

Cloud Physics-Lecture 4

General characteristics of clouds

Warm vs. cold clouds – definition

- Warm cloud - $T > 0\text{ }^{\circ}\text{C}$ throughout the depth
- Cold cloud - $T < 0\text{ }^{\circ}\text{C}$ throughout the depth, or in a portion

Other general cloud properties

1. Horizontal and vertical dimensions
2. Microphysical properties
 - ✓ cloud liquid water content
 - ✓ cloud droplet size
 - ✓ Cloud droplet concentration
3. Kinematic properties
 - ✓ updraft/downdraft magnitude
 - ✓ turbulence
4. Temperature range from cloud base to top; temperature of cloud base

Weather Modification

Weather modification, commonly known as cloud seeding, is the application of scientific technology that can enhance a cloud's ability to produce precipitation.

Cloud seeding is increasingly being used for both rain enhancement and weather damage reduction.

Ground seeding - There are times when it's beneficial to seed from the ground. For example, ground seeding is an excellent option for the treatment of low-level clouds over complex terrain.

Aerial cloud seeding - is the process of delivering a seeding agent by aircraft - either at the cloud base or cloud top.

- Top seeding allows for direct injection of the seeding agent into the supercooled cloud top.
- Base seeding is the release of the seeding agent in the updraft of a cloud base.

In order to select a site for the cloud seeding experiments, it is necessary to have a clear idea of the background CCN distribution, and macrophysical and microphysical characteristics of clouds over climatically divergent regions of the country.

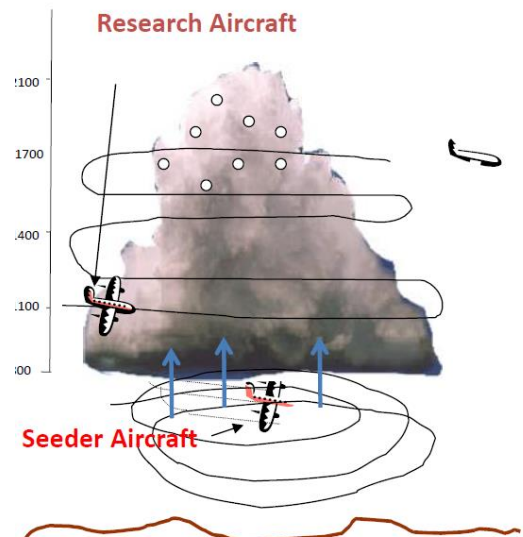
Types of Cloud seeding

Hygroscopic seeding

The term “hygroscopic seeding” has been associated with warm cloud seeding. The objective is to enhance rainfall by promoting the coalescence process using hygroscopic particles.

Hydroscopic particles (salt powders and hygroscopic flare-produced particles) are injected into a cloud to increase the concentration of “collector drops” that can grow into raindrops by collecting smaller droplets and enhancing the formation of raindrops.

- ✓ Seeder aircraft dispenses salt or pyrotechnic flared aerosol particles as seeding material at the cloud base.
- ✓ Aerosol particles transform to CCN.
- ✓ Water vapor condenses on to CCN to form cloud droplets.
- ✓ Droplets grow by accumulating more water vapor by diffusion.
- ✓ When droplet diameter exceeds the threshold value, collision and coalescence of droplets takes place, large droplets form and rain out



Glaciogenic seeding

This involves the injection of ice-producing materials into a supercooled cloud to stimulate precipitation by ice particle growth. The objective of glaciogenic seeding is to introduce seeding material that will produce the optimum concentration of ice crystals for precipitation formation.

Most cloud-seeding operations use **silver iodide (AgI)** in cold clouds.

Silver Iodide (AgI): used as a cloud-seeding agent because it has a crystalline structure similar to an ice crystal; it acts as an effective ice nucleus at $T = -4^{\circ}\text{C}$ and lower.

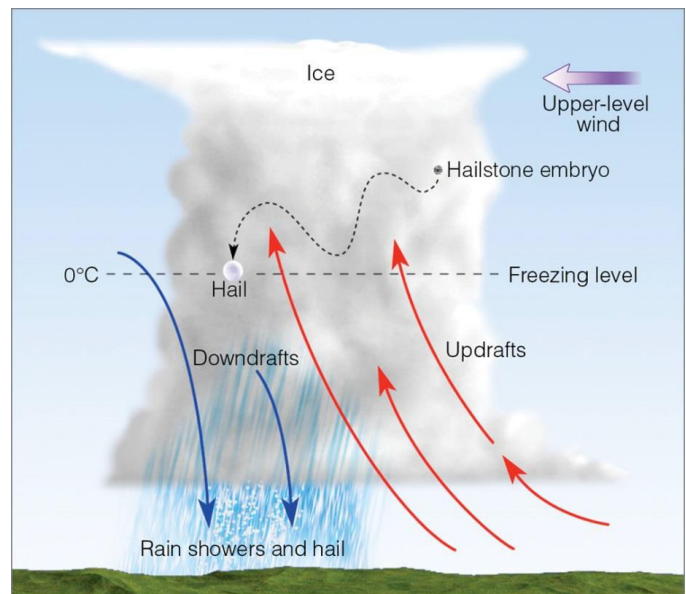
Theories of generation of hail in thunderstorm

In a mixed phase cloud, ice particles can increase in mass by colliding with super-cooled droplets that then freeze onto them. This process is referred as growth by **accretion**.

If the droplets freeze immediately on contact they form a coating of rime, leading to rimed crystals or graupel. If the freezing is not immediate, denser structures are created, of which hail is an extreme example. Hail represents an extreme case of the growth of ice particles. They form in vigorous convective clouds that have high liquid water contents.

Hail

- ✓ Hailstones are produced when either graupel or large frozen raindrops grow by accreting super-cooled cloud droplets. Strong updrafts are needed.
- ✓ A hailstone is a grain of ice, generally having a laminar structure and characterized by its smooth glazed surface and its translucent or milky white center.
- ✓ Hail is usually associated with those atmospheric conditions that accompany thunderstorms.
- ✓ Thunderstorms contain both graupel and large drops.



- Hail is precipitation in the form of large balls or lumps of ice
- Hailstones begin as small ice particles
- Hailstones grow by accretion of supercooled water droplets
- Dry growth occurs when the drops freeze on contact with little liquid water on the surface
- Wet growth occurs when the droplet don't freeze quickly and spread across the surface of the hailstone forming a film of liquid water on the surface

Ingredients for Hail Growth

In a basic sense, 3 Main “ingredients” are required:

1. Adequate updraft to keep hailstone aloft for an appropriate amount of time, -10 to -30C
2. Sufficient super cooled water near the hailstone to enable growth during transit through an updraft
3. A piece of ice or snow (embryo) for it to grow upon

Ordinary Single-Cell Thunderstorm

Life cycle has three distinct stages

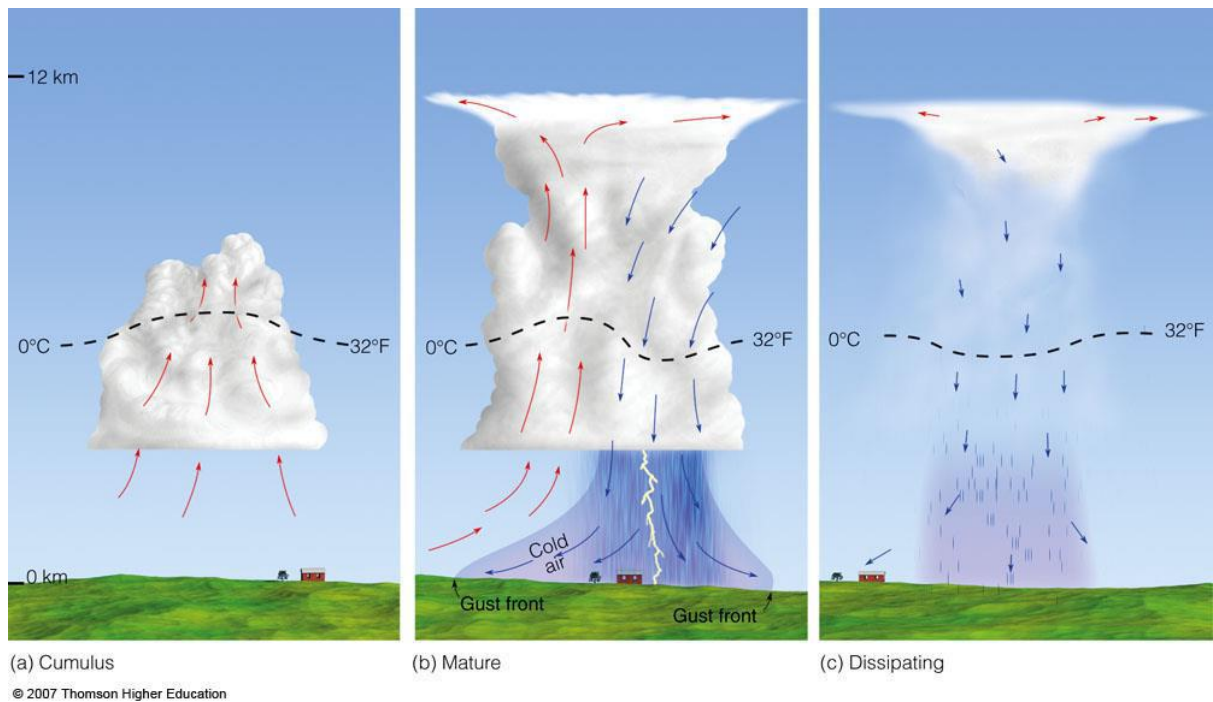
Cumulus stage—characterized by an updraft throughout most of the cell.

Mature stage —characterized by the presence of downdrafts and updrafts

Time of most lightning, rain, small hail

Dissipating stage — updraft weakens, downdraft dominates

Life cycle of an ordinary thunderstorm



Multicell Thunderstorms

Composed of several individual single-cell storms, each one at a different stage of development

- ✓ Can last several hours
- ✓ A moderate amount of vertical wind shear
 - Updraft and downdraft can coexist
 - Updraft and downdraft meet at the gust front
- ✓ Groups of multicell thunderstorms are called **mesoscale convective systems (MCS)**

Severe Thunderstorms

In a multicell storm, if convection is strong and updrafts are intense, the storm can become severe. Updrafts in severe thunderstorms can cause the cloud to reach into the stratosphere and in some cases extend up to 60,000 ft. Strong updrafts can keep hailstones suspended in the cloud long enough for them to grow to considerable size. Once they become large enough they either fall out of the cloud within a downdraft or a strong updraft may toss them out the side. Aircraft have encountered hail in clear air several kilometres away from a storm.

