14. RAINFALL

The amount of moisture in air is commonly recorded as relative humidity; which is the percentage of the total water vapour air can hold at a particular air temperature. The presence of warm, moist and unstable air and sufficient amount of the hygroscopic nuclei is a prerequisite condition for rainfall. The warm and moist air after being lifted upwards becomes saturated and clouds are formed after condensation of water vapour around the hygroscopic nuclei such as dust particles.

How much water vapour a parcel of air can contain before it becomes saturated (100% relative humidity) and forms into a cloud (a group of visible and tiny water and ice particles suspended above the Earth's surface) depends on its temperature. Warmer air can contain more water vapour than cooler air before becoming saturated.

Cooling

The process of condensation begins only when the relative humidity of the ascending air becomes 100% and air is cooled through four main mechanisms to its dew point: adiabatic cooling, conductive cooling, radiational cooling, and evaporative cooling.

- Adiabatic cooling occurs when air rises and expands. The air can rise due to convection, large-scale atmospheric motions, or a physical barrier such as a mountain (orographic lift).
- Conductive cooling occurs when the air comes into contact with a colder surface, usually by being blown from one surface to another, for example from a liquid water surface to colder land.
- Radiational cooling occurs due to the emission of infrared radiation, either by the air or by the surface underneath.
- Evaporative cooling occurs when moisture is added to the air through evaporation, which forces the air temperature to cool to its wet-bulb temperature, or until it reaches saturation.

Further, we note that the very small rain drops are almost spherical in shape. As drops become larger, they become flattened on the bottom, like a hamburger bun. Very large rain drops are split into smaller ones by air resistance which makes them increasingly unstable. When water droplets fuse to create larger water droplets, it is called Coalescence. When water droplets freeze onto an ice crystal, which is known as the Bergeron process.Air resistance typically causes the water droplets in a cloud to remain stationary. When air turbulence occurs, water droplets collide, producing larger droplets. As these larger water droplets descend, coalescence continues, so that drops become heavy enough to overcome air resistance and fall as rain. Coalescence generally happens most often in clouds above freezing, and is also known as the warm rain process.

Convectional Rainfall

The convectional rainfall occurs due to the thermal convection currents caused due to the heating of ground due to insolation. The convectional rainfall is prevalent in equatorial regions. In these, the warm air rises up and expands then, reaches at a cooler layer and saturates, then condenses mainly in the form of cumulus or cumulonimbus clouds. In the equatorial regions, the precipitation due to convectional rainfall occurs in the afternoon. The rainfall is of very short duration but in the form of heavy showers.

Cyclonic / Frontal Rainfall

Frontal rainfall occurs due to the upward movement of the air caused by the convergence of different air masses with different temperatures. The warm air rises over the cold air and cyclonic rain occurs. The cold air pushes up the warm air and sky gets clear again.

Orographic Rainfall

The orographic rainfall occurs due to the ascent of air forced by the mountain barrier. The mountain barrier should be across the wind direction. So that the moist air is forced in obstruction to move upward and get cooled. In Rajasthan, the Aravalli is not an obstructing barrier to the highly moist air coming from

Arabian Sea and that is why they don't play very important role in rainfalls. Thus they produce a Rain shadow area. A rain shadow is a dry area on the lee side of a mountainous area. The mountains block the passage of rain-producing weather systems, casting a "shadow" of dryness behind them. In south India, the Mangalore is located on the western windward slope and gets 2000 mm of rainfall. But Bangalore is in rain shadow area and that is why receives less than 500 mm of rainfall.

Please note that the amount of the rainfall increases with increasing height of the barrier such as mountain, but this is up to a certain limit. After that there is a marked decrease due to lesser moisture content of the air and this phenomenon is called "Inversion of Rainfall"

Distribution of Rainfall

The regions having high temperature and abundance of water receive higher amount of rainfall, such as equatorial regions. In the subtropical regions, the western parts receive lesser rainfalls. This is due to anticyclone activities. Mean annual rainfall for earth is 970mm. The equatorial regions receive rainfall through out the year while the other regions receive rainfall seasonally. The Mediterranean region receives rainfall during the winter generally.

Air Mass & Fronts

Air mass is a volume of air defined by its temperature and water vapour content. An air mass may be of many hundreds or thousands of square miles, and adopt the characteristics of the surface below them. An air mass can be so extensive that it may cover the large portion of a continent below it and may be vertically so thick that may cover the troposphere. The vertical distribution of the temperature in an air mass and moisture content of the air are the two properties of air air mass which control the weather conditions of an area under that particular air mass. The air mass is considered to be cold air mass if its temperature is lower than the underlying surface, while an air mass is terms warm air mass when its temperature is higher than the underlying surface. The boundary between the two air masses is called the front.

Air masses are classified according to latitude and their continental or maritime source regions. Colder air masses are termed polar or arctic, while warmer air masses are deemed tropical. Continental and superior air masses are dry while maritime and monsoon air masses are moist. Weather fronts separate air masses with different density (temperature and/or moisture] characteristics. Once an air mass moves away from its source region, underlying vegetation and water bodies can quickly modify its character.

Frontogenesis and Frontolysis

The boundary between the two air masses is called the front. A temperature difference is essential in the definition of a front because it implies a density difference. The air masses of different densities don't mix readily and tend to retain their identity as far as we care for the moisture. The front represents a transition zone between two air masses of different density. Generally, an air mass from one region moves to the other region which is occupied by some other air mass. When a warmer and lighter air mass moved against a cold and denser air mass, the former rides over the other and it is called warm front. If the cold air mass forces its way under a warm air mass, it is called cold front. When new fronts are created or old fronts are regenerated, it is called Frontogenesis. Please note that fronts don't appear all of a sudden. They appear only after a process of Frontogenesis which is there in place for quite some time. When winds converge towards a point it would lead to Frontogenesis. Frontogenesis takes place only when two conditions are met. First, two air masses of different densities must exist adjacent to one another; and second, a prevailing wind field must exist to bring them together. There are three basic situations, which are conducive to Frontogenesis and satisfy the two basic requirements. The wind flow is cross isothermal and flowing from cold air to warmer air. The flow must be cross isothermal, resulting in a concentration of isotherms (increased temperature gradient]. The flow does not have to be perpendicular; however, the more perpendicular the cross isothermal flow, the greater the intensity of Frontogenesis.

On the other hand, the dying of a front is called Frontolysis. Frontolysis also does not happen all of a sudden. The process of Frontolysis must happen for quite some time to destroy the existingfront.

Types of Fronts

Cold Front

When a cold air invades the warm air, it remains at the ground and forcibly uplifts the warmer and lighter air mass. This is known as Cold front. This upward motion causes lowered pressure along the cold front and can cause the formation of a narrow line of showers and thunderstorms when enough moisture is present. Cold fronts can move up to twice as fast as warm fronts and can produce sharper changes in weather. Since cold air is denser than warm air, it rapidly replaces the warm air preceding the boundary. Cold fronts are usually associated with low-pressure areas. Cold front usually causes a shift of wind from southeast to northwest, and in the southern hemisphere a shift from northeast to southwest.

Warm front

When a warmer and lighter air mass moved against a cold and denser air mass, the former rides over the other and it is called warm front. Being lighter, the warm air mass is unable to displace the cooler air mass and instead is forced upward along the upper boundary of the colder air in a process known as overrunning. The boundary between the two air masses has a gradual slope of 130 and lifting is slow but persistent. As the air mass rises into regions oflower pressure, it expands and cools. As it cools, water vapour condenses and forms extensive cloud coverage. The first clouds to form along the sloping surface of the cold air are high cirrus, which thicken to cirrostratus and altostratus.

Occluded front

An occluded front is a front that is formed when a cold front overtakes a warm front. The cold front moves rapidly than the warm front. Ultimately, the cold front overtakes the warm front and completely displaces the warm air at the ground.