Atmospheres of Venus and Earth

11/16/2009

Opening Discussion

- http://www.youtube.com/watch?v=lhTSfOZUNLo
- 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 CO_2 makes the surface hotter than an oven on the clean cycle.
- High in the atmosphere there are clouds with sulfuric acid and fast winds.

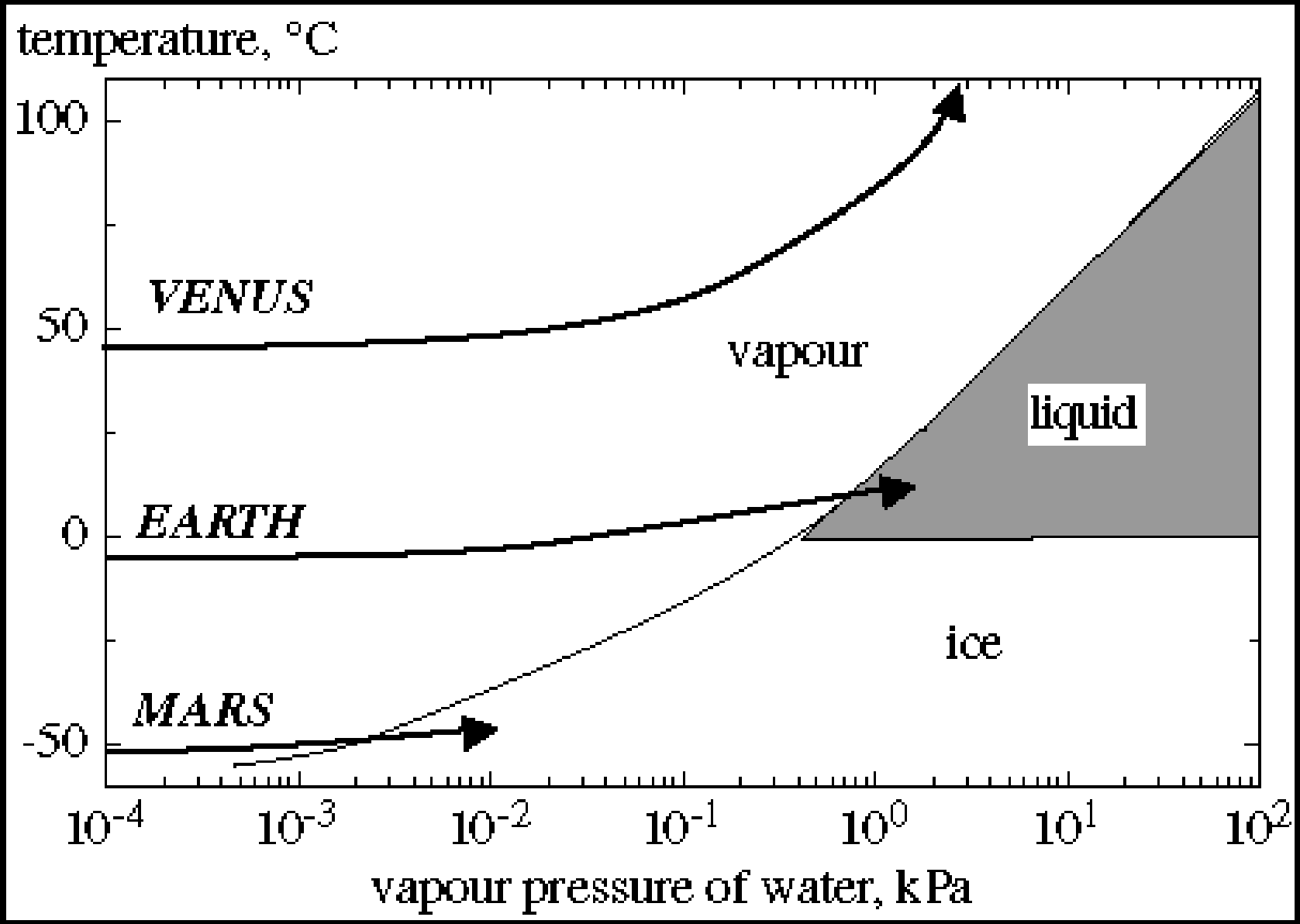
Water and Carbon Dioxide

- Venus's atmosphere has nearly 200,000 times as much CO_2 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 in is the oceans and the CO_2 is trapped in carbonate rocks.
  - Lack of oceans keeps CO_2 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^{o}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, CO_2 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 CO_2 levels linked. Caused by being the right size in the right place.
- High nitrogen content from outgassing and the fact that water and CO_2 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.

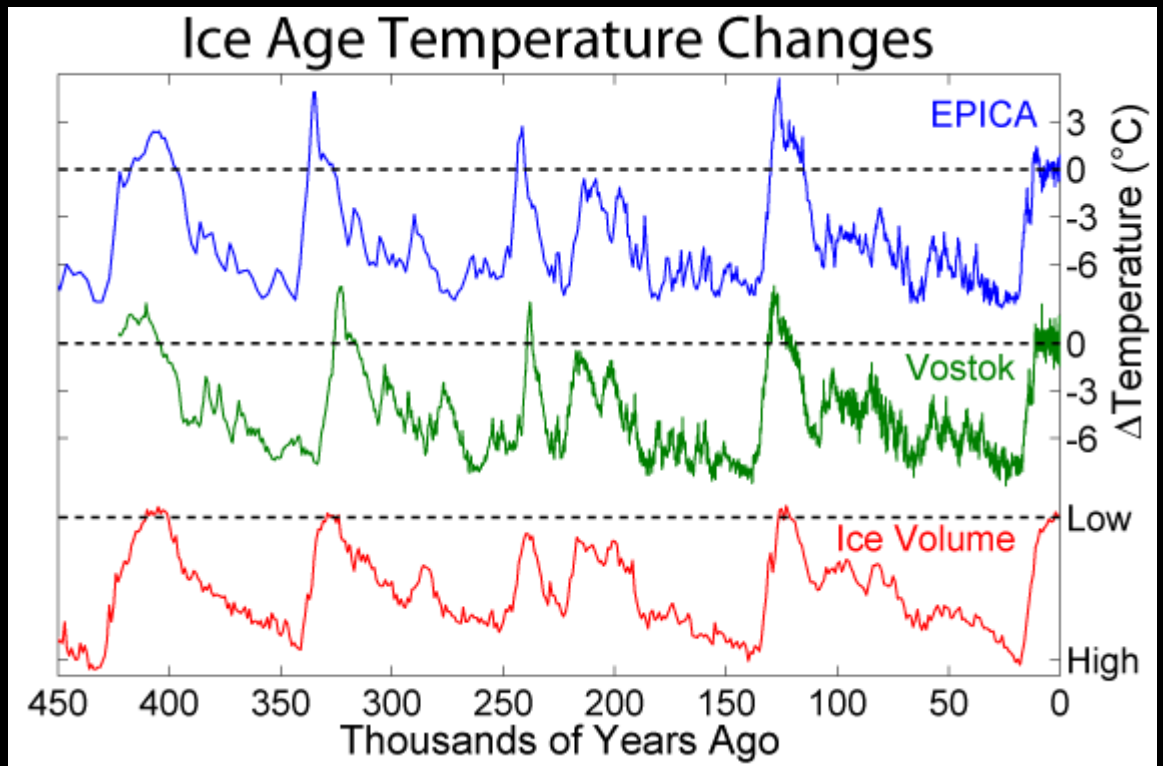
Carbon Dioxide Cycle

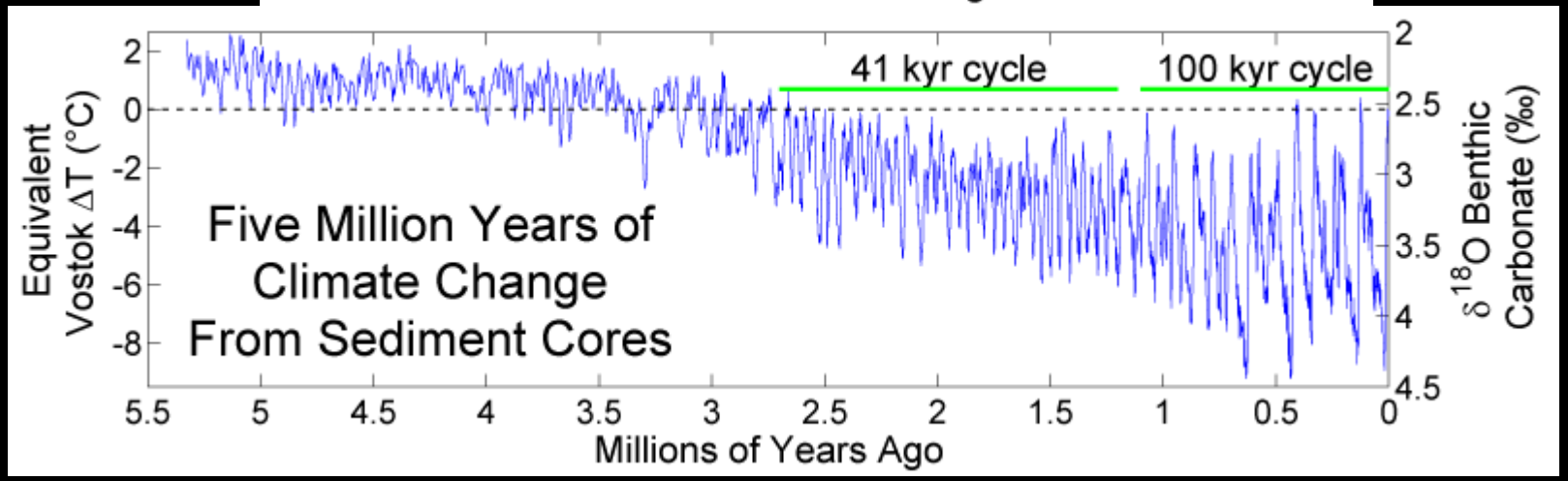
- CO_2 dissolves in water and bonds into carbonate rocks. The rocks are subducted, melt, and release gas in volcanism.
- The Earth has something of a built in thermostat because CO_2 absorption produces a negative feedback cycle.
  - When it warms, CO_2 is removed more quickly. When it cools the rate slows.
  - Takes many thousands of years for this to fully kick in.

Ice Ages and Snowball Earth

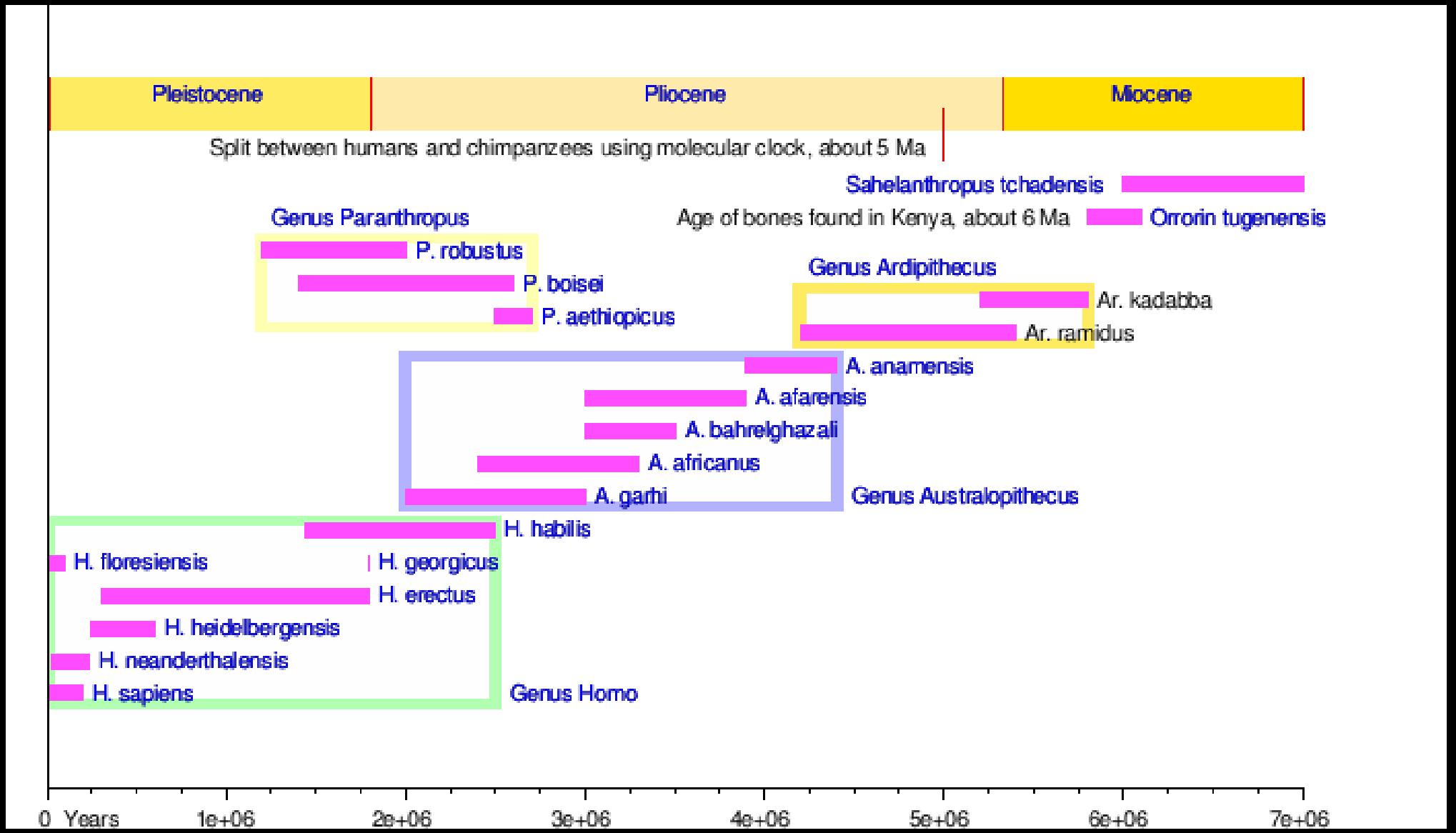
- Ice ages occur when the Earth's temperature drops a few degrees.
- Ice reflects a lot of light so we get a positive feedback.
- This happens regularly due to changes in the tilt of the Earth's axis.
- 750 and 580 million years ago it seems there were extreme ice ages where ice covered the globe. This would cause CO_2 buildup restoring rising temperatures and melting the ice.

Historical Temperatures





Comparison of Timeline



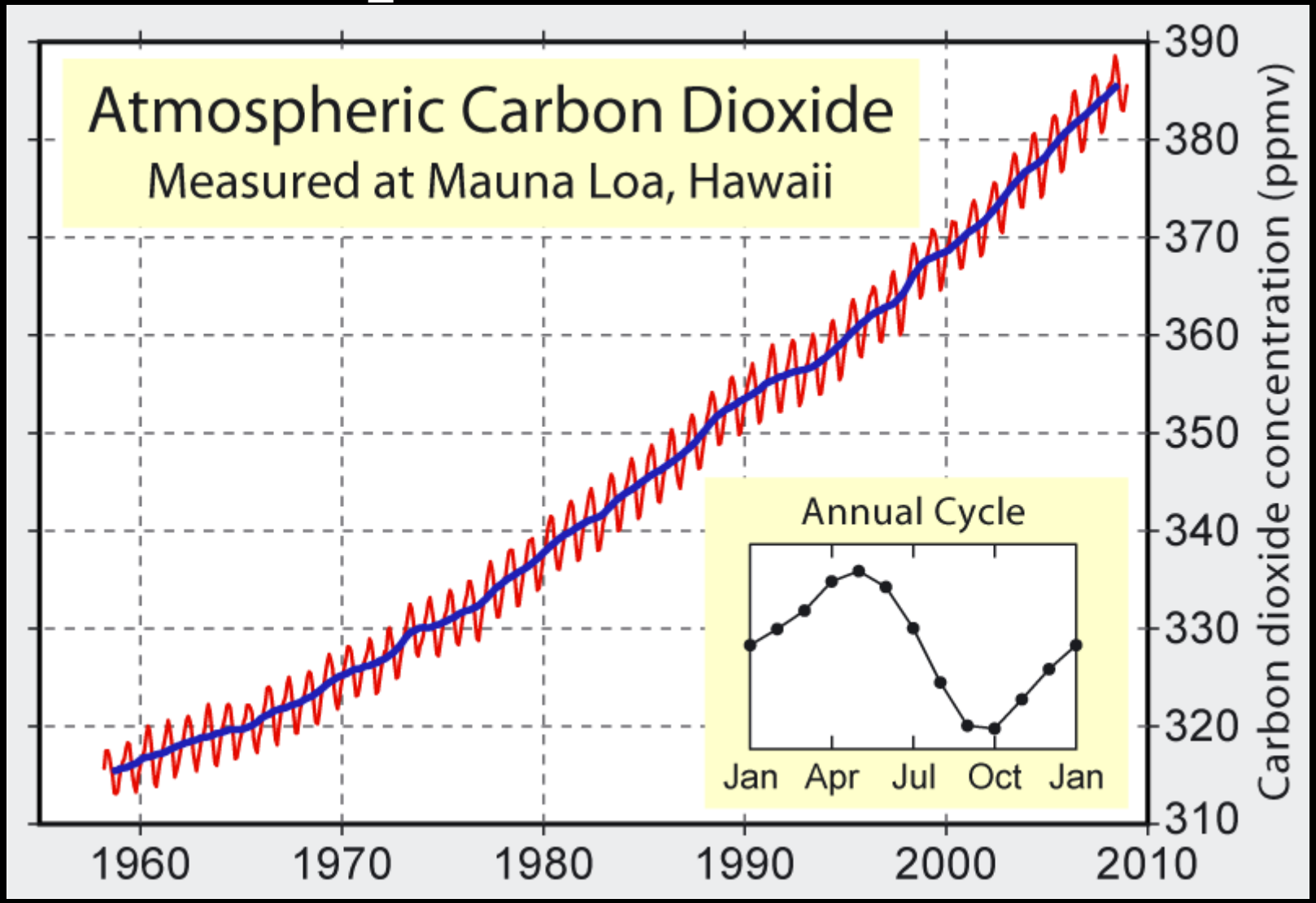
Earth's Future

- 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.

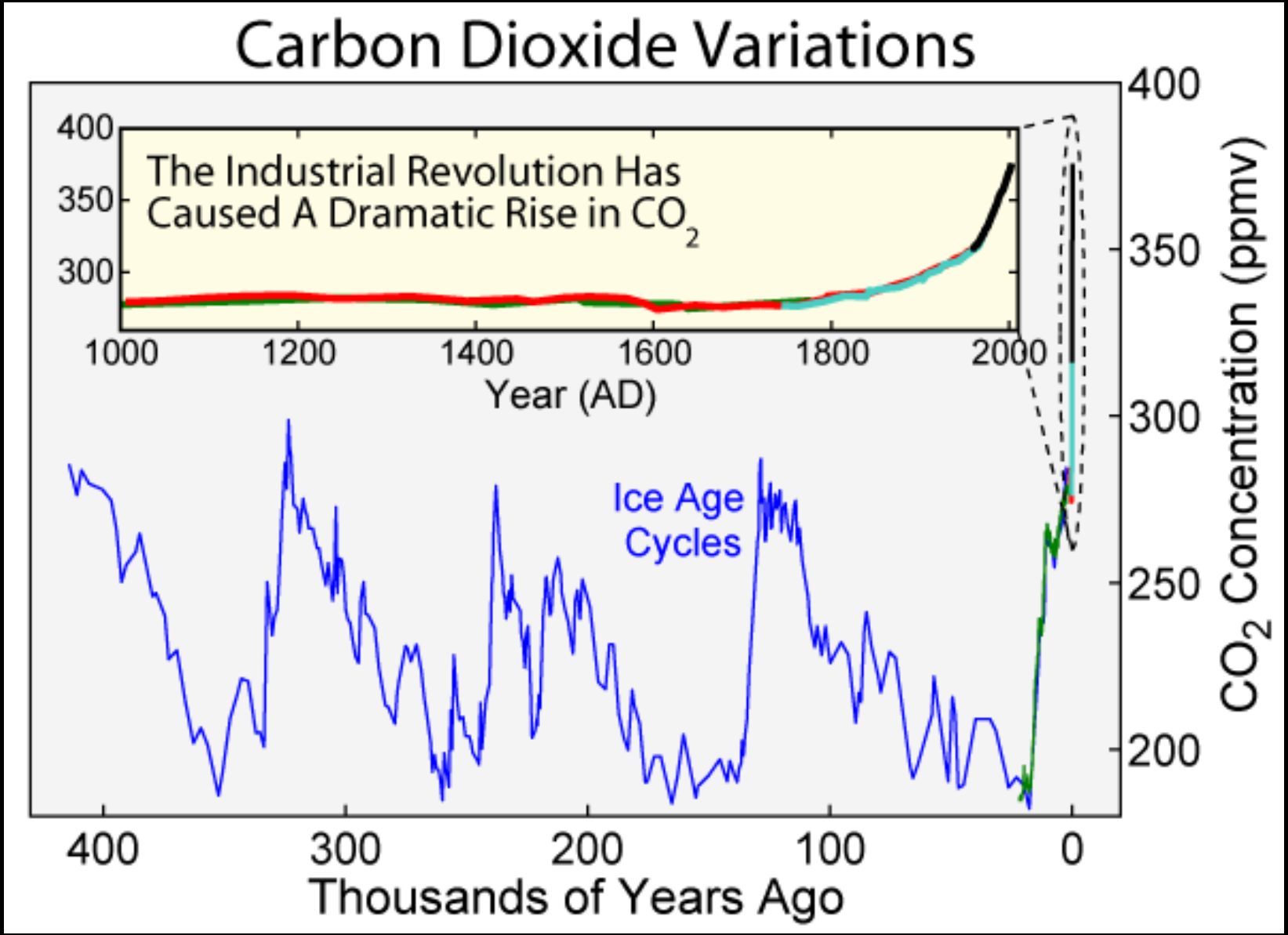
Impact of Human Activity

- Human activity is changing the composition of our atmosphere in ways that is altering the climate.
- CO_2 from burning fossil fuels is the primary problem, but activities like deforestation are also significant.
- Methane worrisome, but further down the list.

CO_2 Concentrations

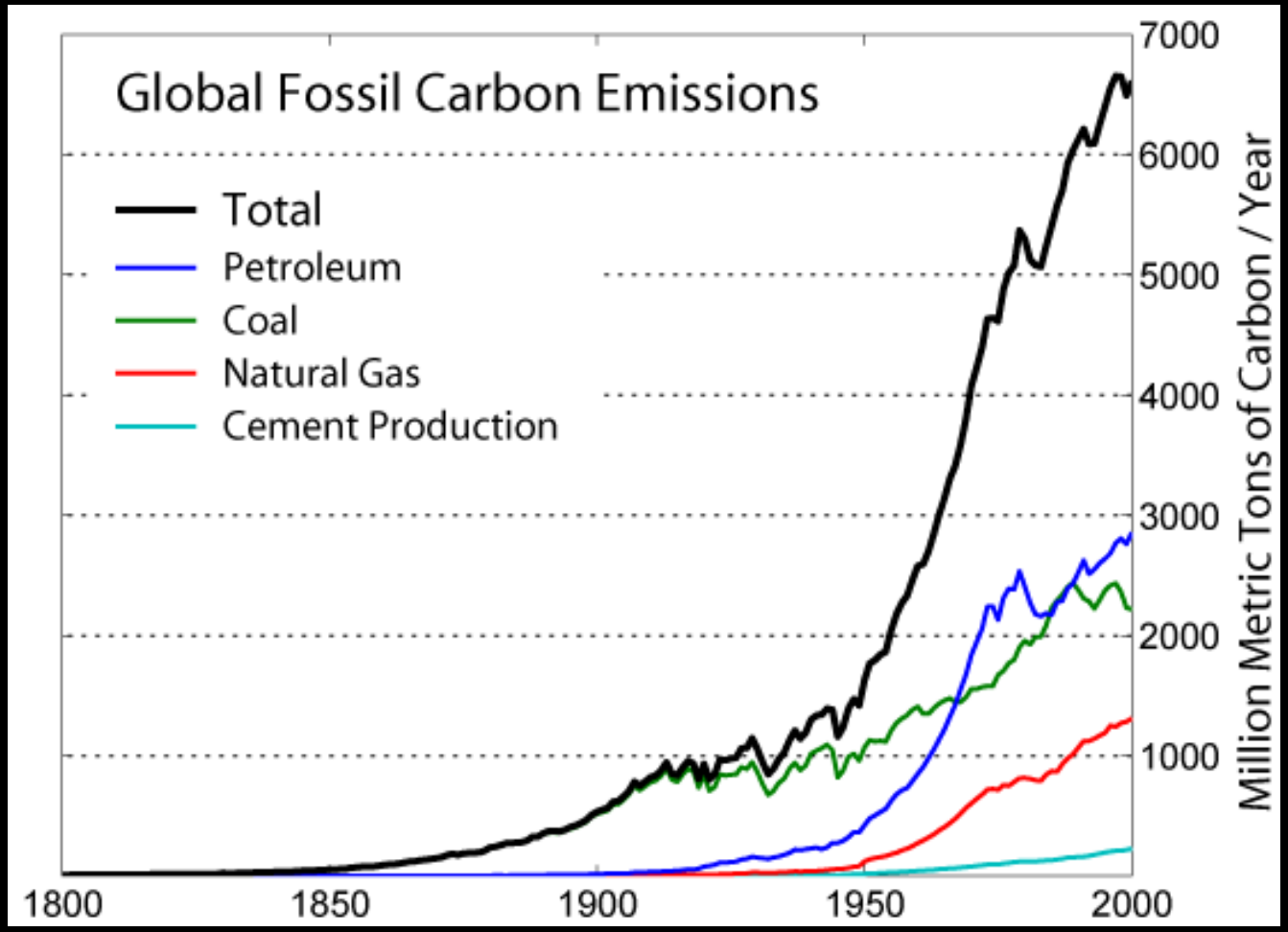


Longer Timeline

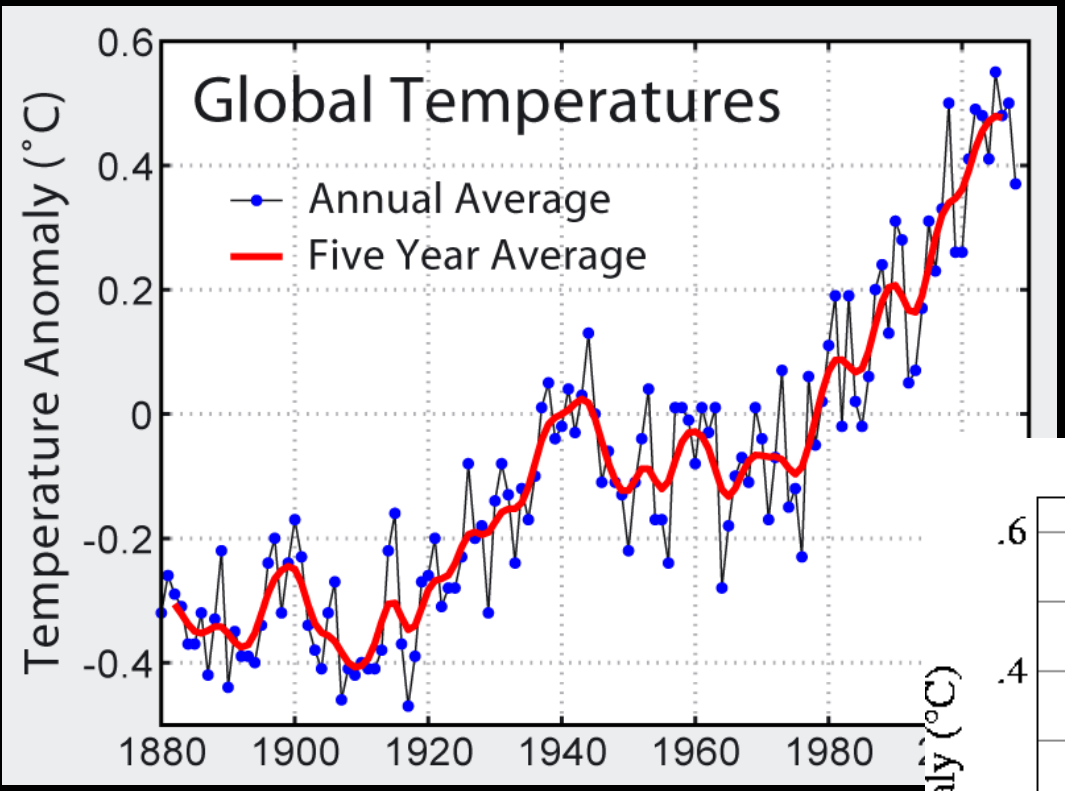


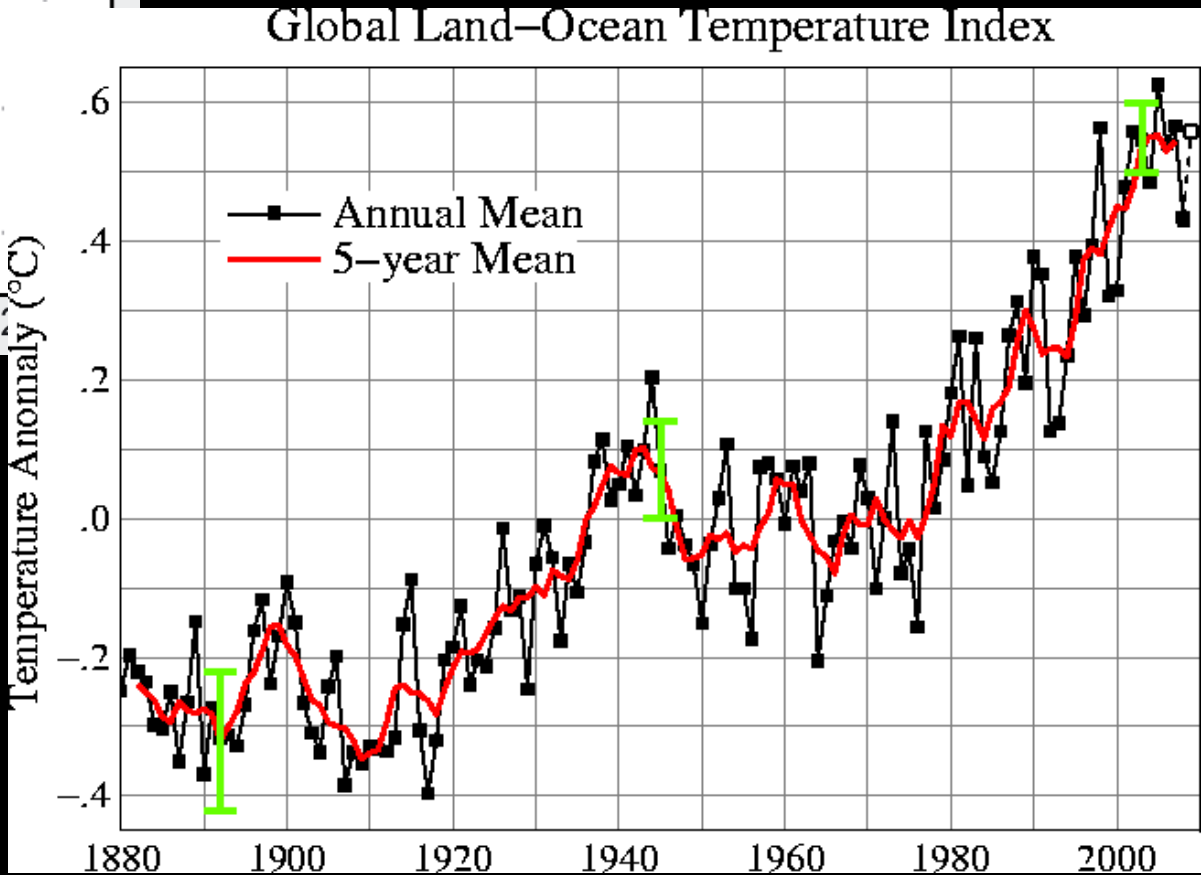
CO_2 Sources

- 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?