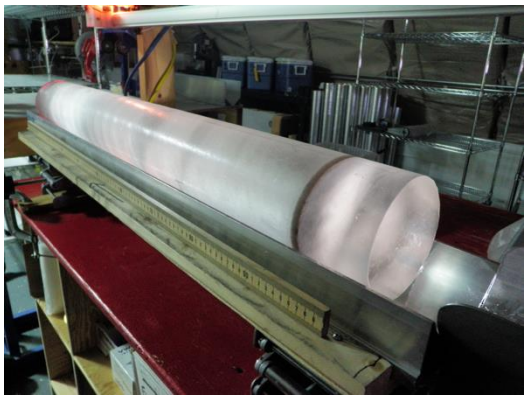
How do we know what the climate was like before we could measure it? -

Ice Cores and Milankovitch cycles

Scientists drill up to 3km into ice sheets and glaciers to collect cylinders of ice, called ice cores. Ice cores have layers that capture sediments and air, that tell us about the Earth's past climate. Layers were formed from falling snow in the winter that lasted through to the next winter. As the snow accumulated it became ice under its own weight. This can take thousands of years. Each layer is different in chemistry and texture providing a treasure trove of information about the climate each year. The longest record of Earth's history is contained in cores from the EPICA (European Project for Ice Coring in Antarctica) project in Antarctica spanning about 800,000 years. Careful study of the layers of long cores of ice from Greenland show that there have probably been eleven very large ice sheets over Canada in the last three million years.

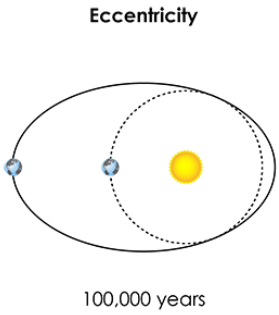


Ice core from the West Antarctic Ice Sheet Divide (WAIS Divide); The dark band in this core is a layer of volcanic ash that settled on the ice sheet approximately 21,000 years ago. — Credit: Heidi Roop, NSF https://icecores.org/about-ice-cores

What causes the ice ages?

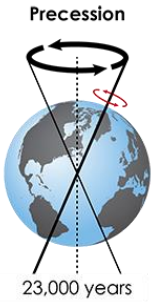
We know from many years of carefully measuring the position of stars in the night sky and the angle of the Sun above the horizon during the day, that the Earth's orbit, or path around the Sun, as well as its tilt toward the Sun are always changing, but very, very slowly; we call this the Milankovitch cycles.

The Earth's journey around the Sun, its orbit, is not a perfect circle. Instead it is an oval, like a stretched elastic band, so that the Earth is closer to the Sun at one end of its orbit than at the other (**Eccentricity**). That means that right now we are closer to the Sun in January (147 million km) than we are in June (152 million km). Remembering that January is our winter in the north, it might seem wrong that we are closer to the Sun in winter, but the angle of the tilt of the Earth causes a larger difference in temperature.



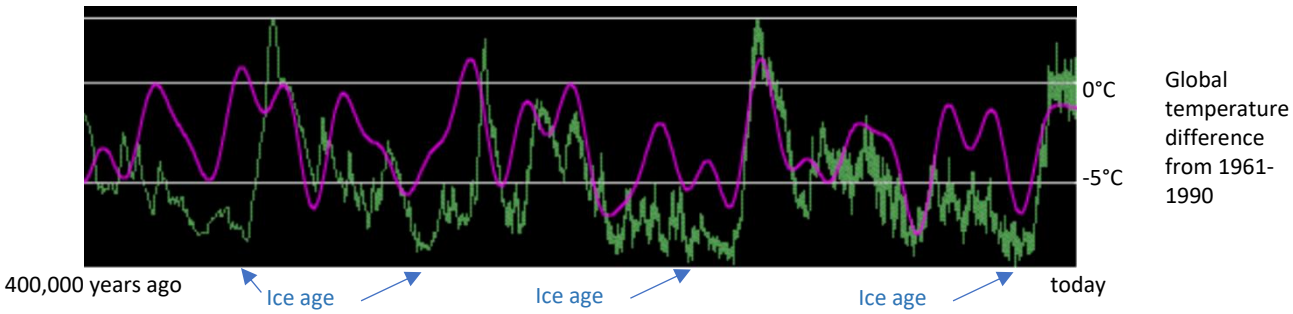
The reason lies in the changes in the **tilt** of the axis of the Earth around which we slowly spin like a spinning top. In Ontario, we are warmer in June because in that part of our orbit the axis of the Earth is pointing toward the Sun. We see the Sun more face on and we enjoy longer days. In the winter, on the other end of the Earth's orbit, the axis is pointed away from the Sun, the north pole is dark all day, we have shorter days and face the Sun at a low angle. That's why January is cooler than July and why our seasons are different. The angle of the tilt of the Earth towards the Sun changes by an extremely tiny amount every year, taking about 40,000 years to increase from just over 22 degrees to 24 ½ degrees and then back again.

To make things more complicated, the axis of the Earth slowly wobbles as it turns like a top that is slowing down (**Precession**). This can mean that it is tilted toward the Sun even more than we are used to today.



So, the Earth can be tilted more directly or less directly toward the Sun when it's either close to or far from the Sun. Each of these changes takes thousands of years and there are many possible combinations. When the Earth is fully tilted away from the Sun (Obliquity and Precession) and farthest from the Sun (Eccentricity) it becomes colder in the north.

Careful calculations of how the very slow changes in the Earth's position affect the warmth of the Sun received in the north have shown that sometimes summer weather could become cool enough to very slowly, over hundreds of years, allow winter snow and ice to last all year round as far as the border between Canada and the US. When it builds up for thousands of years, it can become an Ice Age ice sheet and eventually grow to as much as 2 or even 3 km thick and last 100,000 years.



In this graph, we see Eccentricity, Obliquity and Precession together (Milankovitch cycles) as a purple line and the EPICA ice core estimated temperatures in green. The Milankovitch cycles affect the amount of heat from the Sun that the Earth receives and leads to changes in global temperature. We are currently in a warming phase because the Earth is approaching its closest point to the Sun (low eccentricity, more circular orbit) and the north has been tilted toward the Sun allowing the Earth to capture more heat energy. From our understanding of the cycles of Earth's orbit and from looking at the ice cores in Antarctica (EPICA), we estimate that a cooling phase should soon begin.

What is going on now?

We have evidence that when ice last covered Canada, the average temperature of the Earth was about 5 – 7°C colder than it is today. Eventually, as the tilt of the Earth and its path around the Sun changed, summers in the north became warmer and the ice sheet began to melt. That is what has been happening for the last 12,000 years. When we remember that the ice on the Arctic islands and Greenland is part of that Ice Age ice sheet, we see that it is still going on. But the memories of Elders, the work of scientists, and records from weather stations tell us that what is happening now is different from the past. Earth is warming much faster today.

Read more:
https://earthobservatory.nasa.gov/features/Paleoclimatology_IceCores
An interesting Milankovitch interactive:
cimss.ssec.wisc.edu/wxfest/Milankovitch/earthorbit.html

UP NORTH ON CLIMATE
Climate Change Impact and Adaptation Study for the North of Ontario