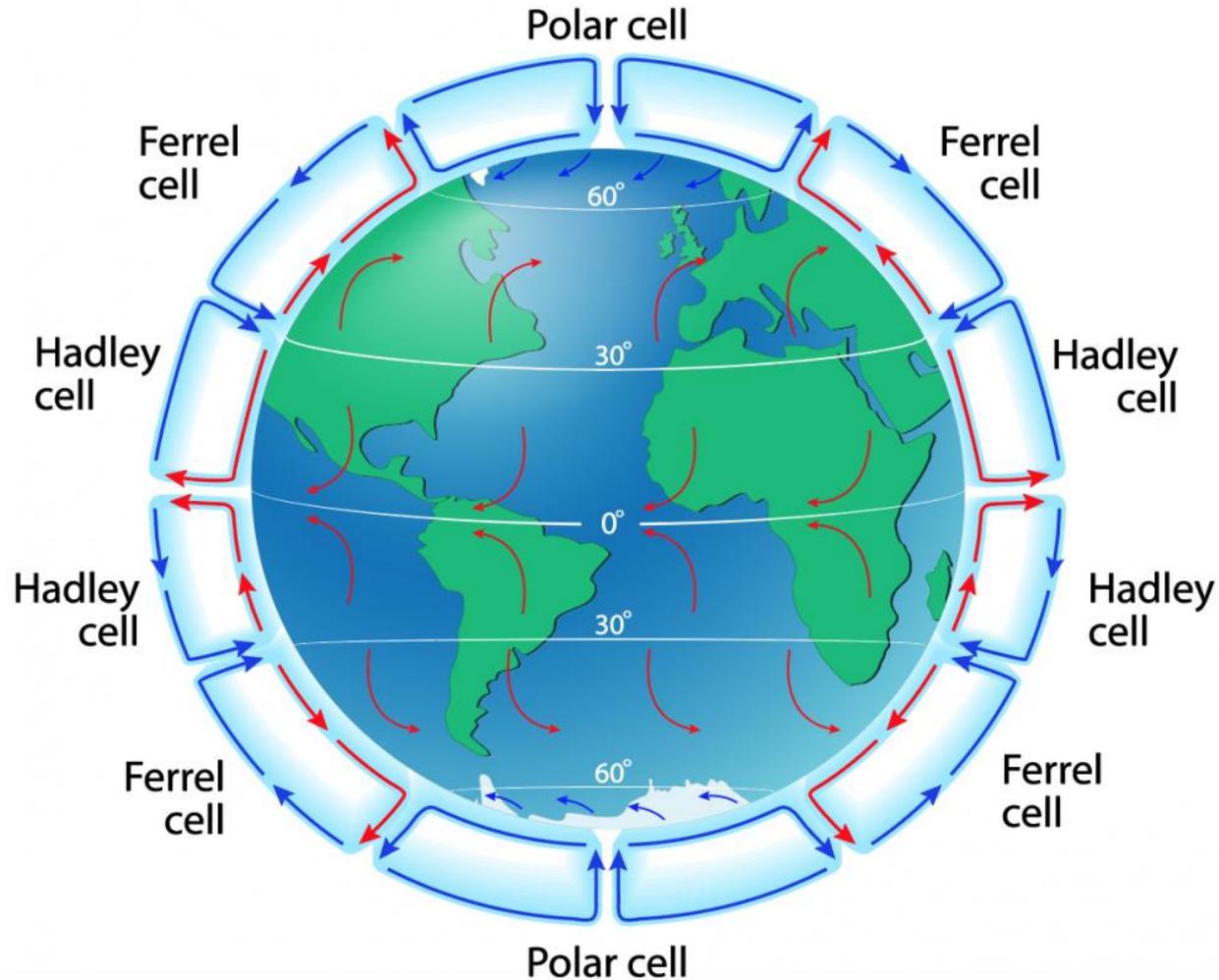


General Atmospheric Circulation



The troposphere is characterized by the presence of large-scale air movements,



both horizontal and vertical (upward and downward),



which follow one another over time in a fairly regular and continuous manner.



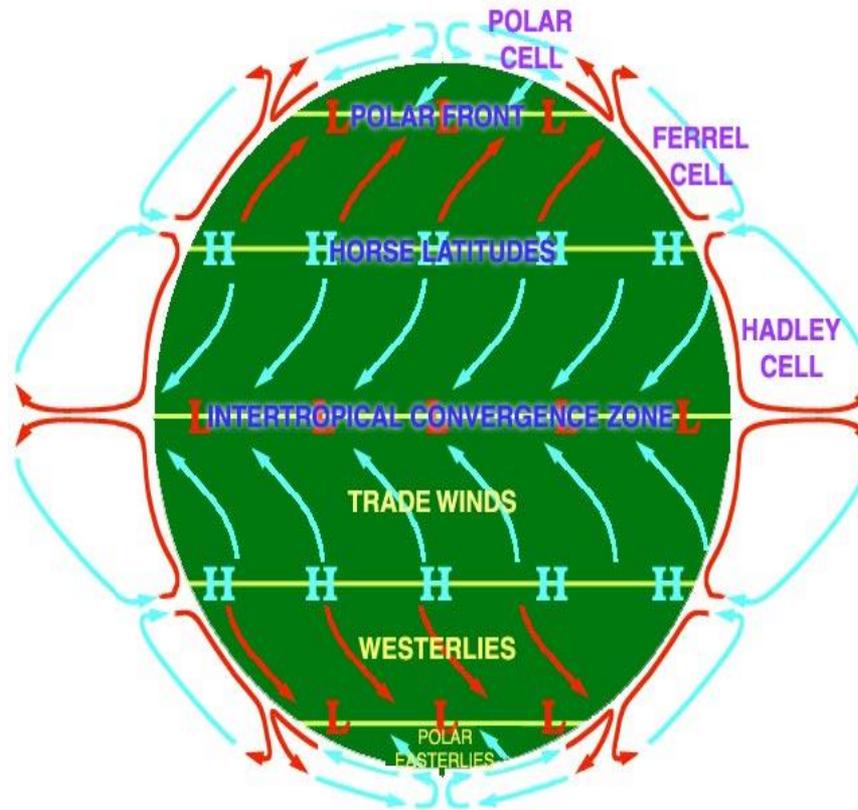
These movements, which manifest themselves in the form of winds, constitute the general circulation of the atmosphere.



General Atmospheric Circulation

Large-Scale Movements

The general circulation of the atmosphere is divided into three cells in each hemisphere.

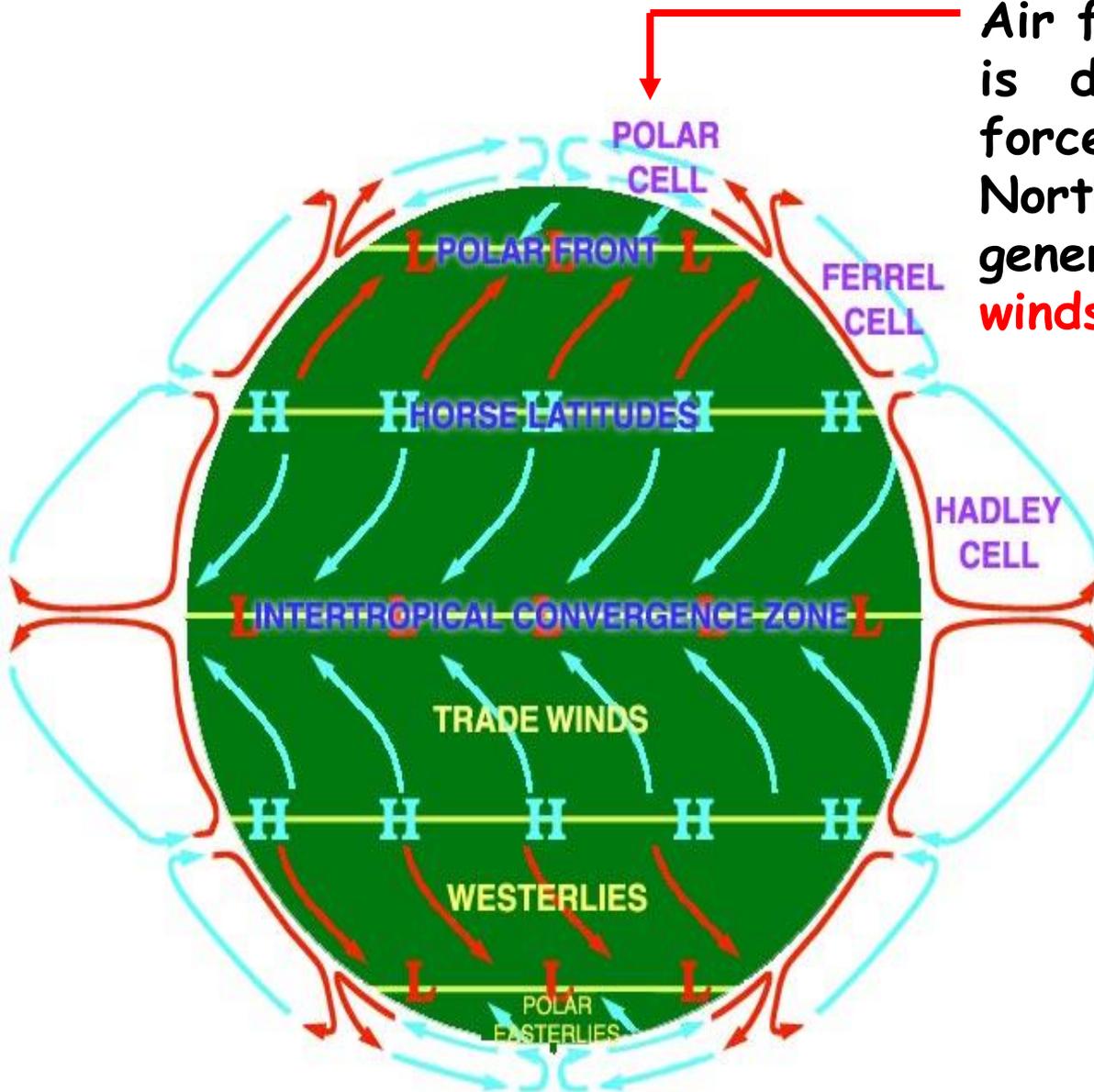


a. Planetary Winds at Low Altitude

1. Trade
2. WindsWesterlies
3. Polar Winds

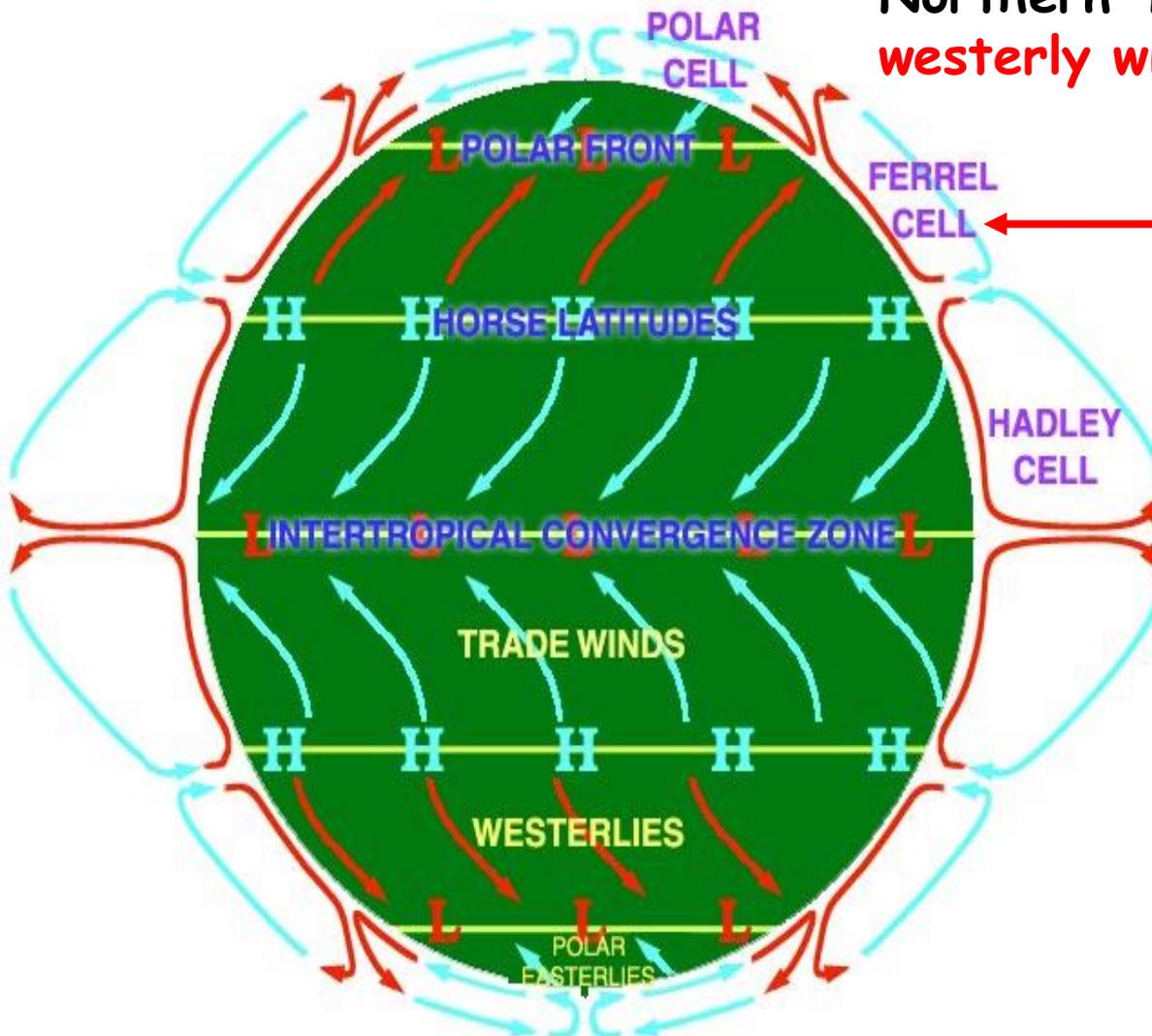
The Polar Cell:

Air flowing away from the poles is deflected by the Coriolis force toward the right in the Northern Hemisphere. This generates the polar easterly winds.



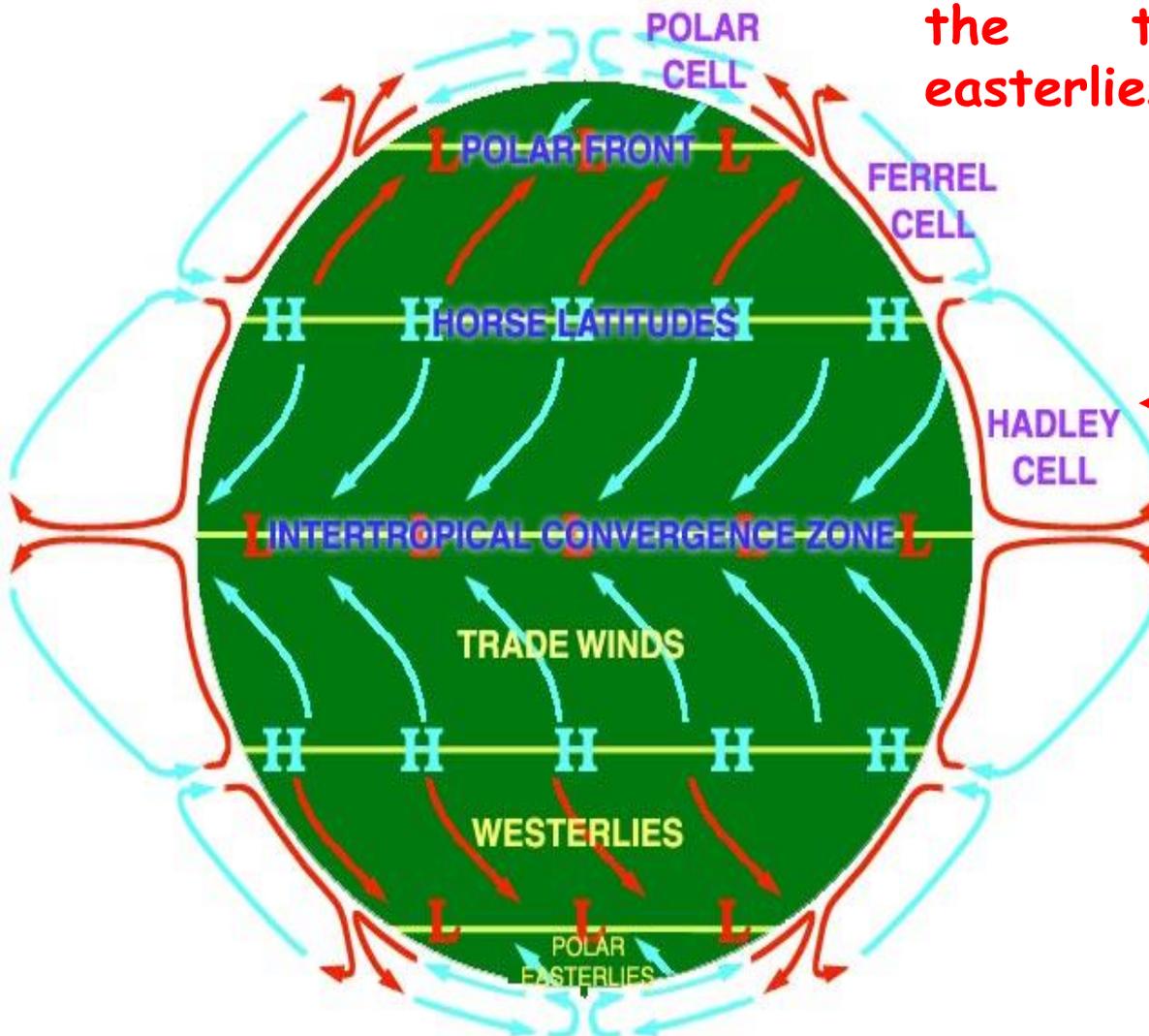
The Ferrel (or Temperate) Cell

Air moving from latitudes around 60° toward latitudes around 30° is deflected to the right in the Northern Hemisphere, producing the westerly winds

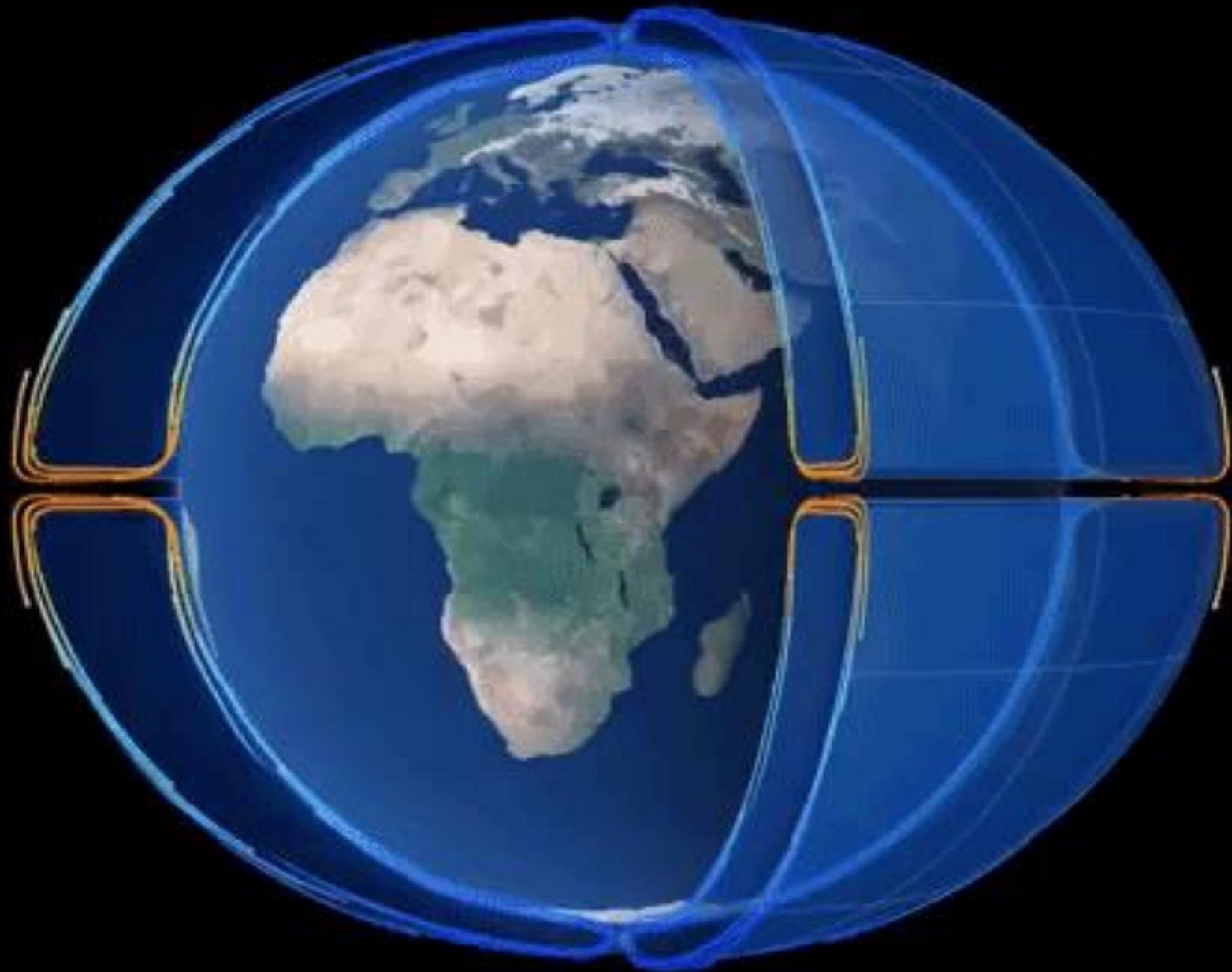


The Hadley (or Equatorial) Cell

Air moving from latitudes around 30° toward the Equator generates, near the surface, winds known as **the trade winds (tropical easterlies)**.



esa



b. Planetary Winds at High Altitude

- Westerly Currents
- Easterly Currents
- Jet Streams

Westerly Currents → These airflows move from west to east at an altitude of about 5,000 meters, and their speed increases progressively with height

Easterly Currents → These winds blow from east to west in the region between the Tropic of Cancer and the Tropic of Capricorn.

Jet Streams → These extremely rapid air currents travel thousands of kilometers with speeds reaching approximately 500 km/h. Their trajectory is sinusoidal.

Mesoscale Movements

1. Monsoons
2. Cyclones

✓ Monsoons

These are seasonal winds characteristic of Asian regions. During summer, they blow from the sea toward the coast, and the reverse occurs in winter. They bring heavy rainfall.

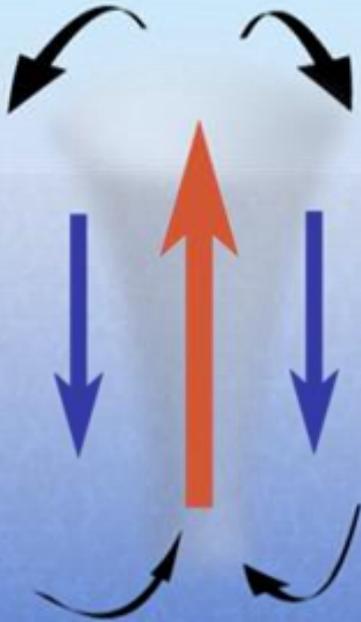
✓ Cyclones

These are strong atmospheric disturbances generated by **frontal** systems.

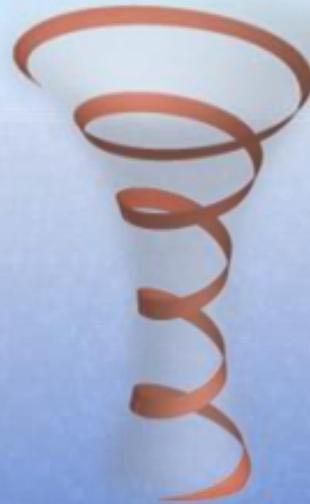
A meteorological front is an extensive discontinuity surface that separates two air masses with different physical properties (e.g., temperature, humidity, pressure).

In the Philippines they are called **typhoons**, and in the Gulf of Mexico they are known as **hurricanes**..

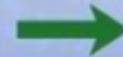
Cyclone formation



Hot and moist air
raise up ,
while cold air fall on
the edges

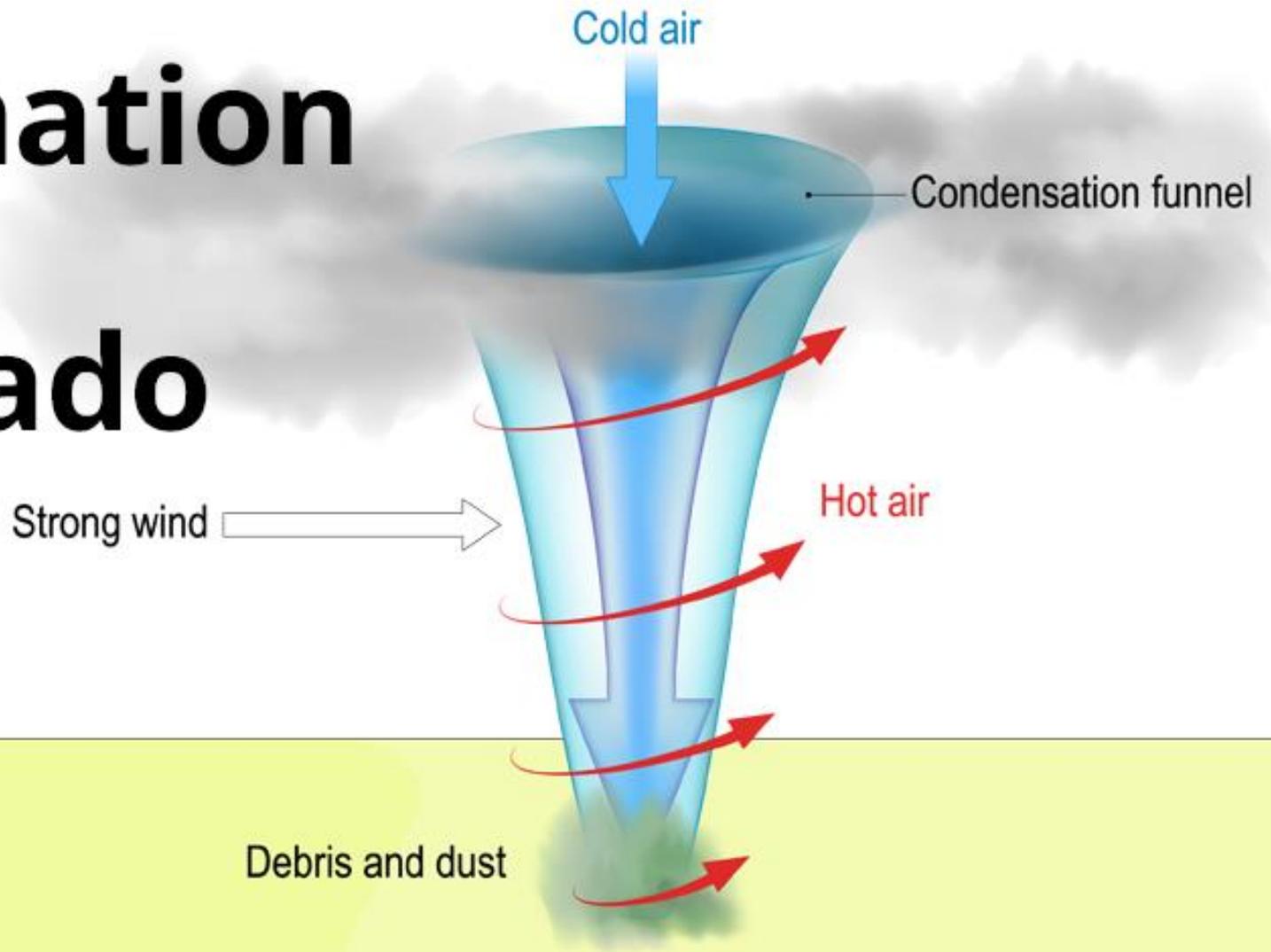


Because of the
terrestrial rotation,
the moist air turn
around to the top



The mix of the two
phenomena form the
Cyclone

Formation of a Tornado



CYCLONE

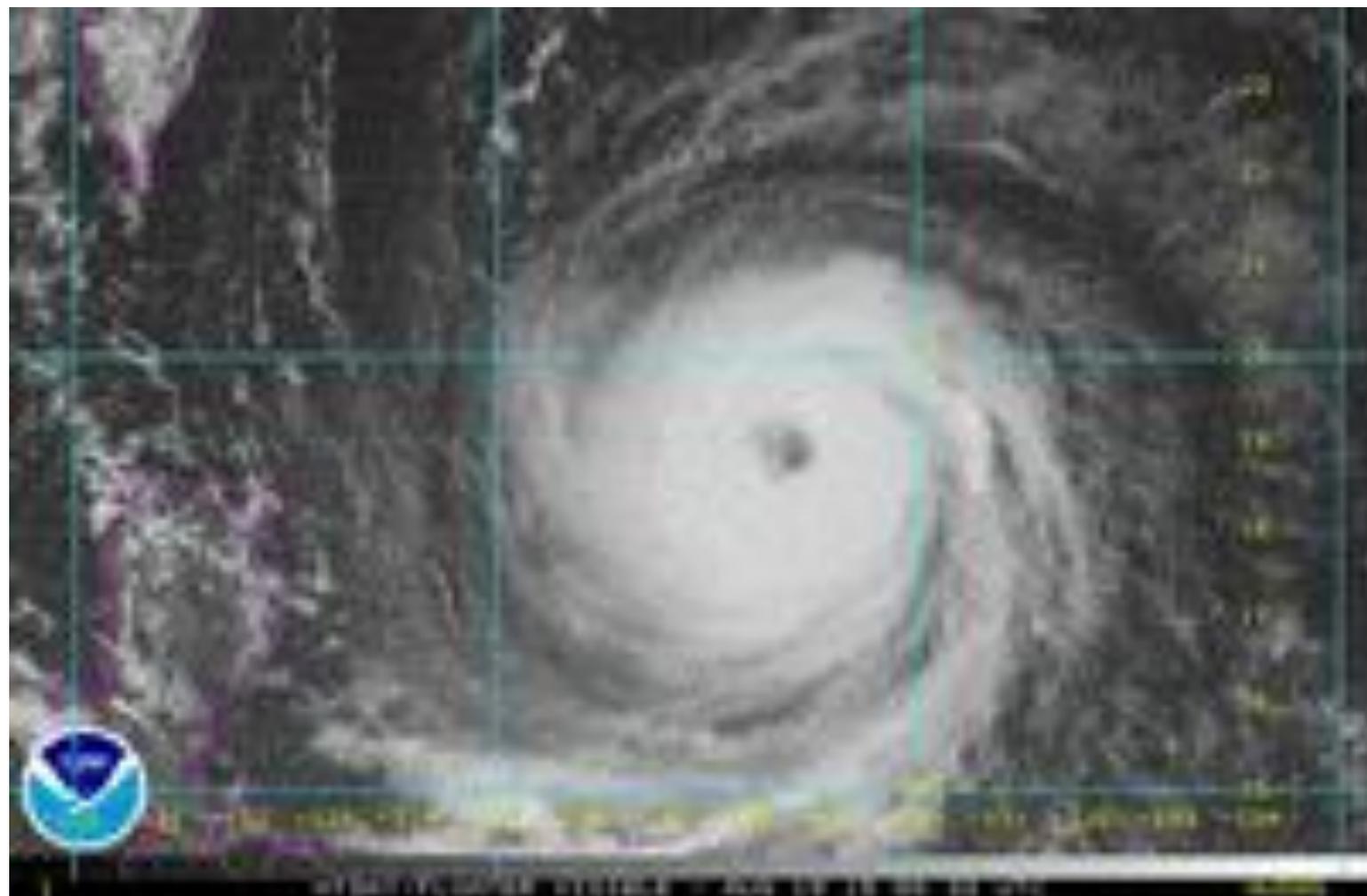


- Large-scale system of rotating winds around a low-pressure center
- Hundreds to thousands of kilometers in diameter
- Days to weeks
- Formed over warm ocean waters
- Moderate to very strong (up to 300 km/h in extreme cases)
- Large, widespread damage over hundreds of km

TORNADO



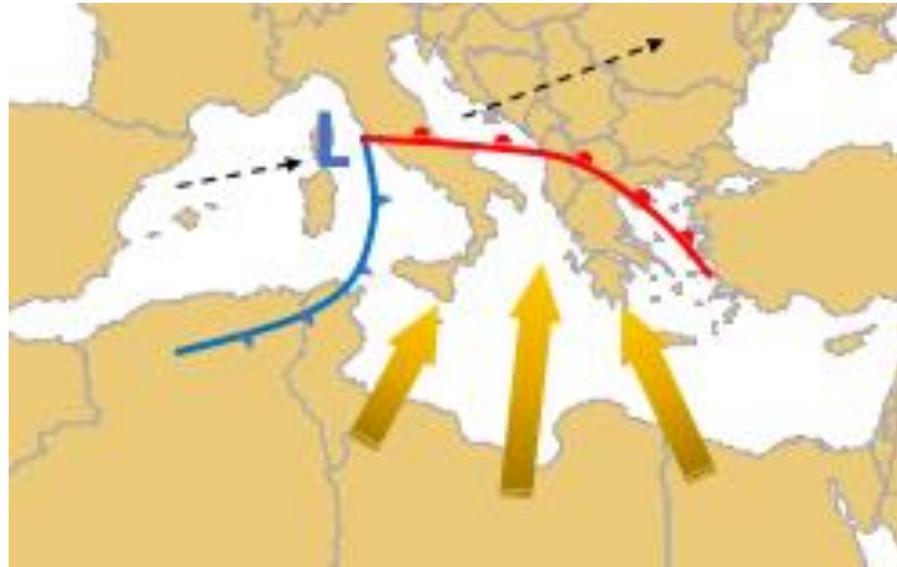
- Small-scale, violently rotating column of air in contact with the ground and a cloud base
- Tens to hundreds of meters in diameter (much smaller)
- Minutes to a few hours (usually very short-lived)
- Formed over land, usually associated with severe thunderstorms or supercells
- Extremely high locally (can exceed 500 km/h)



Small-Scale Movements

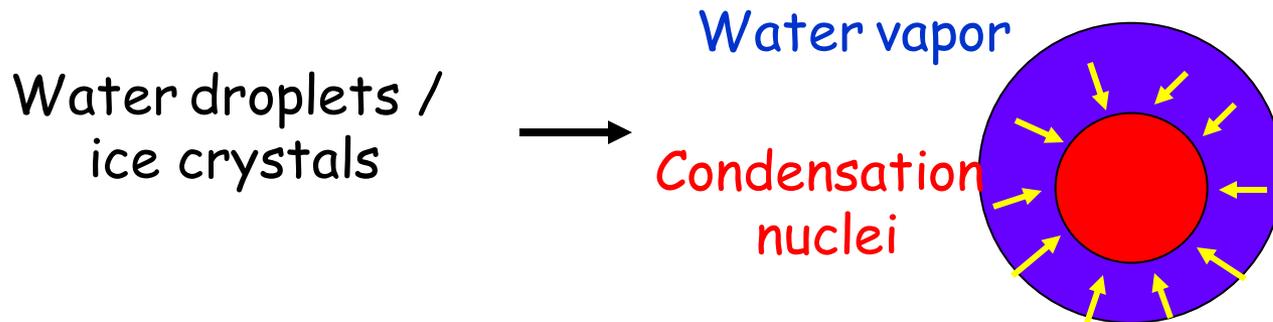
- ✓ Foehn Wind
- ✓ Sea and Land Breezes
- ✓ **Sirocco**

Sirocco : It originates from the south-east and from the Sahara. It is a very hot and dry wind when it blows over Africa, but it can become humid as it crosses the Mediterranean Sea, bringing rainfall.



Cloudiness:

Clouds are formed of very small water droplets or ice crystals (1 to 100 μm in diameter), produced by the condensation of atmospheric water vapor around tiny impurities known as condensation nuclei (such as pollen grains, pollutants, etc.).



A cloud is characterized by:

- ✓ Shape
- ✓ Texture
- ✓ Opacity
- ✓ Color

Cloud types

Vary depending on their constituents and atmospheric conditions.

Three families:

Cirrus
(hair-like streaks)

Cumulus
(heaps or clusters)

Stratus
(layers)

Cirrus
(hair-like streaks)



Cumulus
(heaps or clusters)



Stratus
(layers)



Cirrus

Cumulus

Stratus

Clouds are **classified** into ten different genera:

- ✓ Cirrus
- ✓ Cirrostratus
- ✓ Cirrocumulus
- ✓ Altostratus
- ✓ Alto cumulus
- ✓ Stratocumulus
- ✓ Stratus
- ✓ Nimbostratus
- ✓ Cumulonimbus
- ✓ Cumulus

takes into account the cloud **shape** and **altitude**.

The names of clouds are derived from three aspects:

- Their shape,

with three fundamental forms:

Cumulus clouds (heap of droplets) **Stratus** clouds (stratified, layered) **Cirrus clouds** (hair-like streaks)

The altitude at which the cloud base forms:

- High clouds (above 6000 m); designated by "**Cirrus**" or the prefix "**Cirro**"
- "Mid-level clouds (2000 - 6000 m); designated by the prefix "**Alto**-"
- Low clouds (below 2000 m); no prefix

Their ability to produce precipitation:

Precipitation-producing clouds carry the prefix "**Nimbo**-"

10 genres de nuages

12km

11km

Cirrus
6000 à 12000 m

10km

Cirrostratus 6000 à 10000 m
avec halo et parhélie

9km

Cumulonimbus
Sommet 12000 à 18000 m
base 500 à 2000 m

8km

Cirrocumulus
6000 à 10000 m

7km

6km

5km

Altostratus
2000 à 5000 m

Alto cumulus
2000 à 5000 m

4km

3km

Nimbostratus
500 à 2000 m

2km

Stratocumulus
500 à 2000 m

Cumulus
500 à 2000 m

1km

Stratus 0 à 1000 m



Kelvin-Helmholtz phenomenon (**Fluctus, Asperatus clouds**)

Their origin comes from a variation in **speed and density** between two superimposed air layers.

They form when the wind at higher altitude is faster than the wind within the cloud. This difference in speed creates shear, shaping the cloud into a series of small successive vortices.



Bioclimatic Syntheses

Bioclimatic Syntheses

Due to the spatio-temporal variability of climatic parameters and the need to describe, classify, and compare climate and vegetation types across the world,

- ✓ Numerical syntheses
- ✓ Graphical syntheses
- ✓ Chromatic syntheses

Numerous authors have proposed various approaches, including:

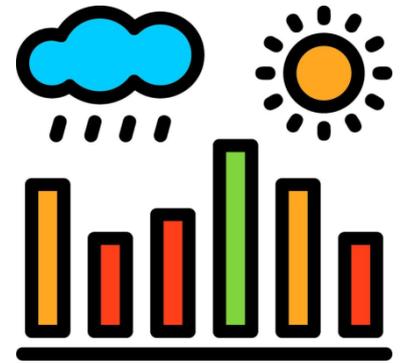
I. Numerical Syntheses

(Climatic indices)

These are based on the calculation of indices

a combination of at least two numerical values describing the state of the atmosphere, used to characterize the climate of a given location for the purpose of large-scale (global) classification.

They make it possible to:



- ✓ Classify and map climates (e.g., De Martonne index, Gaussen and Bagnouls index, Emberger index).
- ✓ Explain the biological distribution of species.
- ✓ Define the boundaries of distribution areas (biotic-climatic factor).

I.1. De Martonne Aridity Index

This index is used to characterize the **evaporative power** of the air based on temperature.

✚ **At the annual scale:**

$$I = \frac{P \text{ (mm)}}{T \text{ (}^\circ\text{C)} + 10}$$

← **At the annual scale:**

P : Σ sum of annual precipitation (mm)
 T : mean annual temperature

- ✓ Aridity increases as the value of the index decreases.
- ✓ Low aridity corresponds to abundant rainfall and/or low temperatures.

$$I = \frac{P \text{ (mm)}}{T \text{ (}^\circ\text{C)} + \underline{10}}$$



To avoid negative index values,

the expression is essentially empirical.



Application :

Question: Calculate the De Martonne aridity index for Skikda.

Tableau 1 : Climatic data for Skikda region (1971-2006)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
P(mm)	120	90	95	80	70	50	40	35	60	100	115	101.1
T(C°)	12	13	15	18	21	25	28	28	24	20	16	14

Calculation of the index:

$$I = \frac{P \text{ (mm)}}{T \text{ (°C)} + 10}$$

$$\left. \begin{array}{l} P = 1056,01 \\ T = 17.96 \end{array} \right\} \begin{array}{l} I = 1056.01/(17.96+10) \\ I = 37.76 \end{array}$$

De Martonne proposed six major climate types based on the values of the annual index:

I < 20: risk of drought

I Value	Aridity type	Signification
< 5	absolute Aridity (Hyper aride)	Desert without cultivation (e.g., Tanezrouft region)
5-10	Desert (aride)	Desert and steppes: no cultivation without irrigation (e.g., Sahara, Arizona)
10-20	Semi-aride	Herbaceous formations, steppes, or savannas: irrigation required for crops needing moisture (e.g., Sahel)
20-30	Sub-humide	Natural prairie: irrigation not necessary
30-40	Humide	Trees increasingly important in the landscape (e.g., Mediterranean region)
> 40	Per-Humide	Forest everywhere: cereal crops tend to be replaced by pastures

✚ At the monthly scale:

For a given month characterized by mean precipitation and temperature p and t , the aridity index is calculated using the formula below.

$$I = \frac{12 p \text{ (mm)}}{t \text{ (}^\circ\text{C)} + 10} \quad \longleftarrow \text{ Monthly index}$$

p : Σ of monthly precipitation.

t : mean monthly temperature.

Note: Precipitation is multiplied by 12 in order to obtain an index value comparable to that of the annual index.

This index is particularly useful at the local scale for characterizing a specific year in relation to a 10-year (or longer) average.

I.2. Emberger's Rainfall Quotient:

The Emberger index defines **the degree of climatic humidity**.

It takes into account:

- The mean of the maximum temperatures of the hottest month (**M**)
- Annual precipitation (**P**)
- The mean of the minimum temperatures of the coldest month (**m**)

This index is particularly suited **to Mediterranean regions**, where it allows the distinction of **different climatic belts**.

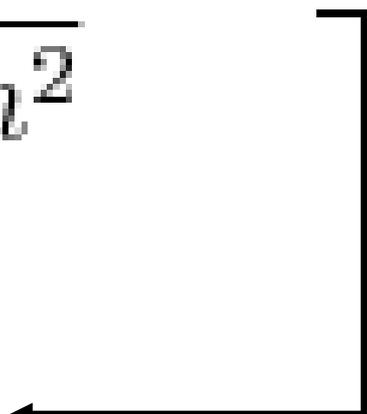
In these regions, Emberger noted that the thermal amplitude ($M - m$), and therefore evaporation, is an important factor in the distribution of vegetation.

Evaporation increases as the thermal amplitude becomes larger.

The precipitation factor considered is the product of the number of rainy days per year (n) and the annual mean precipitation (P).

$$Q_E = \left[\frac{n P}{365 (M + m) (M - m)} \right] \times 100$$

If the number of rainy days is unknown, the following simplified formula has been proposed:

$$Q = \frac{2000P}{M^2 - m^2}$$
$$Q2 = \frac{3,43P}{M - m}$$


M: mean of the maximum temperatures of the hottest month (°K)

P: sum of mean precipitation values

m: mean of the minimum temperatures of the coldest month (°K)

Application :

Question: Calculate the Emberger Quotient (QE) for the Oum El Bouaghi region (1996-2006).

Oum El Bouaghi: Table of "P" (1996-2006)

JAN	FEV	MAR	AVR	MAI	JUN	JUL	AOU	SEP	OCT	NOV	DEC
73,81	55,87	53,94	47,94	41,40	18,33	6,52	10,38	32,03	38,10	55,90	88,94

Mean of "m" (1996-2006)

JAN	FEV	MAR	AVR	MAI	JUN	JUL	AOU	SEP	OCT	NOV	DEC
2,38	2,75	4,78	6,96	11,01	15,48	18,33	18,67	15,5	11,60	7,22	3,87

Mean of "M" (1996-2006)

JAN	FEV	MAR	AVR	MAI	JUN	JUL	AOU	SEP	OCT	NOV	DEC
11,65	13,05	15,80	19,00	24,52	30,4	34,18	33,90	28,86	23,78	17,08	12,71

Question: Calculate the Emberger Quotient (QE) for the Oum El Bouaghi region (1996-2006).

$$Q = \frac{2000P}{M^2 - m^2}$$

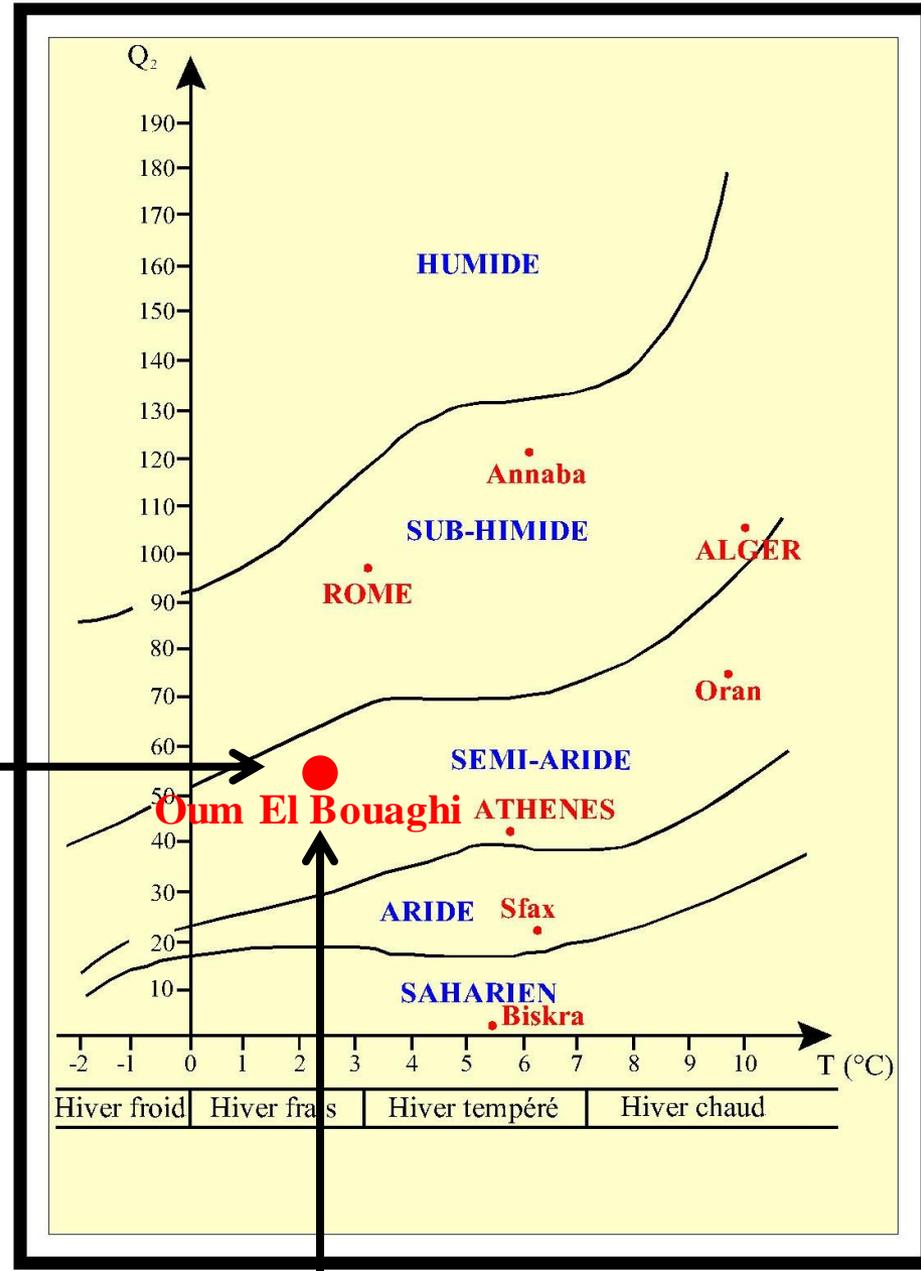
$$Q = 2000 * 523.16 / ((34.18 + 273)^2 - (2.38 + 273)^2)$$

$$Q = 56.48$$

The interpretation of the quotient is performed using the diagram called the **Emberger Climagram**.

Oum El Bouaghi is characterized by a **semi-arid climate with cool winters**.

$$Q_E = 56.48$$



$$m = 2,38$$