Atmospheres, Weather, and Climate

11/11/2009

Opening Discussion

- http://www.youtube.com/watch?v=8crIHgjG1_I&fea
- Do you have any questions about the quiz?
- Have you seen anything interesting in the news?
- What did we talk about last class?

Terrestrial Atmospheres

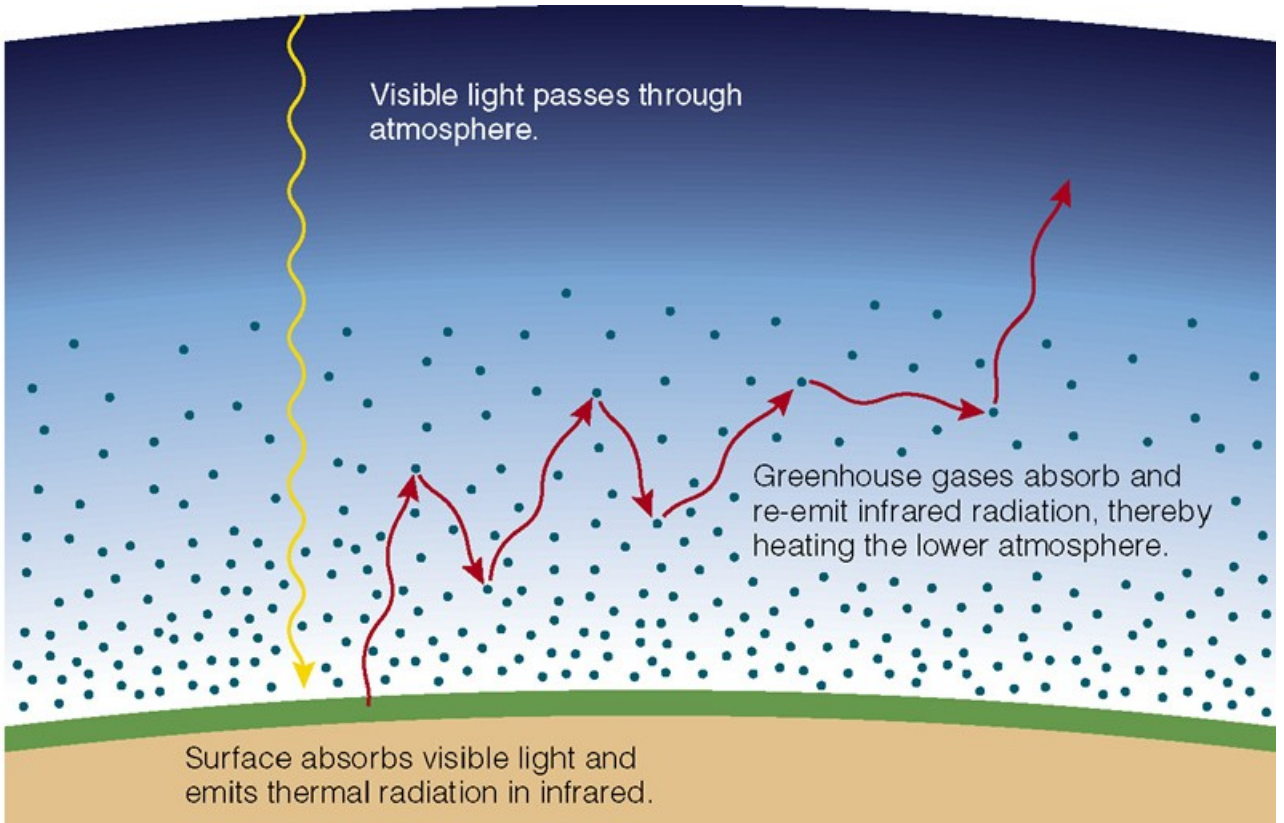
- An atmosphere is nothing more than the outer layer of gas around a planet. Given this definition, all the terrestrial planets have atmospheres. For the Moon and Mercury they just happen to be extremely thin. Even with the Earth, the majority of the atmosphere is within 10 km of the surface.
- The top layers of the atmosphere are supported by the pressure from the layers above them. At any point, the pressure is equal to the sum of the weight of all the air above that point. On the Earth this pressure is about 14.7 psi.
- It is hard to define where the top of the atmosphere is.

Functions of Atmospheres

- Atmospheres can warm planets (the greenhouse effect) and evenly distribute heat.
- They can absorb and scatter light. This protects us from high energy radiation and causes our sky to be blue.
- The atmosphere provides pressure. This is critical for keeping water in a liquid state.
- Atmospheres allow for wind and weather.
- Atmospheres interact with the solar wind and magnetic fields of the planets.

The Greenhouse Effect

- Some gases, mainly molecules with more than 2 atoms that can spin and vibrate, transmit visible light and absorb infrared light. This traps heat and warms up the lower atmosphere and surface of the planet.



Temperatures Without Atmospheres

- We can figure out how hot planets should be if they had no greenhouse effect. They radiate energy in all directions from the full surface and absorb energy across a cross section on one side. If we know how much they reflect and how intense the Sun is we can figure out at what temperature they radiate as much as they absorb. This assumes a decent spin rate.
- Your book gives this helpful formula where d is in AU.

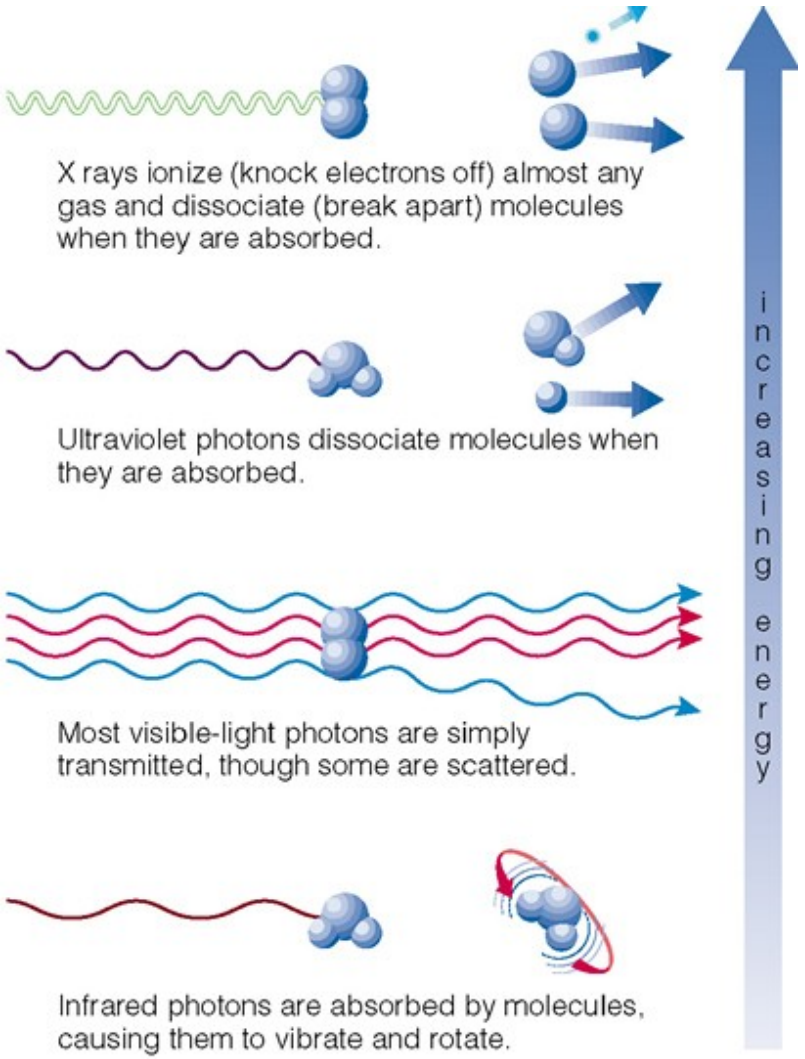
$$T = 280[K] * \sqrt[4]{\frac{(1 - reflectivity)}{d^2}}$$

- This predicts the following: Mercury 164C, Venus -43C, Earth -17C, Moon 0C, Mars -55C. That prediction is only close for Mars which is actually -50C. For the Moon and Mercury the spin rate is too slow.

Greenhouse Effect: Good or Bad?

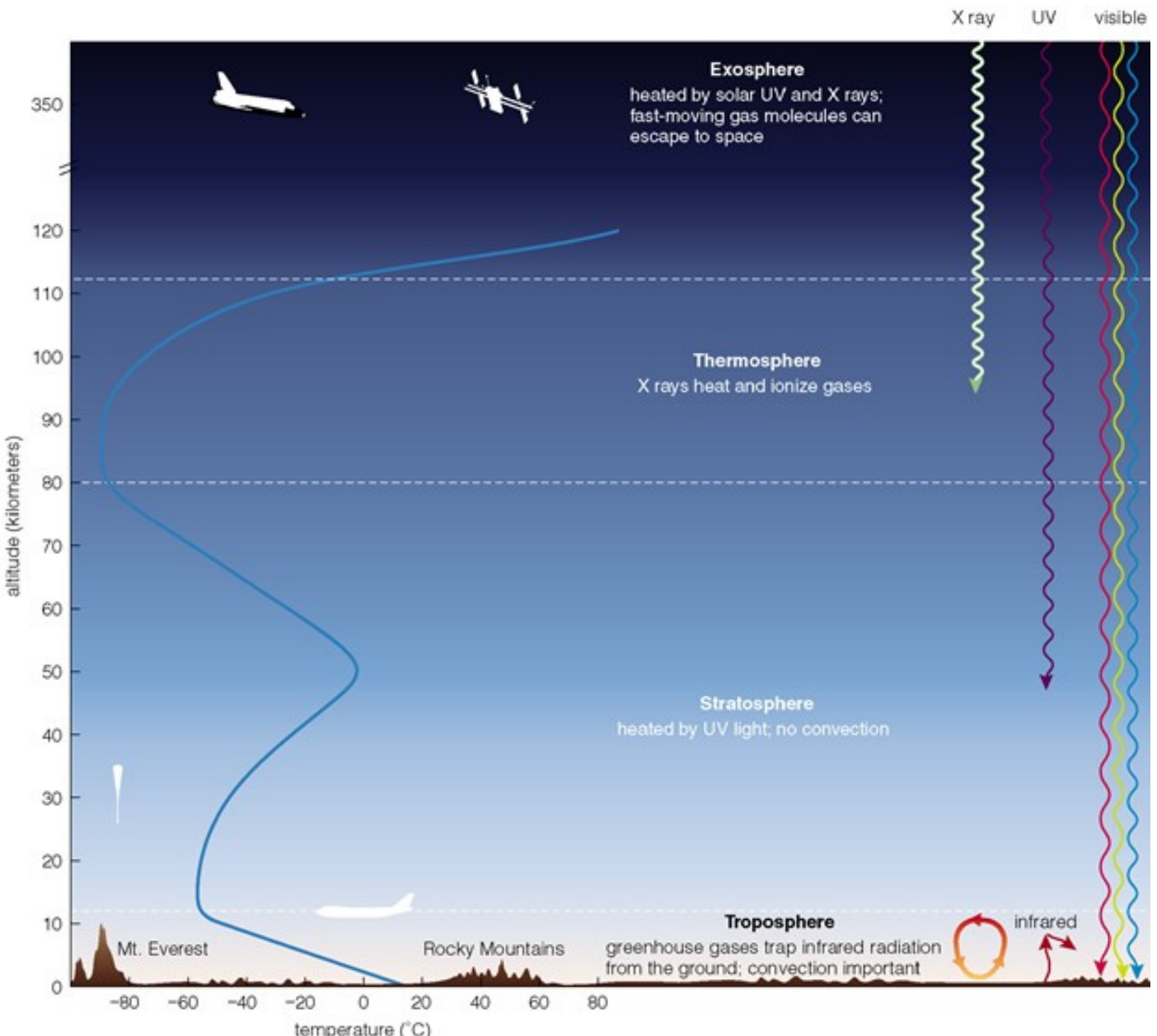
- The greenhouse effect is a major political hot spot these days. You have to understand some things about it to really have an informed opinion. The most significant greenhouse gas in our atmosphere right now is water.
- Should we be worried about the buildup of carbon dioxide and methane in our atmospheres? Is it possible to increase the amount of carbon dioxide in our atmosphere and not have it trap more heat and warm the planet?

Light Interacting with Atmospheres



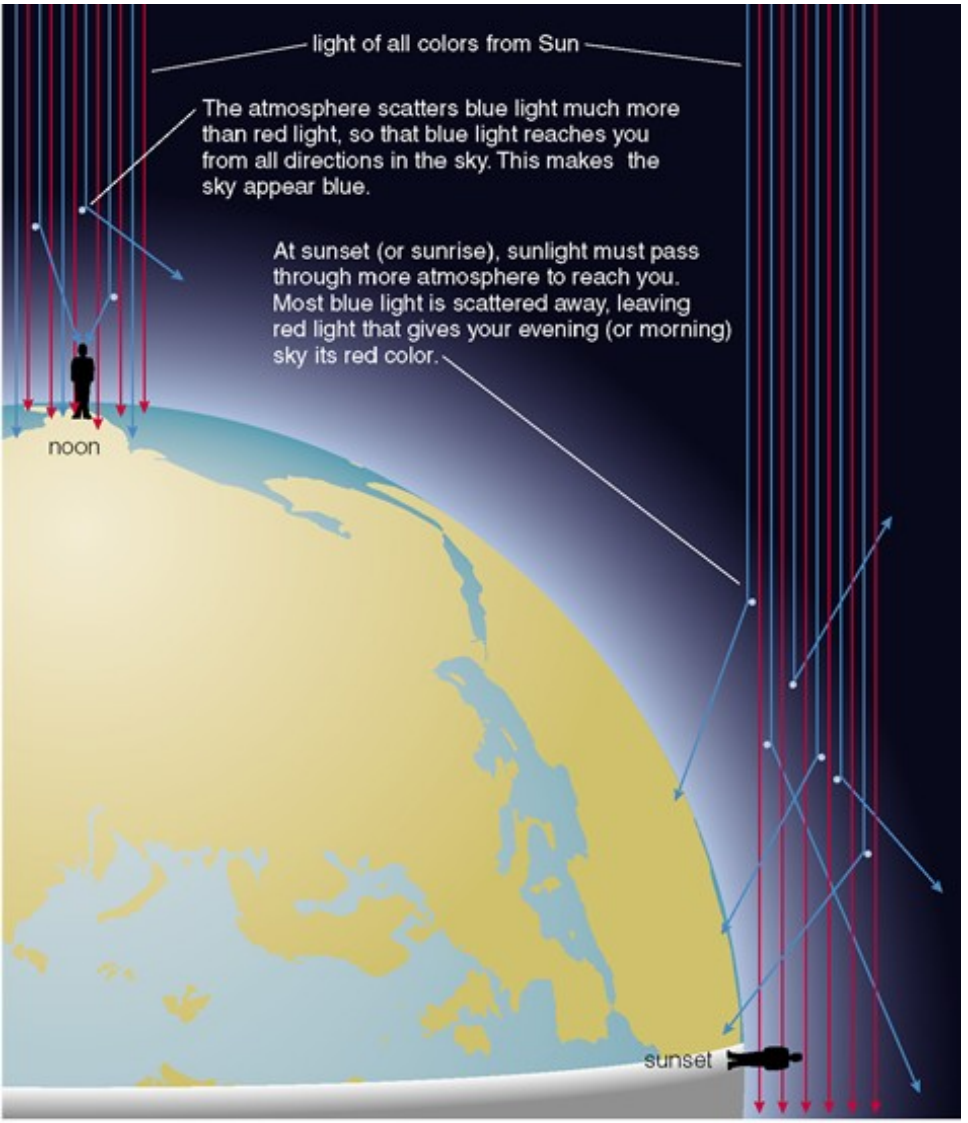
- To understand the structure and dynamics of atmospheres we need to understand how gases interact with different types of light.
- X-ray absorption dissociates molecules and ionizes atoms.
- UV absorption dissociated loosely bound molecules.
- Visible light is transmitted or scattered.
- IR light is absorbed giving rotational or vibrational energy.

Earth's Atmospheric Structure



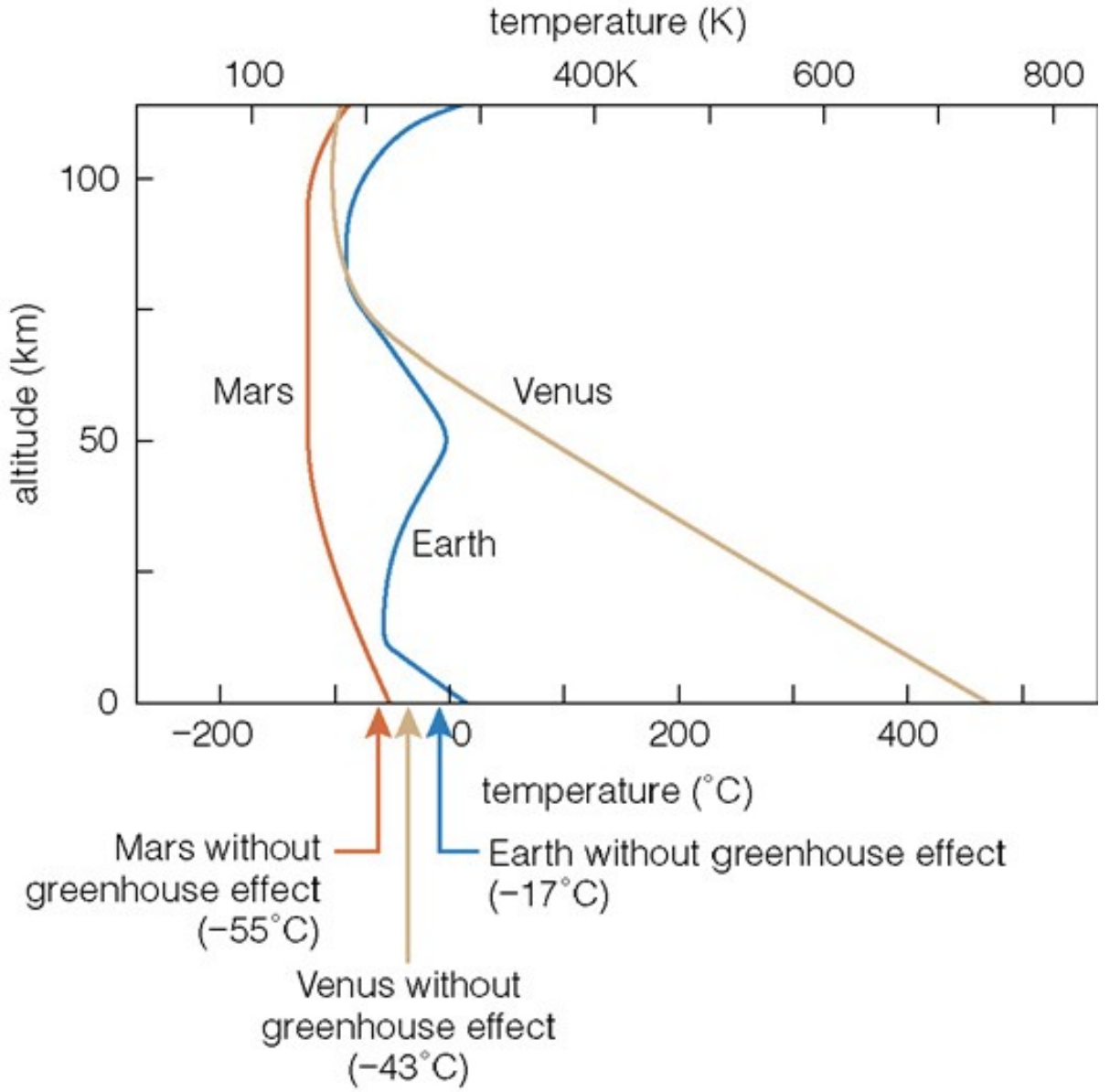
- “Layers” of atmosphere determined by how the air interacts with light.
- Everything we do happens down in the troposphere where IR absorption drives the dynamics.
- Other layers absorb Sun light.

Why the Sky is Blue

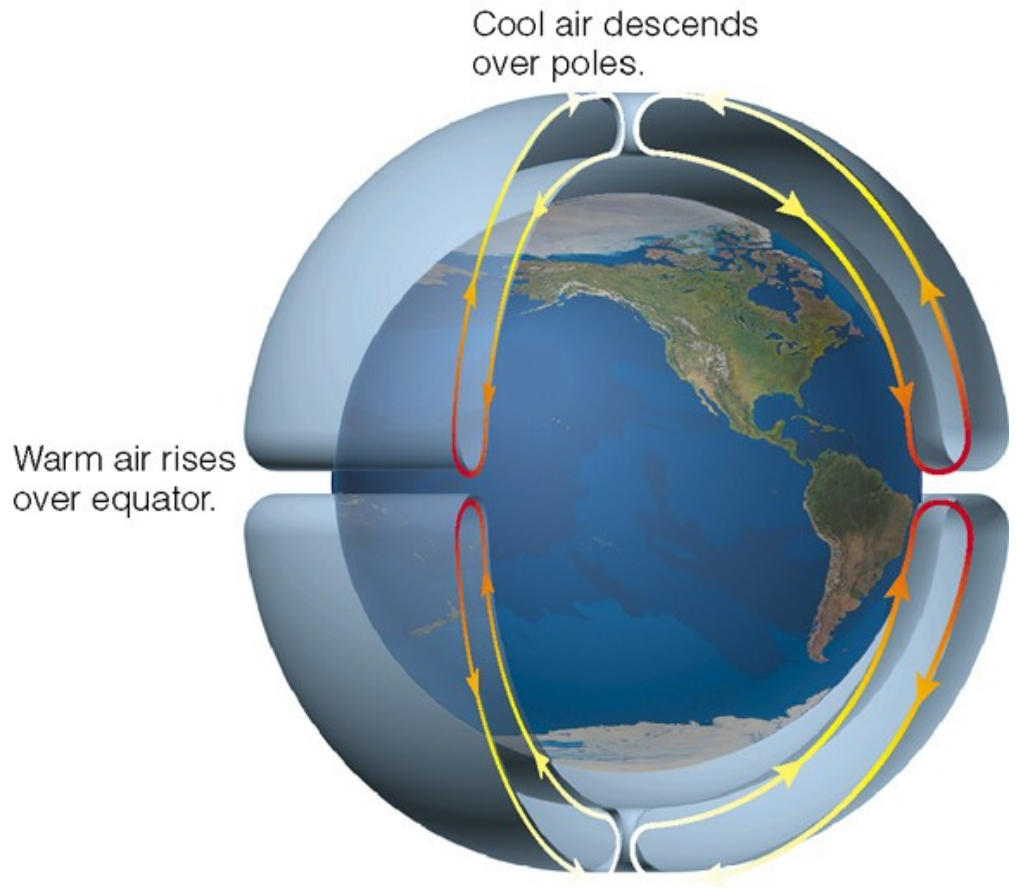


- The sky is blue because blue light is scattered more than red light.
- This is also the reason why sunsets are red. Blue light doesn't pass through that much atmosphere well and by that distance some red light has been slightly scattered.
- This type of scattering is mostly forward scattering like from dust in the air.

Comparisons to other Planets



Circulation Cells

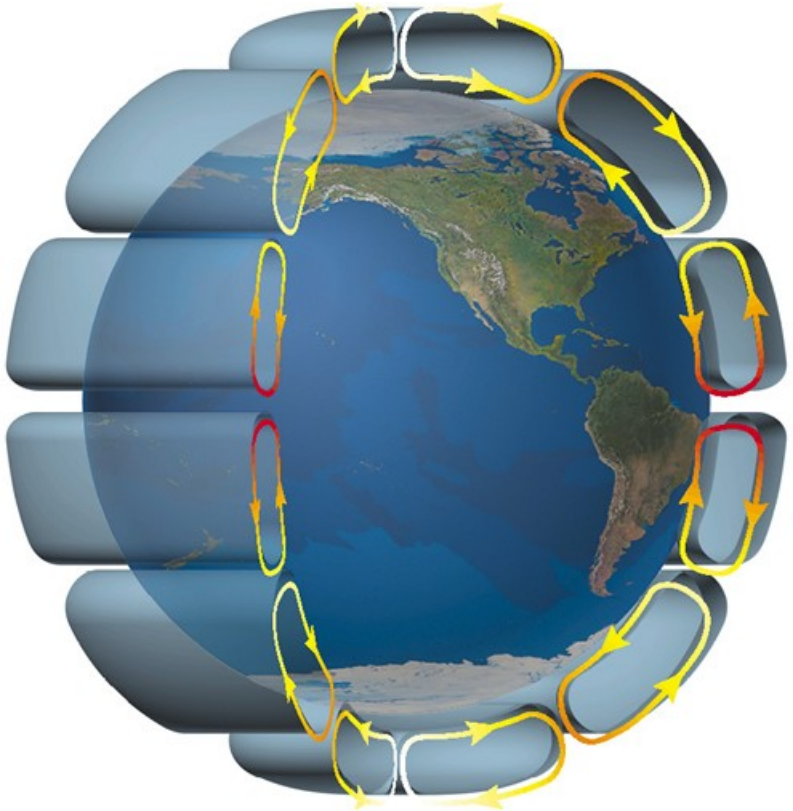


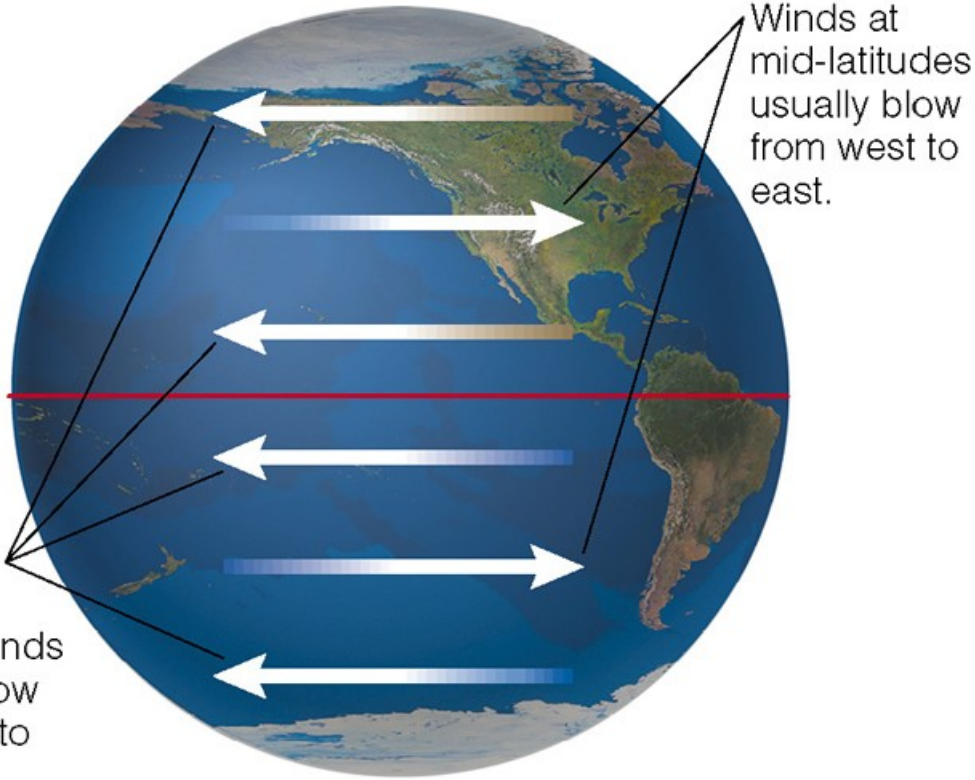
- Air will naturally move to transport heat around a planet. In a convective like manner hot air rises and cold air sinks, but you also have hotter equatorial air swapping with colder polar air.
- If nothing stopped it, the cells would look like this and the planet would be a fairly uniform temperature. That is true on Venus. The thin Martian atmosphere leaves the poles much colder than the equator.

Coriolis Effect

- If a planet spins, then air moving from one latitude to another is also changing its radius of rotation. The air has to conserve angular momentum so it must slow down or speed up depending on whether it is moving toward or away from the equator.
- This is why large weather systems, where air moves in toward a low pressure region, spin in characteristic directions and those directions are the opposite for the north and south hemispheres.

Global Wind Patterns





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Climate Change

- Climate is a long term average of weather. There are four main factors that can lead to changes in climate.
  - Solar brightening – main sequence stars get brighter as they age. Our Sun is roughly 30% brighter now than it was 4 billion years ago.
  - Changes in axis tilt.
  - Changes in planetary reflection – changes in fractional coverage for clouds, ice, aerosols, trees, pavement, etc.
  - Changes in greenhouse gas abundance.

Minute Essay