

This will be a lesson for students in grades 4-5. The subject matter includes types of weather, weather instruments/forecasting and impacts of extreme weather events. It is meant to be an interactive presentation with the teacher asking questions of the students on nearly every slide.

This presentation was assembled as part of the outreach initiative for the Canadian Network for the Detection of Atmospheric Change.

# CANDAC

Canadian Network for the Detection of Atmospheric Change

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- In 2002, a group of university researchers joined together under the title of the **Canadian Network for the Detection of Atmospheric Change** (CANDAC) with the objective of improving the state of observational atmosphere research in Canada.
- This group recognized the need for an Arctic laboratory and identified the **Polar Environment Atmospheric Research Laboratory** (PEARL) in Eureka, Nunavut as the ideal station.
- They worked enthusiastically to raise funds to run the facility and had a fully-functional Arctic lab operating in 2005.
- Since then, researchers have been taking various measurements to monitor and better understand current atmospheric conditions.

# Funding for CANDAC has been provided by:



Canadian Foundation for Climate and Atmospheric Sciences (CFCAS)  
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Ontario Innovation Trust



Canada Foundation for Innovation  
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Environment Canada

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**NSERC**  
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Ontario MINISTRY OF RESEARCH & INNOVATION



NOAA  
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION  
U.S. DEPARTMENT OF COMMERCE



International Arctic System for Observing the Atmosphere  
IASOA

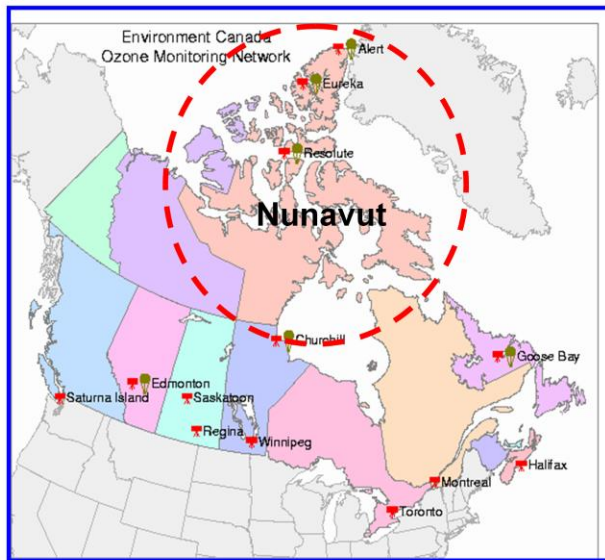


Nova Scotia Research and Innovation Trust

Polar Continental Shelf Project (PCSP)

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## Where do we take measurements?



- CANDAC researchers collect data in Nunavut.
- Nunavut is a Canadian territory located in the Arctic.

<http://exp-studies.tor.ec.gc.ca/e/ozone/ozonecanada.htm>

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Teacher: What else do you know about Nunavut?

Responses will vary depending on student knowledge and experience.

Additional Information:

Facts about Nunavut can be found at: <http://www.gov.nu.ca/en/Facts.aspx>.

- Nunavut means “our land” in Inuktituk.
- Iqaluit is the capital city of Nunavut.
- Nunavut is the newest Canadian territory; it officially separated from Northwest Territories on April 1<sup>st</sup>, 1999.
- The total area of Nunavut is 2,093,190 km<sup>2</sup>.
- The total population is 33,220.

- Many animals including caribou, polar bears, Arctic wolves, Arctic hares, whales and seals live in Nunavut.



Teacher: What similarity do you notice in all of the animals shown?

Response: All of the animals have white fur.

Teacher: Correct. Why do you think many of the animals in the Arctic have white fur?

Response: In order to blend in (camouflage) with the snow and ice found in their environment.

ment Canada  
nitoring Network

The map shows the northern part of Canada, highlighting the territories of Yukon, Northwest Territories, and Nunavut. Three locations are marked with red squares and green circles: Alert on Ellesmere Island, Eureka on Ellesmere Island, and Resolute on Resolute Bay. A red dashed circle encloses Alert and Eureka. The map is titled 'ment Canada nitoring Network'.

- Eureka is located on Ellesmere Island in the High Arctic.
- It is not too far from the North Pole.

<http://exp-studies.tor.ec.gc.ca/e/ozone/ozonecanada.htm>

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Teacher: Nunavut is the geographically the largest of all thirteen provinces and territories, but is the least populated.



Photo courtesy of Pierre Fogal

- Many CANDAC researchers operate their instruments from the Polar Environment Atmospheric Research Laboratory (PEARL) located in Eureka.
- Researchers typically travel to PEARL by airplane.



Photo courtesy of Pierre Fogal

## CANDAC International Polar Year Legacy Project: Educational Resources

- As part of the International Polar Year (IPY) Legacy Project, CANDAC has created educational resources aimed at enhancing environmental science education in classes from kindergarten to grade 12.
- Educational materials can be found at:  
<http://candac.ca/candac/Outreach/Outreach.php> .
- This particular presentation is about:

Weather Instruments and  
Weather Forecasting!

# What is Weather?

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Weather is.....

- what is happening outside.
- temperature, cloudiness, snow/rain and wind.
- always changing.

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This slide is an opportunity for the teacher to ask the students about previous weather knowledge.

The teacher can then share the information on the slide to ensure a clear understanding of the weather.

For each of the following picture slides, the students are to identify the type of weather that is being represented.

# What kind of weather?



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Allow many students to provide their response to demonstrate that many different types of weather occur simultaneously.

Teacher: What kind of weather do you see?

Response: Cold, icy, snowy

Additional information: Snow generally forms if the air in a cloud is below freezing. The water vapor then turns into ice instead of rain and the tiny ice crystals stick together until they form snowflakes. When they get heavy enough to fall, they drop out of the clouds. All snowflakes have six sides, but no two snowflakes are the exact same!

Information courtesy of:

<http://www.thecanadianencyclopedia.com/index.cfm?PgNm=TCE&Params=A1ARTA0010749>

# What kind of weather?



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Teacher: What kind of weather do you see?

Response: Rainy, foggy, warm, sunny, rainbows

Additional information: While fog is a type of cloud, the term fog is typically distinguished from the more generic term cloud in that fog is low-lying and the moisture is generated locally. A dense fog develops if the liquid water droplets or ice crystals formed by condensation are trapped and concentrated in a shallow layer near the ground by a temperature inversion (in which a layer of warmer air is trapping cooler air near Earth's surface).

Information courtesy of:

<http://www.thecanadianencyclopedia.com/index.cfm?PgNm=TCE&Params=A1ARTA0002873>

# What kind of weather?



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Teacher: What kind of weather do you see?

Response: Cloudy, sunny, cold

Additional information: “Clouds are formed when air containing water vapor is cooled below a critical temperature called the dew point and the resulting moisture condenses into droplets on microscopic dust particles in the atmosphere. A cloud is a visible mass of droplets of water or frozen crystals suspended in the atmosphere”

(<http://www.thecanadianencyclopedia.com/index.cfm?PgNm=TCE&Params=A1ARTA0001692>).

# What kind of weather?



Teacher: What kind of weather do you see?

Response: Rainbow, cloudy, wet

Additional information: A rainbow is a coloured arc that occurs when sunlight shines onto falling raindrops and is refracted, then reflected back towards the observer. In this process, each drop acts as a tiny prism, splitting the sun's rays (according to wavelength) into their component colours.

<http://www.thecanadianencyclopedia.com/index.cfm?PgNm=TCE&Params=A1ARTA0006661>

# What kind of weather?



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Teacher: What kind of weather do you see?

Response: Sunny, windy, warm, muggy

Additional information: All winds, from gentle breezes to raging hurricanes, are caused by differences in the temperature of the atmosphere, by rotation of the Earth, and by uneven heating of the continents and oceans. Since cool air is more dense than warm air, the cool air sinks towards the Earth's surface causing the less dense, warm air to rise. This process is called circulation.

<http://www.thecanadianencyclopedia.com/index.cfm?PgNm=TCE&Params=A1ARTA0008633>

The study of weather  
is call meteorology.

How do we measure  
the weather?



In this section of the presentation, the teacher will show different instruments (tools) that are used to measure some of the aspects of weather. This section is more informative with fewer questions asked to the students.

# Stevenson Screens

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Stevenson screen is the name for the white boxes shown. They are located in hundreds of places in Canada, including all weather stations. Inside the boxes are instruments used to measure temperature and sometimes humidity or pressure.

Teacher: Raise your hand if you know what instrument is used to measure temperature. If no student knows the answer, tell them that they will learn about it on the next slide.

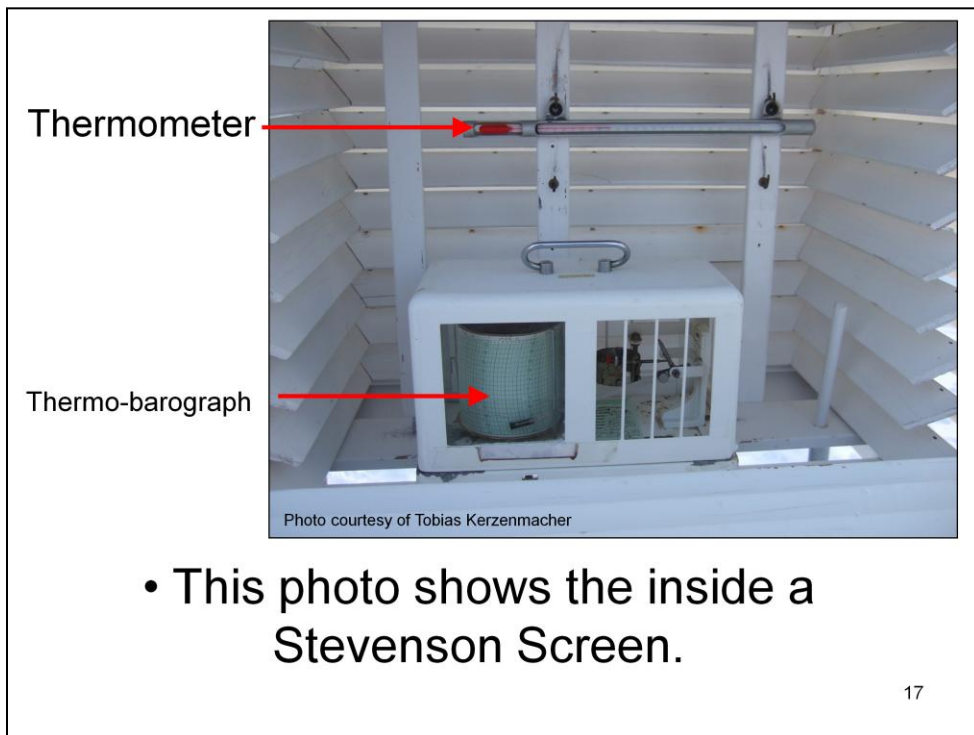
Response: A thermometer

Teacher: Yes! When the temperature is warm, the liquid inside the thermometer expands and the liquid moves upwards. When the temperature is cold, the liquid inside the thermometer contracts (takes up less space). Why do you think these instruments are placed inside a box?

Response: The box protects the temperature sensors from being influenced by direct or reflected sunlight.

Additional information: “Stevenson screens are always painted white to better reflect the sun's rays. The louvered sides allow outside air to flow around the thermometers. In the picture above, two hinges can be seen at the bottom of the door, with a latch at the top. The door swings down rather than to one side so that the wind won't catch it on windy days and rip it off the hinges. Stevenson screens are always installed so that the door opens facing north, to keep the sun from shining directly on the thermometers and affecting the readings”

([http://www.on.ec.gc.ca/skywatchers/ontario/wx\\_office\\_tour/compound/screen\\_e.html](http://www.on.ec.gc.ca/skywatchers/ontario/wx_office_tour/compound/screen_e.html)).



Teacher: This is a picture taken of inside one of the Stevenson screens. The thermometer at the top measures temperature. The thermo-hydrograph measures both temperature and air pressure. The thermo-barograph keeps a record of the temperature and air pressure over time. Some Stevenson Screens also house hydrometers, which measure humidity.

Note: If you have access to a thermometer, bring one in to show the students. You can use hot and cold water to demonstrate how a thermometer works.

Teacher: You may have heard people use the word humidity or humid before. Does anyone know what humidity means?

Response: The amount of water vapor in the air. So if a region is experiencing high humidity, the air will feel muggy and thick. The air temperature also feels hot. If a region is experiencing low humidity, the air will feel dry. The air temperature may feel hot, warm or cool.

Teacher: Although sunlight is important for the body to make vitamin D, too much heat and humidity can also be dangerous to one's health. In extreme heat, high humidity, or vigorous physical exercise under the sun, the body may not be able to get rid of enough heat, causing body temperature to rise and the person to experience heat stroke. This can cause symptoms like nausea, vomiting, weakness, headaches and muscle cramps. Infants, elderly people and people working outdoors are especially susceptible to heat stroke.

Information courtesy of: [http://www.weatheroffice.gc.ca/mainmenu/faq\\_e.html#weather4](http://www.weatheroffice.gc.ca/mainmenu/faq_e.html#weather4) and <http://www.hc-sc.gc.ca/hl-vs/iyh-vsv/environ/heat-chaleur-eng.php>



# Snow Gauge



Photo courtesy of Tobias Kerzenmacher



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A snow gauge measures how much snow has fallen. The snow falls inside the inner tube as shown. It is then taken inside where it melts, and the volume of the water is measured to determine the amount of snowfall.

Information courtesy of:

<http://www.theweathernetwork.com/index.php?product=help&pagecontent=formulae#Q1>

Teacher: You may have heard people use the word wind chill before. For example, weather forecasters may say, “Today is going to  $-23^{\circ}\text{C}$ , but will feel like  $-30^{\circ}\text{C}$  with the wind chill”. Does anyone know what wind chill means?

Response: “On a calm day, our bodies insulate us somewhat from the outside temperature by warming up a thin layer of air close to our skin, known as the boundary layer. When the wind blows, it takes this protective layer away, exposing our skin to the outside air. It takes energy for our bodies to warm up a new layer and, if each layer keeps getting blown away, our skin temperature will drop and we will feel colder. Wind also makes you feel colder by evaporating any moisture on your skin, a process that draws more heat away from the body. Studies show that when skin is wet, it loses heat much faster than when it is dry” (<http://www.ec.gc.ca/meteo-weather/default.asp?lang=n&n=5F816A-1#wc1>).



# Rain Gauge



[www.campbellsci.ca/Museum\\_Precipitation\\_1.html](http://www.campbellsci.ca/Museum_Precipitation_1.html)



Model CS700 (c) 2002 Campbell Scientific (Canada) Corp.  
<http://www.campbellsci.ca/Catalogue/prfull/cs700.jpg> 19

Additional Information: A rain gauge is used to measure the amount of precipitation (rain) that has fallen. Precipitation comes in many forms: rain, drizzle, freezing rain, freezing drizzle and hail. Some rain gauges have a measuring device inside the collection container, while others need to be transferred into graduated cylinders (similar to measuring cups) to be measured. Precipitation is usually measured in millimeters.

Information courtesy of:

[http://www.weatheroffice.gc.ca/mainmenu/faq\\_e.html#weather1ba](http://www.weatheroffice.gc.ca/mainmenu/faq_e.html#weather1ba)



## Wind Measurements

Anemometer  
(measures wind speed)



Wind Sock  
(measures wind direction)



Teacher: Both anemometers and wind socks are used to measure the wind. Wind socks show the direction of the wind. The sock turns to point in the direction in which the wind is blowing. Anemometers measure how fast the wind is blowing. Both of these instruments are commonly seen at airports.

Information courtesy of:

[http://www.on.ec.gc.ca/skywatchers/ontario/wx\\_office\\_tour/compound/anemometer\\_e.html](http://www.on.ec.gc.ca/skywatchers/ontario/wx_office_tour/compound/anemometer_e.html)

Additional activity: Using a wind sock (homemade wind socks can be made with ribbon or light paper attached to a ruler), a fan and a paper with a compass rose drawn, you can demonstrate how a wind sock works. Have one student hold the fan on any side of the wind sock while the remaining students determine which way the wind is blowing.



## Ice Thickness Measurements



Chris Polashenski of Dartmouth College (left) and Benny Hopson from the Barrow (Alaska) Arctic Science Consortium bore a hole through sea ice in the Chukchi Sea on July 4.

Caption courtesy of:

[http://www.nasa.gov/topics/earth/features/icescape2010\\_arctic\\_ice.html](http://www.nasa.gov/topics/earth/features/icescape2010_arctic_ice.html)

Photo courtesy of NASA/Kathryn Hansen

- Ice thickness can be determined using drill-hole measurements.
- A hole is drilled in the ice using an ice auger.
- Ice thickness is measured using a measuring tape equipped with a hinged weight at the end.
- The tape and weight are lowered through the hole and then pulled upward until the weight catches on the bottom of the ice.
- The tape is then read to determine the thickness of the ice.


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### Additional information:

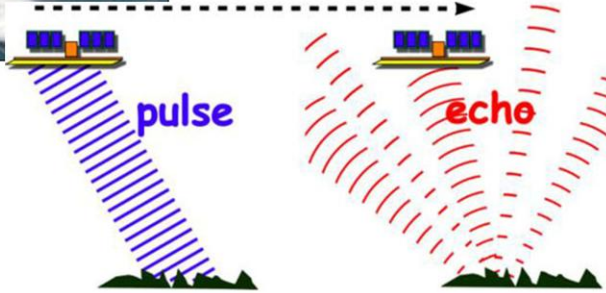
“Many things contribute to how thick the ice can be; such as the depth of the water, if the ice is exposed to the air and/or sun, as well as how much snow is on top of the ice. Think of the snow as a blanket. When snow is on ice it insulates it, preventing it from becoming thicker and stronger”

(<http://www.taiga.net/nce/schools/lessonplans/seaice.html>).

**RADARSAT-2**



- Ice thickness can also be measured using satellites equipped with radar.



<http://www.asc-csa.gc.ca/images/recherche/photo.aspx?id=448&format=0&search=radarsat-1&l=eng>

<http://polar09.yesican-science.ca/Blogs/?view=136>

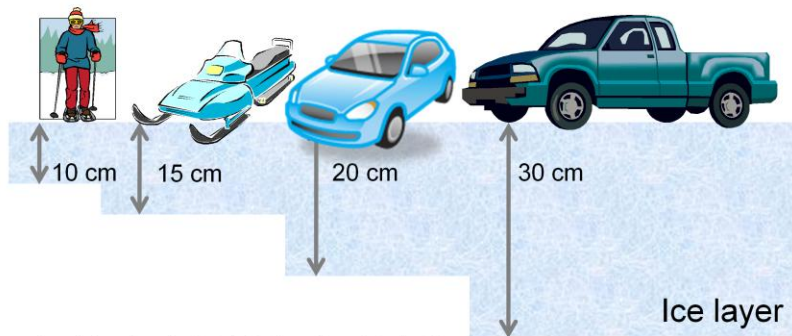
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Additional Information: Remote-sensing technology used to measure ice thickness from space was developed in Canada. RADARSAT is an Earth observation satellite developed to monitor environmental changes and the planet's natural resources. RADARSAT transmits pulses of radio waves towards the Earth, which then bounce off snow and ice as an echo. The strength of the echo is used to determine the thickness of the ice. If the echo is loud, the ice is hard and thick. If the echo is dull, the ice is soft and thin.

Information courtesy of:

<http://www.thecanadianencyclopedia.com/index.cfm?PgNm=TCE&Params=A1ARTA0006639>

- Thicker ice can usually support more weight than thinner ice, but the quality of the ice and the way it formed is also important.
- People planning to travel or play on ice should determine the thickness and approximate weight the ice is able to support.



The diagram above is based on the Ontario Outdoors ice safety chart found at <http://www.ontariooutdoors.com/images/icefish/safetychart.jpg>.

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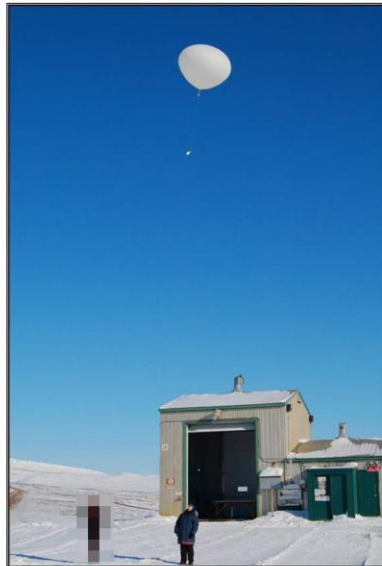
Additional Information: The diagram above shows the approximate ice thickness required to support various loads. Environment Canada has different safety requirements based on fresh and sea ice conditions. These can be viewed at <http://ice-glaces.ec.gc.ca/App/WsvPageDsp.cfm?ID=10167&Lang=eng>.

# Weather Balloons

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Photos courtesy of: Tara Cunningham



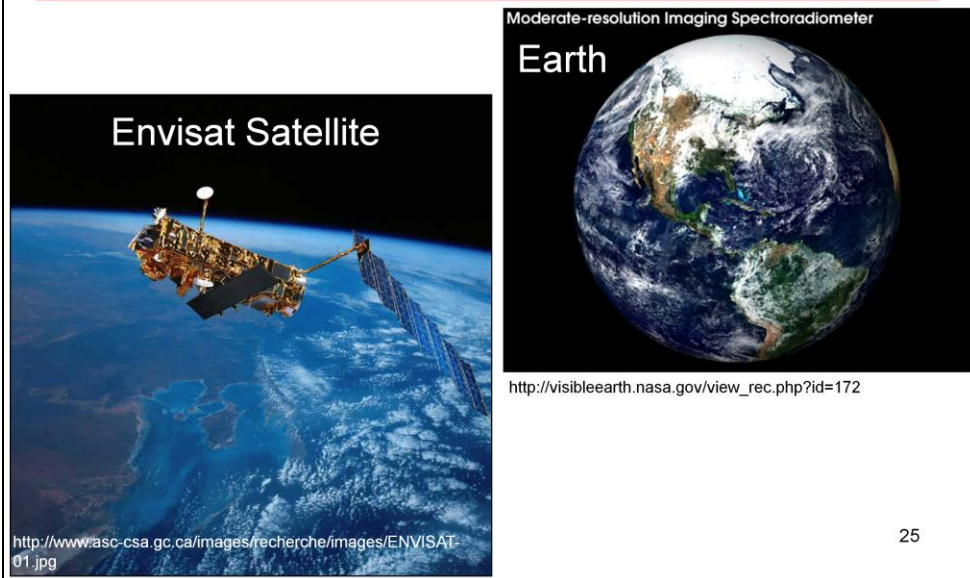
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Additional information: Each station collects data primarily from radiosonde instruments attached to hydrogen-gas weather balloons, which are launched every 12 hours. Radiosondes transmit temperature, pressure and humidity information from ground to 30 km; wind velocity and the direction the balloon travels is also tracked electronically. In addition to addressing issues of climate change, global warming and long-range transport of pollutants, researchers maintain that this data is important for generating extended weather forecasts.

Information courtesy of:

<http://thecanadianencyclopedia.com/index.cfm?PgNm=TCE&Params=A1ARTA000375>

# Weather Satellites



Teacher: Weather can also be monitored using satellites. What is shown in the picture on the right? (Point to the Earth.)

Response: The Earth

Teacher: Yes, this picture was taken by the Moderate Resolution Imaging Spectroradiometer, MODIS, which is on the Terra Satellite. MODIS will help us understand global dynamics and processes taking place on the land, in the oceans, and in the lower atmosphere in order to accurately predict global changes. What do you think is shown in the picture on the left? (Point to the satellite.)

Response: A satellite

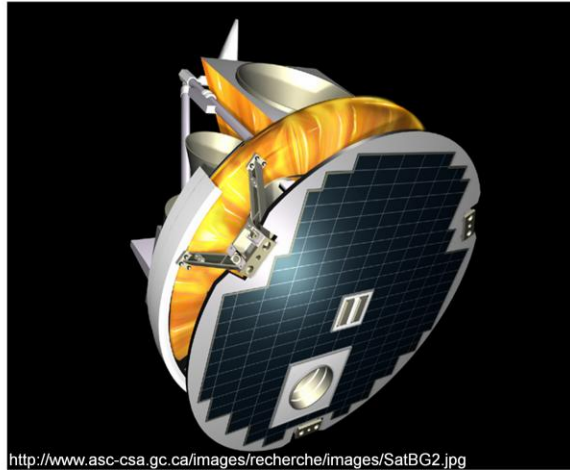
Teacher: Yes! This is a picture of the Envisat Satellite.

Additional Information: “By observing the Earth from space, satellites provide essential information on ocean, ice, land environments, and the atmosphere. Earth-observation satellites help us monitor and protect our environment, manage our resources, and ensure the safety and security of Canadians. Satellite imagery and expertise is also used to support global humanitarian efforts and sustainable development” (<http://www.asc-csa.gc.ca/eng/satellites/default.asp>).

# SCISAT-1

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- Launched in 2003, the Atmospheric Chemistry Experiment (ACE) is a Canadian satellite used to study the Earth's atmosphere.



<http://www.asc-csa.gc.ca/images/recherche/images/SatBG2.jpg>

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Teacher: The Atmospheric Chemistry Experiment on SCISAT-1 is an example of a Canadian Satellite. It monitors the atmosphere to track changes in ozone, air quality and pollution mainly caused by human activity. How do we get satellites into space?

Response: Rockets!

Teacher: Correct!

**Additional information: SCISAT measures over 30 different chemicals as it orbits over the Earth's polar regions, as well as tropical and mid-latitude locations. Some of the chemicals it monitors in the stratosphere affect (and often deplete) ozone, which protects life on Earth from harmful UV radiation.** These data are used to support ozone-protecting policies and initiatives like the Montreal Protocol. SCISAT not only measures ozone depletion, but also collects data on climate change, and air quality and pollution. Together with other satellite data and ground-based measurements, scientists continue to build their understanding of Earth's atmosphere.

Information courtesy of: [http://www.asc-csa.gc.ca/eng/satellites/scisat/scisat\\_061213.asp](http://www.asc-csa.gc.ca/eng/satellites/scisat/scisat_061213.asp)

# Launching a Satellite

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First stage of ACE launch. Photo courtesy of <http://www.ace.uwaterloo.ca/gallery.html>



Second stage of ACE launch. Photo courtesy of <http://www.ace.uwaterloo.ca/gallery.html>

- Space shuttles carry some satellites into space, but most satellites are launched by rockets that fall into the ocean after their fuel is spent.

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Teacher: This is a picture of the Atmospheric Chemistry Experiment being launched into orbit!

Additional information: “The satellite was launched by NASA on August 12, 2003 using a Pegasus XL rocket developed by Orbital Sciences Corporation. At an altitude of 39,000 feet, the 3-stage Pegasus XL was dropped from by a L-1011 carrier aircraft that took off from Vandenberg Air Force Base in California”

([http://www.ace.uwaterloo.ca/mission\\_launch.html](http://www.ace.uwaterloo.ca/mission_launch.html)). Many satellites require minor adjustments of their orbit before they begin to perform their function. Built-in rockets called thrusters make these adjustments. Once a satellite is placed into a stable orbit, it can remain there for a long time without further adjustment.

Information courtesy of:

[http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/How\\_Rockets\\_Work.html](http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/How_Rockets_Work.html)

# Weather Forecasting

- Once meteorologists have collected weather data and observations from hundreds of weather observation sites, as well as from satellite and radar installations, they analyse the information and make weather forecasts.
- Weather forecasts are often able to predict extreme weather events such as:
  - droughts, floods, storms, heat waves, tornadoes, tsunamis, etc.
- Weather events significantly impact human populations living in affected areas.

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Teacher: Can anyone provide an example of an extreme weather event?

Response: Drought, floods, storms, tornadoes, cyclones, wildfires, heat waves, etc.

Teacher: What kind of impacts can extreme weather events have on human populations?

Response: (Allow many students to provide responses.)

- Homes can be destroyed and people can be displaced
- People can be injured or killed
- Sickness may spread
- Crops can be destroyed and food shortages may occur
- Financial loss
- Commercial buildings and infrastructure destroyed or damaged
- Loss of wildlife and vegetation
- Schools, hospitals and other social services out of service

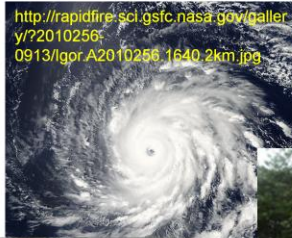
- For example, the 2010 **Haiti Earthquake** affected an estimated three million people and caused approximately 250,000 homes and 30,000 commercial buildings to collapse or be severely damaged.



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Information courtesy of: <http://www.cbc.ca/world/story/2010/02/16/haiti-quake-damage016.html>

- Also in 2010, **Hurricane Igor** blew through Newfoundland bringing powerful winds and heavy rain. It caused over \$100 million in damage, left 70 000 residents without power, and destroyed roads causing 50 communities to be isolated for several days.



[http://rapidfire.sci.gsfc.nasa.gov/gallery/?2010256;0913/Igor\\_A2010256\\_1640\\_2km.jpg](http://rapidfire.sci.gsfc.nasa.gov/gallery/?2010256;0913/Igor_A2010256_1640_2km.jpg)



Photo courtesy of Kim Toope



Photo courtesy of Paul Daly/Canadian Press

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Information courtesy of: <http://news.nationalpost.com/2010/12/30/2010-in-review-a-wild-weather-year-for-canada/>

Additional activity: Ask students to provide examples of extreme weather events they have heard about in the news or provide students with a list of recent extreme weather events. Have students work in groups to brainstorm the impacts a specific event may have had on the human populations affected. Allow each group to present their ideas to the class, and then provide an opportunity to discuss the usefulness of forecasting extreme weather events.

# How to Make a Rocket!

- **STEP ONE**
  - Roll your large piece of paper into a tube and tape it together (ask a friend for help!).
- **STEP TWO**
  - Cut out a circle from your small piece of paper to form the point of the rocket.
- **STEP THREE**
  - Tape the top of the rocket onto the cone (best if done with a friend).
- **STEP FOUR**
  - Decorate and add fins and fire onto the bottom of the rocket.
- **STEP FIVE**
  - When you're done, raise your hand and you will get string to hang your rocket.



Photo courtesy of Tara Cunningham 31

Additional rocket-launching activities are available through the NASA website:  
[http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/OTM\\_Launch\\_I t.html](http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/OTM_Launch_I t.html)

# Build A Hygrometer!

# Build A Barometer!

For instructions visit:

[http://www.science.gc.ca/Lesson\\_Plans/Lesson\\_Plans:\\_Monitoring\\_the\\_Atmosphere-WS8E2607CB-1\\_En.htm](http://www.science.gc.ca/Lesson_Plans/Lesson_Plans:_Monitoring_the_Atmosphere-WS8E2607CB-1_En.htm)