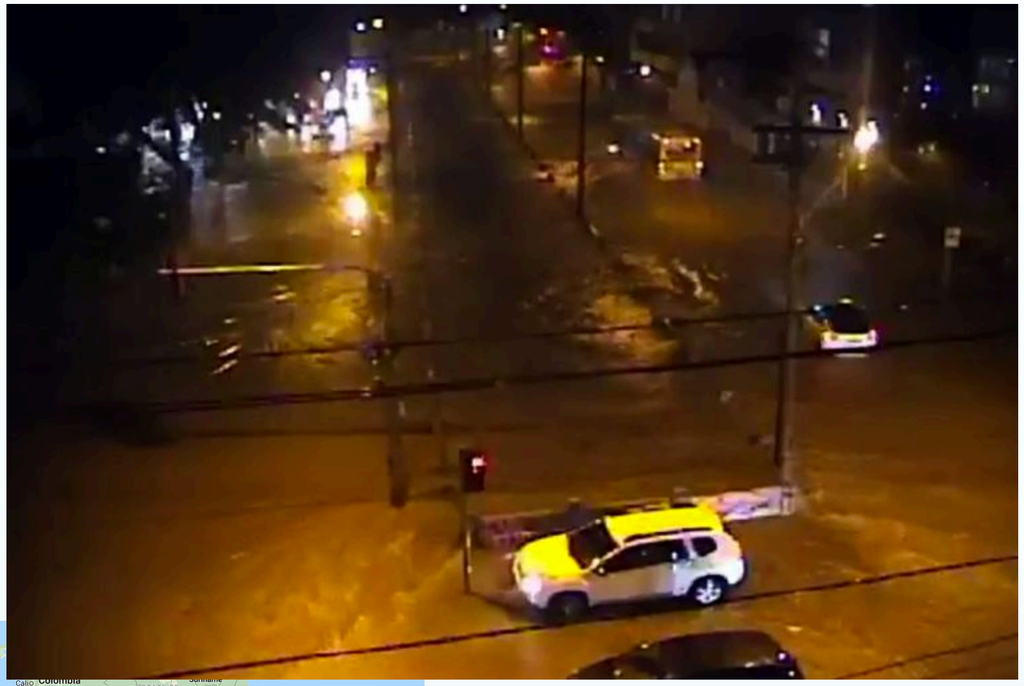
ATM S 103

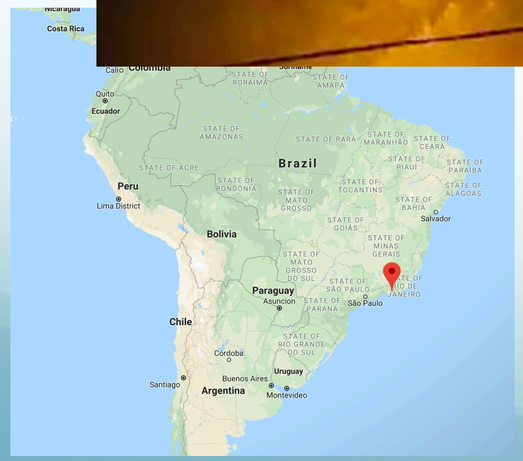
Hurricanes and Thunderstorms

Their Science and Impacts

A deadly storm in Rio De Janeiro

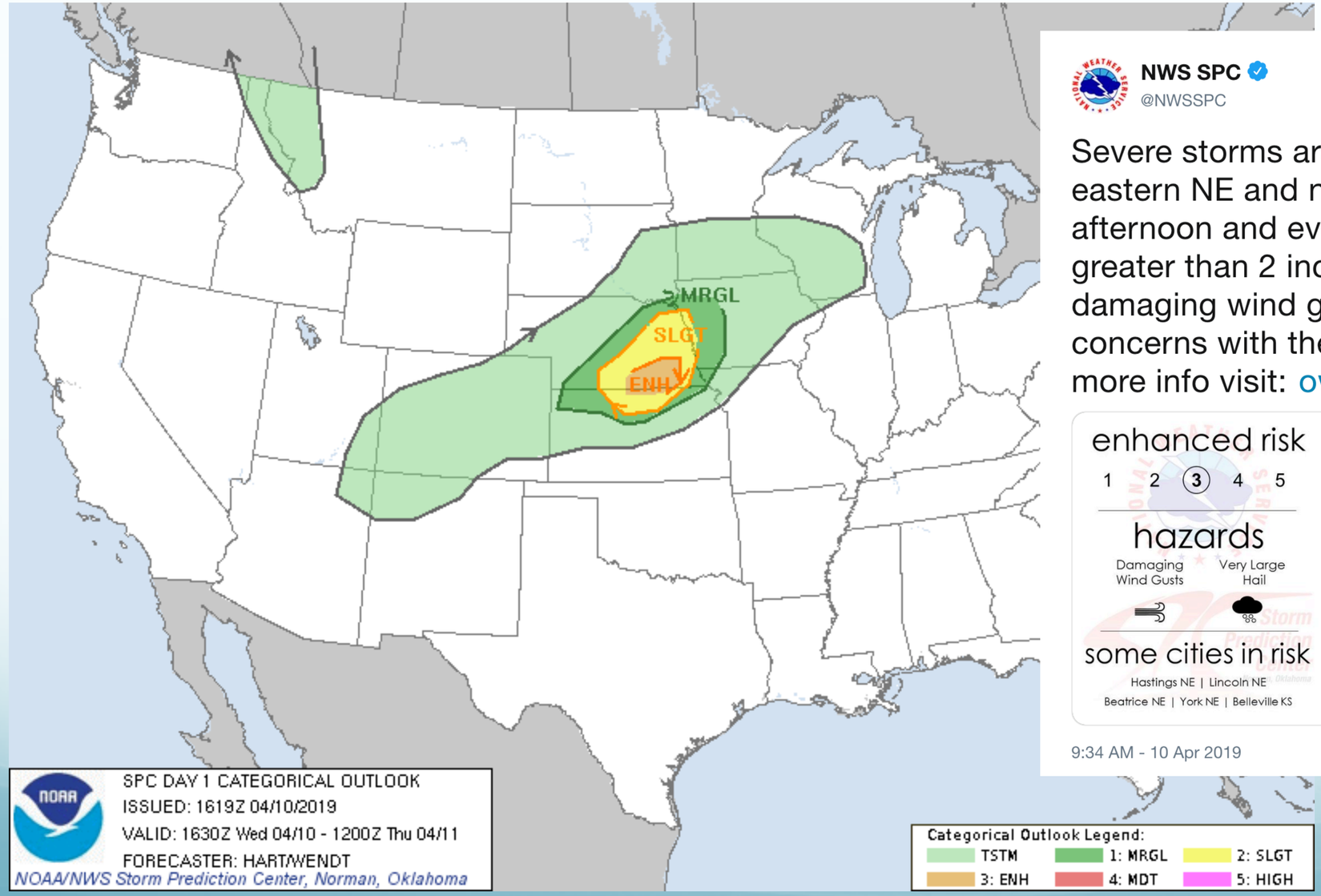


More than 300mm of rain in 24 hours to 09 April, in some cases more than 3 times the monthly average.
The city declared a state of crisis late on Monday, 08 April.
At least 10 people have been killed by flash floods in Rio de Janeiro after a storm brought strong winds and massive amounts of rain.



Source: http://floodlist.com/america/brazil-rio-floods-april-2019; https://www.youtube.com/watch?v=Gzq40LVSBqA

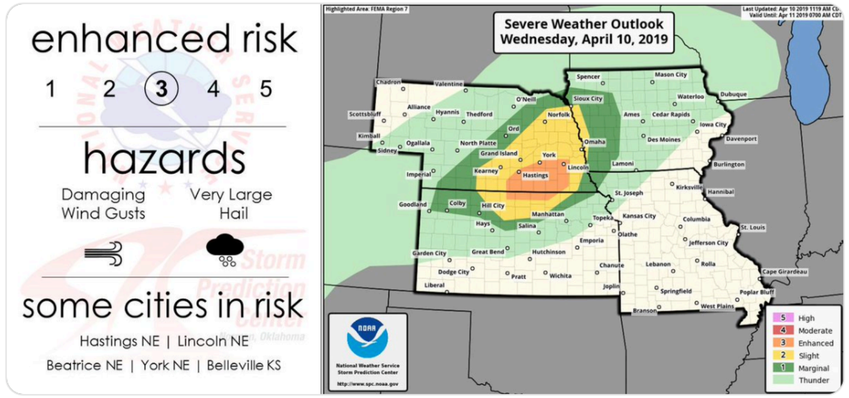
An enhanced risk of severe thunderstorms today



NWS SPC
@NWSSPC

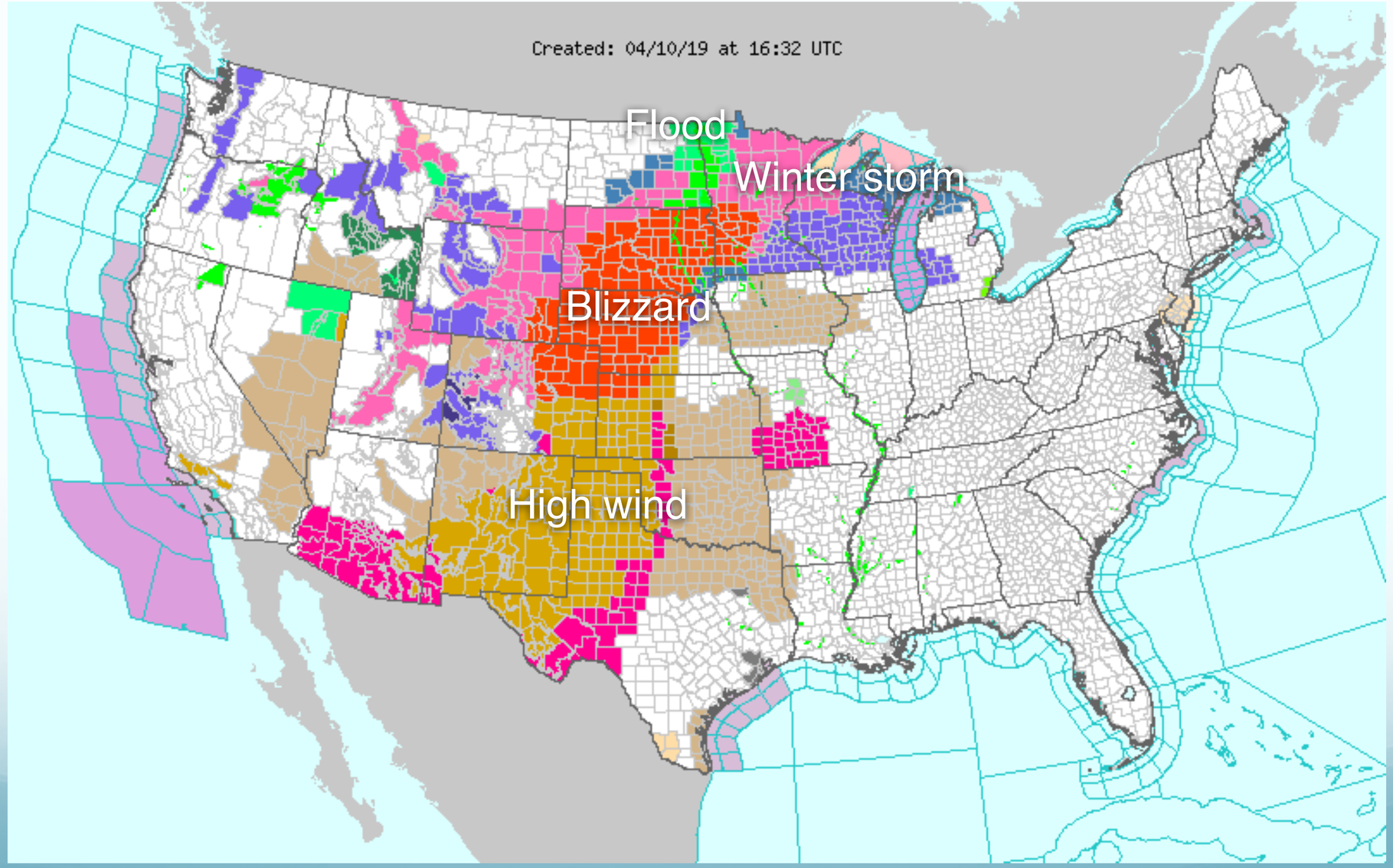
Follow

Severe storms are expected over parts of eastern NE and north-central KS this afternoon and evening. Large hail, some greater than 2 inches in diameter, and damaging wind gusts are the primary concerns with these storms later today. Fore more info visit: ow.ly/qdGR50pL0cz

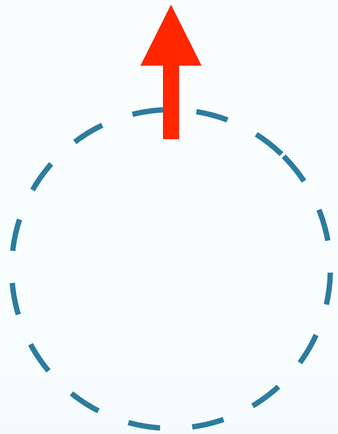


9:34 AM - 10 Apr 2019

And.. other warnings for today



A rising air parcel



What is NOT happening when an air parcel is raised up?

it expands

its temperature goes down

its relative humidity goes up

its saturation vapor pressure goes up

Answer: its saturation vapor pressure goes up

- As an air parcel rises
  - it expands
  - its temperature goes down
  - its saturation vapor pressure decreases
  - its relative humidity increases

$$\text{Relative humidity} = \frac{\text{(actual) Vapor pressure}}{\text{Saturation vapor pressure}} \times 100$$

Question for Today: What fuels the rising motion in cumulus clouds?

https://www.youtube.com/watch?v=0YatiDf9A8A

When does an air parcel rise?

An air parcel rises when

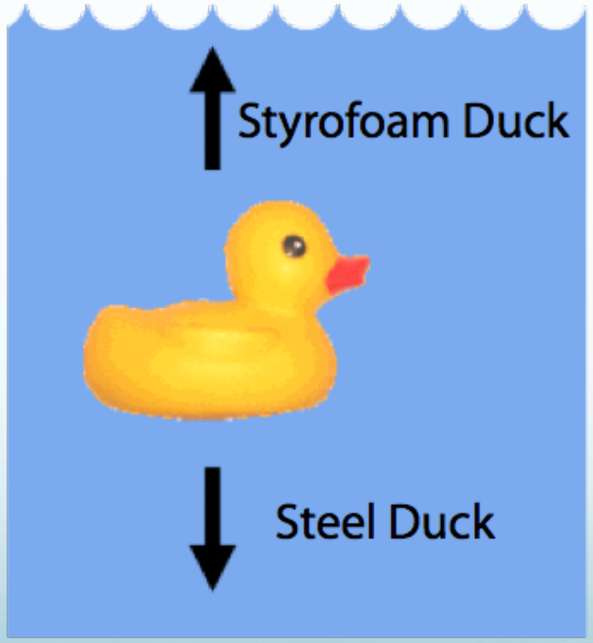
its relative humidity is higher than the surrounding air

its dew point is lower than the surrounding air

its density is lower (i.e., it is lighter) than the surrounding air

Answer: when its density is lower than the surrounding air

- *Density* and *Buoyancy*
- Objects (or fluid parcels)
  - *Less dense* than surrounding fluid *float upward*.
  - *More dense* than surrounding fluid *sink downward*



Positively buoyant

Negatively buoyant

Perfect buoyancy?

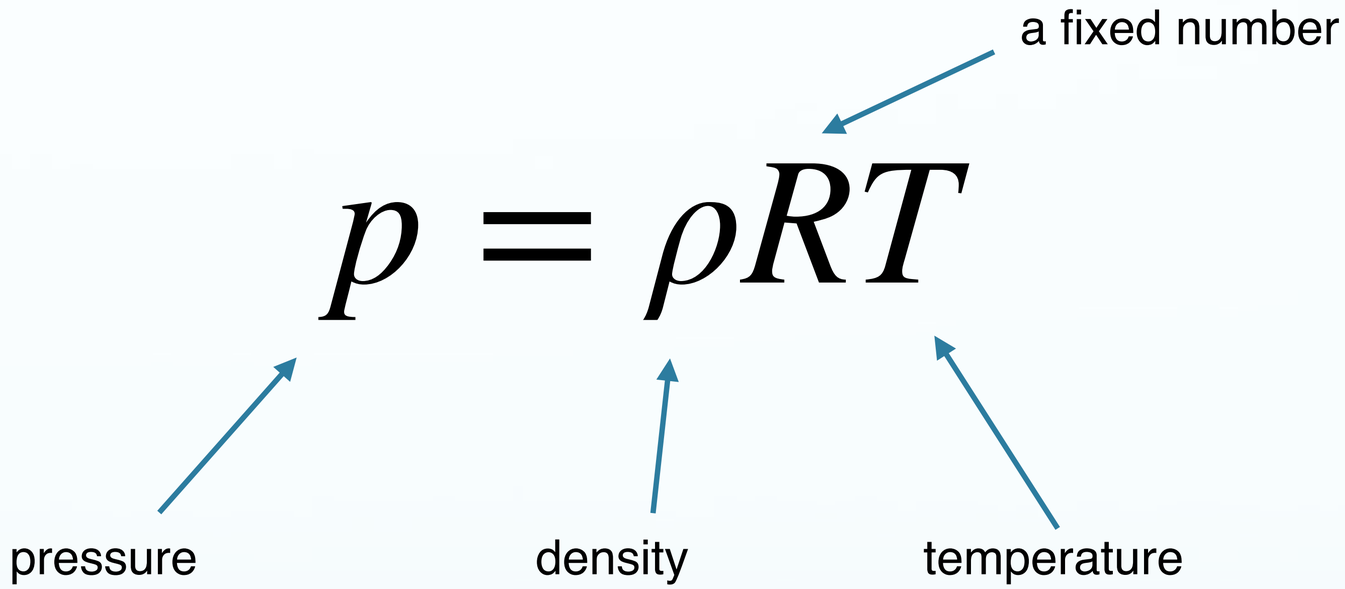
The story for today

- An air parcel rises when it is lighter than the surrounding air (just learned)
- A rising air parcel expands and cools down (last lecture)
- The cooling from expansion alone will push the parcel back down
- If the parcel contains enough moisture, the latent heat from condensation counteracts the cooling and help the parcel keep rising

We know warm air rises, how is temperature related with density?

Density and temperature

- Gas law



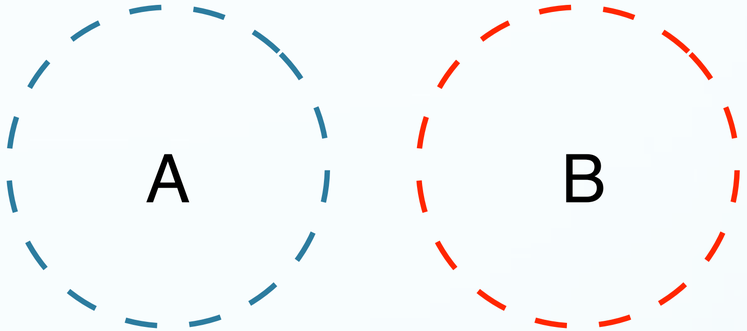
- Pressure is proportional to density x temperature

Density and temperature

$$p = \rho R T$$

pressure density temperature

Which air parcel is lighter
(i.e., has a lower density)?

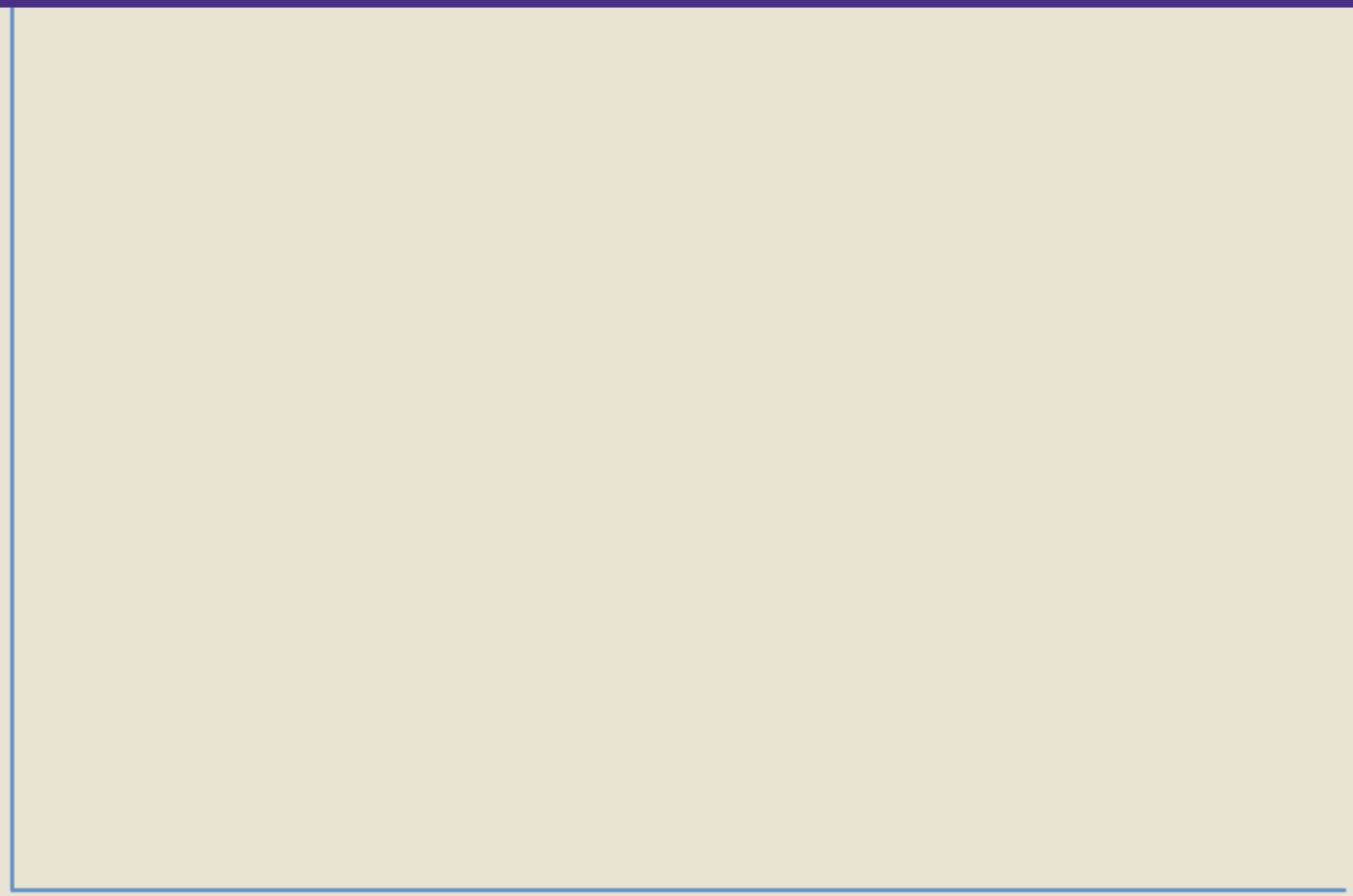


	A	B
pressure	1000 hPa	1000 hPa
temperature	0 ^{o}C	27 ^{o}C

Which air parcel is lighter?

A (pressure: 1000 hPa, temperature: 0 C)

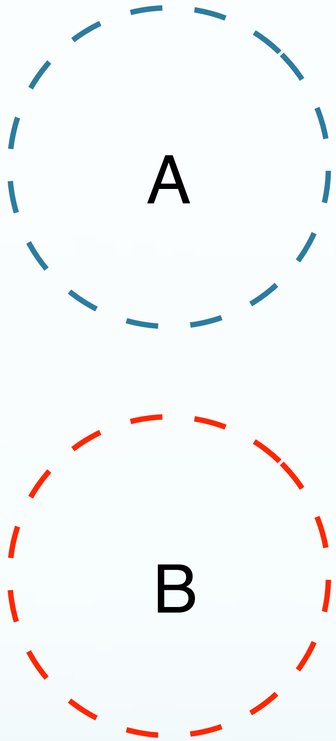
B (pressure: 1000 hPa, temperature: 27 C)



Start the presentation to see live content. Still no live content? Install the app or get help at **PollEv.com/app**

Total Results

Answer: B



1000 hPa 0 ^{o}C (=273 K)

$$p = \rho RT$$

1000 hPa 27 ^{o}C (300 K)

Density of parcel B must be lower than that of parcel A

For parcels with same pressure, warmer parcels are lighter!!

Density and temperature

- Gas law

$$p = \rho R T$$

pressure density temperature

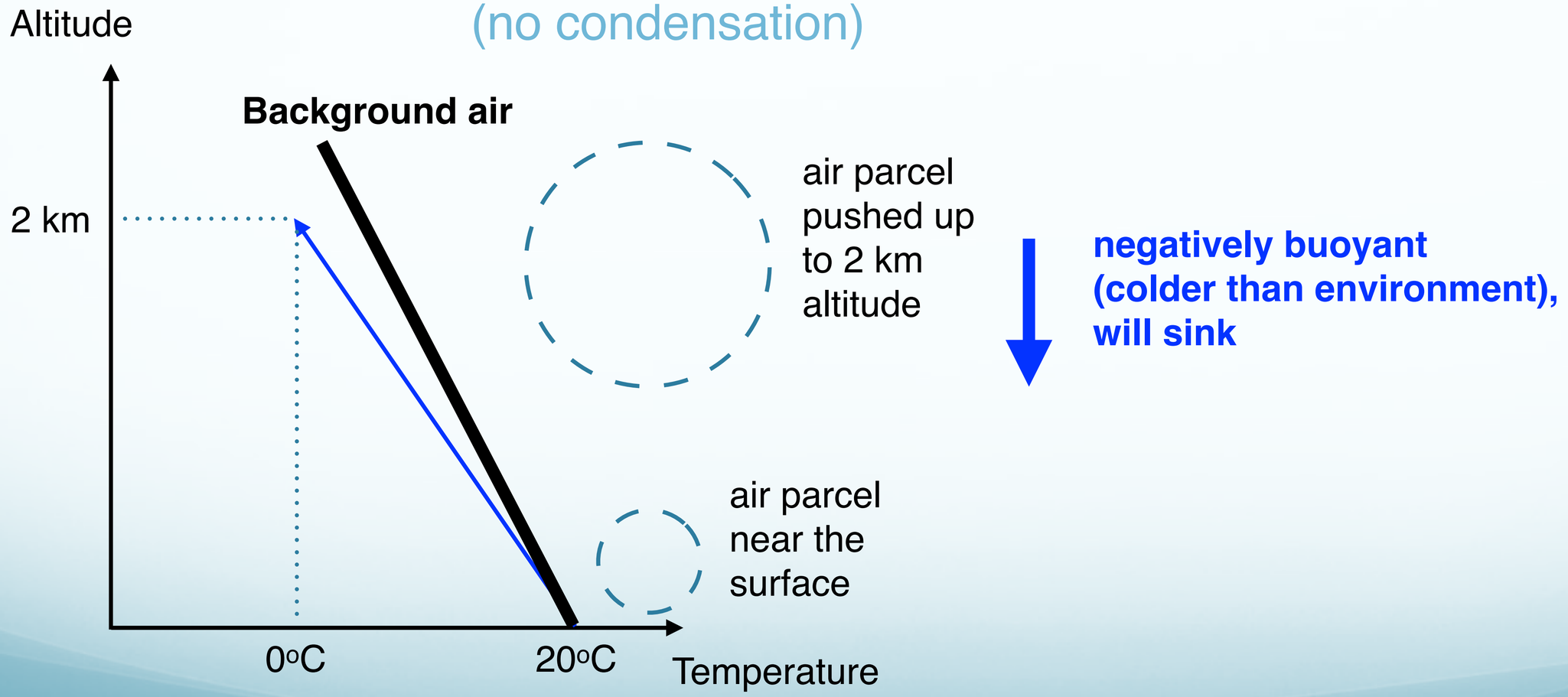
- When pressure of an air parcel matches that of the surrounding air, the air parcel is positively buoyant when its temperature is higher than the surrounding air

Why are these clouds growing upwards?

Air in the clouds is warmer than its surroundings.

Wait, didn't we learn that rising air cools?

"Without moisture"
(no condensation)



Water in the Atmosphere

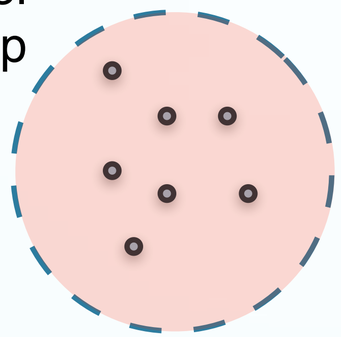
Vapor (gas): all bonds between molecules are broken

Liquid: some broken bonds between molecules

Ice (solid): almost no bonds broken between molecules

When clouds form

air parcel raised up



air parcel near the surface

(Latent) Heat → **Warm the air nearby**

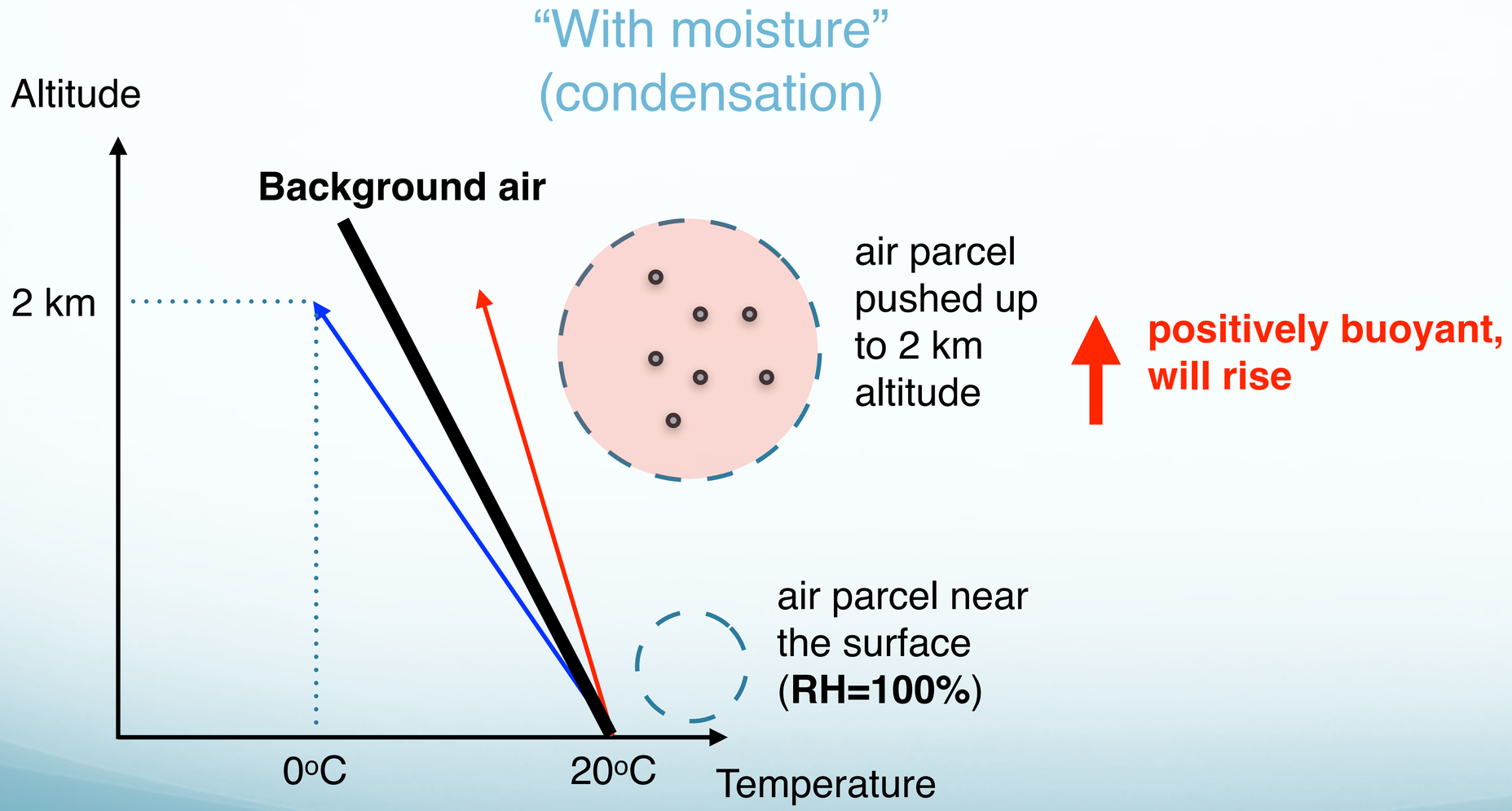
↑

Condensation (bonds build)

Water vapor → **Liquid**

The warming from the latent heat release partly cancels out the cooling from expansion!!

If condensation occurs while being pushed up



Why is the air in a rising cloud turret warmer than its surroundings?

Because air warms as it rises.

Because cloud droplets absorb more sun lights than the surrounding air.

Because latent heat is released as water vapor condenses to form cloud droplets.

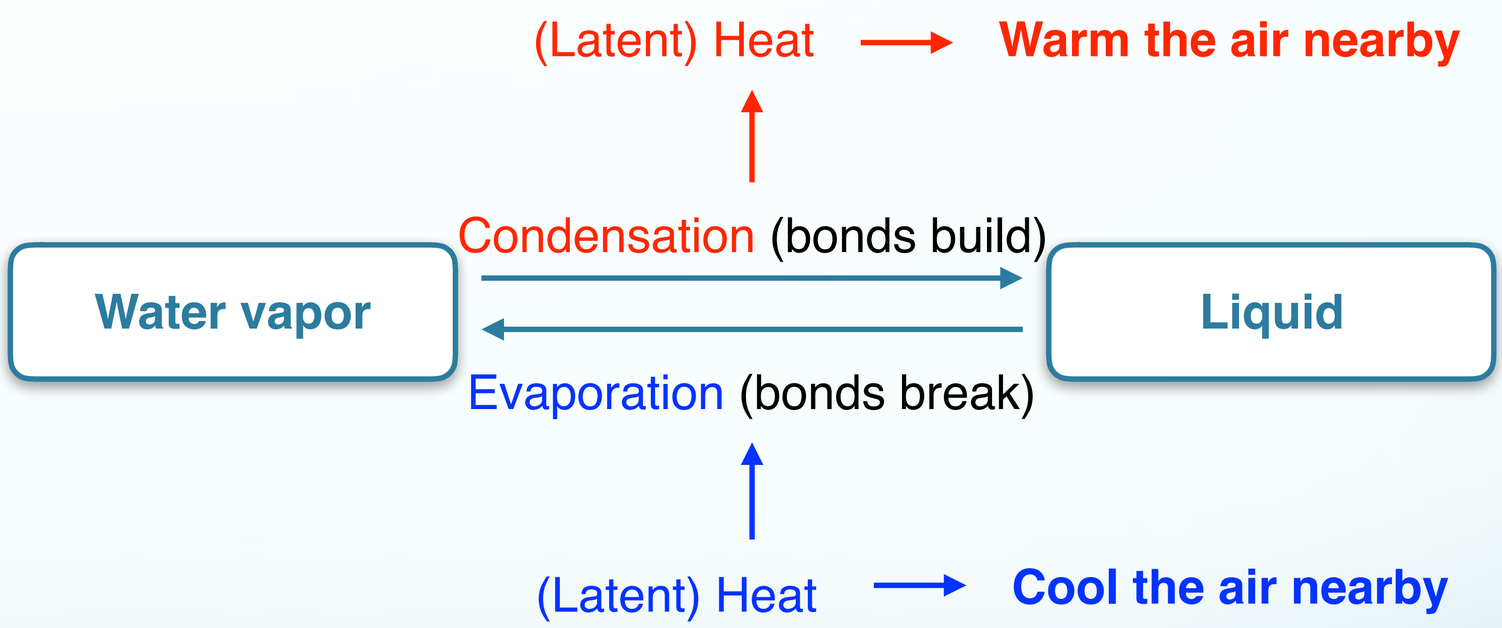
Answer: latent heat is released as water vapor condenses to form cloud droplets.

Latent heat powers thunderstorms

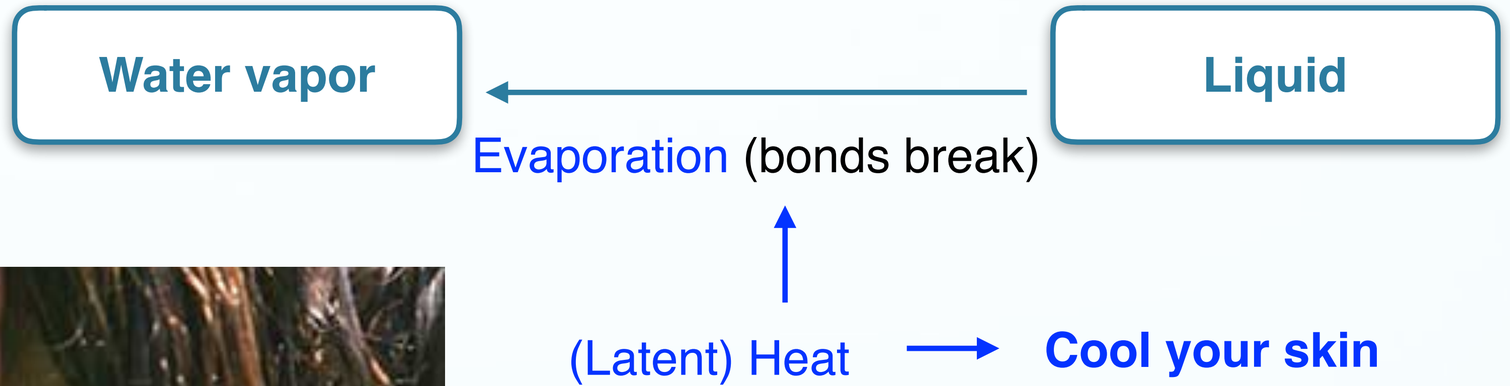
Latent heat

- The heat input required to break molecular bonds is called **Latent Heat**
- If bonds reform, the same amount of heat is released.
- Heat must be **added** to **evaporate** water
- Heat is **released** when water vapor **condenses** into a liquid.

The process is reversible!!!



Exchange of latent heat cools your body



(Latent) Heat → **Cool your skin**

Exchange of latent heat warms … ?

Your drink!

(Latent) Heat → **Warm the surface of a can/bottle**

Water vapor → Condensation (bonds build) → **Liquid**

Oven vs. Latent Heat

UW Atmospheric Science grads outreach video

Suppose a 12-oz can near 0° C is covered with 0.1 mm of condensed water (0.1 mm is width of a human hair)

If all the latent heat of condensation is transferred to the drink, what is the change in its temperature?

- Surface of 12-oz can is roughly 286 cm^2
- 2.86 gm of water condenses
- Heat released is 2.86 gm x 598 cal/gm = 1710 cal
- Temperature rise is 1710 cal/340 gm = 5.0° C (9° F)

The story for today

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Cloud types

What is keeping the fair-weather cumulus from growing to higher heights?

Fair weather cumulus

Cumulus congestus

Cumulonimbus

Very Stable Air

How unstable is the atmosphere?


gravityglue.com

Michael Grab

See also rock balancing.

Stability

“Stable”

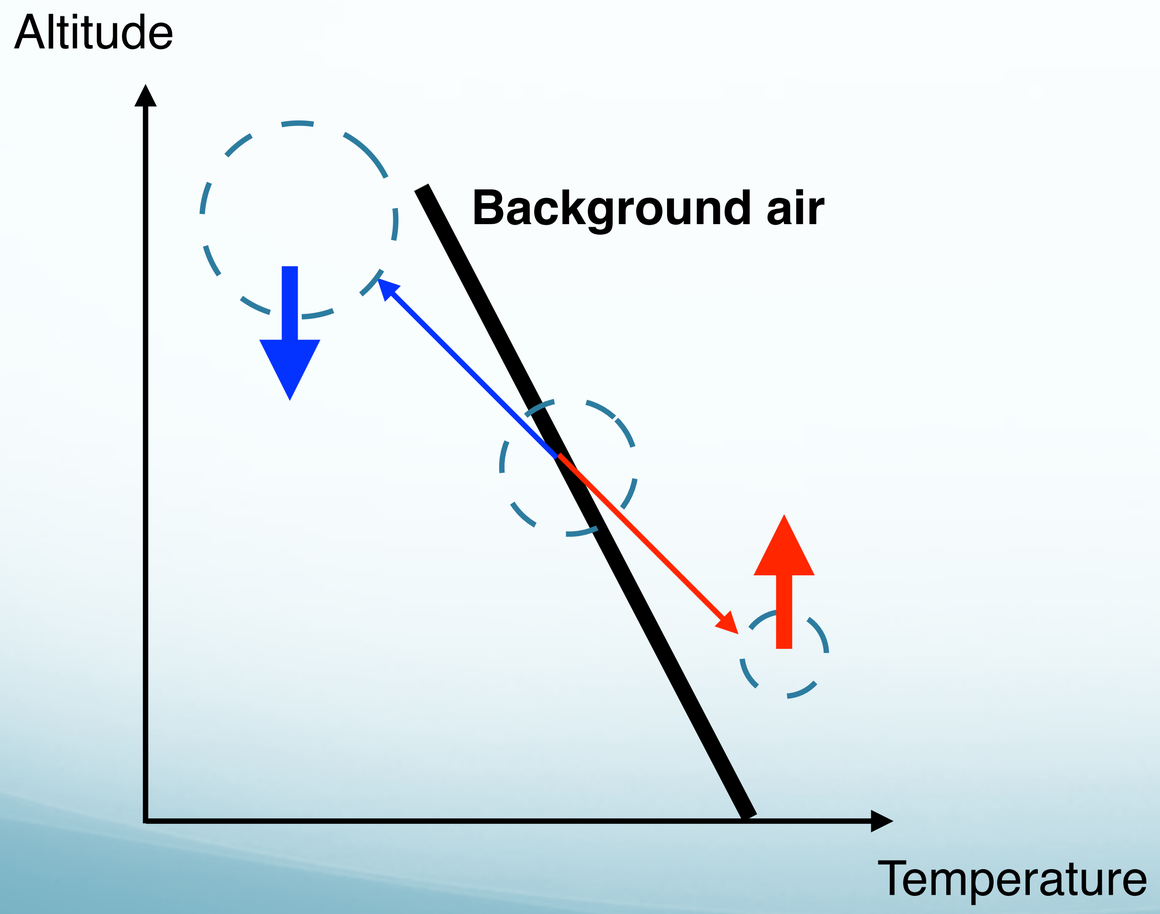
When pushed to the left or right, the ball will eventually come back to its original position

“Unstable”

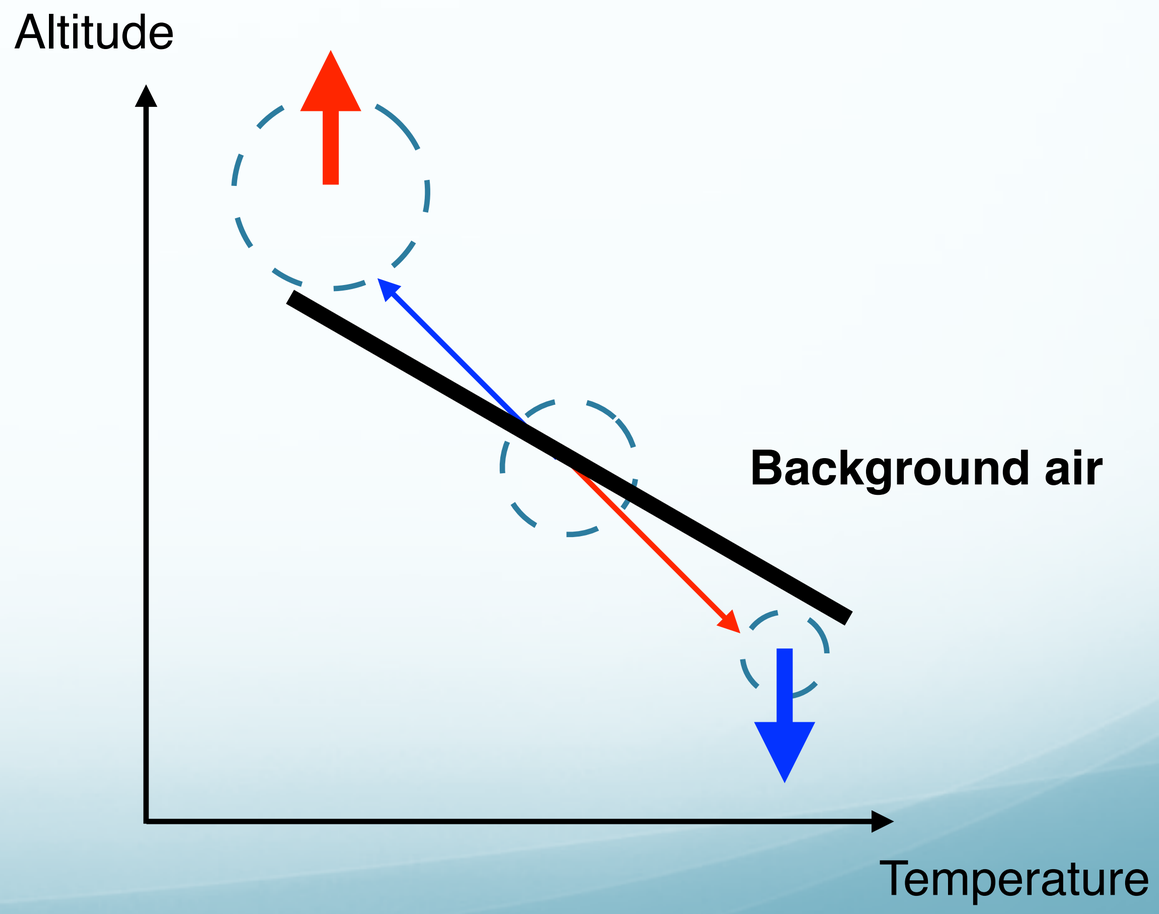
A slight change in the position of the ball will make it to move away from its original position

Atmospheric stability

"Stable"

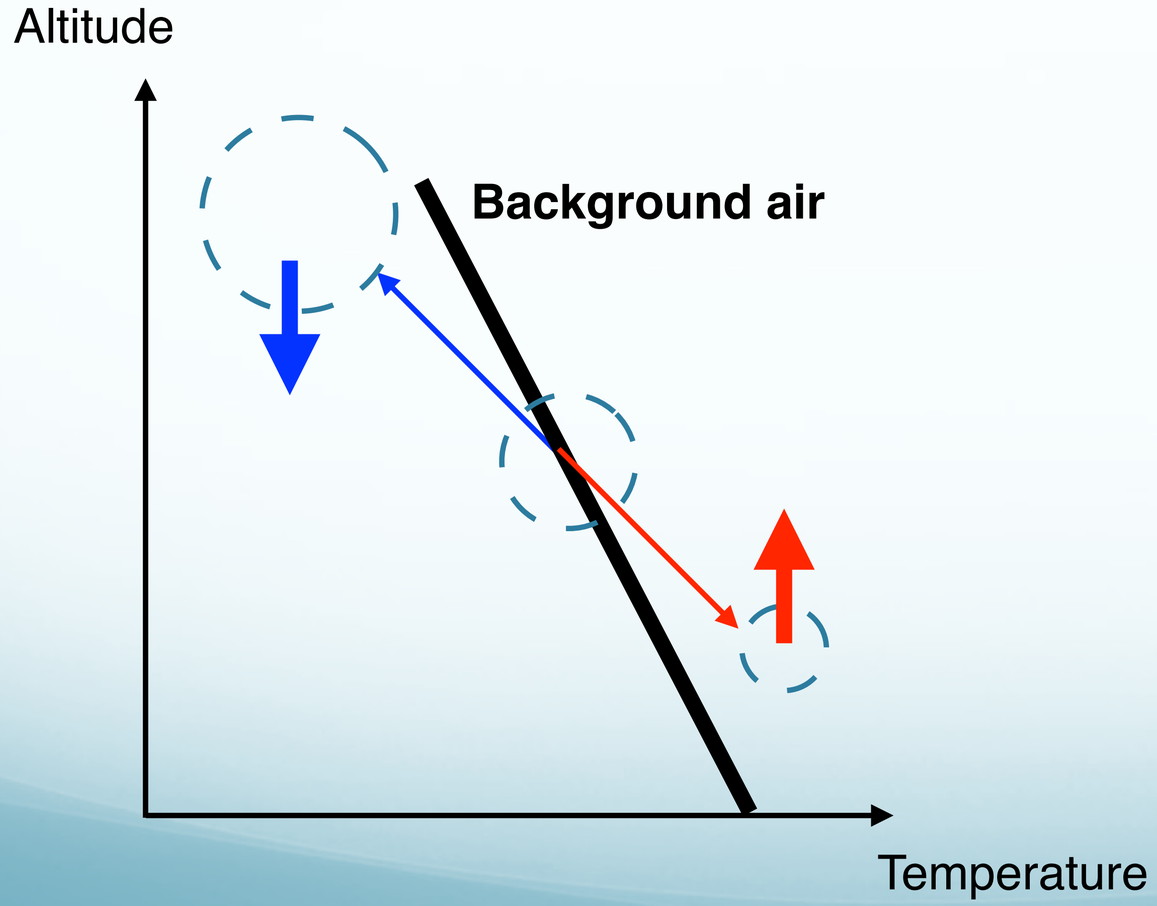


"Unstable (unusual)"



Atmospheric stability

"Stable"



"Conditionally unstable"
(thunderstorms develop under this condition!)