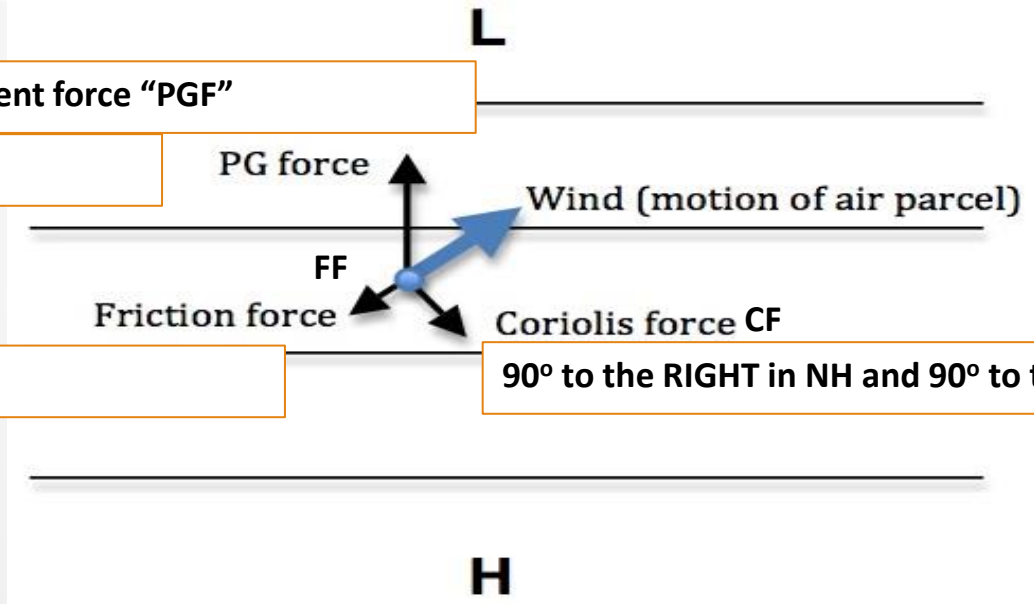
Air pressure corrections owing to elevation, using a temperature of approximately 20°C.

High- and low-pressure areas



Wind

Forces Governing and Affecting Wind



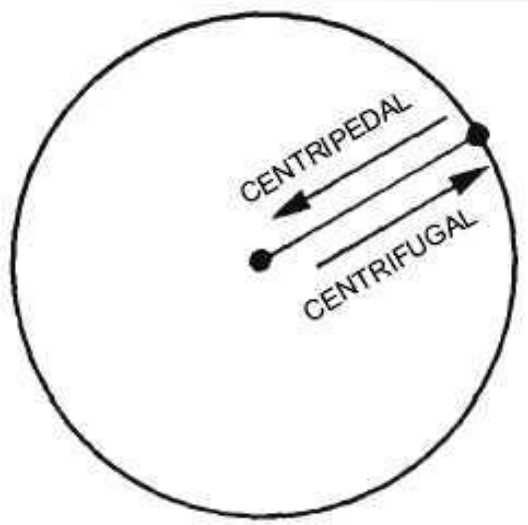
Pressure gradient force "PGF"

Always from H to L

acts opposite to the wind direction

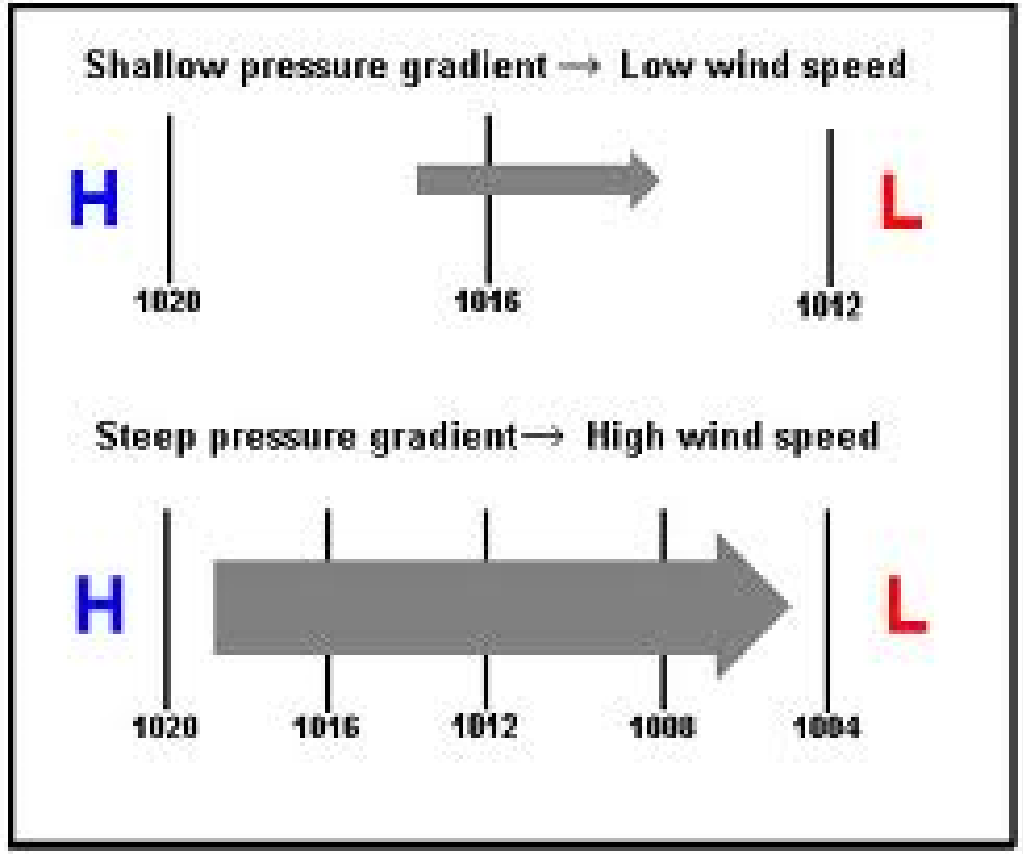
90° to the RIGHT in NH and 90° to the LEFT in SH

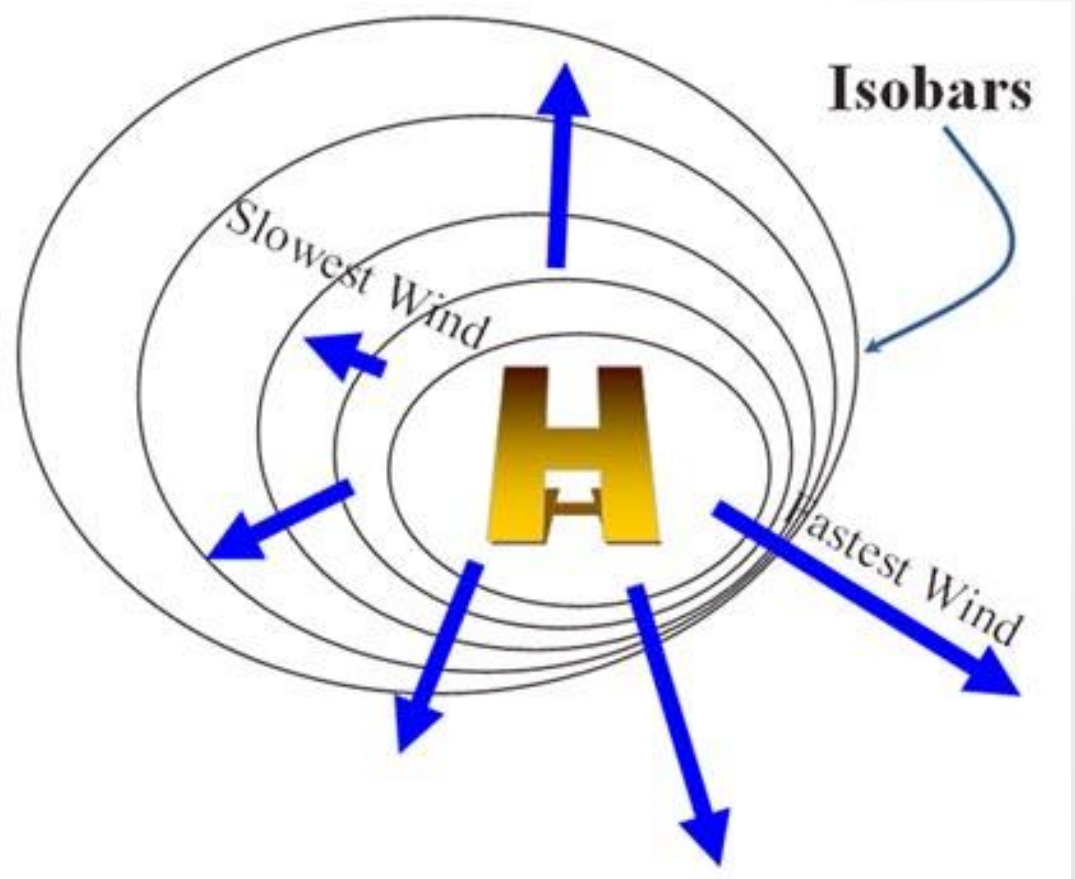
- **Other forces:**
  - **Centripetal force aka Gravity force "GF" "acts toward Earth center"**
  - **Centrifugal force "CentriF" "acts outward from the radius of curvature"**



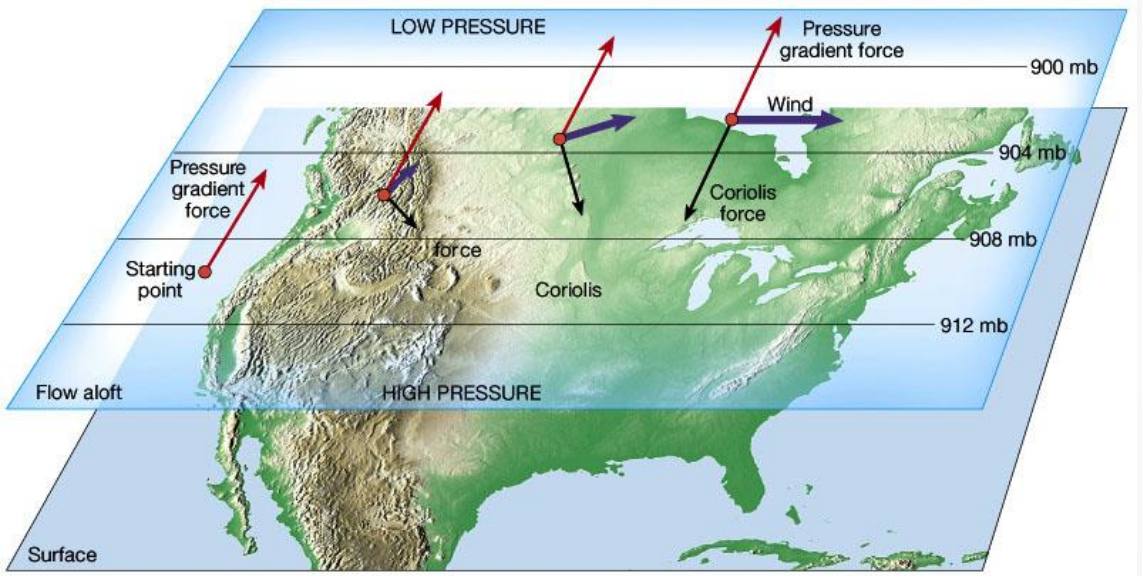
Pressure Gradient Force

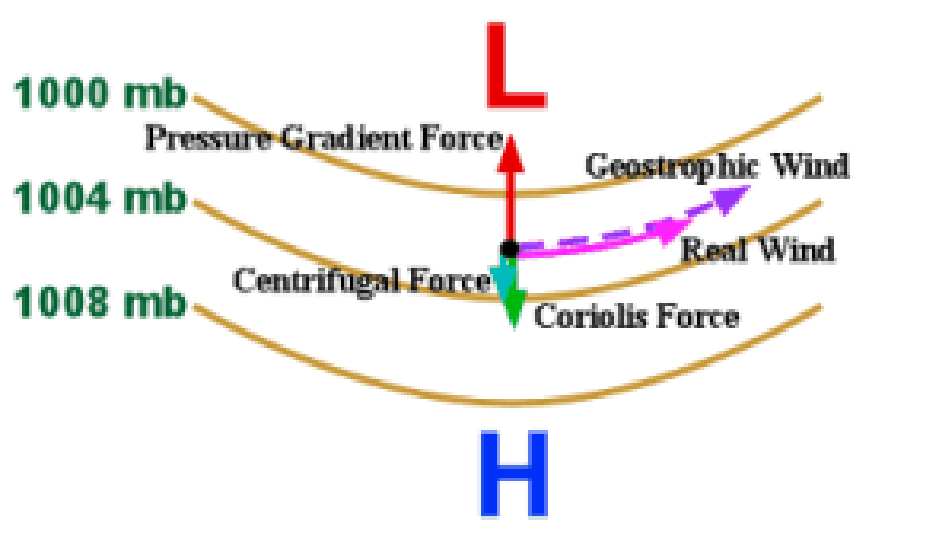
- Which pressure gradient would result in greater wind velocity?





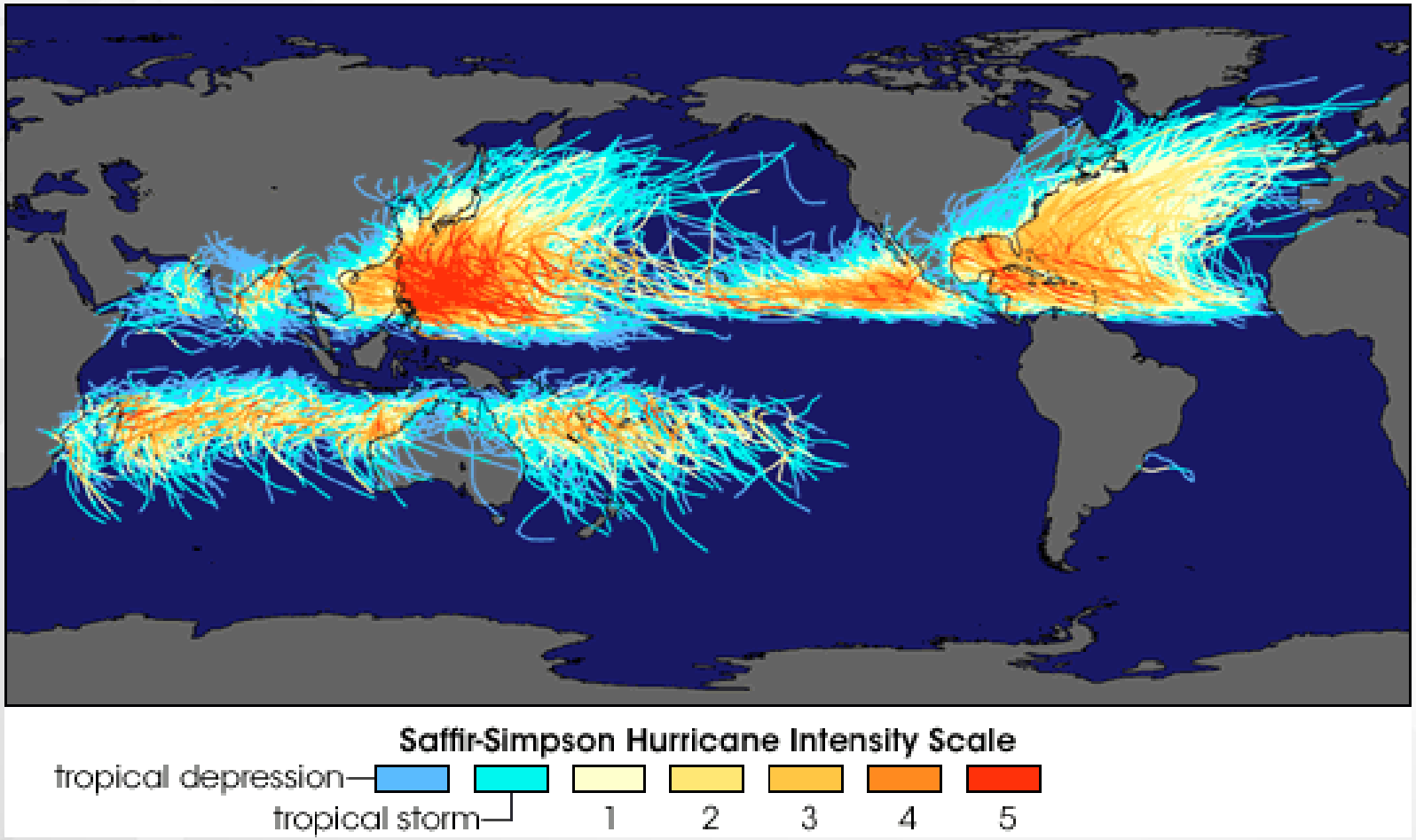
Geostrophic wind





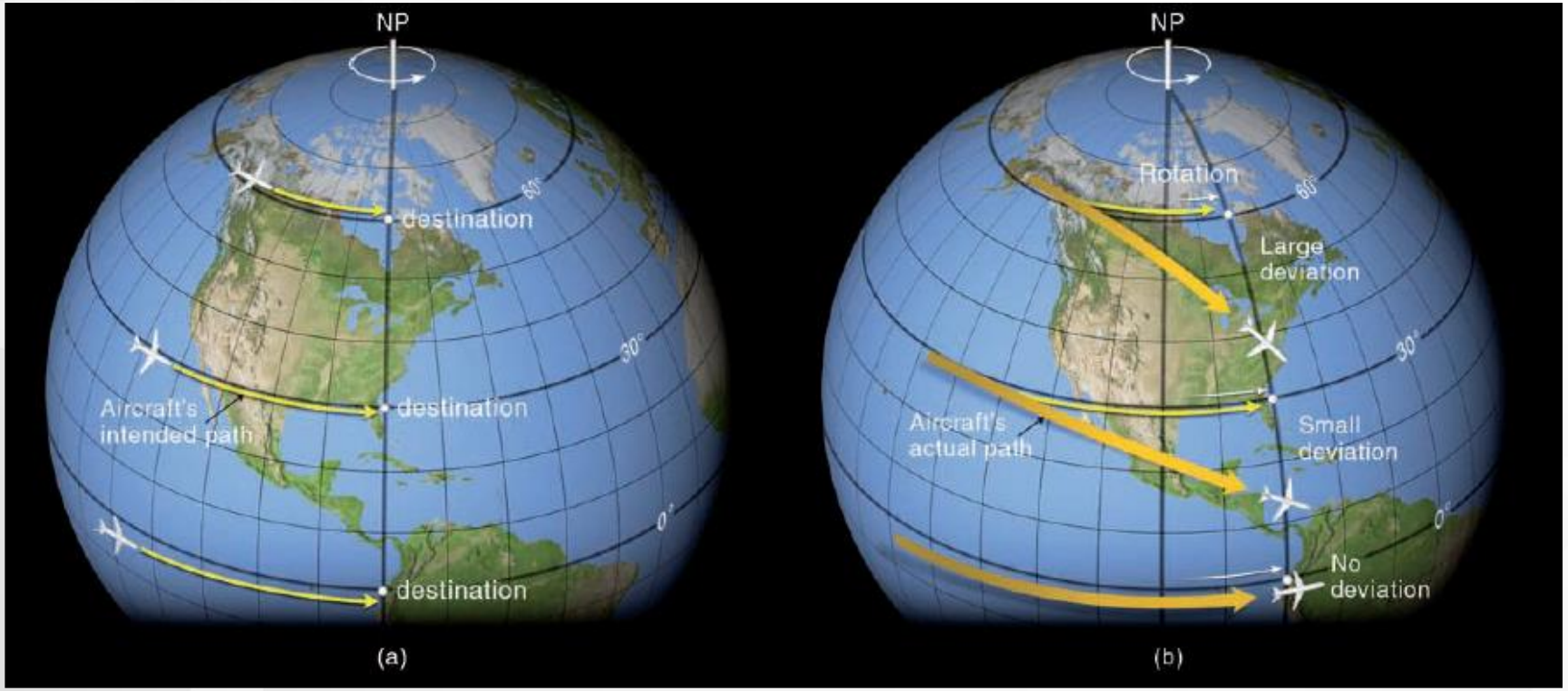
Gradient wind

Why are there no cyclones at the equator?



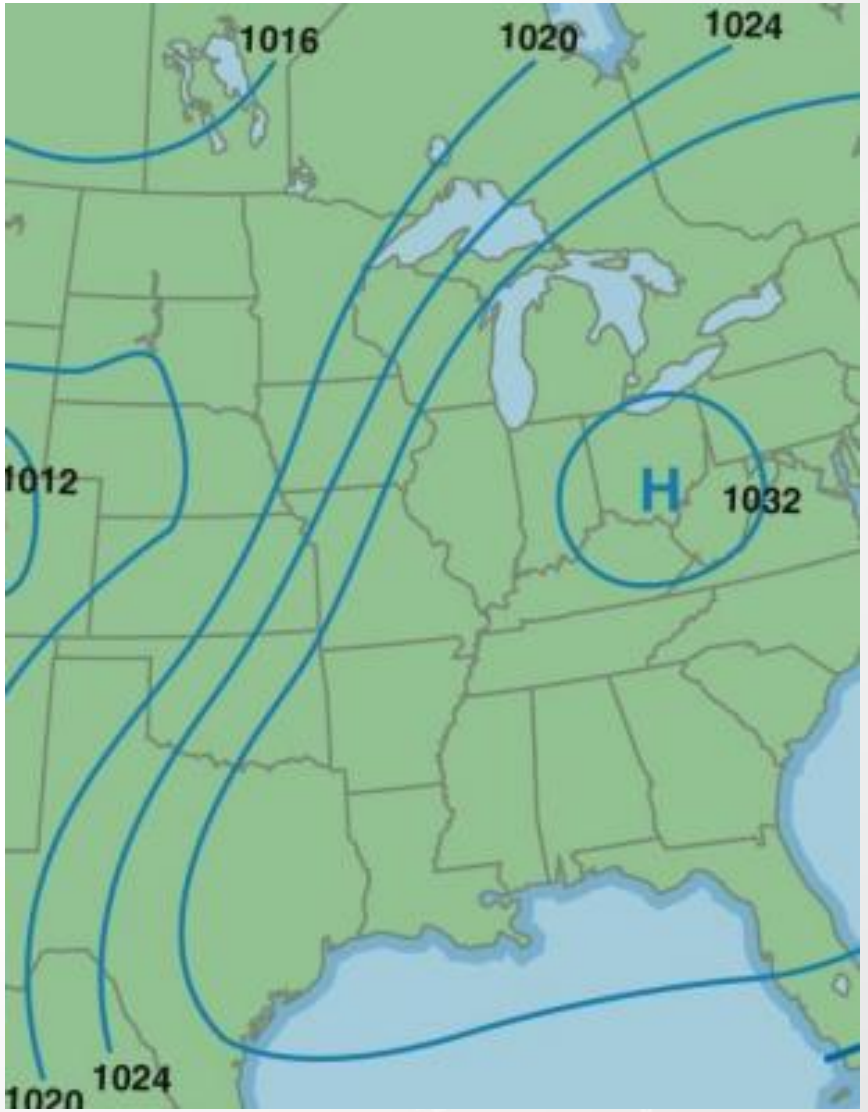
The effect of the Coriolis Force

The farther from the equator the object is, the greater the deflection, and the faster an object is moving, the greater the deflection



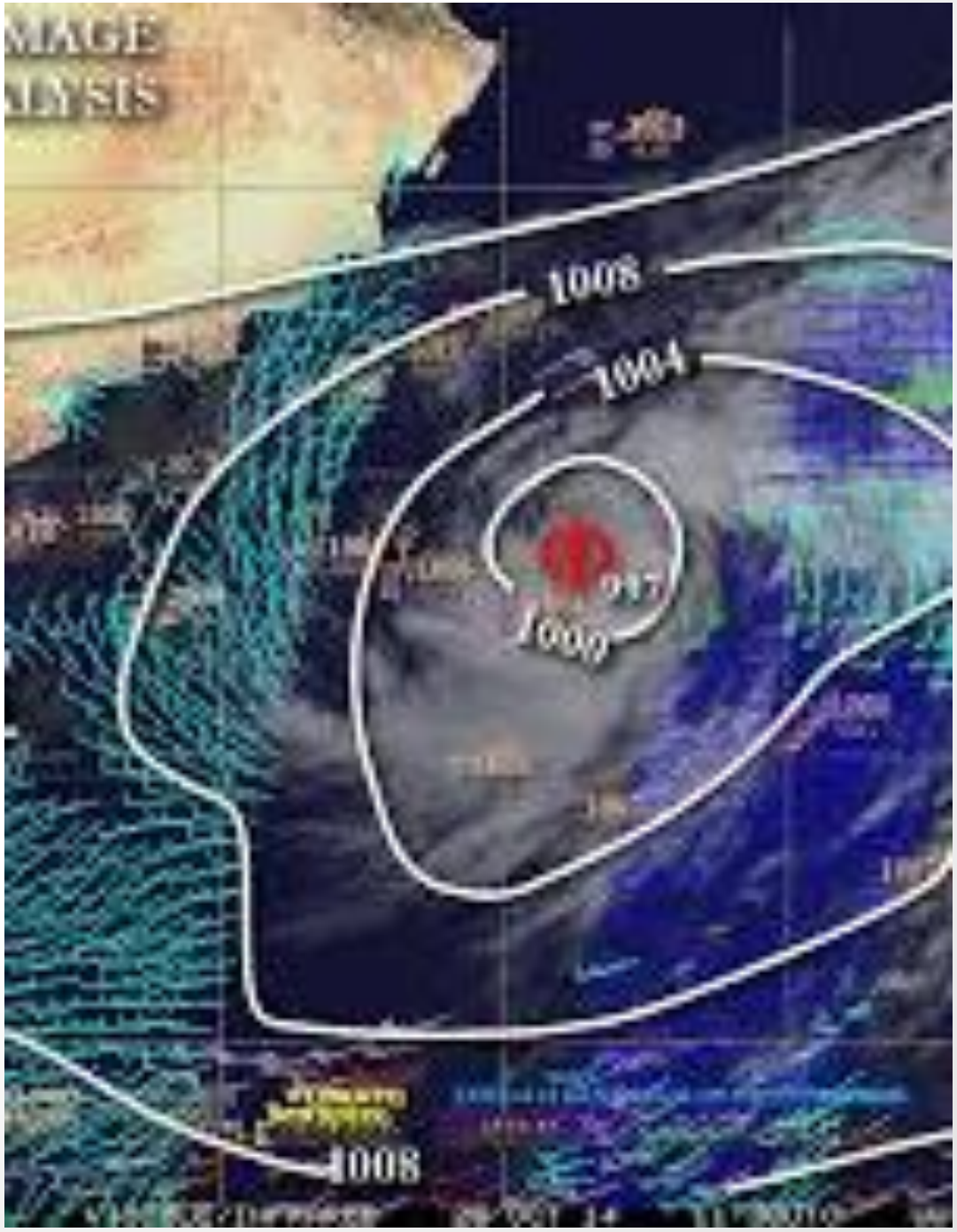
High Pressure area

- A high pressure center is where the pressure has been measured to be the highest relative to its surroundings. That means, moving in any direction away from the "High" will result in a decrease in pressure.
- A high pressure center also represents the center of an anticyclone and is indicated on a weather map by a blue "H".
- Winds flow **clockwise** around a high pressure center in the northern hemisphere, while in the southern hemisphere, winds flow counterclockwise around a high.
- Sinking air in the vicinity of a high pressure center suppresses the upward motions needed to support the development of clouds and precipitation. This is why fair weather is commonly associated with an area of high pressure.

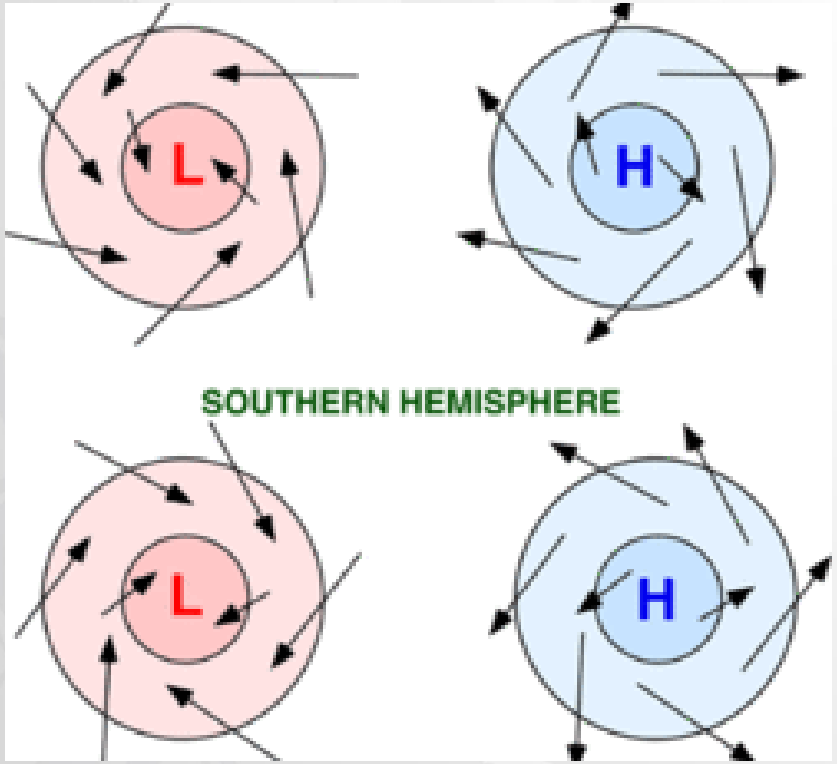


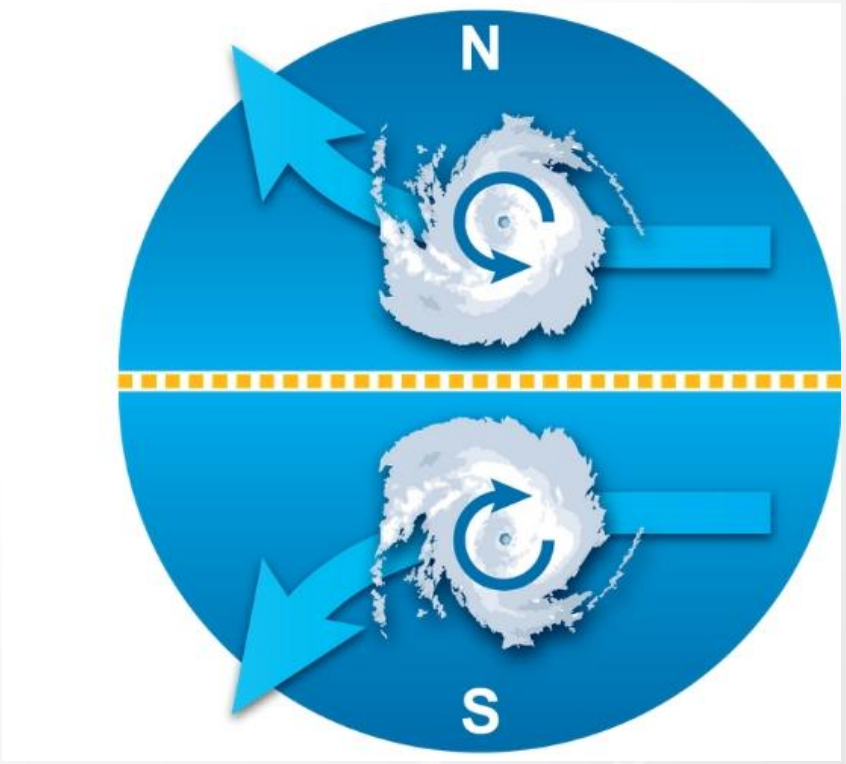
Low Pressure area

- A low pressure center is where the pressure has been measured to be the lowest relative to its surroundings. That means, moving in any horizontal direction away from the "Low" will result in an increase in pressure.
- Low pressure centers also represent the centers of cyclones.
- A low pressure center is indicated on a weather map by a red "L" and winds flow counterclockwise around a low in the northern hemisphere. The opposite is true in the southern hemisphere, where winds flow clockwise around an area of low pressure.
- Rising motion in the vicinity of a low pressure center favors the development of clouds and precipitation, which is why cloudy weather (and likely precipitation) are commonly associated with an area of low pressure.

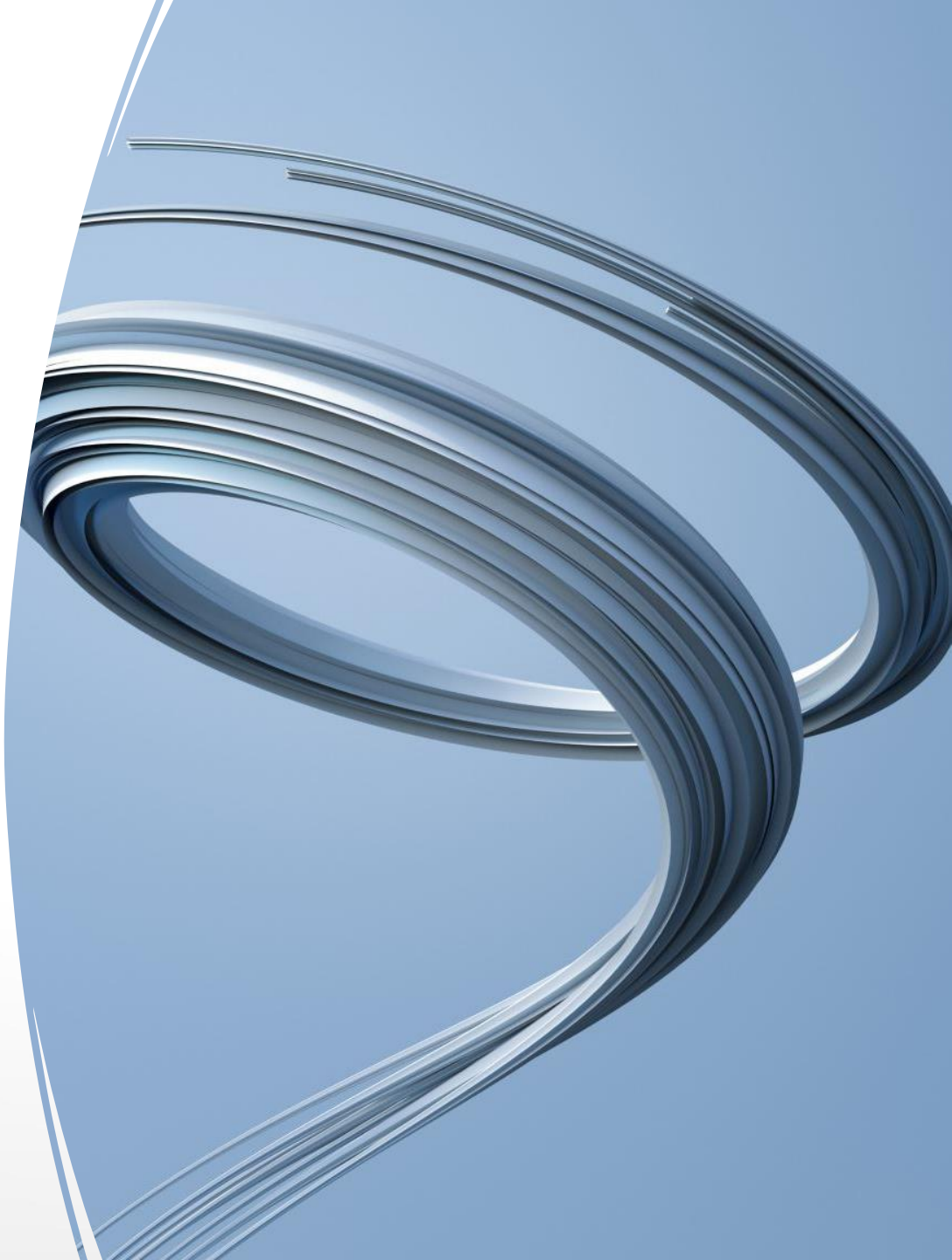


High, low and Wind Flow



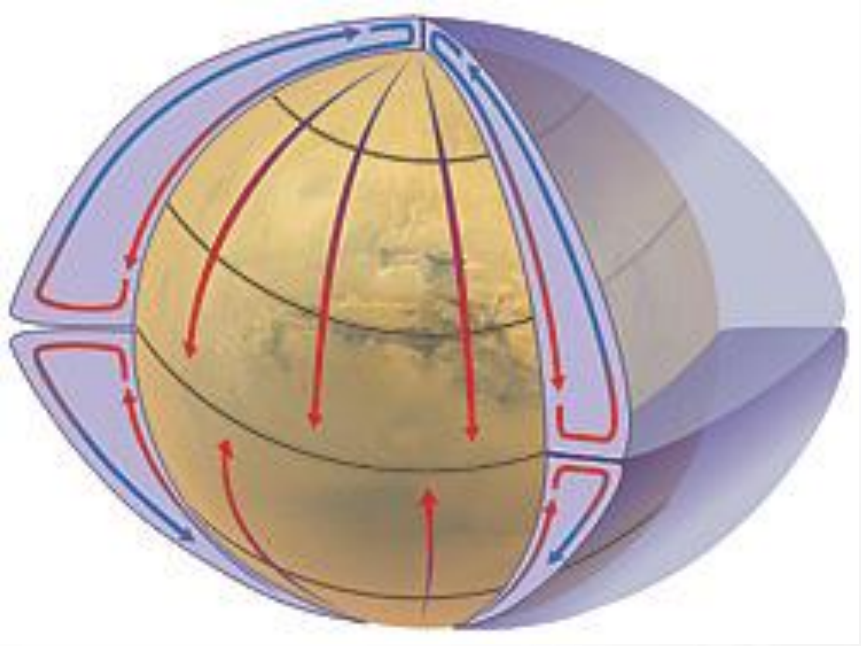


General Air Circulation



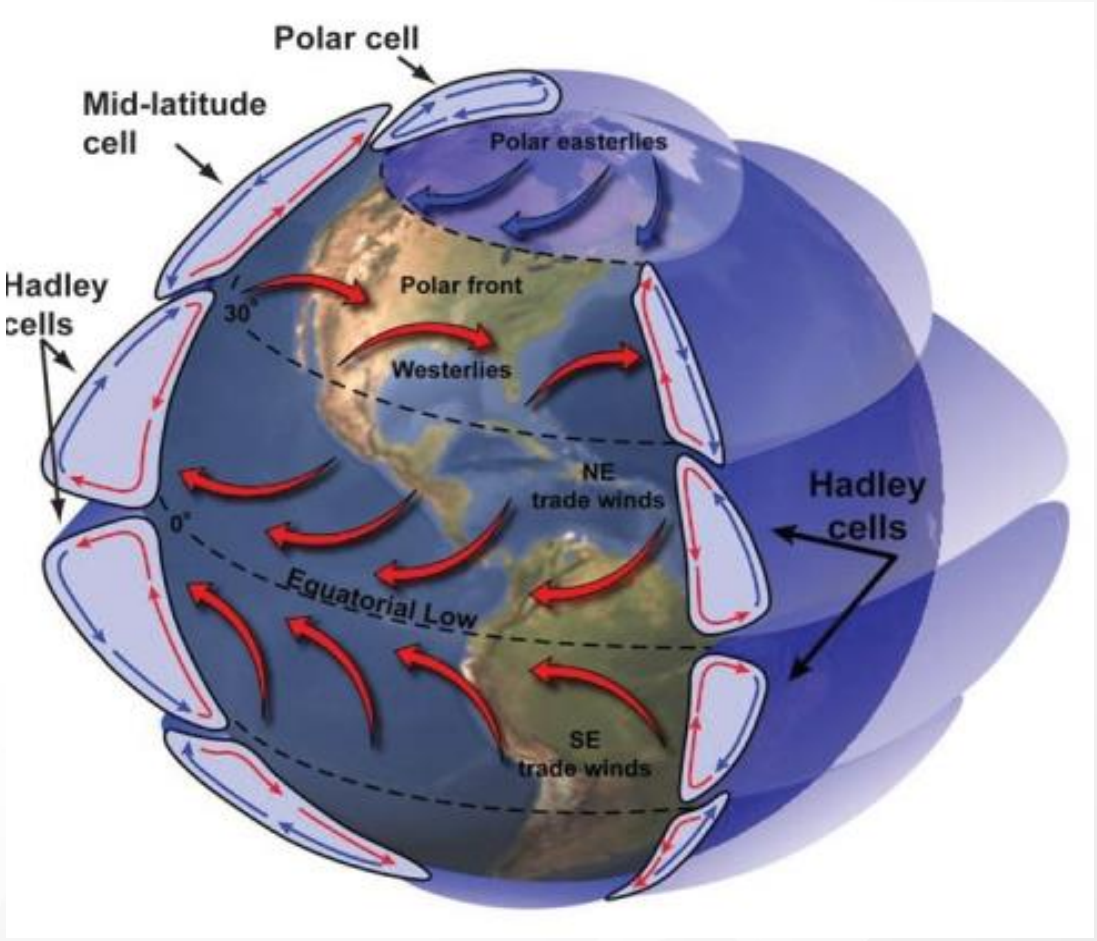
Global Air Circulation
Single-Cell Circulation

- One way to transfer heat from the equator to the poles would be to have a single circulation cell where air moved from the tropics to the poles and back. This single-cell circulation model was first proposed by Hadley in the 1700's.
- Air circulation around the globe would be simple (and the weather boring) if the Earth did not rotate and the rotation was not tilted relative to the Sun.

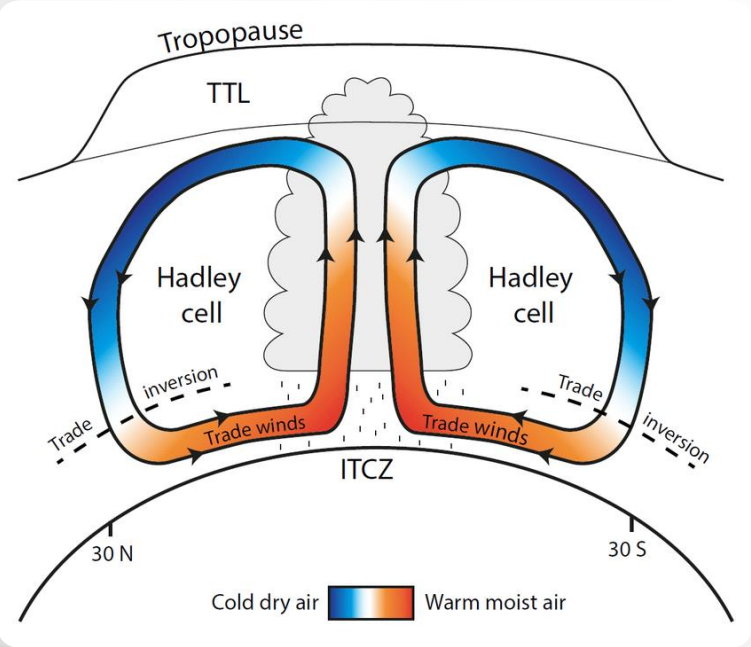


Global Air Circulation (3-Cells Pattern)

Since the Earth rotates, its axis is tilted and there is more land in the Northern Hemisphere than in the Southern Hemisphere, the actual global air circulation pattern is much more complicated. Instead of a single-cell circulation, the global model consists of three circulation cells in each hemisphere. These three cells are known as the tropical cell (also called the Hadley cell), the midlatitude cell and the polar cell.

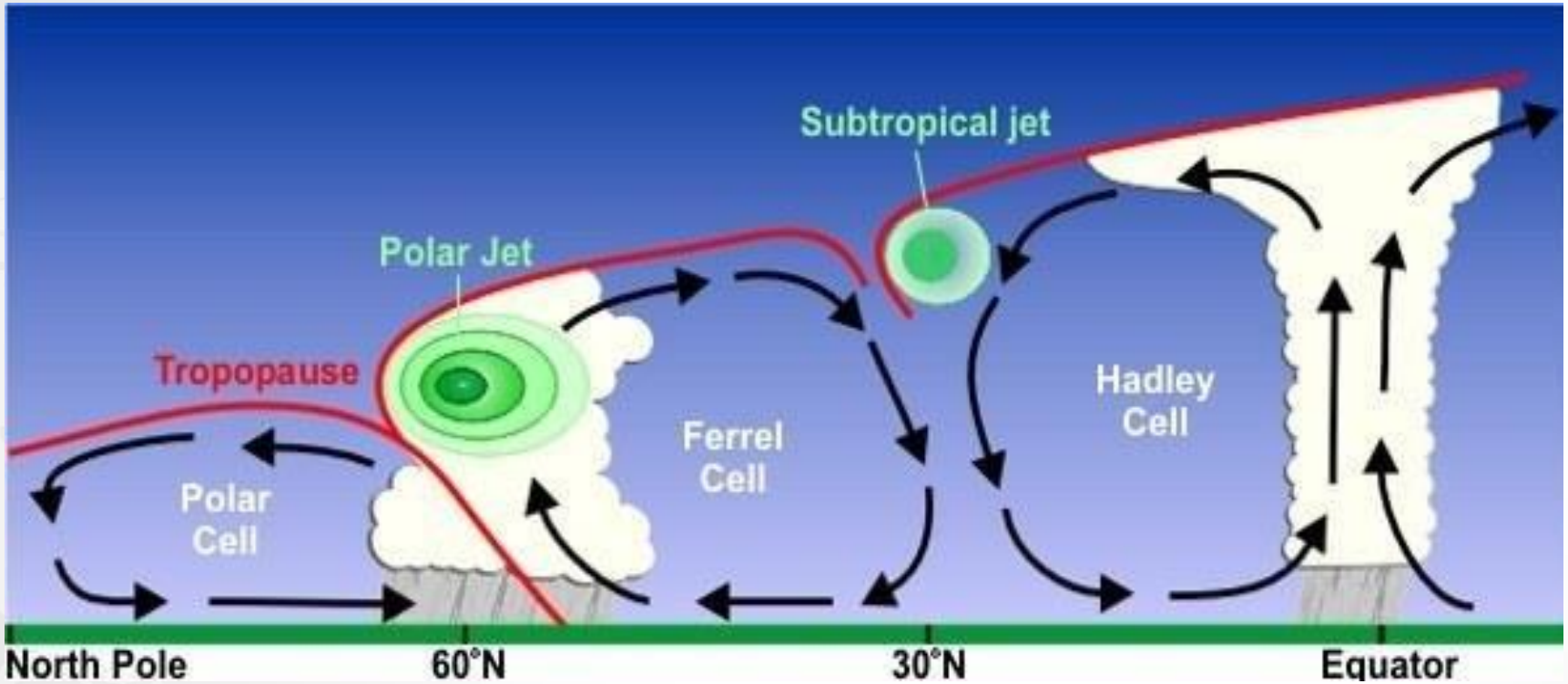


Hadley Cell



At low latitudes, air moves toward the equator, where it is heated and rises vertically. In the upper atmosphere, air moves poleward. This forms a convection cell that covers tropical and sub-tropical climates.

This cell is named for English physicist and meteorologist George Hadley, who proposed the single circulation for each hemisphere in 1735.



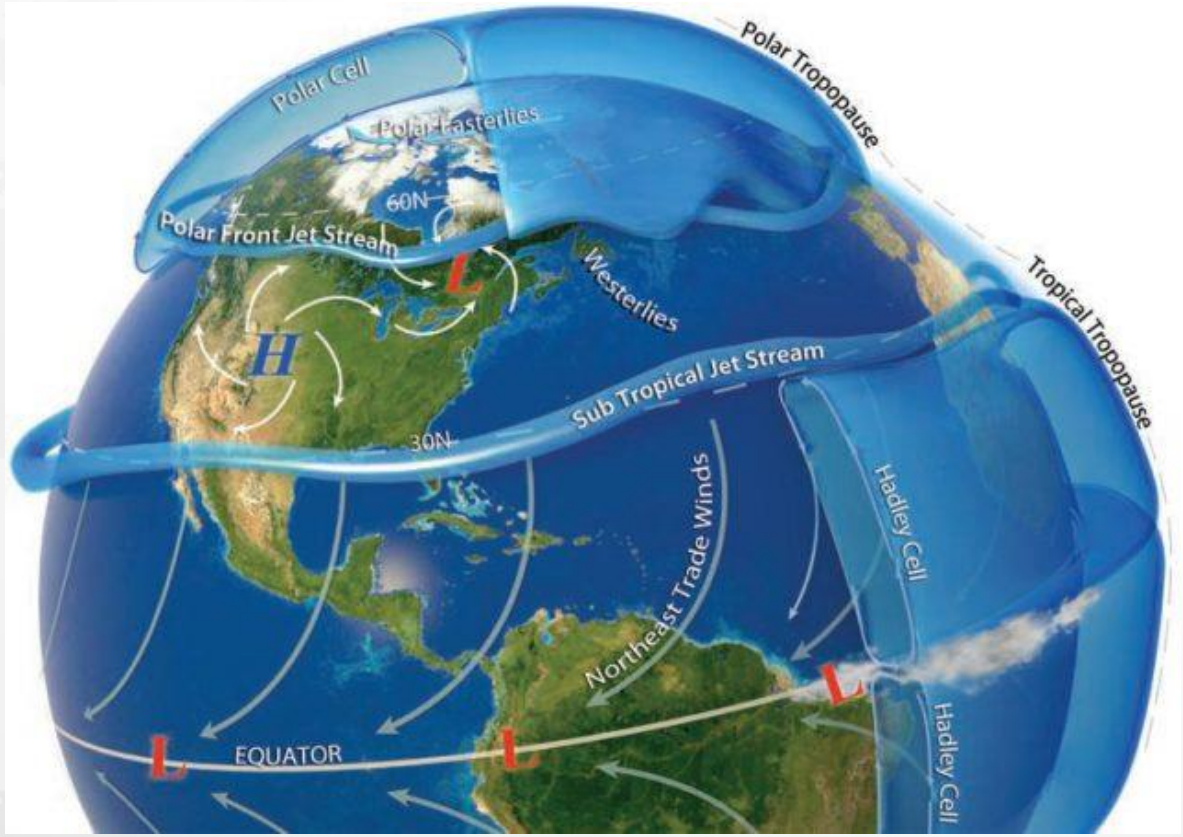
Ferrel cell

In this mid-latitude atmospheric circulation cell, air near the **surface** flows **poleward** and **eastward**, while **air higher** in the **atmosphere** moves **equatorward** and **westward**.

Proposed by William Ferrell in 1856, it was the first to account for **westerly** winds between 35° and 60° N/S, which are caused by friction, not heat differences at the equator and poles.

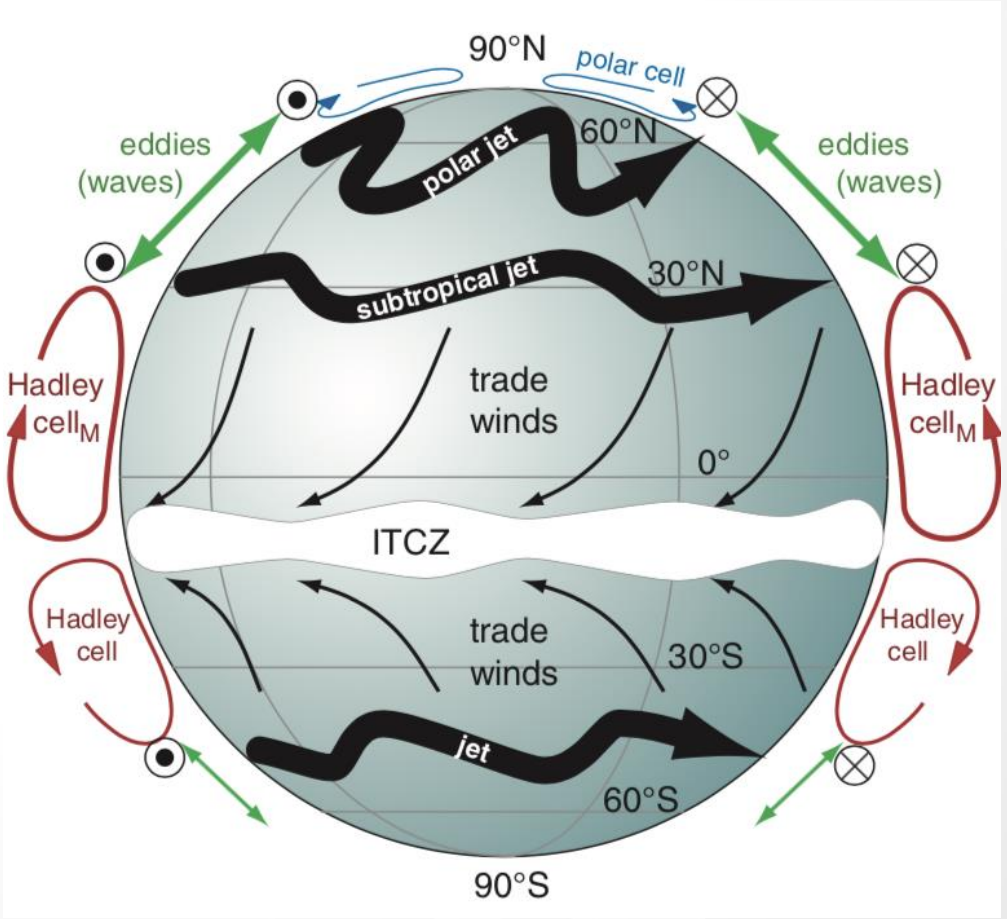
Polar Cell

At higher latitudes, air rises and travels toward the poles. Once over the poles, the air sinks, forming areas of high atmospheric pressure called the **polar highs**. At the surface, air moves outward from the polar highs, creating east-blowing surface winds called **polar easterlies.** It is the smallest and weakest of the cells.

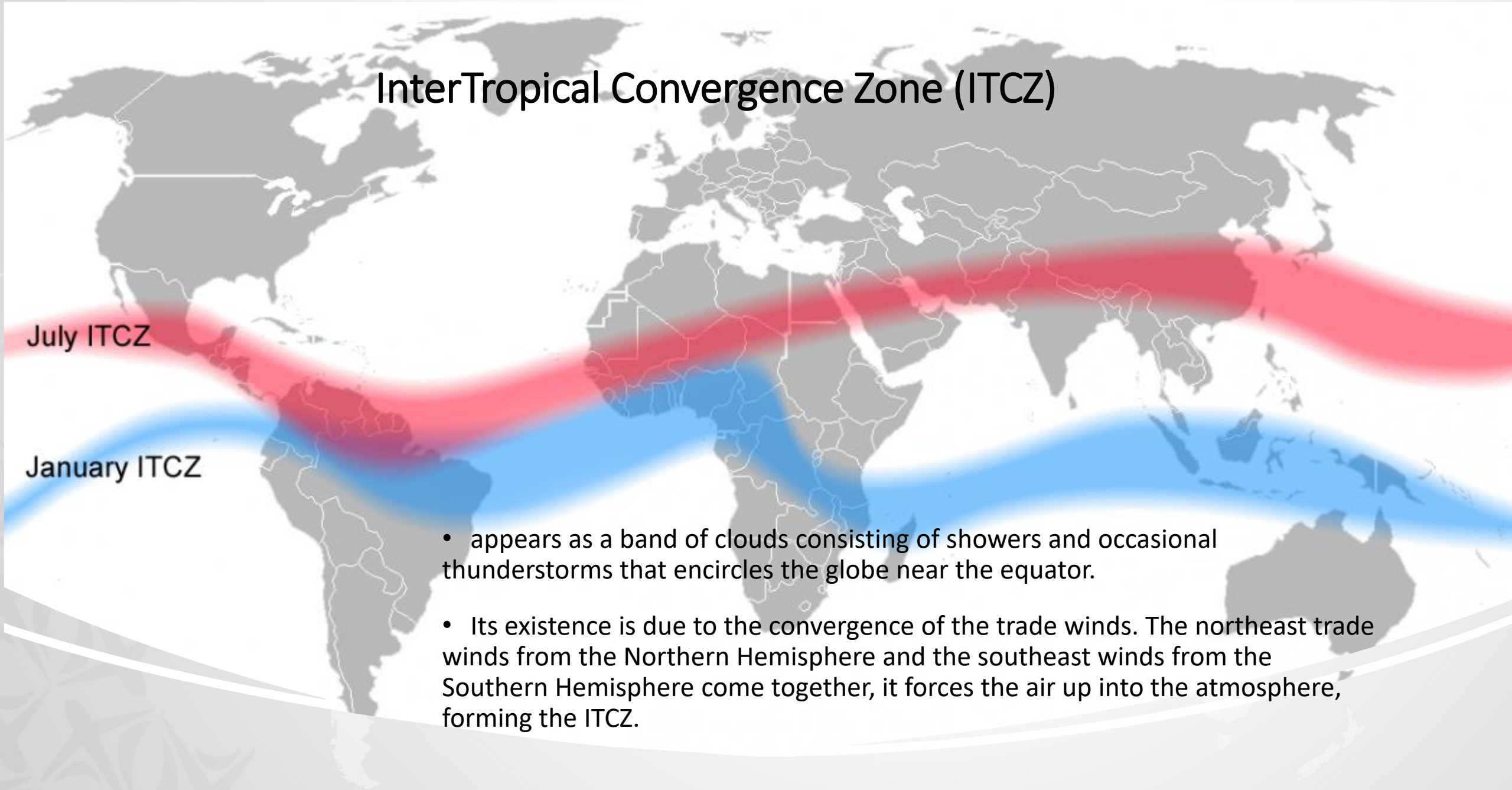


Trade Winds

- It is a pattern of wind that are found in bands around the Earth's equatorial region.
- It is the prevailing winds in the tropics, blowing from the high-pressure area in the horse latitudes towards the low-pressure area around the equator.
- It blows predominantly from the northeast in the northern hemisphere and from the southeast in the southern hemisphere.
- It acts as the steering flow for tropical cyclones that form over world's oceans, guiding their path westward.



InterTropical Convergence Zone (ITCZ)



- appears as a band of clouds consisting of showers and occasional thunderstorms that encircles the globe near the equator.

- Its existence is due to the convergence of the trade winds. The northeast trade winds from the Northern Hemisphere and the southeast winds from the Southern Hemisphere come together, it forces the air up into the atmosphere, forming the ITCZ.

Thanks

Please Scan the Q-code