18CEO406T - GLOBAL WARMING AND CLIMATE CHANGE

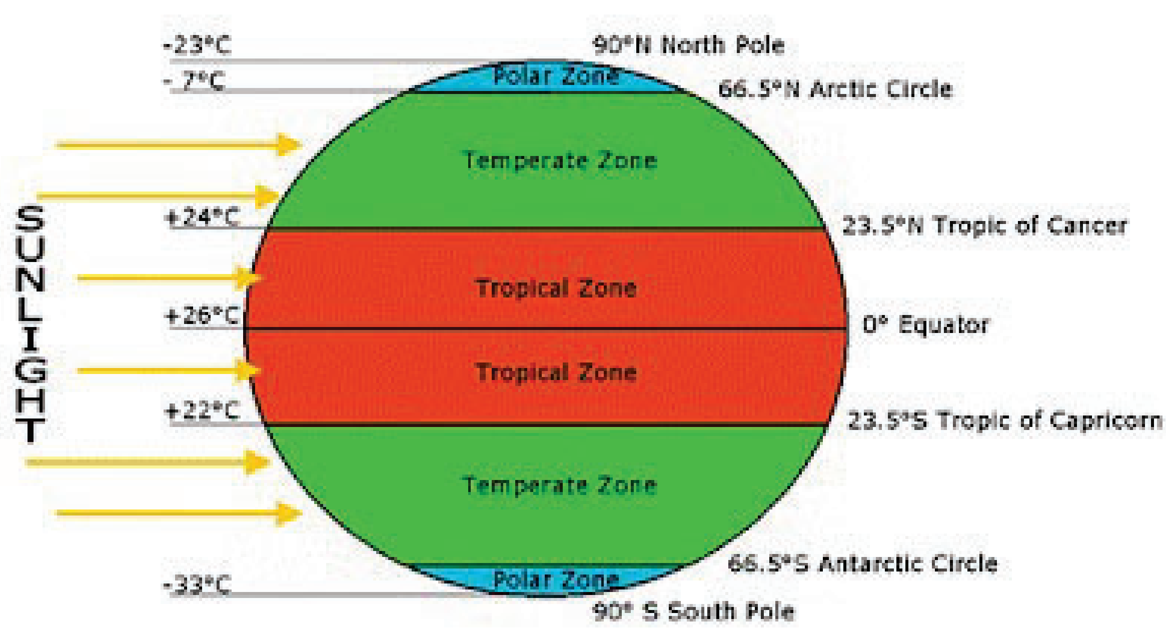
UNIT – 1 [S1 to S3]

S1 : Introduction to earth system – Hydrosphere, lithosphere, cryosphere, atmosphere and biosphere

Introduction to earth Climate

The climate of a place may be defined as a "composite" of the long-term prevailing weather that occurs at that location. In a sense, climate is "average weather". Climate can be measured quantitatively by calculating the long term averages of different climate elements such as temperature and rainfall. Extremes in the weather however, also help us define the climate of a particular area.

We can study climate on a range of geographical scales.



1. Local climate
2. Regional climate
3. Global climate

Local climate:

At the smallest scale, local climates influence areas maybe only a few miles or tens of miles across. Examples of local climatic phenomena include sea breezes and urban heating.

Regional climate:

At larger scales, regional climates provide a picture of particular patterns of weather within individual countries, or within climate zones that exist at different latitudes on the Earth. Climate zones include tropical, subtropical, desert, Savannah, temperate and polar climates. Different climate zones reveal variable patterns of temperature and rainfall

Global climate

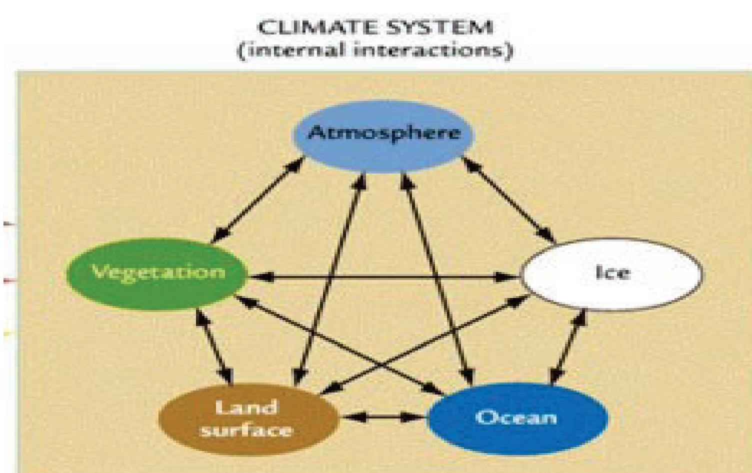
The term "global climate" is used to refer to the general state of the world's climate. Whilst different climate zones may be identified, with different types of weather in different parts of the world, climatologists sometimes like to study the general climate of the whole Earth, for example when investigating evidence for climate change.

The simplest means of assessing the state of the global climate is to measure the global average temperature of the Earth's surface and atmosphere in contact with it

Climate system

The **climate system** is a complex, interactive **system** consisting of the atmosphere, land surface, snow and ice, oceans and other bodies of water, and living things. The atmospheric component of the **climate system** most obviously characterises **climate**; **climate** is often defined as 'average weather'.

The key to understanding global climate change is to first understand what global climate is, and how it operates. At the planetary scale, the global climate is regulated by how much energy the Earth receives from the Sun. However, the global climate is also affected by other flows of energy which take place within the climate system itself. This global climate system is made up of the atmosphere, the oceans, the ice sheets (cryosphere), living organisms (biosphere) and the soils, sediments and rocks (geosphere), which all affect, to a greater or less extent, the movement of heat around the Earth's surface.



Earth's climate arises from the interaction of five major climate system components:

1. Atmosphere (air),
2. Hydrosphere (water),
3. Cryosphere (ice and permafrost),
4. Lithosphere (earth's upper rocky layer) and
5. Biosphere (living things)

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Atmosphere:

The atmosphere plays a crucial role in the regulation of Earth's climate. The atmosphere is a mixture of different gases and aerosols (suspended liquid and solid particles) collectively known as air. Air consists mostly of nitrogen (78%) and oxygen (21%). However, despite their relative scarcity, the so-called greenhouse gases, including carbon dioxide and methane, have a dramatic effect on the amount of energy that is stored within the atmosphere, and consequently the Earth's climate. These greenhouse gases trap heat within the lower atmosphere that is trying to escape to space, and in doing so, make the surface of the Earth hotter. This heat trapping is called the natural greenhouse effect, and keeps the Earth 33°C warmer than it would otherwise be. In the last 200 years, man-made emissions of greenhouse gases have enhanced the natural greenhouse effect, which may be causing global warming.

The atmosphere however, does not operate as an isolated system. Flows of energy take place between the atmosphere and the other parts of the climate system, most significantly the world's oceans. For example, ocean currents move heat from warm equatorial latitudes to colder polar latitudes.

Heat is also transferred via moisture. Water evaporating from the surface of the oceans stores heat which is subsequently released when the vapour condenses to form clouds and rain. The significance of the oceans is that they store a much greater quantity of heat than the atmosphere. The top 200 metres of the world's oceans store 30 times as much heat as the atmosphere. Therefore, flows of energy between the oceans and the atmosphere can have dramatic effects on the global climate.

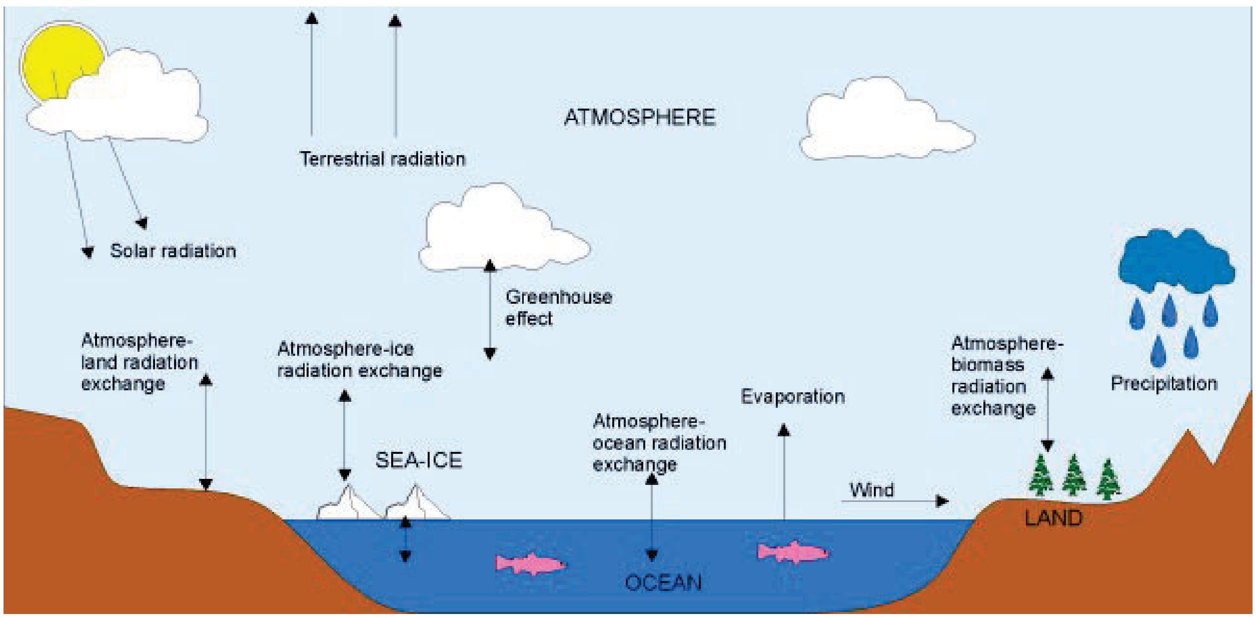

Fig: Earth climate (Atmosphere)

Cryosphere:

The world's ice sheets, glaciers and sea ice, collectively known as the cryosphere, have a significant impact on the Earth's climate. The cryosphere includes Antarctica, the Arctic Ocean, Greenland, Northern Canada, Northern Siberia and most of the high mountain ranges throughout the world, where sub-zero temperatures persist throughout the year. Snow and ice, being white, reflect a lot of sunlight, instead of absorbing it. Without the cryosphere, more energy would be absorbed at the Earth's surface rather than reflected, and consequently the temperature of the atmosphere would be much higher.

Biosphere:

All land plants make food from the photosynthesis of carbon dioxide and water in the presence of sunlight. Through this utilisation of carbon dioxide in the atmosphere, plants have the ability to regulate the global climate. In the oceans, microscopic plankton utilise carbon dioxide dissolved in seawater for photosynthesis and the manufacture of their tiny carbonate shells. The oceans replace the utilised carbon dioxide by "sucking" down the gas from the atmosphere.

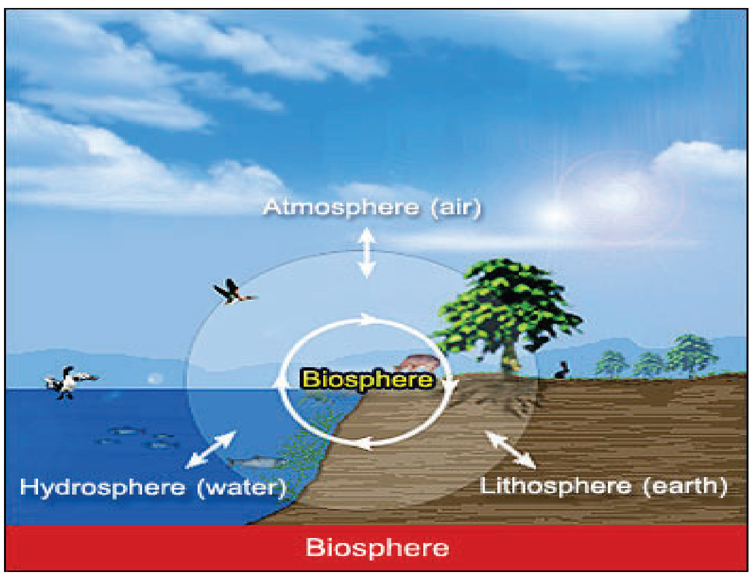

Fig: Earth climate (Biosphere)

LITHOSPHERE

It is believed the lithosphere evolved about 4.6 billion years ago. The lithosphere refers to the solid, rocky crust that covers the entire planet. This solid, rocky crust is composed of a number of different rocks that have been hrouped into three categories based on how they are formed. These three groups include:

- Metamorphic rocks – Metamorphic rocks are formed by heat and / or pressure from pre-existing rocks.
- Igneous rocks – igneous rocks are formed by the cooling of hot molten rock also known as magma. When the hot magma cools it begins to harden meaning once it had fully cooled it create what is known to be an igneous rock.
- Sedimentary rocks – sedimentary rocks are formed from pre-existing rocks. When rocks erode and mix with other dirt, clay and particles then settle together the mix together to form a sedimentary rock.

The lithosphere includes a various number of different landforms such as mountains, valleys, rocks, minerals and soil. The lithosphere is constantly changing due to forces and pressures such as the sun, wind, ice, water and chemical changes.

The earth's surface is composed into two types of lithospheres. There are known as the **oceanic and continental lithospheres.**

The oceanic lithosphere includes the uppermost layers of mantle which is topped with a thin yet heavy oceanic crust. This is where the hydrosphere and lithosphere meet.

The continental lithosphere include the uppermost layers of mantle which is topped with a thick yet light continental crust. This is where the atmosphere, biosphere and hydrosphere meet the lithosphere.

HYDROSPHERE **-**

The hydrosphere refers to the most important resource which I water. The hydrosphere includes all forms of water in the Earth's environment. The forms of water include things such as the ocean, lakes, rivers, snow and glaciers, water underneath the earth's surface and even the water vapour that is found in the atmosphere. The hydrosphere is always in motion as seen through the movement and flow of water in rivers, streams and the ocean (beach). Plant and animal organisms rely on the hydrosphere for their survival as water is essential. The hydrosphere is also home to many plants and animals and it believed that the hydrosphere covers approximately 70% of the earth's surface

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S1 : Earth system-hydrological cycle and carbon cycle

Hydrologic cycle

- Water exists on earth in all three states, liquid, solid and gaseous state and various degrees of motion. The various aspects of water related to the earth can be explained in terms of cycle known as hydrologic cycle.
- Except for deep ground water, the total water supply of earth is in constant circulation from earth tot atmosphere and back to the earth.
- The earth' water circulatory system is known as hydrologic cycle. It is the process of transfer of moisture from atmosphere to earth in the

form of precipitation, conveyance of precipitated water by streams and rivers to oceans and lakes and evaporation of water back to the atmosphere.

- The group of numerous arcs which represents the different path through which water in nature circulates and is transformed is known as hydrological cycle.
- These arcs penetrates into three parts of total earth system, Atmosphere, Hydrosphere and lithosphere.
- Hydrological cycle can be represented in many different ways in pictorial or diagrammatic forms.
- The hydrological cycle has no beginning or end as the water in nature is continuously kept in cyclic motion.

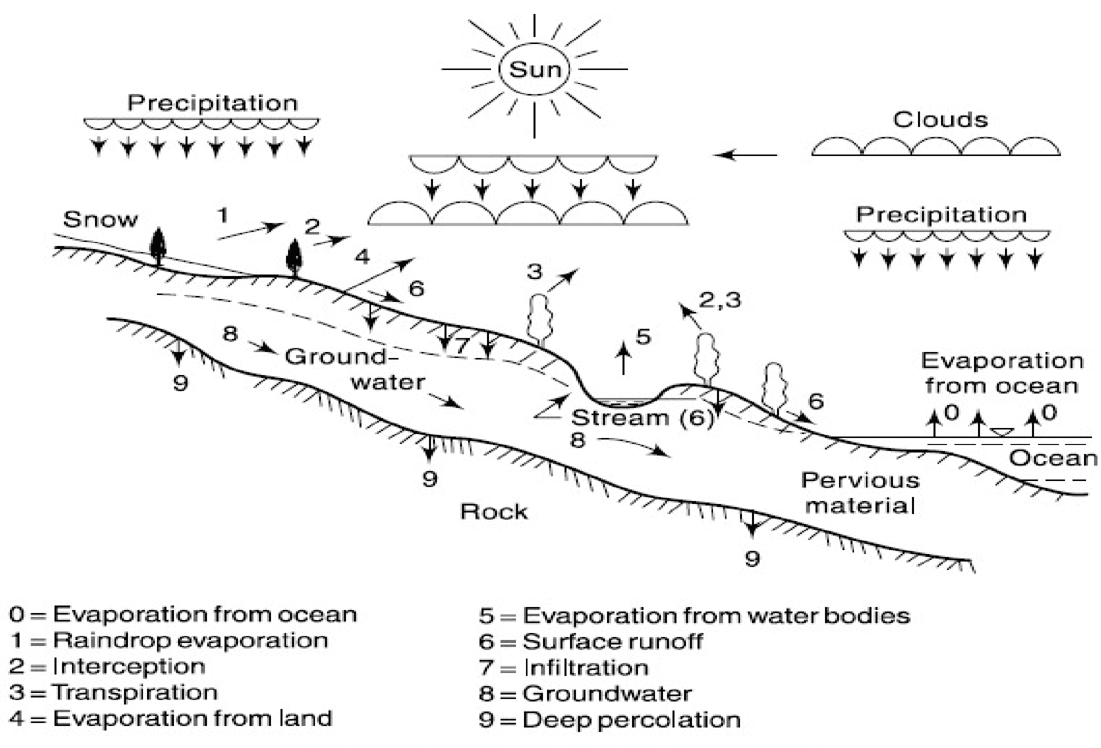

Fig. 1.1 The Hydrologic Cycle

Thus the hydrologic cycle may expressed by the following equation as

Precipitation [P] = Evaporation [E] + Runoff [R]

Provided adjustment is made for the moisture held in storage at the beginning and end of the period.

Precipitation [P]

- Precipitation may be defined as **fall of moisture from atmosphere to the earth surface in any form.**
- The precipitation reaching the ground surface after meeting the needs of infiltration and evaporation moves down the natural slope over the surface and through rivers and streams to reach the oceans.
- Precipitation may be **two forms**

i. Liquid Precipitation – Rainfall

ii. Frozen Precipitation – Snow, Hail, sleet, freezing rain

Measurement of Precipitation

It can be measured by rain gauge. The rain gauge may be

i) Recording type rain gauge [Weighing bucket, Tipping bucket, Floating type]

ii) Non- recording type rain gauge[Symon's Raingauge]

Evaporation [E]

- **Evaporation** from the surfaces of ponds, lakes, reservoirs. ocean surfaces, etc. and transpiration from surface vegetation i.e., from plant leaves of cropped land and forests, etc. take place. These vapours rise to the sky and are condensed at higher altitudes by condensation nuclei and form clouds, resulting in droplet growth.

- It is the process by which water from liquid state passes into vapour state under the action of sunrays.
- Transpiration is the process of water being lost from the leaves of plants from their pores.

Thus **total evaporation inclusive of transpiration** consists of

i. Surface evaporation
ii. Water Surface evaporation [Rivers, oceans]
iii. Evaporation from plants and leaves [Transpiration]
iv. Atmospheric evaporation

A portion of water that reaches the ground enters the earth surface through infiltration, enhance the moisture content of soil and reach the ground water body.

Runoff [R]

- Runoff is the portion of precipitation that is not evaporated.
- When moisture falls to the earth surface as precipitation, a part of it is evaporated from the water surface, soil and vegetation and through transpiration by plants and remainder precipitation is available as runoff which ultimately runs to the oceans through surface or sub-surface streams.

Classification of run off

i. Surface run off
ii. Sub surface runoff
iii. Ground water flow or base flow

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Carbon cycle

The carbon cycle is most easily studied as two interconnected subcycles:

- One dealing with rapid carbon exchange among living organisms.**[Biological carbon cycle]**
- One dealing with long-term cycling of carbon through geologic processes.**[Geological carbon cycle]**

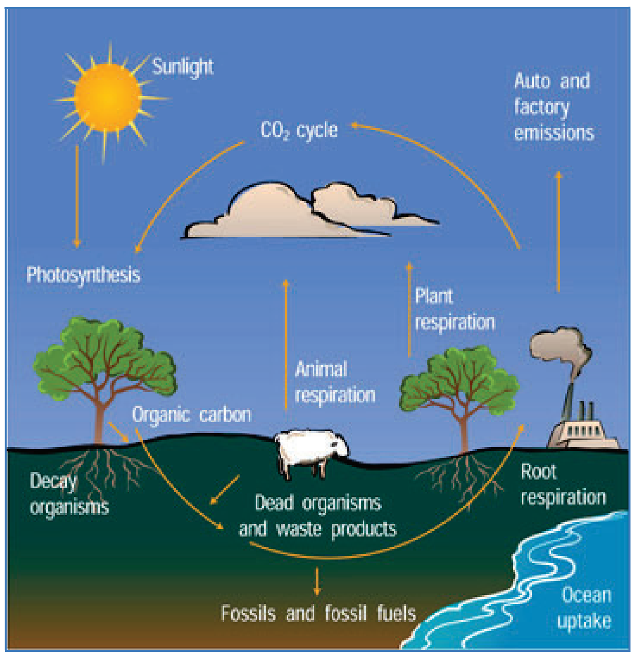


Fig: Carbon cycle

Biological carbon cycle

Carbon enters all food webs, both terrestrial and aquatic, through **autotrophs**, or self-feeders. Almost all of these autotrophs are photosynthesizers, such as plants or algae.

Autotrophs capture carbon dioxide from the air or bicarbonate ions from the water and use them to make organic compounds such as glucose.

Heterotrophs, or other-feeders, such as humans, consume the organic molecules, and the organic carbon is passed through food chains and webs. Carbon can cycle quickly through this biological pathway, especially in aquatic ecosystems. Overall, an estimated 1,000 to 100,000 million metric tons of carbon move through the biological pathway each year.

In the first step, through photosynthesis (the process by which plants capture the sun's energy and use it to grow), plants take carbon dioxide out of the atmosphere and release oxygen. The carbon dioxide is converted into carbon compounds that make up the body of theplant, which are stored in both the aboveground parts of the plants (shoots and leaves), and the below ground parts (roots).

Photosynthesis: Energy (sunlight) + $6CO_2$ + $H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

In the next step, animals eat the plants, breath in the oxygen, and exhale carbon dioxide. The carbon dioxide created by animals is then available for plants to use in photosynthesis. Carbon stored in plants that are not eaten by animals eventually decomposes after the plants die, and is either released into the atmosphere or stored in the soil.

Respiration: $C_6H_{12}O_6$ (organic matter) + $6O_2 \rightarrow 6CO_2 + 6\ H_2O$ + Energy

Large quantities of carbon can be released to the atmosphere through geologic processes like volcanic eruptions and other natural changes that destabilize carbon sinks. For example, increasing temperatures can cause carbon dioxide to be released from the ocean.

Geological Process of carbon cycle

The geological pathway of the carbon cycle takes much longer than the biological pathway described above. In fact, it usually takes millions of years for carbon to cycle through the geological pathway. Carbon may be stored for long periods of time in the atmosphere, bodies of liquid water—mostly **oceans— ocean sediment, soil, rocks, fossil fuels, and Earth's interior.**

The level of carbon dioxide in the atmosphere is influenced by the reservoir of carbon in the oceans and vice versa. Carbon dioxide from the atmosphere dissolves in water and reacts with water molecules in the following reactions:

$$CO_2 + H_2O \rightleftharpoons H_2CO_3 \rightleftharpoons HCO_3^- + H^+ \rightleftharpoons CO_3^{2-} + 2H^+$$

The carbonate—CO_3^{2-}—released in this process combines with Ca^{2+} ions to make calcium carbonate $CaCO_3$ a key component of the shells of marine organisms. When the organisms die, their remains may sink and eventually become part of the sediment on the ocean floor. Over geologic time, the sediment turns into limestone, which is the largest carbon reservoir on Earth.

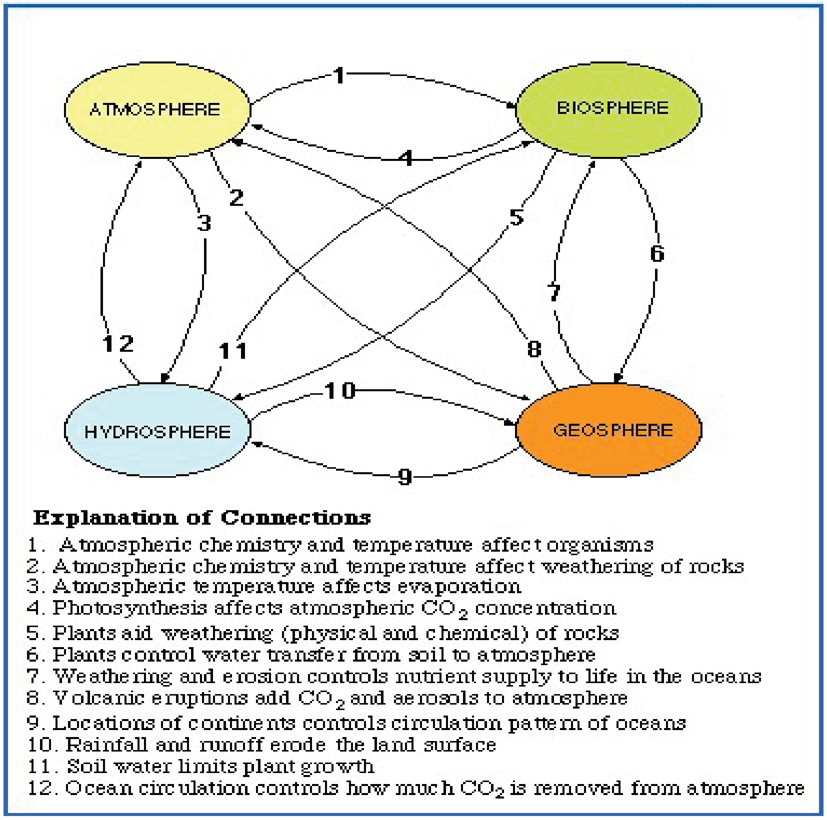
S2: Importance of earth system and climate

Earth System Science is a relatively new field of study that focuses on the operation of the whole Earth, including the **atmosphere, hydrosphere, biosphere, and geosphere.** These four spheres can be thought of as four machines or systems that are connected together to make one larger machine -- the whole Earth system. Earth System Science is especially concerned with the interactions between these different spheres and how these interactions control the global climate. This field of study incorporates and integrates material from traditional geology, meteorology, oceanography, ecology, atmospheric chemistry, and other fields.

	Major Influences on the Global Climate
Atmosphere	CO_2 and H_2O control greenhouse; clouds and aerosols control amount of sunlight reaching surface; global circulation determines climatic zones
Biosphere	Land plants transfer CO_2 from atmosphere and soil; oceanic plants transfer CO_2 from atmosphere to ocean floor; plants affect albedo of surface; land plants transfer H_2O from the soil to the atmosphere; plants and microbes enhance weathering of rocks, which consumes atmospheric CO_2
Hydrosphere	Atmospheric H_2O controls greenhouse and cloud cover and transfers heat energy; surface water controls plant growth and thus albedo and CO_2 transfer; oceans transfer heat and regulate atmospheric CO_2; glaciers control albedo, sea level, and deep ocean circulation patterns
Geosphere	Locations of continents controls ocean circulation, global weather patterns; mountains affect regional weather and are main locations of weathering which removes atmospheric CO_2; volcanoes return CO_2 to the atmosphere; volcanic aerosols block sunlight; sea-floor spreading rates control sea level

In addition to understanding how different parts of the Earth System affect the global climate, it is important to understand how these different parts are linked together &emdash; how they are interconnected. The graph below represents these interconnections in the form of connecting arrows; each arrow represents some set of processes that operate within one of the Earth's four "spheres" that influences the "sphere" that the arrow points to

Connections Within The Earth System



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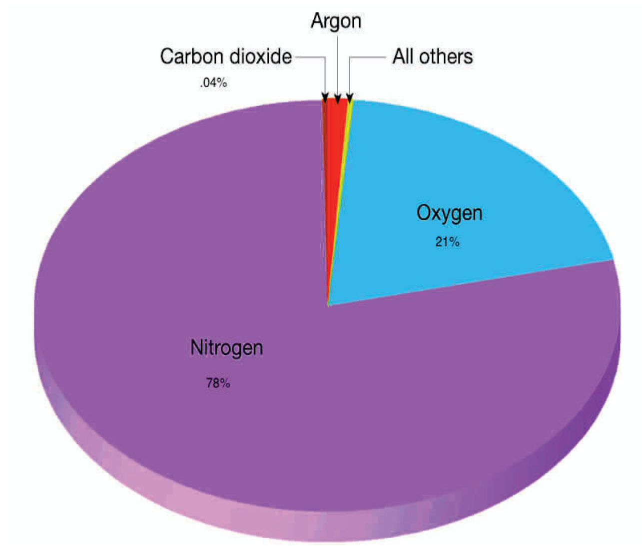
S3: Atmosphere and its composition, different strata of atmosphere and temperature profile

Atmosphere and its composition

The earth's atmosphere is a very thin layer wrapped around a very large planet. The three major constituents of dry air are **nitrogen (N_2) oxygen (O_2) and argon (Ar), which account respectively for 79 percent, 21 percent and 1 percent of the molecules.**



Composition of the Atmosphere	Other Components of the Atmosphere
• Nitrogen 78.08% • Oxygen 20.95% • Argon 0.93% (9300 ppm) • Carbon Dioxide 0.035% (350 ppm) • Neon 18 ppm • Helium 5.2 ppm • Methane 1.4 ppm • Ozone 0.07 ppm	• Water Droplets • Ice Crystals • Sulfuric Acid Aerosols • Volcanic Ash • Windblown Dust • Sea Salt • Human Pollutants

Different strata of atmosphere

Based on temperature, the atmosphere is divided into five layers:

i) Troposphere
ii) Stratosphere
iii) Mesosphere and
iv) Thermosphere
v) Exosphere

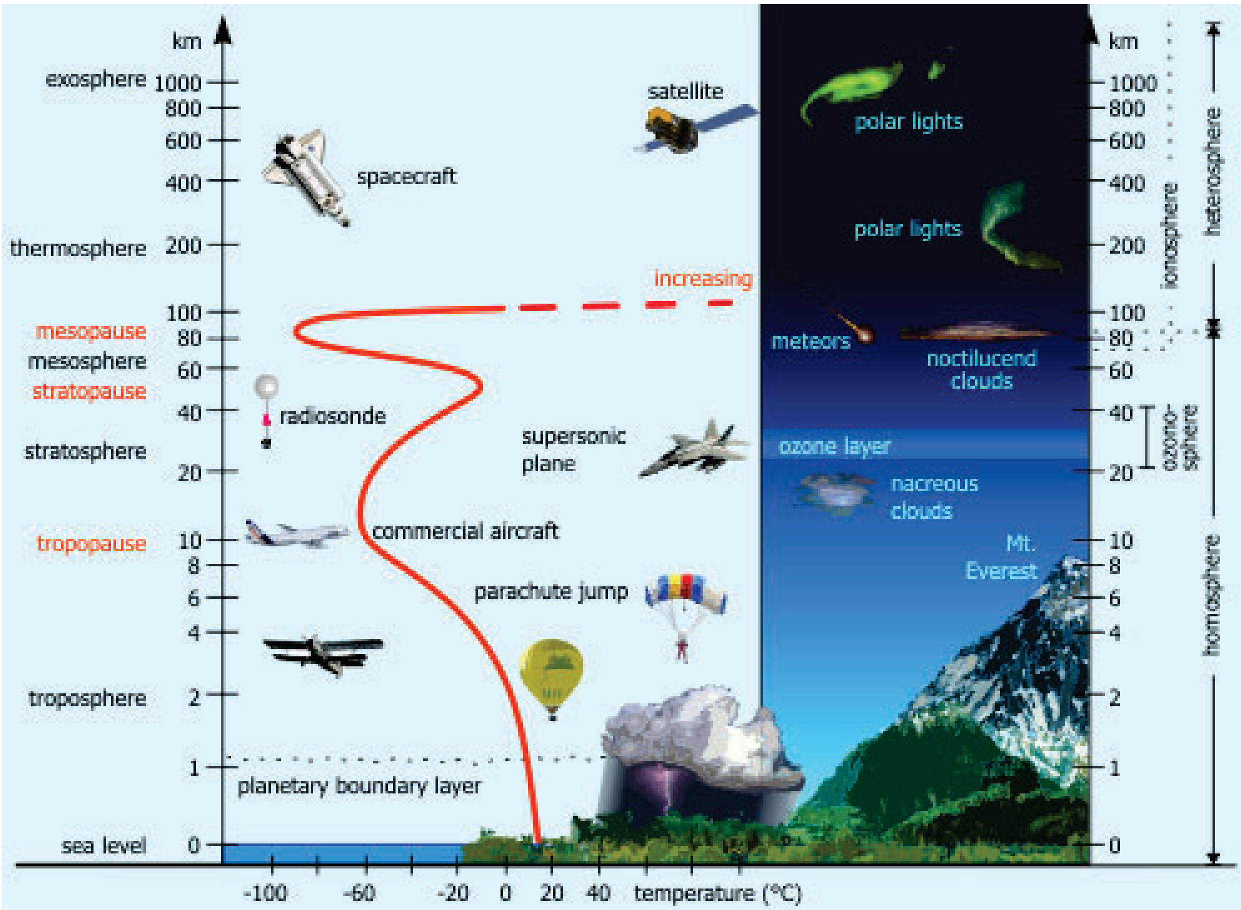


Fig: Different layers of Atmosphere

i) Troposphere

"**Tropos**" means change.

This layer gets its name from the weather that is constantly changing and mixing up the gases, in this part of our atmosphere.This layer is the closest to Earth's surface.

On average the troposphere extends, from the ground to about 12 kilometers or 7.5 miles high.The troposphere contains, about 75% of all of the air in the atmosphere, and, almost all of the water vapor, which forms clouds and rain. In this layer, air is made up of approximately 78% nitrogen, 21% oxygen, and 1% argon with small amounts of additional gases, including water vapor and, carbon dioxide.

(ii) Stratosphere

"**Strat**" means layer.

This layer of our atmosphere has its own set of layers. The boundary between the stratosphere and the troposphere is called the tropopause. It is the region where airplanes fly.

The Stratosphere layer, extends from the tropopause to about 50 kilometers (32 miles) above the Earth's surface.This layer contains a thin layer of ozone molecules which forms a protective layer and absorbs harmful ultraviolet radiation, from the Sun. The high-altitude weather balloons flying into the stratosphere for monitoring atmospheric conditions and climate research.

(iii) Mesosphere

"**Meso**" means middle.

This layer is located above the stratosphere and below the thermosphere. It is the third layer in our atmosphere which is 35 kilometers (22 miles) thick. The transition boundary which separates the mesosphere, from the stratosphere is called the stratopause. In the mesosphere fewer air molecules to absorb incoming electromagnetic radiation from the Sun. Most meteors burn up in this atmospheric layer.

(iv) Mesosphere

"**Thermo**" means heat.

This layer has extremely high temperatures, and located above the mesosphere, and below the exosphere. The boundary between the mesosphere, and the thermosphere atmospheric regions, is called Mesopause. It is the coldest part of Earth's atmosphere. The thermosphere, extends from the mesopause to 700 kilometers (435 miles) above the surface of the Earth. The thermosphere is the thickest layer, in the atmosphere. Only the lightest gases, mostly oxygen, helium, and, hydrogen are found here. The aurora, and satellites mostly occur in this layer.

(V) EXOSPHERE

"**Exo**" means outside.

The exosphere, represents the outermost layer of Earth's atmosphere. It extends, from the top of the thermosphere to 10,000 kilometers (6,214 miles) above Earth's surface.

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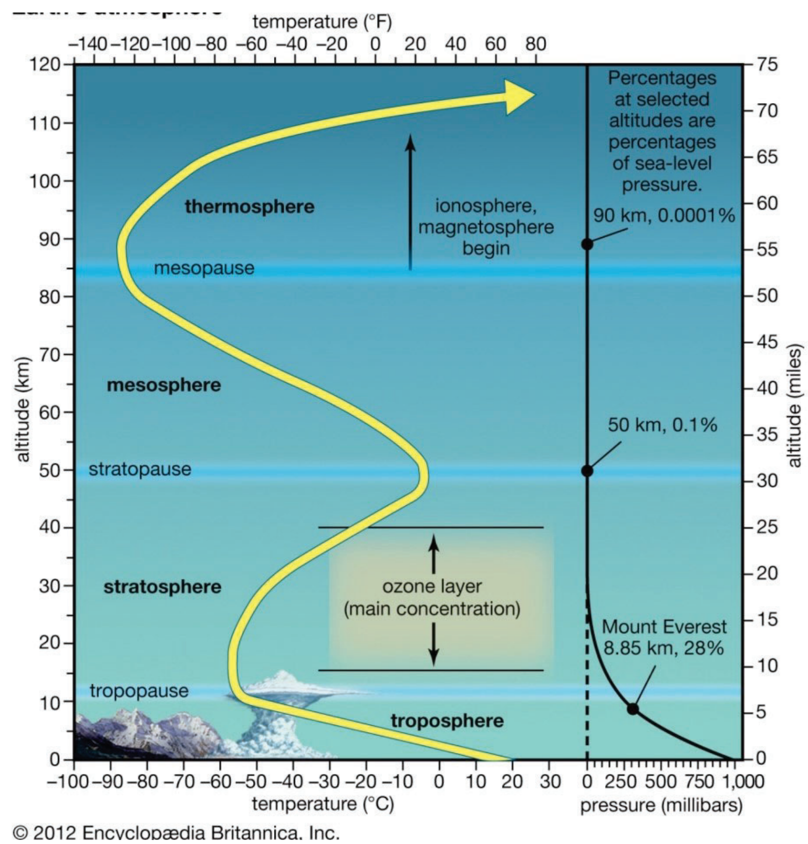
Temperature profile



Atmospheric Composition - affects Air Temperature:

Air temperature also changes as altitude increases. The temperature differences result mainly from the way solar energy is absorbed as it moves through the atmosphere.Some parts of the atmosphere are warmer because they contain a high percentage of gases that absorb solar energy. Other parts of the atmosphere contain less of these gases and are cooler

Heat and Temperture:

Temperature: Average energy of molecules or atoms in a material.
Heat: Total energy of molecules or atoms in a material.
It’s possible to have large amount of heat but low temperatures and high temperatures but little heat.
The Arctic Ocean has a large amount of heat (because of large mass) even though the temperature is low. Air in an oven at 500ºF has high temperature but little heat.
However if you touch anything solid in the oven you’ll get burned. Same temperature but much larger amount of heat. The earth’s outermost atmosphere is extremely “hot” but its heat content is negligible.
It takes time for things to warm up and cool off.

Temperature Scales	Absolute Temperature
1) Fahrenheit a) Water Freezes at 32 F b) Water Boils at 212 F 2) Centigrade or Celsius a) Water Freezes at 0 C b) Water Boils at 100 C 3) Two scales exactly equal at -40	Kelvin scale uses Celsius degrees and starts at absolute zero Absolute Zero specify - 273ºC / - 459ºF.

18CEO406T - GLOBAL WARMING AND CLIMATE CHANGE

UNIT – 1 [S7 to S9]

S7: Atmospheric stability continuation, Pollutant dispersion

Pollutant Dispersion

The stream of polluted air downwind of a smoke stack is called a smoke plume. If the plume is buoyant, or if there is a large effluent velocity out of the top of the smoke stack, the center of the plume can rise above the initial emission height. This is called plume rise. The word "plume" in air pollution work means a long, slender, nearly-horizontal region of polluted air. However, the word "plume" in atmospheric bound-ary-layer (ABL) studies refers to the relatively wide, nearly vertical updraft portion of buoyant air that is convectively overturning. Because smoke plumes emitted into the boundary layer can be dispersed by convective plumes, one must take great care to not confuse the two usages of the word "plume".

Dispersion is the name given to the spread and movement of pollutants. Pollution dispersion de-pends on

- wind speed and direction,
- plume rise, and
- atmospheric turbulence.

Pollutants disperse with time by mixing with the surrounding cleaner air, resulting in an increasingly dilute mixture within a spreading smoke plume.

Wind and turbulence are characteristics of the ambient atmosphere, as were described in earlier chapters. While emissions out of the top of the stack often have strong internal turbulence, this quickly decays, leaving the ambient atmosphere to do the majority of the dispersing.

The amount of a pollutant in the air can be given as a fraction or ratio, q. This is the amount (moles) of pollution divided by the total amount (moles) of all constituents in the air. For air quality, the ratios are typically reported in parts per million (ppm). For example, 10 ppm means

10 parts of pollutant are contained within 106 parts of air. For smaller amounts, parts per billion (ppb) are used.

For a standard atmosphere at sea level, where temperature is 15°C and pressure is 101.325 kPa, the equation above reduces to

$$q(\text{ppmv}) = \frac{b}{M_s} \cdot c(\mu\text{g/m}^3)$$

where $b = 0.02363$ (ppmv) / (μg m^{-3}).

For example, nitrogen dioxide (NO_2) has a molecular weight of $M_s = 46.01$ g/mole (see Table 1-2 in Chapter 1). If concentration $c = 100$ μg m^{-3} for this pollutant, then the equation above gives a volume fraction of $q = (0.02363/46.01) \cdot (100) = 0.051$ ppmv.

Table 19-1. Air quality concentration standards for the USA (US), Canada (CAN), and The European Union (EU) for some of the commonly-regulated chemicals, as of Sep 2017. Concentrations represent averages over the time periods listed. For Canada, the CAAQS are changing over years 2015 -> 2020. Older Canadian National Ambient Air Quality Objectives (acceptable levels) are in grey.

Avg. Time	US	CAN	EU
Sulfur Dioxide (SO_2)			
1 yr		->5 ppb	
1 day			125 μg m^{-3}
3 h	1300 μg m^{-3} or 0.5 ppm		
1 h	75 ppb	->70 ppb	350 μg m^{-3}
Nitrogen Dioxide (NO_2)			
1 yr	100 μg m^{-3} or 53 ppb	53 ppb	40 μg m^{-3}
1 h	100 ppb	213 ppb	200 μg m^{-3}
Carbon Monoxide (CO)			
8 h	10,000 μg m^{-3} or 9 ppm	13 ppm	10,000 μg m^{-3}
1 h	40,000 μg m^{-3} or 35 ppm	31 ppm	
Ozone (O_3)			
8 h	0.070 ppm	63 -> 62 ppb	120 μg m^{-3}
Particulates, diameter < 10 μm (PM_{10})			
1 yr		70 μg m^{-3}	40 μg m^{-3}
1 day	150 μg m^{-3}	120 μg m^{-3}	50 μg m^{-3}
Fine Particulates, diam. < 2.5 μm ($PM_{2.5}$)			
1 yr	12 μg m^{-3}	10->8.8 μg m^{-3}	25 μg m^{-3}
1 day	35 μg m^{-3}	28->27 μg m^{-3}	
Lead (Pb)			
1 yr			0.5 μg m^{-3}
3 mo	0.15 μg m^{-3}		
Benzene (C_6H_6)			
1 yr			5 μg m^{-3}
Arsenic (As)			
1 yr			6 ng m^{-3}

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S8; Introduction to greenhouse gases and global warming, Photo chemical smog

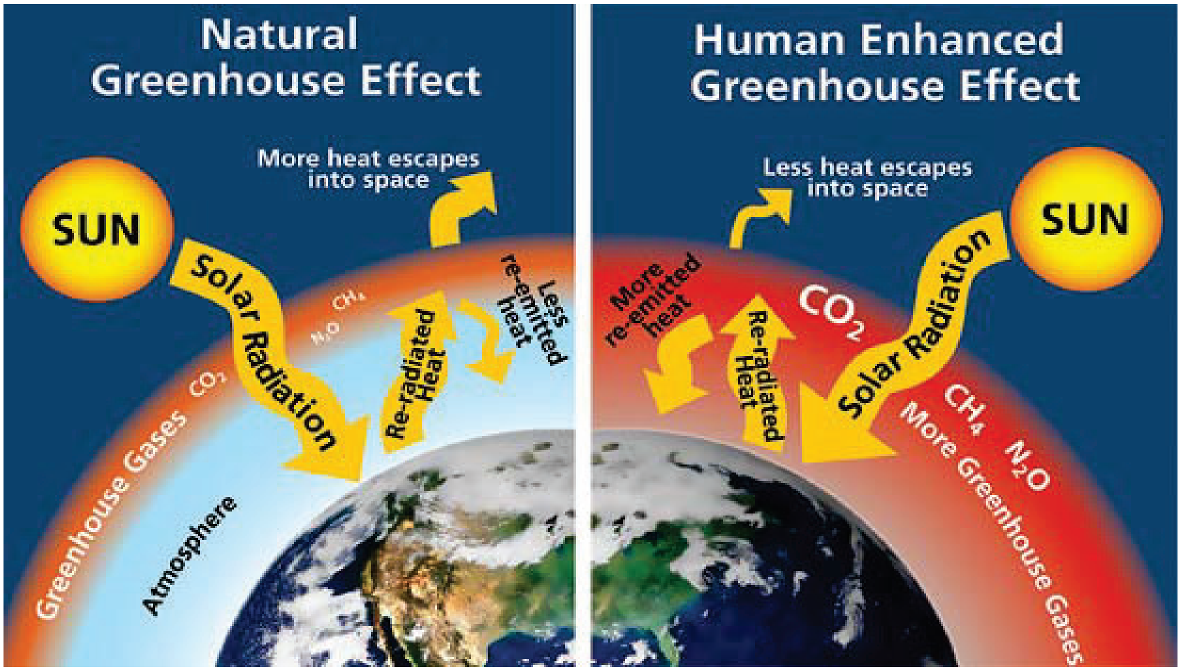
GREEN HOUSE GASES

Allowing short wave solar radiation into earth's surface and retaining the long wave infrared radiation reflected by the earth's surface by greenhouse gases in the atmosphere is termed as greenhouse effect.

Greenhouse gases include any gas in the atmosphere that is capable, as a result of its particular molecular structure, of absorbing infrared radiation or heat. They are called greenhouse gases because they behave like glass in a greenhouse gas, allowing sunlight to pass through but trapping the heat formed and preventing it from escaping, thereby causing a rise in temperature.

Greenhouse gases cause the **greenhouse** effect on planets. The primary **greenhouse gases** in Earth's atmosphere are

1. CO_2 Carbon dioxide
2. CH_4 Methane
3. N_2O Nitrous Oxide
4. SF_6 Sulphur hexafluoride
5. PFCs Perfluorocarbones
6. HFCs Hydrofluorocarbons



Energy from the sun drives the earth's weather and climate, and heats the earth's surface.

In turn, the earth radiates energy back into space.

Some atmospheric gases (water vapor, carbon dioxide, and other gases) trap some of the outgoing energy, retaining heat (like the glass panels of a greenhouse).

These gases are therefore known as greenhouse gases. The greenhouse effect is the rise in temperature on Earth as certain gases in the atmosphere trap energy.

Sources of Green house gases:

- **Carbon dioxide**, which is emitted whenever coal, oil, natural gas and other carbon-rich fossil fuels are burned. Although carbon dioxide is not the most powerful greenhouse gas, it is the largest contributor to climate change because it is so common. In order to reduce carbon dioxide emissions, we need to reduce the amount of fuel we use in our cars, homes, and lives.

- **Methane** is caused by the decomposition of plant matter, and is released from landfills, swamps, rice paddies. Cattle also release methane. Although methane emissions are lower than carbon dioxide emissions, it is considered a major greenhouse gas because each methane molecule has 25 times the global warming potential of a carbon dioxide molecule.
- **Nitrous oxide** is released from bacteria in soil. Modern agricultural practices — tilling and soil cultivation, livestock waste management, and the use of nitrogen-rich fertilizers — contribute significantly to nitrous oxide emissions. A single nitrous oxide molecule has 298 times the global warming potential of a carbon dioxide molecule.
- Additional greenhouse gases include **hydrofluorocarbons** (1,430-14,800 time the global warming potential of carbon dioxide), **sulfur hexafluoride** (22,800 times the global warming potential of carbon dioxide), and water vapor.

Causes of Greenhouse Effect

The major causes of the greenhouse effect are:

Burning of Fossil Fuels

Fossil fuels are an important part of our lives. They are widely used in transportation and to produce electricity. Burning of fossil fuels releases carbon dioxide. With the increase in population, the utilization of fossil fuels had increased. This has led to an increase in the release of greenhouse gases in the atmosphere.

Deforestation

Plants and trees take in carbon dioxide and release oxygen. Due to the cutting of trees, there is an inconsiderable increase in the greenhouse gases which increases the earth’s temperature.

Farming

Nitrous oxide used in fertilizers is one of the contributors to greenhouse effect in the atmosphere.

Industrial Waste and Landfills

The industries and factories produce harmful gases which are released in the atmosphere.

Landfills also release carbon dioxide and methane that adds to the greenhouse gases.

Effects of Greenhouse Effect

The main effects of increased greenhouse gases are:

Global Warming

It is the phenomenon of a gradual increase in the average temperature of the Earth's atmosphere. The main cause for this environmental issue is the increased volumes of greenhouse gases such as carbon dioxide and methane released by the burning of fossil fuels, emissions from the vehicles, industries and other human activities.

Depletion of Ozone Layer

Ozone Layer protects the earth from harmful ultraviolet rays from the sun. It is found in the upper regions of the stratosphere. The depletion of the ozone layer results in the entry of the harmful UV rays to the earth's surface that might lead to skin cancer and can also change the climate drastically.

The major cause of this phenomenon is the accumulation of natural greenhouse gases including chlorofluorocarbons, carbon dioxide, methane, etc.

Runaway Greenhouse Effect

This phenomenon occurs when the planet absorbs more radiations than it can radiate back. Thus, the heat lost from the earth's surface is less and the temperature of the planet keeps rising. Scientists believe that this phenomenon took place on the surface of Venus billions of years ago.

This phenomenon is believed to have occurred in the following manner:

- A runaway greenhouse effect arises when the temperature of a planet rises to a level of the boiling point of water. As a result, all the water from the oceans converts into water vapour, which traps more heat coming from the sun and further increases the planet's temperature. This eventually accelerates the greenhouse effect. This is also called the "positive feedback loop".
- There is another scenario giving way to the runaway greenhouse effect. Suppose the temperature rise due to the above causes reaches such a high level that the chemical reactions begin to occur. These chemical reactions drive carbon dioxide from the rocks into the atmosphere. This would heat the surface of the planet which would further accelerate the transfer of carbon dioxide from the rocks to the atmosphere, giving rise to the runaway greenhouse effect.

In simple words, increasing greenhouse effect gives rise to a runaway greenhouse effect which would increase the temperature of the earth to such an extent that no life will exist in the near future.

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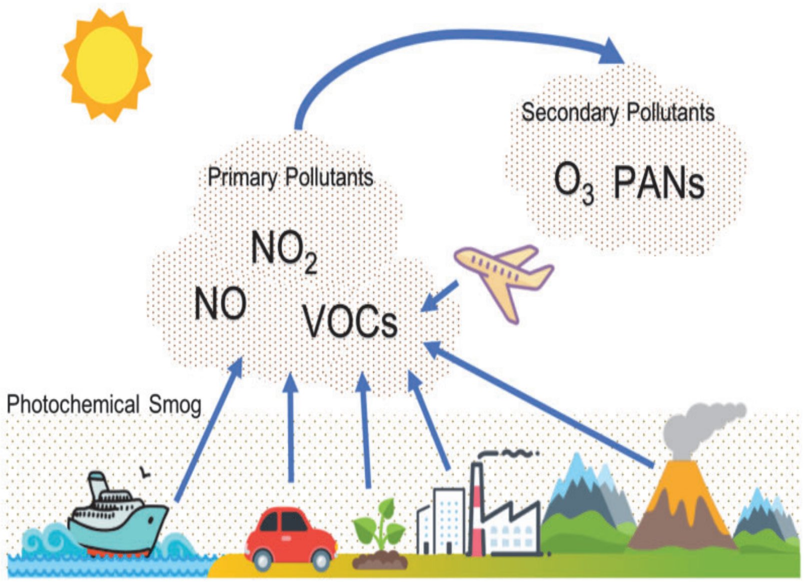
Photochemical smog:

Photochemical smog is a mixture of pollutants that are formed when nitrogen oxides and volatile organic compounds (VOCs) react to sunlight, creating a brown haze above cities. It tends to occur more often in summer, during more sunlight.



Photochenical smog is a major contributor to air pollution. The word "smog" was originally coined as a mixture of "**smoke" and "fog".** This type of air pollution is formed through the reaction of solar radiation with airborne pollutants like nitrogen oxides and volatile organic Compounds.

These compounds, which are called primary pollutants, are often introduced into the atmosphere through automobile emissions and industrial processes. Products like ozone, aldehydes, and peroxyacetyl nitrates are called secondary pollutants. The misture of these primary and secondary pollutant forms photochemical smog. Both primary and secondary pollutants in photochemical smog are highly reactive.

Photochemical smog, which is also known as **"Los Angeles smog,"** occurs most prominently in urban areas that have large numbers of automobiles. It requires neither smoke nor fog. This type of smog has its origin in the nitrogen oxides and hydrocarbon vapours emitted by automobiles and other sources, which then undergo photochemical reactions in the lower atmosphere. The highly toxic gas ozone arises from the reaction of nitrogen oxides with hydrocarbon vapours in the presence of sunlight, and some nitrogen dioxide is produced from the reaction of nitrogen oxide with sunlight.

Effect of smog:

- causes a light brownish coloration of the atmosphere,
- reduced visibility,
- plant damage,
- irritation of the eyes, and respiratory distress.
- Surface-level ozone concentrations are considered unhealthy if they exceed 70 parts per billion for eight hours or longer; such conditions are fairly common in urban areas prone to photochemical smog.

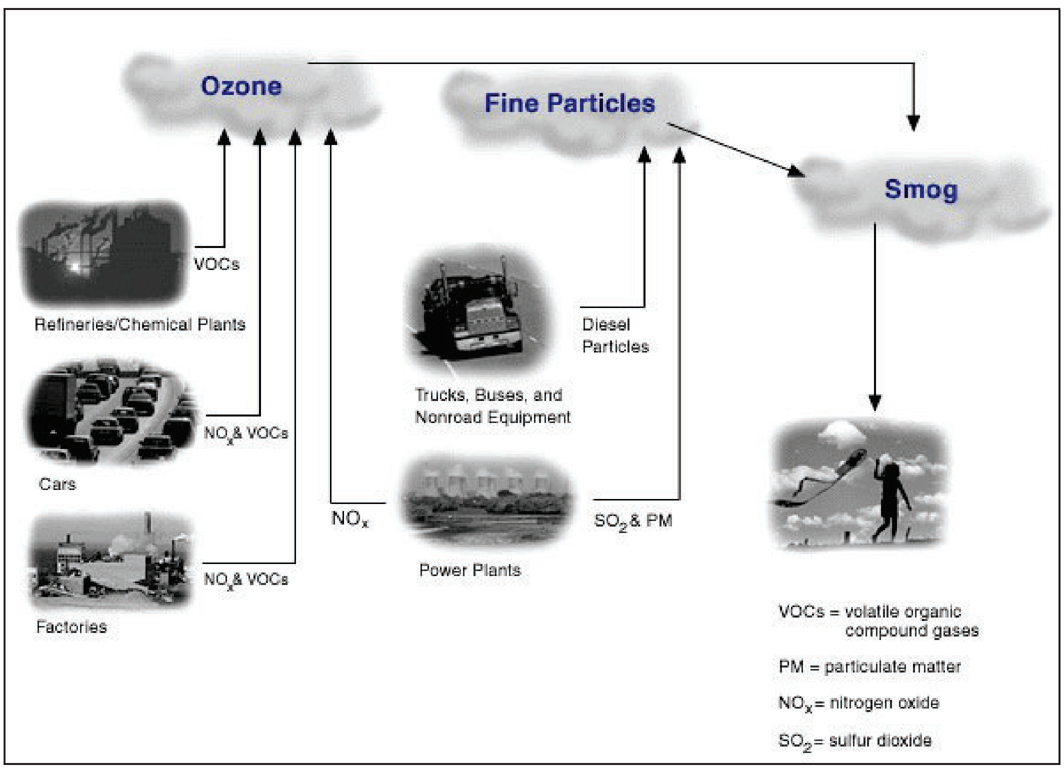


Fig: sources of Smog

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S8 ; OZONE DEPLETION and El Nino and their impact

OZONE DEPLETION

Ozone layer depletion, is simply the wearing out (reduction) of the amount of ozone in the **stratosphere**. Ozone depletion occurs when destruction of the stratospheric ozone is more than the production of the molecule. The scientists have observed reduction in stratospheric ozone since early 1970s. It is found to be more prominent in Polar Regions.

There are two regions in which the ozone layer has depleted.

In the mid-latitude, for example, over Australia, ozone layer is thinned. This has led to an increase in the UV radiation reaching the earth. It is estimated that about 5-9% thickness of the ozone layer has decreased, increasing the risk of humans to over-exposure to UV radiation owing to outdoor lifestyle.

Since 1928, Chlorofluorocarbons have been produced, originally as nonflammable refrigerants for use in refrigerators, and eventually for use in fire extinguishers, dry cleaning agents, pesticides, degreasers, adhesives, and as propellants for aerosol products.

As these CFCs have been released into the atmosphere, the level of ozone in the stratosphere has decreased.

CFCs have an estimated lifespan of **more than 100 years**

Cause of ozone depletion:

Natural causes of depletion of ozone layer: Ozone layer has been found to be affected by certain natural phenomena such as Sun-spots and stratospheric winds. But this has been found to cause not more than 1-2% depletion of the ozone layer and the effects are also thought to be only temporary. It is also believed that the major volcanic eruptions (mainly El Chichon in 1983 and and Mt. Pinatubo in 1991) has also contributed towards ozone depletion.

Man-made causes of depletion of ozone layer: The main cause for the depletion of ozone is determined as excessive release of chlorine and bromine from man-made compounds such as chlorofluorocarbons (CFCs). CFCs (chlorofluorocarbons), halons, CH_3CCl_3 (Methyl chloroform), CCl_4(Carbon tetrachloride), HCFCs (hydro-chlorofluorocarbons), hydrobromofluorocarbons and methyl bromide are found to have direct impact on the depletion of the ozone layer. These are categorized as ozone-depleting substances (ODS). Chlorofluorocarbons are released into the atmosphere due to:

- Cleaning Agents
- Coolants in refrigerators
- Packing material
- Air conditioning
- Aerosol spray cans etc.

The problem with the Ozone-Depleting Substances (ODS) is that they are not washed back in the form of rain on the earth and in-fact remain in the atmosphere for quite a long time. With so much stability, they are transported into the stratosphere. The emission of ODS account for roughly 90% of total depletion of ozone layer in stratosphere. These gases are carried to the stratosphere layer of atmosphere where ultraviolet radiations from the sun break them to release chlorine (from CFCs) and bromine (from methyl bromide and halons). The chlorine and bromine free radicals react with ozone molecule and destroy their molecular structure, thus depleting the ozone layer. One chlorine atom can break more than 1, 00,000 molecules of ozone. Bromine atom is believed to be 40 times more destructive than chlorine molecules. The chlorine becomes actively involved in the process of destruction of ozone. The net result is that two molecules of ozone are replaced by three of molecular oxygen, leaving the chlorine free to repeat the process:

$$Cl + O_3 \rightarrow ClO + O_2$$

$$ClO + O \rightarrow Cl + O_2$$

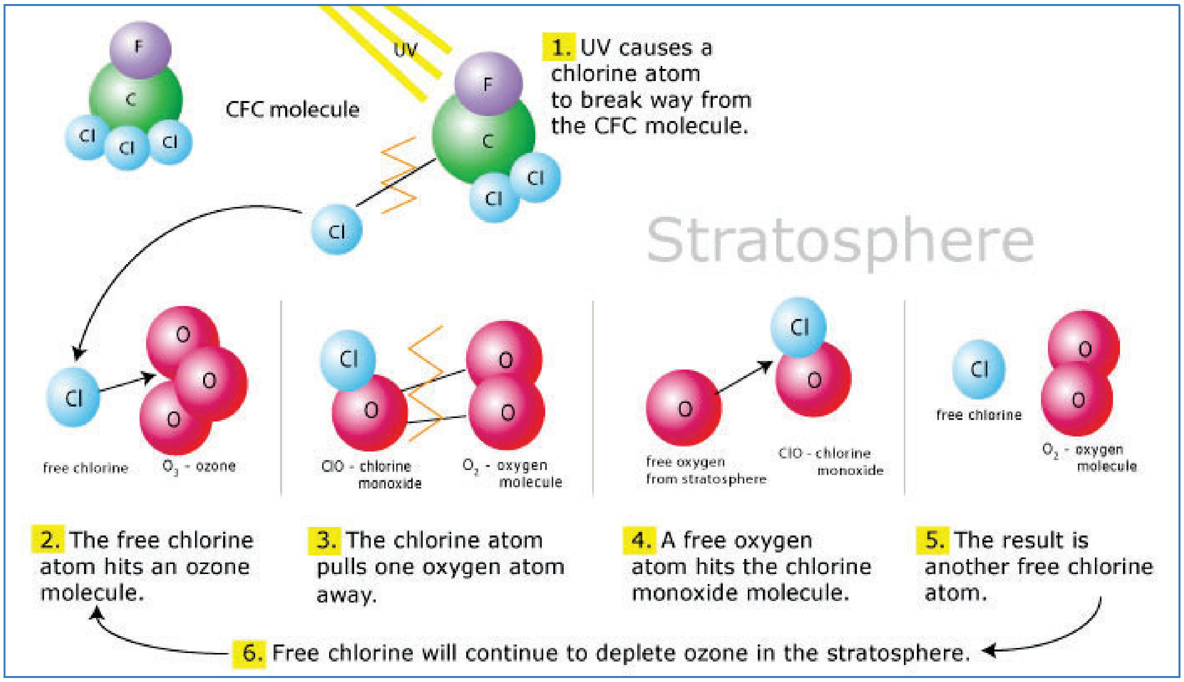

Fig: Ozone depletion by CFCs

Main Ozone Depleting Substances (OCD)

- **Chlorofluorocarbons:** Account for more than 80% of ozone depletion. Used in freezers, air cooling component, dry-cleaning agents, hospital sterilants.
- **Methyl Chloroform:** Used for vapour degreasing, some aerosols, cold cleaning, adhesives and chemical processing.
- **Hydro chlorofluoro carbons:** Substitutes for CFC's but still play a vital role in ozone depletion.
- **Halons**
- **Carbon Tetrachloride:** Mainly used in fire extinguishers

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El Nino and their impact

El Niño and La Niña events are a natural part of the global climate system. They occur when the Pacific Ocean and the atmosphere above it change from their neutral ('normal') state for several seasons.

El Niño events are associated with a warming of the central and eastern tropical Pacific, while La Niña events are the reverse, with a sustained cooling of these same areas.

Impacts of global warming

1) **Rising Seas**--- inundation of fresh water marshlands (the everglades), low-lying cities, and islands with seawater.
2) **Changes in rainfall patterns** --- droughts and fires in some areas, flooding in other areas. See the section above on the recent droughts, for example!
3) **Increased likelihood of extreme events**--- such as flooding, hurricanes, etc.
4) **Melting of the ice caps** --- loss of habitat near the poles. Polar bears are now thought to be greatly endangered by the shortening of their feeding season due to dwindling ice packs.
5) **Melting glaciers** - significant melting of old glaciers is already observed.
6) **Widespread vanishing of animal populations** --- following widespread habitat loss.
7) **Spread of disease** --- migration of diseases such as malaria to new, now warmer, regions.
8) **Bleaching of Coral Reefs due to warming seas and acidification due to carbonic acid formation** --- *One third* of coral reefs now appear to have been severely damaged by warming seas.
9) **Loss of Plankton due to warming seas** --- The enormous (900 mile long) Aleution island ecosystems of orcas (killer whales), sea lions, sea otters, sea urchins, kelp beds, and fish populations, appears to have collapsed due to loss of plankton, leading to loss of sea lions, leading orcas to eat too many sea otters, leading to urchin explosions, leading to loss of kelp beds and their associated fish populations.

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18CEO406T
Global warming and Climate change

UNIT - II
[S1 – S3]

S1: SLO 1: Climatology

- Climatology, or sometimes known as **climate science**, is the **study of the Earth's weather patterns and the systems** that cause them. From the ocean oscillations to trade winds, pressure systems that drives temperature, airborne particles that influence local conditions and even the phases of the moon and Earth's wobble all affect the climate

  The word “climatology” comes, as may scientific words and terms do, from the Greek. **clima means “zone” or “area” and “logia” means “study”.** This means that climatology is the “study of zones” although in reality it is much more complicated than that.

Climatology: An Atmospheric Science

Atmospheric scientists often subdivide study of complexity of gaseous envelope that surrounds the earth into specific areas of interest. One such division identifies the fields of meteorology and climatology. **Meteorology** is a science that deals with motion and the phenomena of the atmosphere with a view to both forecasting weather and explaining the processes involved. It deals largely with status of atmosphere over a short period of time and utilizes physical principles to attain its goal. **Climatology** is the study of atmospheric conditions over a longer period of time. It includes the study of different kinds of weather that occur at a place. Dynamic change in the atmosphere brings about variation and occasionally great extremes that must be treated on the long term as well as the short term basis. As a result, climatology may be defined as the aggregate of weather at a place over a given time period.

There is diversity of approaches available in climate studies. Figure 1. Illustrates the major subgroups of climatology, the approaches that can be used in their implementation, and the scales at which the work can be completed.

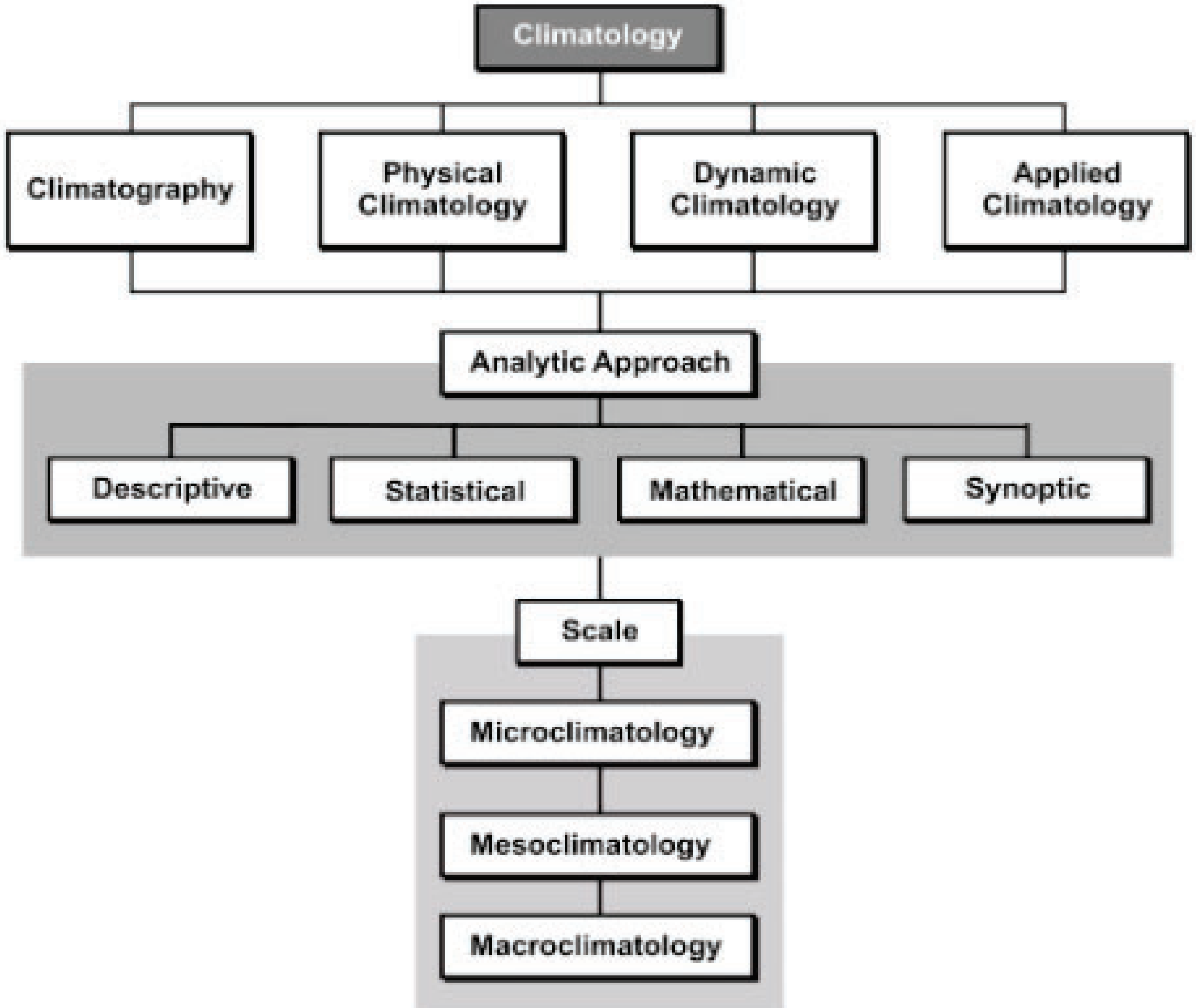


Figure 1. Subgroups, Analytical methods and scales of climatic study.
(From J. E. Olive 1981, P4 used by permission of V. H. Winston and Sons.)

What does climatology deals with?

Climatology deals with the following characteristics.

- Earth sun relationship
- Distribution of solar radiation
- Terrestrial radiation and heat balance
- General circulation of atmosphere
- Distribution of wind, temperature, pressure over the surface of the earth.

Applications of Climatology

- Climatology is a fascinating area of study. It relates directly in which the environment functions and the everyday lives of people in addition to workings and nature of the atmosphere. Applied Climatology is used to –

a)Improve efficiency of various economic activities that are influenced by climate

b)Aid in the needs of societal activities

c)Reduce the losses incurred from climatic hazards

EXAMPLES: Energy, Food, water, Health etc..

S1: SLO 2: Paleoclimatology

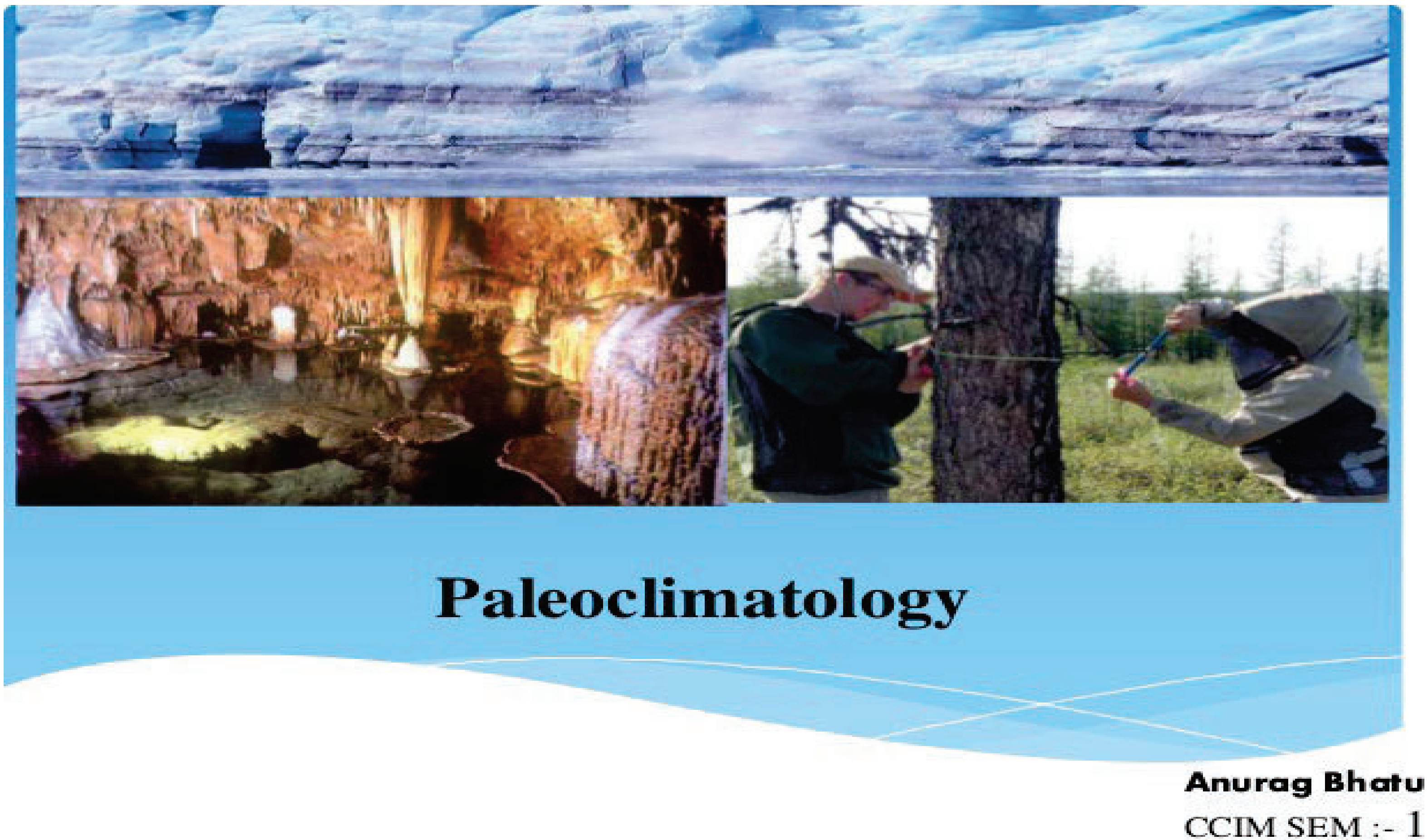
Definition

Paleoclimatology is the **study of past climates.** Since it is not possible to go back in time to see what climates were like, scientists use imprints created during past climate, known as proxies, to interpret paleoclimate.

Proxy data is data that paleoclimatologists gather from natural recorders of climate variability.

Example: tree rings, ice cores, fossil pollen, ocean sediments, coral and historical data.

S1: SLO 2: Paleoclimatology



S1: SLO 2: Paleoclimatology

- **Paleoclimatology** is the study of climates for which direct measurements were not taken.
- As instrumental records only span a tiny part of Earth history, the reconstruction of ancient climate is important to understand natural variation and the evolution of the current climate.
- Paleoclimatology uses a variety of proxy methods from the Earth and life sciences to obtain data previously preserved within rocks, sediments, boreholes, ice sheets, tree rings, corals, shells, and microfossils.
- Combined with techniques to date the proxies, these paleoclimate records are used to determine the past states of Earth's atmosphere.

S1: SLO 2: Paleoclimatology

- The scientific field of paleoclimatology came to maturity in the 20th century.
- Studies of past changes in the environment and biodiversity often reflect on the current situation, specifically the impact of climate on mass extinctions and biotic recovery and current global warming.
- Paleoclimatologists employ a wide variety of techniques to deduce ancient climates.
- The techniques used depend on which variable has to be reconstructed (temperature, precipitation or something else) and on how long ago the climate of interest occurred.

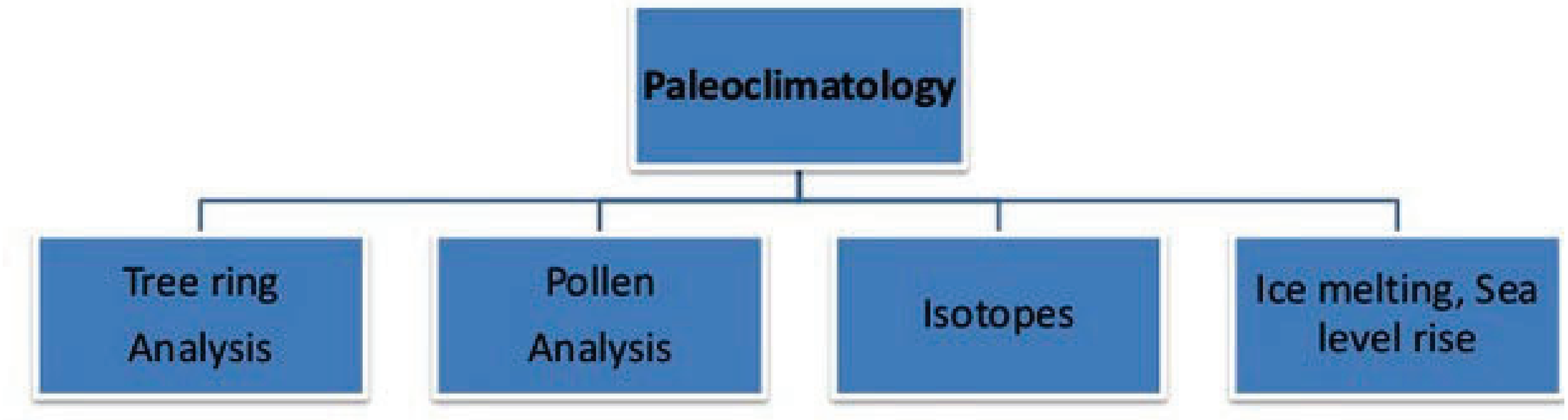
S1: SLO 2: Paleoclimatology

- For instance, the deep marine record, the source of most isotopic data, exists only on oceanic plates, which are eventually subducted.
- **NCEI [National Centre for Environmental information]** provides the paleoclimatology data and information scientists need to understand natural climate variability and future climate change. We also operate the World Data Service for Paleoclimatology, which archives and distributes data contributed by scientists around the world

S1: SLO 2: Paleoclimatology

- The study of paleoclimates has been particularly helpful in showing that the Earth's climate system can shift between dramatically different climate states in a matter of years or decades. The study of past climate change also helps us understand **how humans influence the Earth's climate system.**
- The paleoclimatic record also allows us to examine the causes of past climate change and to help unravel how much of the 20th century warming may be explained by natural causes, such as solar variability, and how much may be explained by human influences.

S1: SLO 2: Paleoclimatology



S1: SLO 2: Paleoclimatology

Tree Ring Analysis

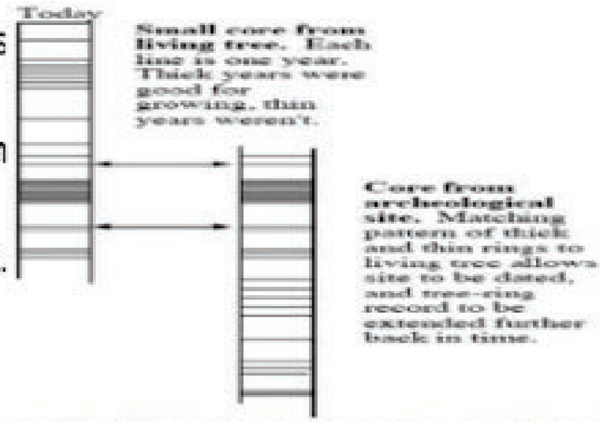
- Tree ring analysis is also known as dendrochronology.
- From the growth rings or tree rings we can easily predict about the past climates.
- There are mainly two type of chronologies.

Dendrochronology

Floating Chronology

Anchored Chronology

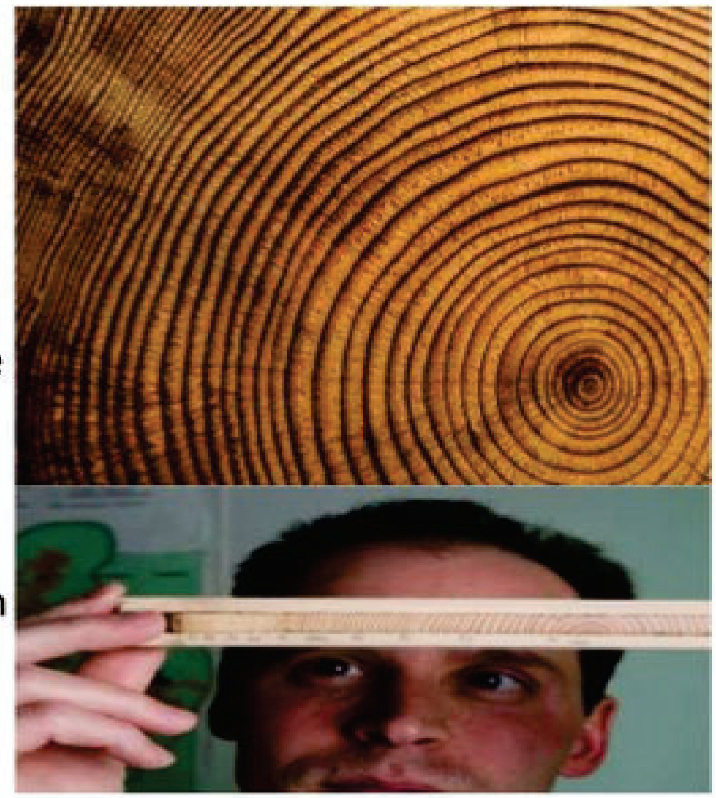
- Also the instrument which used for the taking cross section is called as Borer.



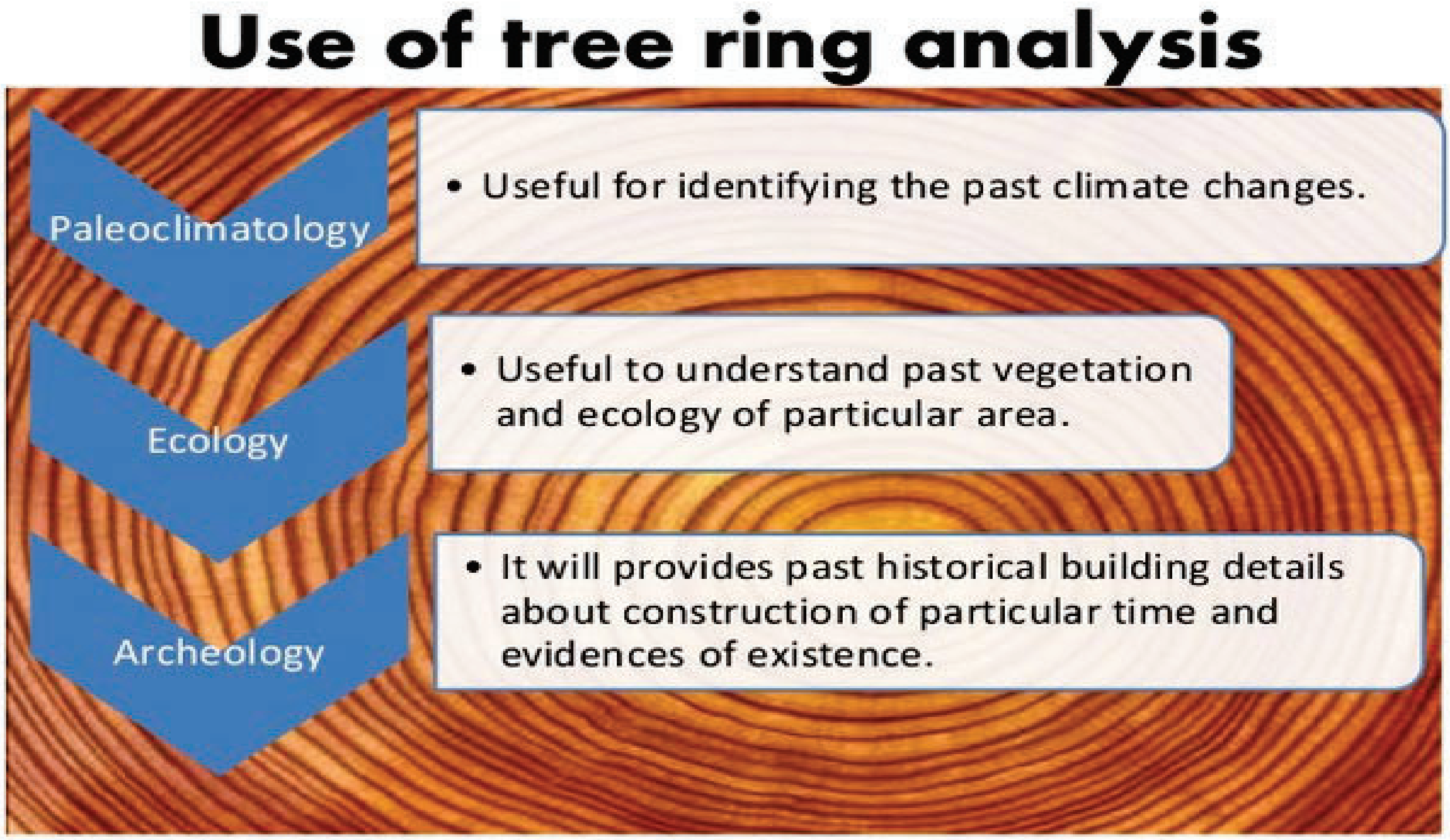
S1: SLO 2: Paleoclimatology

About tree ring analysis

- Each ring represents one year
- Records are thousands of years old in some trees
- Light colored – Spring
- Dark colored – Late summer
- Tree rings are more visible in temperate zone
- Also during studies need attention towards identifying false rings
- Fully anchored chronologies in northern hemisphere are extended upto 13,900 years



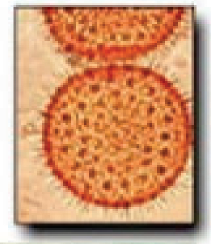
S1: SLO 2: Paleoclimatology

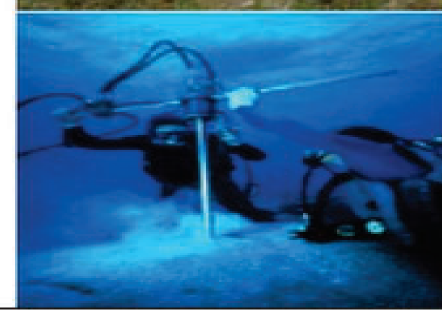


S1: SLO 2: Paleoclimatology

Pollen analysis

- Pollen analysis is also known as Palynology.
- Used for analyze the plant pollen
- Pollen grains rang size 10 to 150 μm
- In summer air is filled of pollens
- Palynologists collects core of sediment or pea date layer
- Pollen grains are well pressed in the sediment layer in pond lake and oceans
- Type of plants also identified
- pollen analysis to study long-term patterns of vegetation diversity.
- Prepared slide and add silicon oil, glycerol-jelly and observed in scanning electron microscopy. And they counts no. of grains of each pollen taxon.





S1: SLO 2: Paleoclimatology

- Palaeoclimatological use of pollen records has become more quantitative and has included more precise and rigorous testing of pollen-climate calibration models with modern climate data.

- Pollen data provide of changes in vegetation , climate and human disturbances of terrestrial ecosystem.

Methodology :-

1.Palynomorphs

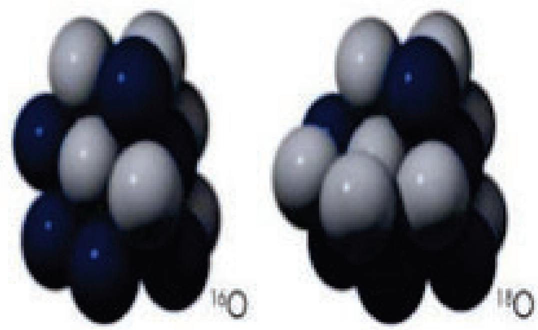
2.Chemical Preparation

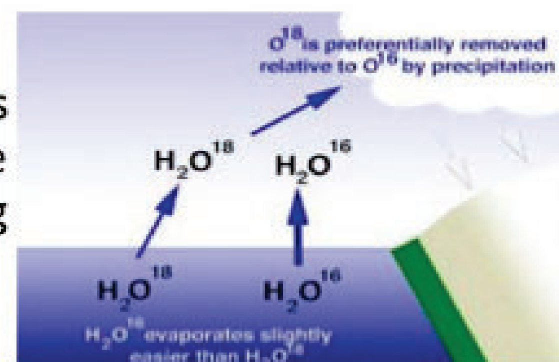
3.Analysis

S1: SLO 2: Paleoclimatology

Isotopes

- The elements who have same atomic number but different atomic weight those elements are called as Isotopes
- Oxygen is one of the most significant element for paleoclimatology research.
- Oxygen is having three isotopes: ^{16}O, ^{17}O, ^{18}O
- Occurrence of ^{16}O and ^{18}O in water changes and their ration in marine sediments, ice cores or fossils is useful for studying paleoclimatology.





S1: SLO 2: Paleoclimatology

Ice Malting And Sea level rise

- Sea ice influences climate because it reflects sunlight and because it influences ocean circulation.
- Less sea ice leads to acceleration of global warming
- There is evidence of ice melt, sea level rise to +5-9 m, and extreme storms in the prior interglacial period that was less than 1°C warmer than today.
- Arctic sea-ice cover is shrinking by 8.9% per decade in summer and 2.5% per decade in winter. It is also becoming thinner and there is less multi-year ice.
- Melting sea ice, in combination with melting glaciers and ice sheets, may cause major changes to global patterns of ocean circulation.
- As with snow, less sea ice increases absorption of heat from the sun, resulting in increased warming

PROXY - - - PROXIES

PROXIES - the authority to represent someone else, …

Unit 1; S2 : SLO1

CLIMATOLOGY PROXIES

S2 : SLO1: CLIMATOLOGY PROXIES

- **Climate proxies** are preserved physical characteristics of the past that stand in for direct meteorological measurements and enable scientists to reconstruct the climatic conditions over a longer fraction of the Earth's history.
- Reliable global records of climate only began in the 1880s, and proxies provide the only means for scientists to determine climatic patterns before record-keeping began.
- A large number of climate proxies have been studied from a variety of geologic contexts.

S2 : SLO1: CLIMATOLOGY PROXIES

- Proxies can be combined to produce temperature reconstructions longer than the instrumental temperature record and can inform discussions of global warming and climate history.
- The geographic distribution of proxy records, just like the instrumental record, is not at all uniform, with more records in the northern hemisphere

S2 : SLO1: CLIMATOLOGY PROXIES

1 Proxies
- 1.1 Ice cores
  - 1.1.1 Drilling
  - 1.1.2 Proxy
- 1.2 Tree rings
- 1.3 Fossil leaves
- 1.4 Boreholes
- 1.5 Corals
- 1.6 Pollen grains
- 1.7 Dinoflagellate cysts
- 1.8 Lake and ocean sediments
- 1.9 Water isotopes and temperature reconstruction
- 1.10 Membrane lipids
- 1.11 Pseudoproxies

S2 : SLO2: *Indian climate system and their classification*

- India has tropical monsoon climate with large regional variations in terms of rainfall and temperature.
- While classifying Indian climatic regions, most geographers have given more importance to **rainfall** than to temperature as variations in rainfall are much more marked than those of temperature.
- Here we will see **two** classifications –

(i) Stamp's Classification of Climatic Regions of India

(ii) Koeppen's Classification of Climatic Regions of India

S2 : SLO2: *Indian climate system and their classification*

Stamp's Classification of Climatic Regions of India

- Stamp used **18°C isotherm** of mean monthly temperature for January to divide the country into two broad climatic regions, viz., **temperate or continental zone** in the north and **tropical zone** in the south.
- This line runs roughly across the root of the peninsula, more or less along or parallel to the Tropic of Cancer.
- The two major climatic regions are further divided into eleven regions depending upon the amount of rainfall and temperature.

S2 : SLO2: *Indian climate system and their classification*

Temperate or Continental India

- The Himalayan region (heavy rainfall)
- The north-western region (moderate rainfall)
- The arid low land
- The region of moderate rainfall
- The transitional zone

Tropical India

- Region of very heavy rainfall
- Region of heavy rainfall
- Region of moderate rainfall
- The Konkan Coast
- The Malabar Coast
- Tamil Nadu

S2 : SLO2: *Indian climate system and their classification*

Koeppen's Classification of Climatic Regions of India

- Koeppen's Classification of Climatic Regions of India is an empirical classification based on mean annual and mean monthly temperature and precipitation data.
- Koeppen identified a close relationship between the distribution of vegetation and climate.
- He selected certain values of temperature and precipitation and related them to the distribution of vegetation and used these values for classifying the climates.
- Koeppen divided India into **nine climatic regions** making use of the above scheme

S2 : SLO2: *Indian climate system and their classification*

- Koeppen recognized **five** major climatic groups,

  four of them are based on temperature and

  one on precipitation.

- The capital letters:
- **A, C, D and E delineate humid climates and**
- **B dry climates.**

S2 : SLO2: *Indian climate system and their classification*

- The climatic groups are subdivided into types, designated by small letters, based on seasonality of precipitation and temperature characteristics.
- The seasons of dryness are indicated by the small letters : f, m, w and s, where
- **f – no dry season,**
- **m – monsoon climate,**
- **w – winter dry season and**
- **s – summer dry season.**

  The above mentioned major climatic types are further subdivided depending upon the seasonal distribution of rainfall or degree of dryness or cold.

S2 : SLO2: *Indian climate system and their classification*

a: hot summer, average temperature of the warmest month over 22°C

c: cool summer, average temperature of the warmest month under 22°C

f: no dry season

w: dry season in winter

s: dry season in summer

g: Ganges type of annual march of temperature; hottest month comes before the solstice and the summer rainy season.

h: average annual temperature under 18°C

m (monsoon): short dry season.

S2 : SLO2: *Indian climate system and their classification*

- The capital letters S and W are employed to designate the two subdivisions of dry climate:

1. **semi-arid or Steppe (S) and**
2. **arid or desert (W).**

- Capital letters T and F are similarly used to designate the two subdivisions of polar climate

1. **tundra (T) and**
2. **icecap (F).**

S2 : SLO2: *Indian climate system and their classification*

Table : Climatic Groups According to Koeppen

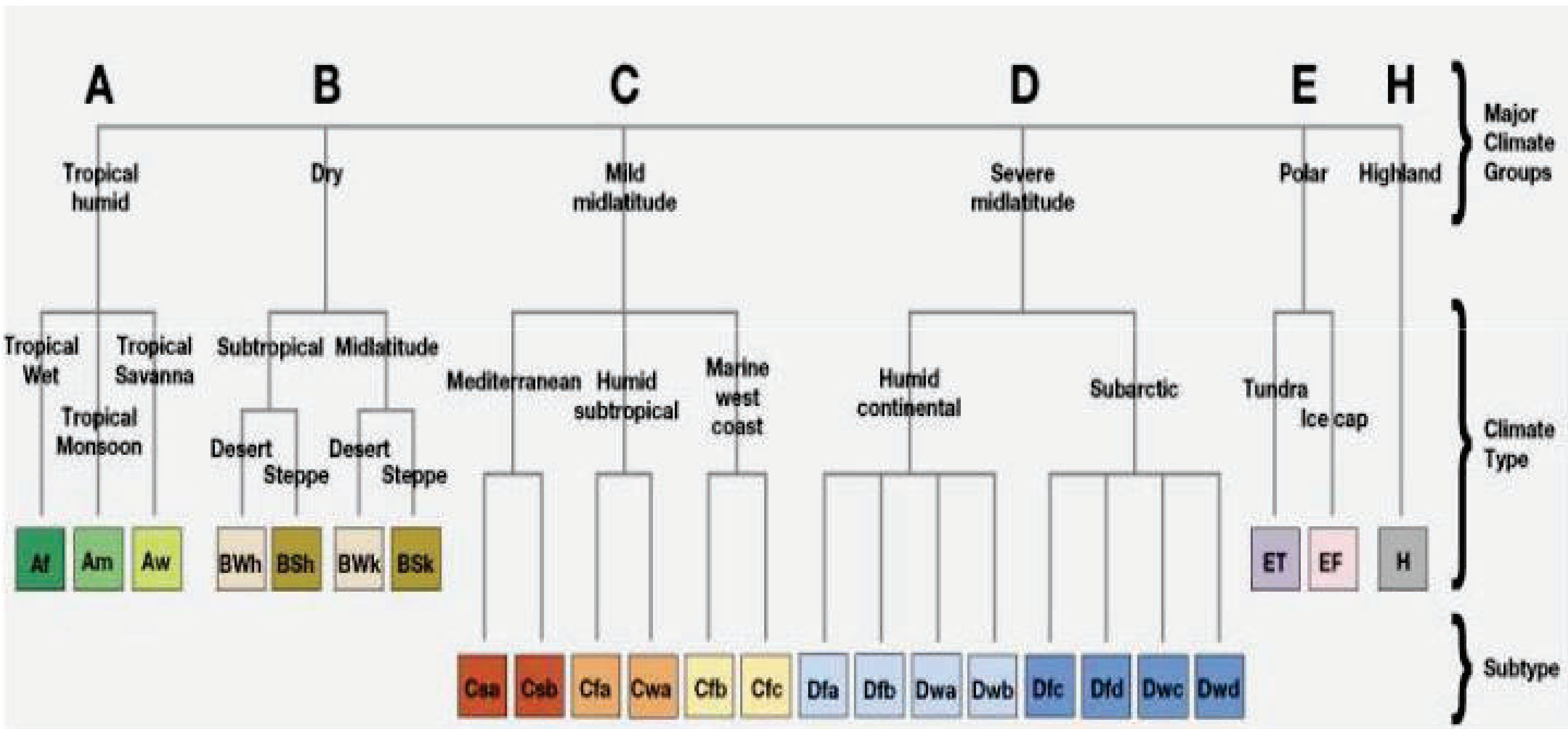
Group	*Characteristics*
A - Tropical	Average temperature of the coldest month is 18° C or higher
B - Dry Climates	Potential evaporation exceeds precipitation
C - Warm Temperate	The average temperature of the coldest month of the (Mid-latitude) climates years is higher than minus 3°C but below 18°C
D - Cold Snow Forest Climates	The average temperature of the coldest month is minus 3° C or below
E - Cold Climates	Average temperature for all months is below 10° C
H - High Land	Cold due to elevation

S2 : SLO2: *Indian climate system and their classification*

Table : Climatic Types According to Koeppen

Group	*Type*	*Letter Code*	*Characteristics*
A-Tropical Humid Climate	Tropical wet	Af	No dry season
	Tropical monsoon	Am	Monsoonal, short dry season
	Tropical wet and dry	Aw	Winter dry season
B-Dry Climate	Subtropical steppe	BSh	Low-latitude semi arid or dry
	Subtropical desert	BWh	Low-latitude arid or dry
	Mid-latitude steppe	BSk	Mid-latitude semi arid or dry
	Mid-latitude desert	BWk	Mid-latitude arid or dry
C-Warm temperate (Mid-latitude) Climates	Humid subtropical	Cfa	No dry season, warm summer
	Mediterranean	Cs	Dry hot summer
	Marine west coast	Cfb	No dry season, warm and cool summer
D-Cold Snow-forest Climates	Humid continental	Df	No dry season, severe winter
	Subarctic	Dw	Winter dry and very severe
E-Cold Climates	Tundra	ET	No true summer
	Polar ice cap	EF	Perennial ice
H-Highland	Highland	H	Highland with snow cover

Koppen Classification system



https://www.youtube.com/watch?v=xhbUflzb9yU

S3: SLO 1: *Role of land and ocean to regulate climate*

Role of land to regulate climate

According to IPCC, Intergovernmental panel on climate change

Land provides the principal basis for human livelihoods and well-being including the supply of food, freshwater and multiple other ecosystem services, as well as biodiversity. Human use directly affects more than 70% (likely 69-76%) of the global, ice-free land surface. Land also plays an important role in the climate system.

- The link between land use and the climate is complex.
- First, land cover--as shaped by land use practices--affects the global concentration of greenhouse gases.
- Second, while land use change is an important driver of climate change, a changing climate can lead to changes in land use and land cover.

S3: SLO 1: *Role of Land to regulate climate*

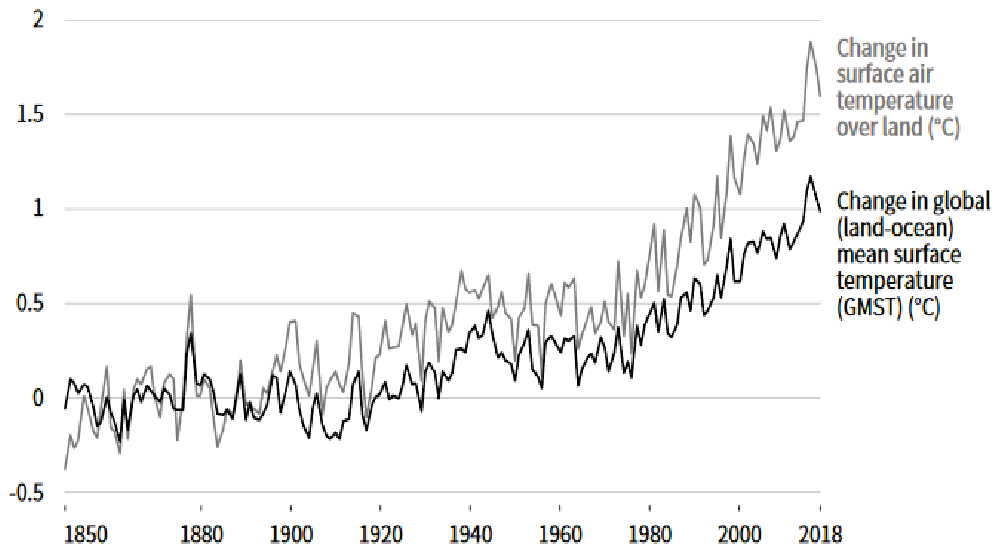
- Land is both a source and a sink of **greenhouse gases (GHGs)** and plays a key role in the exchange of energy, water and aerosols between the land surface and atmosphere.
- **Land ecosystems and biodiversity** are vulnerable to ongoing climate change and weather and climate extremes, to different extents.
- **Sustainable land management** can contribute to reducing the negative impacts of multiple stressors, including climate change, on ecosystems and societies

S3: SLO 1: *Role of land to regulate climate*

Land use and observed climate change

A. Observed temperature change relative to 1850-1900
Since the pre-industrial period (1850-1900) the observed mean land surface air temperature has risen considerably more than the global mean surface (land and ocean) temperature (GMST).

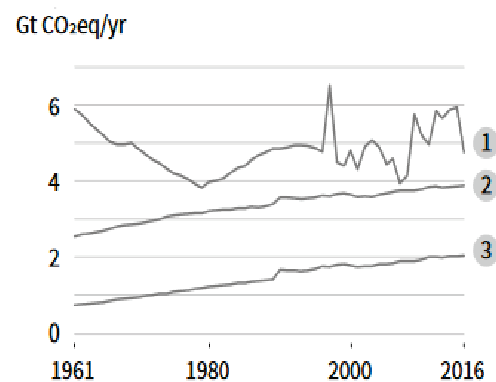
CHANGE in TEMPERATURE rel. to 1850-1900 (°C)



B. GHG emissions
An estimated 23% of total anthropogenic greenhouse gas emissions (2007-2016) derive from Agriculture, Forestry and Other Land Use (AFOLU).

CHANGE in emissions rel. to 1961

1 Net CO_2 emissions from FOLU (Gt CO_2/yr)
2 CH_4 emissions from Agriculture (Gt CO_2eq/yr)
3 N_2O emissions from Agriculture (Gt CO_2eq/yr)



S3: SLO 1: *Role of Land to regulate climate*

- Since the pre-industrial period **(1850-1900)** the observed mean land surface air temperature has risen considerably more than the global mean surface (land and ocean) temperature (GMST) (high confidence).
- From **1850-1900 to 2006-2015** mean land surface air temperature has increased by 1.53°C (very likely range from 1.38°C to 1.68°C) while GMST increased by 0.87°C (likely range from 0.75°C to 0.99°C).
- Climate change can exacerbate land degradation processes (high confidence) including through **increases in rainfall intensity, flooding, drought frequency and severity, heat stress, dry spells, wind, sea-level rise and wave action,** permafrost thaw with outcomes being modulated by land management

S3: SLO 1: *Role of ocean to regulate climate*

- The ocean is an important component of the climate system.
- It provides the surface temperature boundary condition for the atmosphere over 70% of the globe.
- It absorbs over 97% of solar radiation incident on it from zenith angles **less than 50°.**
- It provides **85% of the water vapour** in the atmosphere.
- It exchanges, absorbs and emits a host of radiatively important gases.
- It is a major natural source of atmospheric **aerosols.**

S3: SLO 1: *Role of ocean to regulate climate*

- Thus, even a static ocean would significantly influence the climate. However, the ocean is dynamic and its surface properties will vary on all time scales, allowing great scope for feedbacks between the ocean and atmosphere.
- Over the last two decades the importance of the ocean to understanding, and predicting the evolution of, the climate system has become generally recognized.
- This development in scientific understanding of the role of the ocean in climate change can be seen in the **Third assessment reports** of the **Intergovernmental Panel for Climate Change (IPCC)**

https://www.nationalgeographic.com/environment/2019/09/ipcc-report-climate-change-affecting-ocean-ice/

S3: SLO 1: Role of Ocean to regulate climate

The Effect Oceans on Weather Systems

1. Oceans affect atmospheric pressure which then develop clouds that lead to weather change.
2. Oceans transport the heat from solar radiation to different parts of the world; regulating regional temperatures.
3. Oceans are driven largely by surface winds, salinity, and temperature differences trying to reach state of equilibrium.

1. Cirrus Clouds- Fair weather.
2. Stratus Clouds- Steady rain.
3. Cumulus Clouds- Nice sunny weather
4. Cumulonimbus Clouds-THUNDERSTORMS!!!

---

https://www.youtube.com/watch?time_continue=68&v=WNpzc3SLkxs&feature=emb_logo

S3: SLO 2: *Role of ice and wind to regulate climate*

ROLE OF ICE TO REGULATE CLIMATE

- Sea ice is frozen water that forms, expands, and melts in the ocean.
- It is different from **icebergs, glaciers, ice sheets, and ice shelves**, which originate on land. For the most part, sea ice expands during winter months and melts during summer months, but in certain regions, some sea ice remains year-round.
- About **15 percent** of the world's oceans are covered by sea ice during part of the year.
- While sea ice exists primarily in the polar regions, it influences the global climate

S3: SLO 2: Role of ice to regulate climate

Sea ice in the Arctic Ocean. While sea ice exists primarily in the polar regions, it influences the global climate.

S3: SLO 2: Role of ice to regulate climate

- The bright surface of sea ice reflects a lot of sunlight out into the atmosphere and, importantly, back into space. Because this solar energy "bounces back" and is not absorbed into the ocean, temperatures nearer the poles remain cool relative to the equator.
- Changes in the amount of sea ice can disrupt normal **ocean circulation**, thereby leading to changes in global climate.
- **Even a small increase in temperature** can lead to greater warming over time, making the polar regions the most sensitive areas to climate change on Earth.

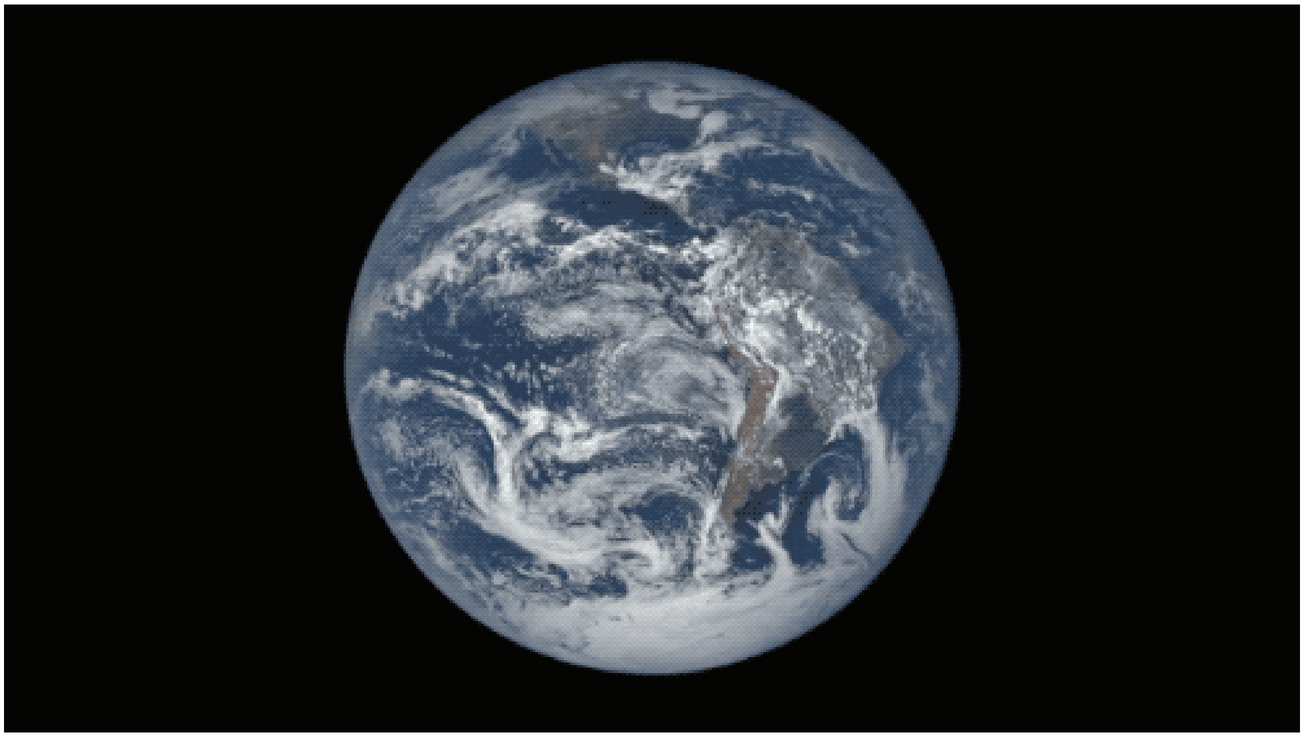
S3: SLO 2: Role of Wind to regulate climate

- Winds that blow from the sea often bring rain to the coast and dry weather to inland areas.
- Winds that blow to Britain from warm inland areas such as Africa will be warm and dry.
- Winds that blow to Britain from inland areas such as central Europe will be cold and dry in winter. Britain's prevailing (i.e. most frequently experienced) winds come from a south westerly direction over the Atlantic.
- These winds are **cool in the summer, mild in the winter** and tend to bring wet weather

S3: SLO 2: Role of Wind to regulate climate

- India lies in the region of **north easterly winds.**
- These winds originate from the **subtropical high-pressure belt of the northern hemisphere.**
- They blow **south**, get deflected to the **right due to the Coriolis force**, and move on towards the equatorial low-pressure area.
- Generally, these winds carry very little moisture as they originate and blow over land. Therefore, they bring little or no rain. Hence, India should have been an arid land, but, it is not so.
- The pressure and wind conditions over India are unique. These winds blow over the warm oceans, gather moisture and bring widespread rainfall over the mainland of India.

Milankovitch Cycle



Introduction

- The Milankovitch or astronomical theory of climate change is an explanation for changes in the seasons which result from changes in the earth's orbit around the sun. The theory is named for Serbian astronomer Milutin Milankovitch

Natural causes of Milankovitch Cycle

- Eccentricity
- Obliquity
- Precession

Who was Milutin Milankovitch?

- Born May 28, 1879, Dalj, Austria-Hungary [now in Croatia]
- Died December 12, 1958, Belgrade, Yugoslavia [now in Serbia]
- Mathematician and geophysicist
- Best known for his work that linked long-term changes in climate to astronomical factors affecting the amount of solar energy received at Earth's surface.
- Published *Kanon der Erdbestrahlung und seine Anwendung auf das Eiszeitenproblem* (1941; *Canon of Insolation and the Ice-Age Problem*).

- Earth experienced it's most recent ice ages during the Pleistocene epoch, which lasted from 2.6 million years ago to 11,700 years ago. For thousands of years at a time, even the more temperate regions of the globe were covered with glaciers and ice sheets, according to the University of California Museum of Paleontology.
- To determine how Earth could experience such vast changes in climate over time, Milankovitch incorporated data about the variations of Earth's position with the timeline of the ice ages during the Pleistocene. He studied Earth's variations for the last 600,000 years and calculated the varying amounts of solar radiation due to Earth's changing orbital parameters. In doing so, he was able to link lower amounts of solar radiation in the high northern latitudes to previous European ice ages, according to AMNH.
- Milankovitch's calculations and charts, which were published in the 1920s and are still used today to understand past and future climate, led him to conclude that there are three different positional cycles, each with its own cycle length, that influence the climate on Earth: the eccentricity of Earth's orbit, the planet's axial tilt and the wobble of its axis.

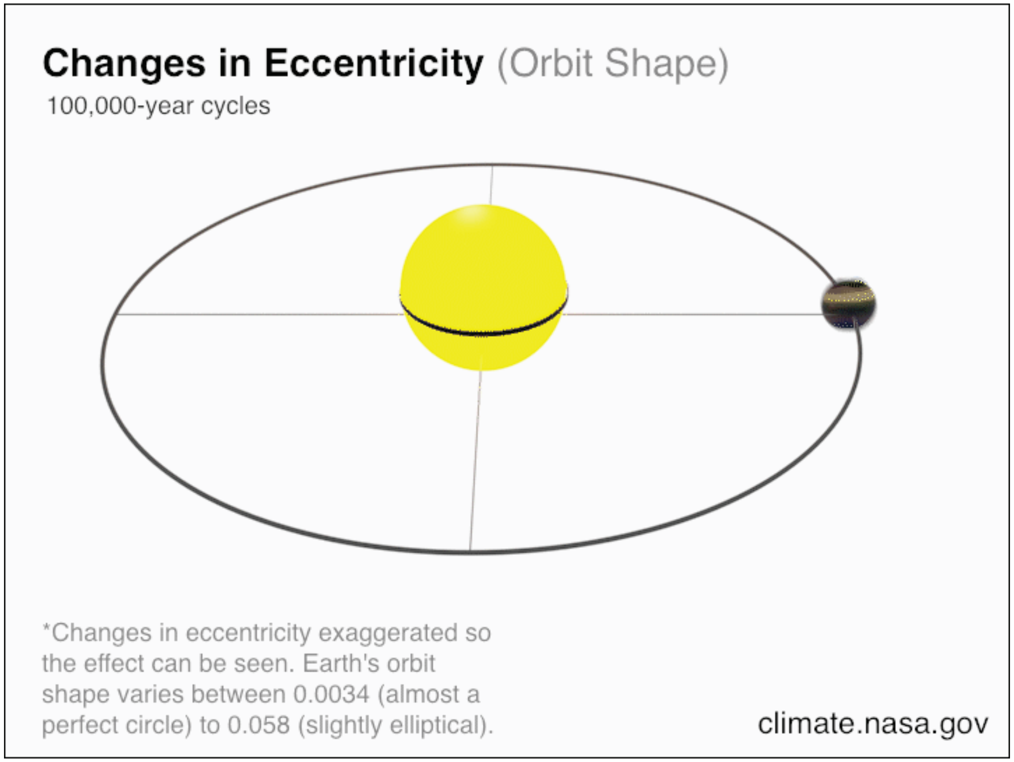
Eccentricity

Eccentricity is a term used to describe the shape of Earth's orbit around the sun. The variation of Earth's orbit around the sun ranges from an almost exact circle (eccentricity = 0.0005) to a slightly elongated shape (eccentricity = 0.0607). The impact of the variation is a change in the amount of solar energy from perihelion (around January 3) to aphelion (around July 4).

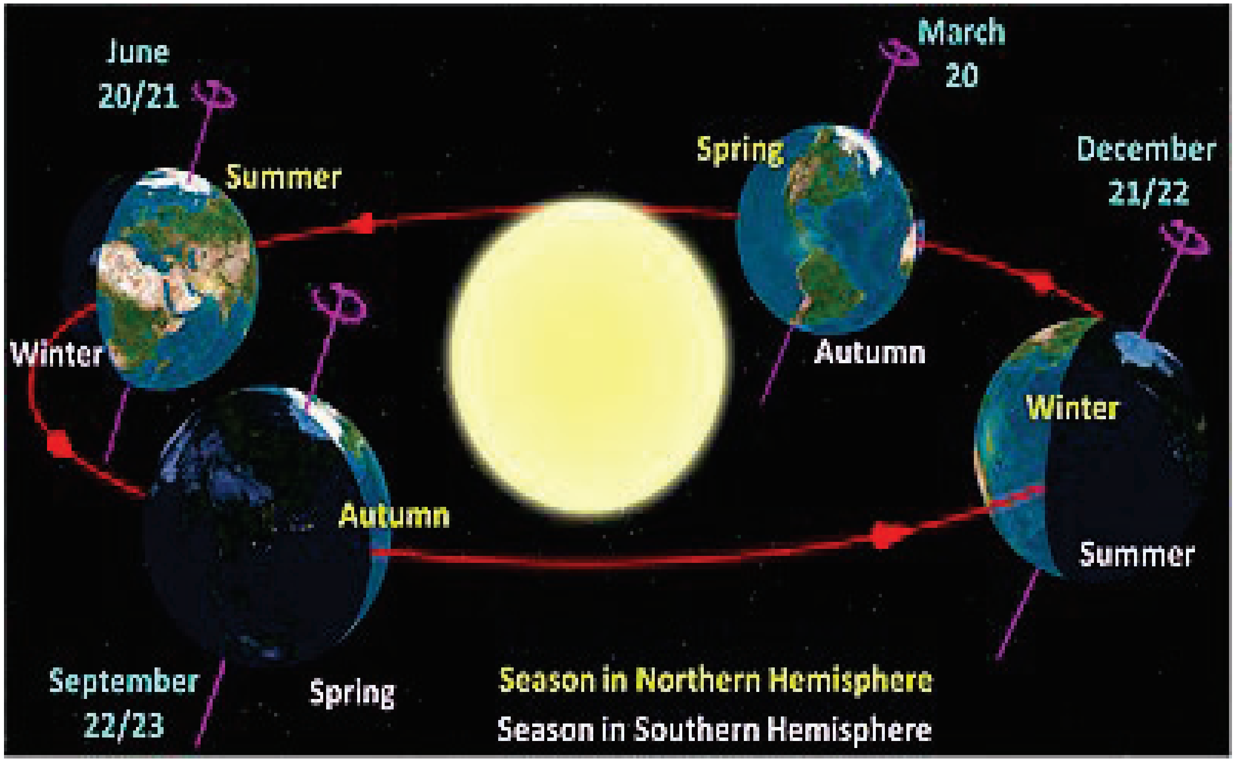
The Earth's orbit around the Sun, like other planet's orbits, is not a perfect circle. It is an ellipse. This means that the Earth is closer to and further away from the Sun at different times in the year.

- Perihelion - when the Earth is closest to the Sun (usually happens in January)
- Aphelion - when the Earth is furthest from the Sun (usually happens in June)

Changes in eccentricity



Season in Northern and southern hemisphere

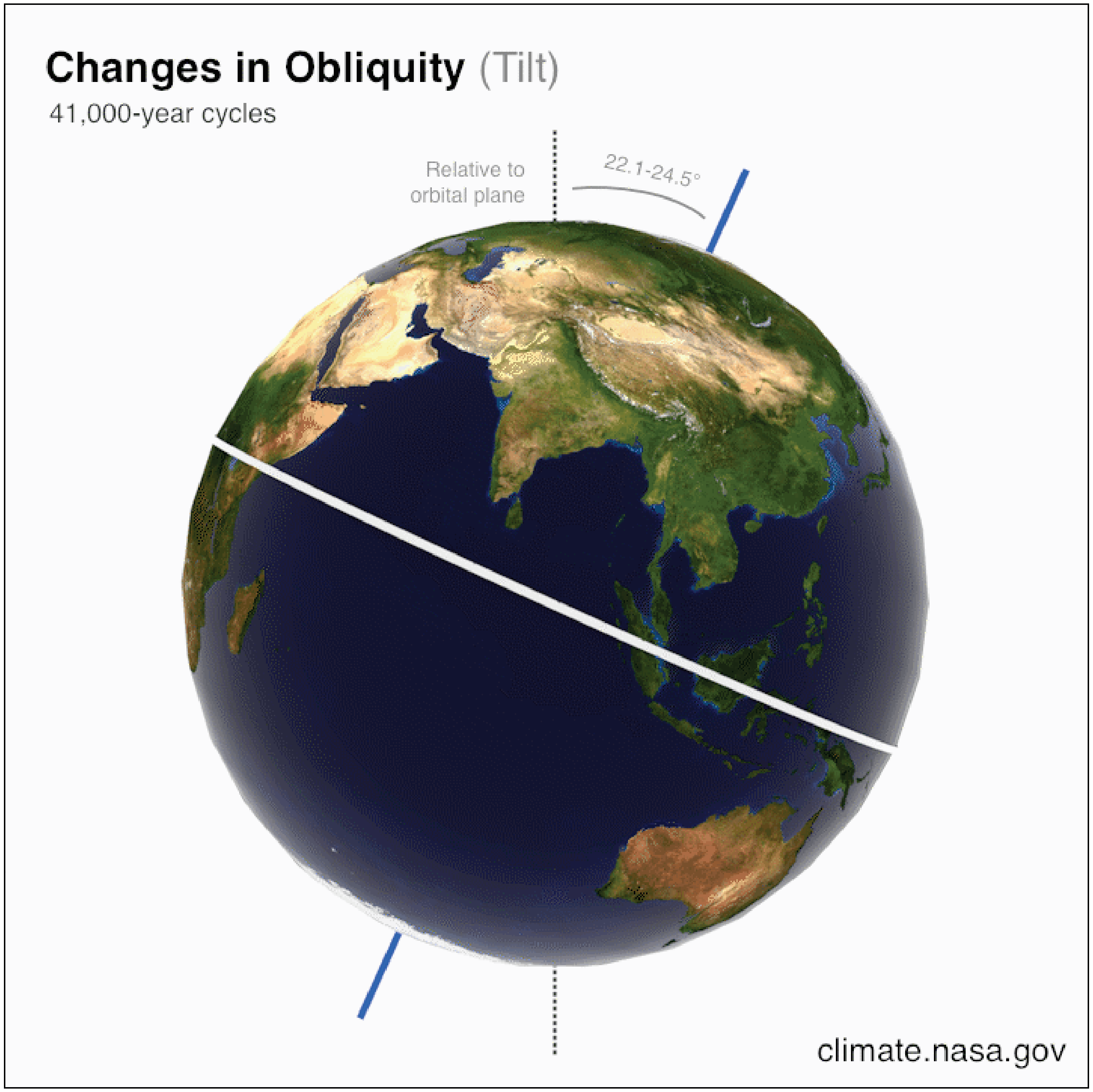


Obliquity

- Obliquity is the variation of the tilt of the earth's axis away from the orbital plane.
- The tilt varies between 22.1 º and 24.5 º and the average is 23.5 º
- The obliquity changes on a cycle taking approximately 40,000 years
- Currently, the axis of rotation for the earth is tilted at 23.5°

However, this value changes from a minimum of 22.5° to a maximum of 24.5° and takes 41,000 years to complete one cycle

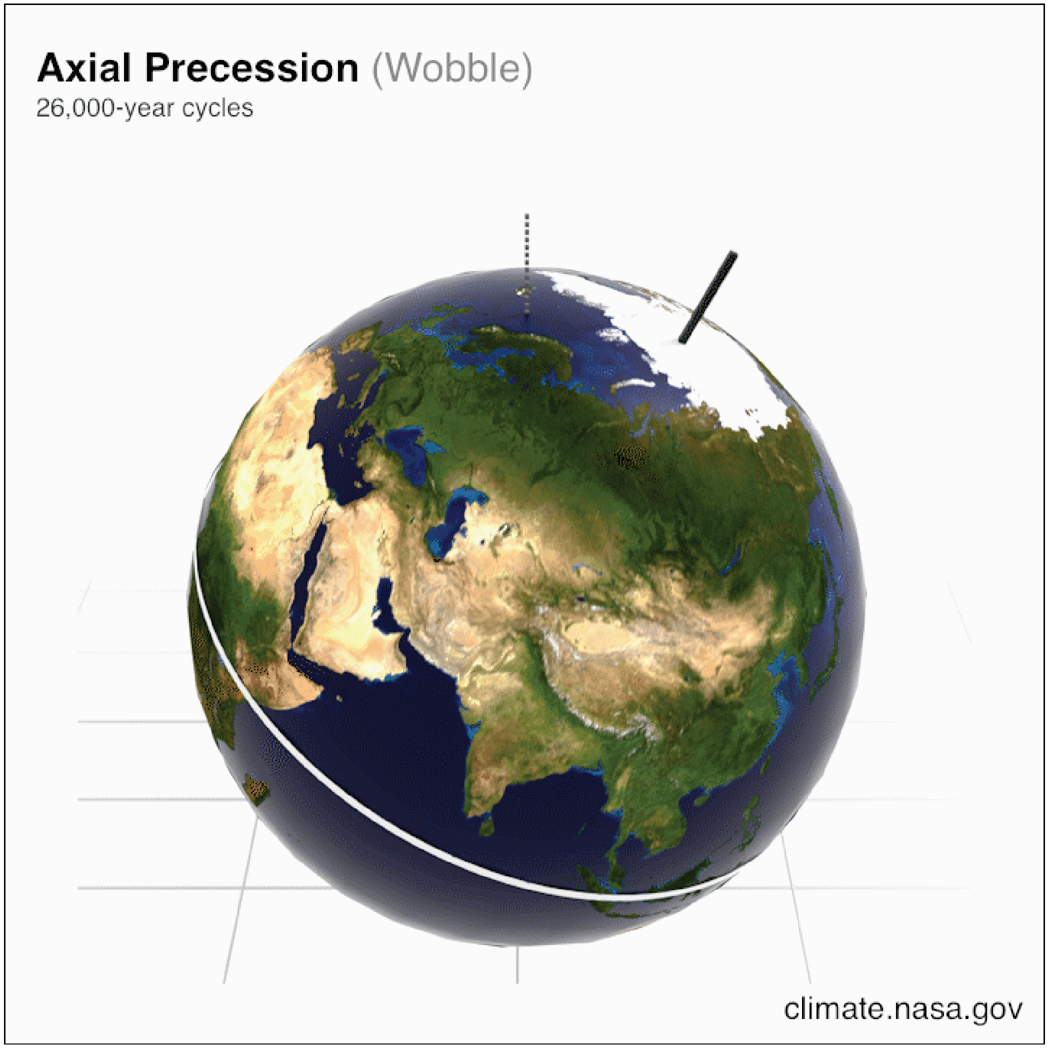
The more tilt means more severe seasons - warmer summers and colder winters; less tilt means less severe seasons - cooler summers and milder winters



Precession

- Precession is the change in orientation of the Earth's rotational axis. The precession cycle takes about 19,000 - 23,000 years.
- Earth wobbles just slightly as it spins on its axis, similarly to when a spinning top begins to slow down. This wobble, known as precession, is primarily caused by the gravity of the sun and moon pulling on Earth's equatorial bulges. The wobble doesn't change the tilt of Earth's axis, but the orientation changes. Over about 26,000 years, Earth wobbles around in a complete circle, according to Washington State University.
- Now, and for the past several thousands of years, Earth's axis has been pointed north more or less toward Polaris, also known as the North Star. But Earth's gradual precessional wobble means that Polaris isn't always the North Star. About 5,000 years ago the Earth was pointed more toward another star, called Thubin. And, in approximately 12,000 years, the axis will have traveled a bit more around its precession circle and will point toward Vega, which will become the next North Star

- As the Earth completes a precession cycle, the orientation of the planet is altered with respect to perihelion and aphelion. If a hemisphere is pointed toward the sun during perihelion (shortest distance between Earth and sun), it will be pointed away during aphelion (largest distance between Earth and sun), and the opposite is true for the other hemisphere. The hemisphere that's pointed toward the sun during perihelion and away during aphelion experiences more extreme seasonal contrasts than the other hemisphere.
- Currently, the southern hemisphere's summer occurs near perihelion and winter near aphelion, which means the southern hemisphere experiences more extreme seasons than the northern hemisphere.


Axial Precession (Wobble)
26,000-year cycles
climate.nasa.gov

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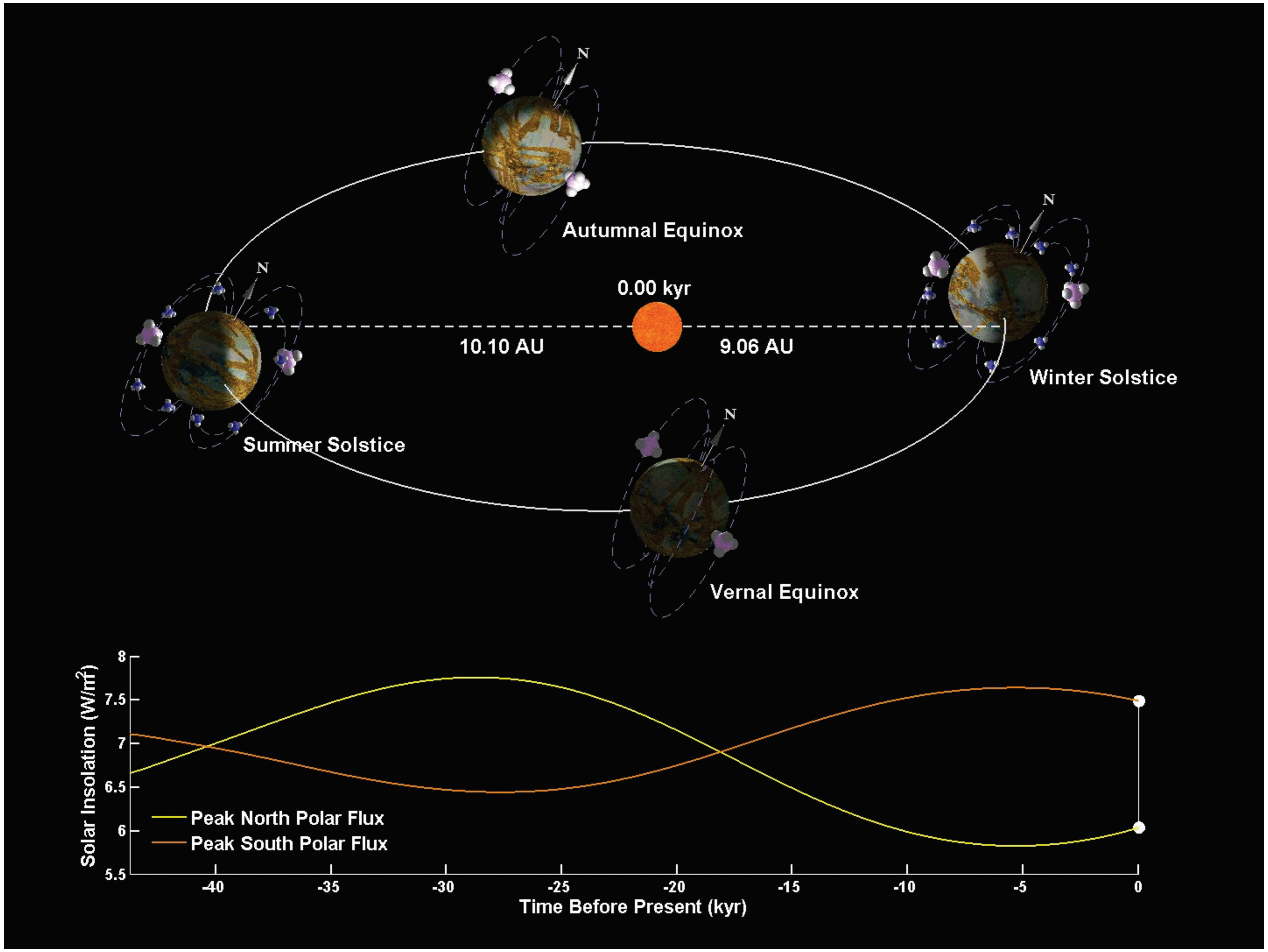


https://www.youtube.com/watch?v=wi-VEby3m9E

S5

SLO 1 - Human induced climate change (anthropogenic causes)

SLO 2- Global radiance balance of climate system

S5 – SLO 1 Human causes

- Climate change can also be caused by **human activities**, such as the burning of fossil fuels and the conversion of land for forestry and agriculture.
- Since the beginning of the Industrial Revolution, these human influences on the climate system have increased substantially. In addition to other environmental impacts, these activities change the land surface and emit various substances to the atmosphere. These in turn can influence both the amount of **incoming energy and the amount of outgoing energy** and can have both warming and cooling effects on the climate. The dominant product of fossil fuel combustion is carbon dioxide, dioxide, a greenhouse gas. The overall effect of human activities since the Industrial Revolution has been a warming effect, driven primarily by emissions of carbon dioxide and enhanced by emissions of other greenhouse gases.
- The build-up of greenhouse gases in the atmosphere has led to an enhancement of the natural greenhouse effect. It is this **human-induced enhancement** of the greenhouse effect that is of concern because ongoing emissions of greenhouse gases have the potential to warm the planet to levels that have never been experienced in the history of human civilization. Such climate change could have far-reaching and/or unpredictable environmental, social, and economic consequences.

- The Industrial Revolution in the 19th century saw the large-scale use of fossil fuels for industrial activities. These industries created jobs and over the years, people moved from rural areas to the cities. This trend is continuing even today.
- More and more land that was covered with vegetation has been cleared to make way for houses. Natural resources are being used extensively for construction, industries, transport, and consumption. Consumerism (our increasing want for material things) has increased by leaps and bounds, creating mountains of waste. Also, our population has increased to an incredible extent.
- All this has contributed to a rise in greenhouse gases in the atmosphere. Fossil fuels such as oil, coal and natural gas supply most of the energy needed to run vehicles, generate electricity for industries, households, etc.
- The **energy sector** is responsible for about ¾ of the carbon dioxide emissions, 1/5 of the methane emissions and a large quantity of nitrous oxide. It also produces nitrogen oxides (NOx) and carbon monoxide (CO) which are not greenhouse gases but do have an influence on the chemical cycles in the atmosphere that produce or destroy greenhouse gases

- **Carbon dioxide** is undoubtedly, the most important greenhouse gas in the atmosphere. Changes in land use pattern, deforestation, land clearing, agriculture, and other activities have all led to a rise in the emission of carbon dioxide.
- **Methane** is another important greenhouse gas in the atmosphere. About ¼ of all methane emissions are said to come from domesticated animals such as dairy cows, goats, pigs, buffaloes, camels, horses, and sheep. These **animals produce** methane during the cud-chewing process. Methane is also released from **rice or paddy fields** that are flooded during the sowing and maturing periods. When soil is covered with water it becomes anaerobic or lacking in oxygen. Under such conditions, methane-producing bacteria and other organisms decompose organic matter in the soil to form methane. Nearly 90% of the paddy-growing area in the world is found in Asia, as rice is the staple food there. China and India, between them, have 80-90% of the world's rice-growing areas.
- Methane is also emitted from **landfills** and other waste dumps. If the waste is put into an incinerator or burnt in the open, carbon dioxide is emitted. Methane is also emitted during the process of oil drilling, coal mining and also from leaking gas pipelines (due to accidents and poor maintenance of sites).
- A large amount of **nitrous oxide** emission has been attributed to fertilizer application. This in turn depends on the type of fertilizer that is used, how and when it is used and the methods of tilling that are followed. Contributions are also made by leguminous plants, such as beans and pulses that add nitrogen to the soil.

How we all contribute every day

All of us in our daily lives contribute our bit to this change in the climate. Give these points a good, serious thought:

1) **Electricity** is the main source of power in urban areas. All our gadgets run on electricity generated mainly from thermal power plants. These thermal power plants are run on fossil fuels (mostly coal) and are responsible for the emission of huge amounts of greenhouse gases and other pollutants.

2) Cars, buses, and trucks are the principal ways by which goods and people are **transported** in most of our cities. These are run mainly on petrol or diesel, both fossil fuels.

3) We generate large quantities of **waste in the form of plastics** that remain in the environment for many years and cause damage.

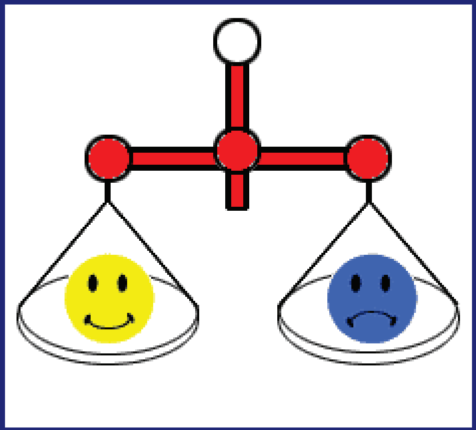
4) We use a huge **quantity of paper** in our work at schools and in offices. Have we ever thought about the **number of trees** that we use in a day?

5) Timber is used in large quantities for **construction** of houses, which means that large areas of **forest have to be cut down**.

6) A **growing population** has meant more and more mouths to feed. Because the land area available for agriculture is limited (and in fact, is actually shrinking as a result of ecological degradation), high-yielding varieties of crop are being grown to increase the agricultural output from a given area of land. However, such **high-yielding varieties of crops** require large quantities of fertilizers; and more fertilizer means more emissions of nitrous oxide, both from the field into which it is put and the fertilizer industry that makes it. **Pollution also results from the run-off of fertilizer into water bodies**.

Global radiance balance of climate system

Global radiance balance of climate system



Look at life as an energy economy game. Each day, ask yourself,

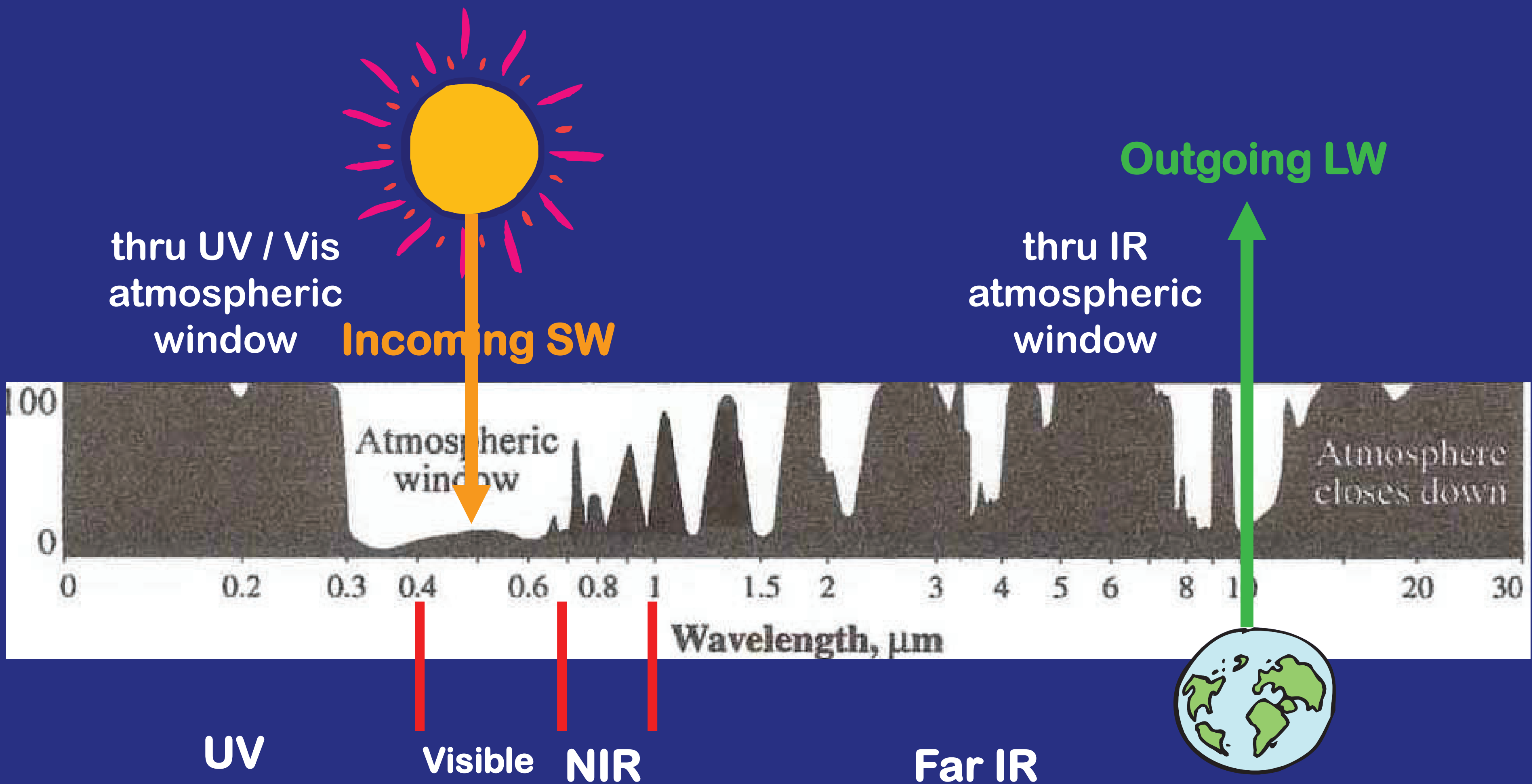
Are my energy expenditures (actions, reactions, thoughts, and feelings) productive or nonproductive?

During the course of my day, have I accumulated more stress or more peace?

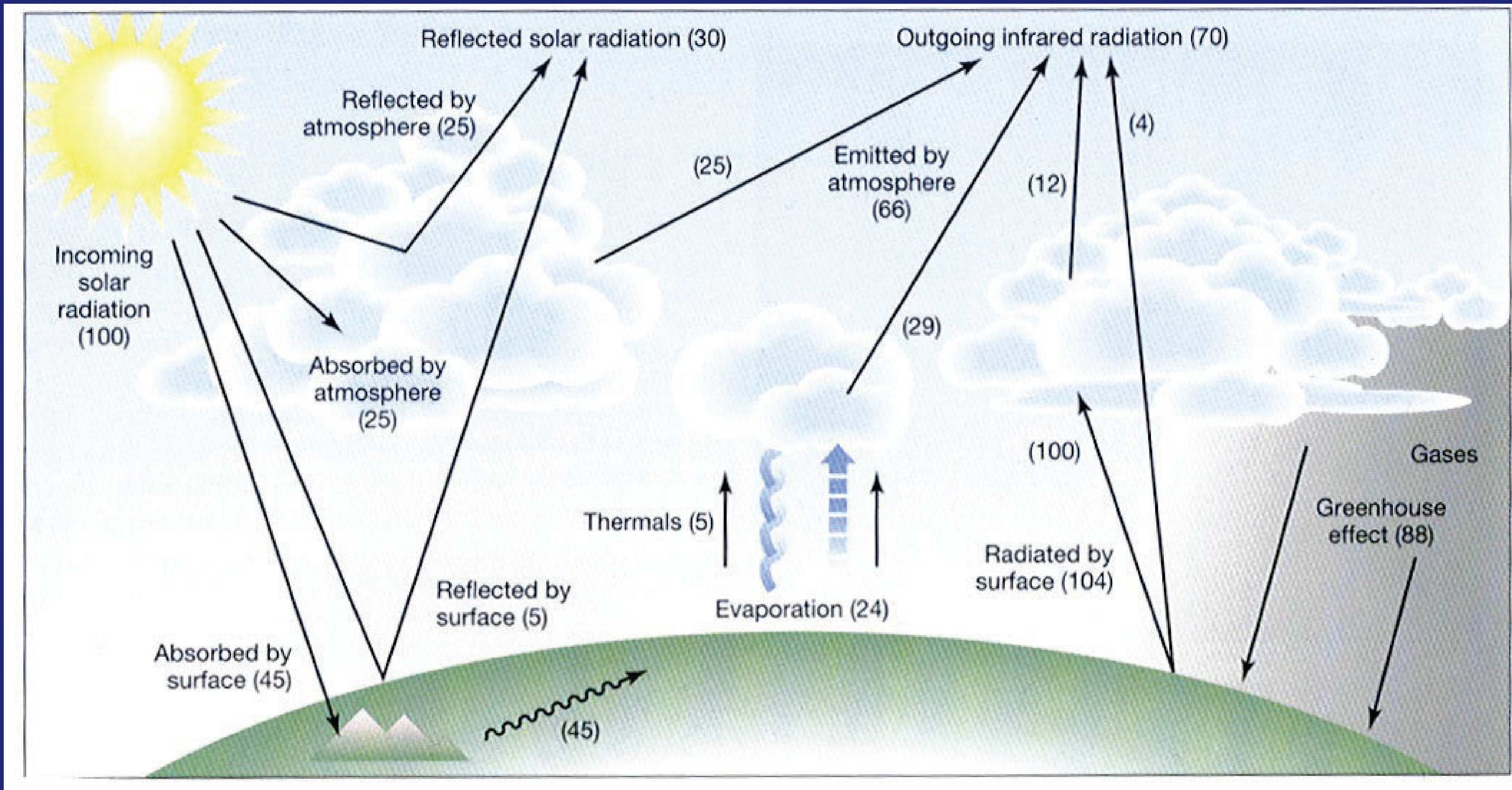
~ Doc Childre and Howard Martin

Review: Absorption curve for the "Whole Atmosphere"

OVERALL BALANCE: **Incoming = Outgoing**



Typical Energy Balance Diagram



mesoscale.agron.iastate.edu/agron206/animations/10_AtmoEbal.html

From SGC-I Chapter 3, p 50, Fig 3-19

Energy Balance Equation:

$$R_{net} = (Q + q) - a - Lu + Ld = H + LE + G$$

(one of several ways this equation can be written)

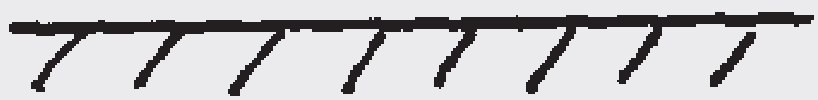
Let's try to find an easy way to understand and remember all the components of the Earth's Energy Balance

We'll use "cartoon symbols" . . .

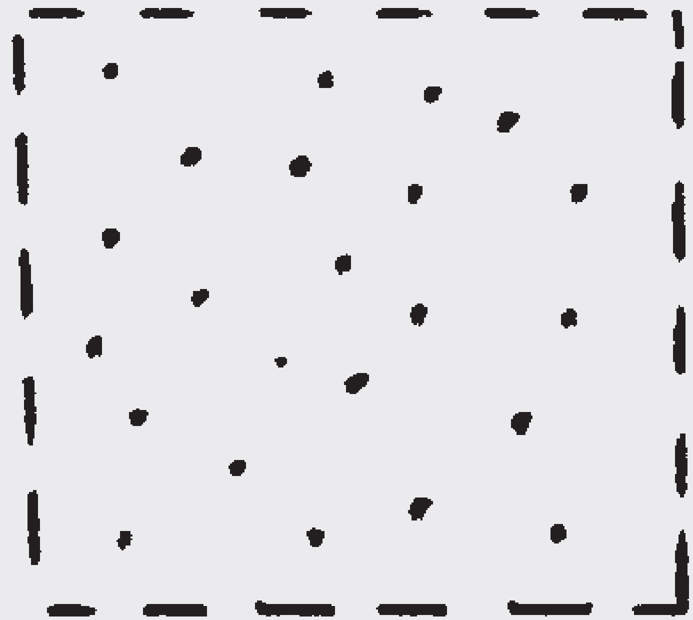
☺

“CARTOON” SYMBOLS:

To represent the Earth’s surface:



“CARTOON” SYMBOLS:



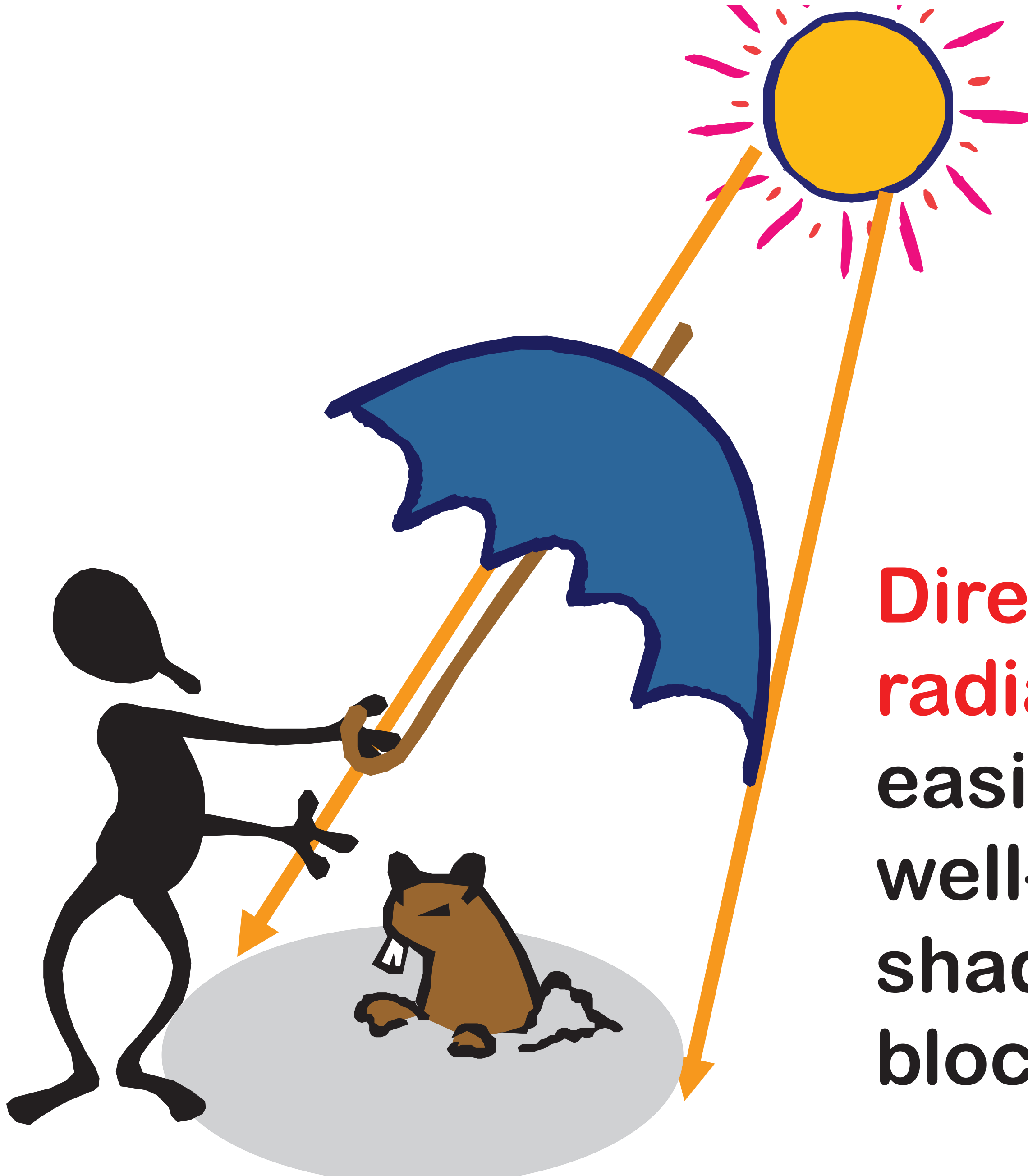
To represent the atmosphere – composed of both invisible gases, aerosols, dust and other particulate matter:

“CARTOON” SYMBOLS:

To represent CLOUDS

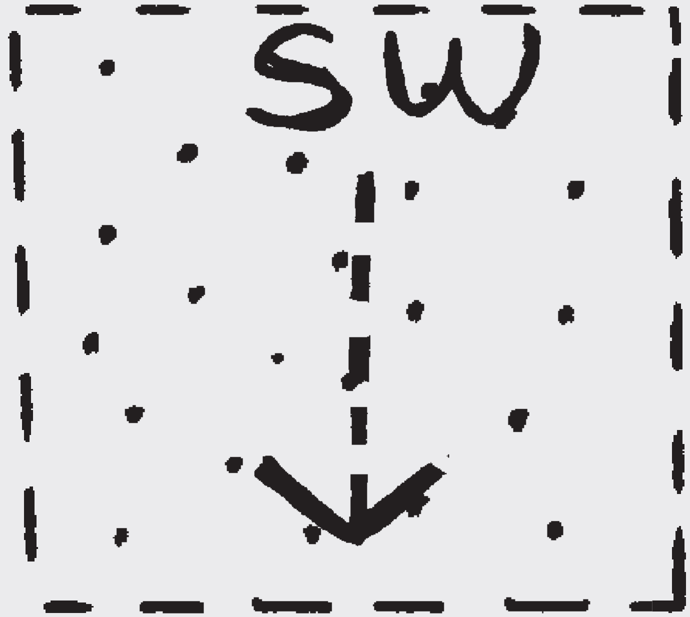
“CARTOON” SYMBOLS:

To represent SOLAR (shortwave) radiation coming in DIRECTLY.
(aka Direct shortwave radiation)



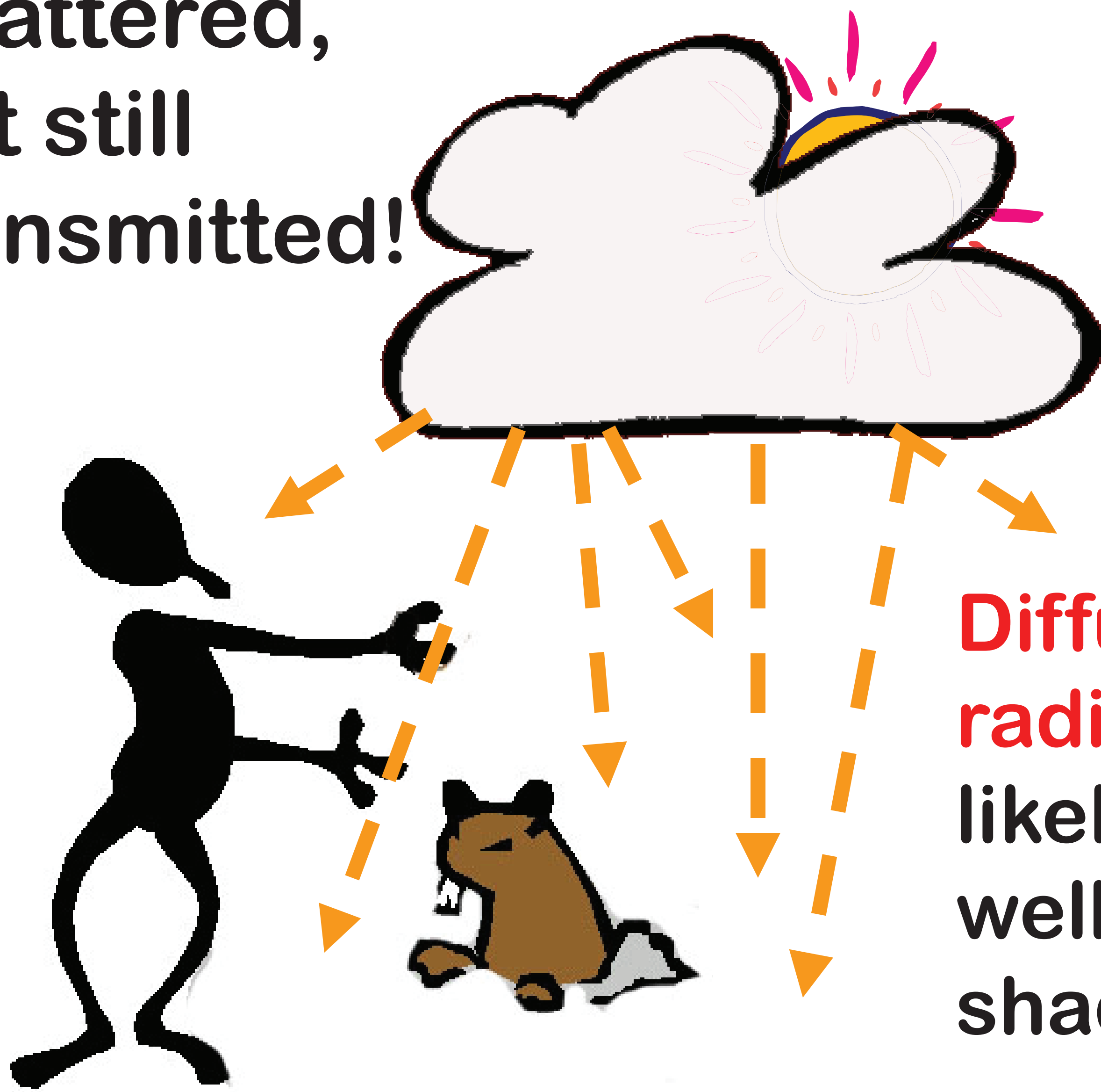
Direct SW radiation easily casts well-defined shadows when blocked

“CARTOON” SYMBOLS:

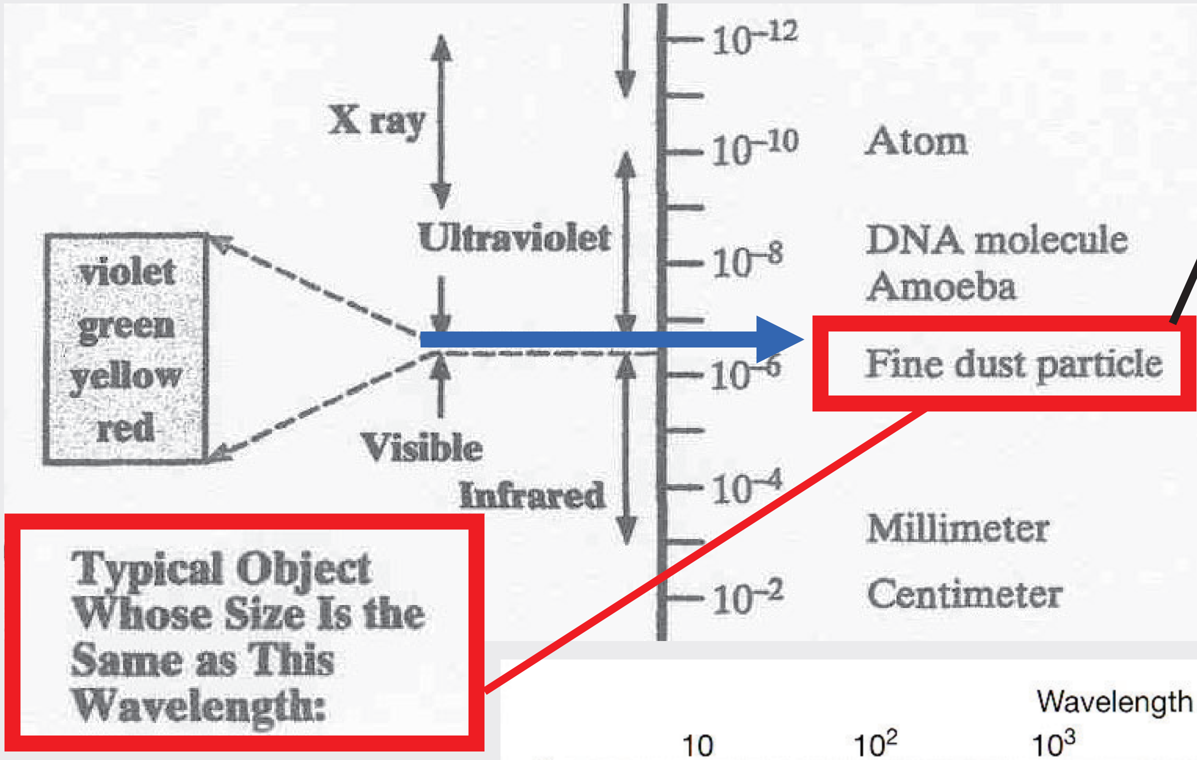


To represent SOLAR (shortwave) radiation coming in as **DIFFUSE shortwave radiation**, i.e. scattered by gases, clouds, and particles in the atmosphere.

Scattered,
but still
transmitted!



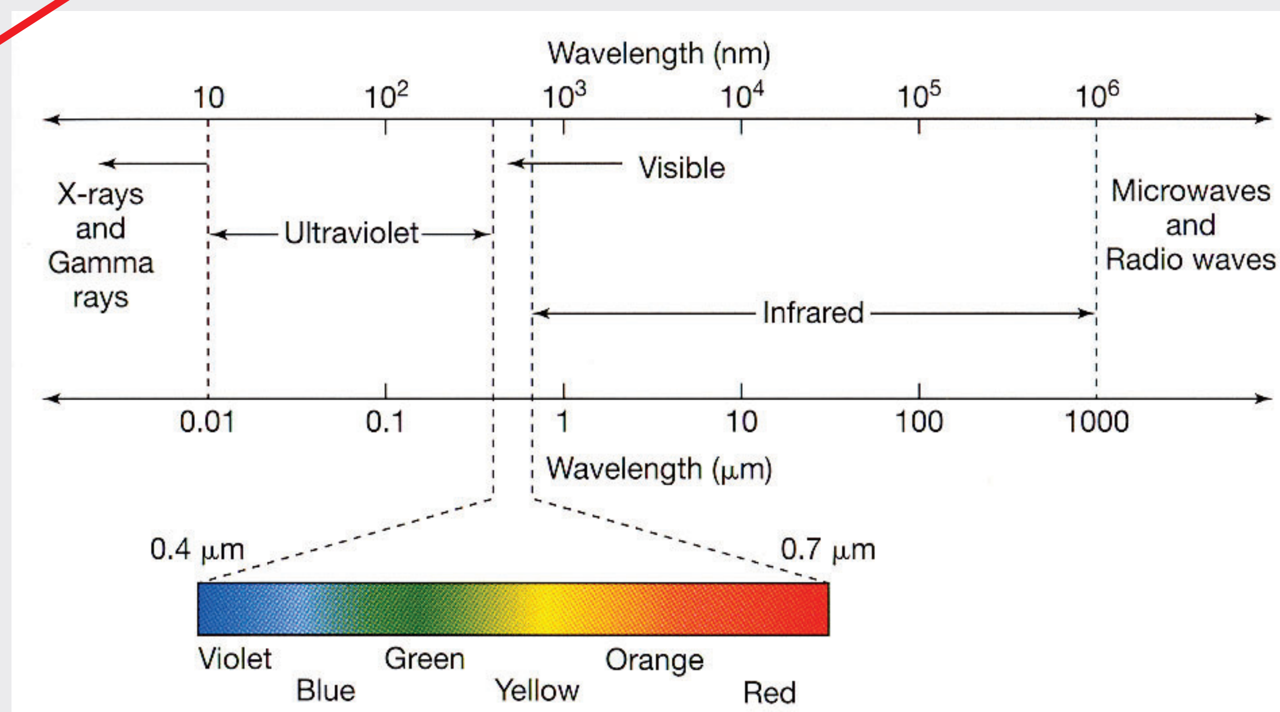
Diffuse SW radiation is less likely to cast a well-defined shadow!

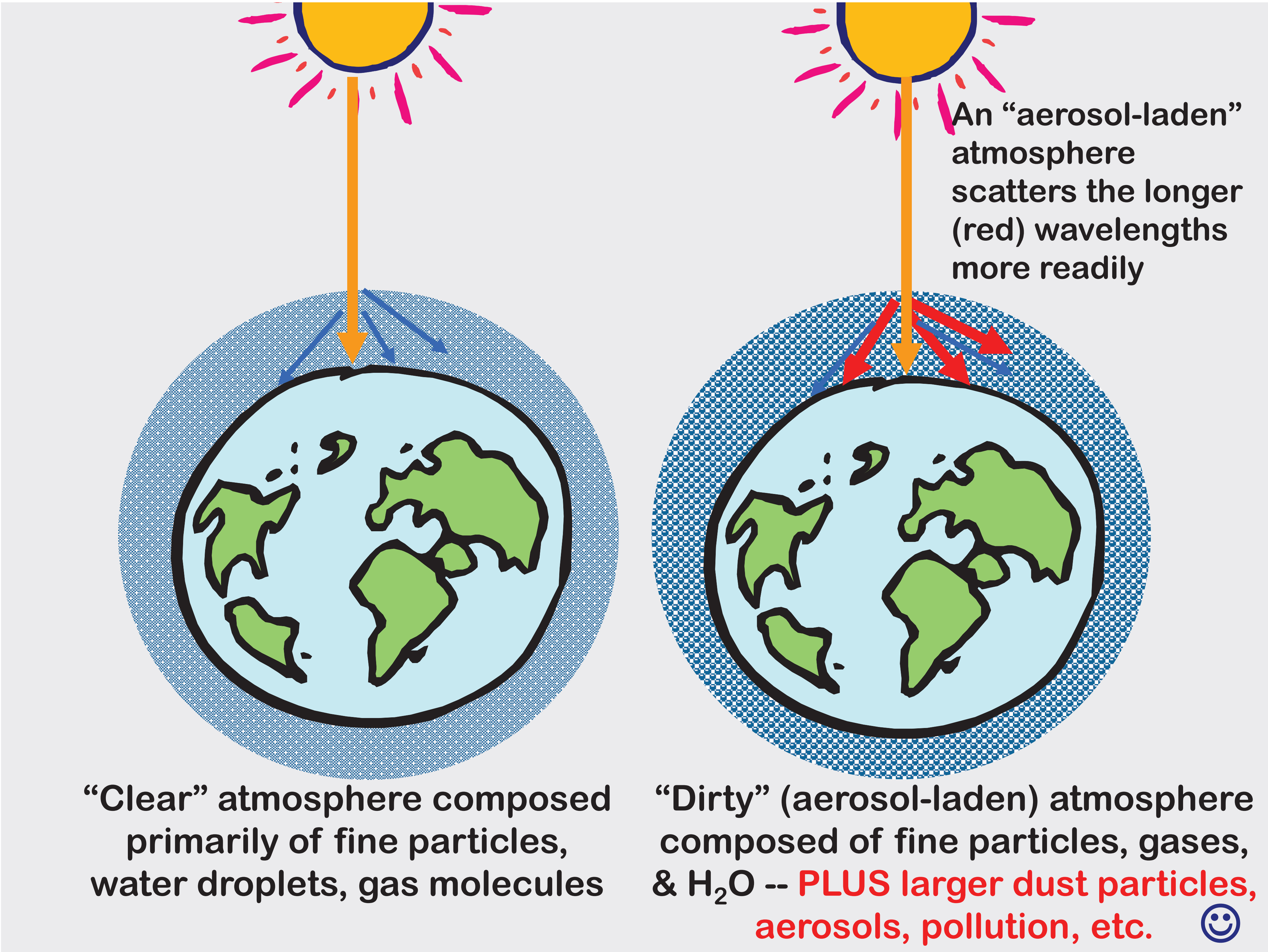


Different sized dust particles, water droplets, aerosols,

(even gas molecules themselves)

Scattering of visible light

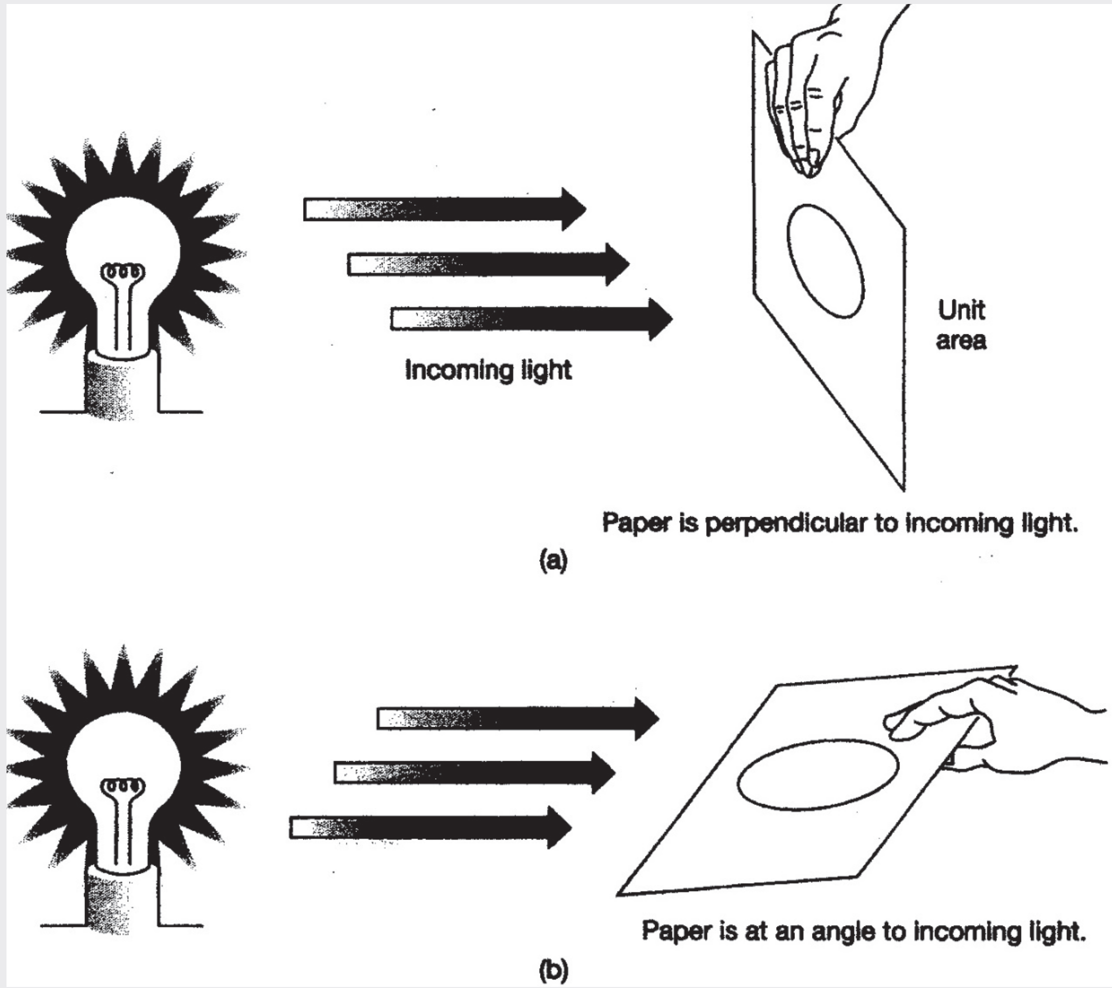


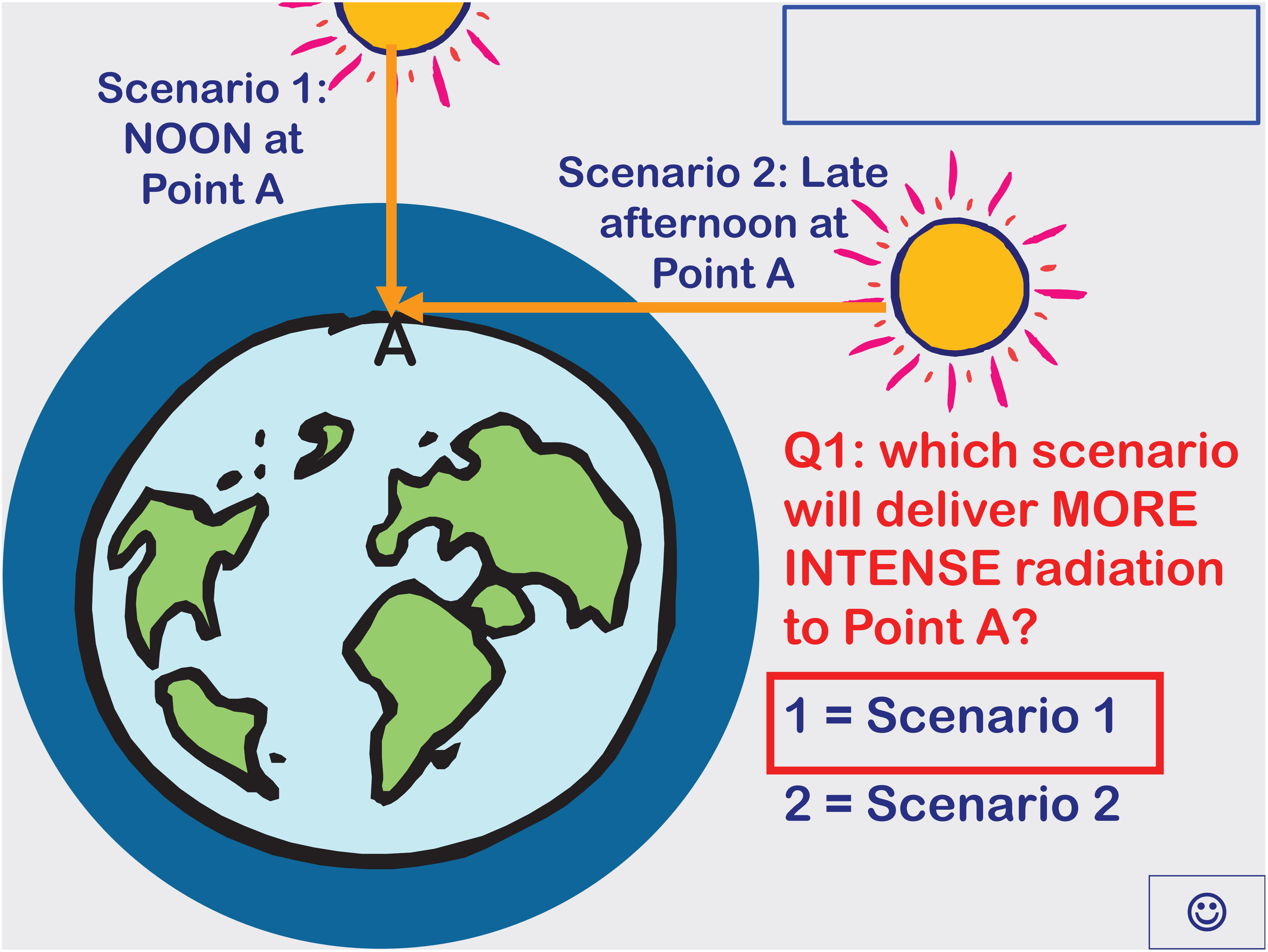

An "aerosol-laden" atmosphere scatters the longer (red) wavelengths more readily
"Clear" atmosphere composed primarily of fine particles, water droplets, gas molecules
"Dirty" (aerosol-laden) atmosphere composed of fine particles, gases, & H_2O -- PLUS larger dust particles, aerosols, pollution, etc.

ALSO: **The angle at which direct SW radiation is intercepted by a surface makes a difference!!**

Radiation is concentrated over a small area & hence is more intense when it comes in perpendicular to the surface

Radiation is spread out over a larger area & hence is less intense <u>per unit area</u> when it comes in at an angle.





Scenario 1: NOON at Point A
Scenario 2: Late afternoon at Point A
A
Q1: which scenario will deliver MORE INTENSE radiation to Point A?
1 = Scenario 1
2 = Scenario 2
☺

Q2 = WHY is the intensity of the SW radiation at Point A not as strong in the late afternoon as it is at noon?

1 = because as the Sun goes down close to sunset time, it gives off less radiation

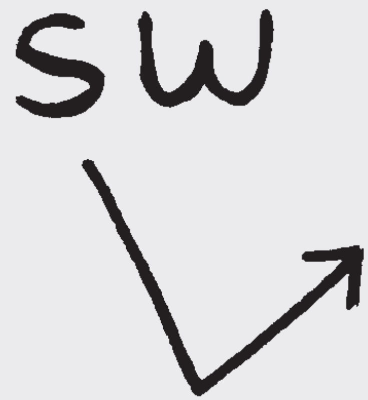
2 = because the SW radiation is coming in at an angle in the late afternoon, and is not directly overhead (perpendicular) like it is at noon.

3 = because the SW radiation is being transmitted through a thicker atmosphere & hence scattered more

BOTH #2 & #3 are applicable!

☺

"CARTOON" SYMBOLS:



To represent SOLAR (shortwave) radiation that is REFLECTED (or scattered) BACK TO SPACE by: atmosphere, clouds, Earth's surface, etc.

New term:

<u>**ALBEDO**</u> **= reflectivity of a surface**

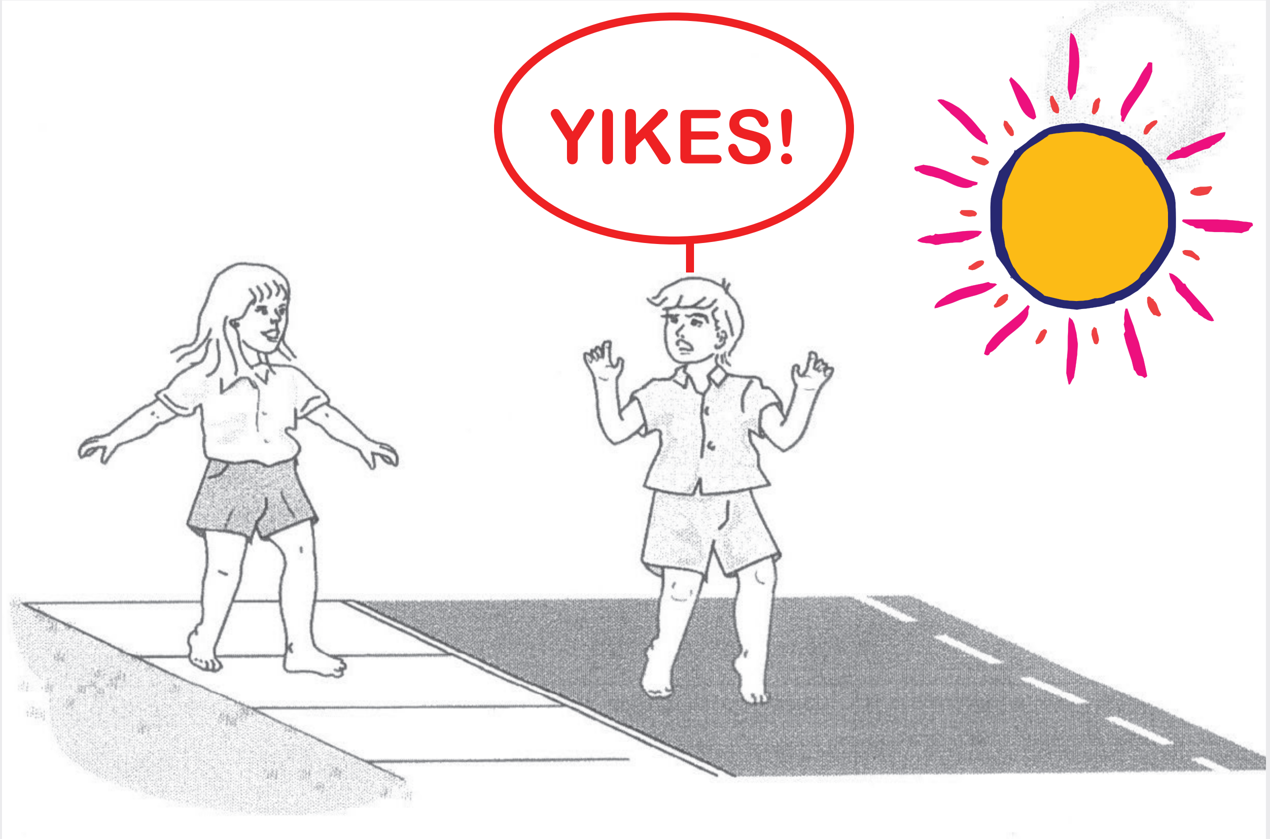
"*symbol*" = a

Represented as:

a decimal from 0 to 1.0 ***or***

% from 0 – 100 % (perfect reflectivity)

Hence, amount ABSORBED = (1 – albedo)



If a surface's albedo is HIGH, absorption by the surface is LOW ➔ COOLER surface

If a surface's albedo is LOW absorption by the surface is HIGH => HOTTER surface!

☺

Albedos of Some Common Surfaces

Type of Surface	*Albedo*
Sand	0.20–0.30
Grass	0.20–0.25
Forest	0.05–0.10
Water (overhead Sun)	0.03–0.05
Water (Sun near horizon)	0.50–0.80
Fresh snow	0.80–0.85
Thick cloud	0.70–0.80

Low albedo

High albedo

→ CLOUDS: 0.44 (high, thin clouds) - 0.90 (low, thick clouds)

AVERAGE PLANET EARTH = ~ 0.30

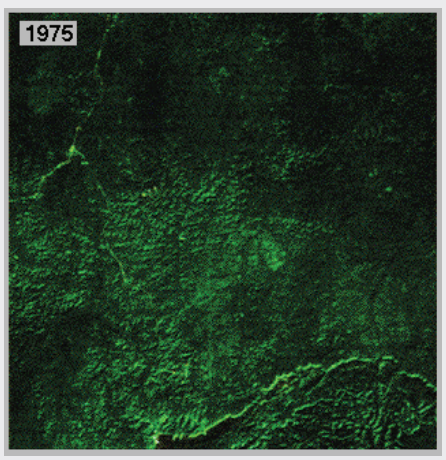
Q3: What will happen to incoming SW over the Amazon Rain Forest if parts of it are deforested?

1 = more SW will be absorbed

2 = less SW will be absorbed

SW

Before



After

“CARTOON” SYMBOLS:

To represent TERRESTRIAL (longwave IR) radiation emitted upward by the Earth’s surface or the atmosphere

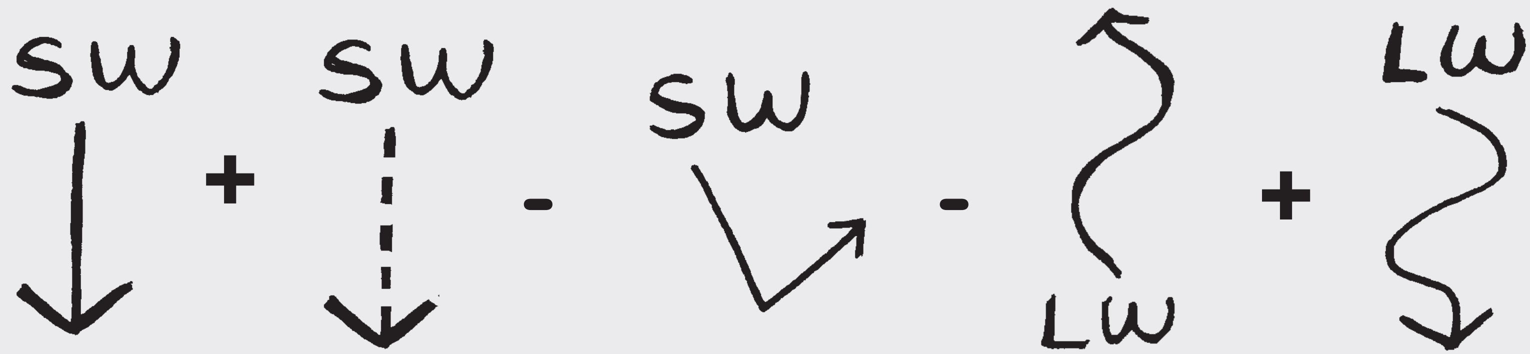
“CARTOON” SYMBOLS:

To represent TERRESTRIAL (longwave IR) re-radiation emitted downward by the Earth’s ATMOSPHERE

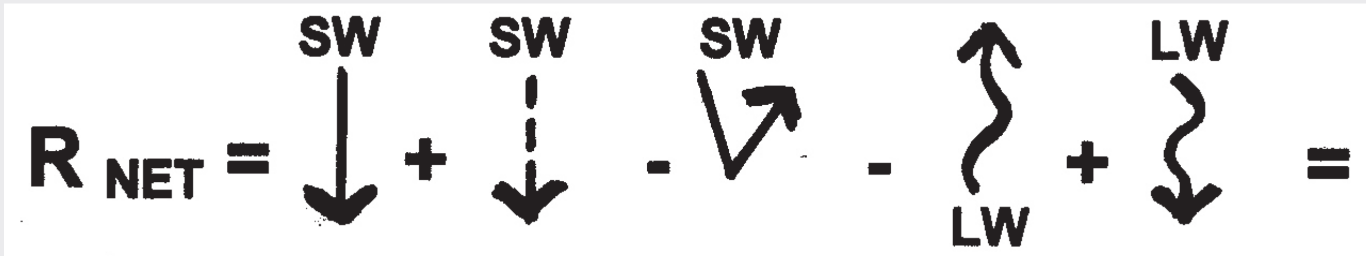
PUTTING IT TOGETHER:

Can you place + and – signs where they ought to go in the equation?

$R_{NET} =$



$$R_{NET} = (Q + q) - a - Lu + Ld$$



Now we'll look at the energy pathways in a bit more detail by combining the cartoon symbols in various ways . . .

First, what if . . .

. . . The Earth didn't have an atmosphere, and therefore didn't have a greenhouse effect??

What would the energy pathways in the Earth-Sun system look like?

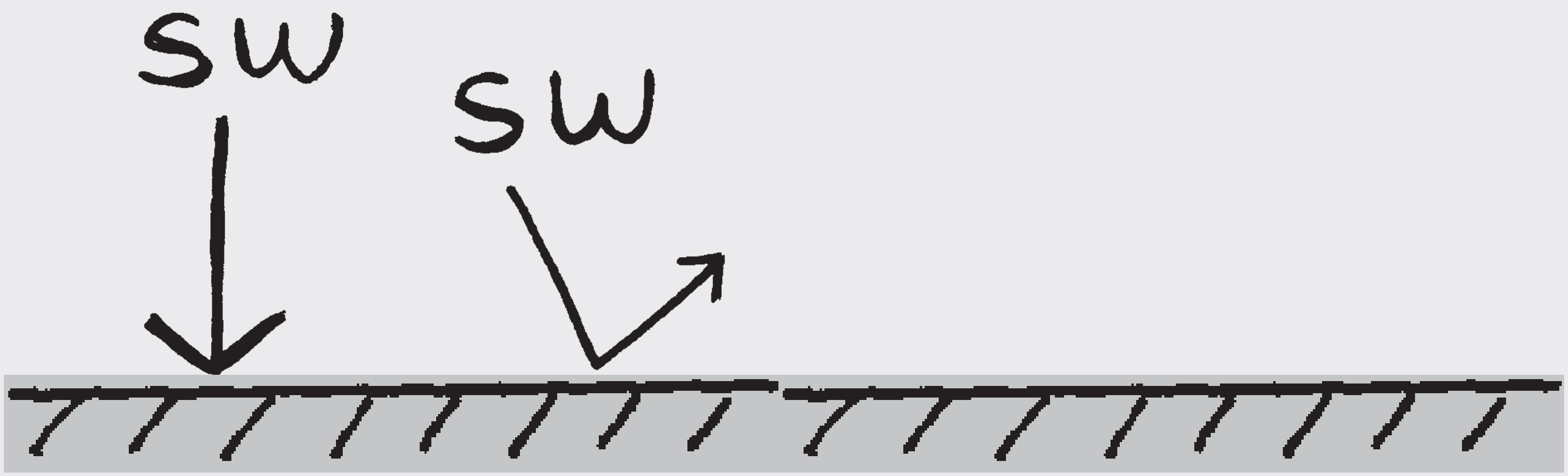
☺

LW

Which terms are not involved?

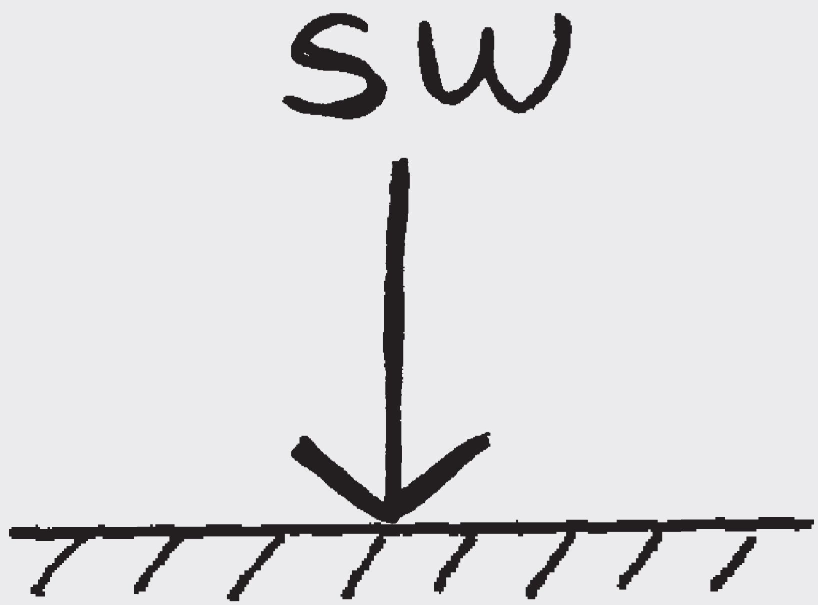
No scattering by atmosphere

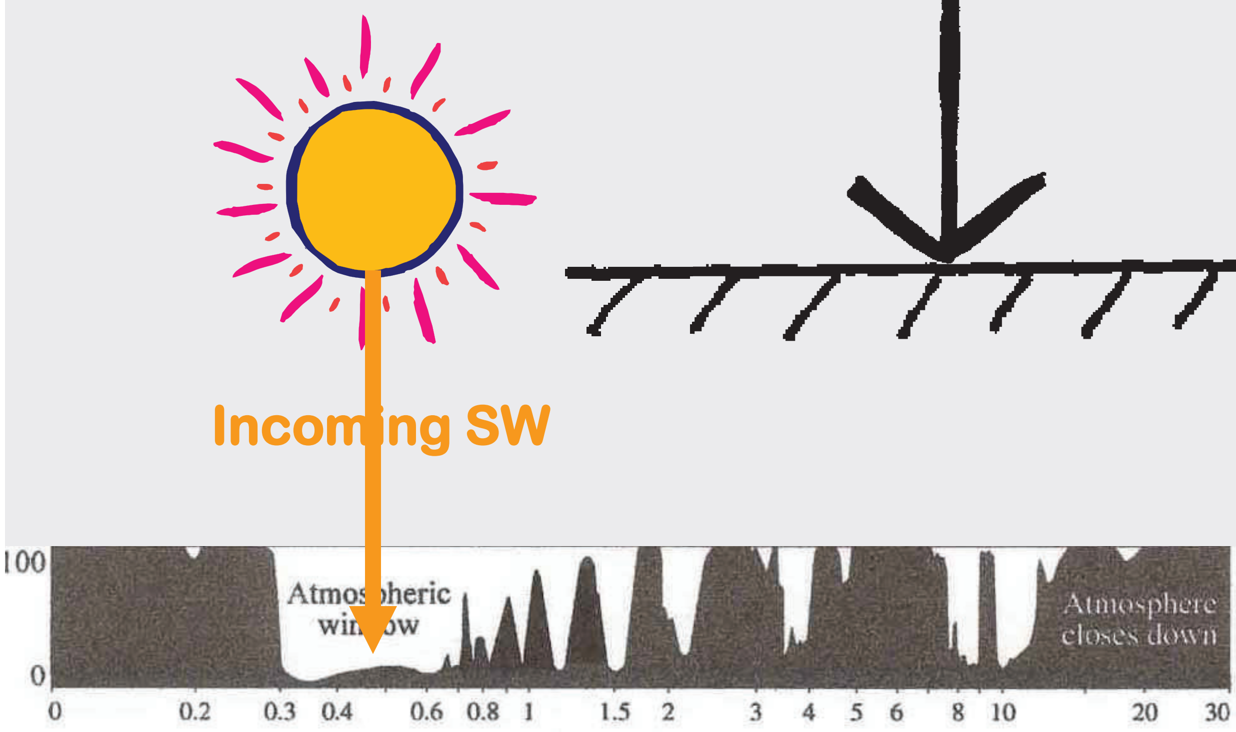
No re-radiation of infrared by GHG's



To describe the real Earth-Atmosphere system, more detail is needed in our simple representation . . . . .
We'll use our symbols to build an energy balance "model"

SW BEAMED DIRECTLY TO EARTH'S SURFACE WHERE IT IS ABSORBED:

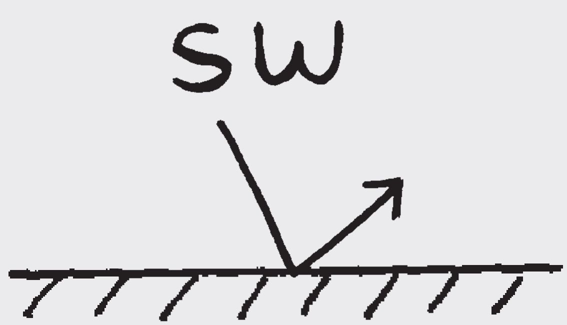




SW REFLECTED BACK TO SPACE:

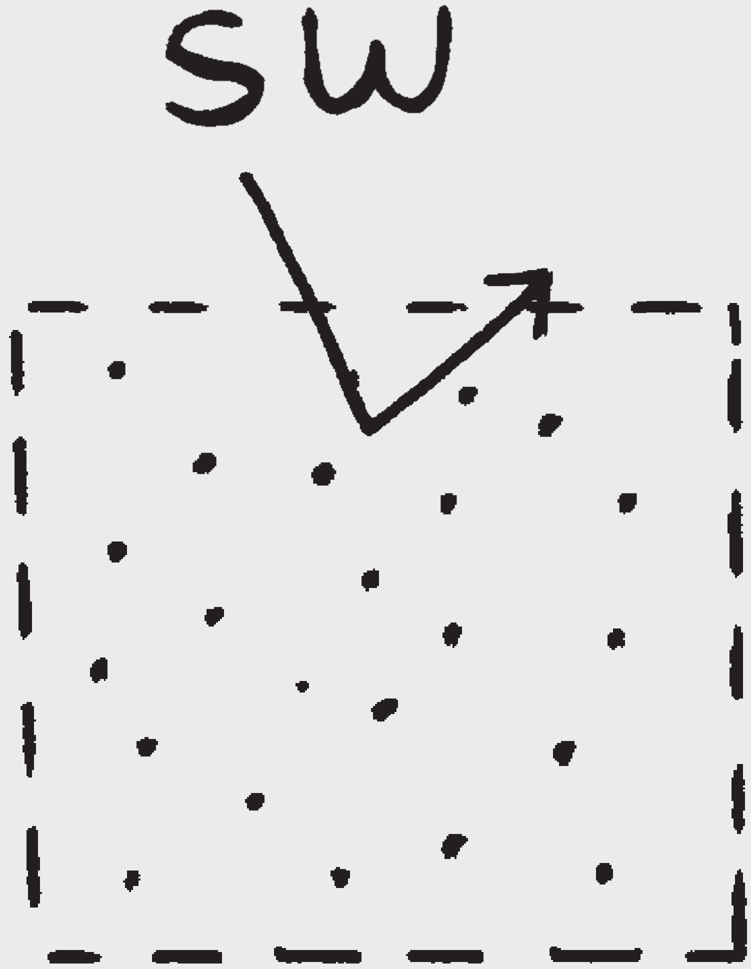
By
clouds

By
Earth's
surface

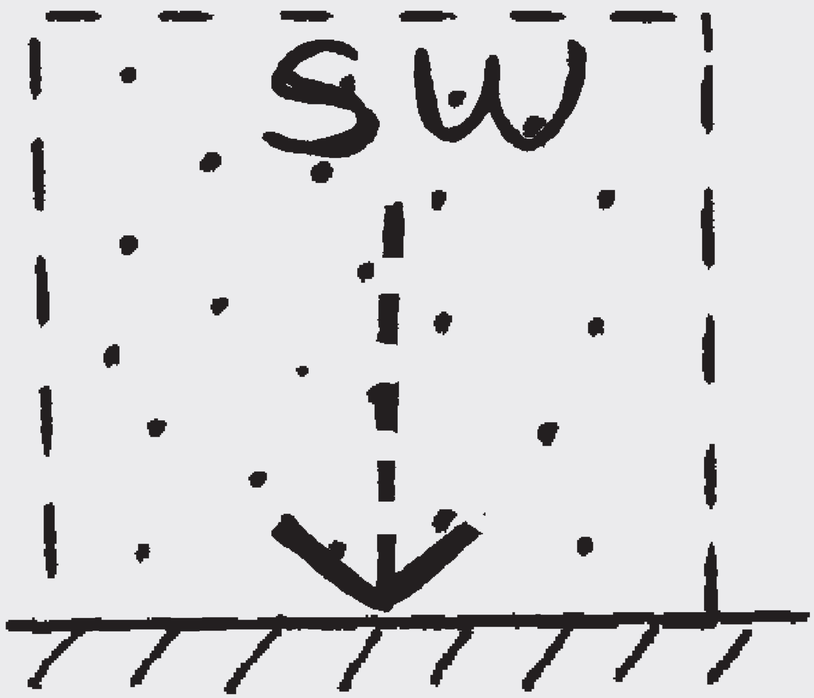


This is determined by
the ALBEDO of the
clouds or surface

SW SCATTERED BACK TO SPACE BY ATMOSPHERE:

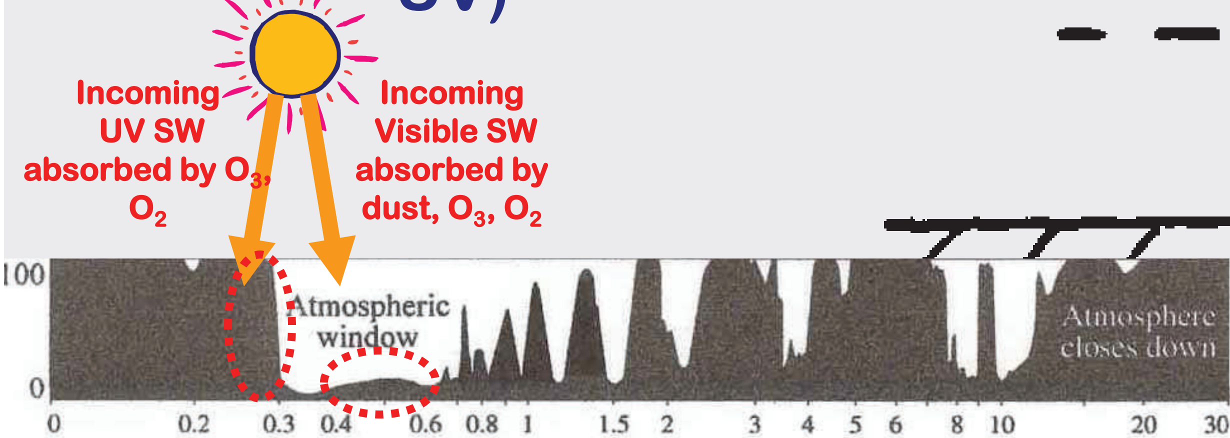


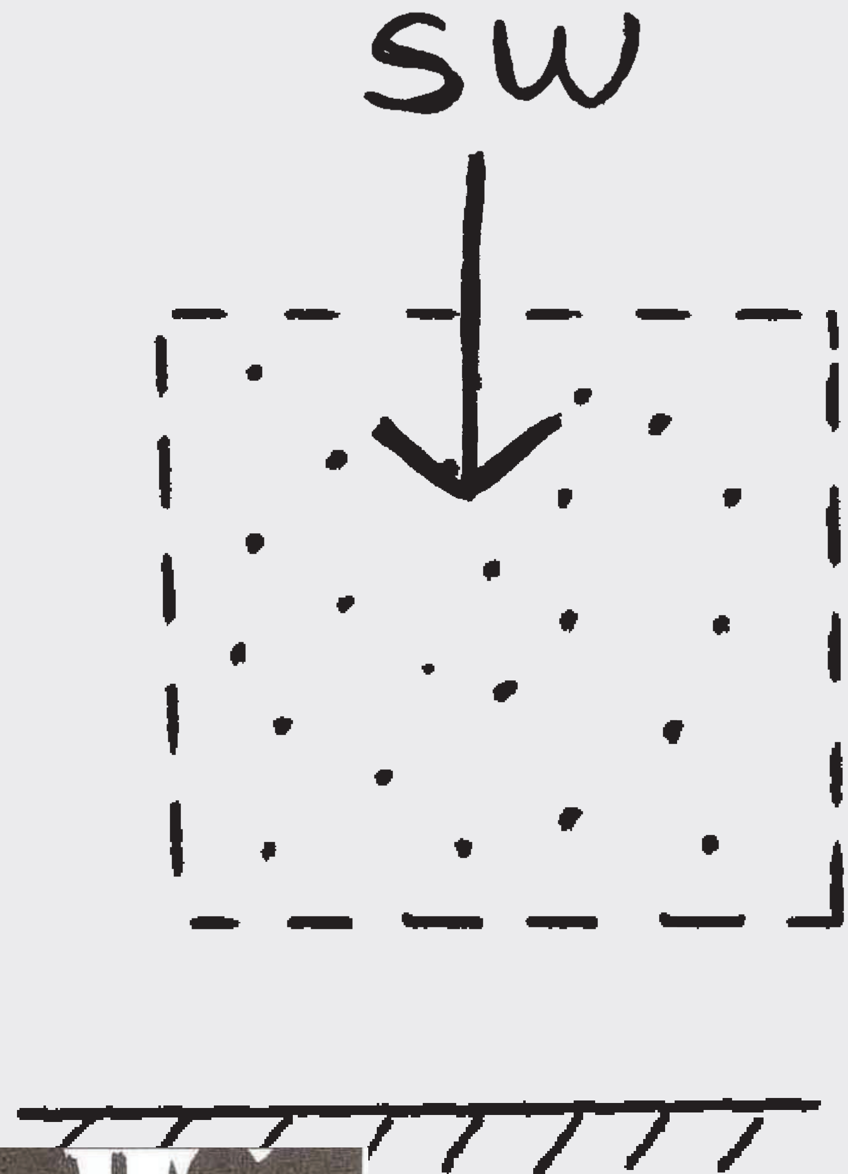
SW SCATTERED DOWN TO EARTH's SURFACE where it is absorbed



SW ABSORBED IN ATMOSPHERE BY GASES, DUST, etc.

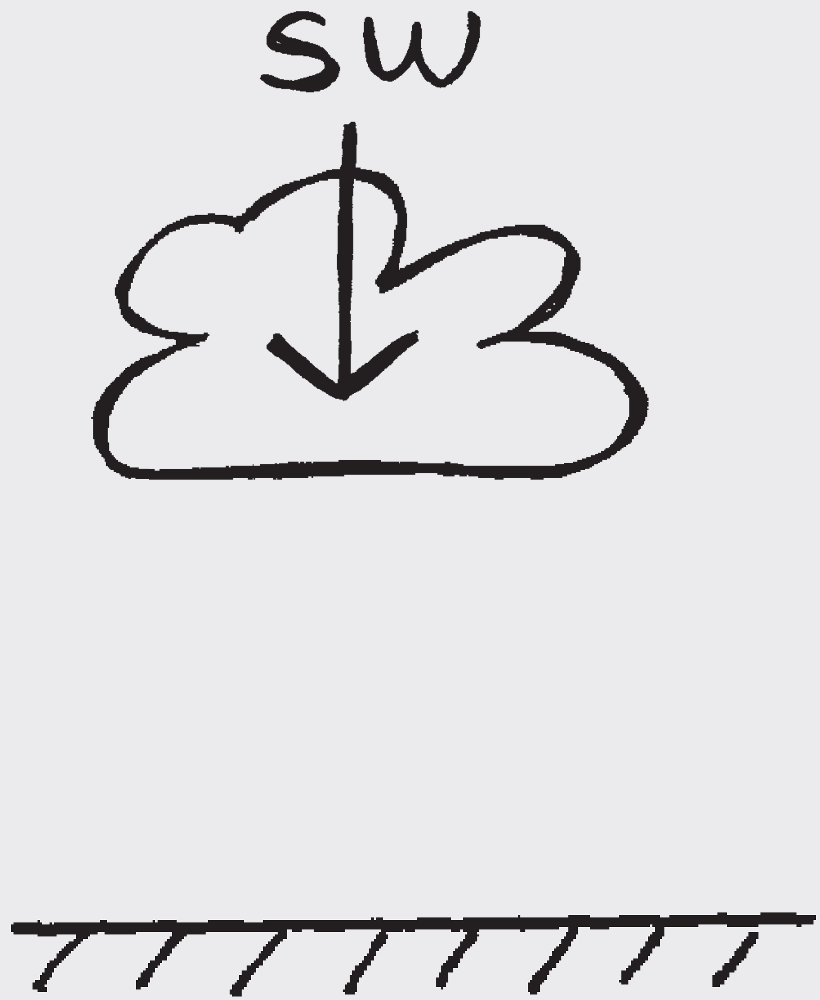
(including Ozone absorbing shortwave UV)

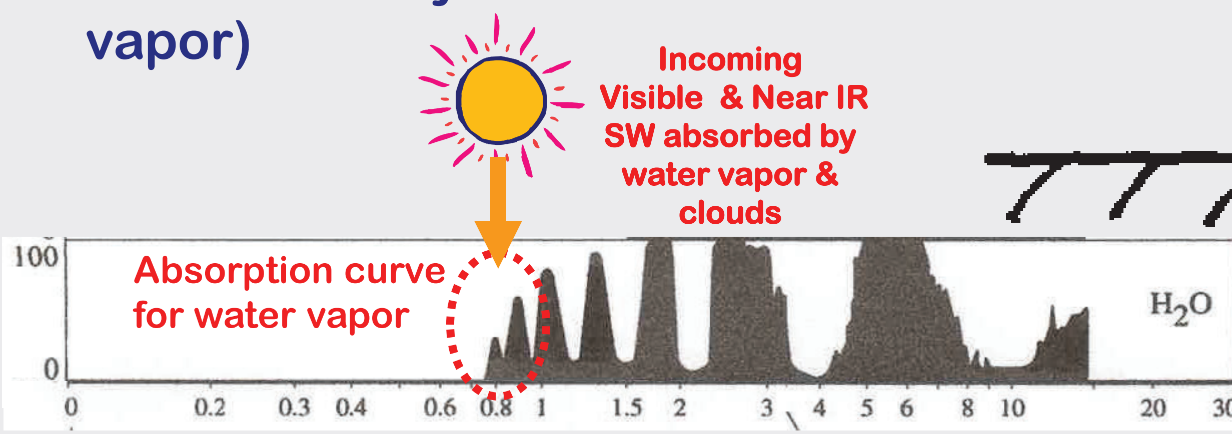




SW ABSORBED In ATMOSPHERE BY CLOUDS & H_2O vapor:

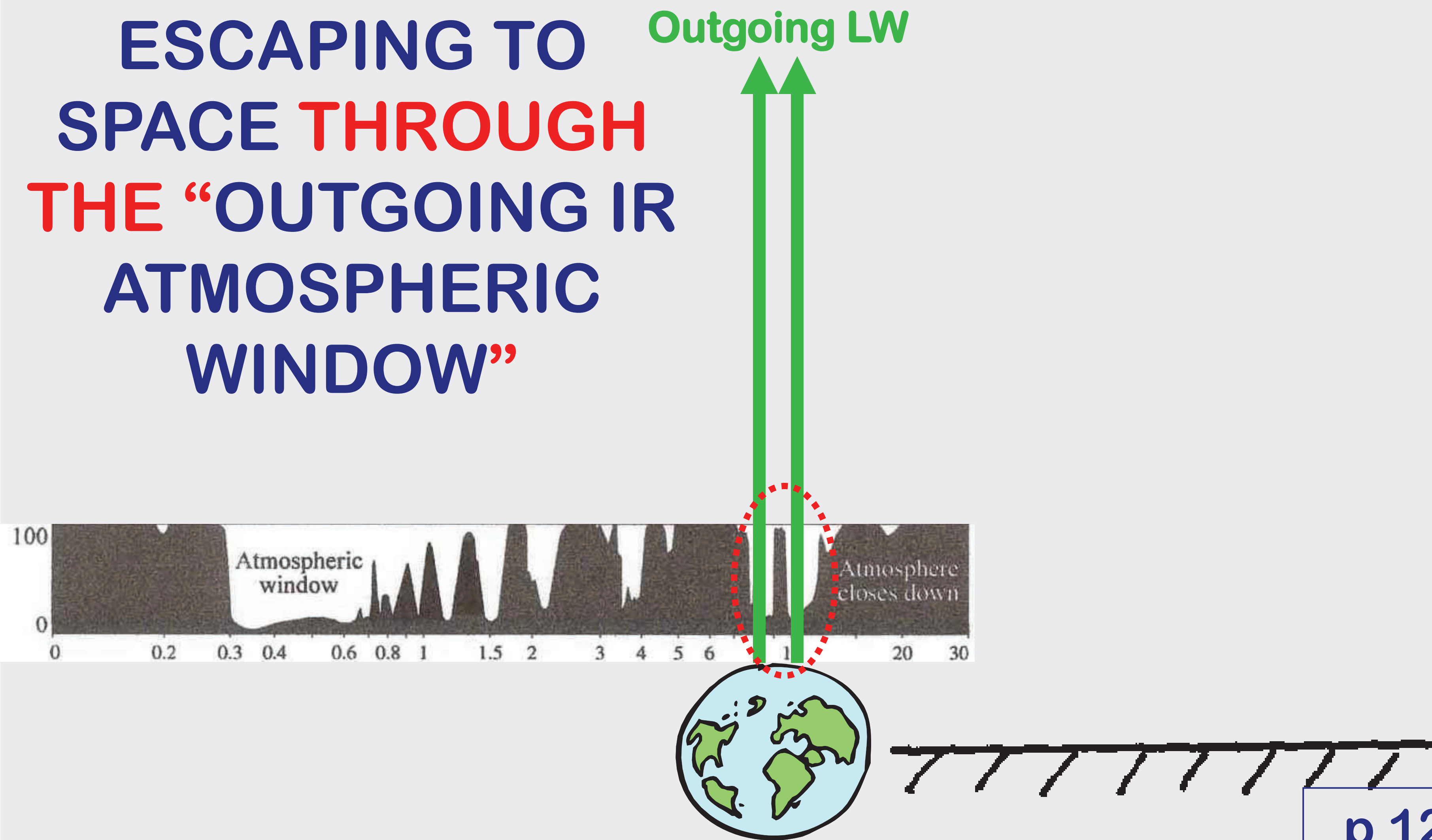
(NOTE: clouds are made up of tiny droplets of water surrounded by lots of water vapor)





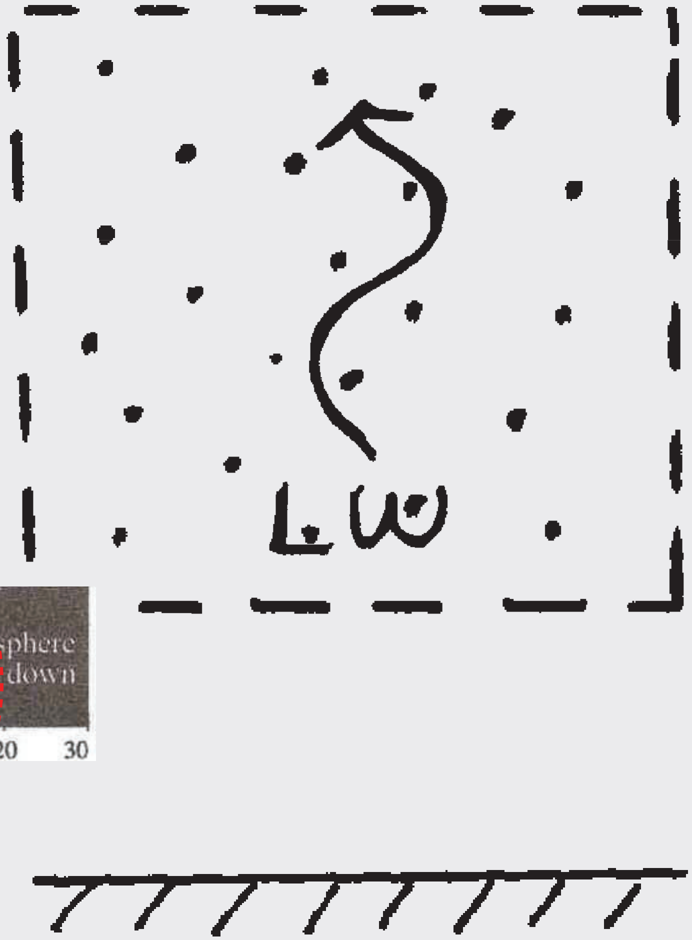
LW

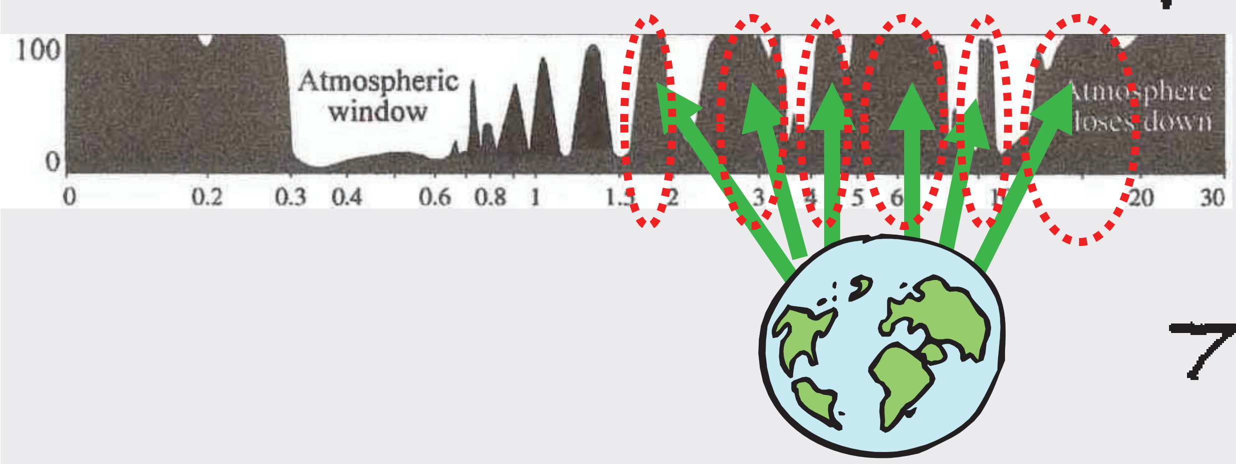
LW (IR) EMITTED FROM EARTH'S SURFACE ESCAPING TO SPACE THROUGH THE "OUTGOING IR ATMOSPHERIC WINDOW"



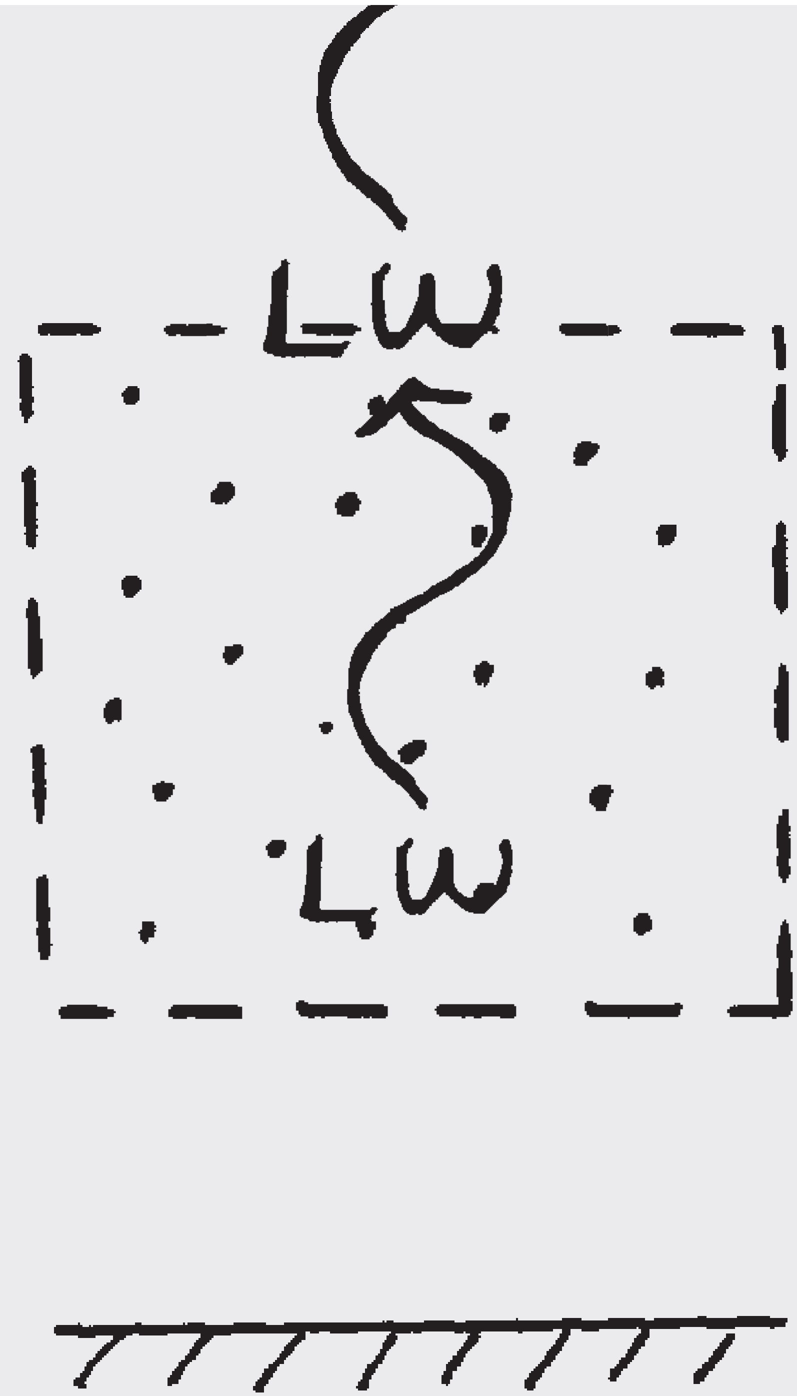
p 124

IR EMITTED FROM EARTH'S SURFACE BUT ABSORBED IN THE ATMOSPHERE BY GREENHOUSE GASES (H_2O, CO_2, CH_4, ETC.)

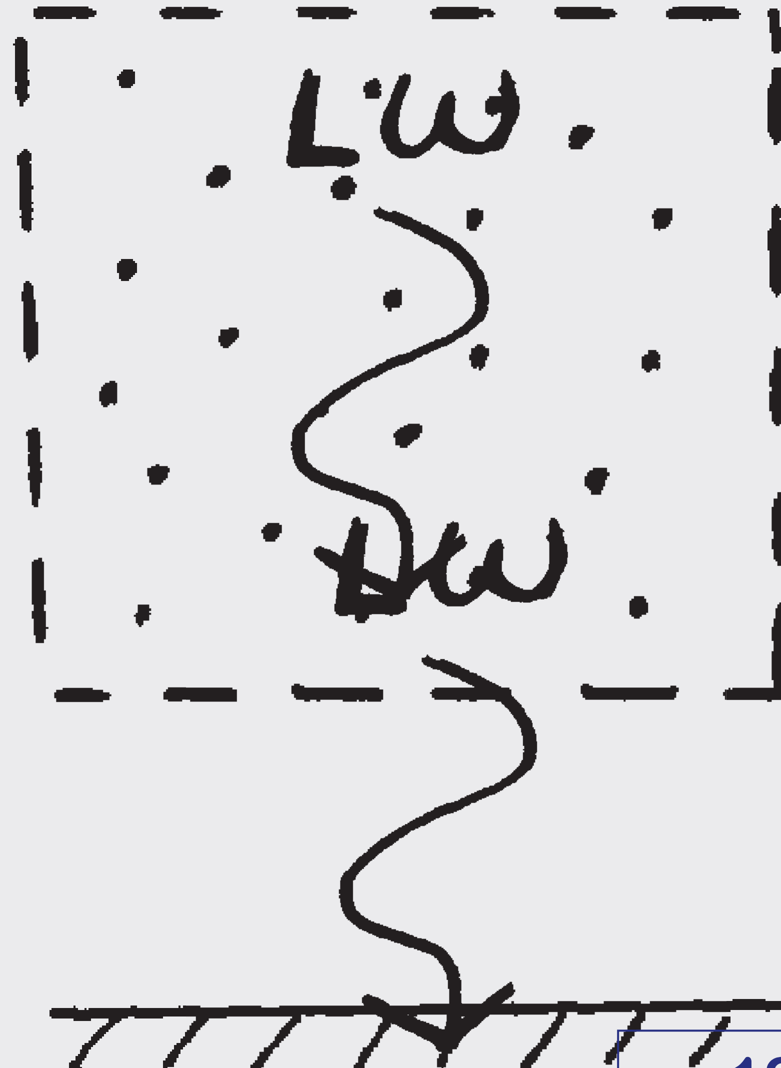




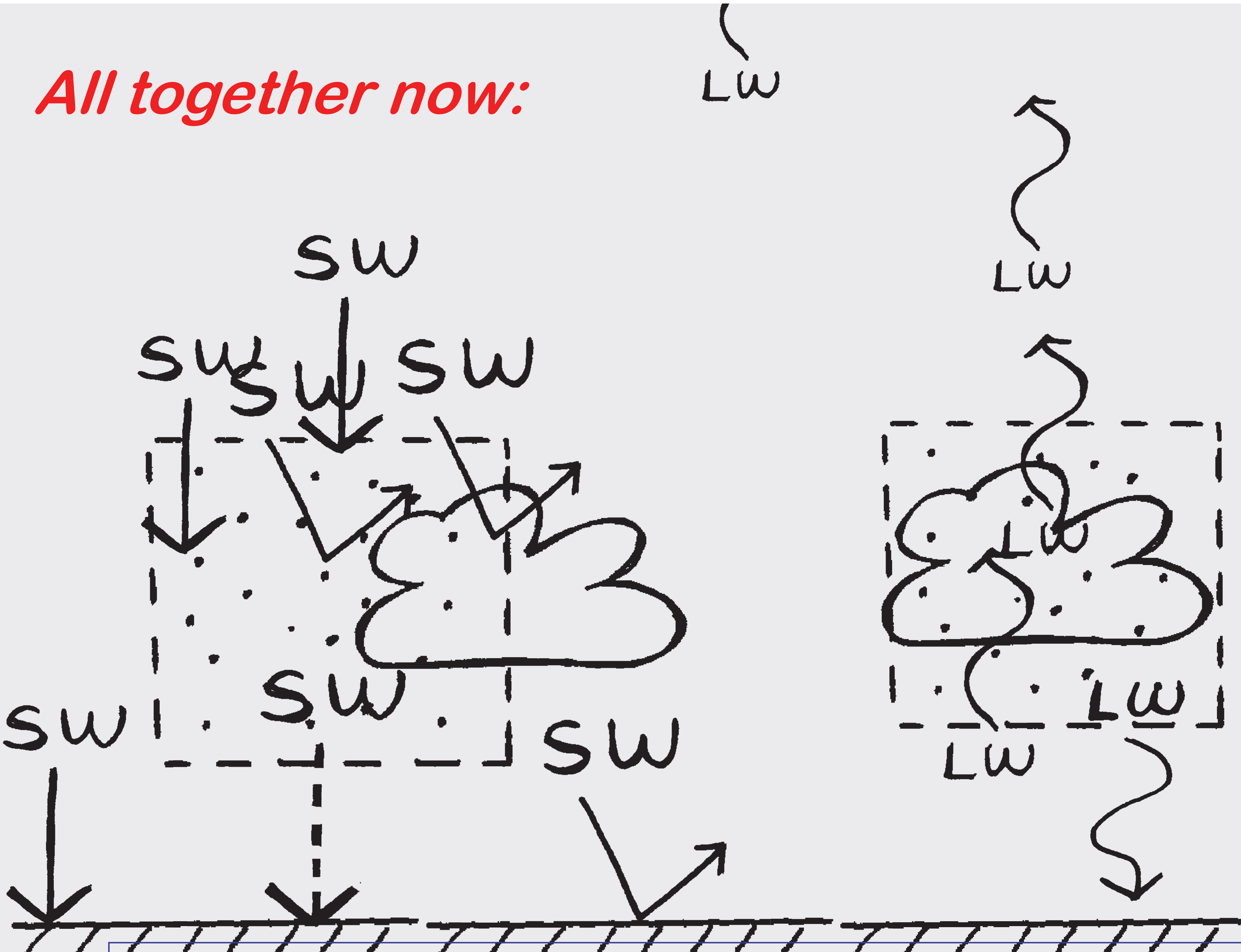
IR EMITTED FROM ATMOSPHERE ESCAPING TO SPACE



IR EMITTED
FROM
ATMOSPHERE
AND RADIATED
BACK TO
SURFACE
WHERE IT IS
ABSORBED

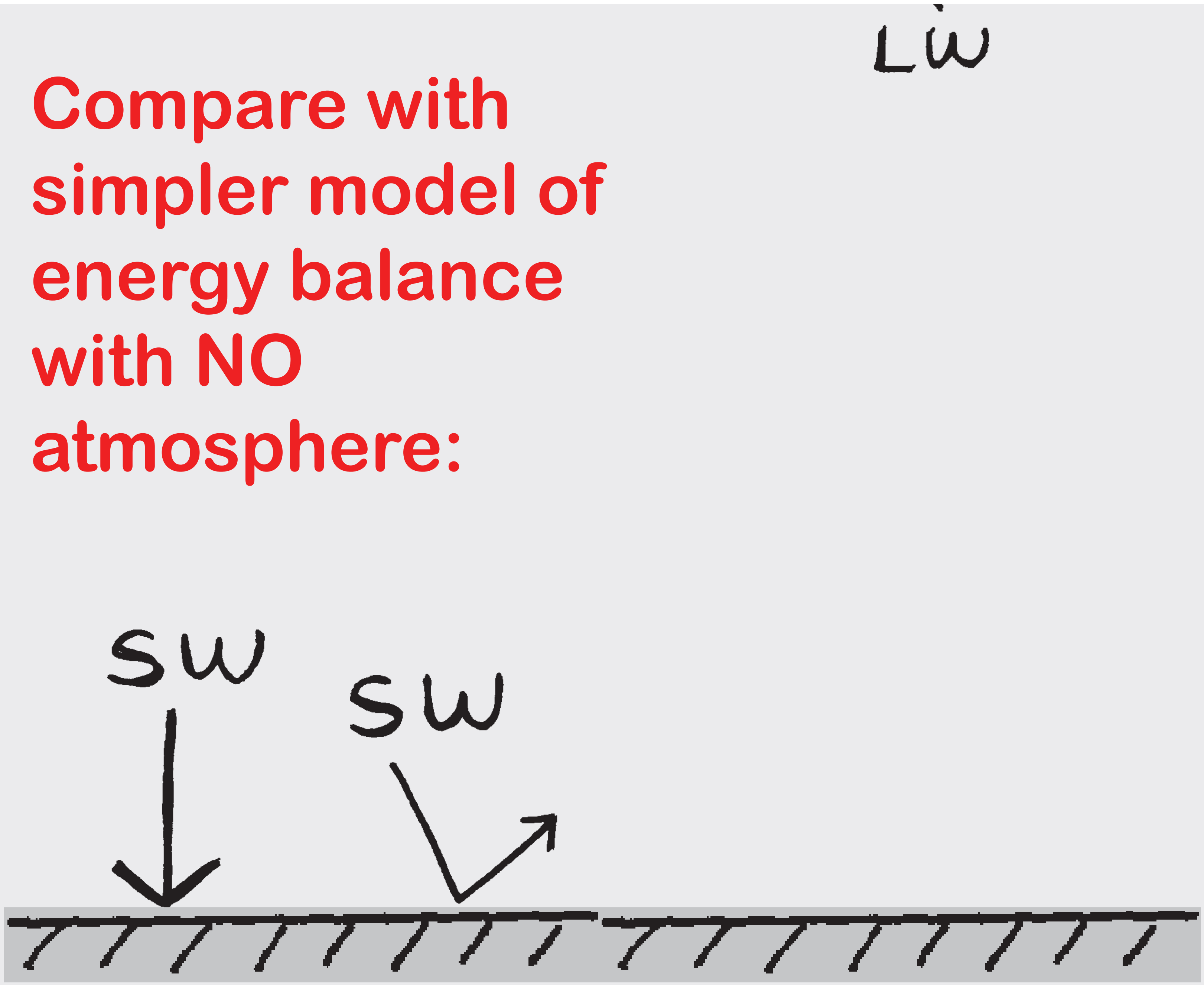


All together now:



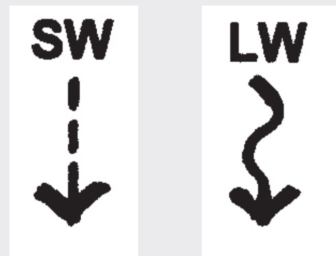
Can you sketch all the pathways in yourself? p 124

Compare with simpler model of energy balance with NO atmosphere:



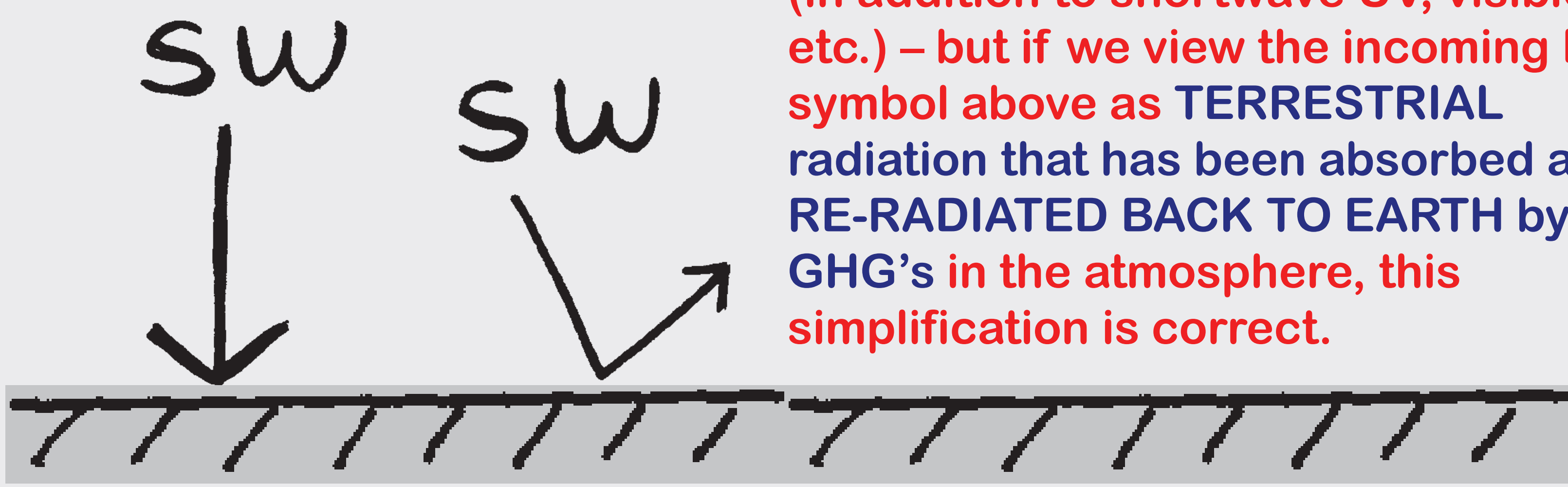
Which terms are not involved?

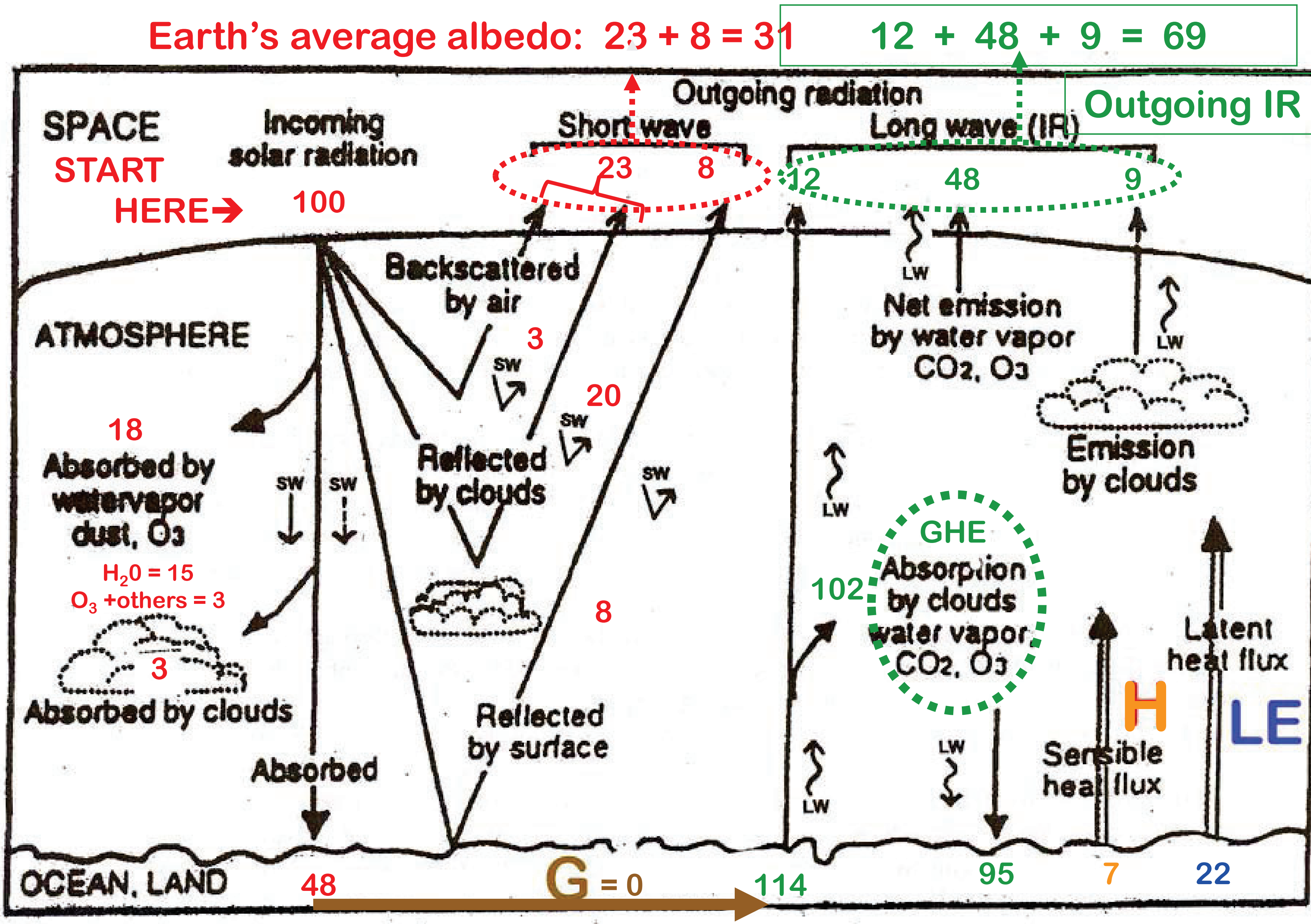
No scattering by atmosphere



No re-radiation of infrared by GHG's

NOTE: Technically, the SUN does give off incoming longwave infrared radiation (in addition to shortwave UV, visible, etc.) – but if we view the incoming LW symbol above as TERRESTRIAL radiation that has been absorbed and RE-RADIATED BACK TO EARTH by the GHG's in the atmosphere, this simplification is correct.





G + H + LE

$48 \downarrow - 114 \uparrow + 95 \downarrow = 29 \rightarrow 0 + 7 + 22 = 29 = R_{net}$

Two Energy Balance Animations

showing energy flow pathways & "units" of energy that eventually balance out:

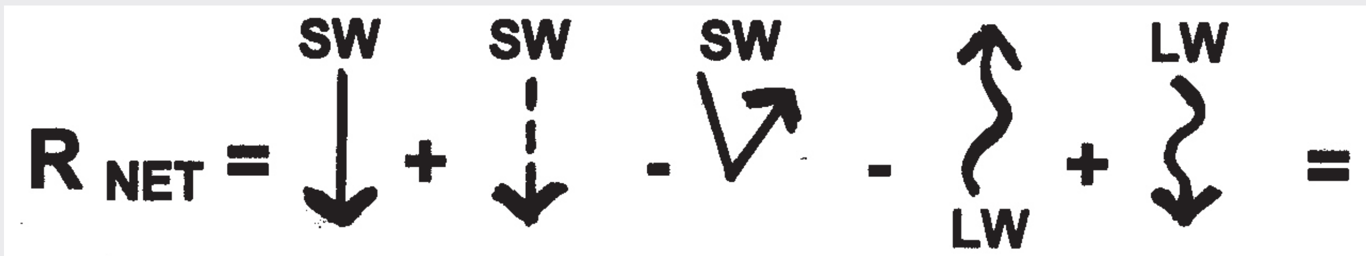
GLOBAL ENERGY BALANCE & PATHWAYS:

http://earthguide.ucsd.edu/earthguide/diagrams/energybalance/index.html

SHORTWAVE & LONGWAVE ENERGY FLOW & BUDGET:
http://mesoscale.agron.iastate.edu/agron206/animations/10_AtmoEbal.html

☺

NET RADIATION = In – Out = Whatever is left over



If some energy is "left over," it can be used to DRIVE WEATHER & CLIMATE through HEAT TRANSFER processes or it can STORED by the Earth (in the ground or ocean).

FINAL PART is:

The <u>RIGHT</u> side of the ENERGY BALANCE EQUATION . . .

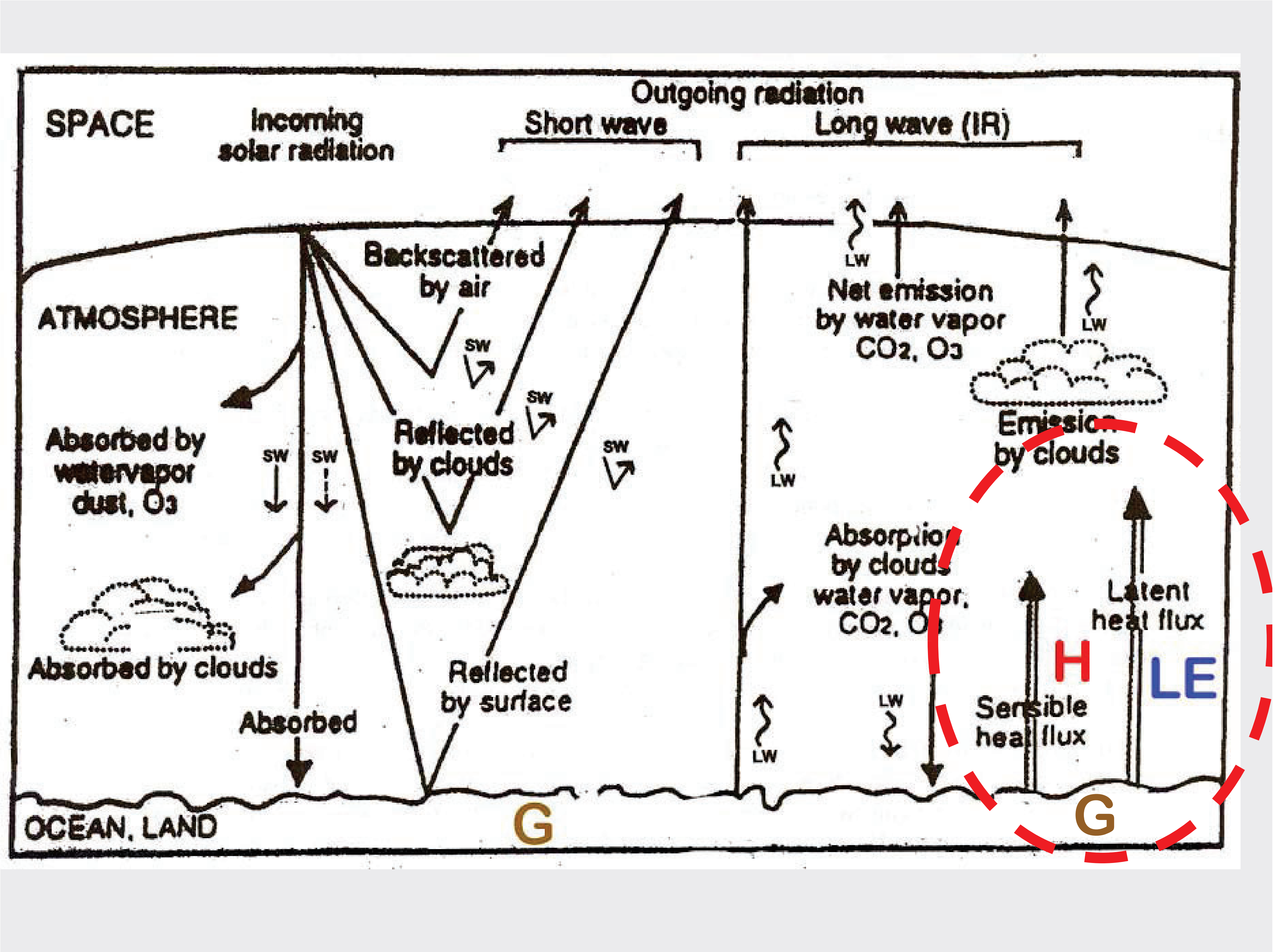
Left side of equation

$$R_{NET} = SW\downarrow + SW\downarrow - SW\nearrow - LW\uparrow + LW\downarrow = H + LE + G$$

Right side of equation

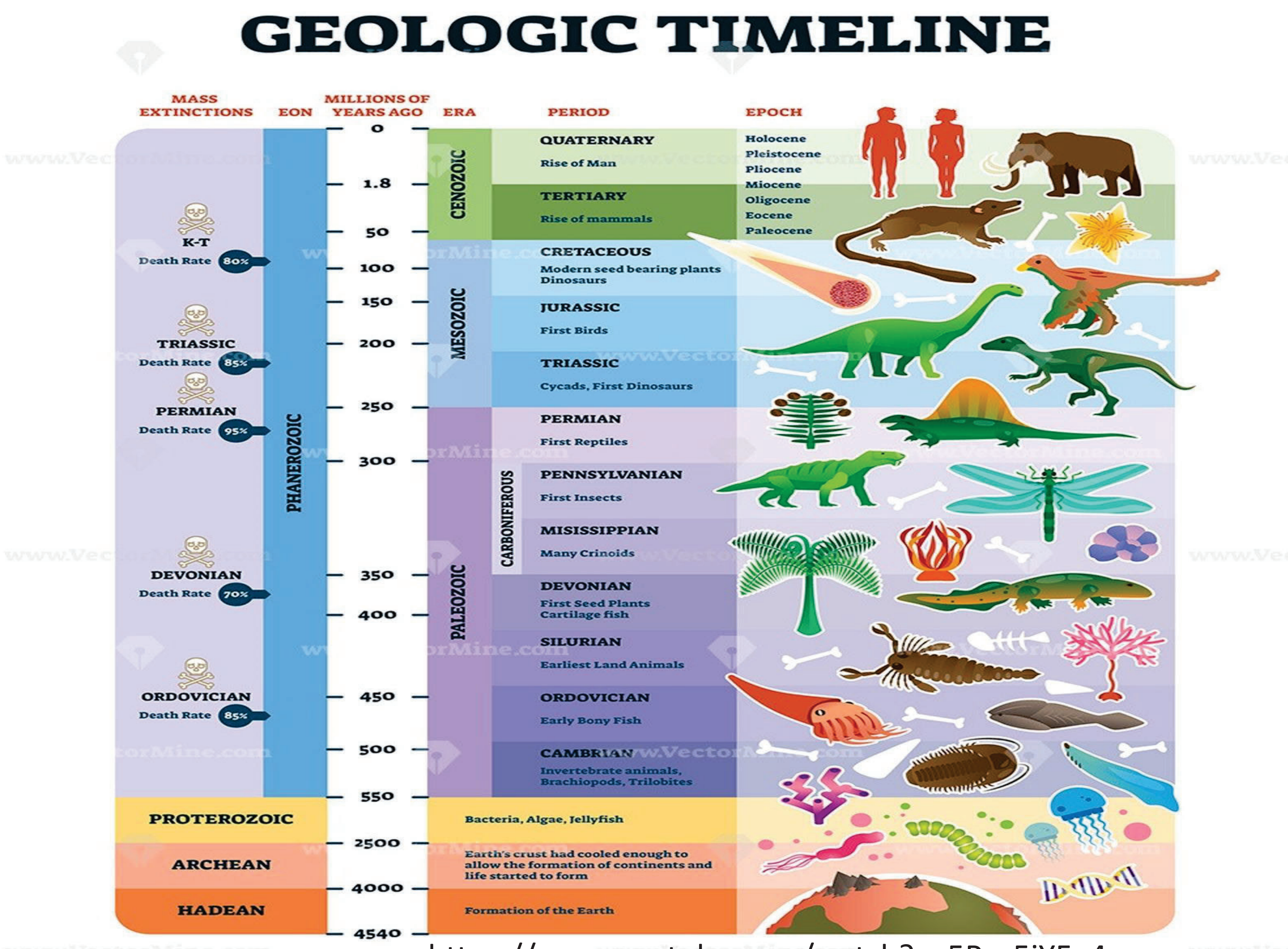
R net = "net" left over energy can be used to **DRIVE WEATHER & CLIMATE** through **<u>HEAT TRANSFER</u>** processes or it can **STORED** by the Earth (in the ground or ocean).

$$R_{NET} = H + LE + G$$



SPACE
Incoming solar radiation
Outgoing radiation
Short wave
Long wave (IR)
Backscattered by air
ATMOSPHERE
SW
LW
Net emission by water vapor CO_2, O_3
Absorbed by watervapor dust, O_3
Reflected by clouds
Emission by clouds
Absorption by clouds water vapor, CO_2, O_3
Latent heat flux
Absorbed by clouds
Reflected by surface
H
LE
Absorbed
Sensible heat flux
OCEAN, LAND
G
G

Global temperature changes



https://www.youtube.com/watch?v=5Prp5iYFu4w

Global temperature change: Highlights

- The relentless global heat continued as average surface temperature on Earth in July 2020 was the second warmest on record

- In 2019, the average temperature across global land and ocean surfaces was 0.95°C above the twentieth-century average of 13.9°C, making it the second-warmest year on record.

- The global annual temperature has increased at an average rate of 0.07°C per decade since 1880 and over twice that rate (+0.18°C) since 1981.

- The five warmest years in the 1880–2019 record have all occurred since 2015, while nine of the 10 warmest years have occurred since 2005.

- From 1900 to 1980 a new temperature record was set on average every 13.5 years. Since 1981, it has increased to every 3 years.

Conditions in 2019

According to the 2019 Global Climate Report from National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information, 2019 began with a weak-to-moderate El Niño event in the tropical Pacific Ocean. Temperatures were warmer than average across most global land and ocean areas during most of the year.

https://www.ldeo.columbia.edu/~martins/irvine/ms/sld001.htm

Effects of global warming

- **Ocean Warming**
  - Thermal expansion
  - Coastal erosion
  - Arctic erosion
  - Warmer bottom water
  - Coral die off
- **Ice loss**
  - Melting glaciers and permafrost
  - Melting ice sheets
- **Climate change**
  - Extreme temperatures
  - Drought
  - Wind events like cyclones, tornados etc.
  - Severe rainfall
- **Sea level rise**
  - Due to thermal expansion, ice loss, melting of glaciers etc.

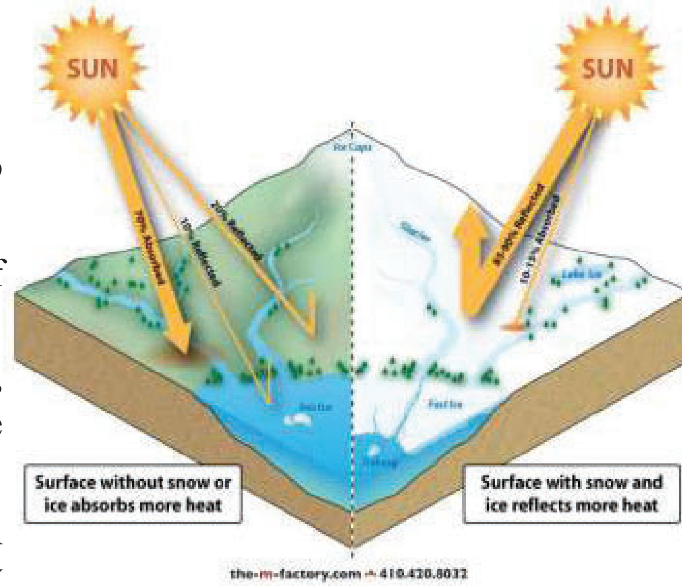
Ice melting :Global overview

Sources of melting ice

- Greenland ice sheets: 286 gt/y
- Antarctic ice sheets: 127 gt/y
- Glaciers (excluding Greenland and Antarctica ice sheets): 335 gt/y

Albedo

- A measure of how much of the Sun's energy is reflected off an object back out to space compared to how much is trapped in Earth's atmosphere.
- Snow, ice and clouds have a relatively high Albedo so generally reflect more of the Sun's energy back to space which has a cooling effect on the Earth.
- Cirrus clouds have a lower Albedo transmitting more radiation through to Earth's surface and trapping **Earth’s reflected radiation**. This increases the temperature on Earth.
- Changes in the polar regions can cause more warming in the entire planet earth system through feedback effects. One such effect is the reduction of ice and snow due to warmer temperatures.
    - When the snow and ice disappears, less sun rays are reflected out and instead the heat is absorbed by land and sea - which causes further increase in the warming.
- Change to the Earth's Albedo is a powerful driver of climate.
- When the planet's Albedo or reflectivity increases, more incoming sunlight is reflected back into space. This has a cooling effect on global temperatures. Conversely, a drop in Albedo warms the planet.



Measuring Albedo

Albedo is measured in scale from 0.0-1.0

- 1.0 being the most reflective.
  - For example an Albedo of 1.0 would be reflecting back 100% of light.
- Albedo of fresh snow is about 0.9
- 0.0 being the most absorbing surface.
  - For example and Albedo of 0.0 would be absorbing 100% of light.

Terrestrial effects

Trees: Because trees tend to have a low Albedo, removing forests would tend to increase Albedo and thereby could produce localized climate cooling. In seasonally snow-covered zones, winter Albedo of treeless areas are 10% to 50% higher than nearby forested areas because snow does not cover the trees as readily .

Snow: Snow Albedo can be as high as 0.9; this, however, is for the ideal example: fresh deep snow over a featureless landscape. If a snow covered area warms, snow tends to melt, lowering the Albedo, and leading to more snowmelt.

Water: Water reflects light very differently from typical terrestrial materials. At the scale of the wavelength of light even wavy water is always smooth so the light is reflected in a locally specular manner. Although the reflectivity of water is very low at low and medium angles of incident light, it increases tremendously at high angles of incident light such as occur on the illuminated side of the Earth near the terminator. However, waviness causes an appreciable reduction. Since the light specularly reflected from water does not usually reach the viewer, water is usually considered to have a very low Albedo in spite of its high reflectivity at high angles of incident light.

Clouds: Cloud Albedo is an important factor in the global warming effect. Different types of clouds exhibit different reflectivity. Albedo and climate in some areas are affected by artificial clouds, such as those created by the contrails of heavy commercial airliner.

Impacts

- Much of the sunlight reflects back when it reaches the earth surface, if it's not reflected then its absorbed, and that's why the temperature increases
- This melts the ice and increases the global temperature to a few degrees, when ice melts, it can cause flooding in some areas.
- Exposed water or exposed land is darker in colour and it absorbs more energy from the sun. When the ice melts, more land is exposed, this absorbs more heat, melting more ice.
- The snow and ice play a important role. Without them the sunlight will not reflect back and temperature will rise causing global warming due to an imbalance of light being reflected and absorbed.

Irreversible changes

- Human influence on the climate system is confirmed.
- Recent anthropogenic emissions of Green house gases are the highest in history.
- Recent climate changes have had widespread impacts on the ecosystems.

Observations

- Atmosphere and ocean have warmed
- Snow and ice amounts have reduced
- Sea level has risen
- Ocean pH has decreased by 0.1

Risk and impacts

- Continued emission of greenhouse gases will cause further warming and long-lasting changes in all components of the climate system.
- It will increase the likelihood of severe, pervasive and irreversible impacts for people and ecosystems.
- All emission scenarios project increase in surface temperature causing more and longer lasting heat waves
- Extreme precipitation events will become more intense and frequent in many regions
- The ocean will continue to warm and acidify
- Global mean sea level to rise.

Sea level rise and its impact

- Sea-level rise due to global warming occurs primarily because **water expands as it warms up**.
- The melting ice caps and mountain glaciers also add water to the oceans, thus rising the sea level.
- The contribution from large ice masses in Greenland and Antarctica is expected to be small over the coming decades. But it may become larger in future centuries.
- Sea-level rise can be offset up by irrigation, the storage of water in reservoirs, and other land management practices that reduce run-off of water into the oceans.
- Changes in land-levels due to coastal subsidence or geological movements can also affect local sea-levels.

Sea level rise: Highlights

- Sea level has risen 8–9 inches (21–24 centimetres) since 1880.
- In 2019, global sea level was 3.4 inches (87.61 mm) above the 1993 average—the highest annual average in the satellite record (1993-present). This is an increase of 0.24 inches (6.1 mm) from 2018.
- The rate of sea level rise is accelerating: it has more than doubled from 0.06 inches (1.4 millimetres) per year throughout most of the twentieth century to 0.14 inches (3.6 millimetres) per year from 2006–2015.
- In many locations along the U.S. coastline, high-tide flooding is now 300% to more than 900% more frequent than it was 50 years ago.
- Even if the world follows a low greenhouse gas pathway, global sea level will likely rise at least 12 inches (0.3 meters) above 2000 levels by 2100.
- If we follow a pathway with high emissions, a worst-case scenario of as much as 8.2 feet (2.5 meters) above 2000 levels by 2100 cannot be ruled out.

OCEAN ACIDIFICATION

- As carbon dioxide (CO_2) dissolves in sea water, it forms **carbonic acid**, decreasing the ocean's pH, a process collectively known as ocean acidification.
- Present ocean acidification occurs approximately **ten times** faster than anything experienced during the last 300 million years, jeopardising the ability of ocean systems to adapt to changes in ocean chemistry due to CO_2.
- Ocean acidification has the potential to **change marine ecosystems** and impact many ocean-related benefits to society such as coastal protection or provision of **food and income**.
- Increased ocean **temperatures and oxygen loss** act concurrently with ocean acidification and constitute the 'deadly trio' of climate change pressures on the marine environment.
- To combat the worst effects of the deadly trio, CO_2 emissions need to be cut significantly and immediately at the source.
- Sustainable management, conservation, restoration and strong, permanent protection of at least 30% of the ocean are urgently needed.

What is the issue ?

Ocean acidification is a direct consequence of increased human-induced carbon dioxide (CO_2) concentrations in the atmosphere. The ocean absorbs over 25% of all anthropogenic emissions from the atmosphere each year. As CO_2 dissolves in sea water it forms carbonic acid, thereby decreasing the ocean's pH, leading to a suite of changes collectively known as ocean acidification. Ocean acidification is happening in parallel with other climate-related stressors, including ocean warming and deoxygenation. This completes the set of climate change pressures on the marine environment – **heat, acidity and oxygen loss** – often referred to as the 'deadly trio'. Interaction between these stressors is often cumulative or even multiplicative, resulting in combined effects that are more severe than the sum of their individual impacts.

Why is it important ?

Present ocean acidity change is unprecedented in magnitude, occurring at a rate approximately **ten times faster** than anything experienced during the last 300 million years. This rapid timeline is jeopardising the ability of ocean systems to adapt to changes in CO_2 – a process that naturally occurs over millennia. Changes in ocean pH levels will persist as long as concentrations of atmospheric CO_2 continue to rise. To avoid significant harm, atmospheric concentrations of CO_2 need to get back to at least the 320-350 ppm range of CO_2 in the atmosphere.

Compared to other similar events in Earth's history, ocean acidification, over hundreds of years, has been happening very fast. However, its **recovery has been very slow** due to the inherent time lags in the carbon and ocean cycles.

Ocean acidification has the potential to change marine ecosystems and impact many ocean-related benefits to society such as coastal protection or provision of food and income. Although more knowledge on the impacts of ocean acidification on marine life is needed, changes in many ecosystems and the services they provide to society can be extrapolated from current understanding. Some of the strongest evidence of the potential effects of ocean acidification on marine ecosystems stems from experiments on calcifying organisms.

Increased sea water acidity has been demonstrated to affect the formation and dissolution of calcium **carbonate shells and skeletons** in a range of marine species, including corals, molluscs such as oysters and mussels, and many phytoplankton and zooplankton species that form the base of marine food webs.

Changes in **species growth and reproduction**, as well as structural and functional alterations in ecosystems, will threaten **food security, harm fishing** industries and decrease natural shoreline protection. They will also increase the risk of inundation and erosion in low-lying areas, thereby hampering climate change adaptation and disaster risk reduction efforts.

Increased ocean temperatures are likely to have direct effects on the physiology of marine organisms and influence the geographical distribution of species. Some species such as reef-forming corals, already living at their upper tolerance level, will have more difficulties ‘moving’ fast enough to new areas. Drastic changes in ocean temperature can also lead to coral bleaching events, where corals expel the symbiotic algae living in their tissues, causing them to turn completely white. The role of coral reefs in buffering coastal communities from storm waves and erosion, and in supporting income generation (fisheries and tourism) for local communities and commercial businesses, is jeopardised. The potential recovery of such bleaching events is hampered due to the declining calcification rates on reefs caused by ocean acidification.

What can be done?

The long time lags inherent in the marine carbon cycle put an added penalty on delaying **limits on CO_2 emissions** and a premium on early action if the worst damages associated with ocean acidification are to be avoided. While climate change is the consequence of a range of greenhouse gas (GHG) emissions, ocean acidification is primarily caused by increased concentrations of atmospheric CO_2 dissolved in sea water. It becomes evident, however, that the objective of the United Nations Framework Convention on Climate Change (UNFCCC) to achieve 'stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system' cannot be encapsulated by a single 'one-size-fits-all' climate indicator. The current emissions targets need significant tightening if they are to tackle the issue of ocean acidification and ocean warming. Limiting the global average temperature increase to well below 2°C, rather than a lower level, will significantly harm the ocean life on which we all depend in some form or another. Scientists even suggest that a **healthy ocean needs an atmospheric carbon concentration of much less than 400 ppm**. This benchmark has recently been exceed.

Other initiatives such as the Ocean Acidification international Reference User Group (OAIRUG), composed of scientists and various stakeholders, need to be engaged as a key means of conveying scientific results. The OAIRUG examines in detail the types of data, analyses and products that are most useful to managers, policy advisers, decision makers and politicians, and ensure an appropriate format and distribution pathways.

Sustainable management, conservation and restoration of the ocean are needed. At the IUCN World Conservation Congress 2016, IUCN Members approved a resolution calling for the protection of 30% of the planet's ocean by 2030.

The Biological Impacts

Ocean acidification is expected to impact ocean species to varying degrees. **Photosynthetic algae and sea grasses may benefit from higher CO_2** conditions in the ocean, as they require CO_2 to live just like plants on land. On the other hand, studies have shown that lower environmental calcium carbonate saturation states can have a dramatic effect on some calcifying species, including oysters, clams, sea urchins, shallow water corals, deep sea corals, and calcareous plankton. **Today, more than a billion people worldwide rely on food from the ocean as their primary source of protein**. Thus, both jobs and food security in the U.S. and around the world depend on the fish and shellfish in our oceans.

Pteropods

The pteropod, or "sea butterfly", is a tiny sea creature about the size of a small pea. Pteropods are eaten by organisms ranging in size from tiny krill to whales and are a food source for North Pacific juvenile salmon. The photos below show that a pteropod's shell dissolves over 45 day when placed in sea water with pH and carbonate levels projected for the year 2100.

In recent years, there have been near total failures of developing oysters in both aquaculture facilities and natural ecosystems on the West Coast. These larval oyster failures appear to be correlated with naturally occurring upwelling events that bring low pH waters undersaturated in aragonite as well as other water quality changes to nearshore environments. Lower pH values occur naturally on the West Coast during upwelling events, but a recent observations indicate that anthropogenic CO_2 is contributing to seasonal undersaturation. Low pH may be a factor in the current oyster reproductive failure; however, more research is needed to disentangle potential acidification effects from other risk factors, such as episodic freshwater inflow, pathogen increases, or low dissolved oxygen. It is premature to conclude that acidification is responsible for the recent oyster failures, but acidification is a potential factor in the current crisis to this $100 million a year industry, prompting new collaborations and accelerated research on ocean acidification and potential biological impacts.

Coral

Many marine organisms that produce calcium carbonate shells or skeletons are negatively impacted by increasing CO_2 levels and decreasing pH in seawater. For example, increasing ocean acidification has been shown to significantly reduce the ability of reef-building corals to produce their skeletons. In a recent paper, coral biologists reported that ocean acidification could compromise the successful fertilization, larval settlement and survivorship of Elkhorn coral, an endangered species. These research results suggest that ocean acidification could severely impact the ability of coral reefs to recover from disturbance. Other research indicates that, by the end of this century, coral reefs may erode faster than they can be rebuilt. This could compromise the long-term viability of these ecosystems and perhaps impact the estimated one million species that depend on coral reef habitat.

https://www.youtube.com/watch?v=6SMWGV-DBnk

https://www.youtube.com/watch?v=mQ10xBl8XMQ

PRECIPITATION PATTERN

Major types for rainfall by - Convectional rainfall – orographic rainfall – Cyclonic rainfall

There are many types of precipitation: **rain, snow, sleet, and hail,** to name a few. In this lesson we will learn about the mechanisms that produce various types of precipitation. It is important to note that the presence of clouds and their associated condensation nuclei alone do not always produce precipitation. Very specific conditions must occur in order for a cloud to produce precipitation

In order for cloud droplet to form a non-equilibrium condition, where condensation exceeds evaporation, must exist. The curvature of a cloud droplet affects its rate of evaporation. The more curved the droplet, the more evaporation that occurs. Smaller cloud droplets will evaporate quickly unless the air is *supersaturated* (the relative humidity exceeds 100%). Because of the curvature effect, air that is saturated with respect to a flat surface is unsaturated with respect to a curved cloud droplet. An ordinary cloud droplet 100 times smaller than raindrop.

Though supersaturation is required in order for cloud droplets to sustain themselves, relative humidity rarely approaches 101%, even in very wet clouds. How do cloud droplets ever grow to raindrop size? The answer lies in the *Hygroscopic* nature of certain condensation nuclei. Recall that condensation on hygroscopic particles will commence when the relative humidity is below 100%. This is known as the *solute effect.*

Consider a parcel of air unsaturated air rich with condensation nuclei. As the air cools the relative humidity increases. At some point below 100% saturation, condensation commences on the most hygroscopic of the available nuclei. These nuclei continue to grow as the air cools further and the relative humidity approaches 100%. The curvature effect becomes negligible for larger droplets but remains appreciable for smaller nuclei. The rise in relative humidity within the air mass is slowed by the fact that the larger particles begin to remove lots of water vapor from the air. Soon, the particles are removing water vapor from the air as fast as it can be replaced from external sources. At this point the relative humidity actually begins to decrease. Condensation in clouds is such an inefficient precipitation producing process that it is very unlikely to produce, by itself, precipitation in any appreciable amount. Another mechanism is clearly responsible for producing precipitation from clouds. Two additional mechanisms are responsible for producing precipitation from clouds the *collision-coalescence process,* and the *ice-crystal process.*

The collision-coalescence process occurs in warm clouds. As cloud droplets form within clouds they become electrically charged. The cloud droplets grow larger by sticking to each other in the aftermath of collisions due to electrical attraction. As time passes the droplets grow larger and larger. Updrafts help keep the droplets suspended in the cloud longer. If the cloud is thick the droplets will also stay suspended longer. Finally, the droplets will grow large enough that they can no longer remain suspended and will begin to fall. As soon as they leave the cloud base they begin to shrink due to evaporation. Raindrops that reach the ground are smaller than those leaving the base of the cloud.

The ice-crystal process occurs in colder clouds that exist mainly in the middle to high-Iatitudes. Even in these extremely cold clouds there are liquid water droplets (existing well below freezing). These are referred to as *supercooled* water droplets. The temperature of a cloud, in fact, must exceed -4O°C in order for it to consist entirely of ice crystals. Such clouds are referred to *glaciated.*

When the temperature drops low enough within a cloud, large numbers of water molecules begin to bond in a rigid form within supercooled liquid water droplets. This leads to the formation of *ice embryos,* i.e., small ice crystals in the center of supercooled water droplets The water molecules must have very low rms speeds in order for ice embryos to remain intact since even slight thermal motions disrupt them. Even colder temperatures enable the crystal to become a *freezing nucleus*. The presence of these ice embryos enhances the freezing process. The presence of *ice nuclei* also enhance the freezing process. Ice nuclei may be clay (kaolinite), biological material, or anything that looks like an ice crystal. *Contact freezing* is another important method by which ice crystals to form in a cloud, involving collisions between ice nuclei (freezing nuclei) and supercooled droplets.

As we have seen, when precipitation first begins to fall it is usually in a frozen state. Often precipitation begins in the form of either *graupel* or *snowflakes.* Snowflakes are an aggregation of ice crystals. Much precipitation falling at middle latitudes, even in mid-summer, falls as snow flakes in the beginning. Graupel is formed by collisions between supercooled cloud droplets and ice crystals.

In a precipitation theory known as the *Bergeron Process* all raindrops begin as ice crystals. When the ratio of ice crystals to water droplets in clouds is on the order of 1:100,000, conditions are right for precipitation to begin. When there are too few ice crystals, the existing crystals grow large and fall out of the cloud, leaving it unaffected. When there are too many crystals, a cloud of ice crystals is formed, and no precipitation occurs because the individual crystals are all too small to fall to the ground.

Cloud seeding is an important process used quite often in the winter to create precipitation. The object is to find clouds that are deficient with ice crystals and inject artificial ice nuclei to produce the ratio of 1:100,000. (Silver iodide is usually the artificial ice nuclei used because it resembles an ice crystal so well.) A cold cloud is needed for this to work effectively.

Drizzle is a liquid drop with diameter **less than 0.5mm**. Virga is precipitation that doesn't reach the ground. If updrafts in a cloud change to downdrafts rainfall amount may increase to a shower. If a shower is excessively heavy it is referred to as a cloudburst.

Rain is liquid drop precipitation with diameter greater than or equal **to 0.5mm.**

Snow consists of **frozen ice** crystals falling to the ground. Because snow scatters light more effectively than rain one may easily observe where snow changes to rain below a cloud (above the freezing line is darker). If, however, one looks directly up into the precipitation from below the snow appears lighter because it scatters light in all directions below the cloud. As a result the bottom of a rain cloud appears much darker than a cloud with snow in it.

Fallstreaks are a virgalike phenomenon consisting of snow rather than rain.

Flurries are brief snow showers, typically from cumuliform clouds. A *snow squall* is a more intense snow shower, essentially the equivalent of a cloudburst. Continuous snowfall is associated with nimbostratus and altostratus clouds. A *blizzard* is a snowstorm accompanied by low temperatures, strong winds, blowing and drifting snow.

Sleet is melted snow that re-freezes into a tiny ice pellet. *Freezing rain* occurs when raindrops fall through a freezing layer that supercools them and subsequently freeze on contact with the ground.

Freezing drizzle is freezing rain with drop diameters less than 0.5mm. *Rime* is an accumulation of small, supercooled cloud droplets that are milky and granular in appearance. *Snow grains* and *snow pellets* are the solid equivalent to drizzle. Snow grains have a diameter of less than l mm and stick upon hitting a surface, while snow pellets have diameters of greater than 5mm and bounce upon hitting a surface.

Hail is produced when **large, frozen raindrops**, graupel, etc. act as accretion nuclei. In order for a hailstone to form, the accretion nuclei must remain in a cloud a long time and thus travel a large distance within the cloud. This process is facilitated by strong updrafts of the type common within cumulonimbus clouds. Hail is most often associated with such clouds and is therefore more common during the spring and summer than in winter. *Hailstreaks* are long narrow bands of land struck by hail as the precipitating cloud moves along.

About 80 per cent of the precipitation that falls on Idaho each year is in the form of snow. It takes about one foot of snow to make one inch of water when it melts. Since water is Idaho's single most important resource a system has been developed to measure snow depths in the mountains of Idaho. This system almost guarantees that water will be used efficiently, and that it will be well conserved so that everyone will have enough water each year. We all rely on the water that falls on our state each year, not just the farmers who use it for irrigation. We also use water for power, to fish in, and to help wildlife survive. Idaho's industries need water to operate and you and I need it to drink, to bathe in, to do our dishes and to water our lawns. In addition to water supply, precipitation plays a significant role in shaping the landscape around us.

The state precipitation map at left underscores the greatest natural deficiency suffered by the West. The region lacks sufficient precipitation for most of the basic needs of human beings. It has been responsible for the treeless plains and, naturally, the desert. In the Snake River Valley for example there is a yearly average of only eight inches. Where the annual amount is less than fifteen inches and irrigation is not possible, dry farming and grazing are the dominant agricultural activities

The highest amount of precipitation ever recorded in Idaho was on Deadwood Summit in Valley County in the winter of 1964-65. Precipitation of 98.6 inches was recorded that year. Much of that precipitation was in the form of snow (if it takes one foot of snow to make one inch of water when it melts, imagine how much snow fell on Deadwood Summit that winter).

Just 75 miles to the east of Deadwood Summit, Challis has the lowest average yearly precipitation in Idaho, just 7.09 inches. Of the larger cities and towns in Idaho, Boise has an average precipitation of less than 12 inches and Wallace in Shoshone County has the heaviest annual precipitation of 41.64 inches. Snow depths vary widely throughout the state, ranging from skiffs in the lower dry areas to very deep in the central mountains.

FLOODS

FUNDAMENTAL CONCEPT

Floods are always newsworthy whether it is a locality or a town isolated by swirling waters or a major disaster attracting attention of whole world.

Although man has been responding to flood since time unknown and is also leaving in the process much more is to be understood by the hydrologists, engineers, policy makers, farmers and town planners and above all by ***common people***. Therefore, it is necessary to understand the phenomenon of flood.

MEANING, DEFINITION & TYPES

The word *"flood"* comes from the Old English flod, a word common to Germanic languages. Deluge myths are mythical stories of a great flood sent by a deity or deities to destroy civilization as an act of divine retribution, and they are featured in the mythology of many cultures.

The *European Union (EU)* Floods Directive defines a flood as a covering by water of land not normally covered by water.

Thus, flood is a state of high water level along a river channel or on the coast that leads to inundation of land, which is not usually submerged. Floods may happen gradually and also may take hours or even happen suddenly without any warning due to breach in the embankment, spill over, heavy rains etc.

TYPES OF FLOODS

i. Areal Floods

The floods that happen on flat or low-lying areas when water is supplied by rainfall or snowmelt more rapidly than it can either infiltrate or run off. Areal flooding begins in flat areas like floodplains and in local depressions not connected to a stream channel, because the velocity of overland flow depends on the *surface slope*.

Fig. Areal Floods

ii. Flash Floods

Fig. Flash Floods

The floods are generally the events of hill areas where *sudden heavy rain* over the limited area can cause a strong flow. Flash floods also occur when a temporary blockage in hilly areas impounds water which when released suddenly creates havoc.

iii. River Floods

The floods occur due to *heavy inflow* of water from heavy rainfall, snowmelt and short intense storms.

Fig. River Floods

iv. Coastal Floods

Fig.Coastal Floods

The floods are caused due to heavy rainfall from cyclones or due to tsunamis.

v. Urban Floods

Urban flooding is the inundation of land or property in a built environment, particularly in more densely populated areas, caused by rainfall overwhelming the capacity of *drainage systems*, such as storm sewers.

Fig.Urban Floods

vi. Catastrophic Floods

Catastrophic riverine flooding is usually associated with major *infrastructure failures* such as the collapse of a dam, but they may also be caused by drainage channel modification from a landslide, earthquake or volcanic eruption.

CAUSES OF FLOODS

There are several causes of floods and differ from region to region. The causes may vary from a rural area to an urban area. Some of the major causes are:

Heavy rainfall: It is the primary cause for floods in India. Especially, rainfall in a short span of time is of much concern as they are leading to flash floods. For instance, in July 2017, Mount Abu received the heaviest rainfall in over 300 years in a span of 24 hours. The hill station received an unprecedented 700 mm of rain in 24 hours. As per a study instituted by the United Nations, climate change phenomenon is believed to be behind flash floods across the globe.

Siltation of the Rivers: Heavy siltation of the river bed reduces the water carrying capacity of the rivers and streams leading to flooding. For instance, as a result of siltation, the Brahmaputra has been expanding – ranging from 2 km to 14 km – leading to frequent flooding in the North East region.

Blockage in the Drains: Blocked drains are the primary cause for the floods in urban areas, especially in metros. For instance, failure of the drainage system is believed to be one of the primary causes behind the Chennai floods in December 2015 that led to the death of more than 400 people.

Landslides: They are the major reason behind floods in hilly areas of the north and northeast. For instance, in June 2013, landslides caused a blockage of flow of streams and rivers in Uttarakhand and caused major floods, causing 5748 deaths.
Apart from the above reasons, natural hazards like cyclones and earthquakes and encroachments of river banks and water bodies cause flooding.

Impact of recurrent floods

The most important consequence of floods is the loss of life and property. Structures like houses, bridges and roads get damaged by the gushing water. Some of the negative impacts of recurrent floods are given below –

Impact on Agriculture: Recurrent floods impact the agriculture sector adversely. Due to recurrent floods, fields get submerged and lead to the loss of harvest increasing the vulnerability of farmers to indebtedness. The loss is not only for the farming community but also the common man is hit hardly due to persistent inflation. Besides, the threat to life of milch animals impact the farming community adversely.

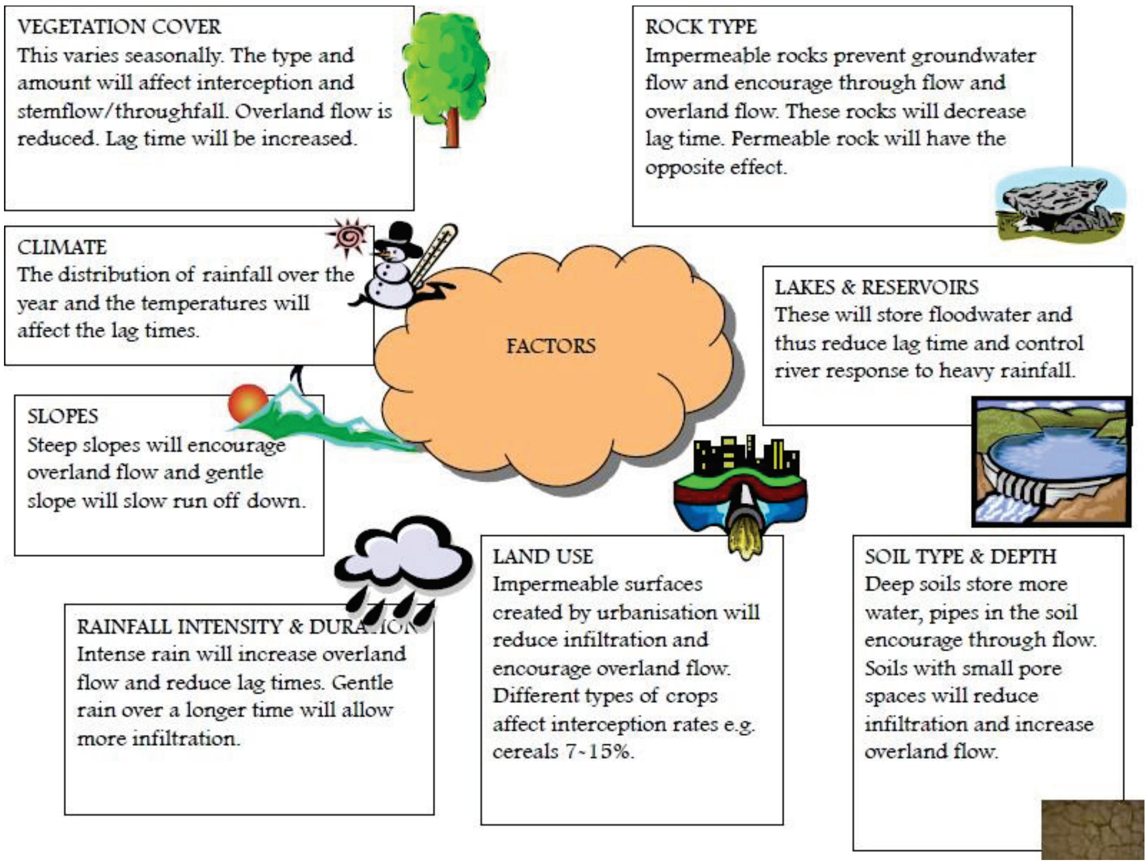
Moreover, floods may also affect the soil characteristics. The land may be rendered infertile due to erosion of top-layer.

Damage to infrastructure: Recurrent floods cause severe damage to economic infrastructure like transportation networks, electricity generation and distribution equipment, etc.

Outbreak of diseases: Lack of proper drinking water facilities, contamination of water (well, ground water, piped water supply) leads to out break of epidemics like diarrhoea, viral infection, malaria and many other infectious diseases. The probability of outbreak of diseases in highly densed areas of India is high.

Besides the above, strain on the administration, cost of rescue and rehabilitation of the flood affected population are other causes of concern.

FACTORS RESPONSIBLE FOR FLOODS



1.2 IMPACTS OF FLOODS

- Human Loss
- Property Loss
- Affects the Major Roads
- Disruption of Air / Train / Bus services
- Spread of Water-borne Communicable Diseases
- Communication Breakdown
- Electricity Supply Cut off

- ➢ Economic and Social Disruption
- ➢ Increase in Air / Water Pollution

FLOODS IN INDIA

FLOODS PRONE AREA IN INDIA

Fig. Major flood prone areas in India

- Floods cause damage to houses, industries, public utilities and property resulting in huge economic losses, apart from loss of lives.
- Though it is not possible to control the flood disaster totally, by adopting suitable structural and non-structural measures the flood damages can be minimised.

VULNERABILITY TREND

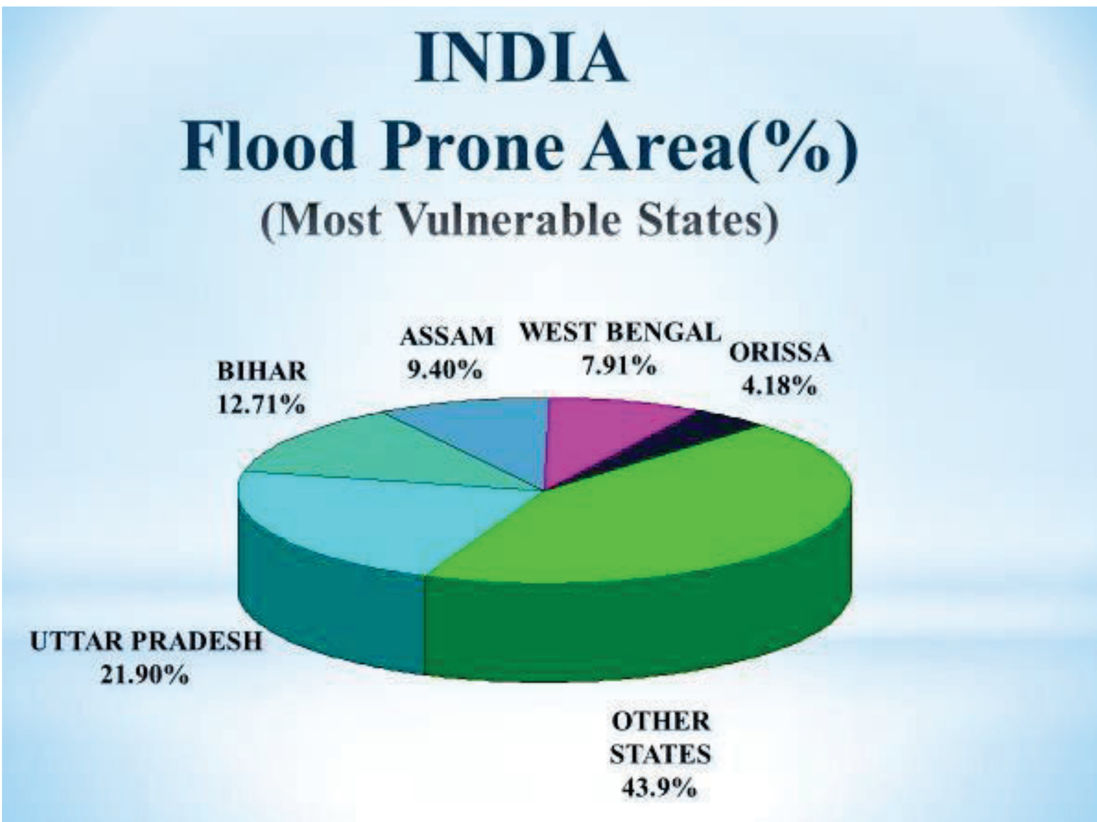


Fig.State wise vulnerability trend in India

MAJOR FLOODS IN INDIA

1. Bihar floods, 1987

- Bihar floods in 1987 remain one of the deadliest to have been seen in India since independence.
- In one of the worst floods in Bihar, 1,399 people and 5,302 animals lost their lives, and nearly 29 million people were affected in 30 districts, 382 blocks, 6,112 panchayats, and 24,518 villages.
- The damage to crops was calculated to be 68 billion Indian rupees and damage to public property was at 68 million rupees.

2. Gujarat floods, 2005

- Gujarat flood accounted for a loss of more than 8,000 crore rupees.
- The floods also caused a great financial and economic loss to the nation.
- More than 123 deaths were recorded and a total of 2,50,000 people were evacuated.
- The day is referred to as a 'BLACK DAY' in Indian History.

3. Maharashtra floods, 2005

- In the Maharashtra floods, approximately 1,094 people died.
- It occurred just one month after the June 2005 Gujarat floods.

- 52 local trains, 37,000 autos, 4,000 taxis, 900 'BEST' buses and 10,000 trucks were either damaged or spoiled.
- The financial cost was calculated to be 550 core rupees.

4. Assam floods, 2012

- The worst floods since the year 1998, Assam floods took the lives of more than 120 people.
- The flood also affected 1,744 villages across nine districts and 70,000 hectares of cropland.
- It was reported that more than five million people were evacuated.
- Flooding significantly affected Kaziranga National Park, where about 540 animals died.

4. Uttarakhand floods, 2013

- In the Uttarakhand floods, the destruction of bridges and roads left about 1,00,000 pilgrims and tourists trapped.
- The Indian Air Force, the Indian Army, and paramilitary troops evacuated more than 1,10,000 people from the flood-hit areas.
- More than 5,000 people were presumed dead.

6. Jammu & Kashmir floods, 2014

- Caused by torrential rainfall, in September 2014, the Kashmir region suffered disastrous floods across many of its districts.

- According to the Home Ministry of India, 2,600 villages were reported to be affected in Jammu and Kashmir -- out of which 390 villages in Kashmir were completely submerged.

Droughts:

Everything needs water. Even when we don't need water, humans tend to use much more water than is necessary on a daily basis. This is why a water shortage is so difficult for us.

Obviously, the drought will impact the agriculture industry. In order to save his crops, the farmer may have to spend money on new irrigation plans. Since he's now paying more money to provide the crops, he will have to charge more for the produce to make a profit. As a result, the public will have to pay more for food. Some foods will also become "scarce"— meaning the cost of goods will rise.

There will also need to be water outages in order to preserve water. Sometimes, public places like schools, offices and restaurants will have to close when they don't have water, which can affect the country's productivity.

During droughts, there may also be an increase in the number of forest fires or bush fires because of the dry conditions.

There are some other issues which result from droughts:

- Affects education since schools have to be closed if there's no water
- Reduces fire fighting capability and also, there's now a risk to public safety from fires or any other accident that requires large volumes of water immediately.
- High food -cost foods cause dietary deficiencies

Potential for conflicts (Water user conflicts, Political conflicts, Management conflicts)

Unit 3

S1: climate change impacts on different sectors

sectors affected by climate change

- Agriculture
- Forestry
- Ecosystem
- Water resources
- Human health
- Industry
- Settlement/Infrastructure
- Society

Intro

- **Economy** is heavily dependent on climate sensitive sectors such as agriculture, fisheries, tourism, forest sector, etc..
- Some of the expected impacts are: Agriculture: Based on a 20-year baseline climate observation, it is projected that yields of maize and other cereal crop will reduce by 7% by 2050.

We are already seeing the economic impacts of the changing climate. According to Morgan Stanley, climate disasters have cost North America $415 billion in the last three years, much of that due to wildfires and hurricanes.

Flooding in Southeast Texas from Hurricane

high tide flooding in coastal area

Agriculture

- Climate change and climate variability are projected to have a substantial effect on **agricultural** production both in terms of crop yields and the location where different crops can be grown.
- Increases in temperature and carbon dioxide (CO_2) can alter crop yield
- Warmer temperatures may make many crops grow more quickly, but warmer temperatures could also reduce yields.

- More extreme temperature and precipitation can prevent crops from growing.
- Many weeds, pests and fungi thrive under warmer temperatures, wetter climates, and increased CO2 levels.
- Changes in the frequency and severity of droughts and floods could pose challenges for farmers and ranchers.
- Overall, climate change could make it more difficult to grow crops, raise animals, and catch fish in the same ways and same places as we have done in the past.
- Affects nutrition and food security of countries affected by climate change.

Forestry

- Effects on **forestry** due to climate change include increased risk of **droughts, storms and fires (abiotic**) and **pests and diseases** (biotic) – all leading to disturbances to forest health.
- Climate influences the structure and function of forest ecosystems and plays an essential role in forest health.

- Climate changes directly and indirectly affect the growth and productivity of forests: directly due to changes in atmospheric carbon dioxide and climate and indirectly through complex interactions in forest ecosystems.
- Warming temperatures could increase the length of the growing season. However, warming could also shift the geographic RANGES of some tree species.

https://www.youtube.com/watch?v=G4H1N_yXBiA

Fishery

- There is strong global evidence for these effects. Rising ocean temperatures and ocean acidification are radically altering marine aquatic ecosystems, while freshwater ecosystems are being impacted by changes in water temperature, water flow, and fish habitat loss.
- Climate change is modifying fish distribution and the productivity of marine and freshwater species.

- while changing rainfall patterns and water use impact on inland **freshwater fisheries** and aquaculture.
- The rising ocean acidity makes it more difficult for marine organisms such as shrimp, oysters, or corals to form their shells – a process known as calcification.
- Many important animals, such as zooplankton, that forms the base of the marine food chain have calcium shells. Thus the entire marine food web is being altered – there are ‘cracks in the food chain’.
- As a result, the distribution, productivity, and species composition of global fish production is changing.

- Fisheries and aquaculture contribute significantly to food security and livelihoods.
- Low-lying countries such as the Maldives are particularly vulnerable and entire fishing communities may become the first climate refugees.
- The impacts of climate change can be addressed through adaptation and mitigation. The costs and benefits of adaptation are essentially local or national, while the costs of mitigation are essentially national whereas the benefits are global.

- Nobel Prize-winning economist Joseph Stiglitz, a professor at Columbia University, wrote :

"We will pay for climate breakdown one way or another, so it makes sense to spend the money now to reduce emissions rather than wait until later to pay a lot more for the consequences…

It's a cliché, but it's true: An ounce of prevention is worth a pound of cure."

https://www.youtube.com/watch?v=390Ar_KtlW0

Unit 3

Climate change impact in various sector

S3 & S4

-SMK

Unit 3 - Climate change impact in various sector

S3

- Socio economic impact – tourism
- Industries and business

S4

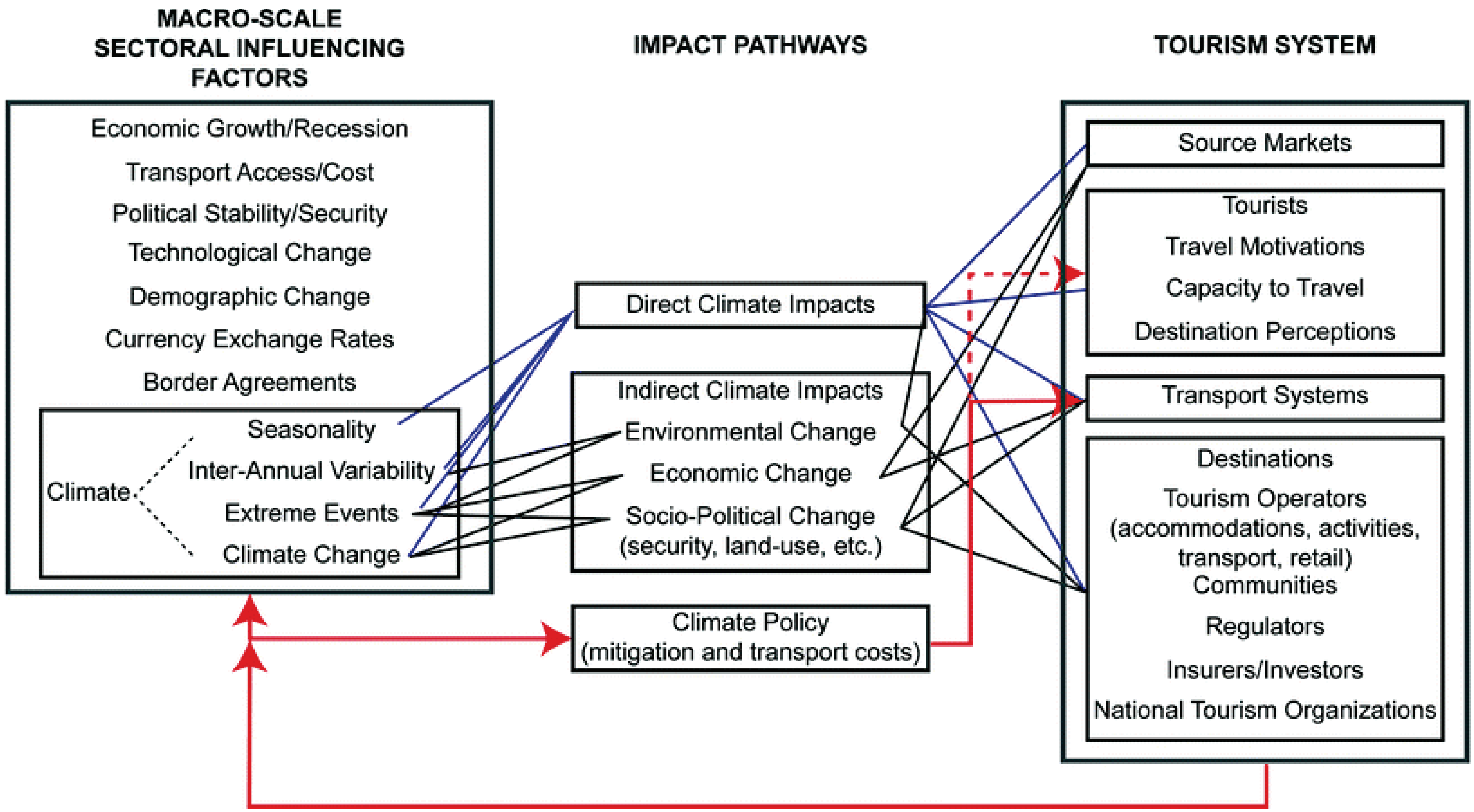
- Acid rain and human health impact
- Sea surface temperature increases and aquatic organisms impact

Unit 3 Climate change impact in various sector

– S3.1

SOCIO ECONOMIC IMPACT – TOURISM

Socio economic impact – tourism



Impact of Climate Change on Tourism

- The tourism sector depends heavily on a **natural and cultural** heritage.
- The tourism sector is highly **climate sensitive** as climate defines the length and quality of tourism seasons, affects tourism operations, and influences environmental conditions that both attract and deter visitors.
- Tourists will quickly switch their choice of destination when the results of climate change impact on their enjoyment.
- Generating more than USD 6 trillion in revenue each year and providing livelihoods to more than 255 million people, the tourism sector is particularly important for some of the world's poorest countries.

Impact of Climate Change on Tourism Subsectors at risk include:

- Mountain and Snow tourism
- Forest and Lake tourism
- Biodiversity and Agricultural tourism
- Cities and Urban Centre tourism
- Beach and Coastal tourism
- Ocean and Sea Life tourism

Impact of Climate Change on Tourism Operational level impacts will include:

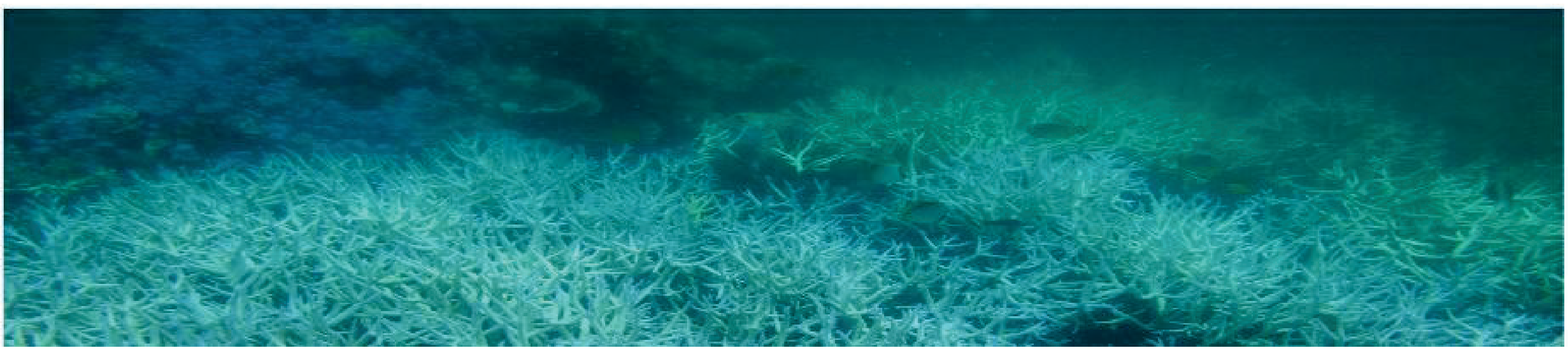
- Reduced water availability could lead to disputes with local industry and communities
- Extreme weather events will increase operational uncertainty, particularly in poorer countries
- Expensive or unavailable insurance in areas exposed to extreme weather or sea-level rise
- Efforts to cut emissions may add costs to the industry, particularly from transport emissions

Some impacts of climate change in

http://daily.bangkokbiznews.com/gallery/20111011

http://www.theatlantic.com/infocus/2011/10/bangkok-underwater/100178/#img10

http://61.19.55.253/mcrd/?p=83



Destroyed infrastructure and beaches in Thailand

Flooding beaches in Chennai

Coral reef

Impact on Society

- As a society, we have structured our day-today lives around historical and current climate conditions.
- We are accustomed to a normal RANGE of conditions and may be sensitive to extremes that fall outside of this range.

- Climate change could affect our society through impacts on a number of different social, cultural, and NATURAL RESOURCES.
- For example, climate change could affect human health, infrastructure, and transportation systems, as well as energy, food, and water supplies.

- Some groups of people will likely face greater challenges than others.
- Climate change may especially impact people who live in areas that are vulnerable to COASTAL storms, drought, and sea LEVEL rise or people who are poor.
- Some types of professions and industries may face considerable challenges from climate change.
- Professions that are closely linked to weather and climate, such as outdoor tourism and agriculture, will likely be especially affected.

- Projected climate change will affect certain groups of people more than others, depending on where they live and their ability to cope with different climate hazards.
- In some cases, the impacts of climate change would worsen EXISTING vulnerabilities.
- People who live in poverty may have a difficult time coping with changes.
- These people have limited financial resources to cope with heat, relocate or evacuate or respond to increases in the cost of food.

- Climate change may make it harder and more expensive for many people to Insure their homes, businesses, or other valuable assets in risk-prone areas.
- Insurance is one of the primary mechanisms used to PROTECT people against weather-related disasters
- Climate change will also likely affect tourism and recreational ACTIVITIES.

Unit 3 Climate change impact in various sector

– S3.2

INDUSTRIES AND BUSINESS

INDUSTRIES AND BUSINESS

- Climate change will have an impact on both industrial raw material supplies and processes.
- Although the greatest effect will most likely be via global MARKET development, climate change can have notable impacts to those industrial sectors in India whose raw materials are heavily dependent on weather and other changes in the natural environment.

- As discussed earlier most of the supplies coming from forests, agriculture and livestock would be heavily hampered due to climate change.
- This could in turn affect industries and pose a problem in procurement of raw materials.

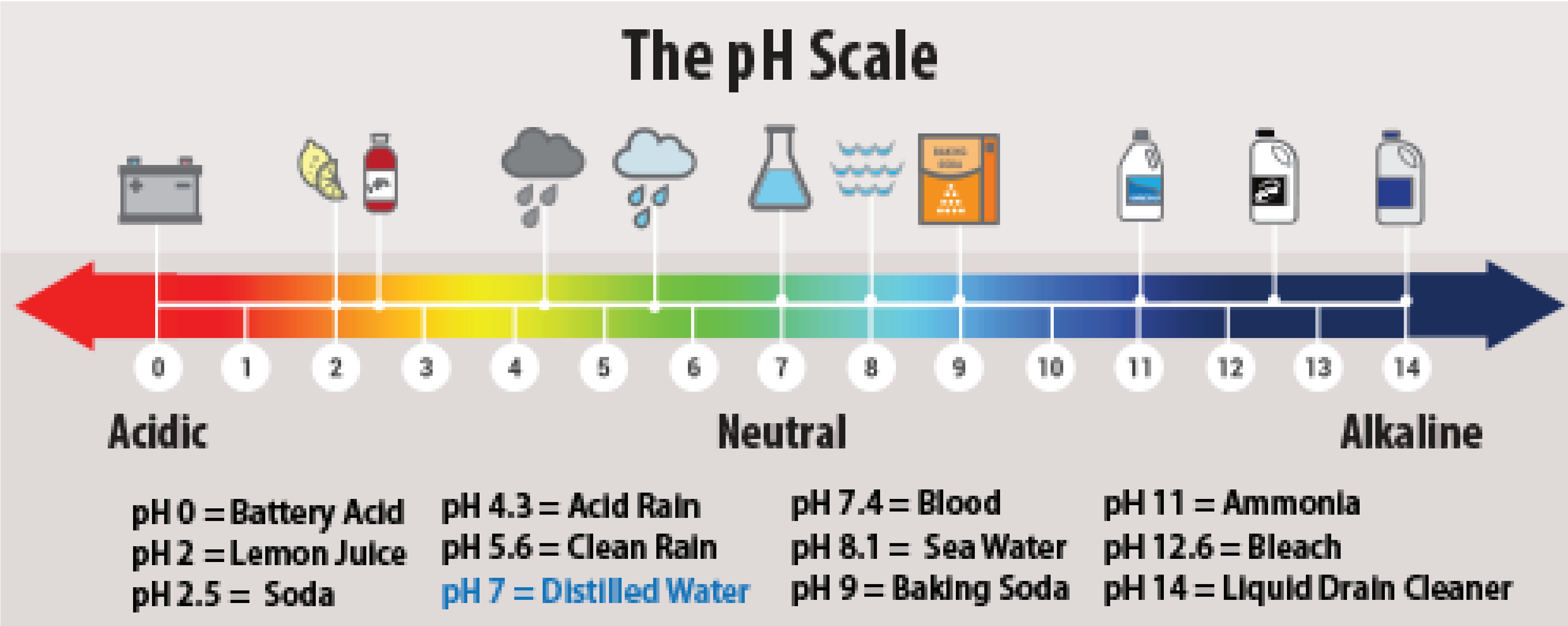
- Climate change can produce new challenges to the CONSTRUCTION industry when changing weather conditions demand the implementation of new type of construction materials and plants.
- For example, the changing damp conditions, frequency of storms and thawing of ground frost require attention.
- Basic work during the winter may become easier due to warmer weather, although rainy weather increases the risk of damage to the structures and increases drying costs.

- Climate change would severely affect the infrastructure and transportation systems hereby compromising with the logistics and supply chain of the industry.
- Changes in temperature, precipitation, sea level, and the frequency and severity of extreme events will likely affect how much energy is produced, delivered, and consumed

- Water impacts due to climate change can drastically affect the industry.
- Power plants can require large amounts of water for cooling.
- It will also increase the electricity consumption.
- Growing crops for biomass and biofuel energy could stress water resources in certain regions, depending on the type of crop, where it is grown, agricultural production in the region, and current water and nutrient management practices.

- Rising temperatures, increased evaporation, and drought may increase the need for energy-intensive methods of providing drinking and irrigation water.
- For example, desalinization plants can convert salt water into freshwater, but consume a lot of energy.

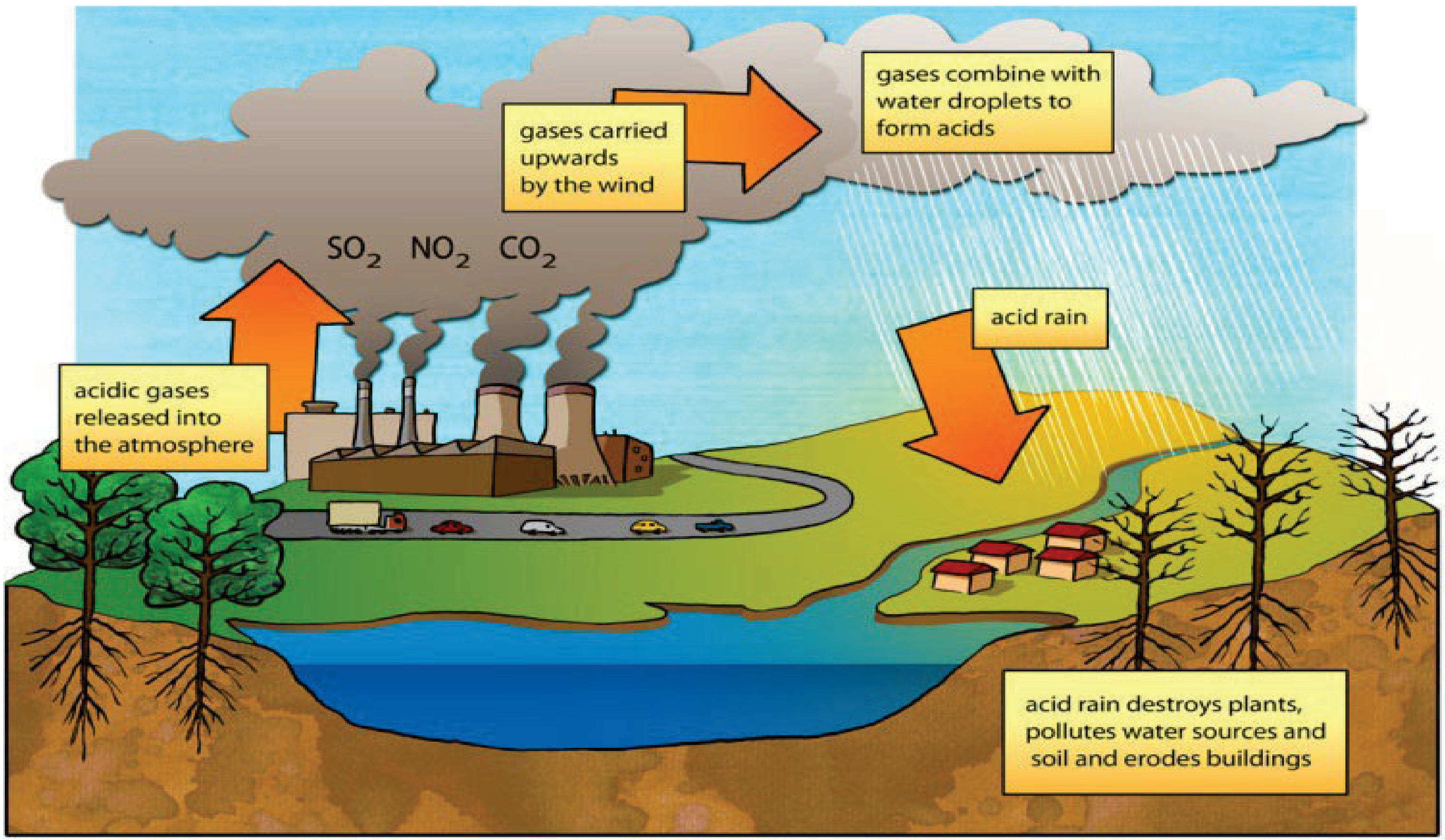
- Flooding and intense storms can damage power lines and electricity distribution equipment.
- These events may also delay repair and maintenance work.
- Electricity outages can have serious impacts on other energy systems as well.
- Climate change could impact wind and solar power, but there is little research in this area.
- Impacts will depend on how wind and cloud cover patterns change, which are very difficult to project using current climate models.



Unit 3 Climate change impact in various sector
– S4.1

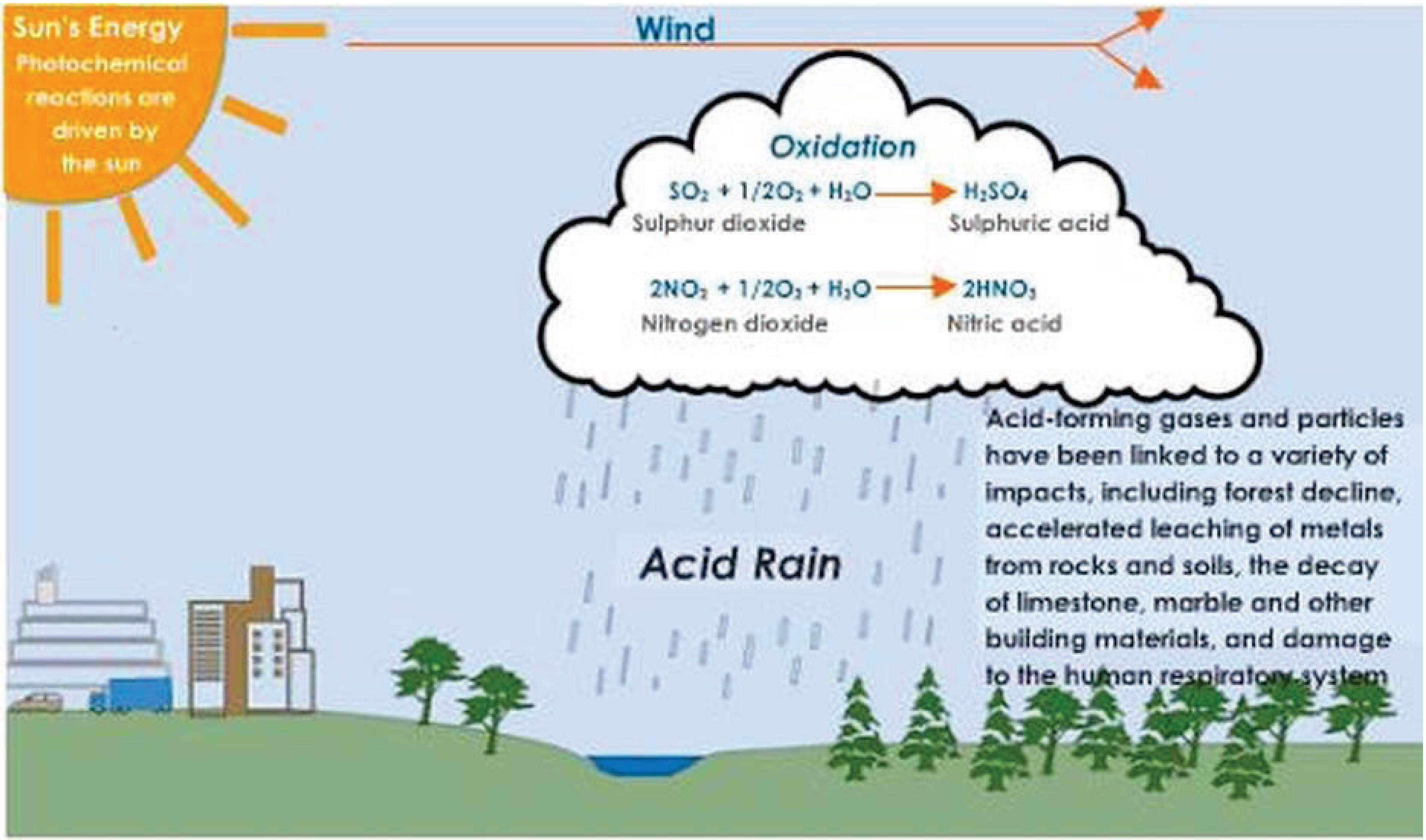
ACID RAIN
AND HUMAN HEALTH IMPACT

Acid rain


gases carried upwards by the wind
gases combine with water droplets to form acids
SO_2 NO_2 CO_2
acid rain
acidic gases released into the atmosphere
acid rain destroys plants, pollutes water sources and soil and erodes buildings

Acid rain

- Climate change and acid rain are closely associated, so much so that acid rain's impacts need to be part of climate change studies.
- Acid rain really has left a legacy in terms of how it has changed our systems.
- Acid rain is caused by air pollutants, mostly **nitrogen oxides and sulfur dioxide**, which are produced by power plants and gasoline-powered vehicles.
- Most rain is slightly acidic, but these pollutants can make rain much more acidic (to a pH of 4 -- neutral pH is 7).
- Acid rain has many ecological effects, especially on lakes, streams, wetlands, and other aquatic environments.
- Acid rain makes such waters more acidic, which results in more aluminum absorption from soil, which is carried into lakes and streams. ... Trees' leaves and needles are also harmed by acids.



Sun's Energy
Photochemical reactions are driven by the sun
Wind
Oxidation
$SO_2 + 1/2O_2 + H_2O \rightarrow H_2SO_4$
Sulphur dioxide
Sulphuric acid
$2NO_2 + 1/2O_2 + H_2O \rightarrow 2HNO_3$
Nitrogen dioxide
Nitric acid
Acid Rain
Acid-forming gases and particles have been linked to a variety of impacts, including forest decline, accelerated leaching of metals from rocks and soils, the decay of limestone, marble and other building materials, and damage to the human respiratory system

What Causes Acid Rain?

- Acid rain results when **sulfur dioxide (SO_2) and nitrogen oxides (NO_X)** are emitted into the atmosphere and transported by wind and air currents. The SO_2 and NO_X react with water, oxygen and other chemicals to form sulfuric and nitric acids. These then mix with water and other materials before falling to the ground.
- While a small portion of the SO_2 and NO_X that cause acid rain is from natural sources such as volcanoes, most of it comes from the burning of fossil fuels. The major sources of SO_2 and NO_X in the atmosphere are:
  - Burning of fossil fuels to generate electricity. Two thirds of SO_2 and one fourth of NO_X in the atmosphere come from electric power generators.
  - Vehicles and heavy equipment.
  - Manufacturing, oil refineries and other industries.
- Winds can blow SO_2 and NO_X over long distances and across borders making acid rain a problem for everyone and not just those who live close to these sources.

Acid Rain

Causes

- Natural Causes
- Electricity generation
- Vehicles
- Agriculture
- Industrial processes and consumption levels

Effects

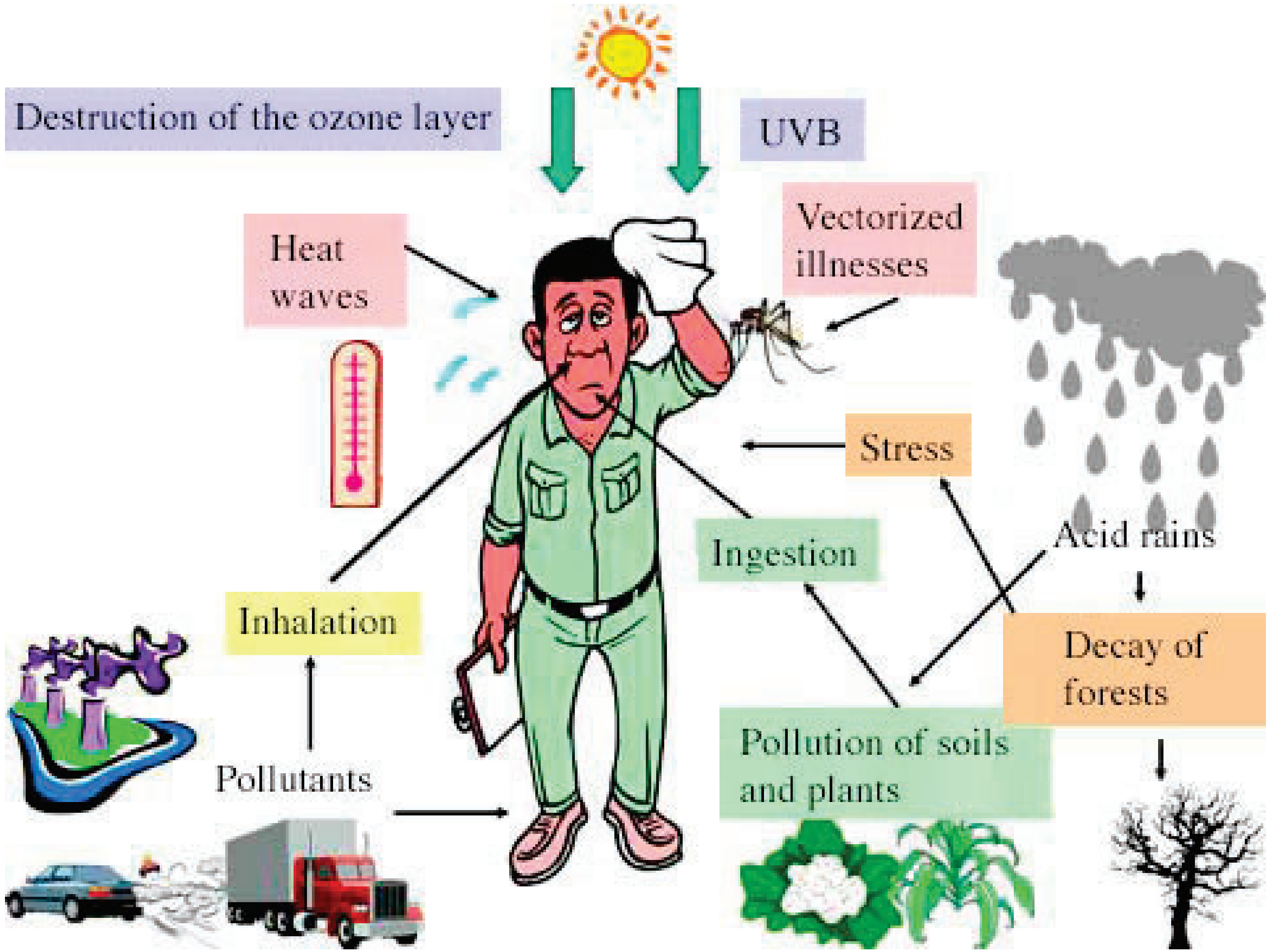
- Effects on aquatic environments
- Effects on animals and plants
- Effects on forests
- Effects on global warming
- Effects on soil
- Effects on vegetation cover
- Effects on buildings
- Effects on health

Solutions

- Optimize fossil energy processes
- Transition to renewable energies
- Confine the use of fertilizers and pesticides
- Restoring environments
- Save energy
- Reduce consumption levels
- Convince others
- Education
- Government regulations

Human health impact

- Weather and climate play a significant role in people's health. Changes in climate affect the average weather conditions that we are accustomed to.
- Warmer average temperatures will likely lead to hotter days and more frequent and longer heat waves which could increase the number of heat related illness and deaths



Destruction of the ozone layer
UVB
Heat waves
Vectorized illnesses
Stress
Ingestion
Acid rains
Inhalation
Decay of forests
Pollution of soils and plants
Pollutants

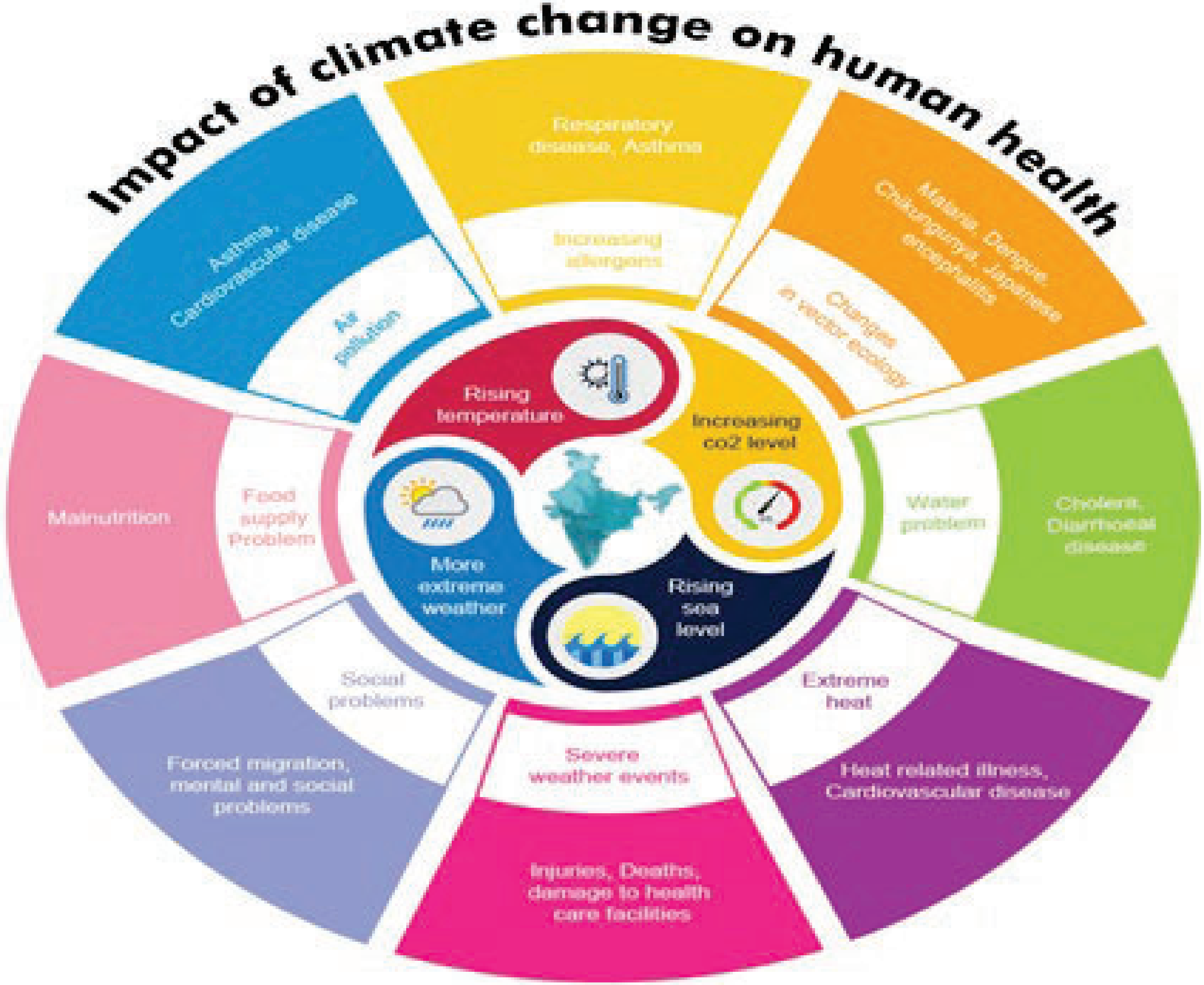
- Increases in the frequency or severity of extreme weather events such as storms could increase the risk of dangerous flooding, high winds, and other direct threats to people and property.
- Warmer temperatures could increase the concentrations of unhealthy air and water pollutants.

- Heat waves can lead to heat stroke and dehydration, and are the most common cause of weather-related deaths. Young children, older adults, people with medical conditions, and the poor are more vulnerable than others to heat-related illness.

- Climate change could lead to extreme weather events which would reduce the availability of fresh food and water;
- Interrupt communication, utility, and health care services;
- Contribute to carbon monoxide poisoning from portable electric generators used during and after storms;
- Increase stomach and intestinal illness among evacuees & Contribute to mental health impacts such as depression and post-traumatic stress disorder (PTSD).
- Climate change could lead to reduced air quality caused due to increases in Ozone, changes in Fine Particulate Matter and changes in allergen.

- Changes in temperature, precipitation patterns, and extreme events could enhance the spread of some diseases.
- These include food borne diseases
  - caused due to rapid growth of bacteria in warm environments and contamination of crops due to overflow
- water-borne diseases
  - caused due to increase in water-borne parasites like Giardia caused due to flooding and storm water runoff
- Animal borne diseases
  - caused due to changes in air temperatures


Every year foodborne diseases cause:
almost
1 in 10
people to fall ill
33 million
healthy life years lost
Foodborne diseases can be deadly, especially in children <5
420 000
deaths
Children account for
almost 1/3
of deaths from foodborne diseases
For more information: www.who.int/foodsafety
#SafeFood
Source: WHO Estimates of the Global Burden of Foodborne Diseases. 2015.
World Health Organization

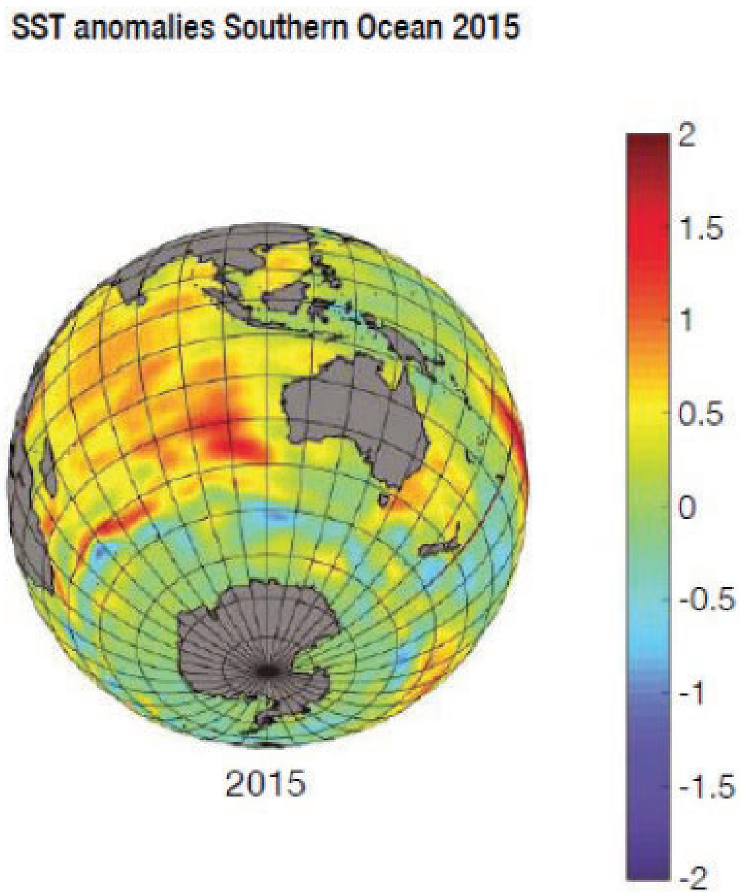

Impact of climate change on human health
Respiratory disease, Asthma
Increasing allergens
Malaria, Dengue, Chikungunya, Japanese encephalitis
Changes in vector ecology
Asthma, Cardiovascular disease
Air pollution
Rising temperature
Increasing co2 level
Malnutrition
Food supply Problem
Water problem
Cholera, Diarrhoeal disease
More extreme weather
Rising sea level
Social problems
Extreme heat
Forced migration, mental and social problems
Severe weather events
Heat related illness, Cardiovascular disease
Injuries, Deaths, damage to health care facilities

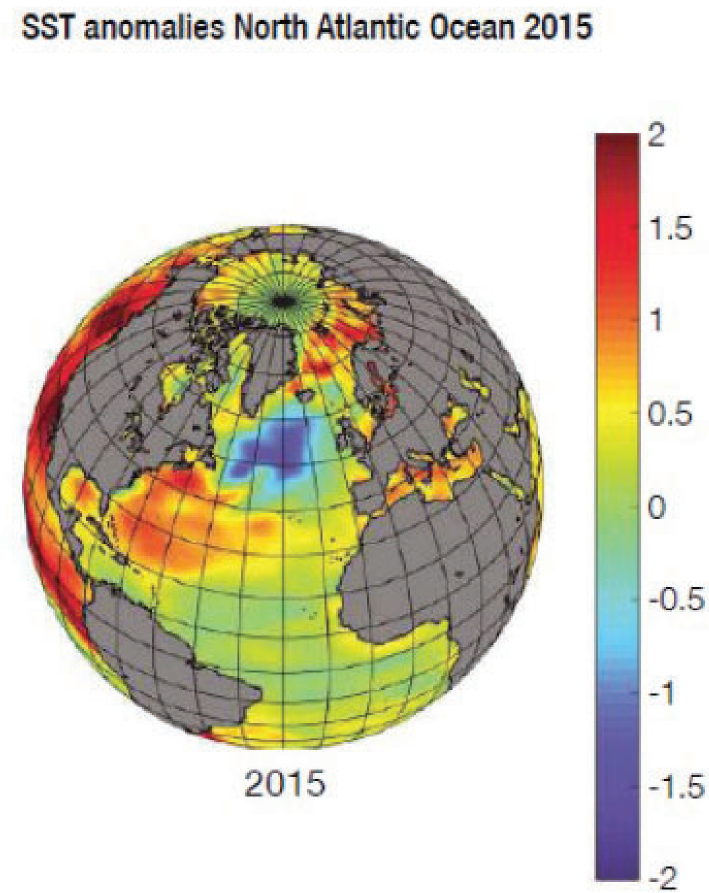
Farm to Table
The Potential Interactions of Rising CO_2 and Climate Change on Food Quality and Safety

Unit 3 Climate change impact in various sector
– S4.2

SEA SURFACE TEMPERATURE INCREASES AND AQUATIC ORGANISMS IMPACT

- The ocean absorbs vast quantities of heat as a result of increased concentrations of greenhouse gases in the atmosphere, mainly from fossil fuel consumption.
- The Fifth Assessment Report published by the Intergovernmental Panel on Climate Change (IPCC) in 2013 revealed that the ocean had absorbed more than 93% of the excess heat from greenhouse gas emissions since the 1970s. This is causing ocean temperatures to rise.



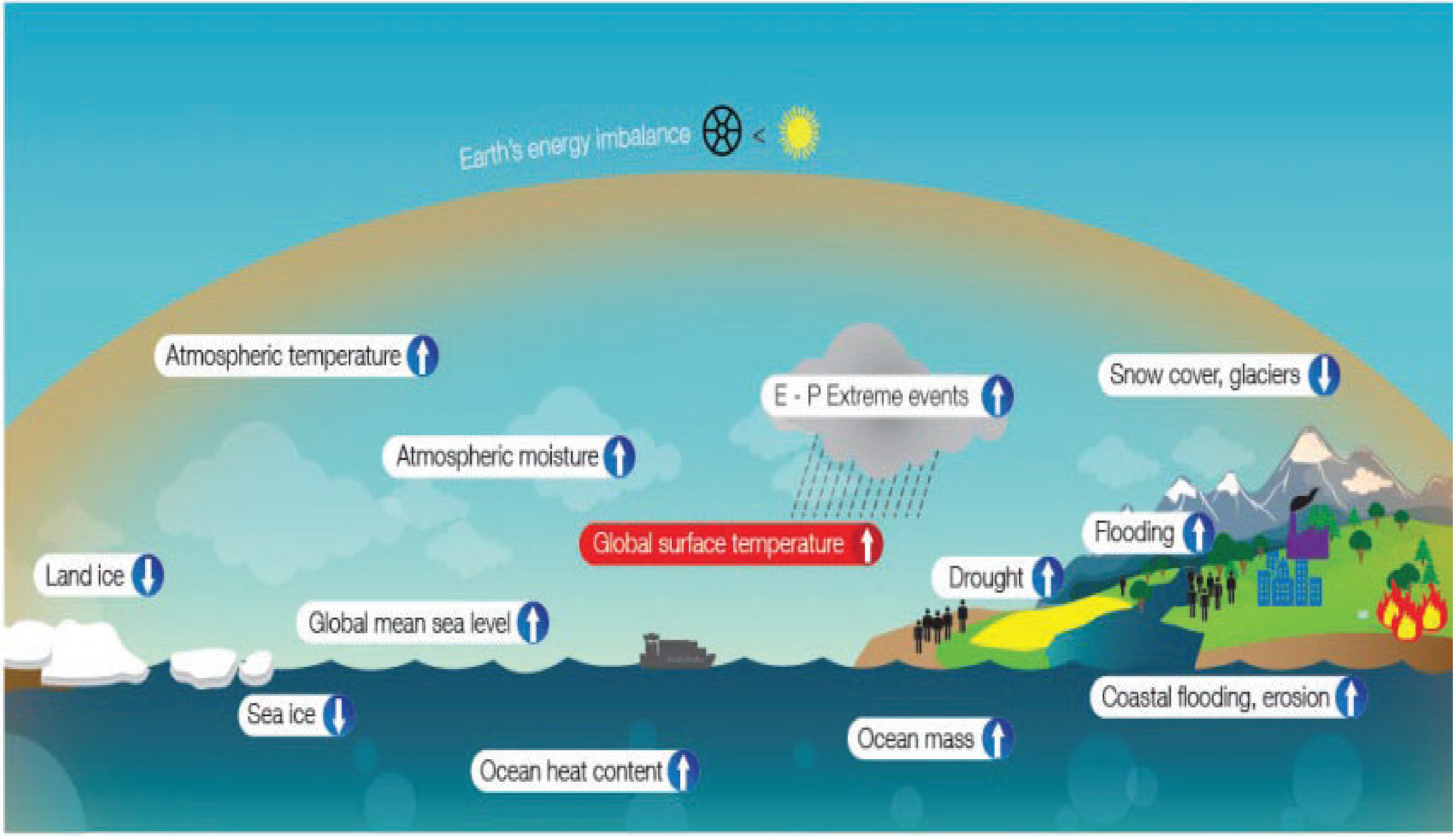


The distribution of excess heat in the ocean is not uniform, with the greatest ocean warming occurring in the Southern Hemisphere and contributing to the subsurface melting of Antarctic ice shelves.

- The ocean's ability to absorb excess heat has shielded humans from even more rapid changes in climate. Without this oceanic buffer, global temperatures would have risen much more than they have done to date.
- IPCC's Fourth Assessment Report published in 2007 estimated that the Earth had experienced a warming of 0.55°C since the 1970s.
- According to an analysis by the Grantham Institute, if the same amount of heat that has gone into the top 2,000 m of the ocean between 1955 and 2010 had gone into the lower 10 km of the atmosphere, the Earth would have seen a warming of 36°C.

Why is it important ?

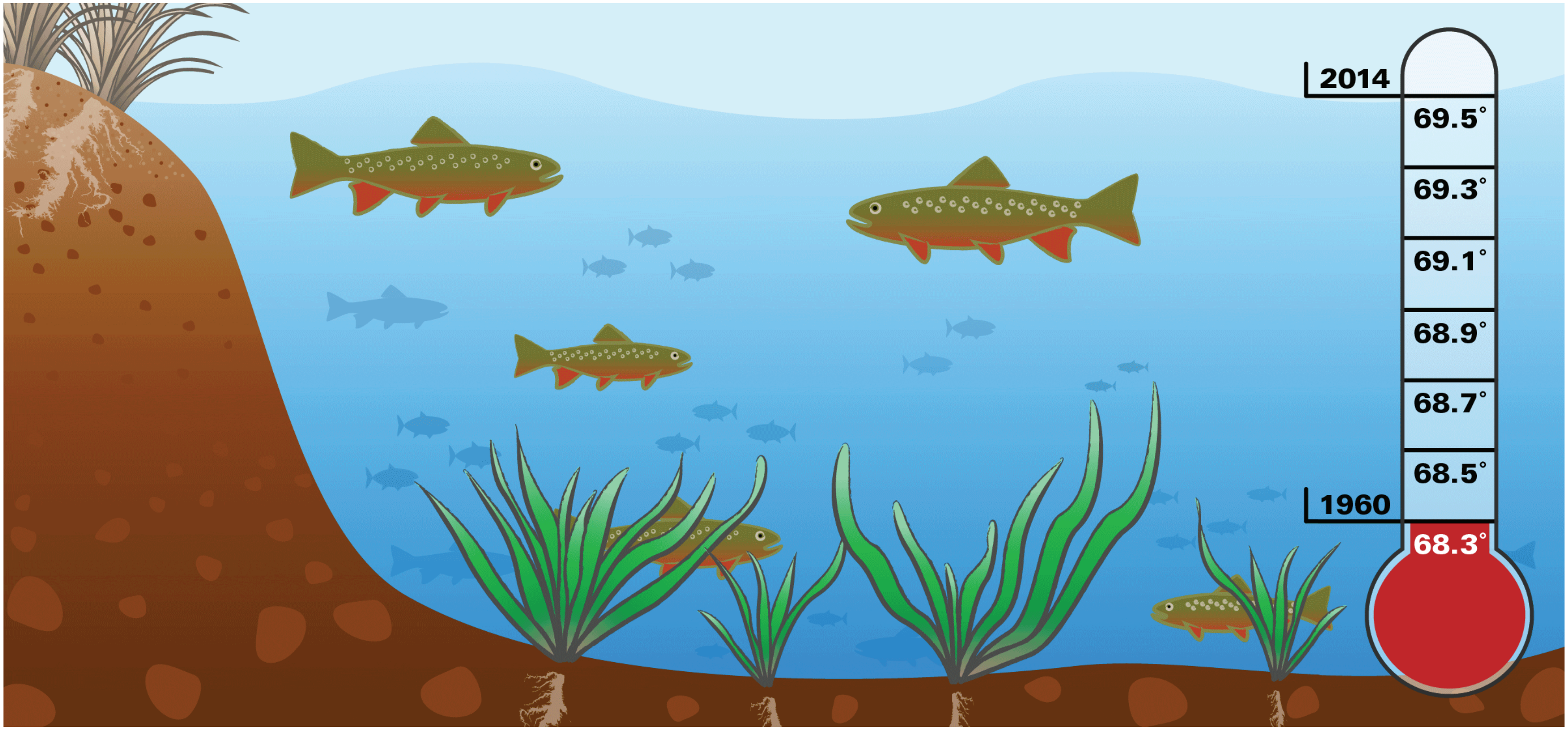
- Ocean warming leads to de-oxygenation – a reduction in the amount of oxygen dissolved in the ocean – and sea-level rise – resulting from the thermal expansion of sea water and continental ice melting.
- The rising temperatures,
  - coupled with ocean acidification (the decrease in pH of the ocean due to its uptake of CO_2)
  - affect marine species and ecosystems and, consequently
  - the fundamental benefits humans derive from the ocean.

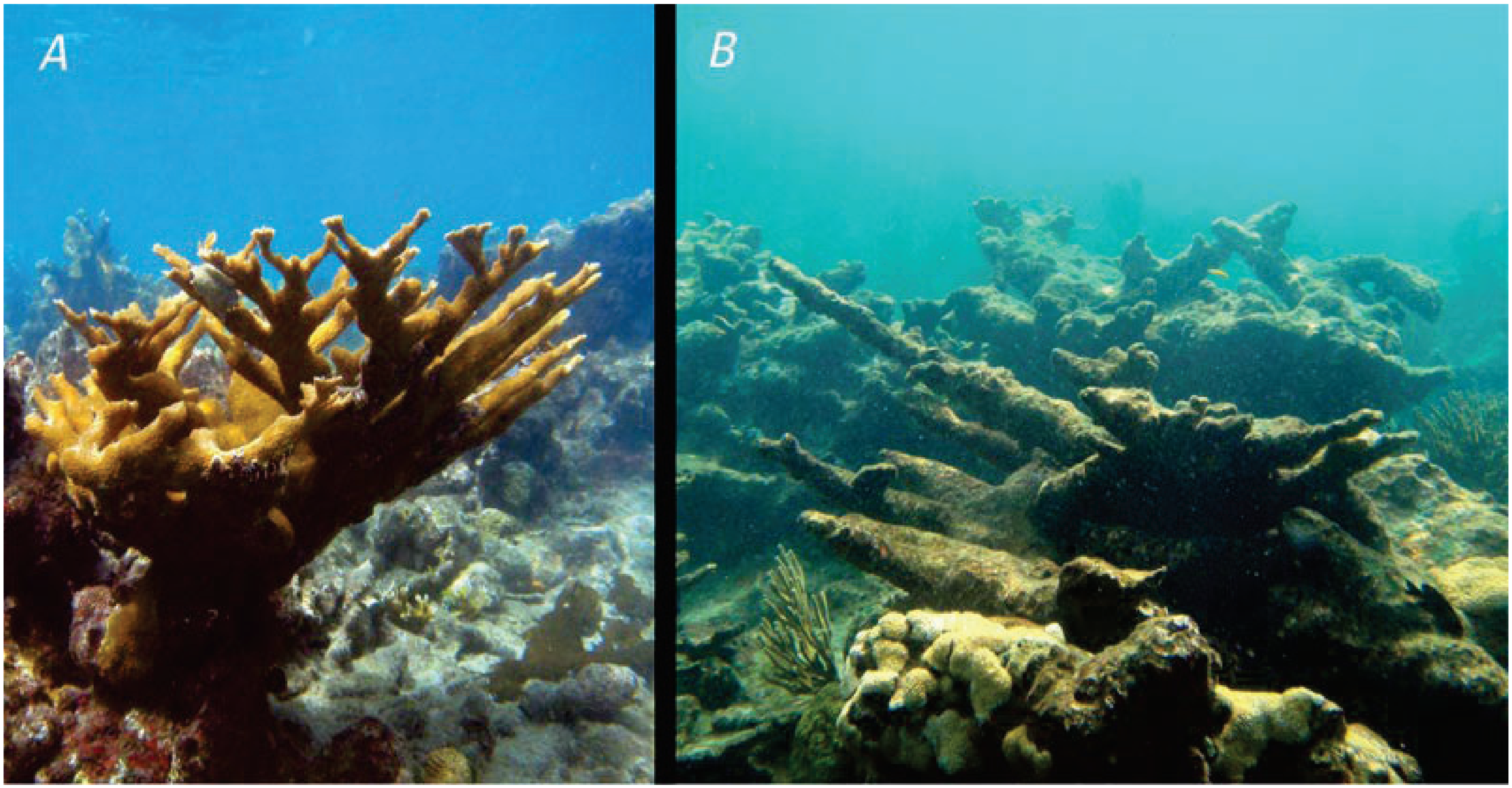

Earth's energy imbalance <
Atmospheric temperature
E - P Extreme events
Snow cover, glaciers
Atmospheric moisture
Global surface temperature
Flooding
Land ice
Drought
Global mean sea level
Sea ice
Coastal flooding, erosion
Ocean mass
Ocean heat content

Impact on marine species and ecosystems

- Marine fishes, seabirds and marine mammals all face very high risks from increasing temperatures, including high levels of mortalities, loss of breeding grounds and mass movements as species search for favorable environmental conditions.
- Coral reefs are also affected by increasing temperatures which cause coral bleaching and increase their risk of mortality.

Impact on marine species and ecosystems




A
B

Impact on humans

- A 2012 report by the Food and Agriculture Organization of the United Nations estimates that marine and freshwater capture fisheries and aquaculture provide 4.3 billion people with about 15% of their animal protein.
- Fisheries and aquaculture are also a source of income for millions of people worldwide. By altering distributions of fish stocks and increasing the vulnerability of fish species to diseases, ocean warming is a serious risk to food security and people's livelihoods globally.
- Economic losses related to ocean warming are likely to run from tens to hundreds of millions of dollars.
- Rising temperatures also affect vegetation and reef-building species such as corals and mangroves, which protect coastlines from erosion and sea-level rise.
- Rising sea levels and erosion will particularly affect low-lying island countries in the Pacific Ocean, destroying housing and infrastructure and forcing people to relocate.

- The rise in sea surface temperatures is causing more severe hurricanes and the intensification of El Niño events bringing droughts and floods. This can have significant socio-economic and health effects in some regions of the world.
- Warming ocean temperatures are linked to the increase and spread of diseases in marine species.
- Humans risk direct transmission of these diseases when consuming marine species, or from infections of wounds exposed in marine environments.

What can be done?

Limiting greenhouse gas emissions

There is an urgent need to achieve the mitigation targets set by the Paris Agreement on climate change and hold the increase in the global average temperature to well below 2°C above pre-industrial levels. This will help prevent the massive and irreversible impacts of growing temperatures on ocean ecosystems and their services.

Protecting marine and coastal ecosystems

Well-managed protected areas can help conserve and protect ecologically and biologically significant marine habitats. This will regulate human activities in these habitats and prevent environmental degradation.

Restoring marine and coastal ecosystems

Elements of ecosystems that have already experienced damage can be restored. This can include building artificial structures such as rock pools that act as surrogate habitats for organisms, or boosting the resilience of species to warmer temperatures through assisted breeding techniques.

Improving human adaptation

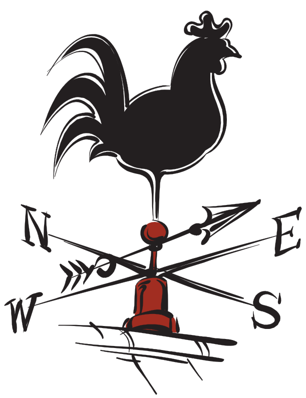
Governments can introduce policies to keep fisheries production within sustainable limits, for example by setting precautionary catch limits and eliminating subsidies to prevent overfishing. Coastal setback zones which prohibit all or certain types of development along the shoreline can minimise the damage from coastal flooding and erosion. New monitoring tools can be developed to forecast and control marine disease outbreaks.

Strengthening scientific research

Governments can increase investments in scientific research to measure and monitor ocean warming and its effects. This will provide more precise data on the scale, nature and impacts of ocean warming, making it possible to design and implement adequate and appropriate mitigation and adaptation strategies.

UNIT-3
WEATHER AND CLIMATE PARAMETERS MEASURING DEVICES

(S6&S7)



Weather Instruments

Essential Questions:

What are weather instruments and how are they used?

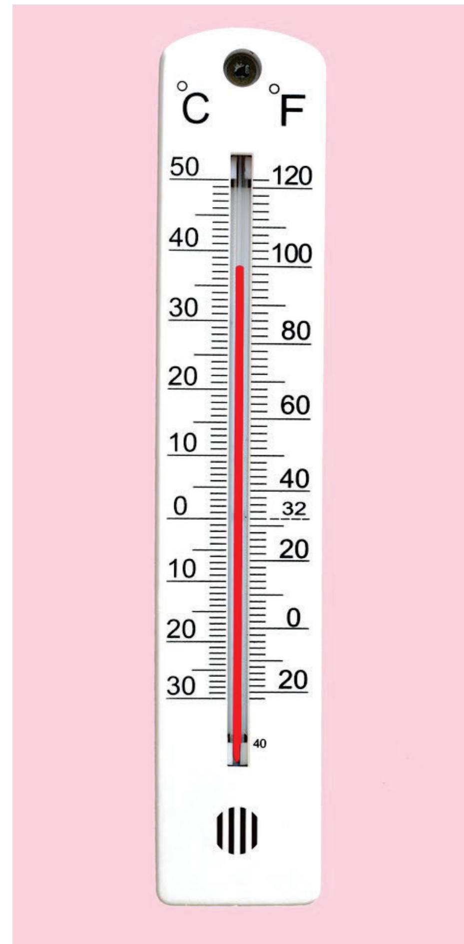
Weather Instruments

Meteorologist use different tools to measure weather. Here are some of the instruments they use:

- Thermometer
- Barometer
- Anemometer
- Hygrometer
- Rain gauge
- Wind Vane
- Weather balloon
- Satellite

Thermometer

A thermometer measures heat and cold. Meteorologist use it to measure air temperature. Liquids **expand** (get bigger) when heated and **contract** (get smaller) when cooled. That means their **volume** (occupied space) changes with their temperature.



Thermometer

The liquid inside older thermometers is mercury. It was used because of its resistance to heat and cold. Unlike water, mercury freezes at minus 39 degrees Celsius (-39°C) and boils at three hundred fifty seven degrees Celsius (357°C).

Thermometer Units of Measure

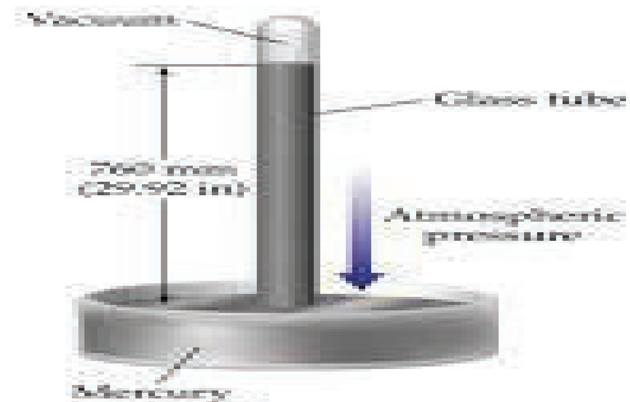
The two (2) measurement units used with a thermometer are degrees ***Fahrenheit*** and degrees ***Celsius***.

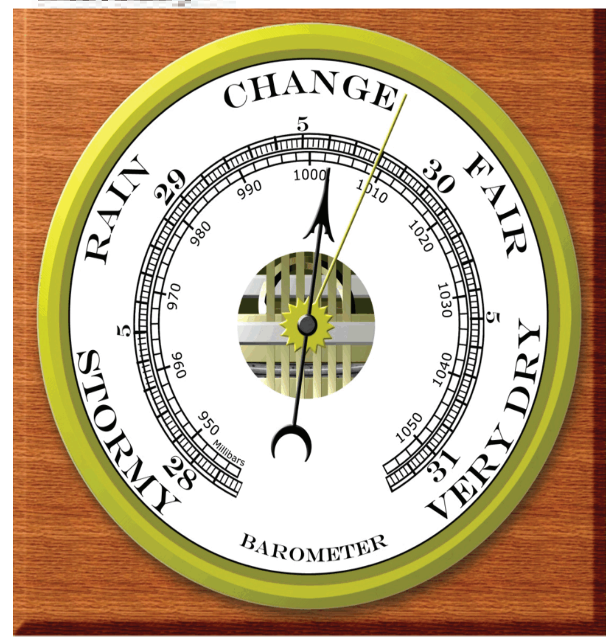
The Fahrenheit scale sets the freezing point of water at 32 degrees (32°F) and the boiling point at 212 degrees (212°F).

The Celsius scale sets the freezing point of water at 0 degrees (0°C) and the boiling point at 100 degrees (100°C).

Barometer

A barometer measures ***air pressure*** or ***barometric pressure***. The barometer dial is marked in two scales. The outer scale shows the units of inches of mercury. The inner scale shows air pressure in ***millibars***.





Air Pressure

Air pressure is a function of the quantity of air and the amount of space in which the air is contained. Air pressure is also the function of temperature.

Air Pressure and Weather

Changing air pressure indicates changing weather.

Rising air pressure usually means that cooler, drier air is coming, so there will be ***fair weather***.

Falling air pressure usually means that warmer, moister air is coming, so there will be ***wet weather***.

Anemometer

An anemometer measures the speed or strength of wind. The most common types of anemometer have a mechanism that rotates as it catches the wind.

Wind Speed and Weather

Wind speed is related directly to wind strength. Wind strength is commonly reported on the ***Beaufort scale.*** The Beaufort scale rates the strength of wind on a scale of 0 – 12.

A Beaufort number of 0 indicates total calm.

A Beaufort number of 12 indicates hurricane strength winds (exceeding 74 mph).

Hygrometer

A hygrometer measures relative humidity. Humidity is the amount of water vapor in the air.

A reading of 100 percent relative humidity means that the air is totally saturated with water vapor and cannot hold any more, creating the possibility of rain.

Weather Instruments

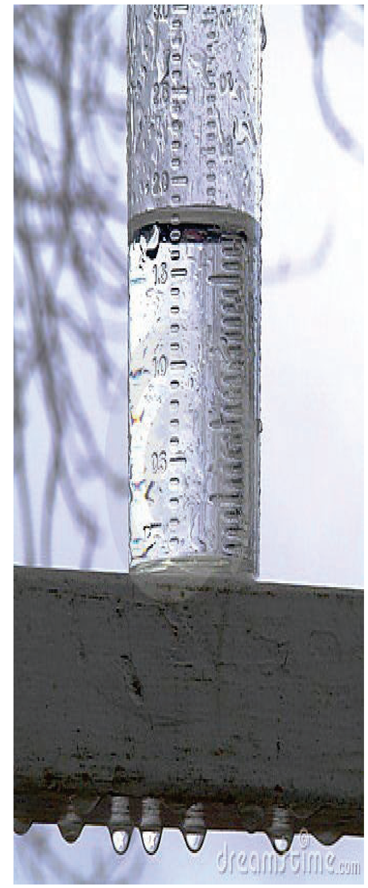
- Hygrometers are instruments used for measuring humidity.
- Psychrometer
  - A simple form of a hygrometer
  - consists of two thermometers, one of which includes a dry bulb and the other of which includes a bulb that is kept wet to measure wet-bulb temperature.
  - Evaporation from the wet bulb lowers the temperature, so that the wet-bulb thermometer usually shows a lower temperature than that of the dry-bulb thermometer, which measures dry-bulb temperature.
  - Relative humidity is computed from the ambient temperature as shown by the dry-bulb thermometer and the difference in temperatures as shown by the wet-bulb and dry-bulb thermometers.

People and Humidity

The process of ***sweating*** is the human body's attempt to keep cool and maintain its current temperature. If the air is at 100-percent relative humidity, sweat will not ***evaporate*** into the air. As a result, we feel much hotter than the actual temperature when the relative humidity is high. If the relative humidity is low, we can feel much cooler than the actual temperature because our sweat evaporates easily, cooling us off.

Rain Gauge

- A **rain gauge** is an instrument used to gather and measure the amount of liquid ***precipitation*** over a set period of time.
- Most standard rain gauges have a wide funnel leading into a cylinder that is marked in inches or centimeters.
- They are calibrated (set up) so that one-tenth of an inch of rain measures one inch when it collects inside. In other words, each inch in the funnel counts as one-tenth of an inch of rain.



Types of Rain gauges

Rain gauges can be broadly classified into two categories as

i) Recording / Automatic type rain gauge

Weighing bucket,

Tipping bucket,

Floating type

ii) Non- recording / Non- automatic type rain gauge :

Symon's Raingauge

Non- recording / Non- automatic type rain gauge : Symon’s Raingauge

- The non-recording gauge extensively used by **Meteorological Department of Government of India is the Symons’ gauge .**
- The rain gauge is set up in a concrete block **60 cm x 60 cm x 60 cm**.
- A cylindrical graduated measuring glass is furnished with each instrument, which reads to 0.2 mm. The rainfall should be estimated to the nearest

  0.1 mm.
- A receiving bottle of rain gauge has a capacity of about **75 to 100 mm of rainfall**, the rain should be measured 3 or 4 times in a day, in case of heavy rainfall. The rainfall is measured every day at **08.30 hours IST.**

- Usually, rainfall measurements are made at 08.30 hr IST and sometimes at 17.30 hr IST also.
- Thus the non-recording or the Symon’s rain gauge gives only the total depth of rainfall for the previous 24 hours (*i.e.,* daily rainfall) and does not give the intensity and duration of rainfall during different time intervals of the day.

The following important points to be kept in mind, while selecting the site for a rain gauge station.

1. The site where a rain-gauge is set up should be an open place.
2. The distance between the rain-gauge and the nearest object should be atleast twice the height of the object. In no case should it be nearer to the obstruction than 30 metres.
3. The rain-gauge should never be situated on the side or top of a hill if a suitable site on a level ground can be found.
4. In the hills, where it is difficult to find level space, the site for the gauge should be chosen where it is best shielded from high winds, and where the wind does not cause eddies.
5. A fence, if erected to protect the gauge from cattle etc. should be so located that distance of the fence is not less than twice its height.

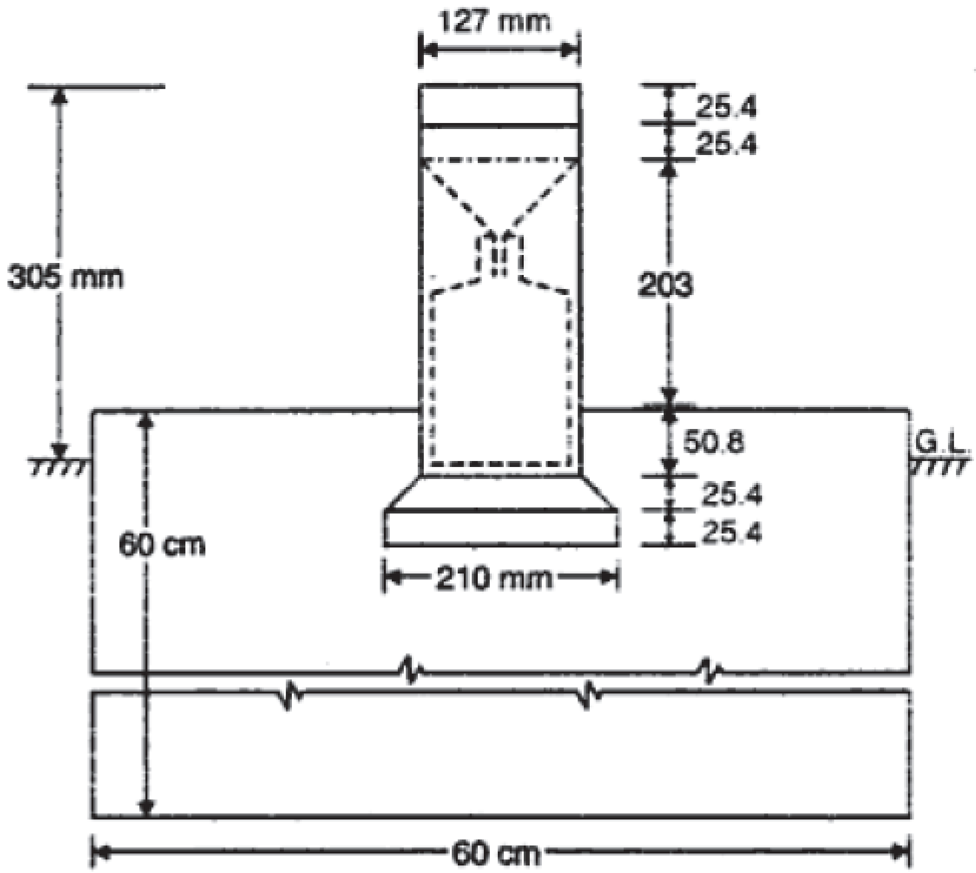


FIG. SYMON'S RAIN-GAUGE (ADOPTEDBY METEOROLOGICAL DEPT. OF GOVT. OF INDIA)

Recording / Automatic type rain gauge

1. Weighing bucket,
2. Tipping bucket,
3. Floating type

Weighing bucket type rain gauge

- Self recording rain gauges are used to determine rates of rainfall over short period of time.
- The most common type of Self recording rain gauge is weighing bucket type. It consists of receiver bucket supported by spring or any other weighing mechanism.
- The movement of the bucket due its increasing weight is transmitted to a pen which traces the record on a clock driven chart.
- The rotation of the drum sets the time scale while the vertical motion of the pen records the cumulative precipitation

- This type of gauge normally has no provision for emptying itself.
- The bucket is been emptied and the pen has been set to zero, whenever the rainfall chart is changed.

Merits.

- The main usefulness of this type of gauge is that, it can record snow, hail, mixture of rain and snow.
- All forms of precipitation are weighed and recorded automatically.

Demerits.

- Effect of temperature and friction on weighing mechanism.
- Shrinkage and expansion of chart paper caused by changes in humidity may distort the time and scale of rainfall.

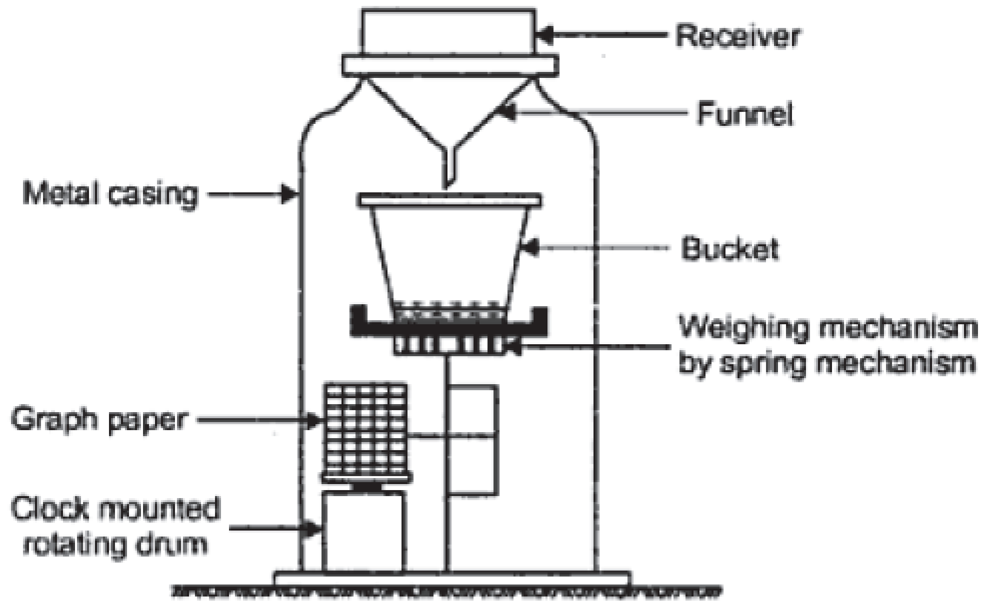


FIG. WEIGHING BUCKET TYPE RAIN-GAUGE.

Tipping bucket type [Tilting bucket]

- A Steven's tipping bucket type rain gauge consists of **300 mm diameter,** sharp edge receiver. At the end of the receiver is provided with a funnel.
- Just below the funnel a pair of tipping buckets is pivoted such that when one of the bucket receives a rainfall of 0.25 mm it tips and empties into a tank below, while the other bucket takes its position and the process is repeated.
- The tipping of the bucket actuates on electric circuit which causes a pen to move on a chart wrapped round a drum which revolves by a clock mechanism. **This type cannot record snow.**

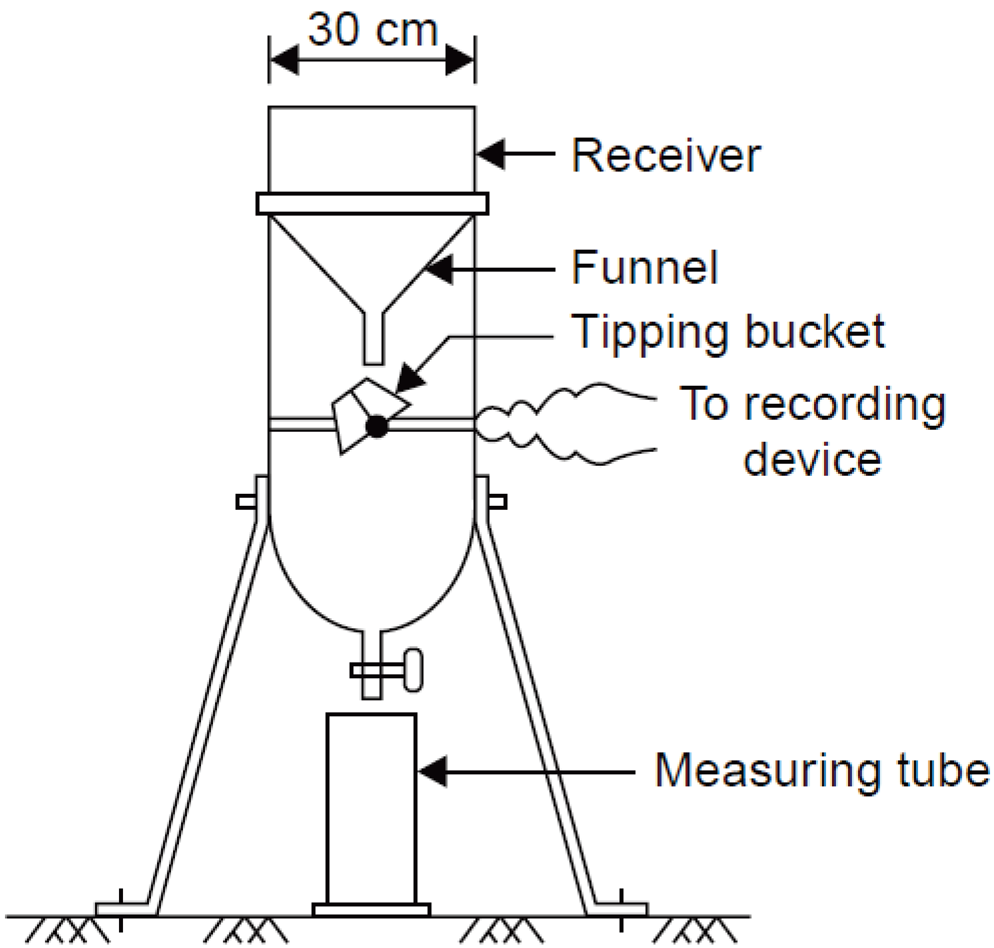


Fig. Tipping bucket gauge

- The water from the tipped bucket is collected in a storage can.
- The water collected in the storage can is measured at regular intervals to provide the total rainfall and also serve as a check.
- It may be noted that the record from the tipping bucket gives **data on the intensity of rainfall.**
- Further, the instrument is ideally suited for digitalising of the output signal.

Merits

- It is the only recording rain gauge, which can be used in **remote places** by installing the recorder at a convenient and easily accessible location.

Demerits

- The instrument is not satisfactory for use in light drizzle of very light rain.
- The time of beginning and end of rainfall cannot be determined accurately.
- This type of gauge is not suitable for measuring snow without heating the collector.

Floating type rain gauge [Natural syphon type]

- This type of rain gauge is also known as **syphon type rain gauge**, as it uses the **syphon mechanism** to empty the rainwater collected in the float chamber.
- This is adopted by **I.M.D**
- The working of float type or syphon type raingauge is **similar to the weighing bucket type rain gauge.**
- In this type, as the rain is collected in a float chamber, the float moves up which makes a pen to move on a chart wrapped round a clock driven drum
- When the float chamber fills up, the water siphons out automatically through a siphon tube kept in an interconnected siphon chamber.

- **The clockwork revolves the drum once in 24 hours.**
- The clock mechanism needs rewinding once in a week when the chart wrapped round the drum is also replaced.
- The vertical lines in the pen-trace correspond to the sudden emptying of the float chamber by syphon action **which resets the pen to zero level.**
- It is obvious that the natural syphon-type recording rain gauge gives a plot of the **mass curve of rainfall.**

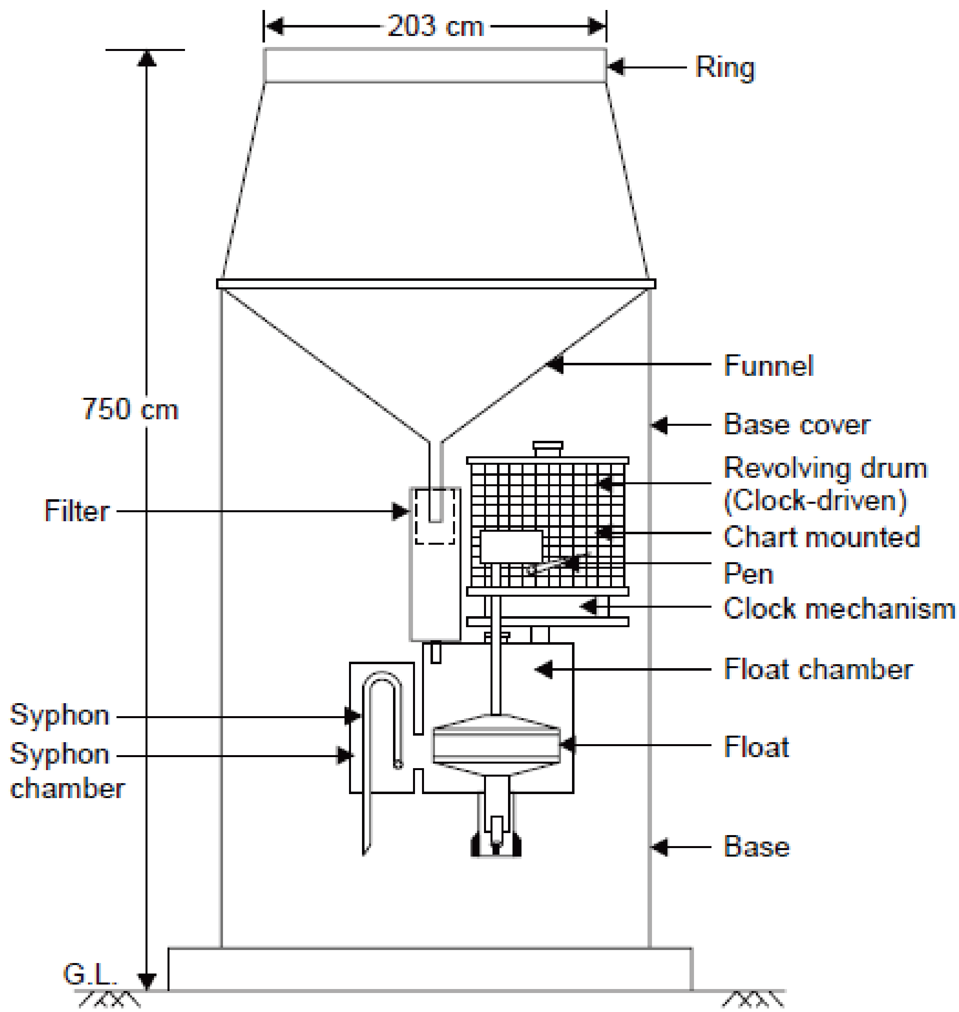
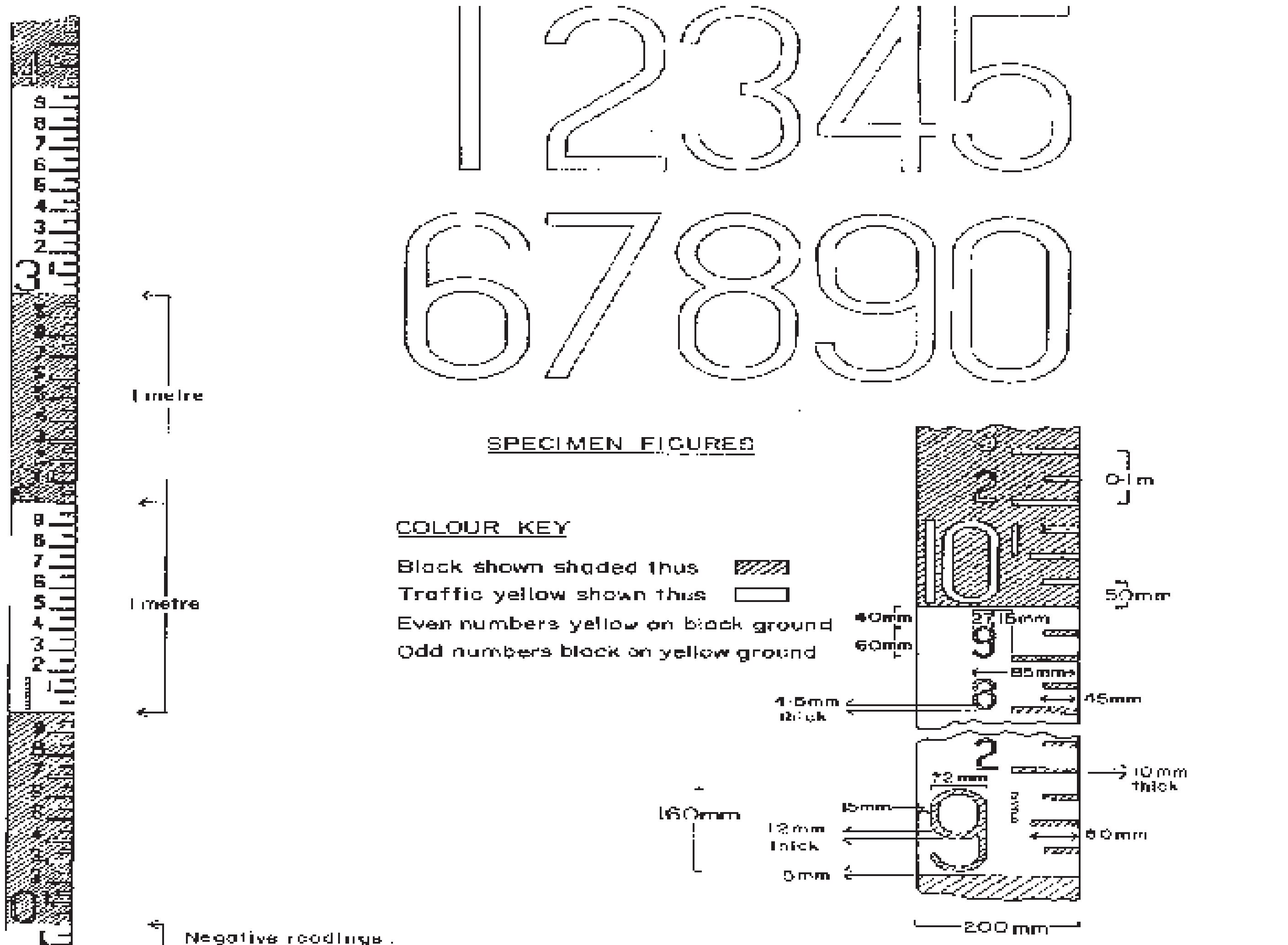


Fig. Float type rain gauge

Tide Pole (or Tide Staff) Gauges

TIDE GAUGES



MARKING OF
VISUAL TIDE SCALE

Committee on
Tide Gauges
January 1978


9
8
7
6
5
4
3
2
7
9
8
7
6
5
4
3
2

Tide pole gauges

- The simplest possible system, and lowest cost
- Very educational
- Important common sense ‘reality check’ alongside modern black box digital tide gauge systems

Of course, tide poles have not for many years been a primary source of sea level data. However, it is always worth having a simple tide pole at every gauge site as a check.

Although they are simple, there is a need for datum control, just as there is for more expensive and complicated gauges

Float Gauges

Classical
Float
Gauge

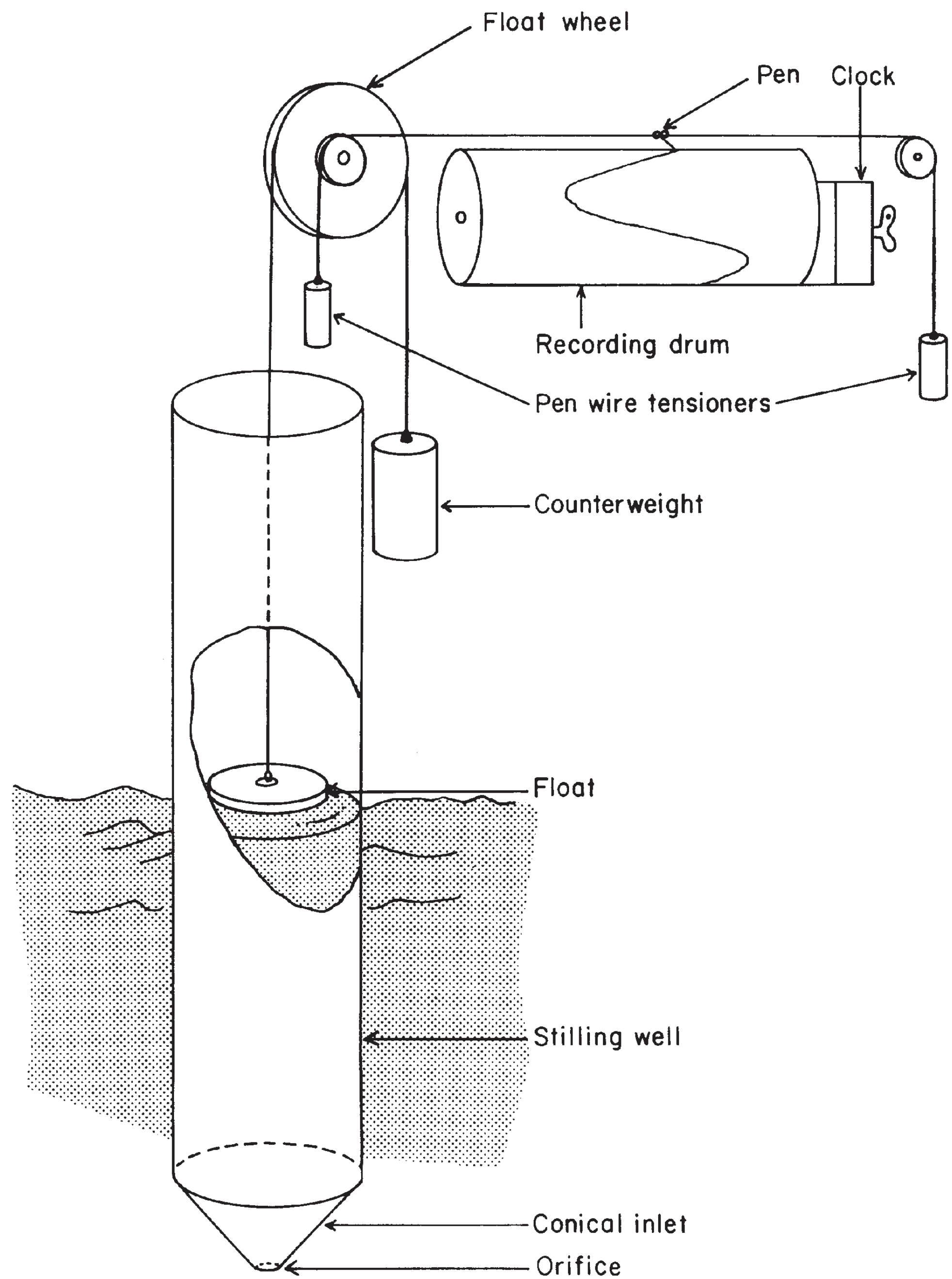
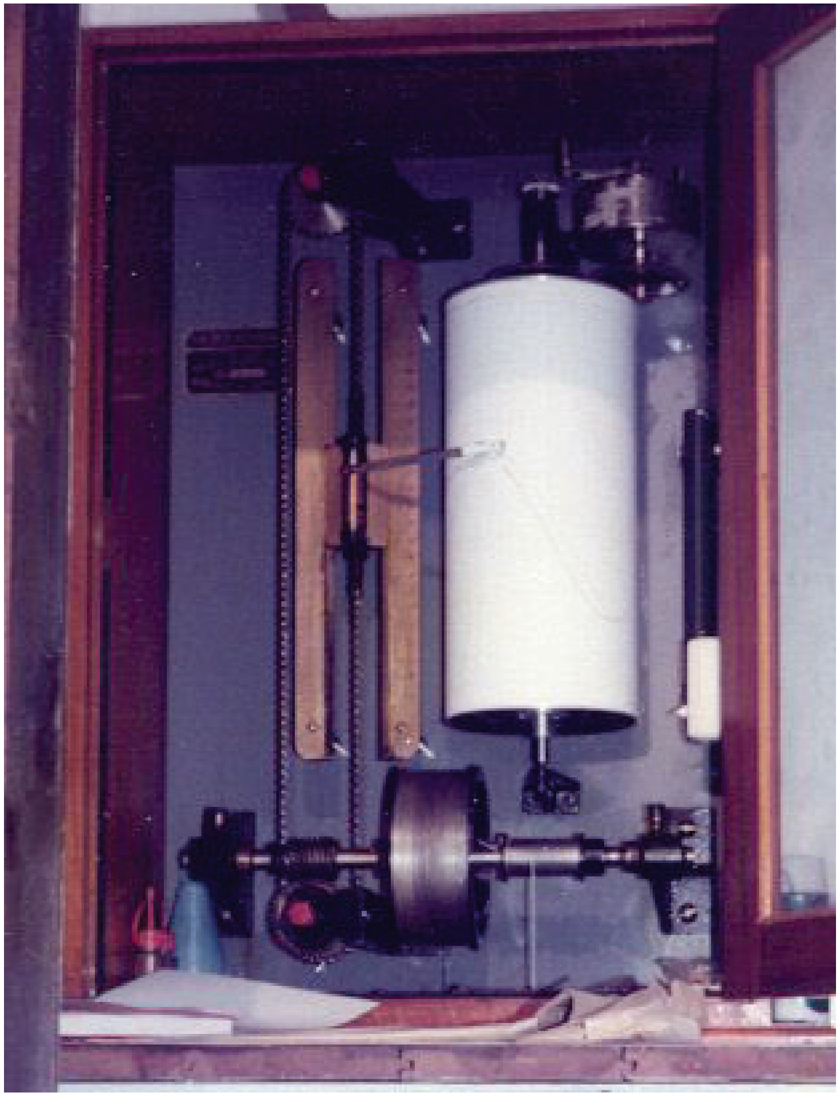


Figure 3.1



Lea chart recorder for a float gauge (photo taken in 1983)

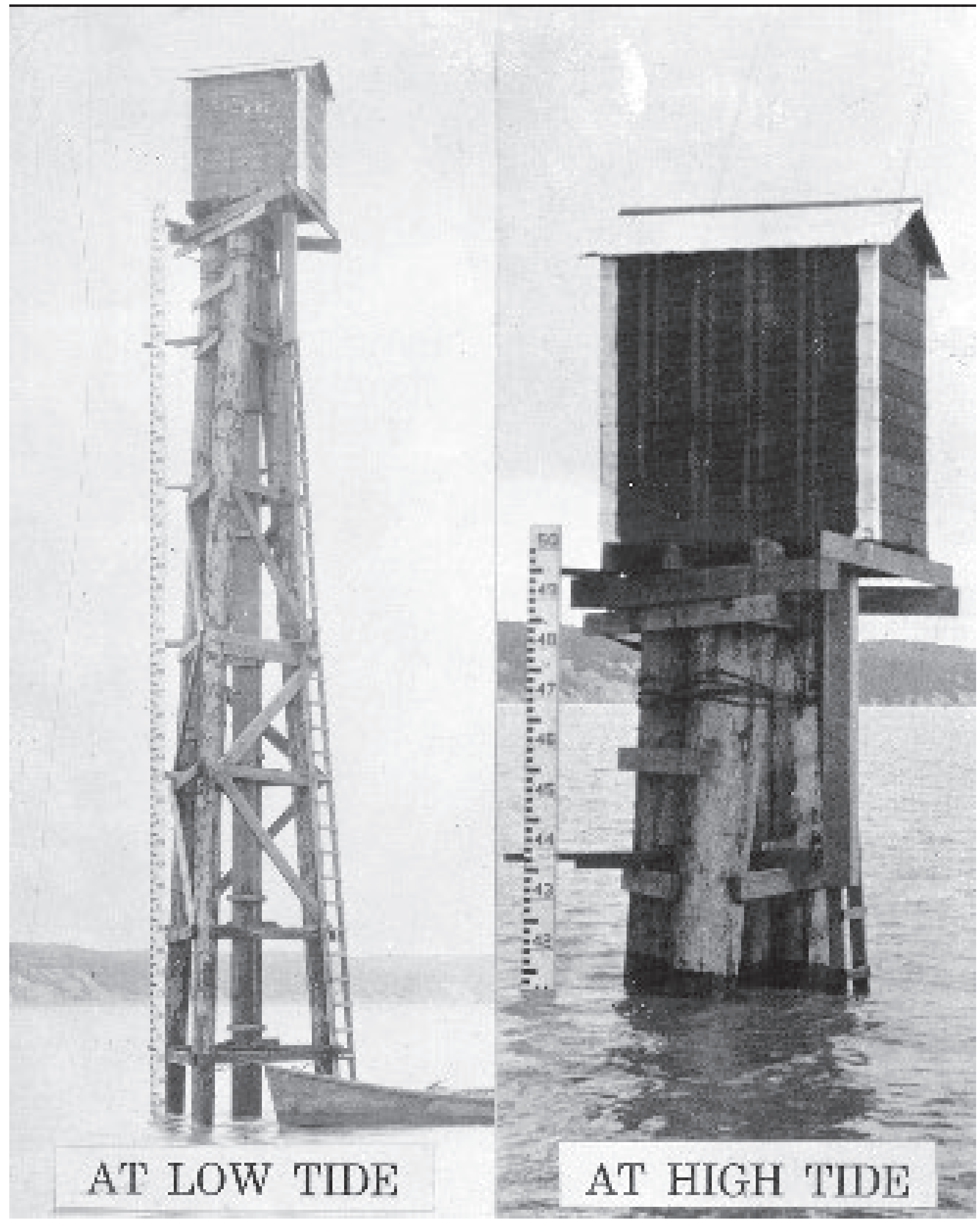
Importance of Float Gauges

- They still form a large part of the global network
- No need for paper charts now. They can be made digital with the use of shaft encoders
- Even if they are now being replaced with acoustic, pressure and radar systems, they were the source of most of the historical record

UK Float Gauge at Holyhead

Float gauges are still important components of GLOSS and can be made into digital gauges with the use of encoders

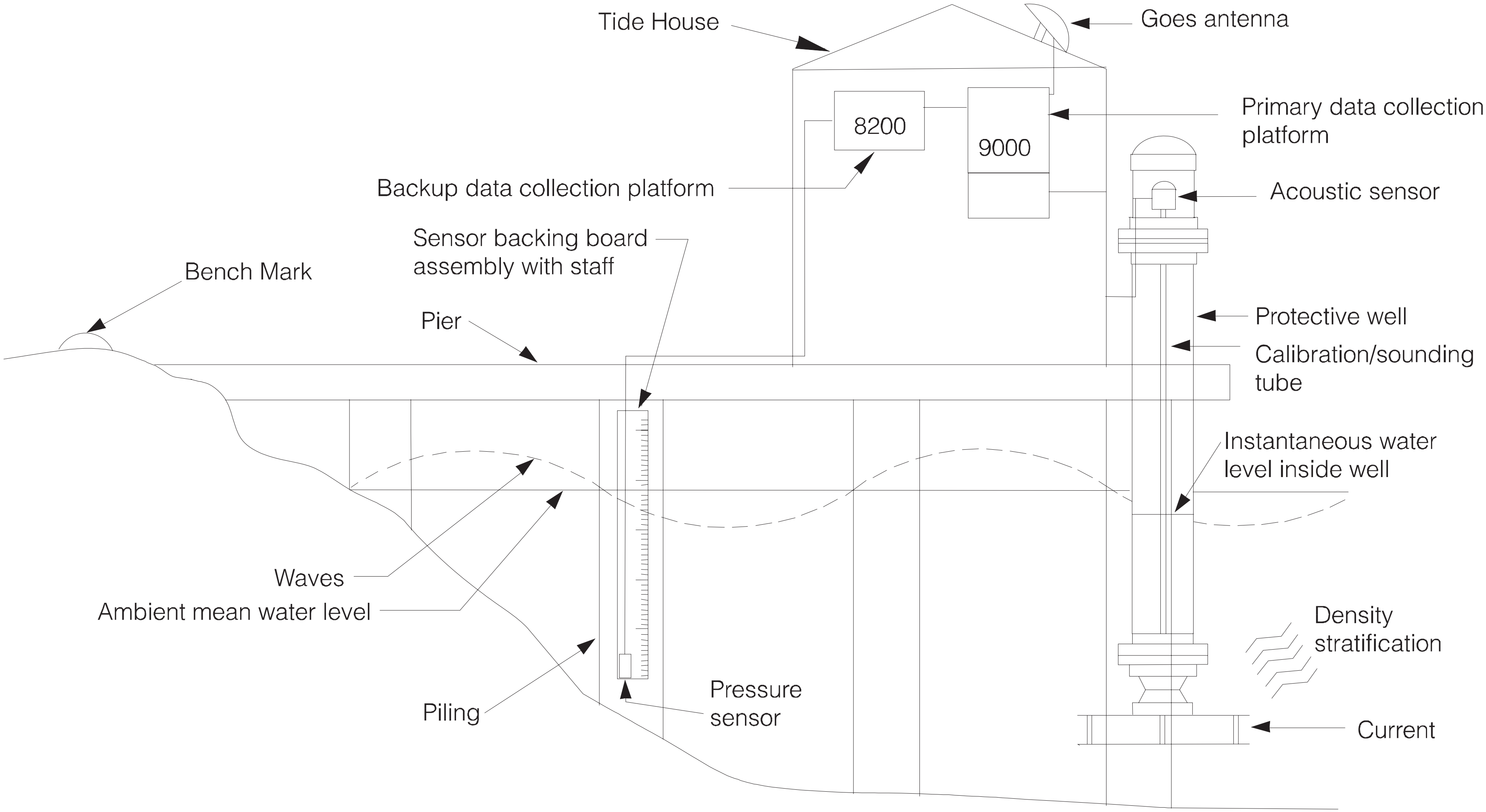
Classical stilling well float gauge from the US east coast high tidal range area



Acoustic Gauges

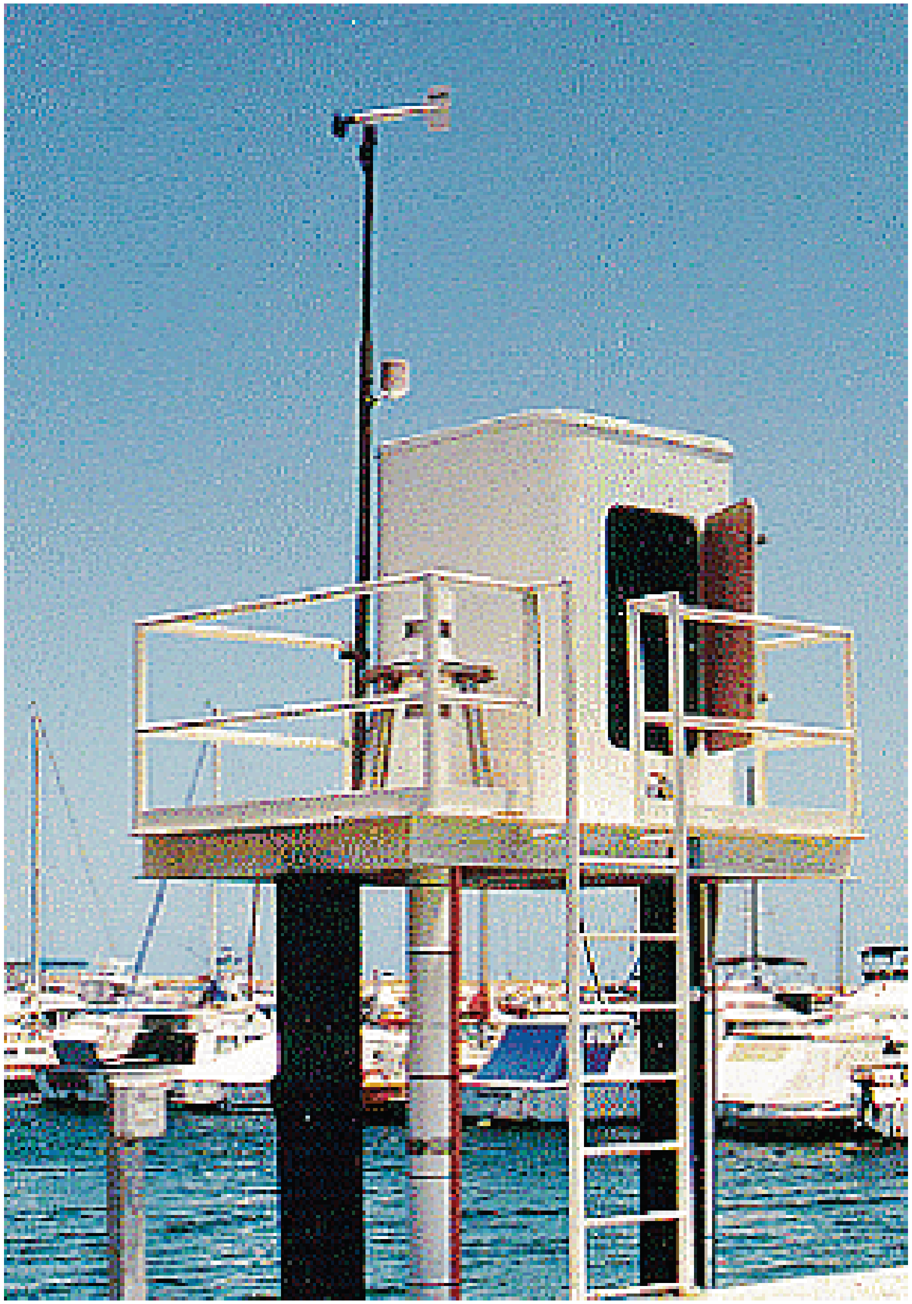
Acoustic gauges

- Acoustic systems in tube with Aquatrak transducer (NGWLMS or SEAFRAME) with various data loggers. These are now something of a GLOSS standard in many areas
- Acoustic systems in open air or inside the stilling wells of float gauges. Cheap but several groups have not been successful in operating them to good standards



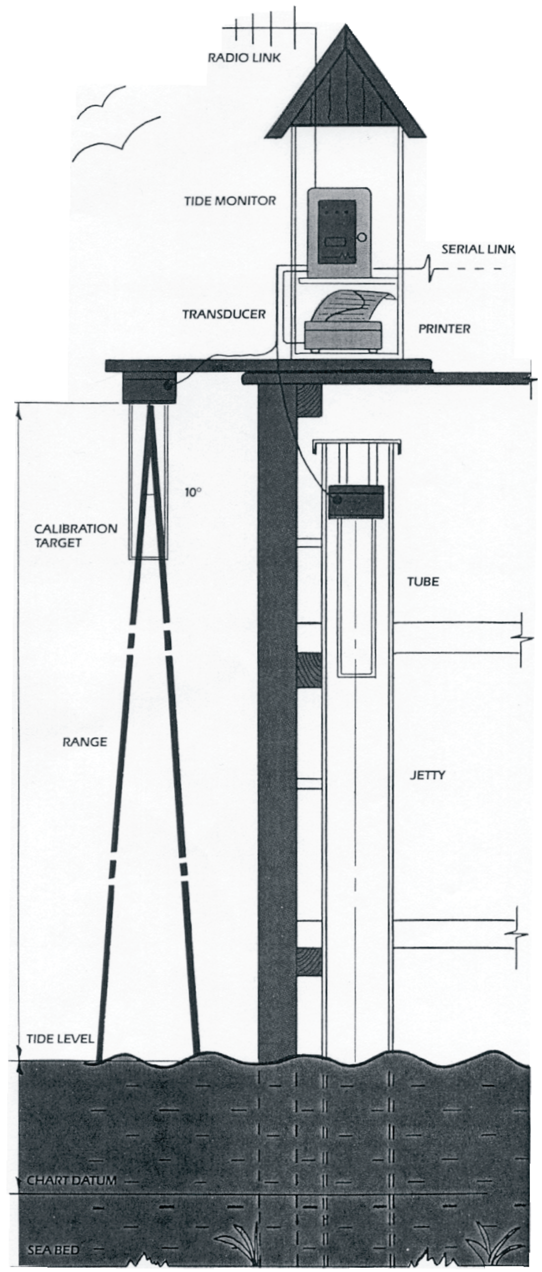
Schematic of the NGWLMS/SEAFRAME system

Acoustic SEAFRAME Gauge in Australia



SRD Tide Monitor
in a well or in open
air – Spain and South
Africa have used these
not very successfully.

Similar systems are
manufactured by other
companies e.g. MORS



SRD TIDE MONITOR

The SRD Tide Monitor has been developed with the active assistance and advice from port authorities and survey companies to meet the requirements for a lightweight, robust, highly accurate and versatile system to replace the float, pressure and bubbler systems now in use. It has been extensively tested and copies of the test results are available from the company on request.

The system is quick and easy to install and no maintenance other than chart checking is required. The reference datum gives the unit excellent accuracy with no recalibration requirements. The telemetry output allows the chart to be printed any distance from the tide gauge using an SRD Tide Monitor Receiver, or for the connection of the tide monitor to a central Tide Data Control.

The use of low cost dot matrix printers with the self printing graph record removes the requirement for pre-printed charts and ensures accurate time and height records.

For permanent installations or where the line of sight of the transducer is likely to be interrupted, it is strongly recommended that the system operate down a plastic tube. The tubes can be supplied to suit the particular application. No additional maintenance is required for the tube, and no flow filter is required as with float systems. The transducer is mounted inside the tube forming a completely protected system.

Operation

The SRD Tide Monitor obtains the distance from the transducer to the sea surface by measuring the time elapsed between transmission and reception of an acoustic pulse. This time is converted to distance using a calibration velocity obtained from the fixed range target measurement. This distance is subtracted from the set datum to give the TIDE LEVEL which is then averaged over the selected period, displayed on the four digit display, printed on the graph and transmitted by whatever telemetry method is selected.

Installation

The fully waterproof transducer is installed at a convenient site, at a minimum height of 2M above the maximum tide height. The transducer has to be mounted within 2 degrees of horizontal to achieve optimum results. The view of the transducer should be unobstructed within a 10 degree conical angle to avoid interfering targets. The required datum, averaging interval, printing options, time and date are selected by a series of rotary switches.

Reference Target

The speed of sound in air is significantly temperature dependent. A temperature sensor in the transducer can go some way to compensate for temperature variations, but the most effective compensation is to use a fixed range target to measure the actual speed of sound. The target provided is fixed 75cm from the transducer and will correct the distances measured to within 0.05%. The correct operation of the reference target compensation is indicated on the tide graph by a target at a fixed range of 1.0M. This information can also be transmitted.

Pressure Gauges

Pressure gauges

- Bubbler gauges
- Transducer in the sea gauges
- ‘B’ (or ‘triple’) pressure systems

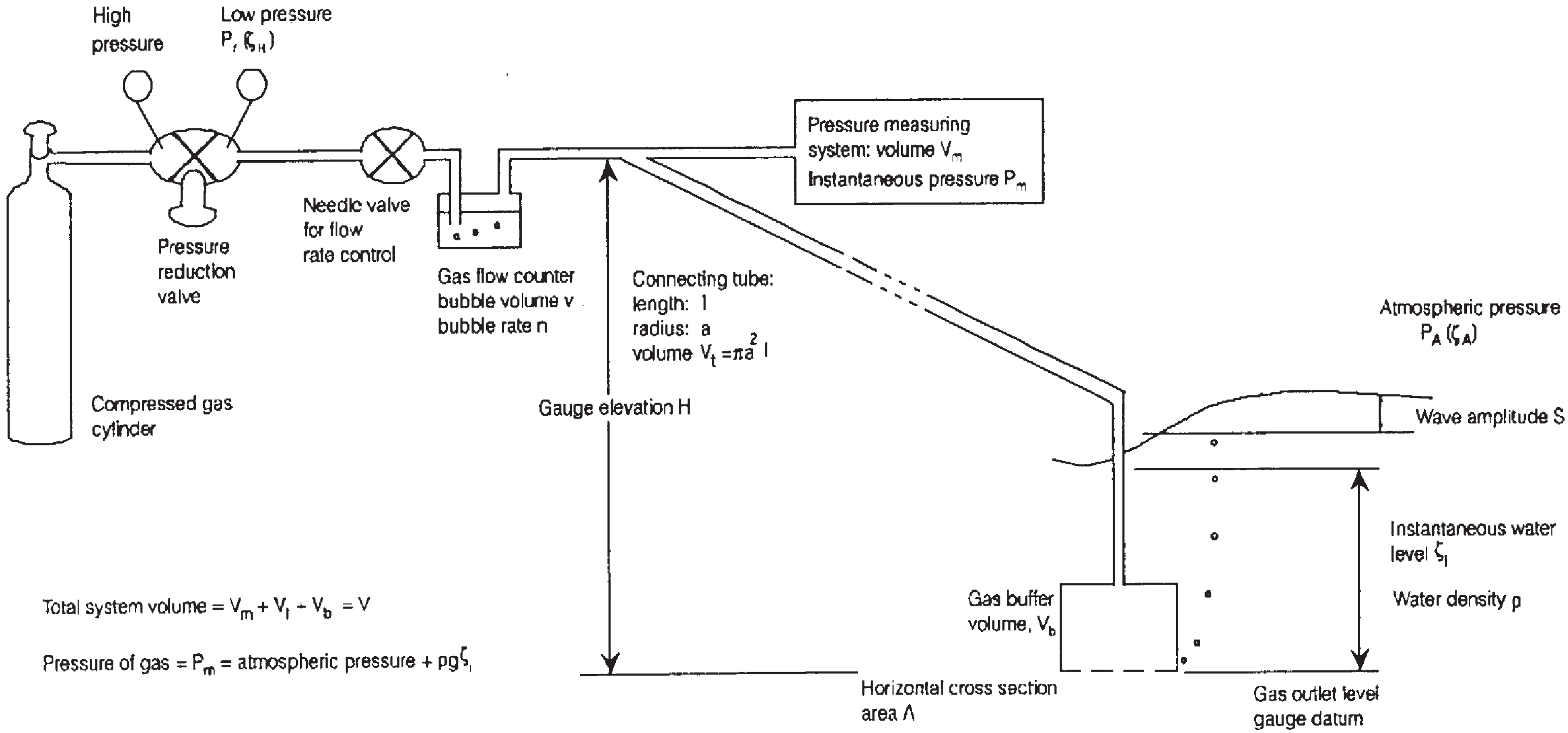
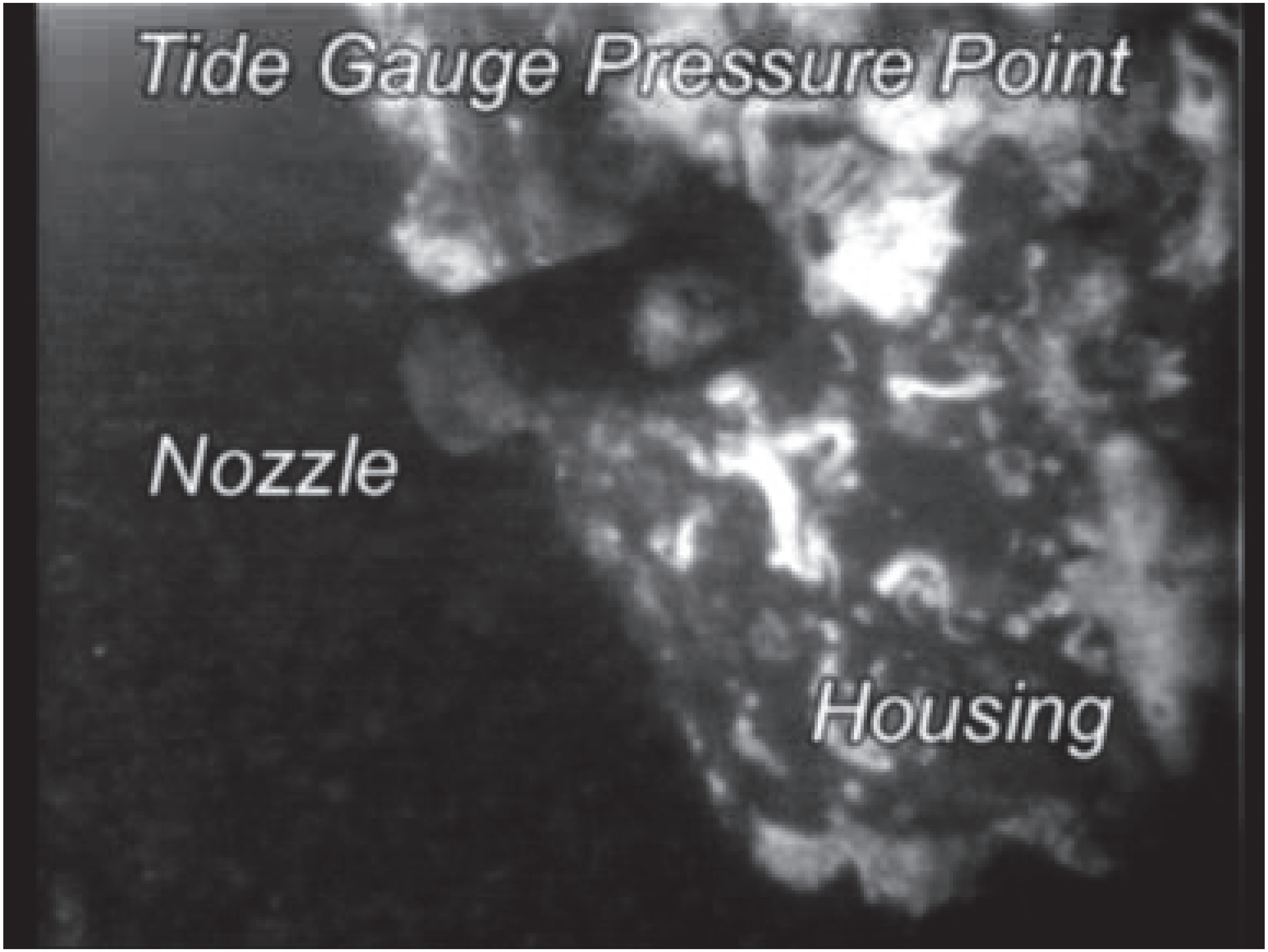
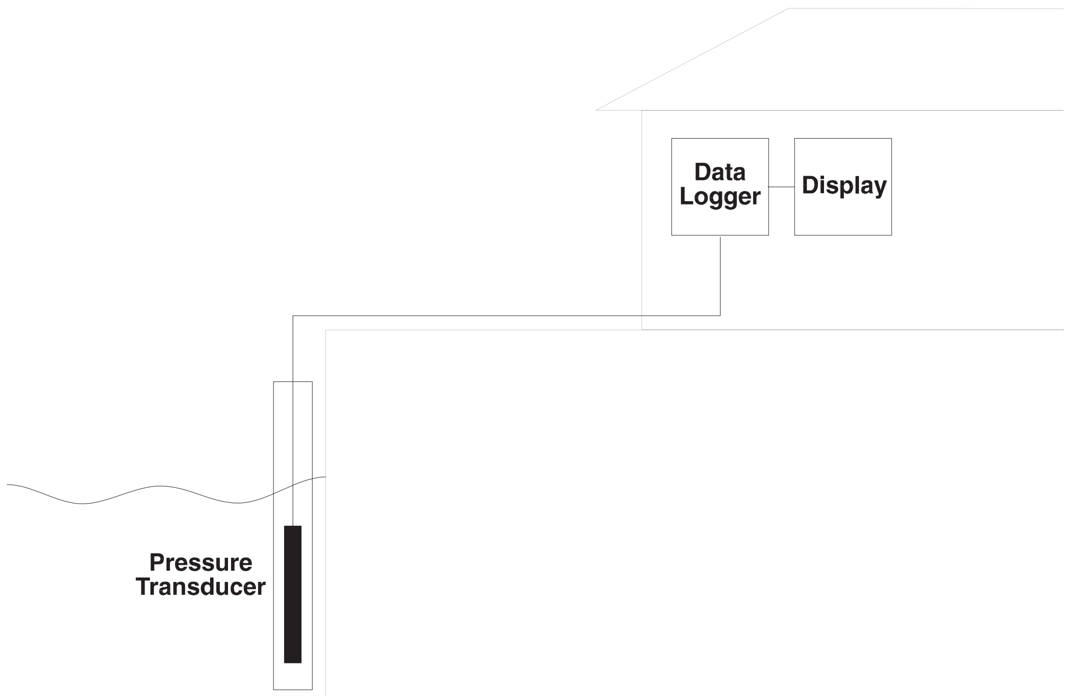


Figure 2.2

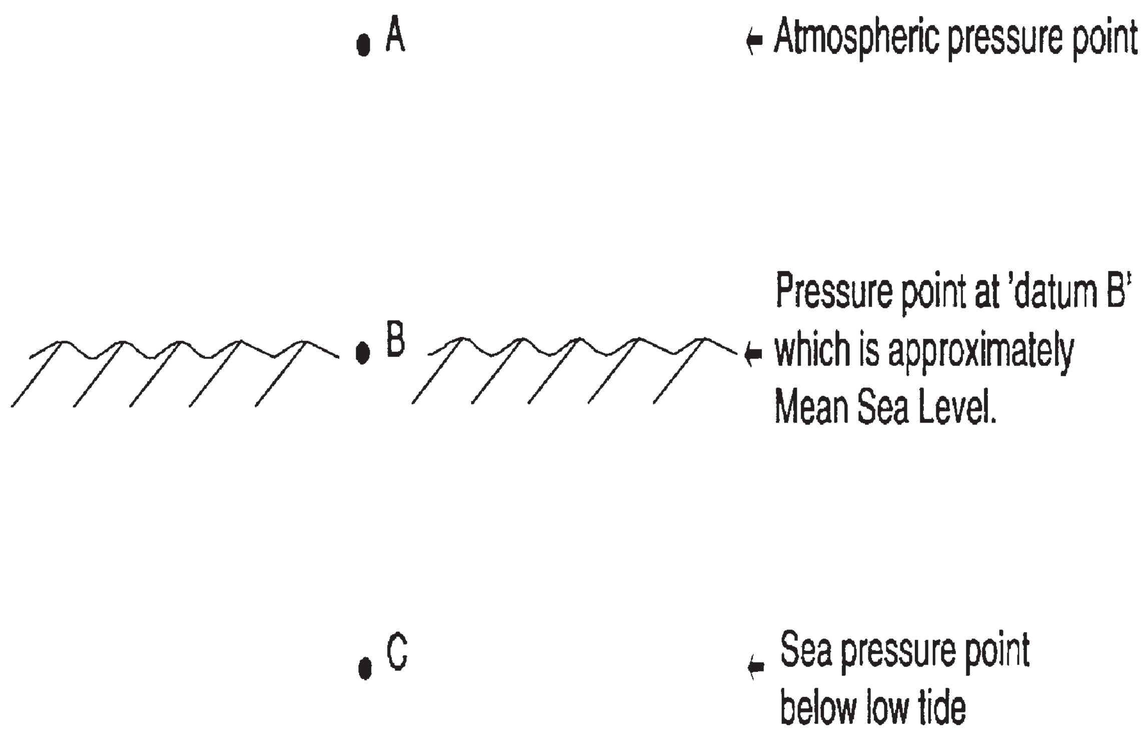
Schematic diagram of the pneumatic tide gauge and its principal system parameters


Tide Gauge Pressure Point
Nozzle
Housing



Schematic of the transducer in the sea pressure system

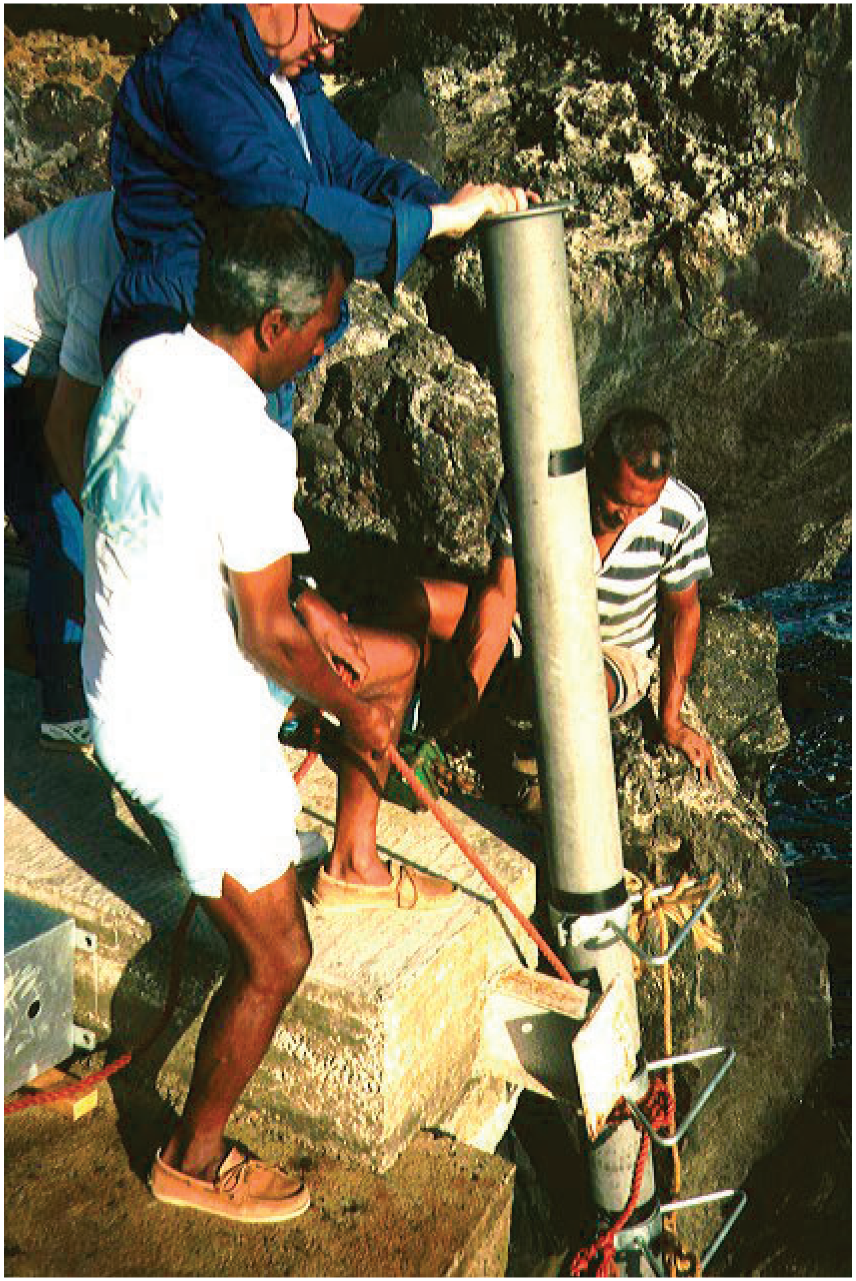
Most Appropriate for Tsunami Monitoring



Schematic illustration of a Triple (or ‘B’) pressure gauge setup containing three pressure transducers

-This can provide ongoing datum control to the ‘C’ data but can be very expensive

Installation of a
'B' gauge –
See IOC Manual
4 for more
details



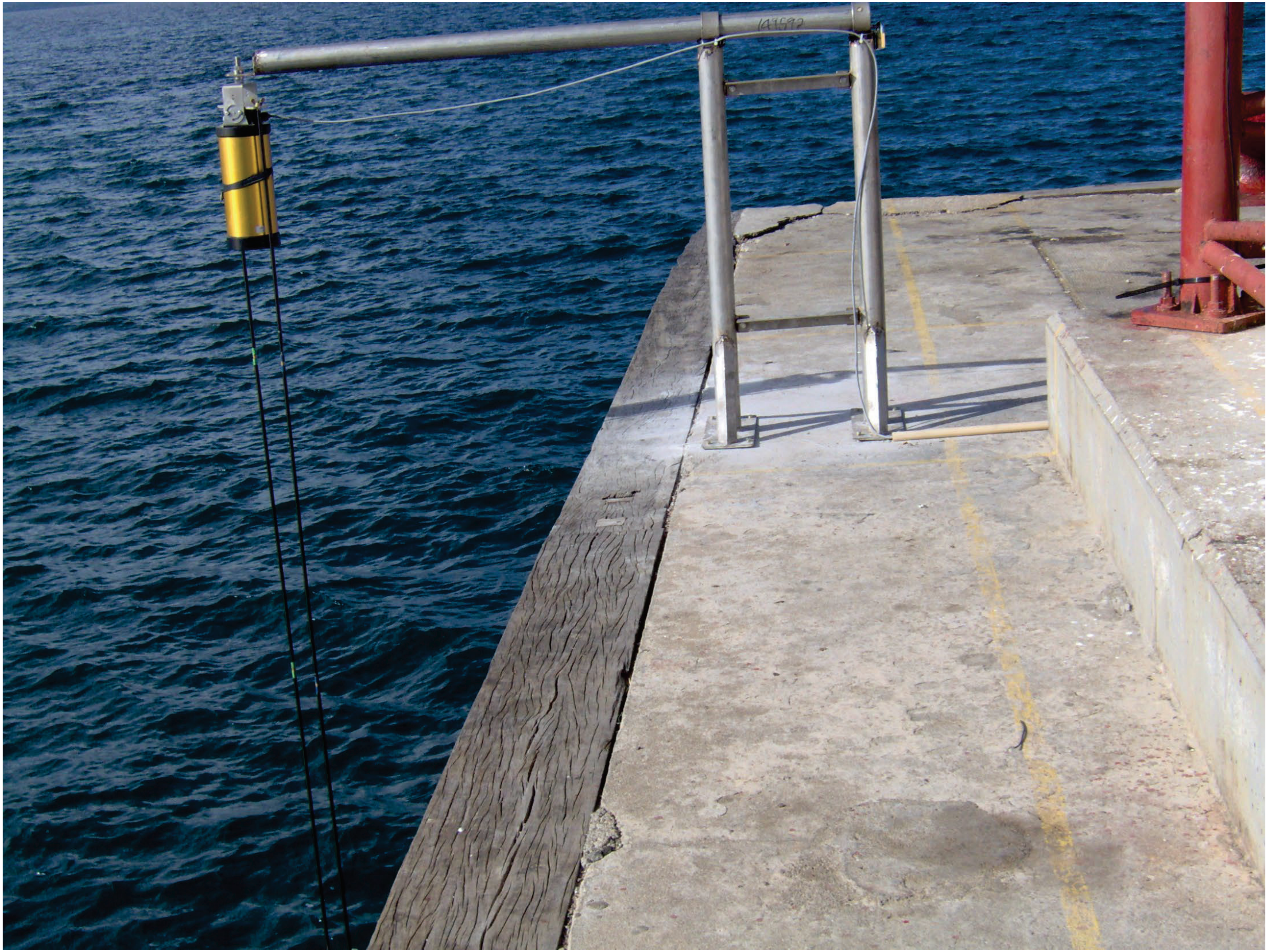
Radar Gauges

Merits of Radar Gauges

- Relatively cheap
- Easily installed (no need for divers or stilling wells etc.)
- Digital so can be ‘real time’
- New technology, but experience so far generally favourable
- Several manufacturers
- But that means not all can be rigorously tested

Liverpool - UK

South Africa




29 7:52 AM

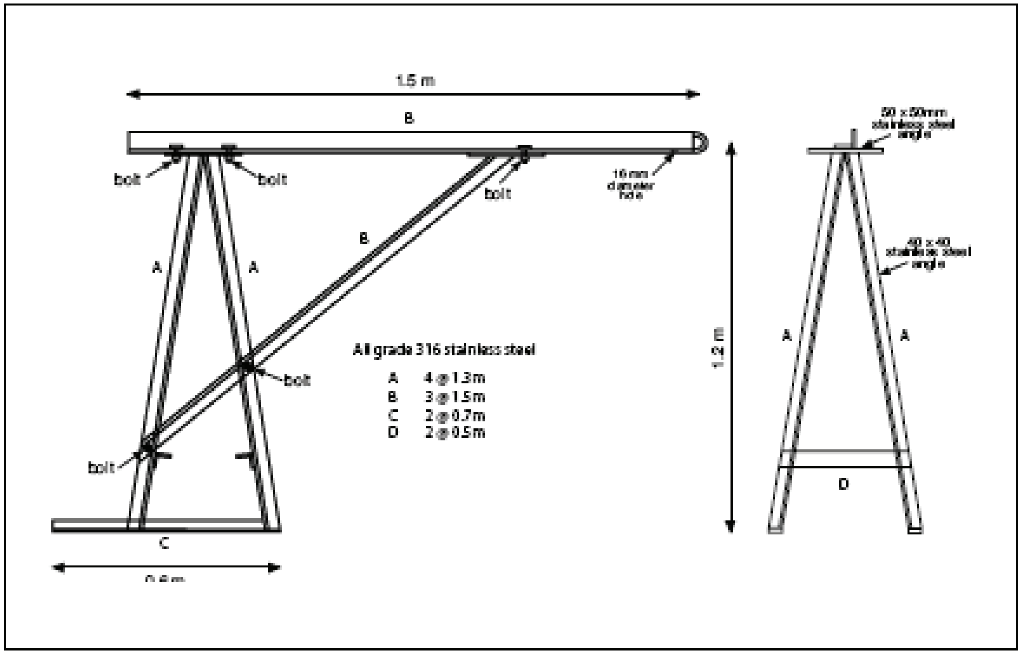

MHF1

Kirinda – Sri Lanka

Infrastructure needed

- An arm for the radar gauge
- Mountings for the pressure sensors (one below low tide and one at approximately MSL)
- A simple stilling well for calibration checks

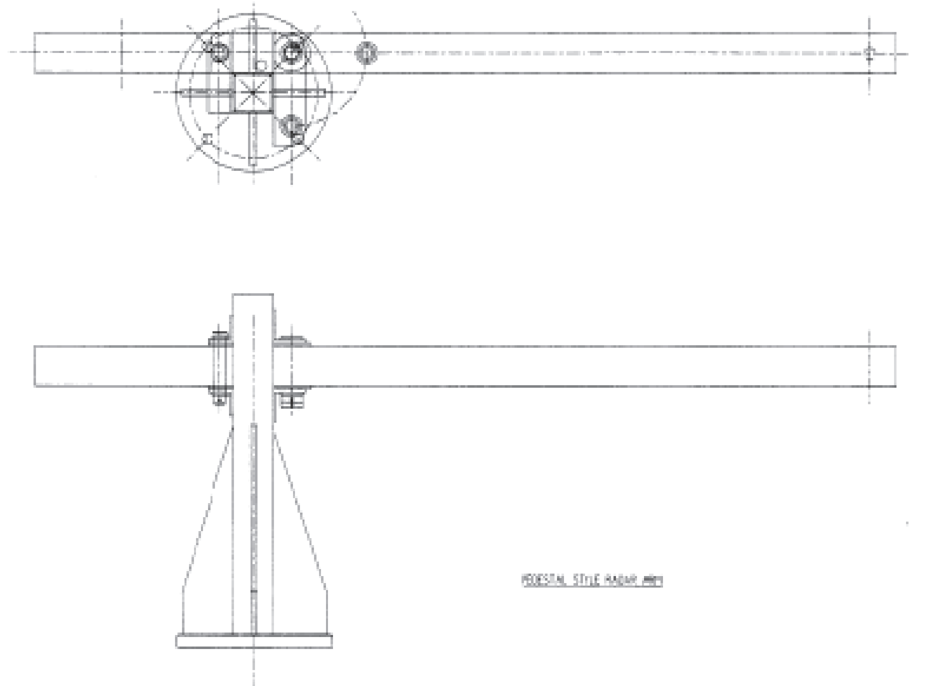
- Also power etc.
- Note that technical details will be discussed by Peter Foden and Ruth Farre later in the week



◄ Assembled davit

Stainless steel self-tapping anchor bolt ►

As used at Pemba

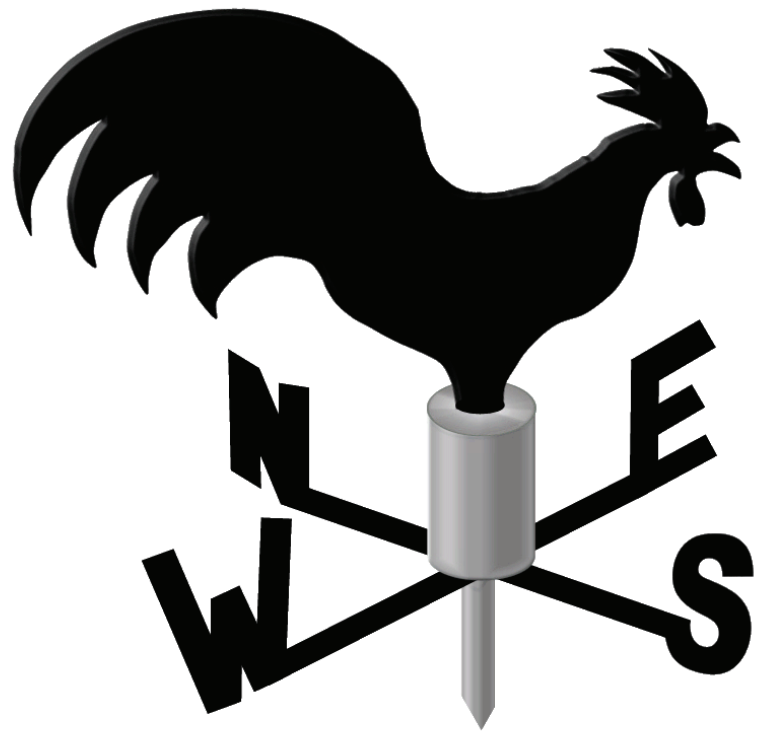


As used at Liverpool

Other Instruments

Wind Vane

A wind vane indicates in what direction the wind is traveling.

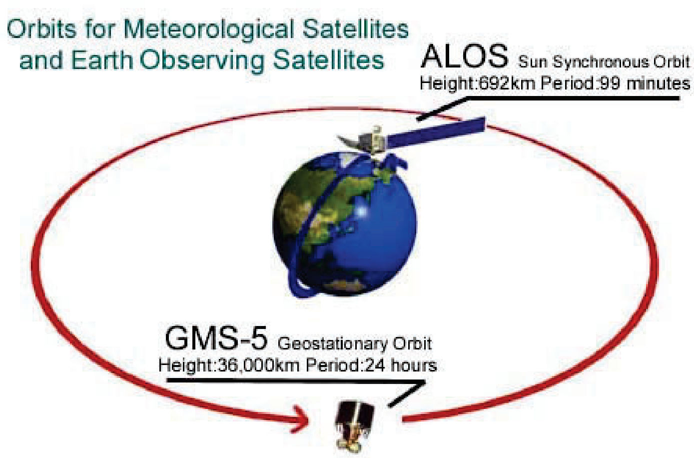


Weather Balloon

- A Weather balloon is a mobile weather station sent up to measure atmospheric pressures, temperature, wind speeds and humidity.

Satellite

- Weather satellites are used for viewing large weather systems on Earth such as hurricanes and other cloud formations.



Unit 3

S7–S9

- S7 :SLO1- Ice probes and sediment cover
  SLO2- Climate feed back
- S8 :SLO1- water vapour feedback
  SLO 2- Ice Albedo feedback
- S9: SLO1- Vulnerability assessment
  SLO2- case study on Vulnerability assessment- flood, drought and heat waves

Ice core

- They contain layer upon layer of snow that fell, never melted, and compacted into glacial ice. Within this ice are clues to past climate known as proxies. For example, gas bubbles trapped in the ice contain chemical clues that reveal past temperature.

Ice core Data

- The amount of dust in each annual layer provides information about airborne continental dust and biological material, volcanic ash, sea salts, cosmic particles, and isotopes produced by cosmic radiation that were in the atmosphere at the time the dust was deposited in the ice.

Sediment cores

- These cores are long cylinders of the earth's crust, drilled up from beneath the seafloor. The cores are arranged end-to-end, they show a glimpse of the Earth's past geology and climate.
- Scientists collect long sediment cores and examine the materials trapped within, to reconstruct past ocean conditions. The varieties and concentration of certain microorganisms record past changes in ocean temperature and composition.

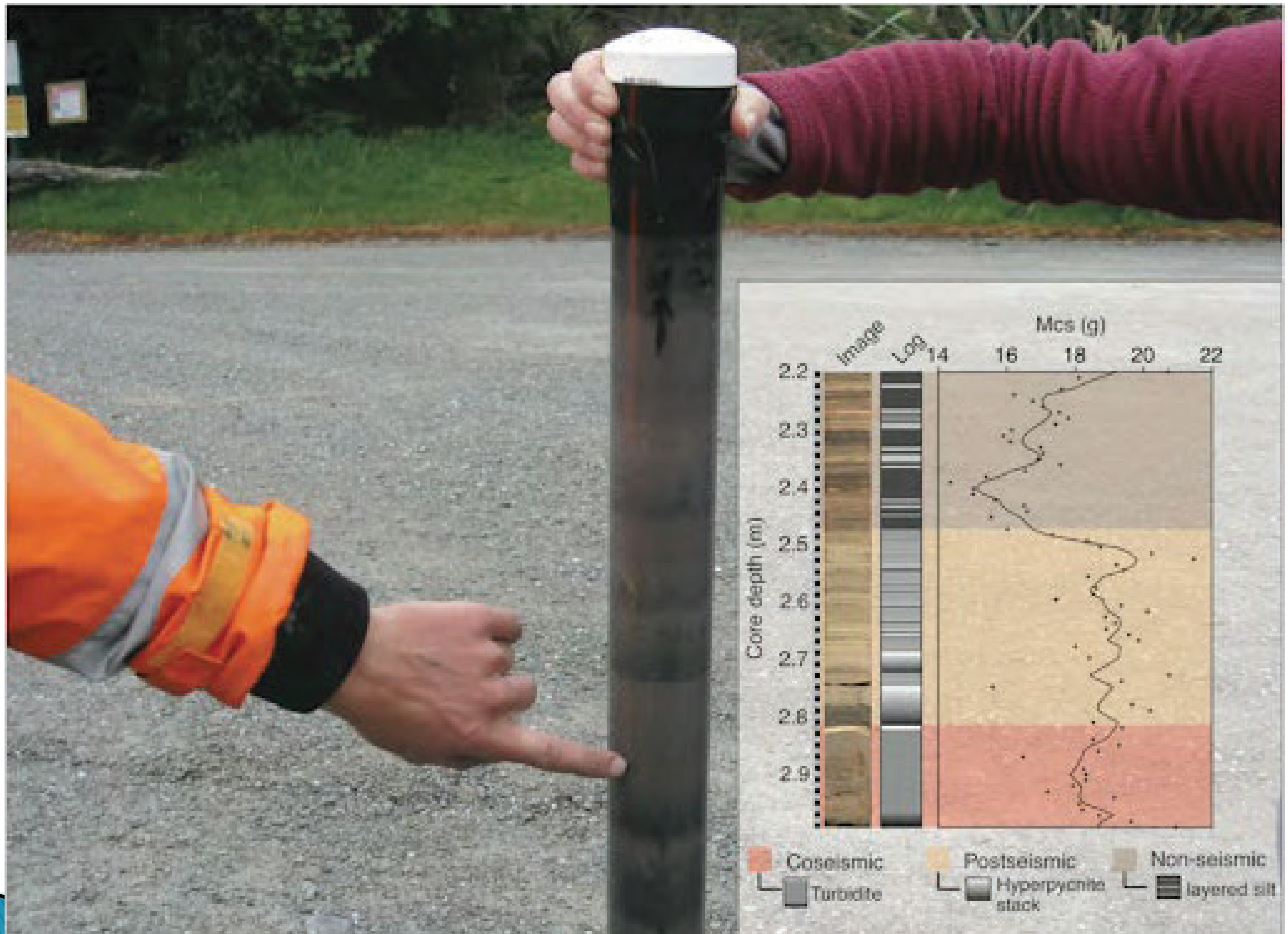


Image
Log
Mcs (g)
14
16
18
20
22
2.2
2.3
2.4
2.5
2.6
2.7
2.8
2.9
Core depth (m)
Coseismic
Turbidite
Postseismic
Hyperpycnite stack
Non-seismic
layered silt

- Sediment cores are collected by hammering 1-m sections of 3 inch (7.6 cm) aluminum pipe into the subsurface, capping the pipe, and extracting it using ropes and a farm jack.
- Sediment samples were wet sieved through 250 μm and 64 μm sieves to separate course from fine fractions.

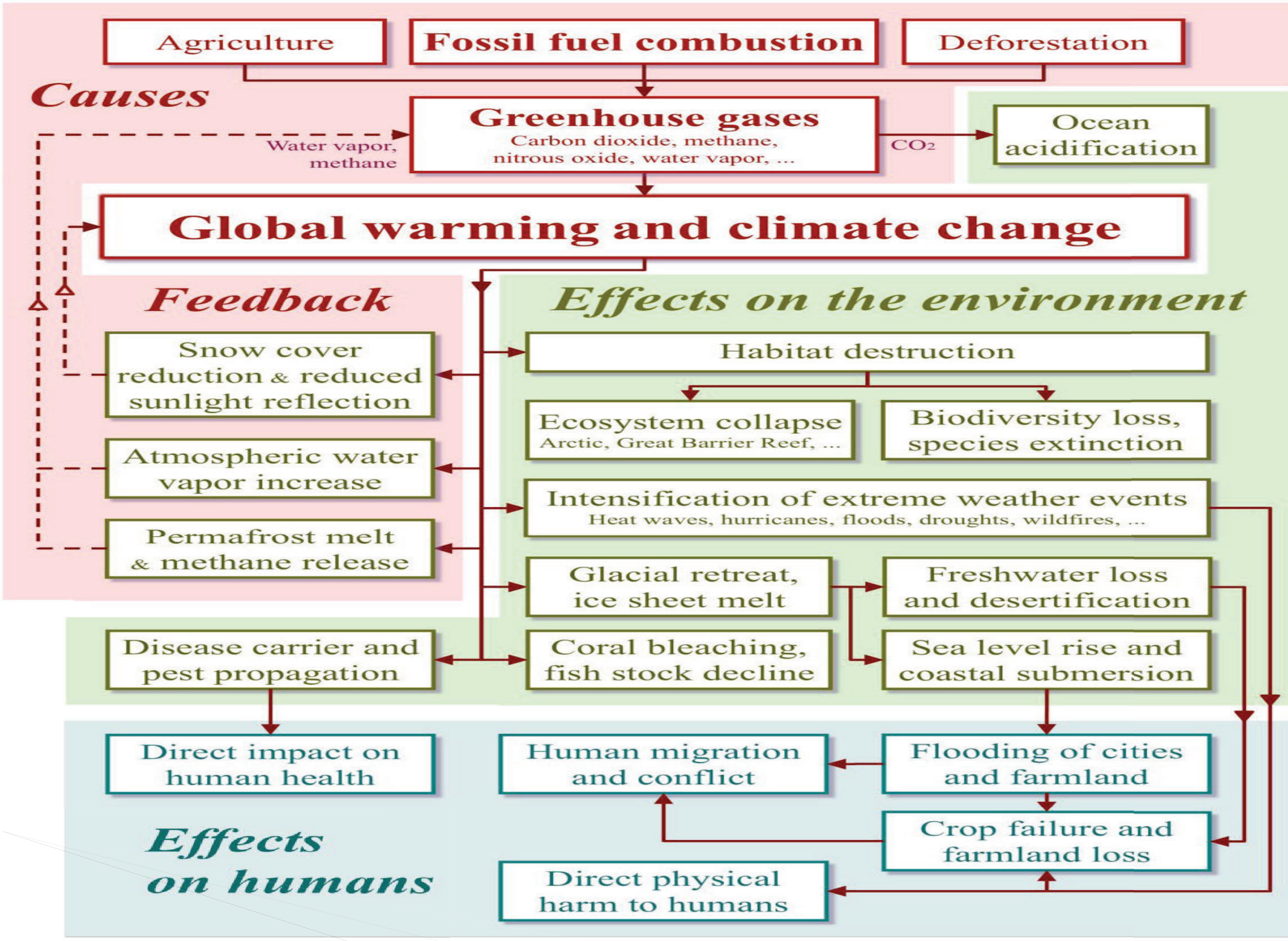
Climate feedback

- Climate feedback is important in the understanding of global warming because feedback processes may amplify or diminish the effect of each climate forcing.
- The term "forcing" means a change which may "push" the climate system in the direction of warming or cooling.
- An example of a climate forcing is increased atmospheric concentrations of greenhouse gases. By definition, forcings are external to the climate system while feedbacks are internal; in essence, feedbacks represent the internal processes of the system.

https://www.youtube.com/watch?v=363HhzYzJlA

Global warming and climate change

Causes and effects



- Feedback occurs when outputs of a system are routed back as inputs as part of a chain of cause-and-effect that forms a circuit or loop. The system can then be said to feed back into itself.
- Feedback in general is the process in which changing one quantity changes a second quantity, and the change in the second quantity in turn changes the first.

Water vapor feedback

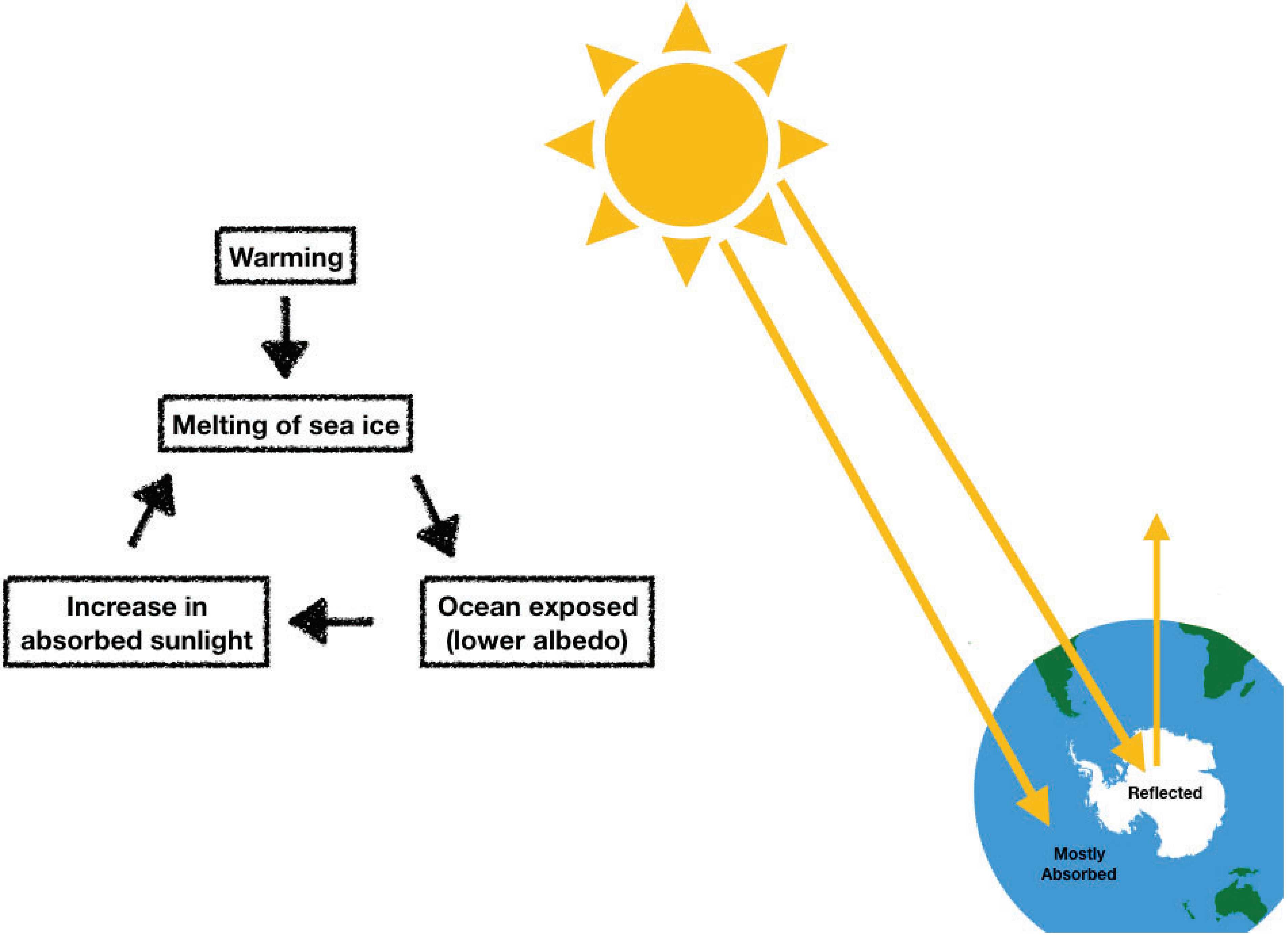
- If the atmospheres are warmed, the saturation vapor pressure increases, and the amount of water vapor in the atmosphere will tend to increase.
- Since water vapor is a greenhouse gas, the increase in water vapor content makes the atmosphere warm further; this warming causes the atmosphere to hold still more water vapor (a positive feedback).
- The result is a much larger greenhouse effect than that due to CO_2 alone.

Contd.

- When ice melts, land or open water takes its place.
- Both land and open water are on average less reflective than ice and thus absorb more solar radiation.
- This causes more warming, which in turn causes more melting, and this cycle continues.
- During times of global cooling, additional ice increases the reflectivity which reduces the absorption of solar radiation which results in more cooling in a continuing cycle.

Ice-albedo feedback

- Ice-albedo feedback is a positive feedback climate process where a change in the area of ice caps, glaciers, and sea ice alters the albedo and surface temperature of a planet. Ice is very reflective, therefore some of the solar energy is reflected back to space.
- Ice-albedo feedback plays an important role in global climate change.


Warming
Melting of sea ice
Ocean exposed (lower albedo)
Increase in absorbed sunlight
Reflected
Mostly Absorbed

Vulnerability assessment

- Methods of vulnerability assessment have been developed over the past several decades in natural hazards, food security, poverty analysis, sustainable livelihoods and related fields. These approaches—each with their own nuances—provide a core set of best practices for use in studies of climate change vulnerability and adaptation

- Climate change vulnerability assessments help establish understanding of the extent to which changing climate will affect the system in question (e.g. basin, water use sector, country, city, etc.).
- Three key components of vulnerability – exposure, sensitivity and adaptive capacity.

- Thus vulnerability assessments eg : in temperature and rainfall (exposure), assessing the characteristics of the system itself and how it may respond to such hazards is (sensitivity), as well its ability to deal with the anticipated impacts is (adaptive capacity).

- In the context of water resource management, vulnerability assessments may focus system vulnerability to reduced water availability, increased seasonal variability, changes in water quality, vulnerability to increased seasonal water variability, but also vulnerability to extreme events such as floods and droughts, amongst other things

- **Vulnerability Assessments can support adaptation planning in several ways:**
- Identify areas most likely to be impacted by projected changes in climate;
- Build an understanding of why these areas are vulnerable, including the interaction between climate change, non-climatic stressors, and cumulative impacts;
- Assess the effectiveness of previous coping strategies in the context of historic and current changes in climate; and
- Identify and target adaptation measures to systems with the greatest vulnerability.

UNIT-4

CLR-5 : Address to different mitigation measures against global warming and their protocol

S1; SLO1: Climate change mitigations and adaptations

SLO2: Climate change Organization and programmes

S1- SLO-1 What is climate change Mitigation and Adaptation?

- Reducing emissions of and stabilizing the levels of heat-trapping greenhouse gases in the atmosphere **("mitigation")**;
- Adapting to the climate change already in the pipeline **("adaptation")**.

Adaptation:

- The goal is to reduce our vulnerability to the harmful effects of climate change (like sea-level encroachment, more intense extreme weather events or food insecurity).
- It also encompasses making the most of any potential beneficial opportunities associated with climate change (for example, longer growing seasons or increased yields in some regions).
- While climate change is a global issue, it is felt on a local scale. Cities and municipalities are therefore at the frontline of adaptation. In the absence of national or international climate policy direction, cities and local communities around the world have been focusing on solving their own climate problems. They are working to build flood defenses, plan for heat waves and higher temperatures, install water-permeable pavements to better deal with floods and storm water and improve water storage and use.

Mitigation:

- Reducing climate change – involves reducing the flow of heat-trapping greenhouse gases into the atmosphere, either by reducing sources of these gases (for example, the burning of fossil fuels for electricity, heat or transport) or enhancing the "sinks" that accumulate and store these gases (such as the oceans, forests and soil).

- The goal of mitigation is to avoid significant human interference with the climate system, and “stabilize greenhouse gas levels in a timeframe sufficient to allow ecosystems to adapt naturally to climate change, ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner”

How to mitigate climate change?

These are some of the mitigation measures that can be taken to avoid the increase of pollutant emissions:

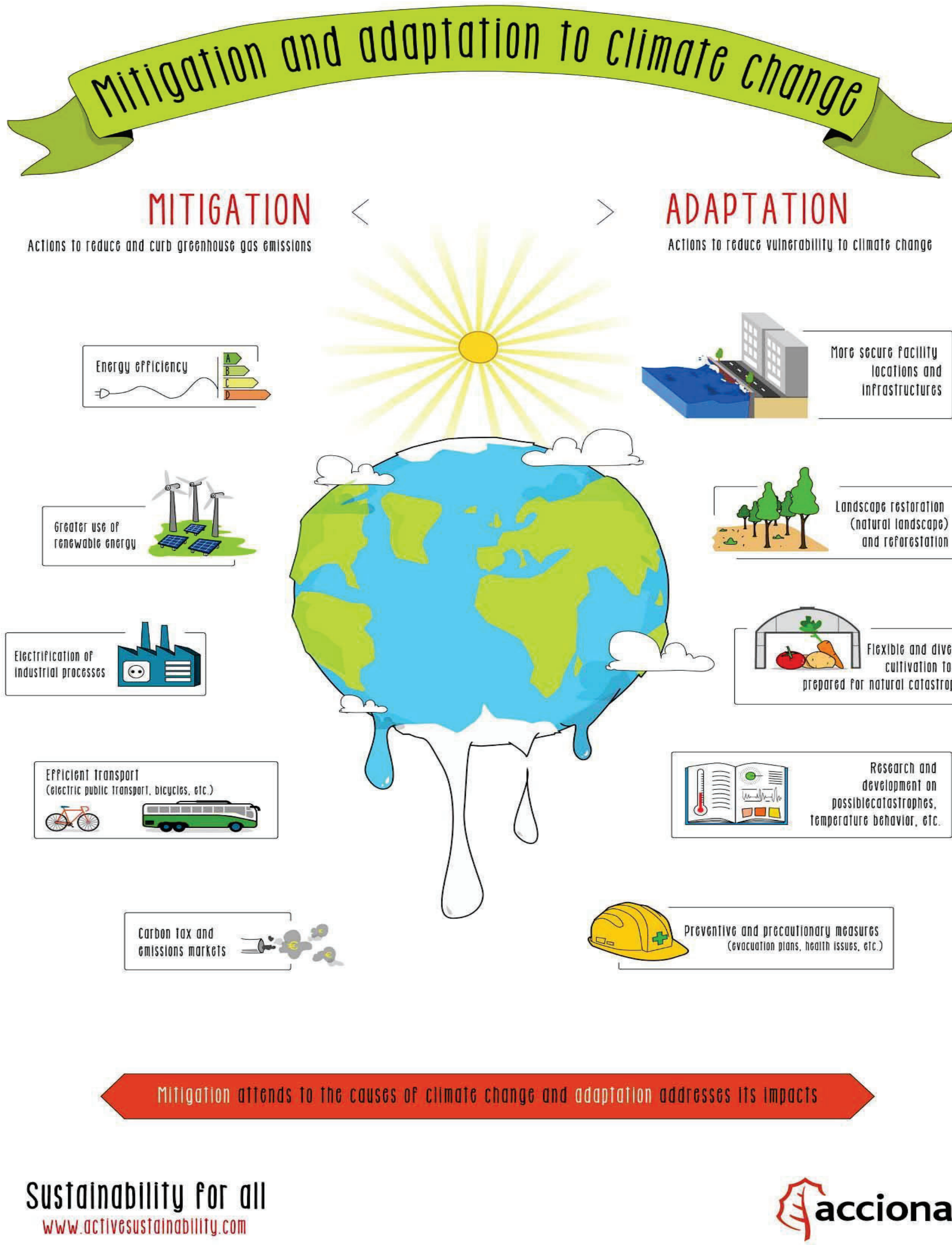
1. Practice Energy efficiency
2. Greater use of renewable energy
3. Electrification of industrial processes
4. Efficient means of transport implementation: electric public transport, bicycle, shared cars ...
5. Carbon tax and emissions markets

Adaptation to climate change:

In terms of adaptation measures, there are several actions that help reducing vulnerability to the consequences of climate change:

1. More secure facility locations and infrastructures
2. Landscape restoration (natural landscape) and reforestation
3. Flexible and diverse cultivation to be prepared for natural catastrophes
4. Research and development on possible catastrophes, temperature behavior, etc.
5. Preventive and precautionary measures (evacuation plans, health issues, etc.)

In this info graphic you can learn what are the measures of adaptation and mitigation to climate change.


Mitigation and adaptation to climate change
MITIGATION
Actions to reduce and curb greenhouse gas emissions
ADAPTATION
Actions to reduce vulnerability to climate change
Energy efficiency
Greater use of renewable energy
Electrification of industrial processes
Efficient transport (electric public transport, bicycles, etc.)
Carbon tax and emissions markets
More secure facility locations and infrastructures
Landscape restoration (natural landscape) and reforestation
Flexible and diverse cultivation to be prepared for natural catastrophes
Research and development on possiblecatastrophes, temperature behavior, etc.
Preventive and precautionary measures (evacuation plans, health issues, etc.)
Mitigation attends to the causes of climate change and adaptation addresses its impacts
Sustainability for all
www.activesustainability.com
acciona

S1- SLO-2 Climate change organization and programmes:

U.S. Environmental Protection Agency (EPA) - Climate Change Science

This section of the EPA website offers scientific information and data on climate change in the past and projections for the future. Specific information about the U.S. government's role in conducting and evaluating science as well as EPA's role in these efforts can be found on the Climate Change Science Program and EPA Research and Assessment pages in the Policy section

NOAA Education - Climate Change and Our Planet

This collection of resources from the National Oceanic and Atmospheric Administration (NOAA) are designed for teachers to use in the classroom or as background reference material

Intergovernmental Panel on Climate Change (IPCC)

The Intergovernmental Panel on Climate Change was established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) to provide objective reports on climate change and its potential environmental and socio-economic consequences. Geography has played a central role in the IPCC's activities. Dr. Thomas Wilbanks, past president of the AAG and recipient of numerous honors in the field of geography, served as lead author of a chapter of the Fourth Assessment Report which was awarded the Nobel Prize in 2007.

National Center for Atmospheric Research (NCAR)

NCAR provides the university science and teaching community with the tools, facilities, and support required to perform innovative research. Through NCAR, scientists gain access to high-performance computational and observational facilities, such as supercomputers, aircraft and radar - resources researchers need to improve human understanding of atmospheric and Earth system processes. NCAR also houses the Geographical Information Systems (GIS) Strategic Initiative, an interdisciplinary effort to foster collaborative science, spatial data interoperability, and knowledge sharing with GIS, within the field of atmospheric research.

Center for Remote Sensing of Ice Sheets (CReSIS)

CReSIS was established by the NSF in 2005 and is headquartered at the University of Kansas. The Center uses a variety of geographic tools and technologies (including Geographic Information Systems, Remote Sensing, and spatial statistics) to complement its goal of measuring and predicting the response of sea level change to the mass balance of ice sheets in Greenland and Antarctica.

National Climate Data Center (NCDC)

NCDC is the world's largest active archive of weather data. NCDC produces numerous climate publications and responds to data requests from all over the world.

World Meteorological Organization

The World Meteorological Organization (WMO) is a specialized agency of the United Nations. It is the UN system's authoritative voice on the state and behavior of the Earth's atmosphere, its interaction with the oceans, the climate it produces and the resulting distribution of water resources.

United Nations Environment Programme (UNEP), Climate Change

The UNEP Climate Change website serves as a gateway to UNEP activities related to adaptation, mitigation, science, and communication/outreach on the effects of climate change, as well as programs to reduce emissions from deforestation and degradation of ecosystems

United Nations Framework Convention on Climate Change (UNFCCC)

The UNFCCC supports UN bodies involved in the climate change process. This UNFCCC website contains numerous resources, such as introductory and in-depth publications, the official UNFCCC and Kyoto Protocol texts and a search engine to the UNFCCC library.

Pew Center on Global Climate Change

The Pew Center on Global Climate Change brings together business leaders, policy makers, scientists, and other experts to bring a new approach to a complex and often controversial issue. The Center conducts analyses of key climate issues, works to keep policy makers informed, engages the business community in the search for solutions, and reaches out to educate the key audiences.

Food and Agriculture Organization (FAO) of the United Nations – Climate Change

FAO's activities in climate change are spread over all departments and cover all agricultural sectors (i.e. agriculture, livestock, forestry, fisheries) as well as highly cross-sectoral topics (e.g. bioenergy, biodiversity, climate risk management). The Interdepartmental Working Group on Climate Change and the Environment, Climate Change and Bioenergy Division (NRC) play an important role in coordinating these activities.

National Snow and Ice Data Center (NSIDC)

The NSIDC supports research on snow, ice, glaciers, frozen ground, and climate interactions that make up Earth's cryosphere. Dr. Mark Serreze, NSIDC Director, has carried out significant geographic research on climate warning in the Arctic and its implications.

International Geosphere-Biosphere Programme (IGBP)

IGBP is a research programme that studies the phenomenon of Global Change. IGBP provides scientific knowledge to improve the sustainability of the living Earth. IGBP studies the interactions between biological, chemical and physical processes and interactions with human systems and collaborates with other programmes to develop and impart the understanding necessary to respond to global change.

What is the IPCC?

The Intergovernmental Panel on Climate Change (IPCC) is the international body for assessing the science related to climate change. The IPCC was set up in 1988 by the World Meteorological Organization (WMO) and United Nations Environment Programme (UNEP) to provide policymakers with regular assessments of the scientific basis of climate change, its impacts and future risks, and options for adaptation and mitigation.

IPCC assessments provide a scientific basis for governments at all levels to develop climaterelated policies, and they underlie negotiations at the UN Climate Conference – the United Nations Framework Convention on Climate Change (UNFCCC). The assessments are policy-relevant but not policy-prescriptive: they may present projections of future climate change based on different scenarios and the risks that climate change poses and discuss the implications of response options, but they do not tell policymakers what actions to take.

The IPCC embodies a unique opportunity to provide rigorous and balanced scientific information to decision-makers because of its scientific and intergovernmental nature. Participation in the IPCC is open to all member countries of the WMO and United Nations. It currently has 195 members. The Panel, made up of representatives of the member states, meets in Plenary Sessions to take major decisions. The IPCC Bureau, elected by member governments, provides guidance to the Panel on the scientific and technical aspects of the Panel's work and advises the Panel on related management and strategic issues .

IPCC assessments are written by hundreds of leading scientists who volunteer their time and expertise as Coordinating Lead Authors and Lead Authors of the reports. They enlist hundreds of other experts as Contributing Authors to provide complementary expertise in specific areas.

IPCC reports undergo multiple rounds of drafting and review to ensure they are comprehensive and objective and produced in an open and transparent way. Thousands of other experts contribute to the reports by acting as reviewers, ensuring the reports reflect the full range of views in the scientific community. Teams of Review Editors provide a thorough monitoring mechanism for making sure that review comments are addressed

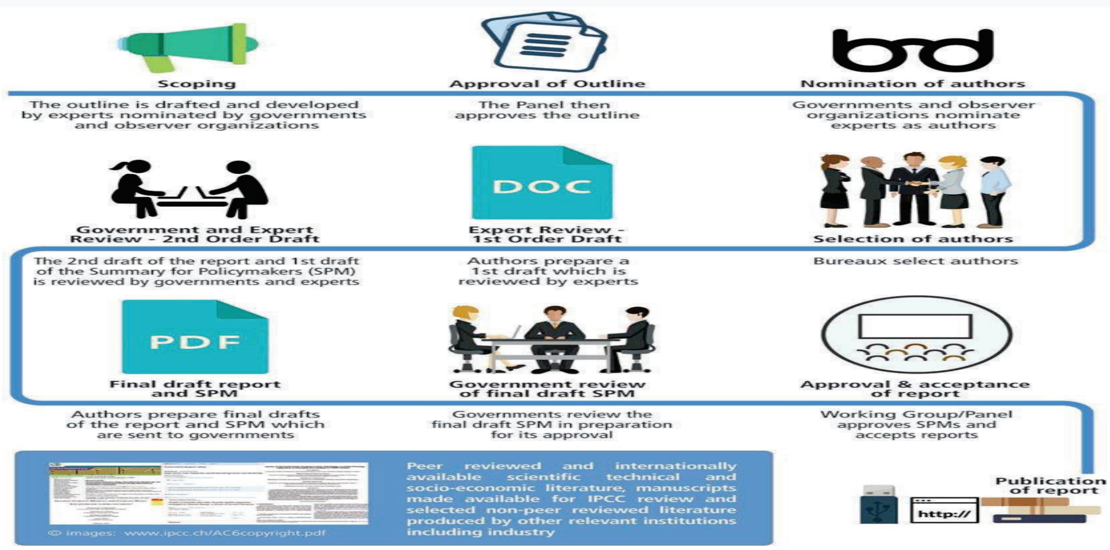
S2- SLO-1 IPCC -Intergovernmental Panel on Climate Change and assessment report highlights

Assessment Reports consist of contributions from each Working Group and a Synthesis Report integrating these contributions and any Special Reports prepared in that assessment cycle. The IPCC also produces Special Reports on specific issues agreed by its member governments and Methodology Reports that provide practical guidelines for the preparation of greenhouse gas inventories. Each IPCC report starts with a scoping meeting to develop a draft outline. Experts nominated by member governments, Observer Organizations and the Bureau and selected by the relevant Bureau prepare a draft outline of the report for the Panel. Based on the report of the scoping meeting, the Panel decides whether work should continue on preparing the report and agrees on its scope, outline and work plan including schedule and budget. Member governments, Observer Organizations and the Bureau (Co-Chairs and Vice-Chairs) of the Working Group or Task Force producing the report then draw up lists of experts, from which the relevant Bureau or Bureaux select the authors of the report. The Bureau may consider other experts known through their publications and work. Scientists who are nominated but not selected as authors are invited to register as expert reviewers for the report. The selection of authors is a careful process that aims to reflect the range of scientific, technical and socio-economic expertise and to strike a good balance in terms of gender, geographical representation, and representation of experts from developing countries, developed countries and those with economies in transition. It is also important to have a mixture of authors with and without previous experience in the IPCC.

About Reports

The IPCC prepares comprehensive Assessment Reports about the state of scientific, technical and socio-economic knowledge on climate change, its impacts and future risks, and options for reducing the rate at which climate change is taking place. The IPCC also produces Special Reports on specific topics agreed by its member governments, as well as Methodology Reports that provide practical guidelines for the preparation of greenhouse gas inventories. The Synthesis Report integrates the Assessment Report and any Special Reports prepared during an assessment cycle. A report consists of a number of chapters. It may also include a Technical Summary, prepared by the authors. Assessment Reports, Special Reports and the Synthesis Report include a Summary for Policymakers that is prepared by the authors and approved line by line by a Plenary Session of the IPCC with the delegates in dialogue with the authors. Since the Fifth Assessment Report, the Summary for Policymakers has generally included headline statements, providing a top-level summary and narrative of the key findings. Methodology Reports include an Overview Chapter corresponding to the Summary for Policymakers.

Preparation of Reports



Once the author teams are selected, they begin work on a First Order Draft of the report based on an assessment of all relevant scientific, technical and social-economic information. Although priority is given to peer-reviewed literature, the IPCC recognizes that non-peer reviewed literature, such as reports from governments and industry, can be crucial for expanding the breadth and depth of the assessment. Use of this literature brings with it an extra responsibility for the author teams to ensure the quality and validity of cited sources. Review is an essential part of the IPCC process and ensures that the assessment of literature is transparent, objective and complete. In the first stage of review, experts from around the world are invited to comment on the accuracy and completeness of the scientific, technical and socio-economic content and the overall balance of the drafts. These expert reviewers self-nominate and are accepted by the IPCC on the basis of relevant expertise. Each and every review comment is considered by the authors in the preparation of a Second Order Draft of the report. At the same time, the authors also prepare a first draft of the Summary for Policymakers (SPM). This is a distillation of the main policy-relevant findings from the underlying report. The Second Order Draft of the report and the first draft of the SPM are then opened up to review by experts and governments, simultaneously. Each chapter of an IPCC report has two or more Review Editors assigned to it, who are selected by the Bureau on the basis of their expertise and whose job it is to make sure that all comments received during the reviews are taken into account by the author teams. All review comments, and the responses by authors, are published on completion of a report. In the assessment, authors express the confidence with which a statement is made, reflecting agreement in the scientific literature and the evidence available. They use calibrated language to communicate certainty in key findings. Following the second stage of review, the authors then prepare the final drafts of the report and Summary for Policymakers. These are distributed once again to governments, who provide comments on the Summary for Policymakers. Finally, all IPCC reports must be formally endorsed by the responsible Working Group or Working Groups or Task Force and by the Panel at an IPCC Plenary Session. There are three levels of endorsement:

1. “Approval” means that the material has been subjected to detailed line-by-line discussion and agreement. This is the procedure used for the Summary for Policymakers.
2. “Adoption” describes a section-by-section endorsement. This is used for the Synthesis Report and overview chapters of Methodology Reports.

3. “Acceptance” signifies that the material has not been subject to line-by-line or section-by-section agreement but nevertheless presents a comprehensive, objective and balanced assessment of the subject matter.

Special rules apply to the Synthesis Report, which integrates the findings of the Assessment Report and any Special Reports prepared during an assessment cycle. These are written in a non-technical style suitable for policymakers and address a broad range of policy-relevant but policy-neutral questions approved by the Panel. The Synthesis Report consists of two sections: a Summary for Policymakers and a longer report. The IPCC Chair leads a writing team whose composition is agreed by the Bureau after nominations by the IPCC Chair in consultation with the Working Group Co-Chairs. It typically draws on members of the Bureau, authors of the Assessment Report, and experts from the Technical Support Unit and Secretariat for its Core Writing Team. The writing team prepares a draft of both the longer report and Summary for Policymakers, which undergo simultaneous review by governments and experts. The report is then revised and submitted to the Panel for consideration. The Panel approves the Summary for Policymakers line by line, and the adopts the longer report section by section – roughly one page at a time.

https://www.youtube.com/watch?v=z_JMC9fhADA

S2-SLO-2 IPCC Assessment Report-1- 1990 & Sub1992

The **First Assessment Report** (**FAR**) of the Intergovernmental Panel on Climate Change (IPCC) was completed in 1990. It served as the basis of the United Nations Framework Convention on Climate Change (UNFCCC). This report had effects not only on the establishment of the United Nations Framework Convention on Climate Change (UNFCCC), but also on the first **conference of the parties** (COP), held in Berlin in 1995.

The report was issued in three main sections, corresponding to the three Working Groups of scientists that the **IPCC had established**.

- Working Group I: Scientific Assessment of Climate Change
- Working Group II: Impacts Assessment of Climate Change
- Working Group III: The IPCC Response Strategies

Each section included a summary for policymakers. This format was followed in subsequent Assessment Reports.

The executive summary of the policymakers' summary of the WG I report includes:

- We are certain of the following: there is a natural greenhouse effect...; emissions resulting from human activities are substantially increasing the atmospheric concentrations of the **greenhouse gases:** CO_2, methane, CFCs and nitrous oxide. These increases will enhance the greenhouse effect, resulting on average in an additional warming of the Earth's surface. The main greenhouse gas, water vapour, will increase in response to global warming and further enhance it.
- We calculate with confidence that: ...**CO_2 has been responsible** for over half the enhanced greenhouse effect; long-lived gases would require immediate reductions in emissions from human activities of over 60% to stabilise their concentrations at today's levels...
- Based on current models, we predict: under [BAU] increase of global mean temperature during the [21st] century of about **0.3 ºC per decade** (with an uncertainty range of 0.2 to 0.5 ºC per decade); this is greater than that seen over the past 10,000 years; under other ... scenarios which assume progressively **increasing levels of controls**, rates of increase in global mean temperature of about 0.2 ºC [to] 0.1 ºC per decade.
- There are **many uncertainties** in our predictions particularly with regard to the timing, magnitude and regional patterns of climate change, due to our incomplete understanding of: sources and **sinks of GHGs**; clouds; oceans; polar ice sheets.
- Our judgement is that: global mean surface air temperature has **increased by 0.3 to 0.6 ºC** over the last 100 years...; The size of this warming is broadly consistent with predictions of climate models, but it is also of the **same magnitude as natural climate** variability. Thus the observed increase could be largely due to this natural variability; alternatively this variability and other human factors could have offset a still larger human-induced greenhouse warming. The unequivocal detection of the enhanced greenhouse effect is not likely for a decade or more.
- under the IPCC business as usual emissions scenario, an average rate of **global mean sea level rise** of about **6 cm per decade over the next century** (with an uncertainty range of 3 – 10 cm per decade), mainly due to thermal expansion of the oceans and the melting of some land ice. The **predicted** rise is about 20 cm ... by 2030, and 65 cm by the end of the next century.

S3 SLO1: IPCC assessment report 2 - 1995

Key role regarding the adoption of Kyoto Protocol – COP meet

Cont…

This Report responds to the invitation for IPCC '… to provide a Special Report in 2018 on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways' contained in the Decision of the 21st Conference of Parties of the United Nations Framework Convention on Climate Change to adopt the Paris Agreement

The IPCC accepted the invitation in April 2016, deciding to prepare this Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. This Summary for Policymakers (SPM) presents the key findings of the Special Report, based on the assessment of the available scientific, technical and socio-economic literature relevant to global warming of 1.5°C and for the comparison between global warming of 1.5°C and 2°C above pre-industrial levels. The level of confidence associated with each key finding is reported using the IPCC calibrated language. The underlying scientific basis of each key finding is indicated by references provided to chapter elements. In the SPM, knowledge gaps are identified associated with the underlying chapters of the Report.

A.1. Human activities are estimated to have caused approximately 1.0°C of global warming above pre-industrial levels, with a *likely* range of 0.8°C to 1.2°C. Global warming is *likely* to reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate.

A.1.1. Reflecting the long-term warming trend since pre-industrial times, observed global mean surface temperature (GMST) for the decade 2006–2015 was 0.87°C (*likely* between 0.75°C and 0.99°C higher than the average over the 1850–1900 period (*very high confidence*). Estimated anthropogenic global warming matches the level of observed warming to within ±20% (*likely* range). Estimated anthropogenic global warming is currently increasing at 0.2°C (*likely* between 0.1°C and 0.3°C) per decade due to past and ongoing emissions (*high confidence*).

A.1.2. Warming greater than the global annual average is being experienced in many land regions and seasons, including two to three times higher in the Arctic. Warming is generally higher over land than over the ocean. (*High confidence*)

A.1.3. Trends in intensity and frequency of some climate and weather extremes have been detected over time spans during which about 0.5°C of global warming occurred (*medium confidence*). This assessment is based on several lines of evidence, including attribution studies for changes in extremes since 1950.

A.2. Warming from anthropogenic emissions from the pre-industrial period to the present will persist for centuries to millennia and will continue to cause further long-term changes in the climate system, such as sea level rise, with associated impacts (*high confidence*), but these emissions alone are *unlikely* to cause global warming of 1.5°C (*medium confidence*).

A.2.1. Anthropogenic emissions (including greenhouse gases, aerosols and their precursors) up to the present are *unlikely* to cause further warming of more than 0.5°C over the next two to three decades (*high confidence*) or on a century time scale (*medium confidence*).

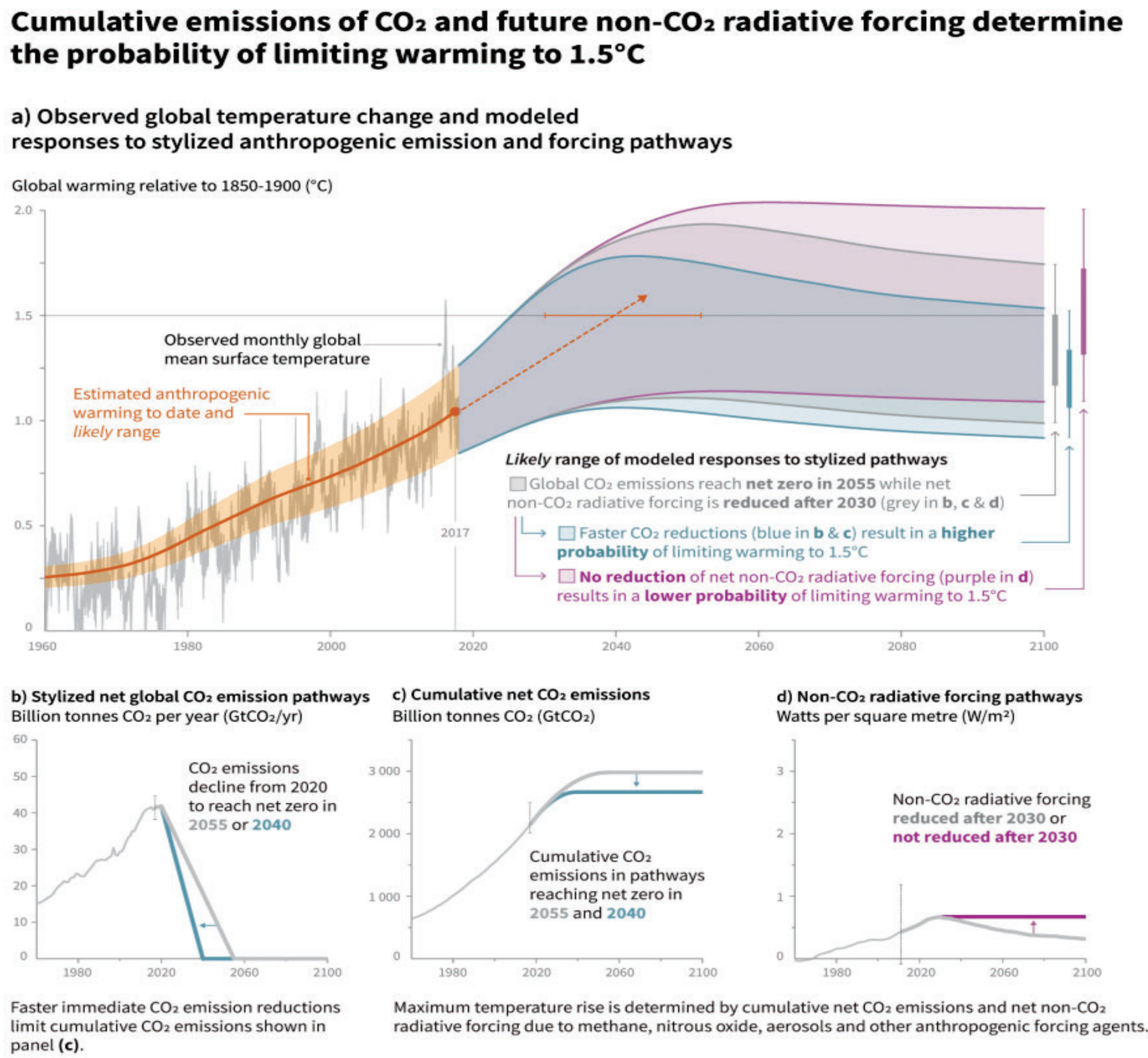
A.2.2. Reaching and sustaining net zero global anthropogenic CO_2 emissions and declining net non-CO_2 radiative forcing would halt anthropogenic global warming on multi-decadal time's cales (*high confidence*). The maximum temperature reached is then determined by cumulative net global anthropogenic CO_2 emissions up to the time of net zero CO_2 emissions (*high confidence*) and the level of non-CO_2 radiative forcing in the decades prior to the time that maximum temperatures are reached (*medium confidence*). On longer time scales, sustained net negative global anthropogenic CO_2 emissions and/or further reductions in non-CO_2 radiative forcing may still be required to prevent further warming due to Earth system feedbacks and to reverse ocean acidification (*medium confidence*) and will be required to minimize sea level rise (*high confidence*).

A.3. Climate-related risks for natural and human systems are higher for global warming of 1.5°C than at present, but lower than at 2°C (*high confidence*). These risks depend on the magnitude and rate of warming, geographic location, levels of development and vulnerability, and on the choices and implementation of adaptation and mitigation options (*high confidence*).

A.3.1. Impacts on natural and human systems from global warming have already been observed (*high confidence*). Many land and ocean ecosystems and some of the services they provide have already changed due to global warming (*high confidence*).

A.3.2. Future climate-related risks depend on the rate, peak and duration of warming. In the aggregate, they are larger if global warming exceeds 1.5°C before returning to that level by 2100 than if global warming gradually stabilizes at 1.5°C, especially if the peak temperature is high (e.g., about 2°C) (*high confidence*). Some impacts may be long-lasting or irreversible, such as the loss of some ecosystems (*high confidence*).

A.3.3. Adaptation and mitigation are already occurring (*high confidence*). Future climate-related risks would be reduced by the upscaling and acceleration of far-reaching, multilevel and cross-sectoral climate mitigation and by both incremental and transformational adaptation (*high confidence*).



S3 SLO2: IPCC assessment report 3 - 2001

The Third Assessment Report of Working Group I of the Intergovernmental Panel on Climate Change (IPCC) builds upon past assessments and incorporates new results from the past five years of research on climate change. The global average surface temperature has increased over the 20th century by about 0.6°C. •The global average surface temperature (the average of near surface air temperature over land, and sea surface temperature) has increased since 1861. Over the 20th century the increase has been 0.6 ± 0.2°C5,6 This value is about 0.15°C larger than that estimated by the SAR for the period up to 1994, owing to the **relatively high temperatures** of the additional years (1995 to 2000) and improved methods of processing the data. These numbers take into account various adjustments, including urban heat island effects.

- The record shows a great deal of variability; for example, most of the warming occurred during the 20th century, during two periods, 1910 to 1945 and 1976 to 2000.
- Globally, it is very likely that the 1990s was the **warmest decade** and 1998 the warmest year in the instrumental record, since 1861
- New analyses of proxy data for the Northern Hemisphere indicate that the increase in temperature in the 20th century is likely to have been the largest of any century during the past 1,000 years. It is also likely that, in the Northern Hemisphere, the 1990s was the warmest decade and 1998 the warmest year. Because less data are available, less is known about annual averages prior to 1,000 years before present and for conditions prevailing in most of the Southern Hemisphere prior to 1861.
- On average, between 1950 and 1993, **night-time daily minimum air temperatures** over land increased by about 0.2°C per decade. This is about **twice the rate of increase** in daytime daily maximum air temperatures (0.1°C per decade). This has lengthened the freeze-free season in many mid- and high latitude regions. The increase in sea surface temperature over this period is about half that of the mean land surface air temperature. Some important aspects of climate appear not to have changed.
- A few are a soft he globe have not warmed in recent decades, mainly over some parts of the **Southern Hemisphere oceans** and parts of Antarctica.
- No significant trends of Antarctic sea-ice extent are apparent since 1978, the period of reliable satellite measurements.
- Changes globally in tropical and extra-tropical storm intensity and frequency are dominated by inter-decadal to multi-decadal variations, with no significant trends evident over the 20th century. Conflicting analyses make it difficult to draw definitive **conclusions about changes in storm activity, especially in the extra-tropics**.
- **No systematic** changes in the frequency of **tornadoes, thunder days, or hail events** are evident in the limited areas analysed.

S4 SLO1: IPCC assessment report 4 -2007

Greater attention to integrate the climate change with substantial development polices

Relation between mitigation and adaptation

FOURTH ASSESMENT OF IPCC- 2007

IPCC stands for Intergovernmental Panel on Climate Change. It is a group of scientists chosen by governments and other large groups from around the world who study the way that **humans are making the Earth heat up unnaturally**. The group was established in 1988 by the World Meteorological Organization and the United Nations Environment Programme, two organizations of the United Nations. The report is the largest and most detailed summary of the climate change situation ever undertaken, produced by thousands of authors, editors, and reviewers from dozens of countries, citing over 6,000 peer-reviewed scientific studies. The report was released in four principal sections:

- Contribution of Working Group I: Climate Change 2007: The Physical Science Basis
- Contribution of Working Group II: Climate Change 2007: Impacts, Adaptation and Vulnerability
- Contribution of Working Group III: Climate Change 2007: Mitigation of Climate Change
- Contribution of Working Groups I, II, and III: The Synthesis Report (SYR)

WORKING GROUP I: The physical science basis:-

The first working group states (WGI) was published in March 2007. It includes a Summary for Policymakers (SPM), which was published in February 2007, and a Frequently Asked Questions section. It assessed current scientific knowledge of "the natural and human drivers of climate change" as well as observed changes in climate. It looked at the ability of science to attribute changes to different causes, and made projections of future climate change. It was produced by 676 authors from 40 countries, then reviewed by over 625 expert reviewers. More than 6,000 peer-reviewed publications were cited. Before being approved, the summary was reviewed line by line by representatives of 113 governments during the 10th session of WGI, in January to February 2007. The key observations of this report were

- Changes in the atmosphere
- Warming of the planet
- Ice, snow, permaforest, rain and oceans.
- Hurricanes

This report also stated the factors responsible for climate change and thy term it as radiative forcing. It shows the individual contribution of the various gases.

- Total radiative forcing from the sum of all human activities is about +1.6 watts/m^2
- Radiative forcing from an increase of solar intensity since 1750 is about +0.12 watts/m^2
- Radiative forcing from carbon dioxide, methane, and nitrous oxide combined is very likely (>90%) increasing more quickly during the current era (1750–present) than at any other time in the last 10,000 years.

Climate sensitivity had also been discussed. Climate sensitivity is defined as the amount of global average surface warming following a doubling of carbon dioxide concentrations. It is likely to be in the range of 2 to 4.5 °C, with a best estimate of about 3 °C.

WORKING GROUP II:- Impacts, adaptation and vulnerability:-

It was released on April 6, 2007. WGII states that "evidence from all continents and most oceans shows that many natural systems are being affected by regional climate changes, particularly temperature increases. With a high confidence WGII asserts that climate change has resulted in Increasing ground instability in permafrost regions. Increasing rock avalanches in mountain regions. With a very high confidence WGII asserts that climate change is affecting terrestrial biological systems in that Spring events such as the unfolding of leaves, laying of eggs, and migration are happening earlier.

Fresh water

Heavy precipitation events are very likely to become more common and will increase flood risk. Water supplies stored in glaciers and snow cover will be reduced over the course of the century.

Ecosystems

Carbon removal by terrestrial ecosystems is likely to peak before mid-century and then weaken or reverse. This would amplify climate change.

It is projected with very high confidence that coasts will be exposed to increasing risks such as coastal erosion due to climate change and sea-level rise.

WORKING GROUP III:- Mitigation of Climate change:-

Working Group III's was published on 4 May 2007 at the 26th session of the IPCC. The full WG III report was published online in September, 2007. The IPCC convened in Bangkok on April 30 to start discussions on the draft Summary, with the participation of over 400 scientists and experts from about 120 countries. Despite this, the figures from the original proposal were incorporated into the Summary for Policymakers. The Summary concludes that stabilization of greenhouse gas concentrations is possible at a reasonable cost, with stabilization between 445ppm and 535ppm costing less than 3% of global GDP.

WORKING GROUP IV:- The synthesis report:-

A draft version of the Synthesis Report, said to be subject to final copyedit, was published on 16 November 2007. In fact, this Conference was postponed to December to allow the IPCC Synthesis Report to come out first. The six topics addressed in the Synthesis Report are:

- Observed changes in climate and its effects (WGI and WGII).
- Causes of change (WGI and WGIII).
- Climate change and its impacts in the near and long term under different scenarios (WGI and WGIII).
- Adaptation and mitigation options and responses, and the inter-relationship with sustainable development, at global and regional levels (WGII and WGIII).
- The long-term perspective: scientific and socio-economic aspects relevant to adaptation and mitigation, consistent with the objectives and provisions of the Convention [sic], and in the context of sustainable development (WGI and WGIII).
- Robust findings, key uncertainties (WGI, WGII and WGIII).

S4 SLO2: IPCC assessment report 5

IPCC FIFTH Assessment Report – 2014

The Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) finds, beyond reasonable doubt, that the Earth's climate is warming.1 Since the 1950s, the rate of global warming has been unprecedented compared to previous decades and millennia.2 The Fifth Assessment Report presents a long list of changes that scientists have observed around the world. Since the mid-19th century, the average increase in the temperature of the Earth's surface has been 0.85 degrees Centigrade (°C).3 Globally, sea levels have risen faster than at any time during the previous two millennia – and the effects are felt in South Asia.4 Changing patterns of rainfall or melting snow and ice are altering freshwater systems, affecting the quantity and quality of water available in many regions, including South Asia.5 Climate change will have widespread impacts on South Asian society and South Asians' interaction with the natural environment.6 The IPCC finds with 95% scientific certainty (Box 1) that increasing concentrations of greenhouse gases in the atmosphere due to human activities have been the dominant cause of the observed warming since the mid-20th century.7 Current science provides the clearest evidence yet that human activity is changing our climate.8 The impacts of climate change will influence flooding of settlements and infrastructure, heat-related deaths, and food and water shortages in South Asia.9 The following pages explore these risks in more depth. Given the interdependence among countries in today's world, the impacts of climate change on resources or commodities in one place will have far-reaching effects on prices, supply chains, trade, investment and political relations in other places. Climate change will progressively.

The IPCC assigns a degree of certainty to each key finding based on the type, amount, quality and consistency of evidence (e.g., data, theory, models, expert judgment), and the degree of agreement among scientists. The terms to describe evidence are: limited, medium or robust; and to describe agreement: low, medium or high. When the Fifth Assessment Report talks about 'confidence' in a finding, the level of confidence derives from a synthesis of the evidence that exists and the degree of scientific agreement on what the evidence means. The levels of confidence IPCC assigns are: very low, low, medium, high and very high. IPCC describes the likelihood or certainty of an outcome having occurred or occurring in the future in terms of percentages: Virtually certain 99% or more Extremely likely 95% or more Very likely 90% or more Likely 66% or more More likely than not more than 50% About as likely as not 33–66% Unlikely 33% or less Very unlikely 10% or less Extremely unlikely 5% or less Exceptionally unlikely 1% or less On this scale, the world's leading climate scientists consider it extremely likely that human activities have been the dominant cause of observed warming. Scientists consider 95% confidence as the 'gold standard', the standard at which theories are accepted as valid. For example, the theory of evolution, the theory on the age of the Earth and the Big Bang theory all meet this standard of scientific confidence.

The draft outlines had been prepared following a scientific scoping meeting in May held in Addis Ababa, Ethiopia. At the meeting in Montreal, representatives of the IPCC's 195 member governments discussed this draft and agreed on a final outline.

The IPCC includes three working groups: Working Group I assesses the physical science basis of climate change; Working Group II is responsible for impacts, adaptation and vulnerability; and Working Group III assesses the mitigation of climate change. It also includes a Task Force on National Greenhouse Gas Inventories that focuses on developing internationally agreed methodologies for calculating and reporting greenhouse gas emissions.

The outline of the Synthesis Report, the final instalment of AR6, will be agreed in 2019. The Synthesis Report will integrate the three working group contributions and the Special Reports produced during the AR6 cycle. It will be finalized in April 2022.

The agreed outlines, subject to final copy edits, are available now on the IPCC website. The full agenda and documents can be found **here**.

Among other business in Montreal the IPCC also considered options for strengthening the financial stability of the IPCC and for aligning its work with the global stocktake cycles of the United Nations Framework Convention on Climate Change. WMO scientific products, including its annual statement on the status of the global climate and its Greenhouse Gas Bulletin contribute to the global stocktake between the full IPCC assessment reports.

Temperature trends: Warming has occurred, at a country scale, across most of South Asia over the 20th century and into the 2000s (Figure 1). There were more temperature extremes (high confidence).14 Records indicate that it is likely that the numbers of cold days and nights have decreased and the numbers of warm days and nights have increased across most of Asia since about 1950. Heat wave frequency has increased since the middle of the 20th century in large parts of Asia.15 Rainfall trends: Most areas of the Asian region lack sufficient observational records to draw conclusions about trends in annual rainfall over the past century. Rainfall trends, including extremes, are characterised by strong variability, with both increasing and decreasing trends observed in different parts of Asia (Figure 2).16 Observations also show that there have been more extreme rainfall events and fewer weak rainfall events in the central Indian region.17 Sea level rise: Globally, the rate of sea level rise since the 1850s has been larger than the average rate during the previous 2,000 years (high confidence). Sea level rise can vary between regions, though. Shifting surface winds, the expansion of warming ocean water, and the addition of melting ice can alter ocean currents which, in turn, lead to changes in sea level that vary from place to place. Past and present variations in the distribution of land ice affect the shape and gravitational field of the Earth, which also cause regional fluctuations in sea level. Additional variations are caused by sediment and tectonics. Changes of sea level in the Indian Ocean have emerged since the 1960s, driven by changing wind patterns.

Observed effects of climate change: Even today, climaterelated risks threaten lives, food security, health and wellbeing across many parts of South Asia. There are clear signs that the impacts of climate change are already being felt.21 The Asia region as a whole experienced the most weatherand climate-related disasters in the world between 2000 and 2008 and suffered the second highest proportion (almost 30%) of total global economic losses.22 The risk of deaths due to flooding is highly concentrated in Asia. At the same time as sea levels are rising, most Asian deltas are sinking as a result of groundwater extraction, floodplain engineering and trapping of sediments by dams.23 Severe floods in Mumbai in 2005 have been attributed to both climatic and non-climatic factors, suggesting an interaction between climate change and other stressors.24 Extreme rainfall and flooding is causing illnesses, deaths and mass displacement. In

2008, the embankments of the Kosi River, a tributary of the Ganges, broke, displacing over 60,000 people in Nepal and 3.5 million in India, and disrupting transport and power across large areas.25 Climate change is impacting on human health in several ways. Contaminated urban flood waters have caused exposure to disease and toxic compounds, for example, in India and Pakistan.26 The incidence of many diseases increases at higher temperatures: the pathogens and parasites that cause disease multiply faster. Dengue and Japanese encephalitis outbreaks in South Asia have been associated with temperature and rainfall. Malaria prevalence in India and Nepal has been linked to rainfall patterns.

Special issue

The IPCC accepted the invitation in April 2016, deciding to prepare this Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty.

- **Understanding the global warming of 1.5°C**

Human activities are estimated to have caused approximately 1.0°C of global warming.

Warming from anthropogenic emissions from the pre-industrial period to the present will persist for centuries to millennia and will continue to cause further long-term changes in the climate system, such as sea level rise, with associated impacts, but these emissions alone are *unlikely* to cause global warming of 1.5°C.

Climate-related risks for natural and human systems are higher for global warming of 1.5°C than at present, but lower than at 2°C. These risks depend on the magnitude and rate of warming, geographic location, levels of development and vulnerability, and on the choices and implementation of adaptation and mitigation options.

- **Projected climate change**

Temperature extremes on land are projected to warm more than GMST (high confidence): extreme hot days in mid-latitudes warm by up to about 3°C at global warming of 1.5°C and about 4°C at 2°C, and extreme cold nights in high latitudes warm by up to about 4.5°C at 1.5°C and about 6°C at 2°C. The number of hot days is projected to increase in most land regions, with highest increases in the tropics.

By 2100, global mean sea level rise is projected to be around 0.1 metre lower with global warming of 1.5°C compared to 2°C. Sea level will continue to rise well beyond 2100, and the magnitude and rate of this rise depend on future emission pathways. A slower rate of sea level rise enables greater opportunities for adaptation in the human and ecological systems of small islands, low-lying coastal areas and deltas.

On land, impacts on biodiversity and ecosystems, including species loss and extinction, are projected to be lower at 1.5°C of global warming compared to 2°C. Limiting global warming to 1.5°C compared to 2°C is projected to lower the impacts on terrestrial, freshwater and coastal ecosystems and to retain more of their services to humans.

Limiting global warming to 1.5°C compared to 2°C is projected to reduce increases in ocean temperature as well as associated increases in ocean acidity and decreases in ocean oxygen levels (high confidence). Consequently, limiting global warming to 1.5°C is projected to reduce risks to marine biodiversity, fisheries, and ecosystems, and their functions and services to humans, as illustrated by recent changes to Arctic sea ice and warm-water coral reef ecosystems.

Climate-related risks to health, livelihoods, food security, water supply, human security, and economic growth are projected to increase with global warming of 1.5°C and increase further with 2°C.

- **Strengthening the Global Response in the Context of Sustainable Development and Efforts to Eradicate Poverty**

The avoided climate change impacts on sustainable development, eradication of poverty and reducing inequalities would be greater if global warming were limited to 1.5°C rather than 2°C, if mitigation and adaptation synergies are maximized while trade-offs are minimized.

Adaptation options specific to national contexts, if carefully selected together with enabling conditions, will have benefits for sustainable development and poverty reduction with global warming of 1.5°C, although trade-offs are possible.
Limiting the risks from global warming of 1.5°C in the context of sustainable development and poverty eradication implies system transitions that can be enabled by an increase of adaptation and mitigation investments, policy instruments, the acceleration of technological innovation and behaviour changes.
Sustainable development supports, and often enables, the fundamental societal and systems transitions and transformations that help limit global warming to 1.5°C. Such changes facilitate the pursuit of climate-resilient development pathways that achieve ambitious mitigation and adaptation in conjunction with poverty eradication and efforts to reduce inequalities.

- **Contributors**

Researchers from 40 countries, representing 91 authors and editors contributed to the report, which includes over 6,000 scientific references

- **Reactions from different countries**

Australia
Prime Minister Scott Morrison emphasised that the report was not specifically for Australia but for the whole world.
Canada
Canadian Environment Minister Catherine McKenna acknowledged that the SR15 report would say Canada is not "on track" for 1.5 °C. Canada will not be implementing new plans but it will continue to move forward on a "national price on carbon, eliminating coal-fired power plants, making homes and businesses more energy-efficient, and investing in clean technologies and renewable energy.

India

The Centre for Science and Environment said the repercussions for developing countries such as India, would be "catastrophic" at 2 °C warming and that the impact even at 1.5 °C described in SR15 is much greater than anticipated. Crop yields would decline and poverty would increase.

New Zealand

The Minister for Climate Change James Shaw said that the Report "has laid out a strong case for countries to make every effort to limit temperature rise to 1.5° Celsius above pre-industrial levels. ... The good news is that the IPCC's report is broadly in line with this Government's direction on climate change and it's highly relevant to the work we are doing with the Zero Carbon Bill."

United States

President Donald Trump said that he had received the report, but wanted to learn more about those who "drew it" before offering conclusions. In an interview with ABC's "This Week" the director of the National Economic Council, Larry Kudlow, stated, "personally, I think the UN study is way too difficult," and that the authors "overestimate" the likelihood for environmental disasters. Since the publication Trump stated in an interview on 60 Minutes that he didn't know that climate change is manmade and that "it'll change back again", the scientists who say it's worse than ever have "a very big political agenda" and that "we have scientists that disagree with [manmade climate change]."

IPCC Sixth Assessment Report – 2018 – sub2019…..

Course Code: **18CEO406T**

Course Name: GLOBAL WARMING AND CLIMATE CHANGE

Unit – 4; CLO-4: Understand different protocol related to climate change

S5

SLO-1; UNEP - United Nations Environment Programme

SLO-2; WMO - World Meteorological Organization

S6

SLO-1; UNFCCC - United Nations Framework Convention on Climate Change

SLO-2; UNDP - United Nations Development Program

S5SLO-1; UNEP - United Nations Environment Programme

https://www.unenvironment.org/

The United Nations Environment Programme (UNEP) is the **leading global environmental authority that sets the global environmental agenda**, promotes the coherent implementation of the environmental dimension **of sustainable development** within the United Nations system, and serves as an authoritative advocate for the global environment.

Headquartered in Nairobi, Kenya, we work through our divisions as well as our regional, liaison and out-posted offices and a growing network of collaborating centres of excellence. They also host several environmental conventions, secretariats and inter-agency coordinating bodies. UN Environment is led by our Executive Director.

Process of UNEP

The United Nations Environment Programme (UNEP) is the leading environmental authority in the United Nations system. UNEP uses its expertise to strengthen environmental **standards and practices** while helping implement environmental obligations at the country, regional and global levels. **UNEP's mission** is to provide **leadership and encourage partnership** in caring for the environment by inspiring, informing, and enabling nations and peoples to improve their quality of life without compromising that of future generations.

UNEP's categorize their work into **seven broad thematic areas**: climate change, disasters and conflicts, ecosystem management, environmental governance, chemicals and waste, resource efficiency, and environment under review. In all of our work, we maintain our overarching commitment to sustainability.

1. CLIMATE CHANGE UNEP **strengthens** the ability of countries to **integrate** climate change responses by providing leadership in **adaptation, mitigation,** technology and finance. UNEP is focusing on facilitating the transition to low-carbon societies, improving the understanding of climate science, facilitating the development of renewable energy and **raising public awareness**.
2. POST-CONFLICT AND DISASTER MANAGEMENT UNEP conducts environmental assessments in crisis-affected countries and provides guidance for implementing legislative and institutional frameworks for **improved environmental management**. Activities undertaken by UNEP's Post-Conflict & Disaster Management Branch (PCDMB) include post-conflict environmental assessment in Afghanistan, Côte d'Ivoire, Lebanon, Nigeria and Sudan.

3. ECOSYSTEM MANAGEMENT Facilitates management and **restoration of ecosystems** in a manner consistent with sustainable development, and promotes use of ecosystem services. **Examples** include the Global Programme of Action (GPA) for the Protection of the Marine Environment from Land-Based Activities.
4. ENVIRONMENTAL GOVERNANCE UNEP supports governments in establishing, implementing and strengthening the necessary processes, institutions, **laws, policies** and programs to **achieve sustainable development** at the country, regional and global levels, and mainstreaming environment in development planning.
5. HARMFUL SUBSTANCES UNEP strives to minimise the impact of harmful substances and hazardous waste on the environment and human beings. UNEP has launched negotiations for a global agreement on mercury, and implements projects on mercury and the Strategic Approach to International Chemicals Management (SAICM) to reduce risks to human health and the environment.
6. RESOURCE EFFICIENCY/SUSTAINABLE CONSUMPTION AND PRODUCTION UNEP focuses on regional and global efforts to ensure natural resources are produced, processed and consumed in a more environmentally friendly way. For example, the Marrakesh Process is a global strategy to support the elaboration of a 10-Year Framework of Programs on sustainable consumption and production.

UNEP's **work** is made possible by partners who fund and champion our mission. UNEP's depend on voluntary contributions for 95 per cent of our income.

Every year, UNEP's **honor** and celebrate individuals and institutions that are doing outstanding work on behalf of the environment.

UNEP's host the secretariats of many critical multilateral environmental agreements and research bodies, bringing together nations and the environmental community to tackle the greatest challenges of our time. These include the following:

- The Convention on Biological Diversity
- The Convention on International Trade in Endangered Species of Wild Fauna and Flora
- The Minamata Convention on Mercury
- The Basel, Rotterdam and Stockholm Conventions

- The Vienna Convention for the Protection of Ozone Layer and the Montreal Protocol
- The Convention on Migratory Species
- The Carpathian Convention
- The Bamako Convention
- The Tehran Convention

UNEP's main activities are;

- climate change
  - including the Territorial Approach to Climate Change (TACC)
- disasters and conflicts
  - UNEP has endeavored to lighten the influence of emergencies or natural disasters on human health and to prepare for future disasters. It contributes to the reduction of the origin of disasters by controlling the balance of ecosystems and actively support Sendai Framework for Disaster Risk Reduction which aims to reduce the risk of disasters (DRR). As well as preventing natural disasters, the UNEP supports countries such as to make laws or policies which protect the countries from getting serious damage by disasters. Since 1999 it has helped 40 countries to recover from the effect of disasters.
- ecosystem management
- environmental governance
- environment under review
  - UNEP provides information and data on the global environment to stakeholders including governments, non-governmental organizations and the public for them to engage in realizing the Sustainable Development Goals. The information which UNEP shares is based on the latest science and is collected in a proper way. This makes policy makers find reliable information effectively. Through this The Environment Outlook and the Sustainable Development Goals Indicators stakeholders can have access to information easily. In addition, the UN environment Live Platform and Online Access to Research in Environment(OARE) provide transparent information collected by UNEP.[19]
- harmful substances

- resource efficiency

https://en.wikipedia.org/wiki/United_Nations_Environment_Programme

UNEP Collaboration with Geneva-based UN Organisations

- UNEP and The World Health Organization (WHO)
- UNEP and The International Labour Organization (ILO)
- UNEP and The UN High Commissioner for Refugees (UNHCR)
- UNEP and The World Meteorological Organization (WMO)
- UNEP and The UN Conference on Trade and Development (UNCTAD)
- UNEP and The World Trade Organization (WTO)
- UNEP and the International Telecommunication Union (ITU)
- UNEP and the Office of the High Commissioner for Human Rights (UNHCHR)

https://unep.ch/glo/glo%20pages/areas%20of%20cooperation.htm

SLO-2; WMO - World Meteorological Organization

https://public.wmo.int/en

The World Meteorological Organization (WMO) is an intergovernmental organization with a membership of 193 Member States and Territories. It originated from the International Meteorological Organization (IMO), the roots of which were planted at the 1873 Vienna International Meteorological Congress. Established by the ratification of the WMO Convention on **23 March 1950**, WMO became the **specialised agency** of the United Nations for meteorology (weather and climate), operational hydrology and related geophysical sciences a year later. The Secretariat, **headquartered** in Geneva, is headed by the Secretary-General. Its supreme body is the World Meteorological Congress.

WMO has **187 Member States** and 6 Member Territories. Members are divided into six regions:

- Region I: Africa
- Region II: Asia
- Region III: South America
- Region IV: North America, Central America and the Caribbean
- Region V: South-West Pacific
- Region VI: Europe

Vision, Mission, Strategic Planning

WMO provides world leadership and expertise in international cooperation in the delivery and use of high-quality, authoritative weather, climate, hydrological and related environmental services by its Members, for the improvement of the well-being of societies of all nations.

WMO Mission

WMO works to facilitate worldwide cooperation in the design and delivery of meteorological services, foster the rapid **exchange of meteorological information**, advance the standarization of meteorological data, build cooperation between meteorological and hydrological services, encourage research and training in meteorology, and expand the use of meteorology to benefit other sectors such as **aviation, shipping, agriculture and water management**.

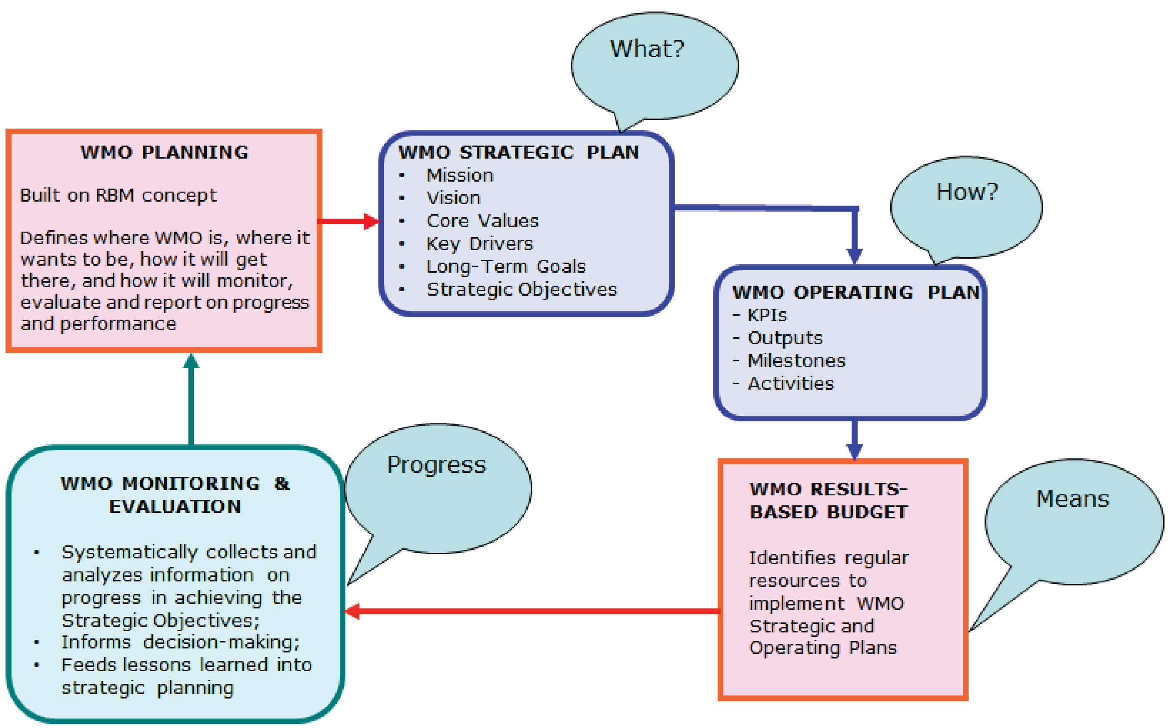
Focus area, within its mandate in the areas of weather, climate and water, WMO focuses on many different aspects and issues from observations, information exchange and research to weather forecasts and early warnings, from capacity development and monitoring of greenhouse gases to application services and much, much more

WMO Strategic Plan 2020–2023

WMO strategic and operational planning is built on the results-based management concept established by the fifteenth World Meteorological Congress as fundamental for managing the planning, budgeting, implementation, monitoring and reporting of programmatic work. The **WMO planning process** is based on three interlinked components:

1. The WMO Strategic Plan articulates the high-level vision, mission, core values and overarching priorities of the Organization. It outlines a set of long-term goals and strategic objectives with a 2030 horizon as well as identifies areas of focus for the 2020-2023 financial period.
2. The WMO Operating Plan 2020-2023 translates the strategy into specific actions by defining outputs to be delivered (i.e. lower-level results) and annual milestones to be achieved. It also lists planned activities, indicates the resources available, and outlines performance indicators intended to measure progress in achieving the strategic objectives.
3. The WMO Results-based Budget (maximum expenditure approved by Congress) identifies resources for implementation of the Strategic Plan, including the functioning of constituent bodies and the Secretariat.

Risk management and quality assurance are embedded in both strategic and operational planning, as well as in monitoring and evaluation processes.



Operational planning

Implementation of the strategic plan is facilitated by the WMO Operating Plan 2020-2023 which reflects the results chain towards strategic objectives and long-term goals and provides details on:

- Focus Areas / Outcomes
- Performance Indicators
- Outputs
- Milestones
- Activities

These elements are expected to contribute to achieving the long-term results defined in the WMO Strategic Plan, with the resources provided under the WMO Results-based Budget – Maximum expenditure approved by Congress, and the in-kind support of technical commissions and regional associations.

For each strategic objective, regional aspects and priorities are highlighted based on the WMO Monitoring and Evaluation system, data collected through the Country Profile Database, and information provided by regions. Risks and mitigation measures are also defined for each Strategic Objective.

Monitoring and evaluation

Monitoring and Evaluation are essential components of the WMO Results Based Management System. They constitute the tools for measuring performance in the timely implementation of the WMO Strategic Plan and Operating Plan. They also contribute to the identification of good practices and lessons learned which inform the next phase of the strategic planning cycle.

S6 - SLO-1; UNFCCC - UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

United Nations Framework
Convention on Climate Change

https://unfccc.int/

What is the purpose of the Secretariat?

The UNFCCC secretariat (UN Climate Change) is the United Nations entity tasked with supporting the global response to the **threat of climate change**. **UNFCCC stands for United Nations Framework Convention on Climate Change**. The Convention has near universal membership (**197 Parties**) and is the parent treaty of the **2015 Paris Agreement**. The **main aim** of the Paris Agreement is to **keep the global average temperature rise this century as close as possible to 1.5 degrees Celsius above pre-industrial levels.** The UNFCCC is also the parent treaty of the **1997 Kyoto Protocol**. The ultimate objective of all three agreements under the UNFCCC is to **stabilize greenhouse gas** concentrations in the atmosphere at a level that will prevent dangerous human interference with the climate system, in a time frame which allows ecosystems to adapt naturally and enables sustainable development.

When was the secretariat created?

The secretariat was established in 1992 when countries adopted the UNFCCC. The original secretariat was in Geneva. Since 1995, the secretariat has been located in Bonn, **Germany**.

Who works at the secretariat?

Around 450 staff are employed at UN Climate Change. Secretariat staff come from over 100 countries and represent a blend of **diverse cultures, gender and professional backgrounds**.

At the head of the secretariat is the Executive Secretary, a position currently held by Patricia Espinosa.

What does the secretariat do?

Focussing in its early years largely on facilitating the intergovernmental climate change negotiations, the secretariat today supports a complex architecture of bodies that serve to advance the implementation of the Convention, the Kyoto Protocol and the Paris Agreement.

S6 - SLO-2; UNDP - UNITED NATIONS DEVELOPMENT PROGRAMME

https://www.undp.org/content/undp/en/home.html

https://www.youtube.com/watch?v=a4zLqIGXxbg&feature=youtu.be

Mission

On the ground in about 170 countries and territories, UNDP works to **eradicate poverty** while protecting the planet. We help countries develop strong policies, skills, partnerships and institutions so they can **sustain their progress**.

Impact in 2018

- 31M people had better access to services to tackle poverty

- 20M people gained access to financial services
- 256M tonnes of carbon emissions cut

Function of UNDP

UNDP is committed to ending poverty once and for all. That's why we work to get to the root causes of poverty and create lasting change. The good news is we have a plan. But we need your help to get the job done.

The Objectives

UNDP supports countries in their efforts to successfully address diverse development challenges, framed around three broad settings which require different forms of support:

1. Eradicating **poverty** in all its forms and dimensions;
2. Accelerating structural transformations for **sustainable development**; and

3. **Building resilience** to crises and shocks

These **three development challenges** often coexist within the same country, requiring tailored solutions that can adequately address specific deficits and barriers. Underpinning all three development challenges is a set of core development needs, including the need to **strengthen gender equality** and the empowerment of women and girls, and to ensure the **protection of human rights.**

The Progress to success

To fulfill the aims of the Strategic Plan with the multi-dimensionality and complexity that the 2030 Agenda demands, UNDP is implementing **six cross-cutting approaches** to development, known as Signature Solutions. A robust, integrated way to put our best work – or 'signature' skillset – into achieving the Sustainable Development Goals.

1. Keeping people out of poverty
2. Governance for peaceful, just, and inclusive societies
3. Crisis prevention and increased resilience
4. Clean, affordable energy
5. Women's empowerment
6. gender equality

Working together with partners across the UN system and beyond, UNDP is implementing these Solutions building on UNDP’s strengths and expertise to help countries reach the SDGs. Because the six Solutions are interrelated, we can tailor a unique combination to best meet each country’s needs.

Protecting Development Gains

The **2030 Agenda** is a plan of action for **people, planet and prosperity**. It also seeks to strengthen universal **peace** in larger freedom. It recognizes that eradicating poverty in all its forms and dimensions, including extreme poverty, is the greatest global challenge and an indispensable requirement for sustainable development. All countries and all stakeholders, acting in collaborative **partnership**, are implementing this Agenda.

SDG Integration

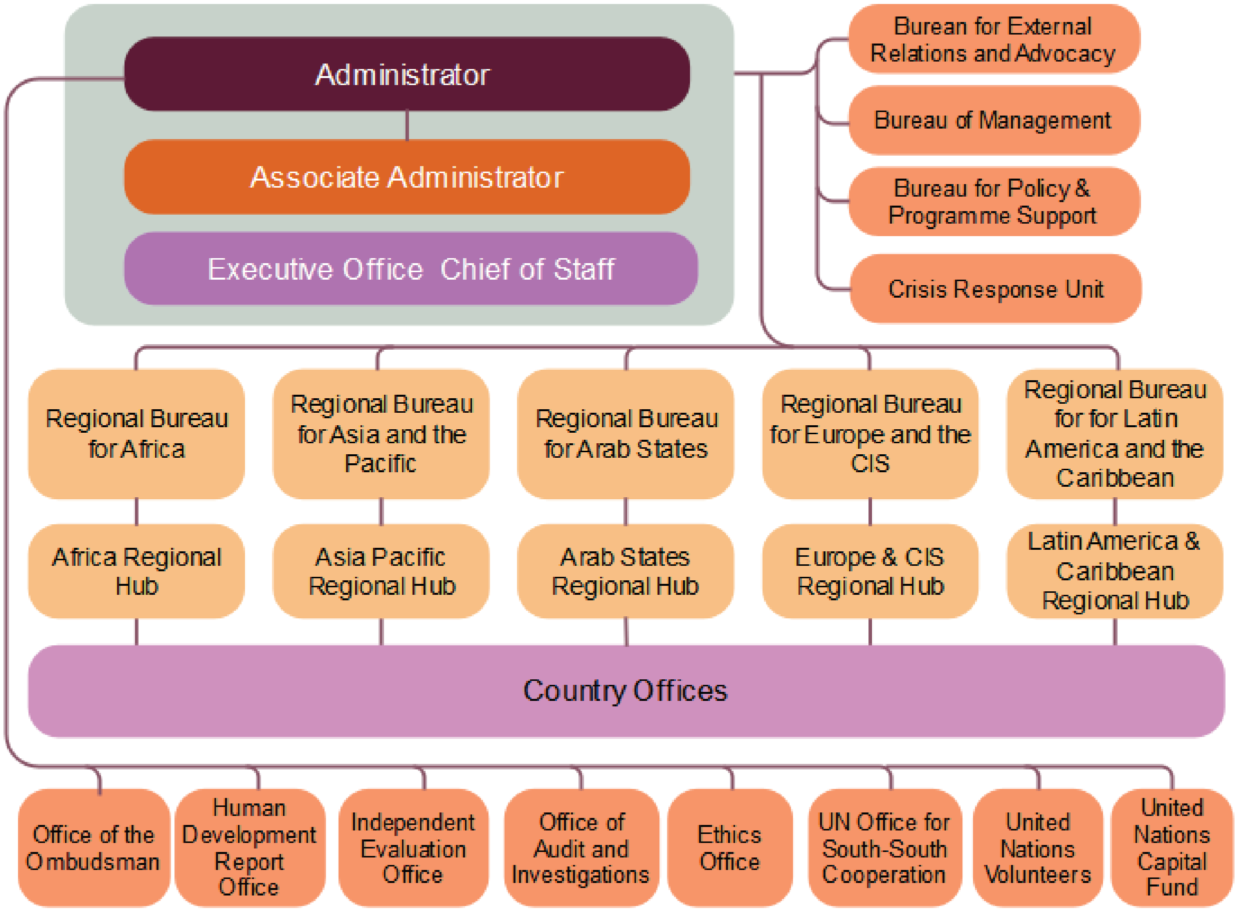
The Sustainable Development Goals (SDGs), also known as the Global Goals, were adopted by all United Nations Member States in 2015 as a universal call to **action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity by 2030**.

The **17 SDGs** are integrated—that is, they recognize that action in one area will affect outcomes in others, and that development must balance social, economic and environmental sustainability.

Through the pledge to **Leave No One Behind**, countries have committed to fast-track progress for those furthest behind first. That is why the SDGs are designed to bring the world to several life-changing 'zeros', including **zero poverty, hunger, AIDS and discrimination against women and girls.**

Everyone is needed to reach these ambitious targets. The creativity, knowhow, technology and financial resources from all of society is necessary to achieve the SDGs in every context.

UNDP Org Chart



18CEO406T - Global Warming and Climate Change

UNIT – IV

[S7 – S9]

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Topic; S7

SLO 1: Need for international protocols of climate change

SLO 2: Kyoto protocol

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SLO 1: Need for international protocols of climate change

The main objective of this important **climate change** treaty is to: achieve stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the **climate** system.

The atmosphere and climate change illustrate the need for, but also the difficulty of negotiating institutionalized cooperation in order to avert the tragedy of a global commons. Climate change became an issue of political concern as the scientific evidence of human interference with the climate system increased and this was coupled with growing public concern over global environmental issues in the mid-1980s.

The **greenhouse gas emissions** of a country correlate with its gross domestic product (GDP) and thus its economic growth.

Over the course of successive **Conferences of the Parties — known as COP** — new elements have been introduced into the international structure of the negotiations on climate change. These elements allow for specific challenges to be tackled such as **mitigation financing, adaptation to climate change, and the technological transfer.**

The United Nations Conference on Environment and Development, held in Rio de Janeiro in 1992, was a reflection of the international consensus when it came to approaching the problem of climate change. **During the summit, the United Nations Framework Convention on Climate Change (UNFCCC)** was created, which was initially signed by 166 countries and finally came into force on 21 March 1994. As of today, its has been ratified by 197 countries.

Below are the most significant agreements on climate change:

i. The setting of the target for developed countries to provide 100 billion dollars for climate finance projects in developing countries.

ii. The formalisation of the goal to limit the global temperature rise to below 2ºC compared to the pre-industrial era.

iii. The launching of the Ad Hoc Working Group on the Durban Platform and its two lines of work: Workstream 1, dedicated to working towards a binding global climate agreement for the post-2020 era; and Workstream 2, dedicated to raising the level of climate ambition before 2020.

iv. The second period of commitment arising from the Kyoto Protocol runs until 2020, through what is known as the Doha Amendment (COP18).

v. The launch of the Marrakesh Partnership for Global Climate Action as a platform to involve the general public and increase their role in the process of global climate action.

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S7: SLO 2: Kyoto protocol

The Kyoto Protocol was adopted on Kyoto, Japan , 11 December 1997. Owing to a complex ratification process, it entered into force on 16 February 2005. By 1997, **186 nations** signed kyotoprotocoal. Currently, there are 192 Parties to the Kyoto Protocol.

In short, the Kyoto Protocol operationalizes the United Nations Framework Convention on Climate Change by committing industrialized countries and economies in transition to limit and reduce greenhouse gases (GHG) emissions in accordance with agreed individual targets. The Convention itself only asks those countries to adopt policies and measures on mitigation and to report periodically.

The Kyoto Protocol is based on the principles and provisions of the Convention and follows its annex-based structure. It only binds developed countries, and places a heavier burden on them under the principle of “common but differentiated responsibility and respective capabilities”, because it recognizes that they are largely responsible for the current high levels of GHG emissions in the atmosphere.

In its Annex B, the Kyoto Protocol sets binding emission reduction targets for 37 industrialized countries and economies in transition and the European Union. Overall, these targets add up to an average 5 per cent emission reduction compared to 1990 levels over the **five year period 2008–2012 (the first commitment period).**

Doha Amendment

i. In Doha, Qatar, on 8 December 2012, the Doha Amendment to the Kyoto Protocol was adopted for a second commitment period, starting in 2013 and lasting until 2020. However, the Doha Amendment has not yet entered into force; a total of 144 instruments of acceptance are required for entry into force of the amendment. New commitments for Annex I Parties to the Kyoto Protocol who agreed to take on commitments in a second commitment period from 1 January 2013 to 31 December 2020.

ii. A revised list of greenhouse gases (GHG) to be reported on by Parties in the second commitment period.

iii. Amendments to several articles of the Kyoto Protocol which specifically referenced issues pertaining to the first commitment period and which needed to be updated for the second commitment period.

- On 21 December 2012, the amendment was circulated by the Secretary-General of the United Nations, acting in his capacity as Depositary, to all Parties to the Kyoto Protocol in accordance with Articles 20 and 21 of the Protocol.
- During the first commitment period, 37 industrialized countries and the European Community committed to reduce GHG emissions to an average of five percent against 1990 levels.
- During the second commitment period, Parties committed to reduce GHG emissions by at least 18 percent below 1990 levels in the eight-year period from 2013 to 2020; however, the composition of Parties in the second commitment period is different from the first.

KYOTO MECHANISMS

- Under the Protocol, countries must meet their targets primarily through national measures. However, the Protocol also offers them an additional means to meet their targets by way of three market-based mechanisms.

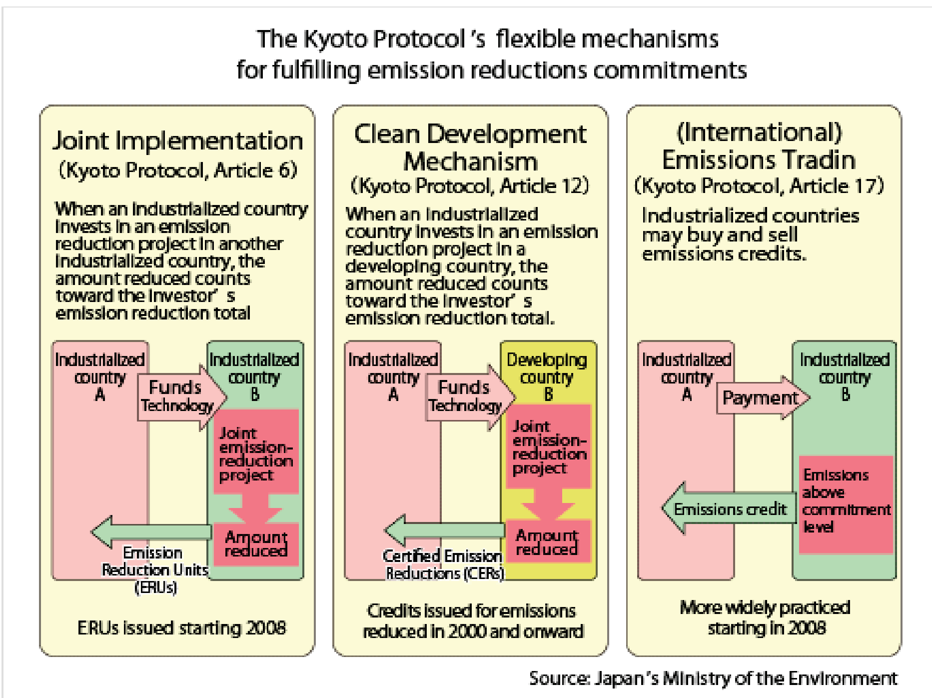
The Kyoto mechanisms are:

1) International Emissions Trading [Article 17]
2) Clean Development Mechanism (CDM) [Article 12]
3) Joint implementation (JI) [Article 6]

These mechanisms help to stimulate green investment and help Parties meet their emission targets in a cost-effective way.

These mechanisms are introduced in the Protocol with a **two fold aim:**

- **To aid Annex I countries to meet their emissions reduction and limitation commitments.**
- **To offer support for sustainable development in developing countries, non-Annex I countries, through the transference of clean technologies.**



Features of the Kyoto mechanisms as defined in the Kyoto Protocol.

Article	*Mechanism*	*Units*	*Participants*	*Requirements*
17	Emissions trading (ET)	Assigned amounts units (AAU)	Annex I Parties	Any trading shall be supplemental to domestic actions.
6	Transfer or acquire emissions reduction units resulting from projects (JI)	Emissions reduction units (ERU)	Annex I Parties and legal entities authorized by Parties	Emissions reductions must be: Approved by the Parties involved; additional to measures that would have otherwise been implemented; acquired only by Parties that comply with their reporting obligations; and supplemental to domestic action.
12	Acquire certified emission reductions from projects in non-Annex I Parties from 2000 and onwards (CDM)	Certified emissions reductions (CER)	Annex I Parties buy, non-Annex I Parties sell	Supervised by an executive board; emissions reductions will be certified by operational entities designated by the COP/MOP. [5]
			Private and/or public entities	A share of the proceeds of certified project activities shall cover administrative costs as well as assist particularly vulnerable developing countries with adaptation.

1. International Emissions Trading (IET)

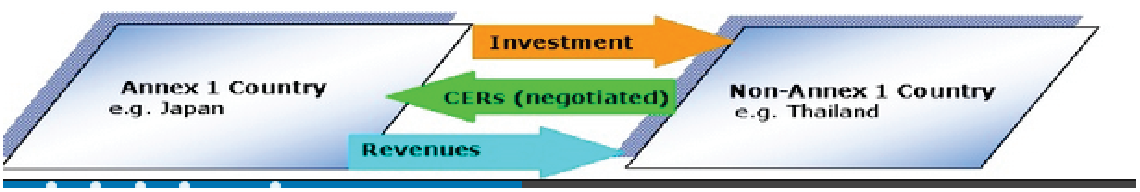
- Under this mechanism, an Annex I Party may transfer Kyoto units to or acquire units from another Annex I Party.
- Emissions trading does not affect the total assigned amount of Annex I Parties collectively; rather, it re-distributes the assigned amount among them.
- A Party may acquire an unlimited number of units.
- The number of units that a Party may transfer to other Parties is limited by the Party's commitment period reserve (CPR).
- The CPR is the minimum level of units that a Party must hold in its national registry at all times. The requirement for each Party to maintain a CPR prevents a Party from over-transferring units, and thus impair its ability to meet its commitments

2. Joint implementation (JI)

- It is a project-based mechanism by which one Annex I Party can invest in a project that reduces emissions or enhances sequestration in another Annex I Party, and receive credit for the emission reductions or removals achieved through that project.
- The unit associated with JI is called an emission reduction unit (ERU).
- The total projected emission savings from JI by 2012 are about one tenth that of the CDM.
- Russia accounts for about two-thirds of these savings, with the remainder divided up roughly equally between the Ukraine and the EU's New Member States.

3. Clean Development Mechanism

- CDM credits may be generated from emission reduction projects or from afforestation and reforestation projects in non-Annex I Parties.
- Unlike emissions trading and JI, projects under the CDM create new Kyoto units and their acquisition by Annex I Parties increases both the total assigned amount available for those Annex I Parties collectively and their allowable level of emissions.
- CDM projects result in three types of Kyoto units.
  - Certified emission reductions (CERs) are issued for projects that reduce emissions
  - Temporary CERs (tCERs)
  - Long-term CERs (lCERs) both of which may be issued for projects that enhance removals through afforestation and reforestation projects.



MONITORING EMISSION TARGETS

- Under the Protocol, countries' actual emissions have to be monitored and precise records have to be kept of the trades carried out.
- Registry systems track and record transactions by Parties under the mechanisms. The UN Climate Change Secretariat, based in Bonn, Germany, keeps an international transaction log to verify that transactions are consistent with the rules of the Protocol.
- Reporting is done by Parties by submitting annual emission inventories and national reports under the Protocol at regular intervals.
- A compliance system ensures that Parties are meeting their commitments and helps them to meet their commitments if they have problems doing so.

Adaptation:

- The Kyoto Protocol, like the Convention, is also designed to assist countries in adapting to the adverse effects of climate change. It facilitates the development and deployment of technologies that can help increase resilience to the impacts of climate change.
- The Adaptation Fund was established to finance adaptation projects and programmes in developing countries that are Parties to the Kyoto Protocol. In the first commitment period, the Fund was financed mainly with a share of proceeds from CDM project activities. In Doha, in 2012, it was decided that for the second commitment period, international emissions trading and joint implementation would also provide the Adaptation Fund with a 2 percent share of proceeds.

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Topic; S8

SLO 1: Climate Change and Carbon credit

SLO 2: Clean Development Mechanism

....

S8 SLO 1: Climate Change and Carbon credit

S8: Climate Change

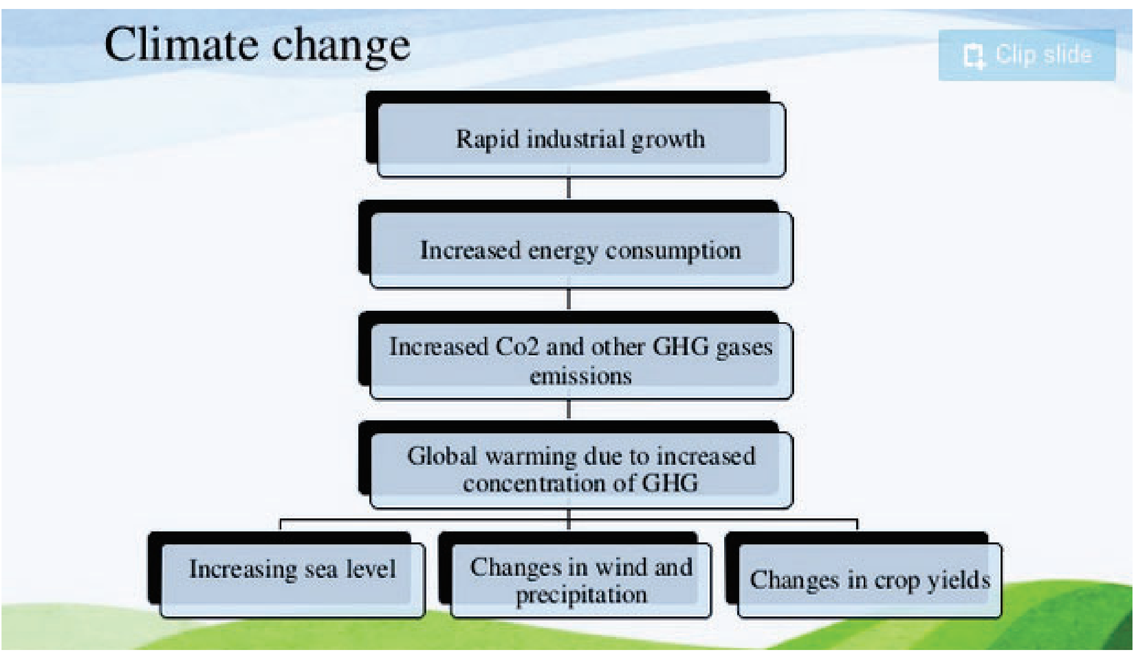
Climate Change is the defining issue of our time and we are at a defining moment. From **shifting weather patterns that threaten food production**, to rising sea levels that increase the risk of catastrophic flooding, the impacts of climate change are global in scope and unprecedented in scale. Without drastic action today, adapting to these impacts in the future will be more difficult and costly.

There are some basic well-established scientific links:

- The **concentration of GHGs** in the earth's atmosphere is directly linked to the average global temperature on Earth;
- The most abundant GHG, accounting for about **two-thirds of GHGs, carbon dioxide (CO_2),** is largely the product of burning fossil fuels.

State Indicators of Climate Change

- The anthropogenic concentrations of the greenhouse gases, and among them **carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O),** have grown significantly since pre-industrial times. These trends can be attributed to human activities, mostly fossil fuel use, land-use change and agriculture. Concentrations of other anthropogenic greenhouse gases have also increased. An increase of greenhouse gas concentrations leads on average to an additional warming of the atmosphere and the Earth's surface. Many greenhouse gases remain in the atmosphere-- and affect climate for a long time (IPCC, 1995). UNFCCC Article 4.1(a) states that:
- All Parties, taking into account their common but differentiated responsibilities and their specific national and regional development priorities, objectives and circumstances, shall develop, periodically update, publish and make available to the Conference of the Parties, in accordance with Article 12, national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, using comparable methodologies to be agreed upon by the Conference of the Parties.
- **Atmospheric concentrations of CO_2, CH_4, and N_2O are key indicators** in formulating policies for mitigating the effects of climate change.



S8 : Carbon Credit: A Step Towards Green Environment

Carbon Credit Trading is generated from the **Kyoto Protocol**. The main aim of this concept is basically to trade the carbon credit in the market. This type of trading is now the one of the fastest trading market in India.. This research is used for the several benefits and challenges which are directly or indirectly associated with carbon credit trading. It is a tradable certificate or permit representing the right to emit **1 tonne of carbon di oxide.**

In today's scenario Global Warming is costing a lot of money, so Green Environmentalist aims to promote policy and business that works for the environment. As we all know, **carbon dioxide, the most important greenhouse gas** produced by combustion of fuels, has become a cause of global panic as its concentration in the Earth's atmosphere has been rising alarmingly. This has created an opportunity for the trade of carbon credits both within and outside of the regulated area, thereby creating a global "carbon market".

In this system of carbon trading, controls are imposed on **Green House Gas (GHG) emissions under the Kyoto Protocol,** and the pre-decided emission limits are then allocated across countries, which have to control the greenhouse gas emissions from the various industries and commercial units operating within them.

What Is Carbon Credit?

Carbon credits are basically an element which is used to aid in regulation of the amount of gases that are being released into the air. This is basically a larger international plan which has been created in an effort to reduce global warming and its effects. International treaties have set quotas on the amount of GHG countries can produce, which in turn set quotas for businesses. **Instruments like carbon credits and carbon offset were introduced in order to improve the scenario by encouraging firms** to be more environment friendly in conducting their business.

One carbon credit allows one tonne of carbon dioxide or a corresponding amount of other greenhouse gases to be discharged in the air.. The amount of global emissions can be controlled through the buying and selling of carbon credits in the carbon trading method. But still the increased demand flowing to carbon credits and the introduction of newer financial instruments for emission trading are all signs of heightened activity. It can also be concluded that India is an emerging leader for the developing countries in designing innovative strategies and portfolios for carbon trading.

Sectors in Which Carbon Credits Can Work?

There are several sectors in which carbon credits work as shown in figure.

Energy Supply
Transport
Residential and Commercial Buildings
Industry
Agriculture
Forestry
Waste management

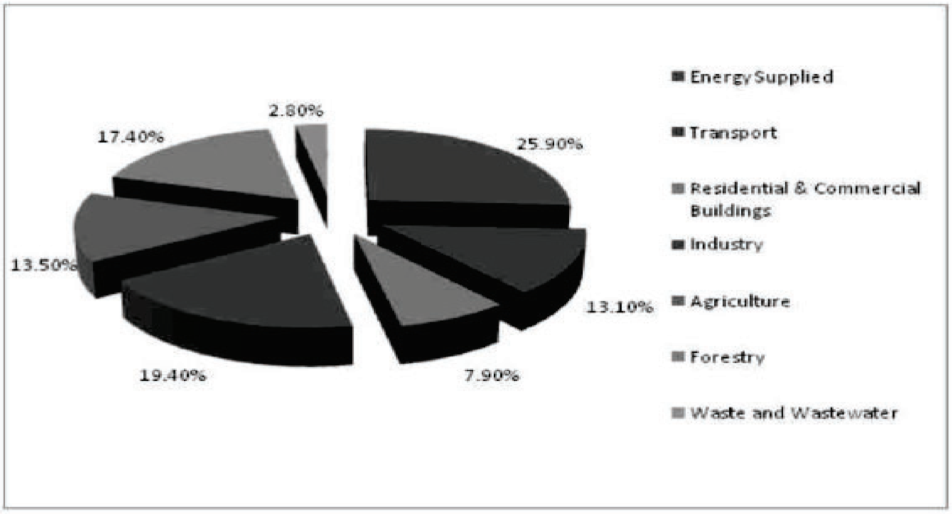
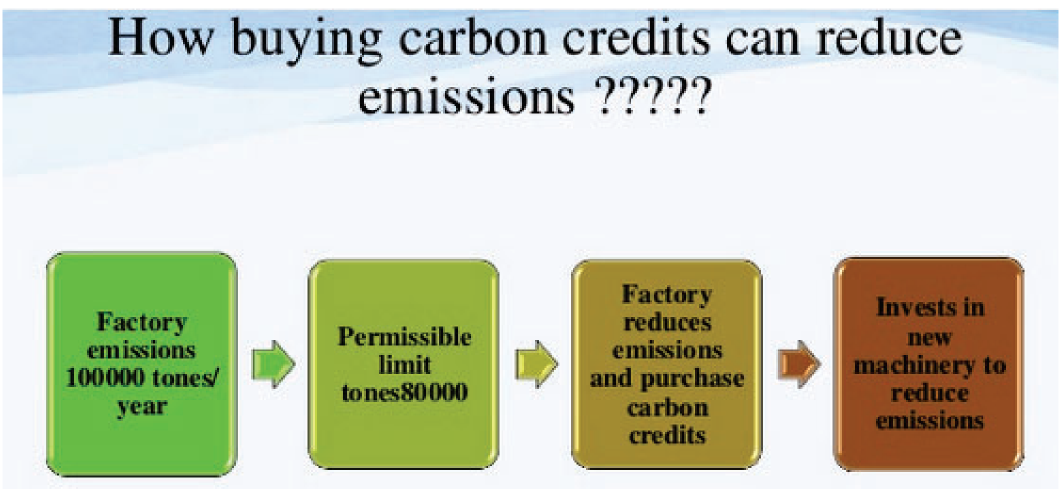


Fig. Different Sectors in which Carbon Credit Works with Percentage

How buying carbon credits can reduce emissions?



Reducing carbon emissions

i. Use of renewable energy such as wind farms, installation of solar.
ii. Afforestation
iii. Reforestation
iv. It is also duty of each individual to contribute the following
  - Drive less
  - Use solar energy
  - Plant more tress
  - Turn off electronic devices
  - Reuse and recycle.

Carbon credits in India

India signed the **kyoto protocoal in August 2002.**

India is the second largest seller of carbon credits globally with **489 CDM projects.**

Carbon credit traders in India

- Andhyodaya green energy
- Grasim industries Ltd.
- Indo gulf fertilizer
- Indus technical and financial consultants Ltd.
- Madhya Pradesh rural livelihoods project
- Rajasthan renewable energy corporation
- Reliance energy Ltd.
- Tata motors Ltd.
- Tata steel Ltd.
- Bajaj Fiserv Ltd.
- Dhariwal industries Ltd.
- Tata power company Ltd.
- Blue star energy services Inc.
- Valera global Inc.

Merits and demerits of carbon credits

Merits of carbon credits	De merits of carbon credits
Technology trasfer from developed to developing countries	Gives false sense of pollution
Better technology for company	It is not regulated
Can change country's financial situation	Developed countries purchase CER's rather than finding new ways to reduce emissions
Development of Cleaner technologies	Lack of comprehensive and structured international system.
Environmental benefits	
Helps in developing extra income	

S8: SLO2: Clean Development Mechanism (CDM)

Clean Development Mechanism (CDM)

- A mechanism that allows Annex B Countries to undertake GHG emission reduction projects in non-annex B countries, and to use the achieved emission reductions to meet their own emission goal. The Clean Development Mechanism (CDM), defined in **Article 12 of the Protocol**, allows a country with an emission-reduction or emission-limitation commitment under the Kyoto Protocol **(Annex B Party)** to implement an emission-reduction project in developing countries. Such projects can earn saleable **certified emission reduction (CER)** credits, each equivalent to one tonne of CO_2, which can be counted towards meeting Kyoto targets.
- It is the first global, environmental investment and credit scheme of its kind, providing a standardized emissions offset instrument, CERs.
- A CDM project activity might involve, for example, a rural electrification project using solar panels or the installation of more energy-efficient boilers.
- The mechanism stimulates sustainable development and emission reductions, while giving industrialized countries some flexibility in how they meet their emission reduction or limitation targets.

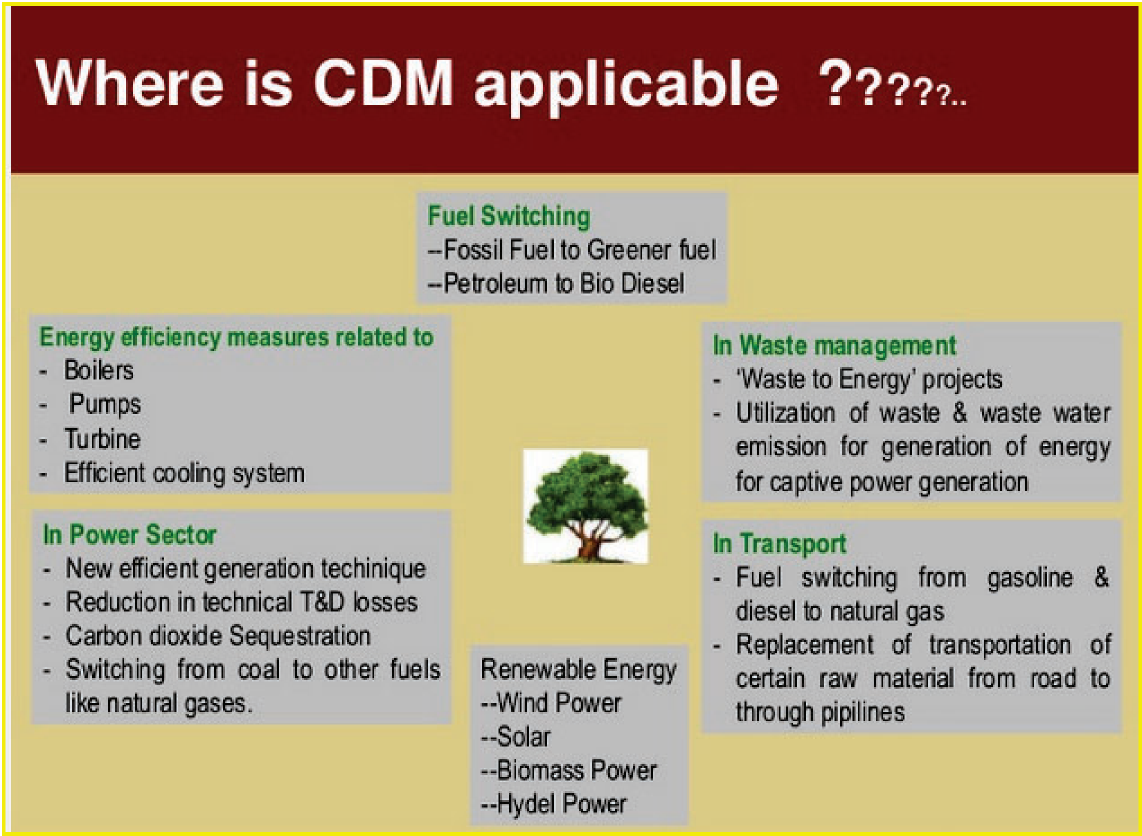
Annex B: A list in the Kyoto Protocol of 38 countries plus the European Community that agreed to QELRCs (emission targets), along with the Quantified Emission Limitation and Reduction Commitment (QELRCs) they accepted. The list is nearly identical to the Annex I Parties listed in the Convention except that it does not include Belarus or Turkey.

Two main goals of CDM

i. To assist countries **without emissions targets (i.e developing countries)** in achieving sustainable development.

ii. To help those countries **with emission reduction targets under Kyoto (i.e developed countries)** in achieving compliance by allowing them to purchase offsets created by CDM projects.

Where CDM will be applicable?



Operating details of the CDM

- A CDM project must provide emission reductions that are additional to what would otherwise have occurred. The projects must qualify through a rigorous and public registration and issuance process. Approval is given by the Designated National Authorities. Public funding for CDM project activities must not result in the diversion of official development assistance.
- The mechanism is overseen by the CDM Executive Board, answerable ultimately to the countries that have ratified the Kyoto Protocol.
- Operational since the beginning of 2006, the mechanism has already registered more than 1,650 projects and is anticipated to **produce Certified Emission Reductions (CERs) amounting to more than 2.9 billion tonnes of CO_2 equivalent in the first commitment period of the Kyoto Protocol, 2008–2012**

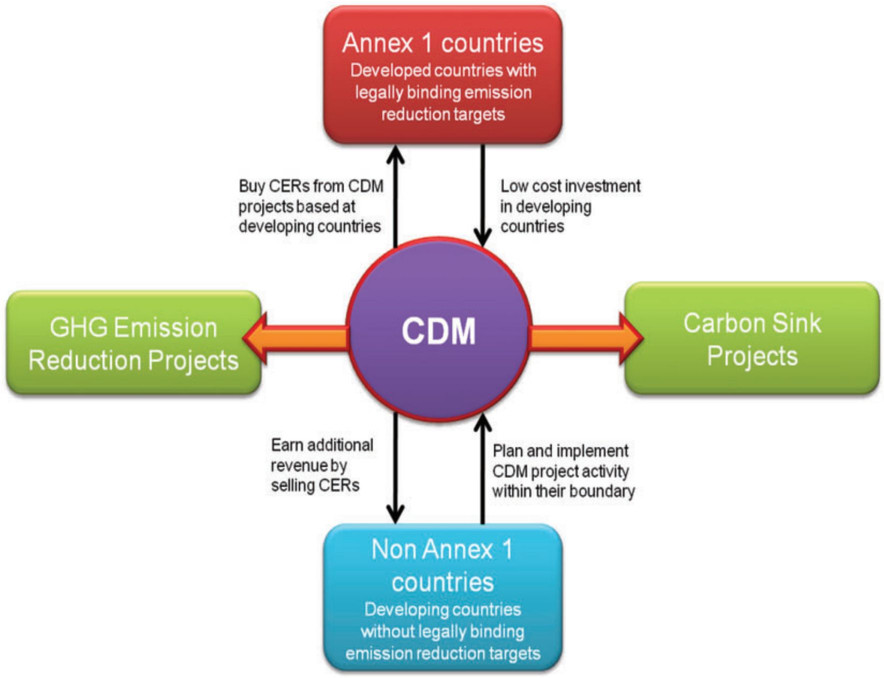


Fig: CDM Mechanism

Article 6 lay the foundation of a new mechanism different from JI and CDM

CDM and Joint Implementation [JI]were created to reach countries' commitments of GHG emission reduction. CDM allows developed countries to generate certified emission reduction (CER) emitted thanks to a mitigation project in developing countries. JI is very similar but includes mitigation outcomes transfers between Annex I countries.

CDM PROJECT CYCLE

The Designated National Authority in India is the National Clean Development Mechanism Authority (NCDMA). The Chairperson of the NCDMA is the Secretary of Environment and Forests. The NCDMA meets once per month to review project proposals, evaluating them on the probability of success and the extent to which they meet sustainable development objectives

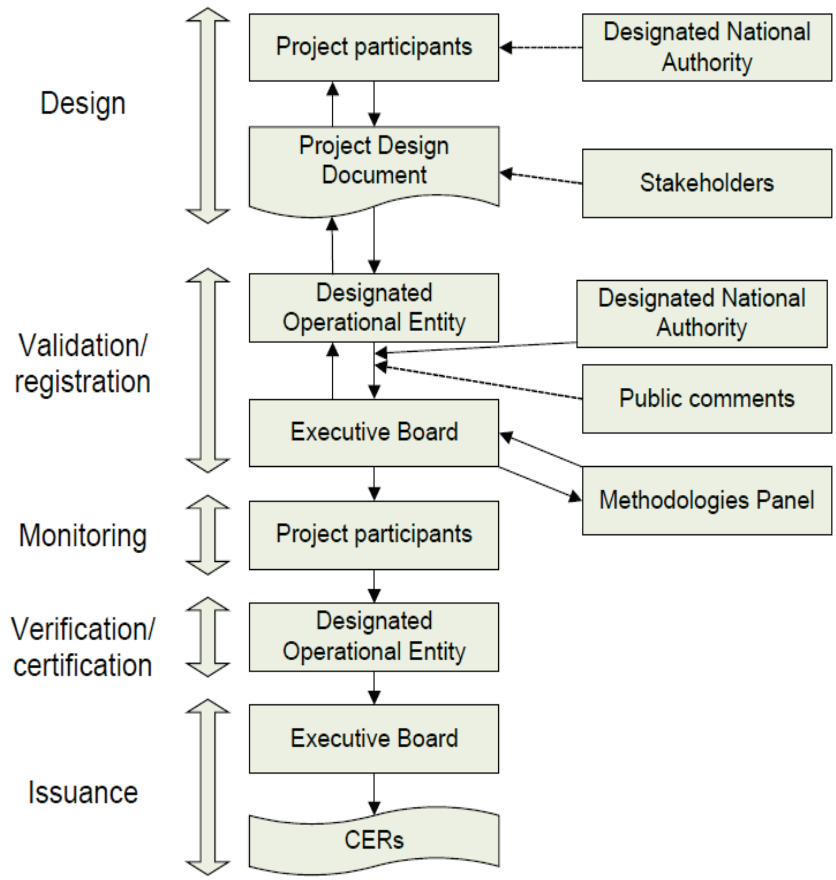


Fig: Project cycle of CDM

CDM Benefits for industrialized and developing countries.

CDM benefits for industrialized and developing countries

- Industrialized Countries
  - CDM emission reductions count towards the GHG emissions targets of the Kyoto Protocol.
  - Lower cost for GHG emissions reductions in developing countries than in industrialized countries.
  - Opportunities to market new technologies in developing countries.
- Developing countries
  - CDM projects generate sustainable development benefits (for example sustainable energy and poverty reduction).
  - Transfer of technologies to achieve sustainable development
  - Additional financial assistance for sustainable development

Disadvantages of CDM

- Concerns have also been raised regarding the conduct of project owners, with certain CDM projects implicated in land rights issues and human rights abuses.
- Meanwhile, the geographical distribution of CDM projects, over 80% of which originate in China and India, calls into question the ability of the CDM to drive broad engagement with sustainable development across developing countries.
- What's more, critics would suggest a more fundamental flaw in the CDM is that it is impossible to prove the 'additionality' of a project in comparison to a hypothetical baseline.

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S9: TOPIC

SLO 1: UNFCCC and India

SLO 2: MONTREAL PROTOCOL

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SLO 1: UNFCCC and India

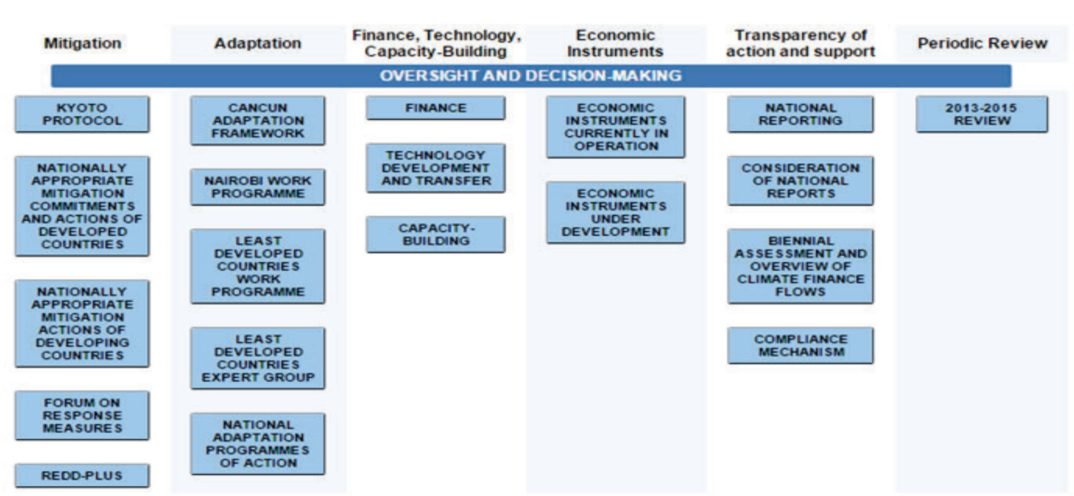
The UNFCCC **[United Nations Framework Convention on Climate Change]** is a framework Convention which aims to limit the level of climate change. The UNFCCC is a framework Convention which focuses on promoting cooperation by means of systematic observations, research and information exchange on the effects of human activities on climate, and adopting legislative or administrative measures against activities likely to have adverse effects. Climate change is a complex problem, which, although environmental in nature, has consequences for all spheres of existence on our planet. It either impacts on or is impacted by global issues, including poverty, economic development, population growth, sustainable development and resource management. The **(UNFCCC)** is an international environmental treaty negotiated at the Earth Summit in Rio de Janeiro from 3 to 14 June 1992, then entered into force on 21 March 1994.

The main objective of UNFCCC is to **"stabilize greenhouse gas concentrations in the atmosphere** at a level that would prevent dangerous anthropogenic interference with the climate system One of the first tasks set by the UNFCCC was for signatory nations to establish national greenhouse gas inventories of greenhouse gas (GHG) emissions and removals, which were used to create the 1990 benchmark levels for accession of Annex I countries to the Kyoto Protocol and for the commitment of those countries to GHG reductions.

UNFCCC Members

1) **Annex 1 countries** → Developed Nations and Nations with Economies in Transition (EIT)
2) **Annex II Countries** → These are Annex I countries without the countries with Economies in Transition (EIT).
3) **Non-annex I countries** → Developing countries

Action of UNFCCC



The UNFCCC secretariat supports all institutions involved in the international climate change negotiations, particularly the **Conference of the Parties (COP),** the Conference of the Parties serving as the **meeting of the Parties (MOP)** The question of what happens beyond 2020 was answered by Parties in Durban in 2011.

At the very heart of the response to climate change, however, lies the need to reduce emissions. In 2010, governments agreed that emissions need to be reduced so that global temperature increases are limited to below 2 degrees Celsius.

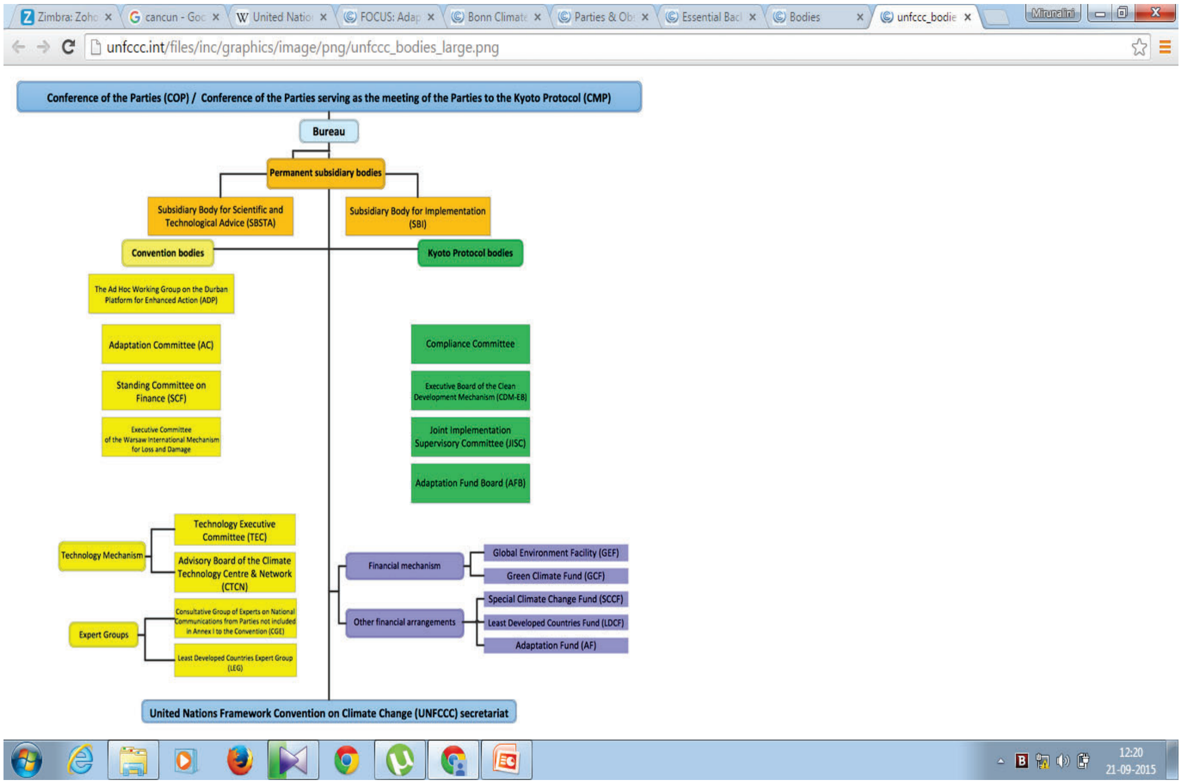
In 1992, countries joined an international treaty, the United Nations Framework Convention on Climate Change, to cooperatively consider what they could do to limit average global temperature increases and the resulting climate change, and to cope with whatever impacts were, by then, inevitable.

By 1995, countries realized that emission reductions provisions in the Convention were inadequate. They launched negotiations to strengthen the global response to climate change, and, two years later, adopted the Kyoto Protocol. The Kyoto Protocol legally binds developed countries to emission reduction targets. The Protocol's first commitment period started in 2008 and ended in 2012. The second commitment period began on 1 January 2013 and will end in 2020.

There are now

195 Parties to the Convention and

192 Parties to the Kyoto Protocol.



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S9 : SLO 2: MONTREAL PROTOCOL

- The **Montreal Protocol on Substances that Deplete the Ozone Layer** (a protocol to the Vienna Convention for the Protection of the Ozone Layer) is an international treaty designed to protect the ozone layer by phasing out the production of numerous substances that are responsible for ozone depletion.
- It was developed under the management of **UNEP [United Nations Environment Programme]** on 16 September 1987, and entered into force on 1 January 1989, followed by a first meeting in Helsinki, May 1989. Since then, it has undergone eight revisions, in 1990 (London), 1991 (Nairobi), 1992 (Copenhagen), 1993 (Bangkok), 1995 (Vienna), 1997 (Montreal), 1998 (Australia), 1999 (Beijing) and 2007 (Montreal).
- The **Montreal Protocol and Vienna convention frame work aggrement from which protocol was born were the first global aggrements to protect the earth's atmosphere.**
- International treaty ratified in 1987 in which 180 signatory nations agrred to **restrict production of chloroflurocarbon [CFC]** inorder to forestall stratospheric ozone depeltion. Because of its effectiveness in decreasing global CFC emissions, the

Montreal protocol is considered the most successful effort to date in addressing a global environment problem.

- As a result of the international agreement, the ozone hole in Antarctica is slowly recovering. Climate projections indicate that the ozone layer will return to 1980 levels between 2050 and 2070.
- Due to its widespread adoption and implementation it has been hailed as an example of exceptional international co-operation, the single most successful international agreement to date has been the Montreal Protocol".
- In comparison, effective burden sharing and solution proposals mitigating regional conflicts of interest have been among the success factors for the Ozone depletion challenge, where global regulation based on the Kyoto Protocol has failed to do so.
- In case of the **ozone depletion** challenge, there was global regulation already being installed before a scientific consensus was established. As well in comparison, lay people and public opinion were more convinced about possible imminent risks.
- The two ozone treaties have been ratified by **197 parties,** which includes 196 states and the European Union, making them the first universally ratified treaties in United Nations history.

Terms and purposes

- The treaty is structured around several groups of halogenated hydrocarbons that have been shown to play a role in ozone depletion.
- All of these ozone depleting substances contain either chlorine or bromine (substances containing only fluorine do not harm the ozone layer).
- For each group, the treaty provides a timetable on which the production of those substances must be shot out and eventually eliminated.

Scope of Protocol

The Montreal Protocol is an international agreement adopted in 1987 to control the production and consumption of specific man-made chemicals that destroy the ozone layer, the earth's protective shield. An agreement /mechanism to reduce and eliminate the production and consumption of ODS Developed and developing countries have different phase out schedules

INDIA'S COMMITMENT TO THE MONTREAL PROTOCOL

i. 19th June 1991 : India became a Party to the Vienna convention.

ii. 17th September 1992 : India became a Party to the Montreal Protocol and ratified the London Amendment.

iii. 3rd March 2003 : India ratified Copenhagen Amendment (1992), Montreal Amendment (1997) and Beijing Amendment (1999).

iv. November 1993 : India's Country Programme was prepared.

v. January 2006 : India's Country Programme was updated.

MONTREAL PROTOCOL – Prevention of OZONE Depletion

The Montreal Protocol is designed to protect the ozone layer by phasing out the production of **ODS (Ozone Depleting Substances),** Chemicals that potentially deplete the ozone layer.

Gases considered in terms of **Ozone Depletion Potential (ODP):**

The ODP is based on the **amount of chlorine** which is released by the refrigerant as it degrades.

Reference ODP is for CFC R11 (also known as Freon-11, CFC-11, or R-11)
which is taken as 1.

Most of refrigerants are strong GHG emissions and thus limitation of ODS will help climate change as well.

Without the Montreal Protocol by 2050

Ozone depletion would have reached to at least 50 % in the northern hemisphere's mid latitudes 70% in the southern mid latitudes.

Doubling on the UV-B radiation reaching earth's surface.

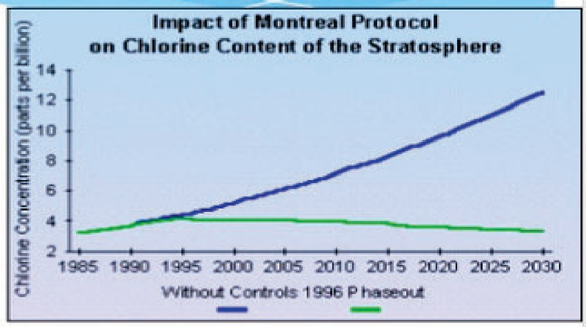
Estimated increases of 19 million more cases of non-melanoma cancer 1.5 million more cases of melanoma cancer 130 million more eye cataracts

Montreal Protocol

- Signed 16 September 1987
- Location Montreal
- Effective 1 January 1989 if 11 states have ratified by then
- Condition ratification by 20 states
- Signatories 46
- Ratifiers 197 (all United Nations members, as well as Niue, the Cook Islands, the Holy See and the European Union)
- Depositary Secretary-General of the United Nations
- Languages Arabic, Chinese, English, French, Russian and Spanish.

Results to date

- The Montreal Protocol is working. There is clear evidence of a decrease in the atmospheric burden of ozone-depleting substances in the lower atmosphere and in the stratosphere;
- Some early signs of the expected stratospheric ozone recovery are also evident.
- Furthermore, if the Parties were to eliminate all emissions of ozone depleting substances soon after 2006, it would advance by about 15 years (from around 2050 to 2035) the global ozone layer recovery to pre-1980 levels



18CE0406T GLOBAL WARMING AND CLIMATE CHANGE

UNIT – 5

[S1 – S3]

S1: SLO 1: Climate change negotiations

The climate negotiation process occurring through the United Nations Framework Convention on Climate Change (UNFCCC) and its related agreements is the primary forum for international cooperation on stabilizing atmospheric greenhouse gas concentrations at a level that would prevent catastrophic anthropogenic substances.

The United Nations Framework Convention on Climate Change (UNFCCC), agreed in 1992, is the main international treaty on fighting climate change. Its objective is **to prevent dangerous man-made interference with the global climate system**. The European Union (EU) and all its member countries are among the 197 Parties of the Convention.

The Intergovernmental Panel on Climate Change (IPCC) is a scientific and intergovernmental body of the United Nations (UN) tasked with providing an objective scientific assessment of climate change and its potential political, economic, social and environmental impacts.

IPCC reports support the United Nations Framework Convention on Climate Change (UNFCCC), the main international treaty on climate change that has the purpose of stabilising greenhouse gas (GHG) emissions at a level that will prevent 'dangerous' anthropogenic climate change (i.e. that caused by human activity).

An annual 'Conference of Interested Parties' (COP) assesses progress towards achieving this goal, and in December 2015 agreed the 'Paris Agreement' that set out member countries obligations to reduce GHG emissions and fund measures to mitigate the effects of climate change.

195 countries signed the agreement. This activity simulates the negotiation process that created it.

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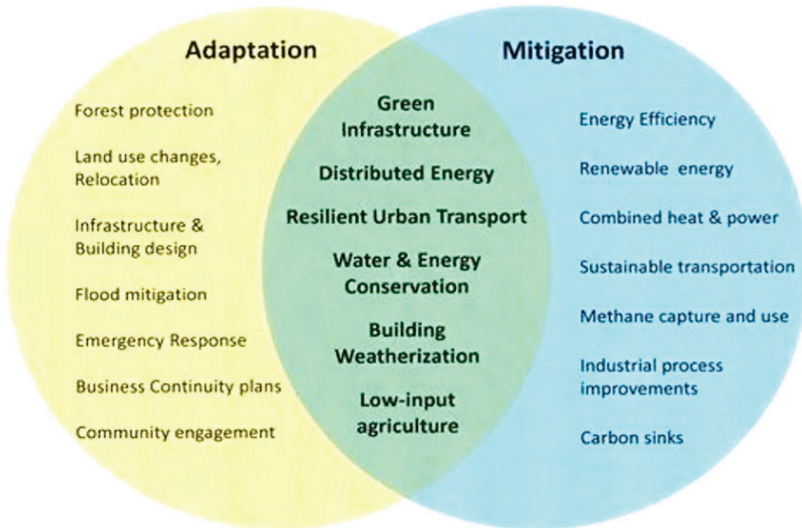
S1: SLO2: Mitigation measures

	Mitigation policy	Mitigation technology
Energy supply sector	• reduction of fossil fuel subsidies • taxes or carbon charges on fossil fuels	• switching fuel from coal to gas
Waste sector	• financial incentives for improved waste and wastewater management • renewable energy incentives • obligations and waste management regulations	• waste incineration with energy recovery • composting of organic waste • controlled wastewater treatment and recycling • waste minimization
Buildings sector	• appliance standards and labeling • building codes and certification	• efficient lighting and daylighting • more efficient electrical appliances • heating and cooling devices



S2: Use of renewable resources

(i) Solar energy

(ii) Wind energy

(iii) Tidal energy

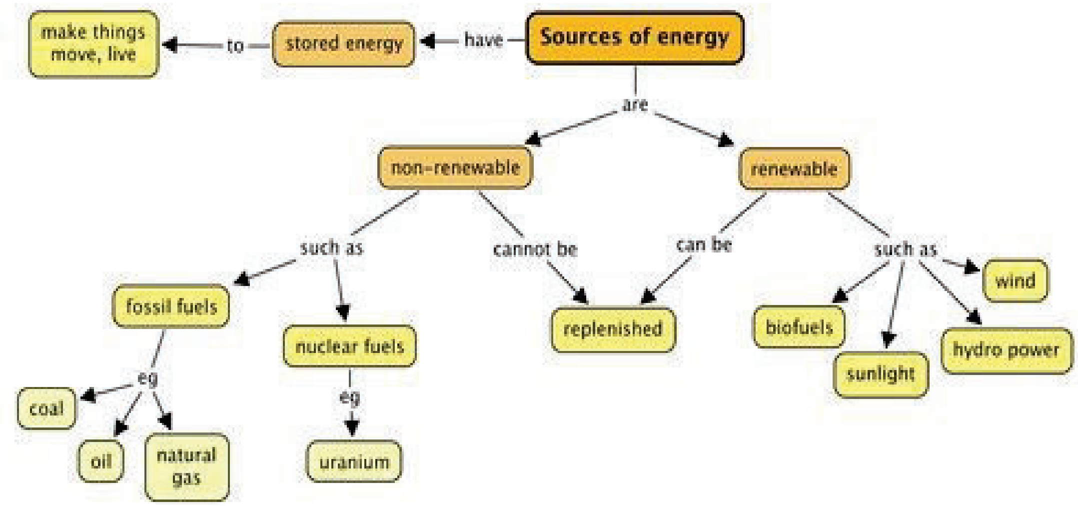
(iv) Hydrothermal energy

(v) Geothermal energy

Renewable energy is energy that is collected from renewable resources, **which are naturally replenished** on a human time scale, such as **sunlight, wind, rain, tides, waves, and geothermal heat.**

Non-renewable energy comes from sources that will run out or will not be replenished in our life times—or even in many, many life times. Most non-renewable energy sources are **fossil fuels: coal, petroleum, and natural gas**. Carbon is the main element in fossil fuels.

When we pump gas at the station, we're using a finite resource refined from crude oil that's been around since prehistoric times.



Renewable Energy Source	Non-Renewable Energy Source
Renewable Sources of Energy are those Sources of Energy which can be renewed naturally over time.	Non-Renewable Sources of Energy are those sources which are available in limited quantity..
They are replaced by nature in a short period of time	They cannot be replaced by nature
They are inexhaustible.	They will be exhausted one day
They do not cause any pollution	They cause pollution when used
Example - Solar Energy, Wind Energy	Example - Fossil Fuels, Nuclear Energy

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Solar Energy

Humans have been harnessing solar energy for thousands of years—to grow crops, stay warm and dry foods. According to the **National Renewable Energy Laboratory**, "more energy from the sun falls on the earth in one hour than is used by everyone in the world in one year." Today, we use the sun's rays in many ways—to heat homes and businesses, to warm water, or power devices.

Solar, or photovoltaic (PV), cells are made from **silicon** or other materials that transform sunlight directly into electricity. Distributed solar systems generate electricity locally for homes and businesses, either through rooftop panels or community projects that power entire neighborhoods. Solar farms can generate power for thousands of homes, using mirrors to concentrate sunlight across acres of solar cells. Floating solar farms—or "floatovoltaics"—can be an effective use of wastewater facilities and bodies of water that aren't ecologically sensitive.

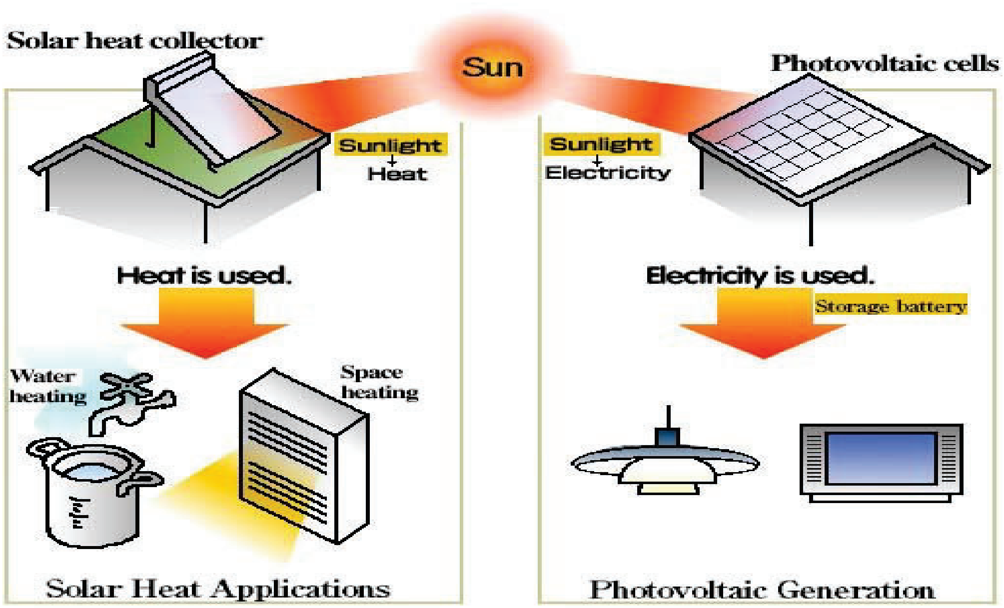
Solar supplies a little more than 1 percent of U.S. electricity generation**.** But nearly a third of all new generating capacity came from solar in 2017, second only to natural gas.

Solar energy systems don't produce air pollutants or greenhouse gases, and as long as they are responsibly sited, most solar panels have few environmental impacts beyond the manufacturing proces.

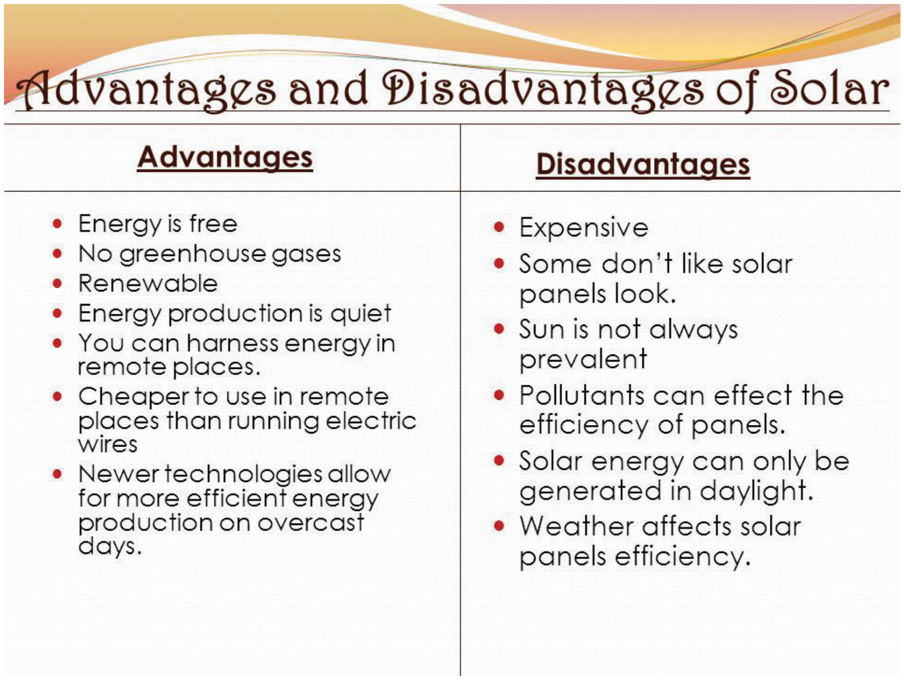
Concentrated solar power (CSP), uses mirrors to concentrate solar rays. These rays heat fluid, which creates steam to drive a turbine and generate electricity. CSP is used to generate electricity in large-scale power plants.

Solar energy corporation of India

- Installed grid connected solar power capacity is 4,229.36 MW (2015)
- Solar Thermal
- Solar PV system
- Solar concentrator
- Solar cookers
- Solar electrification for rural areas
- Solar pumping
- Solar dryers



Merits & demerits of solar energy



Wind Energy

Wind energy is a form of solar energy. Wind energy (or wind power) describes the process by which wind is used to generate electricity. Wind turbines convert the kinetic energy in the wind into mechanical power. A generator can convert mechanical power into electricity.

Wind power is a clean energy source that we can rely on for the long-term future. ... Because wind is a source of energy which is non-polluting and renewable, the turbines create power without using fossil fuels. That is, without producing greenhouse gases or radioactive or toxic waste.

Wind in India are influenced by the strong south-west summer monsoon, which starts in May-June, when cool, humid air moves towards the land and the weaker north-east winter monsoon, which starts in October, when cool, dry air moves towards the ocean.

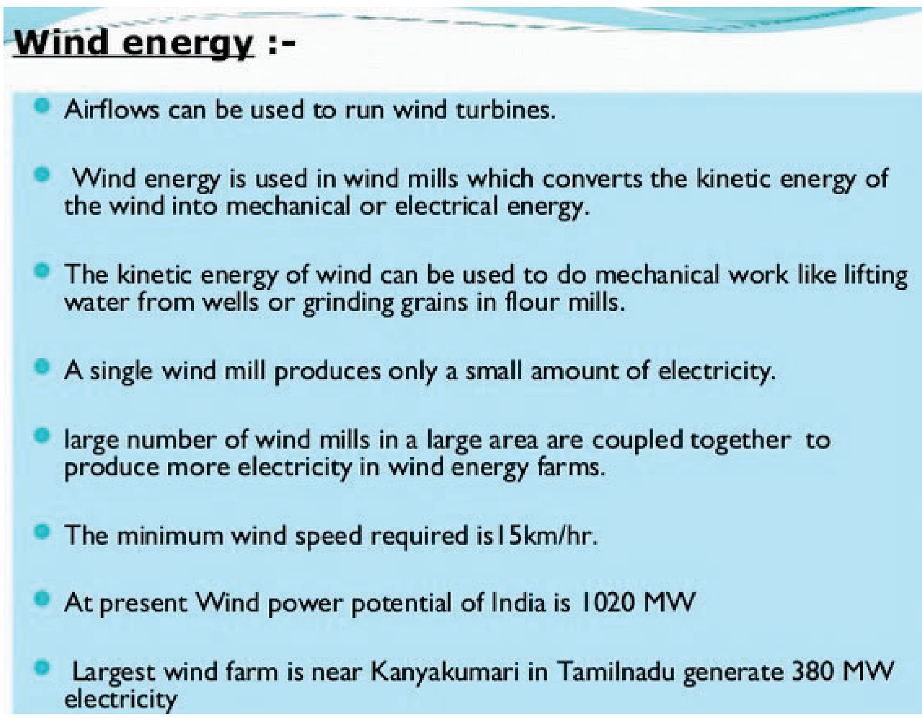
During the period march to August, the winds are uniformly strong over the whole Indian Peninsula, except the eastern peninsular coast. Wind speeds during the period November to march are relatively weak, though higher winds are available during a part of the period on the Tamil Nadu coastline.

Indian Wind Energy Association

The Indian wind energy sector has an installed capacity of **23,439.26 MW (as on 2015).**

In terms of wind power installed capacity, **India is ranked 5th in the World**. Today India is a major player in the global wind energy market. The potential is far from exhausted. Indian Wind Energy Association has estimated that with the current level of technology, the 'on-shore' potential for utilization of wind energy for electricity generation is of the order of 102 GW.

The unexploited resource availability has the potential to sustain the growth of wind energy sector in India in the years to come.



Challenges of Wind Power

Wind power must still compete with conventional generation sources on a cost basis. Even though the cost of wind power has decreased dramatically in the past several decades, wind projects must be able to compete economically with the lowest-cost source of electricity, and some locations may not be windy enough to be cost competitive.

Good land-based wind sites are often located in remote locations, far from cities where the electricity is needed. Transmission lines must be built to bring the electricity from the wind farm to the city. However, building just a few already-proposed transmission lines could significantly reduce the costs of expanding wind energy.

Wind resource development might not be the most profitable use of the land. Land suitable for wind-turbine installation must compete with alternative uses for the land, which might be more highly valued than electricity generation.

Turbines might cause noise and aesthetic pollution. Although wind power plants have relatively little impact on the environment compared to conventional power plants, concern exists over the noise produced by the turbine blades and visual impacts to the landscape.

Wind plants can impact local wildlife. Birds have been killed by flying into spinning turbine blades. Most of these problems have been resolved or greatly reduced through technology development or by properly siting wind plants. Bats have also been killed by turbine blades, and research is ongoing to develop and improve solutions to reduce the impact of wind turbines on these species.

Advantages of Wind Power

(i) Wind power is cost-effective.
(ii) Wind creates jobs.
(iii) Wind enables U.S. industry growth and U.S. competitiveness
(iv) It's a clean fuel source.
(v) Wind is a domestic source of energy
(vi) It's sustainable.
(vii) Wind turbines can be built on existing farms or ranches, the energy it produces doesnot cause green house gases.

Disadvantages of Wind Power

i. Wind is not available at all times.
ii. It requires a large area of land.
iii. **A minimum wind speed of 15km/hr is required.**

••

S3: Tidal energy

Tide is created due to gravitational force between earth sun and moon. Tidal energy is a renewable energy powered by the natural rise and fall of ocean tides and currents. Some of these technologies include turbines and paddles.

Although not widely used, tidal energy has the potential for future electricity generation.

Tidal power is one of the major renewable energy sources, but also one of the most infantile.

Using the power of the tides, energy is produced from the gravitational pull from both the moon and the sun, which pulls water upwards, while the Earth's rotational and gravitational power pulls water down, thus creating high and low tides.

This movement of water from the changing tides is a natural form of kinetic energy.

How does it work?

Tidal energy is produced through the use of tidal energy generators. These large underwater turbines are placed in areas with high tidal movements, and are designed to capture the kinetic motion of the ebbing and surging of ocean tides in order to produce electricity.

How Tidal energy is generated?

Tidal energy is created using the movement of our tides and oceans, where the intensity of the water from the rise and fall of tides is a form of kinetic energy. Tidal power surrounds gravitational hydropower, which uses the movement of water to push a turbine to generate electricity

How is tidal energy used today?

We can use tidal energy to supply electricity to our homes and businesses. We can use tidal energy in some places instead of burning coal and oil that contribute to global warming. Tidal generators (or turbines) work like wind turbines, except it is ocean currents, not wind, that turns them.

How does tidal energy affect the environment?

Tidal energy is a renewable source of electricity which does not result in the emission of gases responsible for global warming or acid rain associated with fossil fuel generated electricity. Use of tidal energy could also decrease the need for nuclear power, with its associated radiation risks.

Advantages of Tidal Energy

- It is an inexhaustible source of energy.
- Tidal energy is environment friendly energy and doesn't produce greenhouse gases.
- As 71% of Earth's surface is covered by water, there is scope to generate this energy on large scale.
- Efficiency of tidal power is far greater as compared to coal, solar or wind energy. Its efficiency is around 80%.
- Tidal Energy doesn't require any kind of fuel to run.
- The life of tidal energy power plant is very long.
- The large density of water, almost 1000 times greater than in air, results in very large amounts of energy to get out of the tidal currents even if the speed is low.

Disadvantages of Tidal Energy

- Cost of construction of tidal power plant is high.
- There are very few ideal locations for construction of plant and they too are localized to coastal regions only.
- Intensity of sea waves is unpredictable and there can be damage to power generation units.
- Influences aquatic life adversely and can disrupt migration of fish.
- The actual generation is for a short period of time. The tides only happen twice a day so electricity can be produced only for that time.
- Usually the places where tidal energy is produced are far away from the places where it is consumed. This transmission is expensive and difficult.

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Geotehermal energy

The word geothermal comes from greek word Geo- Earth and Thermal – Heat.

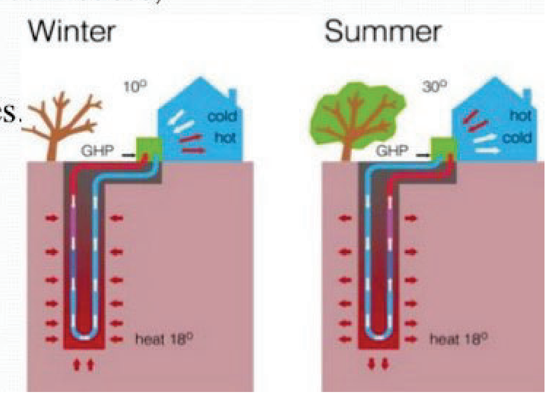
Geothermal energy is the heat from earth. It's source lies 6500 km beneath the earth surface, core containing hot magma. Geothermal energy is a clean renewable energy resource. It accounts for 3% of the total renewable based energy electricity.

What is Geothermal Energy ?
Geothermal Energy is thermal energy generated and stored in the earth. Thermal energy determines the temperature of the matter.
Earth's geothermal energy originates from the original formation of the Planet and from radioactive decay of minerals.

Geothermal Power Plant uses superheated water to generate electricity. It is a most efficient way or we can say a much better way to generate electricity because they require no raw materials and having little or no impact on the environment

Direct use of Geothermal Energy

- Hot springs, used as spas.
- Heating water at fish farms.
- Provide heat for buildings.
- Raising plants in greenhouses, drying crops.
- Provides heat to industrial processes.



Geothermal energy potential: India

- India has about 400 thermal springs distributed in 7 geothermal provinces
  - These springs are perennial and their surface temperature range from 37 to 90°C and their cumulative surface discharge is over 1000 l/m.
  - Temperature of the water at Tattapani is 90°C; at Puga (Himalaya) it is 98°C and at Tuwa (Gujarat) it is 98°C
- Estimated reservoir temperature are 120°C (west coast), 150°C (Tattapani) and 200°C (Cambay)
- The geothermal systems are mostly liquid dominated (steam dominated systems are seen in Himalayan & Sonata provinces)
- Depth of the geothermal reservoir is about 1 to 2 km
- The power generating capacity of the thermal springs is estimated at about 10,000 MW
  - Binary cycle method can be utilized to generate power
  - Puga valley (Ladakh) has the most promising geothermal field

Technologies

- Traditional/ conventional hydrothermal power production systems (geothermal power plants) types
  - Dry steam
  - Flash steam (2 types: single flash and double flash power plants
  - Binary cycle
  - Combined cycle and Hybrid
- Coproduction, Enhanced Geothermal Systems (EGS), Geo-pressured and Supercritical systems
- Direct use of geothermal heat (without involving a power plant or a heat pump)
  - Space heating and cooling, food preparation, hot spring bathing and spas, agriculture, aquaculture, green houses, snow melting and industrial uses
  - These are applied at aquifer temperatures 90-200C.
  - The geothermal water/steam is accessed and brought to a plate heat exchanger
- Ground Source Heat Pumps (GSHP)/ Geothermal Heat Pumps (GHPs) – Geothermal Heating and Cooling Systems

Geothermal Energy

Advantages

- Geothermal energy does not produce any pollution i the form of greenhouse gases.
- Running costs for a geothermal power station are very low.

Disadvantages

- It is difficult to find suitable sites to put a geothermal power station.
- If not carefully managed, a borehole can 'run out of steam' and may not be useable for several decades.
- Dangerous gases and minerals can come out of a borehole, which may be difficult to dispose of.

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Hydrothermal energy

Hydrothermal energy is the process of obtaining heat or energy from a large body of water. 'Heat', in this case should not be associated with high temperature (as it may be with geothermal energy) but rather a relative heat content or relative temperature difference.

What is the source of hydrothermal energy?

Magma heats nearby rocks and underground aquifers. Hot **water** can be released through geysers, hot springs, steam vents, underwater hydrothermal vents, and mud pots. These are all sources of geothermal energy. Their heat can be captured and used directly for heat, or their steam can be used to generate electricity.

Hydropower uses a fuel—water—that is not reduced or used up in the process. Because the water cycle is an endless, constantly recharging system, hydropower is considered a **renewable energy**. When flowing water is captured and turned into **electricity**, it is called **hydroelectric** power or hydropower.

Why is hydrothermal energy important?

Hydropower is fueled by water, so it's a clean fuel source, meaning it won't pollute the air like **power** plants that burn fossil fuels, such as coal or natural gas. ... Because hydropower plants can generate **power** to the grid immediately, they provide **essential** back-up **power** during **major electricity** outages or disruptions.

Why is hydropower better than geothermal energy?

Geothermal and hydroelectric are renewable sources of **energies** and produce "clean" fuel sources. **Geothermal energy** is heat stored deep inside the earth or occasionally in hot springs. ... **Hydropower** is fueled by water and driven by the sun, therefore; it is a sustainable fuel source

Who uses hydropower the most?

Hydropower is the most important and widely-used renewable source of energy. Hydropower represents about 17% (International Energy Agency) of total electricity production. China is the largest producer of hydroelectricity, followed by Canada, **Brazil**, and **the United States** (Source: **Energy Information Administration**).

Disadvantages of Hydroelectric Energy

- Environmental Consequences. The environmental consequences of **hydropower** are related to interventions in nature due to damming of water, changed water flow and the construction of roads and power lines. ...
- Expensive. ...
- Droughts. ...
- Limited Reservoirs.

18CE0406T GLOBAL WARMING AND CLIMATE CHANGE

UNIT – 5

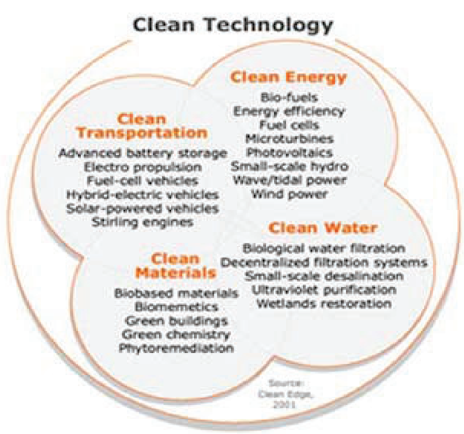
[S4 – S6]

S4: SLO 1: Clean Technology, biodiesel, compost, biodegradable plastics,

SLO 2: Concept of sustainable development

Clean Technology

- Clean technology, in short cleantech, is any process, product, or service that reduces negative environmental impacts through significant energy efficiency improvements, the sustainable use of resources, or environmental protection activities.



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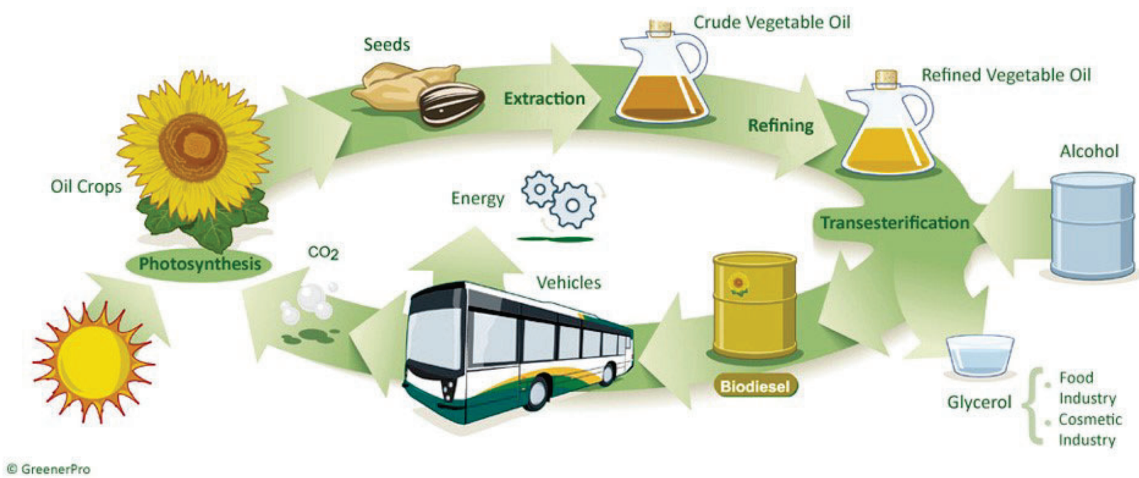
BIODIESEL

- Biodiesel is a domestically produced, renewable fuel that can be manufactured from vegetable oils, animal fats, or recycled restaurant grease for use in diesel vehicles.
- Biodiesel's physical properties are similar to those of petroleum diesel, but it is a cleaner-burning alternative.
- Using biodiesel in place of petroleum diesel, especially in older vehicles, can reduce emissions.
- Biodiesel is a liquid fuel often referred to as B100 or neat biodiesel in its pure, unblended form. Like petroleum diesel, biodiesel is used to ***fuel compression-ignition*** engines, which run on petroleum diesel.

➢ How well biodiesel performs in cold weather depends on the blend of biodiesel. The smaller the percentage of biodiesel in the blend, the better it performs in cold temperatures.

The Biodiesel Cycle



1) Biodiesel is a clean burning renewable fuel made using natural vegetable oils and fats.
2) Biodiesel is made through a chemical process which converts oils and fats of natural origin into fatty acid methyl esters (FAME) through a process called trans-esterification.
3) Biodiesel is intended to be used as a replacement for petroleum diesel fuel, or can be blended with petroleum diesel fuel in any proportion.
4) Biodiesel does not require modifications to a diesel engine to be used.
5) Biodiesel has reduced exhaust emissions compared to petroleum diesel fuel.
6) Biodiesel has lower toxicity compared to petroleum diesel fuel.
7) Biodiesel is safer to handle compared to petroleum diesel fuel.
8) Biodiesel quality is governed by ASTM D 6751 quality parameters.
9) Biodiesel is biodegradable.

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COMPOST

- Composting is the process that speeds up decomposition of organic materials by providing ideal conditions for microorganisms to thrive.
- Compost is rich in nutrients. It is used, for example, in gardens, landscaping, horticulture, urban agriculture and organic farming. The compost itself is beneficial for the land in many ways, including as a soil conditioner, a fertilizer, addition of vital humus or humic acids, and as a natural pesticide for soil.
- Compost is simply decayed organic matter — and "organic matter" is a pretty wide-ranging label. A twig can be organic matter, but so can a banana peel. When you mix a bunch of these items together in a compost pile, they break down naturally into a nutrient-rich fertilizer that helps gardens grow.enhouse gas emissions.
- Studies further show that compost can aid in **carbon sequestration**. When applied to soil, compost potentially functions as a "carbon sink," trapping and containing the element in the dirt. And if the carbon is in the ground, it isn't in our atmosphere, where it can wreak havoc on the planet.

Types of Composting

- Composting Basics.
- Onsite Composting.
- Vermicomposting.
- Aerated (Turned) Windrow Composting.
- Aerated Static Pile Composting.
- In-Vessel Composting.

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Biodegradable plastics

- **Biodegradable plastics** are **plastics** that can be decomposed by the action of living organisms, usually microbes, into water, carbon dioxide, and biomass. **Biodegradable plastics** are commonly produced with renewable raw materials, micro-organisms, petrochemicals, or combinations of all three.

- While the words "bioplastic" and "biodegradable plastic" are similar, they are not synonymous. Not all bioplastics are biodegradable.

Which plastic is biodegradable?

- One set of degradable plastics are **materials** such as PLA (**Polylactic Acid**) that are unique plastics for which biological degradation potential is part of the nature of the plastic. The second set is **materials** of the standard #1 **PET**, #2 HDPE, #4 LDPE, #5 PP and #6 PS with special degradable additives included.
- **Biodegradable plastics** are very rarely recyclable, and **biodegradable** does not mean **compostable**–so they often up in the landfill. **Compostable** and bioplastic goods can be a better choice than **biodegradable** ones, but often still end up in landfills unless you can compost appropriately.

What are the problems with biodegradable plastics?

- When some biodegradable plastics decompose in landfills, they produce methane gas. This is a very powerful greenhouse gas that adds to the problem of global warming. Biodegradable plastics and bioplastics don't always readily decompose.
- Biodegradable plastics take **three to six months** to decompose fully. That's much quicker than synthetic counterparts that take **several hundred years**. Exactly how long a biodegradable bag takes to break down depends on various factors, such as temperature and the amount of moisture present.

Concept of Sustainable development

- Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."
- The aim of sustainable development is to balance our economic, environmental and social needs, allowing prosperity for now and future generations. ... These include social progress and equality, environmental protection, conservation of natural resources and stable economic growth.
- Sustainable development is maintaining a delicate balance between the human need to improve lifestyle and feeling of well being on one-hand and preserving natural resources and ecosystems on which we and future generations depend.
- Political **barriers**: Inadequate economic, social and environmental **methods** for policies, plans and projects are the **major barrier** combating the implementation of **sustainable development.**

The aim of sustainable development

The aim of sustainable development is to define viable schemes combining the economic, social, and environmental aspects of human activity. That is making sure that there is a balance between the three types of sustainable development:

***Environmental sustainable development**

***Economic sustainable development**

***Social sustainable development**

It is Constant tussle between the Planet(environment), the People(social) and Profit(profits)

Why sustainable Development is Important

It's no secret that people are living longer and that the global population is on the rise. In fact, the United Nations projects that there will be more that 10 billion people living on the Earth by the year 2100. This explosion in population is perhaps one of the greatest reasons why sustainable development is so important.

Provide Basic Human Needs (social)

A rising population will also make use of the bare essentials of life such as food, water, and shelter.

Agricultural Necessity

Agriculture will have to catch up with that growing population as well, figuring out ways to feed around 3 billion more people than it currently does

Accommodate City Development (social)

As populations rise, cities will need to become larger to accommodate the influx of new residents.

Control Climate Change

Climate change is another issue that can be at least partially remedied through sustainable development. Sustainable development practices would mandate a lower use of fossil fuels, which are not sustainable and which produce greenhouse gases.

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S5: Concept of Carbon sequestration, Terrestrial sequestration

S6: Ocean sequestration

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Concept of Carbon sequestration

Carbon Sequestration is capturing and securely storing carbon dioxide emitted from the global energy system. Carbon sequestration is the placement of CO_2 into a depository in such a way that it remain safely and not released back into the atmosphere.

Sources of CO_2 emission	
Natural sources	**Manmade sources**
Volcanoes	Industries
Wild fires	Transportation
Decomposition	Soil cultivation
Respiration	Biomass burning

Objectives of carbon sequestration

i. Reducing pollution in air as well as improving natural carbon content in soil.
ii. Improvement of soil structure
iii. Restoring degraded soil leading to increase yield in crops.
iv. Developing technology to reduce rate of concentration of green house gases in air

Types of carbon Sequestration:

i. Ocean Sequestration: Carbon stored in oceans through direct injection or fertilization.
ii. Geologic Sequestration: Natural pore spaces in geologic formations serve as reservoirs for long-term carbon dioxide storage.
iii. Terrestrial Sequestration: A large amount of carbon is stored in soils and vegetation, which are our natural carbon sinks.

The main strategies for using forests for carbon sequestration

Active forest management

Avoided deforestation

Forest preservation

Afforestation

Challenges in soil carbon sequestration

- Deforestation
- Residue burning
- Conventional tillage
- Imbalanced use of fertilizers
- Reduced inputs of organic matter

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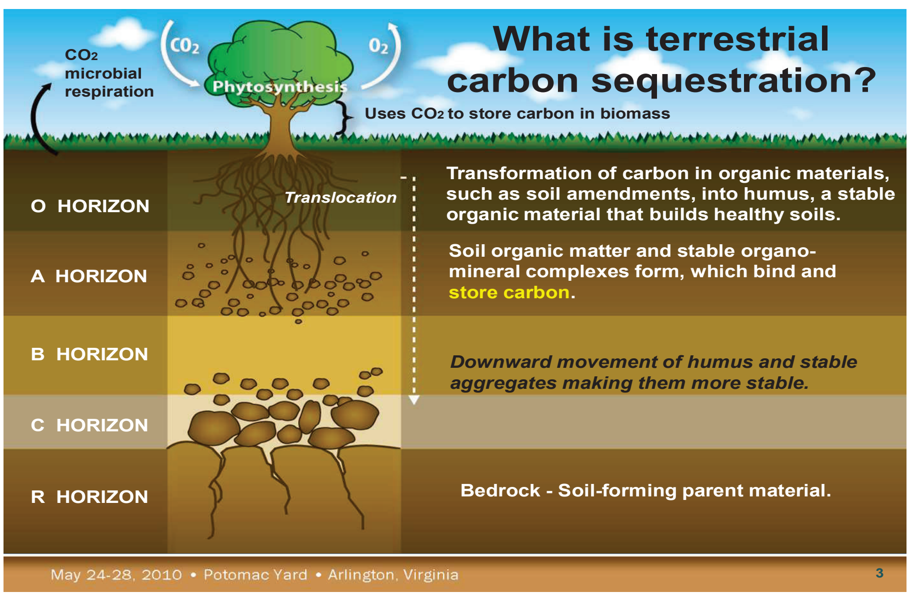
Terrestrial Sequestration

Terrestrial sequestration is a process that captures and stores carbon dioxide (CO_2) in vegetation and soil within a few feet of the Earth's surface, providing them with the components they need to live and grow and reducing CO_2 in the atmosphere.

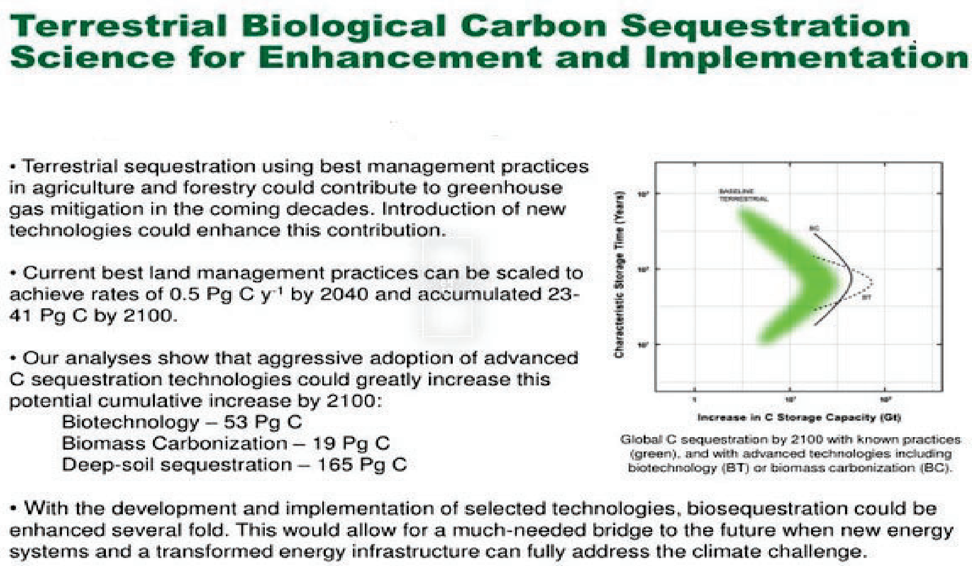
The process through which CO_2 from the atmosphere is absorbed naturally through photosynthesis and stored as Carbon in biomass and soil.

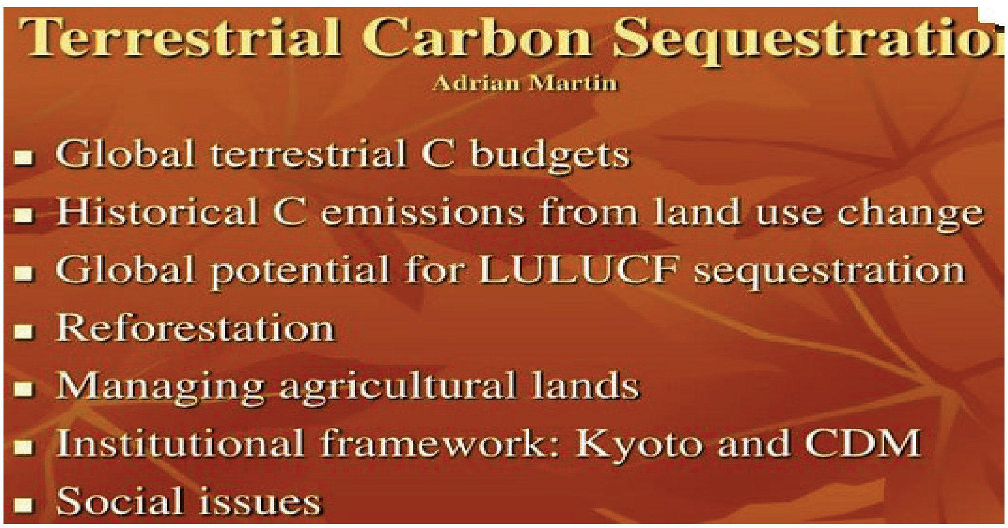


The amount of carbon stored in terrestial carbon sequestration is obtained through the process of **photosynthesis.**

The carbon from corbon di oxide is biochemically transformed into carbohydrates necessary for plant growth and structure.

Most of the carbon eventually cycles back to the atmosphere through the decomposition of plant material, but a fraction is retained in soil and wetland sediments.





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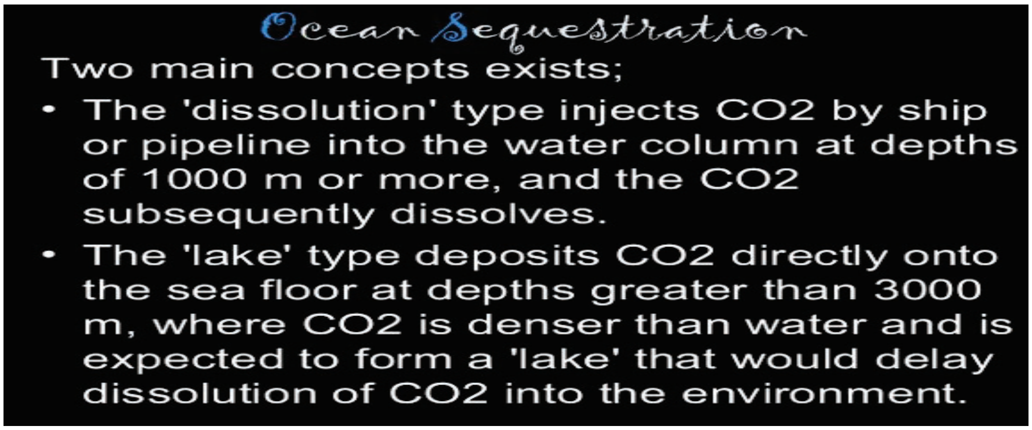
S6: Ocean Sequestration

The ocean represents the largest potential sink for anthropogenic CO_2. Discharging CO_2 directly to the oceanwould accelerate the ongoing, but slow, natural processes by which over 90% of present-day emissions arecurrently entering the ocean indirectly and would reduce both peak atmospheric CO_2 concentrations and their rateof increase.

In the ocean, carbon sequestration, a fancy word for the process by which carbon dioxide is removed from the atmosphere, is achieved through various chemical and biological processes. Plankton at the ocean surface use photosynthesis to convert carbon dioxide into sugars in the same way trees and land plants do on land.

Carbon is naturally stored in the ocean via two pumps, solubility and biological and there are analogous man made methods, direct injection and ocean fertilization, respectively. At the present time, approximately one third of human generated emission are estimated to be entering the ocean.

Carbon sequestration by direct injection into the deep ocean involves the capture, separation, transport and injection of CO_2 from land or tankers. One-third of CO_2 emitted a year already enters the ocean. Ocean has 50 times more carbon than the atmosphere.



18CE0406T GLOBAL WARMING AND CLIMATE CHANGE

UNIT – 5

[S7 – S9]

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S7: Green building technology, Landscaping restoration and plantation

S8: *Mitigations and adaptation in India, Prevent and precaution measures (health issues, environmental damages)*

S9: *Energy policies for a cool future, Energy Audit.*

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S7: Green building technology, Landscaping restoration and plantation

Green building technology

What is green building?

A Green building is nothing more than a building which is built using reusable materials and other materials which make the building efficient and environmentally friendly. And Green building technology typically covers everything from geothermal heating to energy-efficient appliances.

The expression 'green building' refers to both the eco-friendly process of construction and the concrete structure itself, which is realised following the above mentioned sustainable processes.

In this way, with the term green building we can point to the process of construction, but also to the environmentally sustainable building designed to minimise the total environmental impacts on nature.

From the aesthetic point of view, green building follows the philosophy of designing buildings that are in harmony with the surrounding site. Architectural forms must be inspired by nature, with colours that do not seem artificial and using only the materials that nature provides.

Solar, wind, and hydroelectric dams are all examples of green technology because they are safer for the environment and don't produce fossil fuel waste by-products. Besides the environmental benefits of these alternative energy sources, they can also be used to power a home or a utility power plant.

What are the 7 components of green building?

Goals of green building

- Life cycle assessment.
- Siting and structure design efficiency.
- Energy efficiency.
- Water efficiency.
- Materials efficiency.
- Seperior Indoor environmental quality enhancement.
- Operations and maintenance optimization.
- Waste reduction.
- Storm water management

How is green building produced?

The processes involved in green building cover all the fields of the construction industry, from the siting and the initial design of a building, to the renovation of it, always considering the need for sustainability.

In this way, the mail goal of sustainable building is to reduce the impact of building on the environment. More in particular, renewable resources which provides clean energy with zero **CO_2 emissions** (such as solar, geothermal, biomass energy and wind and hydro power) can be employed, thus resulting in a reduction of waste, pollution and contamination.

How can green building improve human health?

Green building takes into consideration also the protection and preservation of human health, through the use of natural materials, improving indoor air quality and the design of healthy indoor environment. Human health can be improved in different ways, for example, as we already said, green buildings can reduce illnesses caused by poor air quality issues. Using nontoxic building materials green building help fight indoor air pollution. Green building can also really improve the quality of life, for example using materials which can reduce noise on the workplace will improve employees' health, as well as preserving their productivity.

What are the other benefits deriving from green building?

Well designed green buildings will not only create healthier environments for people to live and work, but they will also save your money. First of all, as already said, using green materials will cut energy and water costs.

Experts report that businesses that pay the initial 2% increase for green materials as opposed to traditional building materials (on average) will recoup this initial outlay by as much as six to seven times.

Moreover, sustainable building materials save money in maintenance and reparation costs. Sustainable building materials require less energy to be used, and thus, they are low cost.

Try to imagine a building which is totally enlightened or heated by using only natural daylight; that will incredibly help in reducing energy use in buildings and cut the power source costs.

In addition, the federal, the state and the local governments offer rebates, tax credits and other financial incentives for building green (depending upon where you operate your business).

So, even if initial construction costs may be higher, lower operating and energy costs mean that green buildings provide a long-term return on investment.

What are the benefits of green buildings?

- Low Maintenance and Operation Cost. Green buildings incorporate unique construction features that ensure efficient use of **resources** such water and **energy**. ...
- **Energy** Efficiency. ...
- Enhances Indoor Environment Quality. ...

- Water Efficiency. ...
- Better Health. ...
- Material Efficiency. ...
- Better Environment. ...
- Reduces Strain on Local **Resources**.

Green Building Materials used in Construction

Following is the list of Green building materials used in construction :

1. Earthen Materials
2. Wood
3. Bamboo
4. SIPs
5. Insulated Concrete Forms
6. Cordwood
7. Straw Bale
8. Earth Bags
9. Slate/ Stone Roofing
10. Steel
11. Thatch
12. Composites
13. Natural Fiber
14. Polyurethane
15. Fiber Glass
16. Cellulose
17. Cork
18. Polystyrene and isocyanurate
19. Natural Clay
20. Non- VOC paints
21. Natural Fiber Floor
22. Fiber Cement
23. Stone

Top sustainable technologies in green construction

- **Solar power**. In green construction, there is active **solar power** and the other is passive **solar power**. ...
- Biodegradable materials. ...
- Green insulation. ...
- The use of smart appliances. ...
- Cool roofs. ...
- Sustainable resource sourcing. ...
- Low-energy house and Zero-energy building design. ...
- Electrochromic Smart Glass

Landscaping restoration and plantation

Principles of a landscape approach

- Continual Learning and Adaptive Management
- Common Concern Entry-Point
- Multiple Scale
- Multi-Functionality
- Multi-Stakeholder
- Negotiated and Transparent Change Logic
- Clarification of Rights and Responsibilities
- Participatory and User-Friendly Monitoring
- Resilience
- Strengthened Stakeholder Capability

FLR: Forest landscape Restoration

Designing a FLR Project

Identify clear goals & turn them into measurable objectives

	Goal	Objective	Plan
Meaning	Purpose of FLR project	Accomplishment	Activities that result in accomplishment
Measure	Not measurable/tangible	Measurable	Sequenced list of what, where, when, by whom, at what cost
Timeframe	Long-term	Short to mid-term	Short to mid-term
FLR Example	Restore degraded land along river basin	20 m buffer along rivers	Plant 100 ha of native species along rivers in Kigali provice by end of 2016 by local farmers

Technical aspects of FLR implementation

- Implementation specific for landscape units
    - Restoration methods for forest functions (hydrological, protection, biodiversity, carbon, production)
    - Restoration strategies (active/passive)
    - Species choice/planting design
    - Agriculture crops
- Landscape unit plan – overarching FLR plan
- Capacity building

key guiding principles of landscape restoration

i. Select a suitable site or landscape, including the analysis and evaluation of current land uses and land tenure/ownership, and1.identify involved stakeholders.
ii. Analyse and evaluate the drivers of deforestation or forest degradation.
iii. Engage stakeholders, discuss long-term goals of forest restoration considering the interests of all stakeholder groups, and draft a3.preliminary restoration/rehabilitation plan.
iv. Collect seeds, produce seedlings in nurseries and prepare for planting.
v. Plant trees.
vi. Assess capacity-building needs and plan for the necessary training
vii. Establish realistic time schedules and plan for financial requirements.
viii. Monitor restored/rehabilitated areas, and conduct maintenance activities as required.
ix. Consider possible climate-change impacts.
x. Develop a restoration management plan, including:
    - preparing a topographic land-use map, including a designation of forest functions, assessment of road accessibility,existence of natural regeneration and needs for planting;
    - agreeing on restoration/rehabilitation objectivess
    - selecting the restoration/rehabilitation method
    - choosing the species to be used, and establishing a nursery and
    - assessing possible positive and negative social and environmental impacts.

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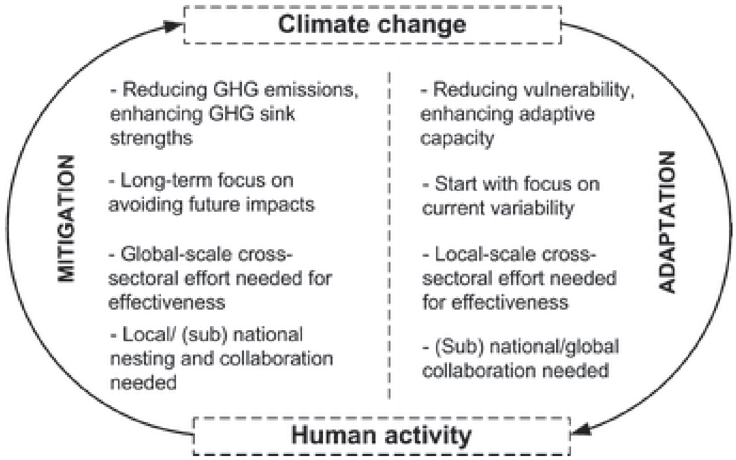
S8: Mitigations and adaptation in India

To promote sustainable, low-carbon, and climate-resilient growth, India will require continuous efforts in mitigation and adaptation through Nationally Appropriate Mitigation Actions and National and State Adaptation Plans.

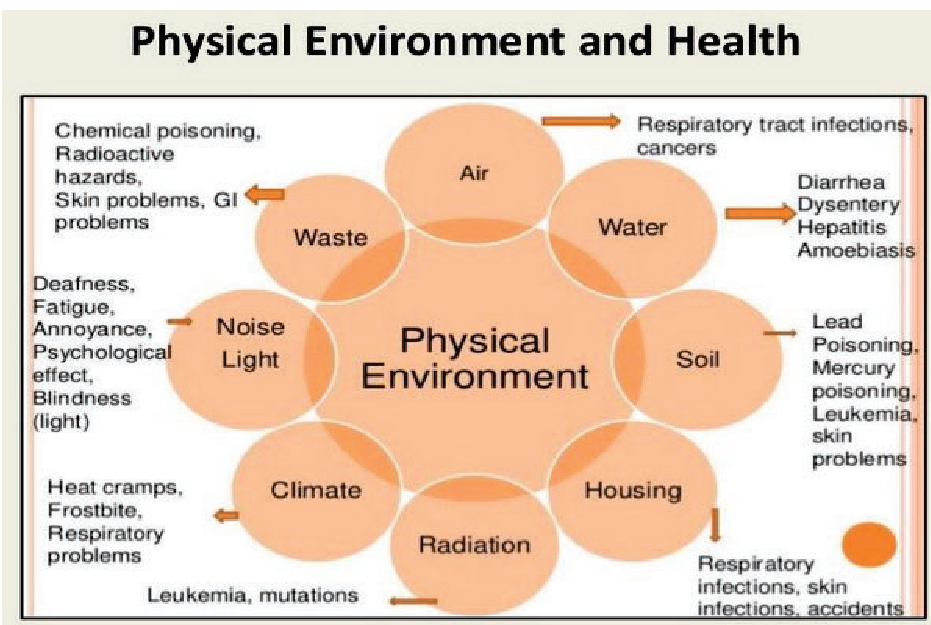
The difference between climate change **mitigation** strategies and climate change **adaptation** is that **mitigation** is aimed at tackling the causes and minimising the possible impacts of climate change, whereas **adaptation** looks at how to reduce the negative effects it has and how to take advantage of any opportunities.

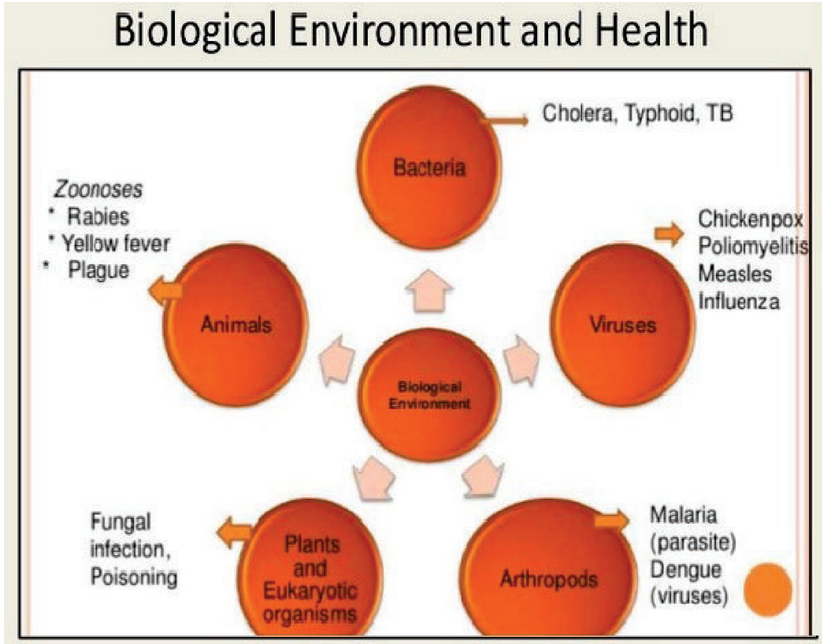


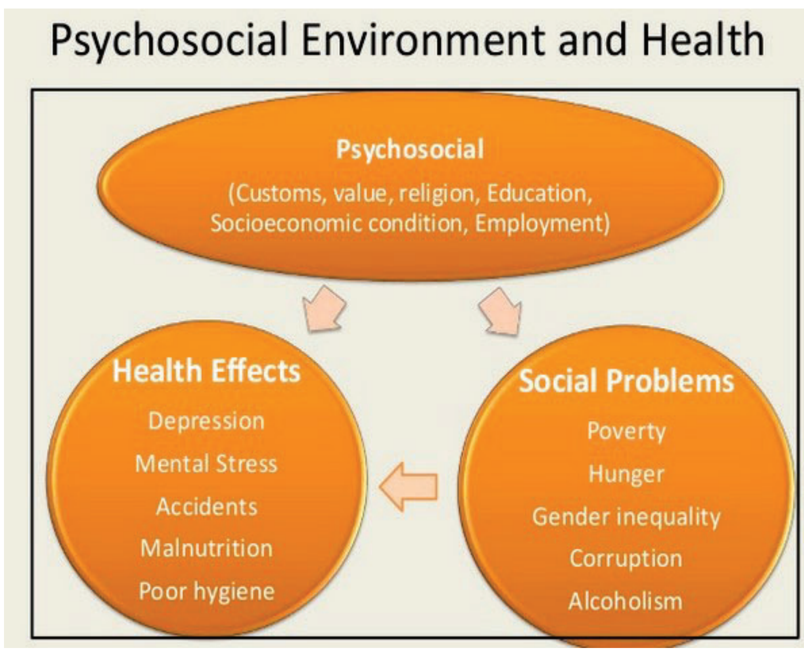
Prevent and precaution measures (health issues, environmental damages)

Environmental Concerns for 2019?

- Biodiversity. Biodiversity is the most complex and vital feature of our planet. ...
- Water pollution is a huge concern for us and our environment. ...
- Air pollution
- Deforestation. We need plants and trees to survive. ...
- Climate Change.




Biological Environment and Health
Bacteria
Cholera, Typhoid, TB
Zoonoses
* Rabies
* Yellow fever
* Plague
Animals
Viruses
Chickenpox
Poliomyelitis
Measles
Influenza
Biological Environment
Fungal infection, Poisoning
Plants and Eukaryotic organisms
Arthropods
Malaria (parasite)
Dengue (viruses)


Psychosocial Environment and Health
Psychosocial
(Customs, value, religion, Education, Socioeconomic condition, Employment)
Health Effects
Depression
Mental Stress
Accidents
Malnutrition
Poor hygiene
Social Problems
Poverty
Hunger
Gender inequality
Corruption
Alcoholism

Effects on Environment

- Plastic waste disposal on land makes it infertile
- Burning generates toxic emissions -CO, HCl, Dioxin, Furans
- Leaching out of toxic chemicals added as additives
- Littering
- Choked drains can cause flooding
- Affects waste processing facilities like composting
- In environment, plastic breaks down into smaller particles, are ingested by wildlife on land and in the ocean and enter human food chain.

Prevention and control

- Some measures which can be adopted in this direction are as follows:

1. Use of unleaded petrol
2. Using fuels with low sulphur and ash content
3. Promotion of use of public transport
4. Sensitive locations (hospitals, schools, playgrounds etc.) should not be located along the busy streets
5. Vegetation cover should be increased along the roadside, busy traffic intersection points, and on the road dividers.
6. Industries and waste disposal sites should preferably be situated in outskirts of the city.

Prevention & Control

- Encourage plantation of trees
- Less use of air conditioners & refrigerators
- Use solar energy, wind mills for power supply
- Cautious use of vehicles
- Preserve wet lands
- Improve water harvesting
- Ban the plastic bag
- IEC activities

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S9: Energy policies for a cool future, Energy Audit.

Energy policies for a cool future

What type of energy will we use in the future?

Atomic energy, **solar energy**, and energy from **wind** and **bio fuels** are just a few of the promising alternatives for a cleaner and greener future. Other relatively new **sources** of energy such as fuel cells, **geothermal energy**, and ocean energy are also being explored.

Energy sector in India: it challenge

- India, one of the fastest under developing country
- Its population is second in world and first in term of density
- In last thirty year, there is boom in power sector with formation of NTPC, NHPC
- 2003 ACT, allowing private player to invest in generating sector change whole picture
- 70% of electricity generation is depend upon coal
- Coal is limited and demand of energy generation rising day by day
- It is need to change the electricity generation pattern.
- Nuclear and Hydro generation may come in picture in future
- Need to invest in renewable form of energy for sustainable growth

Ministry of New and Renewable Energy

- Name it self explain the objective of ministry "to work for exploring and implementation of non conventional and new form of energy"
- MNRE work in five major area:
  1. Grid-interactive renewable power (wind power, Small hydro power, Urban & industrial waste to energy and solar power)
  2. Distributed renewable power (Biomass, Biomass gasifier, waste to energy, Aero generator/ hybrid system)
  3. Rural and Decentralized energy system (family type biogas plant, solar street lamp, home lighting system, Solar Photovoltaic system and wind pump)
  4. Remote village electrification
  5. Other program (energy Park, Akshay urja and hybrid car)

Future Prospective of Renewable Energy in India

- The Integrated Energy Policy Report (IEPR), prepared by the planning commission of India, has recognized renewable energy sources remain important to Indian's energy sector
- With a concerted push and a 40 fold increase in their contribution to the primary energy, renewables may account for only 5-6% of India's energy mix by 2031-32

Resources	Upto 10th plan	11th plan	12th -13th plan	Total
Wind Power	7000 MW	10500 MW	22500 MW	40000 MW
SHP	1960 MW	1400 MW	3140 MW	6500 MW
Bio Power	1037 MW	2100 MW	4363 MW	7500 MW
Solar Power	3 MW	1000 MW	20000 MW	22000 MW
Total				

Energy Audit

An energy audit is an inspection survey and an analysis of energy flows for energy conservation in a building. It may include a process or system to reduce the amount of energy input into the system without negatively affecting the output.

The **main purpose of an energy audit** is to determine whether your home wastes energy, and to pinpoint where energy is being lost so you can evaluate what measures you can take to make your home more energy efficient.

An energy audit is designed to help you identify the most cost effective and practical options to reduce your energy consumption and costs. ... In some cases, identifying billing discrepancies may alone pay for the cost of the audit. An energy audit will look at all common area equipment and central building services.

Energy audits are way for businesses to understand how and where they use energy. An energy audit requires a detailed survey of a business's equipment and an analytical understanding of a business's operating patterns.

Energy audits can be characterised into 4 broad types, they are:

1. Benchmarking
2. Walkthrough Audit
3. Detailed Audit
4. Investment-grade audit

How is an energy audit done?

An **energy audit** is an assessment of your home that takes a look at current **energy** consumption and then identifies **energy** efficiency measures that you can conduct to make your home more efficient. ... Professional **energy audits** can take anywhere from 30 minutes to 4 hours to complete, depending on the size of your home.

Can you do your own energy audit?

To complete your own energy audit, take the following steps.

1. Step 1: Check Heating and Cooling Systems. Heating and air conditioning is the largest **energy** consumer in the United States, accounting for around 48% of the average home's **energy** use. ...
2. Step 2: Inspect Insulation and Sealing. ...
3. Step 3: Account for Electricity Waste.

Energy Audit Instrument

No.	Name of the Instrument	Intended Use
1.	Flue Gas Analysers	Used for optimizing the combustion efficiency by measuring/monitoring the oxygen and CO levels in flue gas of boilers, furnaces etc. and calculation of CO2 percentage in excess air level and efficiency.
2.	Temperature Indicators	Used for measuring temperatures of gases/air, liquids, slurries, semi solids, powders etc. Using different types of probes.
3.	Infrared Thermometers	Used for measuring temperatures from a distance using infrared technology.
4.	Thermal Insulation scanner	Used for measuring loss of energy in Kcal per unit area from hot/cold insulated surfaces. The total loss can be obtained by multiplying the total surface under study.
5.	Steam Trap Monitor	Used for performance evaluation of steam Traps.
6.	Conductivity Meter	Used for on the spot water analysis of the amount of dissolved solids in water.
7.	pH meter	Used for on the spot analysis of effective acidity or alkalinity of a solution/water. Acidity /alkalinity water.
8.	Thermo-hygrometer	Used for measurement of air velocity & humidification, ventilation, Air-conditioning and refrigeration systems etc.
9.	Thermo-hygrometer	Used for measurement of humidity and temperature and the calculation of dew point to find out the heat being carried away by out going gases in industries. Where product drying requires hot air.
10.	Ultrasonic Flow Meter	Used for measurement of flow of liquids through pipelines of various sizes through ultrasonic sensors mounted on the pipelines.
11.	U-Tube Manometer	Used for measurement of differential pressure.
12.	Digital Manometer	Used for measurement of differential pressure.