How Do We Know?

Have you noticed that information on climate change sometimes talks about what the climate used to be like 1,000 years ago or even 100,000 years ago!? For example:

- People say that about 125,000 years ago, temperatures were even warmer than they are today, by about 2°C.
- We are told that since the last ice age – about 10,000 years ago – our temperatures have been pretty stable. However, during the past 100 years things have started warming up rapidly.
- There is far more carbon dioxide in the atmosphere now than at any time in the last 400,000 years.

How the heck do they know this stuff!?

This backgrounder looks at how people figure out what past climates were like. It also provides an overview of how we are monitoring today's changing climate.

Looking Back

Information on temperatures from around the world is available starting in the 1860s. This temperature information gives us a pretty accurate picture of what has been happening for the last 140 years. For example, over the last 100 years, temperature data show clearly that temperatures around the world have increased an average of 0.6° Celsius.

If there weren't any thermometers thousands of years ago, how can today's scientists claim to know what the climate was like back then? Where do they get their information from?

Believe it or not, people who study past climates (paleoclimatologists) do this by looking at things like ice, trees, and muck from lake or ocean bottoms.

Icy information

Imagine looking at a chunk of ice from a glacier and being able to figure out what the weather was like since the time the glacier was first formed! That is exactly what many researchers are doing around the world.

Hundreds or even thousands of years of snowfalls form glaciers. Each year, the snow lands and gets compacted by weather and more snow. Eventually, it becomes ice. The closer to the bottom of the glacier you go, the older the ice will be.

Scientists have figured out how to drill into these glaciers and extract long cylinders of ice that are called cores. In Greenland, they can get core samples that contain 100,000 years of information. In Antarctica, the cores contain 400,000 years of data!

When the scientists look at these cores, they can see layers in the ice. There are a number of things that scientists look for in the layers of ice to get a picture of what our ancient climates were like. These include:

- **Chemical isotopes:** All chemical elements, like oxygen and carbon, are made up of atoms. An isotope is a form of an atom (different isotopes have a different number of neutrons). Scientists look at the isotopes of hydrogen, oxygen and other chemical elements in the ice to help them figure out what the temperatures would have been like at when the layers were being formed.
- **Volcanic ash**: Humans in the northern hemisphere have kept records of volcanic eruptions for the last 1,000 to 2,000 years. So today's scientists look for fine layers of ash in the ice that would have fallen on the glacier during eruptions. This allows them to estimate how old the ice is at that point in the core. They also compare the temperature information (collected by looking at the isotopes) with the volcanic eruptions to figure out the impact of volcanoes on the temperature.
- **Salt**: Scientists might also look for traces of salt in glaciers near oceans. Winter storms over the oceans kick up lots of salt spray that settles on the glaciers. So scientists can sometimes separate one year of winter storms from another because there is less salty layer of summer ice in between.

- **Carbon dioxide, methane and nitrous oxide:** Ice cores also help us figure out how amounts of key greenhouse gases changed in the atmosphere over the period of time covered by the core. Researchers do this by analyzing the tiny air bubbles that get trapped in the glacier as it forms. These bubbles contain carbon dioxide, methane and nitrous oxide.
- **Dust**: Scientists can also see where there were high levels of dust in the ice. This tells them that the climate at that point in time was dry enough to cause dust to get into the atmosphere.

So you might want to think about how much stuff can be found in glacier ice next time you have the chance to take a drink from a glacier fed stream!

Tree tales

Have you looked at a stump or piece of wood and seen small circular lines? Each line represents one year of growth. In years when trees have enough moisture and good temperatures, they usually grow faster. The rings for these years would be thicker than rings for colder, drier years. In the north, rings are usually very close together because the trees grow very slowly.

With a small tool – a hollow drill – scientists can take a core out of a tree so they can look at the rings. By measuring the size of the rings, they can learn a lot about changes in climate, year by year, since the tree first started growing. Some of the trees being analyzed are hundreds, or even thousands, of years old!

Messing in the muck

Some scientists are also figuring out what past climates were like by taking core samples from the mud at the bottoms of lakes, rivers or oceans. Like the snow on glaciers, sediment settles in the bottom of water bodies every year. The layers of muck can help tell the story of past climates.

For example, researchers look at the plant pollen that was trapped in the different layers. This tells them what plants were in the area when the layers of muck were formed (as some of the plant's pollen would have blown onto the water and settled to the bottom). The scientists can then get a good picture of what the climate must have been like if that type of plant was able to survive.

People also look at the fossils of insects, plants and animals that they find in the muck. Carbon dating techniques can be used to sort out how old these things are. Knowing what types of insects, plants and animals were around at a certain time helps the researchers understand what the climate would have been like when the fossil started forming.

Indigenous information

Indigenous people in the North have passed down information on the land and climate from generation to generation. Elders today are sharing their knowledge about the changes they have seen on the land in their lifetime.

But their own observations are enriched by the knowledge they have been given by their elders. This past knowledge includes information about historical changes in wildlife movements, vegetation, conditions on the land and the climate.

These observations and stories from many generations of northern aboriginal people provide a valuable understanding of the relationship between changes in the climate and changes to the land, water, wildlife, vegetation, and people of the north.

Melting ice reveals some surprises!

In the Southwest Yukon, warming temperatures have uncovered quite the pile of...ummm... caribou droppings.

Old patches of ice in some of the Yukon's alpine areas have been melting rapidly as climate change causes temperatures to warm up in the north. As the ice patches disappear, large areas of caribou dung are being revealed. In some areas, the poop has been up to 30 centimetres thick! And some of it is estimated to be over 8,000 years old!

The melting ice has uncovered important information about the history of both the caribou and First Nation people in the southern Yukon. For example, by looking at the dung, scientists can tell that the caribou mostly ate sedges and lichens thousands of years ago. People studying the ice patches have also found many hunting tools that have been well preserved under the ice. One dart fragment has been estimated to be about 6900 years old.

First Nations and scientists are working together to gather artefacts uncovered by the melting ice. Everyone is learning more about the rich history of the area.

Measuring the Here and Now

The understanding and awareness of historical climate change is steadily growing as people around the world gather information from glacier ice, trees, lake bottoms and oral traditions.

There is also a lot of research going on to help us understand what is happening right now – and how it is affecting our environment and our communities.

Some of this research on the "here and now" involves many countries and hundreds of scientists and researchers. These studies are looking at the global picture of climate change. Other projects are being carried out at the community level and involve local people.

When the white people first came here, the native people said "how" and the white people said "why." I spent 90% of my time growing up with my grandparents. They taught me about a lot of stuff. I notice in the traditional world, it's all based on how am I'm going to do this. They never asked why....

Science is always asking why.... Science wants to know why it works.

A good thing today is that people have to come together. We have to know why and how. We have to double understand.

Randall Tetlichi, Old Crow, Yukon
Quoted in "Observations on Traditional, Local and Scientific Knowledge: Notes on a discussion from the 7th Annual Gathering of the Arctic Borderlands Ecological Knowledge Co-op," February, 2002.

The international scene

The Intergovernmental Panel on Climate Change

The Intergovernmental Panel on Climate Change (IPCC) was set up by the United Nations in 1988 to review the stacks of scientific, technical and socio-economic information that are being gathered on climate change. The IPCC:

- looks at the evidence others are collecting on how the climate is changing;
- tries to figure out what the risks and impacts of climate change are; and
- works to identify ways to slow climate change and ways we can adapt to the impacts of climate change.

As over 2500 scientists from 80 countries have participated in the IPCC, it is an important voice on what is happening globally. Much of the information you read about the current impacts of climate change and many of the predictions for the future are based on reports from the IPCC.

Arctic Climate Impact Assessment

The Arctic Climate Impact Assessment project (ACIA) was set up in 2000 by the Arctic Council and the International Arctic Science Committee (IASC). The Arctic Council has eight Arctic countries (including Canada) as members and six indigenous organizations from the Arctic region as permanent participants. The IASC is a non-governmental organization that facilitates cooperation on all aspects of arctic research.

The goal of the Arctic Climate Impact Assessment project is to integrate and evaluate knowledge that is being collected about changes in the climate and increased ultraviolet radiation in Arctic regions. The project will examine possible future impacts on the environment, plants, wildlife, and human health. It will also look at the impacts to buildings, roads and other infrastructure. The aim is to provide useful and reliable information to the governments, communities, organizations and peoples of the Arctic to help them deal with the predicted impacts. The reports out of this project are expected in the fall of 2004.

The Arctic Climate Impact Assessment (ACIA) will include the changes observed by different arctic indigenous peoples. ACIA will also look at indigenous perceptions of climate impacts, such as the effects on their way of life, land and water use, diet, and social and cultural activities.

The local scene

Many of the studies that the IPCC reviews focus on specific pieces of the climate change puzzle. Some might look at ocean temperatures in one region, while others could study melting glaciers somewhere else. They all provide important information on specific issues that IPCC then tries to pull together into one picture.

Community-based studies tend to provide a bigger, more connected part of the puzzle right from the start. Community-based studies collect local observations and knowledge. These studies often look at how climate change is affecting more than one piece of the puzzle. They look at how climate change is impacting the northern environment, people, communities and economies.

Community-based observations also help scientists and other researchers focus in on what needs more detailed study.

Many projects in northern Canada have gathered local information and knowledge. Here is a list of projects and related communities that have provided valuable information on the reality of climate change:

- *Arctic Borderlands Ecological Knowledge Co-op* (Old Crow, Yukon; Aklavik and Fort MacPherson, NWT; Arctic Village and Kaktovik, Alaska).
- *Mackenzie Basin Impact Study* (communities in Yukon, NWT, BC, Alberta and Saskatchewan)
- *Inuit Observations on Climate Change* (Sachs Harbour, NWT)
- *Tuktu and Nogak Project* (Nunavut communities of Ikaluktuuttiak, Kingauk, Kugluktuk, and Umingmaktuuk)
- *Arctic Climate Change: Inuit Observations of Climate Change in the Eastern Canadian Arctic* (Iqaluit, Igloolik, Kangiqtugaapik, Qamani'tuaq – all in Nunavut)
- *Voices from the Bay* (Sanikiluaq, Nunavut)

Time and time again, people involved in all of these projects are reporting things like:

- earlier spring melting and break-ups
- later freezing in the fall
- melting permafrost
- changes in wildlife behaviour and migration routes
- new species of fish and birds in their area
- deeper or icier snow, and
- tougher conditions for travelling on the land and water.

Northern people have always watched the weather closely. The weather determines when the geese and caribou will migrate, when it is safe to go out in boats, when the rivers will freeze up, and when planes will be able to fly between communities.

People on the land rely on generations of observations about the weather and land to identify and understand the connections between changes to the climate and changes to wildlife migrations or hunting opportunities.

For example, northern people have pointed out how warmer spring temperatures are causing earlier break-up of river ice. They have seen how this makes it more difficult for caribou to survive river crossings. Such dangers for the caribou can cause the caribou to change their migration route. This in turn affects the peoples' hunting opportunities. If the caribou travel too far from the communities, it may mean there will be less healthy caribou meat to eat. It is all connected.

As more and more northerners tell similar stories of climate change, they highlight the connections between the changes and the impacts. The climate change puzzle is becoming easier to see. This information is helping to influence governments and international organizations that are debating and discussing what to do about climate change.

It is springtime that has changed really much. Fall is not the same every year – some early, some late, but fairly close. But spring is different. Much different from year to year.

Peter Esau, Sachs Harbour, NWT

Long ago [it] used to be [a] long spring. Used to stay out there [at his hunting camp] for months. In the springtime… we do fishing first. After that, hunt geese, then go fishing again after that. Now we don't even go fishing after geese hunting because it melts too fast.

Geddes Wolki, Sachs Harbour, NWT
Reported in: Nichols, T., F. Berkes, D. Jolly, N.B. Snow and the Community of Sachs Harbour. Climate Change and Sea Ice: Local Observations from the Canadian Western Arctic. Arctic, 2003 (In Press).

Mapping the plants

Across the north, there are also a number of people working on scientific research projects to collect information on the impacts of climate change. People are monitoring things like changes to plant growth and species or changes in the amount of rain and snowfall.

Some of these research studies are part of the International Tundra Experiment (ITEX). There are ITEX project sites set up across the Canadian north.

Some of these ITEX projects look at plants in a very small area called a plot (each plot is one square metre in size). The locations of the plots are marked permanently so that researchers can find them every few years. Researchers place a wire grid over the plot to help them map where certain plant species are growing and how big the plants are. By doing this every few years, they can see what kind of changes are happening.

At some ITEX sites, researchers have set up a second plot that they cover with a transparent material. This raises the temperature in the plot by about 1° to 3°C during the growing season. This is like faking climate change – it allows researchers to get a better idea of how the plants will be affected by climate change.

All of these efforts – at the international, national, regional and community levels – are helping to build our understanding of climate change and how it is impacting people and the environment. Together, the scientific research and the community-based studies provide different but critical pieces of the climate change puzzle.

Key Points

- World wide, temperatures have only systematically been measured and recorded since 1860.
- Scientists use information from glacier ice, tree rings, and the sediment at the bottom of water bodies to understand what climates were like thousands of years ago.
- Indigenous knowledge is another valuable source of information about what climates have been like over multiple generations. Indigenous knowledge also helps us to understand how changes in the climate have affected plants, the land, wildlife and people.
- The Intergovernmental Panel on Climate Change (IPCC) involves over 2500 scientists from 80 countries in its work. It is the main source of information on global climate change.
- Many local projects in the north are helping to gather information on climate change and its impacts on the environment and people.

Want to Know More?

These websites will tell you more about how scientists measure climate change:

- **Arctic Climate Impact Assessment:** http://www.acia.uaf.edu/ – Learn more about this Arctic project that measures climate change and its impacts.
- **Arctic Borderlands Ecological Knowledge Co-op:** http://taiga.net/coop/reference/indicator_assessments/rptperm.html – This page tells about methods of monitoring permafrost and soil temperatures to measure climate change.
- **International Institute for Sustainable Development:** http://iisd1.iisd.ca/climate/arctic/#one – Outlines a number of ways this IISD is working with Arctic communities to gather information. Click on the three 'Current Projects' at the bottom of the page.
- **International Tundra Experiment (ITEX):** http://www.itex-science.net/default.cfm – Find out more about this network of experiments.
- **Northern Climate Exchange Knowledge Site (Matrix Maker):** http://yukon.taiga.net/matrix/index.html – Use this amazing matrix to learn what scientists know about different aspects of climate change in the north.
- **Waiscores Project:** http://waiscores.dri.edu/index.html – Gives information about an ice core project in West Antarctica. Go to 'Background Information' to find out what ice cores tell us about climate change.