Understanding Canadian Weather Extremes

Lesson Overview
This lesson teaches about the dynamic interaction between North American air masses and the often spectacular and extreme weather patterns that result. Students will explore both the nature and the origin of the five major air masses that affect Canada’s weather and then investigate the dramatic weather results (both thunderstorms and tornadoes) of the interaction between these air masses.

Grade Level
Grades 9-12 (secondary school)

Time Required?
Between 60 to 120 minutes depending on the grade level and the fluency of computer literacy skills

Curriculum Connection (Province and course)
• British Columbia, Geography Grade 12 and Earth and Space Science Grade 11
• Any other physical geography course from grades 9-12

Link to Canadian National Geography Standards
Essential Elements #1 (Grade 9-12) - The World in Spatial Terms (Location)
• Map, Globe, and Alas Use (Use maps and other geographic representations to analyze world events and suggest solutions to world problems)

Essential Elements #2 (Grade 9-12) - Places And Regions
• Interdependence of places and regions (Interpret the connections between and within the parts of a regional system)

Essential Elements #3 (Grade 9-12) - Physical Systems
• Components of Earth’s Physical System / Inter-annual climate variation (Describe the ways in which Earth’s physical processes are dynamic and interactive)

Geographic Skills #1 (Grade 9-12) - Asking Geographic Questions
• Ask, speculate on, and answer questions about why things are where they are

Geographic Skills #2 (Grade 9-12) - Acquiring Geographic Information
• Locate and collect data, observe and systematically record information, read and interpret maps and other graphic representation of places from both primary and secondary geographic sources

Geographic Skills #4 (Grade 9-12) - Analyzing Geographic Information
• Note associations and similarities between areas, recognize patterns, and draw inferences from maps, graphs, diagrams, tables and other sources

Geographic Skills #5 (Grade 9-12) - Answering Geographic Questions
• Synthesize geographic information and develop generalizations and conclusions based on data collected, organized, and analyzed
The Canadian Atlas

Go to the Canadian Atlas website found at www.canadiangeographic.ca/atlas. The following parts of the Web site will be accessed by the students during the lesson: Extremes of Weather – Where Our Weather Begins / When Air Masses Collide / Anatomy of a Thunderstorm / Terrifying Twisters

NOTE: You may also use the print version of the Canadian Atlas to complete this activity (pages 14 – 15)

Additional Resources, Materials and Equipment Required

- Computer lab with Internet access and printer http://atlas.gc.ca/site/english/index.html
- Student Activity Sheet A – Understanding Canadian Weather Extremes
- For extension activities:
  - Project Atmosphere Canada Modules 1 (Hazardous Weather), 8 (Pressure: Highs and Lows), and 9 (Westerlies and the Jet Stream) found at http://www.msc-smc.ec.gc.ca/education/teachers_guides/toc_e.html
  - Weather lessons can be found at the weather network in the United States: http://www.weatherclassroom.com/index.php
- An explanation of air masses and frontal precipitation can be found at:
  http://www.met-office.gov.uk/education/training/air.html#table (UK)
  http://www.physicalgeography.net/fundamentals/7r.html (Canada)
  http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/af/home.rxml (USA)

Main Objective

The primary goals of the lesson are to analyze the sources of Canada’s extreme weather and to understand how extreme weather occurs.

Learning Outcomes

By the end of the lesson, students will be able to:

- Navigate the Canadian Atlas website for Canadian weather extremes
- Understand the nature of the air masses that affect Canadian weather
- Investigate the boundaries between air masses to determine what conditions are necessary to produce thunderstorms
- Explain the atmospheric conditions that help to create extreme weather phenomena
- Make conclusions about extreme weather in Canada based on data collected and analyzed from the Atlas of Canada website
## The Lesson

<table>
<thead>
<tr>
<th><strong>Teacher Activity</strong></th>
<th><strong>Student Activity</strong></th>
</tr>
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</table>
| **Introduction**     | • Before going to the computer lab assess student knowledge base and interest by asking the class to partner up and brainstorm a list of what weather is and both what the different types of weather extremes are and where in Canada those extremes might be.  
• Synthesize this information into a set of class notes with additional information from the Canadian Atlas and additional resources (see further reading). |
|                      | • In partner groups, students should brainstorm a list of what weather is and what and where they think the different types of weather extremes are (hottest / coldest / wettest / windiest / sunniest / foggiest / tornadoes / hurricanes / lightning / fire). This information can be placed on chart paper and the class a whole should synthesize a set of notes with the assistance of the teacher. |
| **Lesson Development** | • Once the class has finished the synthesis of weather extreme information then take the class to the computer room and introduce the class to the Canadian Atlas website (or if being done by print then review that atlas itself).  
• Help the students load the Web page and explain the importance of following the instructions on the work sheet. Have the students follow along and answer the questions on the work sheet. |
|                      | • Students will work on and complete the questions about air masses and extreme weather through the Student Worksheet A, and from obtaining information from the Canadian Atlas website. |
| **Conclusion**       | • Review student answers with the class. The worksheet will provide a basis of knowledge as to the causes of frontal precipitation in the mid latitude cyclone. One example of an extreme associated with this would be tornadic activity. |
|                      | • Students will make corrections on their worksheets to confirm master of knowledge. |
| **Conclusion** (cont’d) | • It would be wise to extend the lesson to fully appreciate the nature of the three dimensional atmosphere and make meaningful connections between air masses and severe weather. (see lesson extension) |
Lesson Extension

- The Project Atmosphere Canada modules are an excellent resource and could be used to extend the lesson. Each module has a basic narrative explaining the subject and one or two activities for a class to complete on that subject. PAC Module 1 is on severe weather and is sub divided into three categories (thunderstorms / hurricanes / winter weather); PAC module 8 is on air pressure (surface air patterns and the movement of air in highs and lows); and PAC module 9 is about the upper air westerlies and the jet stream. The lessons are self explanatory and easy to follow.

- This experiment comes from the weather network in the United States, which has lessons on weather and the atmosphere.

<table>
<thead>
<tr>
<th>Demonstration: Air Masses and Weather Fronts</th>
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<tbody>
<tr>
<td><strong>Materials:</strong></td>
</tr>
<tr>
<td>large glass jar, 1 pitcher, red food coloring, very hot tap water</td>
</tr>
<tr>
<td><strong>Purpose:</strong></td>
</tr>
<tr>
<td>Demonstrate the movement of air of different temperatures (densities)</td>
</tr>
<tr>
<td><strong>Hypothesis:</strong></td>
</tr>
<tr>
<td>When cold and warm water meet,...</td>
</tr>
<tr>
<td><strong>Procedure:</strong></td>
</tr>
<tr>
<td>1. Fill the jar half way with ice cold water.</td>
</tr>
<tr>
<td>2. Put hot tap water in the pitcher and add a drop of red food coloring.</td>
</tr>
<tr>
<td>3. Tilt the jar and slowly trickle the hot red water down the inside of the jar.</td>
</tr>
<tr>
<td>4. Illustrate and describe your observations.</td>
</tr>
<tr>
<td>5. Wait a while and illustrate and describe your observations.</td>
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<tr>
<td><strong>Analysis:</strong></td>
</tr>
<tr>
<td>1. Why don’t the two waters mix at first?</td>
</tr>
<tr>
<td>2. Why do the two waters mix later during your observations?</td>
</tr>
<tr>
<td>3. How does this illustrate the movement of air masses in the atmosphere?</td>
</tr>
<tr>
<td><strong>Solution:</strong></td>
</tr>
<tr>
<td>The hot, red water stays above the cold water. As the waters equalize temperature, they begin to mix. Analysis: Higher density cold air masses in the atmosphere do not mix with lower density warm air masses. Where they meet, they form a front. Eventually the densities and temperatures equalize, but the movement of air masses and fronts are an important part of the weather machine</td>
</tr>
</tbody>
</table>

Assessment of Student Learning

Evaluate responses to the Student Activity Sheet.

Further Reading

- Smith, Douglas B., *Everything You Need to Teach Weather & Climate* from Discovery Channel School Teachers A-Z Resource Books
- Buckley, Bruce, *Weather a Visual Guide* from Firefly Books
- Challoner, Jack *Hurricane and Tornado* from Dorling Kindersley Eyewitness Books
- Cosgrove, Brian *Weather* also from Dorling Kindersley Eyewitness Books
Student Activity Sheet:
Understanding Canadian Weather Extremes

Name: ________________________________ Date: _________________

In the following activities you will use the Canadian Atlas website in order to analyze geographic information about the nature and the origin of the five major air masses that affect Canada’s weather and then investigate the dramatic weather results (both thunderstorms and tornadoes) of the interaction between these air masses.

Go to the Canadian Atlas website located at www.canadiangeographic.ca/atlas (alternately you may use the text version of the atlas – go to pages 14-15).

PART A: Air Masses (Where Our Weather Begins and Where Air Masses Collide)

1. Go to the section in your Atlas on page 15 entitled “Where Our Weather Begins” and answer the following questions:
   a) An air mass is defined by which two uniform conditions?

   ___________________________________________________________________
   ___________________________________________________________________
   ___________________________________________________________________

   b) Canada’s bitter winters are caused by the Continental Arctic (A) air mass that originates over the snow covered barrens of northern Canada. What are the uniform conditions associated with this air mass?

   ___________________________________________________________________
   ___________________________________________________________________

   c) Travelling over large open bodies of water, the ______________________ air mass is both mild and moist.

   d) The Maritime Polar (mP) air mass over both the Atlantic and Pacific Oceans soak coastal areas with rain, fog, and snow. What are the uniform conditions associated with this air mass?

   ___________________________________________________________________
   ___________________________________________________________________
e) The Atlantic Maritime Tropical (mT) air mass, that has uniform warm and moist conditions, originates where?

________________________________________________________________

f) The air mass that rarely reaches Canada, because it’s hot and dry impact disappears as it moves northward. What is it called?

________________________________________________________________

g) Look at the map entitled “Winter Air Masses” and “Summer Air Masses”. The jet stream carries air masses across Canada from a westerly route. What are the names of the two dominant air masses that affect your region of the country.

In the summer? _______________________________________________________.

In the winter? _______________________________________________________.

h) The Polar Jet Stream forms perhaps the biggest front that affects our weather. At this boundary _____________________________ winds from the north meet _____________________________ winds from the south.

2. Go to the section in your Atlas on page 14 entitled “Where Air Masses Collide” and answer the following questions:

a) Read through the section entitled “Where Air Masses Collide” and explain how a cold front and a warm front form:

Cold Front: _______________________________________________________

________________________________________________________________

________________________________________________________________

________________________________________________________________

Warm Front: _______________________________________________________

________________________________________________________________

________________________________________________________________

________________________________________________________________
b) Large cumulus and cumulonimbus clouds that trigger heavy rain and thunderstorms are typically associated with which type of front?

________________________________________________________________

c) Circle the area where rainfall and wind are heaviest in a cold front:

Ahead  Behind  Along  Above

d) If you were to look up at the sky and see cirrus clouds and then a larger build up of clouds causing widespread precipitation, you would be observing the passage of which type of front?

________________________________________________________________

PART B: Severe Weather (Anatomy of a Thunderstorm and Terrifying Twisters)

1. Go to the section in your atlas on page 14 entitled "Anatomy of a Thunderstorm" and answer the following questions:

a) Explain the initial process of thunderstorm creation.

________________________________________________________________

________________________________________________________________

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________________________________________________________________

b) How does atmospheric instability assist in the process of thunderstorm creation?

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c) When the thundercloud hits the cumulonimbus stage what causes it to have its "Anvil head" appearance?

________________________________________________________________

________________________________________________________________

________________________________________________________________

________________________________________________________________
d) The rising air in the cumulonimbus cloud will fall back to earth in cool, dry currents of air surrounding the warm moist core of the thunderstorm. These cool currents are called:

________________________________________________________________

These cool currents can cause brief and often violent gusts of wind and rain called:

________________________________________________________________

e) Lightning is created by the static build up between the _____________________

charged downdrafts and the _____________________ charged updrafts in a thunderstorm.

f) Lightning travels at a speed of ________________________ kilometres per second.

2. Go to the section in your atlas on page 15 entitled “Terrifying Twisters” and answer the following questions:

a) What is the only region in Canada that does not experience tornadoes?

________________________________________________________________

b) What is “Tornado season” in Canada (when do they occur most often)?

________________________________________________________________

c) Where do tornadoes occur most often in Canada?

________________________________________________________________

d) Explain how tornadoes develop inside of thunderstorms:

________________________________________________________________

________________________________________________________________

________________________________________________________________

________________________________________________________________
PART C: Putting it all Together

1. Using the information you have learned through this online activity explain why it is that southern Ontario and the Prairie provinces are the most likely "targets" for extreme weather and Tornado development in Canada

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