Surface water Hydrology

Hydrology is the science, which deals with the occurrence, distribution and disposal of water on the planet earth: it is the science which deals with the various phases of the hydrologic cycle. The importance of hydrology in the assessment, development, utilization and management of the water resources, of any region is being increasingly realized at all levels.

Hydrologic cycle

Hydrologic cycle is the water transfer cycle, which occurs continuously in nature; the three important phases of the hydrologic cycle are:

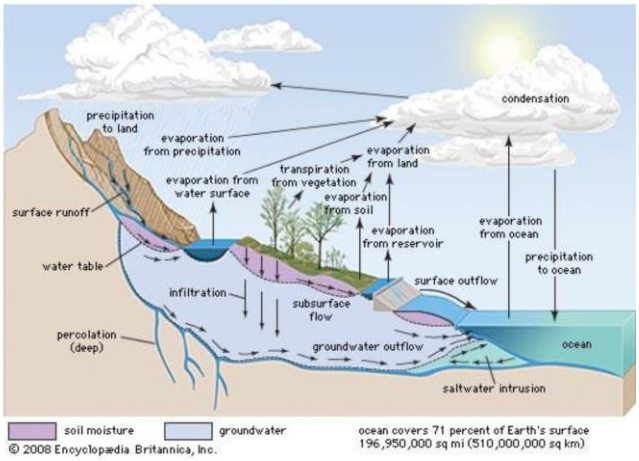
(a) Evaporation and evapotranspiration

(b) Precipitation

(c) Runoff

The globe has one-third land and Two-thirds Ocean. 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 vapors rise to the sky and are condensed at high altitude by condensation nuclei and form clouds, resulting in droplets growth. The clouds melt and sometimes burst resulting in precipitation of different forms like rain, snow, hail, sleet, mist, dew and frost. A part of this precipitation flows over the land runoff part infiltrates into the soils which build up groundwater table.

The surface runoff joins the streams and the water is stored in the reservoir. A portion of runoff and the groundwater flows back to ocean. Again evaporation starts from the surfaces of lakes, reservoirs and ocean and the cycle repeats.



Evaporation is the process by which water changes from a liquid to a gas or vapor. Evaporation is the primary pathway that water moves from the liquid state back into the water cycle as atmospheric water vapor. Studies have shown that the oceans, seas, lakes, and rivers provide nearly 90 percent of the moisture in our atmosphere via evaporation, with the remaining 10 percent being contributed by plant transpiration.

Transpiration is the process by which moisture is carried through plants from roots to small pores on the underside of leaves, where it changes to vapor and is released to the atmosphere. Transpiration is essentially evaporation of water from plant leaves. It is estimated that about 10 percent of the moisture found in the atmosphere is released by plants through transpiration.

Condensation is the process in which water vapor in the air is changed into liquid water. Condensation is crucial to the water cycle because it is responsible for the formation of clouds. These clouds may produce precipitation, which is the primary route for water to return to the Earth's surface within the water cycle. Condensation is the opposite of evaporation.

Precipitation is water released from clouds in the form of rain, freezing rain, sleet, snow, or hail. It is the primary connection in the water cycle that provides for the delivery of atmospheric water to the Earth. Most precipitation falls as rain.

Infiltration is the process by which precipitation or water soaks into subsurface soils and moves into rocks through cracks and pore spaces. As we mentioned before, the bulk of rainwater and melted snow end up infiltrated.

Precipitation

Precipitation is any form of solid or liquid water that falls from the atmosphere to the earth's surface. Rain, drizzle, hail and snow are examples of precipitation. rain is the most common form of precipitation. Evapotranspiration is the process which returns water to the atmosphere and thus completes the hydrologic cycle. Evapotranspiration consists of two parts, Evaporation and Transpiration. Evaporation is the loss of water molecules from soil masses and water bodies. Transpiration is the loss of water from plants in the form of vapour.

Forms of Precipitation

Precipitation occurs in many forms e.g. drizzle, rain, glaze, sleet, snow, hail, dew and frost, depending upon the causes and temperature at the time of formation. Dew is condensation on the ground of atmospheric vapor caused by radiational cooling of the lower layers of atmosphere, usually at night. Frost is dew formed under freezing conditions. Dew and frost are quantitatively unimportant and rarely measured.

1. Drizzle: Drop size < 0.5 mm in dia. and intensity is usually < 1 mm/hr and generally occurs in conjunction with warm frontal lifting.
2. Rain: Drop size is between 0.5 to 6 mm in dia. Drops bigger than 6 mm tend to break up as they fell. It is formed by condensation and coalescence of cloud droplets at temperatures above the freezing point.
3. Glaze: It is the ice coating formed when drizzle or rain freezes as it comes in contact with cold objects on the ground.
4. Sleet: It is frozen raindrops cooled to ice stage while falling through air at sub-freezing temperature.
5. Snow: It is a precipitation in the form of ice crystals resulting from sublimation, i.e., directly from water vapor to ice.
6. Snow Flake: It is made of a number of ice crystals fused to gather.
7. Hail: It is precipitation in the form of balls or lumps of ice over 5 mm diameter formed by alternate freezing and melting as they are carried up and down in highly turbulent air currents.

Mechanisms for Production of Rain fall

The following four conditions are necessary for the production of rainfall.

Mechanism to produce cooling of the air – The pressure reduction due to ascending air from surface to upper levels in the atmosphere is the only known mechanism capable of producing large drops in the temperature.

Mechanism to produce condensation – Condensation in the atmosphere takes place on “hygroscopic nuclei” small particles of substances that have an affinity for water.

Mechanism for droplet growth – A tendency for the droplets to remain small and therefore to resist falling is called “colloidal stability”. The most effective processes for droplet enlargement are,

1. The difference in speeds between large and small droplets, and
2. The co-existence of ice crystals and water droplets.

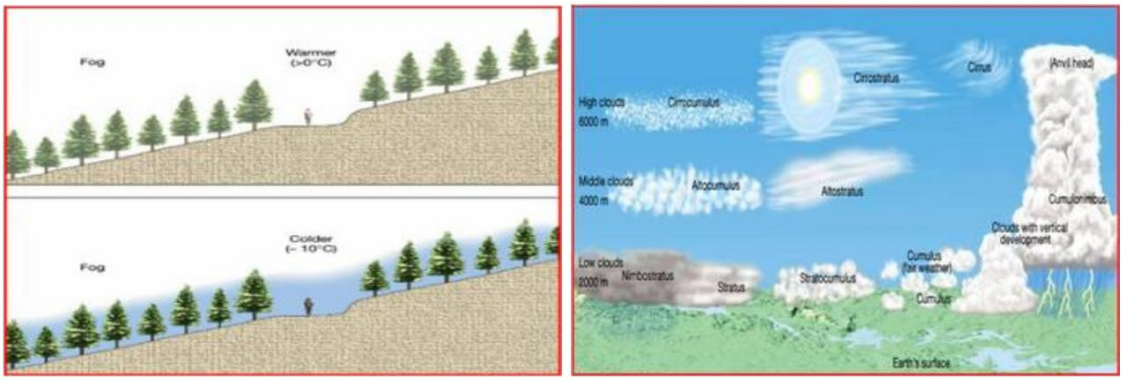
to produce accumulation of moisture of sufficient intensity to account for the observed rates of rainfall – Regardless of whether or not the other conditions for precipitation are fulfilled, continuity considerations demand that there must be a good amount of moisture present in the atmosphere so that evaporation losses between ground and cloud be compensated, if there is to be appreciable rain.

Rain

Technically, rain isn’t just any liquid that falls out of the sky. Rain is defined as being water droplets of 0.5 mm or greater. Droplets smaller than half a millimeter is classified as drizzle. Raindrops often form when small cloud particles collide and stick together, forming bigger drops. Once the drops get large enough, they are too small for rising air to support; gravity draws them down to the ground. In air below 0 °F, raindrops may start as snow or ice crystals but melt when they fall into warmer air. Another reason rain may not reach the ground is updrafts. If the wind is blowing upward faster than the rain is falling, the rain cannot reach the ground.

Clouds

Clouds, visible aggregates of minute droplets of water or tiny crystals of ice, are one form of condensation. Clouds are classified on the basis of two criteria: form and height. The three basic cloud forms are: cirrus (high, white, and thin), cumulus (globular, individual cloud masses), and stratus (sheets or layers).



Fog - Fog, generally considered an atmospheric hazard, is a cloud with its base at or very near the ground. Fogs formed by cooling include: radiation fog (from radiation cooling of the ground and adjacent air), advection fog (when warm and moist air is blown over a cold surface), and up-slope fog (created when relatively humid air moves up a slope and cools adiabatically).

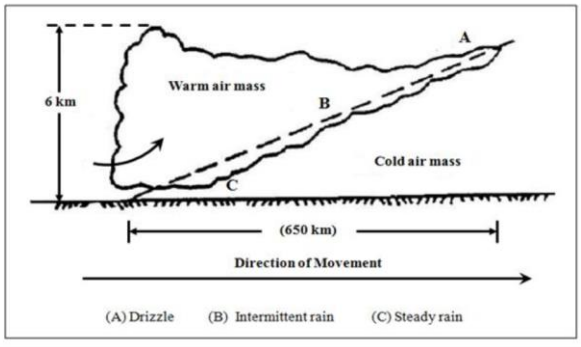
Dew and White Frost - Dew is the condensation of water vapor on objects that have radiated sufficient heat to lower their temperature below the dew point of the surrounding air. White frost forms when the dew point of the air is below freezing.

Types of Precipitation

There are three major types of precipitation: cyclonic, convective, and orographic. Each type represents a different method of lifting an air mass, resulting in cooling and condensation of atmospheric water vapor.

Cyclonic Precipitation: It is caused by lifting associated with the horizontal convergence of inflowing atmosphere into an area of low pressure. There are two kinds of cyclonic precipitation. Non-frontal precipitation involves only this convergence and lifting. Frontal precipitation results when one air mass is lifted over another. A front is defined as the boundary between two air masses of different temperatures and densities. The types of fronts and their commonly associated precipitation are described below.

A warm front is the result of a warm air mass overriding a cold air mass, causing extensive areas of cloudiness and precipitation. As the warm front approaches a given area, the precipitation becomes more continuous and intense. Warm fronts move at a speed of 15-50 km/h (10-30 mph).



Warm Front.

A cold front results from a strong push of a cold air mass against and beneath a warm air mass. At the front towering clouds develop together with intense short duration precipitation. Cold fronts move at a speed of 30-80 km/h (20-50 mph).

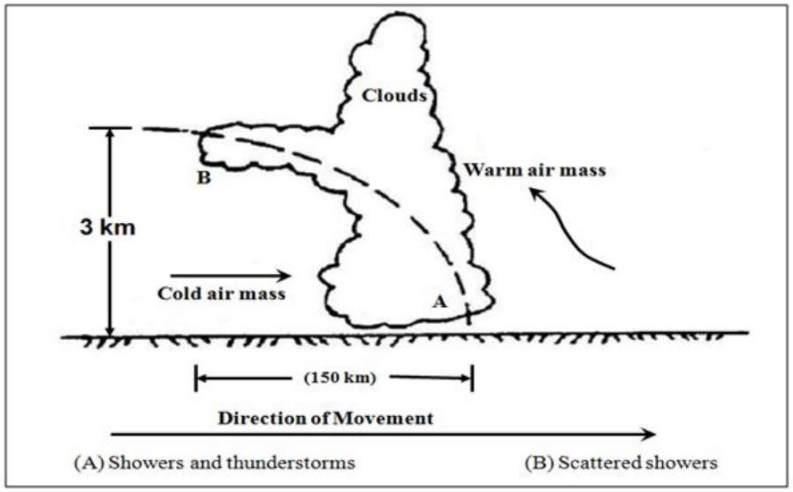
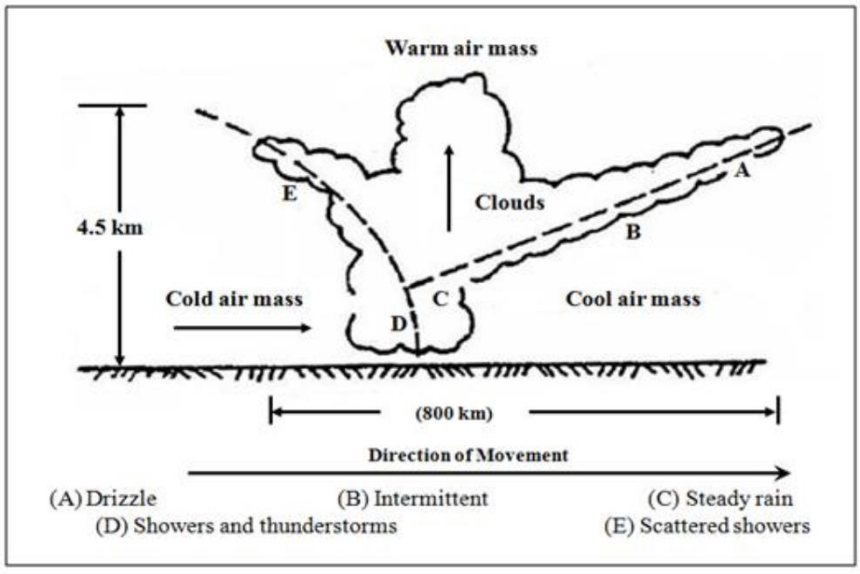


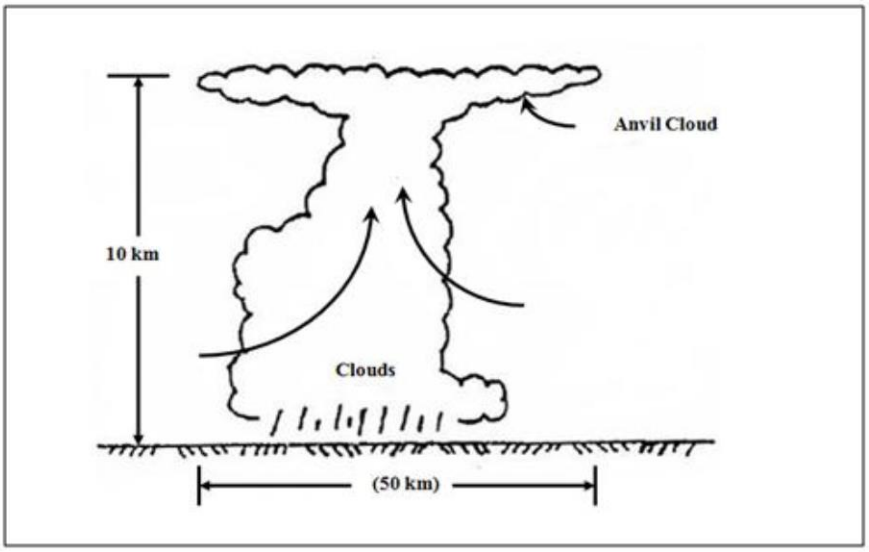
Fig. Cold Front.(Source:Singh, 1994)

An occluded front occurs when a cold front overtakes a warm front. The precipitation pattern is a combination of both warm and cold frontal distribution. Occluded fronts move at a speed of from 8-50 km/h (5-30 mph).



Occluded Front.

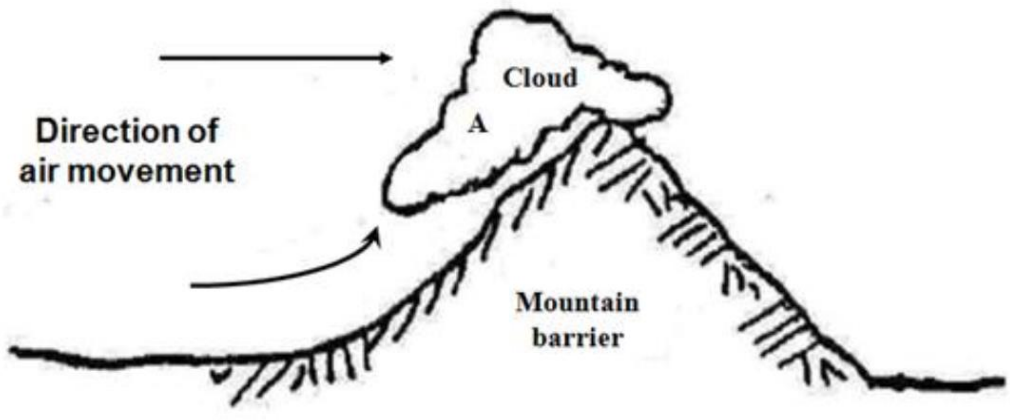
Convective precipitation:



Thunderstorm.

It results when air that is warmer than its surrounding rises and cools. The precipitation is of a shower type, varying from light showers to cloudbursts. The typical thunderstorms resulting from heating of the atmosphere in the afternoon hours is the best example of convective rainfall. Thunderstorms occur throughout the world, especially in the summer. They are the characteristic form of rain in the tropics, wherever cyclonic circulation does not operate. A cross section through a typical thunderstorm is shown in the Fig

Orographic Precipitation: It is caused when air masses are lifted as they move over mountain barriers. Such orographic barriers tend to increase both cyclonic and orographic precipitation due to the increased lifting involved. Precipitation is generally heavier on the windward slope than on the leeward slope.



(A) Showers and light rainfall

Fig. Orographic Precipitation.

WATER SUPPLY AND SANITATION

1 There is a need to remove the large disparity between stipulations for water supply in urban areas and in rural areas. Efforts should be made to provide improved water supply in rural areas with proper sewerage facilities. Least water intensive sanitation and sewerage systems with decentralized sewage treatment plants should be incentivized.

2 Urban and rural domestic water supply should preferably be from surface water in conjunction with groundwater and rainwater. Where alternate supplies are available, a source with better reliability and quality needs to be assigned to domestic water supply. Exchange of sources between uses, giving preference to domestic water supply should be possible. Also, reuse of urban water effluents from kitchens and bathrooms, after primary treatment, in flush toilets should be encouraged, ensuring no human contact.

3 Urban domestic water systems need to collect and publish water accounts and water audit reports indicating leakages and pilferages, which should be reduced taking into due consideration social issues.

4 In urban and industrial areas, rainwater harvesting and de-salinization, wherever techno-economically feasible, should be encouraged to increase availability of utilizable water. Implementation of rainwater harvesting should include scientific monitoring of parameters like hydrogeology, groundwater contamination, pollution and spring discharges.

5 Urban water supply and sewage treatment schemes should be integrated and executed simultaneously. Water supply bills should include sewerage charges.

6 Industries in water short regions may be allowed to either withdraw only the make up water or should have an obligation to return treated effluent to a specified standard back to the hydrologic system. Tendencies to unnecessarily use more water within the plant to avoid treatment or to pollute ground water need to be prevented.

7 Subsidies and incentives should be implemented to encourage recovery of industrial pollutants and recycling / reuse, which are otherwise capital intensive.

REFERENCES AND FURTHER READING FOR STUDENTS

1. Chhandogya upanishad (the philosophical reflections of the vegas)
   Quote from - https://www.ancient.eu/article/1567/upanishads-summary--commentary/

2. Global water partnership (gwp) 2000

https://www.gwp.org/globalassets/global/toolbox/references/towards-water-security.-a-framework-for-action.-executive-summary-gwp-2000.pdf

3. United Nations Water Conference 1977

the report can be found here - https://digitallibrary.un.org/record/724642?ln=en

4. Engineering Hydrology – June 20, 2013 by Subramanya K

5. The relation of hydrographs of runoff to size and character of drainage-basins

LeRoy K. Sherman

6. Lohman, D. F. (1979). Spatial ability: A review and re-analysis of the correlational literature (Technical Report No. 8). Stanford, CA: Aptitudes Research Project, School of Education, Stanford University.

7. D. K. Todd 1980. Groundwater Hydrology

8. World Metrological Organization recomendations

https://public.wmo.int/en/resources/bulletin/guidelines