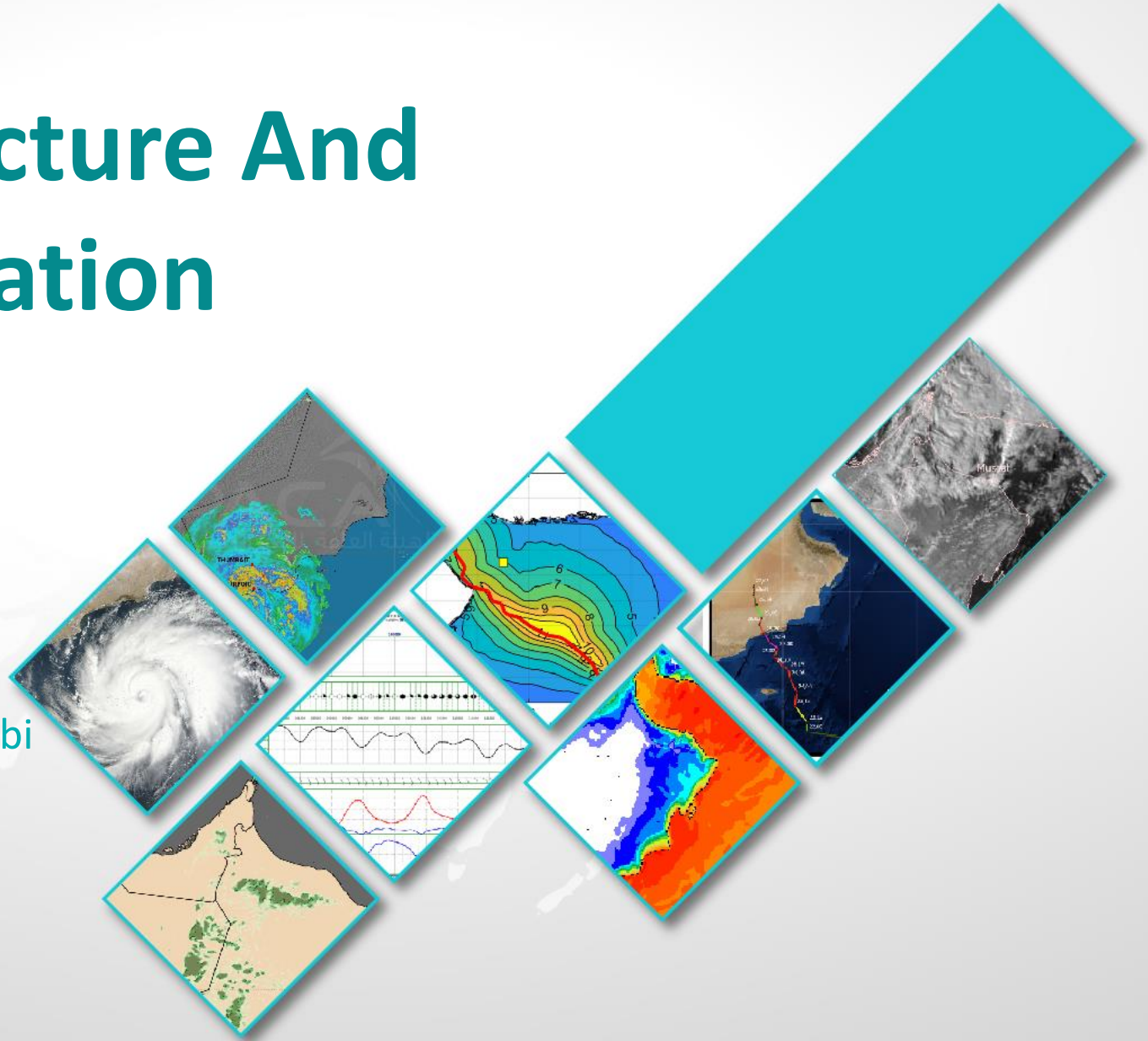
Atmospheric Structure And General Air Circulation

Content creator: Met. Said Al Bahri
Met. Aisha Al Qasmi
Met. Moza Al Marhoobi

Lecturer: Met. Moza Al Marhoobi

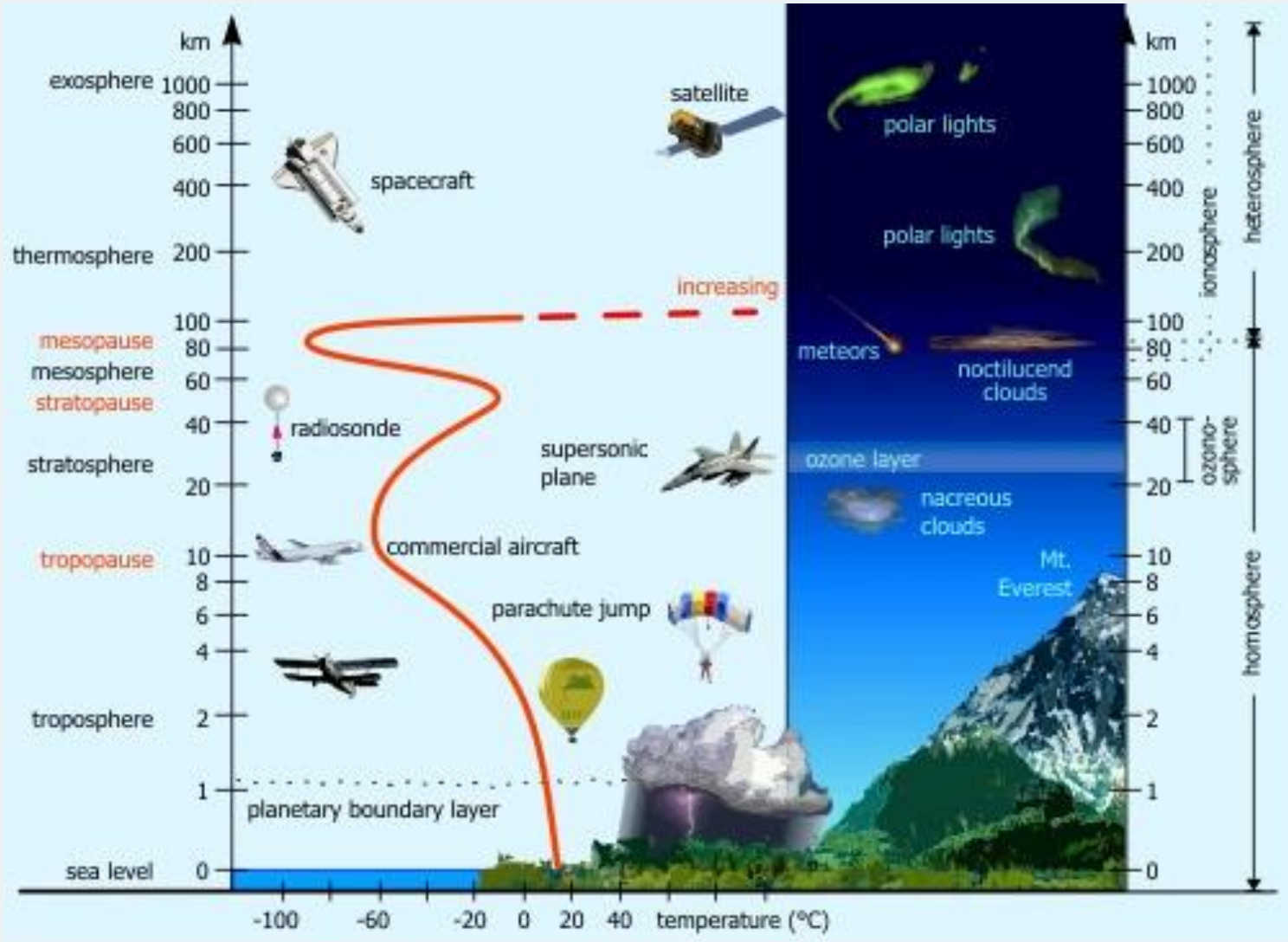


Content

- The Vertical Structure Of The Atmosphere
  - Layers of the atmosphere
    - Troposphere
      - Composition of air
    - Stratosphere
      - Weather Balloon
    - Mesosphere
    - Thermosphere
    - Exosphere
- Radiation
  - The transfer of heat energy
  - The earth-atmosphere energy balance
  - Distribution of radiation
- Global Air Circulation
  - Global air circulation (single cell circulation)
  - Global air circulation (3 cells pattern)
    - Hadley cell
    - Ferrel cell
    - Polar cell
    - Trade wind

Centre of Excellence-MUSCAT for Satellite Applications

CAA هيئة الطيران المدني

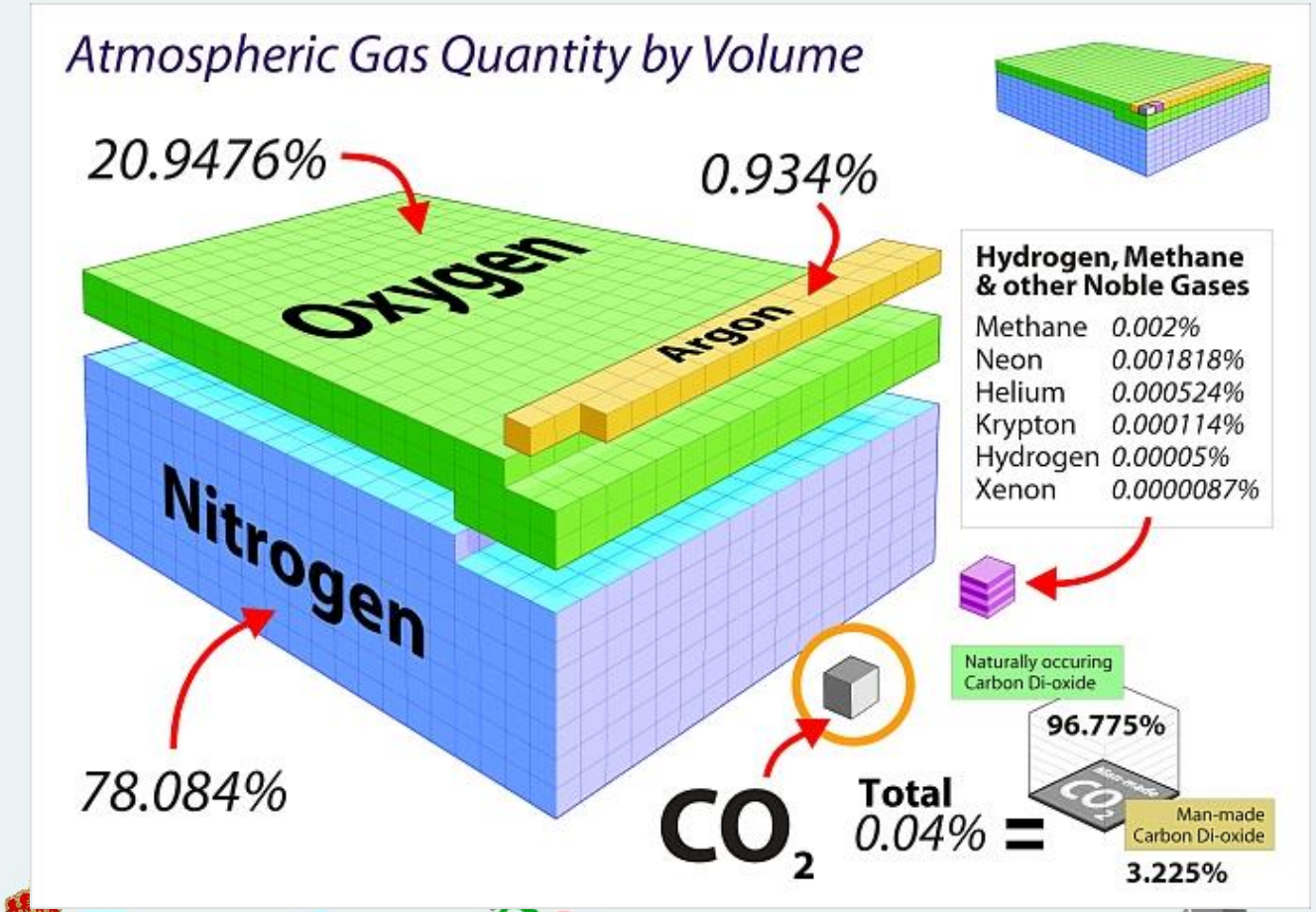

km
exosphere
1000
800
600
400
thermosphere
200
mesopause
mesosphere
stratopause
stratosphere
tropopause
troposphere
sea level
100
80
60
40
20
10
8
6
4
2
1
0
spacecraft
satellite
increasing
radiosonde
supersonic plane
commercial aircraft
parachute jump
planetary boundary layer
polar lights
polar lights
meteors
noctilucend clouds
ozone layer
nacreous clouds
Mt. Everest
ionosphere
heterosphere
ozono-sphere
homosphere
-100
-60
-20
0
20
40
temperature (°C)

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**

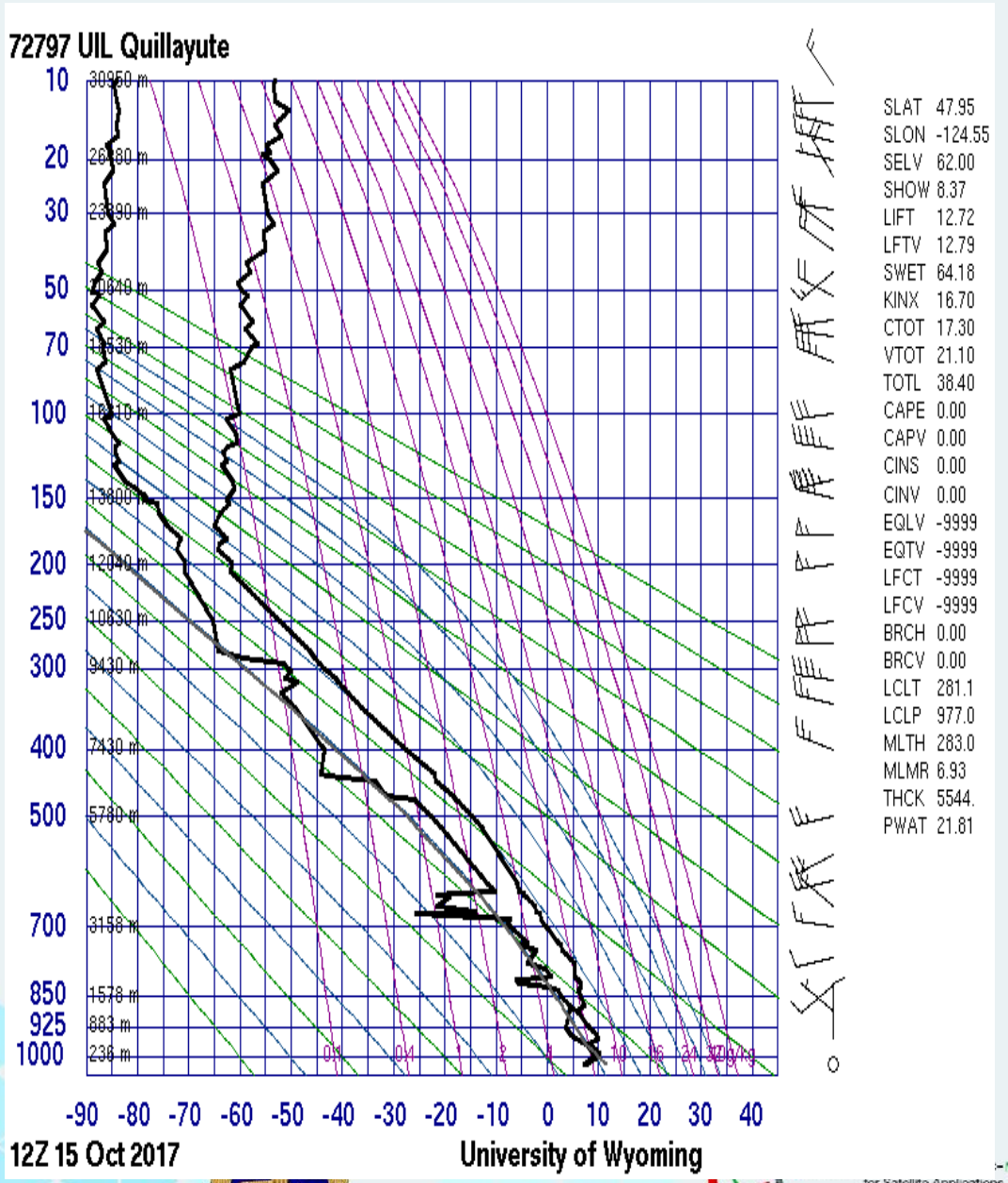
(by ~6.5C per km, 3.6 F per 1000 ft)

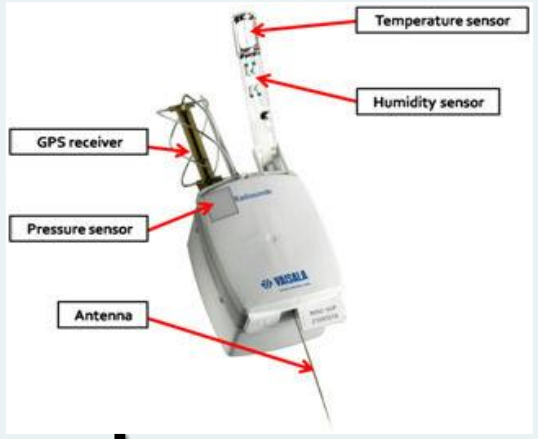
Composition of Air



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





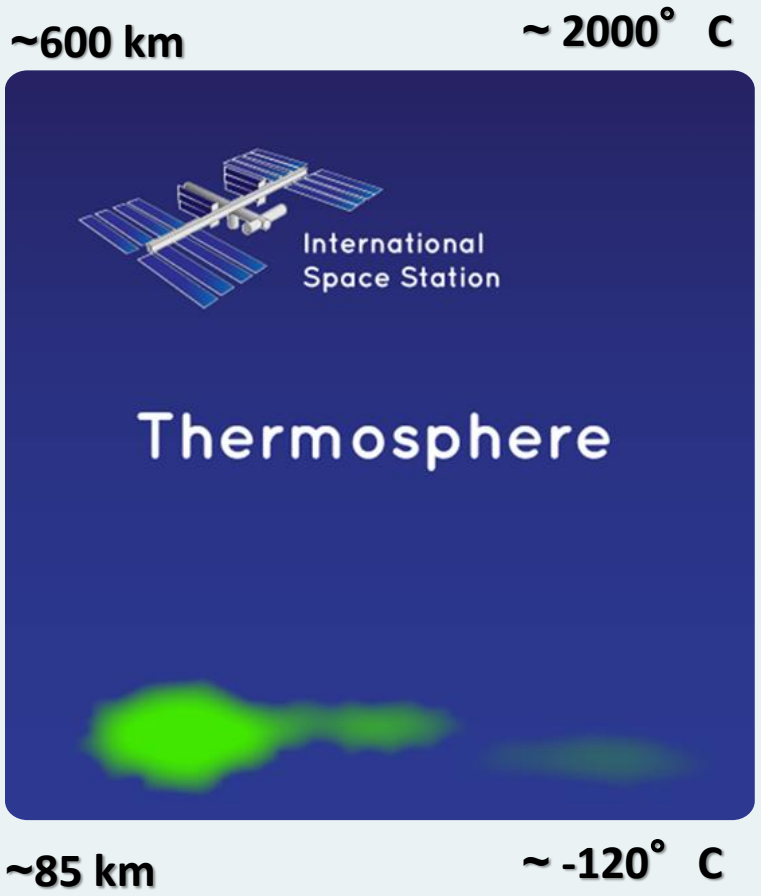
Weather Balloon (Radiosonde)

Mesosphere

- The gases that comprise this layer continue to become denser as one **descends**. As such, temperatures **increase** as one **descends**.
- The gases in the mesosphere are now **thick enough** to slow down **meteors** hurtling into the atmosphere, where they **burn up**, leaving fiery trails in the night sky.
- The bottom of the thermosphere is the mesopause - the transition into the **mesosphere**.
- Features:

  Occasional meteors

Thermosphere



- Known as upper atmosphere.
- As such, incoming high energy ultraviolet and x-ray radiation from the sun begins to be absorbed by the molecules in this layer and causes a large temperature increase.
- Objects Orbiting in the Layer:
  Space Shuttle & International Space Station

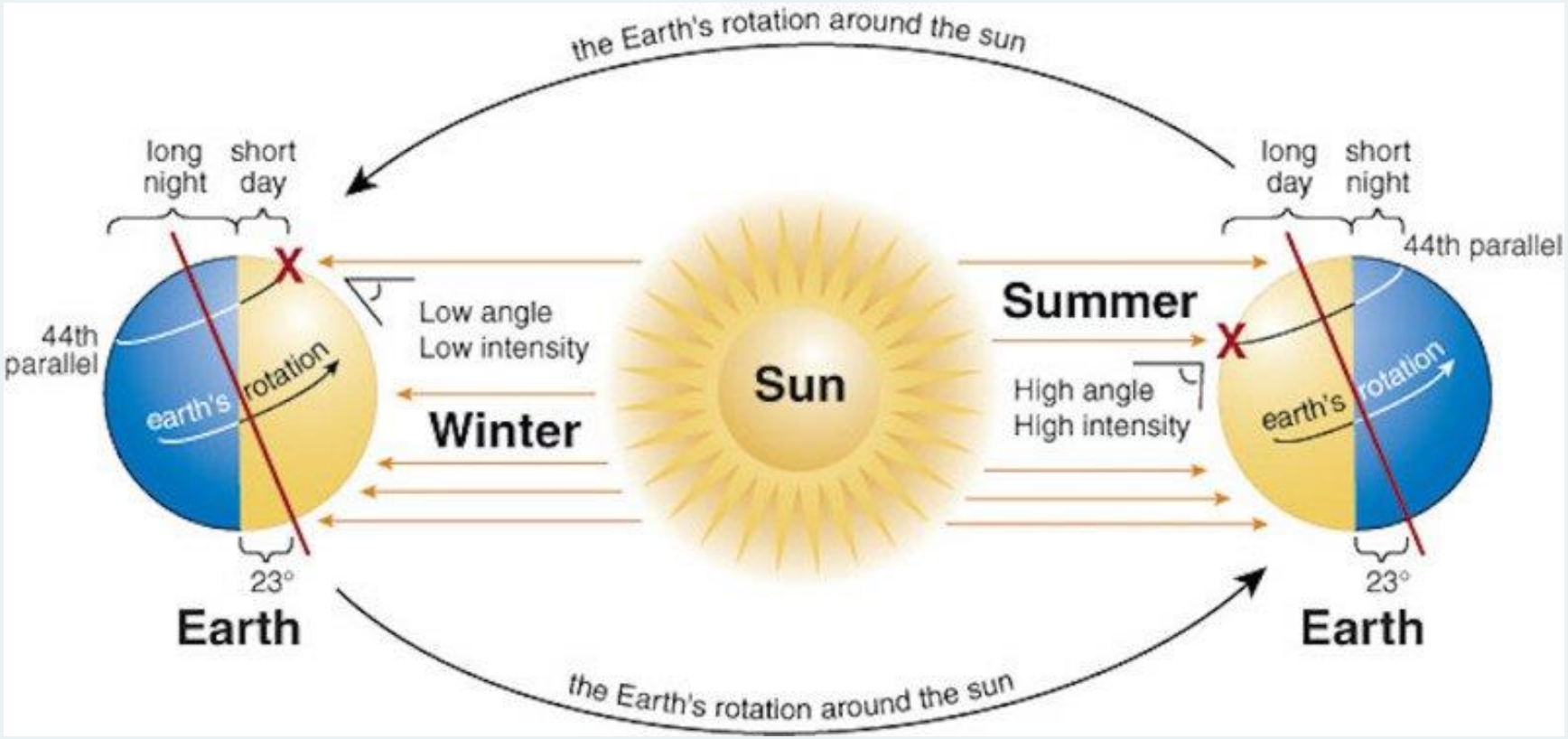
Exosphere

~600 km

~ 2000° C

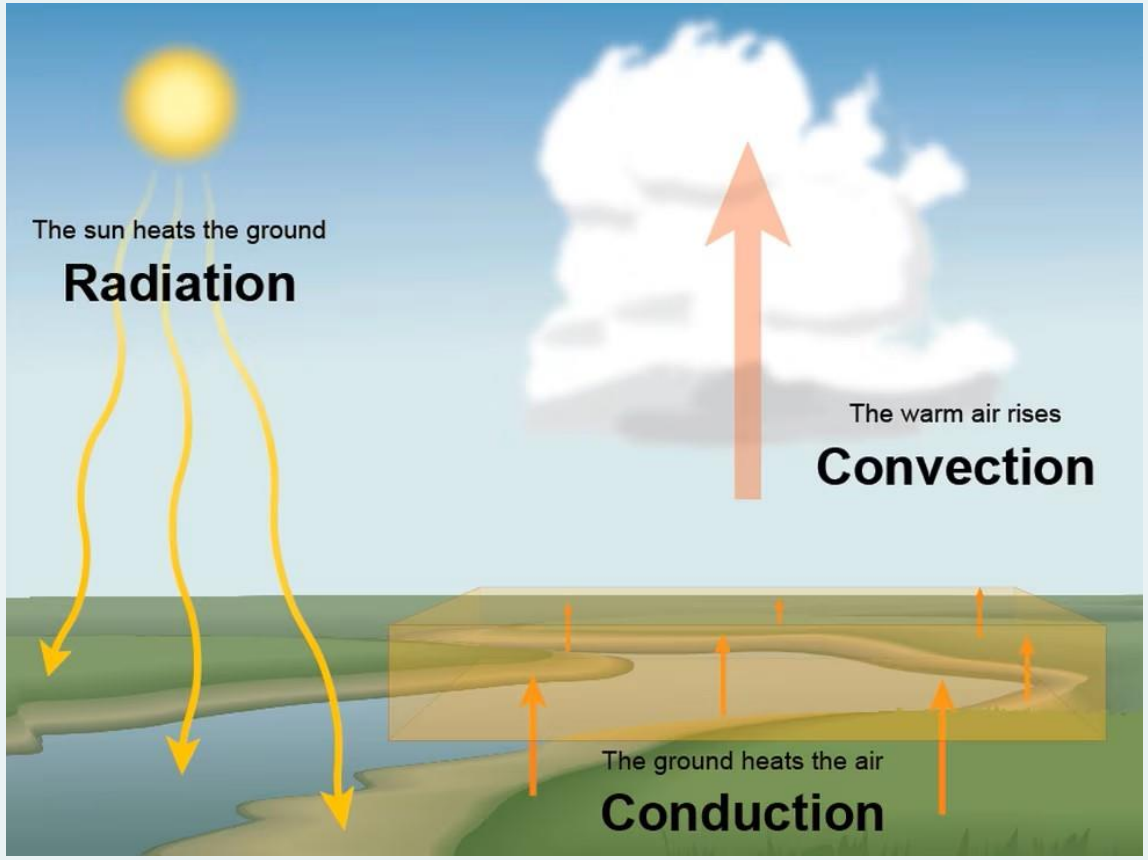
- The outermost layer of our atmosphere.
- The very edge of our atmosphere.
- This layer separates the rest of the atmosphere from outer space.
- It's about 10,000 kilometers thick. That's almost as wide as Earth itself.
- The exosphere has gases like hydrogen and helium, but they are very spread out.
- There is a lot of empty space in between.
- There is no air to breathe, and it's very cold.

Radiation



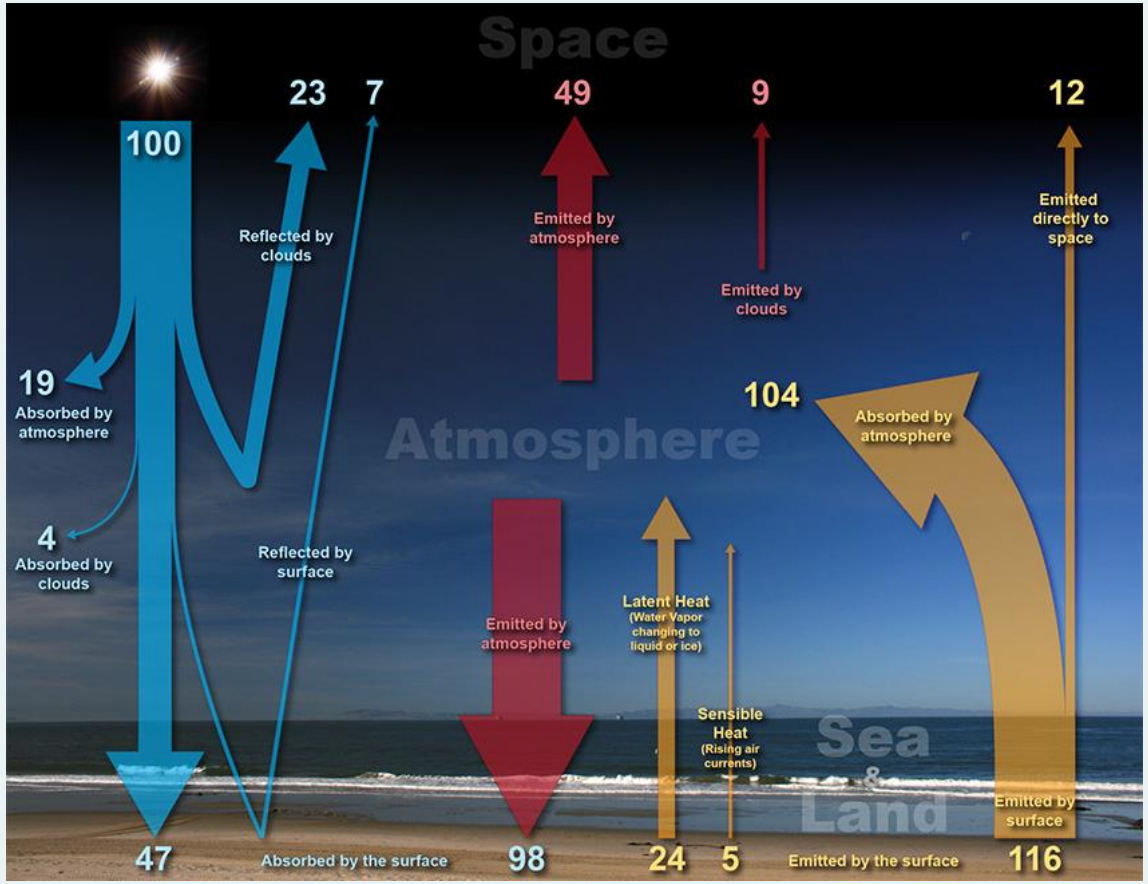
Centre of Excellence-MUSCAT
for Satellite Applications
CAA
هيئة الطيران المدني

The Transfer of Heat Energy



Centre of Excellence-MUSCAT
for Satellite Applications
CAA
هيئة الطيران المدني

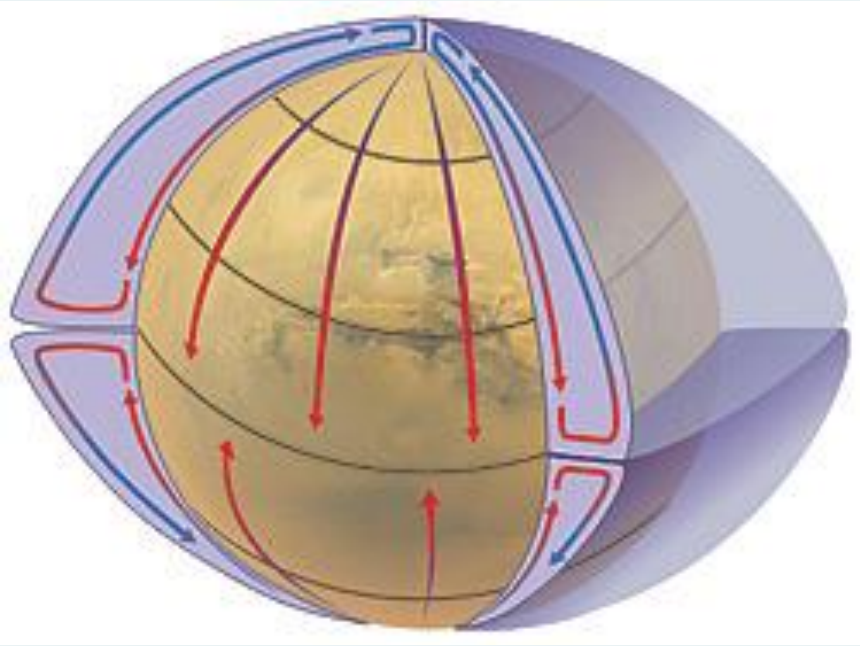
The earth-atmosphere energy balance



Centre of Excellence-MUSCAT
for Satellite Applications
CAA
هيئة الطيران المدني

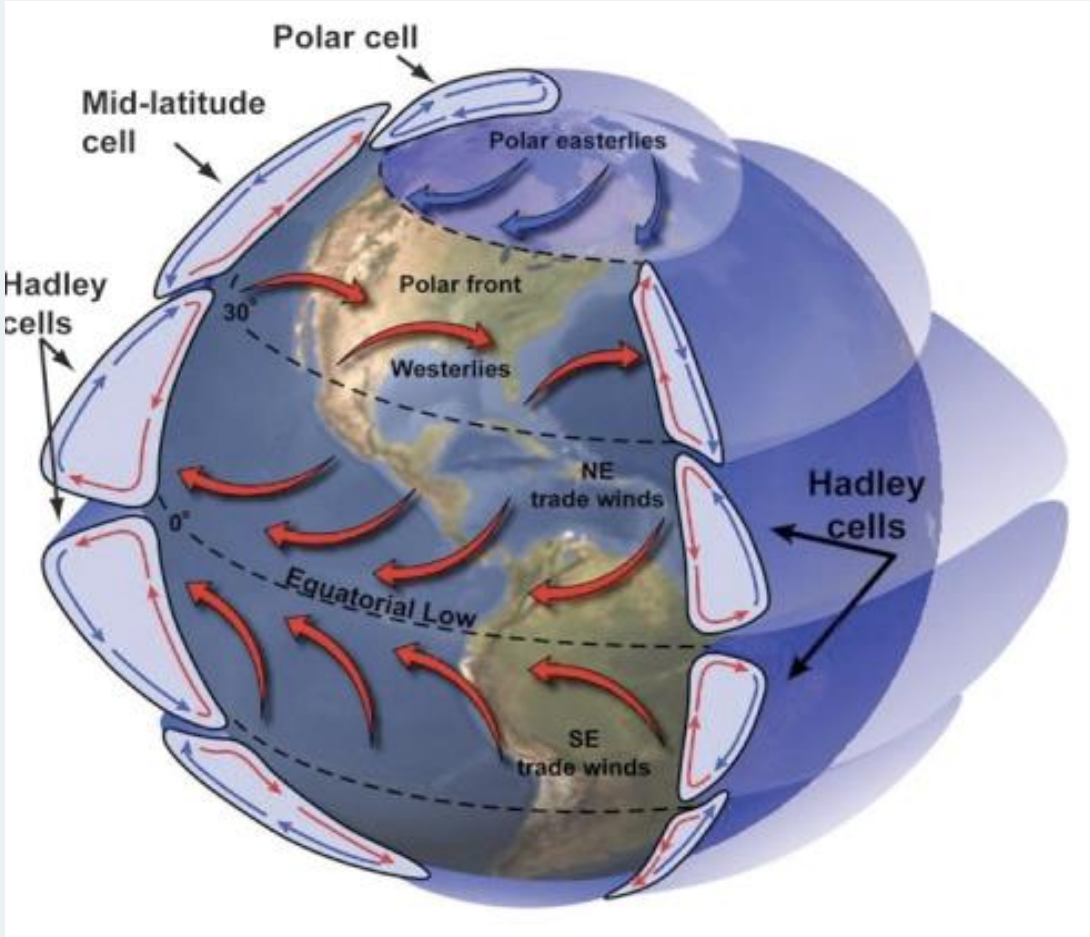
Global Air Circulation
Single-Cell Circulation

- 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)

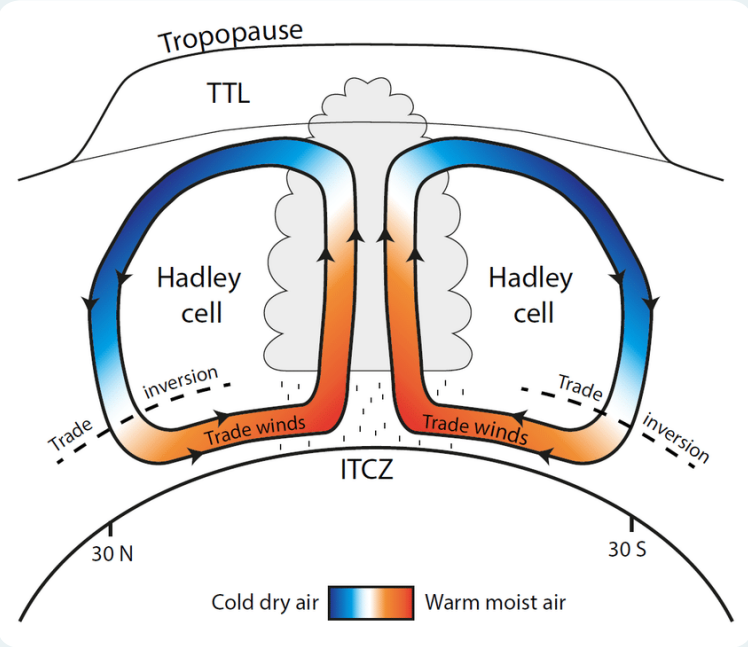
Since the Earth rotates, its axis is tilted and there is more land in the Northern Hemisphere than in the Southern Hemisphere, the actual global air circulation pattern is much more complicated. Instead of a single-cell circulation, the global model consists of three circulation cells in each hemisphere.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



Centre of Excellence-MUSCAT for Satellite Applications

CAA هيئة الطيران المدني

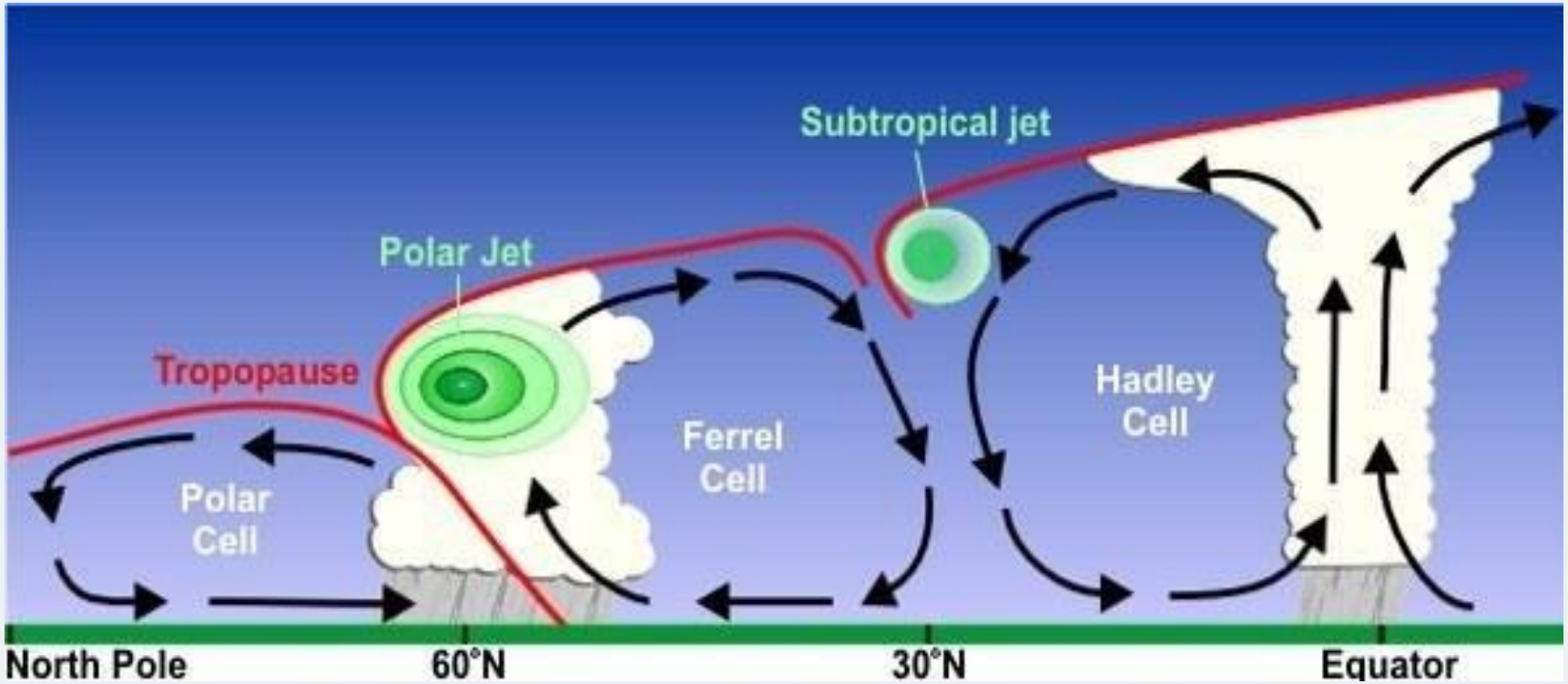
Hadley Cell



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.

Centre of Excellence-MUSCAT
for Satellite Applications
CAA
هيئة الطيران المدني



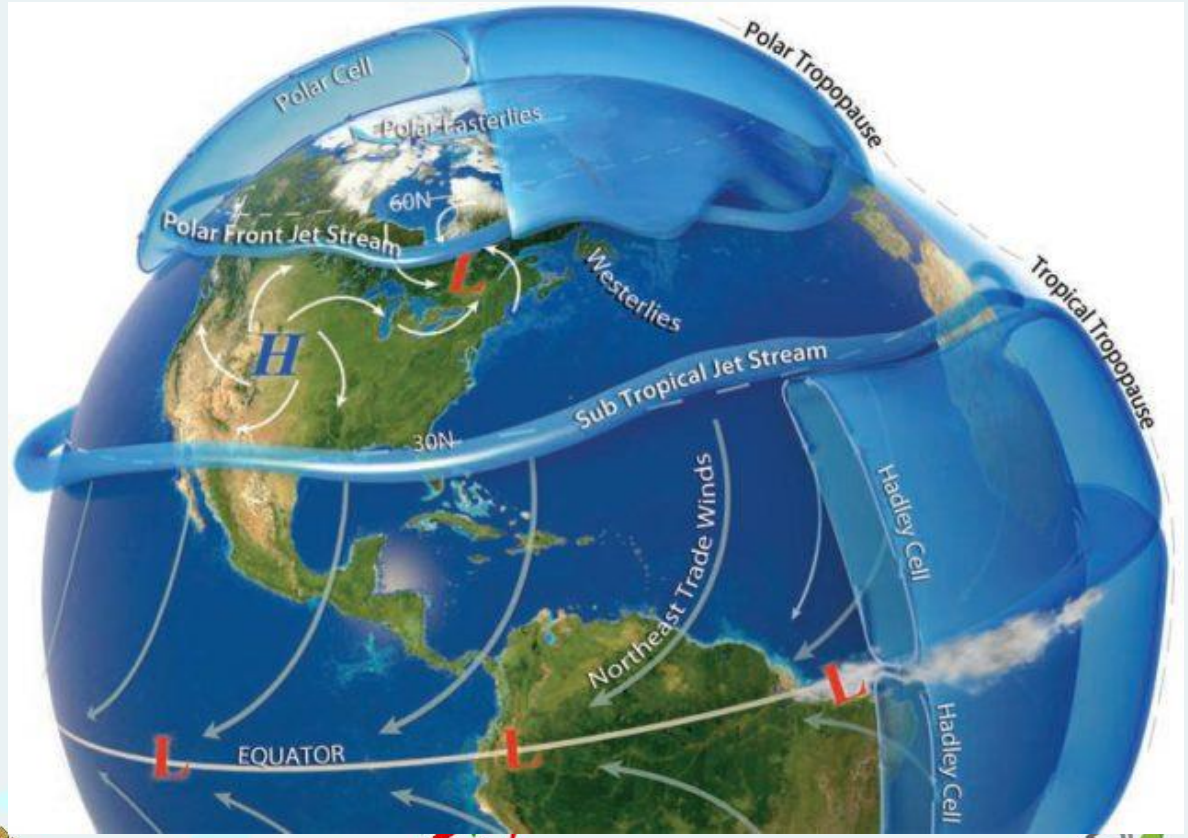
Ferrel cell

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

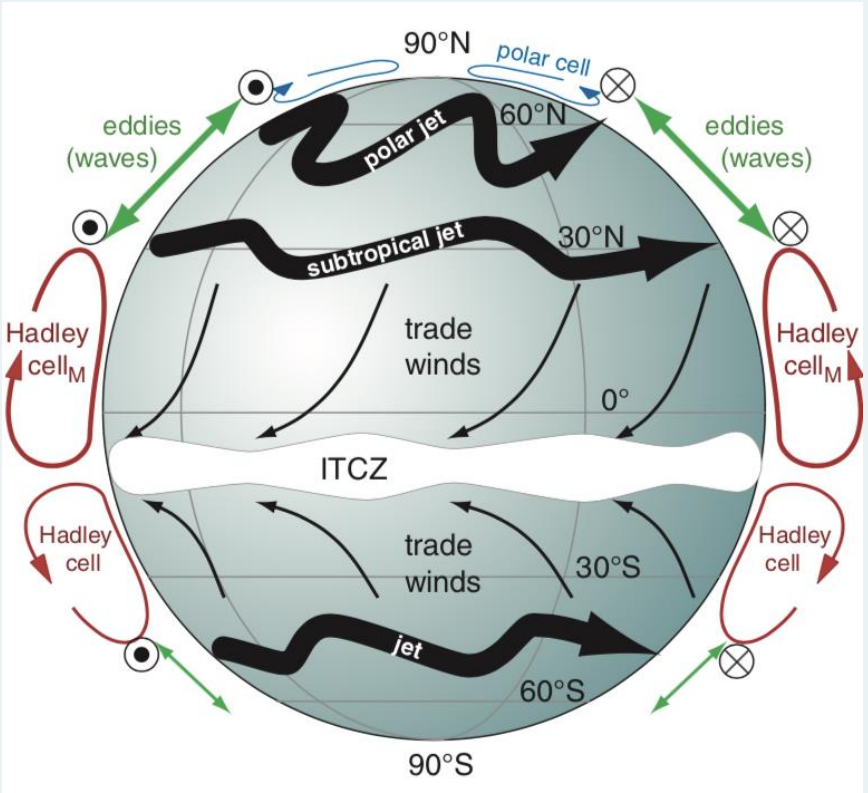
At higher latitudes, air rises and travels toward the poles. Once over the poles, the air sinks, forming areas of high atmospheric pressure called the **polar highs**. At the surface, air moves outward from the polar highs, creating east-blowing surface winds called **polar easterlies.** It is the smallest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

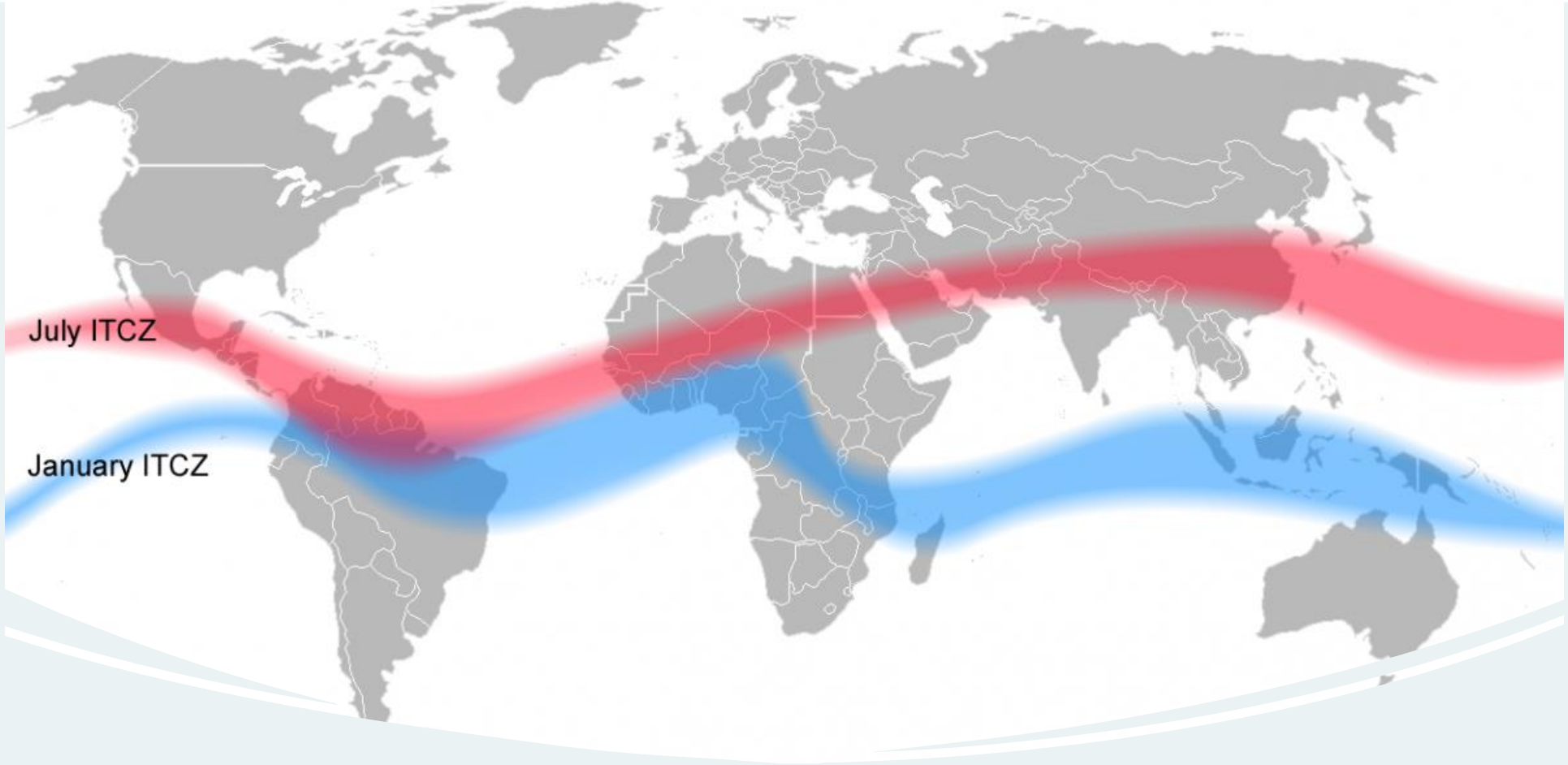


Centre of Excellence-MUSCAT
for Satellite Applications
CAA
هيئة الطيران المدني

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.

Centre of Excellence-MUSCAT
for Satellite Applications

CAA
هيئة الطيران المدني

Thank you

Kindly scan this “QR code”
to evaluate this Lecture