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.

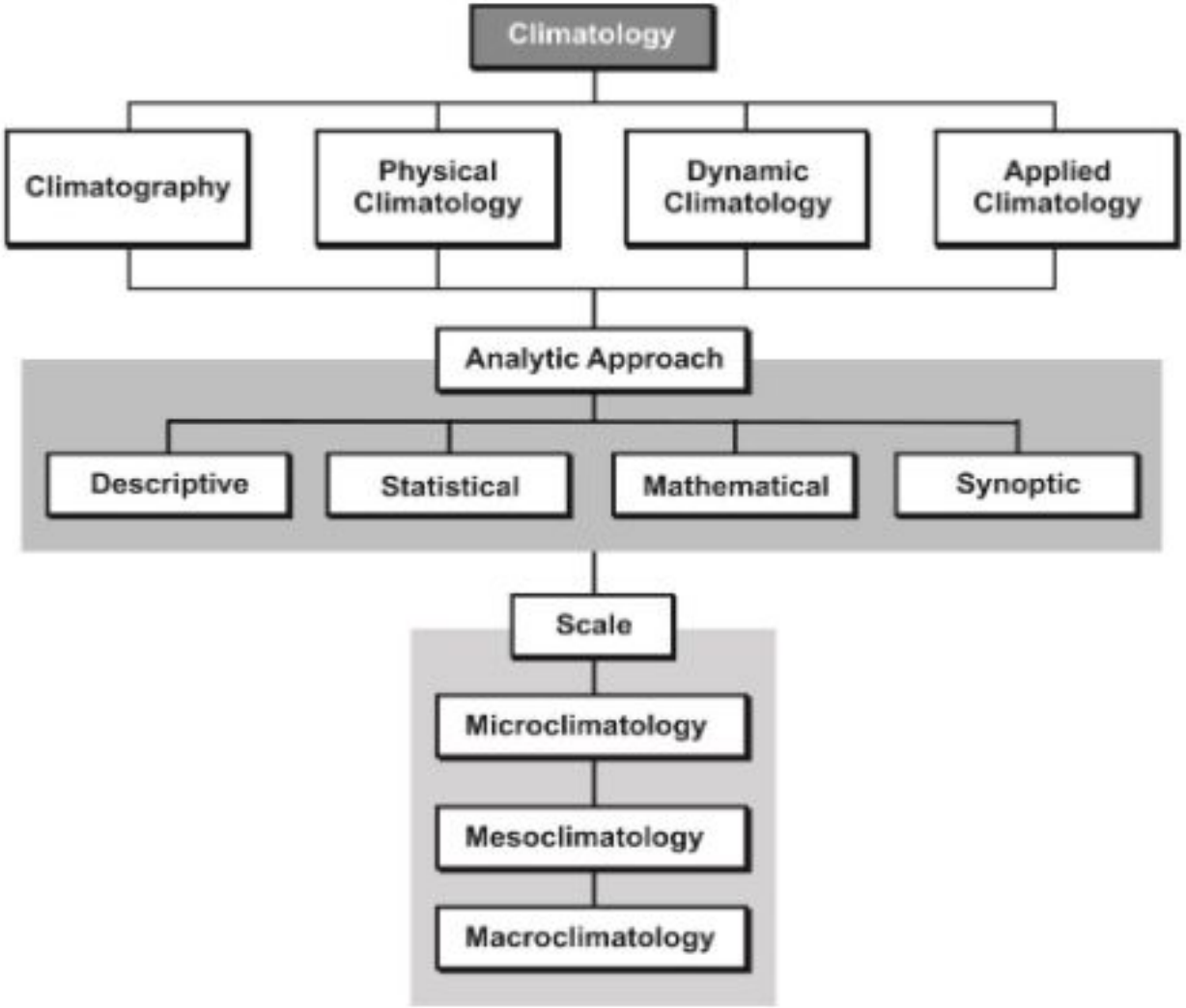


Figure 1. Subgroups, Analytical methods and scales of climatic study.
(From J. E. Olive 1981, P4 used by permission of V. H. Winston and Sons.)

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

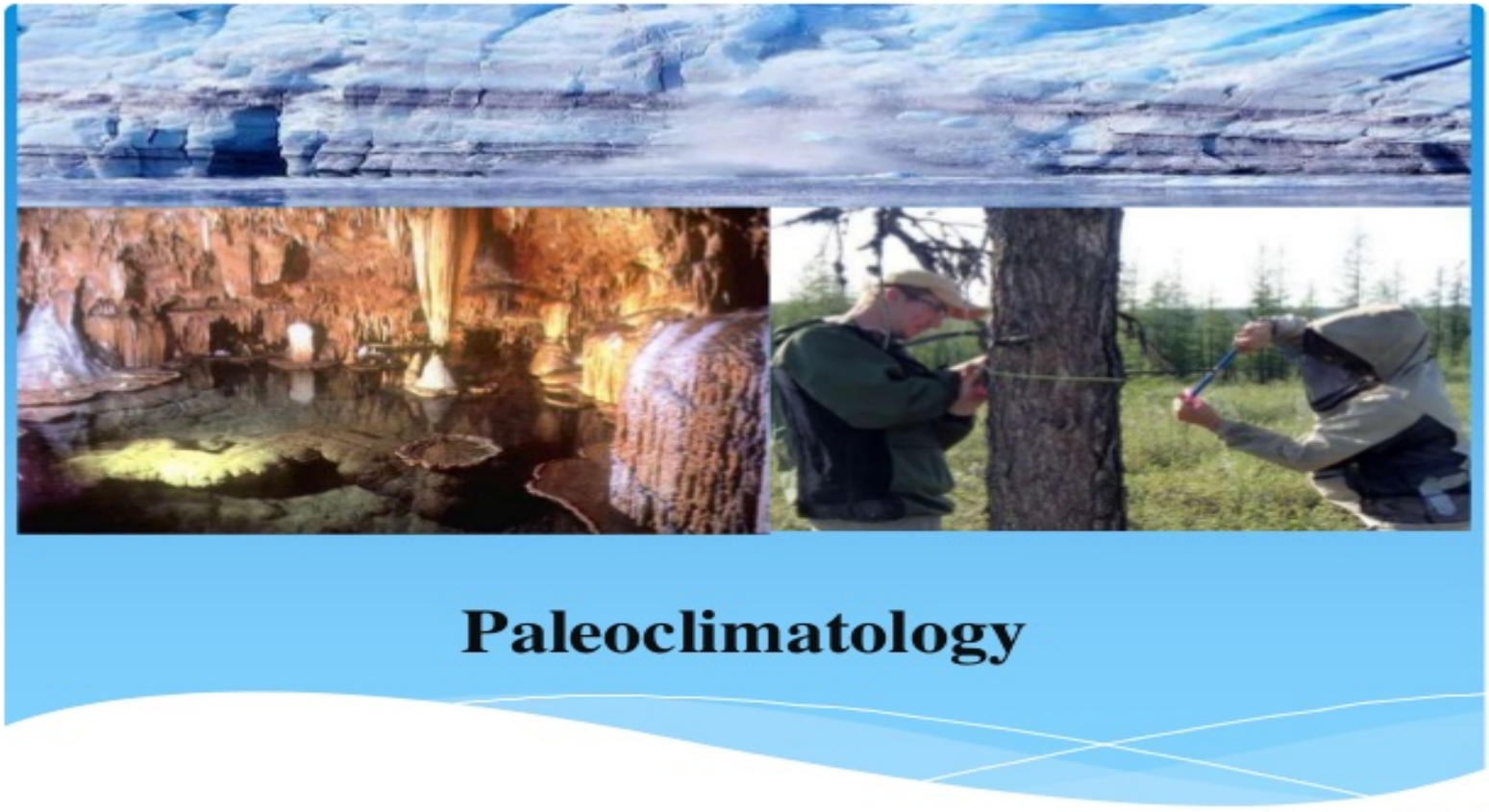
Definition

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 Paleoclimatology uses a variety of proxy methods from the Earth Paleoclimatology uses a variety of proxy methods from the Earth and life sciences Paleoclimatology uses a variety of proxy methods from the Earth and life sciences to obtain data previously preserved within rocks Paleoclimatology uses a variety of proxy methods from the Earth and life sciences to obtain data previously preserved within rocks, sediments Paleoclimatology uses a variety of proxy methods from the

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 extinctionsStudies 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 The techniques used depend on which variable has to be reconstructed (temperature, precipitation or

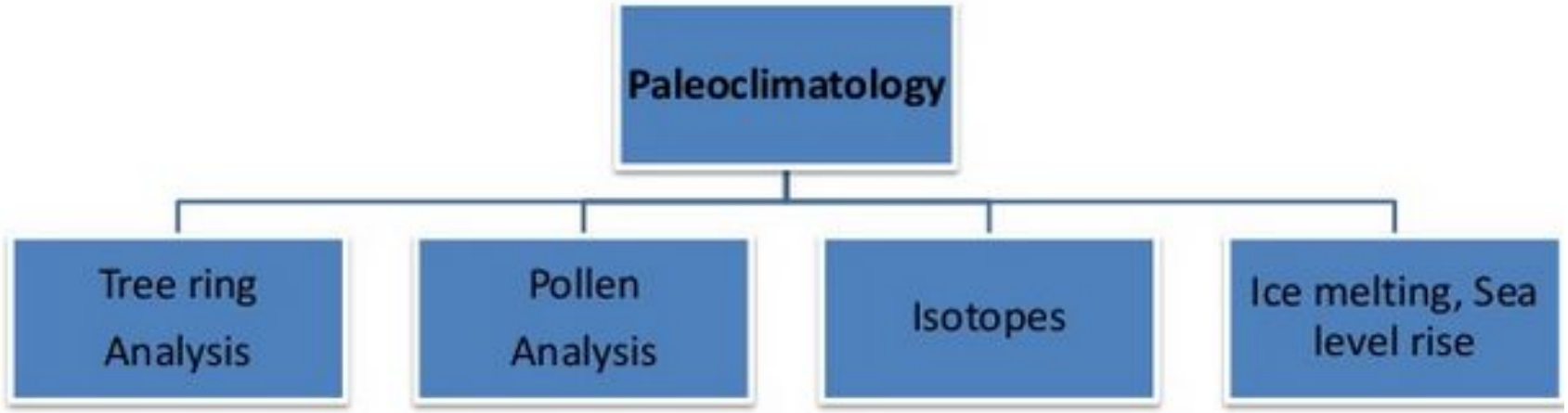
S1: SLO 2: Paleoclimatology

- 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

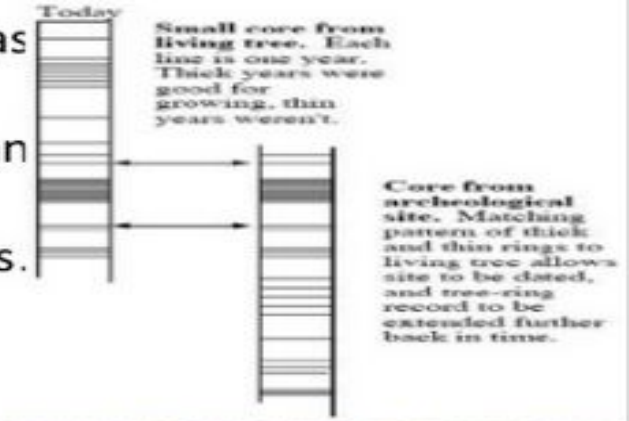
- Tree ring analysis is also known as dendrochronology.
- From the growth rings or tree rings we can easily predict about the past climates.
- There are mainly two type of chronologies.

Dendrochronology

Floating Chronology

Anchored Chronology

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

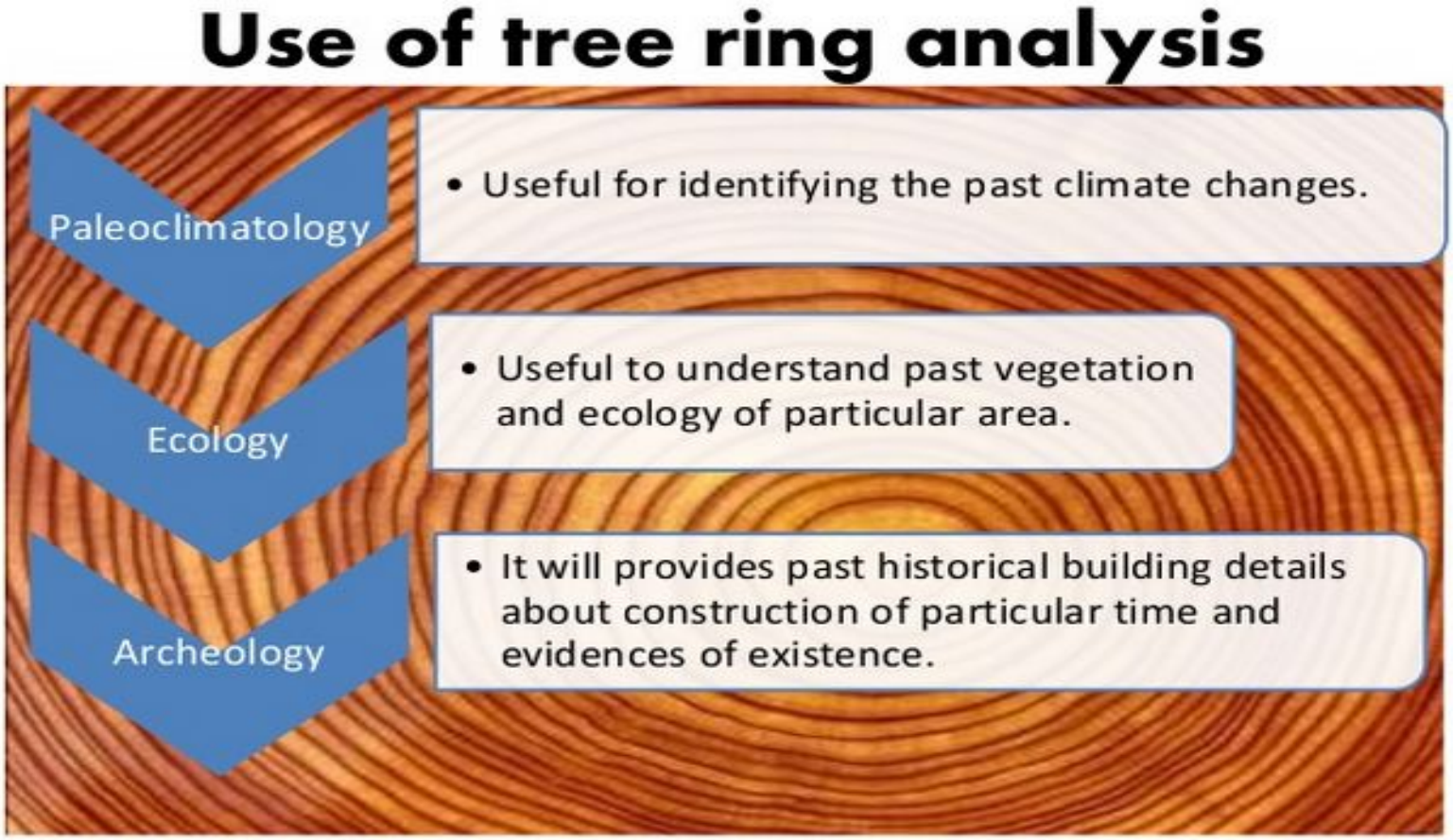


S1: SLO 2: Paleoclimatology

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

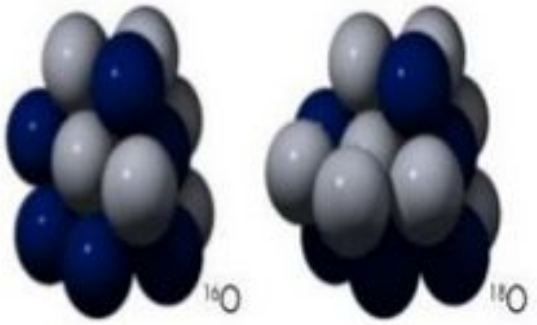
2.Chemical Preparation

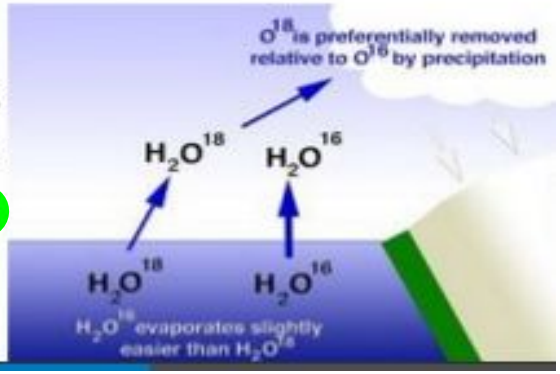
3.Analysis

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 recordProxies 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

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

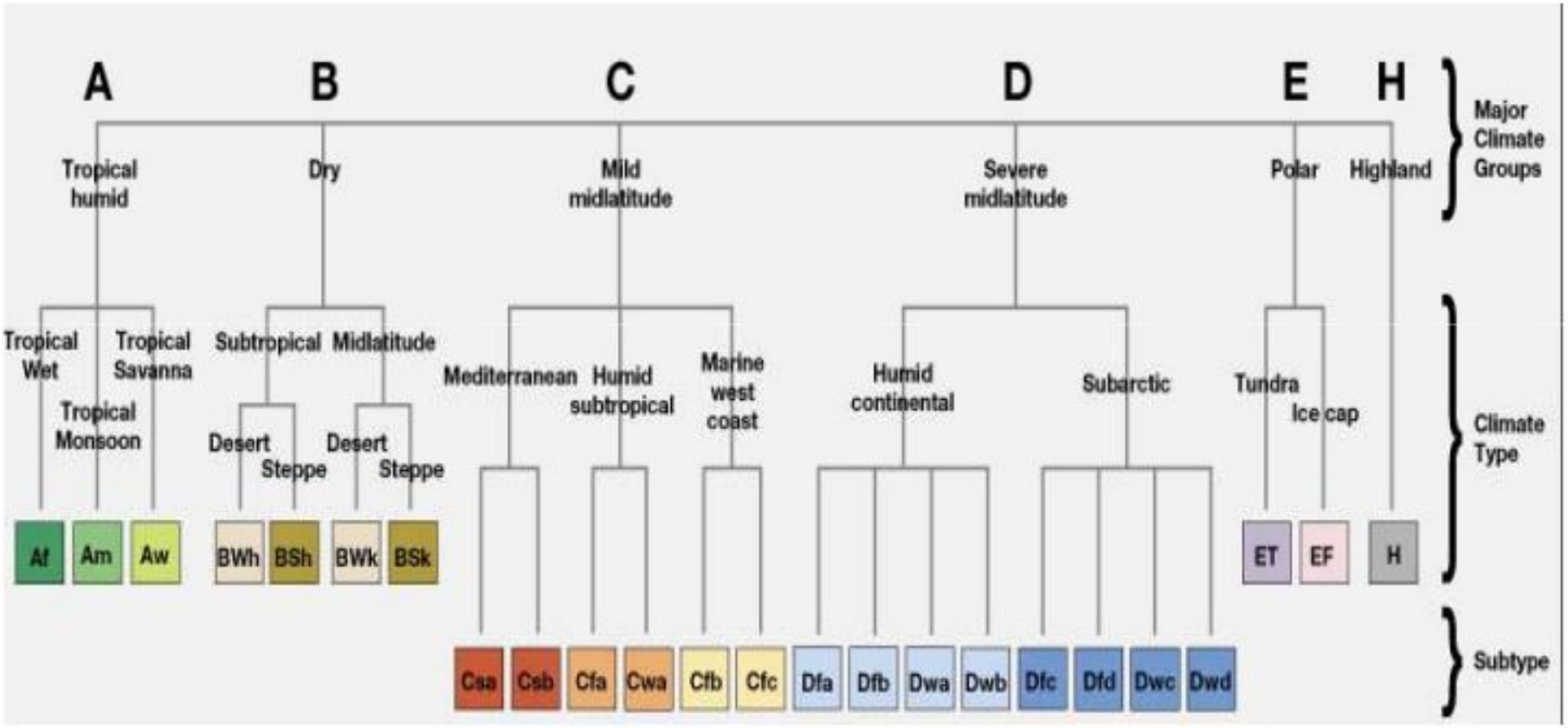
Group	*Characteristics*
A - Tropical	Average temperature of the coldest month is 18° C or higher
B - Dry Climates	Potential evaporation exceeds precipitation
C - Warm Temperate	The average temperature of the coldest month of the (Mid-latitude) climates years is higher than minus 3°C but below 18°C
D - 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*

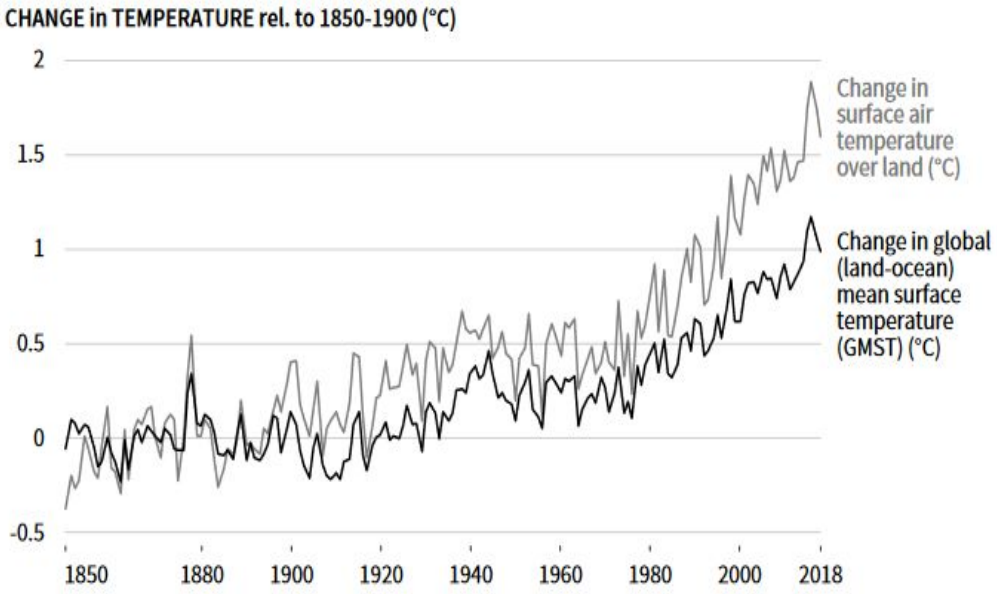
- Land is both a source and a sink of **greenhouse gases (GHGs)** and plays a key role in the exchange of energy, water and aerosols between the land surface and atmosphere.
- **Land ecosystems and biodiversity** are vulnerable to ongoing climate change and weather and climate extremes, to different 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

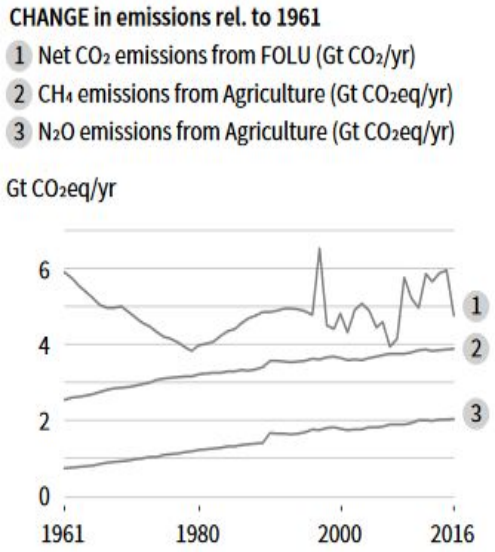
A. Observed temperature change relative to 1850-1900

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).



B. GHG emissions

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



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.