Lecture Number	**6**
Lecture Title	**PRECIPITATION**

Lecture Items

Lecture 6 – PRECIPITATION

6.1 PRECIPITATION PROCESSES

- As we all know, cloudy weather does not necessarily mean that it will rain or snow
- In fact, clouds may form, linger for many days, and never produce precipitation
- How, then, do cloud droplets grow large enough to produce rain? And why do some clouds produce rain, but not others?
- In figure (**6.1**), below we can see that an ordinary cloud droplet is extremely small, having an average diameter of **0.02** millimeters (mm)
- Also, notice in figure **(6.1)**, that the diameter of a typical cloud droplet is **100** times smaller than a typical raindrop

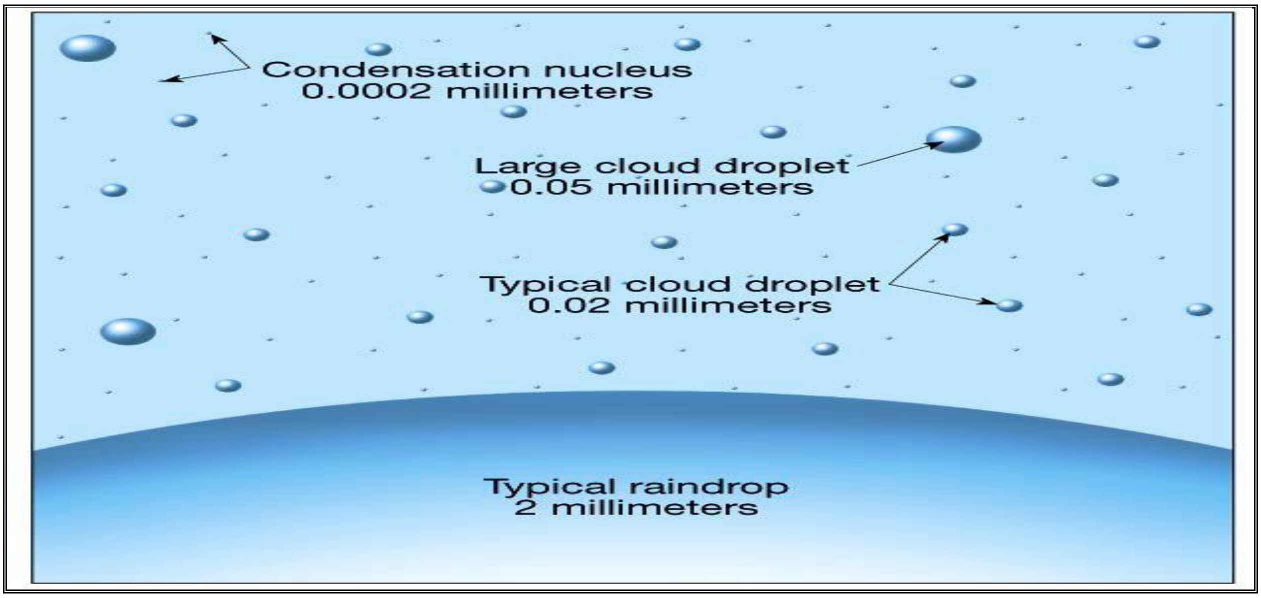

Fig. (6.1) : Relative sizes of raindrops, cloud droplets, and condensation nuclei

- Clouds, then, are composed of many small droplets—too small to fall as rain
- These minute droplets require only slight upward air currents to keep them suspended
- Those droplets that do fall, descend slowly and evaporate in the drier air beneath the cloud
- In Lecture **5**, we learned that condensation begins on tiny particles called *condensation nuclei*
- The growth of cloud droplets by condensation is slow and, even under ideal conditions, it would take several days for this process alone to create a raindrop
- It is evident, then, that the condensation process by itself is entirely too slow to produce rain
- Yet, observations show that clouds can develop and begin to produce rain in less than an hour
- Since, there must be some other process by which cloud droplets grow large and heavy enough to fall as precipitation
- Two important processes stand out:

(**1**) The collision-coalescence process

(**2**) The ice-crystal (or Bergeron) process

6.2 FORMATION OF PRECIPITATION

- Growth of a cloud droplet into precipitation is accomplished through two main ways, depending on the temperature of the clouds, as the following :

6.2.1 WARM CLOUD PROCESS

- Also called the *collision-coalescence* process
- In clouds at temperatures above freezing, collisions between droplets can play a significant role in producing precipitation
- For the collision-coalescence process to work, at least a few cloud droplets must be as large as **20** microns (**0.02** mm) as shown in figure (**6.2**)

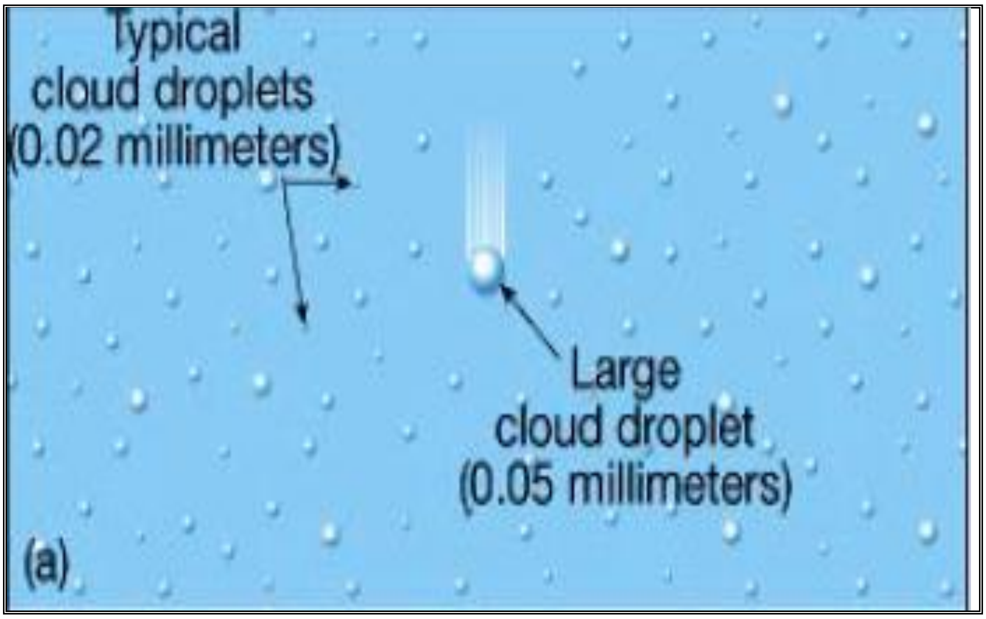

Fig. (6.2) : Formation of precipitation in warm cloud – step 1

- These larger drops fall and collide with smaller droplets
- Some of the smaller droplets will just bounce off, but some will stick, or *coalesce* as shown in figure (**6**.**3**)

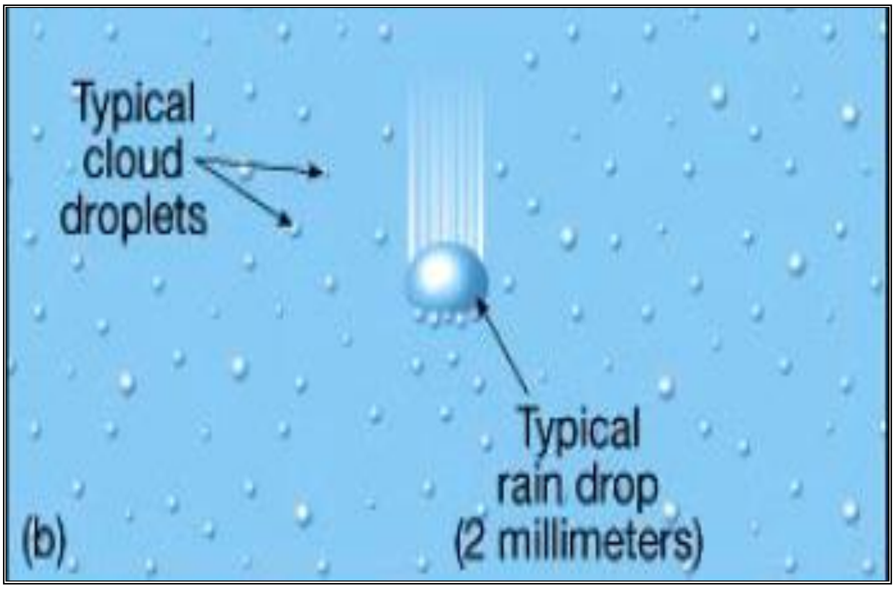

Fig.(6.3) : Formation of precipitation in warm cloud – step 2

- The drop continues to grow through collisions
- As it reaches a size of greater than **4** mm, it becomes unstable and breaks apart into smaller droplets
- These smaller droplets can continue the process of collision with even smaller droplets, and can continue growing as shown in figure (**6.4**)

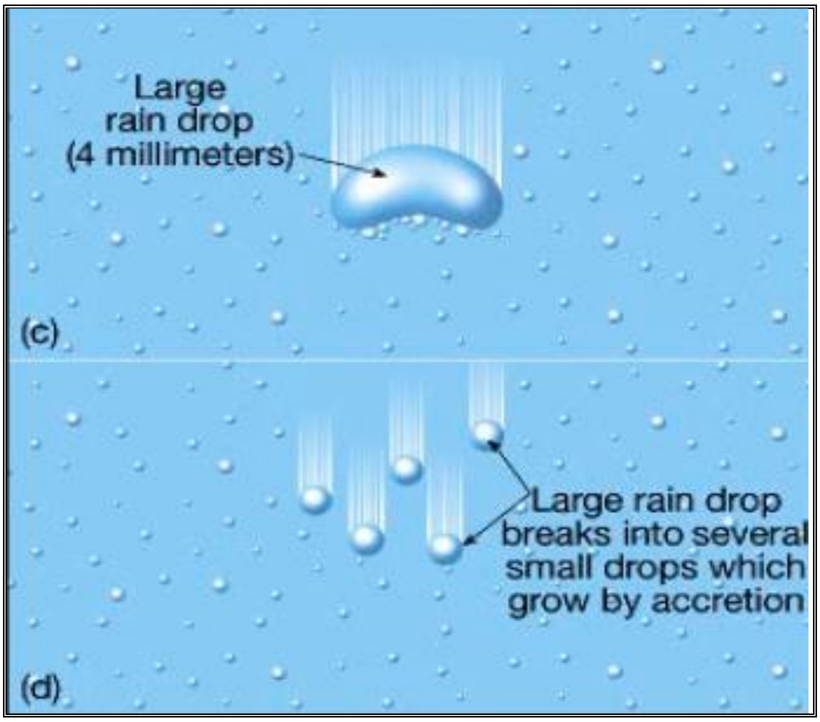

Fig. (6.4) : Formation of precipitation in warm cloud – steps 3 and 4

- An important factor influencing cloud droplet growth by the collision process is the amount of time the droplet spends in the cloud
- Since rising air currents slow the rate at which droplets fall, a thick cloud with strong updrafts will maximize the time cloud droplets spend in a cloud and, hence, the size to which they grow
- The collision-coalescence process is the main means of precipitation formation in the Tropical region, as well as in stratus clouds

6.2.2 COLD CLOUD PROCESS

- Also called the *Bergeron* process
- Process of rain formation proposes that both ice crystals and liquid cloud droplets must co-exist in clouds at temperatures below freezing as shown in figure (**6.5**)
- Such clouds are called *cold clouds*

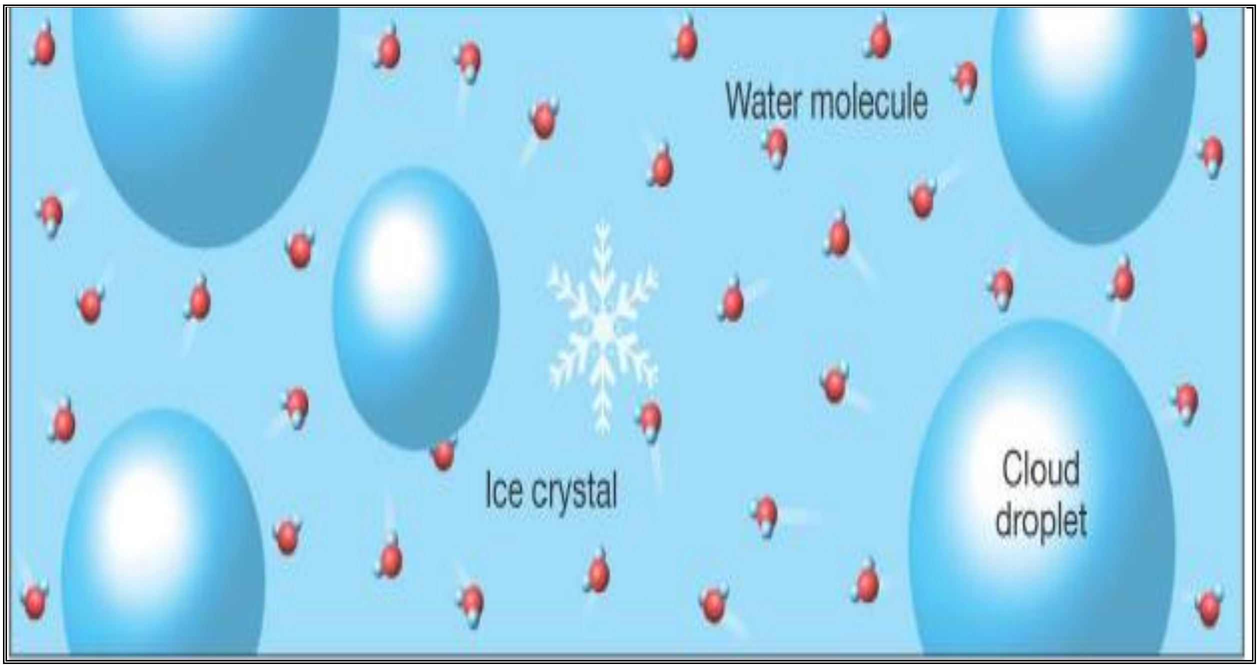

Fig. (6.5) : Formation of precipitation in cold cloud – step 1

- Liquid water exists in the atmosphere at temperatures as low as **–40**°C
- Freezing doesn't occur unless there are *freezing nuclei* present
- Freezing nuclei are not very abundant
- The saturation vapor pressure over ice is less than that over liquid water
- Once ice forms in the presence of *supercooled* liquid water, the ice crystals will grow at the expense of the cloud droplets as shown in figure (**6.6**)

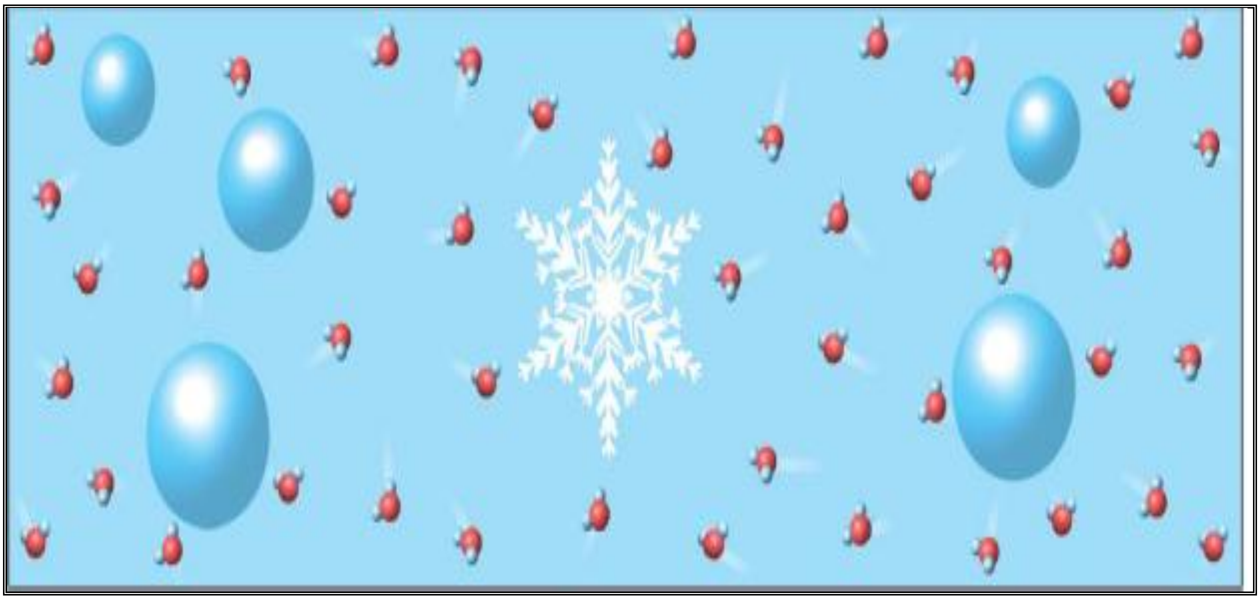

Fig. (6.6) : Formation of precipitation in cold cloud – step 2

- The ice crystals continue to grow until they are heavy enough to fall to the ground as shown in figure (**6.7**)

Fig. (6.7) : Formation of precipitation in cold cloud – step 3

- If the temperature at the ground is near freezing, the snowflakes will reach the ground as snow
- If the temperature at the ground is above about **39** degrees **F**, the snowflakes will have melted to form rain
- The Bergeron process is the primary mechanism for forming precipitation is extremely important in middle and high latitudes, where clouds are able to extend upwards into regions where air temperatures are below freezing

6.3 TYPES OF PRECIPITATION

- Up to now, we have seen how cloud droplets are able to grow large enough to fall to the ground as rain or snow
- While falling, raindrops and snowflakes may be altered by atmospheric conditions encountered beneath the cloud and transformed into other forms of precipitation that can profoundly influence our environment

6.3.1 Mist

- **Approximate size** : **0.005** to **0.05** mm
- **State of water** : Liquid
- **Description** : Droplets large enough to be felt on the face when air is moving **1** m/s , associated with stratus clouds

6.3.2 Drizzle

- **Approximate size** : Less than **0.5** mm
- **State of water** : Liquid
- **Description** : Small uniform drops that fall from stratus clouds ,generally for several hours

6.3.3 Rain

- **Approximate size** : **0.5** mm to **5** mm
- **State of water** : Liquid
- **Description** : Generally produced by nimbostratus or cumulonimbus clouds. When heavy ,size can be highly variable from one place to another

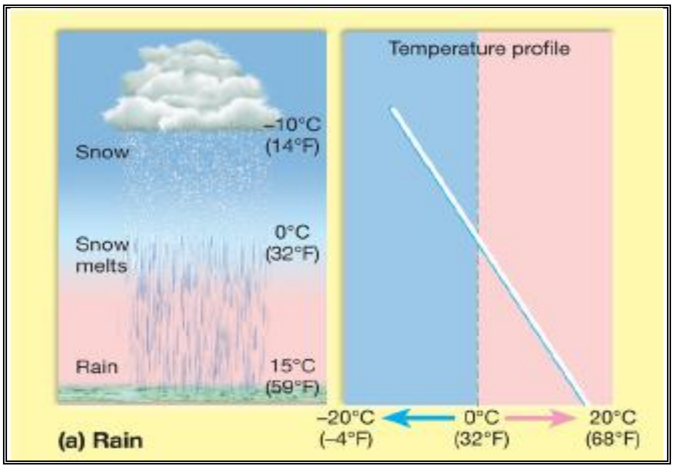

Fig. (6.8) : Rain

6.3.4 Sleet

- **Approximate size** : **0.5** mm to **5** mm
- **State of water** : Solid
- **Description** : Small ,spherical to lumpy ice particles that form when rain drops freeze while falling through a layer of subfreezing air

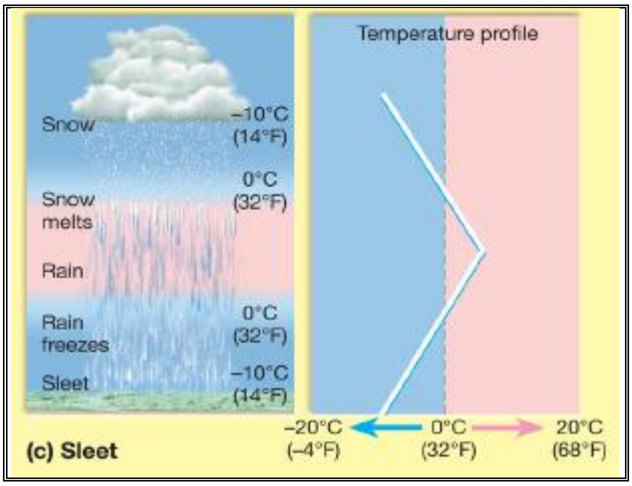

Fig. (6.9) : Sleet

6.3.5 Glaze

- **Approximate size** : Layers **1** mm to **2** cm
- **State of water** : Solid
- **Description** : Produced when super cooled raindrops freeze contact with solid objects

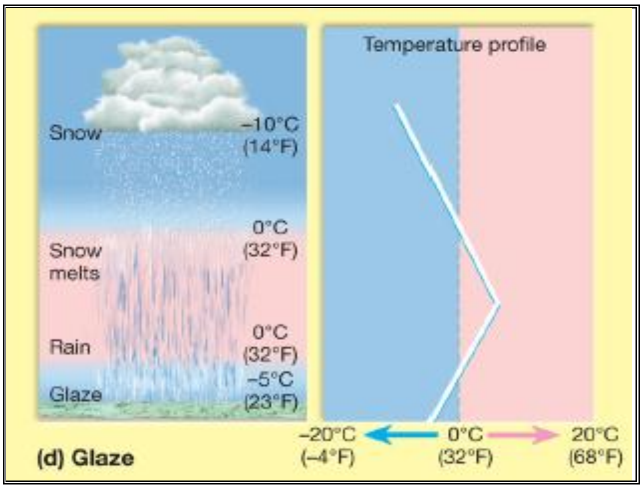

Fig. (6.10) : Glaze

6.3.6 Snow

- **Approximate size** : **1** mm to **2** cm
- **State of water** : Solid
- **Description** : The crystalline nature of snow allows it to assume many shapes , including six sides crystals , plates and needles

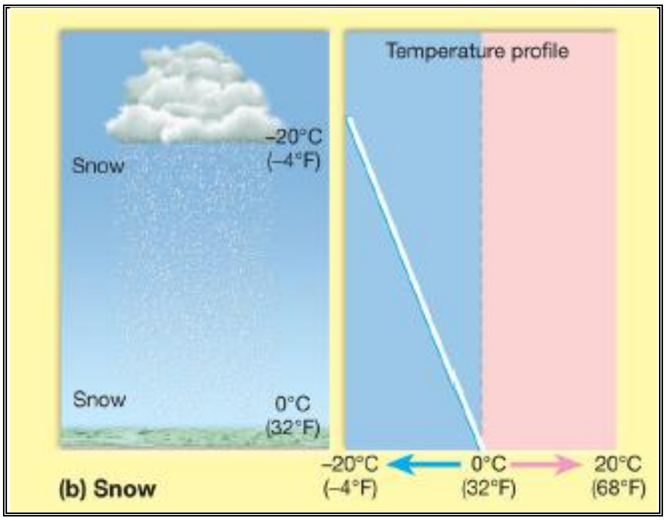

Fig.(6.11) : Snow

6.3.7 Hail

- **Approximate size** : **5** mm to **10** cm
- **State of water** : Solid
- **Description** : Precipitation in the form of hard rounded pellets or irregular lumps of ice , produced in large convective ,cumulonimbus clouds , where frozen ice particles and super cooled water coexist
- The summary of precipitation types illustrated in table (**6.1**)

Table (6.1) : The summary of precipitation types

•TABLE 7.5

Summary of Precipitation Types

PRECIPITATION TYPE	WEATHER SYMBOL	DESCRIPTION
Drizzle	,, (light)	Tiny water drops with diameters less than 0.5 mm that fall slowly, usually from a stratus cloud
Rain	•• (light)	Falling liquid drops that have diameters greater than 0.5 mm
Snow	✱✱ (light)	White (or translucent) ice crystals in complex hexagonal (six-sided) shapes that often join together to form snowflakes
Sleet (ice pellets)	△	Frozen raindrops that form as cold raindrops (or partially melted snowflakes) refreeze while falling through a relatively deep subfreezing layer
Freezing rain	∾ (light)	Supercooled raindrops that fall through a relatively shallow subfreezing layer and freeze upon contact with cold objects at the surface
Snow grains (granular snow)	≙	White or opaque particles of ice less than 1 mm in diameter that usually fall from stratus clouds, and are the solid equivalent of drizzle
Snow pellets (graupel)	◊ (light showers)	Brittle, soft white (or opaque), usually round particles of ice with diameters less than 5 mm that generally fall as showers from cumuliform clouds; they are softer and larger than snow grains
Hail	◆ (moderate or heavy showers)	Transparent or partially opaque ice particles in the shape of balls or irregular lumps that range in size from that of a pea to that of a softball; the largest form of precipitation. *Large hail* has a diameter of $\frac{3}{4}$ in. or greater; hail almost always is produced in a thunderstorm

6.4 RAINFALL RATE CLASSIFICATION

- Rainfall rate is measured in inches (or millimeters) per hour
- Rainfall rate is classified as :
  - **Trace** – less than **0.01** inches per hour
  - **Light** – between **0.01** and **0.1** inches per hour
  - **Moderate** – between **0.1** and **0.3** inches per hour
  - **Heavy** – greater than **0.3** inches per hour

6.5 WEATHER MODIFICATION

- Attempts have been made to "seed" cold clouds with dry ice or silver iodide crystals in order to enhance the Bergeron process
- This is done to either enhance precipitation, or to disperse fog
- It can be somewhat successful on a small scale (such as trying to clear fog at an airport)
- Warm clouds are seeded with salt particles in an effort to get a few large drops to form to initiate the collision-coalescence process