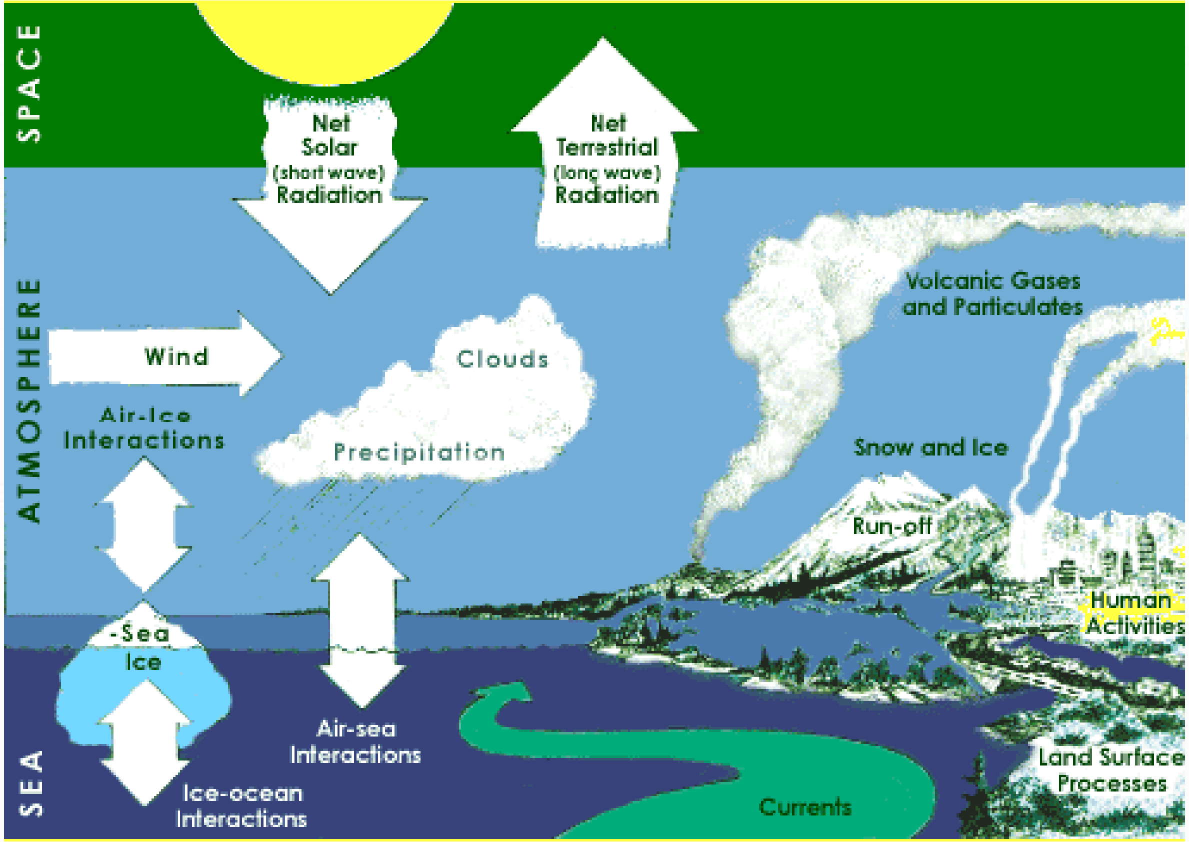
ELEMENTS OF THE CLIMATE

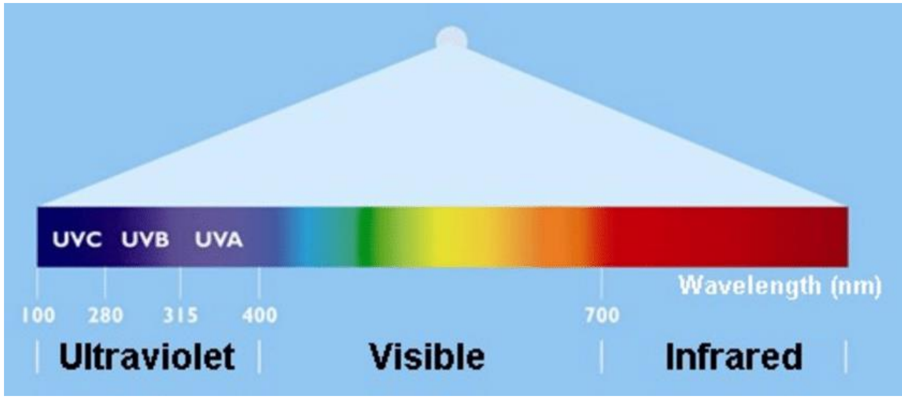


Light as a Climatic Element

1. Definition

Light, in the bioclimatological sense, refers to the **portion of solar radiation that is visible and usable by living organisms**, particularly plants. It is a fundamental **abiotic factor** influencing both climate dynamics and biological processes

Solar radiation reaching the Earth's surface consists of different components **ultraviolet (UV)**, **visible**, and **infrared (IR)** radiation which together shape the energy balance of ecosystems and control the biosphere's functioning.



In ecology, the term **photoclimate** designates the set of light conditions prevailing in a given habitat, characterized by intensity, spectral composition, and duration of illumination.

2. Characteristics of Light

a. Intensity (Illuminance or Irradiance)

Light intensity expresses the **amount of radiant energy** received on a surface per unit area and per unit time.

- **Irradiance** (physical measurement) is expressed in **watts per square meter ($W \cdot m^{-2}$)**.
- **Illuminance** (perceived brightness, relevant to human vision) is measured in **lux (lx)**,

•For biological studies, particularly plant ecology, the **photosynthetically active radiation (PAR)** is often used, corresponding to wavelengths between **400 and 700 nm** the spectral band effectively used in photosynthesis.

Light intensity decreases with latitude, season, altitude, cloud cover, and soil cover structure.

b. Quality (Spectral Composition)

Light quality refers to the **distribution of wavelengths** within the received radiation.

•**The visible spectrum** (400–700 nm) includes **blue (≈450 nm)**, **green (≈550 nm)**, and **red (≈660 nm)** light, each having different physiological effects on plants.

• **UV radiation** (280–400 nm), though limited in intensity, affects epidermal pigmentation, DNA stability, and secondary metabolite synthesis.

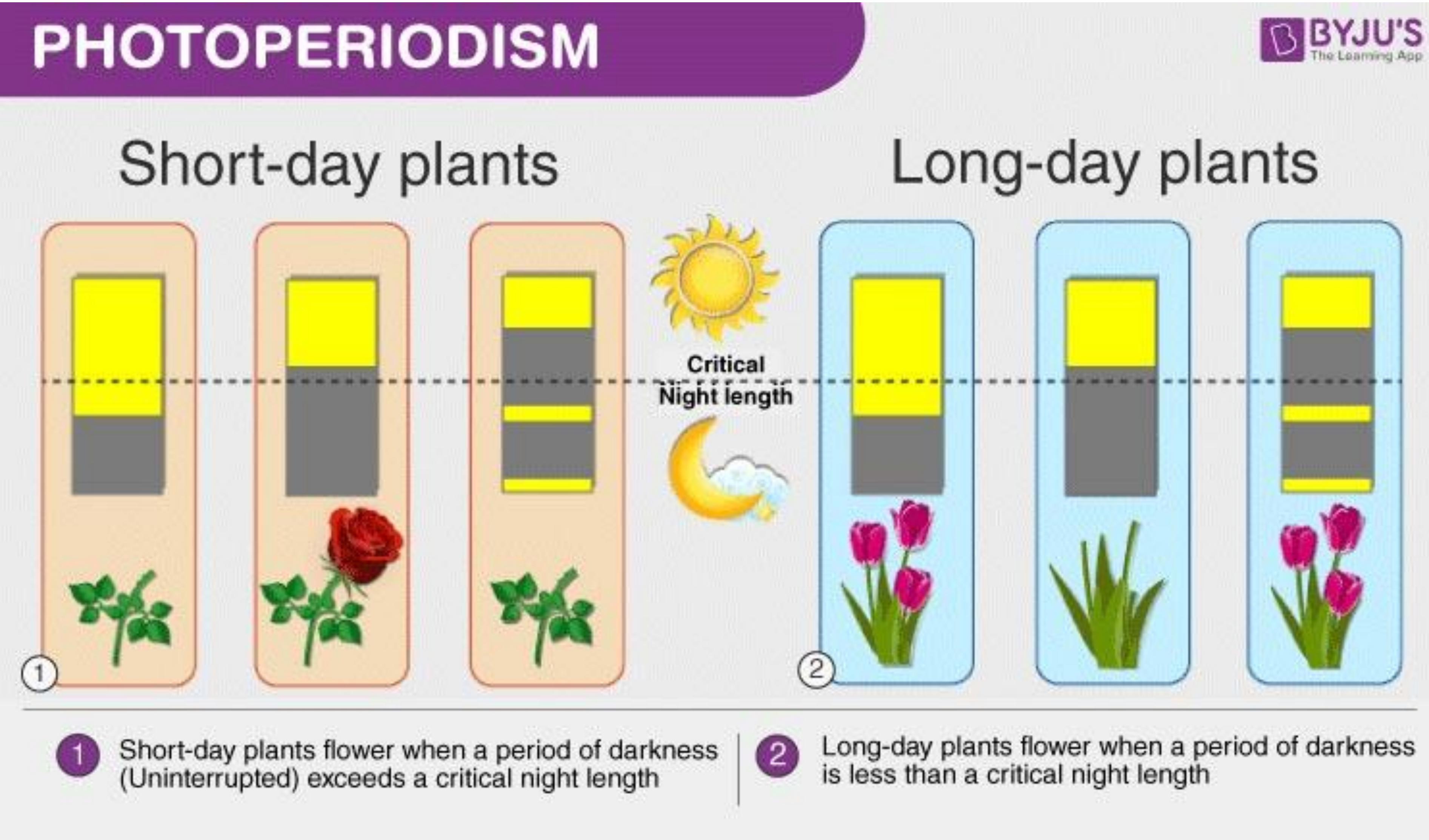
c. Duration (Photoperiod)

The **duration of daily illumination** or **photoperiod** varies with latitude and season.

Photoperiodism is a major adaptive mechanism regulating:

- **Flowering and reproductive cycles** in plants (long-day vs. short-day species);
- **Behavioral and physiological rhythms** in animals (migration, reproduction, diapause);
- **Metabolic and circadian rhythms** in both plants and animals.

The **annual and diurnal variation** in photoperiod defines much of the temporal structure of ecosystems.


PHOTOPERIODISM
BYJU'S
The Learning App
Short-day plants
Long-day plants
Critical
Night length
1
2
1 Short-day plants flower when a period of darkness (Uninterrupted) exceeds a critical night length
2 Long-day plants flower when a period of darkness is less than a critical night length

Pyranometer

Quantum sensor / PAR meter

Luxmeter

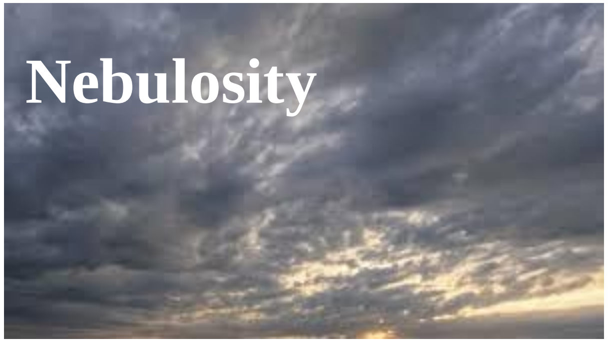
Spectroradiometer

4. Effects of Light on Climate

Light influences the **thermal regime** of the Earth's surface:

- The **absorption of shortwave radiation** drives the heating of the surface and the lower atmosphere.
- Variations in **albedo** (reflectivity of surfaces such as snow, vegetation, or soil) determine how much radiation is absorbed versus reflected.
- Light availability affects **evapotranspiration, air temperature gradients**, and **microclimatic conditions** within ecosystems.

Thus, the spatial and temporal distribution of light is a key determinant of **local and regional climates**



1. Definition

Nebulosity (or **cloudiness**) refers to the **fraction of the sky covered by clouds** at a given time or averaged over a specific period.

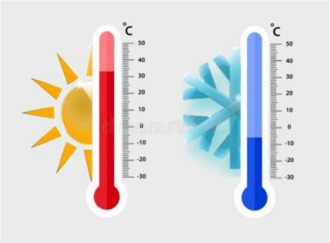
In meteorological terms, nebulosity represents the **degree of cloud cover** observed in the sky vault, expressed either in **oktas** (eighths of sky cover) or as a **percentage.**

It provides a measure of the **cloud fraction** that modulates the amount of solar and terrestrial radiation reaching or leaving the Earth's surface.

Nebulosity depends on **atmospheric moisture**, **air mass dynamics**, and **topographic factors**, and plays a major role in determining **local and regional climates**.

Observations are made either **visually** by trained meteorological observers or **automatically** by **ceilometers**, **nephelometers**, and **satellite sensors**.

Air Temperature



Definition:

Air temperature represents the **degree of heat or cold** prevailing at a given location or within a given layer of the atmosphere.

It is a **fundamental climatic parameter**, as it determines the **thermal state of the atmosphere** and influences numerous **physical, chemical, and biological processes** occurring at the Earth's surface.

Air temperature governs all **physiological activities** and **biochemical reactions** in living organisms:

- Reactivation of the cambium in woody plants,
- Breaking of dormancy in buds or seeds,
- Inhibition or activation of photosynthesis, respiration, and enzyme activity

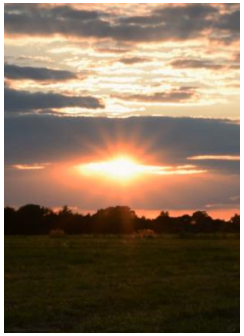
Air temperature depends on several interacting climatic and atmospheric factors, including:

- Solar Radiation
- Atmospheric Pressure
- Composition of the Atmosphere

In a **meteorological station**, air temperature is measured using **thermometers**.

Most stations are equipped with both a minimum thermometer and a maximum thermometer in order to record the daily thermal range.

The **minimum temperature (T min)** generally occurs **around sunrise**, or approximately **half an hour after sunrise**, when nocturnal radiative cooling is at its maximum.



The **maximum temperature (Tmax)** typically occurs about two hours after solar noon, once solar radiation has reached its peak and heating of the air near the surface has continued for some time.

Air temperature is expressed in **degrees Celsius (°C)** or **degrees Fahrenheit (°F)**, depending on the measurement system used.

$$^{\circ}F = (1{,}8 \times {}^{\circ}C) + 32$$

$$^{\circ}C = 0.56 \times ({}^{\circ}F - 32)$$

Numerous factors influence the **diurnal variation of air temperature**, including:

- **Nebulosity (cloud cover):** Clouds reduce daytime heating
- **Altitude:** Temperature generally decreases with increasing elevation
- **Latitude:** controlling the amount of received solar energy
- **Season:** the **solar declination** modify both the intensity and duration of insolation
- **Soil properties:** The **nature and color of the soil**, its **moisture content**, and **thermal conductivity** influence the absorption and release of heat.
- **Relief characteristics:** The **shape**, **exposure**, and **orientation** of slopes affect local radiation balance
- **Atmospheric conditions:** The presence of **wind**, **humidity**, and **aerosols** modulates heat exchange between the surface and the atmosphere.

Precipitation

Definition:

Precipitation refers to **all forms of water**, either **liquid or solid,** present in the atmosphere and **deposited onto the Earth's surface**.

It is one of the principal **hydrometeors**, alongside cloud droplets and fog, and plays a central role in the **hydrological cycle**.

The most common forms of precipitation are **rain**, **snow**, and **hail**.

At any given **temperature**, a specific quantity of **water vapor** corresponds to the **maximum amount of moisture** that the air can hold in a state of equilibrium.

When air cools, its capacity to retain water vapor decreases, leading to an **increase in relative humidity**.

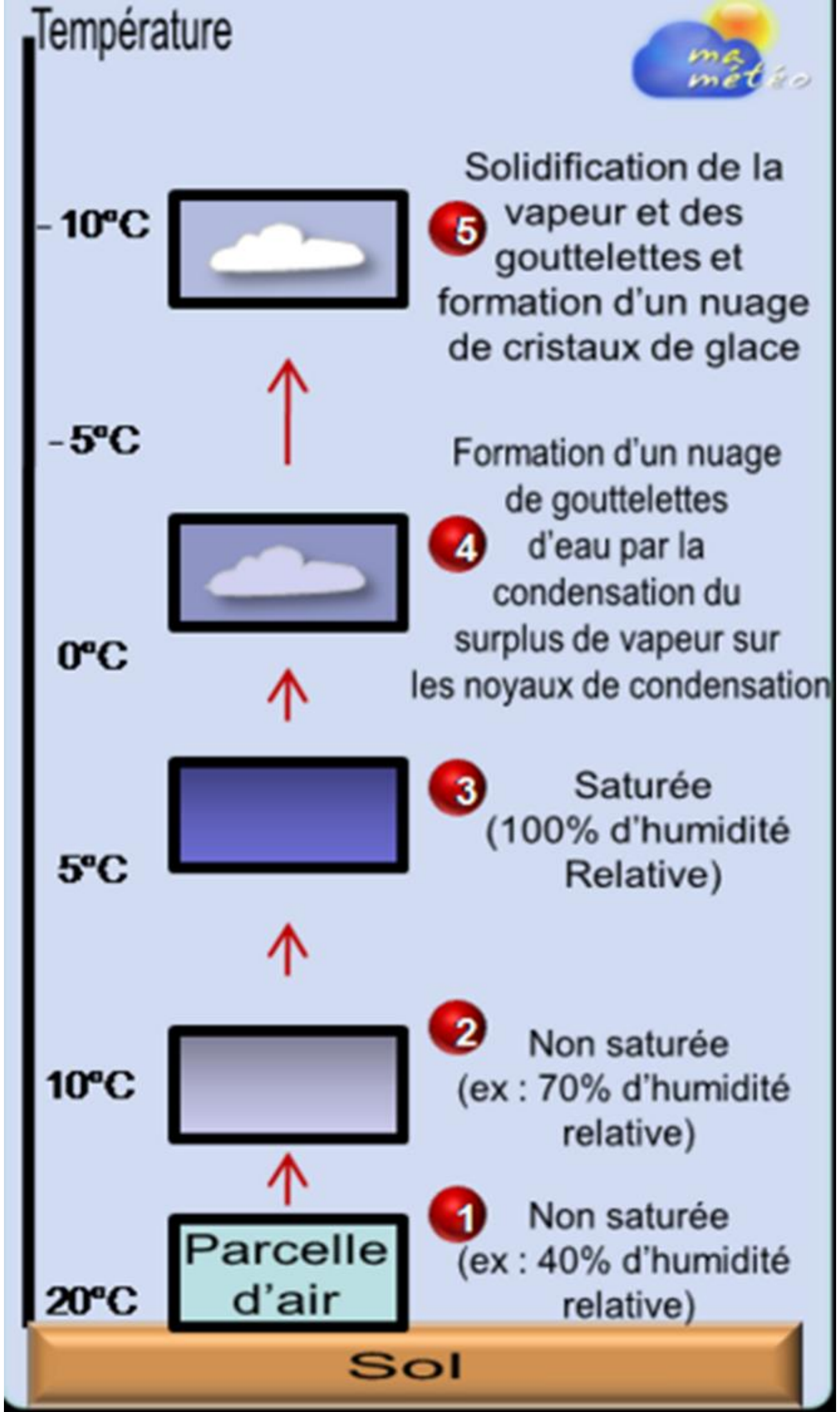
As the air continues to rise and cool, **humidity approaches saturation,** and **condensation** occurs, forming clouds and, under suitable conditions, precipitation

Genesis and Nature of Precipitation

For precipitation to occur, it is necessary that an air mass reaches the **state of saturation**, i.e., when the **air's water vapor content** equals the **maximum amount it can hold** at a given temperature and pressure.

Two main processes can lead an air mass to saturation:

- Cooling of the Air (Most Frequent Case)
- Addition of Water Vapor Without Temperature Change



Solidification : Formation of a cloud of ice crystals

Condensation : Formation of a cloud of water droplets

Saturated air = 100% humidity

Unsaturated air < 100% humidity

When the air is saturated with water vapor, it must eliminate the excess through **condensation**

The temperature at which condensation begins is called the:

dew point

In cold air (below 0°C), water vapor **solidifies**, either **directly** into ice or **after passing through the liquid state**.

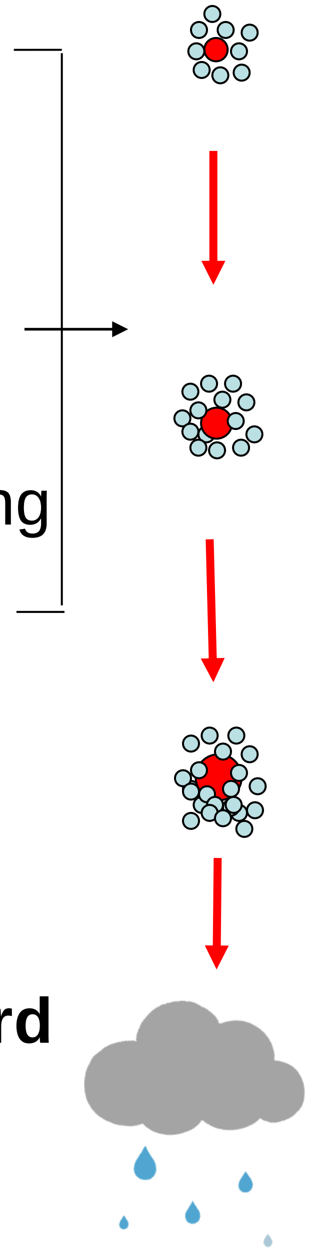
Water droplets form by the **condensation of water vapor around a condensation nucleus**,

which may originate from various sources such as **industrial smoke**, **dust particles**, and other **aerosols**

They then grow by **colliding with one another**,

Increasing in size as they encounter other droplets along their path and eventually becoming **raindrops**.

When they become sufficiently heavy, they **fall toward the ground** despite the **upward air currents**.



The formation of hailstones depends on the presence of strong upward air currents.

↓

Raindrops that begin to fall are then carried back upward into the cloud by these powerful updrafts.

↓

There, they freeze and become coated with successive layers of frozen water vapor.

As the ice crystal grows,

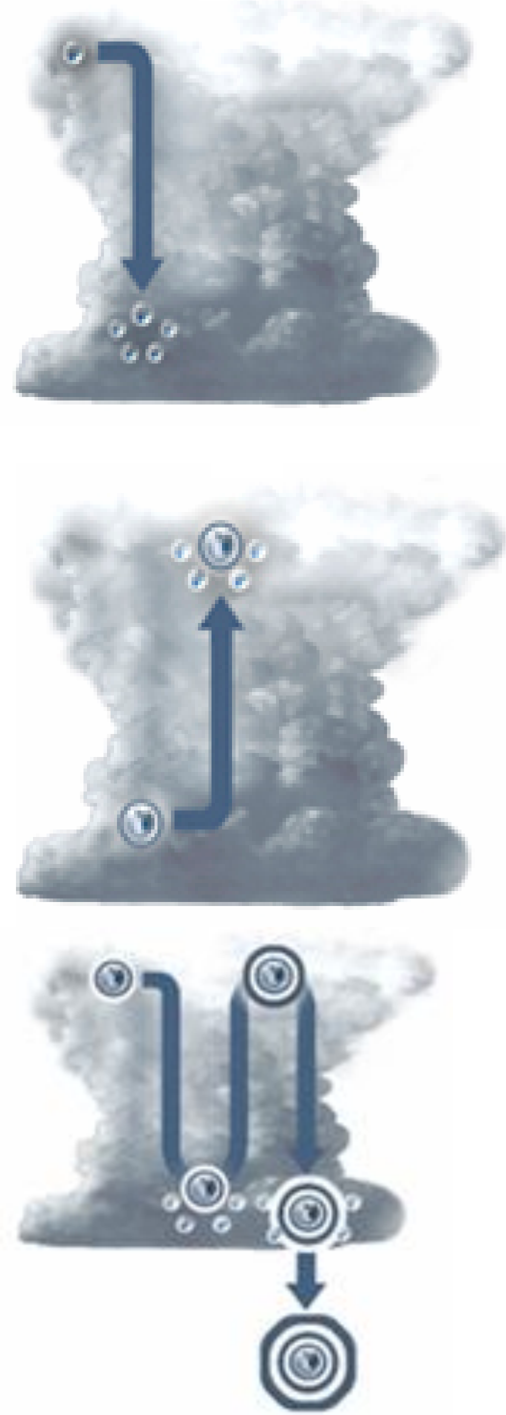
↓

its mass increases until it becomes heavy enough to overcome the ascending air movements.

It then falls toward the ground, capturing other ice crystals along its path

↓

this is the **hailstone.**



Types of Precipitation :

Precipitation can occur in **three main forms:**

- **Liquid precipitation:** rain and drizzle
- **Freezing precipitation:** freezing rain and freezing drizzle
- **Solid precipitation:** snow, sleet, and hail

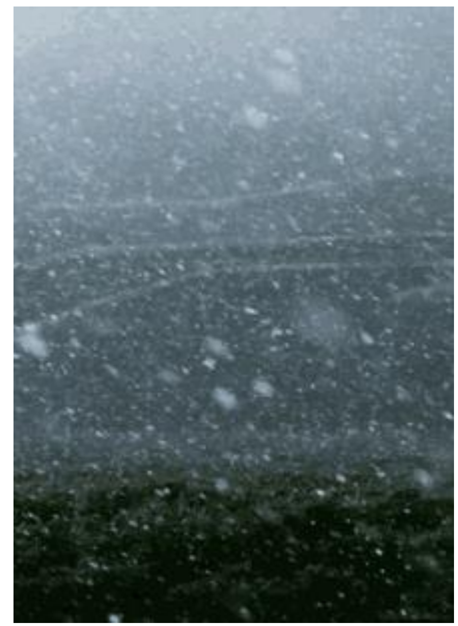
Table 1: Size of the constituent elements of different types of precipitation and the **fall velocity of water droplets** in free atmosphere at **20°C**.

Type	Drop diameter	Speed (cm/s)
Rain	0,4 mm	100
Drizzle	1 mm	403
Hail	2 mm	649
Sleet	3 mm	806
snow	4 mm	883

- → **Drizzle** (very fine, light rain composed of small water droplets)
- → **Hail** (balls or irregular lumps of ice formed in strong convective clouds, usually cumulonimbus)
- → **Sleet** (small, translucent ice pellets formed when raindrops freeze before reaching the ground)

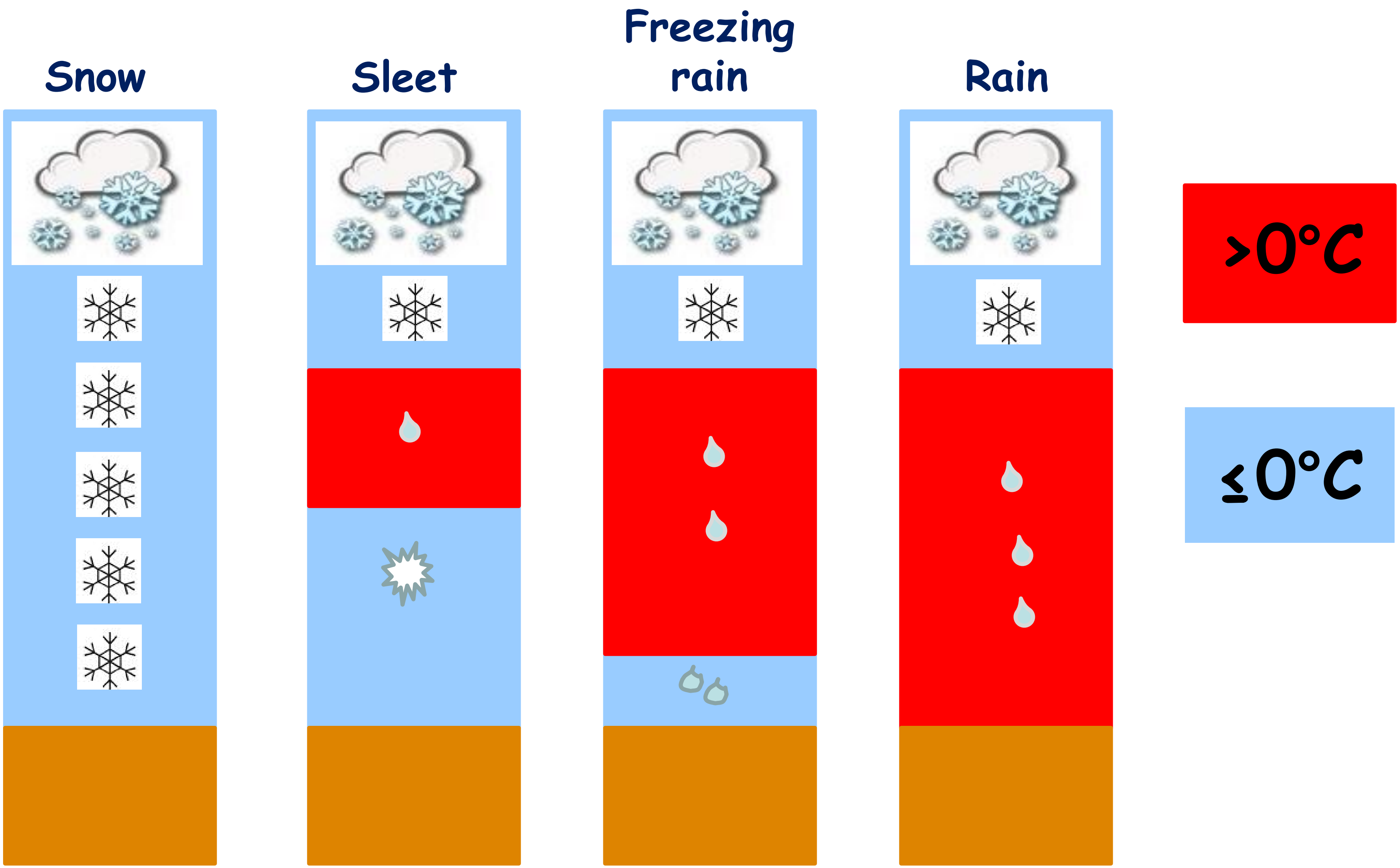
Drizzle

Hail



Sleet

A transitional phase exists between snow and freezing rain:



Sleet consists of raindrops that freeze while falling, **Hail** it is “rain that goes up” where they freeze and fall back to the ground.

Measurement of Rainfall:

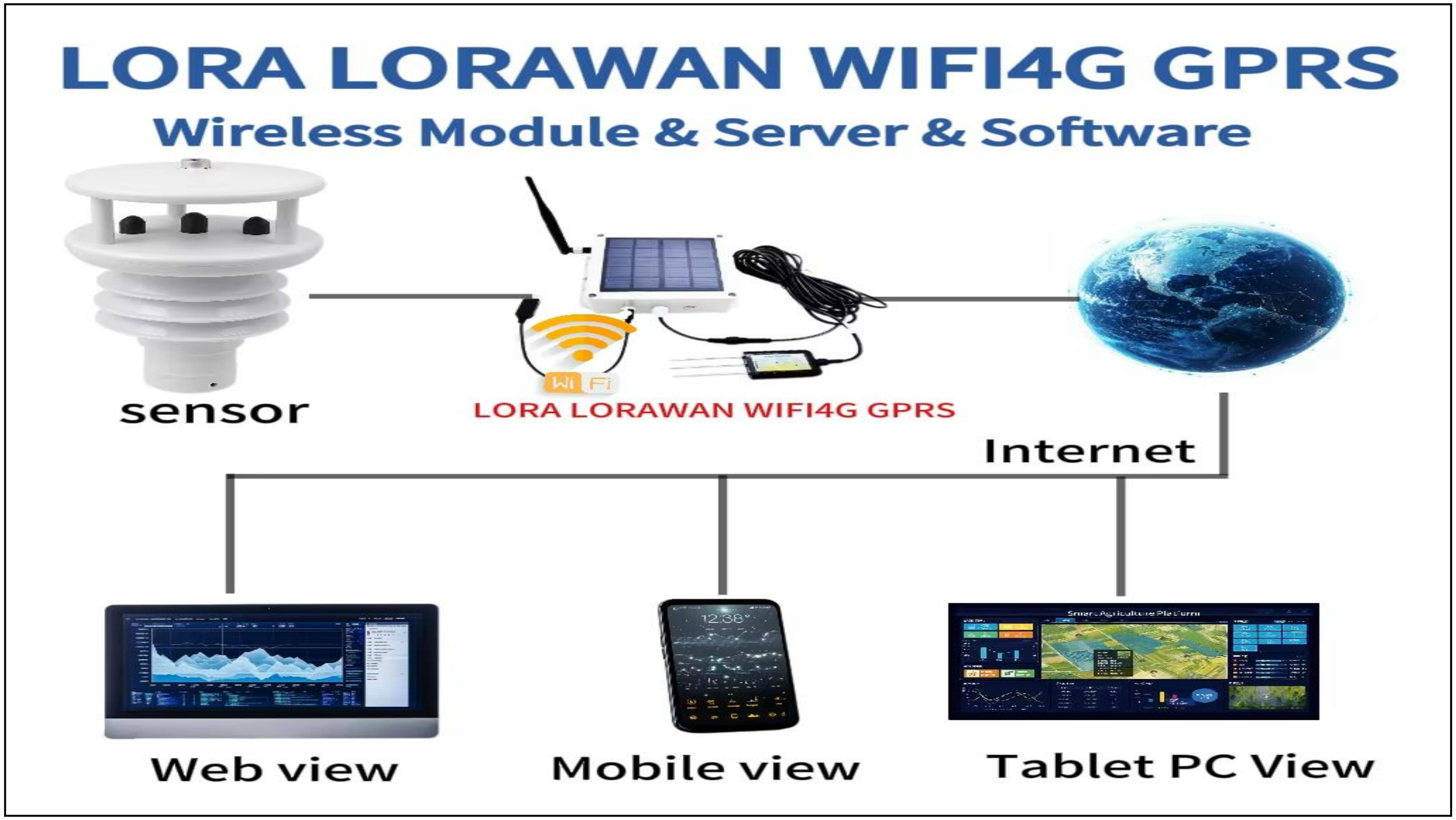
There are two main types of instruments used to measure precipitation:

- The pluviometer (rain gauge) , which records the total amount of rainfall at a given station over a specified period.

- The pluviograph (recording rain gauge), which allows for a more detailed analysis of rainfall distribution over time.

- The pluviograph is provides information on the intensity of precipitation, expressed in millimeters per hour (mm/h) or millimeters per minute (mm/min) during a rainfall event

The latest technologies for measuring rainfall include **smart rain gauges** and **advanced radar systems**, which offer real-time, automatic data collection and analysis.



Water Evaporation

- Evaporation is the physical process by which water transforms from the liquid state to the gaseous state (water vapor), occurring at the interface between water and air.

- Evaporation is a key component of the hydrological cycle, contributing to the exchange of energy and moisture between the Earth's surface and the atmosphere.

- It is strongly influenced by temperature, solar radiation, wind speed, air humidity, and the surface characteristics (such as soil type or vegetation cover).

Evaporimeter / Evaporation pan :
Measures the amount of water lost (in mm) from an open water surface over a specific period.
The measured evaporation is expressed as millimeters per day (mm/day).

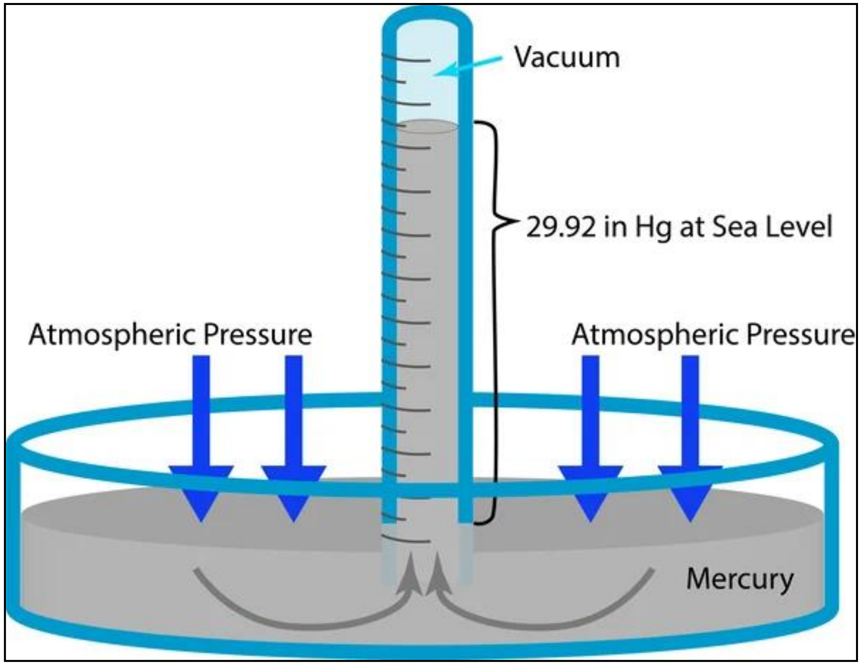
Lysimeter:

Measures the evaporation (and evapotranspiration) from a soil–vegetation system by monitoring changes in mass or water balance in a contained soil volume.

What Is Air Pressure ?

Air pressure is the force exerted by the weight of air molecules on a surface. It is measured using barometers and varies based on factors like the number of air molecules and temperature.

The **mercury barometer** was the earliest instrument, providing accurate but stationary readings.



In modern **bioclimatology and meteorology**, **hectopascal (hPa)** is the **standard unit** used to express air pressure.

Recent advancements employ digital barometers and electronic pressure sensors

Wind:

Definition:

A difference in pressure between two neighboring areas. ← Restoring equilibrium

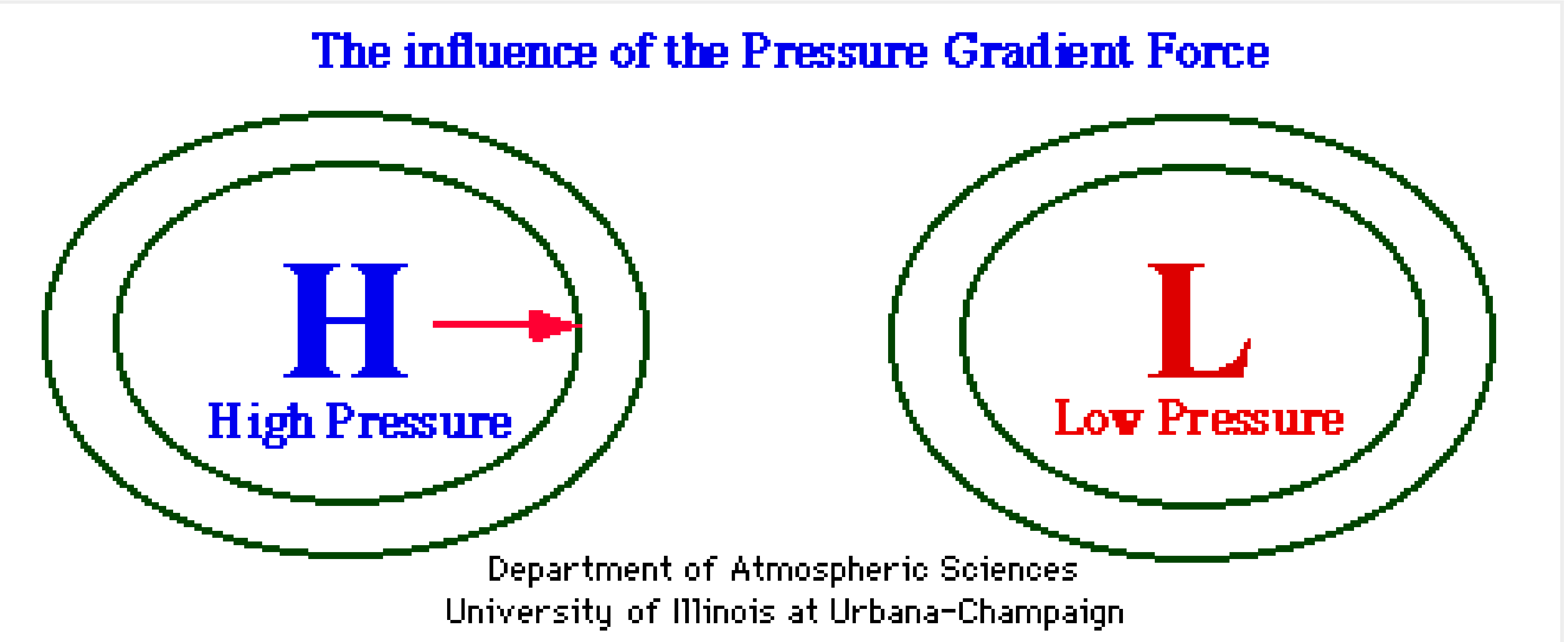
Air movement

Anticyclones release air Vs Depressions are filled.

High-pressure zones Vs Low-pressure zones

H : anticyclone

L : depression


The influence of the Pressure Gradient Force
H
High Pressure
L
Low Pressure
Department of Atmospheric Sciences
University of Illinois at Urbana-Champaign

Measurement of Wind Speed and Direction:

Wind is characterized by its **speed** and **direction**.

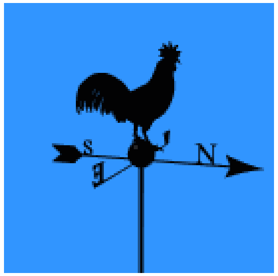
Speed is commonly expressed in knots

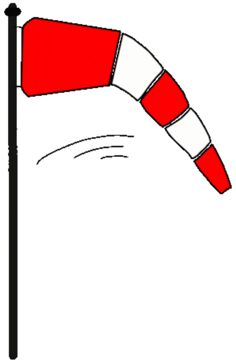
- ✓ (m/s), (km/h),
- ✓1 knot = 1 nautical mile per hour
- ✓1 nautical mile = 1,852 meters/hour = 0.514 m/s

Anemometer.

Direction refers to the origin or source of the wind

- ✓Degrees relative to true North.





Wind vane → Windsock.

Reading Wind Speed and Direction on a Map:

Meteorological maps

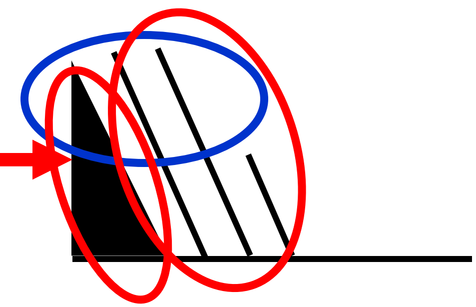
use

A symbol

Represent

Speed and Direction of wind

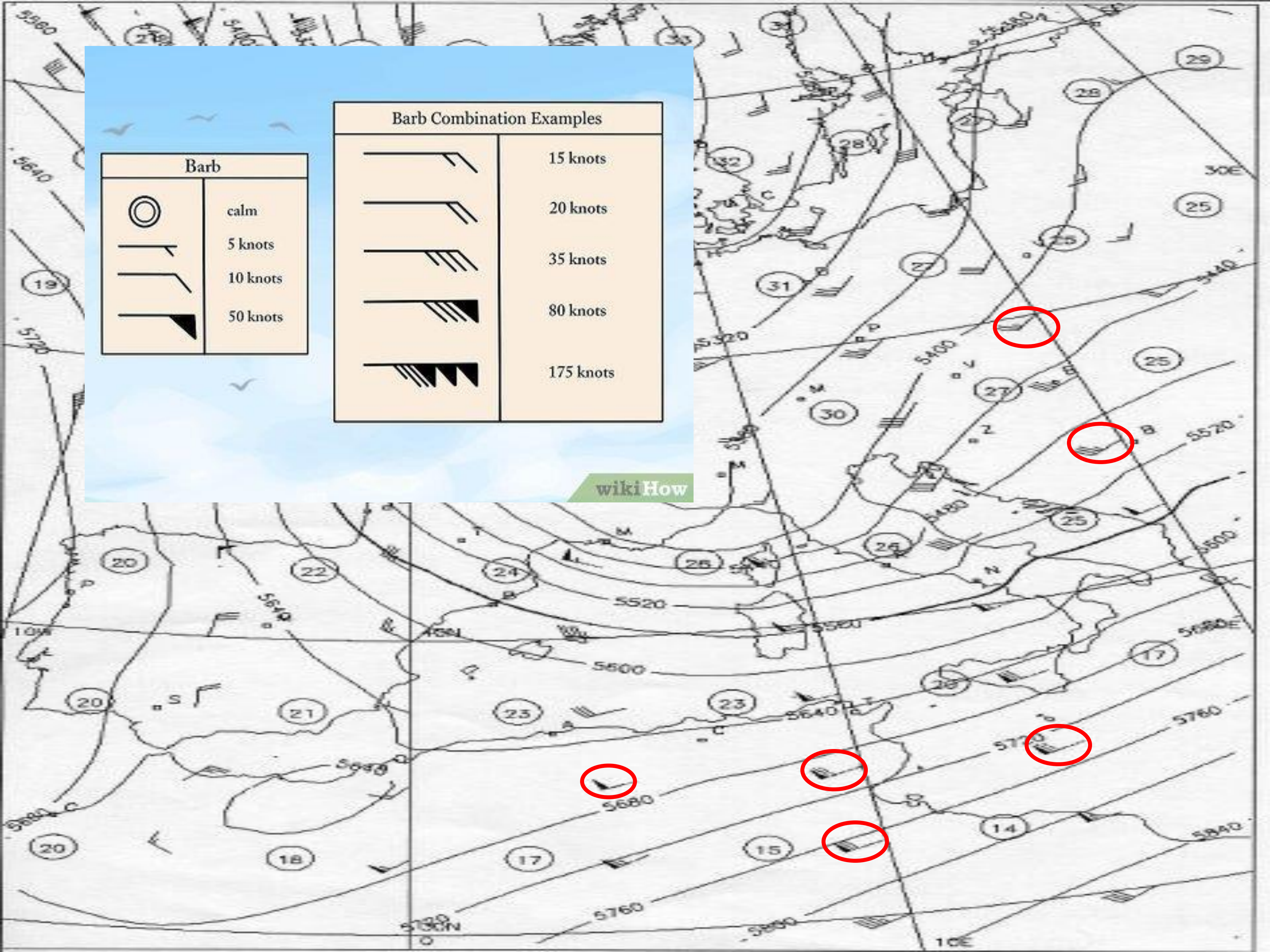
Wind barb



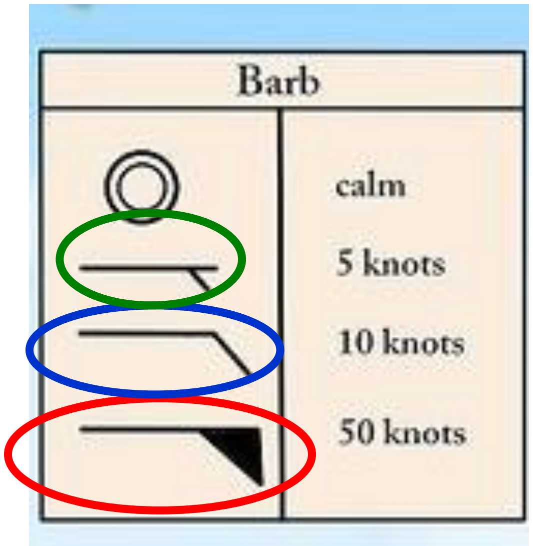
The head of the barb points in the direction from which the wind originates;

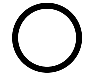
Thus, a barb pointing west indicates a wind **blowing from west to east**.

The wind speed is indicated by the number of lines (barbs) and/or flags attached to the barb.


Barb Combination Examples
15 knots
20 knots
35 knots
80 knots
175 knots
Barb
calm
5 knots
10 knots
50 knots
wikiHow
5520
5600
5680
5760
5640
5400
5440
5480
5840
30E
10E
10W

Determination of Wind Speed:





1 circle < 5 knots (calm)

1 short line (barb) = 5 knots

1 long line (barb) = 10 knots

1 flag = 50 knots

To determine the wind speed, simply add the values of all the barbs and flags attached to the wind barb.

Example :

V=???? → 75 nœuds