CFI Bootcamp

Flight Instructor Training

Technical Subject Areas

Weather Theory

Technical Subject Areas

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The Seven Essential Concepts to Understand Weather

Atmospheric Composition

The Seven Essential Concepts to Understand Weather

Pressure, Temperature and Heat Exchange

The Seven Essential Concepts to Understand Weather

High and Low-Pressure Areas

The Seven Essential Concepts to Understand Weather

Atmospheric Stability

The Seven Essential Concepts to Understand Weather

Precipitation, Clouds, Fog and obstructions to visibility

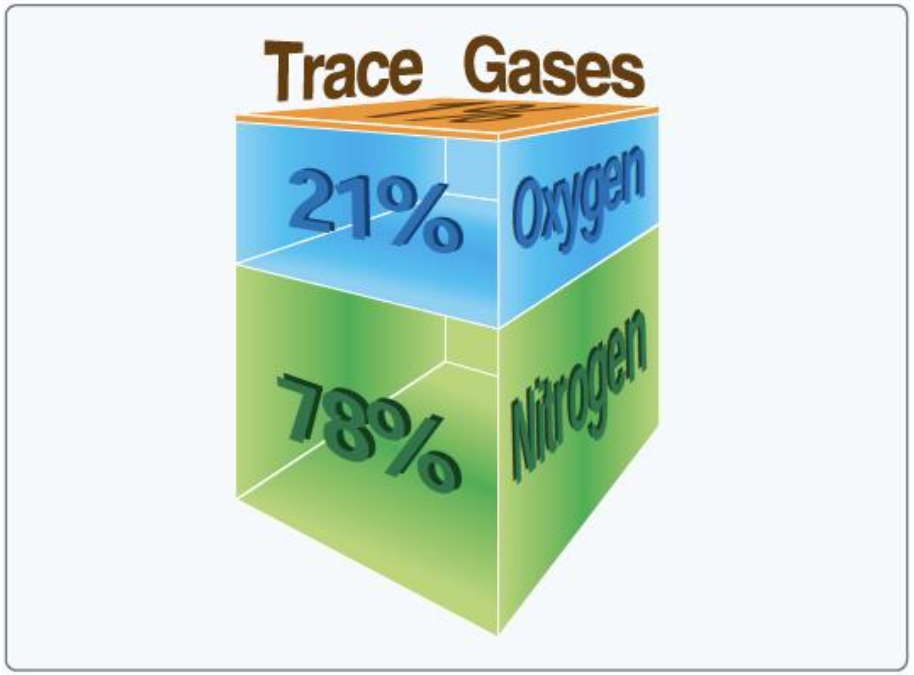
The Seven Essential Concepts to Understand Weather

Icing, Freezing Level Information and Frost

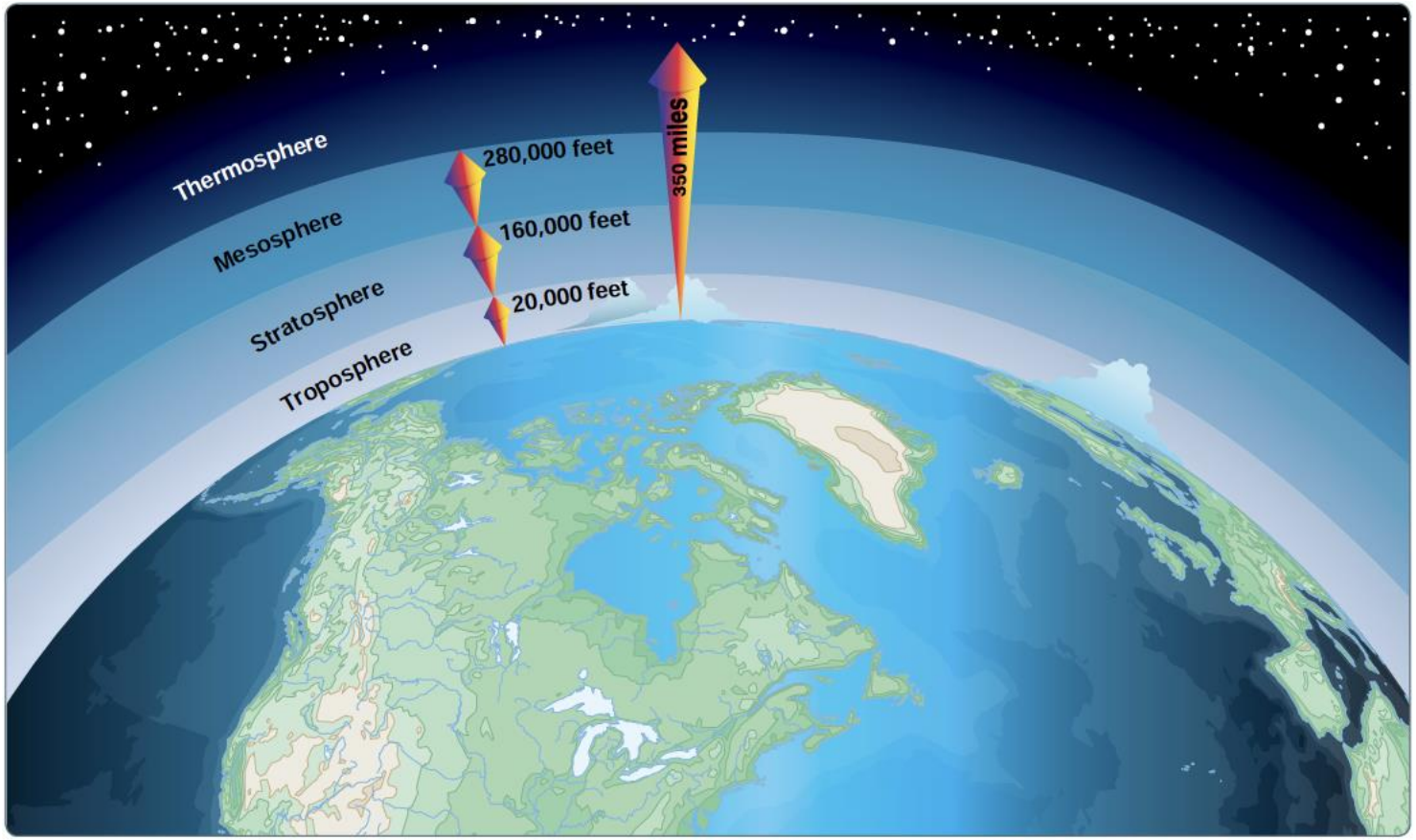
The Seven Essential Concepts to Understand Weather

Frontal Characteristics and Movement

Atmospheric Composition



Atmospheric Composition - Layers

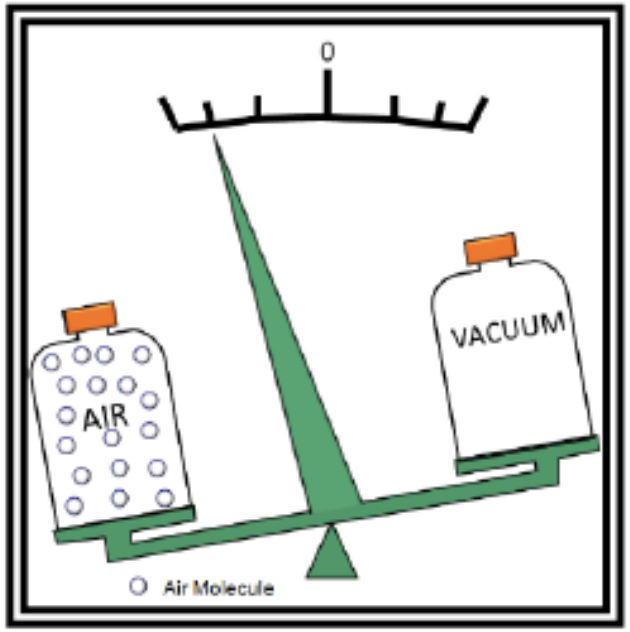


Atmospheric Composition

Solar radiation of the earths surface is what causes weather

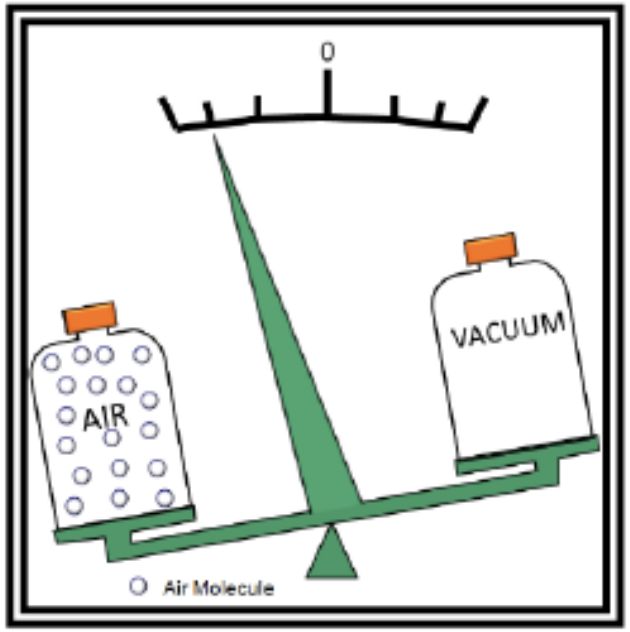
Pressure, Temperature and Heat Exchange

The atmosphere contains matter



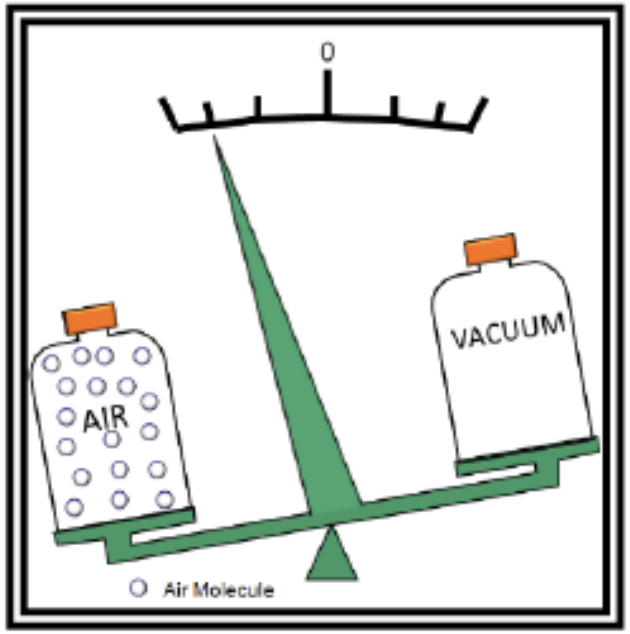
Pressure, Temperature and Heat Exchange

Gravity acts on matter



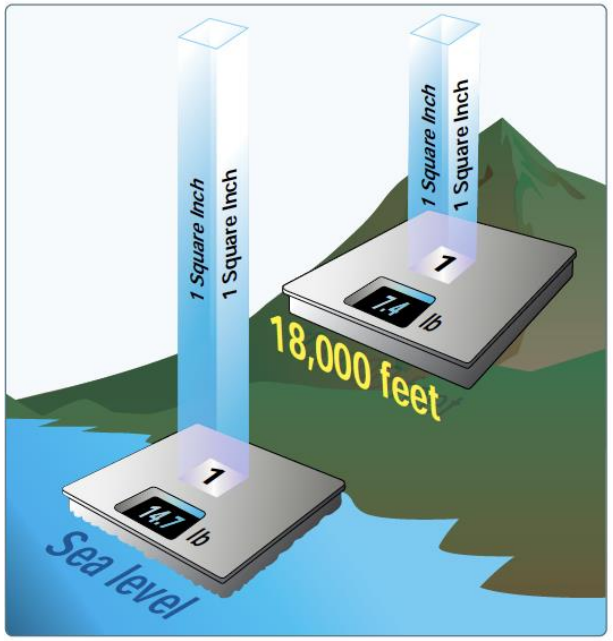
Pressure, Temperature and Heat Exchange

Pressure is higher at sea level - matter and gravity above



Pressure, Temperature and Heat Exchange

The pressure at 18,000 ft. is about ½ as at Sea Level



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Pressure, Temperature and Heat Exchange

Standard Temperature, Pressure and Lapse Rates

Weather Theory

Property	Metric Units	English Units
Sea level pressure	1013.25 hectopascals	29.92 inches of mercury
Sea level temperature	15 °C	59 °F
Lapse rate of temperature in the troposphere	6.5 °C/1,000 meters 2°C/1000 ft	3.57 °F/1,000 feet
Pressure altitude of the tropopause	11,000 meters	36,089 feet
Temperature at the tropopause	-56.5 °C	-69.7 °F
Note: *1 hectopascal = 1 millibar.*		

Pressure, Temperature and Heat Exchange

Temperature is the average kinetic value of atoms or molecules in matter

Pressure, Temperature and Heat Exchange

Radiation – Transfer by electromagnetic radiation

Pressure, Temperature and Heat Exchange

Absorbing body converts electromagnetic waves to heat – Warming by a fireplace is by radiation

Pressure, Temperature and Heat Exchange

Conduction – transfer of heat by molecular energy through contact – Frying an egg is by conduction

Pressure, Temperature and Heat Exchange

Convection – transport of heat through a fluid like air or water – Water boiling is through convection

Pressure, Temperature and Heat Exchange

Evaporation – A liquid is converted to vapor

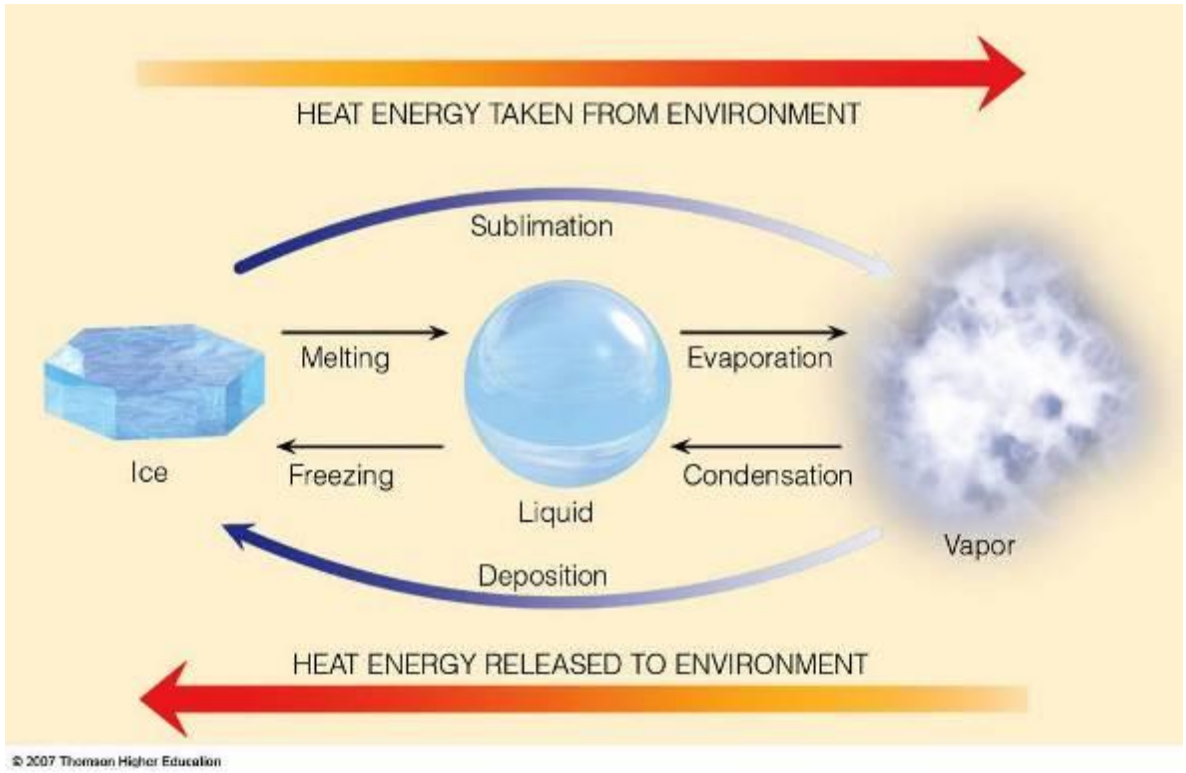
Pressure, Temperature and Heat Exchange

Sublimation – A solid is converted to vapor without going through a liquid phase

Pressure, Temperature and Heat Exchange

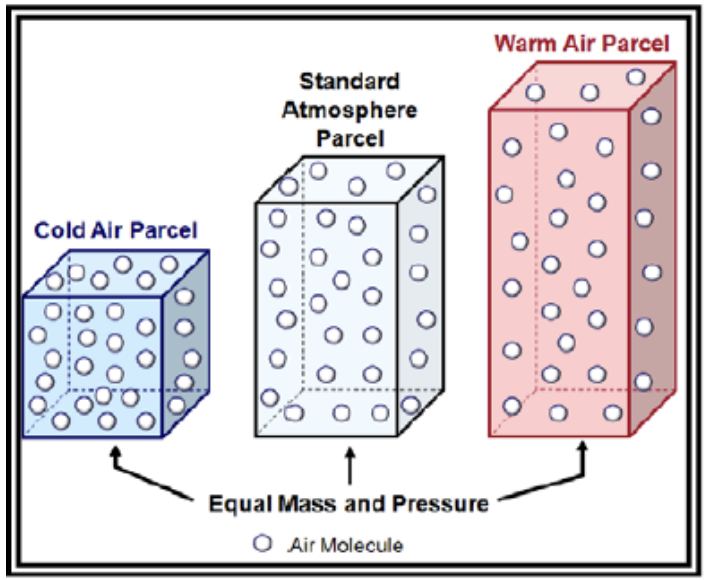
Condensation – Vapor is changed into a liquid – clouds, mist, fog, dew, frost

Pressure, Temperature and Heat Exchange



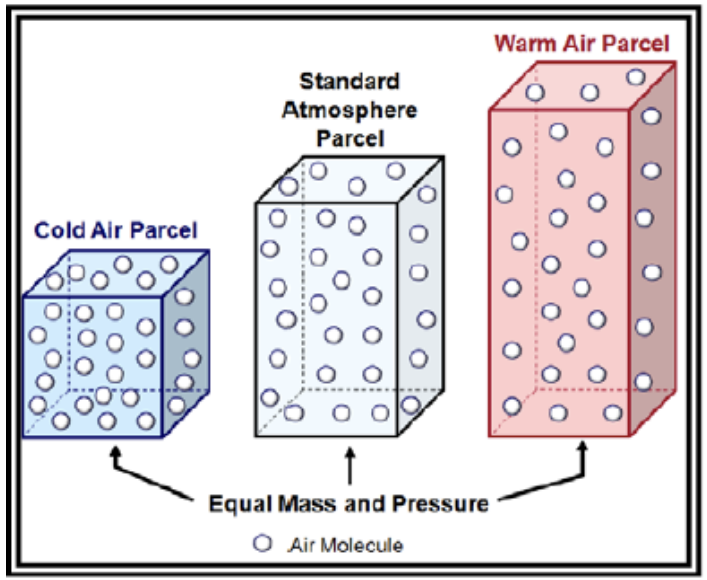
Pressure, Temperature and Heat Exchange

Higher temperatures cause lower pressure – less dense air

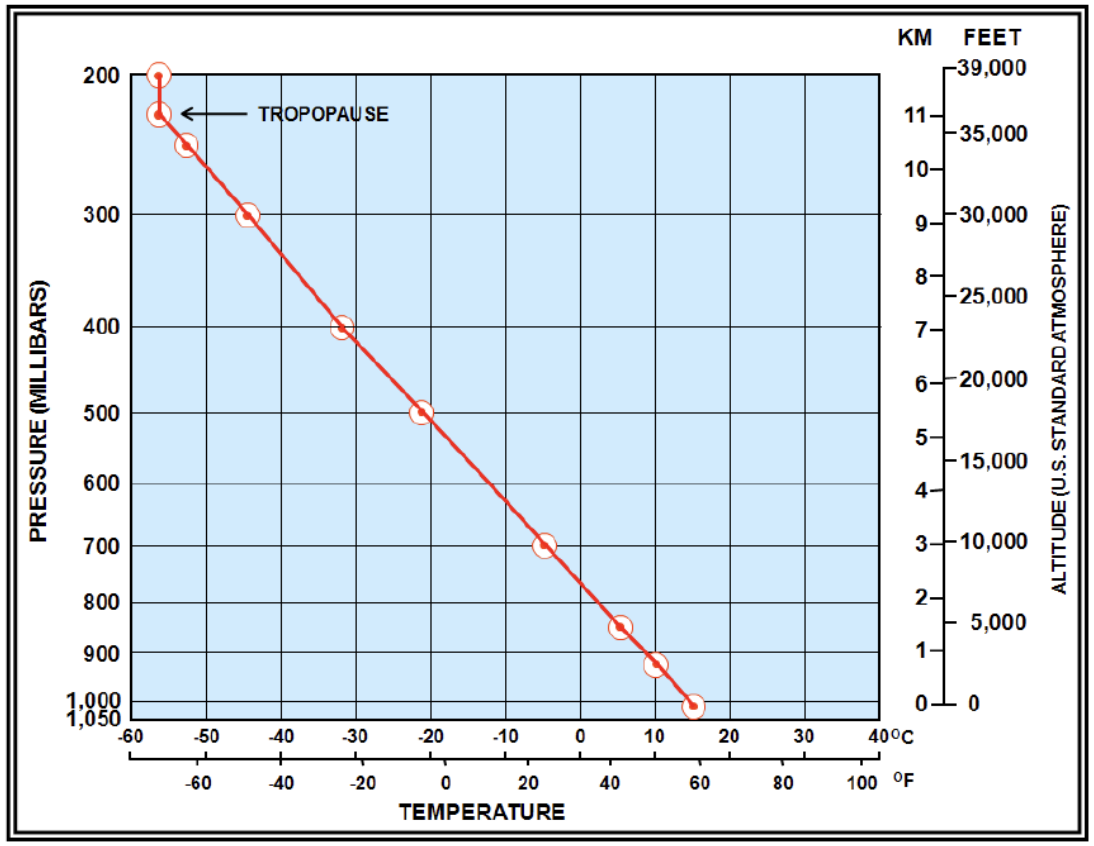


Pressure, Temperature and Heat Exchange

Colder temperatures cause high pressure – heavier air



Decrease of Temperature with Altitude



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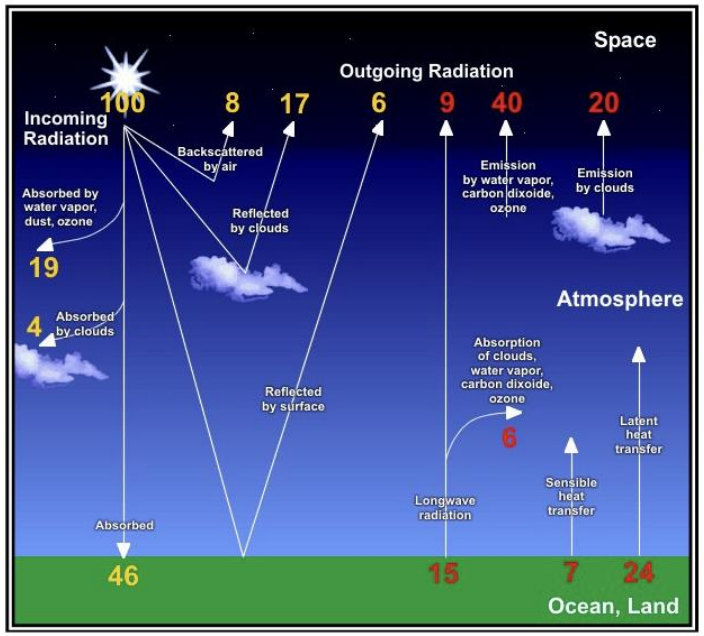
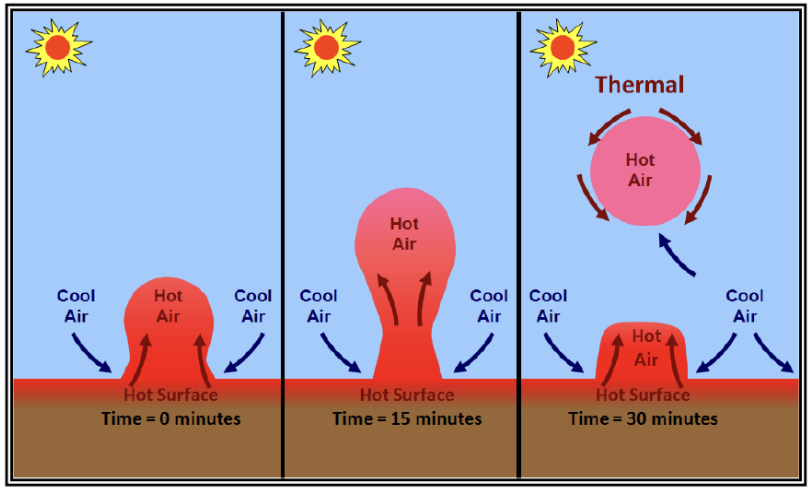
Pressure, Temperature and Heat Exchange

Earth heats unequally – causes different temps/pressures





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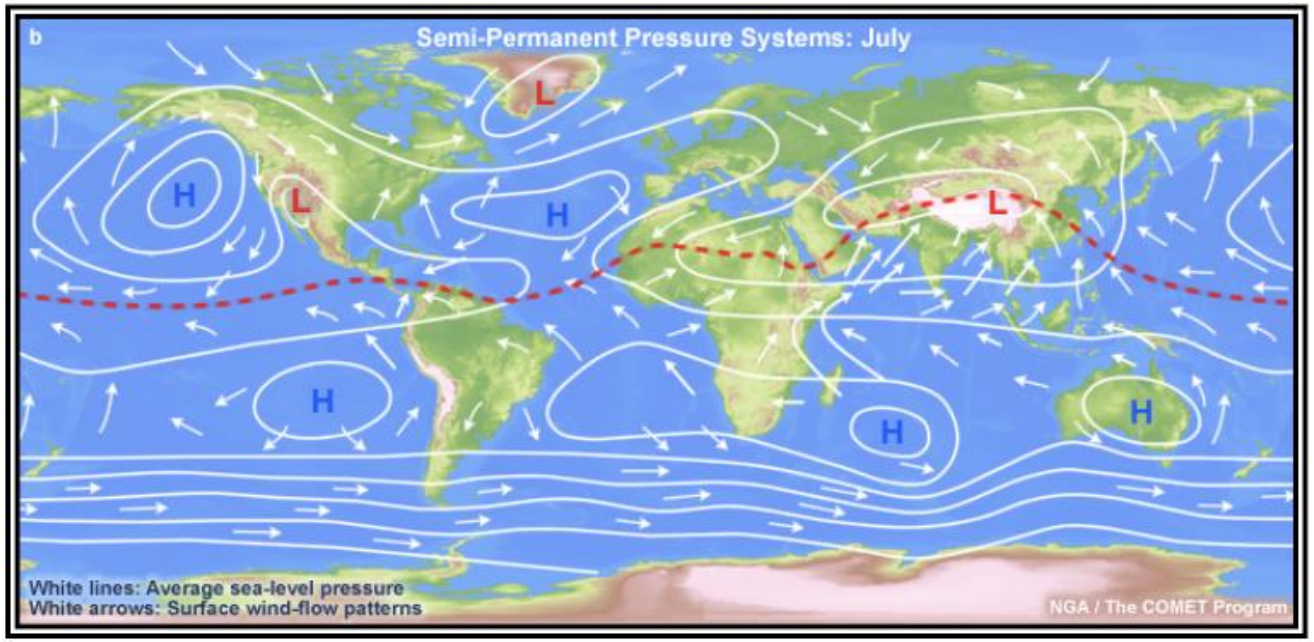
High and Low-Pressure Areas

High pressure areas surrounded by areas of lower pressure



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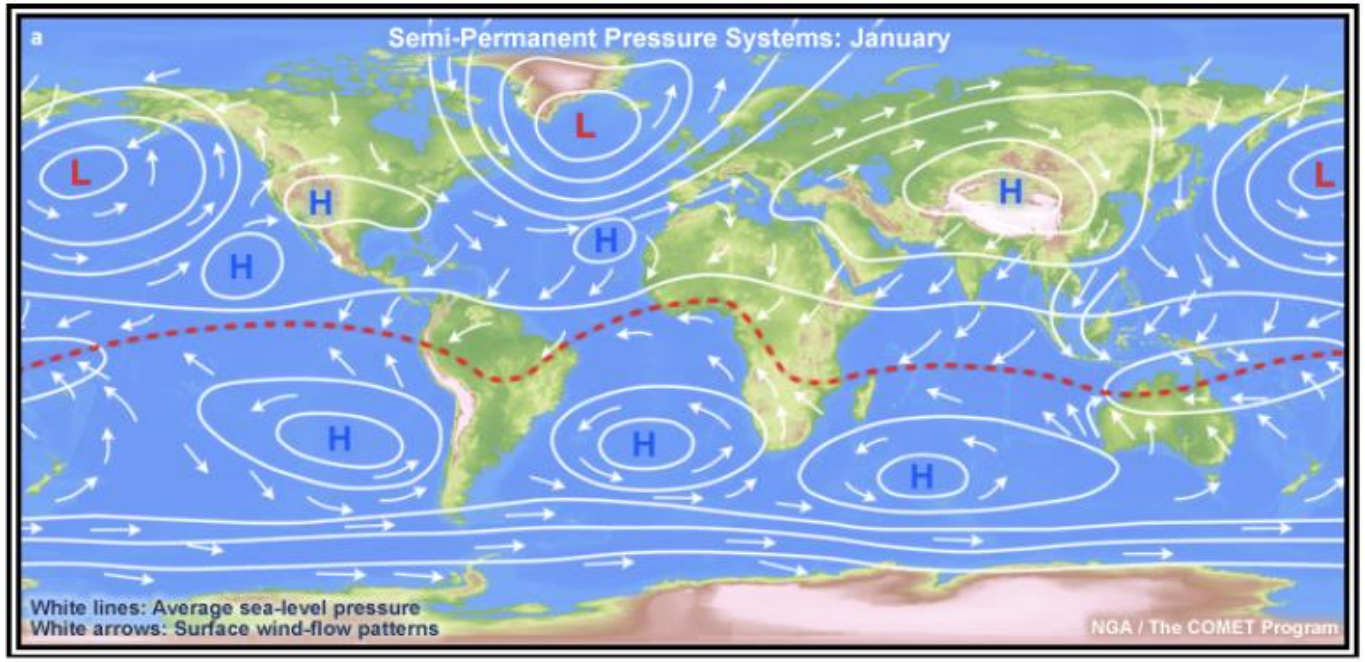
High and Low-Pressure Areas

Low pressure areas surrounded by areas of higher pressure



High and Low-Pressure Areas

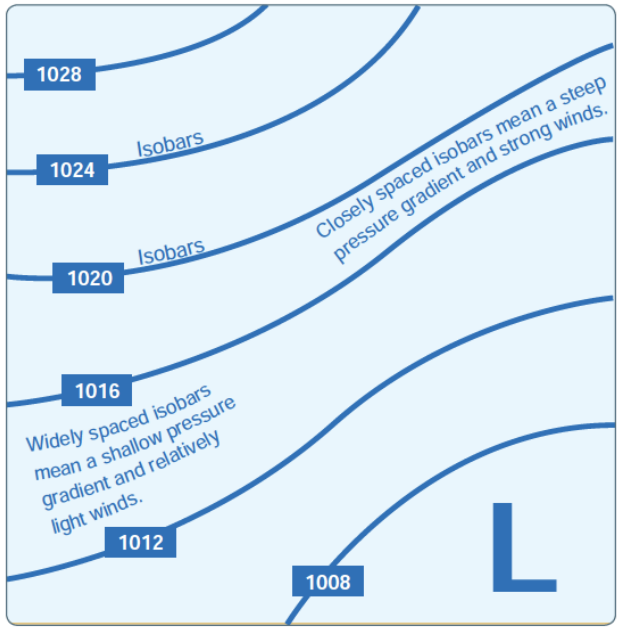
High pressure fills low-pressure areas – matter on the move

High and Low-Pressure Areas

Matter moving - wind

High and Low-Pressure Areas

Closely spaced isobars mean a stronger wind



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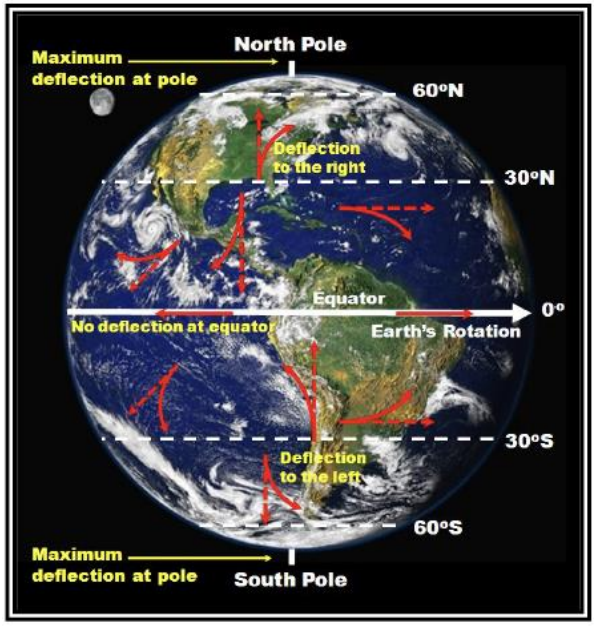
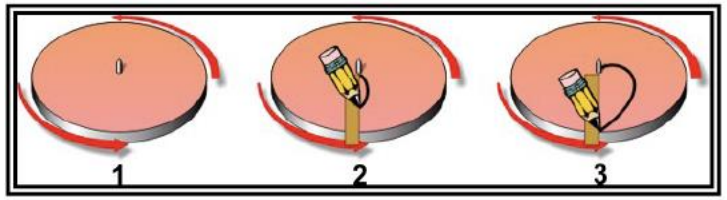
High and Low-Pressure Areas

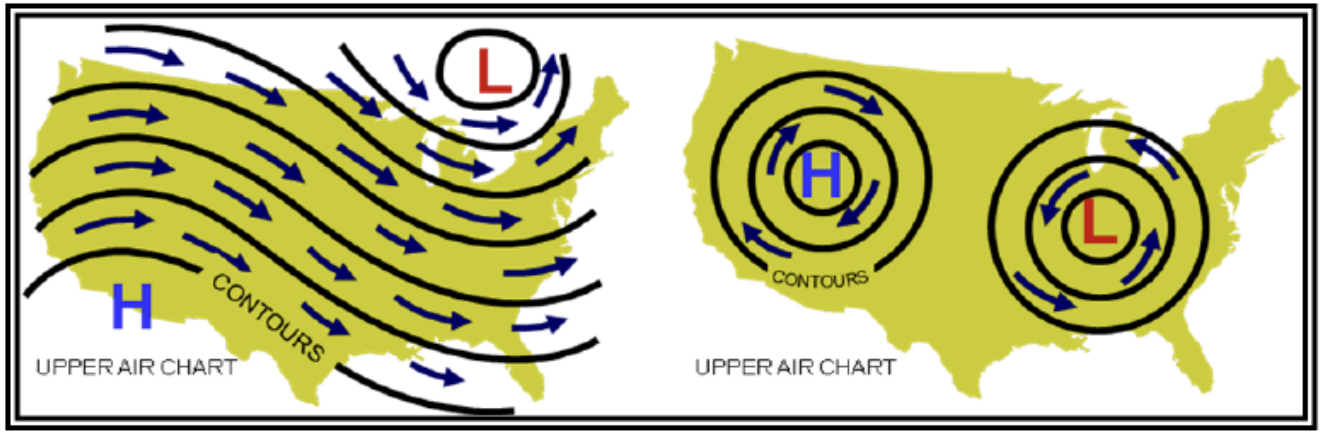
Coriolis force causes the wind to turn to the right





High and Low-Pressure Areas

Wind around a high-pressure area rotates clockwise

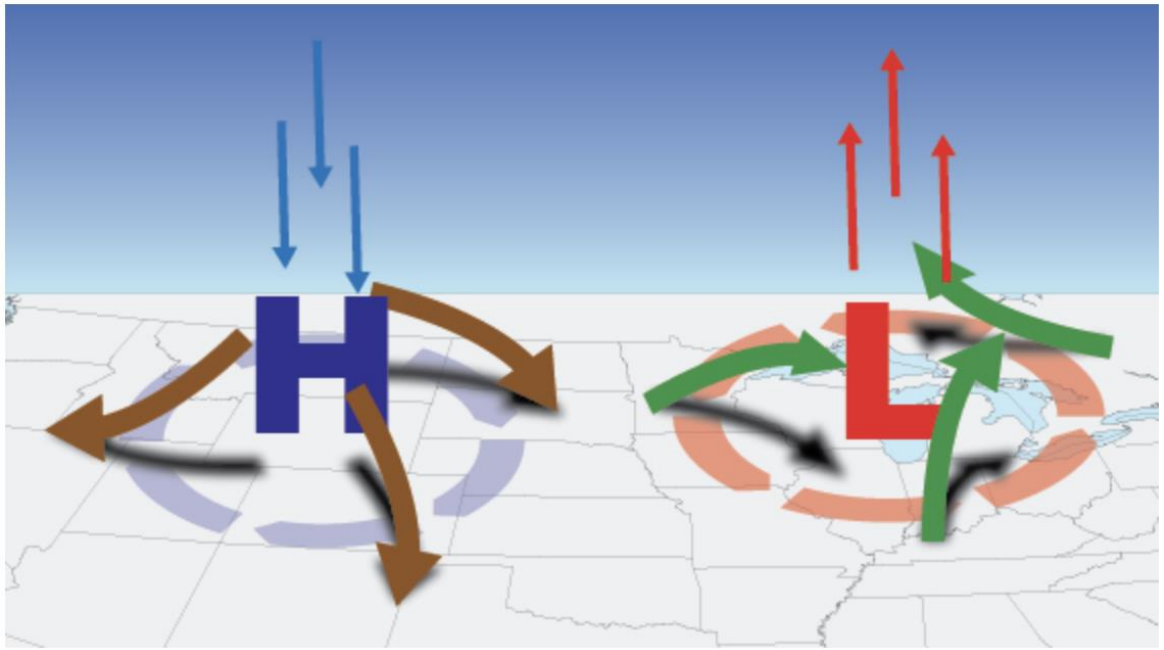


High and Low-Pressure Areas

High pressure area pushes down on the ground and moves lighter objects out of the way like clouds, fog etc.

High and Low-Pressure Areas

Wind around a low-pressure area rotates counter-clockwise

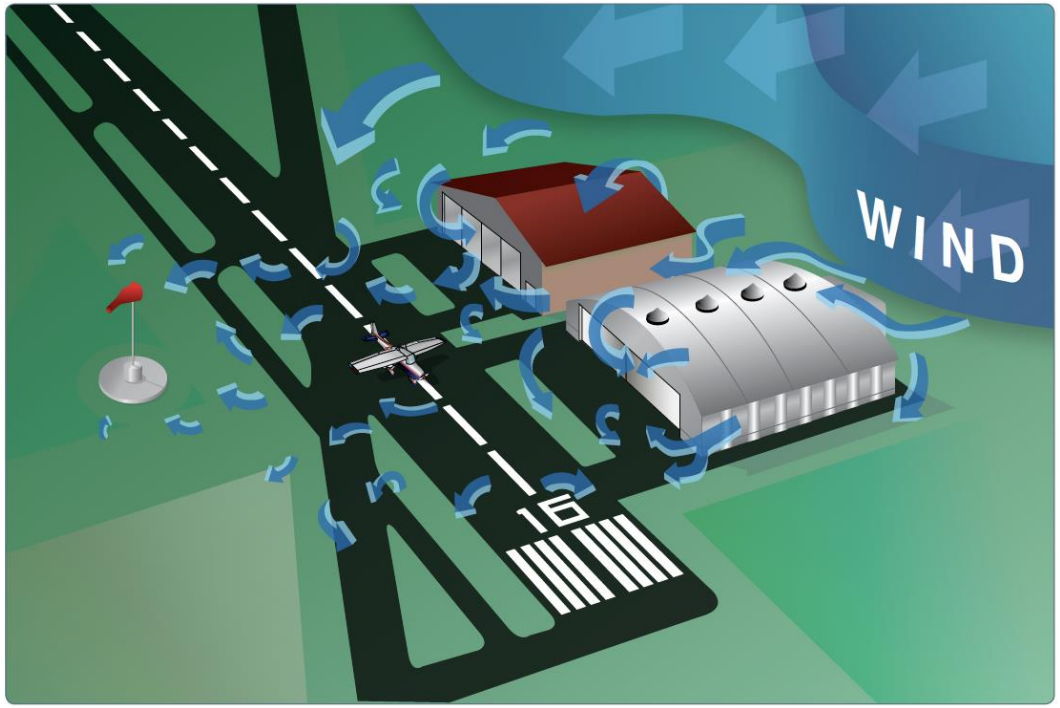


High and Low-Pressure Areas

Low pressure areas draw matter in and cause it to rise as air rises it cools and may condense into clouds etc.

Turbulence and Windshear

Structures can cause different wind currents and turbulence

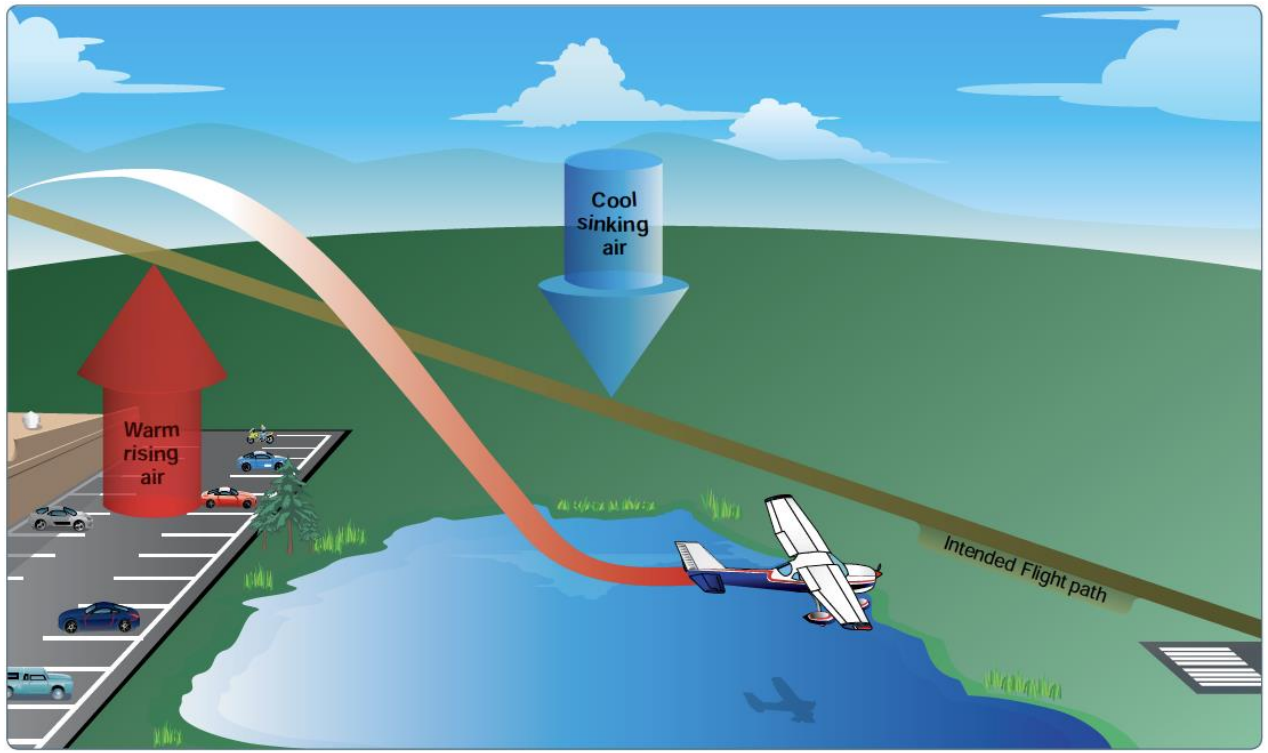


Turbulence and Windshear

Mountains can cause downdrafts/rotors on the leeward side

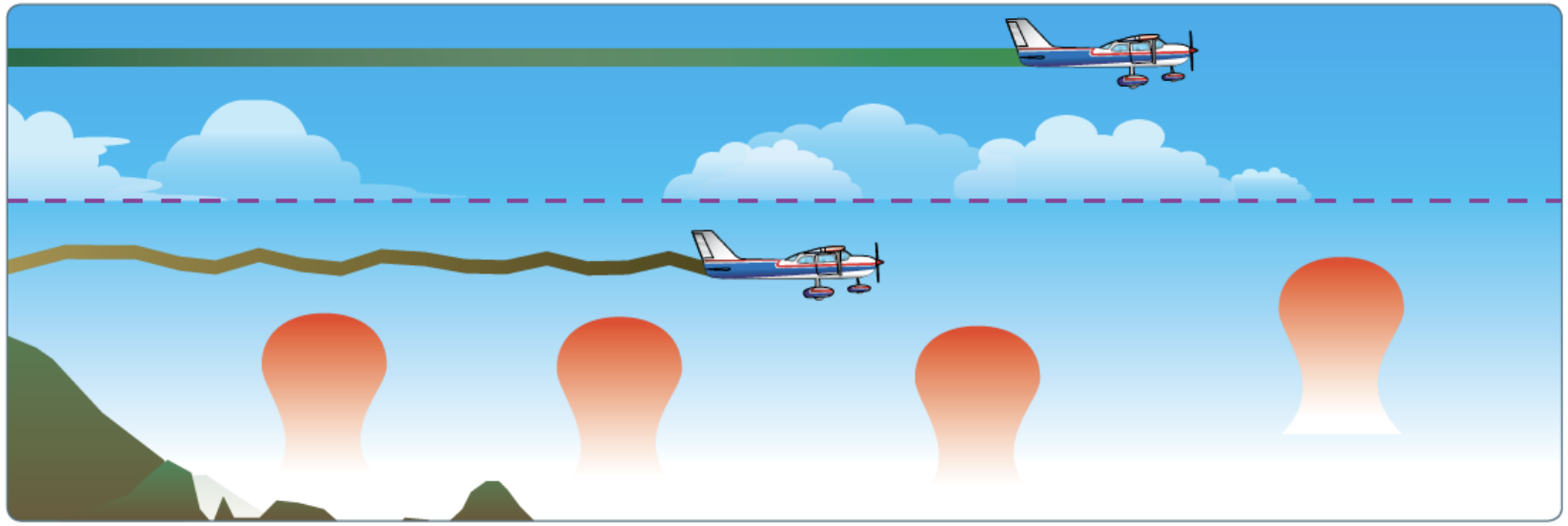
Turbulence and Windshear

Turbulence caused by varying surface conditions



Turbulence and Windshear

Also caused by air currents due to convection – Fly above



Turbulence and Windshear

Windshear is a sudden change in wind speed or direction

Turbulence and Windshear

Windshear results in loss of headwind – Loss of airspeed

Turbulence and Windshear

Or gain of a tailwind – increase in airspeed

Turbulence and Windshear

Causes the airplane to either pitch up or pitch down

Turbulence and Windshear

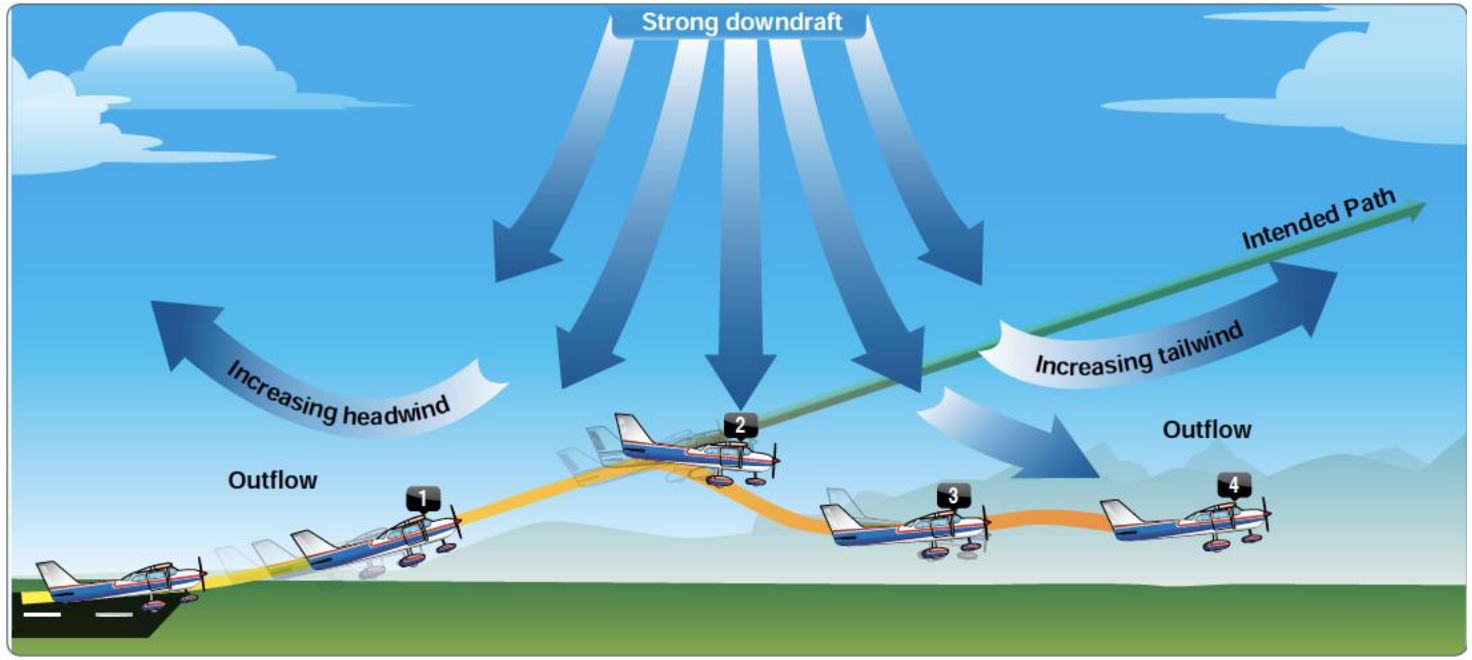
Indicated airspeed are used for takeoff and landing

Turbulence and Windshear

It’s dangerous due to sudden gain/loss of airspeed

Turbulence and Windshear

Effects of a microburst wind



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Turbulence and Windshear

Microbursts have a diameter between 1 and 2 nm

Turbulence and Windshear

Nominal depth of 1000 ft

Turbulence and Windshear

Can cause downdrafts of up to 6000 ft/min

Turbulence and Windshear

Lifespan is 5-15 min

Turbulence and Windshear

Visual indications – Virga at the cloud base and a ring of blowing dust

Turbulence and Windshear

Turbulence Intensity

Turbulence and Windshear

Light – Momentary slight erratic changes in altitude/attitude

Turbulence and Windshear

Moderate – Altitude/Attitude variations, Variations in IAS

Turbulence and Windshear

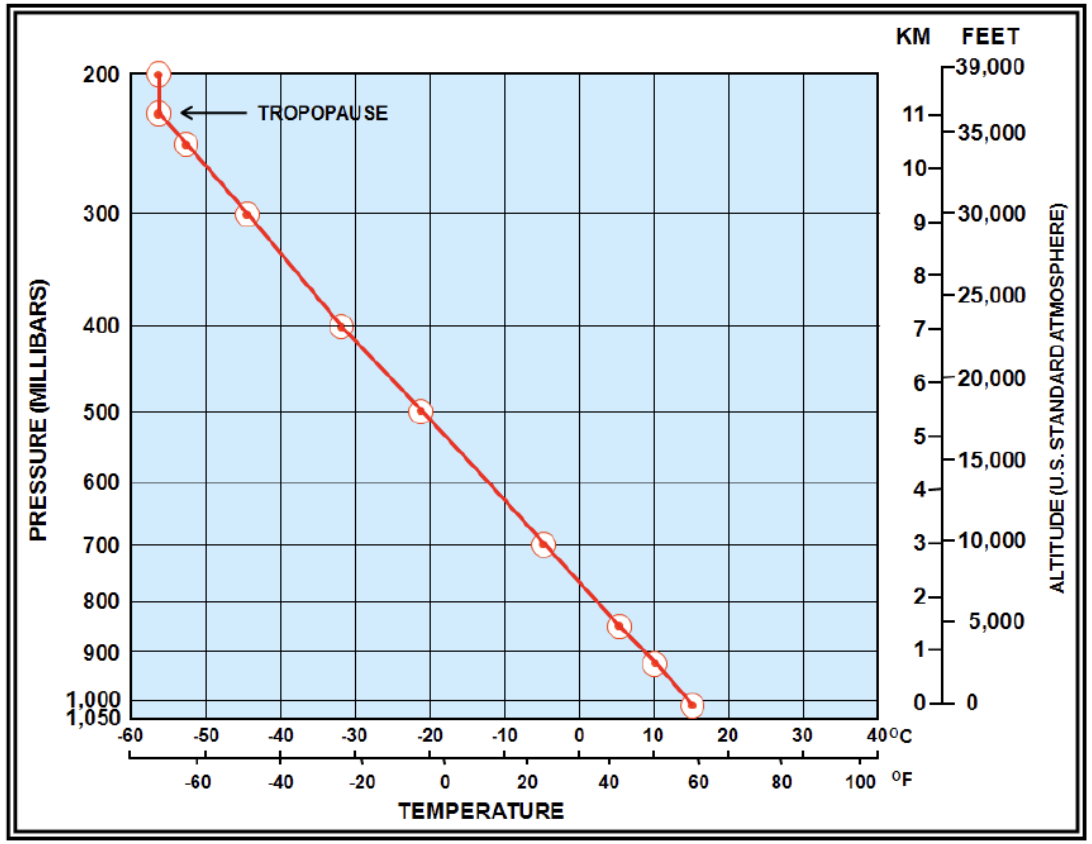
Severe – Large Altitude/Attitude variations, Momentary loss of control

Turbulence and Windshear

Extreme – Violently tossed around, impossible to control

Atmospheric Stability

Air cools at 2°/1000 ft
In dry air



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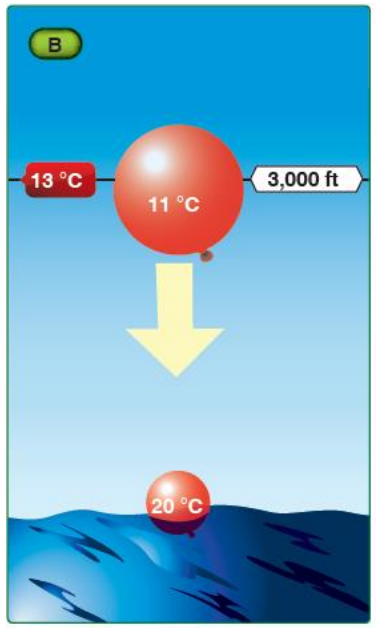
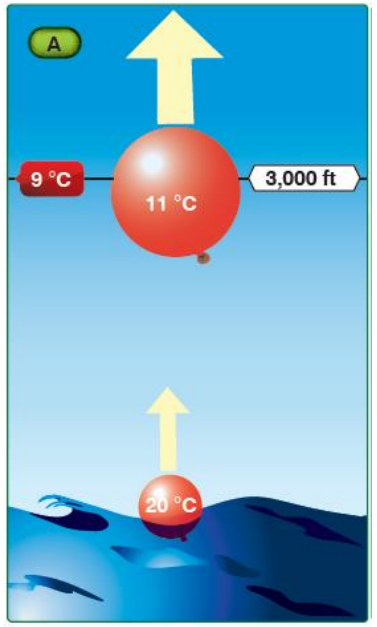
Atmospheric Stability

Air cooling at a lower rate is stable – little movement



Atmospheric Stability

Air cooling at a higher rate is unstable – air can ascend

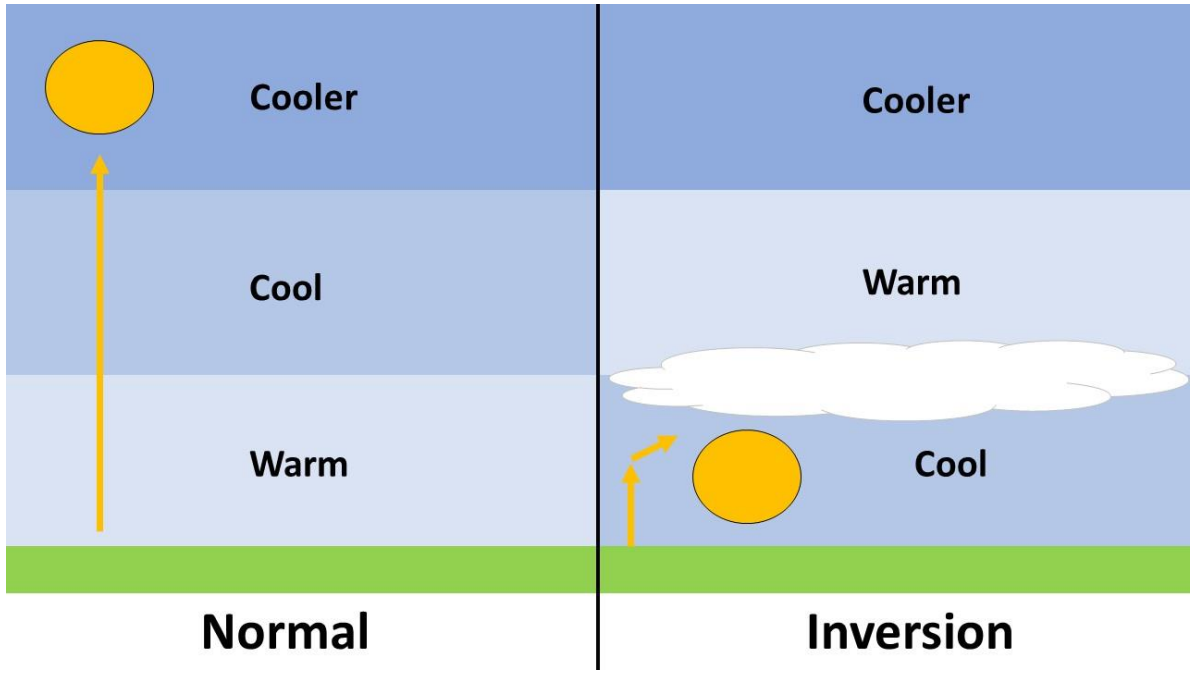


Atmospheric Stability

Stable Air – temp Inversion – temp increases with altitude

Atmospheric Stability

Temp increase with altitude – air can't rise - stable

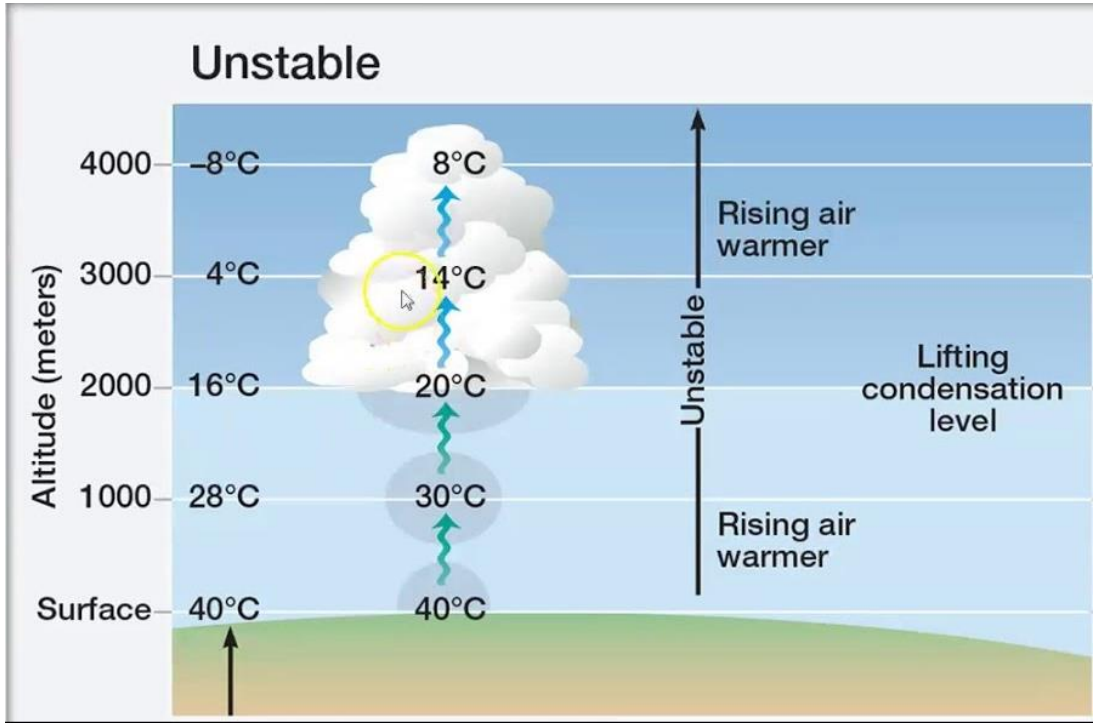


Atmospheric Stability

Smooth – Poor visibility - nothing moves – particles trapped

Atmospheric Stability

Unstable – Air rises – higher lapse rate – more instability



Precipitation, Clouds, Fog and obstructions to visibility

Air has a temperature, dewpoint

Precipitation, Clouds, Fog and obstructions to visibility

Dewpoint – temp that air can no longer hold moisture

Precipitation, Clouds, Fog and obstructions to visibility

If air is cooled to its dewpoint – precipitation will occur

Precipitation, Clouds, Fog and obstructions to visibility

Types of precipitation - fog, mist, rain, snow

Precipitation, Clouds, Fog and obstructions to visibility

Air rising cools – at the dewpoint clouds can form

Precipitation, Clouds, Fog and obstructions to visibility

Clouds continue to grow with instability and moisture

Precipitation, Clouds, Fog and obstructions to visibility

Rain is caused by water vapor lifting in the cloud

Precipitation, Clouds, Fog and obstructions to visibility

Droplets collide with other and combine

Precipitation, Clouds, Fog and obstructions to visibility

When droplets are heavy enough they fall out of the cloud

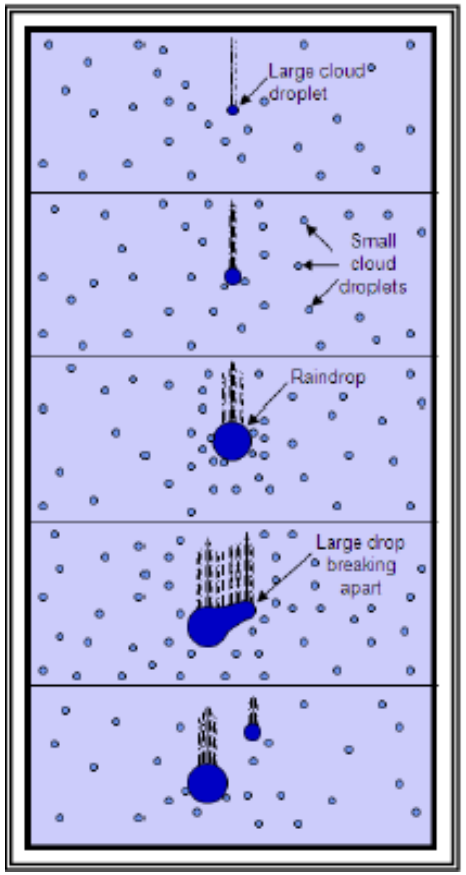
Precipitation, Clouds, Fog and obstructions to visibility

The taller the cloud the more the rain – more droplets

Precipitation, Clouds, Fog and obstructions to visibility

The more unstable the air – taller clouds

Weather Theory



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Precipitation, Clouds, Fog and obstructions to visibility

Fog – a cloud on the ground

Precipitation, Clouds, Fog and obstructions to visibility

Radiation Fog – night-time – earth cools and radiates

Precipitation, Clouds, Fog and obstructions to visibility

The dewpoint and temp are the same or nearly so

Precipitation, Clouds, Fog and obstructions to visibility

Radiation fog - air above the ground cools to the dewpoint

Precipitation, Clouds, Fog and obstructions to visibility

Forms on clear nights – earth can radiate and cool air above

Precipitation, Clouds, Fog and obstructions to visibility

Little to no wind – no thermal mixing (causes heating)

Precipitation, Clouds, Fog and obstructions to visibility

Needs particles to condense on – pollutants, dust, smoke

Precipitation, Clouds, Fog and obstructions to visibility

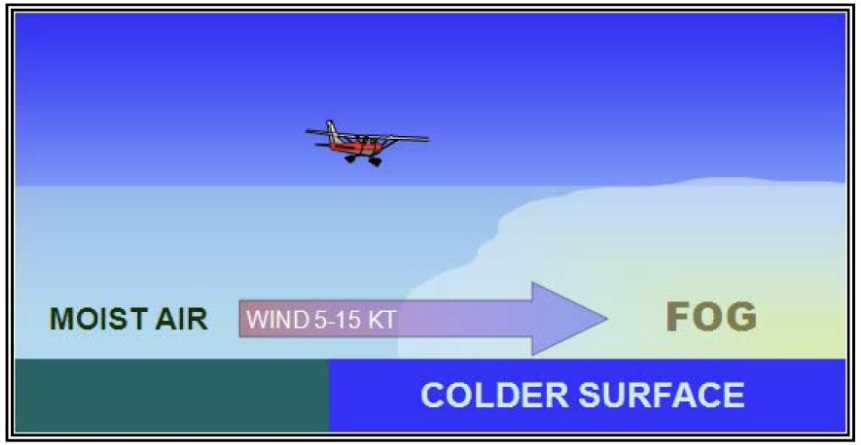
Thin – dissipates quickly after sunrise

Precipitation, Clouds, Fog and obstructions to visibility

Advection Fog – air must be moving

Precipitation, Clouds, Fog and obstructions to visibility

Wind causes moist air to move over colder ground



Precipitation, Clouds and Fog

The air condenses into fog

Precipitation, Clouds, Fog and obstructions to visibility

Is usually thick and clears slowly

Precipitation, Clouds, Fog and obstructions to visibility

Mist – more than 1km visibility

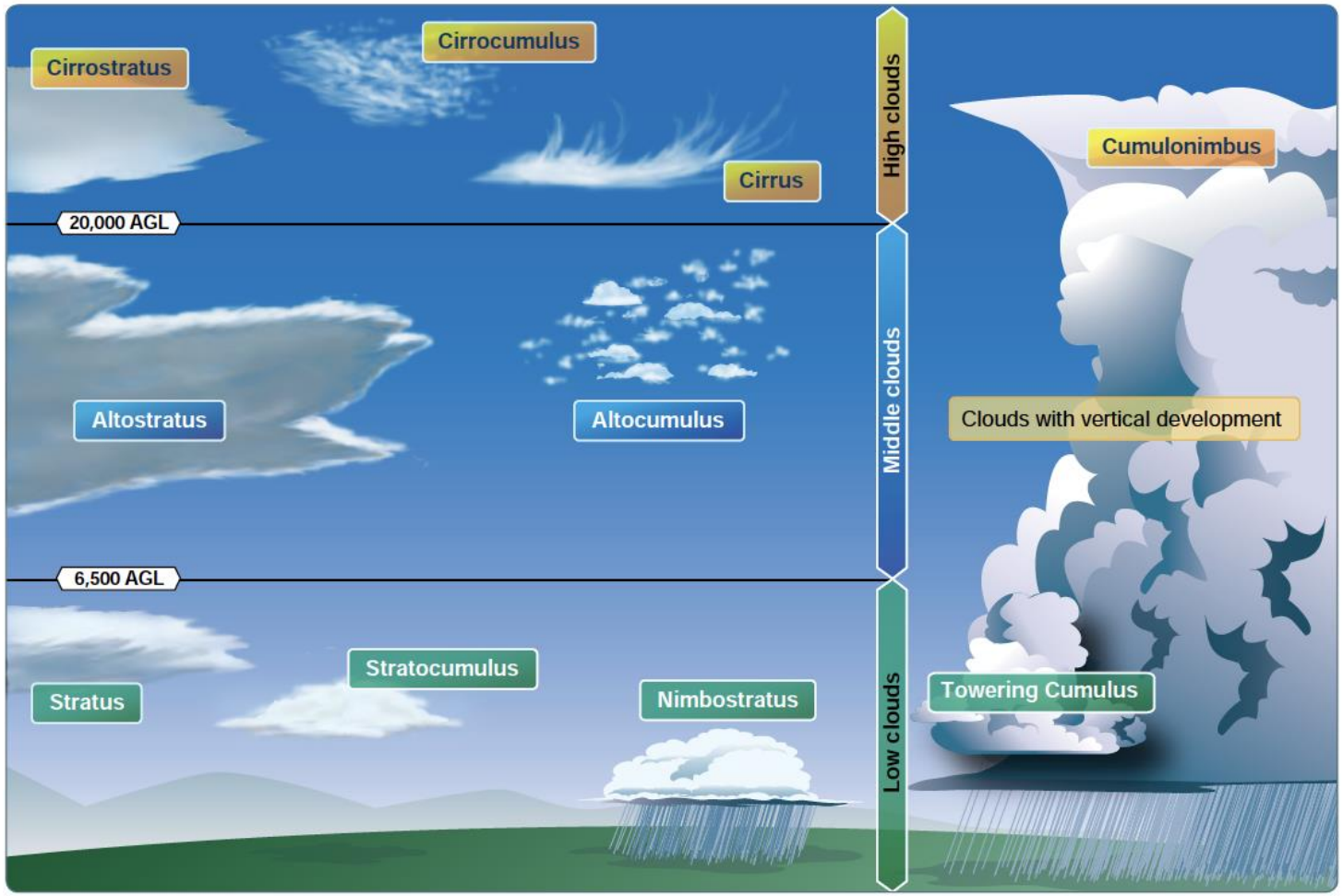
Precipitation, Clouds, Fog and obstructions to visibility

Fog – less than 1km visibility

Precipitation, Clouds, Fog and obstructions to visibility

Cloud Types

Precipitation, Clouds, Fog and obstructions to visibility



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Precipitation, Clouds, Fog and obstructions to visibility

Cumulus – tall and form in unstable air – heavy rain

Precipitation, Clouds, Fog and obstructions to visibility

Stratus – thin and form in more stable air – light rain

Precipitation, Clouds, Fog and obstructions to visibility

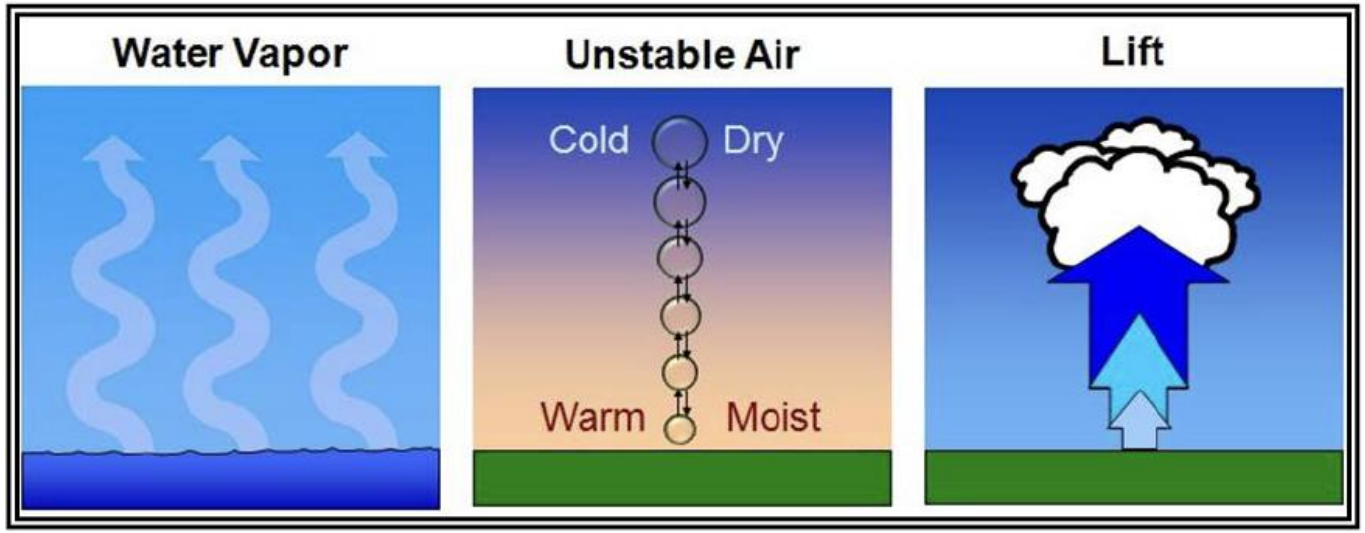
Cirrus – high altitude – mostly ice crystals

Precipitation, Clouds, Fog and obstructions to visibility

Cumulonimbus – thunderstorms

Precipitation, Clouds, Fog and obstructions to visibility

Thunderstorm formation requires



Precipitation, Clouds, Fog and obstructions to visibility

Abundant moisture - fuel

Precipitation, Clouds, Fog and obstructions to visibility

Unstable atmosphere – lifting action

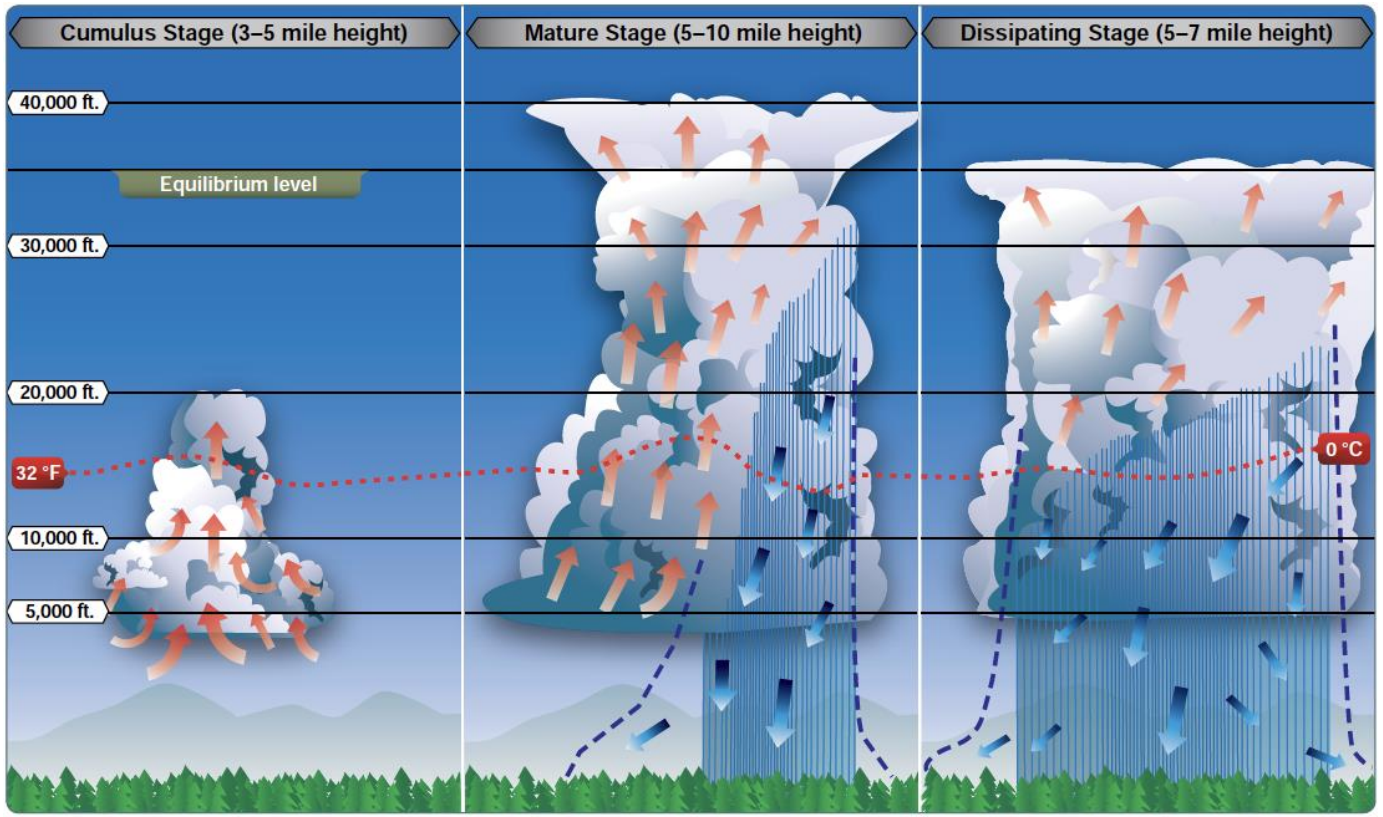
Precipitation, Clouds, Fog and obstructions to visibility

Lift – high heat on the surface or air forced upward

Precipitation, Clouds, Fog and obstructions to visibility

Stages of a thunderstorm

Precipitation, Clouds, Fog and obstructions to visibility



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Precipitation, Clouds, Fog and obstructions to visibility

Cumulus – mostly updrafts and not raining

Precipitation, Clouds, Fog and obstructions to visibility

Mature – up and downdrafts and some rain

Precipitation, Clouds, Fog and obstructions to visibility

Dissipating – downdrafts with heavy rain

Precipitation, Clouds, Fog and obstructions to visibility

Thunder – friction of the airmasses due to collisions

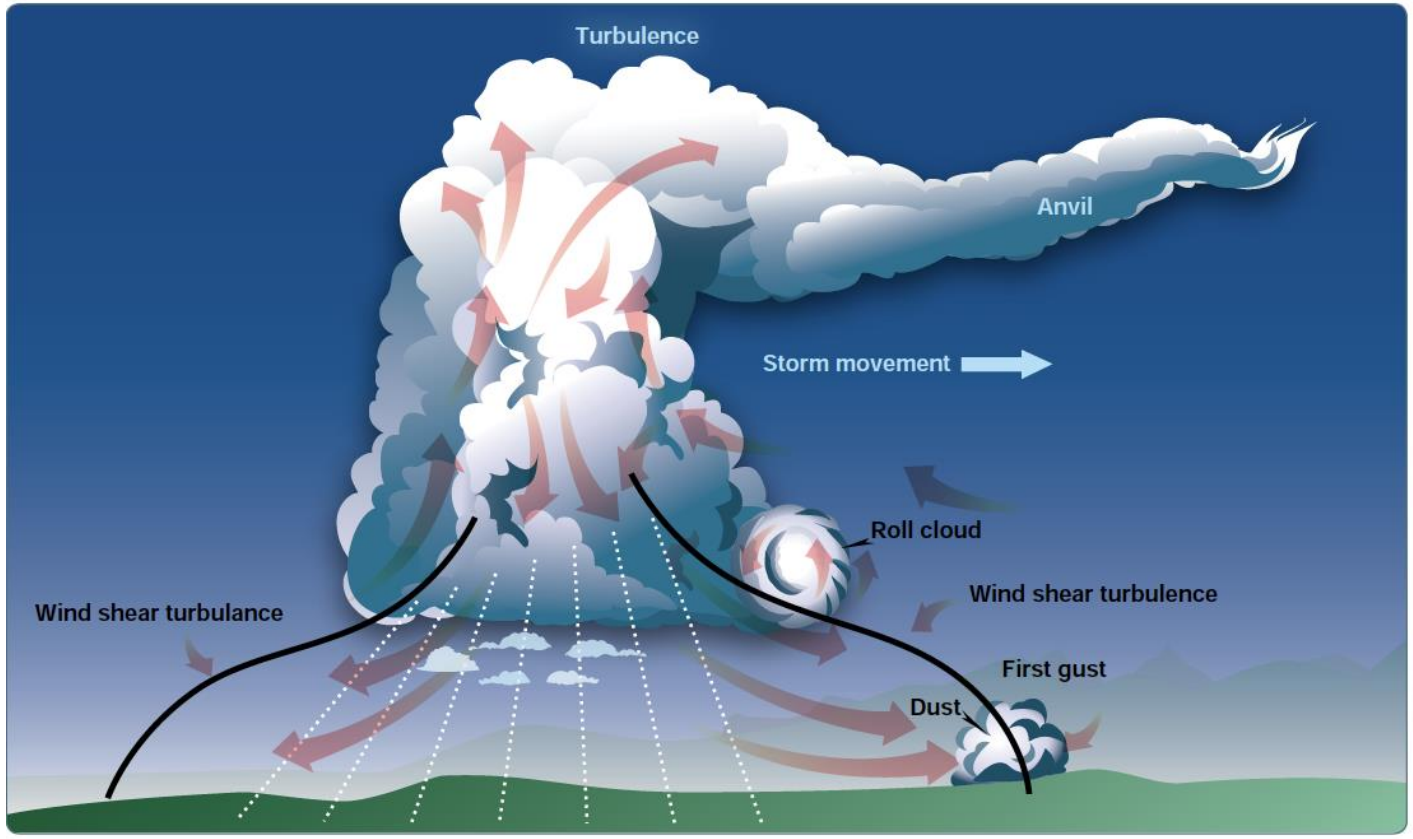
Precipitation, Clouds, Fog and obstructions to visibility

Lightning – energy dissipation

Precipitation, Clouds, Fog and obstructions to visibility

Turbulence around thunderstorms

Precipitation, Clouds, Fog and obstructions to visibility



Precipitation, Clouds, Fog and obstructions to visibility

Obstructions to Visibility

Precipitation, Clouds, Fog and obstructions to visibility

Smoke – Caused by fires

Precipitation, Clouds, Fog and obstructions to visibility

Haze – caused by pollutants

Precipitation, Clouds, Fog and obstructions to visibility

Dust – caused by blowing dry particles

Precipitation, Clouds, Fog and obstructions to visibility

Volcanic Ash – caused by volcano eruptions

Icing, Freezing Level Information and Frost

Ice forms when visible moisture is exposed to freezing temperatures

Icing, Freezing Level Information and Frost

Because airplanes develop lift, low pressure above a wing causes air to accelerate and the temperature to drop

Icing, Freezing Level Information and Frost

This means that ice may form above ambient freezing temperature by a degree or two

Icing, Freezing Level Information and Frost

Frost forms when on calm clear nights moisture condenses on an airfoil

Icing, Freezing Level Information and Frost

If the ambient air or surface is at or below freezing a thin layer of ice, rough in texture forms - Frost

Icing, Freezing Level Information and Frost

Any ice, frost or snow must be removed before flight

Icing, Freezing Level Information and Frost

Freezing level information is included on

Icing, Freezing Level Information and Frost

Winds aloft forecasts - FB

Icing, Freezing Level Information and Frost

Airmets

Icing, Freezing Level Information and Frost

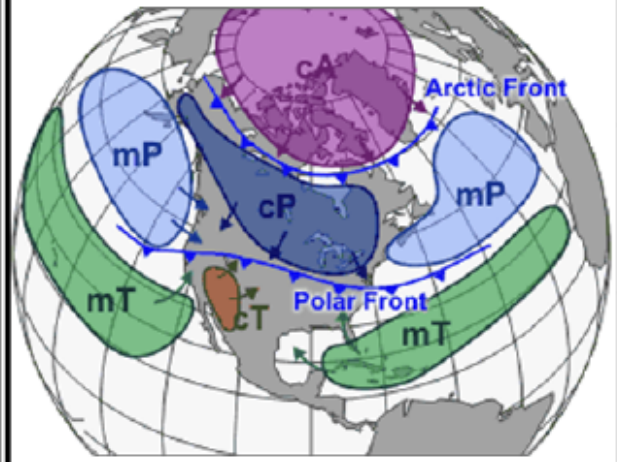
Graphical Forecast for Aviation - GFA

Frontal Characteristics and Movement

Front – marked change in temp over a short distance

Frontal Characteristics and Movement

When airmasses collide a warm or cold front forms



SOURCE REGION	Continental (c)	Maritime (m)
Arctic (A)	Continental Arctic (cA) *(Cold, dry)*	*Not Applicable*
Polar (P)	Continental Polar (cP) *(Cold, dry)*	Maritime Polar (mP) *(Cool, moist)*
Tropical (T)	Continental Tropical (cT) *(Hot, dry)*	Maritime Tropical (mT) *(Warm, moist)*

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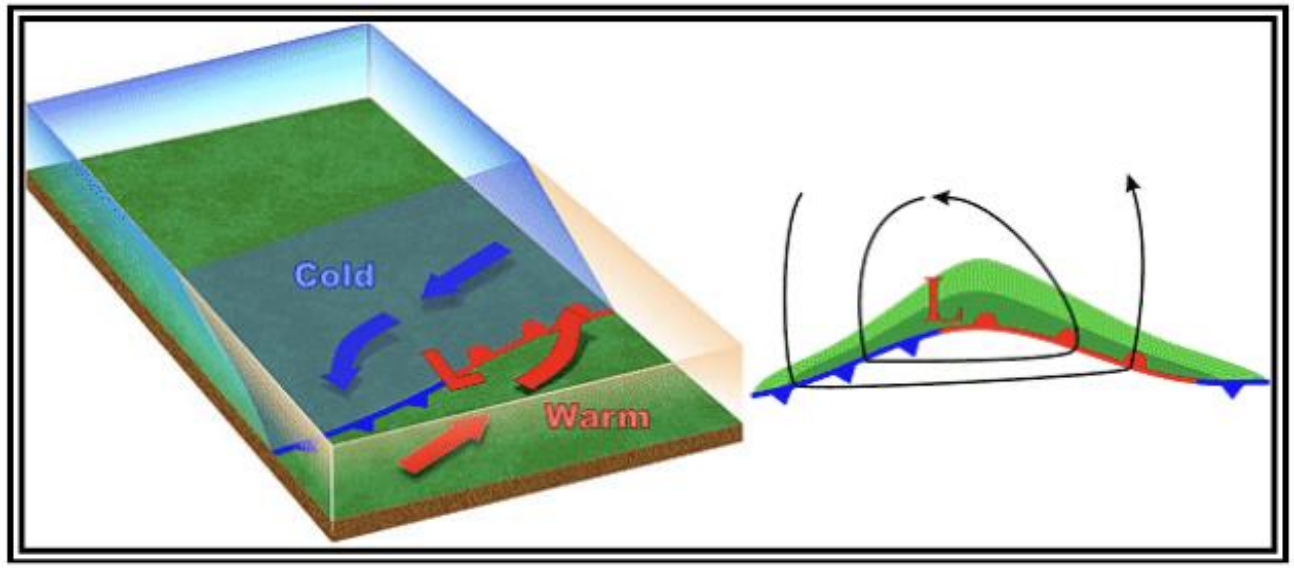
Frontal Characteristics and Movement

FRONT	CHART SYMBOL	DEFINITION
Cold Front		A front that moves in such a way that colder air replaces warmer air.
Warm Front		A front that moves in such a way that warmer air replaces colder air.
Stationary Front		A front which is stationary or nearly so.
Occluded Front		A composite of two fronts as a cold front overtakes a warm front or stationary front.
Note: Frontal symbols point in the direction of frontal movement.		

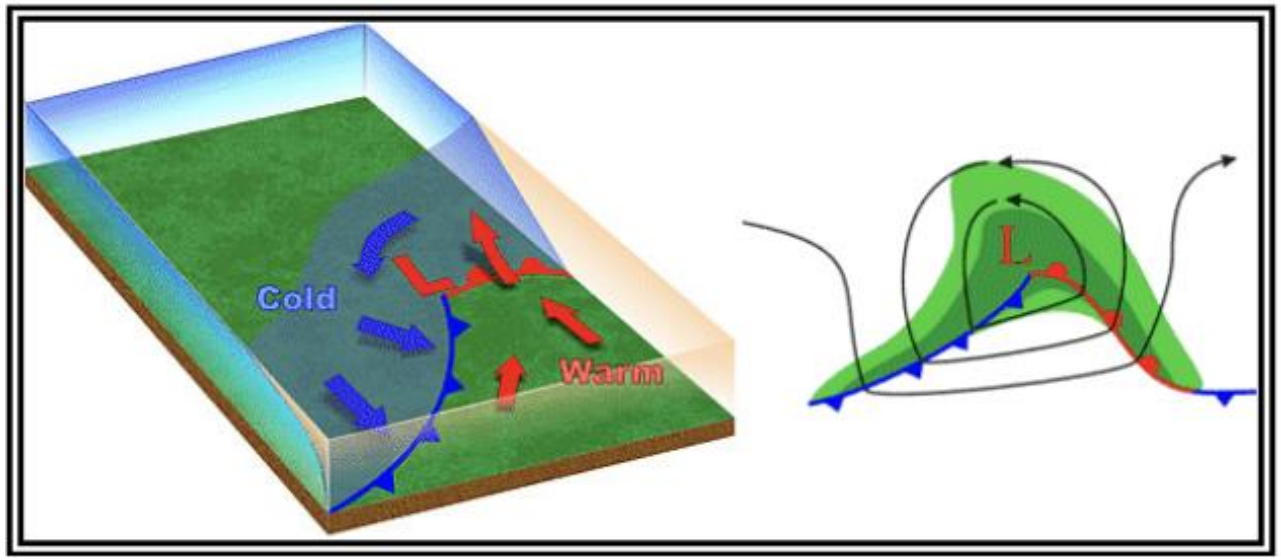
Frontal Characteristics and Movement

Fronts form from a low-pressure area



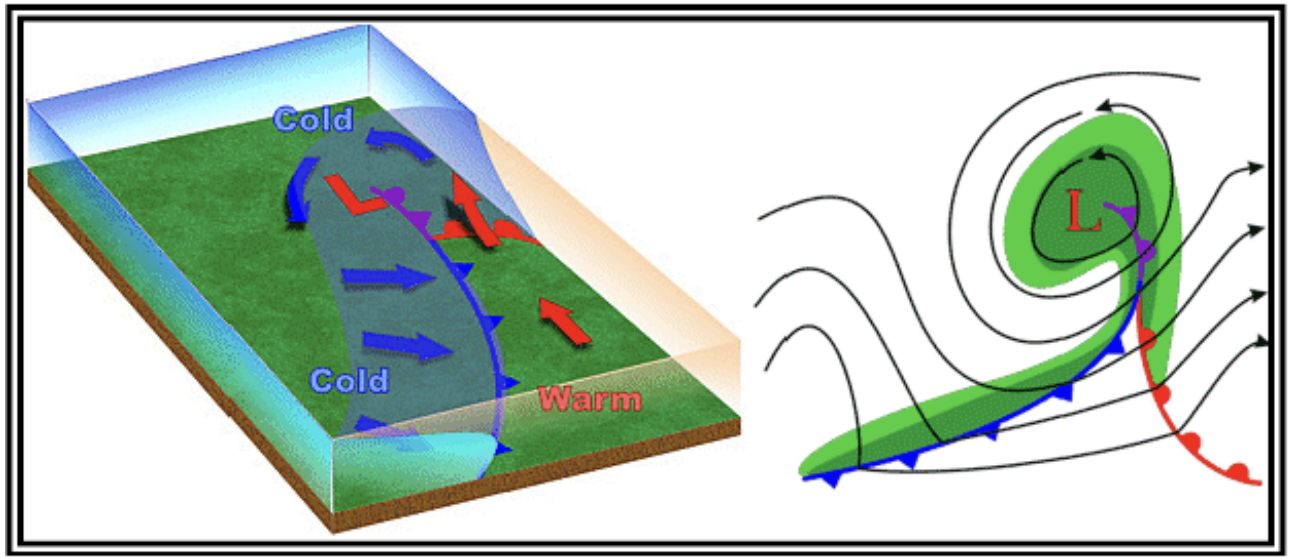
Frontal Characteristics and Movement

Cold fronts move faster than warm fronts and catch up



Frontal Characteristics and Movement

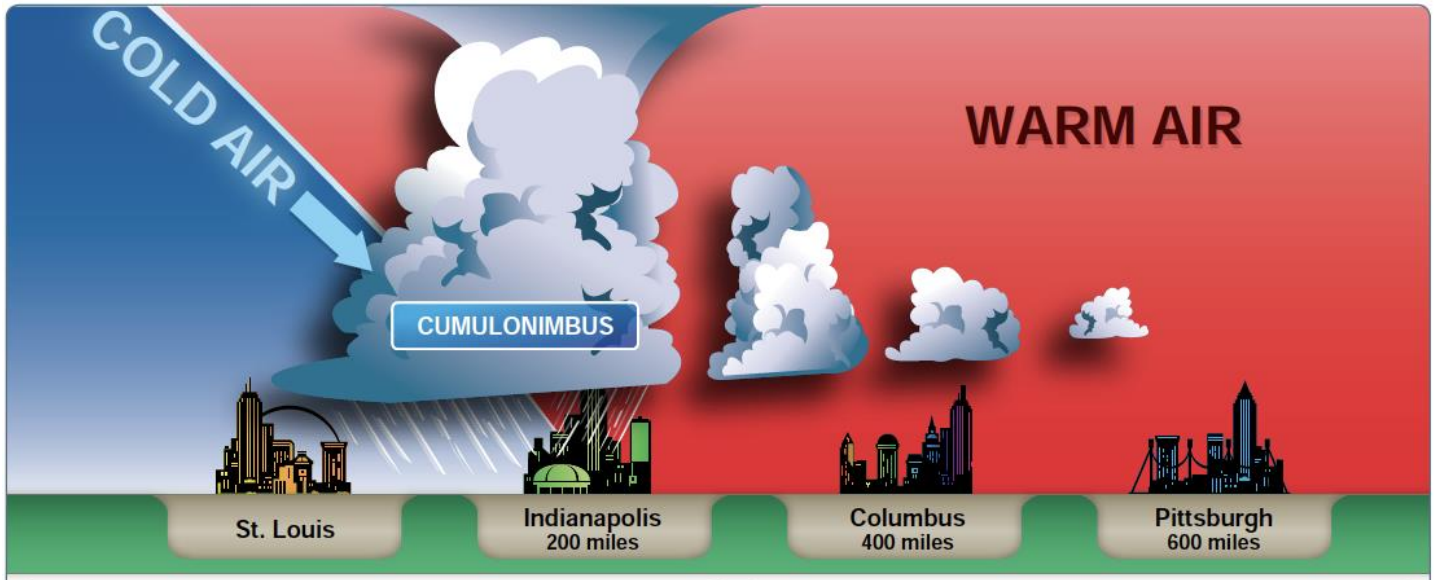
The fronts combine and form an occlusion

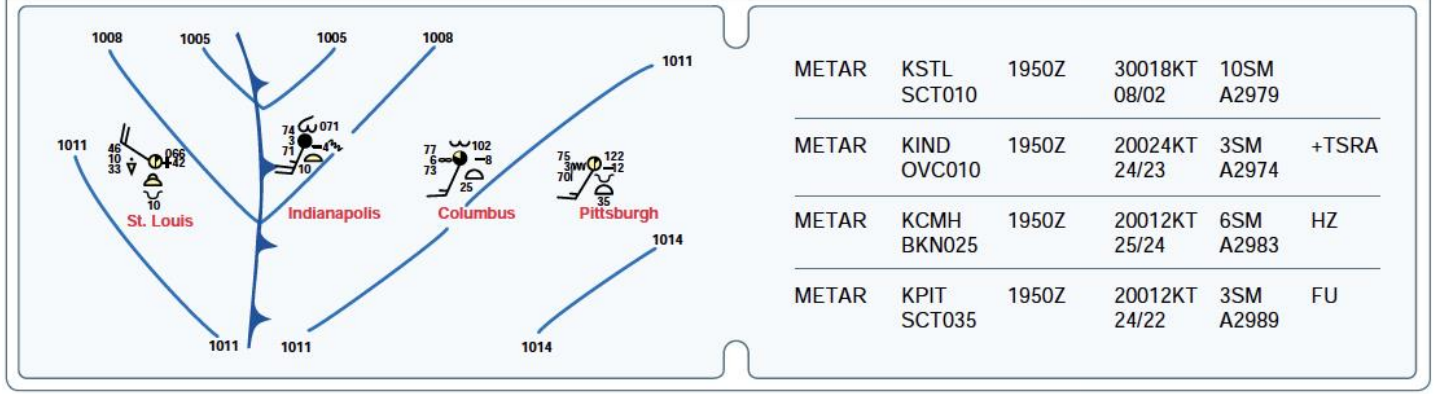


Frontal Characteristics and Movement

Cold Front – cold air overtaking warmer air – pushes air up

Frontal Characteristics and Movement





METAR	KSTL SCT010	1950Z	30018KT 08/02	10SM A2979	
METAR	KIND OVC010	1950Z	20024KT 24/23	3SM A2974	+TSRA
METAR	KCMH BKN025	1950Z	20012KT 25/24	6SM A2983	HZ
METAR	KPIT SCT035	1950Z	20012KT 24/22	3SM A2989	FU

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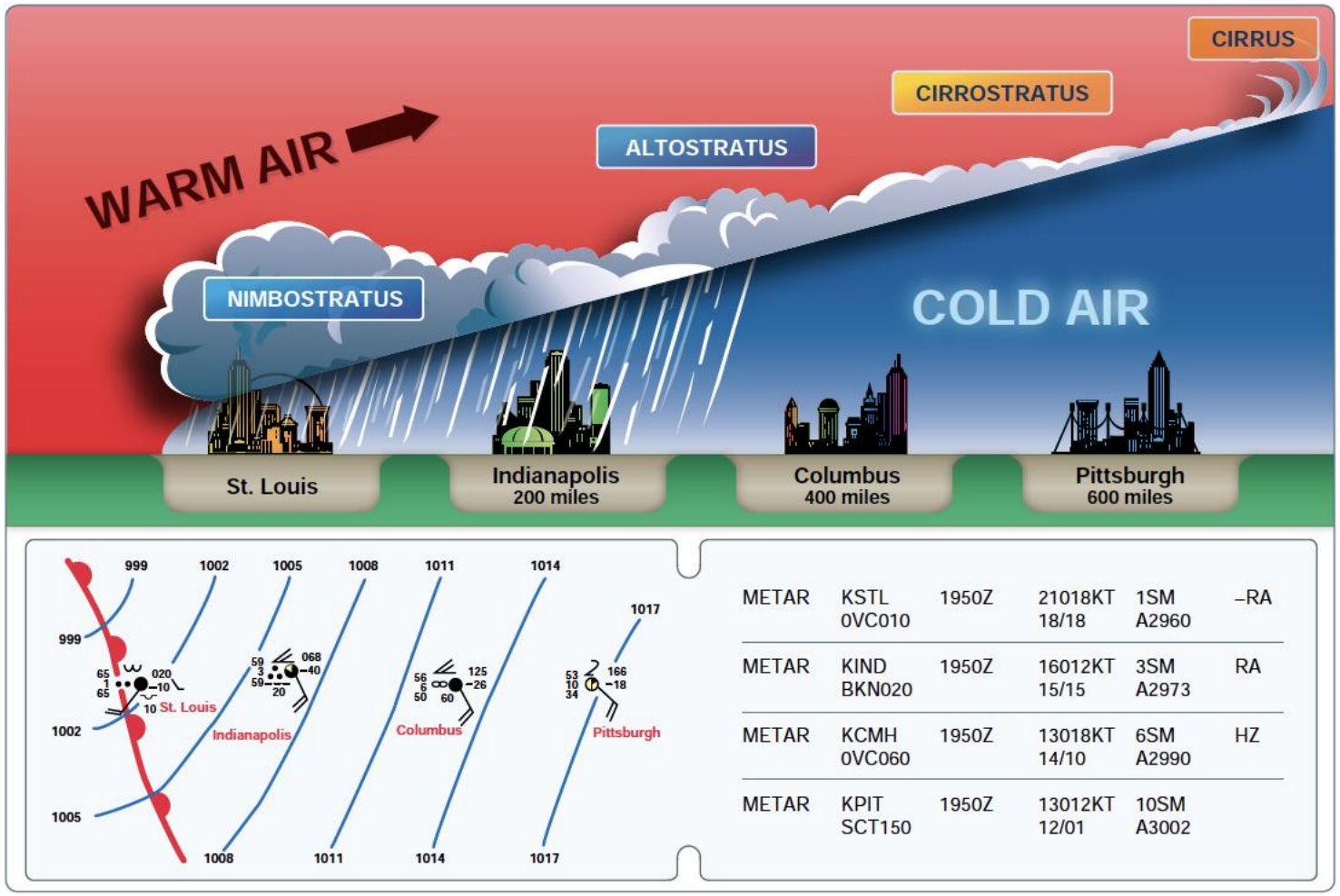
Frontal Characteristics and Movement

Warm Front – warm air slides on top of colder air – less vertical development

Frontal Characteristics and Movement



METAR	KSTL 0VC010	1950Z	21018KT 18/18	1SM A2960	–RA
METAR	KIND BKN020	1950Z	16012KT 15/15	3SM A2973	RA
METAR	KCMH 0VC060	1950Z	13018KT 14/10	6SM A2990	HZ
METAR	KPIT SCT150	1950Z	13012KT 12/01	10SM A3002	

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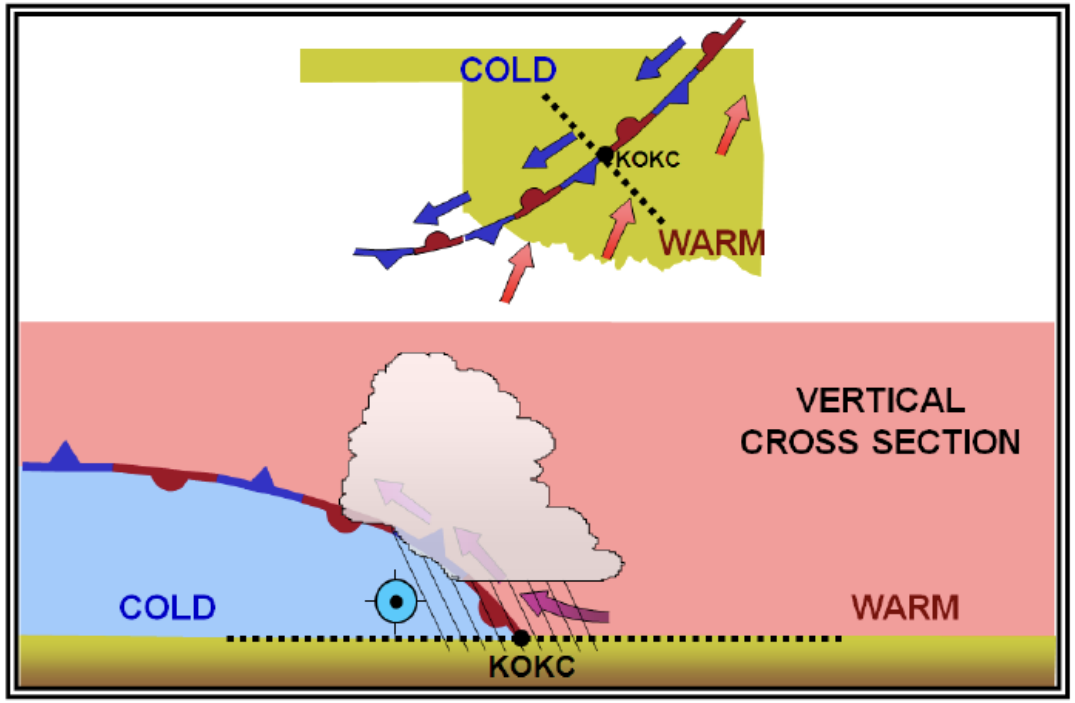
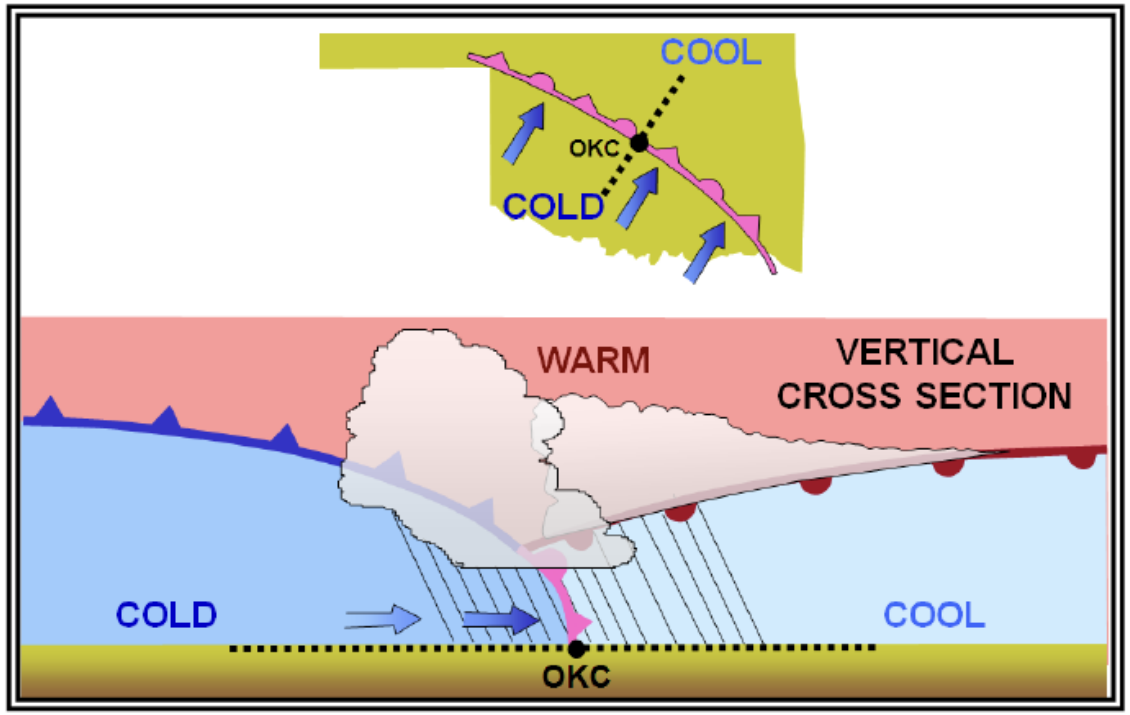
Frontal Characteristics and Movement

Stationary Front – front that is not moving or moving little

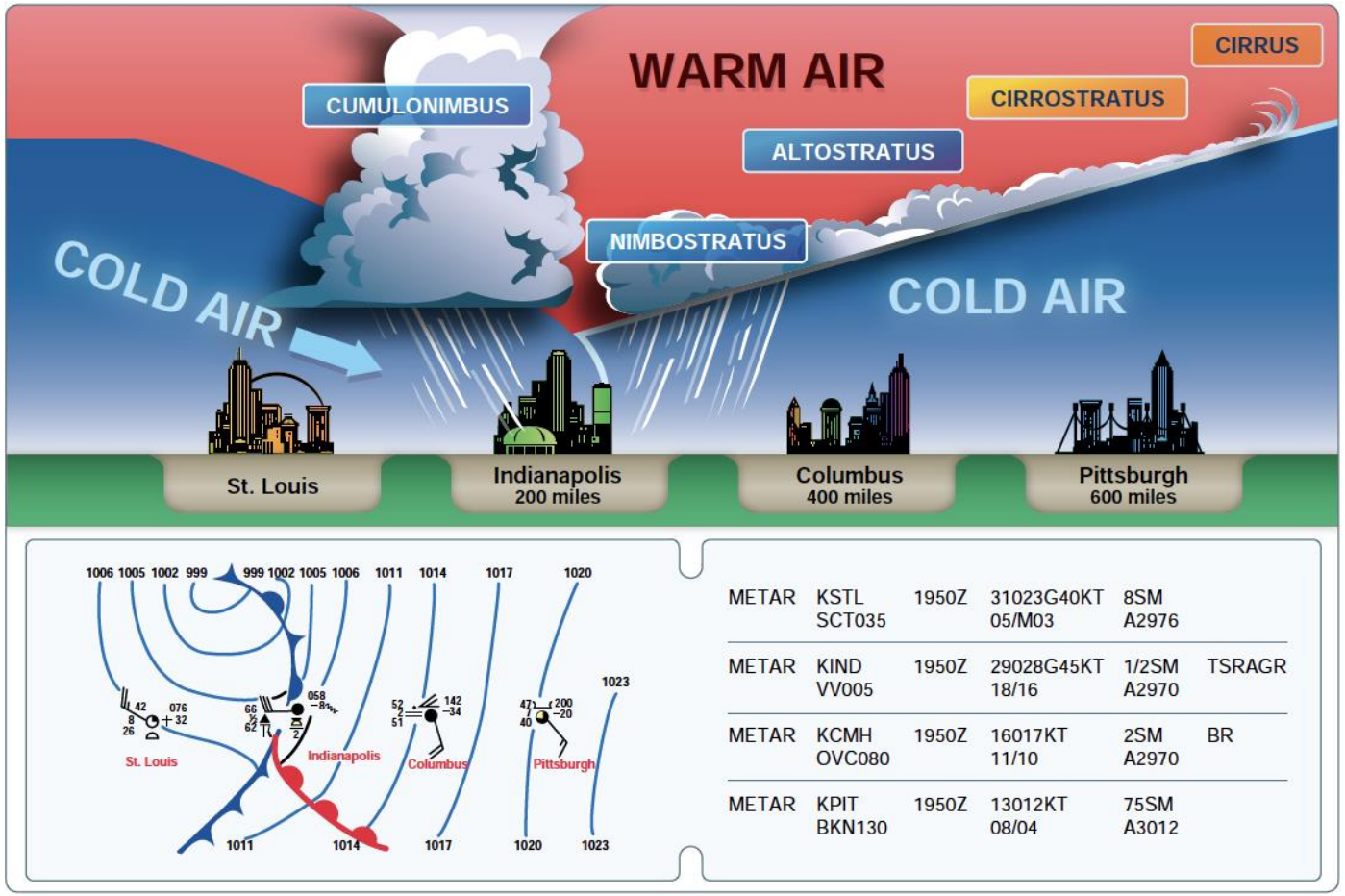


Frontal Characteristics and Movement

Occluded Front – when a cold front catches a warm front



Frontal Characteristics and Movement



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Lifespans associated with weather events