Precipitation - Chapter 8

- A typical rain drop - 2000 μm diameter
  - typical cloud droplet - 20 μm
  - typical condensation nucleus - 0.2 μm
- How do rain drops grow?

Growing a Cloud Droplet

- Droplet formation often starts when the air is less than 100% humid, because good condensation nuclei are **hygroscopic**
- A growing droplet reduces the humidity of the surrounding air, particularly as it gets larger
  - this slows growth
  - many small droplets form in air rich in nuclei
- Drops falling into warmer less humid air shrink by evaporation

Clouds over the Gobi desert

A Matter of Scale

- Volume of a sphere $\propto$ radius^3
  - radius of raindrop = 100 × radius of cloud droplet
  - therefore volume of raindrop = 10^6 volume of cloud drop
- Most clouds don't produce rain because the process of condensation of water onto drops is too slow to build big drops

Garden flooding in St Fillans

Growing a Rain Drop

Rainbow over Findon Moss

- In a cloud, raindrops form from cloud droplets by **collision and coalescence**
- Drops fall at their **terminal velocity** [p. 185/192/166]
  - faster falling, larger drops overtake small drops
  - updrafts within clouds help coalescence

Diam μm	*Terminal velocity ms^{-1}*
20	0.01
100	0.27
200	0.70
1000	4.0

Rain

Exploring in the rain

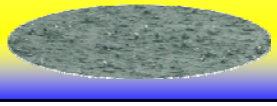
- The most important factor in producing raindrops is a cloud's moisture content

Rain and virga offshore at Findon

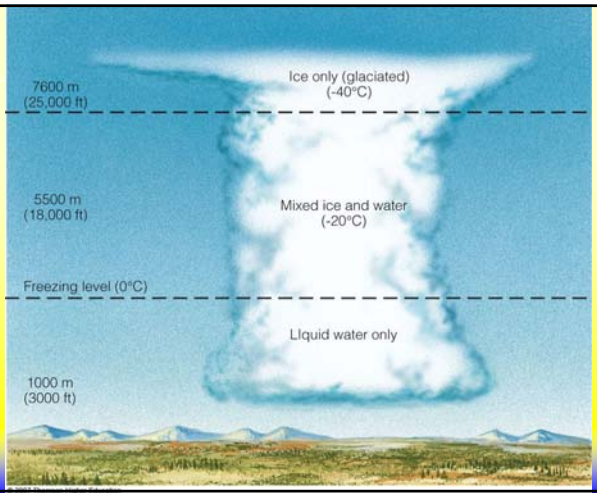
- Other factors: [p 185/193/167]
  - range of droplet sizes
  - cloud thickness
  - updrafts within the cloud
  - electric charge on the droplets induced in cloud's electric field

Drizzle, normal rain, heavy rain

- The kind of the rain is determined by raindrop size
  - ~0.4 mm to 4 mm
- Heavy rain falls from thicker clouds



Loch Aline



Ice Crystal Clouds

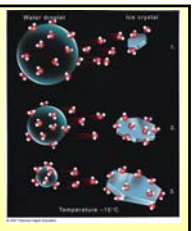
- High clouds consist of ice crystals at least as cold as -40°C [fig. 8.6/8.6/7.6, previous slide]

Anvils over the sea at Findon

- At higher temperatures (lower down), clouds contain mixed ice crystals and water droplets
  - at -10°C, typically water droplets are one million times more common than ice crystals
  - water droplets are **supercooled**
  - embryonic ice crystals easily disintegrate

Water clouds and ice cloud

Growing Ice Crystals



- Ice crystals need **ice nuclei** to grow on
  - ice nuclei can be suitable minerals or existing ice crystals
  - higher in the cloud, ice crystals grow at the expense of water droplets, because of the lower vapour pressure at the surface of ice crystals
  - ice crystals grown high up can become rain lower down
- Ice crystal shapes depend on the growth temperature
  - **dendrites** are the basis of large snow crystals

Ice-crystal shapes, after table 8.2

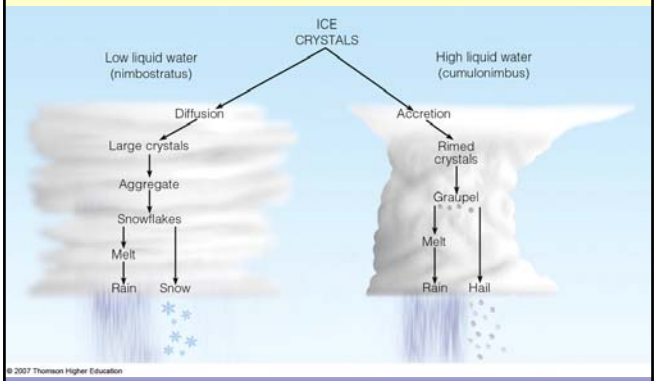
Temperature Range (°C)	Crystal form
0 → -4	thin plates
-4 → -10	columns
-10 → -12	plates
-12 → -16	dendrites
-16 → -22	plates
-22 → -50	hollow columns

Snow

Snow at the weekend in Findon

- Precipitation in clouds often forms as snow
  - common forms of ice crystal are hexagonal plates, hexagonal columns and dendrites [table 8.3/8.3/7.3]
  - different forms grow at different temperatures
    - dendrites grow quickly between -12°C and -16°C
- Most common fate of snow formed in clouds is to turn to rain before it reaches the ground
- Cu clouds produce snow flurries; Cb snow squalls and As and Ns more continuous snow

Generating precipitation



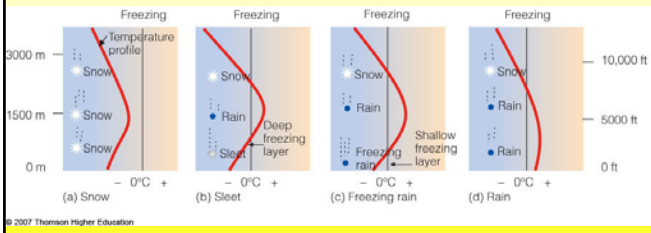
Courtesy: Thomson Higher Education

Sleet, Freezing Rain and Hail

- **Sleet** is formed by rain falling through a deep freezing layer of air [fig. 8.22/8.22/7.23, next slide]
- **Freezing rain** is caused by rain falling through a thin layer of cold air that supercools the rain below 0°C. The supercooled rain freezes on contact
- **Hail** is formed by frozen raindrops being swept in violent updrafts within cumulonimbus clouds. The hailstones grow rapidly as they rise and fall back

Hail on the car roof ↓

Effect of temperature profile



Courtesy: Thomson Higher Education

Measuring Precipitation

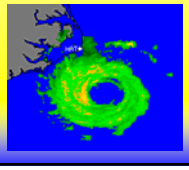
- Rainfall is measured in **millimetres**
  - other precipitation by how much rain it would form if melted
- Simple raingauge is a funnel of standard design that feeds into a measuring cylinder
- Common electronic gauges consist of a funnel that feeds either:
  - an electronic drop counter
  - a pair of tipping buckets on a rocker [p. 203/211/185]

Rainguages on Fraser Noble building

Rain Radar

- Radar pulses of 30 - 100 mm wavelength are scattered back by falling rain. By timing the returning pulses, the distance away of the rain can be measured and displayed
  - the strength of the returning signal gives an indication of the amount of precipitation

Rain radar showing a hurricane



Rain over The Netherlands

Effectiveness of Rain Radar

- Typical resolution of pictures is 2 km/pixel, with complete update every 5 minutes
  - a good 'now' casting tool, not such a good forecasting tool

- Detail finer than 'mesoscale' computer forecast, which is typically 12 km/cell and updated every 6 hours

High resolution rain radar at Chilbolton lab

Rain Radar Availability