Lecture 11

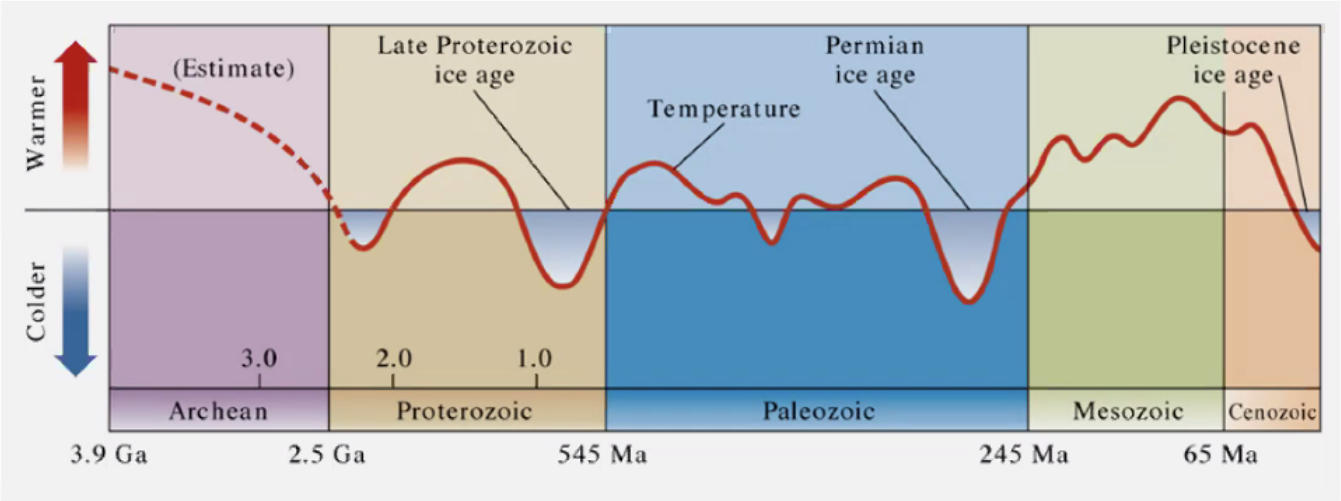
GLY102

3/9/2021

Climate History: "Paleoclimate"

Long-Term Climate Change

The climate history of Earth:



The beginning of the Paleozoic marks the explosion of life, 545 million years ago.

The Cenozoic marks an increase of mammals.

We don't know much about the Archean, but we're able to make estimates (accurate estimates) about everything after around that era. We've also been able to show when Ice Ages happened.

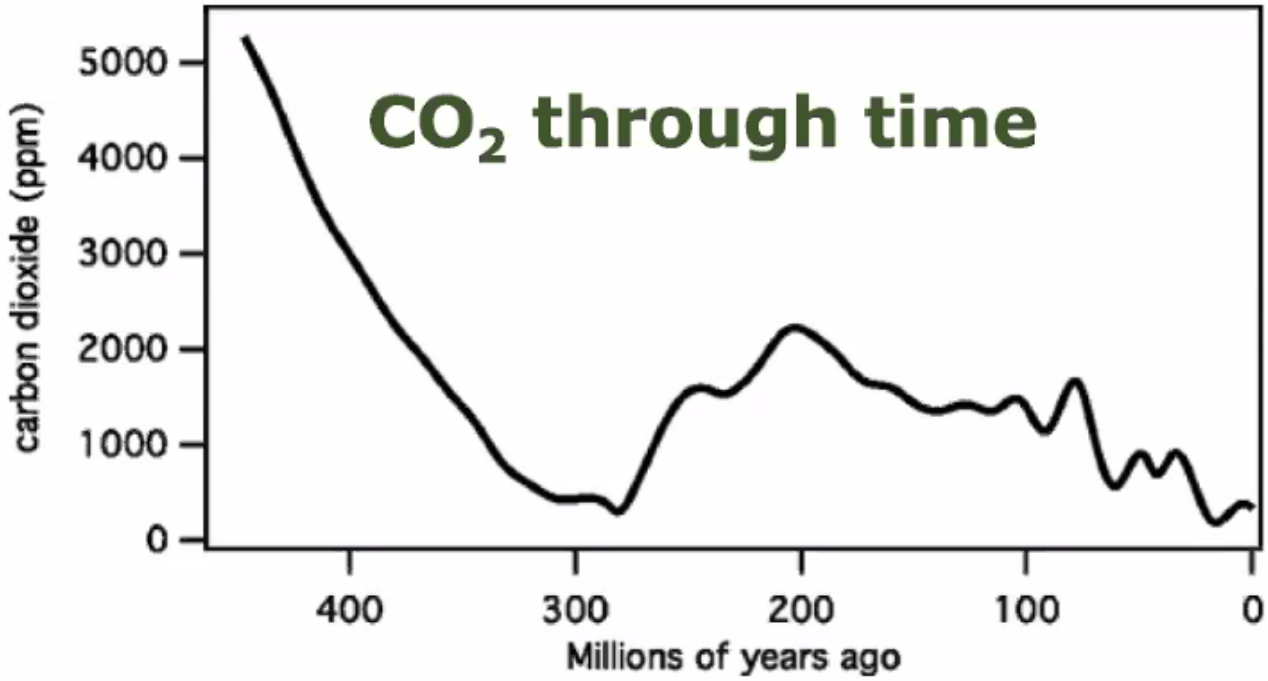
"Long-Term" climate Change – different controls

1. Plate Tectonics - The geographic arrangement of the continents plays an important role in climate
    - The boundaries between plate tectonics are very low, so oceans cover them
    - We have constant reminders that these are present. For example in New Zealand last week where an 8.1 earthquake occurred
        - New Zealand has a tectonic boundary running through it betweenthe Australian and Pacific plate

- There have been different configurations of the plates throughout time. The way the plates were arranged 237 million years ago is much different than the way they are arranged today.

> ### Why Ice Ages?
>
> 1. At times in Earth History when ice sheets exist on planet Earth, the ice sheets themselves lead to further cooling because they're very reflective. As the Earth cools, there will be more ice sheets, causing Earth to cool more. This is called a feedback loop, specifically a positive feedback loop.
> 2. Ice Sheets can't grow in ocean basins, they need continents to grow on.
> 3. Plate tectonics randomly move continents around the globe – at times when more continental area exist at high latitudes, Earth can have more ice sheets

2. CO_2 regulation

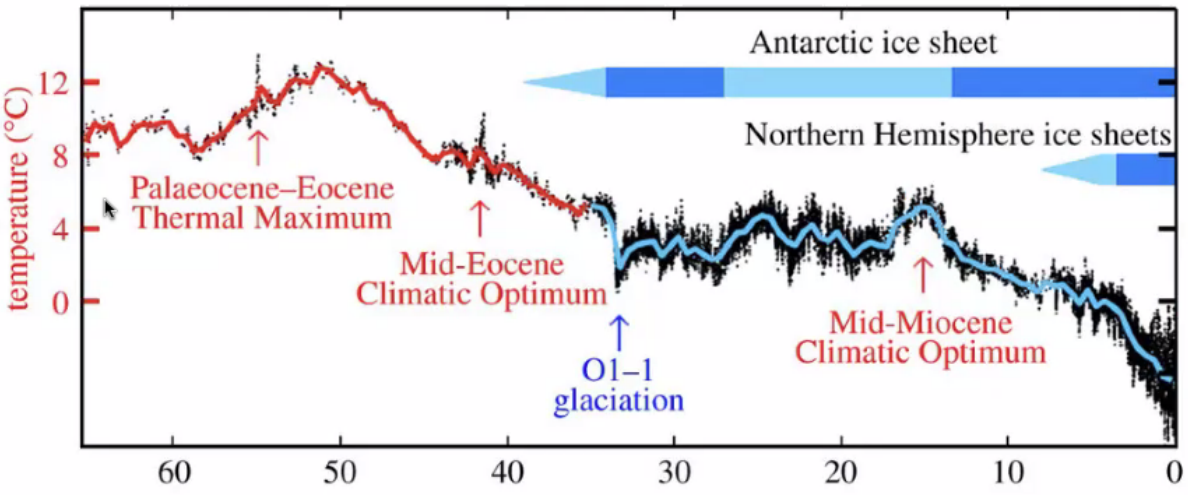


- One source of CO_2 on Earth is through volcanic eruptions
- A lot of volcanic activity built up over millions of years can cause a significant warmth of the planet
    - ***NOTE:*** on short timescales, the amount of CO_2 released from a few volcanic eruptions is too tiny to influence climate change (for example, on Global Warming)

The Last Ice Age

The last ice age was the Pleistocene ice age. Technically, we're still in Ice Age conditions, although this is quickly changing.

This is a chart of the Earth's temperature since the dinosaurs died.



As shown in this chart, the antarctic ice sheet has been on Earth for around 34 million years!

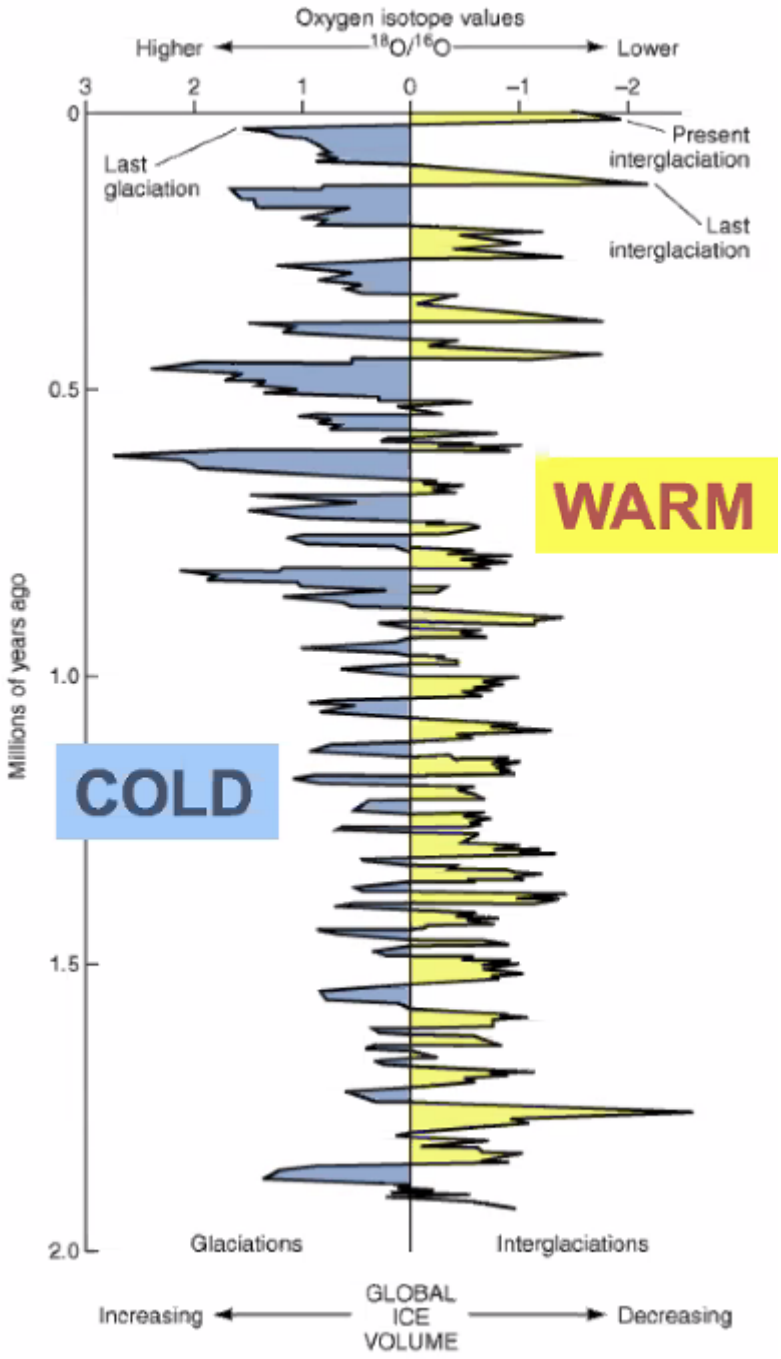
The Drake Passage is the name of the gap between the tip between Antarctica and South America. It is believed that Plate Tectonics are the cause for this gap. As a result of the gap, the Antarctic ice sheet was able to grow through the ocean currents.

To summarize:
The opening of the Drake Passage = thermally isolating the antarctic continent allowing an ice sheet to grow

> ### Some "cool" Ice Age Facts:
>
> 1. 30% of the planet's surface was covered by ice (only 10% is covered today)
> 2. Northern NY was covered by ~1 km thick ice sheet
> 3. Global sea level was ~350 ft. lower than today

Cold Glaciations and Warm Inter-glaciations

Global Ice Volume has been back and forth constantly through time:



We have pretty firm evidence that this is the case.

Glaciation: Time periods in which there is ice covering Canada
Inter-glaciation: All other time periods OR when ice isn't covering Canada

Why does this happen?

Short answer: The way the Earth orbits the sun (it changes in a cyclic pattern)

Milankovitch Cycles

We call the cyclic patterns of Earth's orbit around the sun "Milankovitch Cycles".

Named after:

Milutin Milanković

From Wikipedia, the free encyclopedia

Milutin Milanković (Serbian Cyrillic: Милутин Миланковић [milǔtin milǎ:nkɔvitɕ]; 28 May 1879 – 12 December 1958) was a Serbian mathematician, astronomer, climatologist, geophysicist, civil engineer and popularizer of science.

Milanković gave two fundamental contributions to global science. The first contribution is the "Canon of the Earth's Insolation", which characterizes the climates of all the planets of the Solar system. The second contribution is the explanation of Earth's long-term climate changes caused by changes in the position of the Earth in comparison to the Sun, now known as Milankovitch cycles. This explained the ice ages occurring in the geological past of the Earth, as well as the climate changes on the Earth which can be expected in the future.

He founded planetary climatology by calculating temperatures of the upper layers of the Earth's atmosphere as well as the temperature conditions on planets of the inner Solar system, Mercury, Venus, Mars, and the Moon, as well as the depth of the atmosphere of the outer planets. He demonstrated the interrelatedness of celestial mechanics and the Earth sciences, and enabled consistent transition from celestial mechanics to the Earth sciences and transformation of descriptive sciences into exact ones.

Milutin Milanković

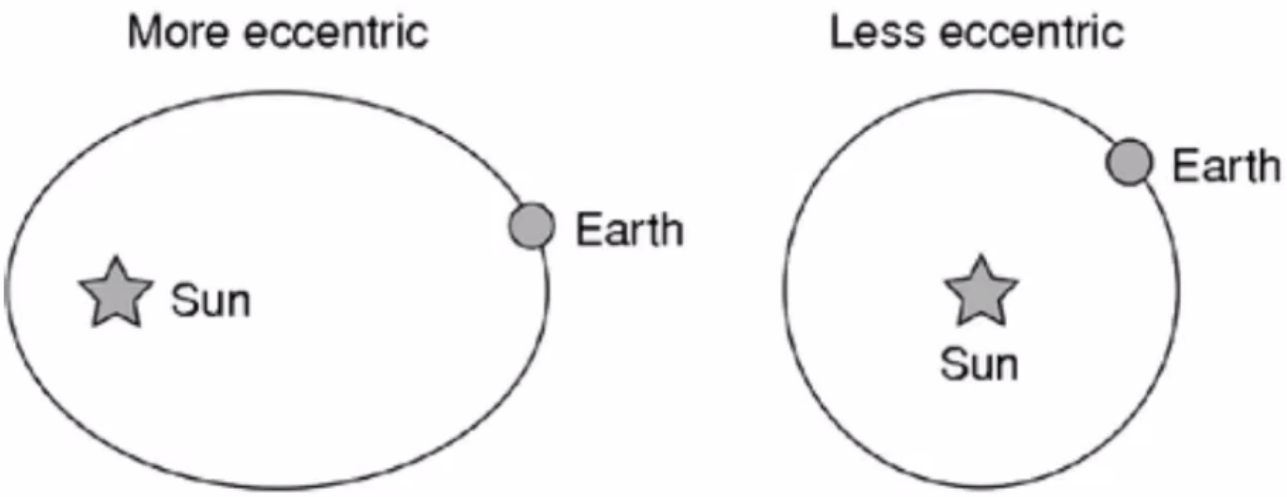
Born	28 May 1879[1] Dalj, Austria-Hungary (modern-day Croatia)[1]
Died	12 December 1958 (aged 79)[1] Belgrade, FPR Yugoslavia[1]
Nationality	Serb

He figured out the Earth moved around in an oscillatory fashion.

There are **THREE** characteristics of Earth's orbit that CHANGE cyclically over time.

1. Eccentricity

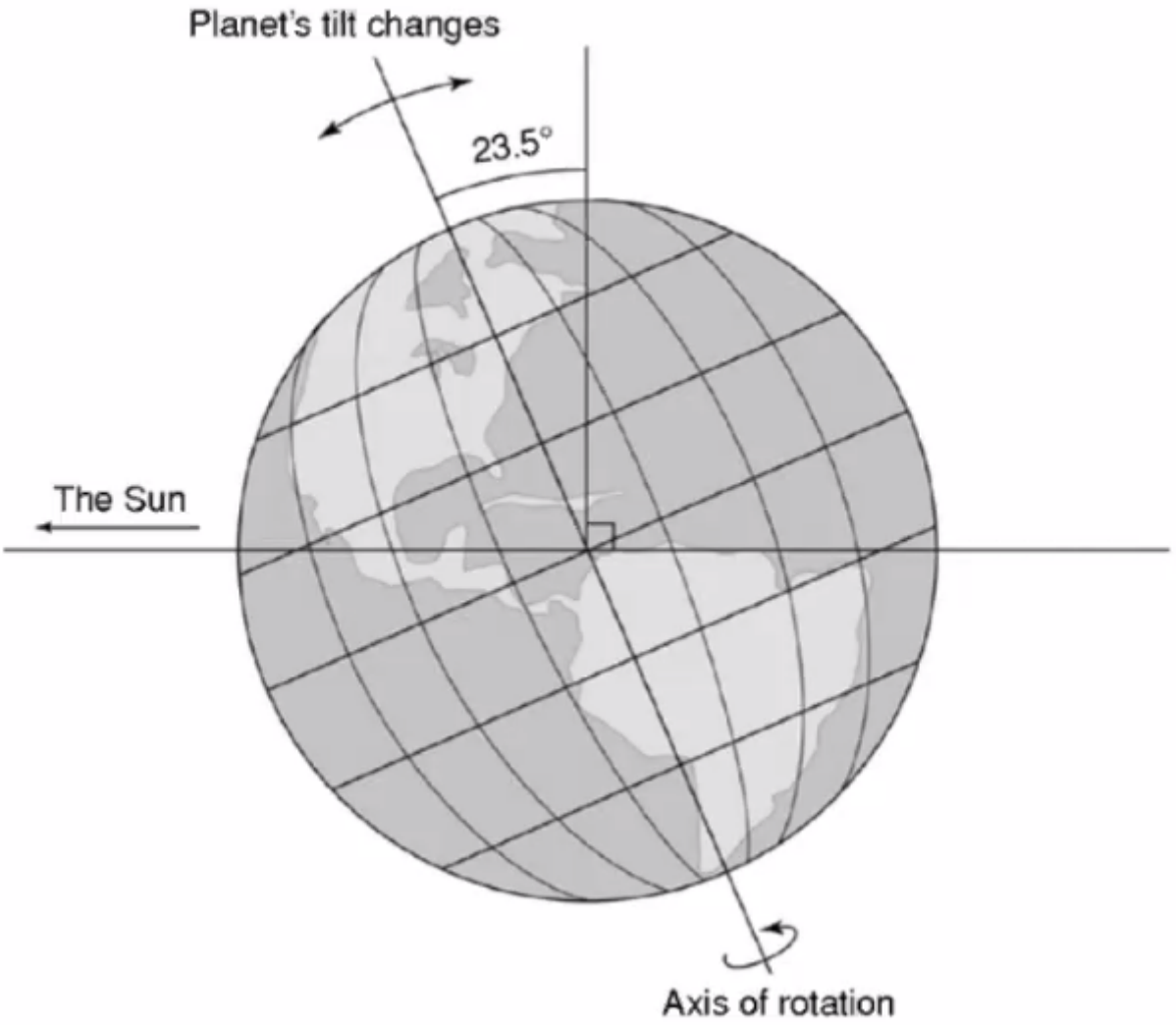
"How circular the orbit is"



2. Obliquity

"How the tilt of the Earth changes"

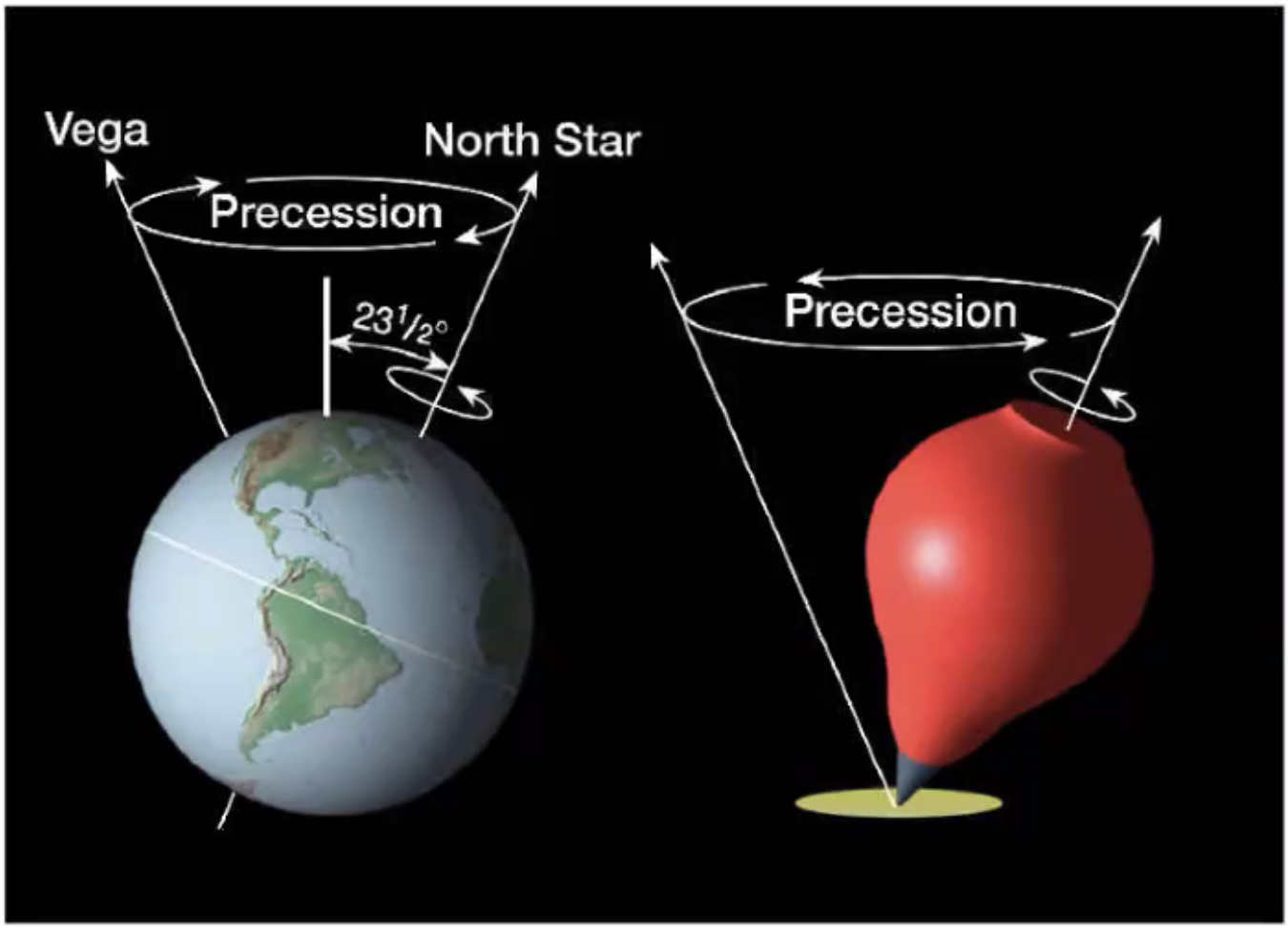
Right now, the tilt of our planet is 23.5° but this is not constant. It can be anywhere between 21.0° and 24.0°.



3. Precession

"What time of the year is the Earth closest to the sun?"

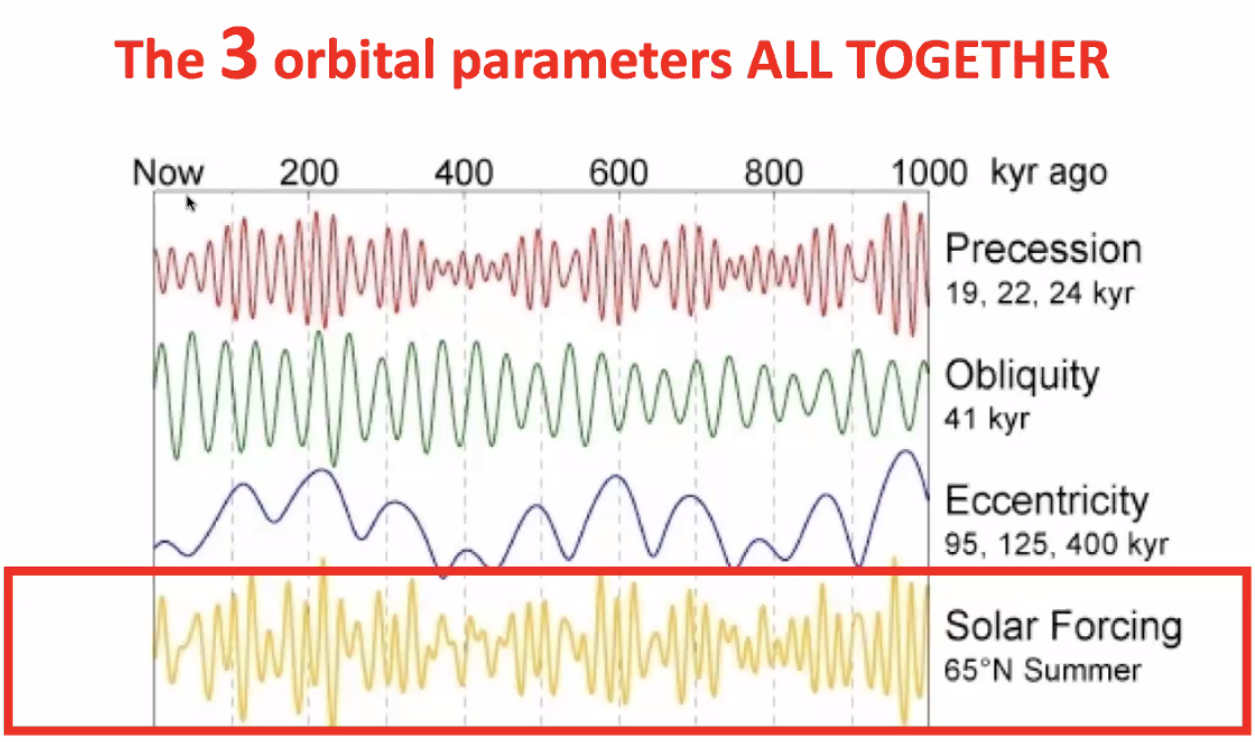
Known as the changing date of the parihelion



For example, if the northern hemisphere is pointed towards the sun, no matter where we are in our orbit, that is summer. The orbit, though, defines the intensity of the sun on our Earth.

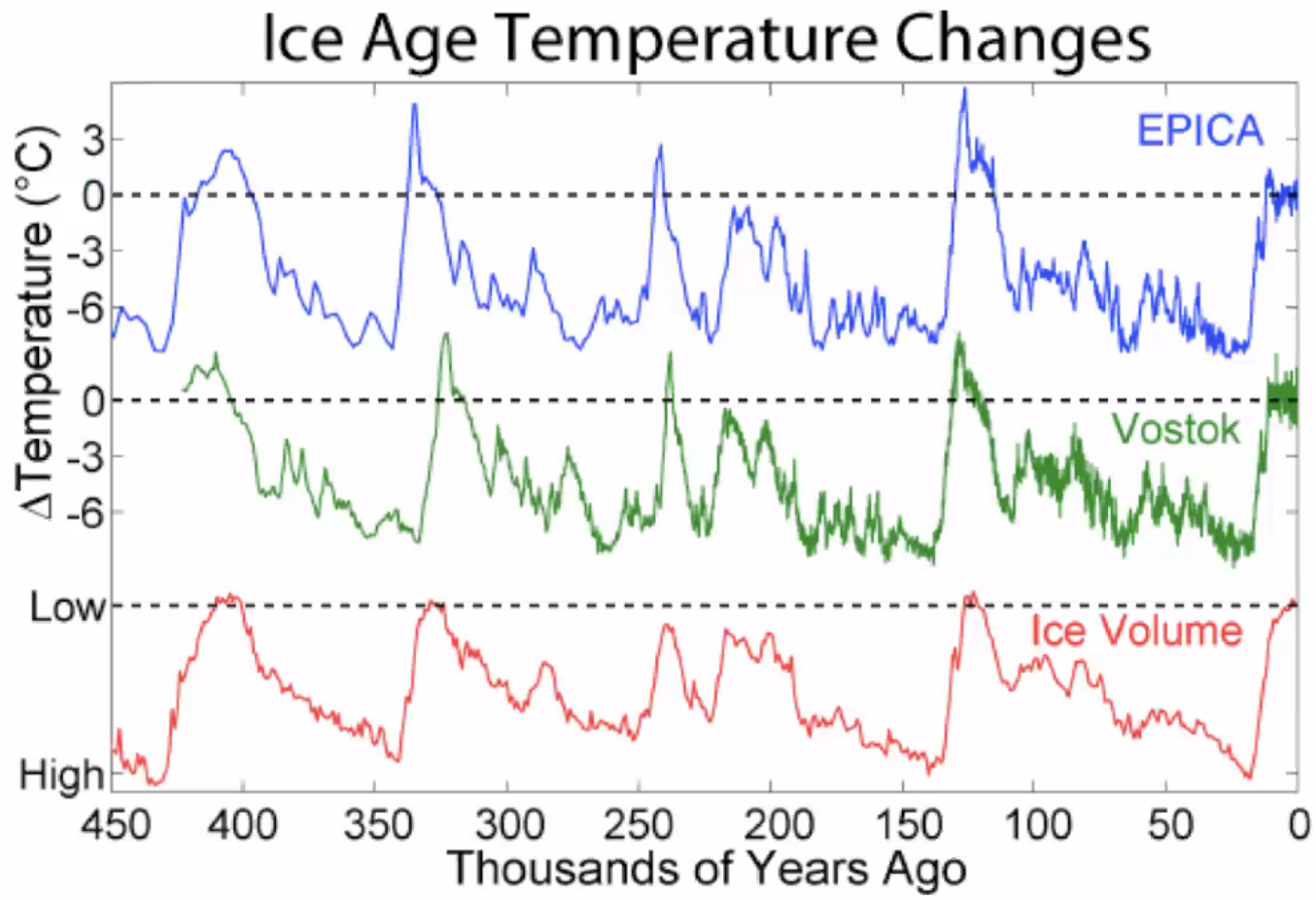
> **The precession influences the strength of the seasons.**

Each of these Milankovitch cycles take different lengths of time to complete.



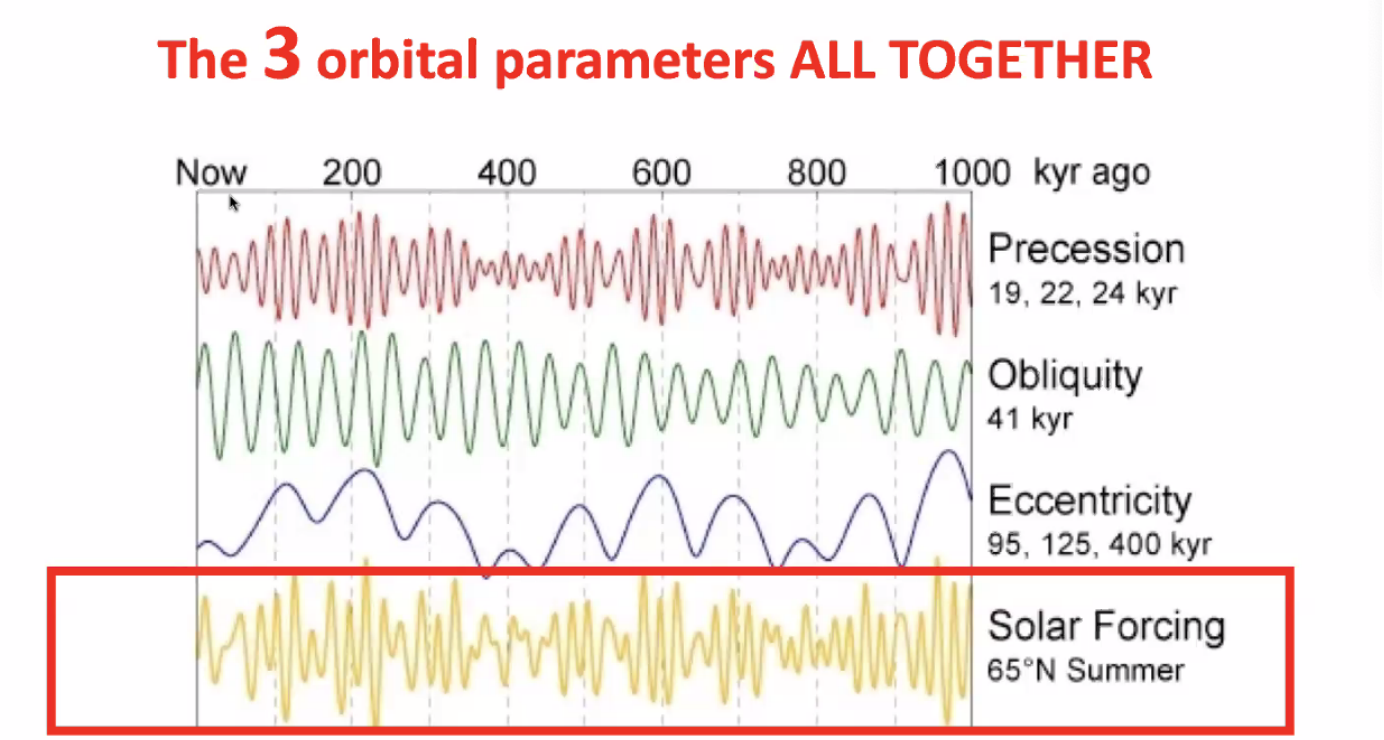
This is why the Earth's Global Ice Volume flip-flops so much. Each of those factors can cause a maximum or minimum amount of ice.

About every 100,000 years, we have a cold spike. Opposite of those, we have a warm spike.

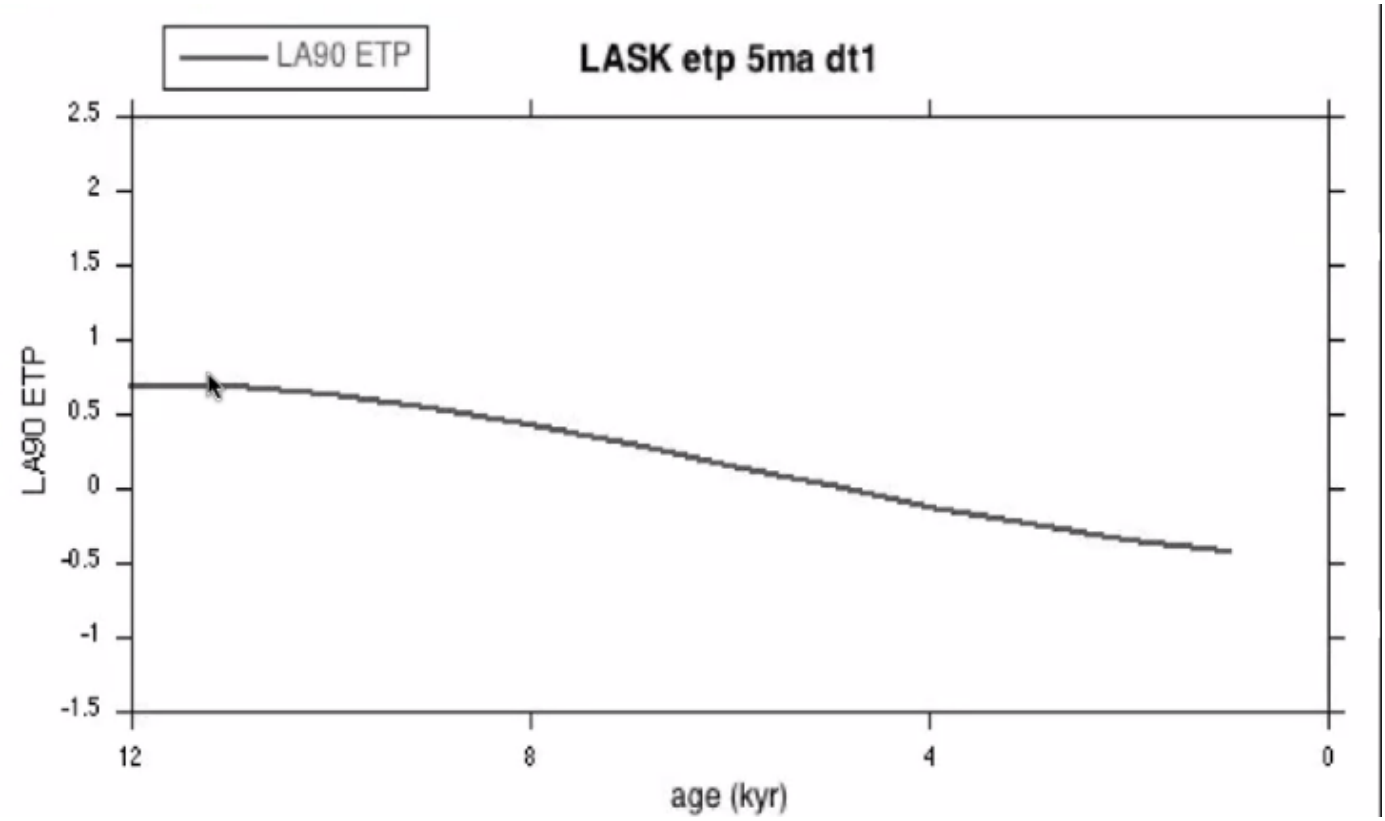


The Relation to Global Warming

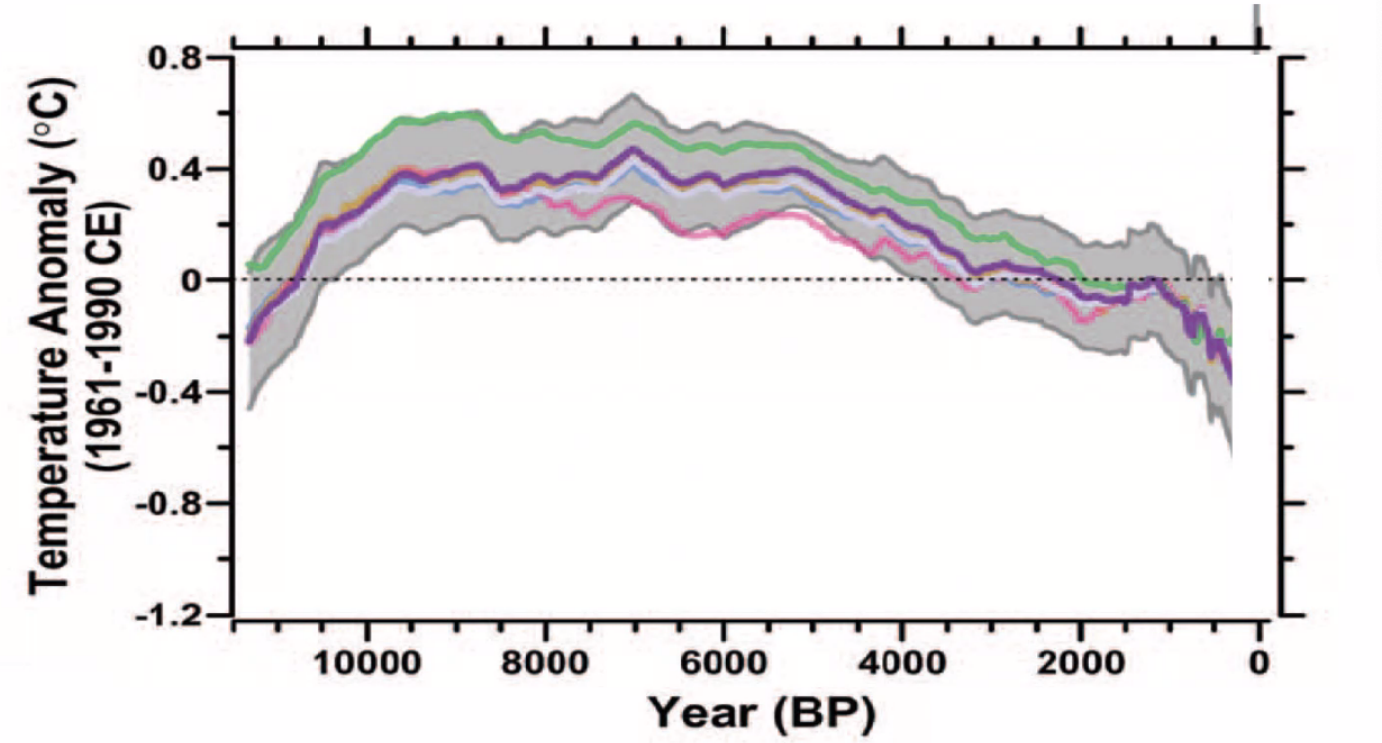
Consider the previously shown image:



The yellow oscillation represents the Incoming Solar Radiation (insolation) for the northern hemisphere.

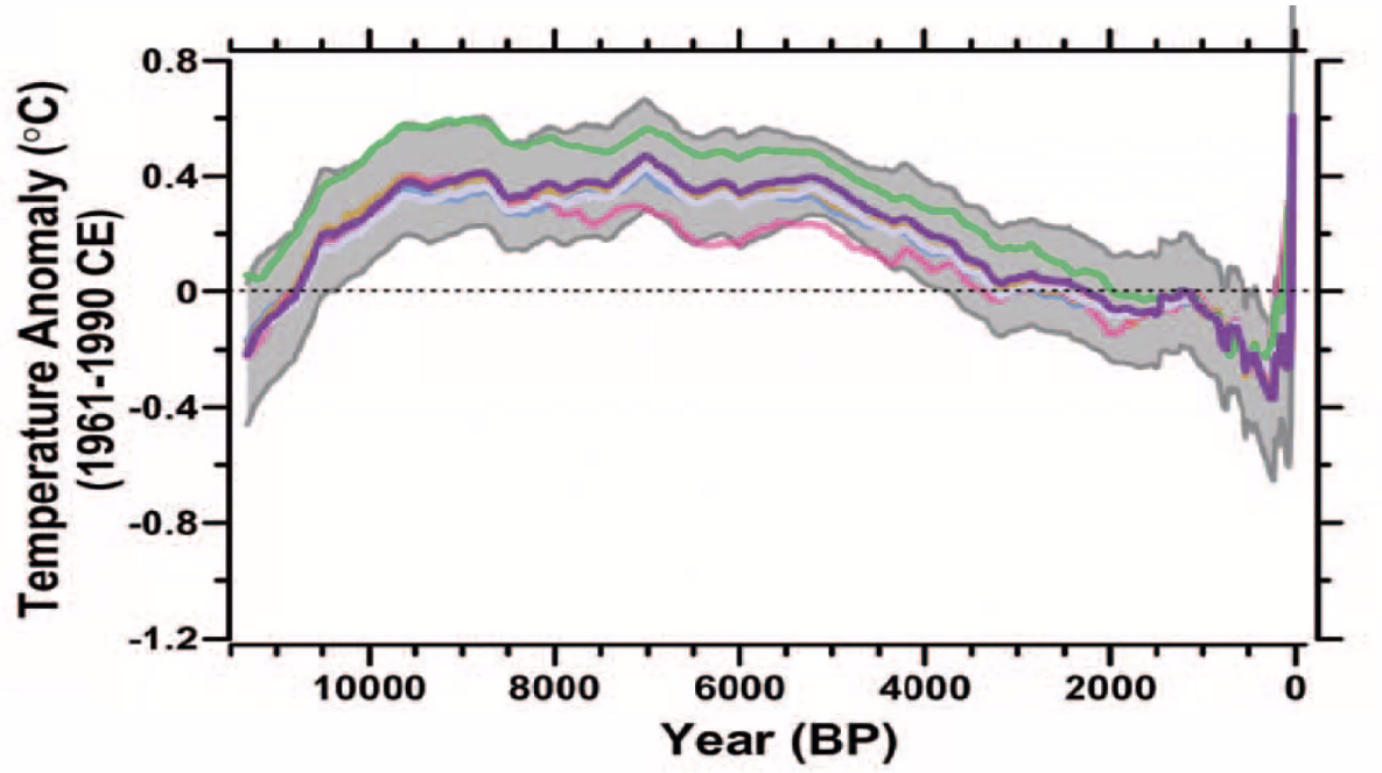


The energy we've been getting from the sun has been **DECREASING** for the last 10,000 years.



This is a reconstruction of Earth's temperature through the last 12 thousand years.

And this is that same reconstruction including post-industrial revolution.



We've intercepted Earth's efforts to cool itself, as it seems.

> ***KEY POINT:*** **Earth's temperature has been declining prior to the industrial revolution because it has been following orbital theory (natural climate variability) of having less and less energy from the sun.**