UNIT 1

INTRODUCTION TO CLIMATOLOGY

Structure

1.1 INTRODUCTION

Climatology is closely related to geography because in geography, climate is studied as a part of the physical environment of man and like geography, the combined nature of various elements is kept in view in the description of events.

Climatology is described as the scientific study of the behavior of the thin gaseous layer surrounding the earth's surface i.e. the atmosphere. In fact, climatology is a holistic science which incorporates data, ideas and theories. Climatology is the science that describes the nature of climate at different places on the earth and explains the reasons for its variations. It also includes the study of the effects of climatic variations on other elements of the environment and human activities.

The primary goal of climatology is to study the unique characteristics of atmosphere in controlling the global climate, origin and types of climate, causes and processes influencing the climate variations, elements of weather and the impact of climate on human beings or vice-versa.

In fact, climatology is the study and description related to various types of climatic conditions of the earth's surface.

Climatology is closely interlinked between Physical Geography, Agronomy, Aerology and Meteorology.

The discoveries of meteorology have been given a more detailed form by climatology both in terms of space and time.

In this unit, you will learn about the climate and its study in the form of climatology. Sec. 1.2 you will familiarise you with the meaning and scope of climatology. In Sec. 1.3, you will learn how climatology as a subject has developed through different phases. Sec. 1.4 will acquaint you with the difference between climatology and meteorology. Sec. 1.5 and Sec. 1.6 will describe different scales and sub-fields of climatology respectively.

Expected Learning Outcomes

After completing the study of this unit, you should be able to:

- explain the basics about climate;
- describe the meaning of climatology;
- discuss the development of climatology;
- compare the scales of climatology;
- differentiate between climatology and meteorology; and
- describe the sub-fields of climatology.

1.2 MEANING AND SCOPE OF CLIMATOLOGY

Climatology is the science of studying the average atmospheric conditions of a region in a long-term perspective. Climatology studies the characteristics of gaseous atmosphere.

Climatology is mainly concerned with the study of atmospheric conditions on the earth surface and deals with the analysis of various climatic elements.

In fact, climatology is the science of climate which studies the physical state of the atmosphere, over a specific region, during a specific period and on the basis of climatic data.

In other words, one can say that the climatology is a science that seeks to describe and explain -

(a) The nature of climate.

(b) Why it differs from place to place?

(c) How it is related to other elements of the natural environment and human activities?

(d) The several types or varieties of climate found on the surface of the earth.

(e) The distribution of climatic types over the surface of the earth.

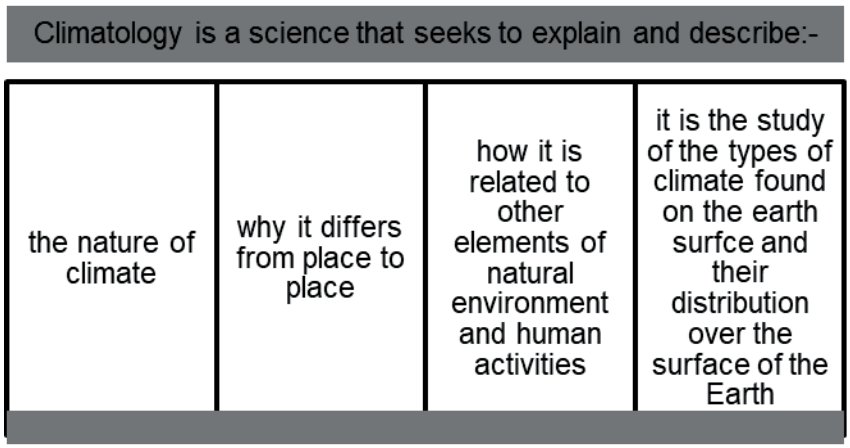

Fig. 1.1: Climatology. (Created by Author)

When we talk about definition of climatology, some important **definitions** of climatology are:-

(i) According to Critchfield:

"Climatology is the science that seeks to describe and explain the nature of climate, how it differs from place to place and how it is related to man's activities".

(ii) According to Austin Miller:

"Climatology is that branch of science which discusses the average conditions of weather".

(iii) According to Koppe and De Lang:

"Climatology is a summary and composition of weather conditions over a long period of time".

(iv) According to Thornthwaite:

"It is the study of the atmosphere as well as the earth's surface".

(v) According to Kendrew:

"In the study of climatology, the basic interest remains in the climatic elements of the earth, which are the essential parts of the natural environment where as the study of the weather factors of the climate remain secondary."

The term "climatology" is derived from the Greek term *"klima"*, means "inclination or latitude" or "slope" or "angle from the sun". It was used for the duration of day and night, and *"logos"*, means "study" or "discourse". Famous philosopher Aristotle used the term "klima" for latitudinal belts.

The meaning and purpose of climatology becomes clear from the above definitions. Climatology is more akin to geography than meteorology because it analyses the regional distribution of atmospheric conditions. In fact, climate is the average weather in a given area over longer period of time .The main objectives of a climatologist is to study the weather patterns and processes that cause them and to predict the weather changes.

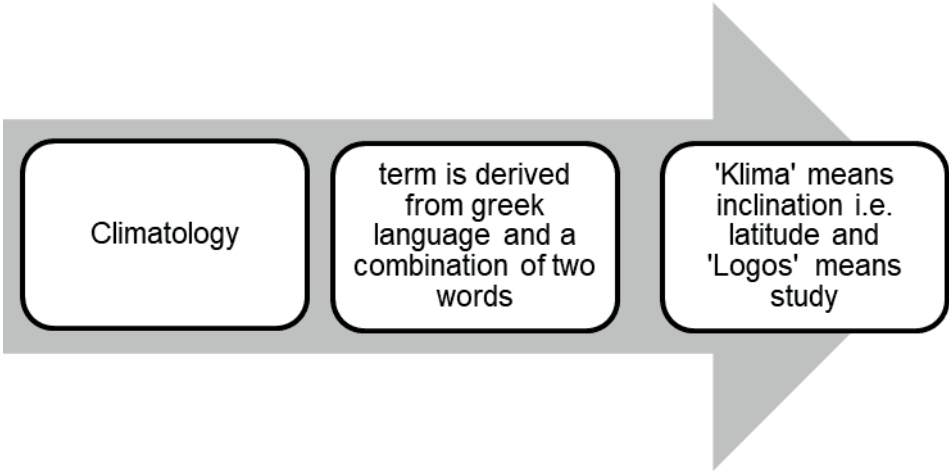

Fig. 1.2: Climatology. (Created by Author)

The main goal of climatology is to study the unique characteristics of atmosphere and its role in controlling the global climate, origin, types of climates, causes and processes influencing the climatic variations, elements of weather and the impact of climate on humans or vice-versa.

Climatology is a science that seeks to describe and explain the nature of climate, why it differs from place to place and how it is related to other elements of the natural environment and human activities. It is the study of the varieties of climates found on the earth and their distribution over the surface of the earth.

There are two aspects of the study of climatology. First, it studies the climatic factors of different types, their relative conditions, the effects of various types of actions on the life and plants and the processes that produce different physical types of climates. This first aspect is basically a scientific one. It is mainly based on causal relationships. It is more closely related to laws of physics and chemistry and the traditions of meteorology. It determines and describes different types of climate. Climate classification and their regional description are based on meteorological data. The second aspect is closely related to methods and principles of territorial divisions. In short, the first aspect can be called as physical climatology and the second aspect can be called as regional climatology.

In the study of climatology, the effects of weather and climate related elements on human life, their health and economy are also studied.

Climatologists seek to understand some main aspects of the climate. First, aspect is, how the weather patterns govern the normal conditions of the different regions of the world. Second is to study the relationship between different aspects of weather. Third is the way how the weather of a place changes over the time. Fourth is how human activities are the cause of climate change. Fifth, is how natural changes occur in the atmosphere and the oceans.

SAQ I

a) What do understand by the word climatology?
b) What are the main responsibilities of a climatologist?

1.3 DEVELOPMENT OF CLIMATOLOGY

With the passage of time, climatology has gone many changes. Since the 6th century B.C., the subject matter of climatology has widened gradually.

Climatology is known as ancient as well as a newer branch of study. Climatology is as old as human curiosity and new as the invention of aircraft, radio, radar and artificial satellites. First, study of the climate can be traced back to the ancient times of Greeks but it did emerge in the present form in the 19th century, only after advent of industrialisation.

From the ancient times, man has the curiosity about atmospheric phenomena.

In ancient saying, many examples related to weather can be seen. For example:

(i) Sayings are there in Old Testament about the description related to weather, which seems to be true after more than 3000 years.

(ii) There are examples related to the names given to the God/ deity for the elements of weather, such as- the Greeks gave the name 'Boreas' to the northern winds, 'Ra' was the deity of the sun for the Egyptian, 'Jupiter Pluvius' is the deity of rain for the Romans, *Indra* is the deity of rain for the Indians. In fact in India, since ancient times most of the forces of nature have been personified as Gods like *Pawandev* as wind, *Varuna* as water *Suryadev* as the Sun.

(iii) The Greeks used to measure wind direction on public buildings before 5th century B.C. The tower of winds in Athens was also built at the same time and for the same purpose.

The history of the development of climatology can be divided into following five periods of times:

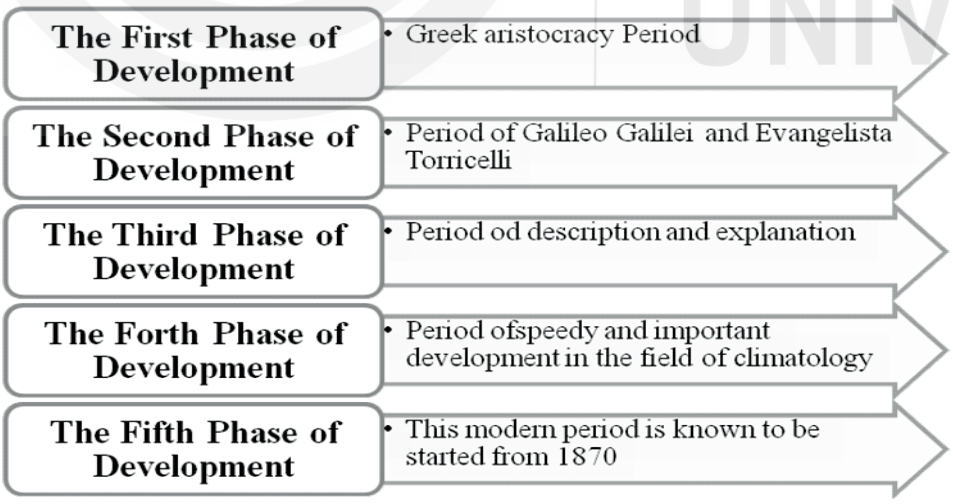

Fig. 1.3: Development of Climatology. (Created by Author)

(i) The First Phase of the Development:

The first phase of the development of climatology, which is known as the Greek aristocracy Period, can be traced between ancient times to 16th century.

The first definition of air is also found in the philosophical works of the Greeks. In the works of Homer and Hesiod, many ideas related to weather were presented in a poetic style.

During this period the evidences were neither authentic nor scientifically proved due to non-availability of the instruments. The experiments that were carried out during this period were not accurate.

Greek philosophers took keen interest in meteorology and climatology. They considered meteorology to literally mean the study of meteors, comets and space scenes. Though they had no clear ideas about the atmosphere, beside this their work formed the basis for the future.

Table 1.1: Significant Events in the History of Climatology

1.	400 B.C.	Influence of climate on health was discussed by Hippocrates the 'Father of Medicine' in his book "Airs, Water and Places.
2.	350 B.C.	Aristotle's masterpiece "Meteorologica" on climatology.
3.	300 B.C.	Description of winds by Theophrastus in his text "De Ventis",
4.	1593 A.D.	Thermometer was invented by Galileo Galilee
5.	1622 A.D.	Francis Bacon published "Historia Ventorum" and provided a systematic natural history of the winds.
6.	1643 A.D.	Barometer was invented by Evangelista Torricelli.
7.	1661 A.D.	Boyle's law was proposed.
8.	1664 A.D.	Weather observations began at Paris.
9.	1668 A.D.	Map on trade winds was constructed by Edmund Hally.
10.	1714 A.D.	Fahrenheit scale was introduced by Anders Celsius.
11.	1735 A.D.	Work on George Hadley described Trade winds and effects of the earth's rotation on the direction of the winds by Anders Celsius.
12.	1736 A.D.	Centigrade scale was introduced.
13.	1779 A.D.	Weather observations began.
14.	1783 A.D.	Hair hygrometer was invented. First time Daily Weather charts wer prepared by Brandes.
15.	1802 A.D.	First cloud classification was suggested by Lamark and Howard.
16.	1817 A.D.	First map showing mean monthly annual temperature was constructed by Alexander Von Humboldt.
17.	1825 A.D.	Psychrometer was invented by August.
18.	1837 A.D.	Pyrheliometer was invented.
19.	1844 A.D.	Coriolis force generated by earth's rotation was formulated by G.D. Coriolis.
20.	1845 A.D.	Berghans prepared the first world map of precipitation.
21.	1849 A.D.	Regular daily weather report started.
22.	1875 A.D.	Meteorological Department of India came into existence.
23.	1892 A.D.	Beginning of use of balloons to monitor air.
24.	1902 A.D.	Existence of stratosphere was identified.
25.	1913 A.D.	Ozone layer was identified.
26.	1925 A.D.	Aircraft was first time used to collect data.
27.	1928 A.D.	Radiosondes were first used.
28.	1940 A.D.	Phenomenon of jet streams was investigated.
29.	1960 A.D.	First meteorological satellite was launched.

(Compiled by Author)

Greek scholar Parmenides had divided the earth into three climatic zones: tropics, temperate and cold zones.

Hippocrates, who is also known as “the Father of Medicine”, had done his work on Medical climatology and wrote a book, titled “Airs, Waters and Places”. Climatological progress almost came to a halt during the time of Socrates.

Aristotle, had written a book on wind system, titled “Meteorologica”. This book is the oldest evidence on Meteorological works. In fact, the basis of all the climatological ideas of Europe is the work of Aristotle. He divided the atmosphere into three regions or parts.

This first period of development of climatology is actually full of superstitions and strange lectures. In the absence of instruments, whatever tests the ancient Greeks, Romans and Arab scientist conducted were not accurate. Quotations from ancient Palestine rain ideas have been found in the Bible and Jewish religious books. During this period only rainfall related tests can be considered quantitative.

The trade and the monsoon winds were the important subjects of the study for the Greek and the Arab merchants. After his expedition to India, Alexander the Great took the monsoon related information to Greece which was first used by Aristotle and later on by the Arab geographers.

In the third century B.C., Philo of Byzantium and Herro of Alexandria had described about the Thermoscope. In fact, from the time of Aristotle to the beginning of 17^{th} century, there was little progress in the field of climatology.

(ii) The Second Phase of the Development:

This Phase was spread over 16^{th}, 17^{th} and 18^{th} century and was with the beginning of the invention of new instruments.

In the 16^{th} century the book *Pneumatics* written by Herro was translated into the Latin and this book was studied by Galileo, Porta and Drebbel.

17^{th} and 18^{th} century is considered as the golden period of climatology. This is the period of Galileo Galilei and Evangelista Torricelli. Galileo Galilei was the professor of mathematics and philosophy, who invented thermometer and telescope. Evangelista Torricelli was the student of Galileo Galilei, who invented Barometer in 1643 AD. Torricelli said that atmosphere has pressure and it can be measured. The invention of the barometer and thermometer proved to be the driving force of a new era in the history of climatology.

The first European rain gauge was invented by Vernedetto Castelli of Italy in 1639 A.D. At the same time a scientific council was established in Italy, in which nine of Galileo’s disciples were its members. This council made a very important contribution to the development of climatology. The credit for the international weather testing goes to Ferdinand, who established meteorological testing centers in northern Italy in 1653 A.D.

In 1735 A.D., George Hadley first mentioned that the effect of earth’s rotation on the trade winds. In 1749 A.D., Wilson of Glasgow succeeded in sending a thermometer to the atmosphere with the help of the kite. This was the first attempt to test the space connection above the earth surface.

In fact, the second phase of the development of climatology begins with Galileo and Torricelli and ends with Halley and Hadley. During this period a large number of instruments were used and new observations were initiated. The use of new instruments increased the accuracy of the knowledge of the atmospheric conditions and started quantitative tests.

Thus 17th and 18th century was the golden age of climatology.

(iii) The Third Phase of the Development:

The first half of the 19th century is considered as the third phase of development of climatology. Description and explanation took place about the experiments observation that was done up to the end of 18th century. In 1800 A.D., John Dalton described the presence of water vapor in the air. First time, between 1800 to 1815 A.D. Chevalier De Lamarch compiled the international weather observations, which were collected through the postcards. In the early 19th century, German climatologist Dove tried to explain the atmospheric air. In America, Redfield had studied the occurrence of land and ocean thunderstorms.

In 1820 and 1826 A.D., Germany's Brandes published two books titled as "Contribution to Meteorology" and "Physical Dissertation on the rapid variations on the pressure of the air" respectively.

In the first half of the 19th century, two Americans J. P. Espy and E. Loomis greatly contributed towards meteorology. Espy established first American weather observatory at Pennsylvania. From 1836 to 1859 A.D., Loomis exhibited several weather maps that shed the light on climate problems.

(iv) The Forth Phase of the Development:

This phase was spread in a very short period of fifteen years i.e. between 1850 to 1865-70 AD. This very short span, witnessed the speedy and important development in the field of climatology. The important scholars of this period were Fitz Roy, Le Verrier, Buys Ballot and Ferrel. Fitz Roy divides Great Britain and Ireland into three weather zones. They developed the system to collect the weather related information collectively. Their weather related observation was published in 1861.

In 1863 A.D. Francis Galton published a book titled as "Meteorographica", in which information related to high and low pressure areas was given.

In Europe, Le Verrier first time developed *the path method* for the study of the path of cyclones. Buys Ballot had organised the weather related services in Holland. In 1860, he gave the famous "Buys Ballot Law". According to this law, if anyone stands with his back to the wind, the atmospheric pressure is low to the left and high to the right in the Northern Hemisphere. In America, two important laws were published in 1856 and 1860. These are called as Ferrel's laws. According to these laws, by the rotation of the earth when air start moving from low to high pressure, in northern hemisphere, it would deflect right side and in the southern hemisphere it would deflect left side.

(v) The Fifth Phase of Development:

This modern period is known to have started from 1870. During this modern phase of development in USA, "National Weather Service" was started. In 1872, "First International Weather Conference" was held at Leipzig. In 1875, "Indian Meteorological Department" was established at Shimla which was transferred to Pune in 1928.

In 1878, "International Meteorological Organisation" was established in Utrecht in Holland. After this, almost each and every country had established his weather information station. During this period the development of climatology were divided into two groups by George R. steward in his book entitled "Storms".

SAQ 2

a) In how many phases we can divide the study of climatology?
b) What is the purpose of tower of winds? When the tower of winds was established in Athens?
c) Name the deity for the rain in India.
d) When and where was the International Meteorological Organisation established?

1.4 CLIMATOLOGY AND METEOROLOGY

The climate of any place is not decided by the weather of only a few days or few years but sometimes it is the average of many years. That is why in general term; climatology is also called an average or general meteorology. For a common person, the weather of one day or one hour is not as important as the average weather of that place or region. That is why climatology has become more popular than meteorology.

Climatology and meteorology are closely related to each other. In climatology general description and explanation is being done whereas the study related to daily changes in atmosphere is the part of meteorology.

Climatology is the study of the atmospheric processes and their impact. Climatology collects and interprets the data observed by meteorology to investigate the spatial patterns of climate and its interaction.

In climatology, the relationship between regional variations of climate and human action is determined, whereas in meteorology, the daily changing conditions of the atmosphere and their physical processes are being studied.

In simple words we can say that meteorology presents observations and evidences like physics and climatology interprets the data obtained from it by various statistical methods.

In general, climatology and meteorology are considered to be the same, although the methods and approaches of both are different.

More attention is being paid to the climate and climatic changes on the location of industries, places of entertainment, agriculture and mining sites.

The word “meteorology” is derived from Aristotle’s famous book “Meteorologica”, which means the study of space.

In meteorology the base of conclusion are observation and facts on which the description can be done in climatology by the use of various statistical methods. Meteorology deals with the day to day atmospheric conditions and their causes.

In India, “Meteorological Department” prepares the daily weather report

Meteorology is defined as the Physics of the atmosphere. Meteorology uses the methods of Physical science to interpret and explain the atmospheric processes. It deals with the meteorological techniques and geographically it deals with the spatial aspects of climatic phenomena.

Meteorology can be further divided into four sub parts-

(i) Dynamic and theoretical Meteorology:

Under this sub part of meteorology, those physical principles are explained which are related to the forces and energy of atmospheric flow. Theoretical aspects can be studied under this sub-part of meteorology. Description about the atmospheric movement is also studied under this sub part.

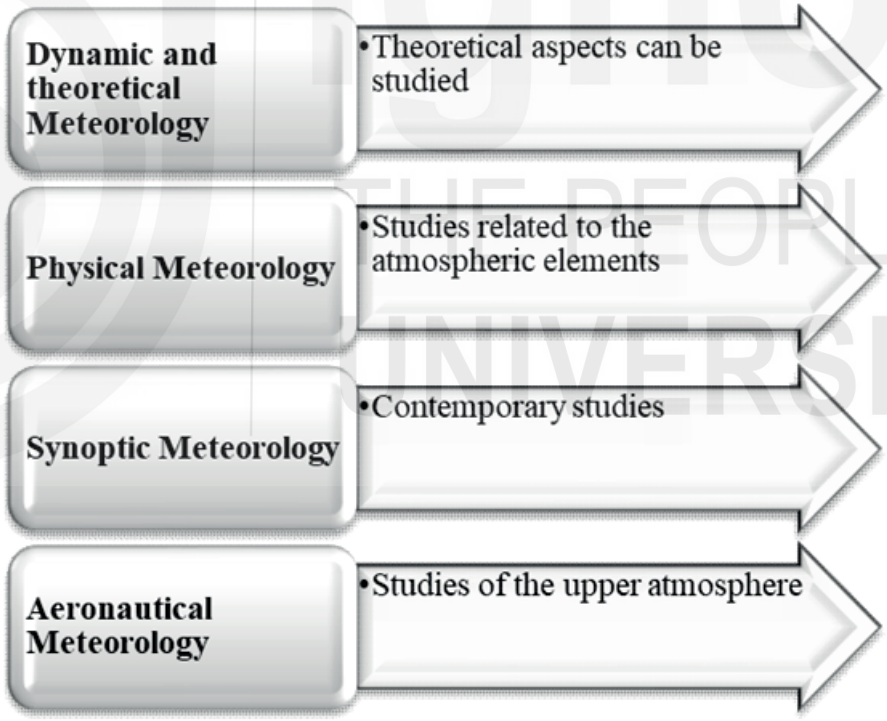

Fig. 1.4: Sub- division of Meteorology. (Created by Author)

(ii) Physical Meteorology:

Study related to the atmospheric elements through the various concepts of physics like- thermodynamic, electrical, optical phenomena etc. is being carried out under this sub-part of meteorology.

(iii) Synoptic Meteorology:

Under this sub-part of meteorology, there is a contemporary study of the subtlest conditions by regional, comparative and analytical methods. In this

sub-field, the complete conditions of the weather are studied in a particular period of a specific region. Making of weather related maps, forecasting the weather, the thorough study of the air masses, fronts and other elements of weather are being done under this sub-branch of meteorology.

(iv) Aeronautical Meteorology:

Under this sub-part of meteorology, the study of the upper atmosphere is carried out. Under this, there is a systematic study of the conditions of high atmospheric temperature, air pressure and humidity. Main aims of this sub-part are as follows-

a) Immediate forecast for the pilot.
b) Determination of height and bases of clouds.
c) Study of atmospheric transparency and visibility.
d) Study of storms, surges and accidental events.

Basic difference between the climatology and meteorology is that *climatology deals with the long term atmospheric behavior over a significant period of time whereas meteorology deals with atmospheric phenomena at any time and over a short period of time that lasts not more than a few days*.

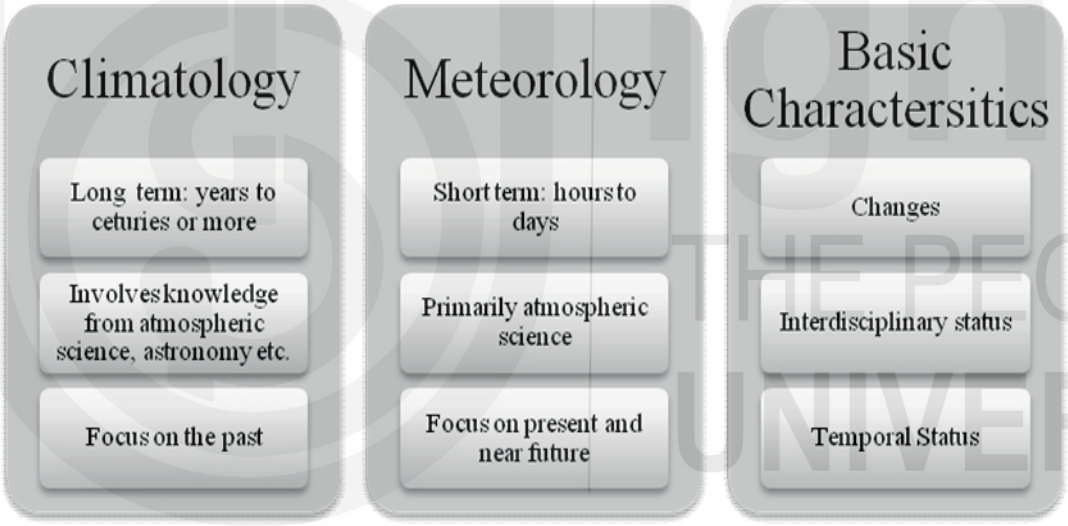

Fig. 1.5: Difference between Climatology and Meteorology. (Created by Author)

SAQ 3

a) Define meteorology.
b) In how many sub-parts meteorology can be divided?

1.5 SCALES OF CLIMATOLOGY

Climatology has following scales:

(i) Micro Scale: Micro Scale is the smallest of all the atmospheric scales. It involves the systems that operate over a smaller area that is less than 0.5 km. Under this scale, the study of the climate is confined very close to the ground. For example- Climate surrounding a house.

(ii) Local Scale: Local Scale is the larger scale than the Micro Scale. It involves the systems that operate over an area between 0.5 and 5 km. For example- Climate of a river valley.

(iii) Meso Scale: It involves the systems that operate over an area between 5-100 km. For example- Climate of a basin or any indentified region.

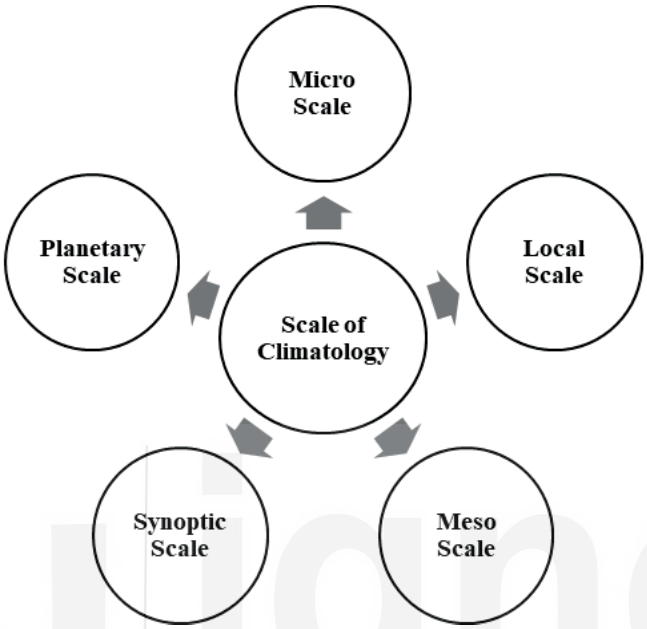

Fig. 1.6: Scale of Climatology. (Created by Author)

(iv) Synoptic Scale: It involves the systems that operate over an area between 100-10,000 km. For example- Climate of a region.

(v) Planetary Scale: Planetary Scale is the largest scale of all atmospheric scales. It involves the systems that operate over an area between 10,000-40000 km. For example- Climate of a hemisphere or the whole earth.

SAQ 4

How Many Scales the climatology have?

1.6 SUB-FIELDS OF CLIMATOLOGY

It is observed that in the past few years, there has not only been an increase in cooperation between branches of traditional science in the investigation of climate related problems, but some new combinations have also developed. Bio-Climatology, Agro-Climatology, Pharma-Climatology, Construction-Climatology and Urban-Climatology are the prime example of this.

According to Critchfield, there are three basic sub-fields of climatology (first three). But at the broad level, Climatology can be divided into following sub-fields –

(i) Physical Climatology

Physical climatology is closely related to meteorology. Physical climatology is mainly concerned with atmospheric phenomena. Physical climatology tries to

explain the factors that are responsible for temporal and spatial changes in atmosphere.

This sub-field of climatology deals with the study of elements of weather, namely- insolation, temperature, air pressure, wind, evaporation, humidity, precipitation, fog etc. Combination of all these or some of these elements formed different climates.

In other words, this sub-field studies the systematic description and analysis of:

(a) Energy balance of atmosphere and earth.
(b) Atmospheric temperature.
(c) Humidity and precipitation.
(d) Atmospheric motion's and air circulation.
(e) Air masses.
(f) Extreme atmospheric events like- atmospheric disturbances, droughts, floods etc.

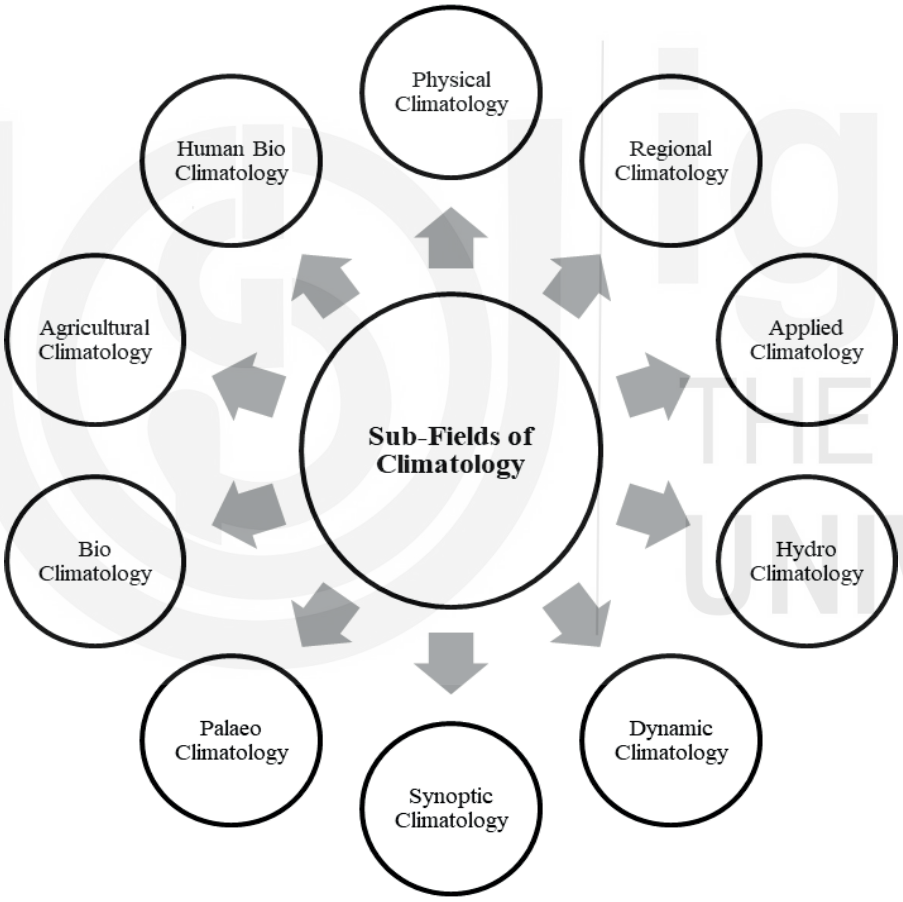

Fig. 1.7: Sub- Fields of Climatology. (Created by Author)

(ii) Regional Climatology

Spatial variations in the combinations of weather related elements can cause different types of climate in different parts of the earth. The size of the area or the region, over which similar types of climatic conditions are observed, can vary from each other. Regional Climatology deals with the description of the climate of a region. It seeks to determine and describe various types of climates. In this sub-branch, all the climatic elements of a certain region are studied by dividing the earth's surface into different climatic divisions. It is also known as specific climatology.

(iii) Descriptive Climatology

This sub-branch of climatology is concerned with the identification of important climatic characteristics and the interaction of weather and climatic elements upon life and the condition of a particular area or a region. In this sub-branch, climate elements are studied on the basis of different elements. Its method is like general geography. It is very difficult to differentiate between physical and descriptive climatology because practically both of them are very same.

(iv) Applied Climatology

The main purpose of the study of climatology is to find out the ways and means to make use of our knowledge of climatic elements for the betterment of human life on the earth.

So, applied climatology is concerned with the study of the effects of climate and with the application of the climatological knowledge to practical problems i.e. application of climatic principles and knowledge to solve various problems faced by human society. It also studies, how humans modify climate by introducing various changes in the physical environment. For example- weather modification by humans through cloud seeding and induced precipitation. It analyses the relationship between climatology and other sciences.

In general, it is in this aspect of climatology that the interdependence and unity of human knowledge emerges among all branches of science.

(v) Hydro Climatology

Hydro Climatology is mainly concerned with the processes of interaction between atmosphere and water in all its forms.

(vi) Dynamic Climatology

Dynamic Climatology is concerned with the general atmospheric processes. This sub-branch of climatology investigates the impact of changes in various physical parameters on climate.

(vii) Synoptic Climatology

Synoptic Climatology is the study of relationship between atmospheric circulation and environment of a particular region. It deals with local or hemispheric climate from the view point of atmospheric circulation because different circulation patterns lead to variations in climates.

It mainly studies the relationship between circulation patterns and severe weather conditions.

(viii) Palaeo-Climatology

Palaeo-Climatology mainly deals with the study of the past climatic data.

(ix) Bio-Climatology

Bio-Climatology is the study of the interaction of living things with their environment.

(x) Human Bio-Climatology

Human Bio-Climatology deals with the impact of atmospheric properties and processes on human beings. It is closely related with life science.

(xi) Agricultural Climatology

Agricultural Climatology deals with the impact of atmospheric properties and processes on agriculture.

SAQ 5

In how many sub-fields climatology can be divided?

1.7 SUMMARY

In this unit you have studied so far:

a) Meaning and scope of climatology.

b) Development of climatology through the ages.

c) Difference between climatology and meteorology.

d) Various scales of climatology.

e) Various sub-fields of climatology.

1.8 TERMINAL QUESTIONS

1. What is climatology? Write about the scope of climatology.
2. Write in detail about the development of climatology.
3. What are the various scales of climatology?
4. Write about the sub-fields of climatology.

1.9 ANSWERS

Self-Assessment Questions (SAQ)

1. a) The term “climatology” is derived from the Greek term “klima”, means inclination or latitude or slope or angle from the sun. It was used for the duration of day and night, and “logos”, means study or discourse. Famous philosopher Aristotle used the term “klima” for latitudinal belts.

   b) The main responsibilities of a climatologist are to study the climate, climate changes, climatic variability and patterns. A climatologist studies the effect of climatic factors on the biosphere. A climatologist must be equipped with the latest technologies for a better climate and weather prediction. This will help in various activities such as agriculture, economic development, resources management etc.

2. a) We can recognise the study of climatology in five phases.

   b) The purpose of tower of winds is to measure the direction of winds.

   c) Indra is the deity of rain for the Indians.

d) In 1878, “International Meteorological Organisation was established in Utrecht in Holland.

3. a) Meteorology is defined as the physics of the atmosphere. Meteorology uses the methods of physical principles to interpret and explain the atmospheric processes. It deals with atmospheric phenomenon over a short period of time.

   b) Meteorology can be divided into four sub-parts: dynamic, physical, synoptic and aeronautical.

4. Climatology has five scales: micro, local, meso, synoptic and planetary scales.

5. Climatology can be divided in ten sub-fields: Physical Climatology, Regional Climatology, Descriptive Climatology, Applied Climatology, Hydro Climatology, Dynamic Climatology, Synoptic Climatology, Palaeo-Climatology, Bio-Climatology and Agricultural Climatology.

Terminal Questions

i) You can start your answer giving the definition of climatology and then write its scope. Refer to Sec. 1.2.

ii) You can start your answer by stating that it is a newer branch of geography and then write in detail about its various phases of development. Refer to Sec. 1.3.

iii) You can start your answer by stating that there are five scales of climatology and after that you can describe it in detail. Refer to Sec. 1.5.

iv) You can start your answer by stating that there are ten sub-fields of climatology. After that you can write about these in detail. Refer to Sec. 1.6.

1.10 REFERENCES AND FURTHER SUGGESTED READING

1. Ayoade, J.O. (2004). *Introduction to Climatology for the Tropics.* Spectrum Books Ltd., Ibedan.

2. Barry, R.G. and Chorley, R.J. (1971). *Atmosphere, Weather and Climate.* Methuen publication, London.

3. Critchfield, H.J. (1993). *General* Climatology. Prentice Hall, India, New Delhi.

4. Lal, D.S. (1986). *Climatology*. Chaitanya Publications, Allahabad.

5. Koeppe, C.E. and Delong, G.C. (1958). *Weather and Climate.* McGraw Hill Publication, New York.

6. Miller, A. (1959). *Climatology.* Methuen publication, London.

7. Singh, S. (2011). *Climatology.* Prayag Pustak Bhawan, Allahabad.

8. Trewartha, G.T. (1954). *Introduction to Climate.* McGraw Hill Publication, New York.