ATMOSPHERE BASICS

Meteorology, Weather and Climate

- **Meteorology** is the scientific **study of the atmosphere.**
- **Weather** refers to the **state of the atmosphere** at a given **time and place.**
- **ELEMENTS OF WEATHER & CLIMATE:** Temperature, Humidity, Clouds, Precipitation, Air Pressure, Winds.
- Climate is what you expect, Weather is what you get.

Climate

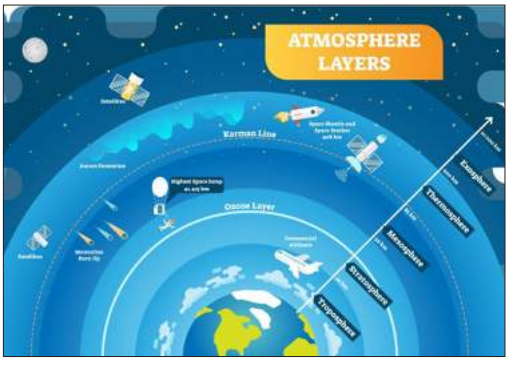
- **Climate** is an aggregate of weather conditions, the sum of all statistical weather information that helps describe **a place or region.**
- The most important elements of atmosphere :

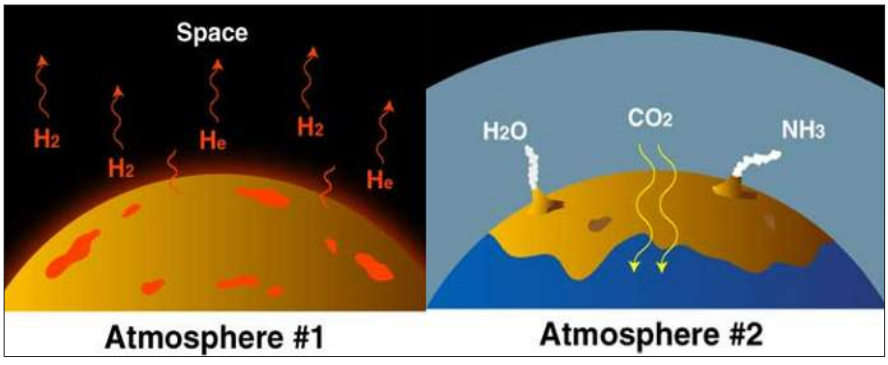
1. air temperature,
2. humidity,
3. type and amount of cloudiness,
4. type and amount of precipitation,
5. air pressure, and
6. the speed and direction of the wind.

- **Forcing** – **An agent that causes a change in a system**, such as a climate system. A volcanic eruption is an example of a natural forcing that can change the composition of the atmosphere.

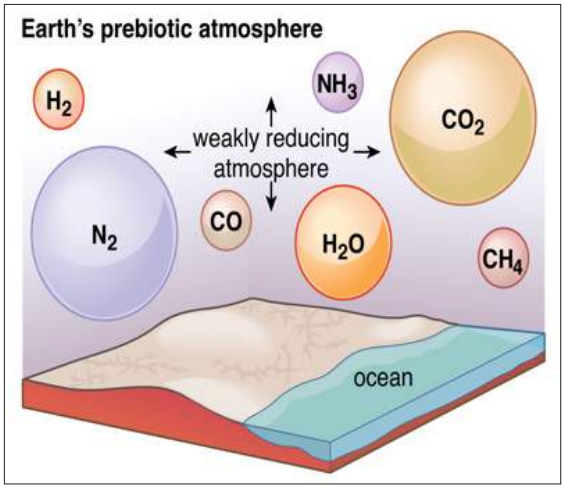
Earth's Atmosphere

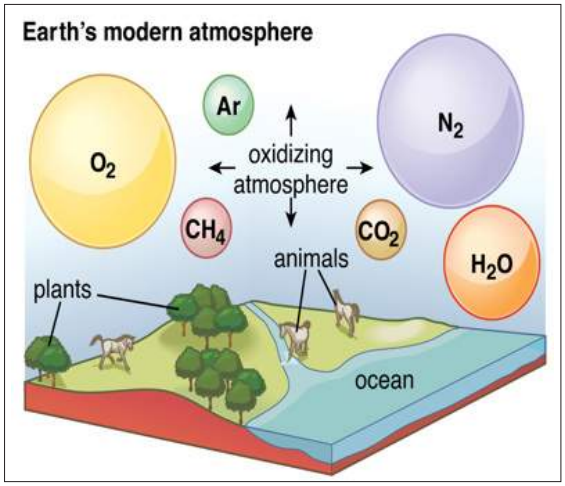
- Origin
- Composition
- Structure

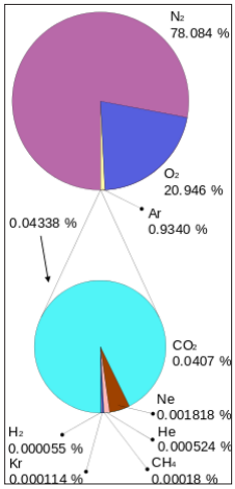




Atmospheric Differentiation

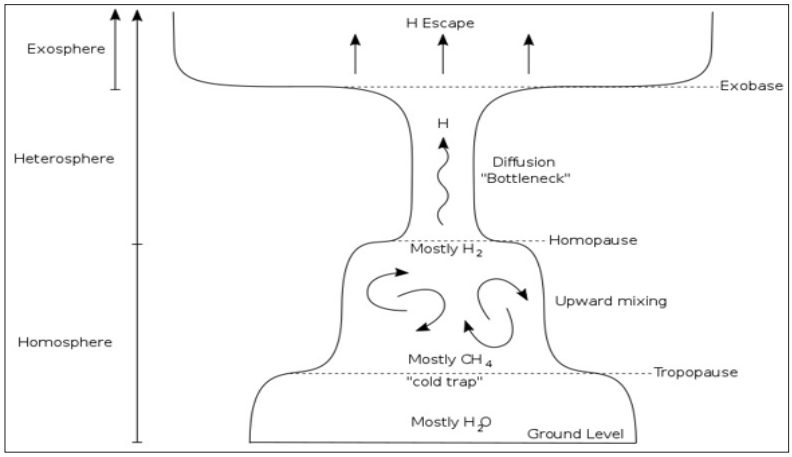






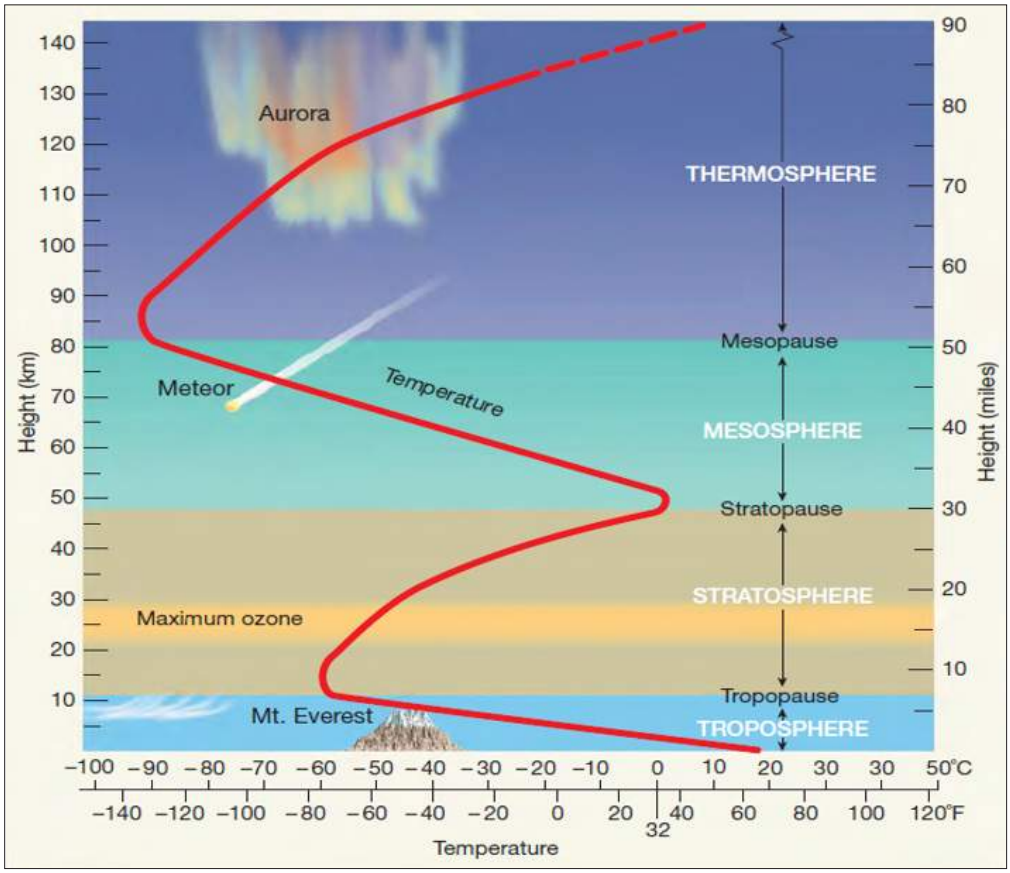
Structure of the Atmosphere

- **One-half** of the atmosphere lies **below an altitude of 5.6** kilometers. About **16 kilometers** above the surface of the earth, about **90 percent** of the atmosphere has been covered.
- The earth's atmosphere consists of zones or layers arranged like spherical shells according to altitude above the earth's surface.



The atmosphere is divided into the following more significant spheres, based on temperature differences (Normal lapse rate 1°C for every 165 m):

1. Troposphere
2. Stratosphere
3. Ozonosphere
4. Mesosphere
5. Ionosphere
6. Exosphere



Troposphere

- The term literally means the region **where air "turns over,"** (vertical mixing of air in this lowermost zone).
- The temperature decrease in the troposphere is called the **environmental lapse rate (6.5°C per km).**
- the **thickness** of the troposphere is not **the same everywhere.**(18 km in the tropics- 9km at poles).
- Warm **surface temperatures** and highly developed **thermal mixing are responsible** for the greater vertical extent.
- The troposphere is the **chief focus of meteorologists** because it is in this layer that essentially all **important weather phenomena** occur. (thus called **weather sphere**)
- It contains 75% of atmospheric mass and 99% of Atmospheric water vapour.

Ionosphere

- Located in the altitude range between 80 to 400 km, and thus coinciding with the lower portions of the thermosphere and heterosphere, is **an electrically charged layer known as the ionosphere.**
- Here molecules of **N and atoms of O are readily ionized** shortwave solar energy.
- Although ionization occurs at heights as great as 1000 km and extends as low as perhaps 50 km, **positively charged ions and negative electrons are most dense in the range of 80 to 400 km.**
- It **consists of three layers of varying ion density.** From bottom to top, these layers are called the **D, E, and F layers,** respectively.
- the **ionosphere has little impact on our daily weather.** But this layer of the atmosphere is the site of one of nature's most interesting spectacles, **the auroras**.

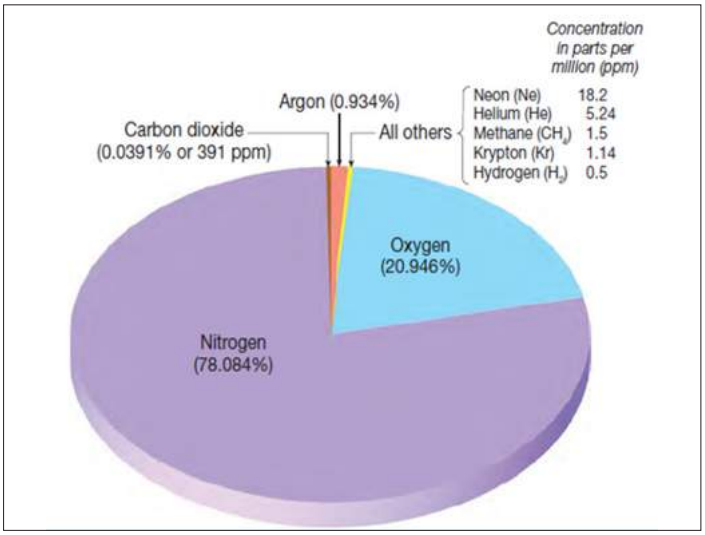
STRUCTURE & COMPOSITION

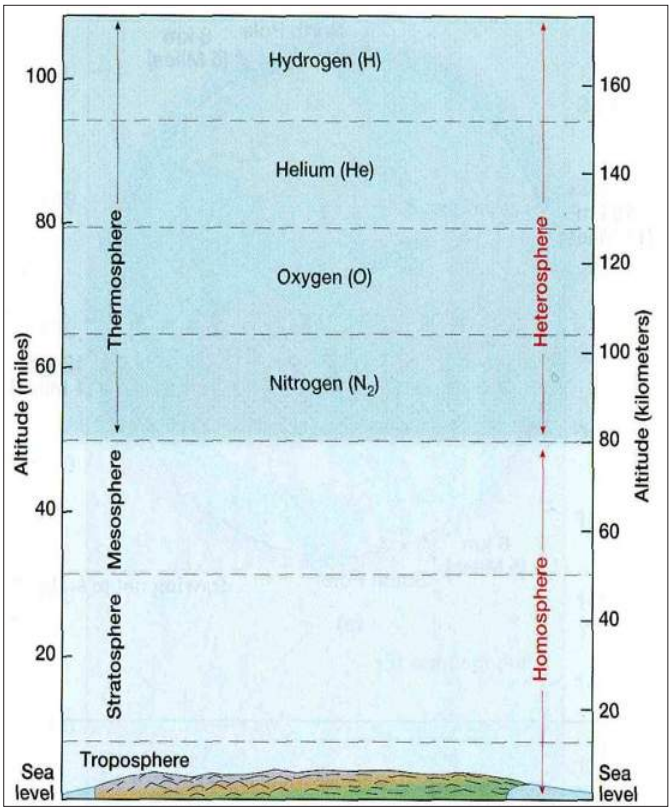
Structure of the Atmosphere

- **One-half** of the atmosphere lies **below an altitude of 5.6** kilometers. About **16 kilometers** above the surface of the earth, about **90 percen**t of the atmosphere has been covered.
- The earth's atmosphere consists of zones or layers arranged like spherical shells according to altitude above the earth's surface.
- **Homosphere :** From Earth's surface to an altitude of **about 80 km,** the makeup of the air is uniform in terms of the proportions of its component gases. **This lower uniform layer is termed the homosphere,** the zone of homogeneous composition.
- **Heterosphere:** In contrast, the **very thin atmosphere above 80 km** is not uniform. In this sphere of heterogeneous composition, the **gases are arranged into four roughly spherical shells,** each with a distinctive composition.

Heterosphere

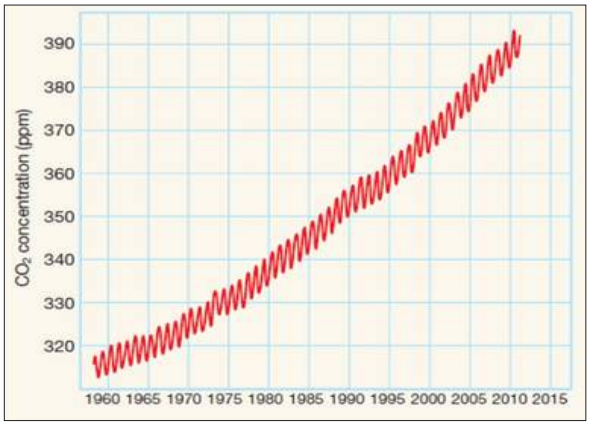
- The stratified nature of the gases making up the heterosphere varies according to their weights. Molecular nitrogen is the heaviest, and so it is lowest. The lightest gas, hydrogen, is outermost.
- **Homosphere**





Heating of Atmosphere

- **Average Feb 2023 temp.** has been reported **29.540C (+ 1.730C)...** World data since 1901, so **122 years' hottest February**
- La Nina phase has ended after 3 years (which causes global temp. to cool) and we are going to **El Nino phase and expect more heat.**
- **Pre monsoon situation** in central India as early as February? **Unprecedented.**



- **El Niño-Southern Oscillation (ENSO)** is a global coupled **ocean-atmosphere phenomenon.** The Pacific ocean signatures, El Niño and La Niña are **important temperature fluctuations in surface waters of the tropical Eastern Pacific Ocean.**

Altitudinal Variation of Temperature

- The **rate of decrease of temperature with increasing altitudes** in a stationary column of air with absence of any vertical motion is **6.50C per 1000 metres.**
- This decrease of temperature is called **vertical temperature gradient or normal lapse rate.**

Latitudinal Variation of Temperature

- The **horizontal lapse** refers to **decrease of temperature with increasing latitudes.**
- The lines joining the places of equal temperature at a given altitude are called isotherms.

HEAT & TEMPERATURE

Temperature and Temperature Distribution

- The Primary source of energy of earth is sun.
- Earth intercepts only **one in two billion** of the total energy radiated by the sun.
- The incoming solar radiation is known as **Insolation.**
- The incoming solar radiation is in the form of short waves.
- The amount of solar energy received at the outer margins of our atmosphere is found to be constant. It is **1.94 calories/sq. cm./minute** and is known **as solar constant.**

Temperature Distribution

- Factors controlling the distribution of insolation
- Processes of Heat energy transfer

Factors affecting the distribution of insolation

1. Angle of incidence
2. Longer the period of sunshine, larger the supply of radiation.
3. Transparency of the atmosphere.
4. Distance between the earth and Sun.

Earth has an elliptical orbit.

Perihelion and aphelion

Approximately 7% difference

5. Solar constant

very negligible change

variations caused by periodic disturbances and explosions in solar surface

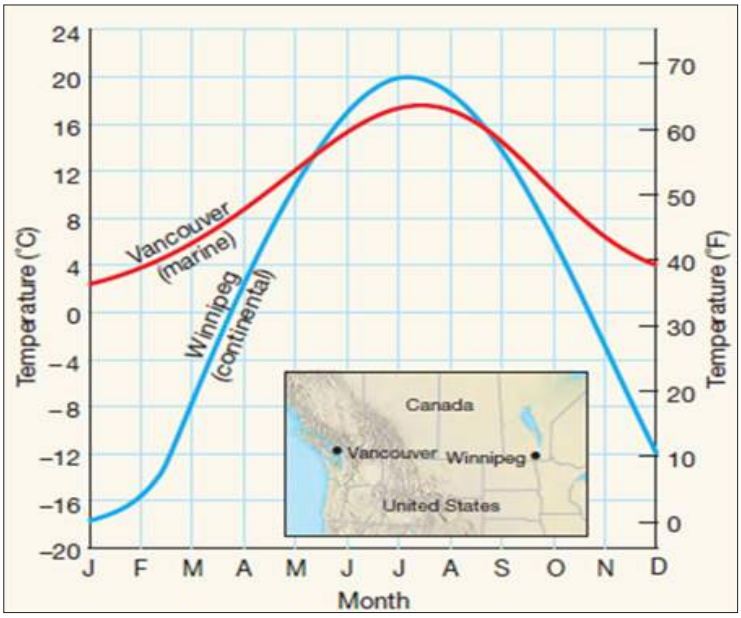
Sunspot cycle – 11 years

Factors controlling Temperature

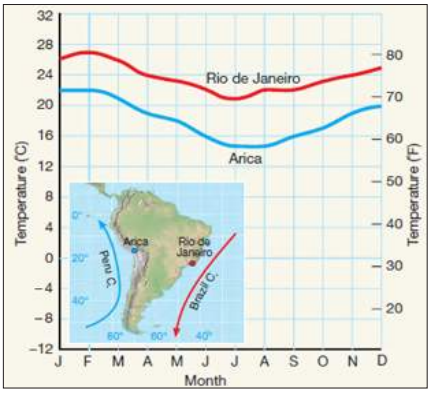
1. **Insolation:** Single greatest cause for temperature variation.
2. **Land and Water:** Differential heating of land and water surfaces.

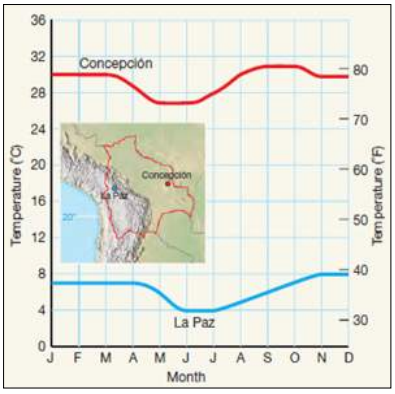
Greater extremes of temperature over land than over oceans. Temperature contrast between land and oceans more in winter than in summer.

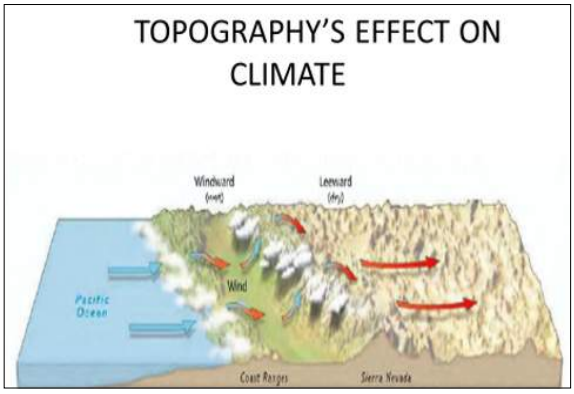
- **Land Hemisphere:** Water covers 61 percent of the Northern Hemisphere; land represents the remaining 39 percent.
- However, the figures for the Southern Hemisphere (81 percent water and 19 percent land) reveal why it is correctly called the **Water Hemisphere.**



3. **Prevailing Winds:** Windward coastal location has moderating influence of the oceans.
4. **Ocean Currents:** Warm currents raise the temperature of the coastal areas. Cold currents lower the temperature e. g. N Atlantic drift, Benguella current.
5. **Altitude:** Atmosphere is heated from below by the terrestrial long wave radiations. Normal lapse rate 10C for every 165 m.
6. **Aspect of Slope:** Slopes more exposed to the sun receive more solar radiation e.g. Himalayas – southern slope.

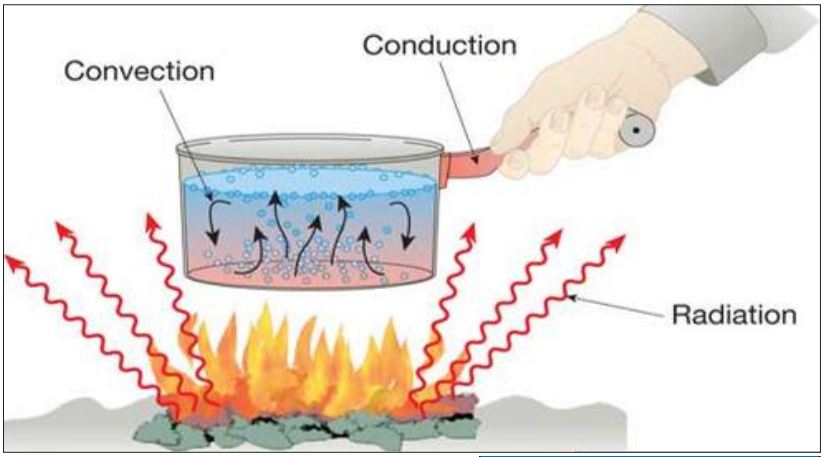




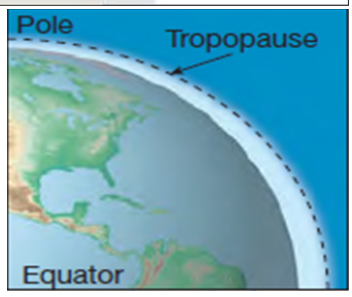


Insolation, Temperature & Heat Budget

Troposphere



- The troposphere is the **chief focus of meteorologists** because it is in this layer that essentially all **important weather phenomena** occur. (Thus called **weather sphere** - It contains **75% of atmospheric mass** and **99%** of **Atmospheric water vapour**)
- The term literally means the region **where air "turns over," (vertical mixing of air** in this lowermost zone).



- The **thickness** of the troposphere is **not the same everywhere**(18 km in the tropics- 9km at poles).
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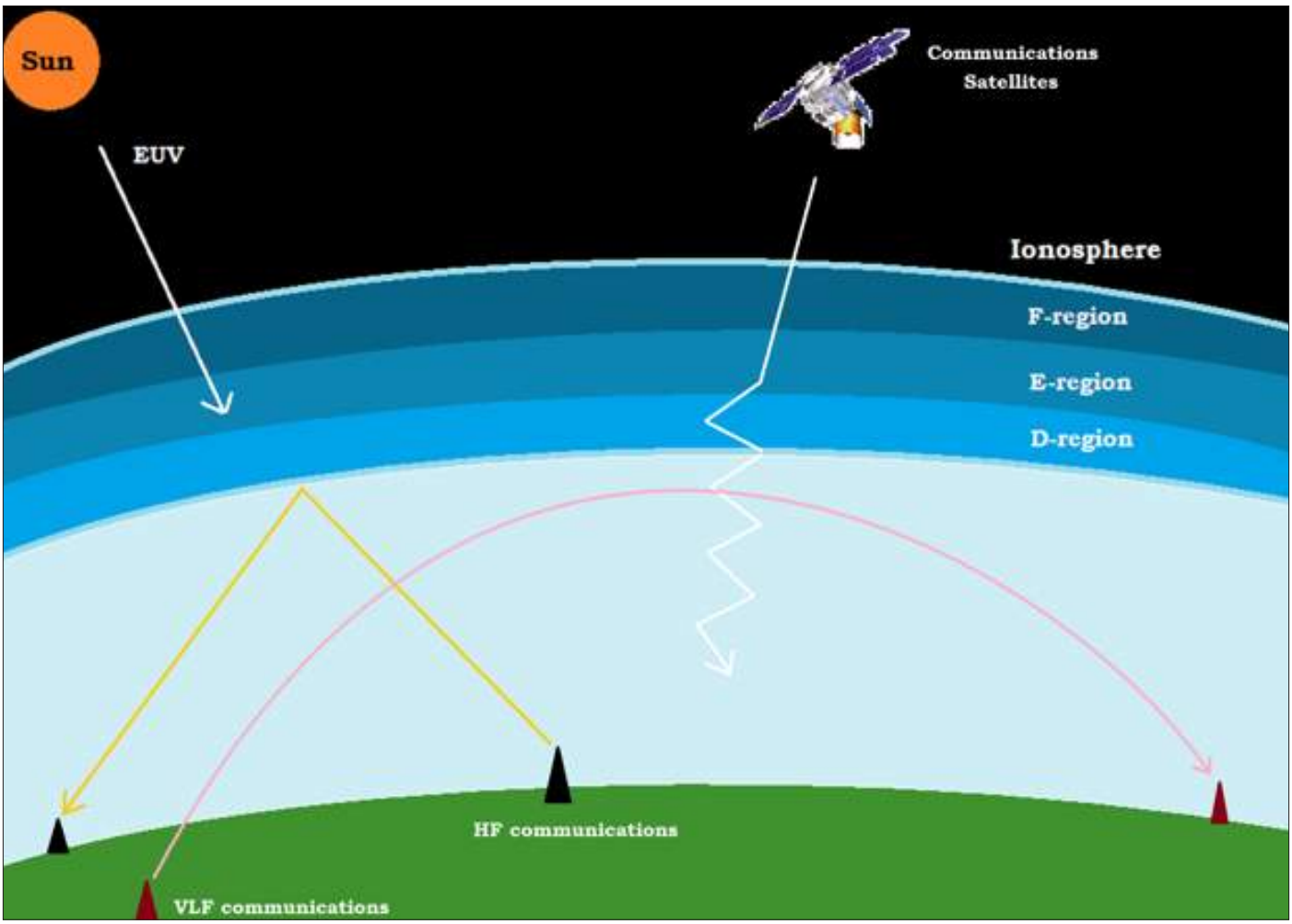
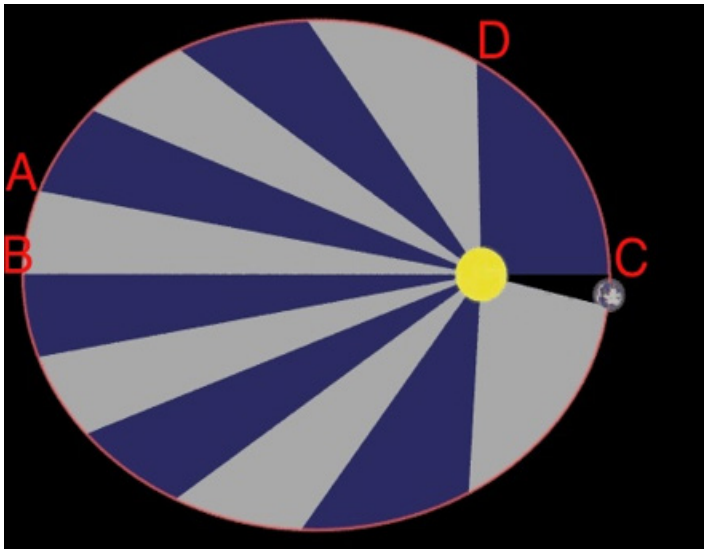


Keppler's Law



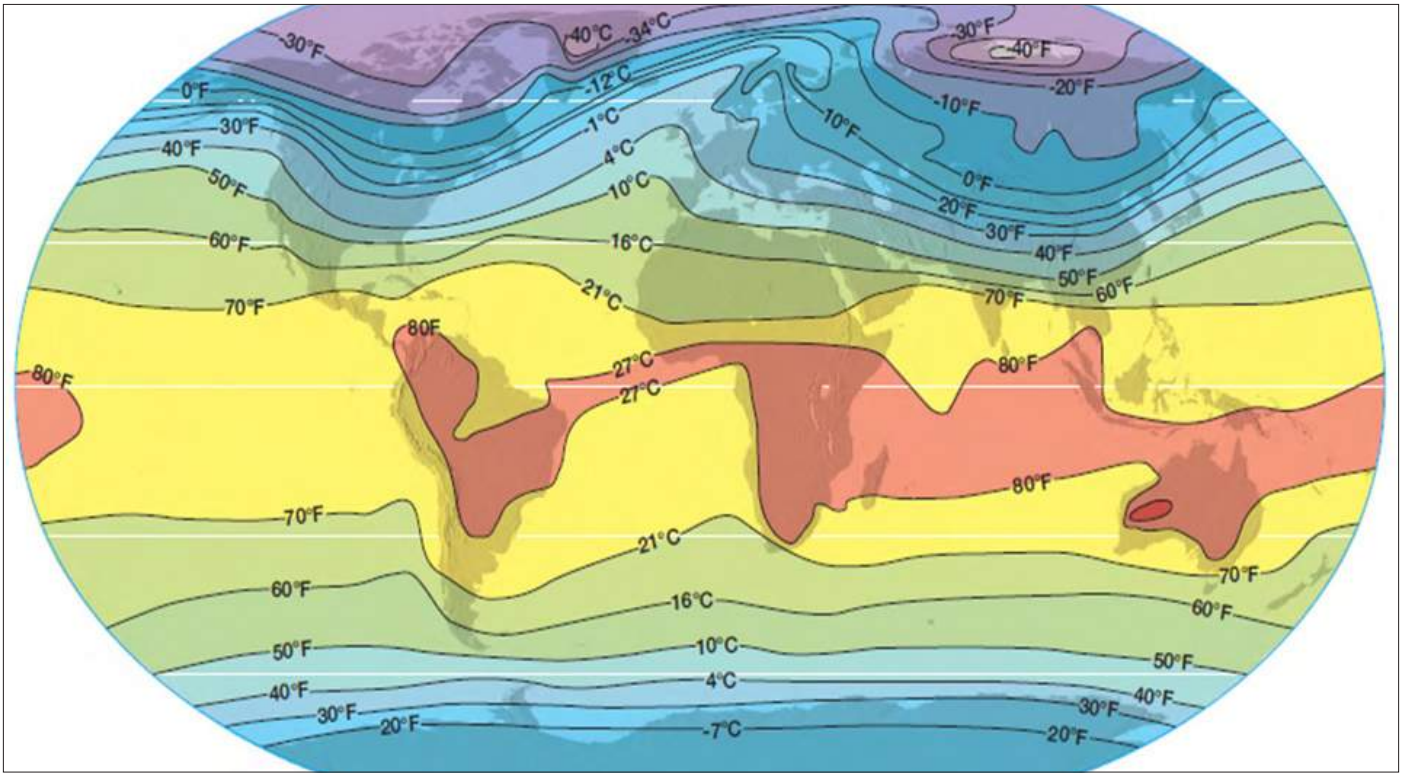
- **Ptolemy and Copernicus** relied on **assumptions**, such as that the **circle is a "perfect" shape and all orbits** must be circular, **Kepler** showed that **mathematically a circular orbit could not match the data** for Mars, but that an elliptical orbit did match the data!
- We now refer to the following statement as Kepler's First Law:

The planets orbit the Sun in ellipses with the Sun at one focus (the other focus is empty).

- Kepler's first law has several implications. These are:

1. The distance between a planet and the Sun changes as the planet moves along its orbit.
2. The Sun is offset from the center of the planet's orbit.

Global Mean Sea Level Temperature (Jan)



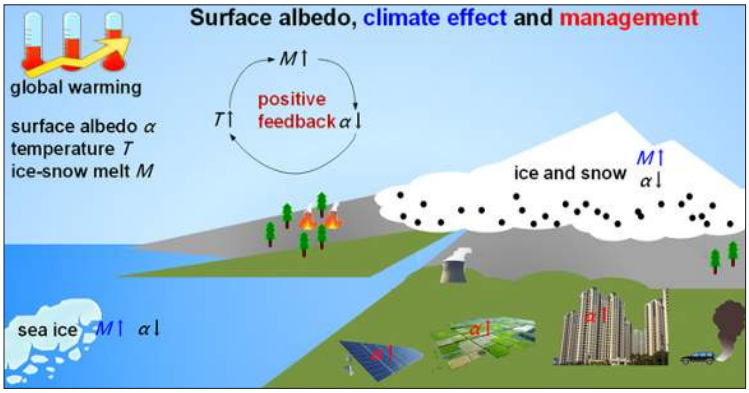
Heat Budget

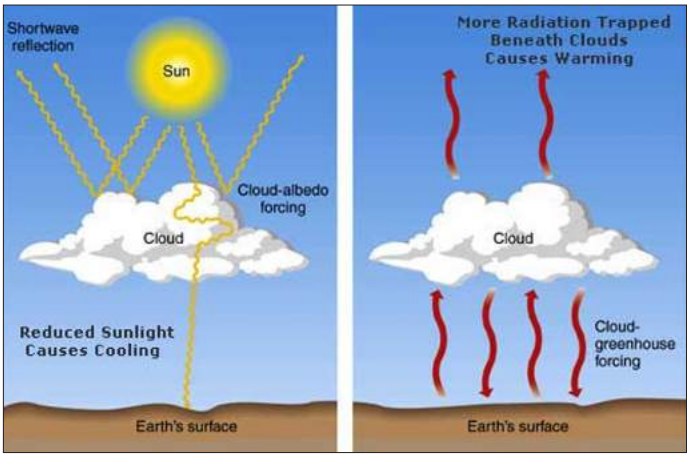
As scientists work to understand why global temperatures are rising and how carbon dioxide and other greenhouse gases are changing the climate system, they have been auditing Earth's energy budget.

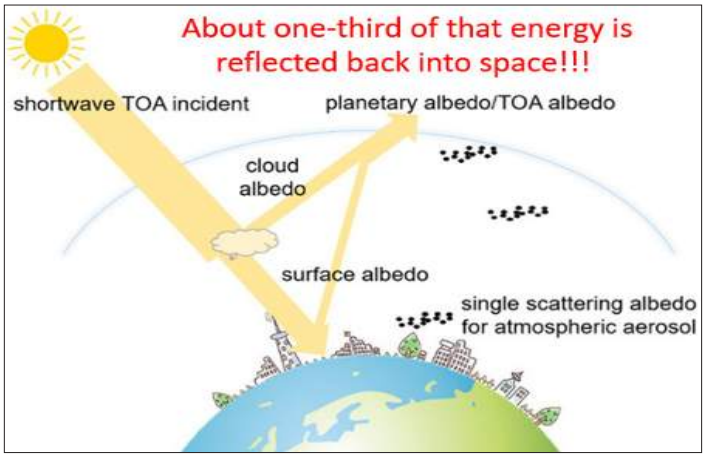
Is more energy being absorbed by Earth than is being lost to space?

Albedo

- Albedo is the **fraction of the incident sunlight that is reflected** from surface of an object.
- A **perfectly black surface** has an albedo of 0 (absorbs all radiations).
- A **perfectly white surface has** an albedo of 1.0 (absorbs all radiations)

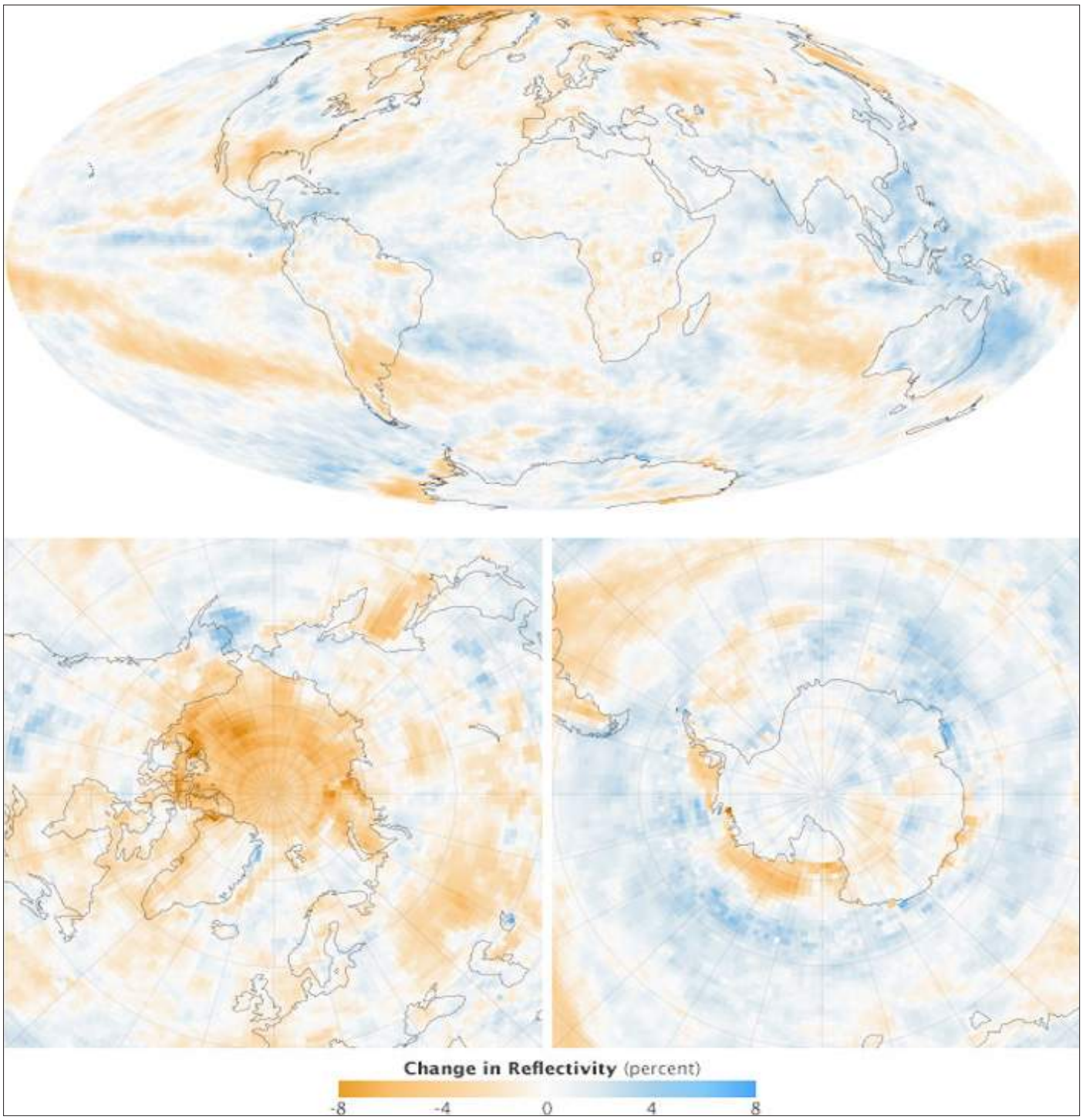






Changing Albedo and Associated Warming

Scientists have been examining this balance sheet with a **series of space-based sensors** known as **Clouds and the Earth's Radiant Energy System, or CERES.**



Albedo Facts

- If **Earth was completely covered in ice**, its albedo would be about 0.84, meaning it would reflect most (84 percent) of the sunlight that hit it.
- On the other hand, **if Earth was covered by a dark green forest canopy,** the albedo would be about 0.14 (most of the sunlight would get absorbed).
- Changes in **ice cover, cloudiness, airborne pollution, or land cover** (from forest to farmland, for instance) all have subtle **effects on global albedo.**

- Using satellite measurements accumulated since the late 1970s, scientists estimate **Earth's average albedo is about about 0.30** (30% in percentage terms)

Surface	Typical albedo
Fresh asphalt	0.04
Open ocean	0.06
Worn asphalt	0.12
Conifer forest (Summer)	0.08, 0.09 to 0.15
Deciduous trees	0.15 to 0.18
Bare soil	0.17
Green grass	0.25
Desert sand	0.4
New concrete	0.55
Ocean ice	0.5–0.7
Fresh snow	0.80–0.90

PRACTICE QUESTIONS

Q 1. Arrange the followings from lower to upper layers in the atmosphere:

1. Stratosphere
2. Ionosphere
3. Troposphere
4. Mesosphere

Select the correct answer from the codes given below

Codes:

(a). 1, 2, 3, 4

(b). 3, 1, 4, 2

(c). 3, 1, 2, 4

(d). 1, 3, 2, 4

Q 2. Which of the following is not a "greenhouse" gas?

(a). Water vapour

(b). Carbon dioxide

(c). CFCs

(d). Nitrogen

Q 3. The jet aircraft fly very easily and smoothly in the lower stratosphere. What could be the appropriate explanation?

1. There are no clouds or water vapour in the lower stratosphere.
2. There are no vertical winds in the lower stratosphere

Which of the statements given above is/are correct?

(a). 1 only

(b). 2 only

(c). Both 1 and 2

(d). Neither 1 nor 2

Q 4. A layer in the Earth's atmosphere called ionosphere facilities radio communication Why?

1. The presence of ozone causes the reflection of radio waves to earth
2. Radio waves have a very long wavelength

Which of the statements given above is/are correct?

(a). 1 only

(b). 2 only

(c). (c) Both 1 and 2

(d). (d) Neither 1 nor 2

Q 5. Consider the following statements:

1. The annual range of temperature is greater in the Pacific Ocean than that in the Atlantic Ocean
2. The annual range of temperature is greater in the Northern Hemisphere than that in the Southern Hemisphere.

Which of the statements given above is/are correct?

(a). 1 only

(b). 2 only

(c). Both 1 and 2

(d). Neither 1 nor 2

Q 6. Consider the following statements:

1. The albedo of an object determines its visual brightness when viewed with reflected light.
2. The albedo of Mercury is much greater than the albedo of the Earth

Which of the statement(s) given above is/are correct?

(a). 1 only

(b). 2 only

(c). Both 1 and 2

(d). Neither 1 nor 2

Q 7. Which one of the following reflects back more sunlight as compared to other three?

(a). Sand desert

(b). Paddy crop land

(c). Land covered with fresh snow

(d). Prairie land

2014 : GS Paper I

Q 1. Explain the formation of thousands of islands in Indonesian and Philippines archipelagos.

Q 2. Why are the world's fold mountain systems located along the margins of continents?