2-2 Weather Forecasting

Outcomes:

1. Define the terms related to weather forecasting. (114-6, 212-1, 330-6)
2. Describe some of the methods of weather forecasting. (331-5)
3. Describe the dominant factors that produce seasonal weather phenomena. (330-6)
4. Apply the effects of ocean currents, air currents and latitude on the climate of Newloundland and Labrador. (115-2, 331-4)
5. Explain how scientific knowledge evolves as new evidence comes to light. (115-6)

Atmospheric Terminology

To understand weather forecasting, you must first have an understanding of the terms used to describe the atmosphere.

1. Air Mass- a large, horizontal body of air with a uniform distribution of moisture and temperature throughout. An air mass may be colder or warmer in comparison to another air mass close by. ***Air pressure*** describes the force exerted by the weight of the atmosphere on the surface of Earth. Air pressure or atmospheric pressure may increase or decrease as air masses are replaced by other air masses. ***High pressure*** refers to an area of high atmospheric pressure with a clockwise movement of air, while ***low pressure*** refers to an area of low atmospheric pressure with a counterclockwise circulation of air. A ***ridge*** is a line of high pressure extending outward from the centre of a high pressure region. A ***trough*** is a line of low pressure extending outward from the centre of a region of low pressure.

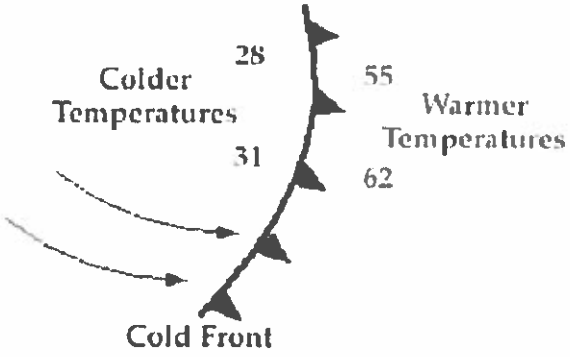
> **Air Pressure:** Is the force exerted by the weight of the atmosphere
>
> **High Pressure:** In the Northern Hemisphere, an area of high atmospheric pressure with a clockwise movement of air, also known as a cyclone
>
> **Low Pressure:** An area of low atmospheric pressure that has a counter-clockwise circulation in the Northern Hemisphere, also known as a cyclone
>
> **Ridge:** An area of relatively high pressure extending from the centre of a high pressure region; the opposite of a trough
>
> **Trough:** An area of relatively low pressure extending from the centre of a low pressure region; the opposite of a ridge

2. Fronts - areas where air masses meet

   A front is defined as the area between warm air and cold air that can extend both vertically and horizontally. Therefore, when a reference is made to a frontal surface (or frontal zone), it refers to both the horizontal and vertical components of the front.

A **cold front** is a transition zone from warm air to cold air, where a cold air mass is replacing a warmer air mass. The air behind a cold front is noticeably colder and drier than the air ahead of it. When a cold front passes through, temperatures can drop more than 15 degrees within the first hour.

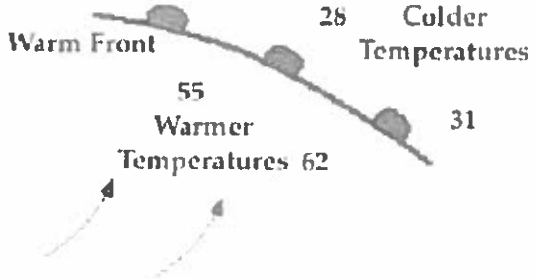
> **Cold Front:** The leading edge of an advancing cold air mass



A ***warm front*** is a transition zone from cold air to warm air, where a warm air mass is replacing a cold air mass. The air behind a warm front is warmer and moister than the air ahead of it. When a warm front passes through, the air becomes noticeably warmer and more humid than it was before. ***Humidity*** is a measure of the amount of moisture (or water) in the air.

Warm Front: The leading edge of an advancing warm air mass

Humidity: A measure of the water vapour content of the air



3. ***Relative humidity*** is the amount of water (in gas form) in the air at a given temperature compared to the maximum amount of water that could exist at that temperature. As the air temperature rises, this increases the amount of moisture it can hold while cold air loses ability to hold water. On hot summer days, the air can feel sticky and uncomfortable. This is because the air does not evaporate sweat easily from a person due to the high relative humidity. The ***humidex*** is the scale describing how hot, humid weather feels to the average person. The humidex combines the temperature and humidity into one number to reflect the perceived temperature. For example, the air temperature on a humid summer day may be 28 °C while the humidex may be 36 °C. We use the humidex to make people aware of the effect the humidity has a air temperature.

Relative Humidity: The amount of water vapour in the air at a certain temperature compared to the maximum amount which the air could hold at that temperature. It is usually expressed as a percentage

Humidex: Ils a way of reporting how hot the air feels as a result of the moisture (humidity) in the air

Pervailing Wind: rThe wind direction most frequently observed during a given period

4. Wind - the horizontal movement of air relative to Earth's surface caused by variations in temperature and pressure. As warm air rises up, cool air, which drops, rushes in to takes its place. The result is wind. Another way to say this is: the air moves over Earth as temperature and pressure changes from place to place. ***Prevailing winds*** are the winds most frequently observed coming from the same direction. Wind direction refers to the direction the wind comes from, for example, north winds blow from the north to the south.

5. ***Chinook*** is a warm down-slope wind in the Rocky Mountains that may occur after an intense cold spell. The temperature could rise by 20°F to 40°F in a matter of minutes when warm air passes over the mountains from the warmer coastal regions of British Columbia. These winds are called snoweaters since they melt snow when they arrive.

Chinook: The relatively warm, dry gusty winds that occasionally occur to the leeward side of mountain ranges

Analysis

1. What are air masses and how are they related to air pressure?
2. What are fronts? What are the differences between cold and warm fronts?
3. What is relative humidity? How is it related to the humidex?
4. What are prevailing winds?

Extension

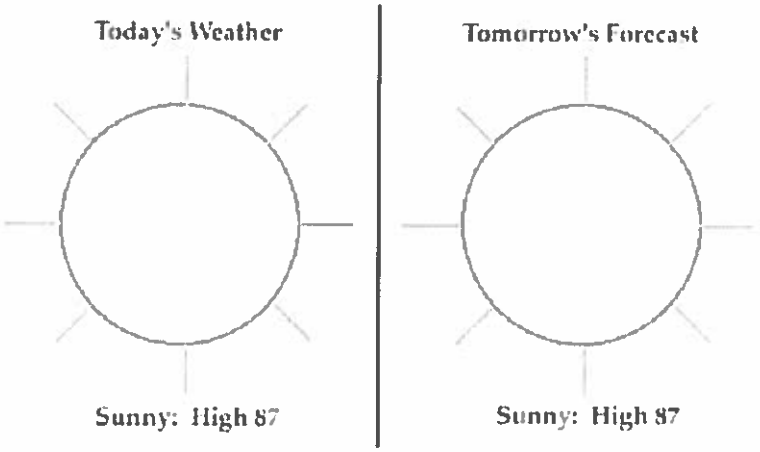
1. Check the latest forecast for your region using newspapers, television or internet. Determine if there are any current fronts approaching or if there are stationary fronts. Record; air pressure, humidity, and wind direction.

Weather Forecasting

There are several different methods that can be used to create a forecast. The method used depends upon the experience of the forecaster, the amount of information available, atmospheric conditions, and the degree of accuracy or confidence needed in the forecast.

Persistence

The first of these methods is the Persistence Method. It is the simplest way of producing a forecast. The persistence method assumes that the conditions at the time of the forecast will not change. For example, if it is sunny and 27 degrees today, the persistence method predicts that it will be sunny and 27 degrees tomorrow. If 20 millimeters of rain fell today, the persistence method would predict 20 millimeters of rain for tomorrow.



The persistence method works well when weather patterns change very little and features on the weather maps move very slowly. It also works well in places like central Australia, where summer time weather conditions vary little from day to day. However, if weather conditions change significantly from day to day, the persistence method is usually not the best forecasting method to use.

It may appear that the persistence method would work only for short term forecasts (e.g. a forecast for a day or two), but one of the most useful roles of the persistence forecast is predicting long range weather conditions or making ***climate forecasts***. For example, it is often the case that one hot and dry month will be followed by another hot and dry month. So, making persistence forecasts for monthly and seasonal weather conditions requires a lot of skill. Some of the other forecasting methods, such as numerical weather prediction, lose all their skill for forecasts longer than 10 days. This makes persistence a "hard to beat" method for forecasting longer time periods.

Climate Forecasts: Forecasting climate conditions over a long period of time, usually years

Trends

The Trends Method involves determining the speed and direction of movement for fronts, high and low pressure centers, and areas of clouds and precipitation. Using this information, the forecaster can predict where he or she expects those features to be at some future time. For example, if a storm system is 1000 kilometers west of your location and moving to the east at 250 kilometers per day, using the trends method you would predict it to arrive in your area in 4 days.

Mathematically, this is how this works out:

1000 km ÷ 250 km per day = 4 days

Using the trends method to forecast only a few hours into the future is known as "Nowcasting" and this method is frequently used to forecast precipitation. For example, if a line of thunderstorms is located 60 kilometers to the northwest and moving southeast at 30 kilometers per hour, you would predict the storms to arrive in your area in 2 hours. Below is an example of using the trends method to forecast the movement of a cold front. Initially, the cold front moved 600 kilometers during the first 24 hours, from the central Quebec to the Gulf of St. Lawrence. Using the trends method, you would predict this weather system to move another 600 kilometers in the next 24 hours, reaching the east coast of Newfoundland and Labrador. The trends method works well when systems continue to move at the same speed in the same direction for a long period of time. If they slow down, speed up, change intensity, or change direction, the trends forecast will probably not work as well.

Climatology

The Climatology Method is another simple way of producing a forecast. This method involves averaging weather statistics accumulated over many years to make the forecast. For example, if you were using the climatology method to predict the weather for St. John's on July 1st, you would go through all the weather data that has been recorded for every July 1st and take an average. If you were making a forecast for temperature and precipitation, then you would use this recorded weather data to compute the averages for temperature and precipitation.

If these averages were 22 degrees with 3 mm of rain, then the weather forecast for St. John's on July 1st, using the climatology method, would call for a high temperature of 22 degrees with 3 mm of rain. The climatology method only works well when the weather pattern is similar to that expected for the chosen time of year. If the pattern is quite unusual for the given time of year, the climatology method will often fail.

Analog

The Analog Method is a slightly more complicated method of producing a forecast. It involves examining today's forecast pattern and remembering a day in the past when the weather pattern looked very similar. This would produce an event similar to current conditions for comparing later. The forecaster would predict that the weather in this forecast will behave the same as it did during the earlier event.

For example, suppose today is very warm, but a cold front is approaching your area. You remember similar weather conditions last week, also a warm day with cold front approaching. You may also remember how heavy thunderstorms developed in the afternoon as the cold front pushed through the area. Therefore, using the analog method, you would predict that this cold front will also produce thunderstorms in the afternoon.

The analog method is difficult to use because it is virtually impossible to find a perfect analog. Weather events are rarely experienced in the same locations as they were in the past. Even small differences between the current time and the previous event can lead to very different results. However, as time passes and more weather data is collected and stored, the chances of finding a "good match" event for the current weather situation should improve, and so should analog forecasts.

Numerial Weather Prediction

Numerical Weather Prediction (NWP) uses the power of computers to make a forecast. Complex computer programs, also known as forecast models, run on supercomputers and provide predictions on many atmospheric ***variables*** such as temperature, pressure, wind, and rainfall. A meterologist examines how the features predicted by the computer will interact to produce the day's weather.

Variables: Are the things or conditions that have the capacity to change

The NWP method is flawed in that the equations used by the models to simulate the atmosphere are not perfect. This leads to some error in the predictions. In addition, since there are many gaps in the initial data this causes problems. For example, we do not receive many weather observations from areas in the mountains or over the oceans. If the initial conditions are not completely known, the computer's prediction of how those conditions will develop may not be entirely correct.

Despite these flaws, the NWP method is probably the best of the five discussed here at forecasting the day-to-day weather changes. Very few people, however, have access to the computer data. In addition, the beginning meteorologist does not have the knowledge to interpret the computer forecast, so the simpler forecasting methods, such as the trends or analogue method, are recommended for the beginner.

Analysis

1. What are the five methods of weather forecasting?
2. Which method requires the least amount of training and technology?
3. Which method uses past weather patterns to predict current weather?
4. Why is the numerical weather prediction method flawed?
5. Which method provides the best forecasting of day to day weather? Why?

Extension

1. Ask students to go to http://weatheroffice.ec.gc.ca/satellite/index_e.html, and then choose one of the current satellite images for Eastern Canada. Based on the image, make a precipitation forecast for the next 24 hours for their region of the province.

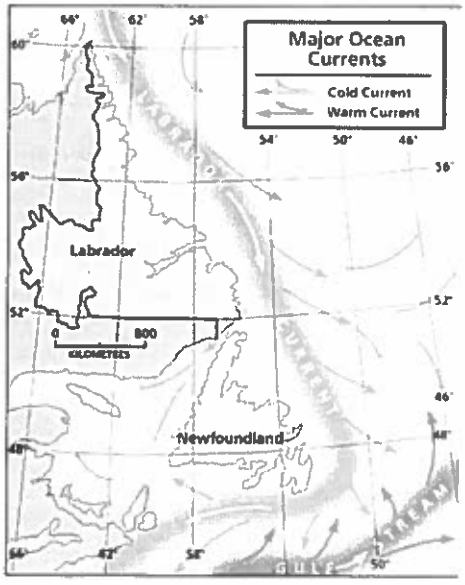
Newfoundland and Labrador Climate

Newfoundland and Labrador has some of the most variable climate and weather conditions in Canada and the world. As one favorite saying goes "If you don't like the weather, wait 10 minutes and it'll change". The physical geography, closeness to the Atlantic Ocean, air movements, and global location help explain many of the unique features of our province's climate and weather.

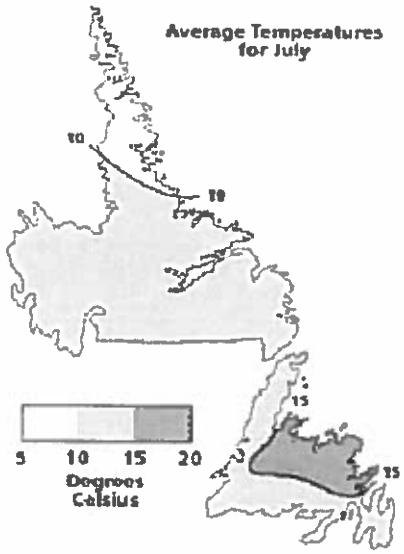
Geography

The island portion covers 5 1/2 degrees of latitude, about the same as the Great Lakes. Labrador covers about 9 degrees of latitude. The southern extremity lies close to the forty-seventh parallel, approximately the same latitude as Seattle and Paris. The northern extremity lies close to the sixty-first parallel, about the same as Yellowknife. The island covers an area of 111 390 km^2, while Labrador has 294 330 km^2, with elevations ranging from sea level to above 1600 m. This geographical spread contributes to the variability in climate and weather from one region to another. For example, Labrador winters tend to be drier and colder than the island. Central and western regions of the island tend to be snowier in the winter and hotter in the summer than Eastern regions.

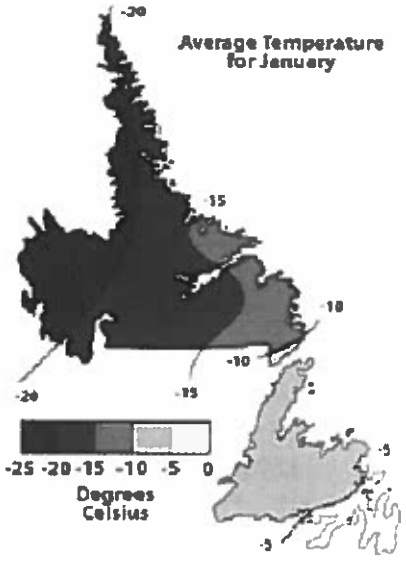
Ocean Influence



It is said the people here live on, by, and from the sea. On the island, no place is more than 100 km from the ocean, and therefore every part of the island is subject to the year-round influences of the cold waters surrounding the island and down the Labrador coast. Many of the communities of Labrador are on the coast or close to it. Surface water temperatures on the eastern side of the island range from summer highs of 11 °C to 13 °C inshore and 8 °C to 11 °C offshore with winter lows of -1 °C inshore and +2 °C offshore. Sea temperatures on the western side are warmer than the eastern side by 1 °C to 3 °C. The open sea keeps winter air temperatures a little warmer and summer air temperatures slightly cooler along the coast than inland. This is due to the two major ocean currents that pass by our province. From the north, bringing cold Arctic water, is the Labrador Current. This current helps keep our province slightly cooler in the summer than other parts of Canada. From the south, bringing warm tropical water, is the Gulf Stream. This current helps keep some areas of the island slightly warmer in the winter than others parts of Canada.



Because of the effect of the ocean on our climate, the island of Newfoundland experiences a maritime climate where there are generally milder winters and cooler summers. Labrador's climate has more Arctic influences due to the larger land mass and air movements from it. A marine climate generally causes more changeable weather, lots of precipitation in a variety of forms (sometimes all at once), higher humidity, lower visibility, more cloud, less sunshine, and stronger winds than a continental climate.



Air temperatures on the island are directly affected by the presence of the Atlantic Ocean. Winter temperatures on the island of Newfoundland show the day-to-day variability that is characteristic of a stormy maritime climate. Movements of moist, mild Atlantic air of the ocean are frequent. There is also a noticeable difference between inland and coastal temperatures. In the interior, winter temperatures average between -6 °C and -10 °C, whereas on the southeast coast, where the moderating influence of the ocean is greatest, the winter average is between -2 °C and -4 °C. The lowest Newfoundland temperature on record is -41.1 °C, set at Wooddale (Central Newfoundland) on February 4, 1975.

Prevailing Winds

There are few physical barriers to protect the island of Newfoundland from weather systems sweeping across it. Its situation on the eastern side of North America

favours strong seasonal changes in the visiting air masses. Due to prevailing westerly winds that move air from across North America and up from the equator, there are plenty of low clouds, heavy precipitation, and strong winds over the island of Newfoundland. This is evident by the number of storms that pass over and near the island on an annual basis. Indeed, many of the storms that cross North America during the year from west to east, or develop and intensify off the East Coast of the United States, pass near the island while they move out to the North Atlantic. The result is that Newfoundland and Labrador has a deserved reputation as one of the stormiest parts of the continent. It also has some of the most changeable weather anywhere. At all times of the year Newfoundland is near one of the principal ***storm tracks***. The severity and frequency of storms is greatest between November and March, although they may occur at any time of the year. In fact, some of the most severe storms ever recorded, have been observed off our coasts. The movie "The Perfect Storm" is a good example of how strong storms develop off Newfoundland and Labrador.

Storm Tracks: Are the paths that storms take as they move from one region to another

Cyclones: In the Northern Hemisphere, a closed counter-clockwise movement of air

Winter ***cyclones*** are fast-moving storms (up to 80 km/h) that bring abundant and varied precipitation in the form of snow, sleet, freezing rain or rain. They pose a serious threat to fishermen, commercial shipping, and offshore oil and gas exploration activities. Winds often mount to gale and sometimes hurricane force. Hardly a winter goes by without at least three or four East Coast gales. Blizzards occur frequently in Newfoundland and Labrador. A common part of winter public forecasts include weather warnings and blizzard warnings. (See **STSE 2-2 Supplement A**) The official Environment Canada definition states a blizzard, in general, is a winter storm lasting for at least three hours with winds exceeding 40 km/h and visibility reduced to under a kilometer by falling or blowing snow. Typically air temperatures of -7 °C are required, however falling snow is not. Many blizzards result from already fallen snow blowing around. The application of the term blizzard differs from region to region across Canada.

Occasionally, throughout the year, large rotating storm centers are prevented from moving out of the region by an upper atmosphere air mass. The resulting cool, cloudy, and rainy weather associated with the system may persist for a week or more.

During the summer and early fall, Newfoundland weather is typically less stormy. However, in the fall, there are tropical storms that begin near the equator and develop in the Caribbean. These may bring windy, wet weather while they pass by the island. They eventually die or gain new strength in the North Atlantic. Over the past thirty-five years, an average of one tropical storm per year has passed within 300 km of Newfoundland and Labrador. One of the most notorious of these was the "Independence Hurricane" that struck eastern Newfoundland on September 9, 1775. About 4000 sailors, mostly from the British Isles, were reported to have been drowned. On September 5, 1978, another violent storm, Hurricane Ella, passed south of Cape Race. Her winds exceeded 220 km/h. At St. John's, 45 mm of rain fell and winds reached 115 km/h.

Analysis

1. Identify four things that influence the climate of Newfoundland and Labrador.
2. What ocean currents directly affect the climate of Newfoundland and Labrador?
3. Are climate conditions the same throughout this province? Explain.
4. How do wind patterns affect our climate?
5. What is a storm track?
6. What is a blizzard?

Extension

1. Ask students to go to http://www.pnr-rpn.ec.gc.ca/air/wintersevere/quiz.en.asp and take the weather quiz. There are many interesting facts to learn here.

Resources

Resource page: http://www.pnr-rpn.ec.gc.ca/air/wintersevere/weatherwords.en.html

World Meteorological Organization
http://www.wmo.ch/index-en.html

WW 2010 – The Weather World 2010 Project, University of Illinois
http://ww2010.atmos.uiuc.edu/

Environment Canada – Understanding Your Forecast
http://www.msc-smc.ec.gc.ca/cd/brochures/forecast_e.cfm#3

Environment Canada – The Climate of Newfoundland
http://www.ns.ec.gc.ca/climate/nfld.html

Envirozine – Canada's Online Weather Magazine
http://www.ec.gc.ca/EnviroZine/english/issues/04/print_version_e.cfm?page=feature1

Winter Warning Criteria
http://www.pnr-rpn.ec.gc.ca/air/wintersevere/warning.en.html