Section 8.9: Long-Term and Short-Term Changes in Climate

- The earth's climate changes (naturally).
- Changes due to various factors:

- If Earth's surface and atmosphere absorb sun's energy differently
    - Amount of energy from the sun changes
- Movement of the Earth's crust affects how much of the sun's energy is absorbed

Long-Term Changes Due to Continental Drift.

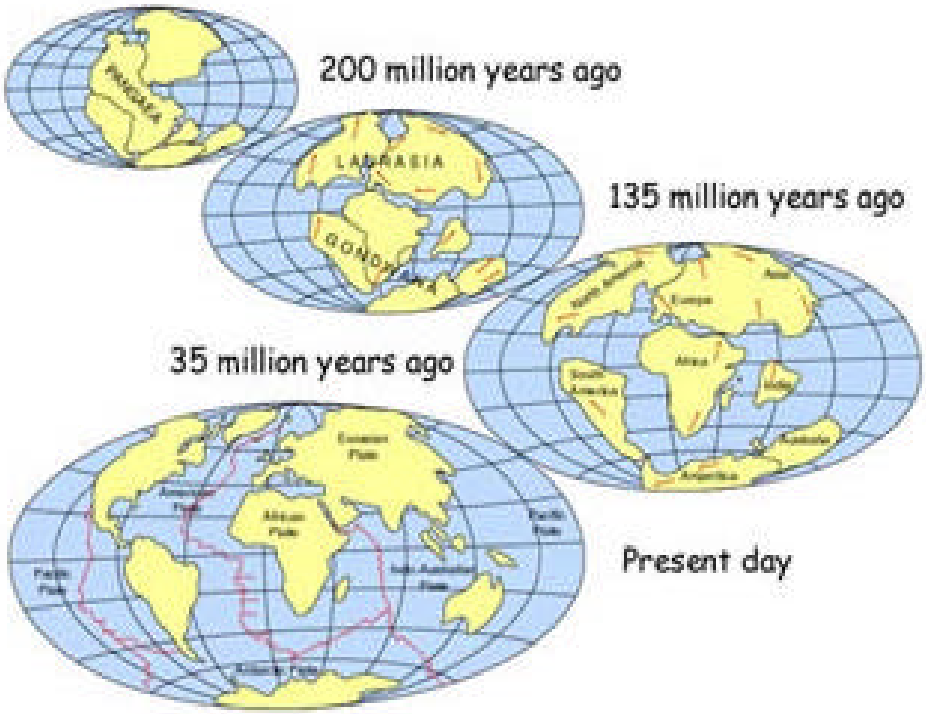
- The movement of continents: **Continental Drift**
- Theory of plate tectonics
- Continental drift affects climate as it changes distribution of land on Earth
- Movement of continents changes ocean currents, and wind patterns; affecting heat transfer
- Regional changes can be caused by the making/weathering of mountain ranges

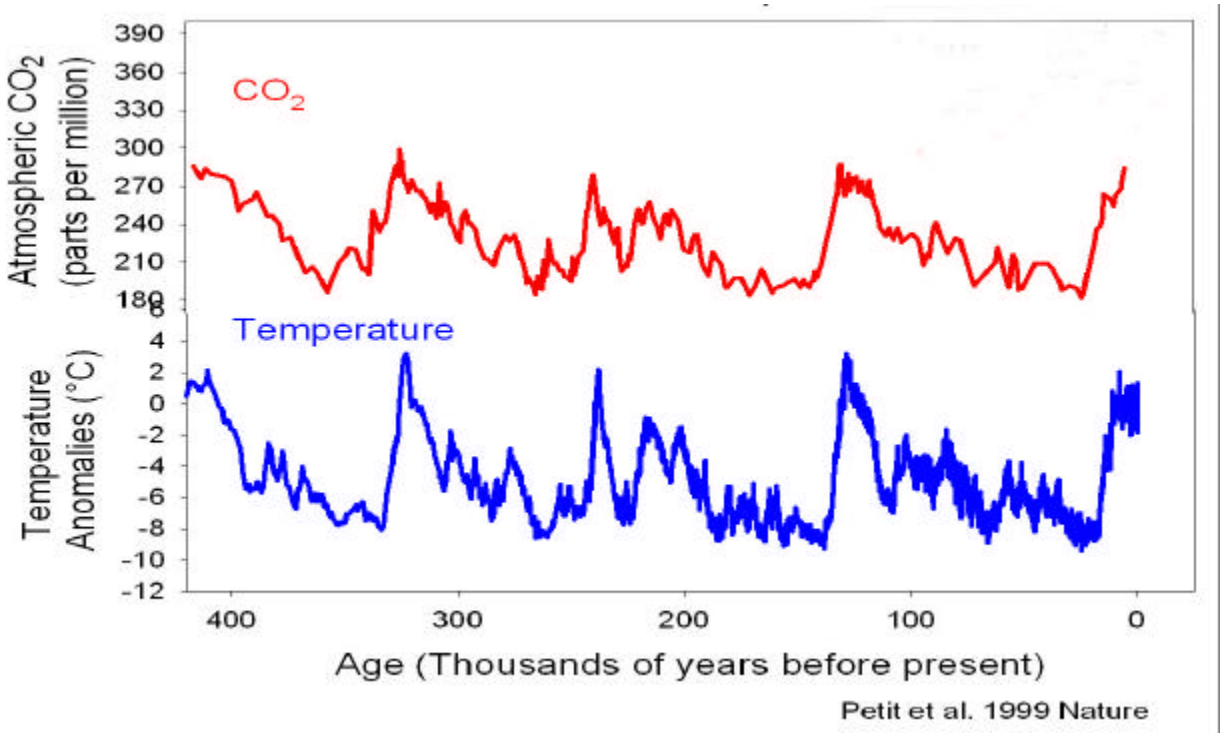
- Canada has both young mountains: The Rockies and old mountains: The Appalachians

- Another long-term factor affecting climate is the amount of energy produced by the sun, which changes over time.

Long-Term Cycles in Climate

- 20,000 Years ago: last ice age
- Average temperature 10 degrees Celsius lower than today
- 3 km thick ice sheets, sea levels dropped forming land bridges
- Plants and animals (including humans) crossed the bridges into new continents
- Last 800,000 climate cycled between freezing ice ages and warmer interglacial periods

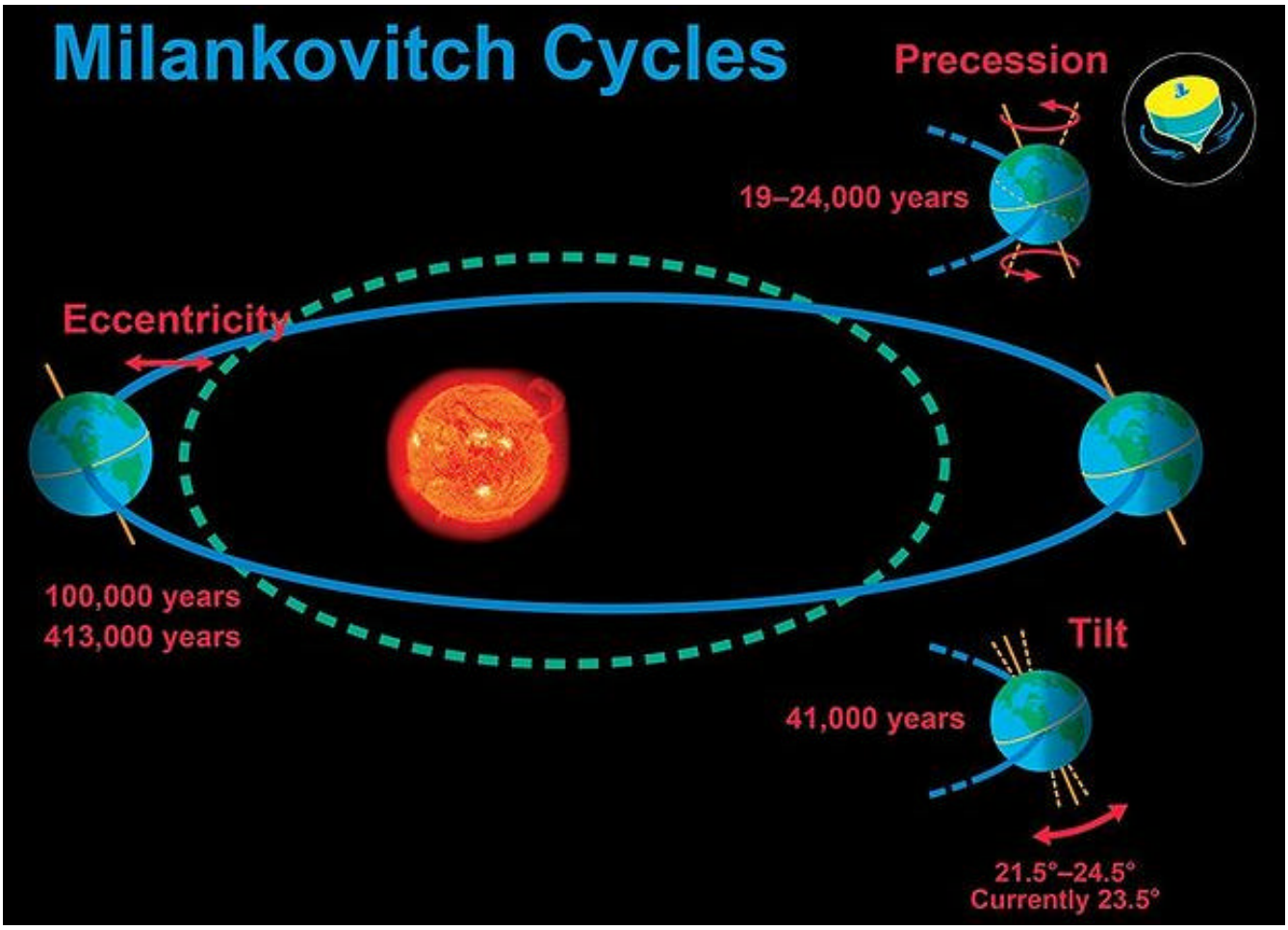




* Notice in the diagram above that major changes in temperature happen in regular cycles. Warm interglacial periods occur about every 100,000 years.

Why Do Interglacial Periods and Ice Ages Keep Occurring?

- 1941 Milutin Milankovitch (engineer and amateur astronomer) developed a theory on the causes of these changes
- Calculated that the Earth's orbit around the sun changes in 3 main ways
- **Eccentricity:** the shape of the Earth's orbit around the sun. Varies from being almost circular to elliptical (oval). Variation in orbit caused by influence of Jupiter and Saturn's gravities. Approximate cycle of 100,000 years. Earth's orbit currently elliptical.
- **Tilt:** Earth tilts back and forth on axis. From 22.1 degrees to 24.5 degrees. As angle increases, seasonal differences increase. Cycle of about 41,000 years. Axis currently at 23.5 degrees nd is decreasing.
- **Precession of tilt (wobble):** As Earth spins on its axis it wobbles. The angle of tilt stays the same but direction changes. Cycle of 26,000 years. Earth's axis pointing to Polaris (currently the North Star) in 1,000 years North Star will be Airai.
- Together these changes cause regular cycles of ice ages and interglacial periods. This has happened for over 400,000 years.
- Changes happen slowly

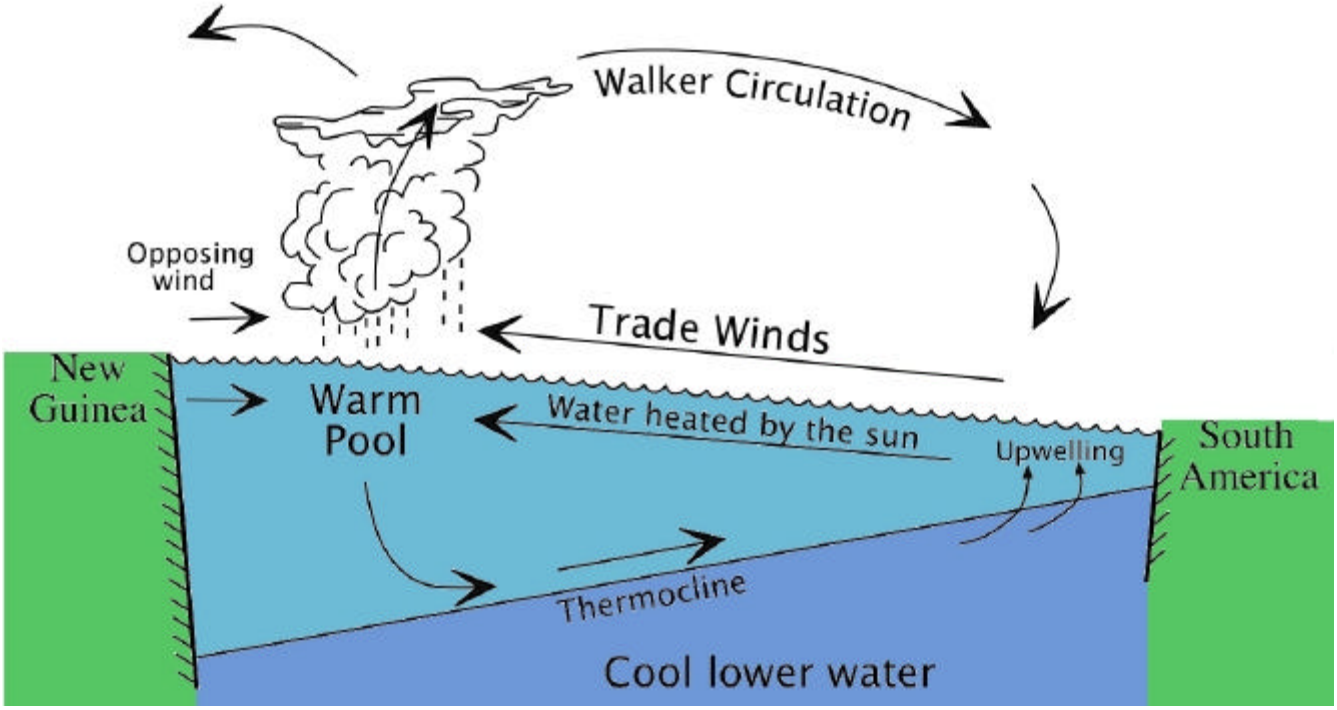


Short-Term Variation in Climate:

- Caused by a variety of factors
- **Volcanic Eruptions:** spew rock, dust,and gases into atmosphere. Sulfur dioxide (especially) reflects the sun's energy back into space, shading Earth's surface. Thus Earth temporarily cools down.
- **Air and Ocean currents:** Many different ways these factors can affect the climate. Changes to the ocean's thermohaline may cause abrupt changes. This phenomenon is not fully understood.

EX. 12,000 years ago Earth's climate in transition from ice age to interglacial period. Large ice sheets melted dumping less dense fresh water into the more dense salty water. The fresh water stayed near the surface, disrupting the thermohaline, making it colder.

- Some changes in the ocean and air currents occur regularly. A change in air currents occurs every 3-7 years in the Pacific Ocean: The prevailing winds temporarily switch direction. This changes ocean currents: Instead of pushing warm surface water to the West it is pushed to the East towards South America. This shift in winds and ocean currents is called El Nino.



- **Changes in the sun's radiation:** If the amount of radiation drops Earth receives less energy and the temperature cools down. The opposite is also true. Even small change can affect our climate. The sun's energy changes over short time scales (the reason is unknown).

- **Summary:**
- Continental drift and other natural factors have affected Earth's climate for millions of years.
- Over the last 400,000 years climate has continually cycled from ice ages to warmer interglacial periods about every 100,000 years.
- Long-term cycles in Earth's climate correspond to changes in the shape of Earth's orbit, changes in Earth's tilt, and the precession of Earth's axis.
- Short-term variations in climate can be caused by volcanic eruptions, changes in the Sun's radiation, and changes in the circulation of air and ocean currents.