Surface Water Hydrology
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Lecture – 06
Different forms of Precipitation and Indian Monsoon

In this lecture, we will learn the hydrologic analysis of precipitation. And week 2 also starts with module 2. So, today we will cover lecture 6, which is based on different forms of precipitation and some characteristics of the Indian monsoon.

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So, these are the three specific concepts covered in this class. The first one is precipitation and its different form, then weather systems associated with the precipitation formation. And lastly, the Spatio-temporal characteristics of precipitation in India, which is mostly dominated by the monsoon. And two types of monsoons are there so, that characteristics we will learn.

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The outline of this lecture goes like this: first we will give a very brief introduction, then different forms of precipitation, then weather systems for precipitation characteristics of precipitation in India, which is dominated by monsoon, and finally, we will summarize.

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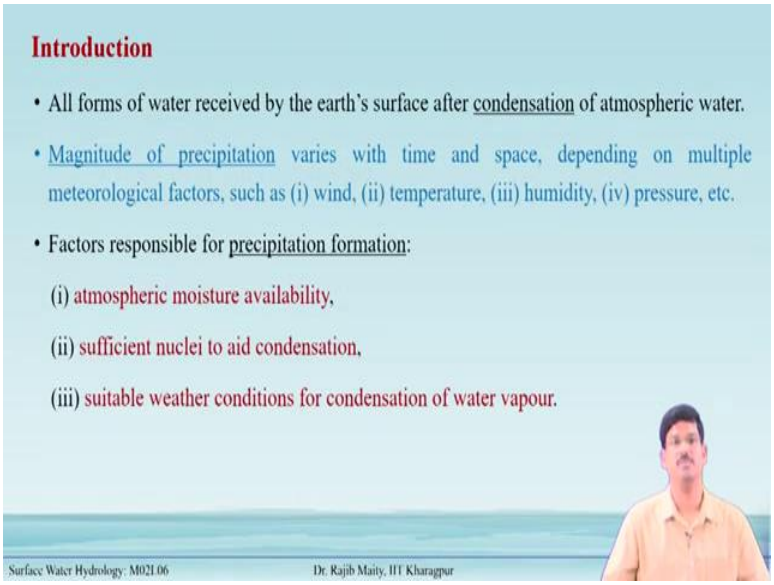

Introduction

All the forms of water that are being received by the earth's surface after the condensation of the atmospheric water. Now, there are two things one is the magnitude of precipitation and the second thing is the precipitation formation.

The magnitude of precipitation that varies over space and time. So, varies over space and time means from one location to another location it can change and at the same location also over the time, throughout the year and even one year after year that may change. The magnitude of precipitation varies with time and space, depending on multiple meteorological factors, such as (i) wind, (ii) temperature, (iii) humidity, (iv) pressure, etc.

Secondly, there are many factors that factorsare responsible for precipitation formation.

(i) Atmospheric moisture availability,

(ii) Sufficient nuclei to aid condensation,

(iii) Suitable weather conditions for condensation of water vapor.

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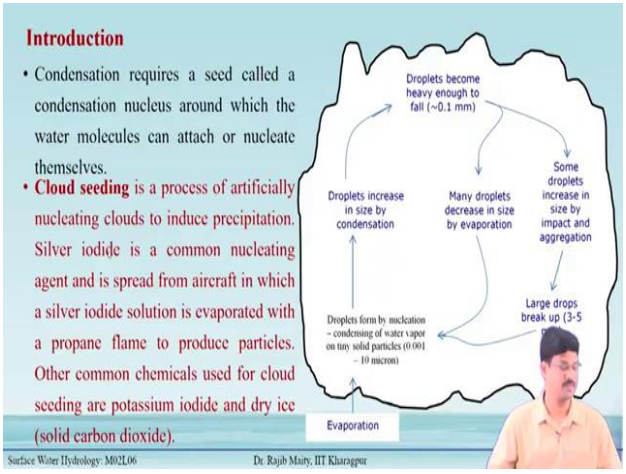

Introduction

Condensation requires a seed called a condensation nucleus around which the water molecules can attach or nucleate themselves. . Here, one overall broad and brief chart is shown in Fig.1.

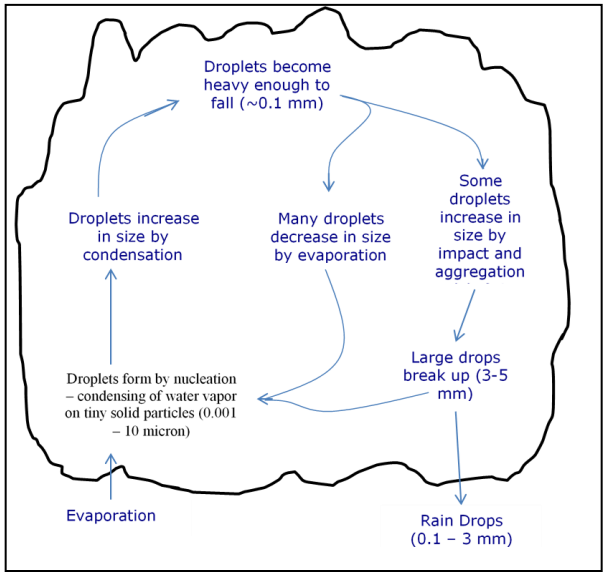

Fig.1 shows the internal operation of clouds starting from Evaporation and ending with rainfall.

In this Fig.1 the boundary is basically for the cloud boundary, and the cloud is fed by the evaporation. Evaporation is a process from the earth surface and water surface, it gets vaporized and go up and it enters in the cloud system. And there is some process going on like this and is the raindrops or snowfall or different forms are come out from the cloud. But in general, inside a cloud system all the droplets formed by the nucleus and the condensing of the water vapor on the tiny and solid particles, and these tiny solid particles are of size surround 0.001 to 10 micron. And then once this condensation keeps on taking place the droplet size increase through the condensation process, the ones that droplet size increase.

Initially it was going upward then the droplet becomes heavier so, heavier enough to fall towards the downward movement with an approximate size about 0.1 mm. Now, these heavier droplets want to come down and there are two partitions of this one the first part, there are many droplets, they again decrease in size when they are coming down. So, that time due to the surrounding wind pattern, it evaporates again.

So, once it becomes heavier, starts to fall and it is again similar, but it loses its size. And again, this group joins to this first part and again it is rotating in this way. If some of the droplet again increase the size, it impacts and the aggregation happens with the other small droplets. So, once they increase the size, it may increase sufficiently and it may go up to say 3 to 5 mm in size.

Once it increases it also can have 2 fates: one is that it the large drops, they may break also and break into a sufficient and smaller size so that it joined in this group or it can also come out as a raindrop and the typical size of this end up is around 0.1 to or 3 mm. Sometimes a new relatively newer technology that is called cloud seeding, this cloud seeding is a process of artificially nucleating clouds to induce precipitation. Silver iodide is a common nucleating agent and is spread from aircraft in which a silver iodide solution is evaporated with a propane flame to produce particles. Other common chemicals used for cloud seeding are potassium iodide and dry ice (solid carbon dioxide).The silver iodide is a common nucleating agent and is sprayed from the aircraft in which a silver iodide solution is evaporated with the propane flame to produce those very fine particles. And other there are other common chemicals are also there for cloud seeding, those are as potassium iodide or dry ice. Dry ice is also known as solid carbon dioxide. So, these are some of the common chemicals that are used for this cloud seeding.

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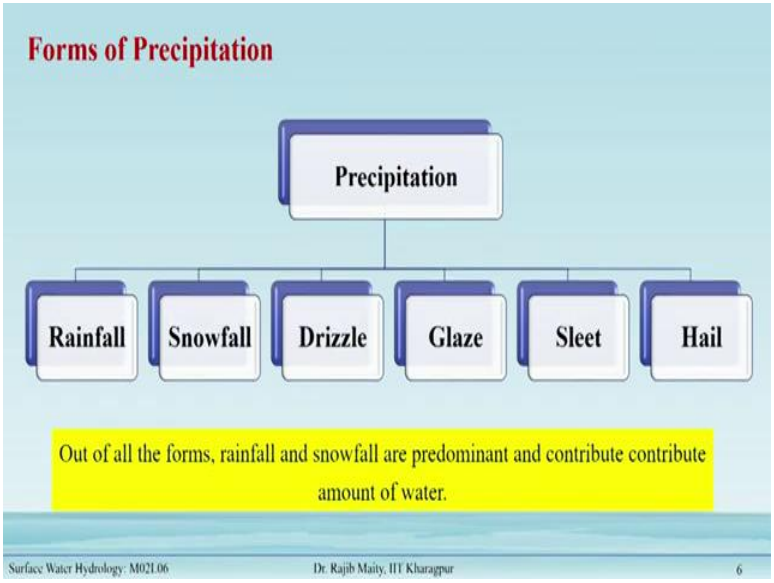

Forms of Precipitation

Next come to the different forms of precipitation. The different types of precipitations are as follows:

i. Rainfall
ii. Snowfall
iii. Drizzle
iv. Glaze
v. Sleet
vi. Hail

Out of all the forms, rainfall and snowfall are predominant and contribute an amount of water.

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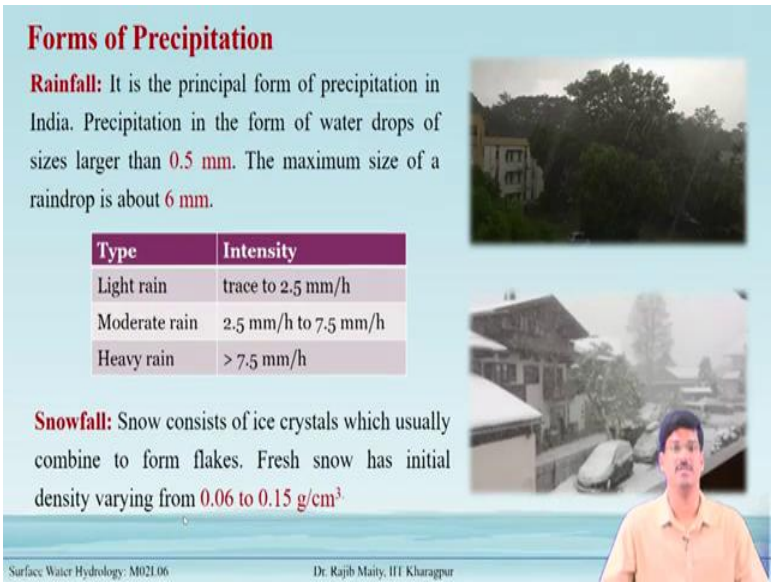

Rainfall: Rainfall is the most predominant one and it is the principal form of this precipitation in many parts of the world including India, and it is the principal form of precipitation in India. Precipitation in the form of water drops of sizes larger than 0.5 mm. The maximum size of a raindrop is about 6 mm. So, there are different types of rains we generally categorize just like the light rain or moderate rain, or heavy rain and their intensity is like this is shown in table 1 Table1: shows the type of rain as per their intensity

Snowfall: Snow consists of ice crystals which usually combine to form flakes. Fresh snow has an initial density varying from 0.06 to 0.15 gm/cm^3.

Type	Intensity
Light rain	trace to 2.5 mm/h
Moderate rain	2.5 mm/h to 7.5 mm/h
Heavy rain	> 7.5 mm/h

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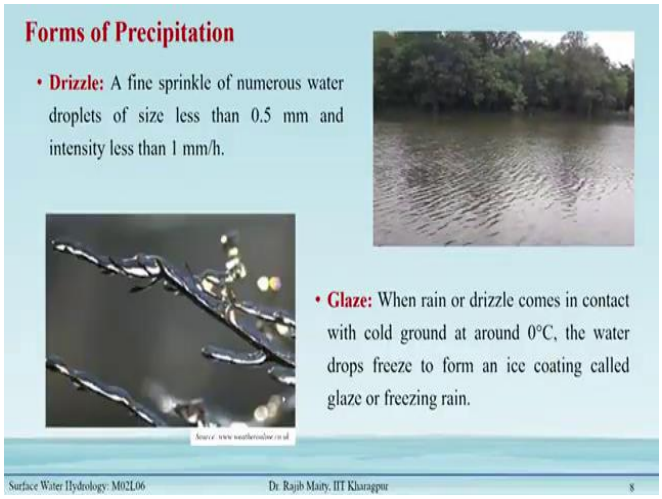

Drizzle: A fine sprinkle of numerous water droplets of size less than 0.5 mm and intensity less than 1 mm/h.

Glaze: When rain or drizzle comes in contact with the cold ground at around 0°C, the water drops freeze to form an ice coating called glaze or freezing rain.

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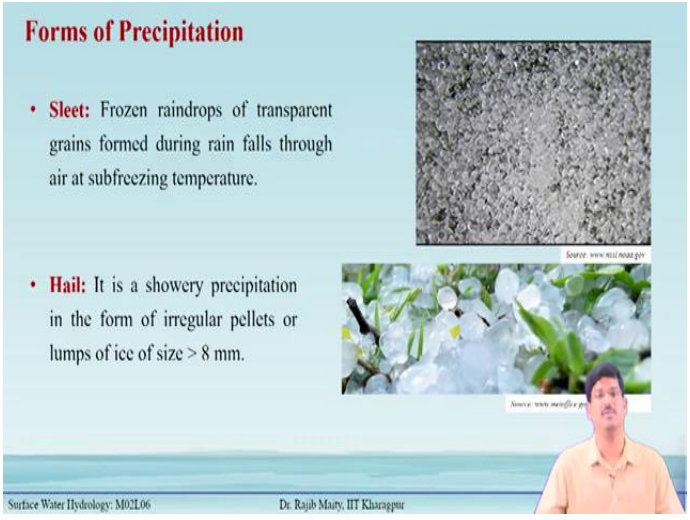

Sleet: Frozen raindrops of transparent grains formed during rain falls through the air at subfreezing temperature.

Hail: It is showery precipitation in the form of irregular pellets or lumps of ice of size > 8 mm

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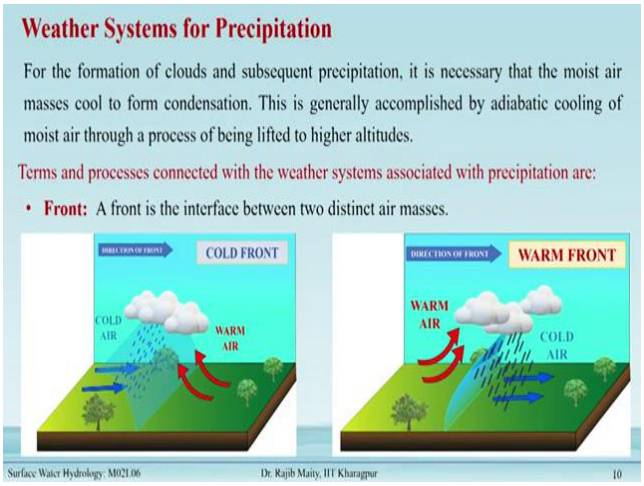

Weather Systems for precipitation

For the formation of clouds and subsequent precipitation, the moist air masses must cool to form condensation. This is generally accomplished by adiabatic cooling of moist air through a process of being lifted to higher altitudes. The first and most important is the front. A front is an interface between two distinct air masses. There are mainly two types of front. The first one is the cold front and the second one is the warm front. In the cold front, there is a cold air that comes in and it pushes the warm air towards the upward direction, the cold air is heavier and the warm air is lighter. So, when it progresses towards the warmer air the warmer will be lifted up. Once it lifted up that the process one of the requirements that, the moist air should be lifted substantially so that it gets lower temperature that are fulfilled and there is the surface there is a distinct surface being formed on wage there is a rapid change in the temperature if it just passes through that particular region. And that zone is called the front and if it is the cold air is focusing it is called the cold front.

The opposite was is called the warm front, whatever the warm air progress to the cold air and once it gets obstructed, it goes up and there is again another front,where the temperature changes very rapidly that forms and the warm air is lifted up and this is what is called the warm front.

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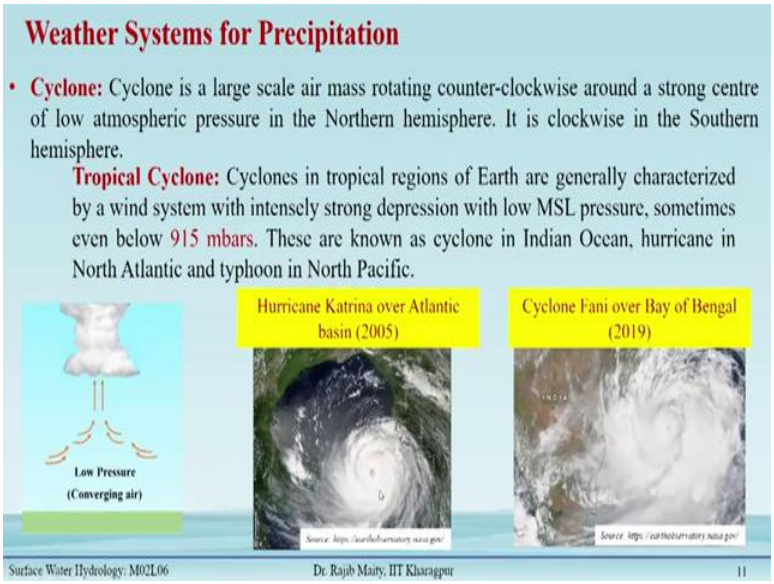

Cyclone: Cyclone is a large-scale air mass rotating counter-clockwise around a strong centre of low atmospheric pressure in the Northern hemisphere. It is clockwise in the Southern hemisphere. Now, we can categorize into two parts one is the tropical cyclone and the other one is the subtropical cyclone.

Tropical Cyclone*:* Cyclones in tropical regions of Earth are generally characterized by a wind system with intensely strong depression with low MSL pressure, sometimes even below 915 mbars. These are known as a cyclone in the Indian Ocean, hurricanes in North Atlantic, and typhoons in North Pacific.

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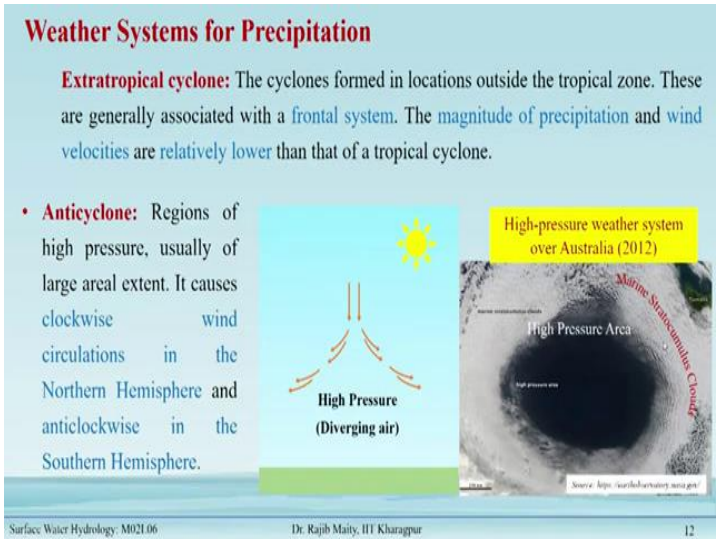

Extratropical cyclone: The cyclones formed in locations outside the tropical zone. These are generally associated with a frontal system. The magnitude of precipitation and wind velocities are relatively lower than that of a tropical cyclone

Anticyclone: Regions of high pressure, usually of large areal extent. It causes clockwise wind circulations in the Northern Hemisphere and anticlockwise in the Southern Hemisphere.

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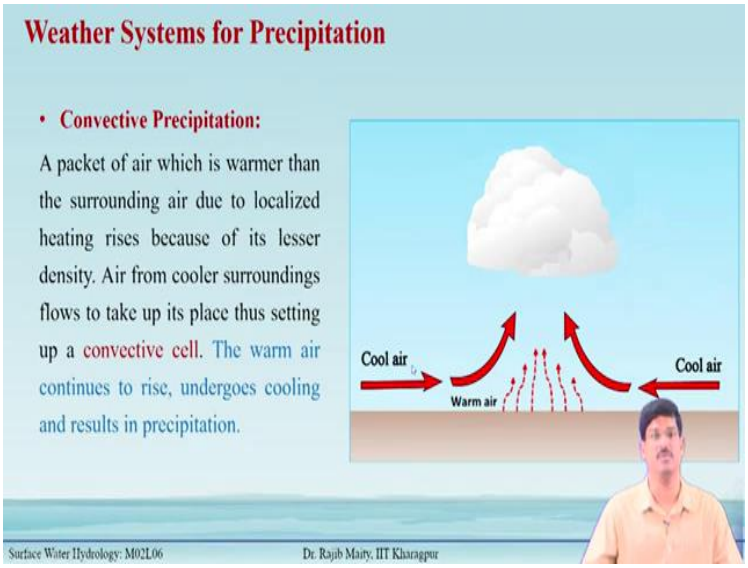

Convective Precipitation:A packet of air that is warmer than the surrounding air due to localized heating rises because of its lesser density. Air from cooler surroundings flows to take up its place thus setting up a convective cell. The warm air continues to rise, undergoes cooling, and results in precipitation..

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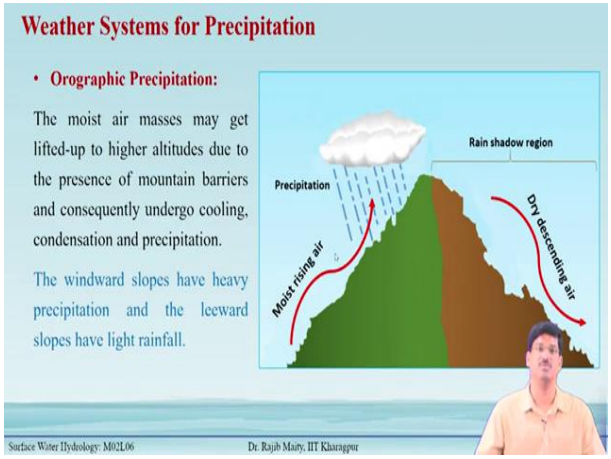

Orographic Precipitation: The moist air masses may get lifted up to higher altitudes due to the presence of mountain barriers and consequently undergo cooling, condensation, and precipitation. The windward slopes have heavy precipitation and the leeward slopes have light rainfall. So, this kind of precipitation in India we generally see in the Western Ghats region when it gets a huge rainfall towards the Arabian Seaside and on the other side it generally remains dry.

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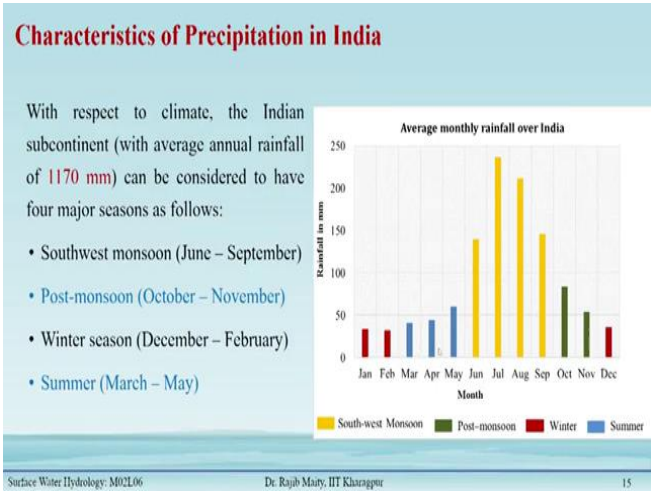

Characteristics of Precipitation in India

The characteristics of precipitation in India with respect to the climate, the Indian subcontinent as we have seen in the first week that on an average annual rainfall is approximately 1170 mm and this can be considered into the four major seasons.

- Southwest monsoon (June – September)
- Post-monsoon (October – November)
- Winter season (December – February)
- Summer (March – May)

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Southwest Monsoon (June – September)

Considered the principal rainy season of India when more than 70% of the annual rainfall is received over the major part of the country. During the southwest monsoon time when it is June July, August, and September, we sometimes abbreviate it as a JJAS. So, during this time, India received the maximum amount of rainfall. So, it starts in June and reaches the peak in July and August and then gradually it becomes weakened in September.

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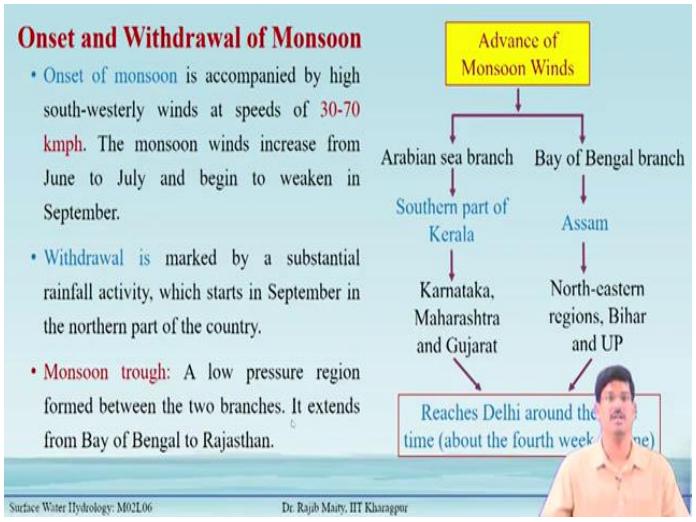

Onset and Withdrawl of Monsoon

There are two branches in the Arabian Sea branch, it hits the southern part of Kerala whereas the Bay of Bengal branch. It hits some part of the northeast and then it proceeds towards the Karnataka, Maharashtra, Gujarat and on the other side Bay of Bengal branch proceed towards the northeastern region Bihar, U.P. Finally, they more or less converge towards the Delhi and surrounding area in the north and northwest part of the country during the fourth week of June.

The onset of monsoon is accompanied by high south-westerly winds at speeds of 30-70 kmph. The monsoon winds increase from June to July and begin to weaken in September. Withdrawal is marked by a substantial rainfall activity, which starts in September in the northern part of the country. Now, there is a term called the monsoon trough, it is a low-pressure region formed between the two branches. It extends from the Bay of Bengal to Rajasthan.

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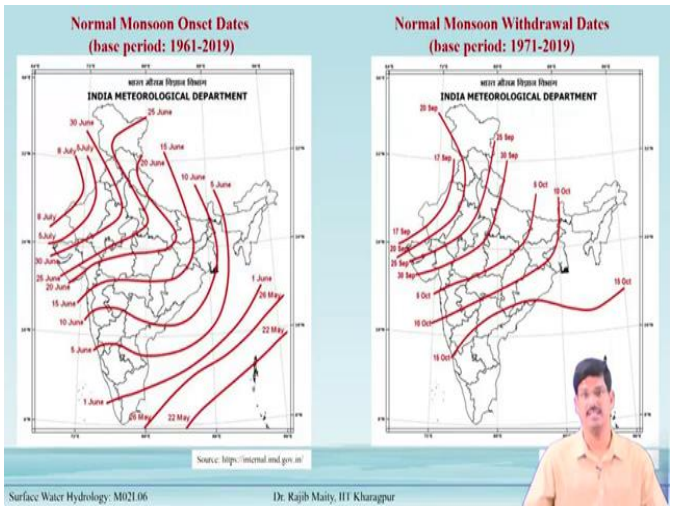
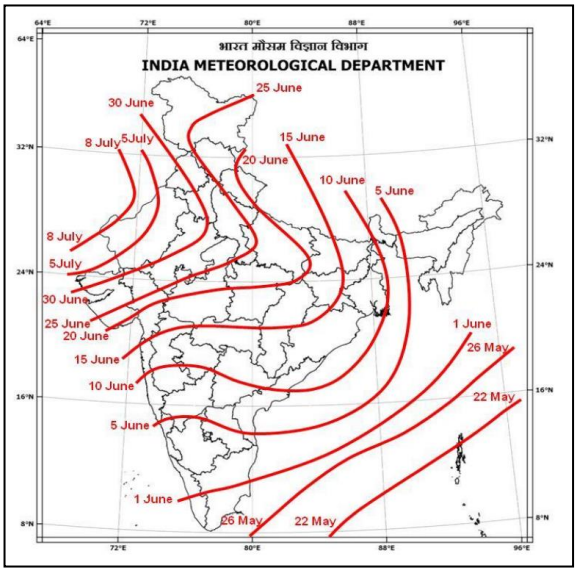


Normal Monsoon Onset Dates

(Base period: 1971-2019)



Normal Monsoon Withdrawal Dates

(Base period: 1961-2019)

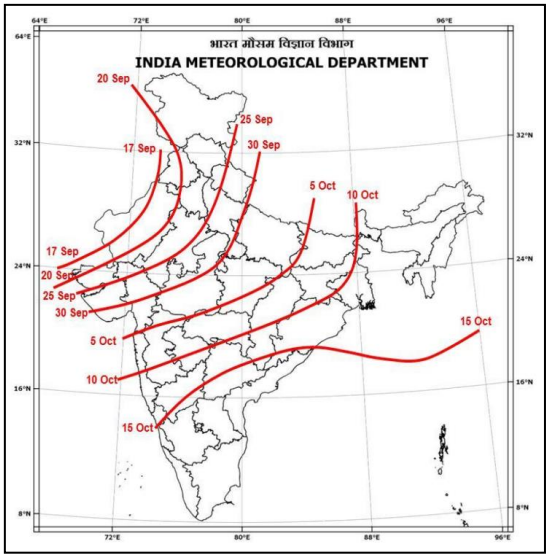


Fig.2 show the normal onset and withdrawal date in the Indian subcontinent part.

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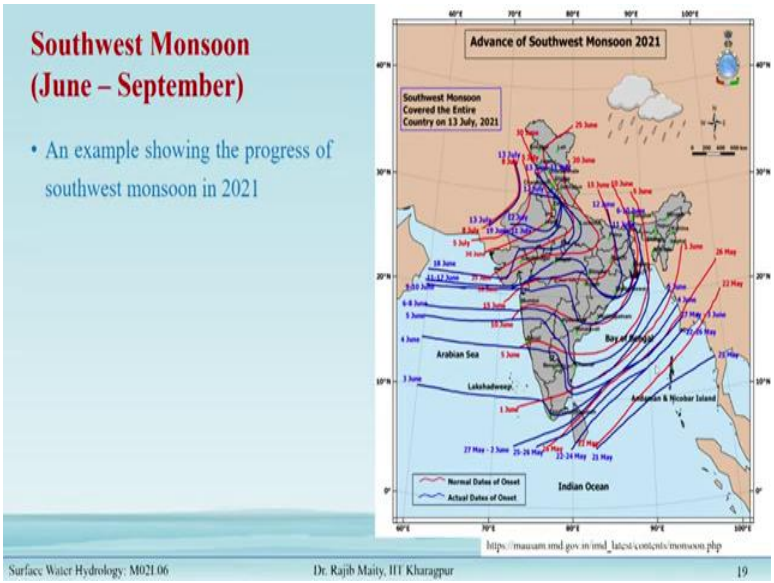

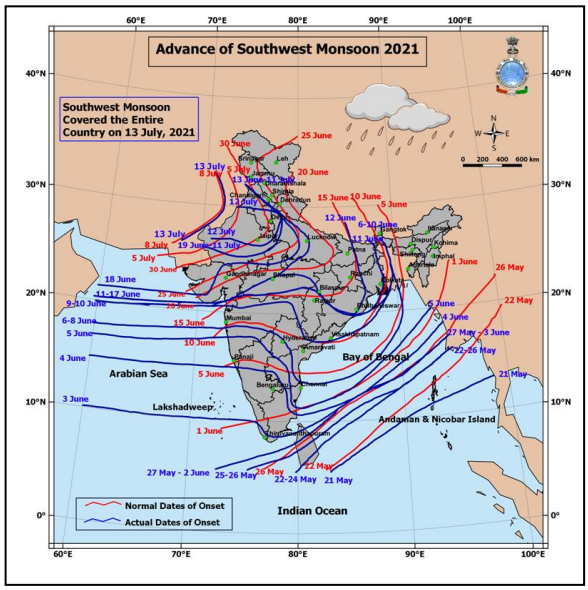

Fig.3 shows the progress of the southwest monsoon in the year 2021

In fig.3, an example showing the progress of the southwest monsoon in 2021. There are two things you can see, one is that the red one is showing the normal onset dates and the blue one is basically what happens in 2021. So, there are, slight change and that variation are there from

year to year. And this is just a typical example for the year 2021 showing the progress of southwest monsoon and it is taken from India metrological department (IMD).

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Post-monsoon (October – November)

This is characterized by low-pressure areas formed in the Bay of Bengal and north-easterly winds. It picks up moisture from the Bay of Bengal and causes rainfall over the eastern part of southern Peninsular.

Winter Season (December – February):

Disturbances of extra-tropical origin travel eastwards across Afghanistan and Pakistan. These are known as western disturbances, cause moderate to heavy rain and snowfall (about 25 cm) in the Himalayas, and Jammu and Kashmir.

Summer (March-May):

Some rain is received due to convective cells associated with thunderstorms mostly in West Bengal, Kerala and Assam.

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Summary

In summary, we learned the following points from this lecture:

- Atmospheric water reaches to earth in various forms such as rain, snow, drizzle, sleet, glaze, etc., which on a whole is termed as Precipitation.
- Various weather systems such as front, cyclone, anticyclone, etc. cause the precipitation to form.
- The Spatio-temporal characteristics of precipitation depend on various geographic and climatic factors of a particular region.
- A major proportion of annual total precipitation across most of India is received during the Southwest monsoon season with considerable spatial variation.