# Canada from Space

This map is out of this world. *Canada from Spac*e is comprised of images taken by the Canadian satellite RADARSAT-2 and is the first of its kind.

Canadian Geographic Education (CG Education) partnered with the Canadian Space Agency (CSA) and the Canada Science and Technology Museums Corporation to give Canadians the opportunity to explore the critical role of Earth observation satellites in our everyday lives. Orbiting far above the Earth, these satellites are used by the CSA to measure, monitor and analyze data to learn more about Canada and to help protect it.

This map is a mosaic of hundreds of RADARSAT-2 images taken in May 2013. It appears different from other maps and incorporates an array of colour, from yellow and purple to sky blue. However, since many different data sets were used to compose this map, the colours do not follow an organized pattern. As a result, the yellow in the north may not mean the same as the yellow somewhere else. A legend, therefore, is difficult to create.

Encourage your students to use the geographical knowledge from the hand-held legends provided in the trunk and attempt to decipher the colours of the map on their own. This is an exciting opportunity for all Canadian educators and students to be a part of groundbreaking research and analysis. Let us know how your students have interpreted the map.

The projection used for this map is also different from *Canadian Geographic*'s traditional giant floor maps of Canada. It shows the curvature of the Earth, and therefore the scale is not consistent. Use this as an opportunity to investigate important geographical themes, such as map projections, atmosphere, seasons and coordinates. There are limitless possibilities for exploration with this unique map.

CG Education has created ten amazing learning activities that will allow your students to see Canada from the perspective of Earth observation satellites. These activities can be used alone, but we recommend that you follow them in numerical order as the first one provides baseline knowledge.

CG Education and its partners are proud to make this innovative educational resource available to teachers and students in Canada. Comments on your experience with the map are welcome at info@cgeducation.ca.

# A Cartographer's Perspective

*Chris Brackley has been* Canadian Geographic's *cartographer for four years and is an integral part of the giant floor map program, creating every one of our detailed 11-by-8-metre maps.*

This satellite radar data map is unlike any I've ever made. What makes it so unique is not what I *have* done to create it, but what I *haven't* done.

The map's technicolour view of Canada is what cartographers usually call raw data. Normally, I would have transformed this information to make a simple, intuitive and easy to interpret map; blue would represent water and greens and browns would represent land. Instead I've left this unfamiliar, incredibly beautiful and somewhat baffling image of Canada much as it was when geographic information system (GIS) experts tiled together raw images of the country gathered by RADARSAT-2, a Canadian Earth observation satellite. The only thing I added to this raw data was a hill-shading effect, so hills and valleys are as they appear.

There are secrets hidden in the colours and patterns of this map. Why do the edges of glaciers look like they've been tie-dyed? Why is half of Toronto bright orange and the other half green? Right now we don't have the answers, but I'm hoping that when you and your students put your mind to it, you can help reveal these secrets — or at least come up with some very interesting guesses.

This map begs for creative minds to imagine, to deduce, to guess. We know RADARSAT-2 took these in May 2013, a time of year when snow and ice are melting and plants and flowers are budding. Radar beams reflect off the Earth differently depending on water content and surface texture, so the colours and patterns reveal something about the texture of the land and the nature of the water in a particular area at that time.

One piece of advice as you begin your detective work: the colours are not consistent across the country, so try to determine where the colour is in relation to recognizable landforms. Does it appear near a river's edge or on a mountain top? Is it in one big patch, or many little ones? What might be happening in that area in May? Each one of these answers offers a clue to decipher this map.

Remember, whether you correctly interpret the colours or not, you will have learned more about Canada's diverse and variable landscape. And that's the point, don't you think?

Chris Brackley

Cartographer

*Canadian Geographic*

## The activities

In this guide, you will find 10 curriculum-linked activities designed for all Canadian students at the elementary and secondary levels.

### 1. Earth Observation: Seeing Canada Differently

This activity gives students the opportunity to review map components, including lines of latitude and longitude. Students will also learn how Canadians benefit from the use of Earth observation satellites, such as RADARSAT-1 and RADARSAT-2.

### 2. Canada from Space

This activity allows students to explore what Canada's provinces and territories look like from space. Students will also examine the aurora borealis and Canada's role in monitoring it.

### 3. Detecting Disasters

This activity teaches students about natural and human-caused disasters. Students will investigate how disasters are monitored in Canada and abroad.

### 4. What Does Pollution Look Like?

This activity explores different causes of pollution and how Canada monitors it. Students will also learn about the ozone layer and how Earth observation satellites track its depletion.

### 5. Fresh from Canada

This activity explores fresh water in Canada and the role that Earth observation satellites play in monitoring the health of this resource.

### 6. Canadian Ice Service

This activity teaches students how Earth observation satellites can help Canadians understand climate change and how this information can protect northern communities.

### 7. To Navigate and Protect

This activity investigates the role of Earth observation satellites in marine navigation and coastline protection.

### 8. Valuable Resources

This activity examines the diversity of Canada's resources and their importance to the environment and economy. Students also learn how Earth observation satellites help to locate and monitor these resources.

### 9. Coast to Coast to Coast

This activity teaches students about the three oceans bordering Canada and how Earth observation satellites monitor them. Students will examine trends in ocean temperature in relation to climate change as well as shifts in marine migration routes.

### 10. Whatever the Weather

This activity explores the connections between weather and climate, and the seasons and the shape of the Earth. Students will also examine how satellites can prepare Canadians for future weather and climate pattern changes.

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# Resources

To learn more about Earth observation satellites and their critical role in the daily lives of Canadians, please visit:

Canadian Geographic Education
cgeducation.ca

Canadian Geographic
canadiangeographic.ca

Canadian Space Agency
asc-csa.gc.ca

Canada Science and Technology Museums Corporation
technomuses.ca

Canadian Ice Service
ec.gc.ca/glaces-ice

Environment Canada
ec.gc.ca

Natural Resources Canada
nrcan.gc.ca

NASA
nasa.gov

Fisheries and Oceans Canada
dfo-mpo.gc.ca

Canadian Forest Service
nrcan.gc.ca/forests

Agriculture and Agri-food Canada
agr.gc.ca

Transport Canada
tc.gc.ca

# 1 Earth Observation: Seeing Canada Differently

**Learning objectives**

- Students will learn how Canada benefits through the use of Earth observation satellites.
- Students will examine the evolution of space technology in Canada by comparing the satellites RADARSAT-1 and RADARSAT-2.
- Students will review the essential components of a map, including lines of latitude and longitude.

**Time required**

75-100 minutes

**Grades**

K-12

**Materials**

- Coloured pylons (16)
- RADARSAT-1 information card (1)
- RADARSAT-2 information card (1)
- Satellite image cards (10)
- Scavenger hunt card (1)

**Set-up**

Review RADARSAT-1 and RADARSAT-2 information cards and ensure all materials are present.

.../continued

## Introduction

Encourage students to explore the giant floor map without using the accompanying legends. Help them to determine what type of map it is by asking guiding questions about what they recognize (i.e., What country is this? What do you recognize on the map? What looks different to you and how?). Discuss and locate the five main components of all maps (border, north point, title, scale and legend) and how they are depicted on this map.

Next, distribute the hand-held legends to assist in their exploration. Explain to your students that this map is comprised of many images taken by satellites orbiting around the Earth. Have students describe the map and how it differs from other maps they have seen. Explain to students that by having the ability to observe the Earth from space, Earth observation satellites collect essential information to monitor and protect our environment, manage our resources and ensure the safety and security of people in Canada and the world.

Now shift your attention down to the Earth's surface, and ask students to stand on a white line on the giant floor map. Explain that these lines are called lines of latitude and longitude and, although they are displayed on this map, they are imaginary. Explain that lines of latitude run from east to west, but measure the Earth north to south; lines of latitude are called parallels, as they never intersect. Choose three students and have them walk from the east coast of Canada to the west, observing that they will never run into each other. Next, explain that lines of longitude run from north to south but measure the Earth from east to west. Choose three different volunteers to walk on lines of longitude from the bottom of the map to the top of the map where the lines intersect.

Point out the numbers on the map and explain that lines of latitude and longitude are given numbers (in degrees) to help measure exact location. The directions N, S, E and W are often given. Or, northern latitudes are given positive numbers and southern latitudes are given negative numbers, while longitudes east of the meridian are given positive numbers and longitudes west of the meridian are given negative numbers. Ask students to determine the latitude and longitude coordinates for Canada's capital (Ottawa: 45.33°, -75.58°). What are the coordinates for their hometown?

## Development

Ask students to share what they know about satellites. What are they? Where are they? What do they do (e.g., Earth observation, communications, data collection)? What types of information do they collect and measure (e.g., temperature, weather patterns)? Why are they important? Help your students by explaining that satellites have the ability to give us information about ice movement, pollution levels, natural disasters, the health of our water and forests, and even crop characteristics. These types of activities fall into the category of Earth observation. The Canadian Space Agency's mission is to lead the development and application of space knowledge for the benefit of all Canadians.

Show your students the diagram of RADARSAT-1 on the information card. Using the information on the card, explain that this satellite was important to Canada because it was the first Canadian Earth observation satellite. Have a student outline the unique features of this satellite. Originally built to have a five-year lifespan, this satellite provided information to the Canadian Space Agency for more than 17 years, before it stopped working in March 2013. Explain how it orbited the Earth, where it went and why this was instrumental in the development of Earth observation in Canada.

Next, show students the RADARSAT-2 information card and have a different student point out its distinguishing features. With space technology changing, RADARSAT-2 was developed to monitor the environment in Canada and the world in greater detail. Compare and contrast RADARSAT-1 and RADARSAT-2 as a class.

Distribute the satellite image cards around the class and have students work in small groups to determine which satellite, RADARSAT-1 or RADARSAT-2, took each image. Discuss the image and how it helps us understand Canada. What does it show? Where is this place? What year was it taken? Have your students locate the image on the map and determine its latitude and longitude coordinates.

## Conclusion

Using your students' knowledge of satellite imagery and latitude and longitude coordinates, play a scavenger hunt game. Read one of the four clues on the scavenger hunt card. Students are to listen to the clue and try to be the first to locate this place on the map. If no one knows the location from the first clue, read the second. Continue reading clues until one student or group finds the correct answer. For younger students, do this as a class. For older students, divide them into four teams, and have each try to be the first to place a coloured pylon on the answer. The group to answer the most questions wins. After each question, discuss the types of data collected by Earth observation satellites.

## Extend your geographic thinking

Ask students questions about the size of Canada. How easy is it to see all places in Canada by car? Are there any areas that are difficult to get to? Why? Have students stand on a place anywhere in Canada that they want to visit or learn more about. Ask students to name the place they are standing on and determine the type of data they would want to gather at this location by an Earth observation satellite. What do they want to measure about this place? Why?

After the map leaves, explore the history of the Canadian Space Agency and how it helps Canadians understand the world through Earth observation. Create a timeline with your class and visit asc-csa.gc.ca to learn more about Canadian space milestones. How have these milestones influenced the role of exploration and cartography?

**Links to the Canadian National Standards for Geography**

**Essential Element 1: The World in Spatial Terms**

- Maps as representations of local and distant places
- Map elements
- Latitude/longitude and the global grid
- Location of major human and physical features on Earth
- Map projections for specific uses
- Spatial graphs (e.g., air photos, satellite images, various map types and atlases)

**Essential Element 2: Places and Regions**

- Concept of physical features (e.g., mountains, plains, hills, oceans and islands)
- Concepts of formal, functional and perceptual regions
- Regional analysis of geographic issues and questions

# 2 Canada from Space

**Learning objectives**

- Students will explore what Canada's provinces and territories look like from space using image cards.
- Students will review their knowledge of latitude and longitude.
- Students will examine the aurora borealis and Canada's role in monitoring it.

**Time required**

100-130 minutes

**Grades**

K-12

**Materials**

- Coloured chains (12)
- Province and territory cards (14)
- Chris Hadfield photo cards (18)
- Aurora borealis image cards (3)

**Set-up**

Ensure all image cards and materials are present.

**Links to the Canadian National Standards for Geography**

**Essential Element 1: The World in Spatial Terms**

- The globe as a model of Earth (hemispheres, poles, equator)
- Latitude/longitude and the global grid
- Map projections

.../continued

## Introduction

Once students have had time to explore the map on their own, ask them to locate and stand on the province or territory in which they live. Ask students how this map differs from others they have seen. Explain that when observing the Earth from space, political boarders do not exist, nor do the colours they see on this map. Divide students into 13 groups, each representing a different province and territory, and distribute one province and territory card to each group. As the teacher, hold onto the image card showing all of Canada. Using the chains provided in the trunk, have students work together as a class to trace the borders of their province or territory on the giant floor map. Next, have students place their card on their capital city. Place your image card of Canada on Ottawa, the nation's capital, as an example. Afterwards, discuss how each province and territory appears differently on the floor map. What would each province and territory actually look like from space compared with what students see on the map?

## Development

Review the concepts of latitude and longitude with students (see the first activity for guidance). Give each student either a Chris Hadfield photo card or an aurora borealis image card. Explain that Chris Hadfield is a Canadian astronaut who travelled into space to live in the International Space Station. He was the first Canadian commander of the International Space Station and the pictures on the photo cards are ones that he took while onboard. Explain that the aurora borealis is a natural phenomenon, better known as the northern lights. Have your students describe what they see in the photos and explain to them that on clear, dark nights in northern climates, green, purple, blue and white lights often dance across the sky.

Have students examine the image and read the text on the opposite side of the card to determine its location on the giant floor map. For an additional challenge, have each student determine the approximate latitude and longitude of their image using the coordinates provided on the giant floor map. For younger students, show the images and try to locate each place as a class.

## Conclusion

Now that students have placed these images on the map, have a class discussion connecting the cards with the satellite image on the giant floor map. What patterns do they see between the images and the map? What can we infer about the physical geography of Canada from the images we see? Was there any particular image that caught someone's attention or surprised them?

## Extend your geographic thinking

Bring attention to the aurora borealis image cards. Have your students describe what they see in the photos and explain to them that on clear, dark nights in northern climates, green, purple, blue and white lights often dance across the sky. The Canadian Space Agency and NASA are working together on a project called THEMIS to better understand the aurora borealis. Through a network of 20 observatories across the Arctic Circle and three small NASA satellites, THEMIS is constantly observing this natural phenomenon. After the map leaves, students can learn more about the aurora borealis on the AuroraMAX website, asc-csa.gc.ca/eng/astronomy/auroramax/connect.asp.

- Major cities of the province and Canada
- Provinces and territories of Canada

**Essential Element 2: Places and Regions**

- Perceptions of places and regions
- Concepts of physical features
- Similarities and differences of local places and regions with other places and regions
- Factors that influence people's perceptions of places and regions

# 3 Detecting Disasters

**Learning objectives**

- Students will learn about natural and human-caused disasters.
- Students will investigate how disasters are monitored in Canada and abroad.

**Time required**

75-100 minutes

**Grades**

4-12

**Materials**

- Coloured pylons (16)
- Coloured chains (12)
- Disaster management cards (4)
- Teacher information card (1)
- Disaster management icons (33)

**Set-up**

Ensure all materials are present for this activity.

**Links to the Canadian National Standards for Geography**

**Essential Element 2: Places and Regions**

- Regions defined by multiple criteria
- Physical and human characteristics of places and regions in Canada and the world

.../continued

## Introduction

Ask your students to define the word disaster. Ensure they distinguish between natural and human-caused disasters. Use the examples provided on the teacher information card to help lead the discussion and ask students to locate parts of Canada where they think disasters have occurred.

Next, ask your students how Earth observation satellites can help during a disaster. Explain that the data collected from Earth observation satellites can help warn communities about impending disasters in near real-time — that is, within hours of a satellite photo being taken. The data collected from Canada's RADARSAT-2 satellite has been proven to support humanitarian, rescue and relief efforts for global communities affected by earthquakes, tsunamis, floods, landslides, forest fires and other disasters.

Divide students into pairs or small groups. Give each group a disaster management icon and have them use the map to predict where a potential disaster may occur in Canada.

Once all icons have been placed on the map, have a class discussion about any patterns or trends that connect disasters to landform regions in Canada. Ask your students to link human geography to the location of different disasters.

## Development

Divide students into four groups, and give each a disaster management card. Each card examines a different disaster management strategy that uses RADARSAT data. Each group will examine the image on the card, read the information provided and highlight key areas on the giant floor map. Using coloured pylons, chains or disaster icons, every group must prepare a short presentation on their disaster and the role that Earth observation satellites play in relation to it.

**The types of disasters examined are:**

- Flood
- Oil spill
- Forest fire
- Landslide

## Conclusion

Once all groups have presented, review any patterns or trends that students find between the location of disasters and landform regions. How can RADARSAT-2 help international communities? Show students the satellite images of Hurricane Tomas on the back of the teacher information card. Explain that Canada's RADARSAT-2 monitored disasters in countries like Haiti and St. Lucia by indicating areas of stress for the environment and local population.

## Extend your geographic thinking

After the map leaves, continue your discussion of the role of Earth observation in global disaster monitoring and preparation. Discuss the future of disaster management and how climate change is influencing the magnitude of natural disasters. How can Earth observation play a role in future preparations?

**Essential Element 5: Environment and Society**

- Impact of extreme natural events (earthquakes, tornadoes, floods, hurricanes, volcanic eruptions, mudslides) on the human and physical environment
- Effects of human modification of the physical environment (e.g., global warming, deforestation, desertification, urbanization)
- World patterns of resource distribution and utilization
- Environmental issues (e.g., global warming, loss of biodiversity, deforestation, ozone depletion, air pollution, water pollution, acid precipitation, disposal of solid waste)

# 4 What Does Pollution Look Like?

**Learning objectives**

- Students will learn how Canada uses satellites to track pollution.
- Students will explore different causes of pollution and track patterns across the country.
- Students will learn about the ozone layer and how Canada monitors its depletion.

**Time required**

75-100 minutes

**Grades**

4-12

**Materials**

- Coloured pylons (16)
- Coloured chains (12)
- Teacher information card (1)
- MOPITT and SCISAT information card (1)
- Pollution image cards (5)
- Ozone information card (1)
- Atmosphere balloon icons (16)

**Set-up**

Read over the teacher, MOPITT and SCISAT information cards. Ensure all image cards and icons are present.

**Links to the Canadian National Standards for Geography**

**Essential Element 1: The World in Spatial Terms**

- Major cities of the province and Canada
- Map, globe and atlas use (e.g., observing and analyzing relationships)

.../continued

## Introduction

Ask students what they think the Earth is made of. Explain that the Earth itself is made of three things: land, water and life. Ask students to locate these three things on the giant floor map. What types of land (Rocky Mountains, the Prairies, boreal forest), water (Great Slave Lake, Pacific Ocean, Great Lakes, Hudson Bay) and life (people, plants and animals) can they identify, and where are they located? Share with your students that land, water and life all depend on oxygen. The Earth's atmosphere helps ensure life can exist by keeping oxygen close to it. There are five levels of atmosphere.

Tell your students that they are going to imagine themselves on a spacecraft headed into space. The spacecraft will need to go through all five layers of the atmosphere to reach space. Each layer has a specific job and works together with the other layers to ensure life can survive on Earth. Using the teacher information card, explain the different layers of the atmosphere with your students. For each layer you discuss, have students use the scales provided in the trunk and coloured chains to measure how far each layer is from the Earth's surface. Once the distances of all atmosphere levels have been discussed and measured, ask students what happens to the size of each atmosphere layer as you head into space.

## Development

Brainstorm with your students about pollution. Focus on the causes, types and solutions for all types of pollution. Have students stand anywhere on Canada and ask them what specific pollution issues are faced in that part of the country. Have students infer connections between pollution and population distribution in Canada.

Explain that Canada can monitor pollution levels in the Earth's atmosphere. Ask students in which layer can pollution be monitored (stratosphere). Using the information provided on the MOPITT (pronounced MOP-it) and SCISAT (SIE-sat) information card, share with students the role of SCISAT, a Canadian satellite that provides information on the ozone layer, and MOPITT, an instrument onboard NASA's Terra satellite that monitors atmospheric pollutants. Ask students what other types of pollution Earth observation satellites can monitor.

Divide your students into five groups, and give each a pollution image card. Have each group examine the image and determine how this information is connected to pollution trends in Canada. What is this image showing? How does this influence our everyday lives? Next, have students share their image with the rest of the class. Encourage students to use the coloured pylons and chains to highlight the significant areas on their pollution card that they wish to share with the class.

## Conclusion

Ask students about the importance of the ozone layer. Explain that the ozone layer is the level in our atmosphere that absorbs the sun's ultraviolet (UV) rays, also called radiation. As a result of harmful emissions, such as chlorofluorocarbons (CFCs) and pesticides, the ozone layer is depleting, causing harmful rays to enter our atmosphere.

Show students the satellite images on the ozone information card. Read the information provided on the card and ask students about what may happen in the future if the ozone continues to deplete.

Divide students into pairs or small groups and give them an atmosphere balloon icon. Students are to read the coordinates on the icon and locate one of the 16 ozone-monitoring stations across Canada. The purpose of these stations is to measure solar UV radiation using a photographic plate. Review latitude and longitude coordinates with your students. Why are these stations located here? Is there a need for any other in Canada? Are these stations important? Why or why not? Where else in the world could stations be located?

## Extend your geographic thinking

Ask students what they think pollution patterns across Canada will be like in five, 10 or 20 years. What about the entire planet? Will it be different from the patterns we see today? How can the Canadian Space Agency's satellite technology help future generations maintain their quality of life?

**Essential Element 5: Environment and Society**

- Environmental issues (e.g., water supply, air quality, solid waste)
- Effects of human modification of the physical environment (e.g., global warming, deforestation, desertification, urbanization)

**Essential Element 6: The Uses of Geography**

- Interaction of physical and human systems and influence on current and future conditions
- Local, regional and world policies and problems with spatial dimensions

# 5 Fresh from Canada

**Learning objectives**

- Students will discover how much fresh water is located in Canada.
- Students will determine how Canada monitors the health of our country's fresh water using RADARSAT-2 technology.

**Time required**

75-100 minutes

**Grades**

4-12

**Materials**

- Coloured pylons (16)
- Freshwater quiz (1)
- Freshwater cards (4)

**Set-up**

Read over the quiz and familiarize yourself with the locations on the map.

**Links to the Canadian National Standards for Geography**

**Essential Element 1: The World in Spatial Terms**

- Map, globe and atlas use (e.g., observing and analyzing relationships)
- Map projections for specific applications

.../continued

## Introduction

Ask students to stand on bodies of fresh water on the giant floor map. Explain that most of the water on Earth is salt water and only a small amount is fresh water, which is found in lakes, rivers and underground aquifers. Of all the countries in the world, Canada has the third highest amount of fresh water. Canada's fresh water accounts for 20 per cent of the world's supply and covers almost nine per cent of our country's total area. Use the giant floor map to point out areas in Canada with a large amount of fresh water (glaciers in the north, Great Lakes, rivers).

Test your students' knowledge of Canada's fresh water with the quiz. For each question, students should locate and stand on the answer on the giant floor map.

## Development

Divide students into four groups, and give each a freshwater card. One side of the card shows an image taken from RADARSAT-2 relating to fresh water in Canada, while the other side provides the image location and information on Earth observation of fresh water in this area. Each card has an overall freshwater theme. Have each group use their card to locate their area on the map, and discuss the types of people and organizations that would use this Earth observation data. Students are to think locally and nationally.

## Conclusion

Allow each group time to present their information to the rest of the class. After each presentation ask specific questions about each group's overall freshwater theme. How do Earth observation satellites play a role in monitoring Canada's fresh water? How do freshwater issues differ across Canada? Once each group has presented, focus on the future of Canada's fresh water. Do students believe Canada's fresh water is clean? What may influence the health of our fresh water? If fresh water across the planet is declining, what role can Canada play in the future? Have students use the giant floor map to locate bodies of fresh water that may be threatened in the future.

## Extend your geographic thinking

Examine the role of watersheds and their connection to Canada's fresh water. Place a pylon on your city or town. Have students identify nearby lakes, rivers, bays and the closest oceans. Explain that groundwater exists everywhere in Canada and combines with other bodies of water to form watersheds. Almost all watersheds in Canada are connected to another, and therefore, the health of one will affect the health of many. Ask students what they can do to ensure the health of their local watershed. After the map leaves, encourage your students to find their local watershed online at canadiangeographic.ca/watershed/map.

**Essential Element 2: Places and Regions**

- Perceptions of places and regions
- Regions defined by multiple criteria
- Factors that influence people's perception of places and regions

**Essential Element 5: Environment and Society**

- Renewable (land, forests, water) and non-renewable (minerals, fossil fuels) resources
- Environment issues (e.g., water supply, air quality, solid waste)

# 6 Canadian Ice Service

**Learning objectives**

- Students will learn how Earth observation satellites help Canadians understand climate change.
- Students will learn about the cryosphere and how climate change affects it.
- Students will learn how data collected through Earth observation helps to protect northern communities.

**Time required**

75-100 minutes

**Grades**

4-12

**Materials**

- Coloured chains (12)
- Coloured pylons (16)
- Ice profile cards (9)
- Community card (1)
- Floe edge community cards (30)
- Arctic ice time cards (7)

**Set-up**

Place ice profile cards and Arctic ice time cards in two piles. Review ice profile cards to familiarize yourself with the types of ice monitored by Earth observation satellites. Read over the community card and the role of the Floe Edge Monitoring Service.

.../continued

## Introduction

Once students have had an opportunity to explore the giant floor map, gather them around Canada's Arctic region. Ask students about the climate in the Arctic and how it relates to plants, animals and humans. Explain what permafrost is and point out that the Arctic has permafrost year-round. Ask students why it is important to monitor land that is permanently frozen.

Bring attention to how Arctic ice is displayed on the giant floor map. Explain that there are nine types of ice in Canada's Arctic: multi-year ice, annual ice, landfast ice, pack ice, pancake ice, glaciers, ice shelf, icebergs and river ice. Studying how ice is formed, where it moves and its age gives scientists information about the Earth's climate. The Canadian Ice Service is a government organization that collects data about Arctic ice and provides the most accurate information about ice in Canada's navigable waters.

Distribute the ice profile cards. In small groups, have students read the information and plot where each type of ice can be found, using coloured pylons on the giant floor map. Have students share their type of ice and where it is located with the rest of the class. How does Earth observation play a role in detecting the types of ice? Explain that radar satellite images have the ability to monitor ice characteristics such as type, thickness, topography, age and movement. How do Canadians benefit from these observations?

## Development

Explain that cryosphere is a term used to describe the frozen places on the Earth. Explain that ice in the Arctic is melting. Ask students why this is worrisome and how it affects Canada. Canada has been monitoring the rate of decline in Arctic sea ice for decades. Distribute the Arctic ice time cards to each group, and have them arrange the cards in chronological order to create a timeline of Arctic sea ice using the information on the back. Have students place the timeline along the top of the map to observe the changes. Ask students what patterns and trends they see in the timeline, what they think about these changes and what could be the consequences of these patterns.

How will the decline in Arctic ice influence local communities? Ask students to think about the people who live in the North and to consider how their way of life depends on the environment around them. Have students brainstorm ways in which the changing northern landscape might affect these communities. Using the community card, share with students the RADARSAT-2 image and information about Igloolik, Nunavut. Explain that this community uses RADARSAT-2 data to help understand the changes in ice in their area. This service is called the Floe Edge Monitoring Service. Using the information provided on the back of the community card, share with your students the purpose of the Floe Edge Monitoring Service, who uses it and its benefits. Use a pylon and the coordinates to locate this community on the giant floor map.

## Conclusion

Explain that Igloolik is not the only community in the North that uses the Floe Edge Monitoring Service. Give each student a floe edge community card. Have students work independently or in pairs to locate their community. Once all communities have been located, discuss the types of information provided to each community by the Floe Edge Monitoring Service and how this community differs from their own. How will the decline in Arctic sea ice influence these communities in the future?

## Extend your geographic thinking

Begin by asking students to describe outer space. Have one student stand on Devon Island, Nunavut, on the map. Ask all students to list adjectives they think describe the island. Encourage students to list any similarities they find between space and Devon Island. Next, share with students that Jeremy Hansen, a Canadian Space Agency astronaut, prepared for living in the harsh conditions of outer space on Devon Island. Explain that Devon Island is the largest uninhabitable island on Earth and has a harsh climate, similar to that of Mars and the Moon.

Hansen and Gordon Osinski, from the Centre for Planetary Science and Exploration, went on a geology field expedition to the Haughton impact crater on Devon Island. After the map leaves, show students the video of Hansen at the crater (www.asc-csa.gc.ca/eng/astronauts/training-geology.asp) and discuss how the landforms on Devon Island are different from their local environment.

**Links to the Canadian National Standards for Geography**

**Essential Element 1: The World in Spatial Terms**
- Location of major human and physical features on Earth
- Physical/political maps of the province, Canada and the world

**Essential Element 2: Places and Regions**
- Perceptions of places and regions
- Regions defined by multiple criteria
- Changes in place and regions over time
- Regional analysis of geographic issues and questions

**Essential Element 3: Physical Systems**
- Ecozones (major ecological communities such as boreal forest, polar regions, grassland, wetlands and desert)
- World climate regions

**Essential Element 4: Human Systems**
- Cultural regions (e.g., religion, language, ethnicity)
- Patterns of culture in Canada and the world (e.g., religion, language, ethnicity, economy)

**Essential Element 5: Environment and Society**
- Impact of extreme natural events (earthquakes, tornadoes, floods, hurricanes, volcanic eruptions, mudslides) on the human and physical environment
- Perceptions of and reactions to extreme natural events
- Environmental issues (e.g., global warming, loss of biodiversity, deforestation, ozone depletion, air pollution, water pollution, acid precipitation, disposal of solid waste)

# 7 To Navigate and Protect

**Learning objectives**

- Students will learn how Earth observation satellites assist in marine navigation.
- Students will discover how Canada's coastlines are protected.

**Time required**

75-100 minutes

**Grades**

5-12

**Materials**

- Coloured chains (12)
- Coloured pylons (16)
- Navigate and protect image cards (6)
- Navigate and protect scenario cards (11)

**Set-up**

Examine the image cards and read over the scenario cards. Adjust the activity to fit the comprehension level of your class.

.../continued

## Introduction

Ask students to place pylons on the countries other than Canada shown on the giant floor map. Can they name these countries and describe how they know they are not part of Canada? Explain that political borders around the Geographic North Pole are still being defined, and many countries are trying to claim areas in the Arctic as their own. Using the chains provided, have students work as a class to layer on international borders in the Arctic Ocean. There is no right or wrong answer to this question, and it is a topic that is currently open for debate. Discuss with your students their thoughts on this and what may happen in the future. Change the borders and ask students how a simple border change could affect Canada.

## Development

Using RADARSAT-2, Canada collects extensive information about its coastline. The information collected varies from environmental and political concerns to the safety of Canadian communities. Have students get into six groups, and give each a navigate and protect image card. Each image card also includes its geographic location. Have students find this place on the giant floor map, examine the Canadian coastal region around it and lay their card there.

Once all image cards have been placed on the map, explain that each image represents a different way that Earth observation satellites help to navigate and protect our coastline. Moving clockwise, have students rotate to the next image, examine it and determine its role in protecting Canada or navigating around its shores. Briefly discuss as a class all images placed on the map. Which images could be placed in a different location?

Next, have all students stand around the border of the map and distribute a navigate and protect scenario card to groups of two or three. This card provides a typical scenario of how Canada relies on or uses RADARSAT data to protect and navigate its borders. Have students read their scenario card to the class and place it beside the image they think best matches their scenario. Encourage students to use the giant floor map to explain why they placed their scenario card there. More than one scenario card can match an image.

## Conclusion

Bring attention to the card highlighting the Northwest Passage, the sea corridor through Canada's Arctic Archipelago. Discuss what the Northwest Passage is and why it is important to Canada and to other countries. As a class, use the coloured chains to find the quickest route through the north travelling from east to west. During this conversation, ask students to consider the flow of ice through channels around the Arctic islands. Monitoring ice structure and movement is extremely important because it helps safely guide ships. Ask students how safe monitoring of the M'Clintock Channel, one of the largest in the Canadian Arctic Archipelago, can help communities in the North.

## Extend your geographic thinking

As a class, discuss each image and further investigate the role of Earth observation satellites in protecting our country. Have students stand anywhere on the map, and ask them which type of data would be the most useful to the area of Canada they are standing on. How does geographic location influence the kinds of data gathered by Earth observation satellites?

Canada has one of the longest coastlines in the world. Using the chains provided in the trunk, your feet, students or anything else you would like to use as a measuring tool, measure Canada's coastlines.

**Links to the Canadian National Standards for Geography**

**Essential Element 1: The World in Spatial Terms**
- Physical/political maps of the province, Canada and the world
- Spatial graphics (e.g., air photos, satellite images, various map types and atlases)
- Map projections for specific applications

**Essential Element 4: Human Systems**
- Development of transportation and communication networks
- Transportation and communication networks in Canada and the world
- Global economic interdependence (trade, commerce and communication)

**Essential Element 5: Environment and Society**
- Limits and opportunities of the physical environment for human activities
- World patterns of resource distribution and utilization

# 8 Valuable Resources

**Learning objectives**

- Students will learn how Earth observation satellites help locate and monitor Canada's resources.
- Students will examine and discuss the importance of Canadian resources to the environment and economy.

**Time required**

75-100 minutes

**Grades**

4-12

**Materials**

- Coloured pylons (16)
- Coloured chains (12)
- Resource discovery cards (4)

**Set-up**

Review the cards and place pylons and cards on each corner of the map.

**Links to the Canadian National Standards for Geography**

**Essential Element 1: The World in Spatial Terms**

- Spatial graphics (e.g., air photos, satellite images, various map types and atlases)
- Map, globe and atlas use (e.g., observing and analyzing relationships)

**Essential Element 2: Places and Regions**

- Regions defined by multiple criteria
- Physical and human characteristics of places and regions in Canada and the world

.../continued

## Introduction

Ask students to list the resources that exist in Canada, encouraging them to think of natural resources, such as fresh water and forests, as well as human-influenced resources, such as cropland. As students list resources, ask them to locate on the map areas where large amounts of each are found and mark them with pylons. Possible resources to highlight include fresh water, forests, energy sources and cropland. Explain that Canada is a resource-rich country and it is important to monitor and protect these resources. Ask students to brainstorm how Earth observation technology can play a role in helping to protect our resources.

## Development

Divide students into four groups, and give each a resource discovery card. Explain that each group is going to investigate how Earth observation satellites contribute to resource management. Students are to examine the image on their card, read the information on the back and place it on the proper location(s) on the giant floor map. Students will then use their newly acquired knowledge to connect this resource to the rest of Canada. Encourage them to use the coloured chains and pylons to show connections throughout different regions in Canada. For example, if one group investigates cropland in the Prairies, have students highlight this region and then determine other places where Earth observation satellites can monitor crops.

## Conclusion

Once each group has highlighted their resource and marked key areas on the map, ask each to present their resource to the class and explain how Earth observation satellites monitor it. After all groups have presented, discuss similarities and differences between the resources examined. What patterns and trends do they see? Why is it important for Earth observation satellites to monitor these resources? Based on the data received from Earth observation satellites, how do you think your resource has changed over the past decade? What issues related to your resource will arise in the next 10 years? How does monitoring this resource benefit Canadians who live close to it? What about the rest of Canada? Is there a greater need to monitor certain resources more than others?

## Extend your geographic thinking

Now that students are more familiar with some of Canada's resources, have them determine which resources are most important to them. How can Earth observation satellites ensure Canada continues to have these resources in the future? What type of technology would Earth observation satellites need to ensure resource security in the future?

**Essential Element 4: Human Systems**

- Human settlement patterns and land use
- Regional development in Canada and the world

**Essential Element 5: Environment and Society**

- Renewable (land, forests, water) and non-renewable (minerals, fossil fuels) resources
- Global effects on the human environment by changes in the physical environment
- Environmental issues (e.g., global warming, loss of biodiversity, deforestation, ozone depletion, air pollution, water pollution, acid precipitations, disposal of solid waste)

# 9 Coast to Coast to Coast

**Learning objectives**

- Students will learn about the three oceans bordering Canada and the role Earth observation satellites play in monitoring them.
- Students will examine trends in ocean temperature in relation to climate change and changes in marine migration routes.

**Time required**

75-100 minutes

**Grades**

4-12

**Materials**

- Coloured pylons (16)
- Coloured chains (12)
- Ocean temperature cards (4)
- Animal cards (19)

**Set-up**

Review and locate the ocean temperature cards. Alter the activity to ensure appropriate comprehension level for your class.

**Links to the Canadian National Standards for Geography**

**Essential Element 1: The World in Spatial Terms**

- Spatial graphs (e.g., air photos, satellite images, various map types and atlases)
- Map types (e.g., topographic, navigational, thematic)

.../continued

## Introduction

Have students explore the map, paying attention to the oceans surrounding Canada. Ask students what role they think Earth observation satellites play in monitoring oceans. Explain that Earth observation satellites are able to measure the ocean wind, waves, temperature, colour and tides. This helps oceanographers get a clear picture of ocean patterns such as temperature and animal migration. Ask students why this is important.

Have students get into pairs and stand on the border of the giant floor map. Hand out all coloured pylons. Ask students who are holding red pylons to place their pylon where they feel the ocean water temperature would be at its warmest, and then go back to stand on the border. Ask students who are holding the yellow pylons to place their pylon where the water is slightly colder, and then head back to the border. Ask students who are holding the green pylons to place their pylons on cold ocean water. Finally, ask the remaining students to place their blue pylons on areas where ice and freezing cold water can be found. Ask students what they notice about ocean temperature as you get closer to the Arctic.

Divide students into four groups, and have each sit on a corner of the map. Next, give each group a different ocean temperature card. This card shows ocean temperatures around Canada and the date this data was taken. Using the pylons already placed on the map, allow one group to move the coloured pylons around to match the colour distribution on their card. Have the rest of the class determine what season the data was taken based on the location of the warm and cold temperatures. Rotate until all four groups have moved the pylons on the map to reflect the temperatures on their card. Ask students what patterns and trends they notice about ocean temperatures in different seasons and the movement of ocean currents.

Compare the August 2013 card with the February 2013 card. What do you notice about Arctic sea ice? Highlight areas like the strong thermal change in the St. Lawrence River (lower than freezing in winter and 20°C in summer). Bring attention to the Beaufort Sea and the change in temperature in the Far North between these two cards. Explain to students that this change is called a thermal plume, caused by the flow of the Mackenzie River. Optional for older grades: Using the red and blue chains provided in the trunk, have groups estimate ocean currents. Use the red chains to demonstrate where the warm currents and the Gulf Stream travel (east coast of Canada) and the blue chains to show the cold currents in the north (Labrador Current) and on the west coast (Subarctic Current). Monitoring and understanding ocean currents is important because it helps us understand climate patterns and animal migration.

## Development

Ask students to predict what would happen to Canada if the temperature of all oceans increased by five degrees.

First, have students think about how marine life would be affected. Ask students about the types of animals and plant life that depend on the ocean for survival. For younger students, have them play a game of charades on the topic of marine animals. Next, have students get into pairs or small groups and hand out one animal card to each. Students are to locate their animal's habitat in Canada using the information on the back of the card and discuss how this animal would be affected if ocean temperatures increased. How will this animal adapt to the change in temperature? Encourage students to use materials from the trunk (chains, pylons) to animate this change on the map. Allow time for students to share their thoughts with the class.

Second, consider how humans would be affected. Have students name some of Canada's major coastal towns and cities and locate them on the map with a coloured pylon. Ask students what would happen to these coastal cities and towns if ocean temperatures increased. Have students get into small groups and discuss different factors influencing a coastal city of their choice. Factors to consider are economic, environmental, political and cultural. What role do Earth observation satellites play? Allow time for students to share their thoughts with the class.

## Conclusion

Have students discuss how changes in ocean temperature would affect them personally, even if they do not live near an ocean, and how this makes them feel. Discuss ways in which humans contribute to changing ocean temperatures and what they can do to prevent it.

## Extend your geographic thinking

Discuss what would happen if all the sea ice in the world melted. Explain that a large part of the world's population lives along coastlines. What would happen to the cities and towns that students highlighted earlier on the map? After the map leaves your school, explore this concept further and visit ngm.nationalgeographic.com/2013/09/rising-seas/if-ice-melted-map to see an interactive map showing what the world would look like if all the ice melted.

**Essential Element 3: Physical Systems**
- Physical processes shape Earth's features and patterns (e.g., weathering, erosion, deposition, plate tectonics, continental drift)
- Global patterns of wind and water
- Global ocean and atmospheric systems

**Essential Element 4: Human Systems**
- Human settlement patterns

**Essential Element 5: Environment and Society**
- Effects of human modification of the physical environment (e.g., global warming, deforestation, desertification, urbanization)
- Global effects on the human environment by changes in the physical environment

# 10 Whatever the Weather

**Learning objectives**

- Students will make connections between weather and climate.
- Students will learn how seasons are influenced by the shape of the Earth.
- Students will observe images of weather from space.
- Students will learn how Earth observation satellites help monitor and predict weather.

**Time required**

75-100 minutes

**Grades**

K-12

**Materials**

- Coloured pylons (16)
- Weather cards (8)
- CloudSat information card (1)
- Inflatable globe (1)
- CloudSat image cards (3)

**Set-up**

Ensure all materials are present. Bring in a copy of your community's seven-day weather forecast to help facilitate a discussion about weather and weather patterns in Canada (optional).

**Links to the Canadian National Standards for Geography**

**Essential Element 1: The World in Spatial Terms**

- Spatial graphics (e.g., air photos, satellite images, various map types and atlases)
- Map, globe and atlas use (e.g., observing and analyzing relationships)

.../continued

## Introduction

Once students have had time to explore the map on their own, ask them to go to the top of the world and place a pylon there. Using the inflatable globe, ask students what shape the Earth is and how it moves. Explain that the Earth moves in two ways: it rotates and it revolves. Have students form a circle on the giant floor map. Choose one volunteer to represent the sun and stand in the centre of the circle. Have the rest of your students walk around the sun in the same direction, and then independently spin in a circle while walking around the sun (remind students to be careful not to bump into each other). Explain to your students that the movement around the sun is revolution and the individual spinning movement is called rotation.

Explain that the Earth's shape and movement influence the time of day and the seasons. Choose two volunteers, and give one a yellow pylon to represent the sun and the other the inflatable globe. Ask the student with the globe to stand with Canada facing the sun and explain that this would be daytime in Canada. Then ask the student to stand so that Canada is facing away from the sun and explain that this would be nighttime in Canada. Ask your students what causes day and night: rotation or revolution? (rotation)

Next, ask the student holding the globe to tilt it just a little to the right (about 20°) and revolve it slowly around the sun. Explain that the tilt in the Earth is important because it is the reason we have seasons. Have the student holding the globe stop four times while revolving around the sun, each representing a different season. When Canada is tilted directly towards the sun it is summer. As Canada begins to turn away from the sun, it becomes fall. When tilted away from the sun, it is winter. And when Canada starts to face the sun again, spring has arrived. Ask your students which type of motion causes the four seasons: rotation or revolution? (revolution)

## Development

Have students describe the different types of weather in Canada. If you brought in a seven-day forecast, use it to describe weather patterns in your own community. Next, have students list types of weather that occur in other parts of the world. Ask them which countries have similar weather patterns to Canada and why. Have a student explain the difference between weather and climate. Explain that weather refers to a specific event or condition that happens over a period of hours or days, while climate refers to average weather conditions that take place over many years (usually a period of 30 years). Explain that thunderstorms, snowstorms and clouds refer to weather and that global warming refers to climate.

Divide students into small groups, and give each group a weather card. Have each group examine the image and read the information on the back. Tell students that they are going to play a game with these cards. Each group is to think of three clues to best describe their type of

weather. Each group will take turns showing their image and reading their clues one by one to the rest of the class. The first group to guess the type of weather in the image wins. After the weather type is revealed, ask students to choose a place in Canada where this type of weather commonly occurs. If there is more than one place, discuss why and choose one location.

## Conclusion

Explain to your students that clouds are an important type of weather that help us understand climate. As shown on the weather cards, clouds have a large influence over many types of weather. Show your students the satellite diagram of CloudSat on the information card. Explain that the Canadian Space Agency and NASA have worked together to create this satellite, which measures clouds in 3D. While most satellites study the location of clouds, CloudSat can determine the cloud thickness by measuring how much water, snow or ice it contains. Ask students why it is important to know this information. Using the same groups and their weather cards from before, have each discuss the types of information that CloudSat gathers to help us better understand the weather. For example, information needed for a tornado would be cloud thickness, wind speed, direction and diameter. Ask students to discuss why this information is important and how it can help the people living in the area. For younger students, do this as a class.

Divide students into three groups and give each a CloudSat image card. Share with students details on the CloudSat information card about how CloudSat analyzes data. Using the three CloudSat images provided, allow each group to examine the image and read the information on the card provided. Either rotate each image card to different groups or present the images to the class while you discuss the differences between them and determine which portrays the most severe weather. Explain that CloudSat not only monitors storms in Canada, it also orbits the globe, gathering information for other countries. Discuss why it is important to share Earth observation data with other countries, particularly with respect to weather. Have students share their opinions with the class.

## Extend your geographic thinking

After the map leaves, create a Venn diagram between the climate patterns of Canada and those of another country. How will these patterns change as our climate becomes warmer? Which country will experience more severe weather patterns? How can Earth observation satellites play a role in preparing us for future changes?

**Essential Element 3: Physical Systems**
- Weather
- Seasons
- Extreme natural events (e.g., floods, hurricanes, earthquakes, tornadoes)
- World patterns of extreme events

**Essential Element 5: Environment and Society**
- Impact of extreme natural events (e.g., earthquakes, tornadoes, floods, hurricanes, volcanic eruptions, mudslides) on the natural environment
- Impact of natural and technological hazards/disasters on the human and physical environment