University Center abdelhafid boussouf – Mila – Algeria

Bioclimatology

For L3 students of; Agro – Ecology , Ecology and environment,

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2025/2026

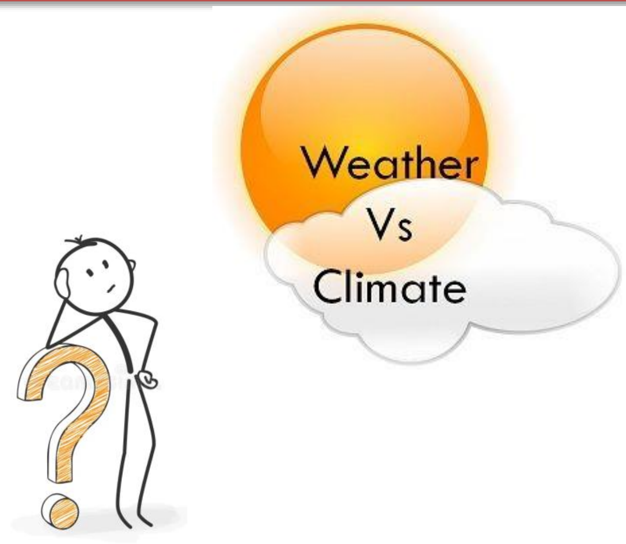
Semester: 5
Fundamental Teaching Unit 1 (UEF 3.1.1):
Course: Bioclimatology
Credits: 4
Coefficient: 2

Teaching Objectives

The purpose of this module is to :

- introduce students to **bioclimatology** (including meteorological aspects) and to the dynamics of ecological systems.
- synthetic overview of ecological diversity,
- emphasis on the study of ecological processes and their intrinsic dynamics,
- The interactions among ecosystem components, and the abiotic factors regulating these interactions

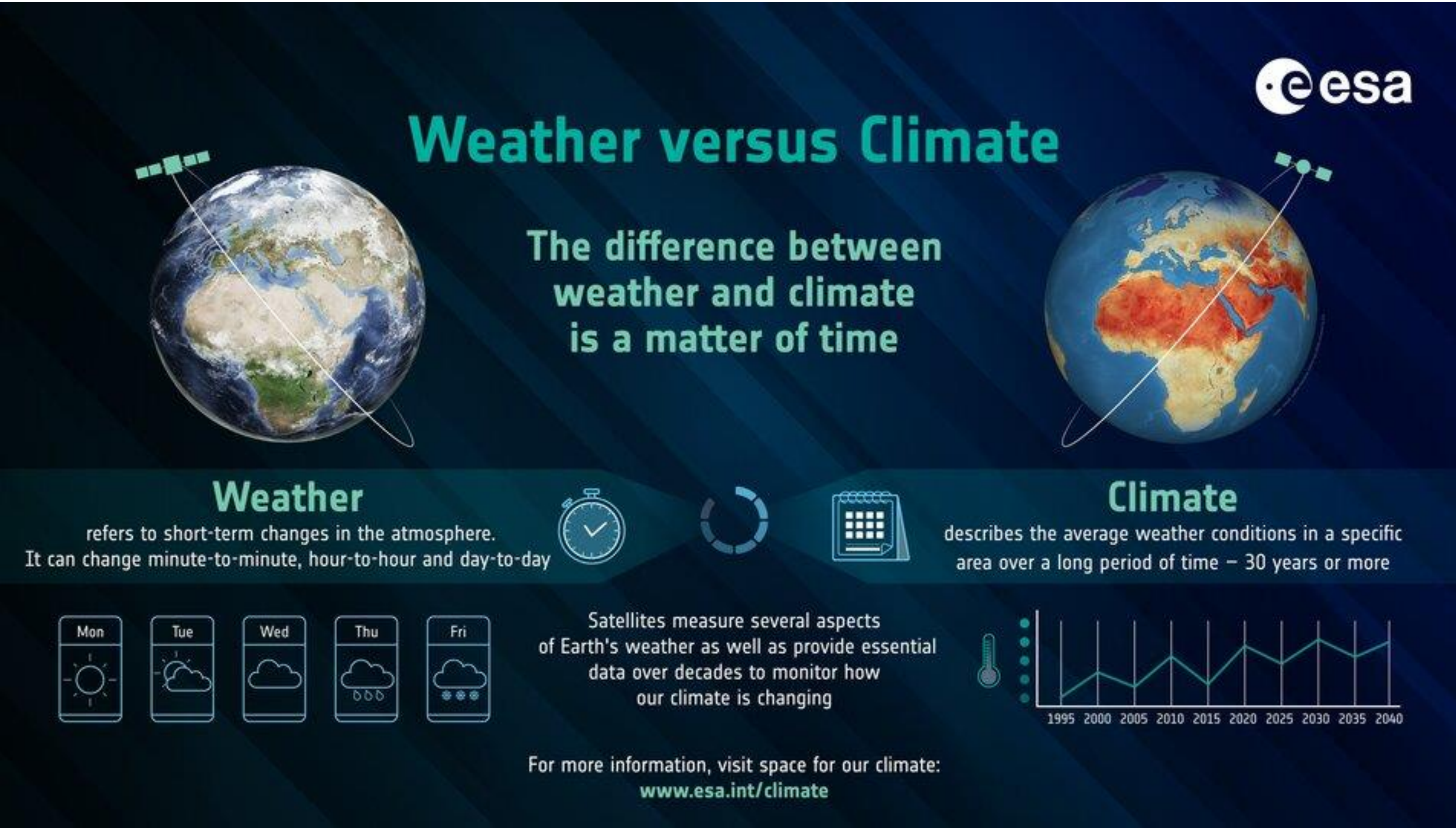
Chapter 1 : Generalities and Definitions



What distinguishes **weather** from **climate** involves both a **temporal** and a **spatial** component.

A meteorological event occurs right at our doorstep, within an hour, a day, or a week in the case of major disturbances.

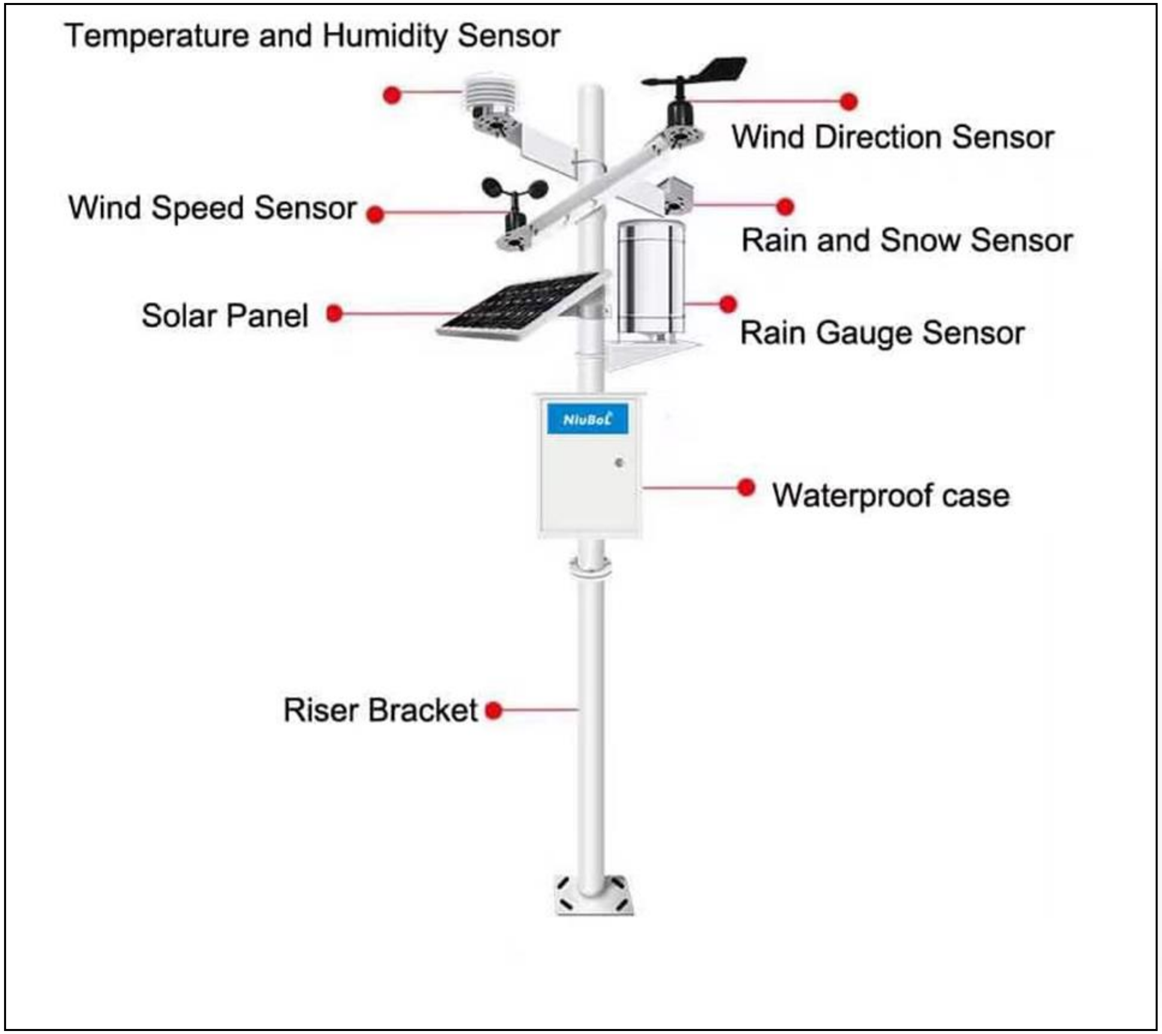
We refer to **climate** when considering a sequence of meteorological events over an extended period. There is no strictly defined duration, but climatologists often refer to a period of at least **30 years**, which allows them to establish a meaningful average.

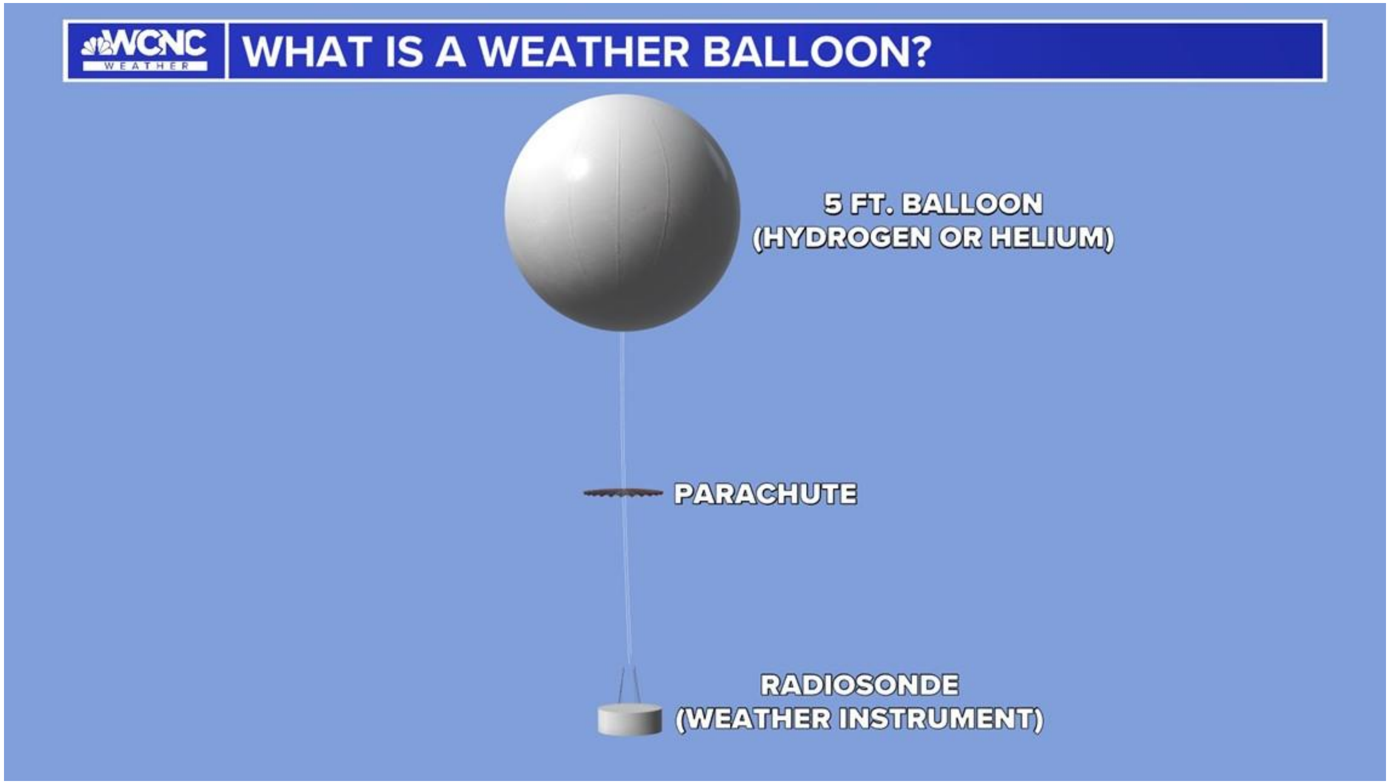


esa
Weather versus Climate
The difference between weather and climate is a matter of time
Weather
refers to short-term changes in the atmosphere.
It can change minute-to-minute, hour-to-hour and day-to-day
Climate
describes the average weather conditions in a specific area over a long period of time – 30 years or more
Mon
Tue
Wed
Thu
Fri
Satellites measure several aspects of Earth's weather as well as provide essential data over decades to monitor how our climate is changing
1995 2000 2005 2010 2015 2020 2025 2030 2035 2040
For more information, visit space for our climate:
www.esa.int/climate

1 . Weather: A Matter of Fluid Mechanics

Weather is defined by a few **instantaneous and local values** such as temperature, precipitation, pressure, and sunshine. These values are provided by **meteorological stations** on the ground,





by **weather balloons**,

or by **satellites**.

Weather predictions are produced using **atmospheric evolution models**.

Meteorology is the science of **clouds, rainfall, and wind**.

It is fundamentally a matter of **fluid mechanics**, specifically concerning air and water.

The development of **thunderstorm cells**, **tornadoes**, or **storms** are examples of major weather events.

Different types of weather

Sunny

Cloudy

Snowy

Rainy

Foggy

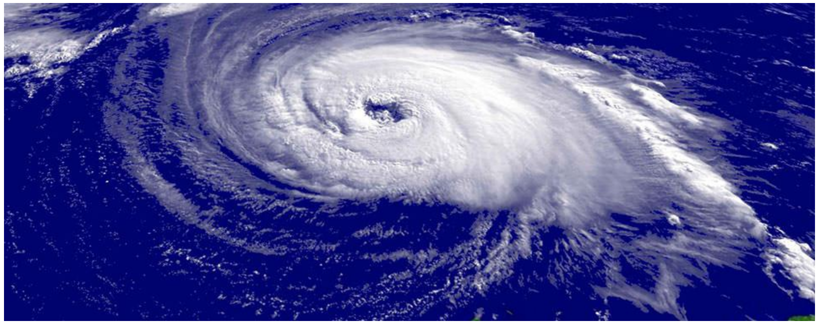
Windy

Different types severe of weather

Thunderstorms

Tornadoes

Blizzards



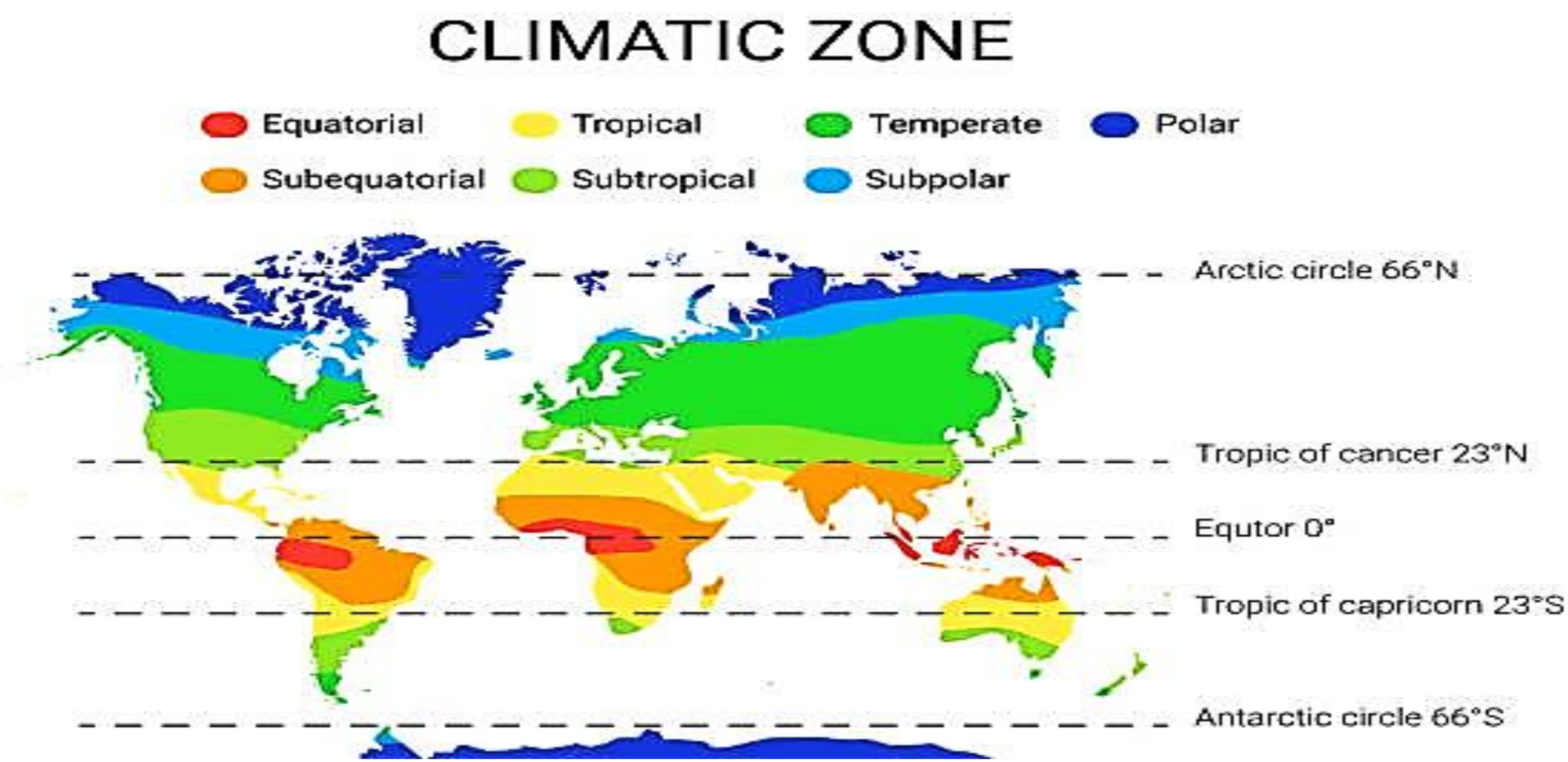
Hurricanes and typhoons

Droughts

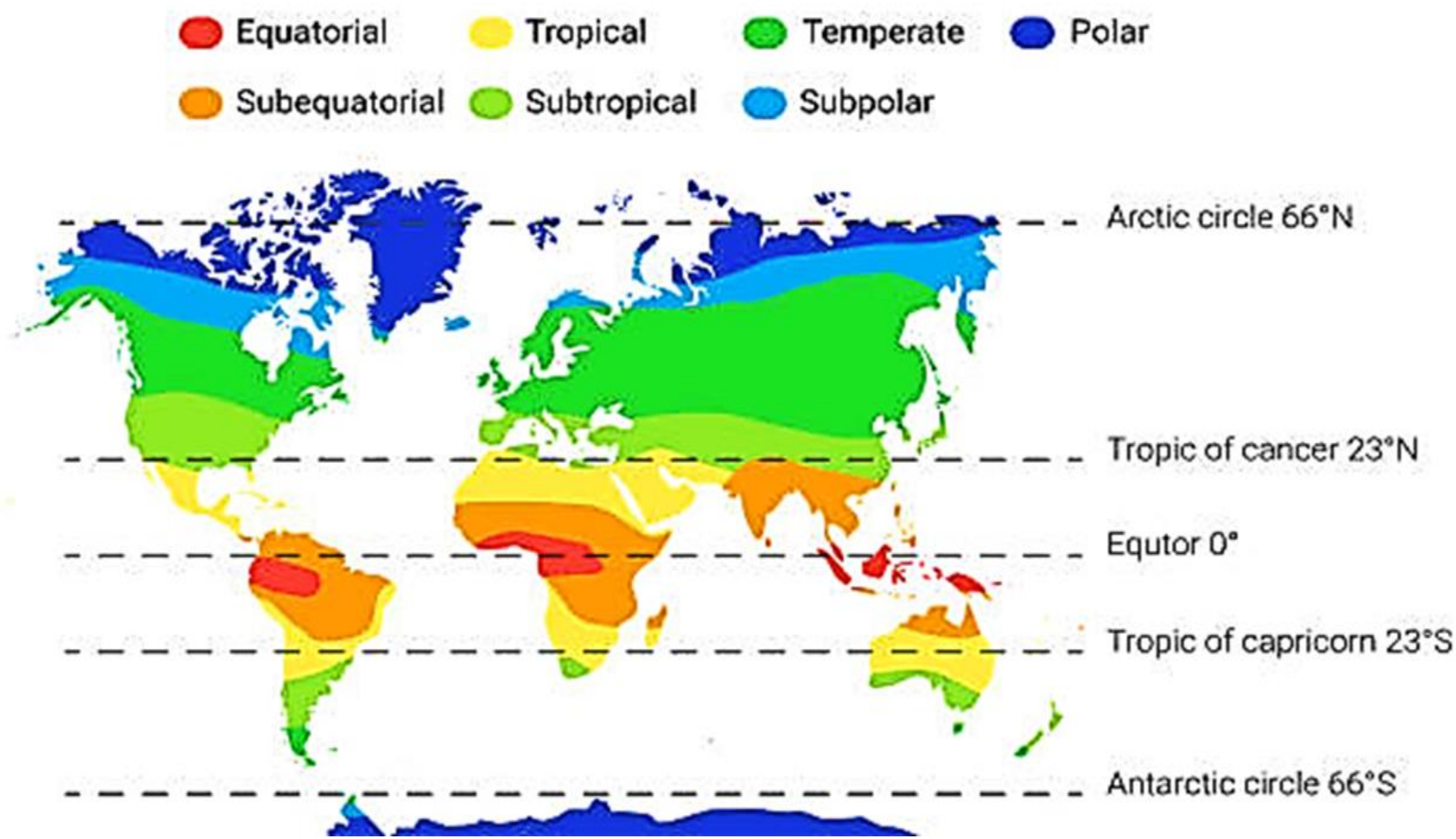
Climate and climatology

The science of climate describes the **average conditions of the atmosphere** over a long time scale and across a wide geographical area. Across the world, a diversity of climates exists, depending on atmospheric, oceanic, and even astronomical conditions.

As with weather, climate also varies, but on a very different time scale.



CLIMATIC ZONE



In climatology, therefore, it is necessary to take into account a wide range of parameters, such as:

•variations in the amount of energy received from the Sun;

•the composition of the atmosphere (greenhouse gases, volcanic eruptions, etc.);

•the extent of polar ice;

•the state of vegetation;

•continental drift.

Among these parameters, some are **natural**, such as the influence of the Earth's orbit around the Sun throughout the year. Others result from **human activities**. The trend of **global climate warming**, observed since the beginning of the 20th century, is correlated with the increase in greenhouse gas emissions in our atmosphere since the **Industrial Revolution**.

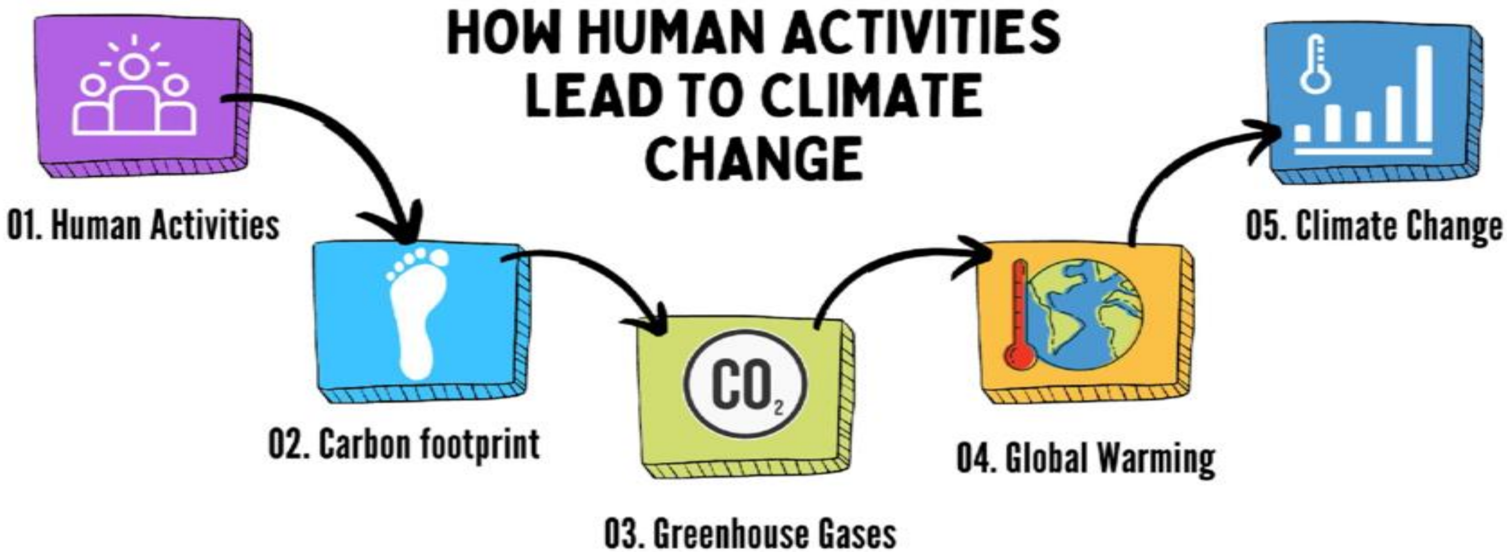
Why is it Important to Study Climate?

The importance of studying climate can be summarized in two main concepts:

- on the one hand, climate determines life on Earth and influences the existence of living organisms; on the other hand, human beings in turn influence climate and drive its change.

Each region has its own specific climate, to which living organisms adapt and in which they live in balance. If one or several atmospheric parameters (temperature, rainfall, humidity, etc.) undergo an unexpected change, this will inevitably affect the daily lives of living organisms. For instance, a sustained increase in temperature promotes water loss through **evapotranspiration**; if this phenomenon persists, it can lead to **drought**. Likewise, unusually intense rainfall occurring over a short period in a given region may cause **flooding.**

Sometimes, the change in these atmospheric parameters is caused by **anthropogenic activity** (human activity). In this case, the study of climate focuses on the human activities that influence it and on strategies to **combat climate change**.



Recent climatological studies rely heavily on **statistics** and **modeling** in order to simulate the behavior of atmospheric parameters. These studies make it possible to **anticipate climatic imbalances** and to **diminish their effects.**

Meteorological Data Bank

This data bank is responsible for managing the database of various climatological networks according to a climatological data and information management system. It includes:

•formats for the exchange of data in real time,

•communication tools for the collection, exchange, and dissemination of data,

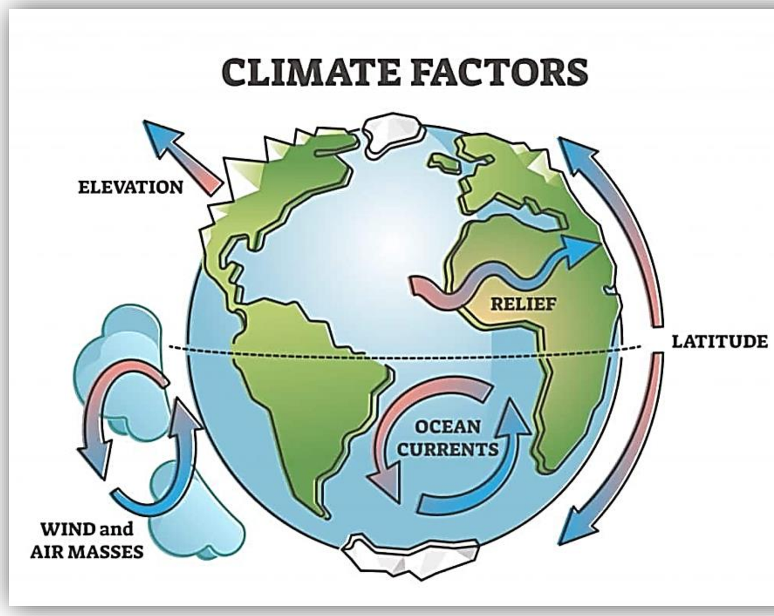
•mechanisms for quality control and data flow monitoring,

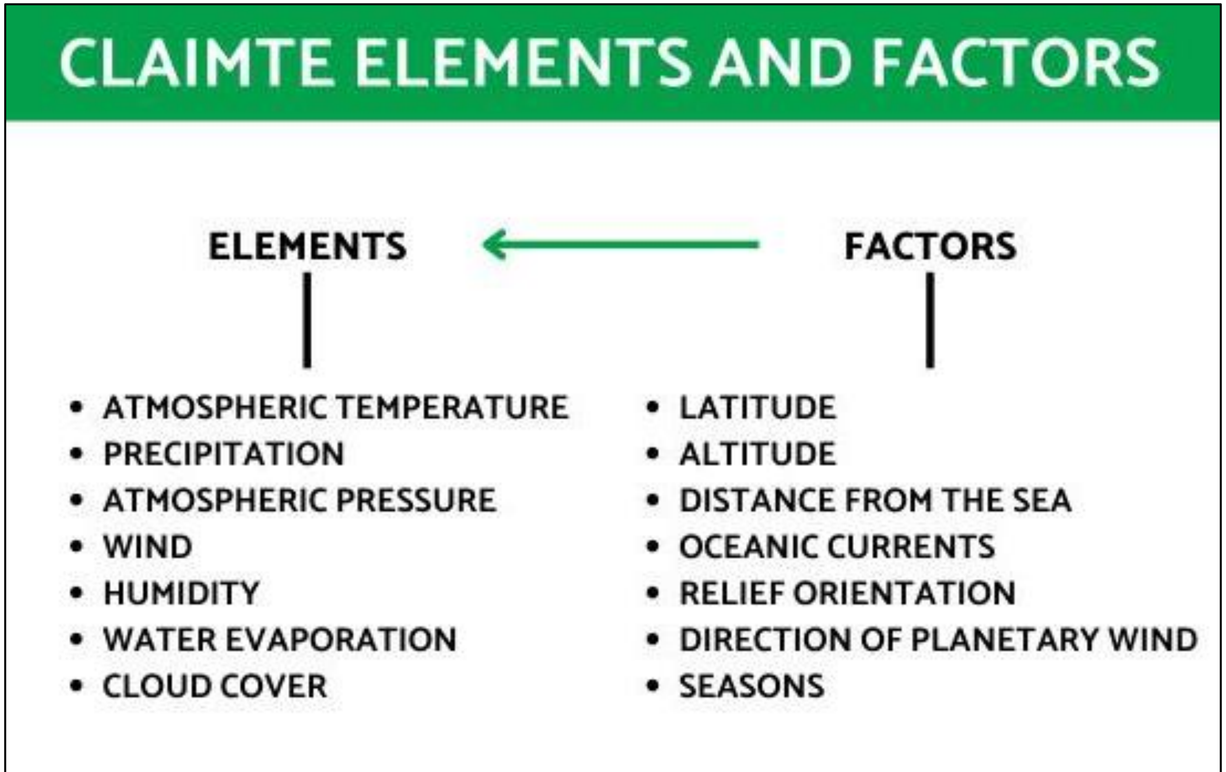
•various types of data (surface, altitude, satellite, radar, and others)

Elements and Factors of Climate

The climate of a region is influenced by two types of factors: **cosmic** and **geographical**.

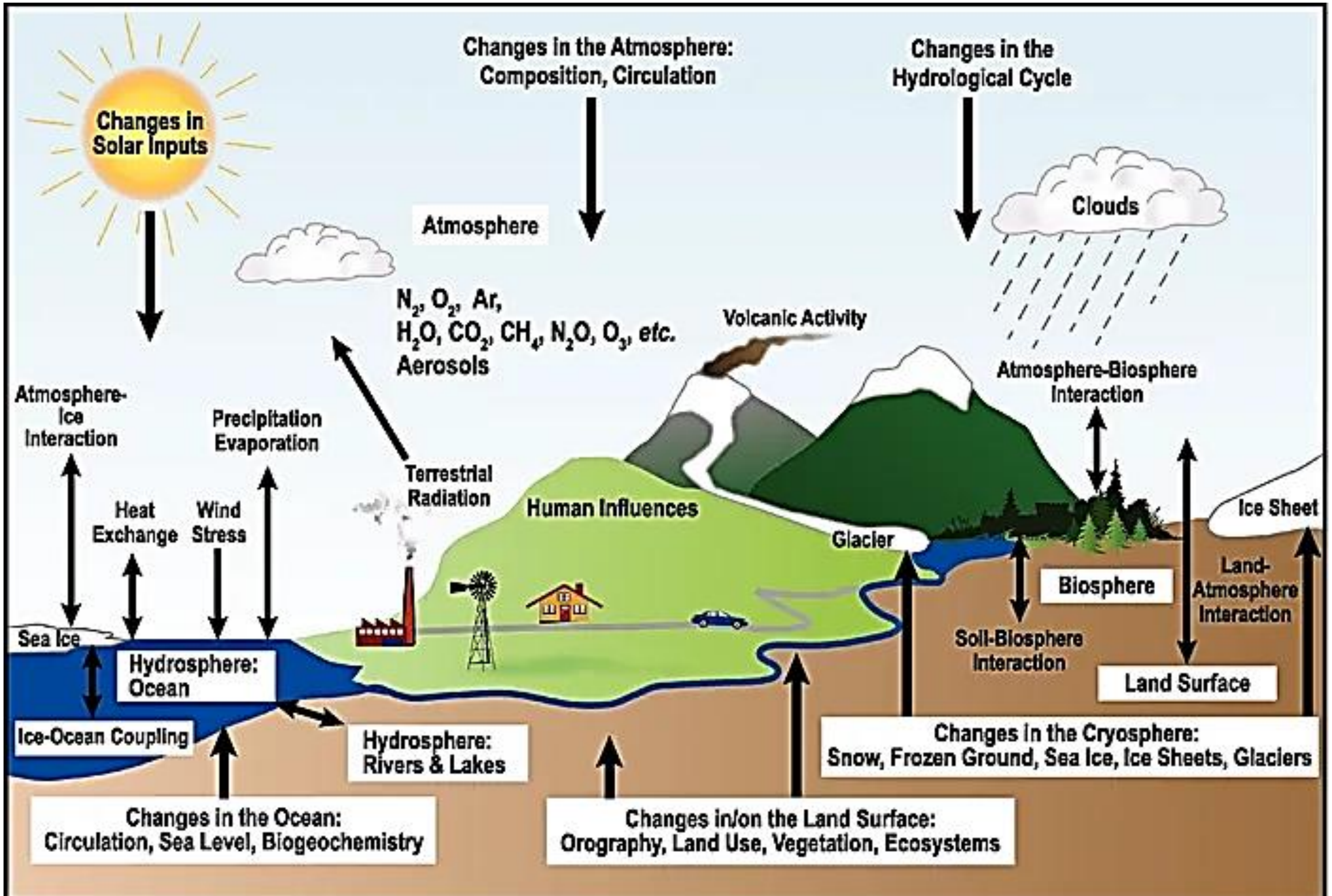
It is defined through the analysis of certain meteorological elements, namely: **temperature, pressure, and precipitations.**





The Climate System

Our planet's climate depends on the whole Earth system. The Sun, land (geosphere), ocean (hydrosphere), ice (cryosphere), and living organisms (biosphere) interact with the atmosphere as part of the climate system in many complex ways.



Bioclimatology

Bioclimatology can be defined as the science that studies the various relationships characterizing the interactions between living organisms and climatic factors.

In addition to climatology and meteorology, it also draws upon several other disciplines, such as **physics, statistics, botany, physiology, soil science (pedology), hydrology**, and others.

Climate Observation

A **meteorological station** is a set of sensors that record and provide physical measurements and meteorological parameters related to climate variations. These sensors are placed in a **meteorological shelter**, which ensures the thermal equilibrium of the thermometer with the air while protecting it from solar radiation.

The variables measured include:

•air temperature (Ta),

•dew point temperature (Td),

•precipitation (P),

•wind speed and direction (U),

•sunshine duration (d),

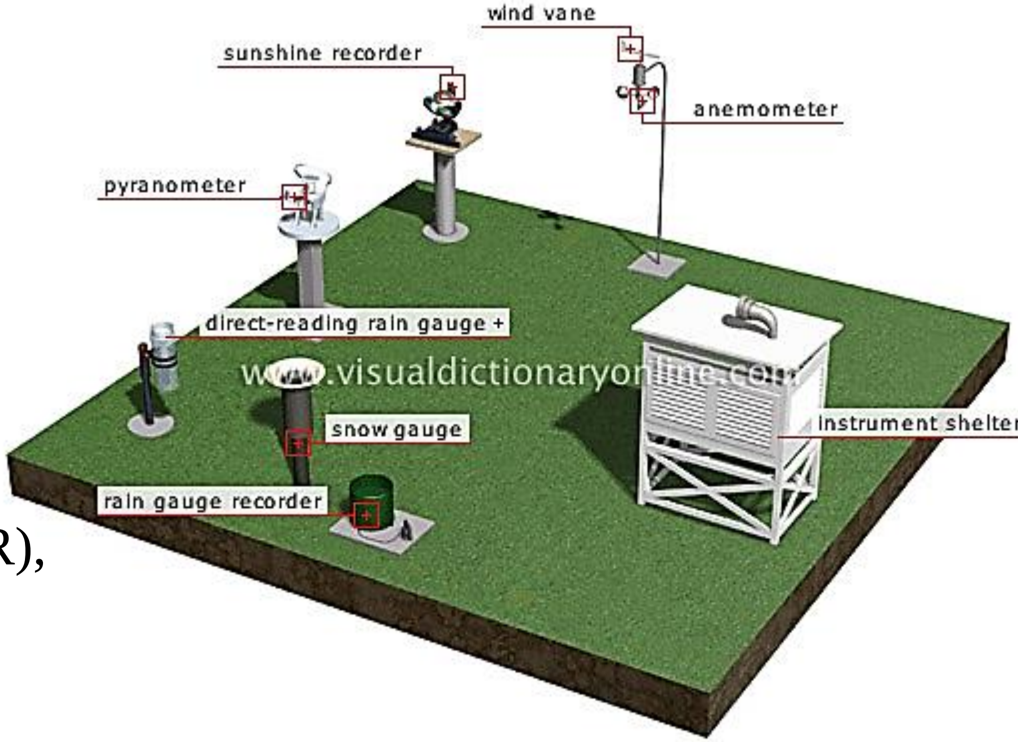
•measurement of radiative components (R),

•evapotranspiration (ETP),

•humidity,

•soil temperature (Ts),

•and visibility



Meteorological Park

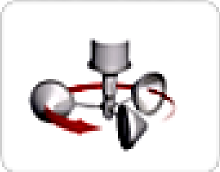
Stations may be equipped with sensors for all, or only part, of this information, depending on their type: **agro-meteorological, airport, road-weather, climatological**, etc.

Meteorological Park

wind vane
Instrument that indicates wind direction using a vane that rotates around a vertical axis.

wind vane

anemometer
Instrument that measures wind speed using cups that rotate around a mobile shaft at varying speeds.

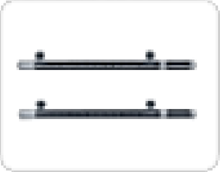


anemometer

instrument shelter
Ventilated shelter designed to protect meteorological instruments from solar radiation and precipitation.

measure of air pressure

measure of humidity



measure of temperature

rain gauge recorder
Instrument that measures rainfall using small calibrated containers that tip when filled with water, producing an electrical impulse.

rain gauge recorder

snow gauge

Instrument that measures the depth of water that originally fell as snow.

snow gauge

direct-reading rain gauge

Instrument that measures rainfall; it uses a measuring tube connected to a funnel that collects rain.

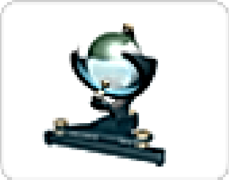
direct-reading rain gauge

pyranometer

Instrument designed to measure overall or indirect solar radiation.

pyranometer

sunshine recorder

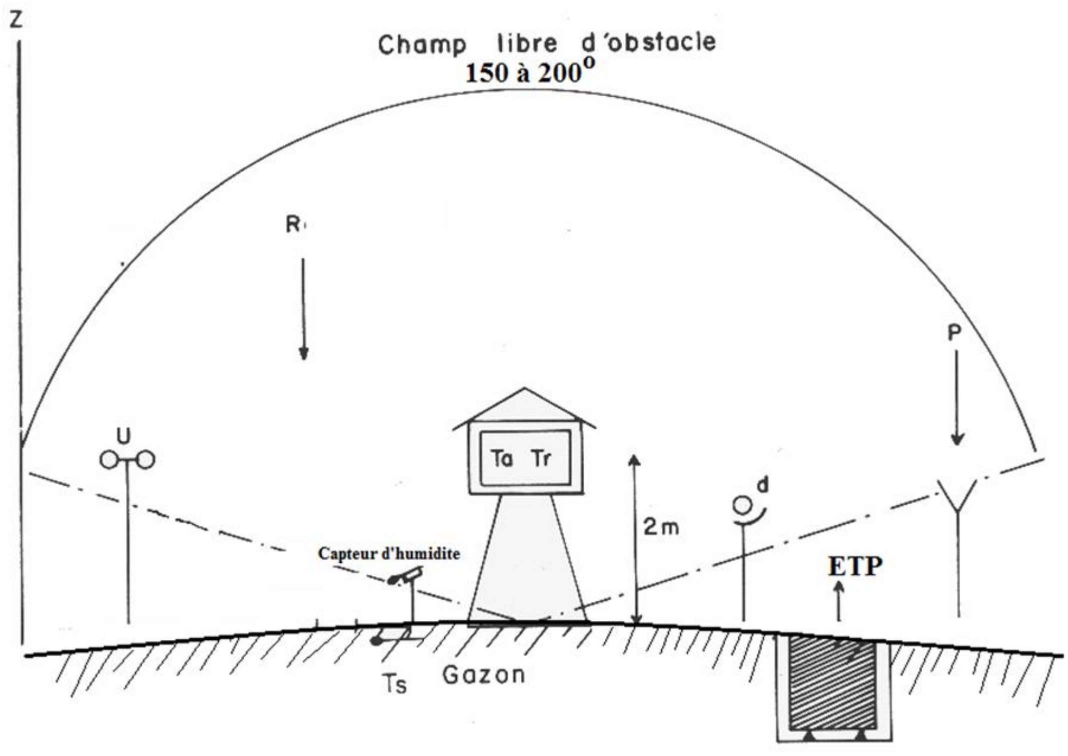


Instrument designed to record daily duration of sunshine.

sunshine recorder

Meteorological stations are most often located at fixed coordinates on islands and continents, but they may also be installed on **aircraft** or **ships** (particularly weather ships).

When selecting the site for a weather station, it is important to avoid depressions, basins, dense forests, water surfaces, and bare soils. In general, a meteorological shelter placed **1.5 to 2 meters above a lawn** on slightly convex land is recommended.



Objectives and Mission of Climatology

Climatology essentially aims to:

- Analyze the meteorological elements that constitute climate,
- Investigate the causes underlying the diversity of climates and the fluctuations associated with them,
- Study the interactions between climate and soils, living organisms, as well as economic and even social activities.

Missions of a Climatological Service

To achieve its various objectives, a **climatological service** must fulfill several missions:

•**Collect data:** gather, verify, and preserve all available meteorological information.

•**Archive:** transfer this information to computer-readable media to create a **climatological database**.

•**Process data:** perform analyses and organize the collected data.

•**Communicate information:** make the archives available to users and publish the data in the form of **reports**.

•**Manage climatological networks.**

•**Participate in international research programs** in the field of climatology

Spatial and Temporal Scale

The values of climatic elements depend on both the **time period** and the **spatial field** under study.

4 main terms are used to describe different climate scales:

Global or Planetary Scale ⟷ Global Climate

Time scale: 1 week and more
Spatial scale: 10,000 kilometers to the entire globe

Large Scale (Synoptic Scale) ⟷ Regional Climate

Time scale: 12 hours to 1 week
Spatial scale: 100 to 10,000 kilometers

Medium Scale (Meso-Scale) ⟷ Medium Scale (Meso-Scale)

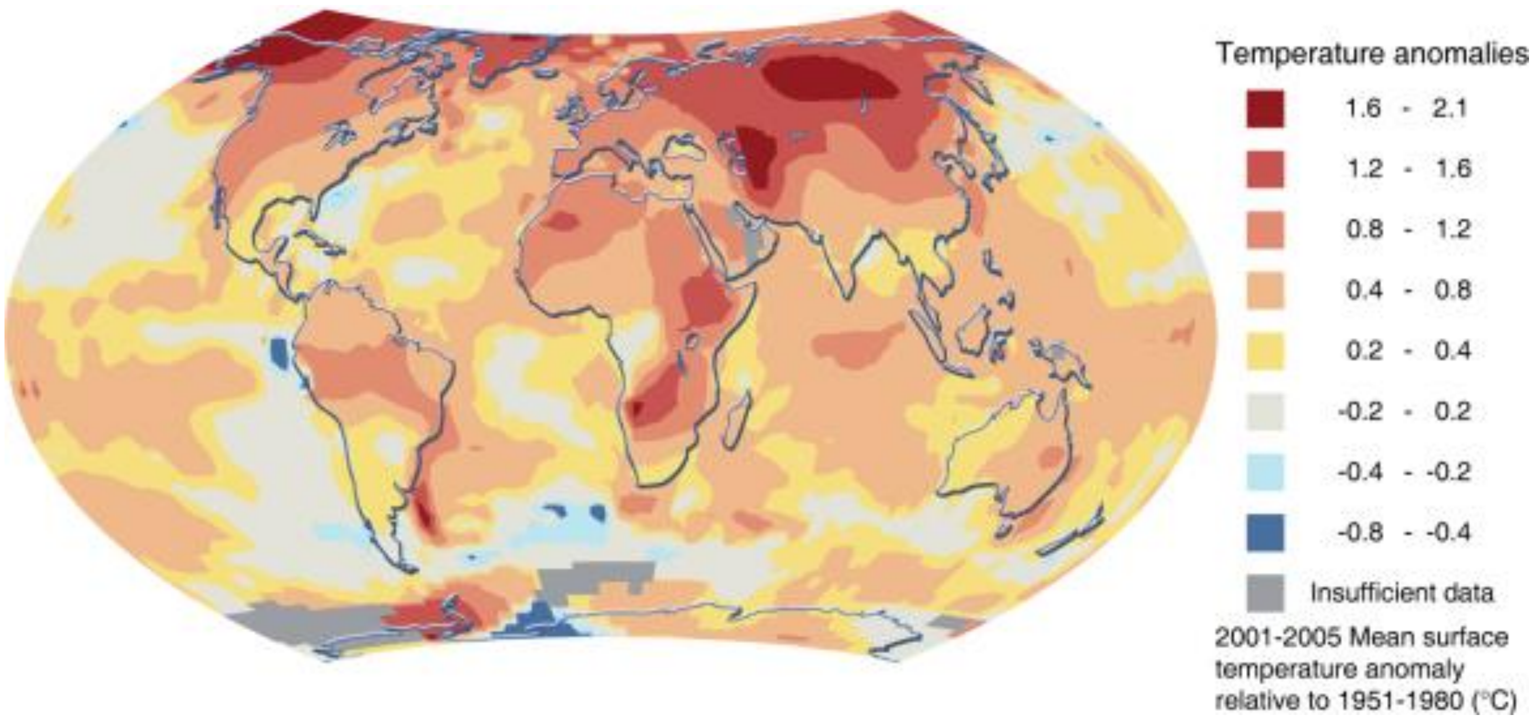
Time scale: 1 to 12 hours
Spatial scale: 1 to 100 kilometers

Small Scale (Micro-Scale) ⟷ Microclimate

Time scale: 1 second to 1 hour
Spatial scale: less than one kilometer

1. The global or planetary scale (global climate):

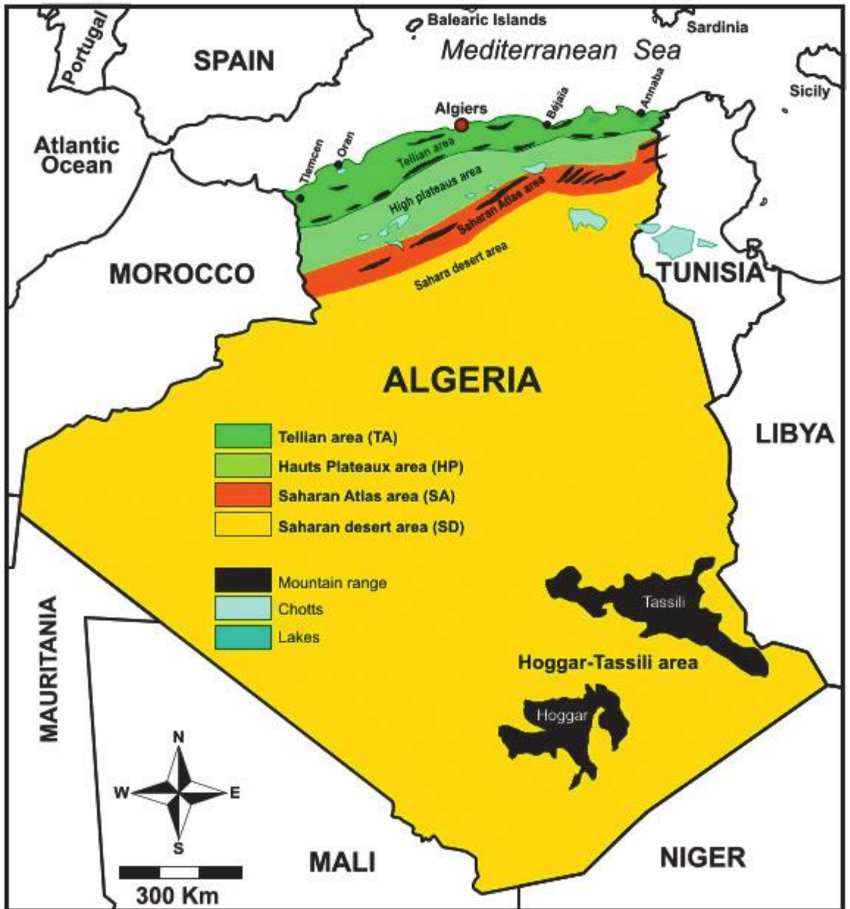
To describe processes and phenomena that extend throughout the entire atmosphere, we refer to them as hemispheric-scale or global-scale phenomena. Examples include seasonal changes, general atmospheric circulation, and the exchange of energy by radiation between the Earth and the surrounding space.

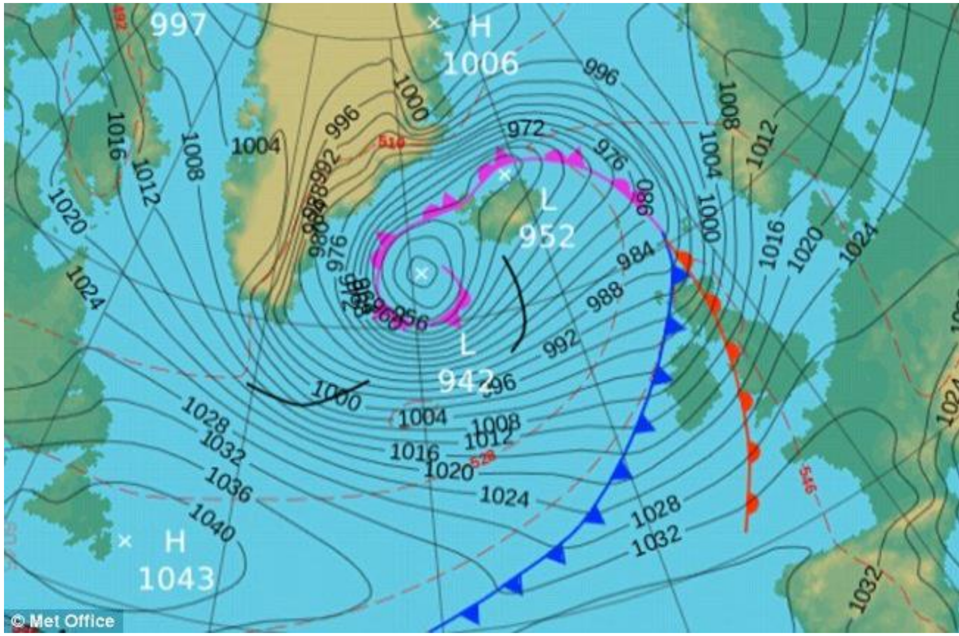


2. The large scale or synoptic scale (regional climate):

Synoptic or large-scale phenomena include, for example, depressions.

The extent of each regional climate is variable and depends on factors such as the configuration of the relief and the proximity of an oceanic area.

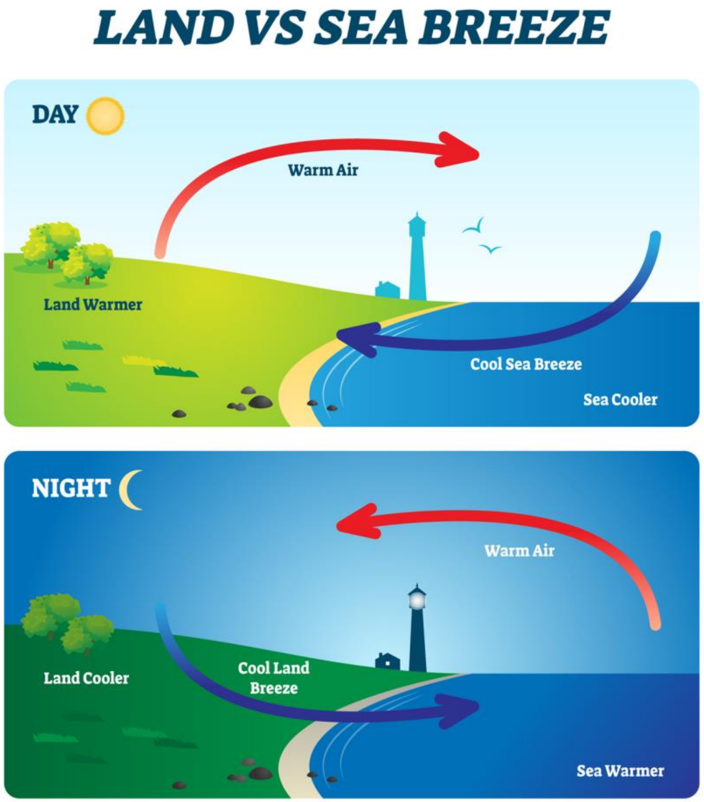




depression

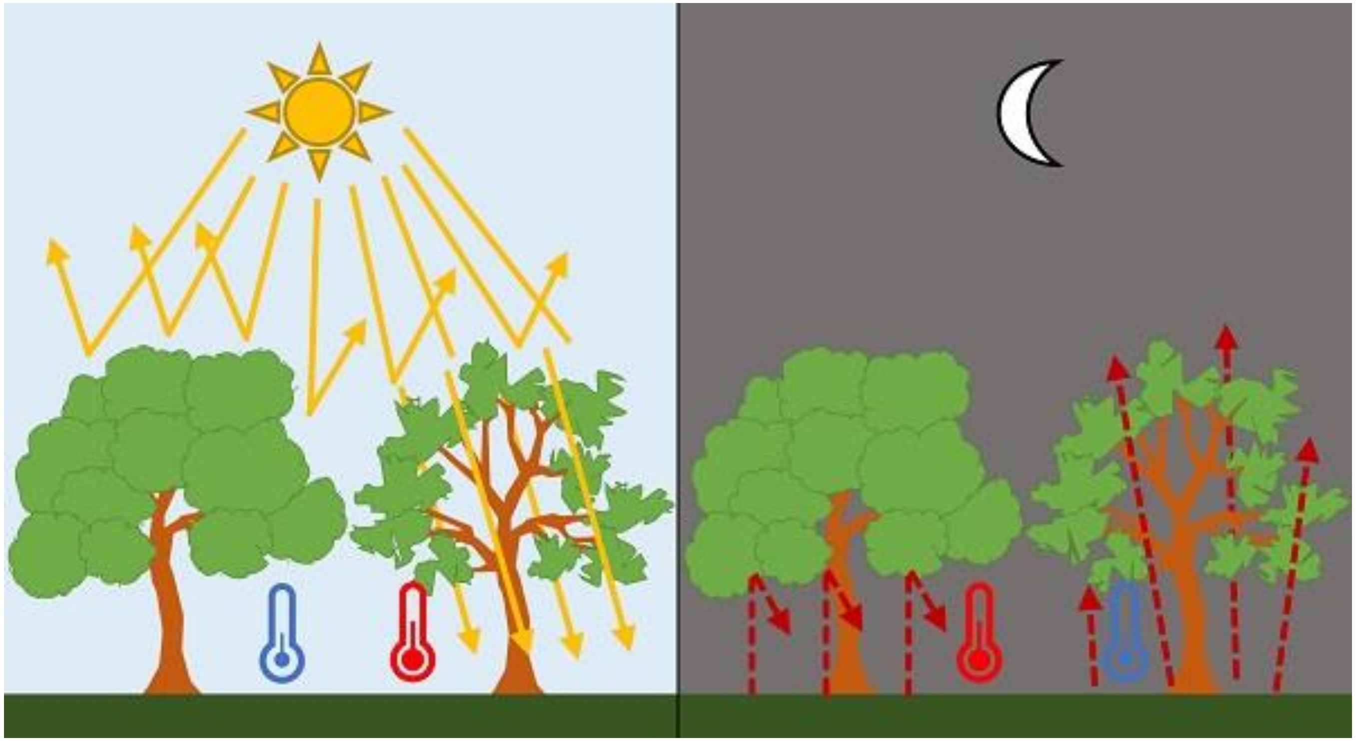
3. The medium scale or meso-scale (topoclimate or local climate):

At this scale, the climate is influenced by the geographical configuration of the relief or topography. Medium-scale processes give rise to thunderstorms and tornadoes, as well as phenomena such as land and sea breezes or the formation of lenticular clouds at the summits of mountain peaks.



4. The small scale or micro-scale (microclimate):

Phenomena that can be observed in a specific location are small-scale phenomena, such as warming or cooling along a building wall, or cooling beneath a tree during the day when the air is calm.



Vertical Structure and Chemical Composition of the Atmosphere

A. Vertical Structure of the Atmosphere

The main thermodynamic variables used in the study of the atmosphere are:

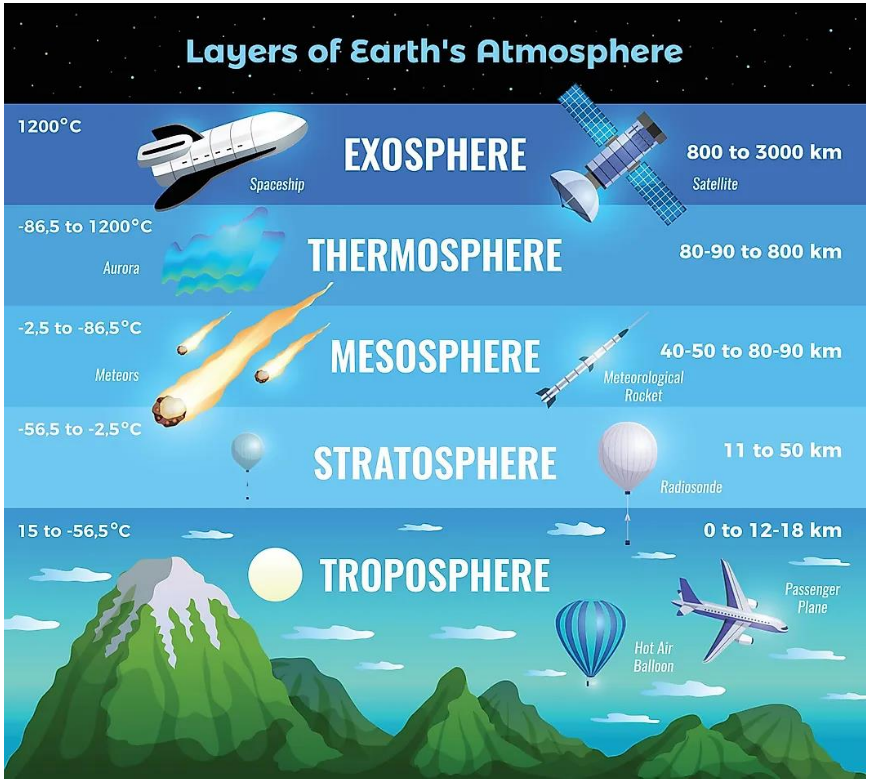
- temperature (T),
- pressure (P),
- density (ρ).

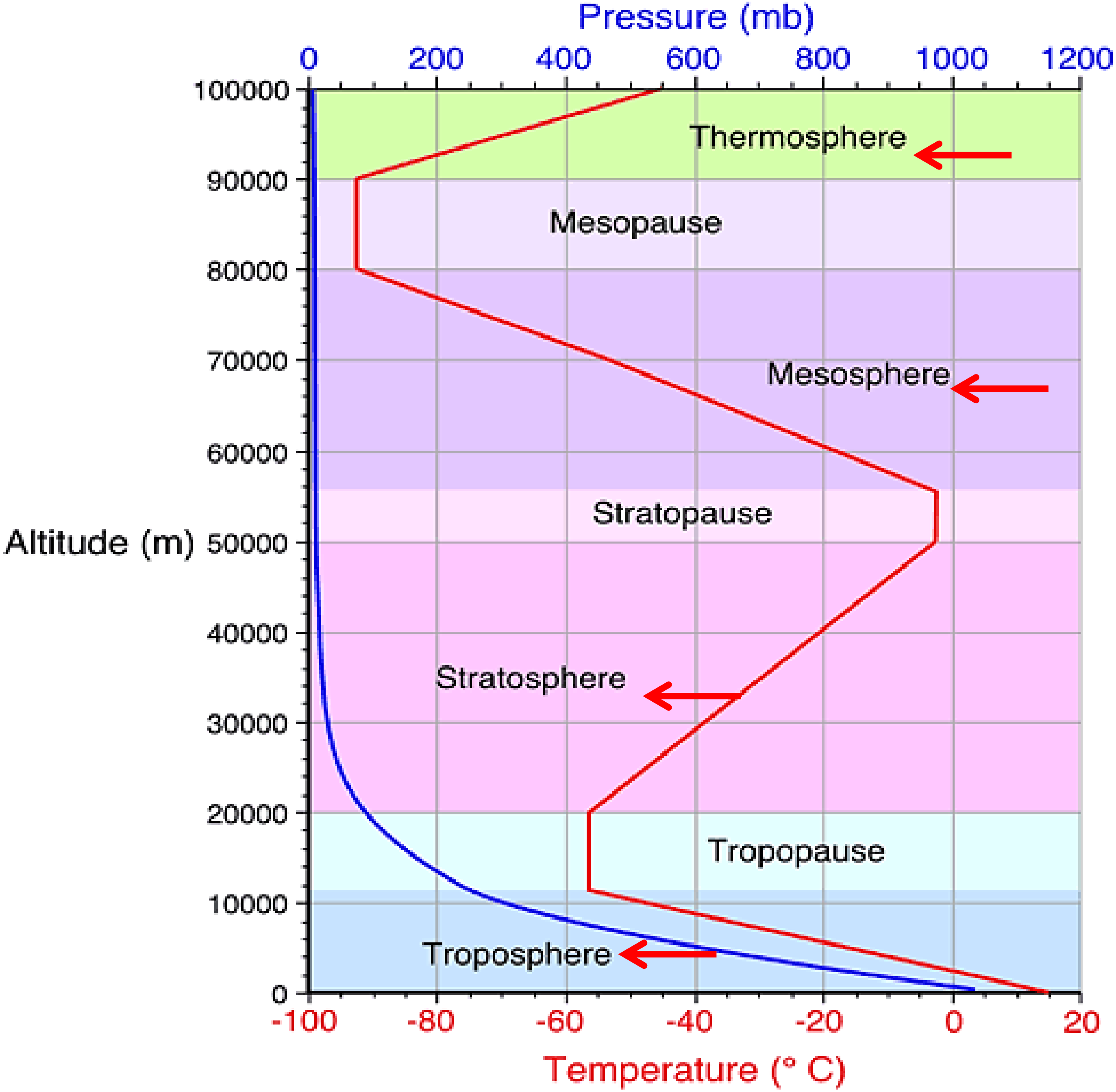
These variables vary much more quickly in the **vertical direction** than in the **horizontal**, which makes it possible to define a **vertical structure** of the atmosphere as a function of altitude

Vertical variations in temperature are highly variable: temperature decreases and increases alternately with altitude.

This vertical temperature structure allows the atmosphere to be divided into several layers with distinct properties, known as **spheres**, whose upper boundaries are called pauses.

Starting from the Earth's surface, the following layers can be distinguished:

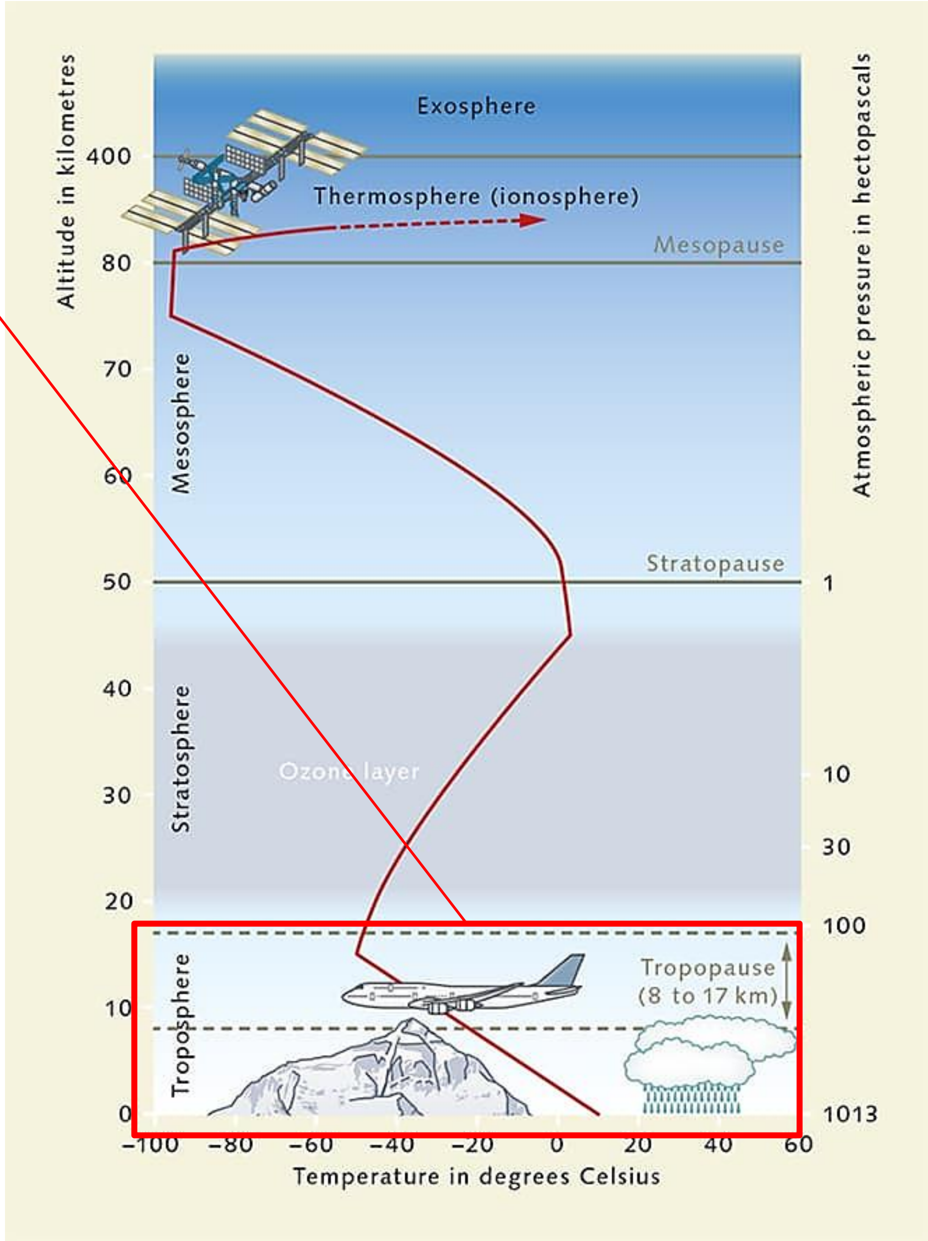




Layers of the Earth's Atmosphere Defined by Its Temperature Profile

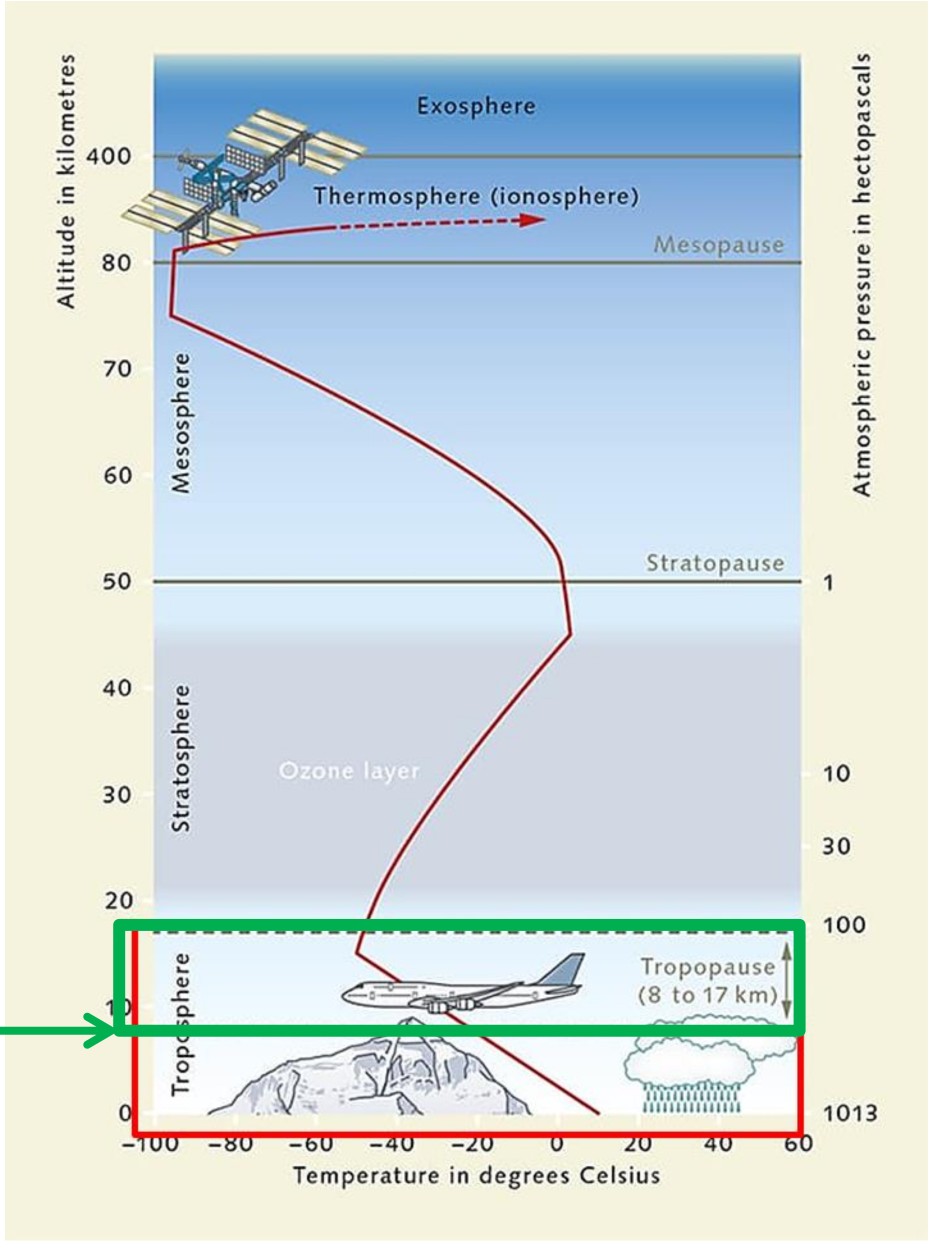
a. The Troposphere:

This is the lowest layer of the atmosphere, in direct contact with the Earth's surface. It extends up to approximately **11 km in altitude**, ranging from about **8 km at the poles** to **16 km above the Equator**. In this layer, the temperature **decreases with increasing altitude** at a rate of **0.6°C per 100 meters**, due to the thinning of the air and the progressive distance from the Earth's surface



- It is the **densest** of the four atmospheric layers.
- It contains up to **75% of the total atmospheric mass**.
- It is composed mainly of **nitrogen (N_2)** and **oxygen (O_2)**, with small concentrations of other trace gases.
- **Water vapor** (atmospheric humidity) and **aerosols** are also found within the troposphere.

The troposphere is topped by the **tropopause**, which forms the boundary between the troposphere and the stratosphere.



- At this level, the **temperature becomes stable** and then begins to **increase within the stratosphere**.
- The tropopause **prevents vertical convection of air** beyond this limit.
- The troposphere is the region where **hydrometeors** (such as clouds, rain, and snow) occur and where **strong air turbulence** is present.
- It is the most **disturbed and dynamic layer** of the atmosphere, constantly affected by **vertical and horizontal air movements**

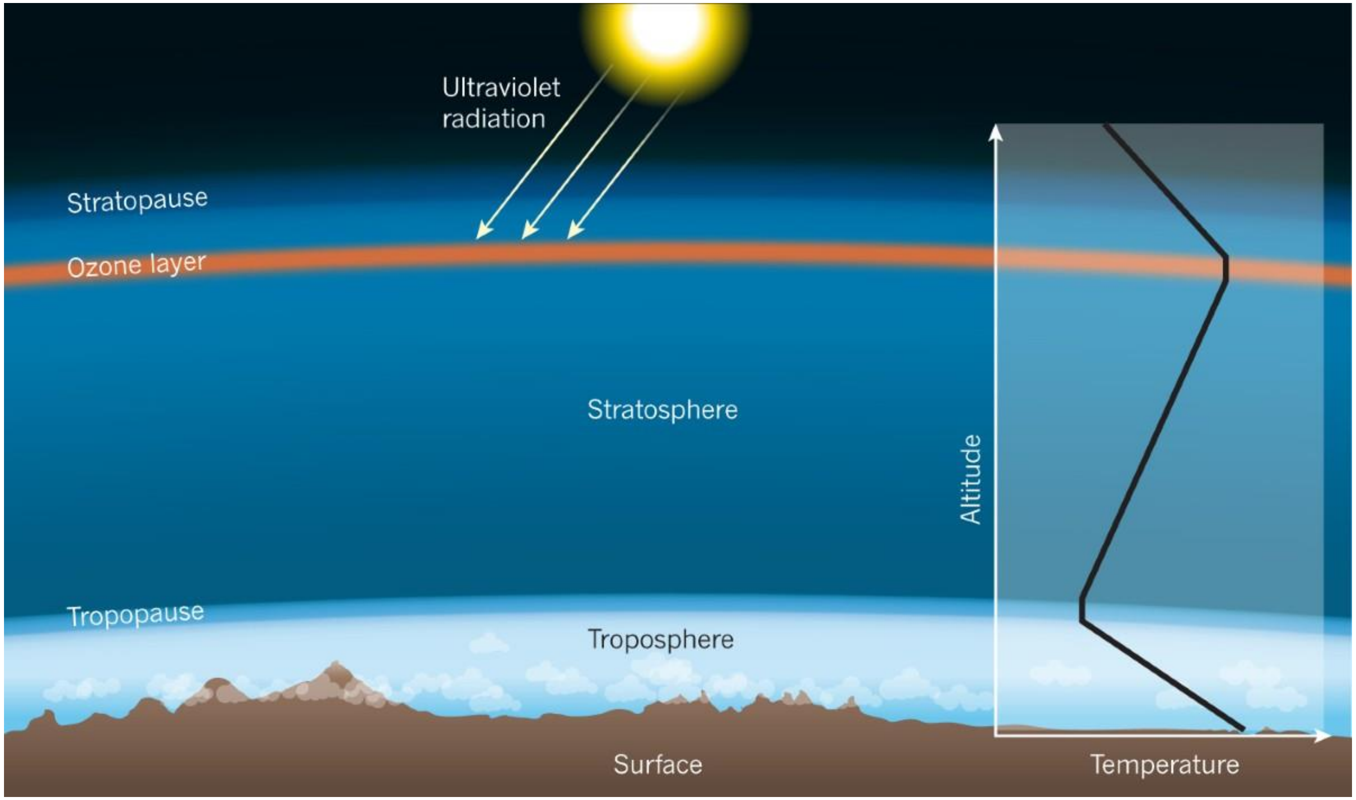
2. The Stratosphere:

The stratosphere is the second major layer of the atmosphere, located between the **tropopause** and an altitude of approximately **50 km**.

In the stratosphere, the **ultraviolet radiation** from the Sun is very intense.

Below 100 km, this radiation **dissociates oxygen molecules (O_2) into free oxygen atoms (O + O)**.

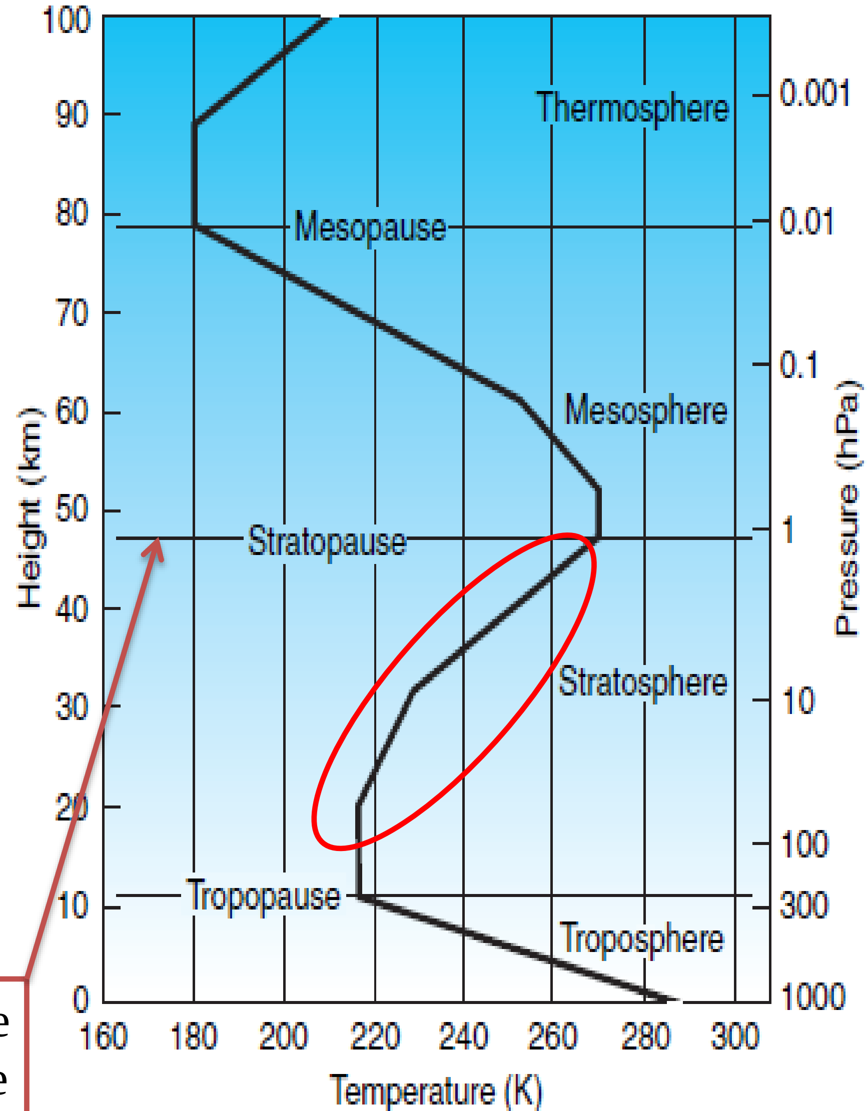
These atoms then **collide with other oxygen molecules** to form **ozone (O_3)**



It contains **very little water vapor** (due to the extremely low temperatures found at the tropopause) but the **majority of atmospheric ozone**.

The **absorption of ultraviolet solar radiation** by ozone explains why the **temperature increases with altitude**, reaching a maximum at the **stratopause** (ranging from **–30°C to +20°C**, depending on the season).

The **residence time of particles** in the stratosphere is very long because of the **absence of clouds and precipitation**



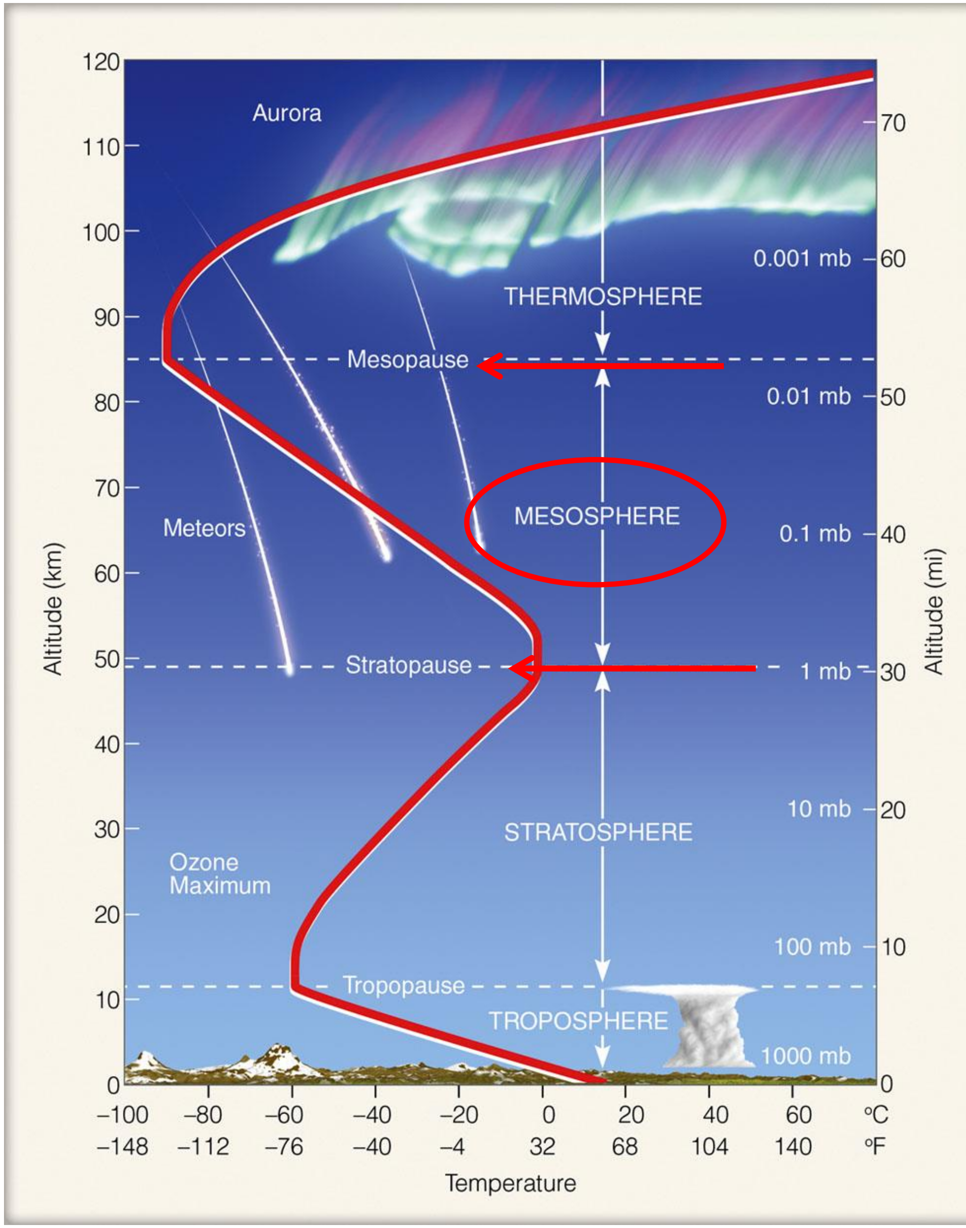
The stratosphere is separated from the mesosphere, which lies just above it, by the **stratopause**.

c. The Mesosphere:

Also called the **“middle sphere,”** the mesosphere is the third highest layer of the atmosphere, extending from about **50 to 80 km above the Earth’s surface** above the troposphere and stratosphere, and below the thermosphere.

It is bounded by the **stratopause** below and the **mesopause** above.

In this layer, **temperatures decrease with increasing altitude**, reaching approximately **100°C**, making it the **coldest layer** of the atmosphere

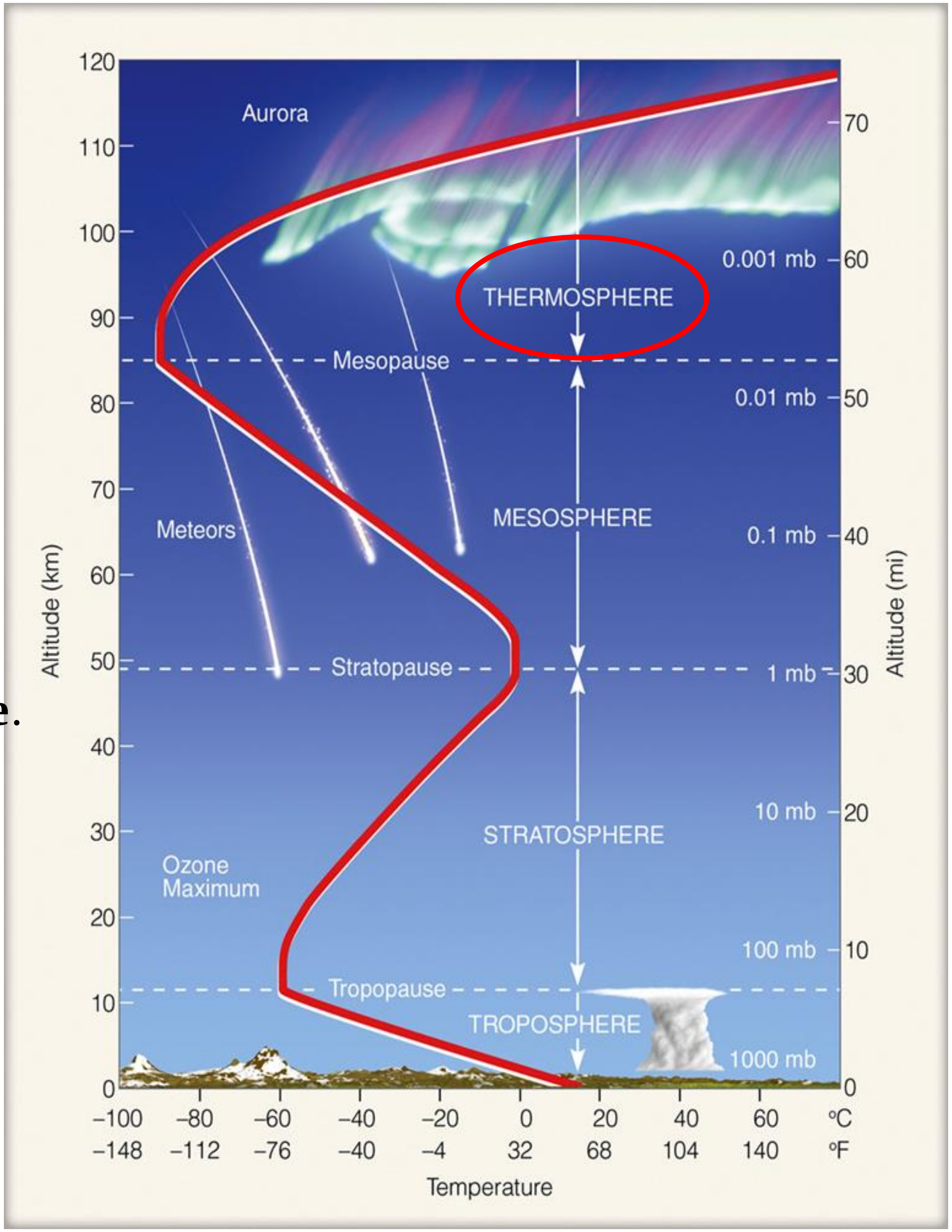


d. The Thermosphere:

The thermosphere is the **uppermost layer of the atmosphere**. It begins at an altitude of about **90–100 km** and extends up to approximately **1,280 km**.

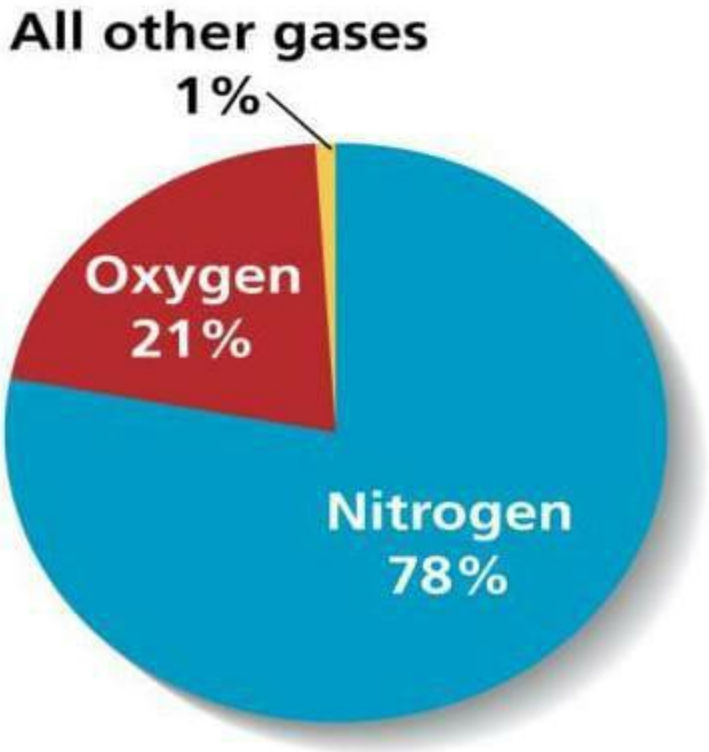
In this region, **air pressure becomes almost zero**, and **air molecules are extremely sparse**.

The **lower part** of the thermosphere is known as the **ionosphere**



- Temperature **increases with altitude** and remains high up to a level called the **thermopause**, located between **250 and 500 km**, depending on solar activity.
- Beyond the thermopause, temperatures fluctuate between **300°C and 1,600°C**, according to the amount of energy received from the Sun. Although temperatures are very high, the **density of matter is so low** that it would feel extremely cold to humans, since the few existing air molecules cannot transfer enough heat to our bodies

Chemical Composition of the Atmospher



Gas	Percentage by Volume
Nitrogen (N_2)	78.084
Oxygen (O_2)	20.946
Argon (Ar)	0.934
Carbon dioxide (CO_2)	0.037
Neon (Ne)	0.00182
Helium (He)	0.00052
Methane (CH_4)	0.00015
Krypton (Kr)	0.00011

Dry air is composed primarily of **nitrogen (78.09%)** and **oxygen (20.95%)**.

The remaining **1%** consists of other gases such as **argon, carbon dioxide (CO_2), neon, helium, krypton, hydrogen, and ozone**.

The composition of dry air remains **practically constant in proportion** up to an altitude of about **80 kilometers**. However, it should be noted that:

- The **carbon dioxide content** of the air is highly variable and depends on **industrial activity** in the lower atmospheric layers.
- The **ozone concentration** near sea level is very low but becomes significantly higher at altitude within the **ozone layer** of the stratosphere.

b. Water Vapor:

The percentage of water vapor in the air is **highly variable** in both time and space.

Water also exists in the atmosphere in its **solid and liquid states**, forming the various types of **clouds**.

c. Impurities (Atmospheric Pollution):

These are of **two types:**

•**Aerosols:** originating either from **natural sources** (such as sandstorms, volcanic dust, pollen, spores, etc.) or from **human activities** (such as industrial smoke).

•**Pollutant gases:** including **hydrogen sulfide (H_2S)**, **carbon dioxide (CO_2)**, **hydrocarbons (HC)**, and **chlorofluorocarbons (CFCs)**, among others.