

Atmospheres of Venus and Earth

11/16/2009

Opening Discussion

- <http://www.youtube.com/watch?v=IhTSfOZUNLo>
- Have you seen anything interesting in the news?
- What did we talk about last class?

Venus Today

- Venus's atmosphere today has 90 times the mass of the Earth's and is nearly all carbon dioxide.
- The density is 10% that of water.
- There is little wind and virtually no weather.
- The greenhouse effect from the CO₂ makes the surface hotter than an oven on the clean cycle.
- High in the atmosphere there are clouds with sulfuric acid and fast winds.

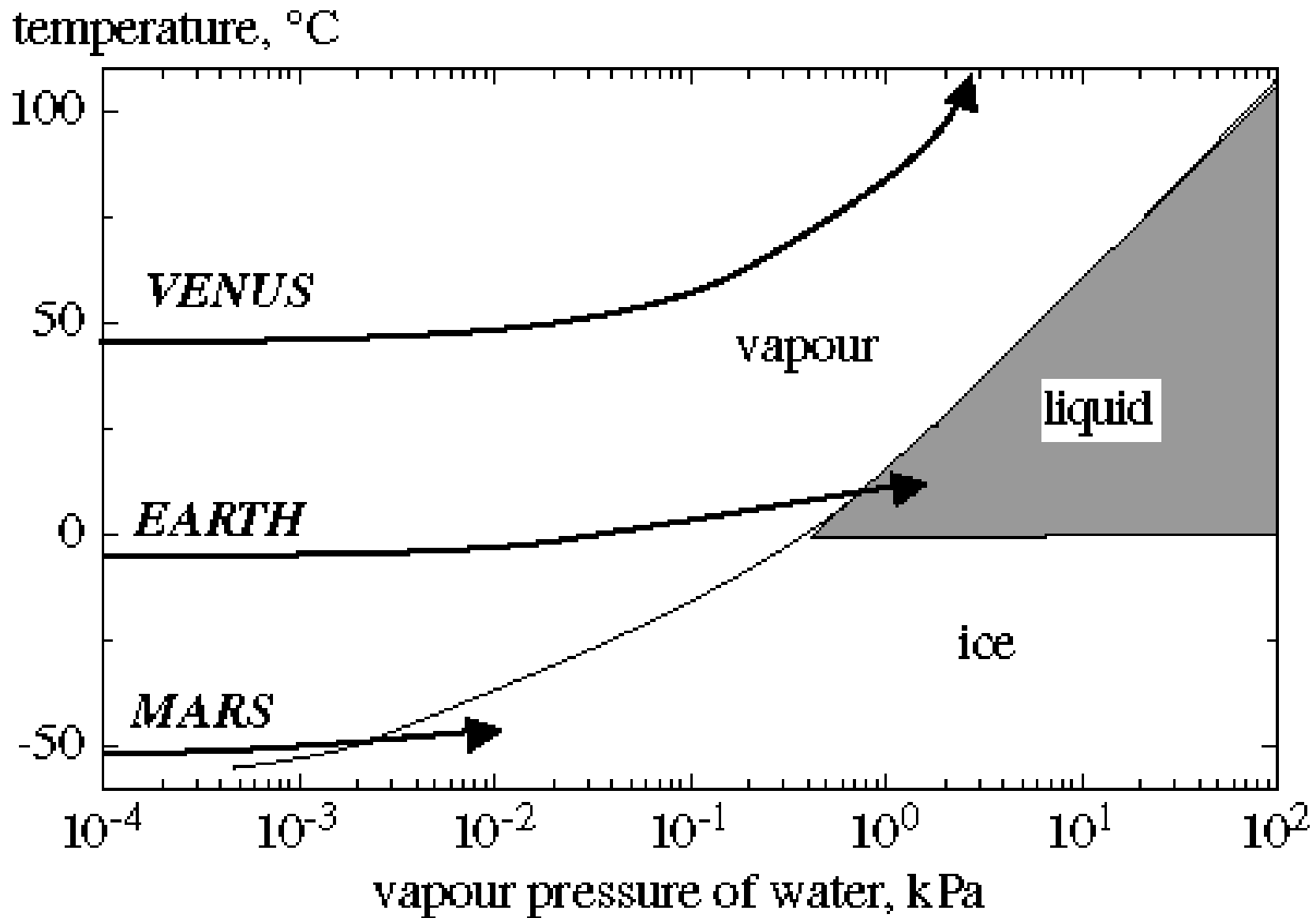
Water and Carbon Dioxide

- Venus's atmosphere has nearly 200,000 times as much CO₂ as the Earth's. It also has virtually no water.
- Large amounts of both should have been outgassed on both Venus and Earth.
 - On Earth the water is in the oceans and the CO₂ is trapped in carbonate rocks.
 - Lack of oceans keeps CO₂ in the atmosphere of Venus.
- Water photodissociated and hydrogen escaped. Evidence in isotopic abundances.

Runaway Greenhouse Effect

- If you were to move the Earth to the location of Venus the temperature would rise about 30°C. This would cause significant water evaporation from the oceans.
- The added water leads to more heating because water is a greenhouse gas.
- This positive feedback loop continues until all oceans have evaporated.
- Over a long time, water would photodissociate and be lost, leaving a planet like Venus.

Comparing Planets



Pleasant Early Venus?

- Because the early Sun was dimmer than the current one, it is possible that early Venus might have been a nice place, much like the Earth.
- As long as it could have oceans and liquid water, CO₂ levels would remain moderate.
- Eventually the warming of the Sun would cause runaway greenhouse.
- Unfortunately, it is unlikely there is any geological evidence of whether this really happened.

Why is Earth Different?

- Liquid water and low CO₂ levels linked. Caused by being the right size in the right place.
- High nitrogen content from outgassing and the fact that water and CO₂ are kept out of atmosphere.
- Molecular oxygen is a product of life. Isn't produced geologically and doesn't remain long without source.
- Ozone layer and stratosphere caused by oxygen chemistry.

Carbon Dioxide Cycle

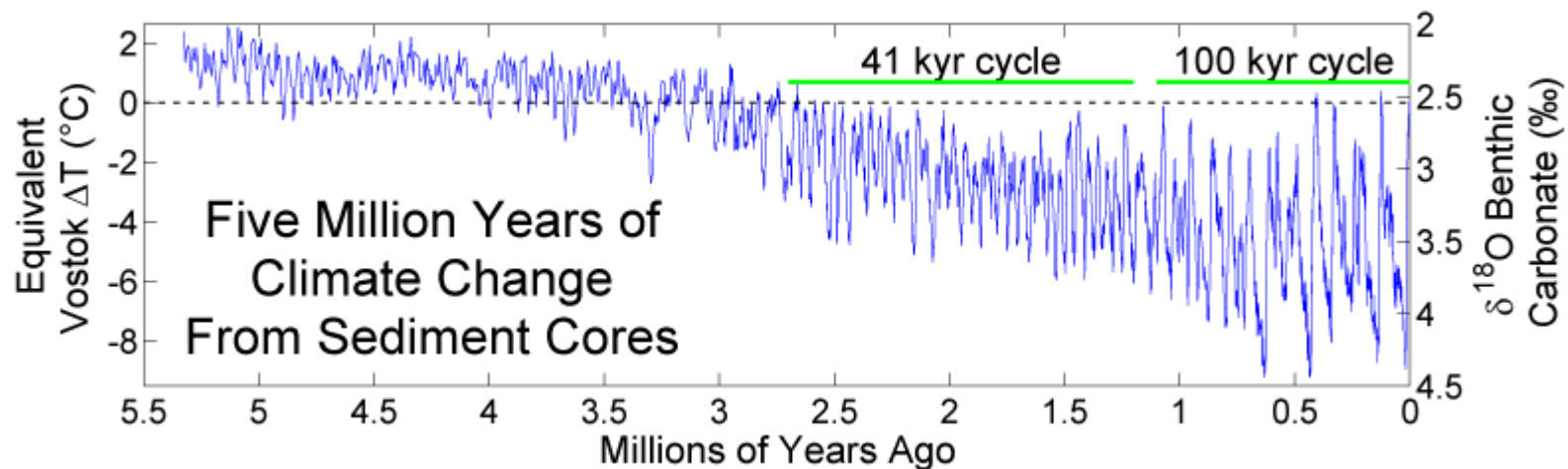
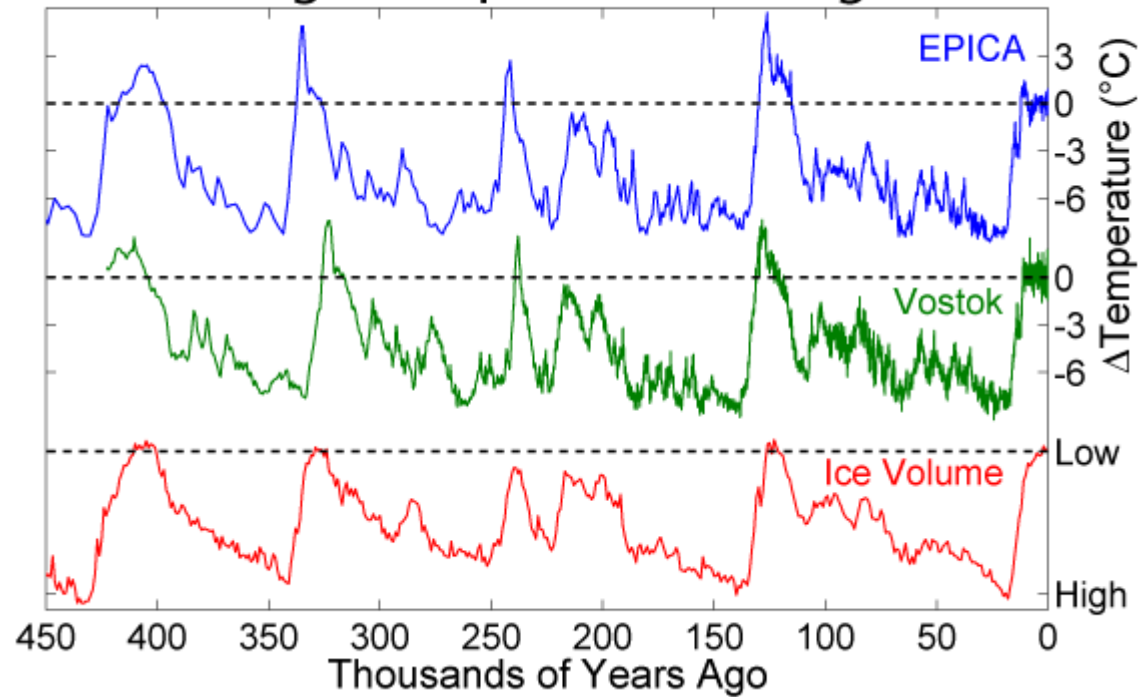
- CO₂ dissolves in water and bonds into carbonate rocks. The rocks are subducted, melt, and release gas in volcanism.
- The Earth has something of a built in thermostat because CO₂ absorption produces a negative feedback cycle.
 - When it warms, CO₂ is removed more quickly. When it cools the rate slows.
 - Takes many thousands of years for this to fully kick in.

Ice Ages and Snowball Earth

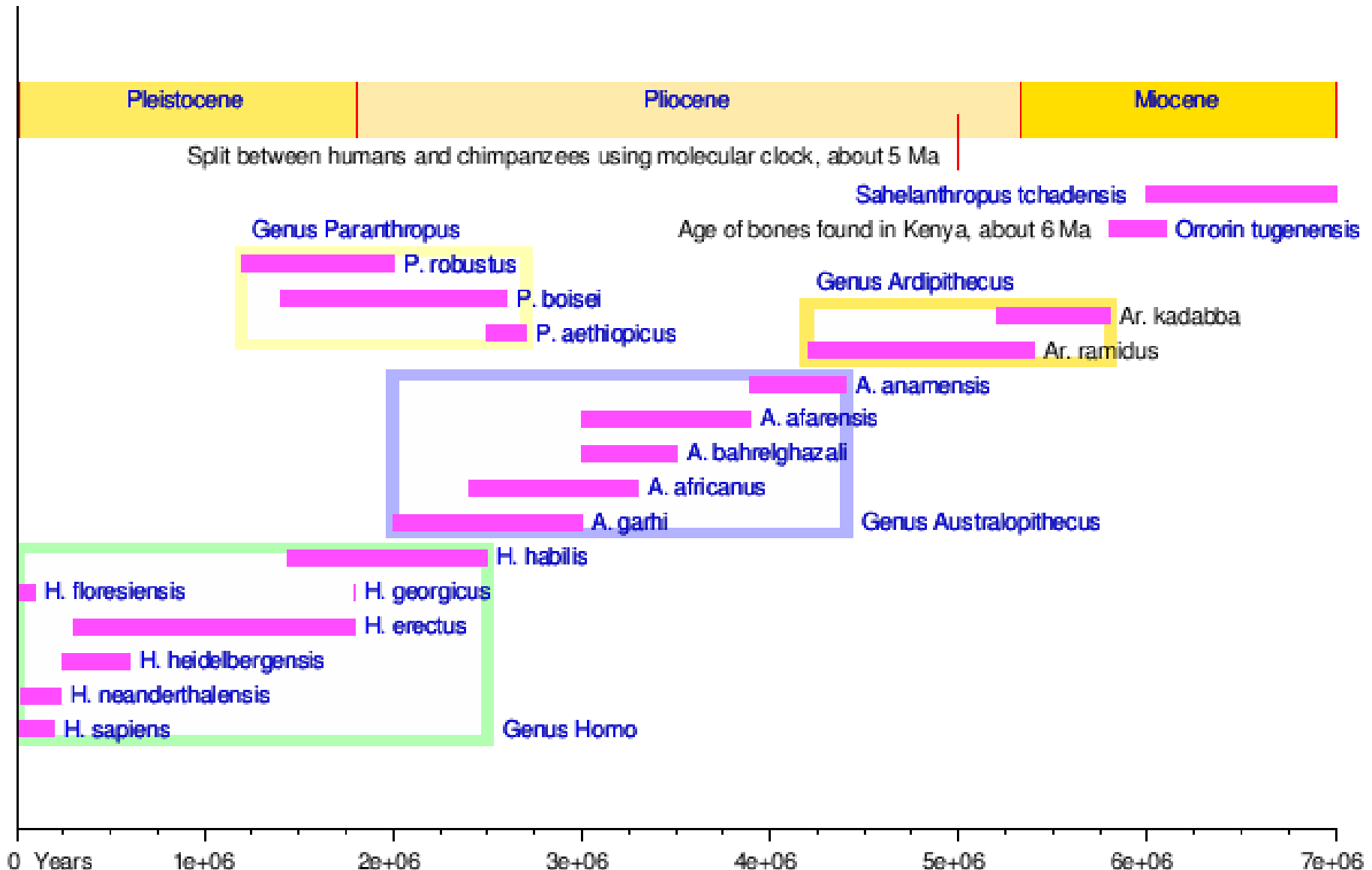
- Ice ages occur when the Earth's temperature drops a few degrees.
- Ice reflects a lot of light so we get a positive feedback.
- This happens regularly due to changes in the tilt of the Earth's axis.
- 750 and 580 million years ago it seems there were extreme ice ages where ice covered the globe. This would cause CO₂ buildup restoring rising temperatures and melting the ice.

Historical Temperatures

Ice Age Temperature Changes



Comparison of Timeline



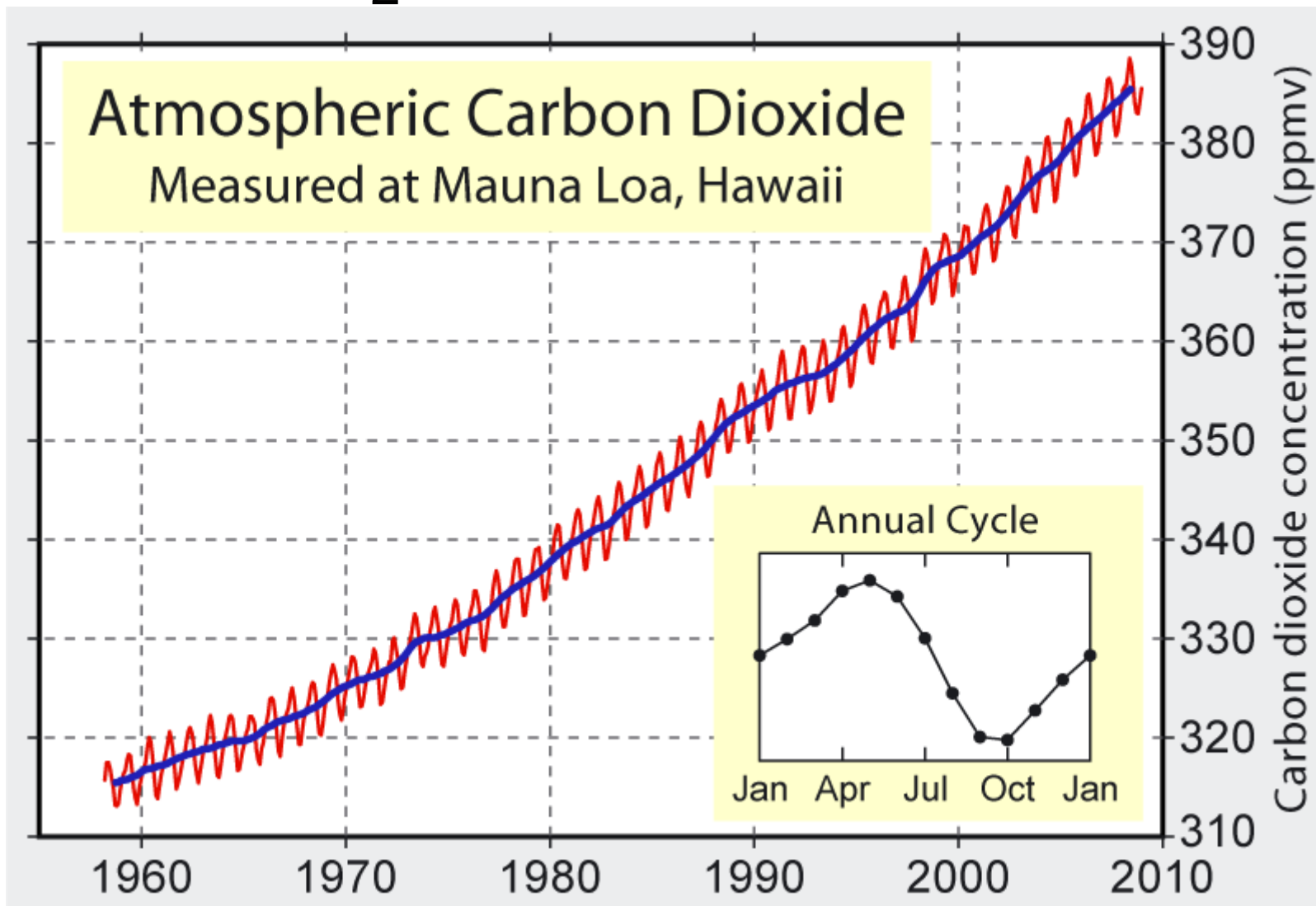
Earth's Future

- The continued warming of the Sun will eventually turn the Earth into Venus.
- The time line for this varies in different models, but it should happen in 1-4 billion years in the future.

Impact of Human Activity

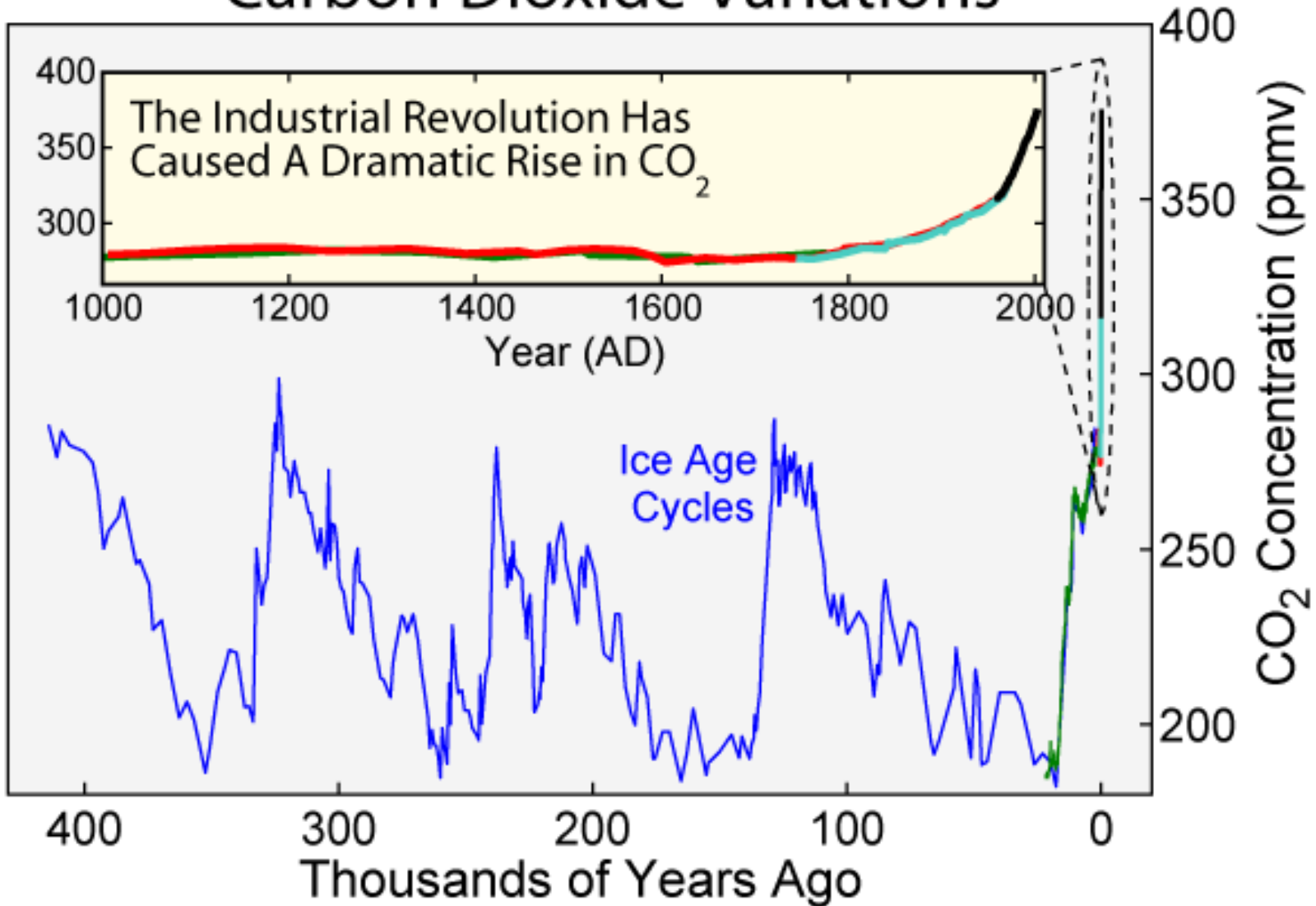
- Human activity is changing the composition of our atmosphere in ways that is altering the climate.
- CO₂ from burning fossil fuels is the primary problem, but activities like deforestation are also significant.
- Methane worrisome, but further down the list.

CO₂ Concentrations



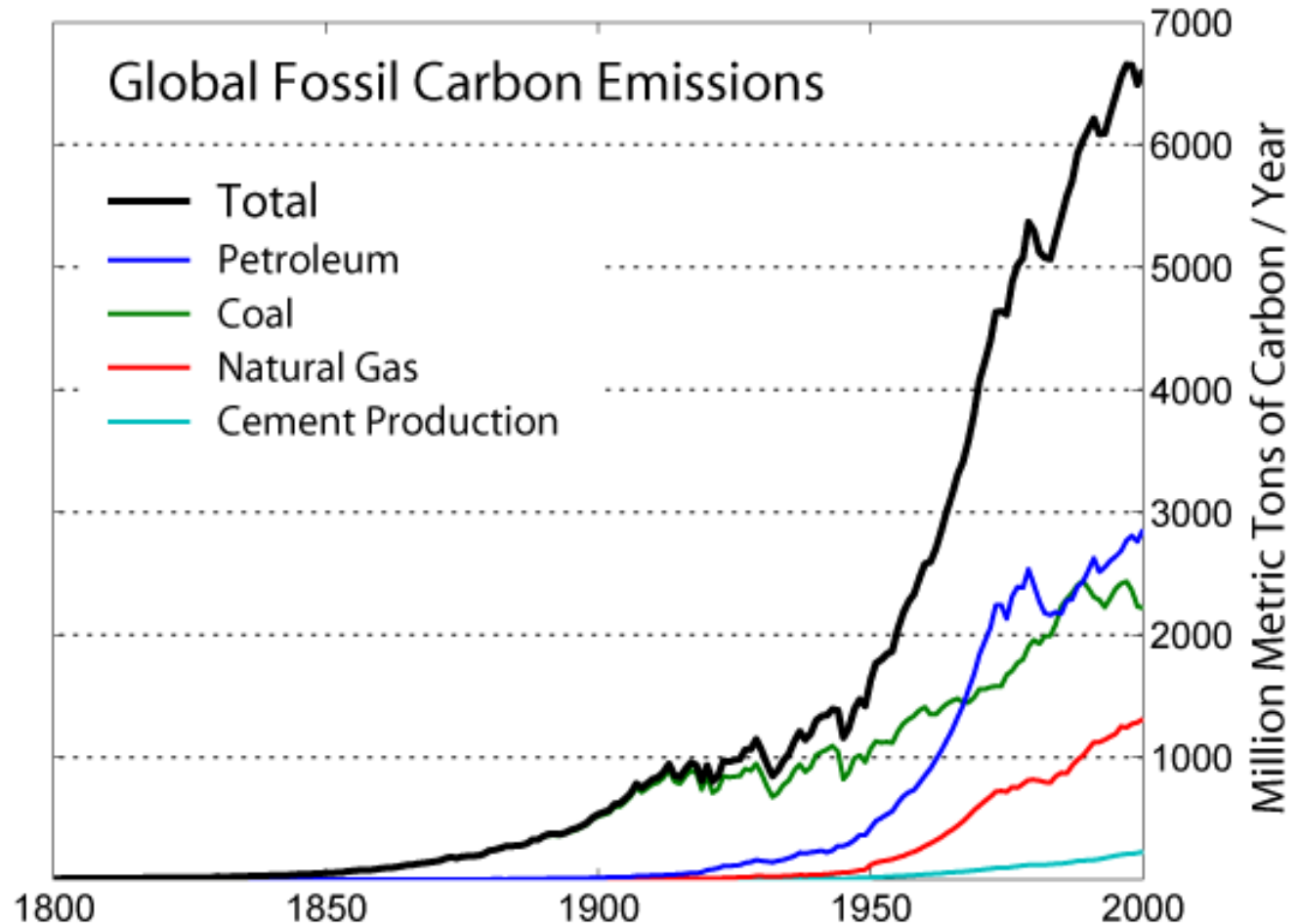
Longer Timeline

Carbon Dioxide Variations

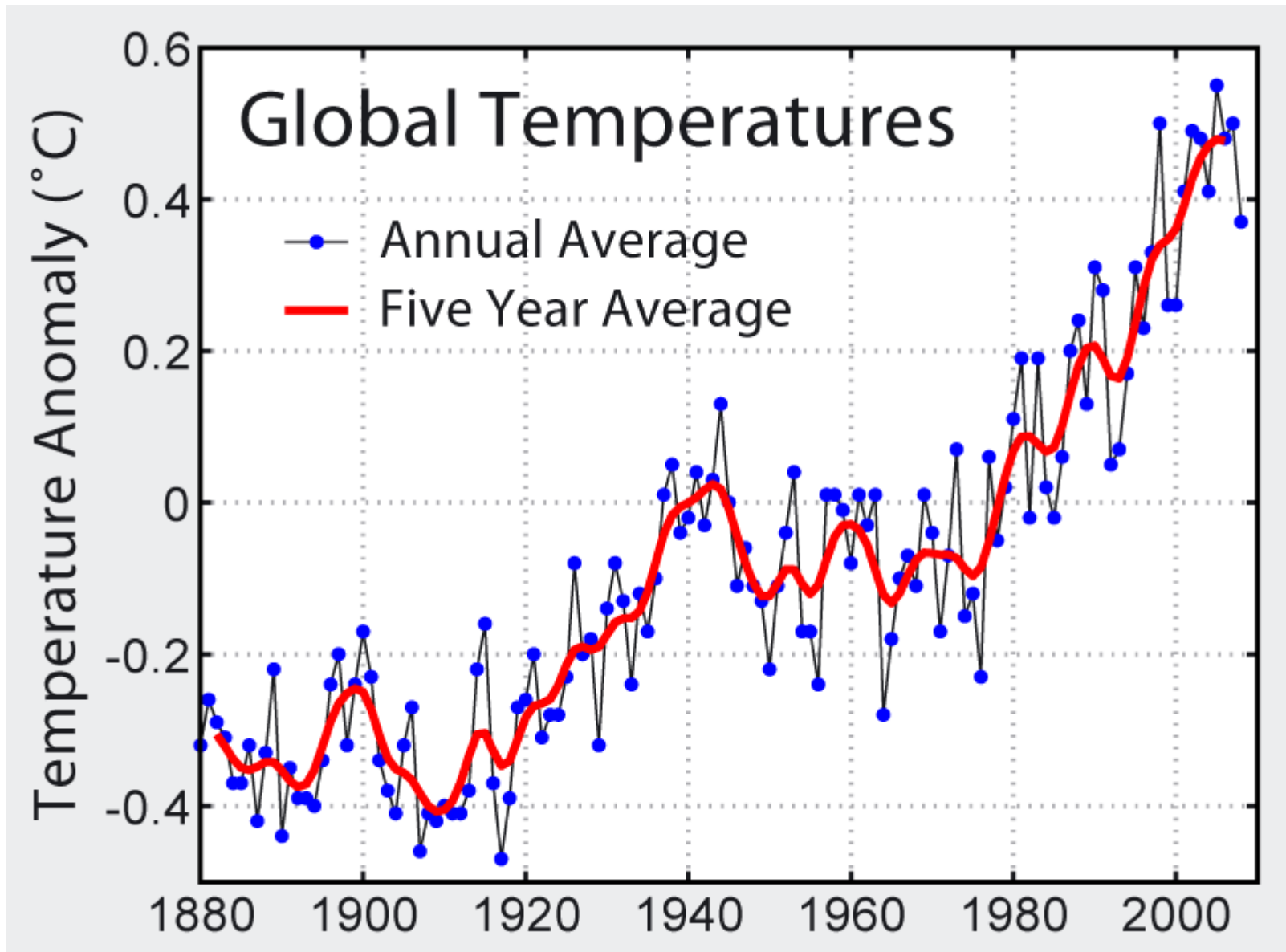


CO₂ Sources

- Volcanism produces less than 300 million metric tons/year



Modern Temperatures



Consequences

- The list here is long and how bad it gets depends a lot on how high temperatures get.
 - Rising ocean levels
 - More severe storms
 - Desertification
 - Droughts and water scarcity
 - Glacial melt
- Worst-case scenario is we trip the Earth into runaway greenhouse early.

Minute Essay

- Today was the last day of planetary atmospheres. Do you have any questions about the material that was covered?