

BASIC CLIMATE SCIENCE II:

TEMPERATURE PROFILE OF ATMOSPHERE, GREENHOUSE GASES

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Physical Resource Theory

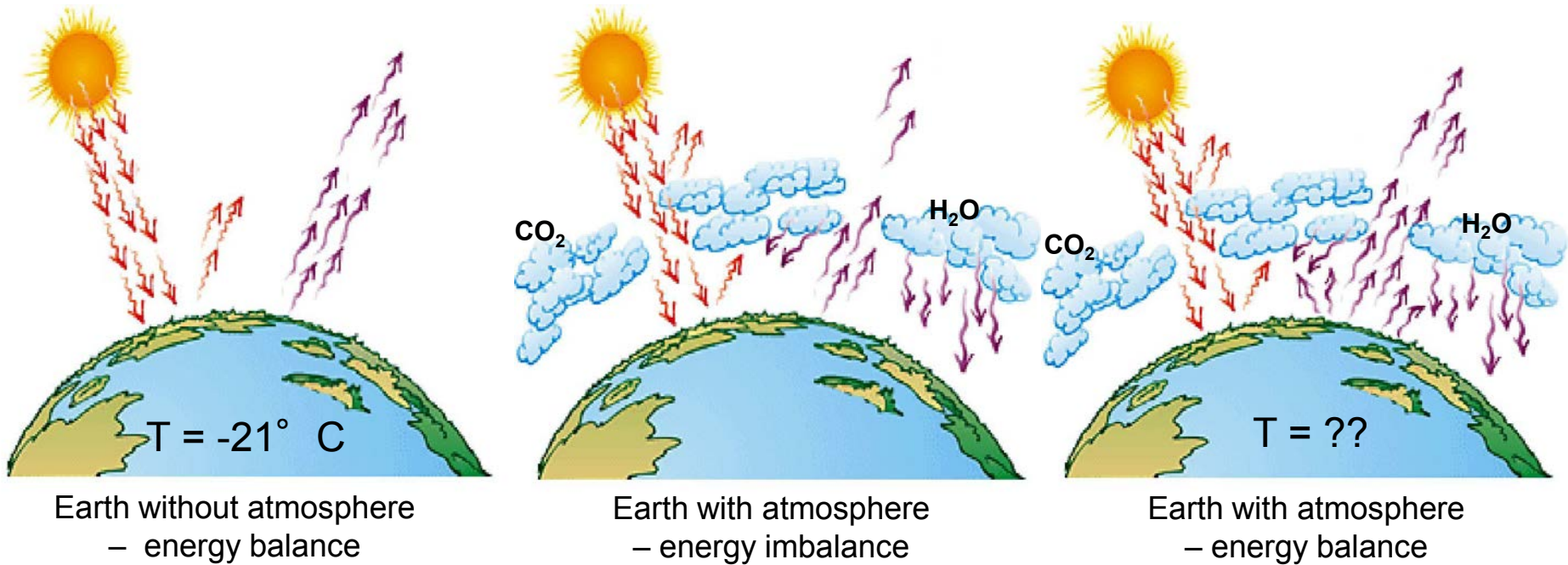
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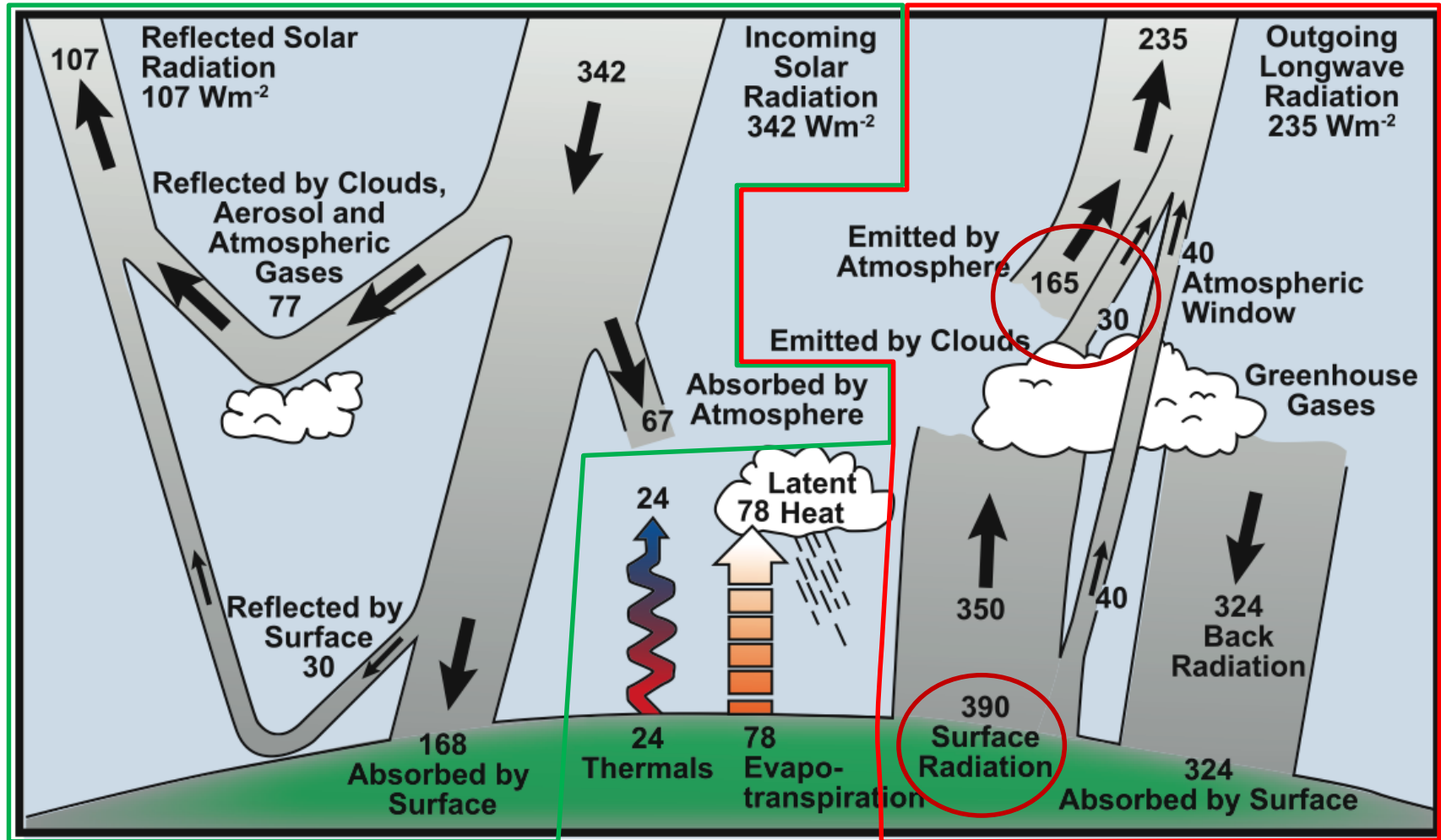
After this lecture you should be able to answer the following questions:

1. What is the greenhouse effect and how does it affect the earth's temperature?
2. How does temperature change as you move up in the atmosphere, and why?
3. Why is the temperature profile in the atmosphere essential for the greenhouse effect?

A simple model of the natural greenhouse effect



Earth's radiation balance & the natural greenhouse effect



Source: IPCC, 2007

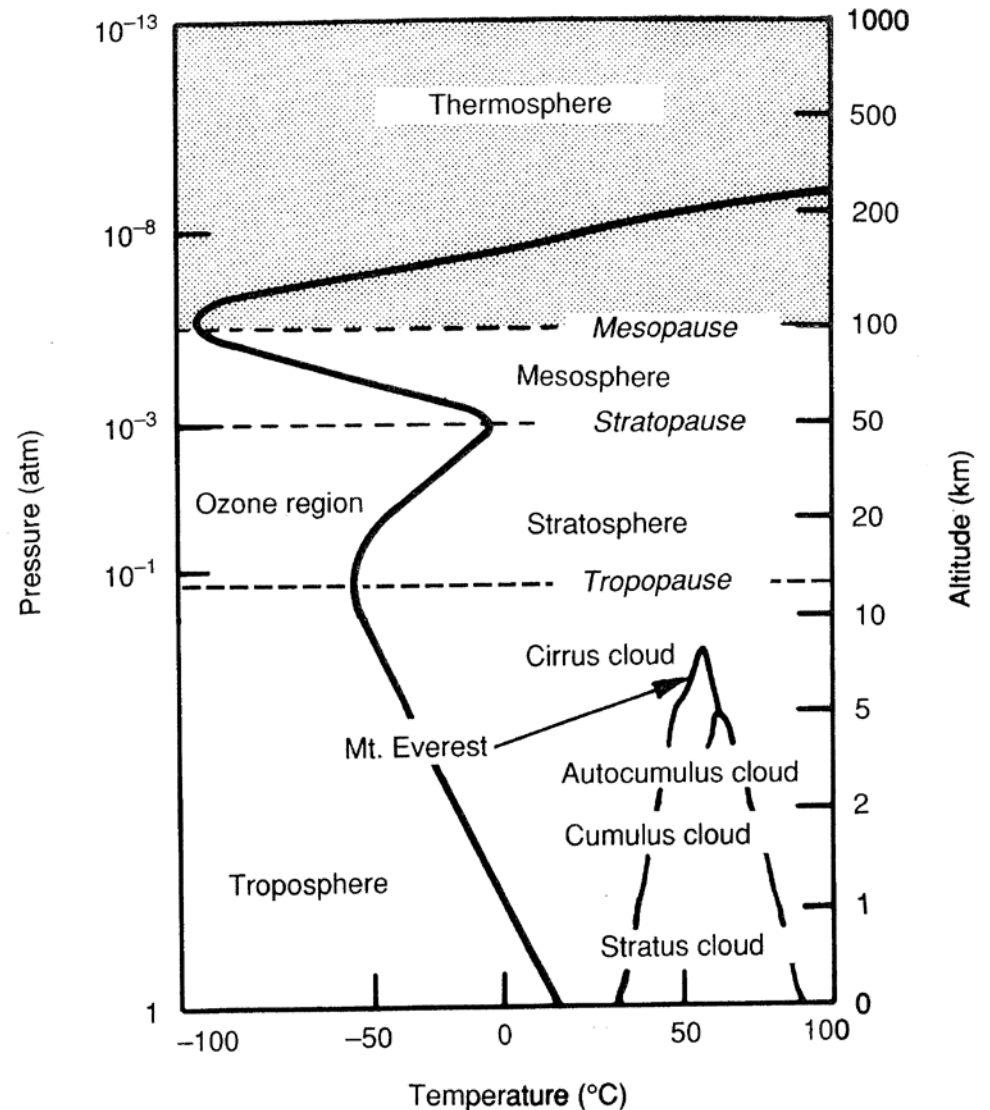
Short-wave, visible radiation

Long-wave, infrared radiation

If the temperature difference between earth's surface and the top of the atmosphere is essential for the existence of the natural greenhouse effect, what drives that temperature difference?

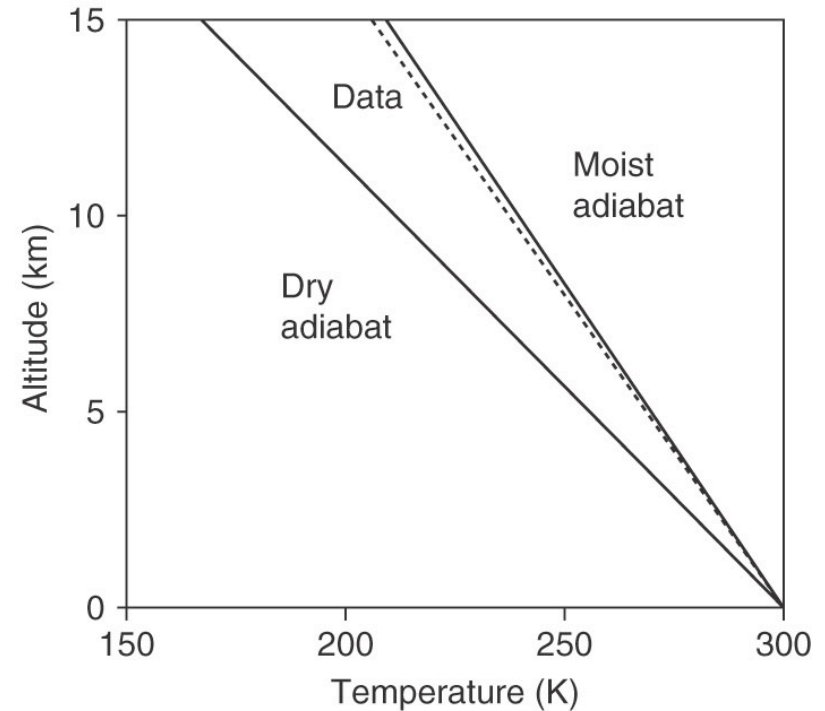
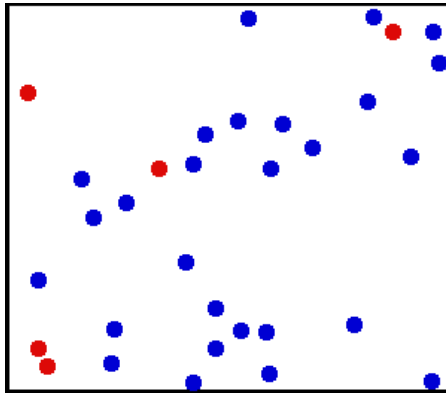
The temperature profile of the atmosphere

Why do temperature decrease with height in the troposphere and then increase with height in the stratosphere? Is it the same processes that govern temperature profile in both these parts of the atmosphere?



Why do temperature decrease with height in troposphere

1. Pressure decreases with height...
2. When air rises and expands, it cools - adiabatic temperature decrease...



3. Counter effect: as it cools, water vapor condenses and releases heat - moist adiabat... -> lapse rate $\sim 6.5^{\circ}\text{C}/\text{km}$

But we got a temperature gradient also in our simple one-layer model of the greenhouse effect that do not include pressure, etc..?

The radiative equilibrium also gives a lapse rate, but it is not stable...

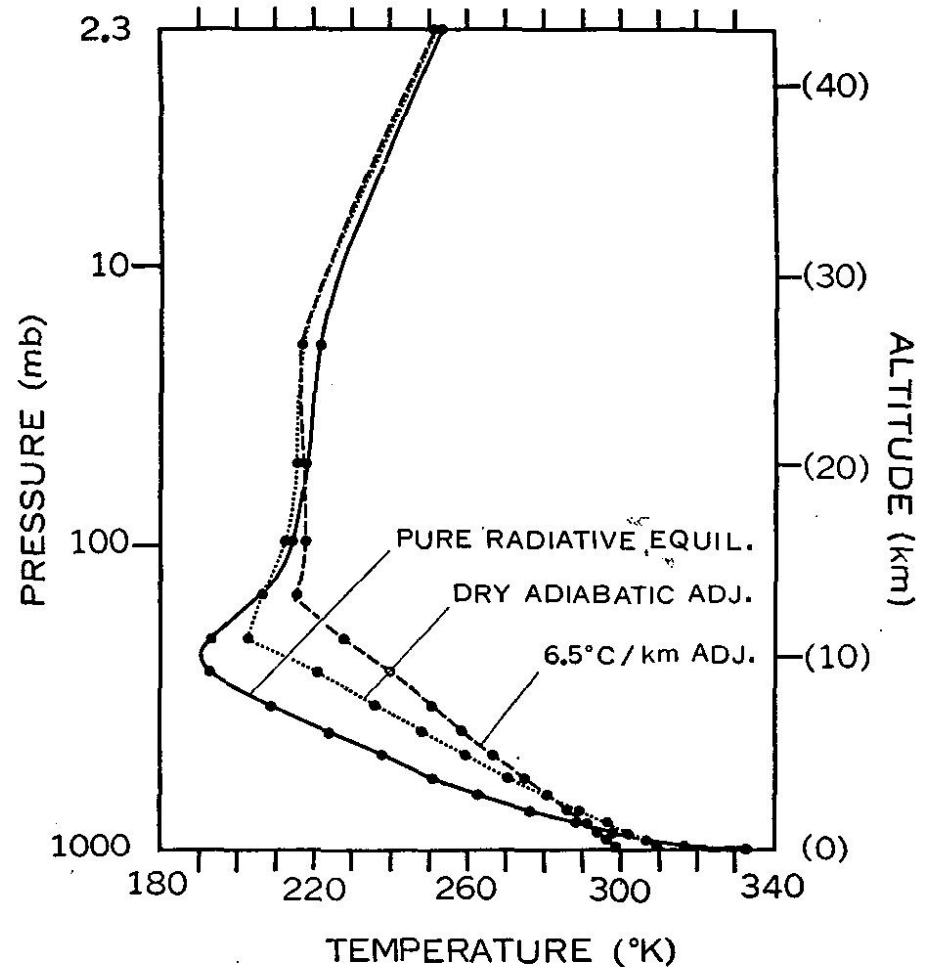
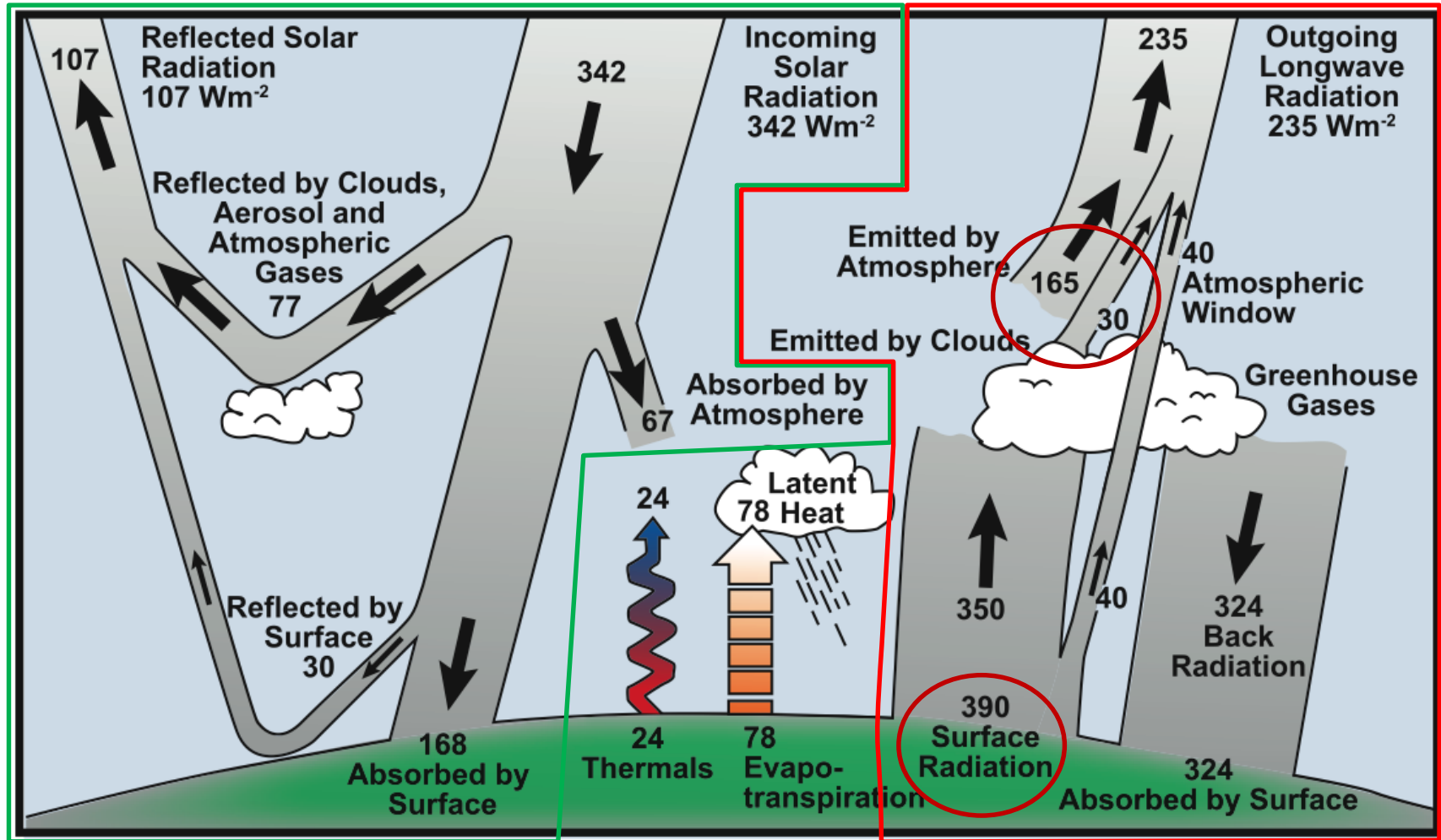


FIG. 4. The dashed, dotted, and solid lines show the thermal equilibrium with a critical lapse rate of 6.5 deg km^{-1} , a dry-adiabatic critical lapse rate (10 deg km^{-1}), and pure radiative equilibrium.

Earth's radiation balance & the natural greenhouse effect



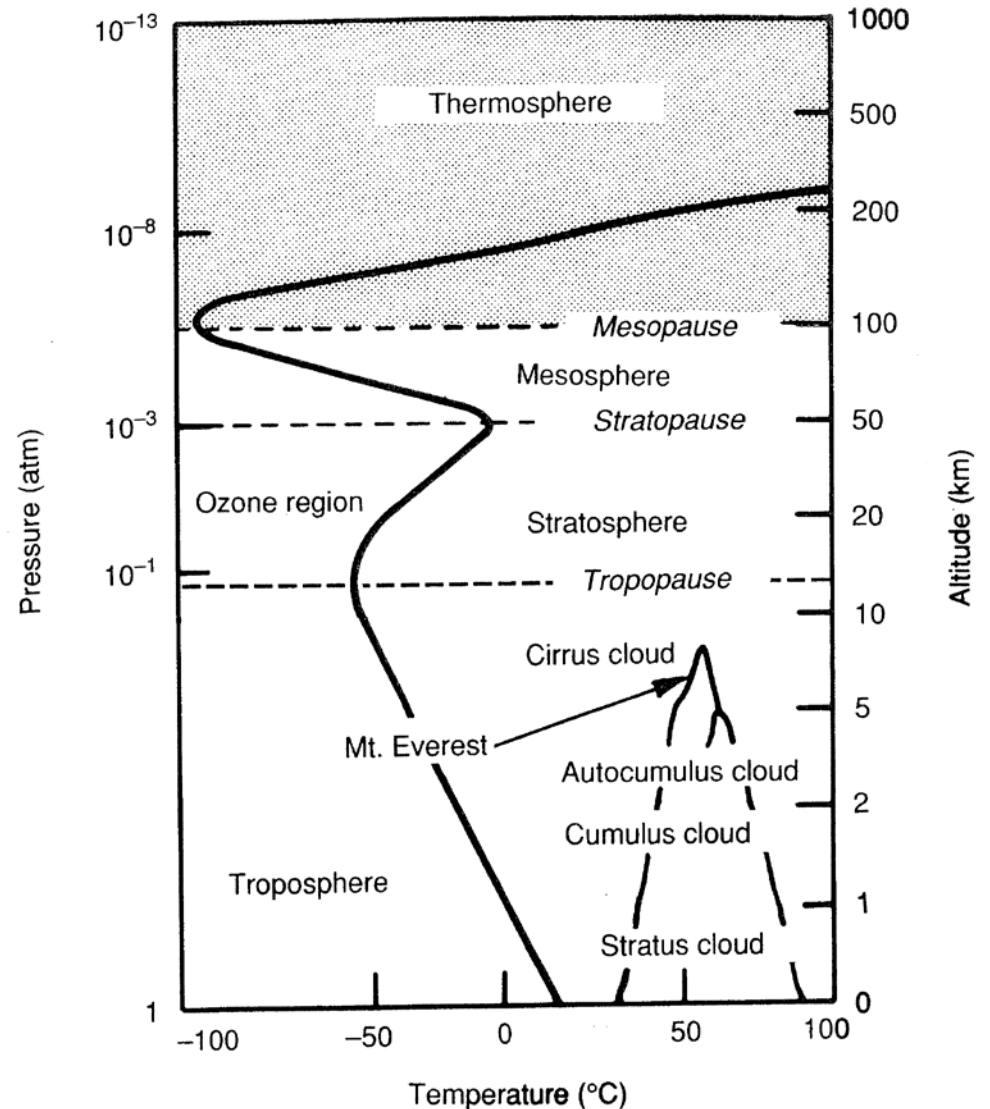
Short-wave, visible radiation

Long-wave, infrared radiation

Source: IPCC, 2007

The temperature profile of the atmosphere

Why do temperature increase with height in the stratosphere?



Take a minute to sum up to your neighbor what you have learnt about the temperature profile of the atmosphere
- then we can take any questions before we move on...

Summary

-The temperature of the troposphere increases by $\sim 6.5^{\circ}\text{C}/\text{km}$ due to (moist) adiabatic expansion as air is heated from below and rises...