Unit 2
Earth and Space Science: Weather Dynamics

Unit Overview

Introduction

Global climate and local weather patterns are affected by many factors and have many consequences. This unit asks students to consider questions such as "What decisions do we face because of weather conditions?"; "How are our lives affected by changing weather conditions (short-term) and changing climate (long-term)?"; and "What causes these weather patterns?"

In Atlantic Canada weather patterns change frequently. Each season provides interesting weather conditions that influence how we dress, how we feel physically and psychologically, and how we interact socially. The direction from which air masses move, and the atmospheric pressures and temperatures in those air masses contribute to changes that can be quite significant in any given season. Rapid temperature rises in spring may cause significant snow melt; clear and dry weather in summer raises the risk of grassland/forest fires; autumn sees the arrival of storms from the Caribbean; winter snowfall and temperature variations depend upon the north/south drift of the atmospheric jet stream. These changes influence Atlantic Canadians in a variety of ways.

Focus and Context

By considering questions that teachers and their students generate, various learning and assessment activities will meet specific curriculum outcomes. Although this unit focusses on decision making, there are opportunities for observation and inquiry as well as problem solving and design technology. Sections in the unit ask students to consider heat energy and its transfer, energy exchange within and between systems, and to observe weather data and the impact of weather forecasting.

Curriculum Links

"Weather Dynamics" connects with other clusters across many grade levels, such as " Populations, Energy Flow, Cycles within Ecosystems", " Energy and Energy Transfer", "The Earth and Its Atmosphere" (primary science); "Weather" (elementary science); "Heat Transfer", "Measuring Temperature" and "Oceanaography" (intermediate science). This unit will support optional studies in high school such as Biology: "Interaction of Living Things"; Chemistry: "Thermochemistry"; Physics: "Force, Motion, Work," "Energy, Momentum, and Waves"; Earth Systems: "The Earth's Systems".

Curriculum Outcomes

(From the K-12 Pan Canadian Science Framework Document)

Students will be expected to

STSE

Nature of Science and Technology
114-6 relate personal activities and various scientific and technological endeavours to specific science disciplines and interdisciplinary studies

115-2 illustrate how science attempts to explain natural phenomena

115-6 explain how scientific knowledge evolves as new evidence comes to light

Relationships between Science and Technology
116-1 identify examples where scientific understanding was enhanced or revised as a result of the invention of a technology

Social and Environmental Contexts of Science and Technology
117-6 analyse why scientific and technological activities take place in a variety of individual and group settings

117-10 describe examples of Canadian contributions to science and technology

118-2 analyse from a variety of perspectives the risks and benefits to society and the environment of applying scientific knowledge or introducing a particular technology

118-7 identify instances in which science and technology are limited in finding the answer to questions or the solution to problems

SKILLS

Initiating and Planning
212-1 identify questions to investigate that arise from practical problems and issues

Performing and Recording
213-2 carry out procedures controlling variables and adapting or extending procedures where required

213-3 use instruments effectively and accurately for collecting data

213-6 use library and electronic research tools to collect information on a given topic

213-7 select and integrate information from various print and electronic sources or from several parts of same source

Analysing and Interpreting
214-3 Compile and display evidence and information, by hand or by computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots

214-10 identify and explain sources of error and uncertainty in measurement, and express results in a form that acknowledges the degree of uncertainty

214-11 provide a statement that addresses or answers the question investigated in the light of the link between data and the conclusion

Communication and Teamwork
215-5 develop, present, and defend a position or course of action, based on findings

KNOWLEDGE

331-1 describe and explain heat transfer within the water cycle

331-2 describe and explain heat transfer in the hydrosphere and atmosphere and its effects on air and water currents

331-3 describe how the hydrosphere and atmosphere act as heat sinks within the water cycle

331-4 describe and explain the effects of heat transfer within the hydrosphere and atmosphere on the development, severity, and movement of weather systems

331-5 analyse meteorological data for a given time span and predict future weather conditions, using appropriate methodologies and technologies

Earth and Space Science: Weather Dynamics

How are changes in the hydrosphere and atmosphere observed and measured?

Outcomes	Elaboration – Strategies for Learning and Teaching
Students will be expected to	
	To frame students' thinking about this unit, they might work in groups to develop concept maps about weather and climate. Individually, they could prepare a "Know - Want to know- have Learned" (KWL) chart about weather and its influence on society.
	These outcomes will be attained throughout this unit. Students will collect weather data early in the unit, but will make interpretations or predictions later.
	Students should realize that the two terms weather and climate are distinct and not interchangable. Students should understand the various factors that influence each.
• relate personal activities and technology used with meteorology in the design of a weather station (114-6)	Students should research and prepare a proposal for the construction of a weather station that will provide basic meteorological data. Consider the following variables: air temperature; humidity; barometric pressure; wind speed and direction; level of precipitation. If feasible at the school, students should become confident in using available equipment to measure and record data.
- identify and explain the function of instruments used in a weather station. Instruments include: thermometer, hydrometer, aneroid barometer, anemometer, and rain gauge	The thermometer is well understood, but may require some practice in reading values. Students can refer to the skills section at the back of the text and focus on "Observing and Recording", pages 679-681. More attention may be required on the other weather instruments that students may not have experience with. Teachers could explain how these instruments are used to record weather data. A procedure for the construction of a simple anemometer can be seen on page 26 in the text. Refer to page 512 for information on the barometer and to pages 558-563 for information on humidity.
• use weather instruments effectively and accurately for collecting local weather data (213-3)	Students should apply their knowledge of weather instruments to set up a school weather station. Some schools may elect to purchase a kit and set up a local weather station or one can be constructed out of household items.
• identify questions to investigate that arise from the operation and findings of the weather station (212-1)	From changes in observed weather patterns, and recorded data, students should generate questions they wish to answer about changes in weather, or the techniques used to acquire data. Later in the unit, activities that investigate heat flow in gases, and liquids and the effect of heat on matter, will help students understand the causes of the weather changes they observe.

Earth and Space Science: Weather Dynamics

How are changes in the hydrosphere and atmosphere observed and measured?

Suggested Assessment Strategies

Presentation

Students could produce a weather chart similar to this example: weather feature (wind velocity); measuring instrument (anemometer); recorded data (50 km/h, from west); date. Assessment will include the style and clarity, accuracy, and completeness. (114-6)

With group members, students could prepare a chart or concept map that shows the points of energy transfer in the water cycle. They could design questions to help other students indicate the direction of energy flow and the forms it takes. (212-1)

A group is to present the comparison of data from the previous exercise. It is important that they illustrate the developing patterns through the five-day period.

Teachers could assess the quality of report findings, comparisons made, and if students appreciate that readings from a given location illustrate the dynamic nature of weather patterns. (114-6, 331-5)

Portfolio

Students could describe how changes in air density and air pressure cause movement of weather systems. (212-1)

Journal

Students could enter in their journal two concepts they have learned about energy exchanges that take place during the water cycle. They should make reference to the sources of the energy and the role water molecules play in the energy transfer.

Students could reflect on how the oceans influence our weather.

Students could reflect on the next question about weather they would like answered. (212-1)

Pencil and Paper

Students have seen a video that describes cloud formation and how lakes and oceans are sources of water vapour. From the notes, the teacher could have them identify the important factors in cloud formation.

They could describe an investigation that tests the assumptions made in the video about each of these factors. (212-1)

Resources

Science 10

page 502

pages 567-570

pages 569; 26; 512; 558-563

pages 512; 560

page 571

Earth and Space Science: Weather Dynamics

How are changes in the hydrosphere and atmosphere observed and measured? (Cont'd)

Outcomes	Elaboration – Strategies for Learning and Teaching
Students will be expected to	
• use print and electronic sources to collect weather data from regional and national weather observational networks (213-6, 213-7)	The description of weather changes at the school station can be compared to, and become part of, a larger picture produced from other sources to show a weather pattern. Students may use this evidence to form conclusions about, and explain, large scale heat energy transfer within the atmosphere. It should also be possible to see how large bodies of water influence weather patterns that pass across them.
- prepare a report in which the student will collect local weather data for a five-day period	This activity can be carried out in groups. Students will collect the following weather data over a five-day period: air temperature, air humidity, air pressure, wind speed and direction, type of cloud cover and the amount of precipitation. (See pencil and paper activity on next page).
- recognize and explain weather symbols seen on weather maps	Note: There are many resources available, especially on the world wide web, to assist in making a simple weather station. Teachers should introduce the students to various symbols often seen on weather maps. Students should be able to read a basic weather map. Teachers should encourage students to record their weather data on a standard meteorological map. To reinforce these concepts students could complete case study 14.3 on page 550 of the text.
• analyze meteorological data for a given time span and predict future weather conditions, using appropriate technologies and methodologies (331-5)	Teachers could encourage students to identify weather trends and make predictions based on them. For example, decreases in temperature usually occur with Northeasterly winds.

Earth and Space Science: Weather Dynamics

How are changes in the hydrosphere and atmosphere observed and measured? (Cont'd)

Suggested Assessment Strategies	Resources
Paper and Pencil	*Science 10*
Teachers could form student groups and assign the following:	page 582
Collect the following weather data (for a given location and at specific times) over a five-day period: air temperature, air pressure, relative humidity, cloud cover, wind velocity.	
Organize these data in a chart.	
Place these data on a single set of graph axes in order to allow comparisons, over the time period time.	page 571
Compare the record of their group with information presented by local newspaper/radio/television reports.	
Teachers could assess the process to organize data collection, graphical presentation, and way in which the comparison was made. (213-6, 213-7, 331-5)	pages 683-685; 550-551; 543
	page 571

Earth and Space Science: Weather Dynamics

What energy source drives the Water Cycle?

Outcomes	Elaboration – Strategies for Learning and Teaching
Students will be expected to	
• identify questions to investigate that arise from considering the energy transferred within the water cycle (212-1)	Students' questions about energy and the water cycle should generate investigations. Discussion in small groups could be summarized in graphical ways such as concept maps. *Questions might include:* - How does the water cycle influence the seasonal high/low temperatures for inland and coastal communities? - Why is the arrival of a snowstorm normally linked to a rise in air temperature? - How and why do clouds form? Why does it rain or snow? - What mutual interactions occur between the atmosphere and large bodies of water such as the ocean or lakes? Groups of students could research, and present for discussion, possible explanations for the questions generated by the above activity.
- identify solar energy (sun) as the driving force behind the water cycle	Students could identify the sun's energy as the source of all life and the cause of changing weather systems on a global scale.
- illustrate the distribution of incoming solar radiation	Students should understand that although the sun is our primary energy source, we do not absorb all incoming solar energy.
- identify that the amount of heat energy absorbed by any material depends on the albedo of the material	Teachers could explain that the albedo plays an important role in the reflection and absorption of solar radiation.
- provide a brief explanation of the water cycle - define and explain evaporation, condensation and precipitation	Students should focus on the four major steps of the water cycle: evaporation (page 501, 535), condensation (page 530-534), precipitation (page 556-557), and runoff. This will provide the basic understanding of the water cycle to allow students to investigate more advanced topics throughout this unit.
- identify and define the three main categories of clouds: convective, frontal, orographic	In defining cloud classification, students should understand the environmental conditions under which clouds form.
- classify clouds into their seperate types	Cloud classification should include the use of prefixes such as nimbus-holding rain, alto-medium height, and cirrus-high level clouds.

Earth and Space Science: Weather Dynamics

What energy source drives the Water Cycle?

Suggested Assessment Strategies

Journal

Students could enter in their journal two concepts they have learned about energy exchanges that take place during the water cycle. Students should make reference to the sources of the energy and the role water molecules play in the energy transfer.

Students could reflect on how the oceans influence our weather. What is the next question about weather they would like answered. (212-1)

Paper and Pencil

Students who have seen a video describing cloud formation and how lakes and oceans are sources of water vapour could make notes. From these notes, they could identify the important factors in cloud formation.

Students could describe an investigation that tests the assumptions made in the video about each of these factors. (212-1)

Presentation

With group members, students could prepare a chart or concept map that illustrates the points of energy transfer in the water cycle. Teachers could design questions to help other students indicate the direction of energy flow and the forms it takes. (214-3, 214-11)

Resources

Science 10

page 523

page 506

pages 32-33

pages 523; 501, 535; 530-534; 556-557

pages 530-534

pages 530-534

Earth and Space Science: Weather Dynamics

What energy source drives the Water Cycle? (Cont'd)

Outcomes	Elaboration – Strategies for Learning and Teaching
Students will be expected to	
• using scientific theory, illustrate and explain heat energy transfers that occur in the water cycle (115-2, 331-1)	Some background in energy transfer is required before investigating its role in weather. Students should briefly review the kinetic molecular theory, page 260, and apply this theory to explain heat energy transfer. Students should understand that radiation, conduction, convection and advection all contribute to the Earth's weather.
– describe and explain how heat energy is transferred by: radiation, conduction, convection and advection	Teachers could demonstrate the significant difference in energy between specific heat for water and its latent heat. In qualitative terms, teachers could encourage students to recognize the importance of fusion, condensation and vaporization in the water cycle and its influence on weather.
- define the conditions necessary to form fog	Parts of Newfoundland have a distinct reputation as having "foggy weather". Students could examine local weather conditions that contribute to fog production. Teachers could ask students to explain examples of weather-related phenomena which are illustrations of heat storage (of water): e.g., (i) fog formed by warm moist air over snow cover; (ii) fog formed by cold air over warm water; (iii) cloud formation in the atmosphere producing rain or freezing into ice/snow. Refer to page 506.
• describe examples that illustrate the atmosphere and hydrosphere are heat sinks in the water cycle (331-3)	The hydrosphere is a heat sink, and the energy stored in the ocean influences many systems. There are examples of this in our region. Students might choose to identify and explain examples of new knowledge in areas including: changing fish stocks in given areas; the timing and routes of wildlife migrations; possible cash crops grown in microclimates; patterns of coastal erosion; transport in "iceberg alley"; airborne pollution and its effects.
- define the terms heat sink and heat source - recognize that the hydrosphere and atmosphere are the Earth's main heat sinks	Once students are comfortable with the concept of heat sink, teachers could challenge them to relate this property to their previous knowledge about the structure of matter and kinetic theory. Teachers could have them suggest why the water cycle occurs and how energy exchanges on a molecular scale are able to produce such large-scale effects. Students should recognize the significant heat storage by water caused by its high value of specific heat, and how this heat energy is transferred between the hydrosphere and atmosphere.
- demonstrate that the energy stored in the hydrosphere influences other systems	Students should know the primary heat source is solar energy; however; this is transferred to water, air and soil. Students should understand that a heat source can be any warm body, i.e., water or land mass (e.g., lake), in contact with colder air. The high specific heat of water and air (gases) provides the potential for energy storage in the hydrosphere and atmosphere. According to differing heat capacity, students should rank air, water, or soil as good or poor heat sinks.

Earth and Space Science: Weather Dynamics

What energy source drives the Water Cycle? (Cont'd)

Suggested Assessment Strategies

Portfolio

Students could develop a written essay or a photo-essay to describe a significant example they have experienced of the connection between water cycle (phase change) – a weather phenomenon. (115-2)

Students could design and produce an entry for their portfolio. This entry is to comprise text and visual images. It could be in paper or electronic form. The entry is to illustrate and explain the link between ocean currents, atmospheric jet streams and coastal weather patterns. (214-3, 331-2, 115-2, 115-6)

Resources

Science 10

pages 260; 522-524

page 532

pages 504-507

pages 526; 632-634

page 506

Earth and Space Science: Weather Dynamics

What energy source drives the Water Cycle? (Cont'd)

Outcomes	Elaboration – Strategies for Learning and Teaching
Students will be expected to	
• conduct experiments to compare the specific heats of common Earth materials and draw conclusions about the effect of solar radiation on water and land surfaces (213-2, 214-11)	Students should consider how to estimate the specific heat of air, water, sand and soil, by heat absorption techniques (*analysis of precise calorimetry is too difficult at this stage but teachers should ensure the high value of specific heat for water is recognized*).
• discuss the design of experiments that compare the magnitude of the specific heat for water with that of its latent heat of fusion and vaporization (214-3) - define latent heat of fusion and latent heat of vaporization	Students should complete Core Lab: "*Energy Changes During Melting and Evaporation*" before comparing latent heat with specific heat. *Teachers should emphasize that latent heat values exceed the value of specific heat for a given material. It is the THINKING process rather than the performance of extending the practical challenge which is important here.* Teachers could use guided discussion to design experiments which can "estimate" values of latent heat (fusion and vaporization), thus allowing comparison with specific heat. It is not necessary to have a detailed explanation of their differences in magnitude. Latent heats are a measure of particle-particle attractions (e.g., when changing solids to liquids attractive forces have to be broken). Specific heat is a measure of how difficult it is to increase the kinetic energy of particles (recall kinetic molecular theory). Teachers should encourage students to solve the challenge of estimating the magnitude of the heat energy. During change of state, the factors to consider include source of heat energy, rate of supply, minimizing heat exchange with surroundings, equipment to be used, and that evidence showing temperature remains constant. The discussion should be open-ended.
• identify and explain the uncertainties in measurement and express them in a form that acknowledges the degree of uncertainty (214-10)	With guidance, teachers could encourage students to plan and run these experiments in order to determine specific heat. Students should consider their experimental technique in order to refine the accuracy of information obtained. They should investigate factors such as type of container for test materials (shape, colour, material), mass, surface area, closed container, open container, air conditions surrounding the container (still or moving). Teachers could have students assess the accuracy of measurement possible with the experimental technique used.

Earth and Space Science: Weather Dynamics

What energy source drives the Water Cycle? (Cont'd)

Suggested Assessment Strategies

Paper and Pencil

Students could write a paragraph (200 words max.) to describe the autobiographical account of a water molecule, together with its "friends", as it experiences a phase change in the water cycle.

Teachers can assess either/both the creative writing and/or the understanding of energy exchanges at both molecular and macroscopic levels. (214-3)

Presentation

Student groups could prepare and present to the class a demonstration/ description that connects a concept of physics (e.g., specific heat, latent heat, density, pressure) and a weather phenomenon. These might include dew point, change of state, pressure gradient, humidity and formation of precipitation.

Assessment should be based on the parameters given, preparation of materials, creative use of equipment, type of medium, understanding of concepts. (214-3)

Performance

Once the experiments have been designed and the intentions declared, there is an opportunity for assessing how students actually perform the intended activity. Do they follow the plan, use correct techniques, and work safely in estimating specific heat values? (214-3, 214-11)

Portfolio

As this is a significant activity, teachers should encourage students to select materials from their presentation as a record of the practical achievements. They should give reasons for their selections. (214-3, 214-11)

Teachers could have students design a "Weather Dynamics - Heat Transfer" concept map for their portfolio. They should explain how this map improves understanding of the topic. (214-3, 331-2, 115-2, 115-6)

Interview

As students plan experiments to find specific heat capacities, teachers could interview them about their plans and how they intend to measure identified variables. Understanding of the tasks, clarity of thought, and creative ways to solve practical problems could be assessed. (214-10)

Resources

Science 10

pages 506-507

Core Lab: *"Heat Absorption and Radiation"* - Appendix A

Core Lab: *"Energy Changes during Melting and Evaporation"* - Appendix A

Investigating the Earth

page 58

Earth and Space Science: Weather Dynamics

What energy source drives the Water Cycle? (Cont'd)

Outcomes	Elaboration – Strategies for Learning and Teaching
Students will be expected to	
• explain how scientific knowledge evolves about changing weather patterns with new evidence about changes in ocean temperature (115-6) - identify why oceans are important in weather dynamics - identify factors that are responsible for causing ocean currents	A study of ocean layers close to coastal regions and the edges of continental shelves will help interpret flow patterns that influence weather patterns.
• compile and display data, using this to support conclusions from experiments which investigate heat energy storage by and heat exchange between, water and air masses (214-3, 214-11)	Teachers should encourage students to compare heat storage/exchange data measured in their controlled, small scale, experiments to those quantities estimated to be in naturally occurring, large scale, weather systems.

Earth and Space Science: Weather Dynamics

What energy source drives the Water Cycle? (Cont'd)

Suggested Assessment Strategies

Presentation

Students could present the data and conclusions of their specific heat/heat absorption experiments. They could explain why they made certain decisions in planning and conducting the experiment. They could ask other groups to offer improvements in design and data collection and add them to notes. (214-3, 214-11)

Resources

Science 10

pages 525-527

pages 516-519; 525-527

Earth and Space Science: Weather Dynamics

Heat energy, its transfer, and Weather Dynamics - Is there a connect?

Outcomes	Elaboration – Strategies for Learning and Teaching
Students will be expected to	
• use weather data to describe and explain heat transfers in the hydrosphere and atmosphere showing how these affect air and water currents (214-3, 331-2)	By observing how weather patterns change as they pass over large bodies of water, and having access to values of water temperature, some conclusions can be made about heat exchange within bodies of water and their effects on currents, and the magnitude of heat exchanges between bodies of water and the air above them.
- identify the different prevailing winds around the Earth - recognize that high heat transfer between oceans and the air above creates convection currents within the atmosphere	Students could obtain data from a source, such as Environment Canada, about temperatures and flow directions for air and water for a weather system moving across a large body of water. For this example, consider energy exchanges within the hydrosphere and atmosphere. Students are better able to appreciate the various exchanges that take place in more complex weather systems. Teachers could have students describe and explain how global air currents (trade winds, westerlies, etc.) and water currents cause these heat transfers.
- explain the importance of convection and the Earth's rotation in causing prevailing winds	Students should use diagrams to explain the cause and consequences of the Coriolis effect. This effect has implications for high and low pressure air masses (covered later).
• select and integrate information about weather from a variety of sources. Compile and display this information to illustrate a particular hypothesis about weather in the Atlantic region (213-7, 214-3, 215-5)	Students should search from various sources: anecdotal, print and electronic, in order to make brief presentations on specific examples of notable weather events. It is important that students are able to relate these historical accounts with the concept of energy exchanges within the systems. Intense or consistent weather events have human or societal impact. The hypothesis might be the relationship between habitation patterns in the region and weather patterns or trends in sectors of the economy of our region and weather events (e.g., students could investigate the role of weather on Newfoundland and Labrador's settlement patterns).
• illustrate how science attempts to explain seasonal changes, and variations in weather patterns for a given location (115-2)	Latitude of a location and incline of the Earth's axis (in terms of incident solar radiation) play a major role in seasonal change. Students may better appreciate these effects if they design a three- dimensional model and use it to illustrate these effects (flashlight & globe). Teachers could challenge some groups to use the model to describe seasonal changes not only for the Atlantic region, but for considerably different locations such as Ireland, Cuba, Hawaii, Tasmania and New Zealand. (An extension activity might compare the average solar radiation density incident to a specific area, on a given latitude and date. Student groups could model this comparison by using the energy from the flashlight incident to a measured area of the globe, for other locations in the world such as listed above.) This promotes an appreciation of seasonal changes across the globe, the skill of estimating, and the assumptions that limit the accuracy of calculations.

Earth and Space Science: Weather Dynamics

Heat energy, its transfer, and Weather Dynamics - Is there a connect?

Suggested Assessment Strategies

Presentation

Students could state a hypothesis about weather patterns in Atlantic Canada. They should make a three-minute oral presentation about a significant weather event, giving where, what, when, and its importance to people. Students should illustrate how it relates to their hypothesis. The presentation should be assessed for clarity, accuracy, and delivery in the allotted time.

Students could use models (print, three-dimensional) and/or drama to illustrate how a high-pressure region moving across Atlantic Canada affects atmospheric flow laterally and vertically. They should show where significant energy transfers are taking place. (214-3, 331-2, 115-2)

Using a flashlight (sun) and globe or ball (Earth), students could describe and illustrate the relationship between light source position and density of radiation incident to the surface of the globe/ball at various locations. Consider:

a) daily changes with globe axis fixed

b) seasonal changes with change in globe axis

Assessment should include the competency of the explanation, clarity of the concept, and appreciation for limitations of the model. (115-2)

Paper and Pencil

Students could write a poem or song to describe how atmospheric temperature and pressure differences cause the "Trade Winds."

In prose or poetry, students could write a brief description of seasonal change and relate it to the sun's energy. (115-2)

Resources

Science 10

pages 516-519

pages 600-603; 608-609; 639-640

pages 503; 508-509; 527

Earth and Space Science: Weather Dynamics

Heat energy, its transfer, and Weather Dynamics - Is there a Connection? (Cont'd)

Outcomes	Elaboration – Strategies for Learning and Teaching
Students will be expected to	
• illustrate how science attempts to explain seasonal changes, and variations in weather patterns for a given location (115-2) (Cont'd) - investigate localized air movement (thermals, sea breezes and land breezes) and its effect on regional weather	The consequences of these differences should contribute to students' understanding how variations in pressure and temperature will contribute to the movement of air both regionally and globally. Teachers could have students use diagrams to explain the cause and consequences of sea breezes, land breezes, and the relative motion of air currents.
• using scientific theory, describe and explain heat transfer and its consequences in both the atmosphere and hydrosphere, relating this science to natural phenomena (115-2, 331-2) - identify and describe the principal characteristics of layers found in the atmosphere - identity the distribution of common atmospheric gases (oxygen, nitrogen, water vapour, carbon dioxide)	To better appreciate heat flow and its consequences, students should experiment with various activities designed to illustrate heat flow (convection, conduction and radiation - already covered) through gases and liquids. These will illustrate movement of energy and account for density and pressure changes that lead to the movement of air masses over the surface of the Earth. While students are investigating characteristics of the atmosphere, they should pay particular attention to the lower layers. Investigating the relationship between altitude, temperature and atmospheric pressure will help students understand weather patterns and changes.
- investigate the relationship between altitude, temperature and atmospheric pressure	Students should investigate the variations in the Earth's atmosphere as altitude increases by using atmospheric temperature and pressure gradients.

Earth and Space Science: Weather Dynamics

Heat energy, its transfer, and Weather Dynamics - Is there a Connection? (Cont'd)

Suggested Assessment Strategies

Journal

Students could write a journal entry that summarizes what new concepts they have learned in this section. Complete the following introduction:

I now realize other people respond to weather conditions differently because…….

I am a carbon dioxide molecule in the air in Boston. Tomorrow I might be in (_____) because…… (115-2, 331-2, 331-4)

Resources

Science 10

pages 553-555

pages 510-513

Earth and Space Science: Weather Dynamics

What is the evidence for movement of heat energy and matter in global systems?

Outcomes	Elaboration – Strategies for Learning and Teaching
Students will be expected to	
• describe and explain the effects of heat transfer on the development, severity, and movement of weather systems (331-4)	Student groups could research, prepare and present demonstrations of radiation, conduction and convection as it applies to one or more of the following:
- define a weather system	- movement of heat energy - unique micro-climates at high altitudes - the effect of atmospheric pressure on air movement, transfer of weather systems, transfer of airborne pollution - consequences in the atmosphere of ash from volcanoes and smoke from large forest fires - welling up/down of ocean water, its impact on krill population (which are vital to ocean food chains), the effect of water temperature and breeding of fish stocks, and the supply of heat energy and water vapour to drive the water cycle - comparing the four major air masses (tropical, polar, maritime and continental) - development of low pressure systems at mid-latitudes and their associated weather fronts - development of high pressure systems and the associated weather patterns
- identify air masses (tropical, polar, maritime, continental) and compare their movements across North America	Students should determine that air masses originate at the North and South of the Northern Hemisphere. Prevailing winds (westerlies) cause the air masses to move primarily from the west to the east.
- identify weather conditions associated with maritime polar, maritime tropical, continental polar, continental tropical air masses	
- identify and explain the formation of low-pressure (cyclone) and high pressure (anti-cyclone) systems	Students should know and understand why low pressure systems carry stormy weather while high pressure systems carry fair weather.
- define front and distinguish betweeen the four types of fronts formed along pressure systems	Students should understand that most fronts are found at mid-latitudes where air masses meet. Students should identify the four major types of fronts that occur: warm front, cold front, occluded front and stationary front.
- determine that low pressure systems at low latitudes have potential to develop into severe weather systems (hurricanes, typhoons, tropical cyclones)	

Earth and Space Science: Weather Dynamics

What is the evidence for movement of heat energy and matter in global systems?

Suggested Assessment Strategies	Resources
Presentation With a partner, students could prepare a three-minute presentation on a selected example that relates heat/matter transfer and weather patterns. This may be presented directly to the class and/or made into a video format for a selected audience (adult, middle, or elementary grades). *This may be assessed for its content only, research and presentation process only, or both. Students should know this before the exercise.* (115-2, 331-2, 331-4)	*Science 10* page 546 pages 546-549 pages 594-599

Earth and Space Science: Weather Dynamics

Accurate weather forecasting - What is its impact?

Outcomes	Elaboration – Strategies for Learning and Teaching
Students will be expected to	
• describe weather satellite imaging, its benefits to society, and Canada's contribution to this technology (117-10)	It is important that all students develop a basic understanding of satellite imaging, and the importance of timely and accurate information. This understanding will help them - to identify and compare the basic weather patterns found at low latitudes (no fronts), middle latitudes (low pressures, high pressures, and fronts), and high latitudes - to identify how imaging technology has improved decision making about projects in which weather systems can have significant economic impact.
• identify examples where improved data gathering technology has resulted in better understanding of weather systems and of forecasting (116-1)	Teachers could have students individually, or as groups, research a technology that has improved the collection and/or analysis of data related to weather forecasting. Such technologies might include Doppler Radar, infra red and visible imaging from satellites, fog detectors, precipitation detectors, remote sensing and transmission data stations.
• describe the impact of Canadian contributions to the field of meteorology (117-10)	Our country has regions that experience some extreme variation in weather conditions. Students can find examples of Canadian contributions to meteorology associated with such regions as the Rocky Mountains, the Arctic, and the Prairies.
• describe the limitations of scientific knowledge and technology in making predictions related to weather (118-7)	In Atlantic Canada, forecasting weather conditions accurately is a challenge. Despite the facilities to accumulate and analyse ever- increasing amounts of data, we live at a "junction" of flowing systems. Through interviews, print, and/or electronic sources, it is important for students to discover and appreciate the limits to accuracy caused by our location on the North American continent. This research may also introduce some discussion of climate, the evidence of its change, and the effects it may have on society.
• relate both personal activities and scientific/technological processes to weather and climate research and the application of the research • identify why some activities tend to be individual or group oriented (114-6, 117-6)	The last three outcomes in this section allow students to reflect on the way in which they are personally influenced by, and respond to, various weather conditions. Although changing climate conditions are less obvious, high school students should take the opportunity to consider evidence of change and consider its consequences for us individually and our society in Atlantic Canada.

Earth and Space Science: Weather Dynamics

Accurate weather forecasting - What is its impact?

Suggested Assessment Strategies

Paper and Pencil

Students could prepare a brief article/flyer that explains the advantages of weather satellite technology compared to methods used in the mid 20th century. (117-10)

Teachers could give students a sequence of weather satellite images for our region. Students should study the sequence of satellite images provided, complete one of the following, and give reasons for their conclusions:

- Describe the weather conditions at the indicated locations.
- On the blank map indicate the cloud conditions one would expect to see six hours later.
- As a farmer-fisher-forester, what are the positive-negative consequences of these images?
- As a sports or tourist director, what are the positive-negative consequences of these images?
- Write a brief autobiography of a nitrogen molecule in this weather system as it may be taken between the two indicated points.
- Write a brief autobiography of a jelly fish for the given location resulting from the weather shown in these images. (117-10)

Observation

During a discussion intended to distinguish weather from climate, teachers could identify students who can clearly express their ideas and make the distinction. (214-2)

Interview

Students could give an example of Canada's contribution to meteorology and how it benefits society.

Students could give an example that illustrates the limitations of predicting weather conditions. (117-10, 118-7)

Presentation

Student groups could give a four-minute presentation about a technology that has improved the accuracy of weather forecasting. Students should use a variety of media during the presentation. (214-2, 116-1)

Resources

Science 10

pages 567-569

pages 567-570

pages 628-644

pages 521; 622; 564; 572

pages 641-644

Earth and Space Science: Weather Dynamics

Accurate weather forecasting - What is its impact? (Cont'd)

Outcomes

Students will be expected to

- identify the impact of severe weather systems on economic, social and environmental conditions (118-2)

Elaboration – Strategies for Learning and Teaching

Teachers could have groups of students choose a severe weather event and analyse its effects on an individual and for the entire community. This can be presented as a written account, a photo/visual image essay, or perhaps as a "news" report.

Teachers could ask student groups to select a particular career/occupation and a community in which to live (other than their own). For a prospective immigrant to Newfoundland, the students could prepare a report/video on how the annual weather cycle affects this occupation.

Teachers could challenge students to offer examples of what society considers "severe" weather systems that occur in each of our four seasons. Groups may develop concept maps about the social impact and consequences of the severe storms. What policies has a community developed to minimize the consequences? How, and on what basis, does society make these decisions?

Earth and Space Science: Weather Dynamics

Accurate weather forecasting - What is its impact? (Cont'd)

Suggested Assessment Strategies

Performance

Students could show a group of younger students how to research information about a severe weather event, identifying the physical data and reports which indicate the social impact of the event. (118-2)

Journal

Students could reflect on the following questions about them and weather:

What have I learned about forecasting weather in Atlantic Canada?

Which types of weather do I most enjoy, and why do I prefer these?

If, or when, I move away from here, how will climate conditions influence my choice of where to live and work? (114-6, 118-2, 214-2)

Portfolio

Students could choose a piece of work from this unit in which they think they have captured the social impact of weather conditions. Students should attach a statement explaining reasons for their selection. (118-2)

Resources

pages 580-581; 600-603; 604-607; 608-609; 639-640