Reflecting on Reflectivity

High School Grades

Lesson Summary

Students plan and construct a "mini-lab" to measure the reflectivity of different earth surfaces.

Prior Knowledge & Skills

- Problem-solving
- Invention
- Research
- Measuring
- Observation
- Inference

AAAS Science Benchmarks

The Nature of Science
Scientific Inquiry
The Nature of Technology
Design and Systems
The Living Environment
Interdependence of Life
Common Themes
Systems
Models

NSES Science Standards

Science as Inquiry
Abilities Necessary to Do Scientific Inquiry
Physical Science
Interactions of Energy and Matter
Earth and Space Science
Energy in the Earth System

NCGE Geography Standards

The World in Spatial Terms
Standard 1
Physical Systems
Standard 7

Teaching Time: Two to four hours

Materials

- Copies of the backgrounders
- Copies of student handout
- Cardboard box
- Black paper
- Flashlight
- Construction materials
- Earth surface materials, e.g., soil, rocks, leaves, snow, ice
- Data-logger with light sensor fitting (optional)

Advanced Planning

Preparation Time: 10 minutes

1. Review the instructions
2. Gather the necessary supplies.
3. Group students into pairs or teams.

Recommended Reading: (included)

- High School Backgrounder #1: Climate Change: What's the Big Deal?
- High School Backgrounder #2: The Greenhouse Effect
- High School Backgrounder #7: The Changing World of Water and Ice

LASP
LABORATORY FOR ATMOSPHERIC AND SPACE PHYSICS

Reflecting on Reflectivity

Printable Version

Grade Level: 9–12

Subjects: Sciences, Social Studies, Geography, Northern Studies

Enrichment: Science, Social Studies, English Language Arts

Time: 2–4 hours

Setting: Classroom

Materials: Copies of the backgrounders, copies of student handout (if you decide to use it), cardboard box, black paper, data-logger (e.g. PASCO 500), with light-sensor fitting, flashlight, various construction materials (glue, tape, scissors, Exacto knife), earth surface materials to measure, e.g., soil, rocks, leaves, snow, clear ice (freshwater), sea ice

Skills: Problem-solving, invention, research, measuring, observation, inference

Key Vocabulary: Greenhouse effect, albedo, reflectivity, feedback loops (positive and negative)

In a Nutshell:

Students plan and construct a "mini-lab" to measure the reflectivity of different earth surfaces. They measure reflectivity of materials, including ice, soil, rocks, etc., and then extrapolate from what they have learned to consider the impacts of melting ice on the Arctic.

Goal:

To have students evaluate the reflectivity of natural surfaces and then relate the significance of albedo and changing albedo to northern climate change.

Background Learning:

Before starting this activity, students should be familiar with the basic science of climate change as reviewed in:

- High School Backgrounder #7: The Changing World of Water and Ice

Learning Outcomes:

Click on the icon for your territory to review the learning outcomes that are addressed by this lesson:

Nunavut NWT Yukon

Introduction to Lesson Plan:

This lesson combines the excitement of planning and constructing a reflectivity "mini-lab," the skills of scientific observation and measurement, and a broader reflection on what these scientific measurements will mean for the north. The one piece of sophisticated equipment you need is a data-logger with a light-sensor attachment. (PASCO 500 is one model; there are others.) If you don't have one in your school, see if you can borrow one.

Grade 11 students at Tusarvik School, Repulse Bay, in Nunavut constructed their "reflectivity lab" in the form of a cardboard box lined with black paper (to stop incidental reflection). A hole was cut into the upper side of a box, and an internal hood constructed over it, so that the beam of the flashlight was directed entirely to the surface at the bottom of the box. The light meter was mounted on the top of the box so that it picked up only the light reflected from the surface below. The class developed a system to allow them to slide trays of various earth surface materials into the bottom of the box. This mini-lab allowed them to measure the reflectivity of different surfaces.

This experiment served as a jumping-off point for reflection on the impacts of northern climate change.

Activity:

1. Introduce the students to the basics of climate change. As well, explain the concepts of albedo, reflectivity, and feedback loops (positive and negative) – see the Glossary, and More Information, below. Decide whether you want to distribute copies of Student Handout: Albedo, describing the basics of the albedo effect.

2. Pose the problem: to design a mini reflectivity lab that will accurately measure the reflectivity of different surface materials. Present the available materials and explain their uses. Challenge students to plan a design for the mini-lab that will ensure that the variables are controlled – the reflectivity of materials will be measured accurately. You may want to divide the class into groups for part of this process, having each group plan and present a design. Then build the mini-lab.

3. With the students, decide how you will record the measurements you are collecting. Make sure the students each keep accurate records as you measure the reflectivity of layers of different textures: e.g., soil, rocks, leaves, snow, clear ice (freshwater), sea ice.

4. Establish that ice reflects a greater amount of light than other substances such as dirt. (Note: Ice and snow are both very reflective: Fresh snow reflects up to 95% of incoming radiation.) Discuss what this means for the north – if there was less ice, how much energy wouldn't be reflected? What would happen to this energy? (Answer: The concern with the melting ice is what lies beneath it... the incredible heat capacity of water (something that students may need to be familiar with) makes it able to absorb and disperse a large amount of heat energy.) What effect would this have on land around? (Answer: Increased energy absorption would lead to increased temperatures, which would lead to increased melting – a positive feedback loop.) If there are questions that you and the students don't know the answers to, write them on a section of the board or on chart paper.

5. Give the students copies of High School Backgrounder #7: The Changing World of Water and Ice. Invite them, using the results of their experiment, to write up a report on the experiment and what the results might mean for the north. Challenge them to use some of their new vocabulary – greenhouse effect, reflectivity, albedo, feedback – in their reports.

Handouts:

The handout that supports this lesson is attached at the end– Student Handout: Albedo.

Student Web-Exchange:

Post student reports, along with pictures of your mini-lab, on the Student Exchange. Click on the icon for information on how to post material.

Evaluation:

Evaluate students on:

- Participation in the experiment
- Records of experiment
- Reports on the experiment and impacts on the north

Enrichment Ideas:

Science/ Social Studies / English Language Arts

Researching Reflectivity: Invite students to decide on a research question arising from the experiment and discussion. (Check the unanswered questions collected by the class – there might be some good questions there.) Direct them to the web links under Resources, and suggest search words to help them find the information they need to create an essay, an informational poster or a future news report.

More Information:

Feedback loops (positive and negative) – http://www.nsidc.org/arcticmet/patterns/feedback_loops.html

Information on melting ice, the Arctic, and more – http://www.solcomhouse.com/

About the Author:

Brent Urie has taught at Tusarvik School for four years. Tusarvik School is a K–12 school with 220 students. It's located in Repulse Bay, a coastal community of 650 people, right where the Arctic Circle meets the west coast of the Hudson Bay. As well as teaching phys-ed, math and science, Brent coaches the men's volleyball team, which won the Territorial competition and is headed for the 2004 Arctic Winter Games.

There are many things Brent likes about teaching in Repulse Bay: great fishing, lots of hunting, and a great variety of wildlife, from polar bears to narwhal and beluga whales. People are very friendly. "People in the community are teaching me how to hunt," explains Brent, who came to Repulse Bay after teaching in South Korea, Colombia, and Mexico.

Student Handout

Albedo

Planetary albedo is the ratio between incoming and reflected radiation at the top of the atmosphere. This includes effects of reflection from the atmosphere, mainly clouds, and surface albedo. On average 24% of incoming radiation is reflected by low altitude clouds and water vapor, and ozone in the stratosphere. Low clouds reflect most sunlight and have little effect on the energy reflected by the earth, helping to cool the current climate. In other words, low clouds do not trap energy that is headed for space. While higher temperatures are the result of high clouds that reflect less radiation and trap more emitted energy. Changes in the atmosphere can alter climate by changing the amount of solar radiation that reaches the Earth's surface.

CLOUD OVERCAST	**% of incoming radiation reflected**
Cumuliform	70–90%
Stratus (500-1,000' thick)	59–84%
Altostratus	39–59%
Cirrostratus	44–50%

Surface albedo is the ratio of incoming radiation to reflected radiation where the atmosphere comes in contact with Earth's surfaces (the boundary between earth surface and the atmosphere). Reflectivity is the capacity of an object to reflect solar radiation. It depends on radiation wavelength and the physical composition of the object. Soil reflectivity varies because of variations of moisture content, particle size, organic matter content, surface roughness, and mineral composition. Vegetation reflectivity varies with how much of the ground it covers, leaf size and area and plant growth stage. Snow reflectivity varies with crystal size, compaction, age, and liquid water content. Water reflectivity is affected by turbidity, depth, and concentrations of small aquatic plants called phytoplankton. Water albedo is lowest when the sun is near zenith and increases to near 100% when the sun is near the horizon. Here are samples of some of Earth's surface albedos in percentages.

WATER SURFACES

Winter:

O°	latitude	6

30° latitude	9
60° latitude	21

Summer:

0° latitude	6
30° latitude	6
60° latitude	7

BARE AREAS & SOILS

Snow, fresh-fallen	75–95
Snow, several days old	40–70
Ice, sea	30–40
Sand dune, dry	35–45
Sand dune, wet	20–30
Soil, dark	5–15
Soil, moist gray	10–20
Soil, dry clay or gray	20–35
Soil, dry light sand	25–45
Concrete, dry	17 –27
Road, black top	5–10

NATURAL SURFACES

Desert	25–30
Savanna, dry season	25–30
Savanna, wet season	15–20
Meadows, green	10–20
Forest, deciduous	10–20
Forest, coniferous	5–15
Tundra	15–20
Crops	15–25

Albedo varies with geographic region and time of year since snow and ice are generally highly reflective. The temperature difference between the Tropics and the Poles is the driving force behind the circulation of the Earth's atmosphere and oceans, thus creating winds and ocean currents that carry excess heat and moisture. When the moisture encounters cooler temperatures as it moves to the poles, clouds form and reduce the emission of energy to space. Any change in surface albedo will alter climate by drastically changing the amount of solar energy absorbed by the planet.

When the angle of the sun to the surface is low (closer to the horizon), solar energy is less intense since it is spread out over a larger area. Changes in this angle are one of the controlling factors that that make latitude one of the strongest influences on climate. The other controlling factor is the length of day. For latitudes of 66.5* and above, the length ranges from zero during winter solstice to 24 hours during summer solstice. The Equator has a constant 12-hour day all year long. The seasonal range of temperature therefore decreases from high latitudes to the tropics.

Human Effects on Earth's Albedo

Suggestions have been made that human modifications of the Earth's surface may be altering the planet's albedo. It has been said that overgrazing in desert regions can increase surface albedo as much as 20%. It has also been estimated that such changes may suppress rainfall, which can enhance the process of desertification. And again it's possible for extensive deforestation in tropical rain forests to increase surface albedo and result in a major climatic change.

Basics of Climate Change
Intermediate Backgrounder 1

Printable Version

Climate Change Basics: What's the Big Deal?

What is climate change?

Climate change is different from the changes in weather you see from day to day. It's the kind of change in weather patterns your parents or elders may have noticed. You may have heard them say that winters aren't as cold as they used to be, or that the ice is thinner on the lakes and in the Arctic. Scientists agree with them. The climate is changing. And it's changing more quickly in the north than anywhere else.

Up until the last hundred years or so, the earth's climate stayed much the same – for almost 10,000 years. Sure, there were some weird winters and really hot summers, and some cold stretches, but temperatures averaged out over the years, and you knew what to expect season to season. Little changed until about a century ago when the average temperature of the globe started to rise.

Over the last century, average temperatures in many Arctic regions climbed by as much as 5°C. The average worldwide temperature increased about 0.6°C.

Some scientists predict that, if these changes continue over the next 100 years, temperatures in the Arctic could rise by as much as twice the global average – and that's expected to go up by 1.4° to 5.8°C.

That doesn't sound like a problem, does it? Don't people in the North deserve a break from long, cold winters? Maybe – but climate change means a lot more than warmer temperatures. It may change many of the things we value about the north - our environment and plants and animals. That makes climate change something worth checking out.

Greenhouse Gases – the Earth's Blanket

To understand climate change, you have to know something about our atmosphere. Even though we can breath it and see through it, as far as the earth is concerned, the atmosphere works like a blanket. It's made up of the air we breathe, plus small amounts of greenhouse gases (GHGs) that can trap heat like a warm, fleecy blanket. If you are chilly at night and cover up with a blanket, the warmth given off by your body gets trapped by the blanket and keeps you cozy. GHGs in the atmosphere do the same thing for the Earth. They trap some of the heat that the earth absorbs from the sun. This trapping of warmth is known as the 'greenhouse effect.'

If the earth's atmosphere didn't have some greenhouse gases, heat would be lost to space and we'd have temperatures more like those on Mars. There, they go up to 37°C during the day - bathing suit weather - but down to, more than minus 100°C at night – tough to survive. The greenhouse gases in our atmosphere help make life on earth possible.

Too Many GHGs – Too Many Blankets

The amount of greenhouse gases we had in the atmosphere for about 10,000 years helped to keep the climate pretty much the same over that period of time. The earth's environment, plants and animals (including us) adapted to that climate. A change in the amount of greenhouse gases could mean too much heat – or too little. That could affect us, and other life on the planet, by changing our environment.

Greenhouse gases need to be kept in a delicate balance. And more greenhouse gases could be too much of a good thing.

Why are we warming up?

Right now, human activities are tipping the balance of gases in the atmosphere. They are changing our climate. We are adding too many heat-trapping greenhouse gases to the atmosphere. The result is some very weird weather – more heat, more storms, more rain in some places and seasons, and more drought and unusual temperatures in others. This build-up of GHGs and what it does to our climate is sometimes called the "Enhanced Greenhouse Effect."

So, what's a few degrees?

A few degrees up or down don't make a big difference day-to-day or even year-to-year. But over many years, it can be a big deal. During the last Ice Age, the earth's average temperature was only 4° to 6°C cooler than it was for the last 10,000 years – that stable climate period we've talked about. During that Ice Age, a thick sheet of ice covered nearly all of Canada, and many plants and animals disappeared completely. So a few degrees can make a big difference over the long haul.

Where Are all these GHGs Coming From?

About 200 hundred years ago, humans began to develop faster ways of making and moving things. This period of time was known as the Industrial Revolution.

The energy that made the revolution possible came from "fossil fuels." These are fuels such as coal, and the diesel oil, furnace oil, kerosene and gasoline that come from petroleum.

When we use fossil fuels to run our cars, trucks, boats, airplanes and snowmobiles, we release greenhouse gases. We may also release GHGs when we heat our homes, run our industries, or generate electricity.

Let's look at the major greenhouse gases and see why more of them are going into the atmosphere.

Greenhouse Gases:

Water vapour

If you have gone into a bathroom after someone has showered and felt dampness in the air, then you have been surrounded by water vapour. Water vapour is part of the world's water cycle. When water in rivers, lakes and oceans warms up, it evaporates. It becomes a gas – water vapour – and rises into the atmosphere. Sooner or later it comes back down as rain or snow. It collects in rivers, lakes and oceans as part of a natural cycle that will always continue. In the atmosphere, water vapour can form clouds. They can act like a blanket and trap heat close to earth. Clouds can also reflect heat from the sun back into space. There is more water vapour in our atmosphere than any other greenhouse gas.

Carbon Dioxide (CO_2)

Carbon Dioxide (CO_2) is the second most common GHG. Many natural processes put carbon dioxide into the atmosphere. Humans and animals breathe out carbon dioxide, and forest fires, volcanoes, and rotting trees and plants release it. Natural levels of CO_2 in the air are important for life, but too much of it can tip the balance.

If you have smelled the fumes from a car or snowmobile, you have also breathed in carbon dioxide (CO_2) at the same time. Humans produce CO_2 whenever we burn fossil fuels. And we burn them whenever we drive our vehicles, heat our homes, run our industries or fly airplanes. In many northern communities, we produce CO_2 when we burn diesel to make electricity. The carbon dioxide produced by human activities is the main reason our climate is changing, and changing fast!

Methane and Nitrous Oxide

Methane and nitrous oxide are two other important greenhouse gases. They're a small part of our atmosphere, but they can trap a lot of heat. In fact, methane is 21 times more powerful as a greenhouse gas than CO_2, and nitrous oxide is 310 times more powerful!

Large-scale farming and garbage dumps produce lots of nitrous oxide and methane. When farmers put nitrogen fertilizers on the soil to help plants grow, nitrous oxide is released. When cattle digest their food, they let out a lot of methane. With over three million cattle in Canada – that is a lot of gas! When food scraps in our garbage dumps rot, they produce methane, too. (When you don't waste food and compost food scraps so air can mix with them, you cut down on methane production!)

Find out what climate change does:

As you can see, some GHGs occur naturally, but human activities are putting more GHGs into the atmosphere and changing our climate. To read more about the effects of GHGs and climate change, read **Backgrounder 2 – Climate Change Impacts: A Changing World.** To see what you can do to help slow down GHG production, read **Backgrounder 3 – Climate Change Solutions: We can all help!**

Hot Facts

- Canada produces only two and a half per cent of the world's GHG emissions. But per person, it is the world's third largest producer of greenhouse gases after USA and Australia.
- North Americans throw away about two kilograms. of garbage every day. When all that garbage sitting in the dump starts to decompose, it produces methane gas.
- Nine of the ten hottest years on record have taken place in the 1990s. 1998 is thought to have been the warmest year yet.

Key Points

- The earth is heating up all over, and especially in the north.
- The atmosphere helps trap the heat of the sun close to earth, just like a blanket traps heat from your body – this is called the "greenhouse effect."
- Too many greenhouse gases in our atmosphere are increasing the earth's temperature and causing the earth's climate of the earth to change.
- The main GHGs are water vapour, carbon dioxide (CO_2), methane and nitrous oxide.
- Carbon dioxide gas is produced when people burn fossil fuels – gas, coal and oil.
- Some of these are created naturally, but many are sent into the atmosphere by human activities – our burning of fossil fuels to power our cars, heat our homes and run our factories.

Want to know more?

Here are some websites to help you learn more about climate change and the greenhouse effect:

General

- **EduGreen:** http://edugreen.teri.res.in/explore/climate/climate.htm

- **Government of Canada Climate Change Website:** http://www.climatechange.gc.ca/english/index.shtml

Greenhouse Effect & GHGs:

- **Cool Climate Kids' Club (It's a Gas!):** http://www.coolclimate.org/itsagas.htm – A good explanation of GHGs.
- **EPA Kids' Site (Greenhouse Effect):** http://www.epa.gov/globalwarming/kids/greenhouse.html
- **Solar School:** http://das.ee.unsw.edu.au/~solar/classrooms/1_1.html

Printable Version

Impacts of Climate Change
Intermediate Backgrounder 2

Climate Change Impacts: A Changing World?

Why is Climate Change Such a "Hot" issue for the North?

Scientists expect northern regions to warm up more than other parts of the world as the earth's climate changes. If you've flown over the Arctic, or over other parts of the north during the winter, you might know why. Snow and ice act like mirrors. They reflect a lot of the sun's heat. But, as the world gets warmer, a lot of snow and ice will melt. This means that darker land and open water will soak up more of the sun's heat.

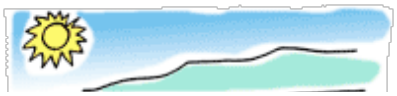
More heat held by earth and water, means later winters and earlier springs. Temperatures will rise more in the north than in other parts of the earth. This will mean changes to our environment. And those changes will affect the plants and animals that have adapted to it.

Climate change could mean big differences to life in the north. It may change the land on which we travel and build our homes. Scientists and people on the land have already noticed differences in the ice on our rivers, lakes and seas.And warmer temperatures will affect plants and trees. All of these changes are bound to affect animals, fish, birds and sea mammals – and possibly our own way of life in the North.

We can't ignore climate change, but we can learn more about what may happen as it changes.

Part 1 – Changing Land

Melting Permafrost



Most of the North has a layer of permanently frozen ground just under the top layer of soil. While the top layer of soil thaws every summer and supports plant life and trees, the permafrost (permanent frost) underneath never thaws. As

temperatures rise due to climate change, permafrost may thaw. This is especially likely to happen where ground has been disturbed around our communities. That means that the ground could turn soft and mushy. Roads and airstrips could turn into roller coasters. Buildings, water lines and power poles could tilt and gradually break or fall as the ground thaws and collapses. Melting permafrost could also make it harder for migrating animals and hunters and gatherers to travel over soft, uneven ground.

Drying wetlands

Wetlands, such as sloughs and marshes, are an important part of the land around us. They offer summer homes, complete with nesting and feeding areas, to lots of migratory birds. As the land and air heats up, some wetlands will dry up or shrink because more water will evaporate. Others may disappear for a different reason. Many wetlands are hollows in the permafrost. If the permafrost melts, they may just drain away. That would be bad news for wetland birds and mammals.

What about the ice?

We all know that when you heat ice, it melts. People are already noticing earlier spring break-ups on rivers, lakes and even on parts of the Arctic Ocean. When ice and snow on land melt, water levels in lakes and rivers rise, sometimes causing floods. Sea ice is breaking up earlier, thinning out, and covering less ocean surface during the summer months.

Less ice means it's harder for trappers, hunters and animals to get around during the winter. When ice is thinner, it makes travel more dangerous. More open water along the Arctic coast, means more lapping or crashing against the shore. When you add that to melting permafrost, you can get collapsing coastlines. Some communities located on the coast may have to plan for big changes.

Everything is on the move

Humans aren't the only creatures that have to adjust to a changing climate. Warmer temperatures are making it easier for some southern species of plants and animals to survive farther and farther north. At the same time, some northern plants and animals are finding it harder to survive as their environment changes.

If northern waters warm as a result of climate change, fish that like to live in warmer water may survive farther north. But fish such as salmon, cod and arctic char already live in the north and need colder waters to survive. As cold-water areas warm and southern species move in, cold-water fish might have a harder time making it.

Changes in climate also mean that animals are on the move. People are seeing moose and other animals, such as coyotes, white-tailed deer and cougars, farther north than ever before. Riding piggyback on these animals are smaller critters like parasites and insects that never used to live as far north. Different kinds of birds are also moving north with warmer weather.

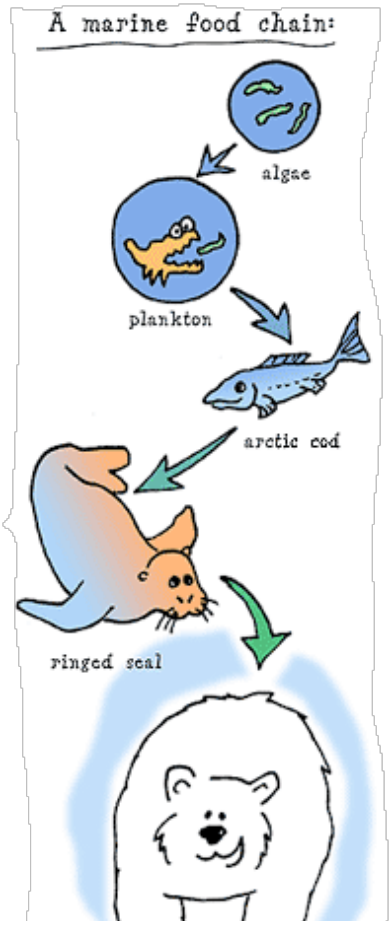
Although plants can't get up and walk to a new home, their seeds fly on the wind, float on rivers and ride in the fur of animals looking for new homes. If the climate is warmer, they may be able to put down roots further north.

When new plants move in, they sometimes crowd out the plants that were there before. With higher temperatures, plants like willows are moving north into areas of tundra. This could make it hard for some animals like caribou to find enough of their normal food. On the other hand, animals may be able to eat sooner in the spring – if plants green up earlier because of warmer temperatures. That's a bonus when bellies are at their emptiest!

Part 2 – How Will Climate Change Affect Northern Animals & People?

What about marine life?

In the Arctic, polar bears eat seals, seals eat codfish, cod eat plankton, and plankton eat algae. This set of links between the eaters and eaten is called the food chain. The food chain in the Arctic is short and each link in the chain is important. This is especially true for marine life. Every link in the food chain depends on every other link.



Animals in the Arctic food chain depend on the particular climate of the Arctic – some more than others. If warmer temperatures affect one part of the chain, they may affect the entire marine ecosystem. Warmer temperatures, thinner ice and more open water, for example, affect several marine animals.

Seals and walruses mate and have their babies on the sea ice. One effect of thinning ice could be lower birth rates. Seals and walruses also rest and hunt from the ice. As it thins, they won't have as good a base for resting and hunting. And as the ice melts away from shore, they'll end up hanging out over deeper waters. That's a problem when they usually depend on shallow water for their munchies. These two changes could make feeding a lot more difficult.

Polar bears will be affected by what happens to the ice and the seals. As the ice melts earlier in the spring, and the edge of the icepack gets farther away from land, polar bears have a harder time reaching the seals that they eat. This has already happened in the Hudson Bay region. There, polar bears are having trouble reaching the seals they usually fatten up on in the spring. That's why scientists report lower weights and birth rates for polar bears in that region.

What about caribou?

Animals on land may be in for trouble, too. Barren ground caribou in northern Canada travel great distances every year, from wintering grounds to calving grounds to insect relief areas and back again. These days, caribou are running into snow that is deeper and heavier than it used to be. Caribou may have to burn more energy breaking through harder, crusted snow to eat. Thinner ice on lakes and rivers and earlier break-up make river and lake crossings trickier. More caribou are likely to break through and drown as a result. On the plus side, caribou may find that some of the plants that they eat will green up earlier in the spring. However, the same warmer temperatures that help plants may also help insects to hatch sooner. That means that caribou could be chased out of their calving areas earlier than usual.

What about the little critters?

If climate change makes snow icier, as some scientists expect, smaller mammals may find it difficult to live and breath under the snow. If they have trouble surviving, the animals and birds that live on small mammals – foxes, for example – could have a tough time.

What about birds?

In the Eastern Arctic, climate change has meant cooler weather. That's why some birds, like snow geese, have been nesting farther south than they used to. But continuing climate change is likely to warm this region in coming decades. In parts of the Arctic that have already warmed, people are seeing new duck species that used to stay farther south.

What about Northern communities?

A warmer climate is going to have a mix of positive and negative impacts on our communities. Melting permafrost will cause some of the biggest changes. It could affect our roads, buildings and industries. People who spend time on the land are already noticing changes- particularly to ice conditions –- that affect their hunting and trapping lifestyles. If we're smart, we'll prepare for changes that may be coming, even if we can't be a hundred percent sure what they'll look like.

What about the rest of the world?

The climate is changing everywhere. People around the world will have to deal with many of the same types of impacts as northerners. For example, worldwide, new plant and wildlife species will appear in some areas. Familiar species will disappear if they can't handle the new climate.

Around the world, many cities, towns and villages are built close to sea level. Scientists expect climate change to cause sea levels to rise. This means that tens of millions of people who live close to the sea will have to move to higher ground. Whole islands or countries could disappear under water. Salt water could flood low-lying farmland and displace fresh water. This would harm farm crops because many plants can't grow in salty soil.

Climate change is expected to mean very unreliable weather. Some parts of the world will get more rain and floods. Other parts will get more droughts and really hot weather. When it gets really hot and dry, more water evaporates. That means less drinking water for people and less water for farm crops and animals. Some countries may find it even more difficult to feed and house their people.

Sounds like disaster!

Most of this is not good news for our planet. And it means major challenges for the animals, plants and people that live here. But don't despair. There are things that people can do – and are doing – to help slow climate change and reduce its impacts. Read about them in **Backgrounder 3 – Climate Change Solutions: We Can All Help!**

Key Points

- A changing climate means that there will be big changes to land, water, plants and animals.
- Climate change is already having an impact on the north. Permafrost is melting, wetlands are drying up, sea ice is melting and sea levels are rising.
- Plants will grow earlier in the spring and new plants will grow in the north that never grew here before. Some southern animals such as moose, coyotes, white-tailed deer and cougars will move farther north too!
- Some northern animals such as cold-water fish, caribou, small mammals and polar bears may find it very hard to adapt to rising temperatures.
- Communities in the north and all over the world face big changes due to climate change. Everyone needs to think about how they will adapt to the changes.

Want to know more?

These websites will help you learn more about the impacts of climate change in the north and around the world:

- **Arctic Borderlands Ecological Knowledge Co-op:** http://www.taiga.net/coop/indics/ocduck.html
- **CBC TV (The Shrinking Polar Bears):** http://www.tv.cbc.ca/national/pgminfo/warming/bears.html
- **Government of Canada Climate Change Website (How will it affect us?):** http://www.climatechange.gc.ca/english/affect/

- **Climate Change in Canada Poster Site:** http://adaptation.nrcan.gc.ca/posters/
- **EPA Global Warming Kids' Site (So What's the Big Deal?):** http://www.epa.gov/globalwarming/kids/bigdeal.html
- **Polar Bear Tracker:-** http://www.panda.org/polarbears/
- **Taiga Net: Caribou:** http://www.taiga.net/caribou/pch/slides/index.html

Impacts of Climate Change
High School Backgrounder 7

Printable Version

The Changing World of Water and Ice

Everyone needs water to survive. Humans, wildlife, birds, fish and plants all need water. Some live in the water, on the water or near the water. It keeps us all alive one way or another.

We also use water to travel on – sometimes when it is open, sometimes when it is frozen. Polar bears hunt on the sea ice. Seals and walruses raise their young on the ice and use it as place to rest. People in northern communities get to their camps, traplines and other towns by travelling across frozen rivers and lakes. Companies exploring for oil, gas or minerals use winter roads that cross frozen lakes, water channels and land.

This backgrounder looks at how climate change is affecting the world of water and ice.

Shrinking Sea Ice

When you think of the Arctic, what comes to mind?

Ice is likely one of the main things; solid ice, floating ice, icebergs, and then bears, seals and walruses on ice. These are all images of the Arctic. Most of the year, the ocean water in the Arctic is covered by ice. Even in the summer, many areas of the Arctic Ocean are ice-covered.

However, recent studies show that the sea ice in the Arctic is both shrinking and getting thinner and thinner than it used to by the end of summer. It's like a human losing weight and getting shorter at the same time. The ice in the Arctic is shrinking as the temperatures in the north increase.

Sea ice in the Arctic covers about 10-15% less area in the spring and summer than it did in the 1950s

The ice is now also estimated to be about 40% thinner in the late summer and early fall than it was in recent decades. That's quite the diet!

More open water means even more ice will melt

Have you ever watched a pond or lake melt? After the snow goes, the ice gets shiny. Then a dark spot appears where the ice

is thin and the darker water can be seen underneath. Suddenly, the melting seems to speed up and the ice is soon gone!

The shinier, white ice reflects most of the sun's heat away. But where the darker coloured water shows through, the sun's heat is absorbed and the remaining ice above it melts. It's like when you wear darker clothes and stand in the sunshine. Darker colours make you warmer than you are when you wear light coloured clothes. The sun shining on the thinning ice works this way too.

Once the darker water starts absorbing the heat, the ice at the edges of the open water quickly melts away and the darker area gets bigger. This bigger area absorbs more heat, and then gets even bigger. The melting speeds up.

This melting pattern is likely happening on the Arctic Ocean. As climate change causes warmer temperatures, more ice will melt simply because the air is warmer. But the open water will also directly absorb the sun's heat and speed up the rate of melting of the sea ice around it.

So what's the big deal with less ice? Well, less ice means there is less ice on which humans and animals can travel, hunt or rest. Thinner ice also makes travelling on ice more dangerous *(see Backgrounders 10 & 11)*.

"It used to be calmer out when the ice was around more; now we stay closer to shore when we go out."

L. Carpenter, Sachs Harbour quoted in *Climate Change and Arctic Communities: Impacts and Adaptations in Sachs Harbour, Banks Island, NWT* (August 2000)

Cruising the Arctic Oceans

Some scientists predict that there might not be any Arctic sea ice in the Northwest Passage and other areas in the late summer months by the year 2050. This could mean that more ships will be able to travel around parts of the Arctic Ocean without any assistance from icebreakers (icebreakers are ships that are designed to clear a path through the ice).

Some people are excited by the economic development that this might create for northern communities along the coasts. It could reduce the cost of bringing in things like construction materials and food. It could make it easier to ship out natural resources like oil and gas or minerals. And more tourist ships will likely venture north into the open Arctic waters.

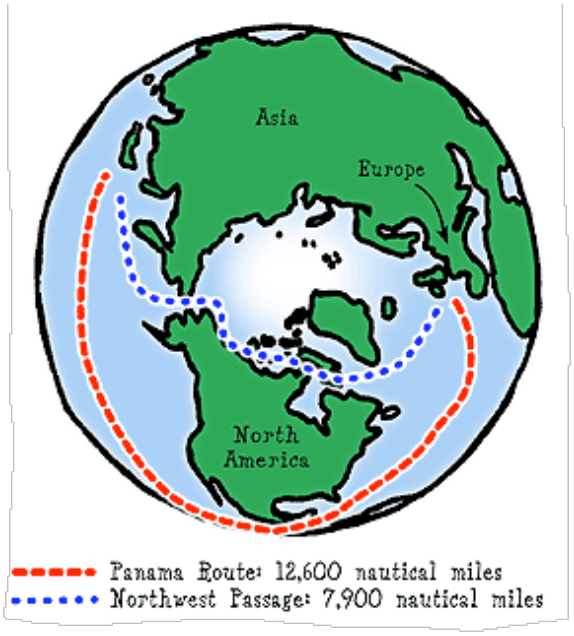
Canadians are not the only ones interested in new shipping opportunities! Other countries are also very interested in seeing the Canadian Arctic's Northwest Passage become a regular shipping route.

Currently, most ships carrying goods between Europe and Asia travel through the Panama Canal. This route is about 12,600 nautical miles long. If the same ships could go through the Northwest Passage, the trip would be only about 7,900 nautical miles. A shorter trip would save many businesses a lot of money!

Right now, the

Between Europe and Asia:

Canadian government considers the Northwest Passage to be in Canadian waters, but some countries are challenging this idea. The United States of America has even had a military vessel in these waters without the Canadian government's permission. Usually countries request permission to enter another country's waters.



However, shipping through this route might not be as safe as some people claim it will be. The long, dark days of winter will ensure that the Arctic will always have winter ice cover. So shorter trips for ships will only be possible in the months of late summer and early fall.

And even if the Northwest Passage does become free of ice most summers, there may still be cold summers where the ice won't clear completely. At anytime, there may also be chunks of super hard pack ice floating in from other parts of the Arctic Ocean.

These hard chunks of pack ice can easily knock holes in ships. If this were to happen, it could threaten the safety of people on board, result in the loss of a ship's cargo and cause pollution in the sensitive northern environment. Sending in rescue and clean-up crews to remote locations would be expensive and take time.

So even if it gets easier to take ships through the Northwest Passage, the risks might outweigh the cost savings. What do you think?

Sea Levels

Canada has over 240,000 kilometres of coastline. If you look at a map, it's easy to see that most of this coast line is in the north, along the shores of the mainland and the islands of Nunavut and the Northwest Territories.

Over the last 100 years, the sea levels in the world have risen by about 10-25 centimetres. These levels are projected to rise by up to 88 centimetres by 2100 (check that out on a ruler!).

There are two main reasons the sea is rising:

- More of the ice on land has been melting and draining into the ocean as climate change causes temperatures to increase.
- When things warm up, they expand. This is called "thermal expansion." Water in the ocean will do the same thing. If the water warms more than usual with climate change, it expands more than usual. This means sea levels will be higher than usual.

Earlier break-up changes derby date!

In the coastal town of Coral Harbour, Nunavut there used to be a local ice-fishing derby in mid-April. However, for three years in a row, participants kept getting their snow machines stuck in slush as they travelled out onto the ice in April. Spring was happening earlier in the year. So the derby is now held in March.

Can you think of any winter or spring events that have been cancelled or changed because of early or late break-up?

Even though less than one metre of sea level rise might not sound like a lot, it can cause a lot of damage. Can you think of some of the impacts that higher sea levels might have? Some of the key impacts are:

- More flooding in coastal areas. This can damage heritage resources and coastal ecosystems. It could also cause ground water to get salty.
- More erosion of the coastline. Higher sea levels mean that the waves will hit the shore higher than they used to so they can do more damage. This can destroy buildings and roads that are along the coast.
- More areas of land will be permanently covered by the ocean.

Rivers And Lakes

In 1960, the ice on the Mackenzie River in the NWT typically broke-up during the first week of June. Now it's more common to see it break-up in mid to late May. By 2050, it is predicted that the ice-free season on the Mackenzie could be up to a month longer than it is now!

The ice on most lakes and rivers in the north will break-up earlier than it used to because climate change is causing temperatures to rise.

It's also predicted that most of the Arctic will get 10-20% more precipitation (rain) in the summer months. Some extra snow will also fall in the winter but the amount will vary depending on where in the Arctic you are. So the pattern of rain and snowfall will be different in different areas in the north. Some parts of the Arctic may be wetter or drier than others.

You might think that the areas that get more rain and snow would end up having more water in the lakes and rivers. But that might not happen. Can you think why this might be?

It's because warmer temperatures will cause more water to turn into water vapour (to evaporate) and travel into the atmosphere. Also, because the ice is melting earlier and freezing later in the year, there will be more weeks in the year when the water in lakes and rivers isn't covered by ice. This means that water will have more time each year to evaporate. So more rain and snow doesn't necessarily mean more water in the rivers and lakes!

Warmer temperatures also cause more rapid melting in the spring. If things melt too quickly, there will be more flooding. This flooding will affect rivers and streams, and nearby communities.

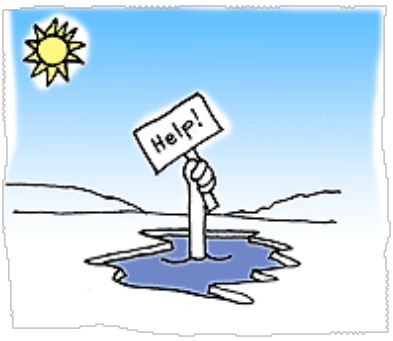
What does snow cover have to do with ice thickness?

Did you know that the depth of the snow affects how thick the ice will get on a lake or river? Do you know why?

When the water in rivers and lakes is directly exposed to the freezing cold air, it freezes. However, once the snow starts landing on the new ice, the snow acts like a blanket and insulates the ice from the cold air. If it is blanketed by snow, the ice won't thicken as quickly. And the deeper the snow, the slower the new ice forms.

For example, in winter in the NWT, about 30-40 centimetres of snow piles up on the lakes close to the town of Inuvik. The average ice thickness on these lakes is about one metre. To the north of Inuvik, only 10-20 centimetres of snow piles up on the lakes near the Arctic coastline because the coastal winds keep blowing the snow inland. On these coastal lakes, the ice is twice as thick as the ones close to Inuvik that are covered by more snow!

So more snow means thinner ice! If the north is going to get more precipitation - more snow - in the winter because of climate change, this means the ice may be thinner that it used to be in the winter. This could create dangerous conditions for people and animals that travel across the ice.



If you'd like to set up your own project to measure the thickness of ice on lakes near you, check out http://www.taiga.net/coop/projects/lakeprotocol.html

Glaciers

Surprisingly, glaciers and ice caps in the Canadian Arctic are expected to change little as the climate changes. Although glaciers in the far north will likely melt more because of the warmer weather, the same glaciers will gain back what they lose! This is because more snow and rain is expected to fall at higher elevations. It will make up for what melts at other times of the year.

However, glaciers at lower elevations and glaciers farther south won't be so lucky. These glaciers are expected to lose more from melting than they will gain back from more snowfall. Southern and lower elevation glaciers are expected to start shrinking and retreating with climate change. Many glaciers are already getting smaller and more climate change is expected to speed up the pace of their retreat.

Alaskan glaciers add 13.2 trillion gallons of melted water to the seas each year – the equivalent of more than 13 million Olympic-sized swimming pools.

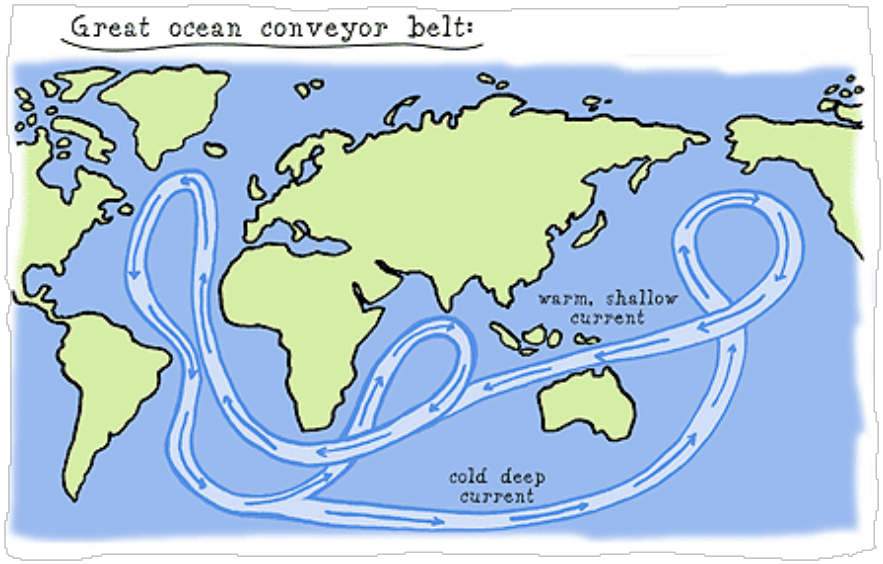
Kansas City Star, July 31, 2003

Freshwater Could Interrupt Ocean Currents

Water slowly moves around the world's oceans. The movement is driven by a system of ocean currents. Both wind and the rotation of the Earth help to determine the flow of surface currents. They also influence how water moves from the surface down to deeper waters.

The biggest force in the ocean is something people describe as an ocean conveyor belt. The fancy name for this movement of ocean water is the "thermohaline circulation".

This moving conveyor belt of water moves warm water from the tropics towards the north and south poles. When the warm water reaches cooler parts of the world, it cools down. The water sinks when it gets to the colder regions of the world because cold water sinks below warmer water. Warm water travels on top towards the poles, and lower, colder water, moves back towards the tropics. This is what creates the conveyor-belt-like action.



But climate change will likely slow down, and could turn off the conveyor belt. As more glaciers melt, and more rain and snowfalls, more fresh water than usual will enter the ocean. Fresh water floats on top of salt water. This fresh, cold water won't be able to sink through the salt water so it may block the movement of the conveyor belt.

If the conveyor belt stops or slows down, it would have a huge impact on ocean life. It would also change how much heat moved from tropical areas to northern areas. Some areas of the northern hemisphere could start cooling down instead of warming up.

What's This Mean For People And Critters Of The World?

To find out more about how the changing world of water and ice will affect animals that live on or by the oceans, read Backgrounder 10. To find out how northern people and people around the world will be affected, check out Backgrounders 11 and 12.

Key Points

- Sea ice in the Arctic is getting thinner and covers less area by late summer.
- Sea levels are rising – which is affecting coastal areas.
- Ice on rivers and lakes is breaking up earlier in the year, and freezing later in the fall.
- Climate change should cause more rain and snow to fall in most areas of the Arctic. But warmer temperatures will also cause more evaporation, so the extra water might disappear into the atmosphere.
- Southern glaciers and ones at lower elevations will likely get smaller because of the warmer temperatures. Glaciers at high elevations or in the far north should stay about the same size.

Want to Know More?

Check out these websites for more information on water, ice, and climate change:

- **Canadian Arctic Resources Committee:** http://www.indelta.com/cgi-bin2/carcpub.cgi?http://www.indelta.com/carc/whatsnew/writings/amitchell.html – Globe and Mail article on the impact to Canadian sovereignty if Northwest Passage becomes a trade route.
- **Community Adaptation and Sustainable Livelihoods:** http://www.iisd.org/casl/projects/inuitobs.htm – Don't miss the video, Sila Alangotok: Inuit Observations on Climate Change. You can view a short version at this site, or get information on buying it.
- **Greenpeace Archives:** http://archive.greenpeace.org/climate/arctic99/reports/seaice3.html – A comprehensive scientific article on what's happening to Arctic ice, and why.
- **Icewatch:** http://www.naturewatch.ca/english/icewatch – Information on the current state of ice.
- **Arctic Borderlands Ecological Knowledge Co-op:** http://www.taiga.net/coop/indics/water.html – Water levels in Old Crow Flats – how the levels have changed, and why.