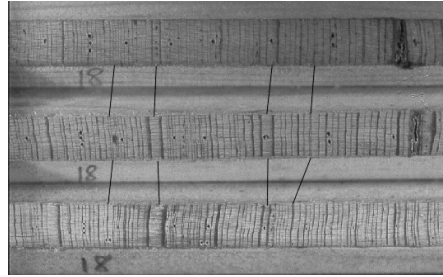


How can we reconstruct past global climate?

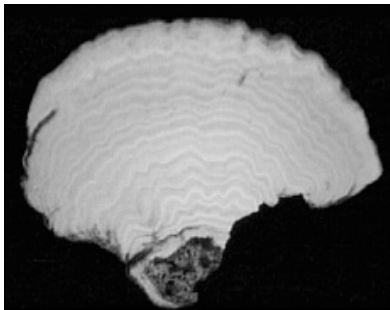
- Tree rings
- Coral growth bands
- Ice cores (see the [NICL](#) for more)
- Lake sediments
- Chemical analyses of carbonate rocks

These wood samples (from three Douglas firs in Arizona) show how growth rings from different trees may be correlated. Wide and narrow bands mean warm or cold growing seasons.



For more information, visit the [Ultimate Tree-Ring Web Pages](#). . .

Like trees, corals also grow in annual layers, and they can provide clues to climate change over time. . .



Lakes have an annual cycle of sediment deposits known as *varves*.



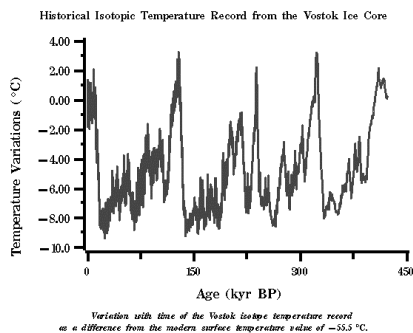
Ice layers also form annually, from compacted layers of snow—and drilling core samples of ice caps can give information on past atmospheres and climates going back hundreds of thousands of years



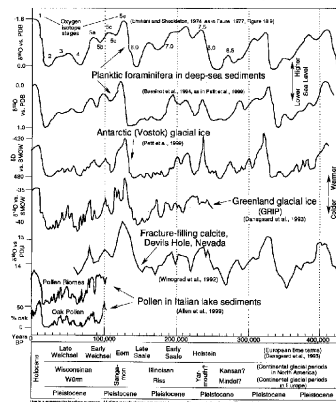
Isotopic analysis

- Oxygen comes in two stable *isotopes*, oxygen-16 and oxygen-18.
- Water that contains ^{18}O , being heavier, is just a little less likely to evaporate than water containing ^{16}O . . .
- So the oceans are a little heavier than precipitation (and ice caps, which come from snow). . .
- . . . and with some mathematical ingenuity, the ratio of ^{18}O to ^{16}O in a sample can give an estimate of the global temperature. (There's a bit more to it than that, but this gives you the idea.)

Temperatures estimated from chemical analysis of an ice core from Vostok Station, Antarctica, going back 420,000 years. . .



THE PULSE OF THE PLEISTOCENE



Temperature estimates from many different sources all point to the same basic patterns over the past 420,000 years.

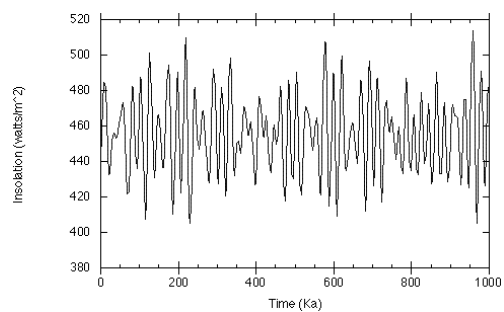
What Affects Global Climate?

- *Milankovitch cycles* (natural variations in Earth's orbit)
- Volcanic eruptions
- Plate tectonics
- Variations in solar activity
- People?

Milankovitch Cycles

- Earth's *eccentricity* varies from more circular to more elliptical: 100,000 year cycle
- Earth's *obliquity* (tilt of its axis) varies from 21 degrees to 24: 41,000 year cycle
- Earth's direction of tilt (*precession of equinoxes*) varies: 23,000 year cycle
- All of these cycles affect how much solar radiation the Earth gets
- Cumulative effect of all of them is the *Milankovitch cycle*

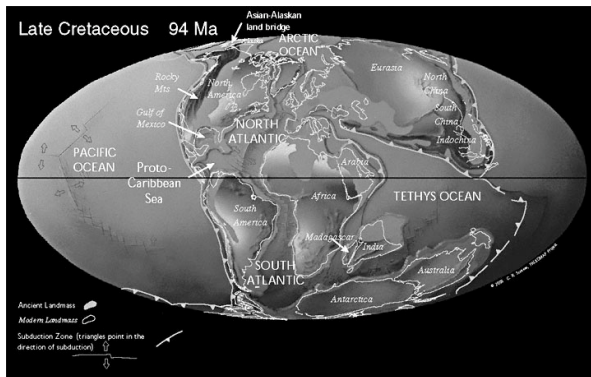
Mathematical estimate of the amount of solar energy reaching 65 degrees N latitude over the past million years



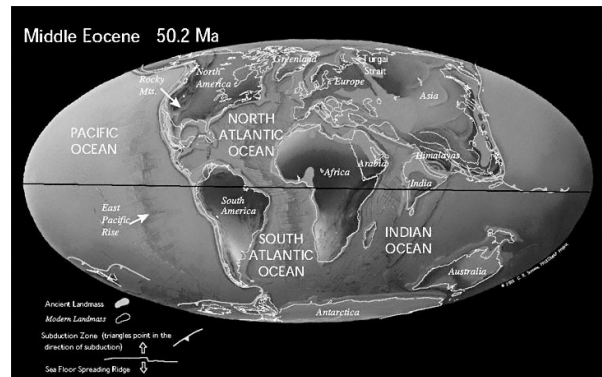
Volcanic eruptions can affect climate by pouring greenhouse gases and aerosols into the atmosphere. . .



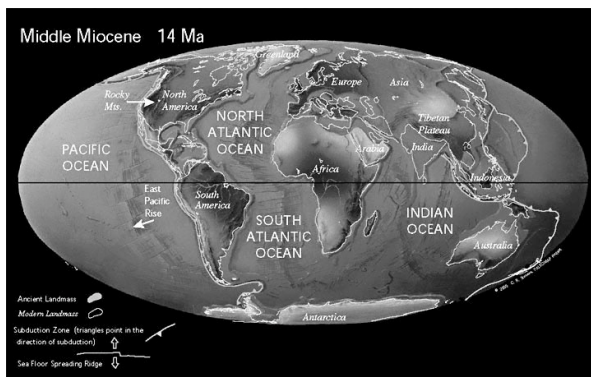
At one time, Antarctica was connected to South America and Australia. (How would ocean currents have flowed?)



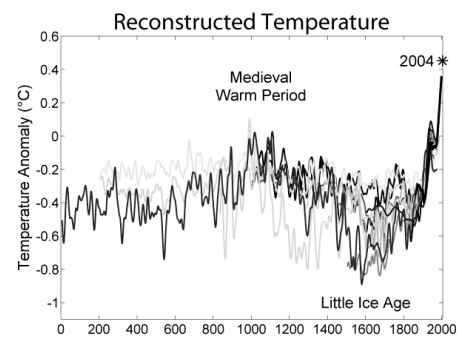
Separation of Antarctica allows for formation of circumpolar current. . .



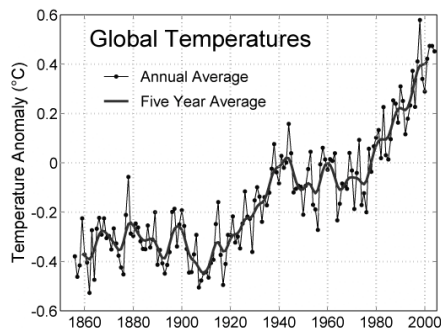
. . . creating a global "chiller" that cooled global temperatures considerably (note the ice caps!)



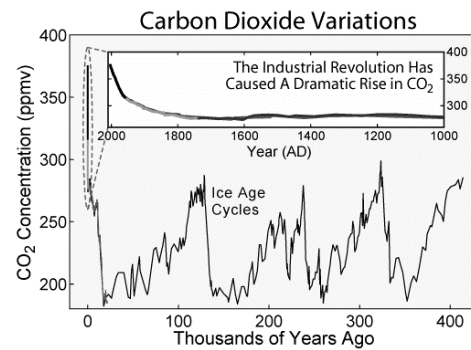
Data from ten different studies giving climate over the past 2000 years. . .



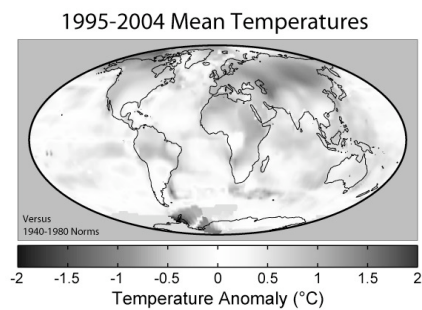
Close-up of global mean temperatures over the past 200 years. . .



Variations in carbon dioxide concentrations



Areas that have warmed or cooled in 1995-2004, compared to 1940-1980 averages. . .



Predictions. . .

