Paleoclimatology

Overview of Paleoclimatology

Paleoclimatology is the study of how climate has changed during the entire history of the Earth.

In the past 150 years, humans started keeping records of weather changes using:

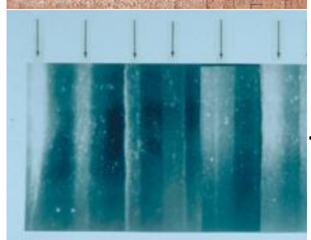
…thermometers

…radar

…satellites

For millions of years, the Earth has been keeping its own records in the form of…

…tree rings



…ice layers

…sediment varves

By combining all this climate data, paleoclimatology can be used to understand how and why our climate changes and to predict future climate change.

Why study paleoclimatology?

The paleoclimate records show that the Earth's climate has always been changing.
Scientists want to know if contemporary (present day) climate changes are natural or unprecedented.

Climatic variability can have a large impact on humans. For example, a change in climate can bring on severe droughts, floods, or storms.

Paleoclimatology has shown that the Earth can dramatically shift between climatic states in a matter of years or decades. A dramatic shift could mean the beginning of another Ice Age.

Climate Proxies

Scientists have been recording climate data for around 150 years. Therefore, when they need to estimate climate conditions from long before that in the geologic past, they study climate data that has been preserved in the environment. These environmental records are called climate proxies and can indicate to scientists the climatic conditions that occurred many millions of years ago.

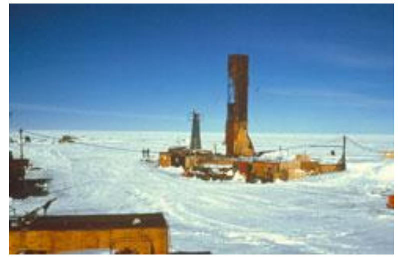
Some climate proxies reveal general climatic patterns that occurred over the entire Earth such as the chemistry of fossil marine organisms or layers of sediment in the ocean that become sedimentary rock.

Some climate proxies are more helpful in understanding seasonal changes in specific regions such as tree rings and coraline red algae.

Studying Ice Cores

Ice cores extracted from glaciers and ice caps contain more climate information than any other proxy record.

Snow fall accumulation throughout the year creates layers in the glaciers. An ice core sample can contain thousands of years of climate data.



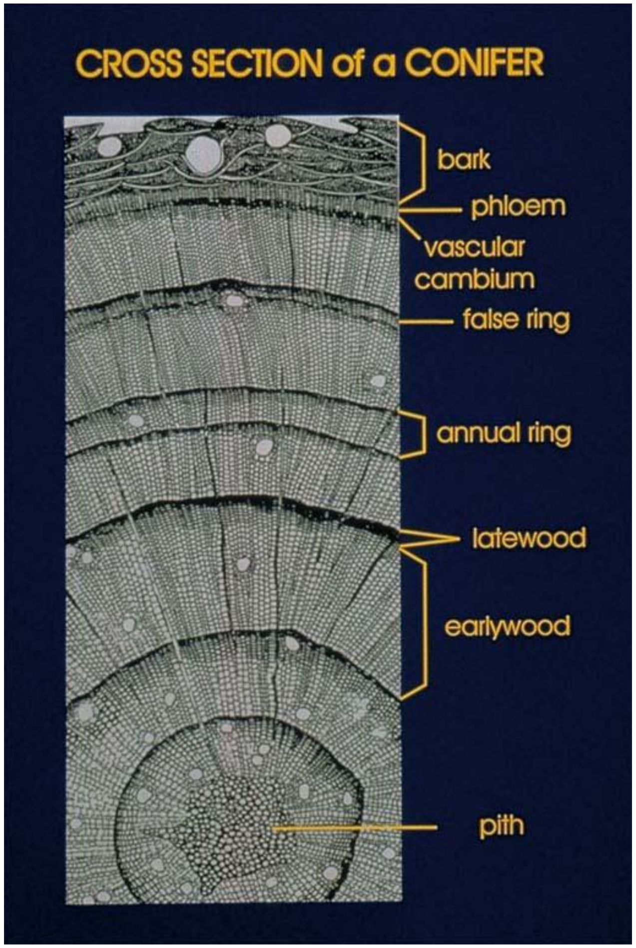
Teams of scientists travel to remote areas to drill down deep into the ice to obtain ice cores.

Cores are packed in insulation for shipping and then stored in a lab that is -35 degrees Celsius.

Comparing layers in the ice reveals changes in temperature and precipitation. Tiny bubbles in the ice preserve bits of ancient atmosphere that can be analyzed in the lab. An ice core sample can even record volcanic eruptions and solar variability.

Studying Tree Rings

Tree rings preserve climate data.

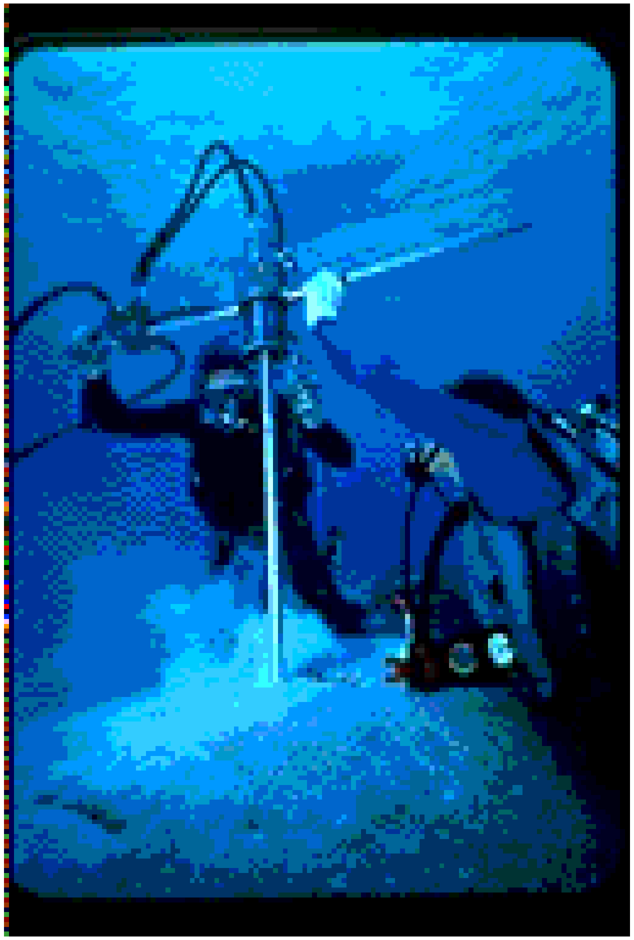


Each year that a tree grows is represented by a ring in its cross-section. Years with good conditions (usually warm or wet) will be represented by wider rings than years with poor growth conditions. A tree-ring record can date back as far as a few thousand years.

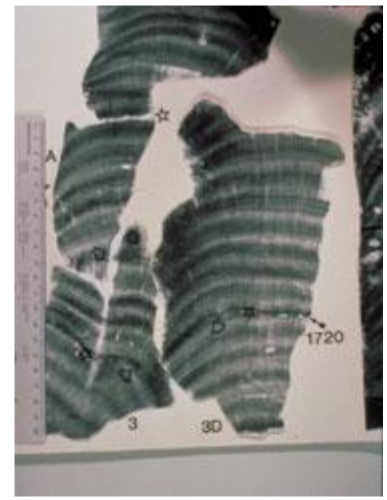
Scientists select an area of trees whose growth is most sensitive to climatic variations. In an area of study, scientists collect samples from many living trees using a handheld borer. These contemporary specimens are then compared to an older, and long dead, fossilized tree. Such a fossil tree can be dated with radiocarbon techniques. Scientists study their collection of tree samples to determine annual growth conditions such as precipitation, temperature, and hydrology. They can even determine if fires occurred that did not actually kill the tree.

Studying Corals

Tropical coral reefs lock in climate records.



Coral reefs have annual growth bands similar to tree rings. Winter growth differs in density from summer growth due to seasonal changes in temperature and cloud cover. A long coral core can date back several hundred years.

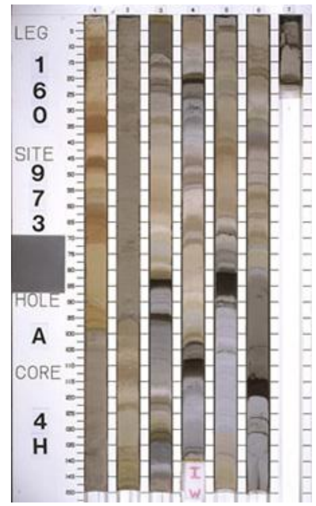


Scientists select a coral reef where they detect a clear and identifiable climatic signal. They take a boat to the area of study and then dive down to carefully drill and remove a core sample. They try to get the longest sample possible. Once the core sample is shipped back to the laboratory, scientists used x-rays to examine the growth bands. Each band, or layer of the coral skeleton, contains calcium carbonate. Isotopes and trace minerals in the calcium carbonate reveal data about the sea water at the time of formation. Scientists study the growth bands to determine the conditions under which the coral skeleton was created in each season of its history.

Studying Ocean and Lake Sediments

Layers of ocean and lake sediments provide hints to temperatures and weather patterns of the past.

Ocean floors and lake basins accumulate tons of sediment annually. Scientists collect sediment cores to study tiny fossils, debris, and chemicals that appear in the layers. These items can reveal information about past climates earlier than, during and after the last Ice Age.

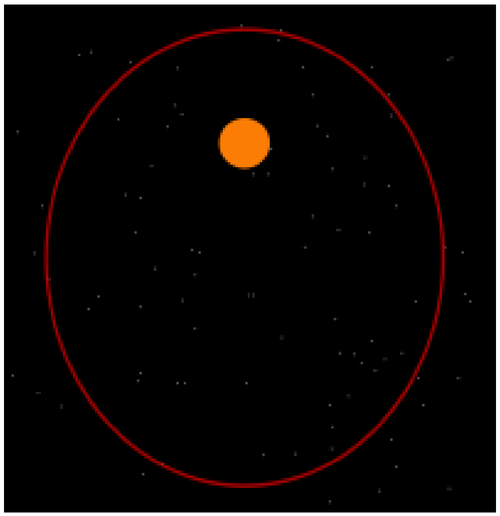


Scientists select a study area based on their phenomenon of interest and the best probability of retrieving an accurate sediment core. They use large ships equipped with heavy-duty winches to collect core sample. To extract the sediment core, they drive a steel barrel into the mud on the ocean bottom, then pull it up and on-board with a winch. They try to get the longest sample possible. They also record seismic profiles of the area. Every research cruise collects tens of meters of sediment cores that are then transported back to shore and stored at a research laboratory. Scientists will then use x-radiographs to examine the color, characteristics, and contents of the cores to understand the history of climate change in that area including how much ice existed.

Milankovitch Theory

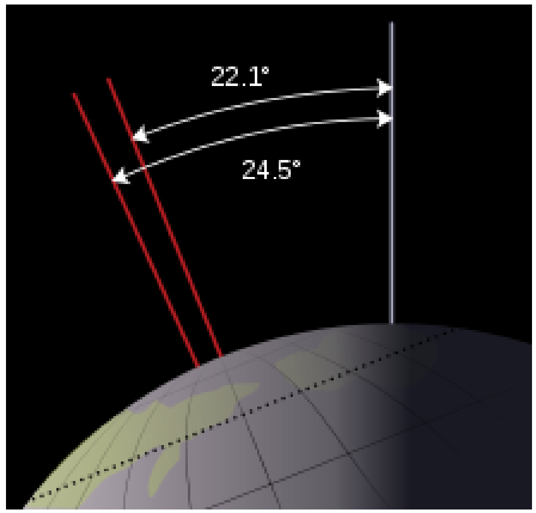
A Serbian mathematician developed a theory about how the Earth's eccentricity, axial tilt, and precession impact its climate patterns. All these changes in the Earth's movements change the overall amount and location of the solar radiation that reaches Earth.

Eccentricity



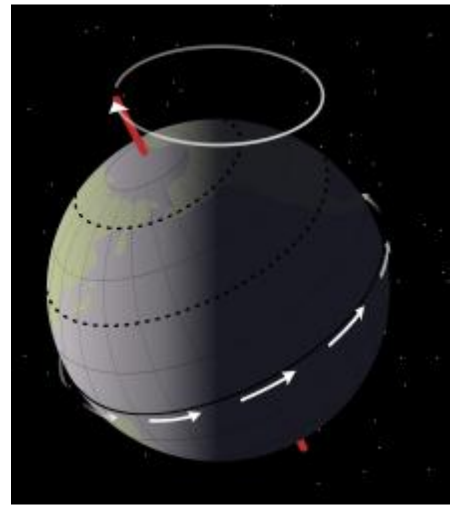
The Earth's orbit is elliptical. Eccentricity is a measurement of how much the orbit differs from being a circular orbit. Sometimes it's more like a circle with a lower eccentricity. Sometimes it's longer and narrower with higher eccentricity. This change in eccentricity that occurs every 100 thousand years or so accounts for an increase in seasonal changes on Earth.

Axial Tilt



The Earth's axis of rotation tilts in a range between 22.1° and 24.5° with respect to the Earth's orbital plane. It takes the Earth roughly 41,000 years to go from 22.1° to 24.5° and back again. As the tilt increases, the solar radiation during the summers increases in both hemispheres. As the tilt increases, the solar radiation during the winters decreases in both hemispheres.

Precession



The Earth's axis of rotation has a gyroscopic motion caused by the gravitational forces of the sun and moon. Precession is the term for the direction that the axis moves in relationship to fixed stars. It takes the Earth roughly 26,000 years to complete one cycle. Depending on where the Earth is in the cycle, one hemisphere will have a greater difference between seasons than the other hemisphere because it will be closer of farther from the sun when it is pointing toward it.