Atmosphere

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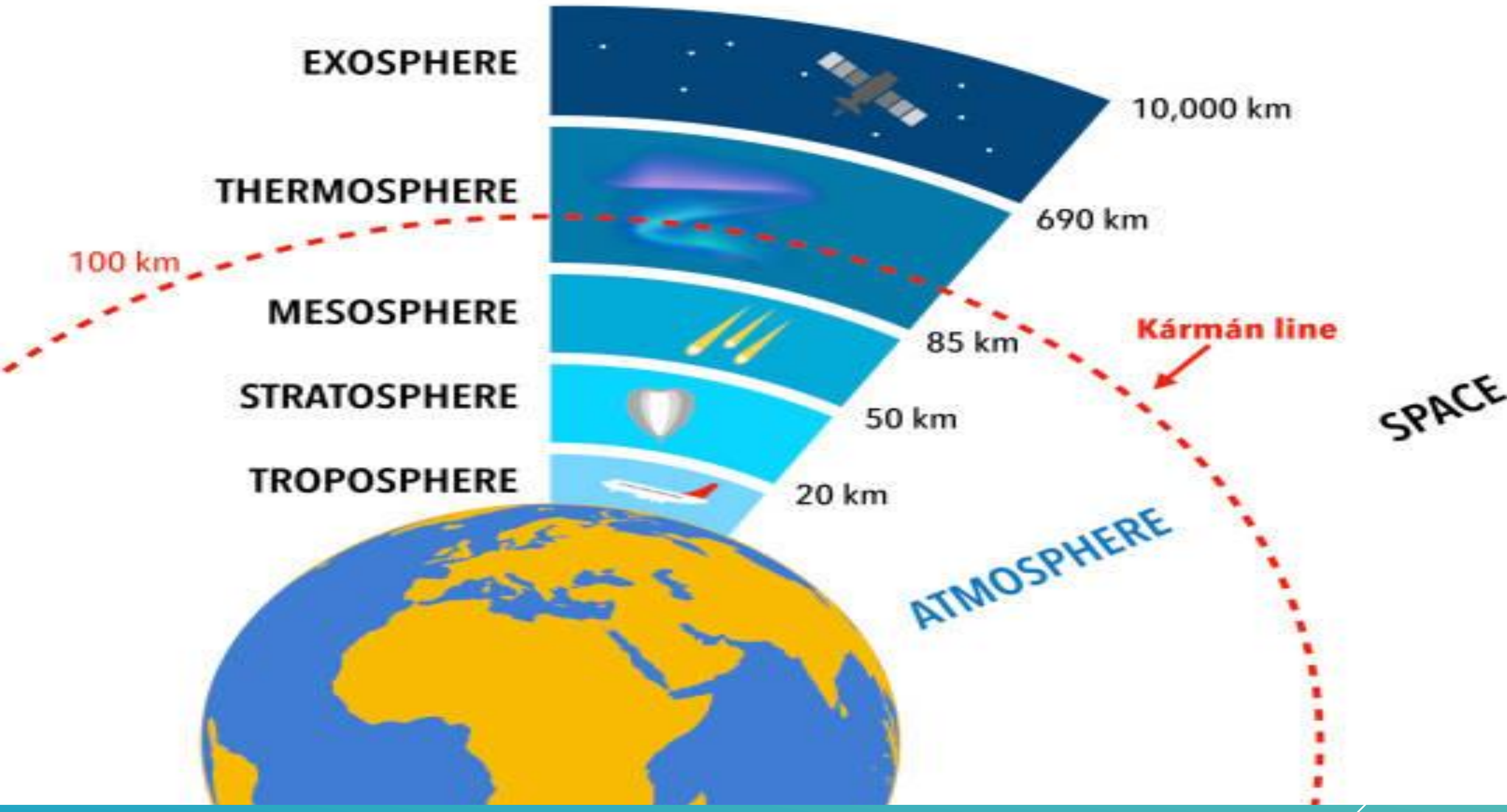
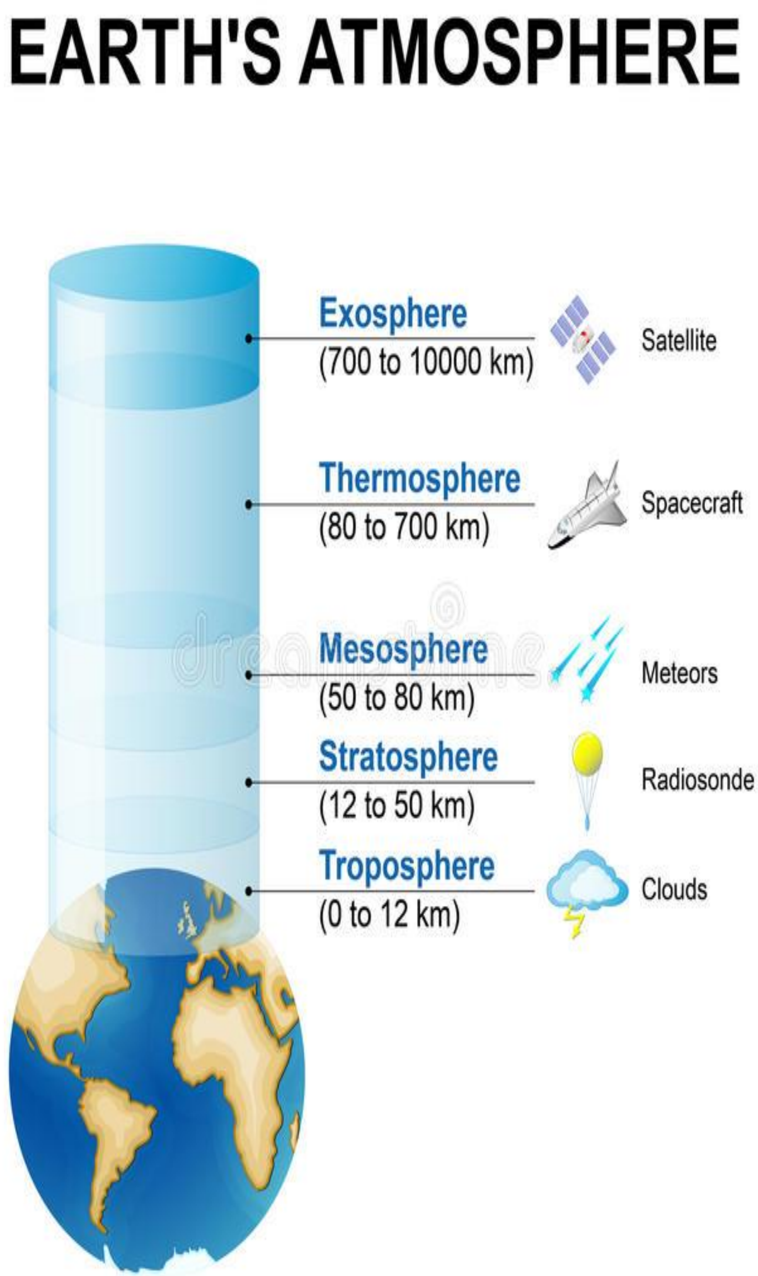
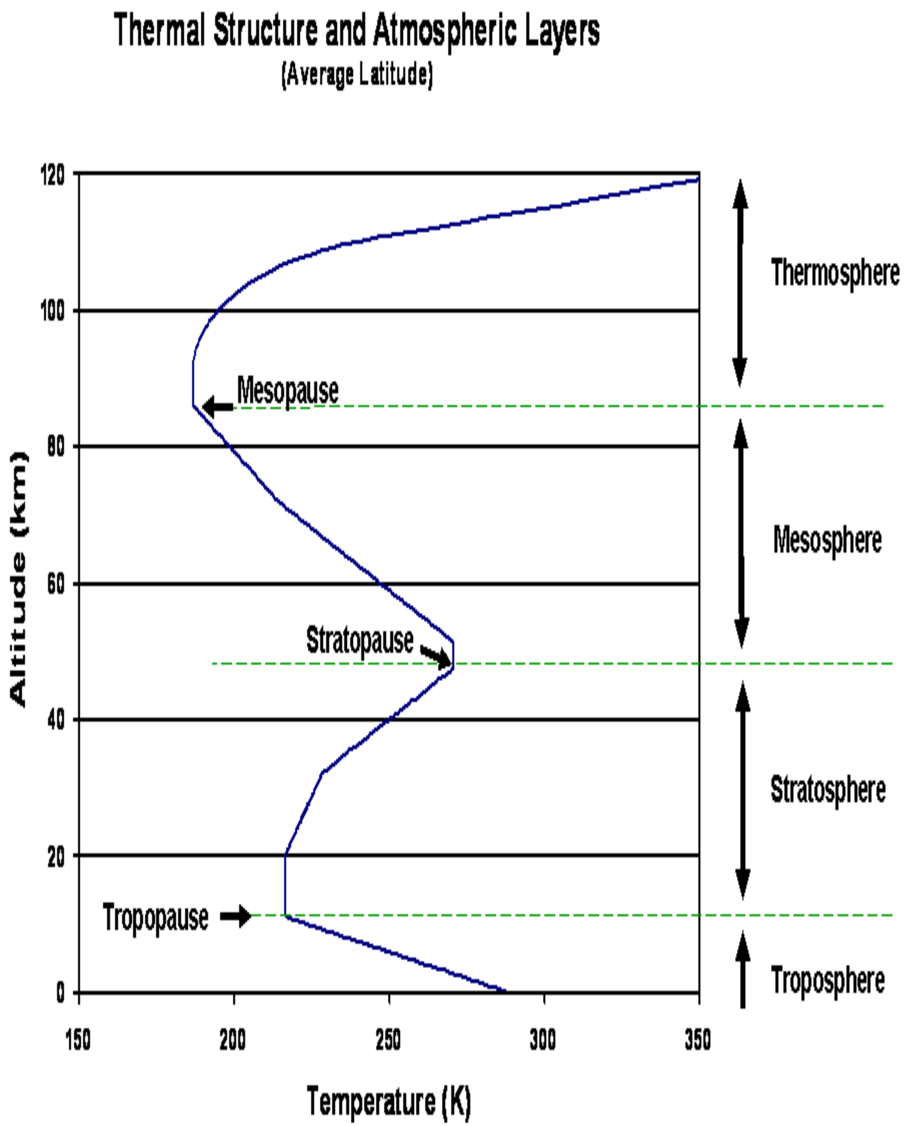
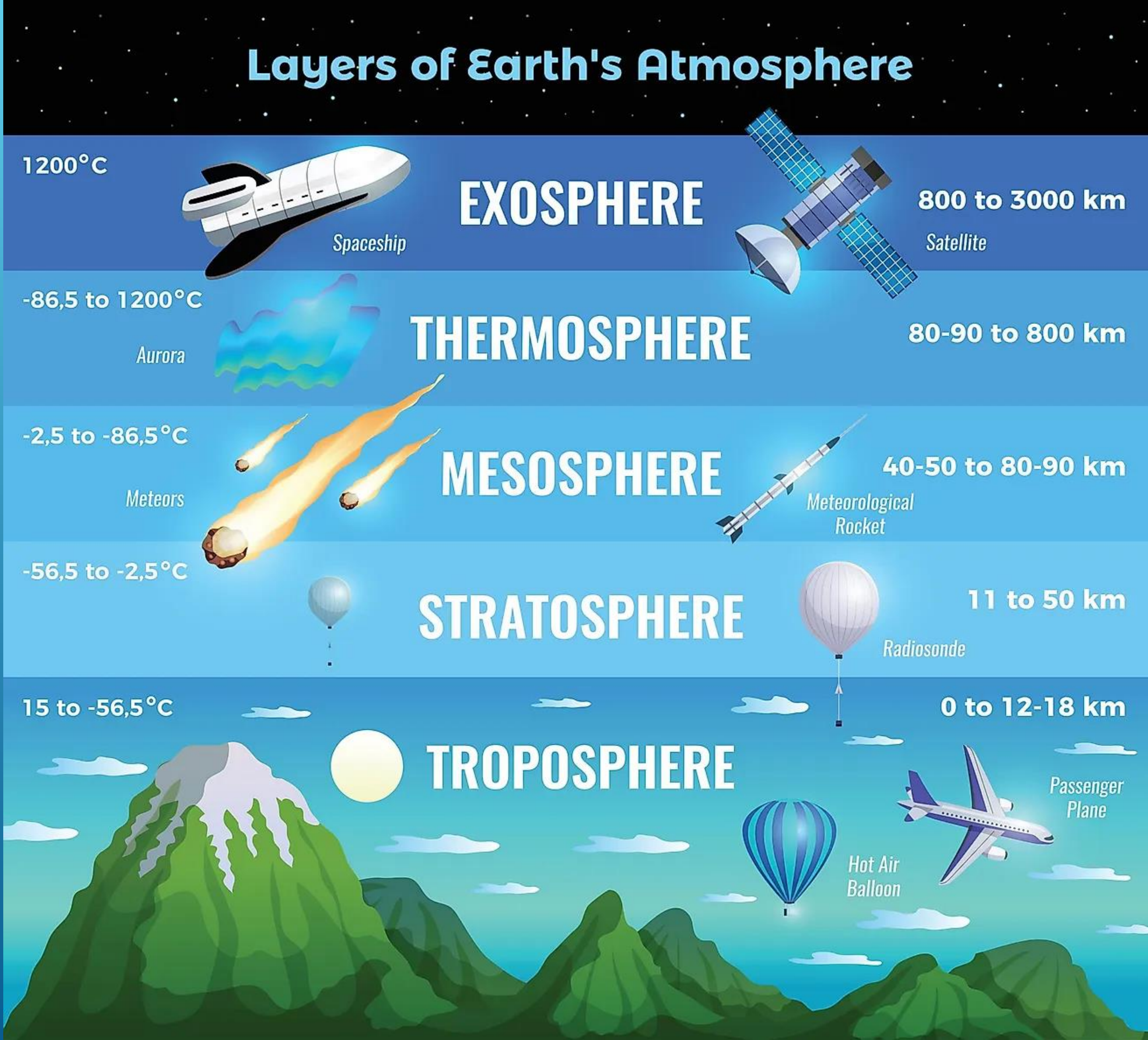
STRUCTURE OF ATMOSPHERE



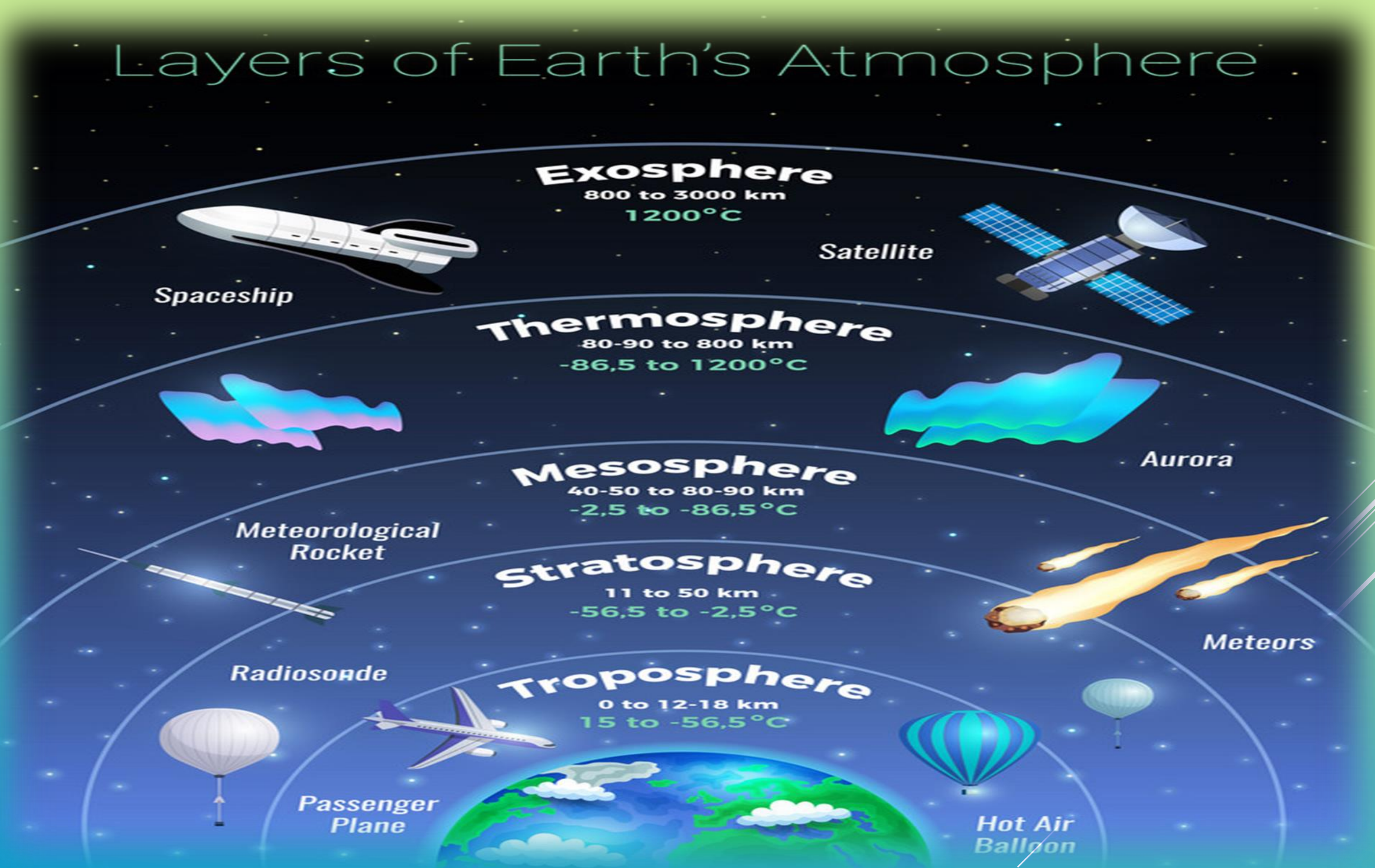
Source: tutorialspoint.com


EARTH'S ATMOSPHERE
Exosphere
(700 to 10000 km)
Satellite
Thermosphere
(80 to 700 km)
Spacecraft
Mesosphere
(50 to 80 km)
Meteors
Stratosphere
(12 to 50 km)
Radiosonde
Troposphere
(0 to 12 km)
Clouds


Thermal Structure and Atmospheric Layers
(Average Latitude)
Altitude (km)
120
100
80
60
40
20
0
150
200
250
300
350
Temperature (K)
Mesopause
Stratopause
Tropopause
Thermosphere
Mesosphere
Stratosphere
Troposphere


Layers of Earth's Atmosphere
1200°C
EXOSPHERE
800 to 3000 km
Spaceship
Satellite
-86,5 to 1200°C
THERMOSPHERE
80-90 to 800 km
Aurora
-2,5 to -86,5°C
MESOSPHERE
40-50 to 80-90 km
Meteors
Meteorological Rocket
-56,5 to -2,5°C
STRATOSPHERE
11 to 50 km
Radiosonde
15 to -56,5°C
TROPOSPHERE
0 to 12-18 km
Passenger Plane
Hot Air Balloon

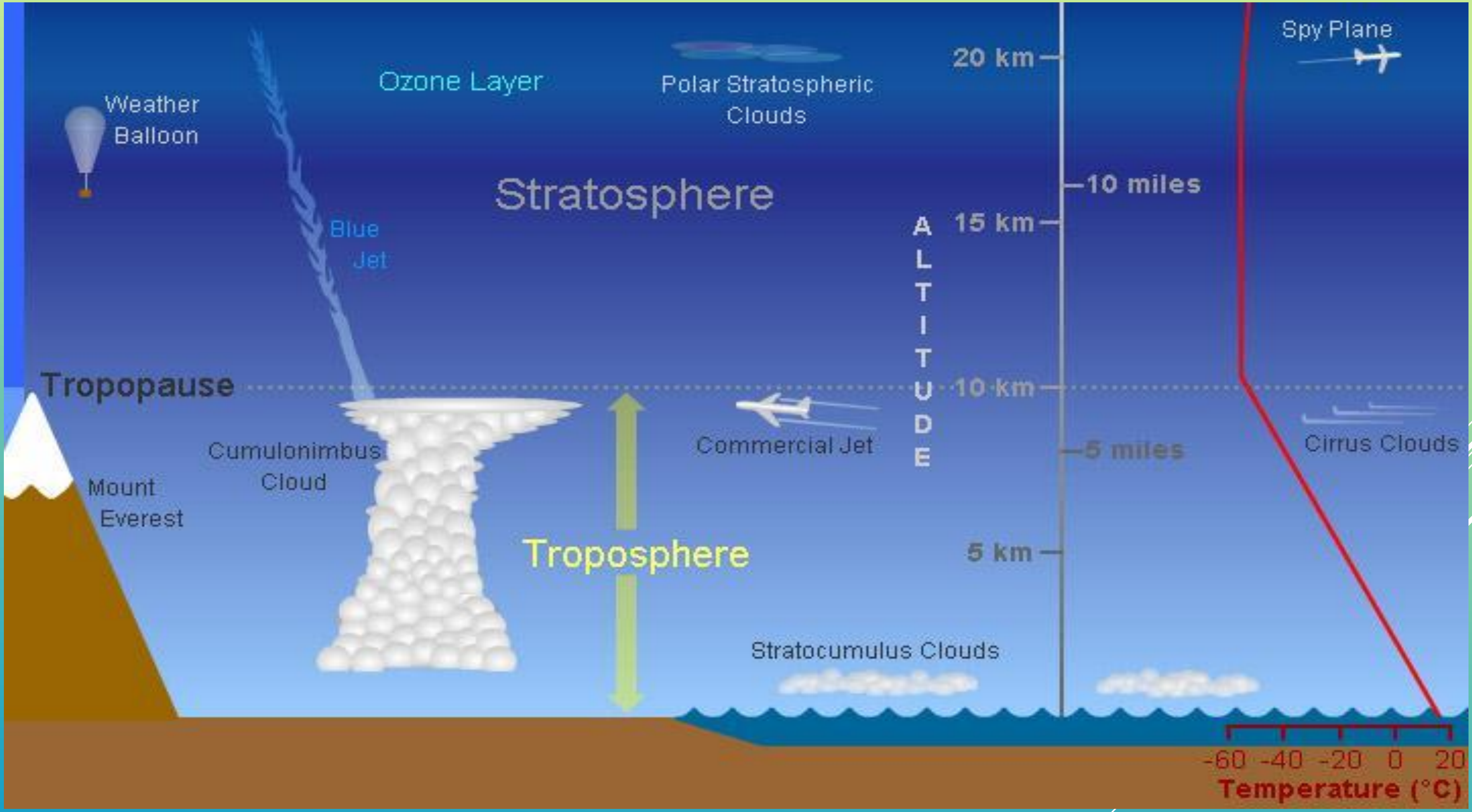
VARIOUS LAYERS



TROPOSPHERE

- 8 km at the poles and 18 km at the equator.
- The thickness is greater at the equator, because the heated air rises to greater heights.
- The troposphere ends with the Tropopause.
- The temperature in this layer, as one goes upwards, falls at the rate of 5°C per kilometer,

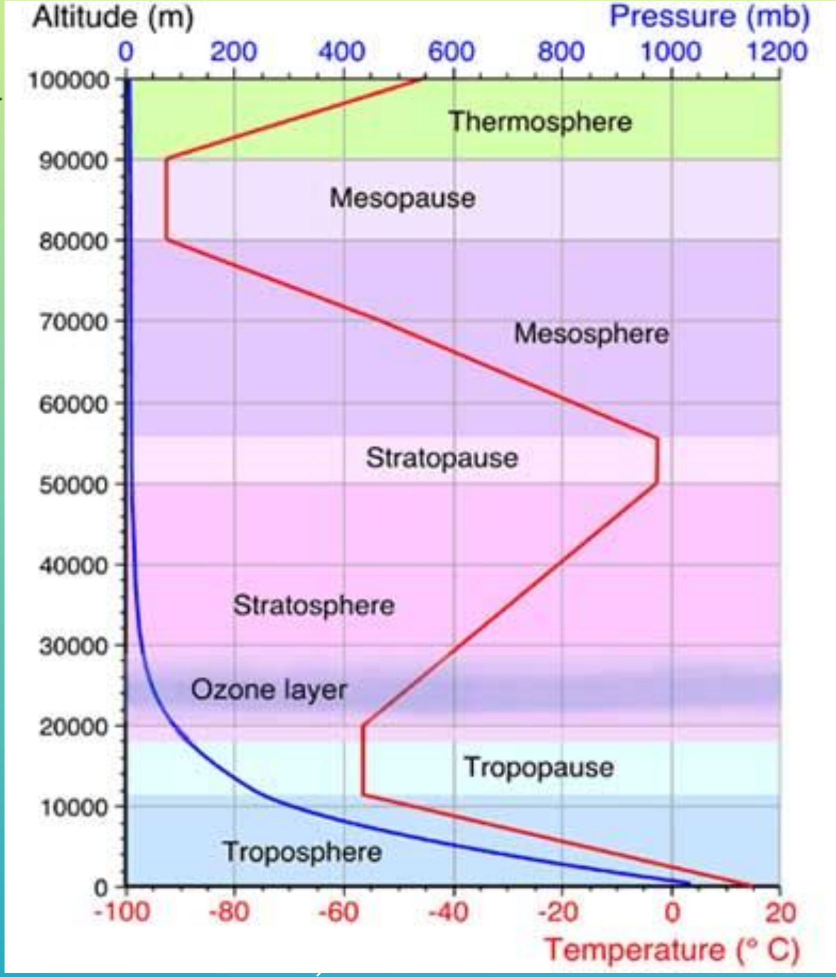
TROPOSPHERE



Source: scied.ucar.edu

TEMPERATURE DISTRIBUTION

- As the altitude rises, the temperature in the troposphere drops.
- The standard atmosphere, also known as the Normal Lapse Rate, is a temperature gradient that exists vertically.
- This usual lapse rate, on the other hand, fluctuates depending on height, season, latitude, and other variables.
- Temperature lapse rates may not necessarily decrease with height.



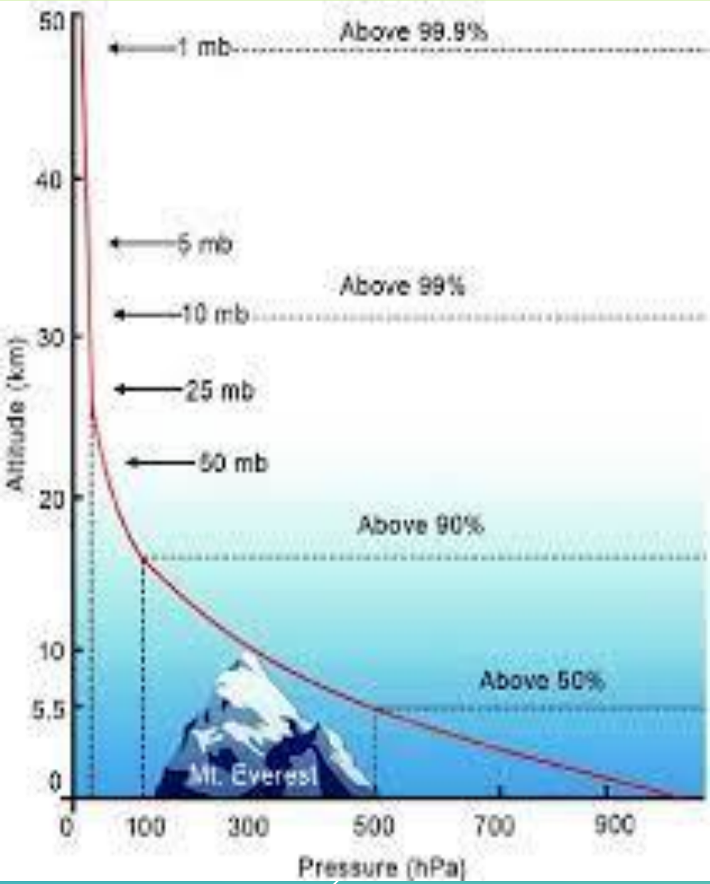
PRESSURE DISTRIBUTION

- Atmospheric pressure does not decrease at the same rate as altitude.
  The following are atmospheric pressure.
  At sea level: 1013.25 millibars.

- 1 km: 898.76 millibar

- 10 km: 265 millibars

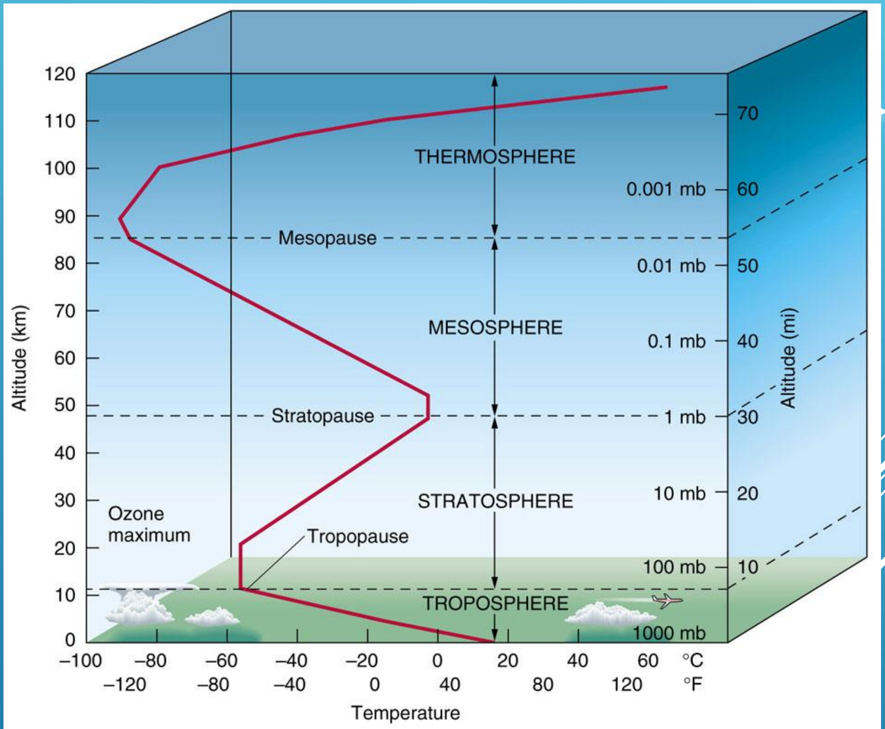
- At 100 km: nearly zero.



DISTRIBUTION OF TEMPERATURE AND GASES IN THE ATMOSPHERIC LAYERS

TEMPERATURE

- The temperature gradually decreases as we move upwards in the troposphere reaching about -51° C at Tropopause.
- Then for some time, it remains constant in Stratosphere before starting to increase and reaching about -15° C at Stratopause.
- Then again, it remains constant in Mesosphere for some time before decreasing and reaching about
- -90° C at Mesopause.
- Then there is a sudden increase in temperature in the Thermosphere where the temperature reaches
- 2000° C at Thermopause.



Gases of atmosphere

Nitrogen and oxygen are by far the most common; dry air is composed of about 78% nitrogen (N2) and about 21% oxygen (O2). Argon, carbon dioxide (CO2), and many other gases are also present in much lower amounts; each makes up less than 1% of the atmosphere's mixture of gases. The atmosphere also includes water vapor.

Table 8.1 : Permanent Gases of the Atmosphere

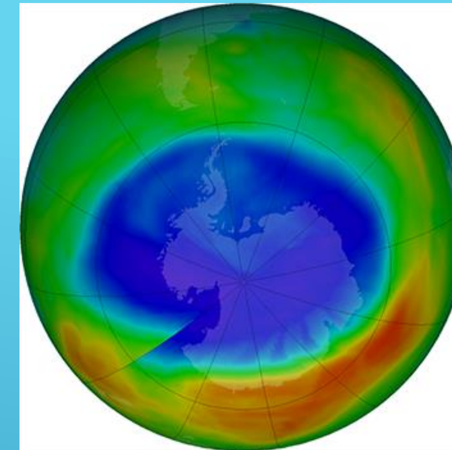
Constituent	*Formula*	*Percentage by Volume*
Nitrogen	N_2	78.08
Oxygen	O_2	20.95
Argon	Ar	0.93
Carbon dioxide	CO_2	0.036
Neon	Ne	0.002
Helium	He	0.0005
Krypto	Kr	0.001
Xenon	Xe	0.00009
Hydrogen	H_2	0.00005

OZONE LAYER

- It is a layer in the earth's stratosphere that contains high levels of ozone.
- This layer protects the earth from the Sun's harmful UV radiation.
- In the absence of the ozone layer, millions of people would be affected by skin diseases including cancer and weakened immune systems.
- Fauna on earth is also adversely affected by the ozone layer depletion.

Source: thecoversation.com

DEPLETION OF OZONE LAYER
Ozone Holes

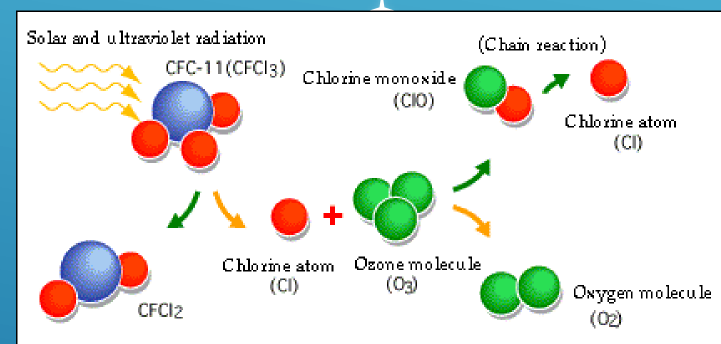


- In 1985, it was discovered
  it was caused due to the chemical compounds called chlorofluorocarbons (CFCs). One example of ozone depletion is the **annual ozone "hole" over Antarctica** that has occurred during the Antarctic spring since the early 1980s.

  In the 1960s, used in air conditioners, aerosol spray cans, industrial cleaning products, styrofoam production.

  They were capable of breaking apart ozone molecules, causing the breakdown of ozone in the stratosphere to happen faster than it could be built back up.

- Once in the atmosphere, CFCs drift slowly upward to the stratosphere, where they are broken up by ultraviolet radiation, releasing chlorine atoms, which are able to destroy ozone molecules.



- Ozone depletion is not limited to the area over the South Pole.
- Research has shown that ozone depletion occurs over the latitudes that include North America, Europe, Asia, and much of Africa, Australia, and South America.

OZONE LAYER DEPLETION

- Ozone layer depletion refers to the thinning of the protective ozone layer in the atmosphere.
- This happens when certain chemicals come into contact with ozone and destroy it.
- Chemical compounds that cause ozone layer depletion are called **Ozone Depleting Substances (ODSs).**
- Examples of ODSs are chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), carbon tetrachloride, methyl chloroform, hydrobromofluorocarbons, halons, etc.
- $O2(g) \rightarrow O(g) + O(g)$ (In presence of UV Rays)
- $O(g) + O2(g) \leftrightarrow O3(g)$

.

CLASS- I ODS

- Ozone Depletion Potential > 0.2
- Halons, chlorofluorocarbons (CFCs), methyl chloroform, carbon tetrachloride, and methyl bromide
- CFCs-Manufacture of aerosol sprays, blowing agents for foams, solvents, refrigerants
- Halons-Fire extinguishing agents (ODP upto 10)
- Methyl Bromide- Fumigant used to control pests

CLASS-II ODS

- Ozone Depletion Potential < 0.2
- They are Hydrochlorofluorocarbons
- Refrigeration, air conditioning, foam blowing, solvents, aerosols, and fire suppression
- Later phase-out than class I .

Ozone Depletion Potential- Amount of stratospheric depletion caused by a substance with respect to that caused by R-11.

CONDITIONS THAT FAVOUR THE FORMATION OF OZONE HOLE AT THE POLES

- Very low winter temperatures (for an extended period)- Allow formation of **Polar Stratospheric Clouds (PSC).**
- Reaction on PSC increases the amount of reactive chlorine gas, chlorine monoxide (ClO).
- Whenever sunlight is available, due to the increased ClO, the catalytic cycles of ClO and BrO will be more active in ozone destruction.
- More PSCs exist in the Antarctic than in the Arctic.
- Due to strong wintertime polar vortices the stratospheric air is isolated from the remaining stratospheric region.[3]

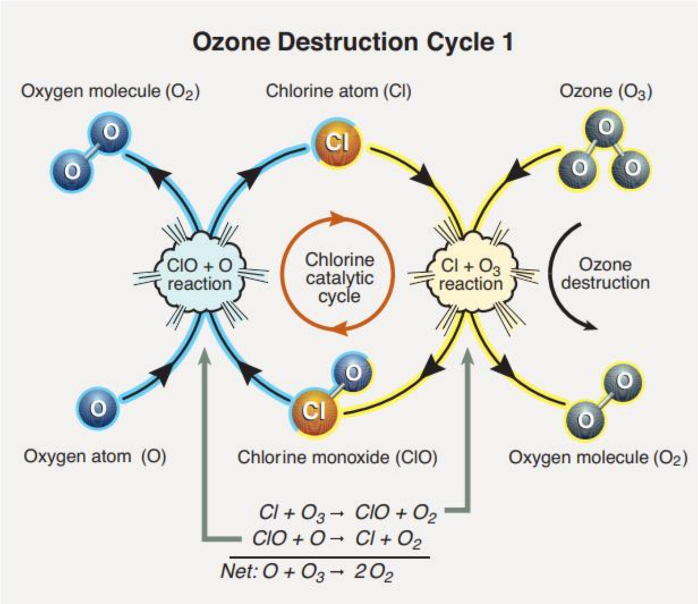


Fig.2. Cycle 1 is most important in the stratosphere at tropical and middle latitudes, where solar ultraviolet radiation is most intense[9].

Cycle 2

$$ClO + ClO \rightarrow (ClO)_2$$

$$(ClO)_2 + \text{sunlight} \rightarrow ClOO + Cl$$

$$ClOO \rightarrow Cl + O_2$$

$$2(Cl + O_3 \rightarrow ClO + O_2)$$

$$\text{Net: } 2O_3 \rightarrow 3O_2$$

Cycle 3

$$ClO + BrO \rightarrow Cl + Br + O_2$$

$$\text{or} \left(\begin{array}{r} ClO + BrO \rightarrow BrCl + O_2 \\ BrCl + \text{sunlight} \rightarrow Cl + Br \end{array} \right)$$

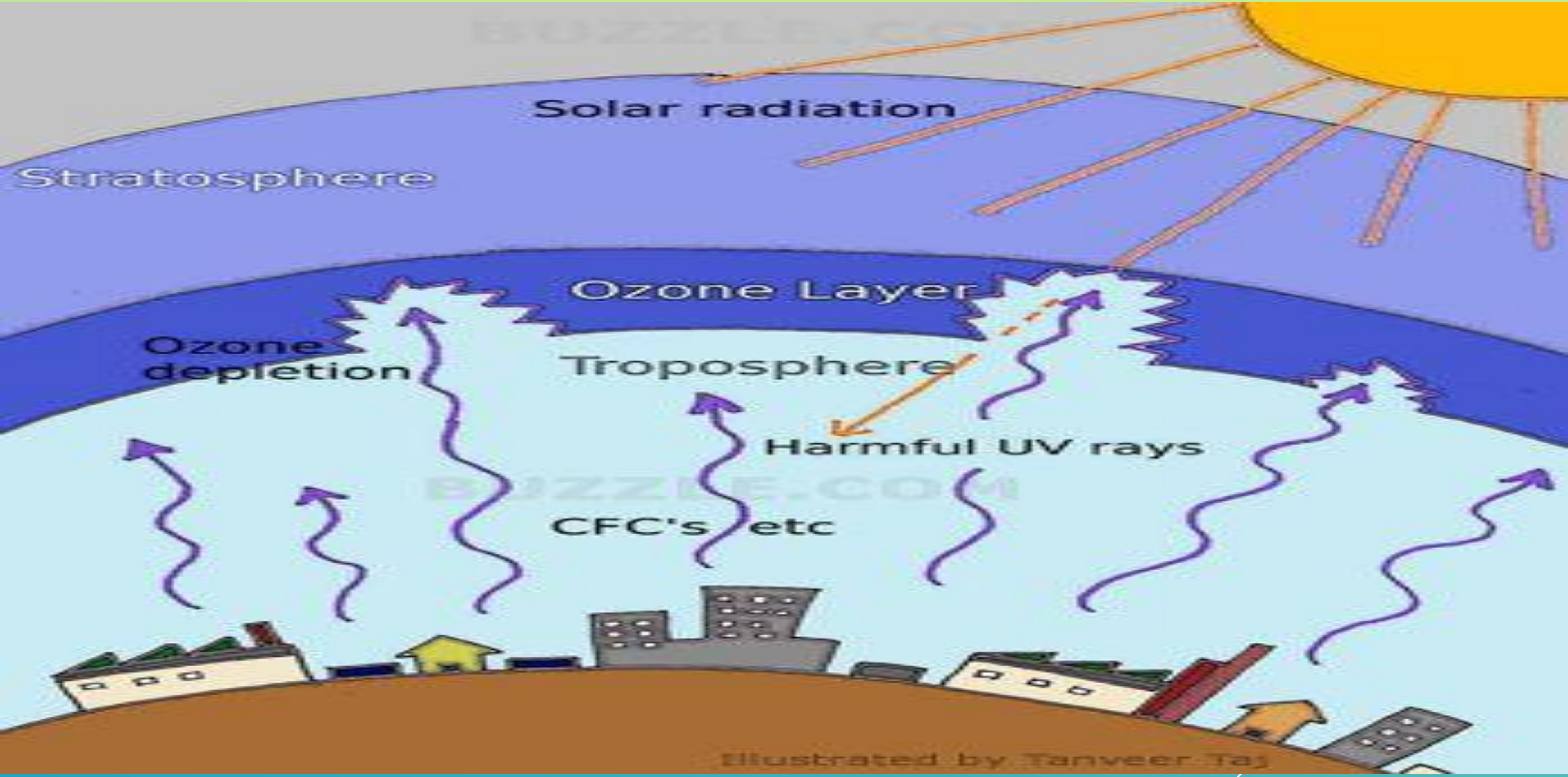
$$Cl + O_3 \rightarrow ClO + O_2$$

$$Br + O_3 \rightarrow BrO + O_2$$

$$\text{Net: } 2O_3 \rightarrow 3O_2$$

Fig.3. The reaction of ClO with another ClO (Cycle 2) or the reaction of ClO with BrO (Cycle 3) efficiently destroy ozone.[9].

OZONE LAYER DEPLETION



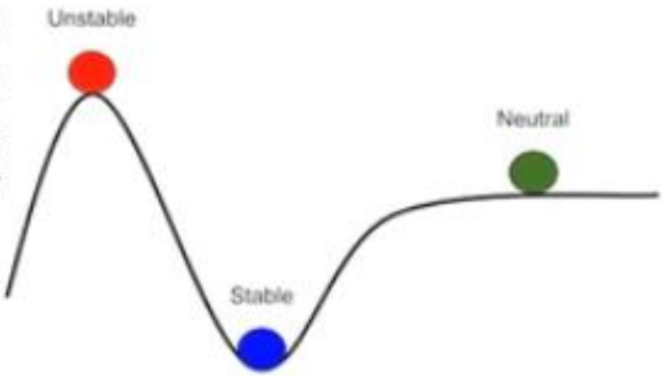
Source: pinterest.com

INTERNATIONAL TREATIES AND CO-OPERATIONS

- 1985-The **Vienna convention-** formalized international cooperation
- 1987-The **Montreal Protocol** on ODS
- 1990-The **London Amendment**-Methyl chloroform added to the list of controlled ODS. CFCs, halons, and carbon tetrachloride complete phase-out were mentioned.
- 1992- The **Copenhagen Amendment-** CFCs, halons, carbon tetrachloride, and methyl chloroform; HCFC phaseout for developed countries.
- 1997-The **Montreal Amendment**-HCFC phaseout for developing countries.
- 1999-The **Beijing Amendment**-Bromochloromethane was added to the list of controlled ODS.
- 2016-The **Kigali Amendment-** Controls to phase down the production and consumption of HFCs [8].

ATMOSPHERIC STABILITY AND INSTABILITY

When you think of the word **"stable,"** you typically think of an **object that is unlikely to change or something that is balanced**. The opposite is true with something that is **"unstable".** An **unstable object is likely to fall or change position with time.**



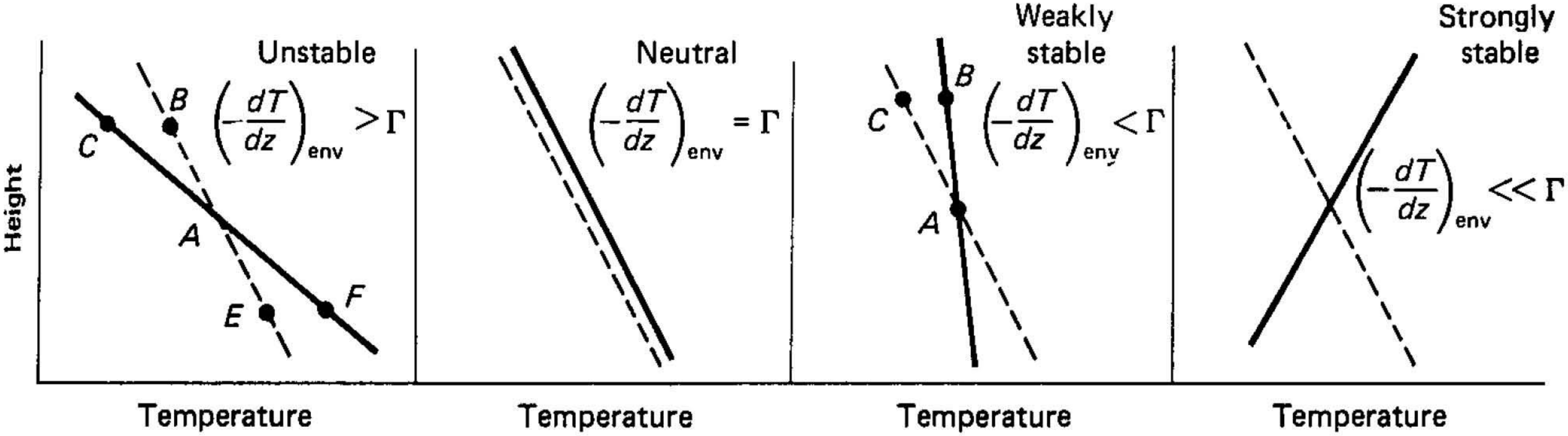
Stable equilibrium

Unstable equilibrium

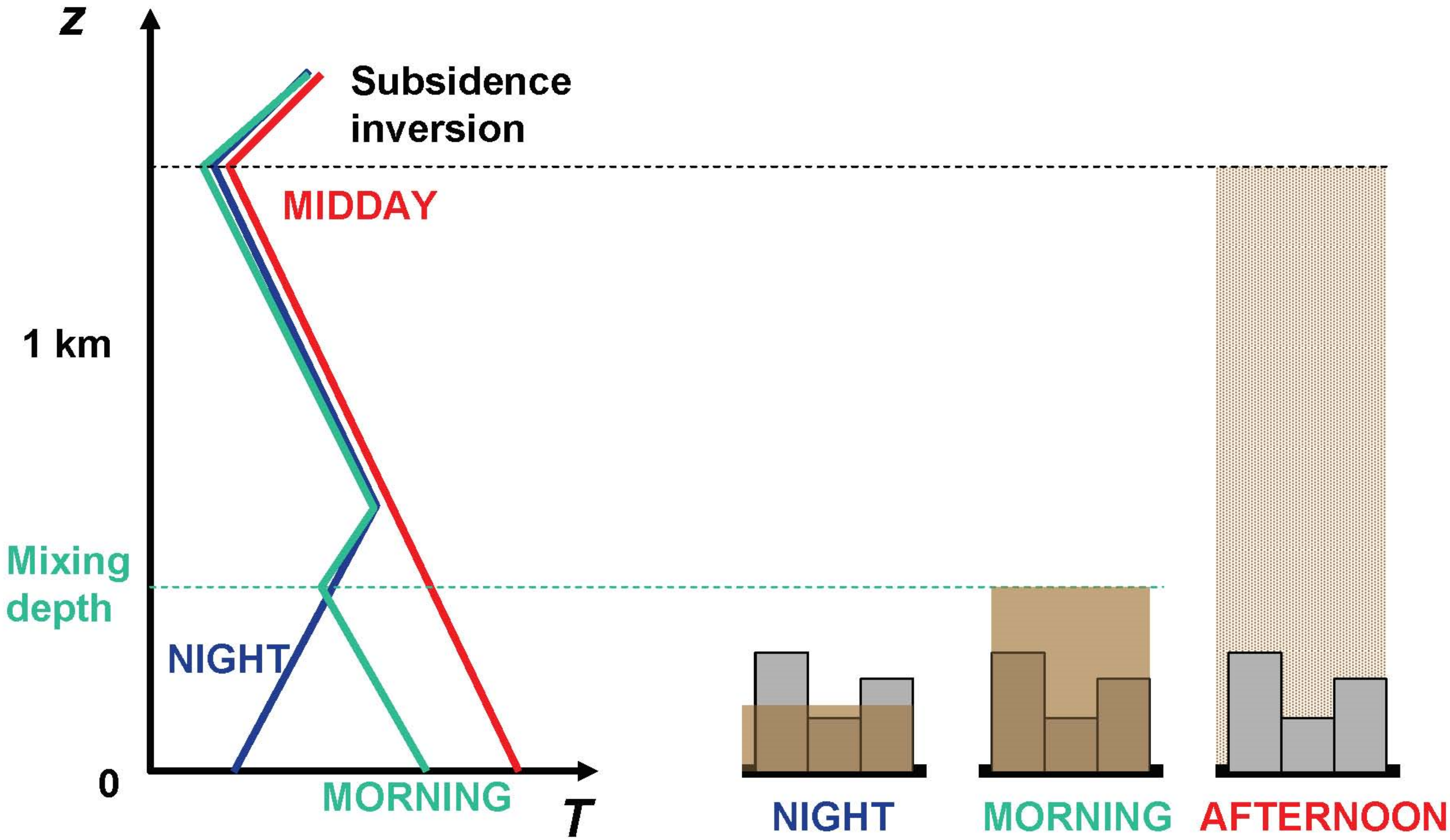
Stability Conditions

- - - - - - **Adiabatic lapse rate**

——— **Actual Air Temperature lapse rate**



Diurnal Cycle of Surface Heating /Cooling



GLOBAL AIR CIRCULATION

- Global atmospheric circulation creates winds across the planet as air moves from areas of high pressure to areas of low pressure.
- It also leads to areas of high rainfall, like the tropical rainforests, and areas of dry air, like deserts.
- **Air flow for no rotation and no water on a planet.** Global Circulations explain how air and storm systems travel over the Earth's surface. The global circulation would be simple (and the weather boring) if the Earth did not rotate, the rotation was not tilted relative to the sun, and had no water.

GLOBAL CIRCULATION OF AIR

- Any atmospheric flow used to refer to the general circulation of the Earth and regional movements of air around areas of high and low pressure.
- In the **subtropical** high-pressure belts near latitudes **30° N and 30° S**, air descends and causes the **trade winds** to blow **westward** and **equatorward** at the Earth's surface.
- These merge and rise in the **intertropical convergence zone** near the Equator and blow **eastward** and **poleward** at altitudes of 2 to 17 km.
- Part of the flow descends in the subtropical high-pressure belts, and the remainder merges at high altitudes with the midlatitude **westerly** winds farther **poleward**.

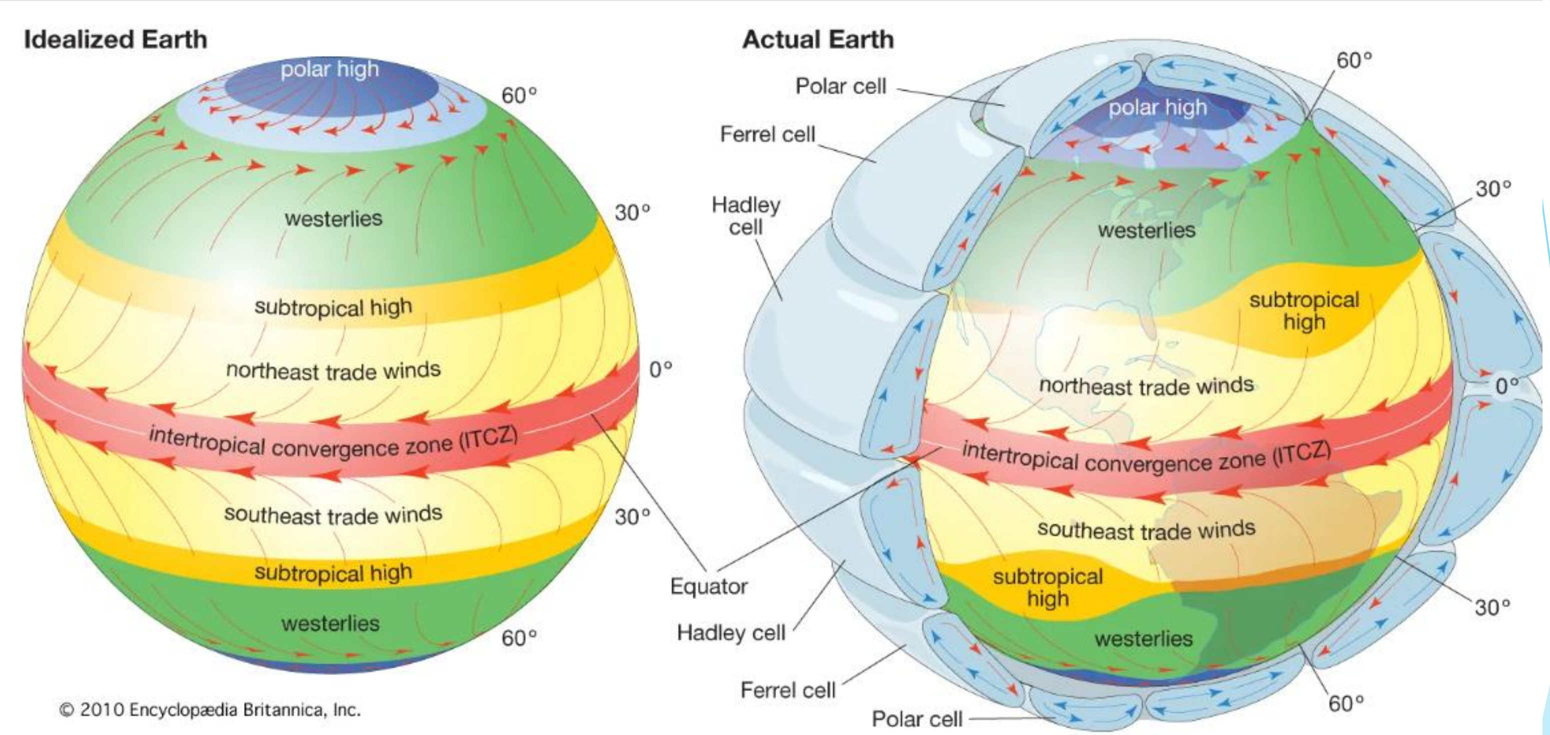
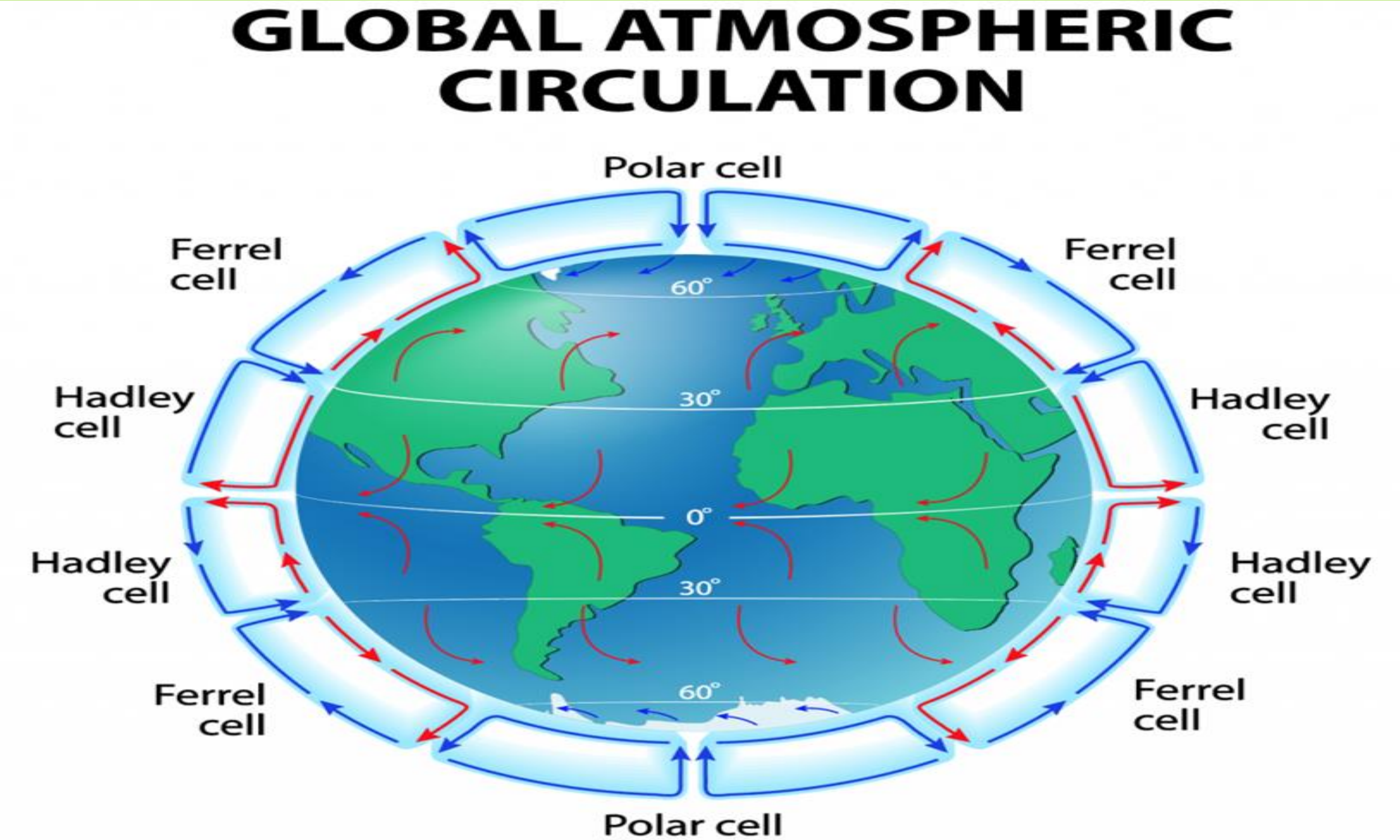


Fig. General patterns of atmospheric circulation over an idealized Earth with a uniform surface (left) and the actual Earth (right). Both horizontal and vertical patterns of atmospheric circulation are depicted in the diagram of the actual Earth[3].



Source: internetgeography.net

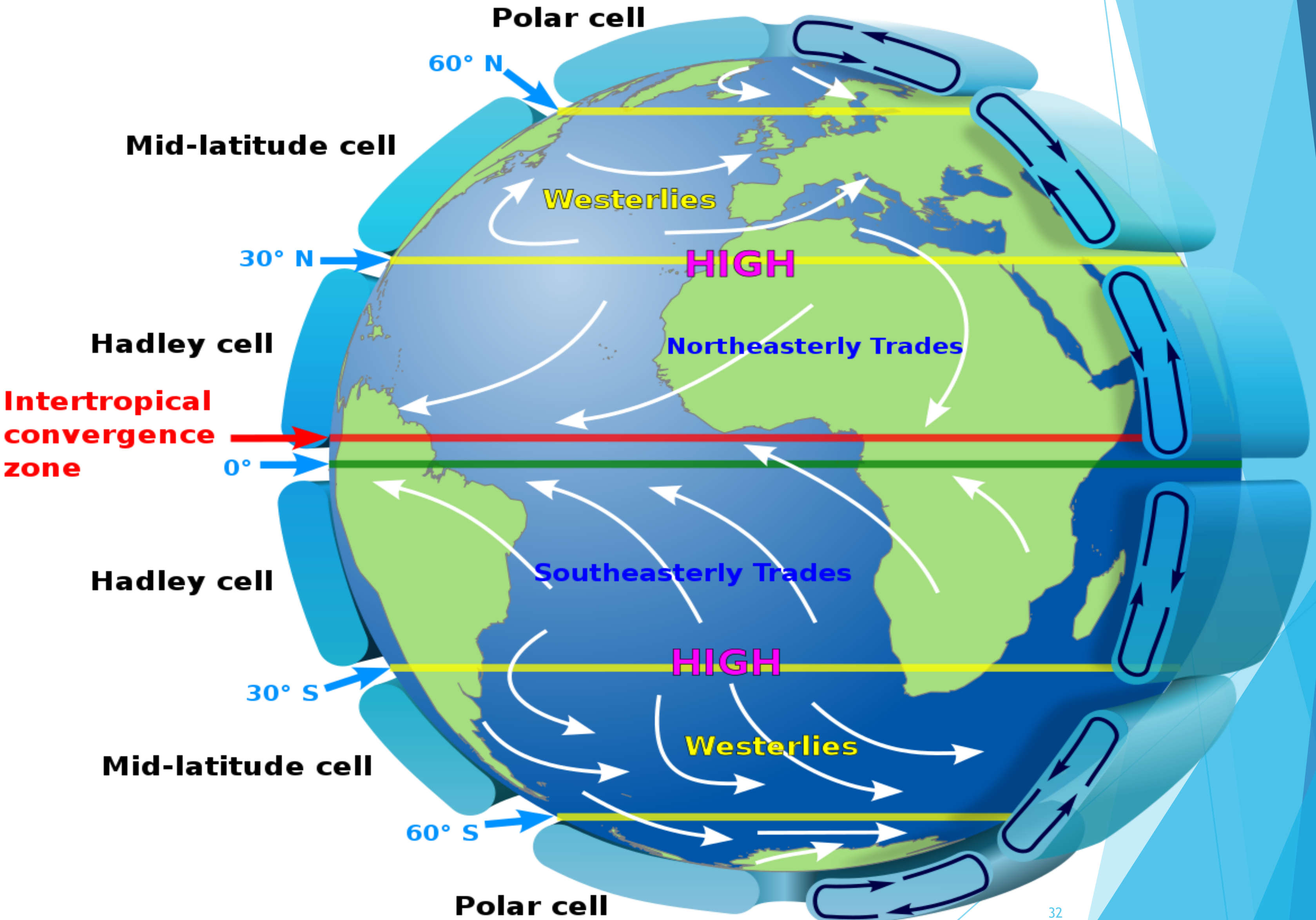
- The descending air in the subtropical high-pressure belts diverges near the surface; the air that does not flow equatorward tends to flow **eastward and poleward** as the mid-latitude **westerlies**.
- The **westerly flow** is most evident between 5 and 12 km or so above the Earth's surface and contains the **jet streams**. Jet streams are relatively narrow corridors of particularly strong winds.
- Polar-front jet streams are permanent in both hemispheres, while subtropical jet streams occur only during the winter periods in each hemisphere.
- Poleward of 60° N and 60° S, the winds generally blow **westward** and **equatorward** as the polar **easterlies**.
- The **zonal wind** belts are more uniform and constant in the Southern Hemisphere because there is little land to disturb the circulation.
- Heat is not directly carried from the equator to the poles.

- The three distinct wind cells of closed wind circulation are:
- <u>**Hadley Cell**</u>
  - The heat from the equator sinks at 30^{o} latitude where a Hadley cell ends.
  - Warmest air, therefore, does not reach the poles.
  - Low latitude overturning circulations where air rises at the equator and sinks at 30^{o} latitude.
  - Responsible for trade winds.

- **Ferrel Cell**

The Ferrel cell, theorized by William Ferrel (1817–1891).

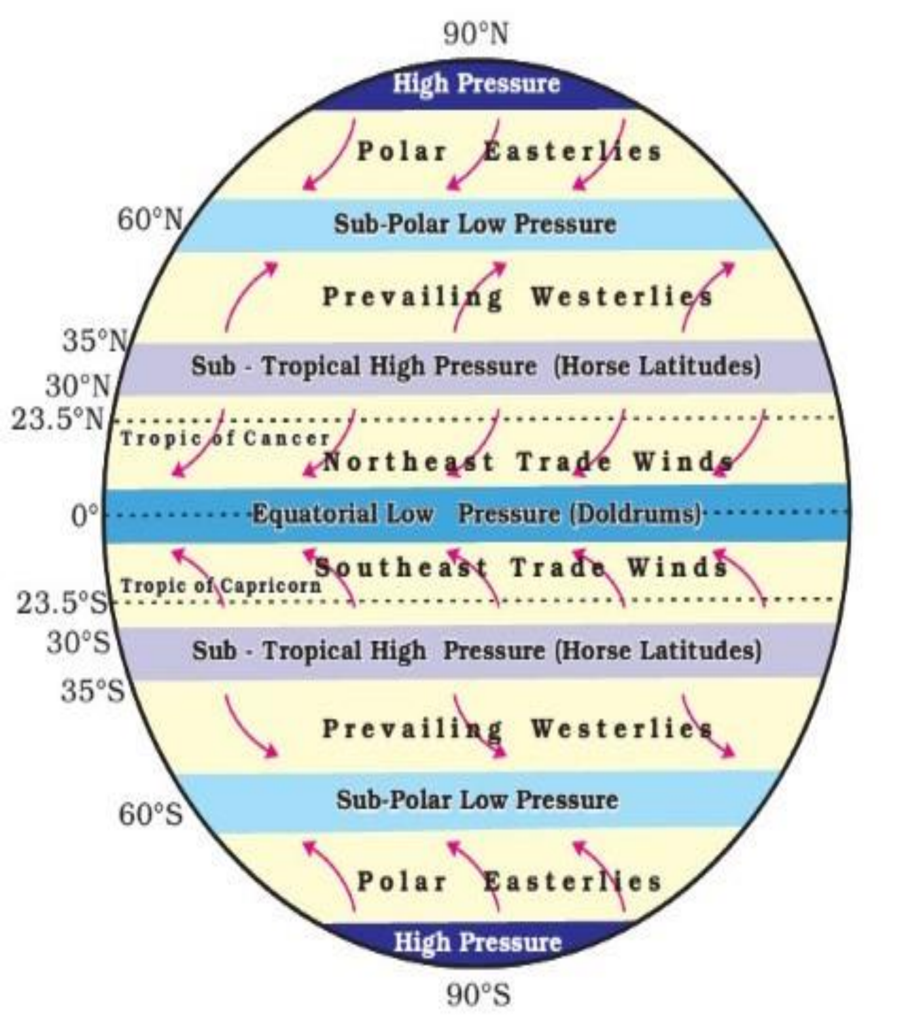
  - Describes the poleward heat transport.
  - The warm air that sinks at the 30-degree latitude sets a westerly flow in the northern zone
  - Air moves poleward and eastward near the surface and equatorward and westward at a higher level.
- **Polar Cell**
  - The air rising at the surface, traveling to the poles, and sinking at the poles constitute this cell.
  - Polar highs are formed at the poles.
  - Polar easterlies are formed at the surface.


Polar cell
60° N
Mid-latitude cell
Westerlies
30° N
HIGH
Hadley cell
Northeasterly Trades
Intertropical convergence zone
0°
Southeasterly Trades
Hadley cell
HIGH
30° S
Westerlies
Mid-latitude cell
60° S
Polar cell

Pressure distribution on atmosphere

- Air pressure is the pressure exerted by the weight of air on the earth's surface.

- As we go up the layers of the atmosphere, the pressure falls rapidly.
- The air pressure is highest at the sea level and decreases with height.



Major Pressure Belts and Wind System

Thank you