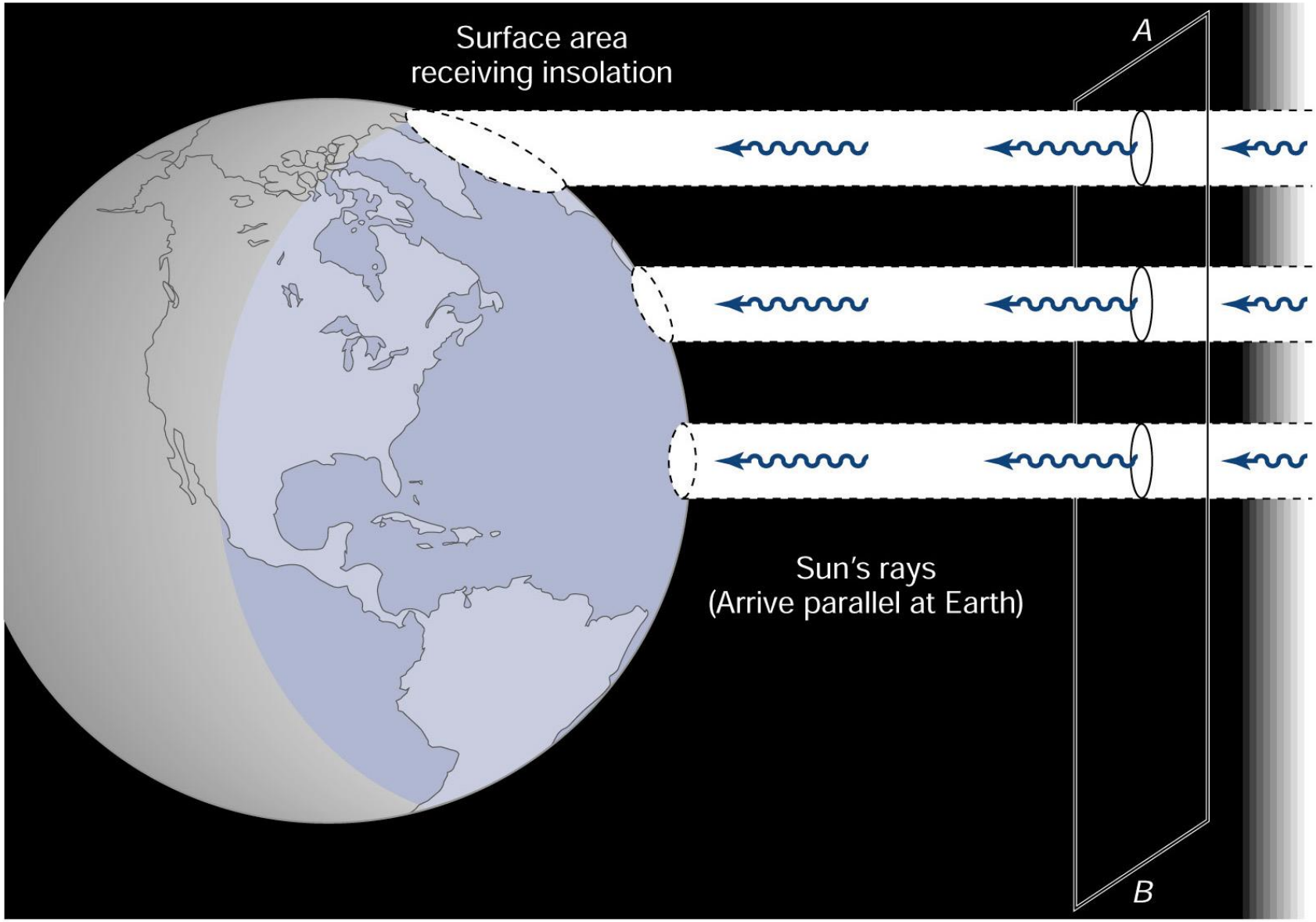
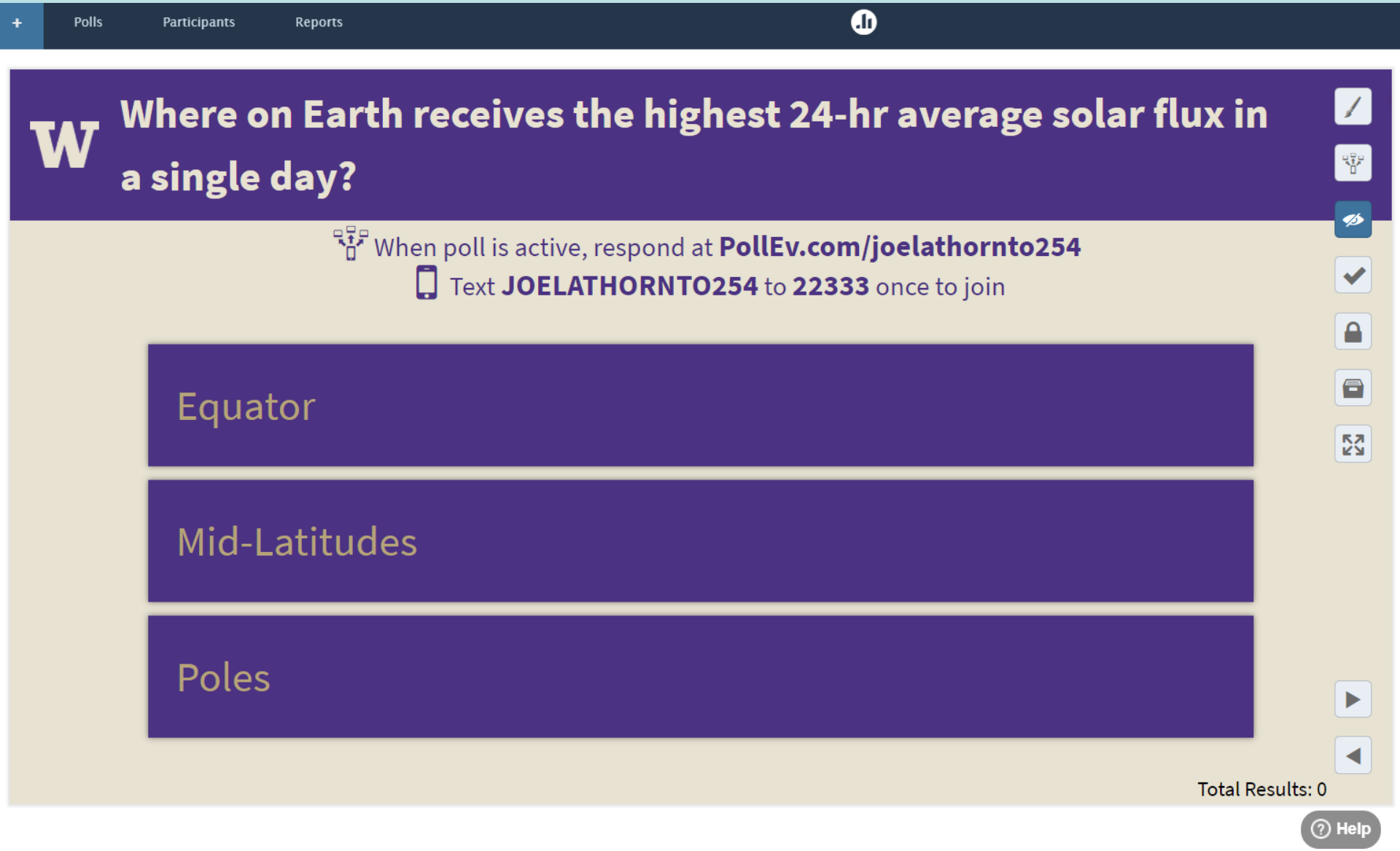
This Week: Towards Regional Climates

- Atmospheric Circulation Patterns
  - Wet tropics, deserts, seasonality
  - Stormy mid-latitudes
  - Land/Sea Contrasts and Continentality

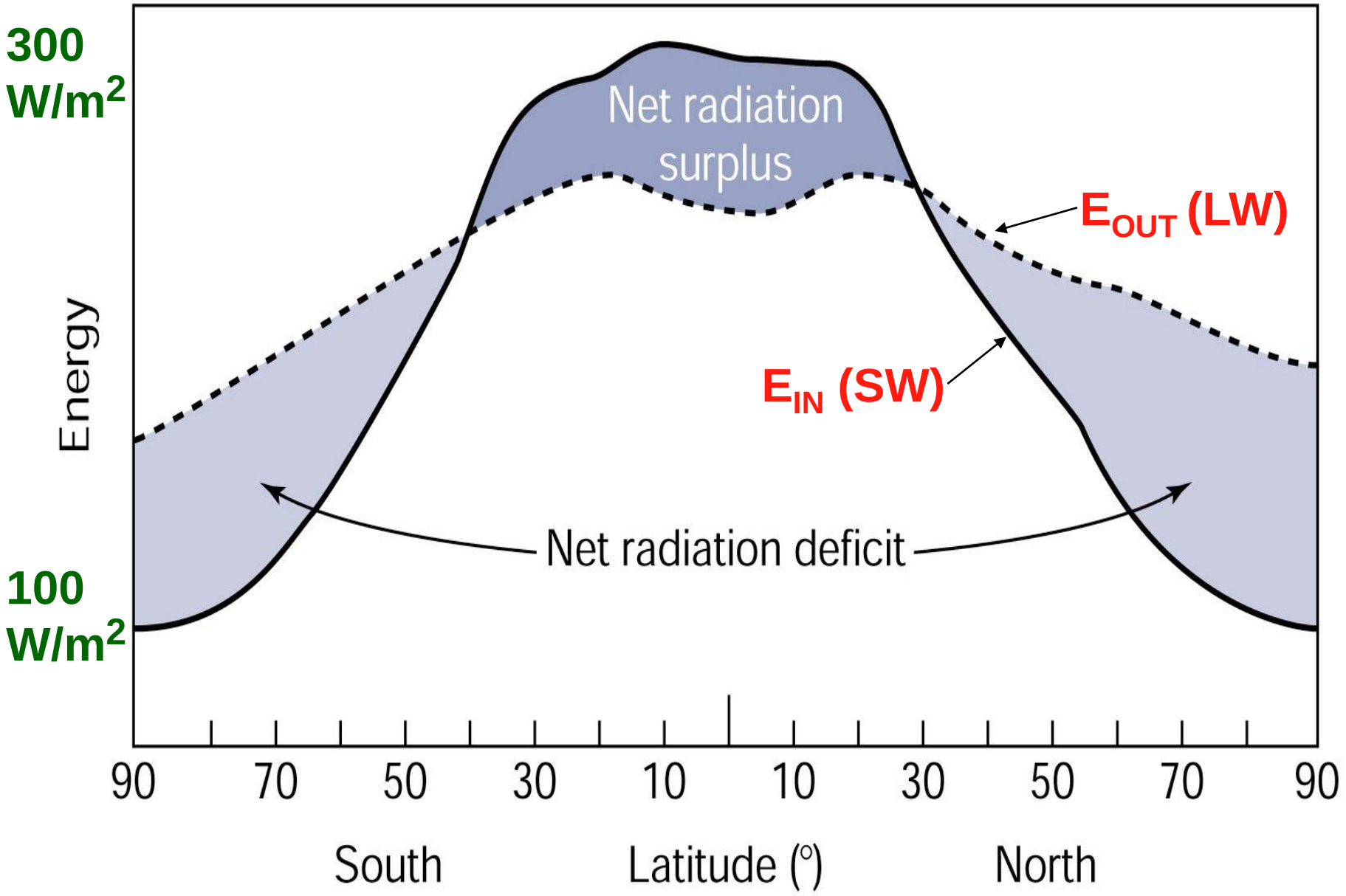
Spatial Radiation Imbalance



Poll Question

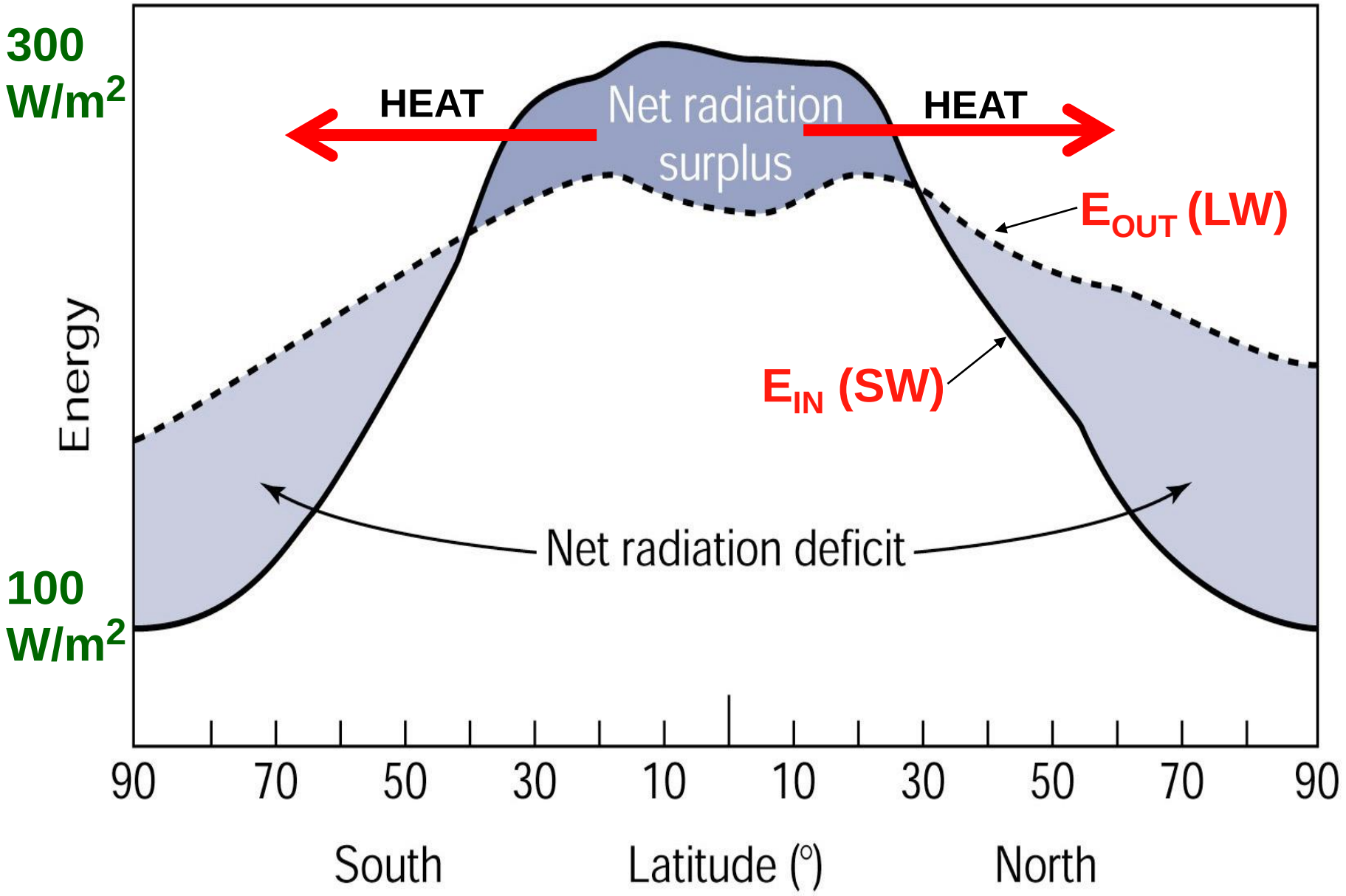


Spatial Radiation Imbalance



Spatial Imbalance in Radiation

Spatial Radiation Imbalance



Spatial Imbalance in Energy Input → Weather

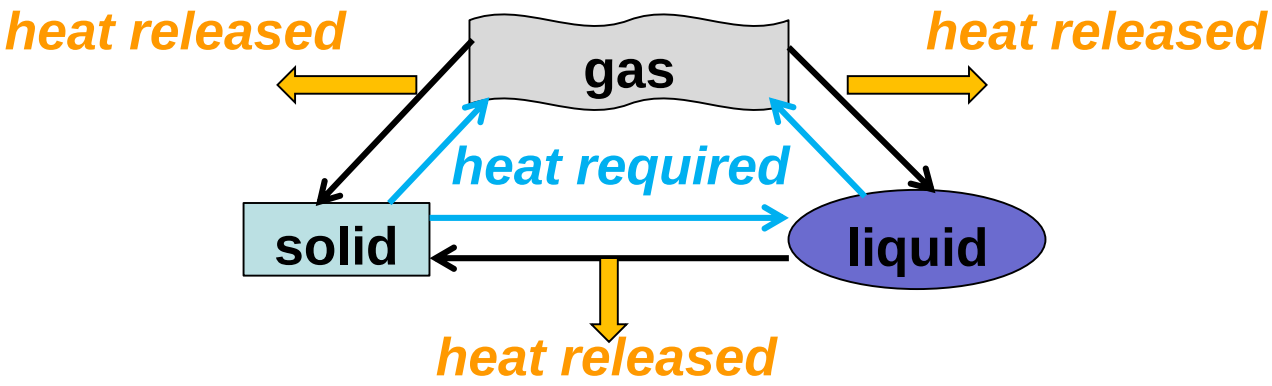
Radiation surplus (and deficits) gives rise to *heat and material transfer* around Earth by the ***atmosphere*** and oceans

Atmosphere as a heat and material transport vehicle

- How does heat get transferred?

- What causes atmosphere to move in vertical and horizontal directions?

Latent Heat – Energy of Phase Transitions

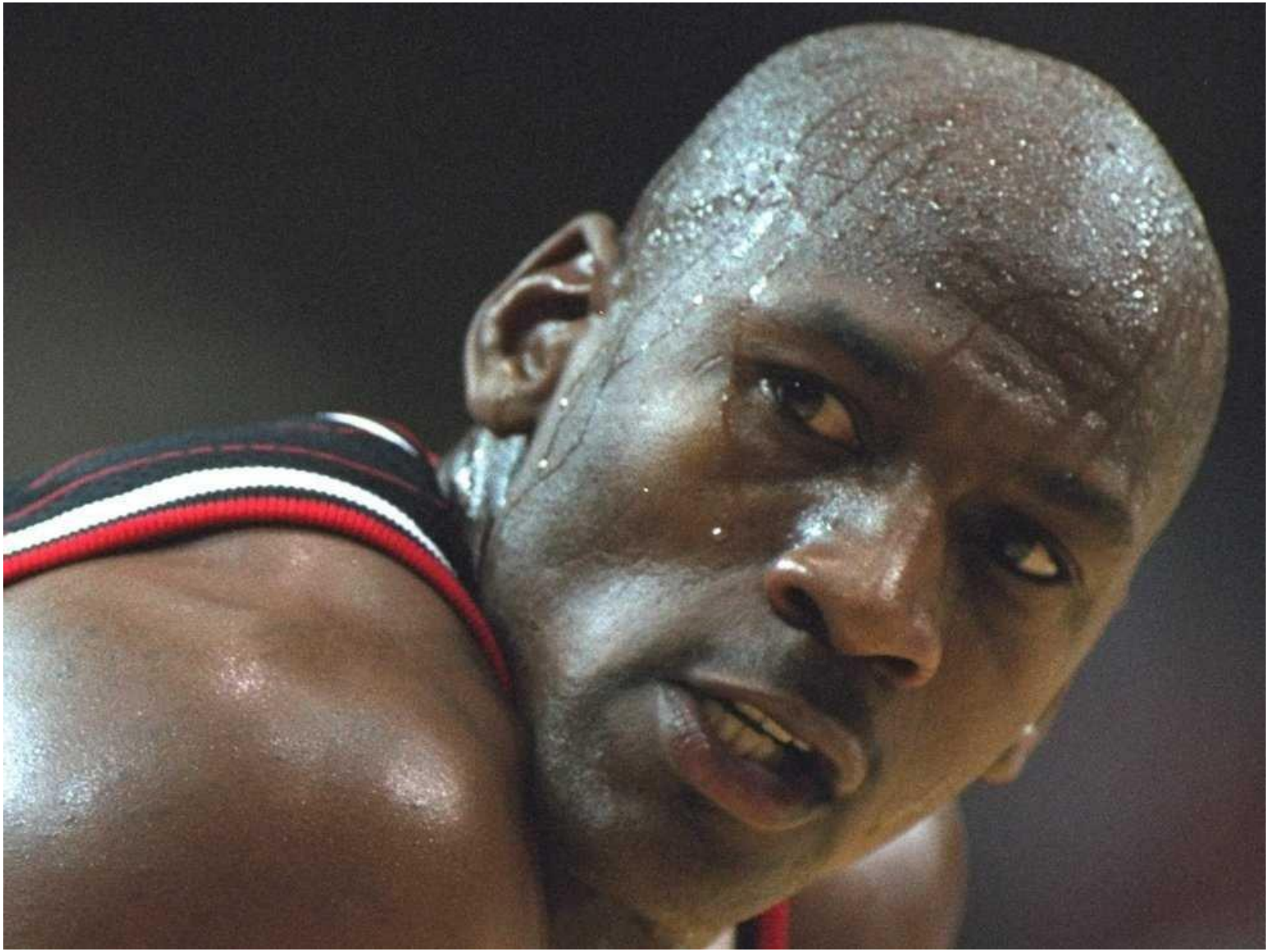


- $H_2O(liq) \rightarrow H_2O(g)$: *Evaporation*
  - ***requires*** energy *from* surroundings

- $H_2O(g) \rightarrow H_2O(liq)$: *Condensation*
  - ***releases*** energy *to* surroundings

2,260 kJ of energy released (or required) per kg of water that condenses (or evaporates)

Evaporative Cooling (aka “sweating”)



“Steam Burns” and Warm Bread

Moist and hot pasta (steam means lots of water vapor present)

Dry and crusty warm bread means not a lot of water vapor

Sauna (w/”steam”) – a latent heat laboratory

Cloud formation *releases* latent heat to atmosphere

Latent Heat Release

Condensation, atmospheric motion, and cold beer

Dale R. Durran and Dargan M. W. Frierson

The latent heat released when water condenses is an important driver of weather phenomena. And as a simple experiment shows, it also makes it tough to enjoy a frosty one in the summertime.

Dale Durran is a professor of atmospheric sciences and **Dargan Frierson** is an associate professor of atmospheric sciences, both at the University of Washington in Seattle.

water vapor. The annual mean equator-to-pole contrast in enthalpy at the surface is about equally divided between contributions resulting from gradients in temperature and those from moisture; each gives about a 50-K difference between the equator and the poles. Consistent with that 50-50 split, moist processes account for roughly half of the total heat transport between the tropics and high latitudes.

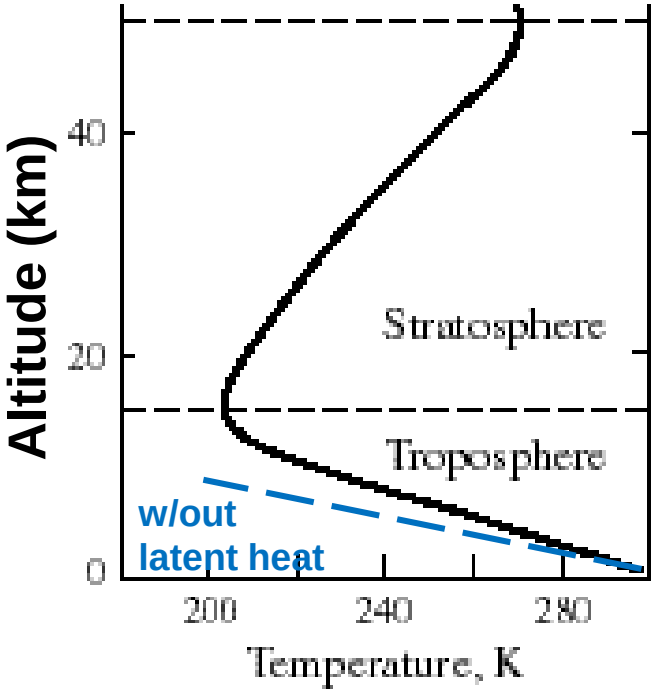
Vertical heat transfer by latent-heat release occurs, for example, in a thunderstorm's updraft core. Like hot-air balloons, the updrafts are warmer than their environment and their ascent is powered by upward buoyancy forces. Rising blobs of air experience a drop in the surrounding atmospheric pressure and cool through adiabatic expansion. Con-

- https://youtu.be/SEnVe0fGTbQ

Latent Heat and Atmospheric Temperature

- **The atmosphere has a variety of heat sources: radiation, conduction, convection, *latent heat (H_2O!)***

- ***<u>Latent heat release</u>*** **(clouds!) makes atmosphere warmer than it would otherwise be.**



Atmosphere as a heat and material transport vehicle

- How does heat get transferred?

- What causes atmosphere to move in vertical and horizontal directions?

Atmospheric Motions

- **Horizontal Motions:** parallel to Earth's surface (the everyday wind)
- **Vertical Motions:** perpendicular to Earth's surface (up/down)

Poll Question

The atmosphere has a mass of 5.2x10^18 kg, and thus feels a force due to gravity of ~5x10^19 Newtons,

Visual settings | Activate | Show results | Show correct | Lock | Clear results | Fullscreen

When poll is active, respond at **PollEv.com/thornton211** Text **THORNTON211** to **22333** on

- Therefore, it is continually falling to the surface due to gravity and being replenished above from space
- Therefore, it feels the force due to friction which balances gravity
- 1 and 2
- Neither 1 nor 2

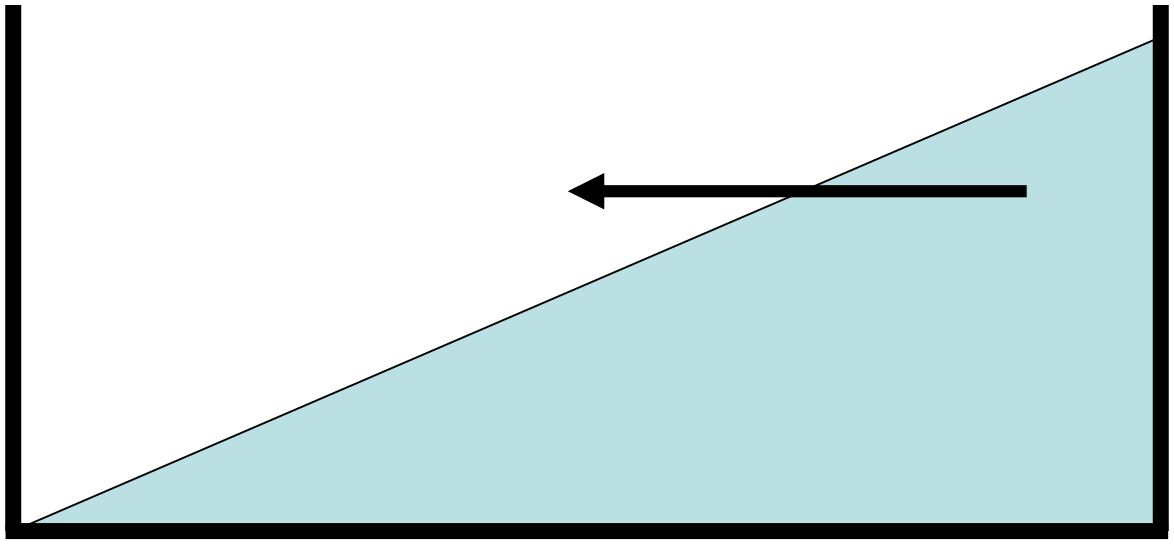
Next | Previous

Total Results: 0

Making Air Move

Pressure Gradient Force (PGF)

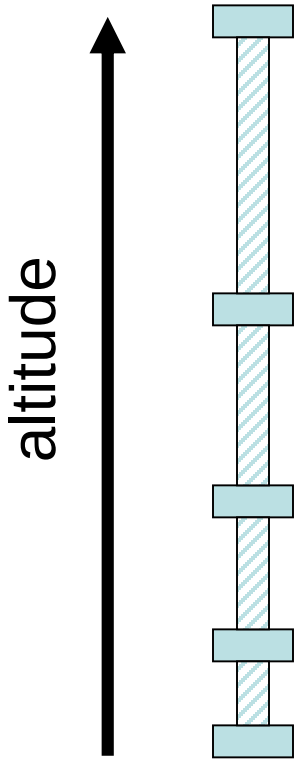
Air/water will move from a region of high pressure to low pressure



Water in a tub with horizontal pressure gradient

Pressure versus Altitude

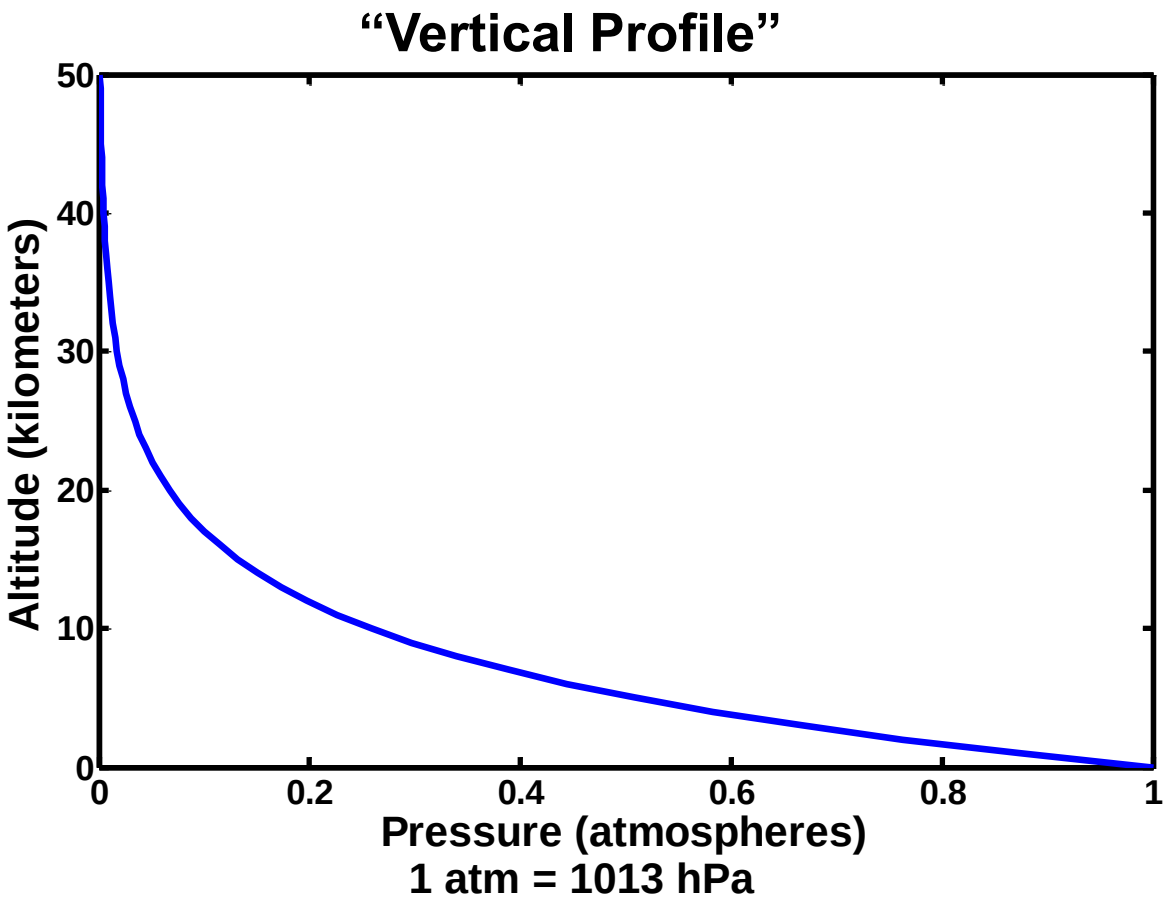
Gases (air) are *compressible* fluids



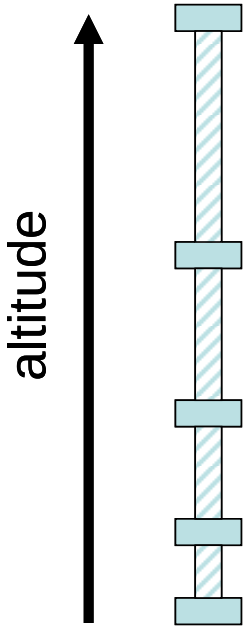
Expect Pressure to *decrease* with altitude (height above ground)

"Compressible" **equal-mass** bricks of air stacked on each other

Pressure Decreases Exponentially w/Altitude



Gases (air) are *compressible* fluids, unlike liquids.



"Compressible" bricks of air stacked on each other

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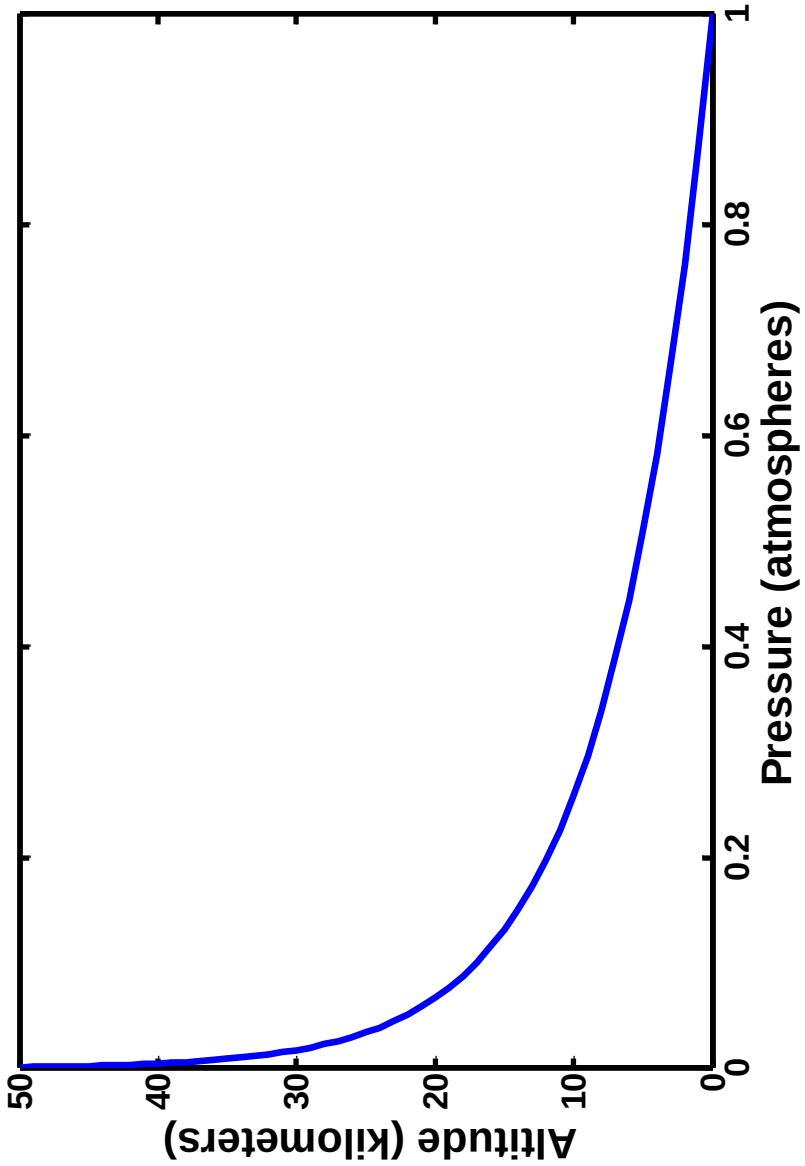

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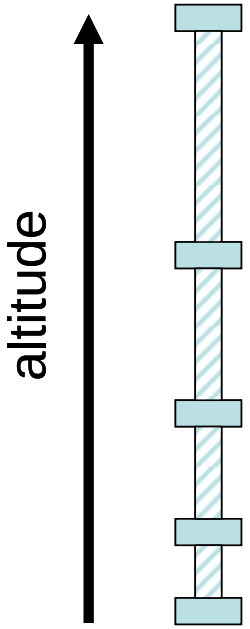

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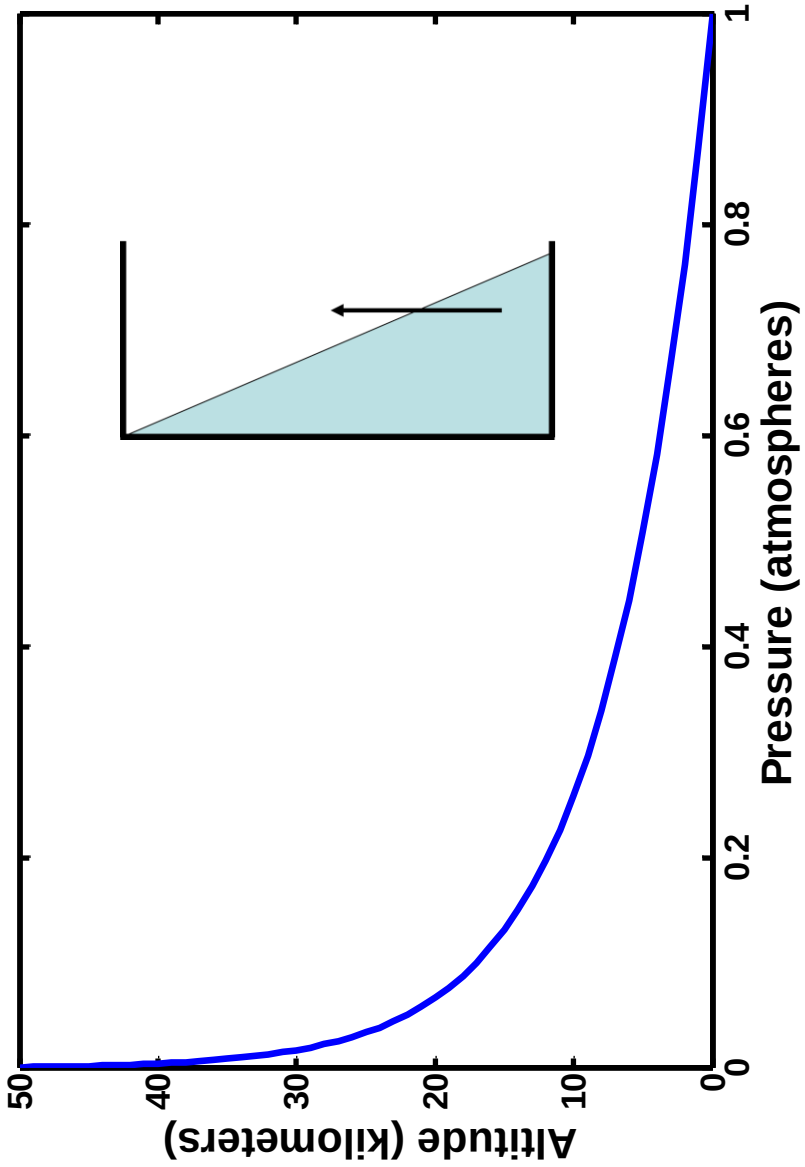

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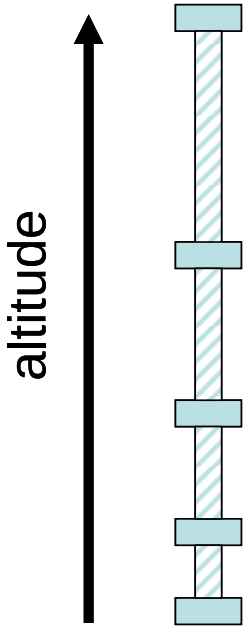
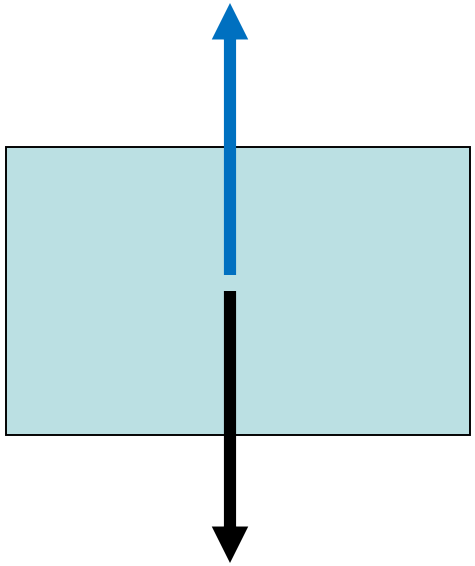


"Compressible" bricks of air stacked on each other

Barometric Law — "Hydrostatic Equation"

Pressure Gradient Force [because $P(z_1) > P(z_2)$]



Z_2 – higher altitude

Z_1 –low altitude

Gravitational Force

The atmosphere's tendency to be forced into space by pressure gradient, is balanced by force due to gravity (on average).

Summary (old and new)

- **The atmosphere has a variety of heat sources: *conduction*, *convection*, *latent heat (H_2O!)*, *radiation***
- **T decreases from 0 – 15 km (troposphere), increases from 15 – 50 km (stratosphere), then decreases…**
- **Atmosphere is a collection of ideal gases → $P = \rho RT$; P and therefore ρ decrease exponentially with altitude**
- **Pressure is force/area; differences in P between two locations (e.g., altitude) will cause air motion**