3. Weather

3.2 - Effects of Weather on Performance

This presentation is provided as a reference to help you prepare for the your exam. It seeks to go beyond memorization and provide explanation and rationale.

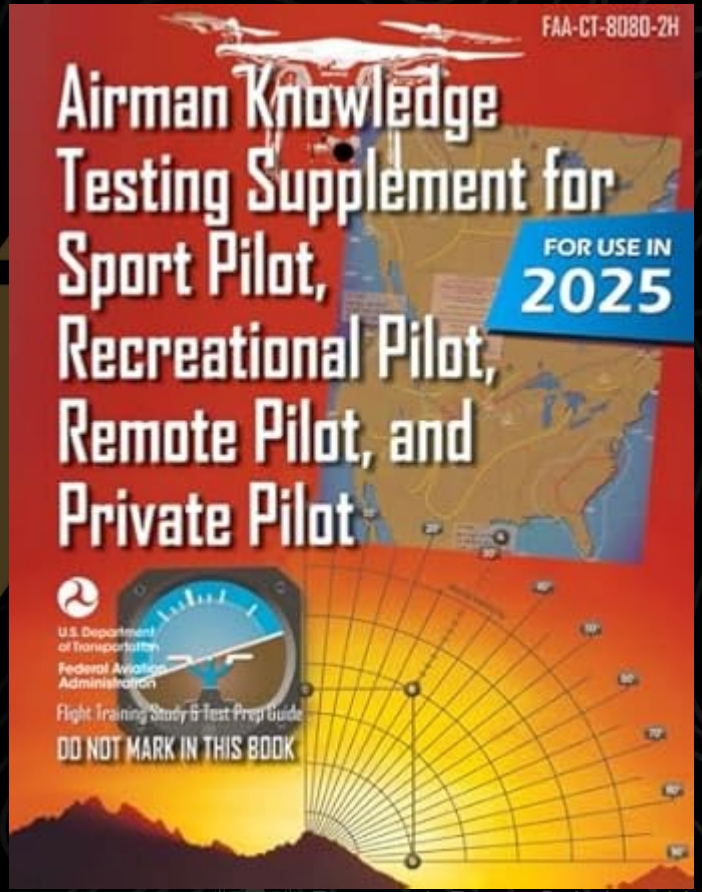
While this reference considers many of the points covered in the exam, given the bredth it is in no way exhaustive. It is suggested to consult a variety of resources when preparing for the exam.

Text that is marked in YELLOW has a high probability of being referenced directly in one of the exam's nearly 400 possible questions.

Take the quiz at the end to gauge your understanding.

slideshow and quiz reference images and concepts found in the “Airman Knowledge Testing Supplement”.

You can download the document from the FAA here. Alternatively, a hard copy can be purchased online for around $10.



3.2 - Why is Weather Important?

The PIC (Pilot in Command) is responsible for knowing and understanding the current and forecasted weather conditions prior to, and during, every sUAS flight.

*Despite the low altitudes that drones fly at weather (including visibility and clouds) can have a significant impact on flight performance.

3.2 - Why is Weather Important?

HEAT = WEATHER

3.2 - Wind & Currents

3.2 - Wind

Wind impacts sUAS **performance** and **maneuverability**.

Be aware that:

- Objects on the ground (buildings, trees, hills, etc.) can impact the flow of wind. Rapid changes in speed and direction can occur.

- High winds will make it difficult to maintain flight position and will result in more battery consumption.

3.2 - Wind

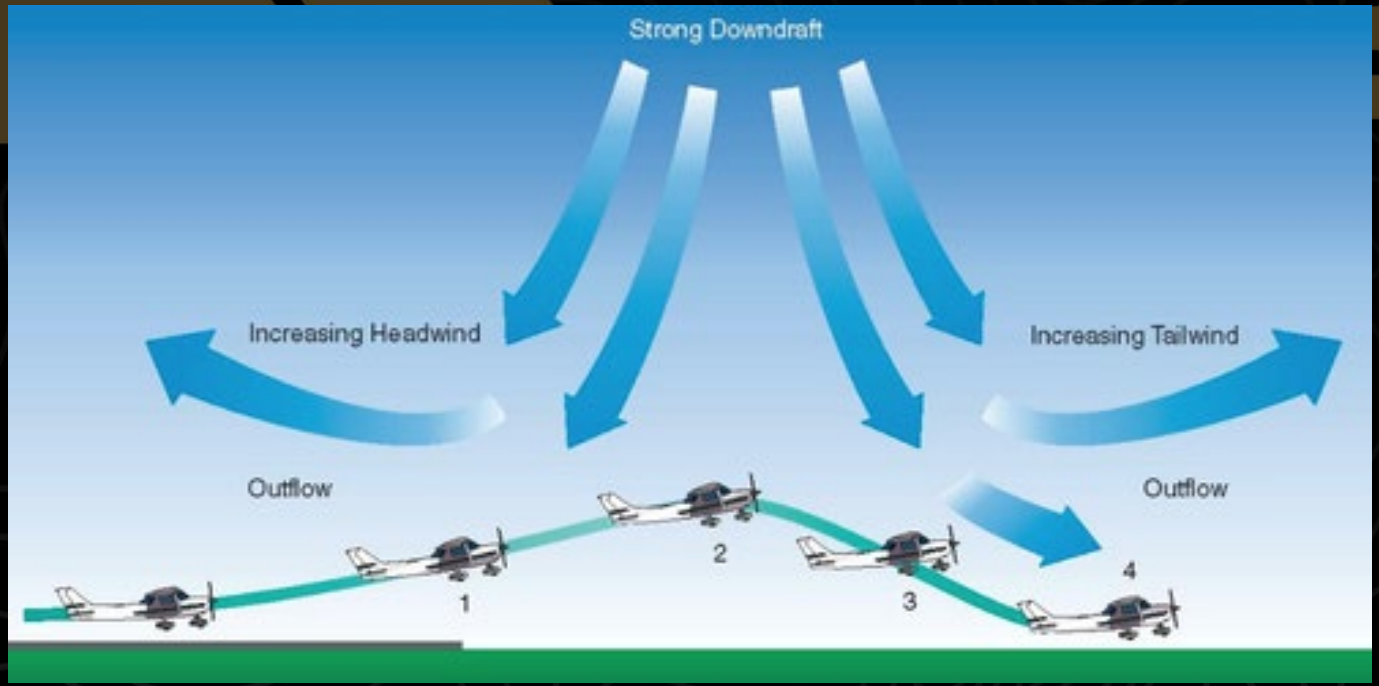
Wind Shear: A sudden and drastic change in wind speed and/or direction in a small area.

Wind shear can move a drone horizontally or vertically quickly and without warning.

Remember that: wind shears can occur at any altitude but they are particularly hazardous near the ground as a sudden downdraft can result in a crash.

3.2 - Wind

Wind Shear



Ascent Ground School

What is the difference between wind and wind shear?

What is the difference between wind and wind shear?

Wind is steady air movement; wind shear is a sudden change in speed or direction.

3.2 - Wind

Wind Speed: measures in knots (nautical mile per hour).

1 nautical mile is equal to 1.15 statute (land) mile

1kt = 1.15mph

3.2 - Wind

Wind Speed

Remember this rule of thumb:

> The max wind speed you are flying in should be no more than ⅔ the max airspeed of the sUAS in operation.

Q: If the Mavic 3 has a max airspeed of 33.6mph in normal mode what should the max wind speed be for flight?

3.2 - Wind

Wind Speed

Remember this rule of thumb:

> The max wind speed you are flying in should be no more than ⅔ the max airspeed of the sUAS in operation.

Q: If the Mavic 3 has a max airspeed of 33.6mph in normal mode what should the max wind speed be for flight?

A: 22.4mph

3.2 - Wind

Wind Direction

Wind directions are given in compass headings (with North as 0°).

Remember that: wind directions are reported as the **direction in which the wind is coming from**.

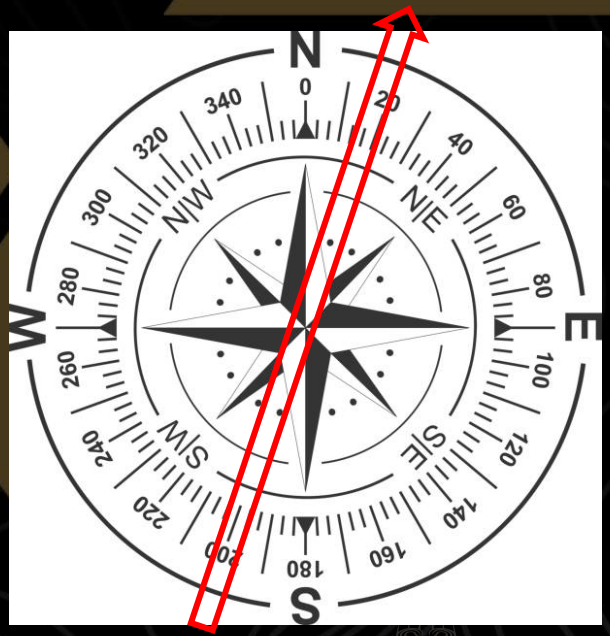
EXAMPLE: Wind direction 45° means that the wind is coming from the North East direction.

3.2 - Wind

Wind Direction

EXAMPLE 1: Wind direction 200° means that the wind is coming from the South West direction.

This is a “South Westerly” wind.

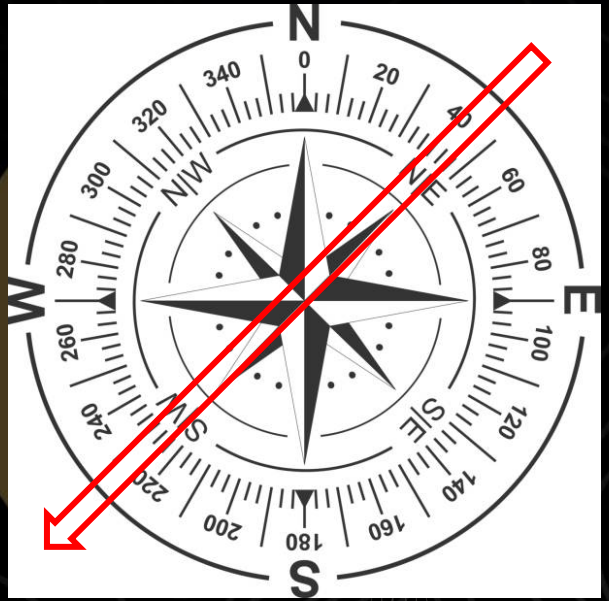


3.2 - Wind

Wind Direction

EXAMPLE 2: Wind direction 45° means that the wind is coming from the North East direction.

This is a “North Easterly” wind.

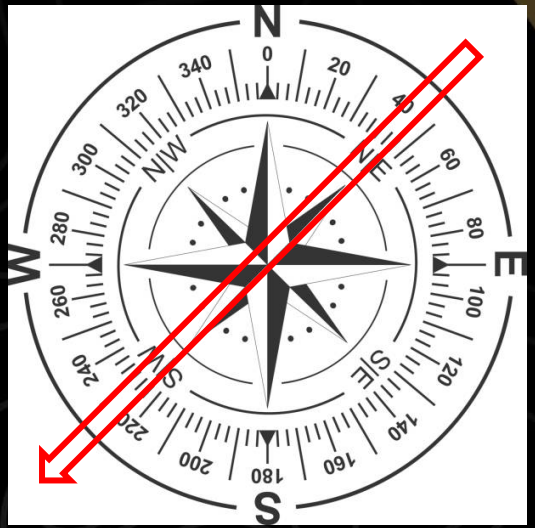


3.2 - Wind

Wind Direction

Remember: When referencing the heading of an aircraft you are referring to the direction of travel.

45° wind direction



≠

45° heading

Note: Always land into the wind to maximize lift.

3.2 - Wind

CAUTION

While flying near an obstruction (like a tree or building) the wind speeds are often lower than they are when flying above.

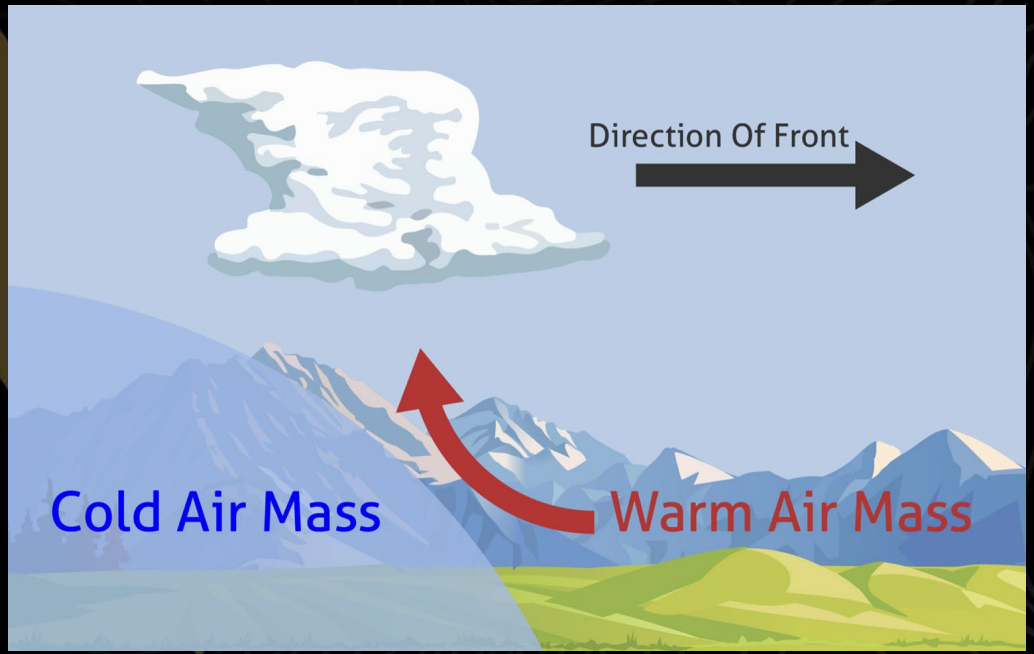
Coverdrone

3.2 - Air Masses & Fronts

3.2 - Air Masses & Fronts

Air Mass: A large body of slow moving air of relatively uniform temperature and moisture content.

Front: The line of collision when two air masses of dissimilar properties collide.

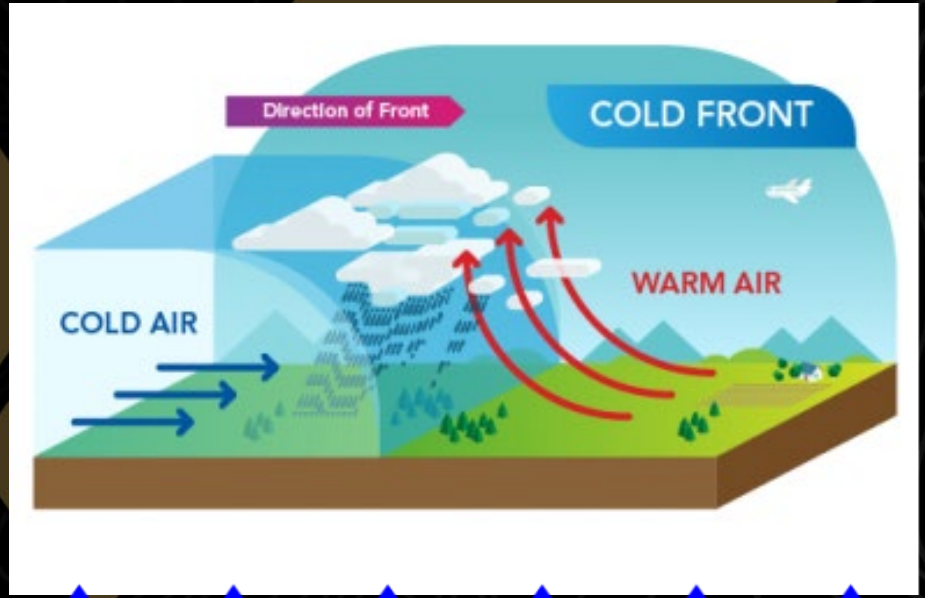


Future Seafarer

3.2 - Air Masses & Fronts

Cold Front: The leading edge of an advancing cold air mass.

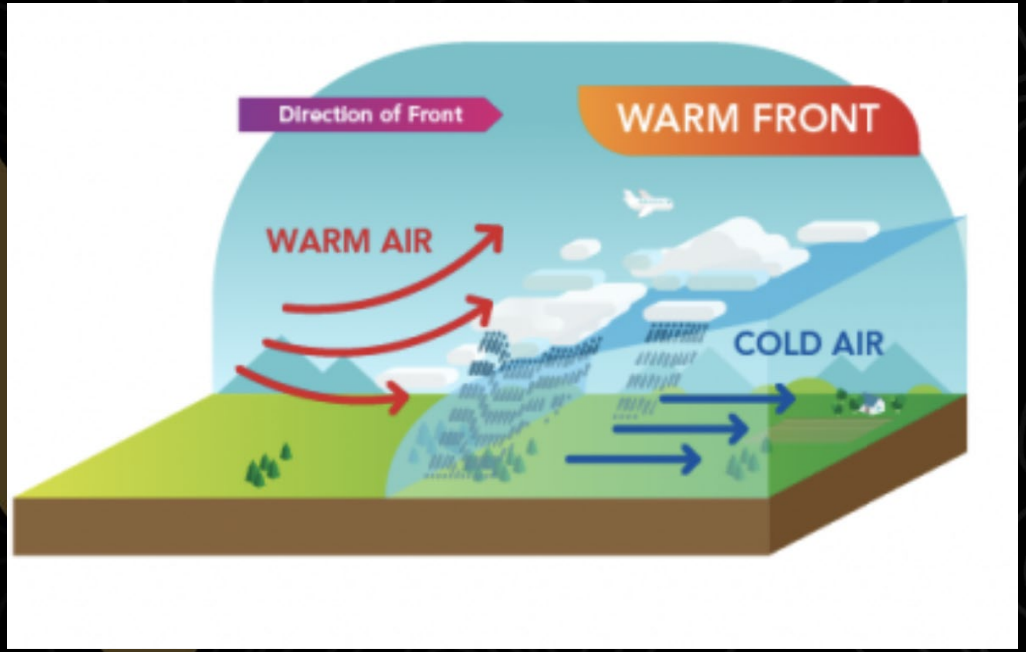
- Accompanied by poor weather that passes quickly.
- After the front has passed a wind shift and turbulent air can be expected.
- Possibility of thunderstorms, hail, and/or tornadoes.



3.2 - Air Masses & Fronts

Warm Front: The leading edge of an advancing warm air mass.

- Moves about 50% slower than cold fronts.
- Usually preceded by low cloud ceilings, precipitation, and reduced visibility



3.2 - Atmospheric Stability

3.2 - Atmospheric Stability

Atmospheric Stability: The resistance of the atmosphere to vertical motion.

Unstable air can result in weather conditions that are unfavorable to sUAS operations.

3.2 - Atmospheric Stability

Stable Air: resists upwards or downwards movement.

- Stratiform clouds & fog
- Continuous precipitation
- Smooth air
- Fair to poor visibility in haze & smoke.

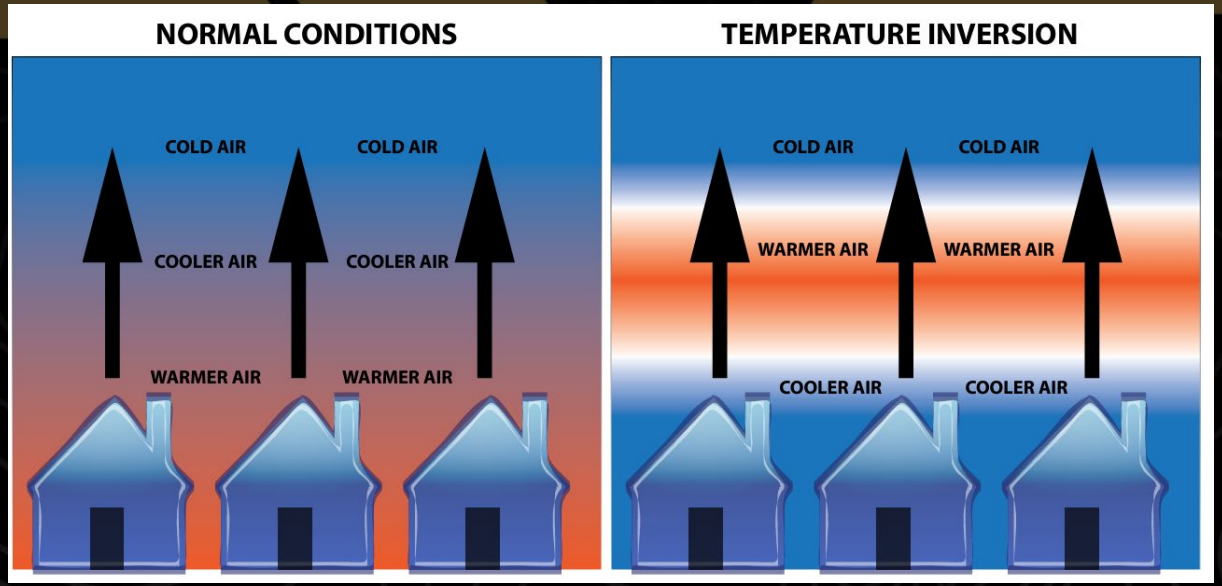
3.2 - Atmospheric Stability

Unstable Air: Allows upwards or downwards movement and the growth of a vertical current.

- Cumuliform clouds
- Showery precipitation
- Rough air (turbulence)
- Good visibility (except in blowing obstructions)

3.2 - Atmospheric Stability

Temperature Inversion: a layer of cool air at the surface that is capped by a layer of warm air.



3.2 - Atmospheric Stability

The result of a temperature inversion is typically fog, haze, and a low temp/dew point spread.

Temperature inversions are usually associated with smooth air which is the result of minimal air convection.

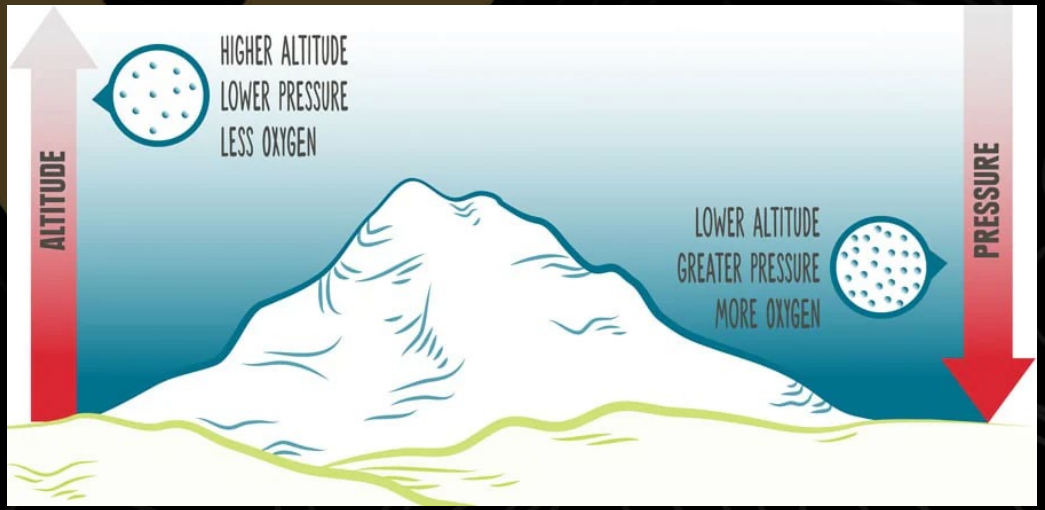
3.2 - Density Altitude

3.2 - Density Altitude

Density Altitude: Is the altitude in the standard atmosphere at which the air has the same density as the air at the place in question.

Density usually decreases as altitude increases.

High altitude = low density
Low altitude = high density



3.2 - Density Altitude

What is a standard day?

A standard day is a measure of the temperature and atmospheric conditions (at sea level).

Standard Temperature: 15°C (59°F)
Standard Atmospheric Pressure: 29.92” Hg (1,013.2 mb)

You may see a standard atmosphere referred to as ISA (International Standard Atmosphere)

3.2 - Density Altitude

Why is density important?

Lower Density Air = More Work For Aircraft

High altitudes are *usually* coupled with lower air density but sUAS performance can degrade when changes in temperature and pressure impact the density of the air.

3.2 - Density Altitude

Lapse Rate

In order to ensure that instruments that work using pressure (like an altimeter) are displaying correctly they must adjust in accordance with the standard “Lapse Rate”

The Lapse Rate is used in a conversion factor where 1” Hg is subtracted for each 1000’ MSL.

3.2 - Density Altitude

Lapse Rate Examples - (standard - 1”Hg x 1000’)

10,000’ MSL — 29.92” Hg - (1” Hg x 10) = 19.92” Hg
7,000’ MSL — 29.92” Hg - (1” Hg x 7) = 22.92” Hg
5,000’ MSL — 29.92” Hg - (1” Hg x 5) = 25.92” Hg
3,000’ MSL — 29.92” Hg - (1” Hg x 3) = 26.92” Hg
2,000’ MSL — 29.92” Hg - (1” Hg x 2) = 27.92” Hg
1,000’ MSL — 29.92” Hg - (1” Hg x 1) = 28.92” Hg

3.2 - Density Altitude

Remember Density Altitude is simply a measure of density at place of operation.

Higher altitude = high density altitude = lower density air

Lower altitude = low density altitude = higher density air

3.2 - Density Altitude

- Obtaining reports is essential.

- Depending on conditions it is possible for the air at sea level to reach the same density as that on top of a tall mountain.

- If an instrument isn’t set correctly it will not show the true altitude.

3.2 - Density Altitude

How does density altitude affect sUAS performance?

sUAS performance can degrade when changes in temperature and pressure impact the density of the air.

Atmospheric Condition	sUAS Performance
↓ Pressure	↓ Performance
↑ Altitude	↓ Performance
↑ Temperature	↓ Performance
↑ Humidity	↓ Performance

3.2 - Ceiling, Visibility, and Clouds

3.2 - Visibility & Clouds

FAA Requirements 

General Visibility - Visibility of 3 statute miles is required for operation.

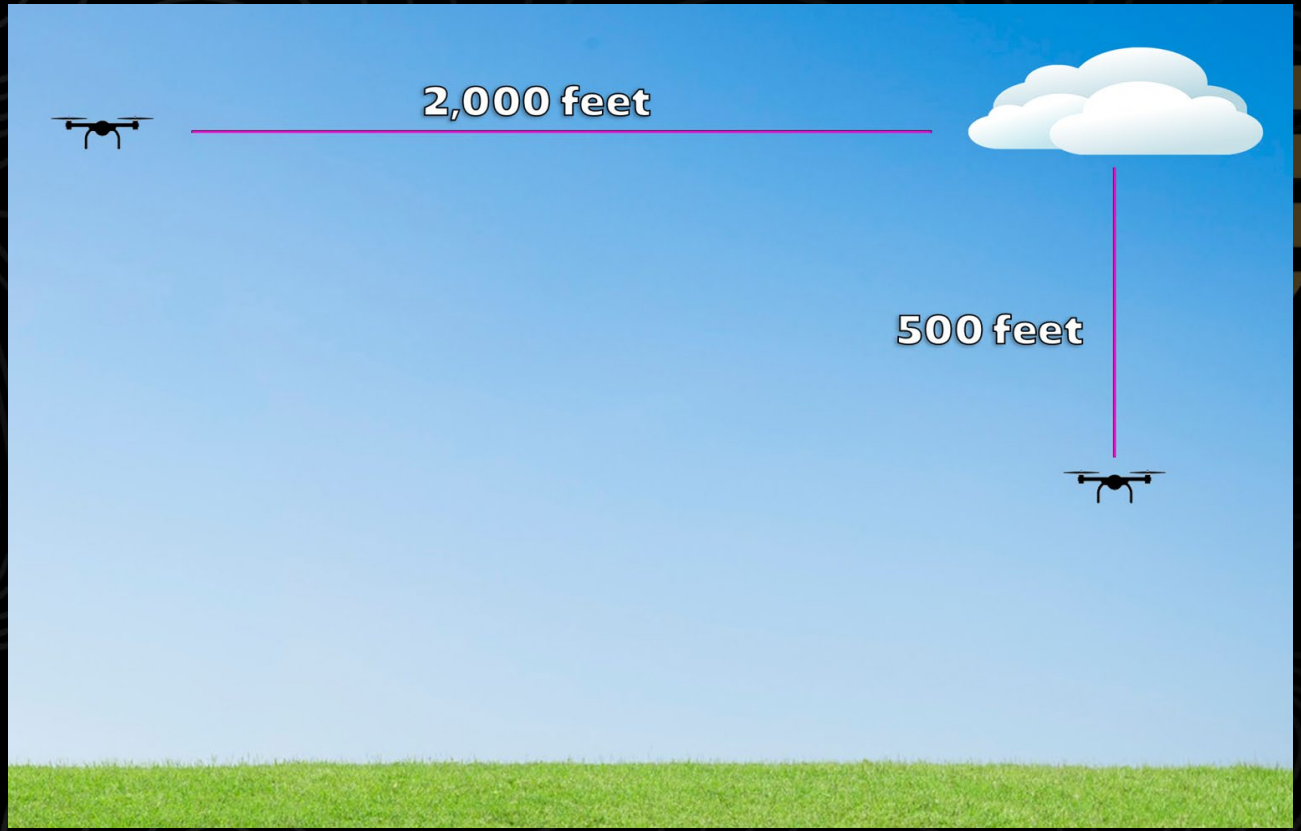
Horizontal - Remote PIC must keep the sUAS at least 2,000 feet horizontally away from a cloud.

Vertical - Remote PIC must keep the sUAS at least 500 feet below a cloud.

3.2 - Visibility & Clouds

Why do these requirements exist?

3.2 - Visibility & Clouds



Q: Why do these requirements exist?

A: To avoid a collision with a manned aircraft coming out of a cloud.

3.2 - Visibility & Clouds

How is “visibility” determined by a Remote PIC?

Verify using a known point a known point at least 3 miles away.
- A tree line 270° W is approximately 2.25 miles away.
- The top of a tower (in the SW direction) is 297 feet AGL according to the sectional chart.

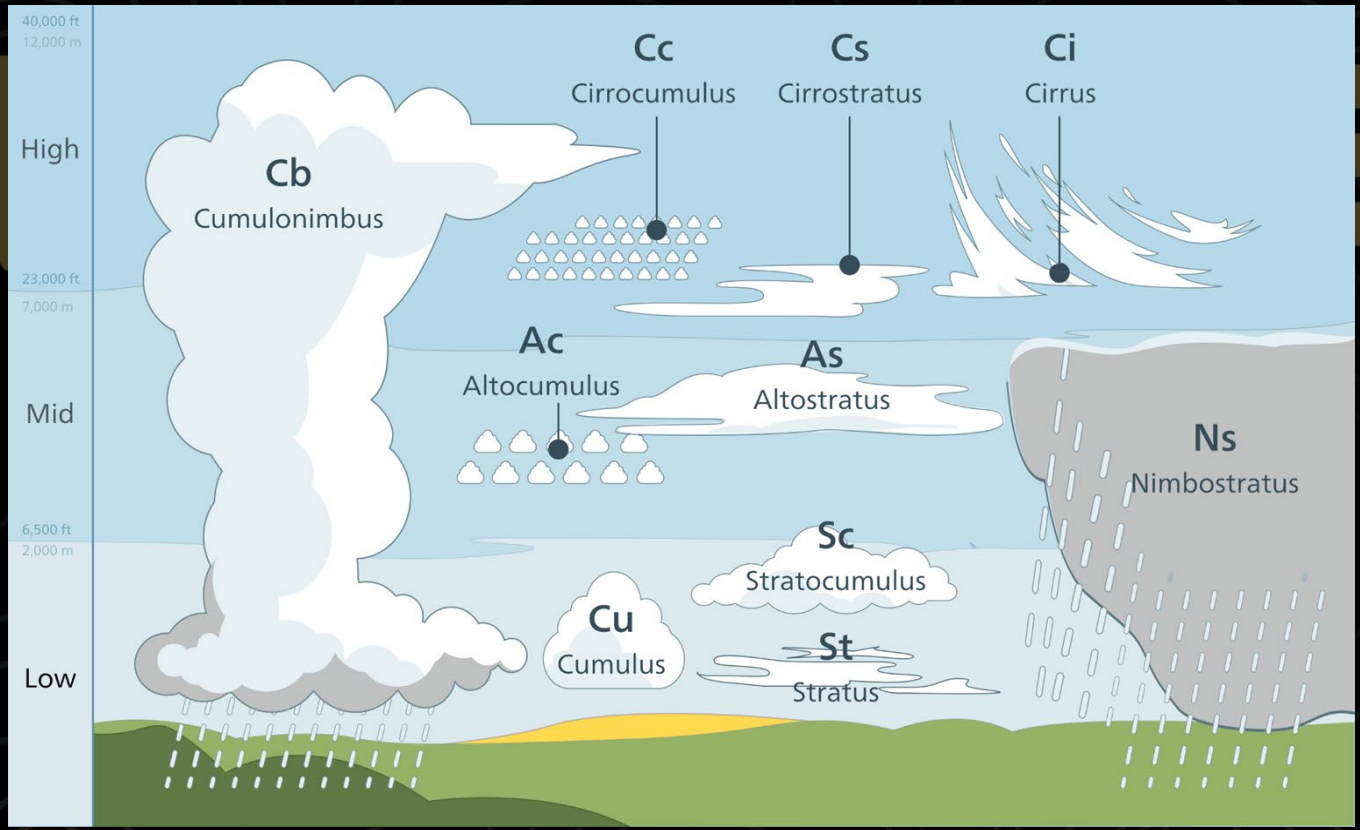
3.2 - Visibility & Clouds

FAA Cloud Categorization

High - 23,000 - 40,000 feet
Middle - 6,500 to 23,000 feet
Low - 6,500 and below

NOTE: As a remote PIC it is unlikely that you will fly near anything other than “low” clouds but you need to know this information for the exam.

3.2 - Visibility & Clouds



NWS

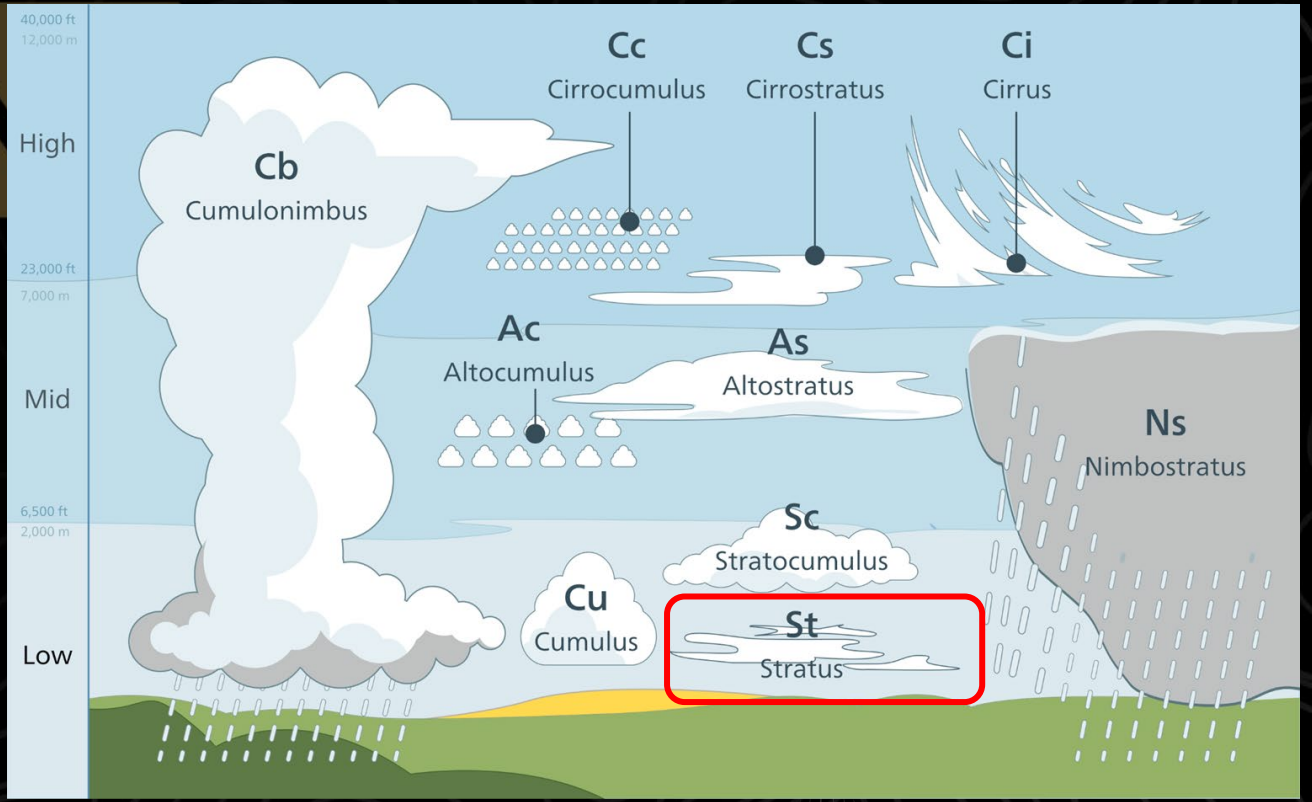
3.2 - Visibility & Clouds

Low Clouds

3.2 - Visibility & Clouds

Stratus:

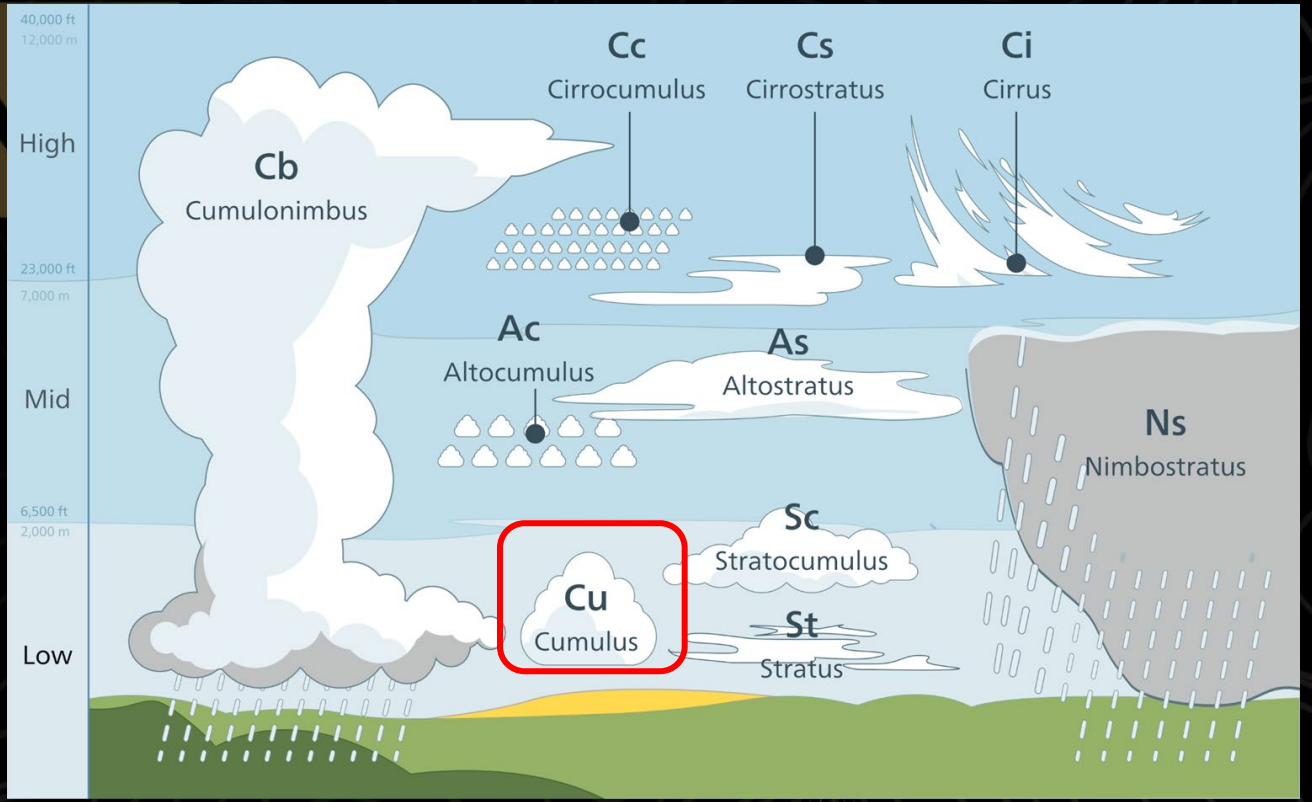
- Low, thin, flat
- Usually of stable air



3.2 - Visibility & Clouds

Cumulus

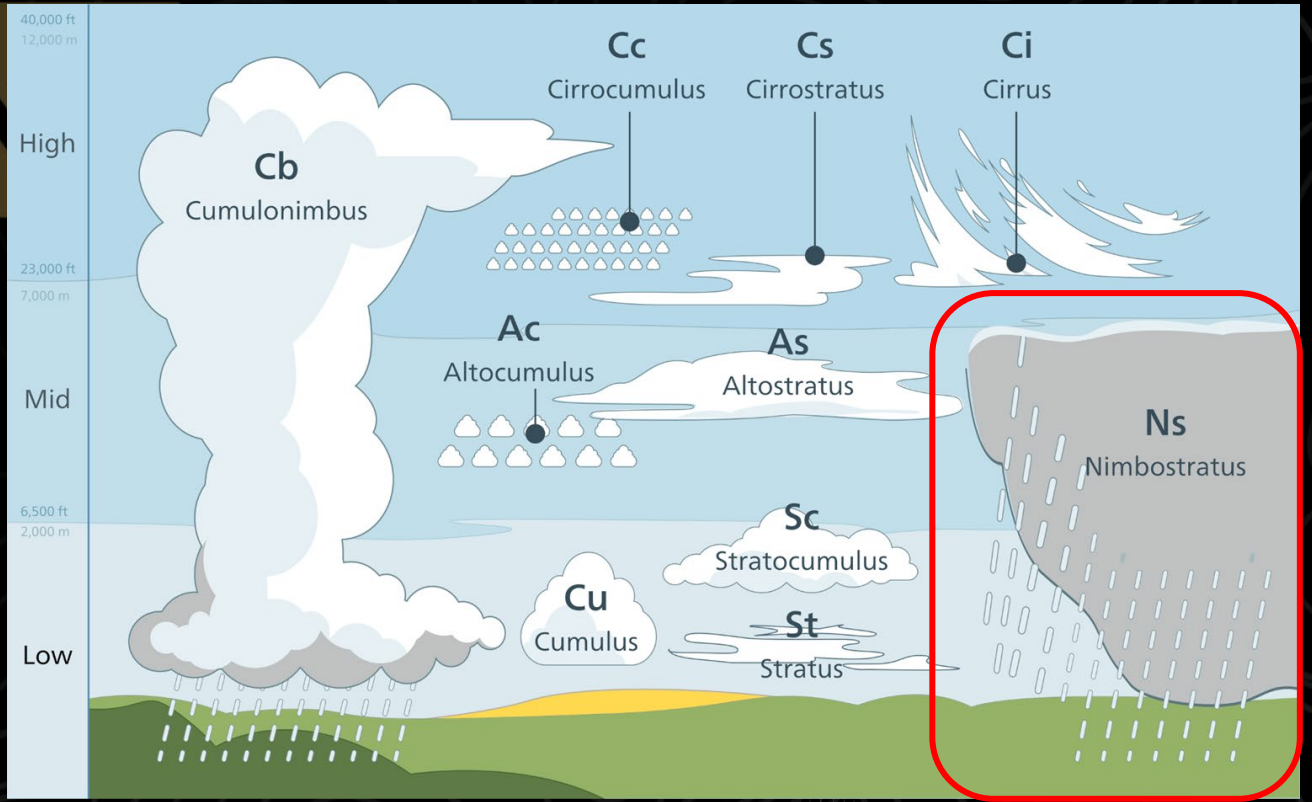
- White fluffy clouds
- Usually unstable air (“puffed” due to vertical air currents)



3.2 - Visibility & Clouds

Nimbostratus

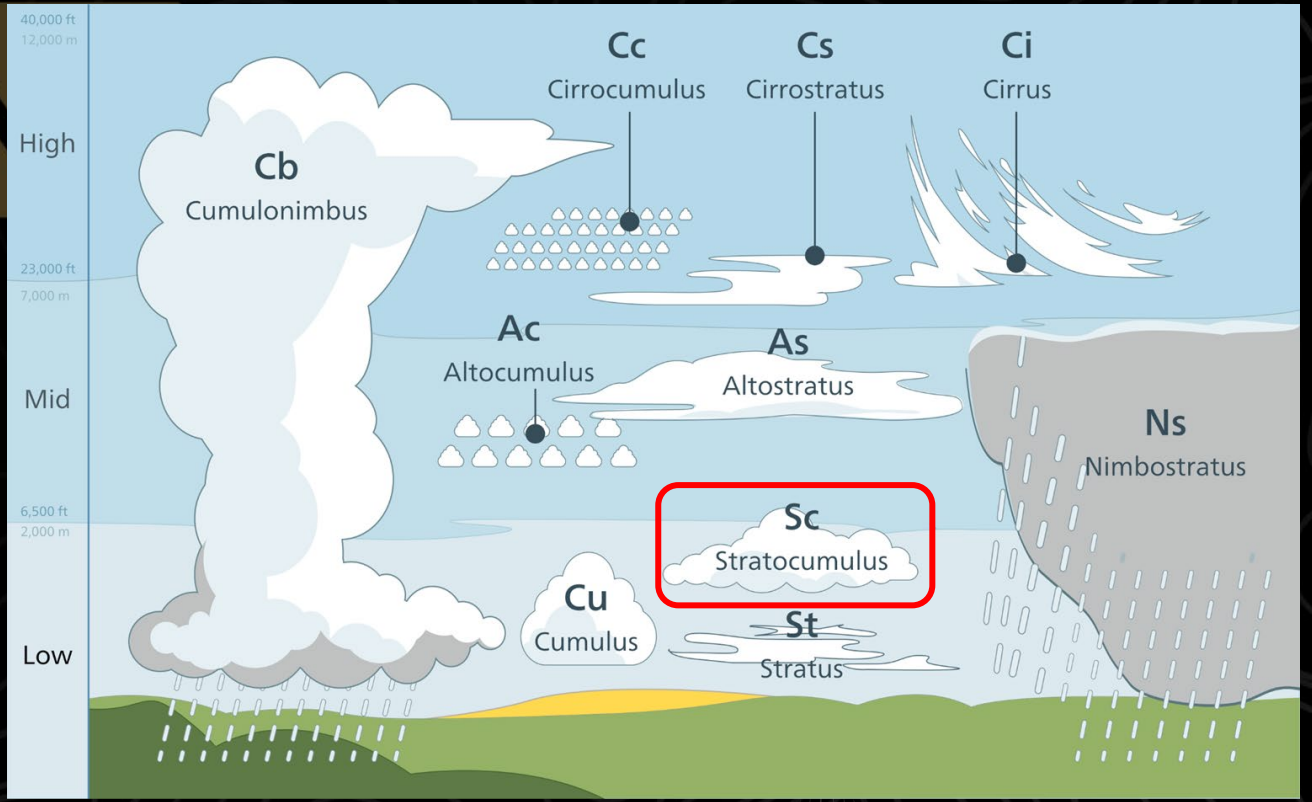
Your typical “rain cloud” with steady precipitation



3.2 - Visibility & Clouds

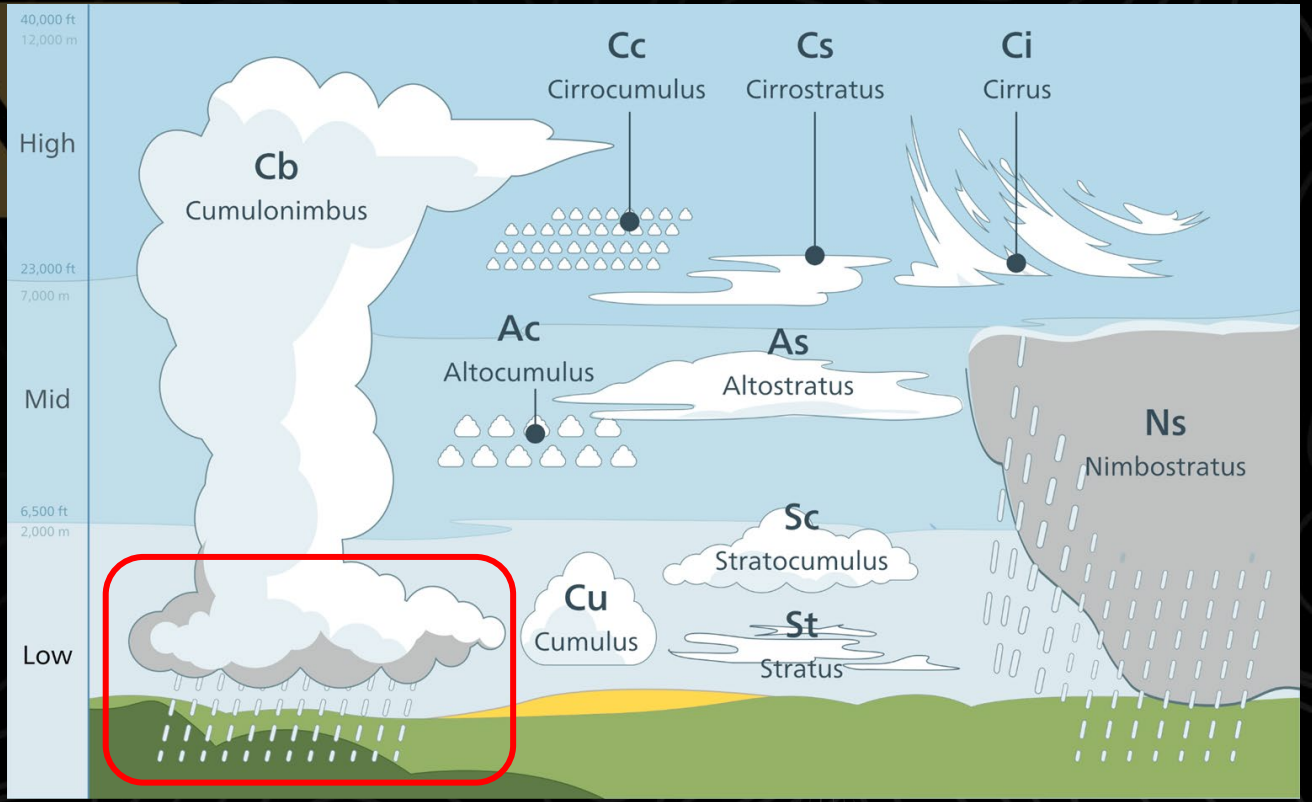
Stratocumulus

Patchy gray or white with a honeycomb-like appearance. They don't produce precipitation but are often a precursor of rain.



3.2 - Visibility & Clouds

Cumulonimbus
Rain cloud with showery precipitation



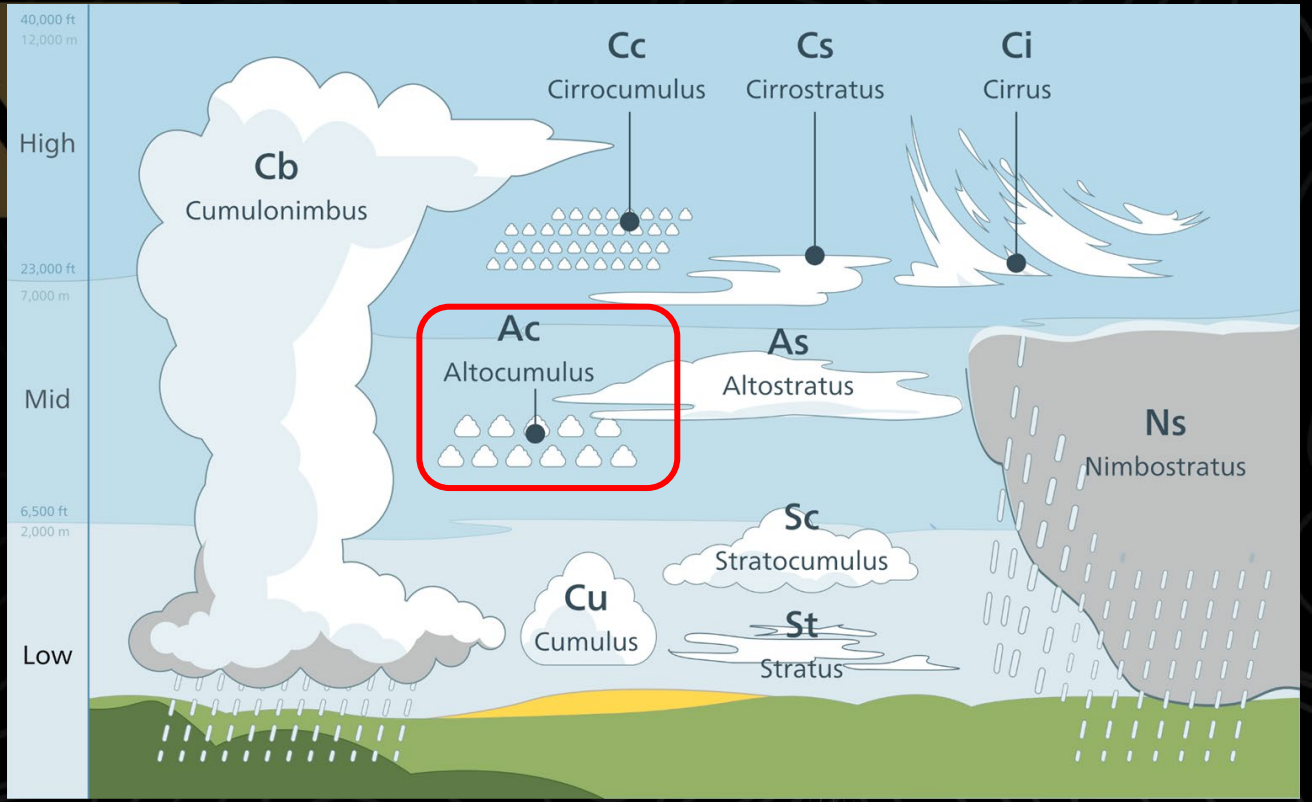
3.2 - Visibility & Clouds

Middle Clouds

3.2 - Visibility & Clouds

Altocumulus

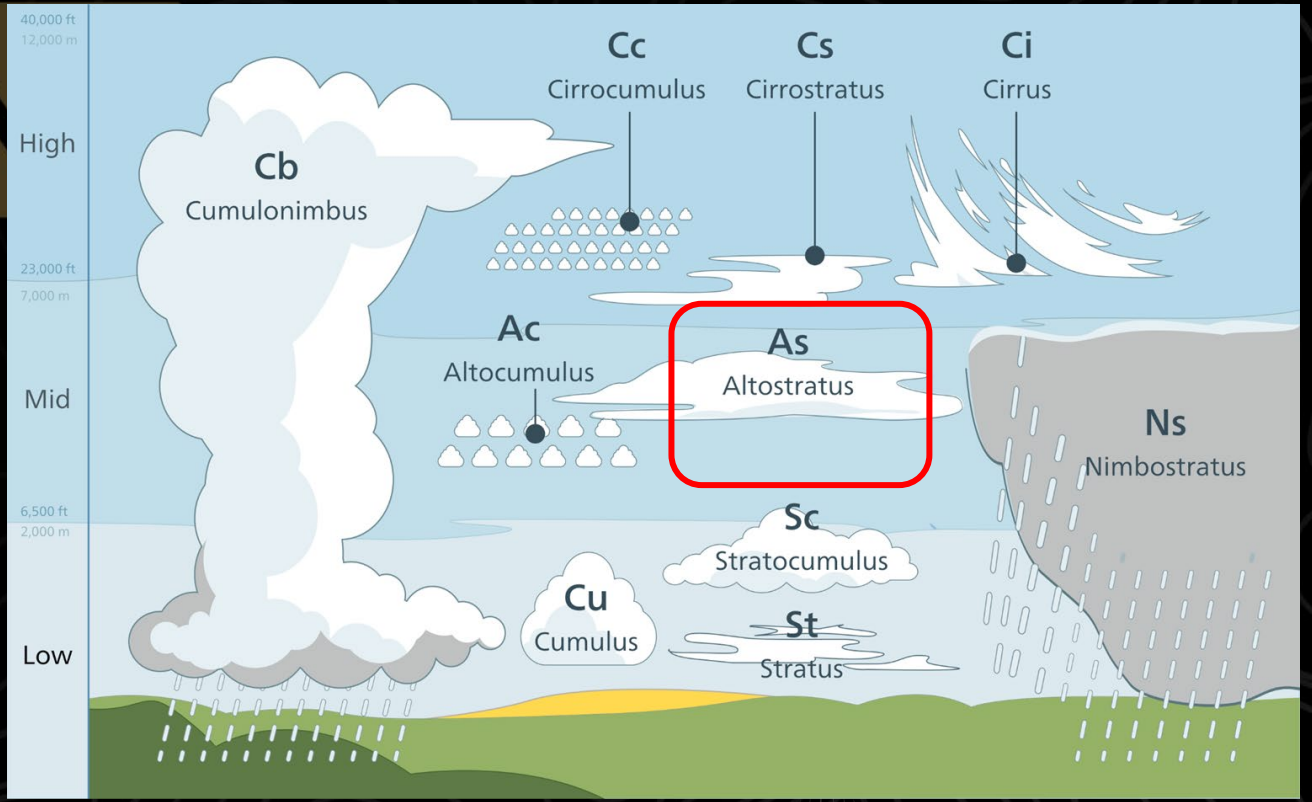
Appear as small rows of fluffy ripples. Made up of liquid water but don't tend to produce rain.



3.2 - Visibility & Clouds

Altostratus

Made up of a mixture of water and ice and often lead to rain or snow.



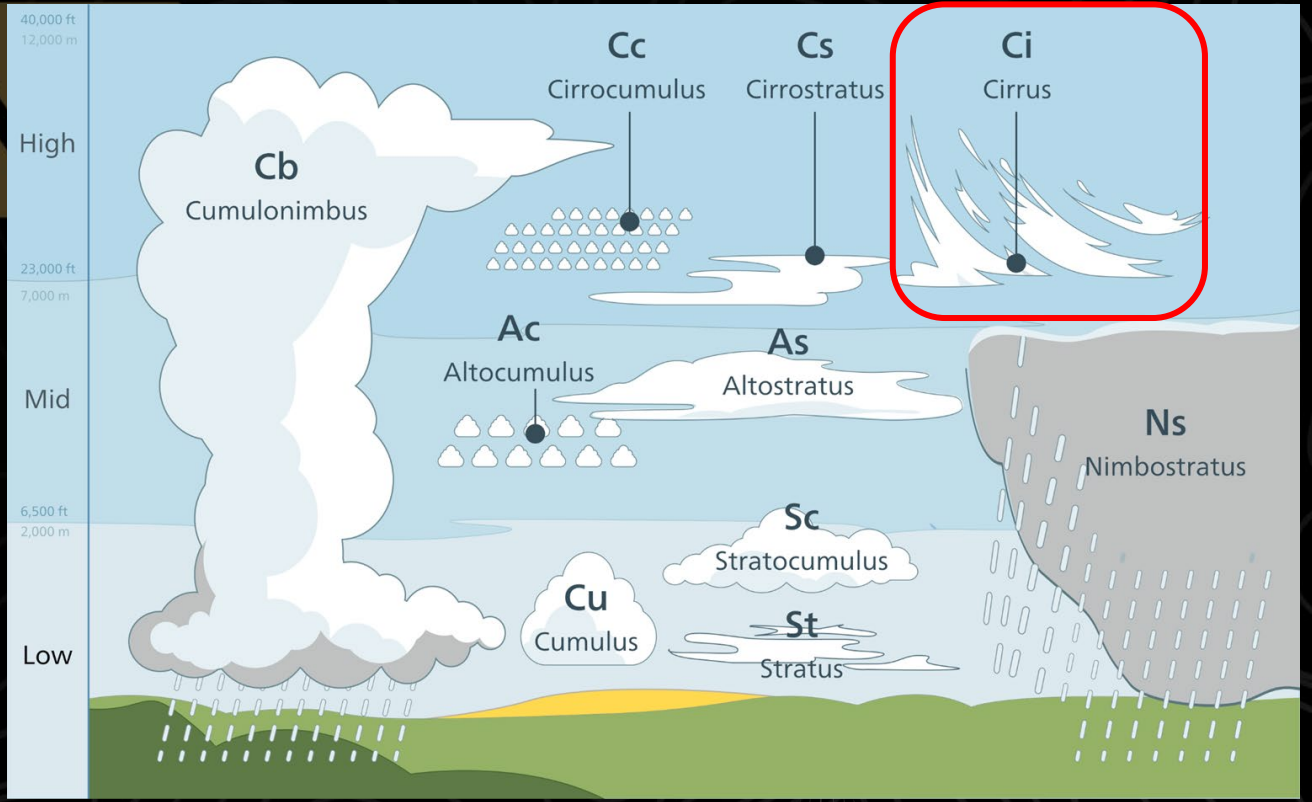
3.2 - Visibility & Clouds

High Clouds

3.2 - Visibility & Clouds

Cirrus

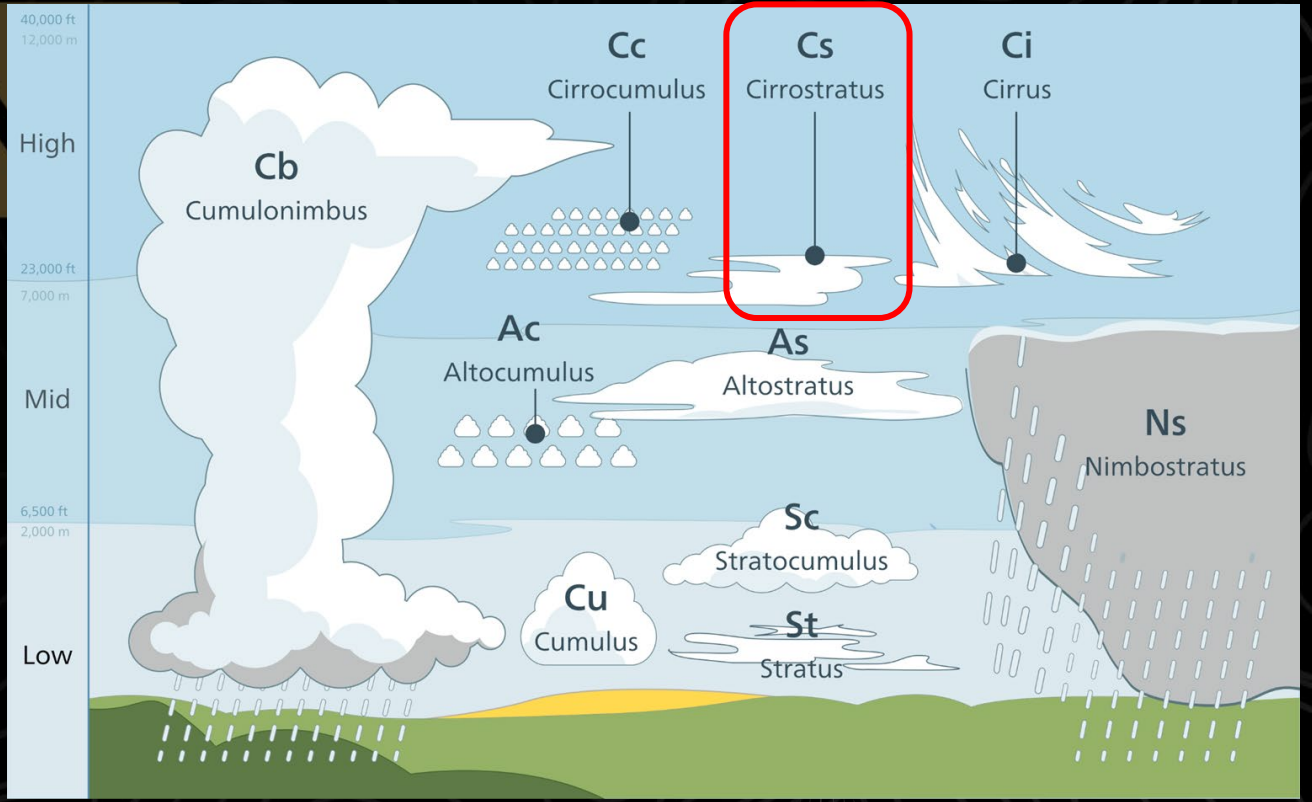
Cirrus clouds appear wispy and are made up of ice crystals.



3.2 - Visibility & Clouds

Cirrostratus

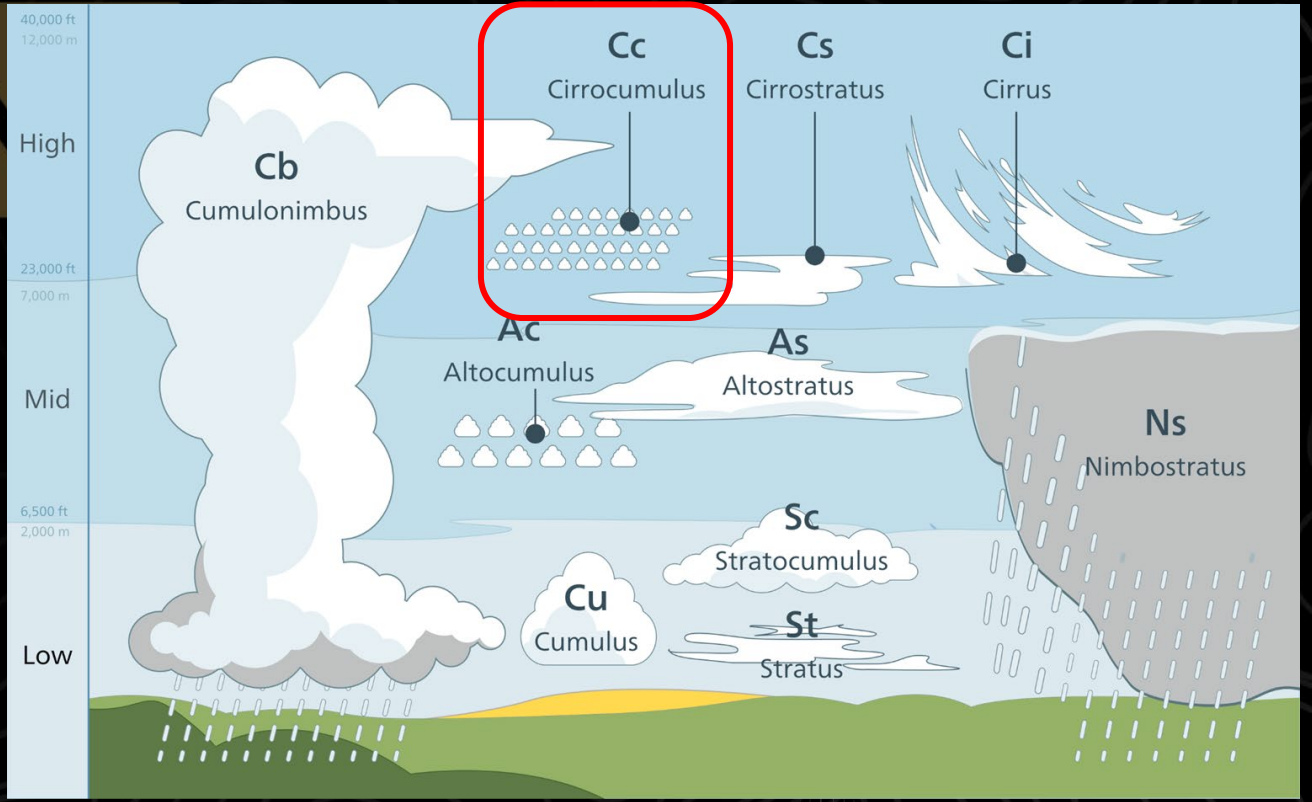
Thin veil like clouds. Often in cold weather/winter. Rain or snow usually follows within 24 hours.



3.2 - Visibility & Clouds

Cirrocumulus

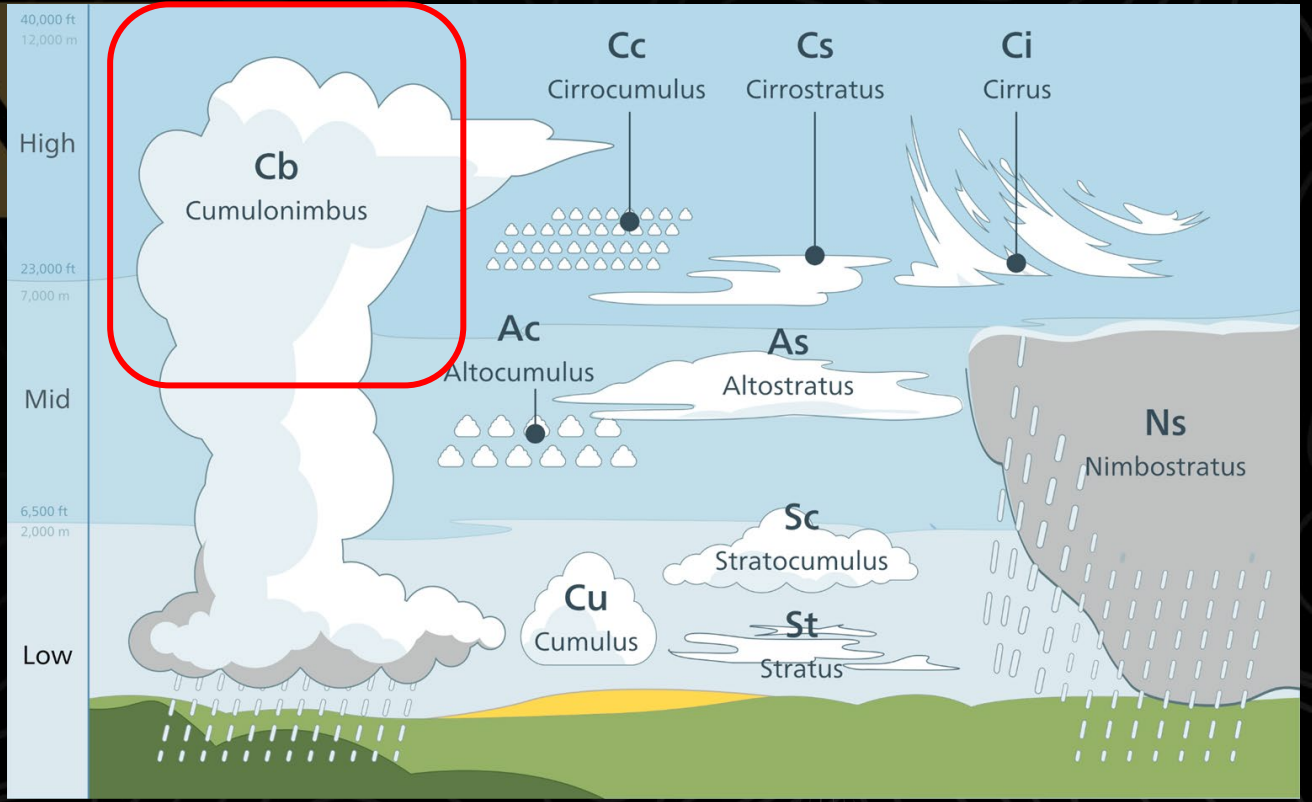
Patchy ripples, often precede cold weather or even a hurricane.



3.2 - Visibility & Clouds

Towering Cumulonimbus

Clouds with extensive vertical developments. Sometimes has an “anvil top that often accompanies bad weather (thunder, wind, rain, hail)

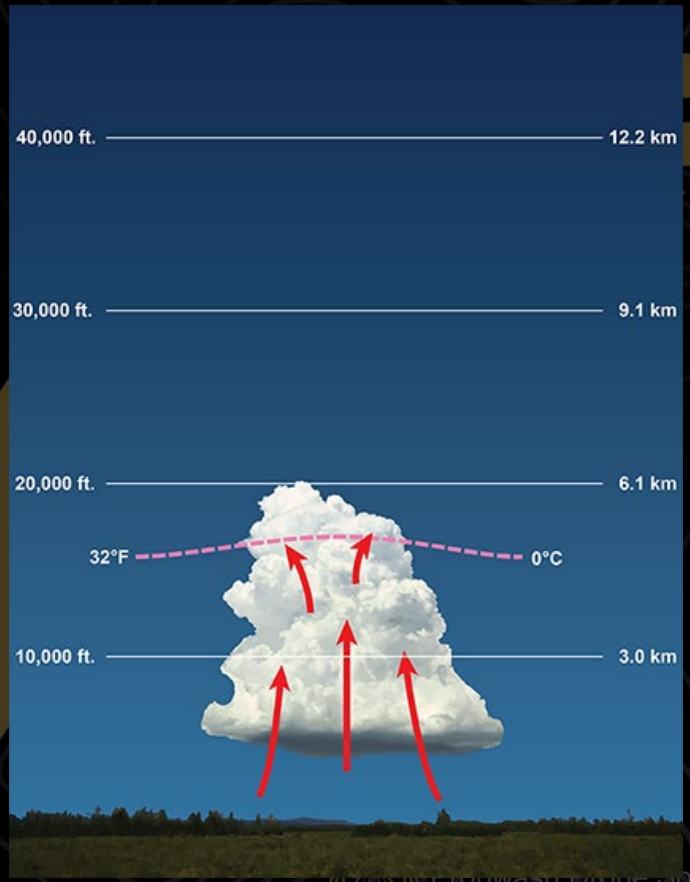


3.2 - Thunderstorm Life Cycle

3.2 - Thunderstorm Life Cycle

STAGE 1 -
DEVELOPING (CUMULUS)

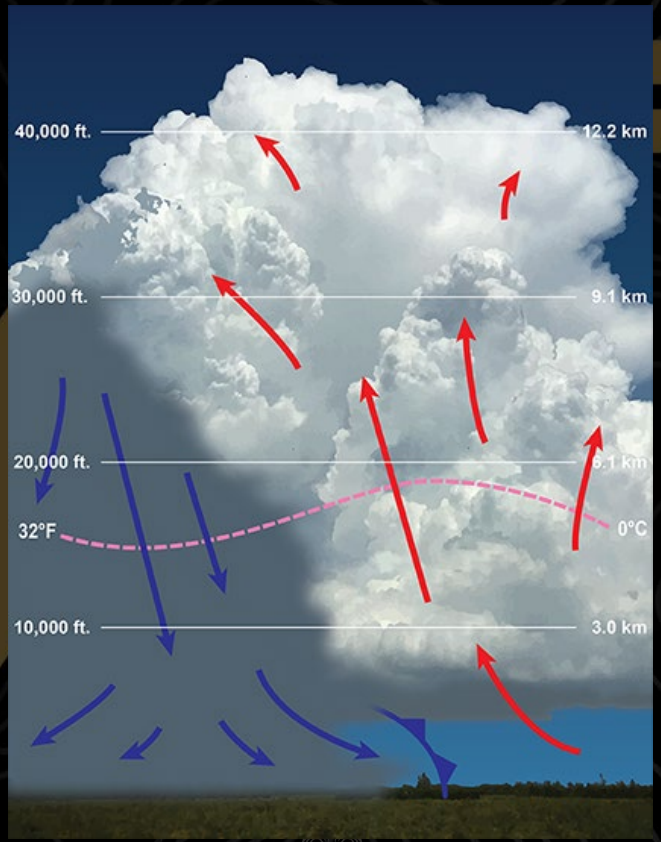
- Vertical Growth
- Warm, moist updrafts
- Up to 20,000’ feet



3.2 - Thunderstorm Life Cycle

STAGE 2 -
MATURE

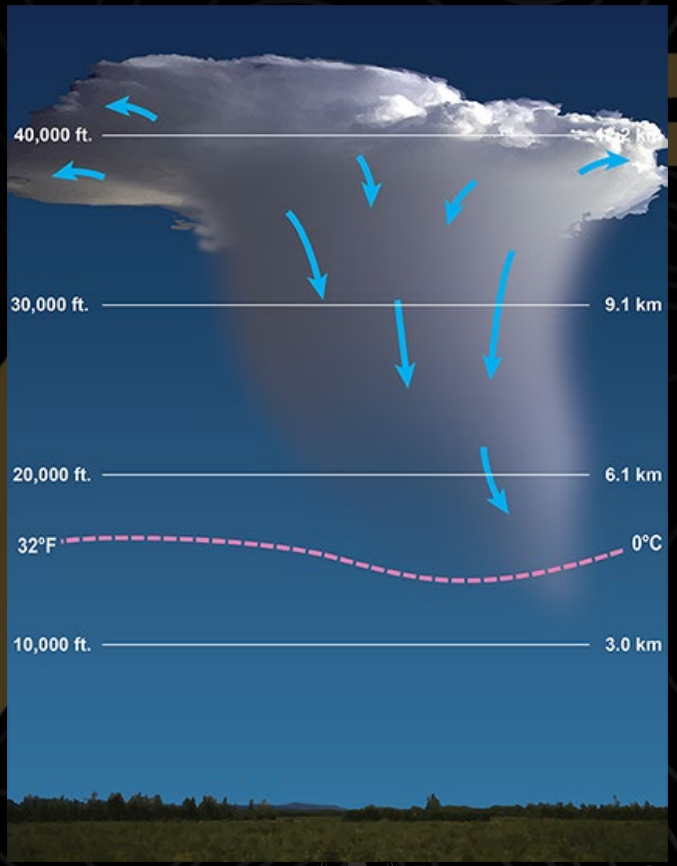
- Strong Updrafts
- Dangerous - tornadoes, hail, high winds
- 40,000-60,000 feet



3.2 - Thunderstorm Life Cycle

STAGE 3 - DISSIPATING

- Downdraft
- Light rain and weak outflow winds
- Anvil top remains



3.2 - Icing & Fog

3.2 - Icing & Fog

Structural Icing: Structural icing can occur when supercooled condensed droplets of water contact any part of the aircraft that is also at a temperature below freezing.

With an sUAS the most common place for structural icing to occur in on a propeller or camera lens.

NOTE: It is important to remember that icing can occur outside of clouds.

3.2 - Icing & Fog

When structural icing occurs on a sUAS:

- Lift decreases
- Thrust decreases
- Drag increases

If icing appears to be accumulating the sUAS should be recovered immediately to avoid a crash.

3.2 - Icing & Fog

Dew Point: The temperature that air must reach in order to become saturated with water vapor.

Once the saturation point (dew point) is reached water vapor will condense to form liquid water (dew).

3.2 - Icing & Fog

Dew Point: An example of dew point is when a cold window makes contact with warmer air from inside a building. The air that contacts the window is cooled to the dew point and water condenses on the surface.

3.2 - Icing & Fog

Dew Point (F)	Dew Point (C)	Comfort
Below 50	Below 10	Dry
50-55	10-12	Comfortable
56-60	13-15	Pleasant
61-65	16-18	Sticky
66-70	18-21	Humid
71-75	21-23	Oppressive
76+	24+	Miserable

Dew Point

The dew point can not be higher than the outside temperature.

When the dew point is within 3°C of the temperature fog is likely to occur.

3.2 - Icing & Fog

Fog: Surface based cloud composed of either water droplets or ice crystals.

Fog forms after air is cooled to its dew point.

3.2 - Icing & Fog

Radiation (Ground) Fog: formed when the ground cools and the ground temperature meets the air temperature. Usually found over low flat areas on clear, calm nights

3.2 - Icing & Fog

Advection (Sea) Fog: formed when warm, moist air is blown over cold ground or water.

3.2 - Icing & Fog

Upslope Fog: formed when moist, stable air is cooled to the dew point as it blows vertically along sloping terrain

3.2 - Icing & Fog

Precipitation Induced Fog: usually associated with frontal activity and is formed by warm drizzle or rain falling through cooler air. The cooler air is saturated causing fog.

3.2 - Icing & Fog

Steam Fog: Formed when cold, dry air passes over comparatively warm waters.

When steam fog is present over large bodies of water turbulence can occur as a result of the updraft.

Unit 3 Weather – 3.2 Review Quiz

- 3.2 - Effects of Weather on Performance – QUIZ
- This quiz contains 80 questions.
  - You may take it as many times as you like.
  - The order of questions are randomized each time.
  - The large majority of the questions are worded exactly as they appear on the exam.