

Precipitation

It's raining, it's pouring...

1

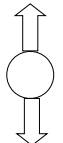
Ch. 7: Precipitation

- Terminal Velocity
- Condensation Growth
 - Cloud Droplets
 - Ice Crystal Process (WBF)
- Collision Growth
 - Collision/Coalescence, Accretion, Aggregation
- Precipitation Types
- Precipitation Modification
- Measurement

2

Terminal Velocity

Air Drag



Gravity

Drag force \propto Speed

Falling object increases speed until:

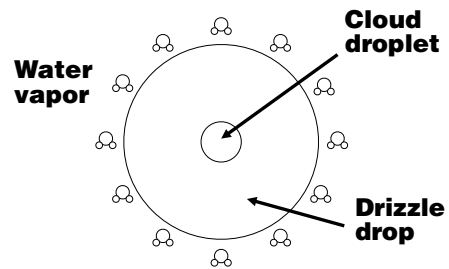
Drag force = Gravitational force

⇒ Steady-state fall

⇒ Fallspeed = Terminal velocity

3

Condensation Growth of Droplets



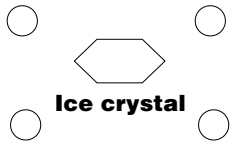
100x increase in diameter → 10⁶x increase in volume to grow up to drizzle drop size

4

Condensation Growth of Ice Crystals

“Bergeron Process”

Supercooled droplets



$$e_{\text{sat},i} < e_{\text{sat},w}$$

$$T < 0^{\circ}\text{C}$$

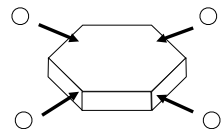
Supersaturated for crystals
Subsaturated for droplets

5

Condensation Growth of Ice Crystals

“Bergeron Process”

Water transfers from droplets to crystal



$$e_{\text{sat},i} < e_{\text{sat},w}$$

$$T < 0^{\circ}\text{C}$$

Droplets evaporate
Crystals grow

6

Collision/Coalescence Growth of Raindrops



**Faster growth than
condensation!**

- **Conditions favoring growth of large raindrops:**
 - ➔ **Wide range of drop sizes**
 - ➔ **Strong updraft in cloud**
 - ➔ **Large cloud depth**
 - ➔ **Electrified cloud**

7

Other Collisional Growth Processes

**Accretion: ice crystal
vs. supercooled cloud
droplet**



**Aggregation: ice
crystal vs. ice crystal**

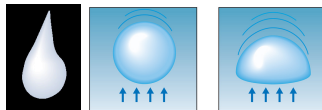


8

Types of Precipitation

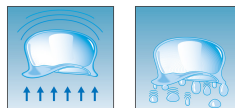
Rain
Snow
Sleet
Freezing Rain
Graupel Particles
Hailstones

Drop shape: not teardrop



**Showers: intermittent,
spotty coverage**

**Rain: steady uniform
coverage**



9

Types of Precipitation

- Rain
- Snow
- Sleet
- Freezing Rain
- Graupel Particles
- Hailstones



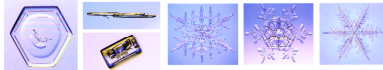
Virga: Rain or snow that evaporates before reaching the ground. Also called “fall streaks”

10

Types of Precipitation

- Rain
- Snow
- Sleet
- Freezing Rain
- Graupel Particles
- Hailstones

Snow crystals: single crystals (plate, column, dendrite)



Snowflakes: aggregates of snow crystals

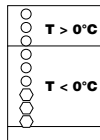
Most middle-latitude precipitation starts out as snow, then melts to rain

11

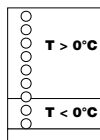
Types of Precipitation

- Rain
- Snow
- Sleet
- Freezing Rain
- Graupel Particles
- Hailstones

Sleet: “Ice Pellets”; frozen raindrops (deep freezing layer)



Freezing Rain: raindrops freeze after reaching ground (shallow freezing layer)

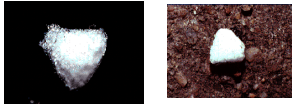


12

Types of Precipitation

Rain
 Snow
 Sleet
 Freezing Rain
 Graupel Particles
 Hailstones

Graupel ≡ “Kernel”
Formed from ice particle accreting supercooled droplets in cloud
Soft and porous texture
Also known as “snow pellet”



13

Types of Precipitation

Rain
 Snow
 Sleet
 Freezing Rain
 Graupel Particles
 Hailstones

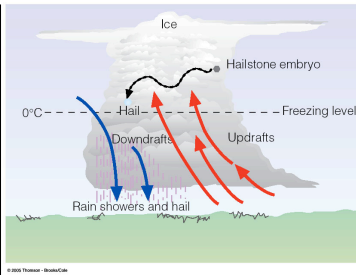
Larger than graupel — falls faster, collects supercooled drops faster
“Wet growth” forms solid ice; causes rock-like damage



14

Types of Precipitation

Rain
 Snow
 Sleet
 Freezing Rain
 Graupel Particles
 Hailstones



15

Precipitation Enhancement

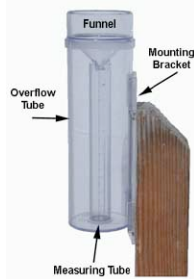
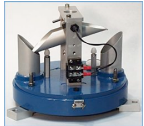
- **Increase number of precipitation particles to get more rainfall**
 - **Cloud seeding with an ice-forming nucleant, usually silver iodide (AgI)**
 - **Overseeding may inhibit precipitation formation —too many particles competing for limited water supply**



16

Precipitation Measurement

- **Rain Gauge**
 - **Gets accumulated rain or snowfall**
- **Recording Gauges**
 - **Tipping Bucket**
 - **Weighing-type**



17