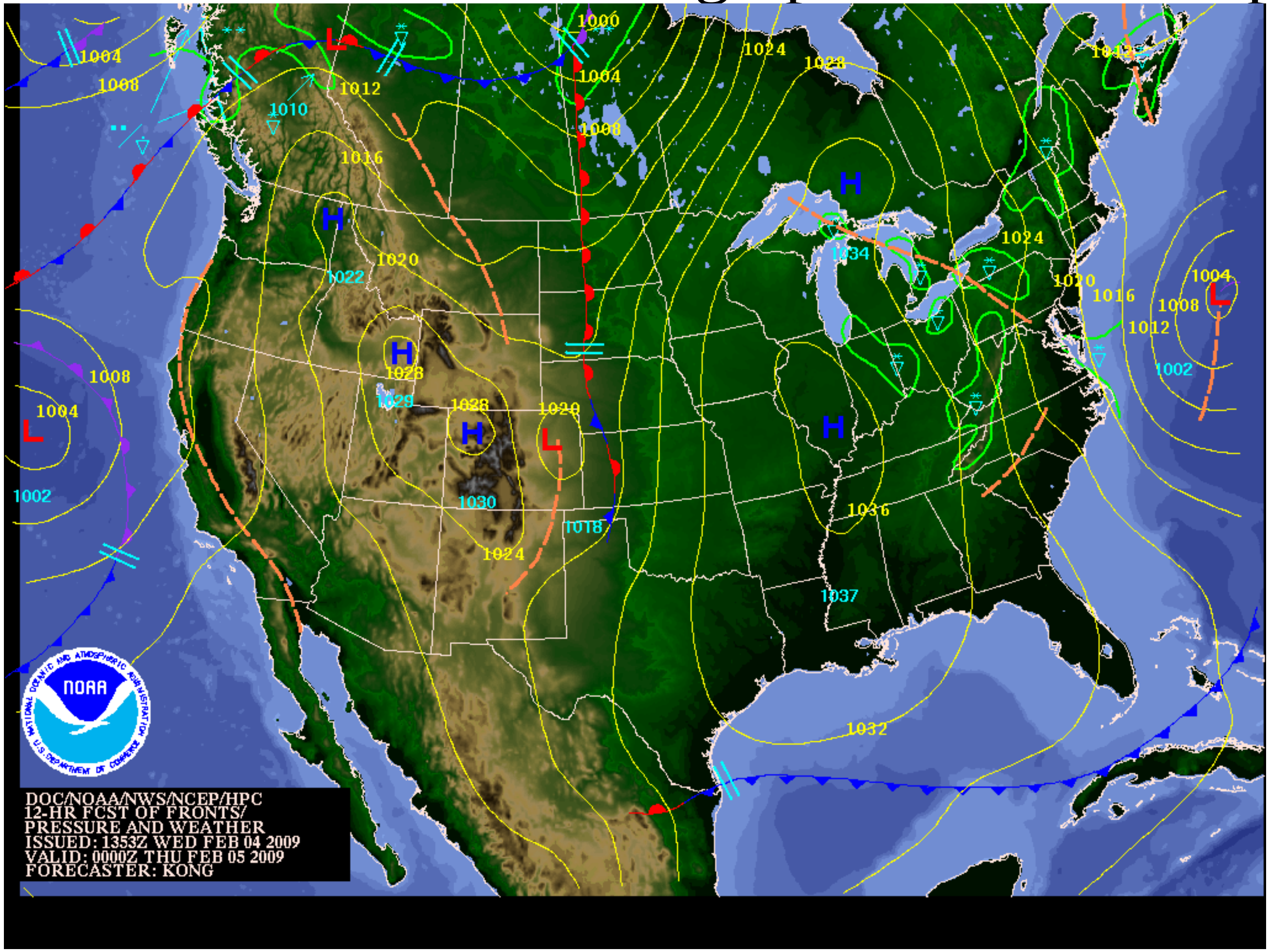
Ideal gas and pressure

Pressure force

- Air wants to move from high pressure to low pressure



Map of pressure at sea level. What about pressure at the surface?

Ideal gas

- Air behaves like an ideal gas.

$$PV = mRT$$

P	pressure (Pascals, Pa)
V	volume (m^3)
T	temperature (K)
m	mass (kg)
R	gas constant (J/K/kg)

Final answer

Ideal gas: some predictions

Consider: $PV = mRT$

Mass (m) is constant and pressure (p) is constant:

What will happen to volume (V) when we increase the temperature(T)?

a) It will increase
b) It will decrease
c) It will stay the same
d) This can never happen
e) The gas constant will change

Hint: the gas constant is always constant!

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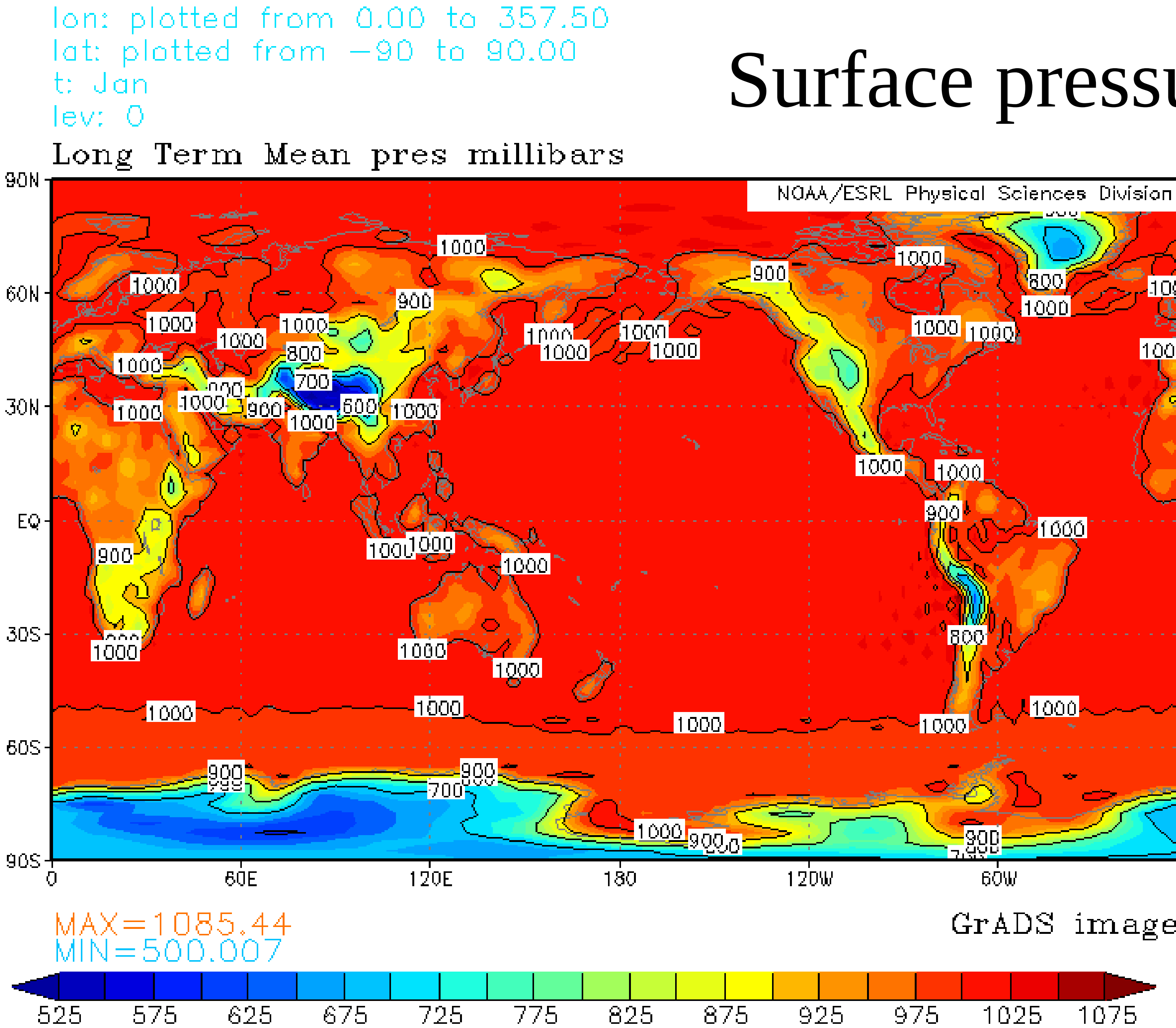
Which exerts more pressure?

A. A tonne of feathers in a $1m^2$ box
B. A tonne of cold water in a $1m^2$ box
C. A tonne of boiling water in a $1m^2$ box
D. A tonne of bricks piled up on a nail
E. A tonne of guacamole all over a football field

Surface pressure

- Sea level (0 meters) 1000 hPa
- Boulder (1650 m) 820 hPa
- Mt. Evens (4200 m) 600 hPa
- Mt Everest (8850 m) 320 hPa
- Tropopause (16 km) 100 hPa

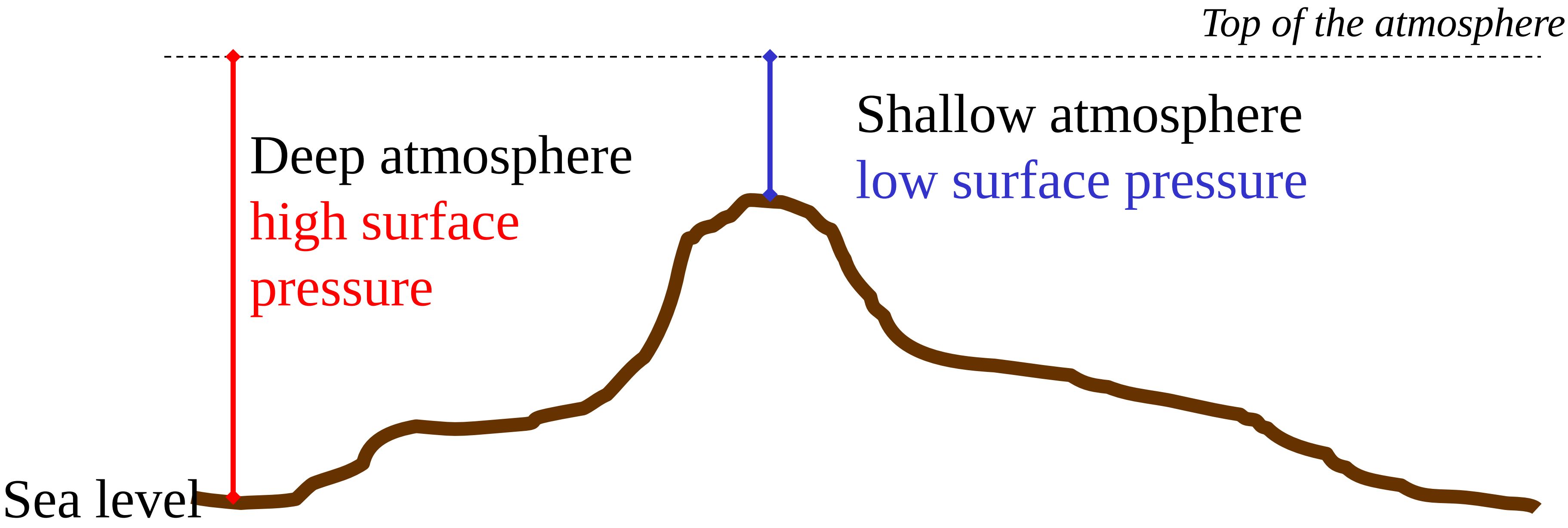
Surface pressure



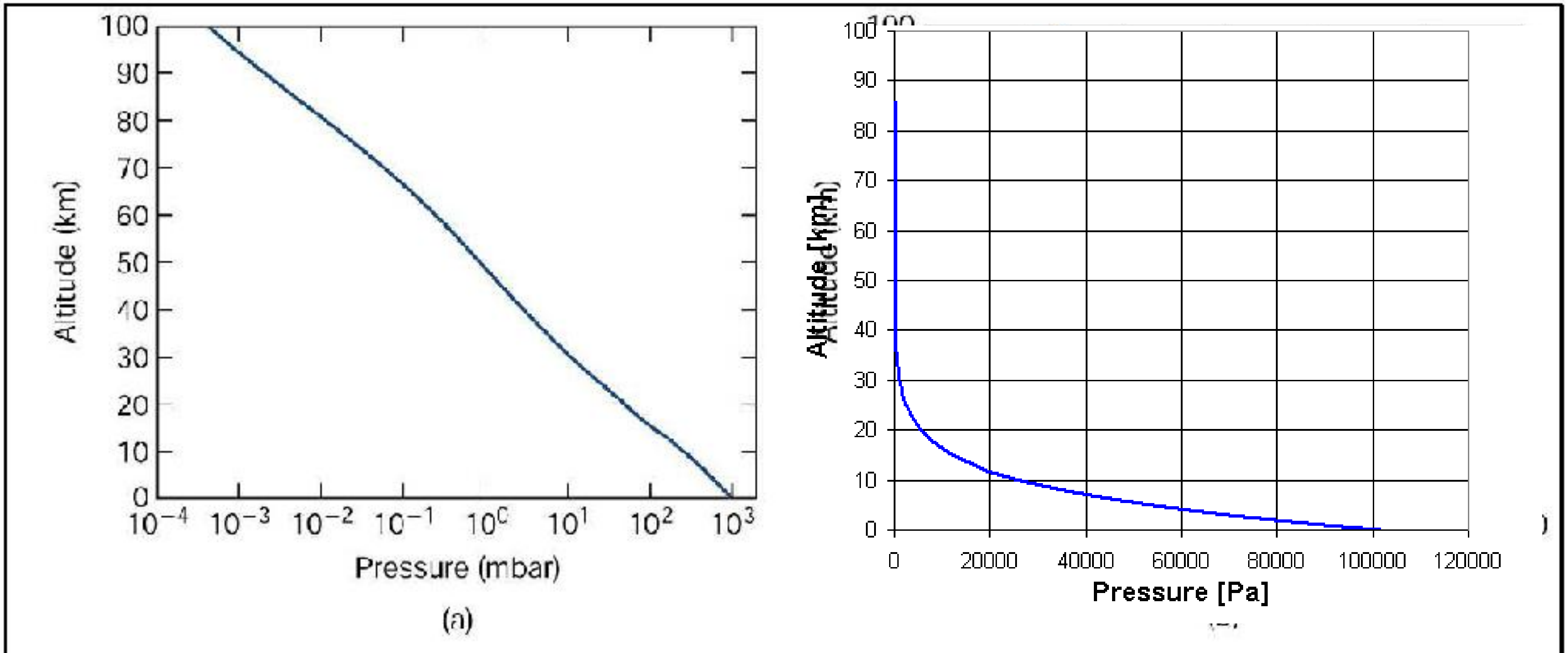
Pressure

- Pressure is a measure of weight per unit area
  e.g., "pounds per square inch"
  Prefer *Newton per meter squared* – called a Pascal
  (which is kg /m/s^2)
- In meteorology usually hecopascal (100 Pascal)
- 1 Pascal is the same as 1 millibar (mb)

- Weight of atmosphere above



Pressure



Decreases by factor of 10 for each 16 km

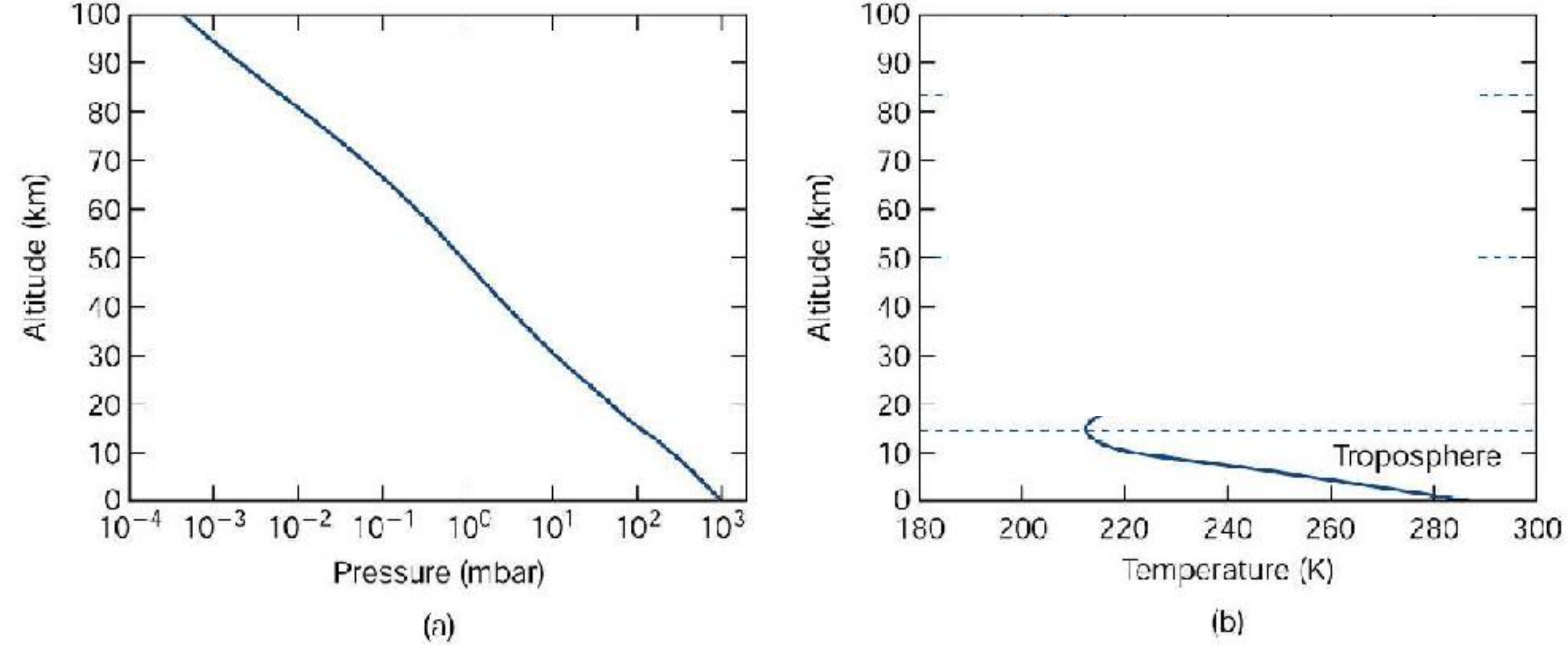
This exponential decrease allows us to use pressure as a measure of "altitude"

If most of the atmosphere about 10,000 meters deep, to what depth of ocean water would you dive to feel a total of 2000 hPa of pressure?

A. 1 m
B. 10 m
C. 100 m
D. 1,000 m
E. 10,000 m

Hint: Density of water is 1000 kg/m^3, density of air is 1.2 kg/m^3

Temperature structure of the atmosphere



Pressure: Example

- Is a measure of force per unit area (consider pounds per square inch)
- With gravity the force is weight

- David weighs about 170 pounds
- David's shoe is about 11 inches by 3 inches, so about 33 square inches.
- Standing on one foot, David exerts about..

170 pounds / 33 square inches = 5.5 pounds/square inch

- Atmospheric pressure is about 13 pounds per square inch… so about a third of the atmosphere!

Nails!

- A nail has a point of about 1/100th of an inch!
- So with 1 nail every square inch…
- David standing on 33 nails will have a pressure of

170 pounds / (33 x 0.01 square inches) = 550 psi!

(so about 34 atmospheres!)

- ***Conclusion (1):***
  professor will become impaled and bleed to death.
- ***Conclusion (2): Professor suggest an alternate calculation***

Nails (2)!

- David lying down flat
  Area is 72 inches tall times 12 inches wide
  72 x 12 = 864 square inches
- So pressure is:

  170 pounds / (864 x 0.01 square inches) = 19 psi
  (or about 1.2 atmospheres)

- This is much more compelling.
- ***Conclusion (1):***
  professor MAY NOT become impaled
  and bleed to death.
- ***Conclusion (2): Class suggests we need proof***

Final answer

If most of the atmosphere is in the troposphere, and the troposphere is about 10,000 meters, to what depth of ocean water would you dive to feel a total of 2000 hPa of pressure?

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C. 100 m
D. 1,000 m
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density of air is 1.2 kg/m^3

Final answer

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Key points (pun intended)

- **Pressure is a measure of weight (or mass) per unit area**
- Horizontal differences in pressure gives rise to motion
- In the vertical, ***pressure always decreases with greater altitude***

- Temperature decrease with greater altitude in the **troposphere**
- But there is a point where the temperature starts going up
- This is the **tropopause**, and above this is the stratosphere?

- We know temperature can change for various reasons (like radiation).
- We also know pressure and temperature changes are related.
- In the next few week we'll find how heating in the tropics and cooling at the poles gives rise to the weather and the ocean currents.