PRECIPTIATION

I. Any liquid or solid that falls from a cloud and reaches the ground is precipitation. If it fails to reach the ground it is called "virga"

II Cloud types:

(a) warm clouds (not part is below freezing)

(b) cold clouds (temperature ranges from above freezing to well below freezing

III. Three sizes of material to form precipitation

(a) condensation nuclei (0.2 μm)

(b) Cloud droplets (20 μm)

(c) raindrops (2000 μm)

IV. Water does not usually condense on itself but needs a condensation nucleus. Without that, RH needs to be more than100%

V. Some condensation nuclei are hygroscopic. For water to condense on these requires a much lower RH (about 78%). If something like salt the bonding is very tight and hard for water to evaporate.

VI. More condensation nuclei appear over the land than water, but the nuclei over the water are larger. Nuclei are very small and it is difficult for any of them to acquire enough water through condensation to fall.

VII Collision-coalescence and the Bergeron (ice crustal) processes are the ones that work over the idea of condensation.

1. Collision-coalescence (warm clouds) – different size particles collide and coalesce into large drops which fall faster than small ones and "collide and coalesce" into ever larger drops.

2. In clouds that are not very thick, the drop does not grow much and if the air below is most, it might reach the ground as drizzle. If the air is dry (or the cloud is very high), the drop would evaporate.

3. In clouds which have greater height, there are strong updrafts keeping the droplet in the cloud for a longer time (moving it up where is gathers enough water to be heavy enough to fall despite the updraft)

4. critical elements are
    a. sufficient liquid water content
    b. the range of droplet size
    c. the updrafts in the cloud
    d. possibly, the electrical charge of the droplet and the electrical field in the cloud

VIII The Ice Crystal or Bergeron Process. (COLD CLOUDS). Important at mid and higher latitude regions

1. In much of the middle of the cloud where the temperature is -20^0C or so, ice crystals and water exists simultaneously. (Very small amounts of water require colder temperatures to freeze)

2. ice crystals require "ice nuclei" to form. These may be clay minerals, ice crystals themselves and even bacteria

3. water vapor may become ice crystals directly by sublimation in which case the nuclei are called sublimation nuclei; or super cooled water droplets collide with freezing nuclei and freeze

4. There is a difference in the saturation pressure between water and ice and it is harder for water molecules to break free of the lattice structure of ice. Hence water droplets lose their escaping molecules to the ice crystal molecules. Ice crystals grow at the expense of the water droplet.

5. There is a growth of the ice crystal and it becomes too heavy to remain aloft and falls. It collides with super cooled liquid on the way down which freezes onto it. This is "accretion" and the icy matter is called "graupel". As the ice crystals fall they sometimes collide and shatter with each piece becoming a new "ice nucleus" or they may stick together and become an aggregate. The end of all this is a snowflake.

6. On the ground, if it is below freezing, may cause super-cooled fog or cloud droplets to freeze and become "rime"

7. Some terms to remember

1. Condensation nuclei = 0.2 μm (more over the land than ocean)
2. Cloud Droplet = about 20 μm
3. Typical Raindrop = about 2000 μm
4. Collisions/coalescence = collisions between cloud droplets makes bigger droplets
5. Ice nuclei: needed to commence the freezing process at sub 0 temperatures
6. Deposition nuclei: nuclei that allow water vapor to deposit on their surfaces
7. Freezing nuclei: promote freezing of super cooled droplets by way of a liquid phase
8. Accretion: Ice crystals collide with supercool droplets – forms graupel
9. Aggregation: ice crystals collide and stick together – results in snowflake
10. Rime: the deposit of ice crystals formed by the freezing of supercooled fog or cloud droplets on objects whose surface temperature is below freezing. This can happen on trees, like pine where the needles act as freezing nuclei

7. Kinds of precipitation
    1. rain
        a. tropics falls from cloud as rain because cloud is above freezing
        b. Middle and higher latitudes Bergeron process is involved
        c. rain in clouds (usually cumuliforms) may be held by updraft and grow, When that ends or lessens it falls with large drops. Heavy=cloudburst
        d. long time rain usually from nimbostratus
        e. air seems clearer after rain because pollutants removed or combined with the rain. May lead to "acid rain"
    2. Snow;
        a. Snow results from the growth of ice crystals through deposition, riming, and aggregation. They have a number of shapes which are dependent on the temperatures at which they formed.

        b. Snowflakes that fall through moist air (slightly above freezing) slowly melt as they fall and a thin layer of water forms on the edge which causes other

snowflakes to adhere to it. Several flakes make a giant snowflake – several inches or more in diameter. These large soggy flakes are connected to moist air and temperatures near freezing. If they fall through cold air with little moisture they are small and powdery dry snow.

c. Most snowflakes have the *dendrite shape* we associate with flakes because most snow forms at the temperature that produces that shape.

d. Snow that falls from developing cumulus clouds in light showers that fall sporadically and don't last long – usually with little or no accumulation falls in "flurries". If it is somewhat more intense the term used is a "snow squall" These are like showers of rain that fall from cummuliform clouds, whereas more continuous steady snow lasting for hours (like continuous rain) falls from stratus clouds like nimbostratus and altostratus

e. A strong wind at the surface can pick up snow and deposit it in drifts. This is often accompanied by "blowing snow" which is lifted from the surface and blown about in such great amount that visibility becomes restricted. If this continues AFTER the snow has stopped falling it is called a "ground blizzard". An actual :"blizzard" is characterized by low temperatures, winds in excess of 30 knots carrying large amounts of fine dry powdery snow which can reduce visibility dramatically

3. Sleet and freezing rain

a. If a snowflake falls into warmer air it begins to melt. If the partially melted snowflake or cold cloud drop then falls through sub freezing air and turns into ice it is called sleet. These are translucent or transparent pellets with diameters of 5mm (0.2 inches) or less.

b. If the cold freezing layer is too narrow to give the water time to freeze, the precipitation may be rain which freezes almost immediately on contact with the ground. This is called freezing rain or "glaze" If the drops are smaller it is called freezing drizzle. This can happen on bridges and overpasses that have cooled to or below freezing before the surrounding area because they are elevated off the land. This produces aa sheet of ice that appears relatively dark called "BLACK ICE".

c. Freezing rain can cover everything with a coat of shiny ice which appears sort of glittery and silvery. It weighs a great deal and can often cause severe damage to power lines, tree branches and the like which cannot sustain the weight and break and fall. If there is considerable piling up of the freezing rain it is called an ICE STORM

4. Hail

a. forms in cumulonimbus clouds – usually in intense thunderstorms. Graupel, or large frozen raindrops or any particles (including insects remember) form "embryos" by accumulating supercooled liquid droplets (accretion) (REMEMBER 1,000,000 cloud droplets are needed to form a single raindrop, but about 10 billion cloud droplets to form a golf ball size hailstone) It must remain in the cloud for at least 5-10 minutes to attain this size. Within these clouds there are violent updrafts that take the small ice particles far up above the freezing level where they grow by colliding with supercooled liquid droplets. In severe thunderstorms called "SUPERCELLS", these ice particles can even be swept horizontally through the cloud. Horizontal movement appears to be the best route for hailstone growth. The strong updrafts keep them rising slowly higher as they continue to grow. When they are moved away from the updraft, or reach a size large enough to overcome the updraft

they fall from the cloud. Usually they melt in the warmer air below, but in the late spring and summer, when the violent thunderstorms form, the hailstone reach sufficient size to survive the journey to the ground as ice.

b. On its journey through the cloud it may pass through areas where the liquid content of the air is relatively low. Supercooled droplets freeze immediately on the hailstone and create a coat of white or opaque rime ice which has lots of bubbles in it. This is called the DRY GROWTH REGIME. If it gets swept into a region where the liquid content is high, supercooled droplets collect so rapidly on the stone that the latent heat that is released causes the surface of the stone to remain at freezing even though the surrounding air is much colder. The supercooled droplet under this WET GROWTH REGIME do not freeze on contact but spread a coat of water around the stone filling in the porous parts, and leaving a clear ice layer around the stone.