

# Clicker question

The temperature today is 67°F, sunny with light winds.

This statement describes

A. weather

B. climate

# **Weather vs Climate**

# Clicker question

In January, Socorro's average high temperature is  $52^{\circ}\text{F}$ , the average low is  $22^{\circ}\text{F}$ .

This statement describes

A. weather

B. climate

# Clicker question

In January, Socorro's record high temperature is 76°F, while the record low is -12°F.

This statement describes

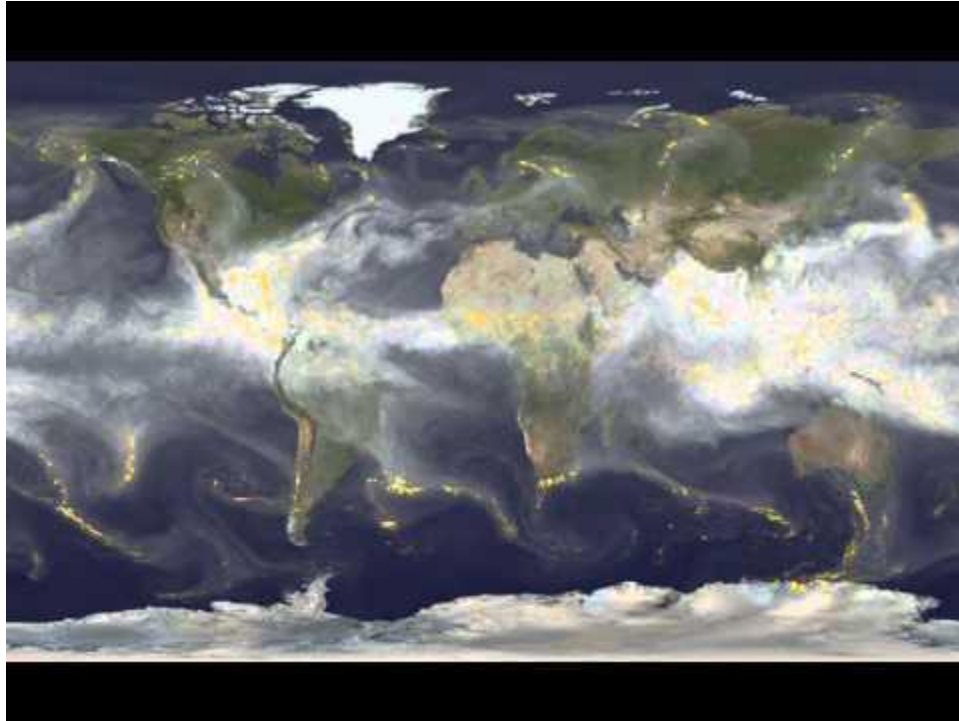
A. weather

B. climate

# Atmospheric composition

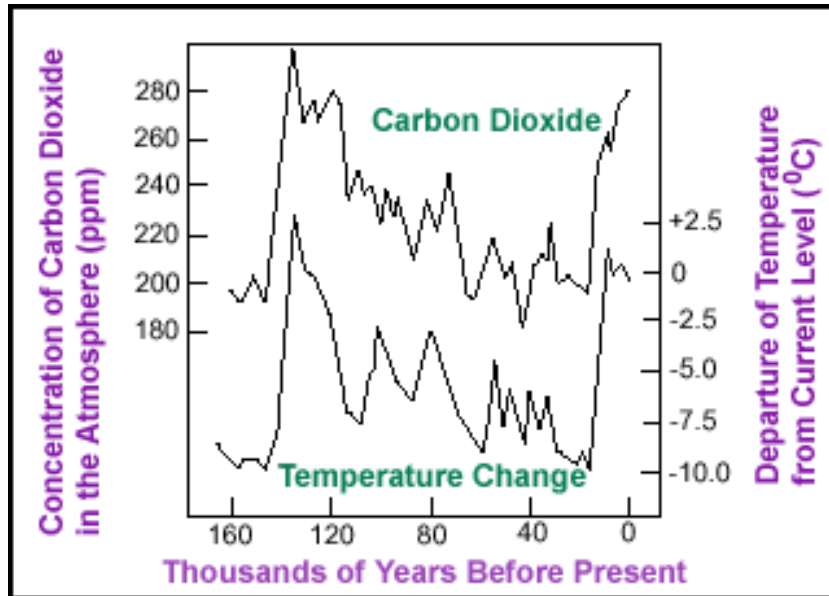
- most abundant gases
- well-mixed vs not well mixed
- important gases:
  - H<sub>2</sub>O vapor
  - CO<sub>2</sub>
  - ozone
  - aerosols

# H<sub>2</sub>O vapor during 1998 La Nina



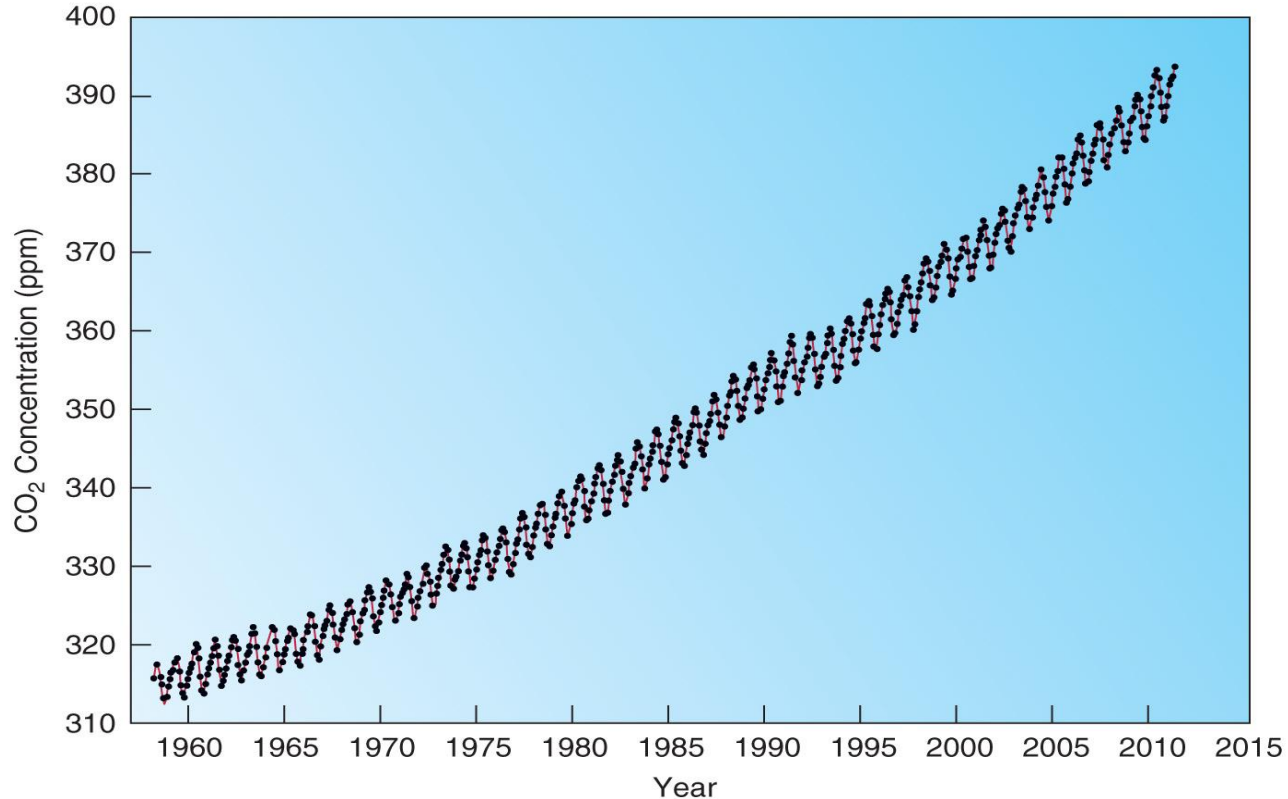
# CO<sub>2</sub> and temperature

Over the past 160,000 years...



From Barnola et al (1987)

# CO<sub>2</sub> concentrations @11,150 ft





# Clicker question

Why has CO<sub>2</sub> increased by about 1.8 ppm per year since measurements began?

- A. anthropogenic combustion of fossil fuels
- B. increased photosynthesis
- C. deforestation
- D. both A and C are correct
- E. all of the above are correct

# Clicker question

What type of energy does CO<sub>2</sub> absorb efficiently?

- A. ultraviolet
- B. radiation emitted by the sun
- C. cosmic and gamma rays
- D. radiation emitted by the earth

# Clicker question

What is the residence time for CO<sub>2</sub>?

- A. 10 years
- B. 50 years
- C. 100 years
- D. 150 years

# Ozone

Why is ozone both good and bad?

# Ozone

- [NASA Ozone video](#)
- [NASA video of 2011 arctic ozone hole](#)
- [What if we didn't ban CFCs in the '80s?](#)

# Aerosols

What are they?

Where do they come from?

Where are they most abundant?

How do they influence weather/climate?

# clicker question

Certain aerosols act as cloud condensation nuclei (CCN). The presence of CCN

- A. increases the chance of rain
- B. decreases the chance of rain
- C. can either increase or decrease chance of rain

# Structure of atmosphere

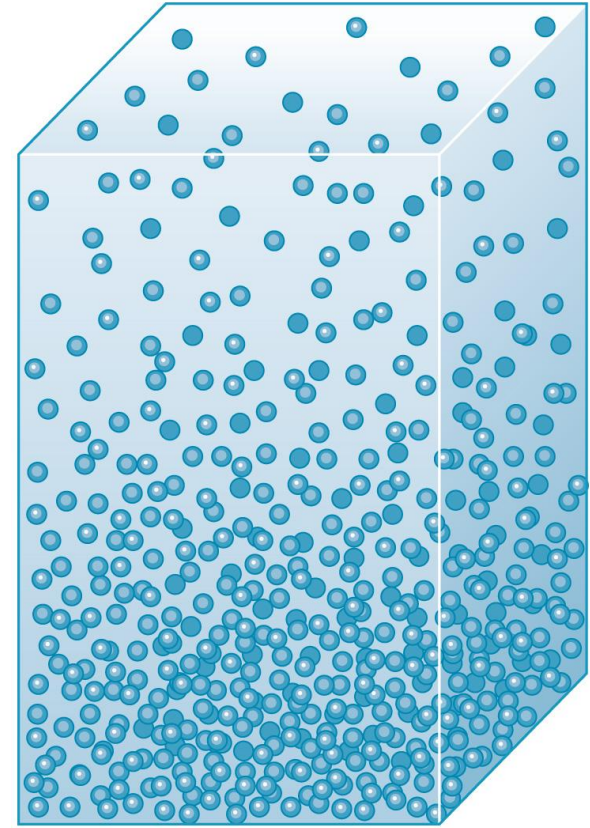
- density
- pressure
- temperature



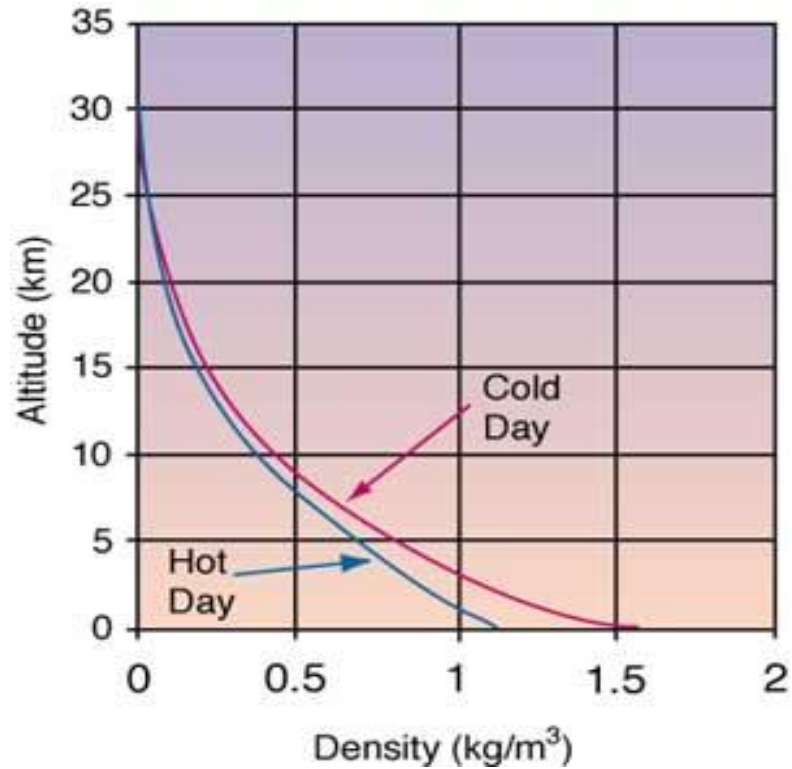
# Clicker question

This column of molecules illustrates:

- A. temperature increases with altitude
- B. air is denser near surface
- C. winds are fastest near surface
- D. water is denser than air



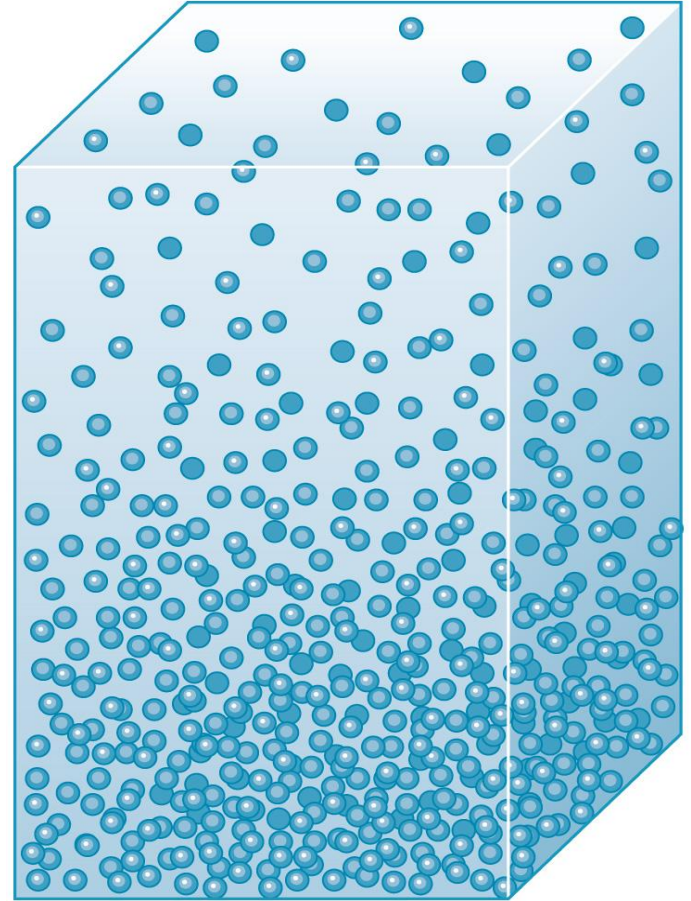
# atmospheric density



# Density

amount of mass in one unit of volume ( $\text{kg}/\text{m}^3$ )

How is density related to *mean free path*?

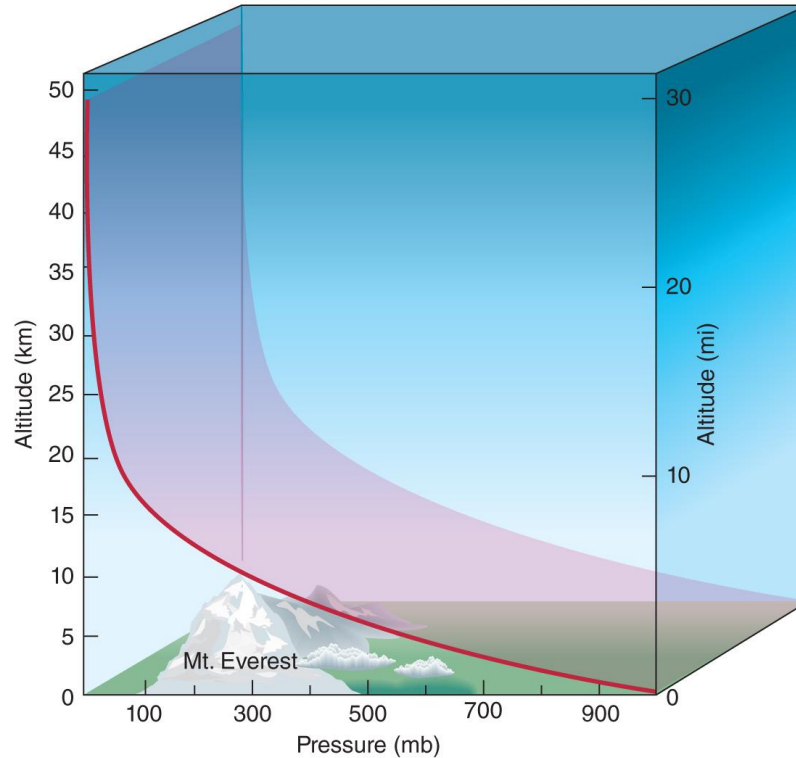


# Clicker question

How does density vary with altitude?

1. Increases with altitude
2. Sometimes it increases, sometimes it decreases depending on temperature
3. Decreases with altitude

# pressure vs. altitude

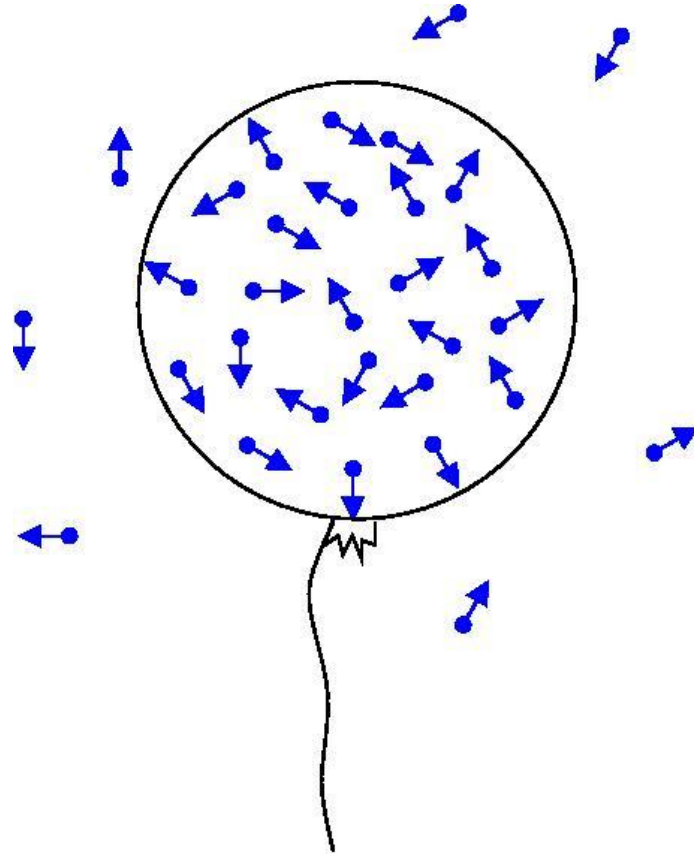


# Pressure

$$\textit{pressure} = \frac{\textit{force}}{\textit{area}}; \quad P = \frac{F}{A}$$

What causes the force?

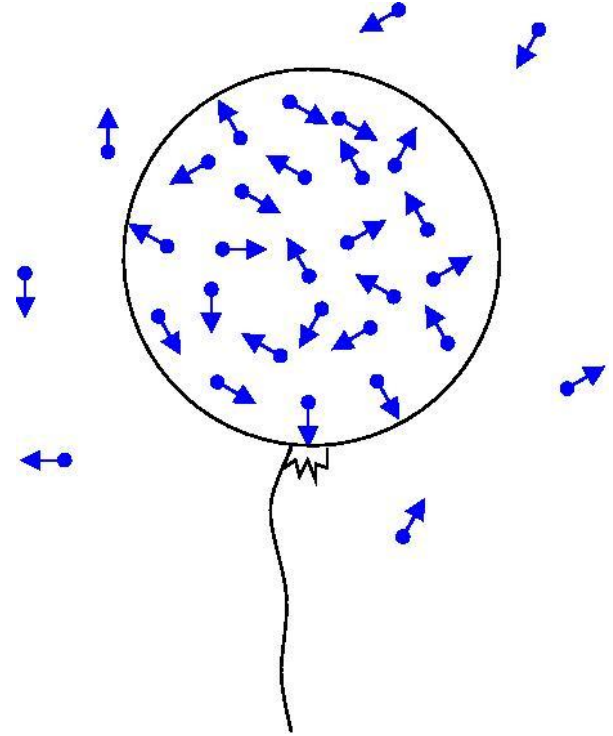
# collisions of gas molecules



# clicker question

To increase pressure in balloon,

- A. increase number of molecules
- B. speed up molecules
- C. decrease temperature of balloon
- D. A & B
- E. B & C
- F. A, B & C





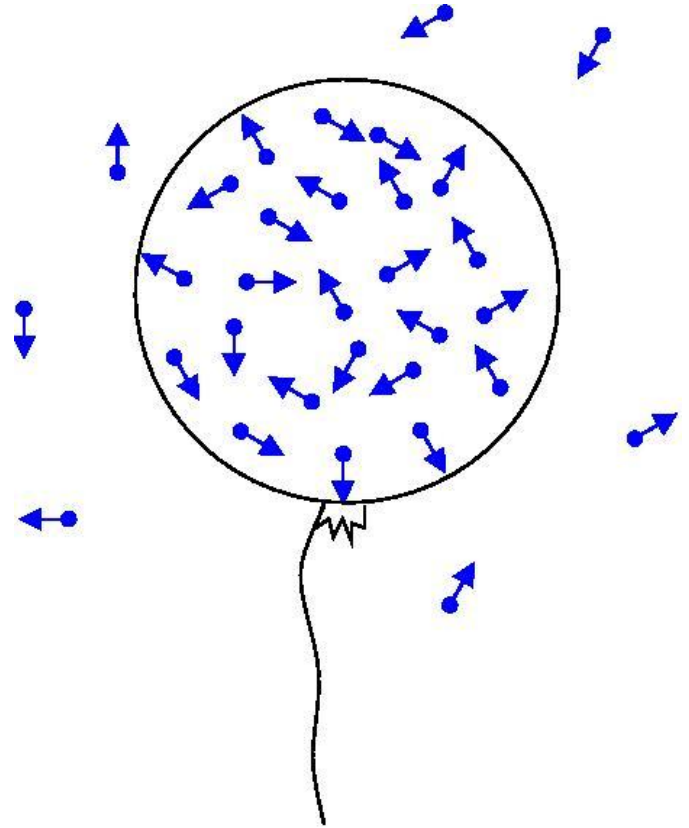
# pressure simulation

Cool pressure simulation on [PHET](#)

# Compare pressure inside and out

What happens if we remove membrane?

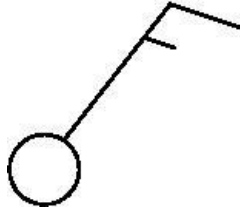
How does this relate to the atmosphere?





# weather map symbols

Arrow points to direction wind is coming *from*.



This shows wind from the

- A. northeast
- B. southwest

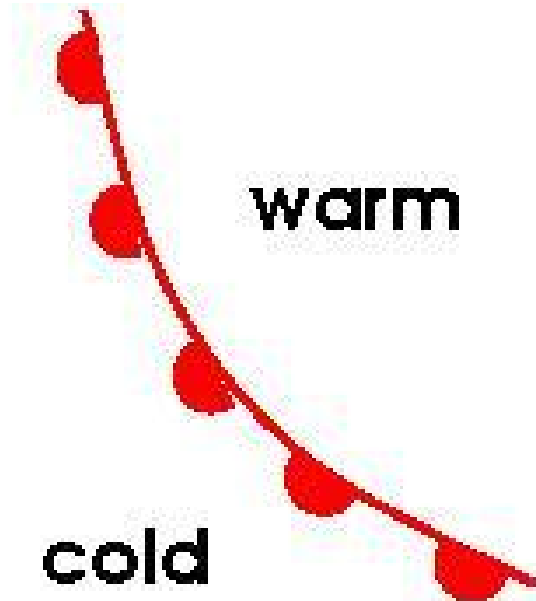
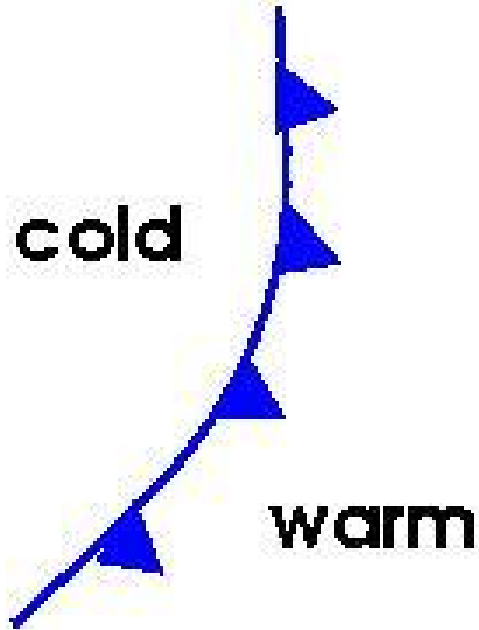
(a)

	Miles per hour	Kilometers per hour
	Calm	Calm
	1-2	1-3
	3-8	4-13
	9-14	14-19
	15-20	20-32
	21-25	33-40
	26-31	41-50
	32-37	51-60
	38-43	61-69
	44-49	70-79
	50-54	80-87
	55-60	88-96
	61-66	97-106
	67-71	107-114
	72-77	115-124
	78-83	125-134
	84-89	135-143
	119-123	192-198

(b)

Cloud Cover	Description
	No clouds
	1/8
	Scattered
	3/8
	4/8
	5/8
	Broken
	7/8
	Overcast
	Sky obscured

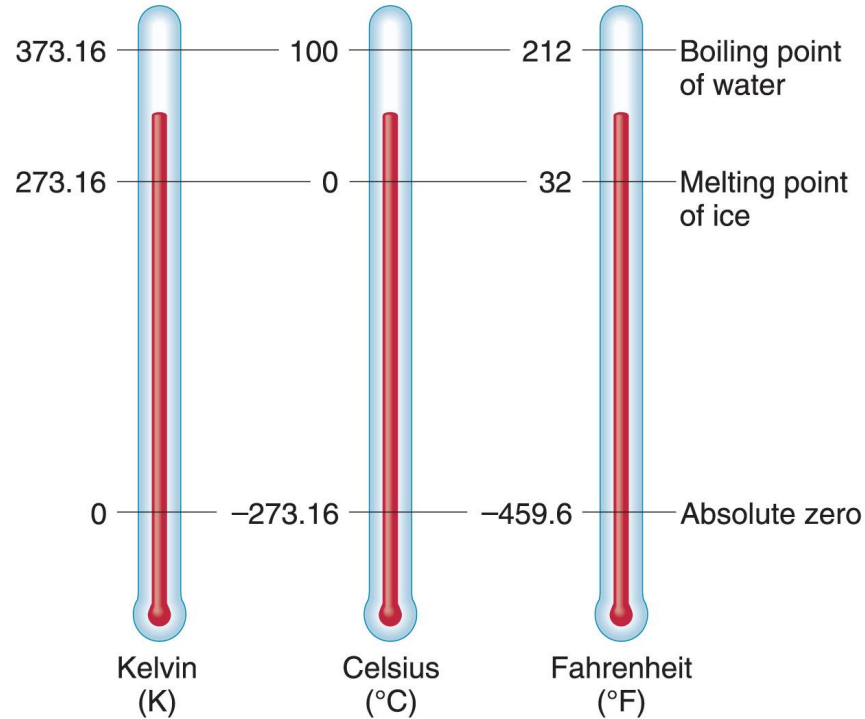
# cold and warm fronts



# What's going on now?

- UCAR (<http://weather.rap.ucar.edu/>)
- <http://earth.nullschool.net/#current/wind/surface/level/winkel3>
- <https://www.khanacademy.org/youcanlearnanything>

# 3 temperature scales

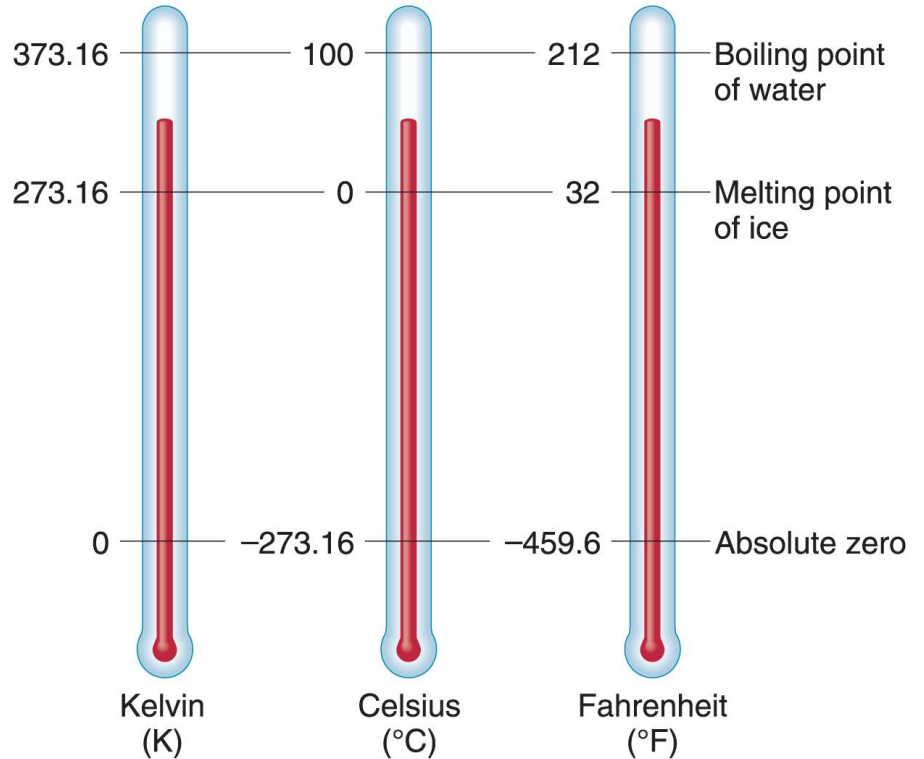


# clicker question

One degree Fahrenheit is

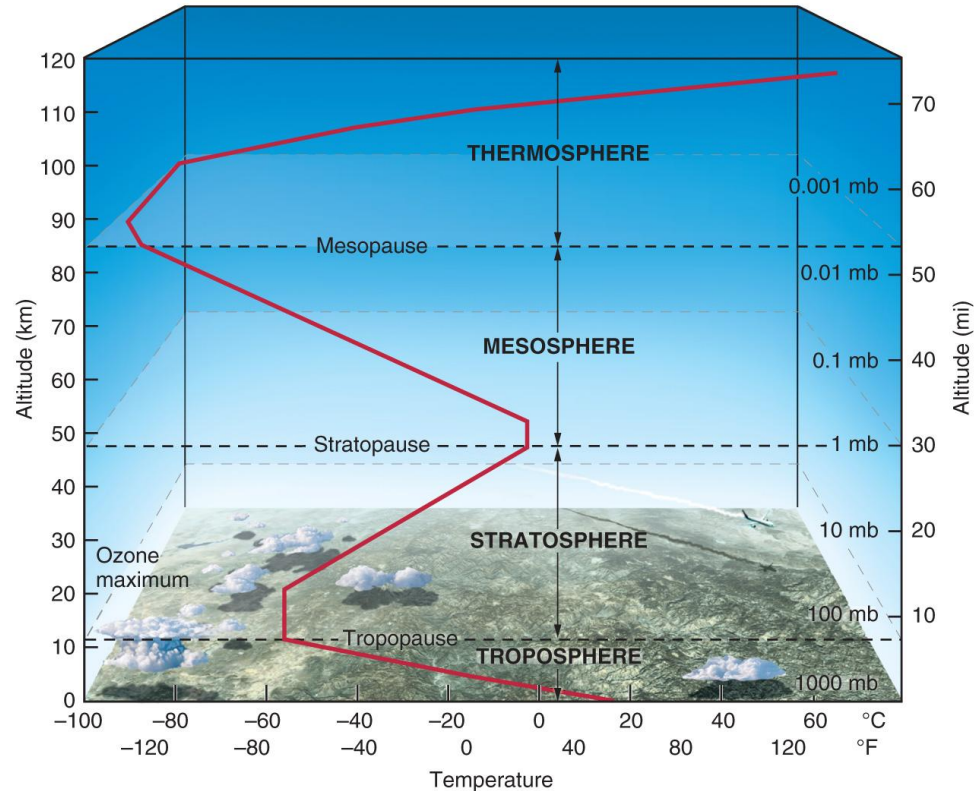
1. larger
2. smaller

than one degree Celcius.





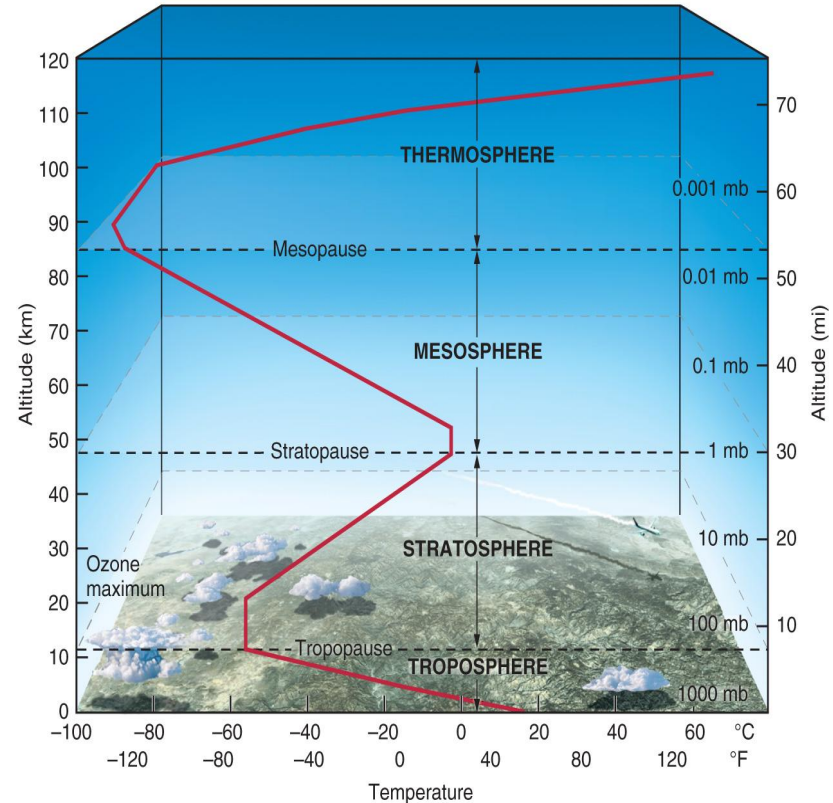
# Stratification by temperature



# Clicker question

Why is the top of the troposphere colder than the bottom?

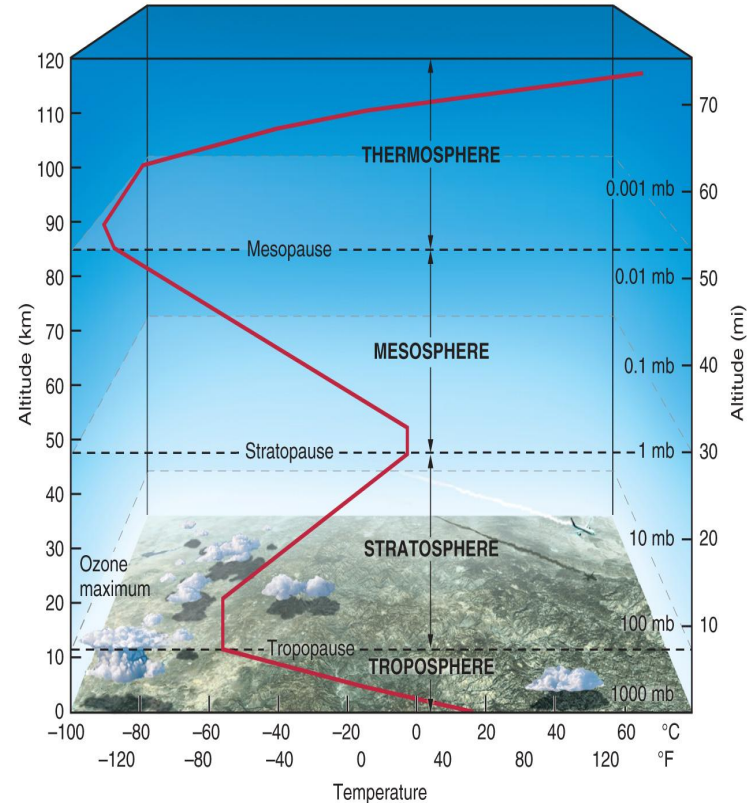
- A. top is farther from energy source
- B. top is protected from stratospheric clouds
- C. air is heated by surface
- D. because of increase in CO<sub>2</sub>



# Clicker question

Why is the top of the stratosphere warmer than the bottom?

- A. ozone absorbs solar energy
- B. because of reflection by clouds
- C. because of large amounts of water vapor
- D. because of recent increase in  $\text{CO}_2$

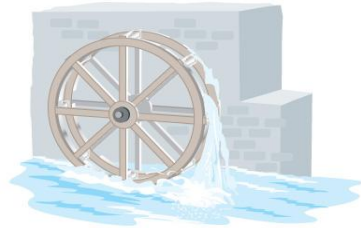


# Energy

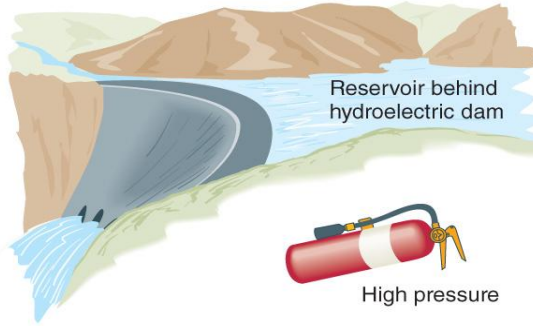
- the ability to do *work*
- what is *work*?

# FORMS OF ENERGY

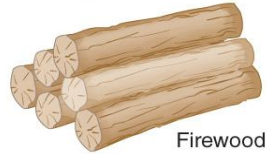
## KINETIC ENERGY



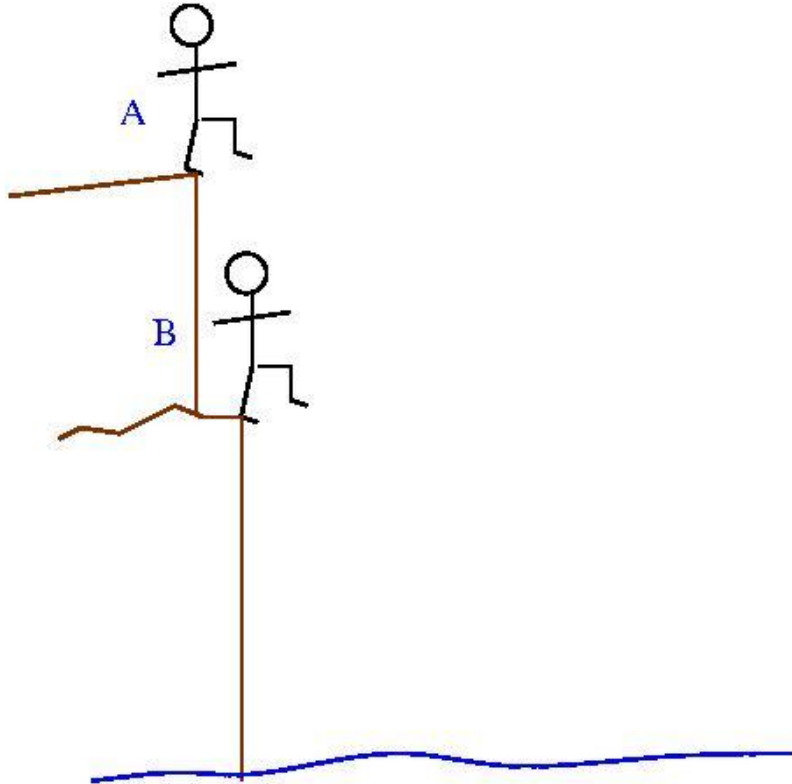
## POTENTIAL ENERGY



### Five types of chemical potential energy



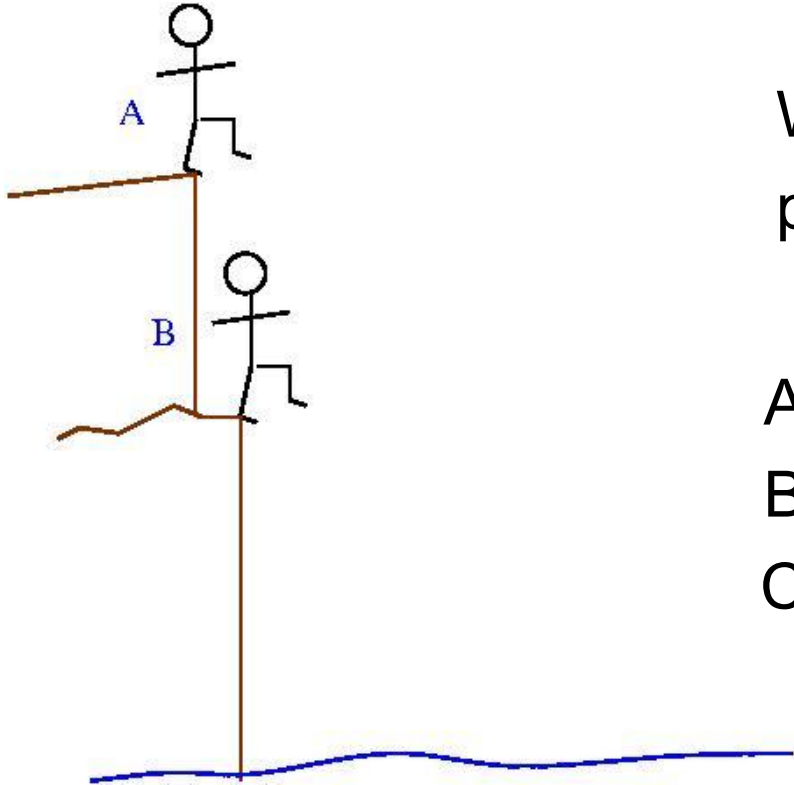
# clicker question



While the jumpers are on the cliffs, what type of energy is demonstrated?

- A. kinetic
- B. potential
- C. nervous

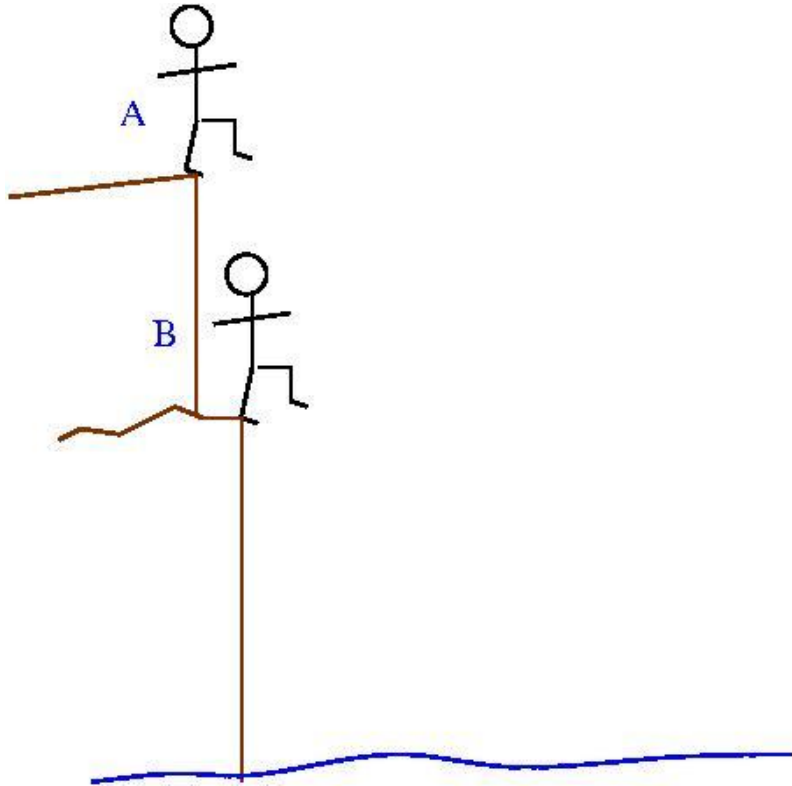
# clicker question



Which jumper has the most potential energy?

- A. A
- B. B
- C. they have the same PE

# clicker question



Which jumper will have the greater amount of kinetic energy at the bottom of the cliff?

- A. A
- B. B
- C. they will have the same KE



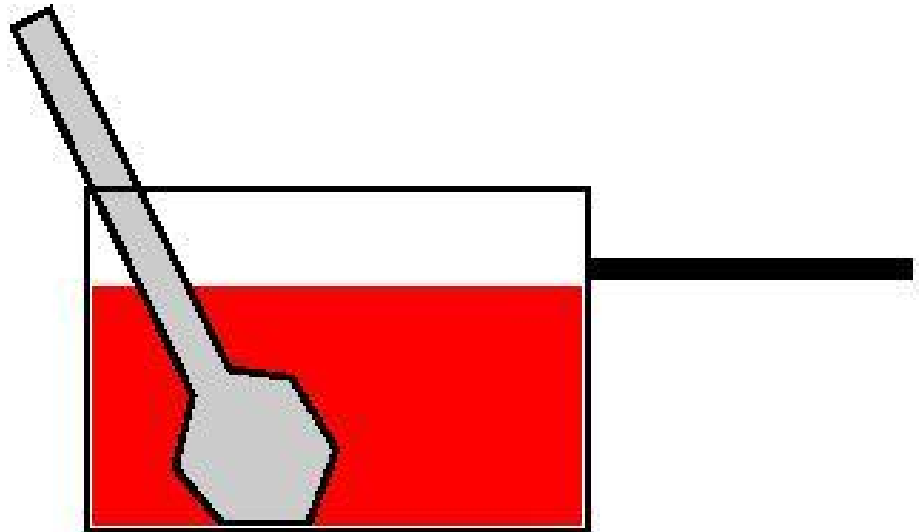
# How is energy transferred?

- 
- 
-

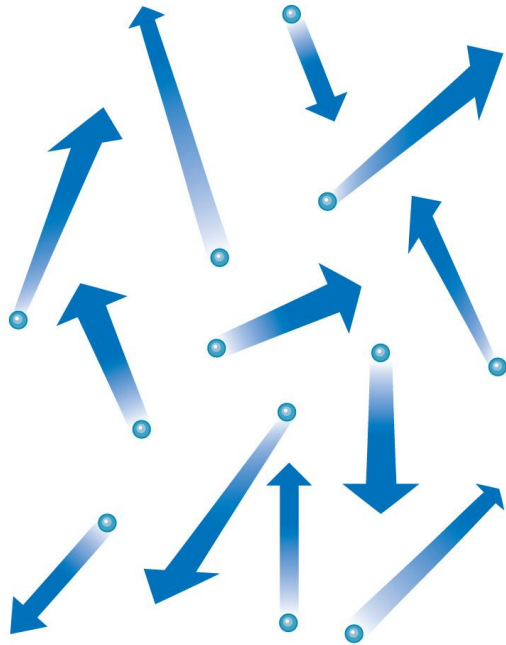
# clicker question

A metal spoon is set in boiling water. What mechanism transfers heat to handle?

- A. conduction
- B. convection
- C. radiation



# conduction



Randomly moving  
air molecules

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kinetic energy is proportional to  
temperature

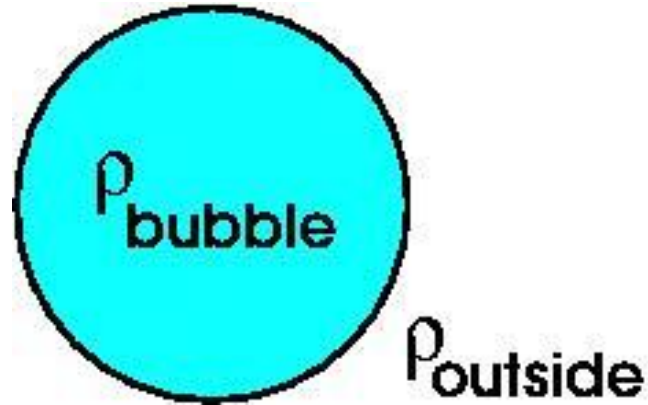
$$K = \frac{1}{2}mv^2 \propto T$$

**what mechanism is shown here?**



# convection: buoyancy

$\rho = \textit{density}$

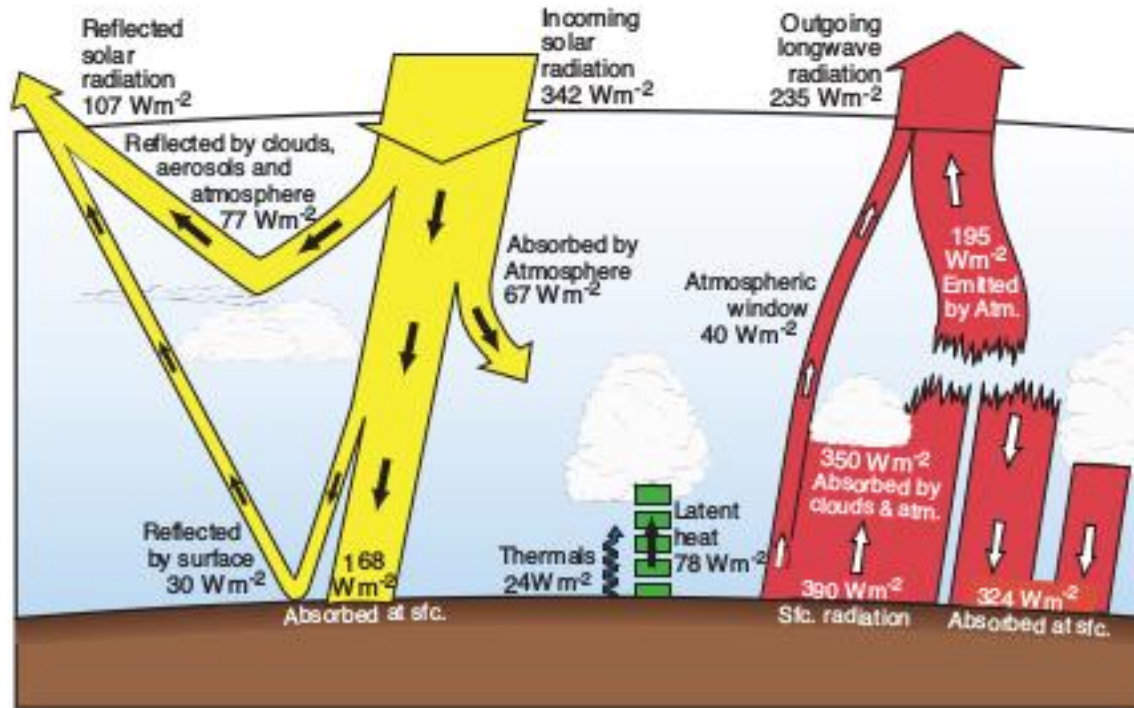


# atmospheric convection



Gregory Thompson [www.inclouds.com](http://www.inclouds.com)

# energy budget



Pathways of energy transfer in the global average energy budget. After Kiehl and Trenberth (1997).