Hazard Risk Analysis

Atmospheric

(related to weather and climate)

Atmospheric Hazards

This section introduces a number of atmospheric hazards: Blizzards, Climate Change, Droughts, Extreme Cold, Fog, Frost, Hailstorms, Heat Waves and Heat Domes, Hurricanes and Post-Tropical Storms, Ice Fogs, Ice Storms and Freezing Rain, Lake Effect Storms, Lightning and Thunderstorms, Microbursts (strong wind caused by downdraft), Sea Storms and Storm Surges, Seiche (atmospheric disturbance over water), Snowstorms, Tornadoes and Waterspouts, and Windstorms. As you will see when completing the risk analysis, all are caused by nature but a few are also caused by people (human-caused). The following hazards are weather related. Don't confuse your community's ability to cope with the hazard (e.g., a blizzard) with the likelihood of it occurring. For example, you may experience blizzards regularly and thus cope very well – but that doesn't change the fact that blizzards are very likely to occur.

Blizzards - Natural

Definition

Although blizzard is often used to describe any major snow storm with strong winds, a true blizzard lasts at least 3 hours in duration; has low temperatures (usually less than minus 7°Celsius or 20F); strong winds (greater than 55 km/h or 35 mph); and blowing snow which reduces visibility to less that 1 kilometre (0.6 miles). Snow does not need to be falling as long as the amount of snow in the air (falling or blowing) reduces visibility to less than 400m(0.2miles). The difference between a blizzard and a snowstorm is the strength of the wind, not the amount of snow. Blizzards usually form when cold air collides with warmer air. Blizzard conditions in the North are often accompanied by very cold temperatures. A snowsquall (or snow squall) is a sudden moderately heavy snow fall with blowing snow and strong, gusty surface winds. It is often referred to as a whiteout and is similar to a blizzard but is localized in time or in space and snow accumulations may or may not be significant.

Discussion

Blizzard conditions occur most often in unforested areas where there are no trees present to break the effects of the wind. Blizzards are considered to be the most dangerous of winter storms. Combining strong winds, low temperatures and poor visibility, blizzards wreak havoc on traffic, buildings, and livestock.

A significant effect associated with blizzards is the disruption of power and communication lines. Blizzard conditions are often accompanied by freezing rain or sleet and the combination of wind blowing and freezing rain causes large buildups of ice on transmission lines, which quickly break. In some areas, such as the leeward shores and coves along large bodies of water, bursts of wind can greatly intensify the blizzard conditions, resulting in a number of serious impacts upon living conditions in rural and urban areas. Blizzard conditions in Northern and remote communities can cause school closures, delay flights, reduce food and fuel supply, reduce mobility, and can result in frostbyte (freezing of skin), hypothermia (a decrease in the core body temperature to a level at which normal muscular and cerebral functions are impaired), other injuries, and death.

Scientists predict that climate change will have direct impacts on the frequency and intensity of blizzards. Global sea temperatures have increased and this change results in higher temperatures above the sea level and so although this will lead to shorter snow seasons but the storms will be more intense.

It Happened Here…

On January 19 2020, a blizzard left as much as 76.2cm (30 inches) of snow on St John's, Newfoundland, and packed wind gusts as high as 130km/h (81mph). The snowfall was an all-time record for the day. A state of emergency was declared and businesses and the international airport were closed. The Canadian military was deployed to assist. The blizzard was described as a bomb blizzard, a blizzard within a cyclone which is when a cyclone undergoes bombogenesis, which occurs when the cyclone drops 24 millibars over 24 hours and happens when a cold air mass collides with a warm air mass, such as air over warm ocean waters. The formation of this rapidly strengthening weather system is a process called bombogenesis, which creates what is known as a bomb cyclone.

In February 2013, a blizzard of historic proportions with as much as 60 cm of snow fell along the Atlantic coast from New York City to Halifax and beyond. The storm left tragedy in its wake as four people in Ontario died amid treacherous roads and blinding blizzards. Following the storm, wind chills dipped close to -30 in blowing snow. Road conditions deteriorated rapidly and hundreds of motorists in Quebec were involved in collisions or ended up in a ditch. Over Atlantic Canada, the storm got a second wind and turned into a powerful nor'easter energized by cold air to the north, warm air to the south and an infusion of energy from warm Gulf Stream waters. The worst of the

storm was felt south of the border with as much as a metre of snowfall and hurricane-force winds cutting power to hundreds of thousands and leading to 18 deaths in New York and New England. Nova Scotia got the worst winds, upward of 140 km/h., while east of Yarmouth at Woods Harbour and Cape Sable Island extreme gusts peaked at 164 km/h. A storm surge at Shelburne, Nova Scotia was the biggest since a major storm nearly 40 years ago. The storm blew the roof off mobile homes and damaged the fronts of some retail stores. Many trees were toppled and power outages left thousands throughout the Maritimes in the dark. The storm surge at high tide flooded roads, damaged docks and shore buildings, and lifted boats onto wharves on Cape Sable Island. The majority of flights at Halifax were cancelled and nearly all Marine Atlantic ferries stayed tethered to shore over the weekend. In places, chunks of floating ice and large rocks were pushed or tossed onshore landing on the front steps of homes and shops.

In January 2008, residents of Whale Cove (population 353), among other communities of Hudson's Bay's western coast in Nunavut, experienced a seven-day blizzard. The event resulted in closures of government offices, schools and banks, as well as delayed flights and mail service. Drifting snow was propelled by winds reaching speeds of 100 km/h, and temperatures dropped to -30°C with -57°C wind chills. There were no deaths or injuries, though food was in scarce supply by the end of the blizzard.

On January 10, 2007, Saskatoon was effectively shut down, as 25 centimetres of snow piled up and winds gusted between 70 and 90 km/h. Snowdrifts blocked roads and highways were closed because of the storm. Two people perished of hypothermia after trying to walk from their stranded vehicles. After the winds calmed, the city was left with around $1 million in cleanup costs.

On 27-29 February 2004, in Cartwright, Labrador: Blowing snow driven by a powerful blizzard battered parts of eastern Labrador. Snowfall at Cartwright over three days measures 121 cm (47.6 inches). With wind gusts in excess of 110 km/h (69 mph), blowing snow reduced visibility to zero.

Blizzards

Hazard Rating	High Risk ☐	Low Risk ☐	Need More Info ☐	Not Applicable ☐

Yes	No	Need More Info	Not Applicable	FACTORS
☐	☐	☐	☐	Blizzards are most likely to occur where they have occurred in the past. Has your community experienced blizzards in the past?
☐	☐	☐	☐	Blizzards occur during below-freezing temperatures. Does your community have cold winters?
☐	☐	☐	☐	Flat and open areas are at greater risk for blizzard weather. Is your community located in a plain or prairie, or in a tundra region?
☐	☐	☐	☐	Blizzards are more likely to occur in an inland (continental) climate. Is your community located away from the ocean?
☐	☐	☐	☐	Blizzards can also occur in certain oceanside communities when weather conditions can quickly change. Is your community located in Eastern Canada, where cold arctic air can meet with warm air from the south?
☐	☐	☐	☐	**In Canada, the areas that experience the most hours of blizzards extend from Resolute, Nunavut to Churchill, Manitoba. Is your community in this area?
☐	☐	☐	☐	Have Traditional Knowledge holders identified blizzards as a hazard in the past?

Climate Change - Natural and Human Induced

Definition

The Intergovernmental Panel on Climate Change (IPCC) states that “Physical and biological systems on all continents and in most oceans are already being affected by recent climate changes, particularly regional temperature increases.” There are strong indications that climate change is linked to human activity and that global warming cannot be solely attributed to natural variations in the climate.

Other impacts of climate change have been added where applicable to specific hazards. For example, projected increased rain and snow falls is predicted to increase the likelihood of snow-melt floods.

Discussion

Climate change is strongly affecting many aspects of systems related to snow, ice and frozen ground (including permafrost – frozen subsoil in polar regions) and evidence shows changes in rivers, lakes and streams, water resources, coastal zones and oceans.

Effects due to changes in snow, ice and frozen ground (including permafrost) include ground instability in permafrost regions, a shorter travel season for vehicles over frozen roads in the Arctic, enlargement and increase of glacial lakes in mountain regions and destabilization of moraines (soil and rock) damming these lakes, changes in Arctic and Antarctic Peninsula flora and fauna including predators higher in the food chain, and changes in Indigenous livelihoods in the Arctic.

Permafrost underlies 40% of Canada’s landmass, contains twice as much carbon as the atmosphere, and northern Canada is warming about three times as fast as the rest of the world. The increased warming of the North could be part of a permafrost carbon feedback loop — as the climate warms and the more permafrost thaws it releases more greenhouse gasses, which further warm the climate and thaws more permafrost. This results in forests being lost, lakes and ponds disappearing or forming in new locations, and buildings cracking.

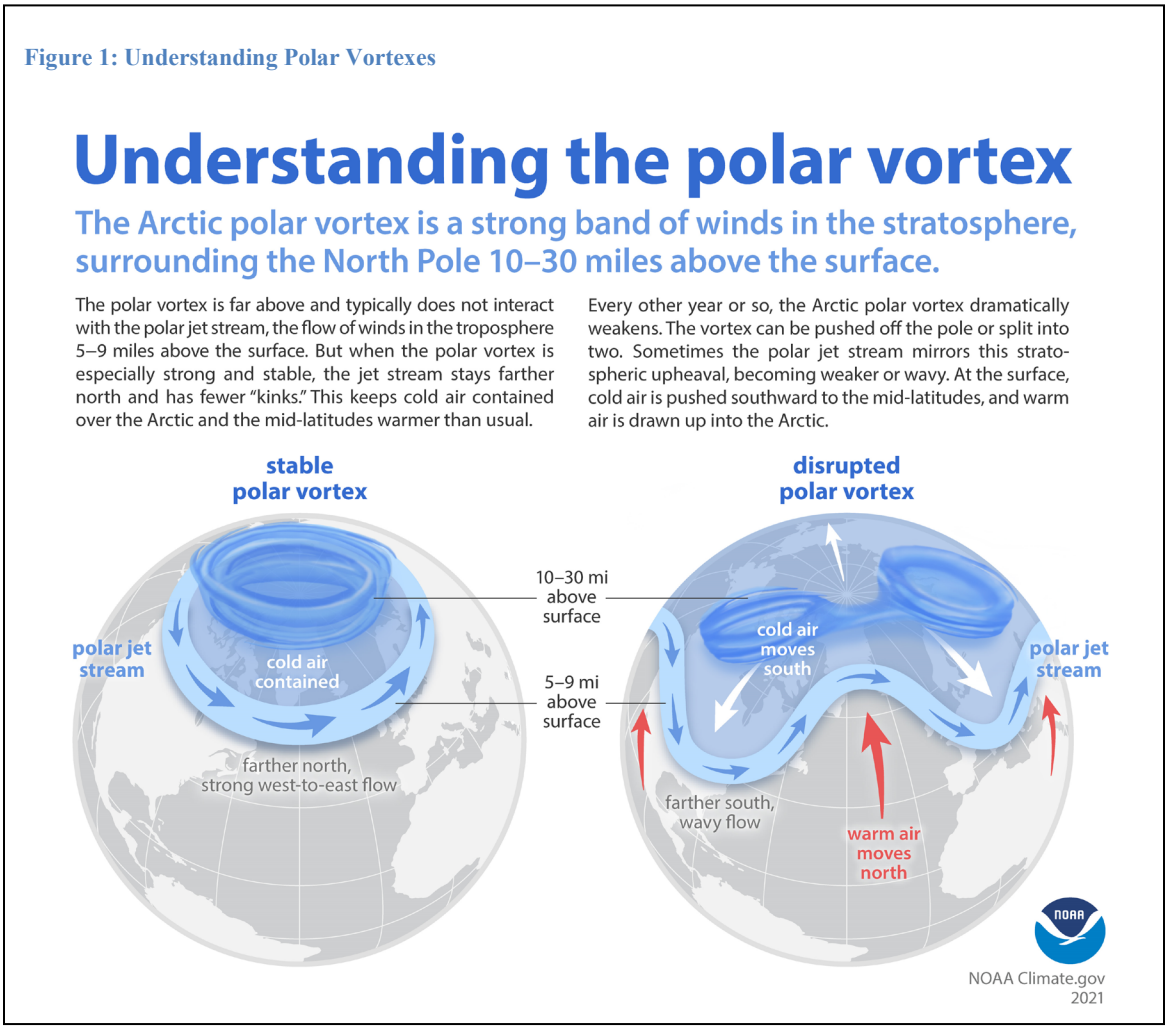
The spring peak discharge is occurring earlier in rivers affected by snow melt, and there is evidence for enhanced glacial melt. Lakes and rivers around the world are warming. The effects of sea-level rise, enhanced wave heights, and intensification of storms are found in some coastal regions – including those not modified by humans, e.g., polar areas and barrier beaches – mainly through coastal erosion. Sea-level rise is contributing to losses of coastal wetlands, and increased damage from coastal flooding in many areas.

Climate change also appears to be affecting weather and temperatures in terms of its effects on on the polar vortex. The polar vortex is not unusual and typically pushes colder air into Canada in most years. However, climate change can influence the behaviour of polar vortexes. Part of the contributing factors are that while the temperature of the world has increased by approximately 1C over the past 100 years, the temperature in the Arctic has increased by 4C. Thus, the temperature differences between the warm temperatures around the equator are not differentiated by as much as those from the Arctic. This change may be leading to weather instabilities that were not prevalent in the past, and of note in regards to the polar vortex.

These changes do not always influence winter weather in the mid-latitudes (in the USA), but when they do, the effects can be extreme for the southern states and result in frigid temperatures and snowfalls. The effects of changes in the usual polar vortex in Canada are

two-fold as it results in increased warm temperatures in northern Canada and colder temperatures in the southern part of Canada.

Figure 1: Understanding Polar Vortexes



It Happened Here…

Changes in the polar vortex resulted in breaking cold weather records in Alberta, Saskatchewan and Manitoba (see Extreme Cold) and warmer than usual temperatures (2C) in eastern Nunavut. Further effects were noted in blizzard and whiteout conditions in Newfoundland and Labrador and snow squalls in Ontario.

In June 2021, a heat dome began in British Columbia and gradually moved east through Alberta and the prairies. The impacts of climate change contributed to the occurrence and temperature records were broken every day along with hundreds of wildfires igniting. See *Heat Waves and Heat Domes* and *Wildfires* for additional information.

On May 02, 2019 it was reported that abrupt permafrost thawing had caused a large landslide into a side channel of the Mackenzie River in the Northwest Territories. Wildfires, becoming larger and hotter every year over the Canadian boreal forest, are also causing rapid permafrost thaw and nearly one-fifth of Arctic permafrost is now vulnerable to rapid warming, including the lowlands south of Hudson Bay.

As reported in June 2010, the Quebec village of Salluit (population 1,201) is just one of many Arctic towns trying to adapt to an increasingly warmer climate. It has seen its fire hall sink and roads buckle in the melting permafrost and buildings are cracking. As well, rising temperatures are being blamed for the rapidly eroding coastline of Tuktoyaktuk, N.W.T., and unprecedented floods that knocked out two bridges in Pangnirtung, Nunavut.

Climate Change

Hazard Rating	High Risk ☐	Low Risk ☐	Need More Info ☐	Not Applicable ☐

Yes	No	Need More Info	Not Applicable	FACTORS
☐	☐	☐	☐	Although scientists are not in agreement as to how high ocean levels will rise in the upcoming years, there is agreement that ocean levels are rising. Is your community near the ocean and only a few metres above sea level?
☐	☐	☐	☐	The spring peak discharge is occurring earlier in rivers affected by snow melt, and there is evidence for enhanced glacial melt. Is your community near rivers that experience spring flooding?
☐	☐	☐	☐	Warmer temperatures are leading to enlargement and increase of glacial lakes in mountain regions and destabilization of moraines (soil and rock) damming these lakes, increasing the risk of flooding. Is your community near glacial lakes with moraines damming these lakes?
☐	☐	☐	☐	Climate change is bringing changes in Arctic flora and fauna including predators higher in the food chain, invasive species, pests, and changes in Indigenous livelihoods in the Arctic. Is your community in the Arctic? Is your community experiencing new predators, invasive species or pests? In your community are Indigenous livelihoods being affected by changes in flora or fauna? (e.g., changes in sea ice cover can affect hunting practices and access to traditional prey)
☐	☐	☐	☐	Climate change is causing ground instability in permafrost regions, and a shorter travel season for vehicles over frozen roads in the Arctic. Is your community experiencing ground instability due to thawing of permafrost? Is your community affected by a shorter travel season for vehicles over frozen roads?
☐	☐	☐	☐	Climate change is causing more variability in local weather (including temperature). Over the last decade there has been an increase in heat waves (hot air days) where temperatures do not subside overnight, increasing the risk to human health and permafrost regions. Does your community have more heat waves or has your community experienced an increase in hot air days?
☐	☐	☐	☐	Climate change is having impacts on the movement of the polar vortex which can result in warmer winter temperatures in the North and colder temperatures primarily in Alberta, Saskatchewan and Manitoba. Has your community been experiencing colder winter temperatures?
☐	☐	☐	☐	Have Traditional Knowledge holders identified noticeable changes in temperature, weather-related events and/or local fauna and flora habitats?
☐	☐	☐	☐	Have Traditional Knowledge holders identified blizzards as a hazard in the past?

Drought

Definition

Drought results from an abnormal water shortage or deficiency – or simply put, abnormally low water levels or availability. While drought is often measured in terms of water shortage, it displays itself in crop failures, dust storms, and polluted water supplies. These effect in turn have a (negative) impact on the economy and the environment.

Discussion

Droughts are usually due to natural causes, but are made worse by growing demands (for example increased pumping of ground water for agricultural activities) , urbanization and other human conditions. Agricultural losses (crop failures) are often most reported, but many other resources and commercial activities are affected.

Forest fires are largely the product of drought. Decreased water levels in lakes and streams can greatly affect ships navigating (inland) streams , fish production, recreation and hydropower generation (the production of electricity through the use of running water) . Crop failure, as a result of drought, can lead to extensive food shortages. Each drought is different, although many droughts appear cyclic in nature, and there may be many years between droughts. In arid regions of the world, which occupy over one-third of the world's land, droughts may appear to be endless. But drought occurs in every type of climate; the intensity, duration and area of impact fluctuates greatly from locality to locality.

While the primary cause of drought is variations in the climate which produce less precipitation (rain or snow) than expected, there are many other underlying factors which need to be considered. The main causal factors to be considered are degradation of the land (through agriculture, logging), climate changes and increased water usage (excessive pumping).

Recent studies have identified two spatially well-defined regions with different temporal evolution of droughts – the Canadian Prairies and northern central Canada. The analyses also revealed the presence of a dominant periodicity of between 8 and 32 months in the Prairie region and between 8 and 40 months in the northern central region.

It Happened Here…

The summer of 2021 is indicating drought conditions across Canada, but especially in Manitoba and Saskatchewan where moisture levels have been low since the fall of 2020. Ontario has only seen 50% of rainfall in the spring of 2021. Crops are threatened across the country, especially in the prairies where farms are the driest since 1988.

The spring of 2009 was the driest in 50 years for agriculture producers in the Canadian Prairies. Drought affected the majority of southern Alberta and Saskatchewan, including the small town of Balgonie (population 1,384) in Saskatchewan. Saskatoon, near Balgonie, had less than 25% of the average precipitation during March, April and May, which was the driest since 1892.

From 2000-2004, some have dubbed this drought the most severe in 800 years. It affected much of western North America, creating havoc for Prairie farmers who rely on water for their livelihood. While it didn’t last as long and wasn’t as bad in Canada, the drought had severe economic consequences for Canada. It was estimated that in 2001 and 2002, agricultural production decreased by $3.6 billion. In 2002, there was no farm income in Alberta and Saskatchewan was at a loss.

In 1992, the Canadian Prairies experienced drought causing $575,352,000 in damages. Livestock yields were low in northern Alberta due to dry conditions; severe and widespread surface water droughts were reported on the Prairies. It was the coldest July since 1884. One of the associated

causes with the increasing intensity of drought in the Prairies is climate change, linked to greenhouse gas emissions generated by humans. The small livestock farming town of Eaglesham, Alberta (population 159) was one of the many affected.

Drought - Natural

Hazard Rating	High Risk ☐	Low Risk ☐	Need More Info ☐	Not Applicable ☐

Yes	No	Need More Info	Not Applicable	FACTORS
☐	☐	☐	☐	** Lower rainfalls in the fall and the spring, and lower snowfalls in the winter, can lead to drought conditions. Are there areas in your community that frequently receive below average rainfall?
☐	☐	☐	☐	**Are there areas in your community that receive constant and/or frequent dry weather?
☐	☐	☐	☐	Are there areas in your community with frequent winds coming from land (as opposed to the ocean)? This indicates low water vapor content in the air.
☐	☐	☐	☐	Are there areas in your community where there is relatively little silt in the soil? Silt holds water and can help prevent drought.
☐	☐	☐	☐	Scientists have observed that in some regions in Canada there have been reduced levels of rainfall over the summer which has led to declines in summer soil-moisture levels. Low moisture levels could result in significant declines in summer and autumn runoff in these regions and lead to drought conditions. Has your community experienced decreases in summer rainfalls?
☐	☐	☐	☐	Have Traditional Knowledge holders identified noticeable changes in temperature, weather-related events and/or local fauna and flora habitats?

Drought - Human-caused

Hazard Rating	High Risk ☐	Low Risk ☐	Need More Info ☐	Not Applicable ☐

Yes	No	Need More Info	Not Applicable	FACTORS
☐	☐	☐	☐	Are there areas in your community where reservoir (aquifers, groundwater, fresh water) levels are dropping?
☐	☐	☐	☐	Are there areas in your community that use excessive irrigation?
☐	☐	☐	☐	Are there areas in your community that have been over-farmed, excessively irrigated, deforested, or eroded? These factors can also prevent the land from capturing and holding water.
☐	☐	☐	☐	Are there areas in your community in which vegetation cover has been lost over time due to human activities? This increases likelihood of wind erosion and drought.
☐	☐	☐	☐	Is your community located on the Canadian Prairies? This region of Canada is at higher risk of drought because of agriculture dependence and the primary water supply is surface water (as opposed to an aquifer, for example).
☐	☐	☐	☐	Have Traditional Knowledge holders identified noticeable changes in temperature, weather-related events and/or local fauna and flora habitats?

Extreme Cold - Natural

Definition

Climatologists define a very cold day as one on which the minimum temperature is below -20°Celsius. January is typically the coldest month of the year.

Discussion

Extreme cold conditions are most likely to occur in January, but may occur throughout the winter months. Not only is the actual temperature of concern, but the Wind Chill Factor can result in further cooling as a result of the combined effect of temperature and wind. With the wind chill factor, temperatures of -40°C to -47°C or higher are considered to be of high risk and exposed skin can freeze in five to ten minutes. If temperatures reach -55°C Environment and Climate Change Canada considers that outdoor temperatures are hazardous, exposed skin can freeze in less than two minutes and no-one should venture outdoors.

Colder temperatures can follow variations in the polar vortex. A polar vortex contains cold Arctic air and the jet stream loops south, that cold air can move into Canada, bringing colder air than usually experienced over the winter months.

It Happened Here…

In February 2021, Canada experienced its coldest temperatures in years. Wekweeti in the Northwest Territories confirmed a -51.9C temperature, the coldest in four year. The cold temperatures were brought on the remnants of a polar vortex with some areas experiencing temperatures of -60C with wind chill. The polar vortex broke cold records across the western provinces with Uranium City, Saskatchewan. tying their all-time cold record at -48.9 C while Fort Chipewyan, Alberta set a new record of -47.2 C.

On January 30, 2019, Environment Canada issued an extreme cold warning from central Saskatchewan to eastern Quebec and through much of Nunavut and advised people to be mindful of the extremely dangerous conditions, frostbite and the safety of their pets. The bitter cold was the result of a split in the polar vortex that allowed temperatures to plunge much farther south in North America than normal.

Bitterly cold arctic air has moved into southern Ontario overnight with overnight low temperatures near minus 20 degrees Celsius combined with strong southwest winds and wind-chill values in the range of minus 30 to minus 35. At 7 a.m. CT, it was -40C in Winnipeg and felt like –50 with the wind chill. Dozens of schools in the province were closed due to the extreme cold.

In January 2008, many cities in the Northwest Territories experienced a severe and long cold stretch—one of its longest in years. Fort Providence (population 727) was amongst the communities affected by nine days of -40°C weather. Emergency shelters were in full use and the Yellowknife School Board closed schools as a result.

With a wind chill factor of -40°C on January 28, 2008 at least seven school divisions in rural southern Manitoba cancelled classes including the Fort La Bosse, Hanover, Seine River, Sunrise, Prairie Spirit, Rolling River, Pine Creek and Beautiful Plains divisions.

Extreme Cold

Hazard Rating	High Risk ☐	Low Risk ☐	Need More Info ☐	Not Applicable ☐

Yes	No	Need More Info	Not Applicable	FACTORS
☐	☐	☐	☐	Extreme cold events are likely to occur where they have occurred in the past. Has your community previously experienced extreme cold (below -30^0 Celsius) in the winter?
☐	☐	☐	☐	Frequent below-freezing temperatures can increase risk of frostbite (exposed skin freezing) or hypothermia. Does your community experience frequent below-freezing temperatures in the winter?
☐	☐	☐	☐	Extreme cold is more likely to occur in a continental climate. Is your community located towards the middle of the continent (away from the ocean)?
☐	☐	☐	☐	Arctic air masses and cold fronts can increase risk of frostbite and hypothermia. Is the influence of arctic air masses/cold fronts felt in your community in the winter? (Check Risk Analysis Resources – Air Masses)
☐	☐	☐	☐	Variability in the polar vortex can result in colder temperatures in the winter. Is your community experiencing colder temperatures than in the past?
☐	☐	☐	☐	Have Traditional Knowledge holders identified noticeable changes in temperature and snow or ice conditions?

Fog - Natural

Definition

Although we may not recognize it as such, fog is actually a cloud formed lying on the ground — even those patchy fogs which fill low spots or hollows in the terrain are cloud fragments. Fogs form when air saturates (its relative humidity reaches around 100 percent), and the water vapour within the air mass condenses on small particles in the air to form liquid cloud droplets. The air

may become saturated either by lowering its temperature to its condensation (dew) point or by adding water vapour into the air until it reaches saturation.

For weather observing purposes, fog is considered an obscurity in the surface layers of the atmosphere which is caused by a suspension of water droplets, with or without smoke particles present, and which is internationally defined as being associated with visibility less than 1,000 metres (1090 yards or 0.62 miles).

Discussion

Fog can form in different ways, due to different causes. Advection fog forms when humid air flows over cold ground or water. Precipitation fog forms as precipitation falls into drier air below the cloud, the liquid droplets evaporate into water vapor. The water vapor cools and at the dew point it condenses and fog forms. Overnight rain can enhance fog that forms in the morning. Radiation fog forms on generally clear, cool nights. Steam fog forms over water or moist land, often in the fall.

Precipitation fog forms when rain or snow falls. As precipitation falls into drier air below the cloud, the liquid drops or ice crystals evaporate or change directly into water vapor. The water vapor increases the moisture content of the air while cooling the air. This often saturates the air below the cloud and allows fog to form. Upslope fog is very common along large hills and mountains. It forms when winds blow up the side of a hill or mountain, which cools the air.

Valley fog forms in mountain valleys during winter and can be more than 1,500 feet thick. Often, the winter sun is not strong enough to evaporate the fog during the day. When the air cools again the following night, the fog often becomes thicker, which makes it even harder for the sun to burn it off the following day. Valley fog is essentially a radiation fog confined by local topography, and can last for several days in calm conditions, until strong winds blow the moist air out of the valley. The tendency for cool, dense air to pool at the bottom of valleys also enhances valley fog.

Sea smoke, also called steam fog or evaporation fog, is created by cold air passing over warmer water or moist land, most often in the fall. Sea fog is heavily influenced by the presence of sea spray and microscopic airborne salt crystals. Arctic sea smoke is similar to sea smoke, but occurs when the air is very cold. Instead of condensing into water droplets, the water vapor changes directly into ice crystals.

Freezing fog occurs when liquid fog droplets freeze to surfaces. The phenomenon is extremely common in the inland areas of the Pacific Northwest, with temperatures in the 10 to 30F (−12 to −1C) range.

The foggiest place in the world is the Grand Banks off the coast of Newfoundland, the meeting place of the cold Labrador Current from the north and the much warmer Gulf Stream from the south.

It Happened Here…

On March

In October 2013, thick fog blanketed British Columbia's Lower Mainland and Vancouver Island for a week to 10 days, making for one of the longest periods of fog ever seen in the region during that month. A stationary, strong ridge of high pressure stalled over the coast trapping air rich in moisture at the surface. With minimal wind and little rain, there was nothing to blow or wash the fog away. Inland the fog wreaked havoc leading to some early morning accidents that included one fatality. It also forced the cancellation of dozens of ferry trips, and was responsible for hundreds of flight delays and cancellations.

Poor visibility due to a heavy fog in the area around Miminegash, Prince Edward Island (population 176) caused a motor vehicle accident on November 16, 2010, resulting in one death.

On September 3, 1999 on a rural stretch of highway outside of Windsor, Ontario dense fog was a contributing factor to a 145-vehicle pileup which resulted in 8 lives lost and over 150 persons injured.

Fog - Natural

Hazard Rating	High Risk ☐	Low Risk ☐	Need More Info ☐	Not Applicable ☐

Yes	No	Need More Info	Not Applicable	FACTORS
☐	☐	☐	☐	Fog is most likely to occur where it has occurred in the past. Does your community experience fog?
☐	☐	☐	☐	Have Traditional Knowledge holders identified noticeable changes in fog conditions?
☐	☐	☐	☐	Fog is likely to occur in coastal areas. Is your community located close to the ocean or other large body of water?
☐	☐	☐	☐	Fog can be caused when warmer air overlies cooler air (temperature inversions). Do temperature inversions occur in or near to your community?
☐	☐	☐	☐	Steam fog is created by cold air passing over warmer water or moist land, often in the fall. Does your community experience fog regularly in the Fall?
☐	☐	☐	☐	Valley fog forms in mountain valleys during winter and can be more than 1,500 feet thick. Is your community in a mountain valley?
☐	☐	☐	☐	Upslope fog is very common along large hills and mountains. It forms when winds blow up the side of a hill or mountain, which cools the air. Is your community near a large hill or mountain?

Frost - Natural

Definition

Frost is the deposition of ice crystals on a surface directly from the water vapour in the air. The process is similar to dew formation except that the temperature of the object must be below freezing, the frost point. Another type of frost is called Hoar frost, which is the formation of interlocking ice crystals directly from the water vapour in the air on objects which usually are of small size and exposed freely to the air such as plant leaves and branches.

Discussion

Frost is a hazard to crops and can result in damaged trees and lower productivity. Deciduous fruit trees are particularly susceptible to damage from frost as are cereal (e.g., wheat, barley) crops. Serious frosts in the spring can result in permanent damage to fruit trees.

It Happened Here…

On June 6, 2018, an unusual "killer" frost caused widespread damage to crops in the Maritimes, with everything from Nova Scotian wine grapes to Island asparagus harmed by a sharp plunge in

spring temperatures. Environment Canada, said record lows were set early Monday; in Kentville, N.S., it dropped to almost -2 C, marking a huge shift from the 28 C high on Friday that had set off a growth spurt in a wide variety of crops before the frost hit.

On May 10, 2012, a large portion of Ontario's apple, peach, cherry and other fruit crops were wiped out by frost in April and farmers were looking for help in what appears to be a devastating season. Warm weather in March accelerated the growth cycle of fruit trees that was then followed by frost in April that killed off fruit buds and blossoms, leaving many of the trees barren this season

On June 9, 2009, two overnight frosts resulted in some Saskatchewan farmers reseeding their canola, a Canadian variant of rapeseed; and in Manitoba, the frost was the worst in memory for its frequency and area covered. With deadlines for full canola crop insurance ranging between June 10 and 20 in Manitoba and Saskatchewan, many farmers chose not to reseed.

On January 5, 1993, in the southwest of British Columbia, temperatures dropped to -7.5°C. Frost caused water pipes to burst and damaged fruit trees. The small town of Hedley (population 350) was among the many communities affected.

Frost - Natural

Hazard Rating	High Risk ☐	Low Risk ☐	Need More Info ☐	Not Applicable ☐

Yes	No	Need More Info	Not Applicable	FACTORS
☐	☐	☐	☐	Frost will usually occur in areas where it has occurred in the past. Does your community experience frost?
☐	☐	☐	☐	Have Traditional Knowledge holders identified noticeable changes in frost conditions?
☐	☐	☐	☐	The ideal conditions for frost formation are nights with clear skies, light winds, and temperature near or a little below freezing. Does your community experience many clear nights with temperatures hovering around freezing?

Hailstorms - Natural

Definition

Hail is precipitation in the form of balls or irregular lumps of ice. Hail usually has a diameter of 5 millimetres or more, while smaller particles are either ice pellets or snow pellets.

Hailstones are created by the gradual accumulation of layers of frozen cloud droplets around an initial ice crystal or a frozen water droplet. These hailstones are formed by the rapid rising of warm air into the high atmosphere, the presence of a large low pressure system, and the subsequent cooling of the air mass, resulting in the formation of ice.

Discussion

Hailstorms can occur anywhere in Canada, but the areas most susceptible to hailstorms are in Western Canada and in south-west Ontario. The impact and hazard of hailstorms is, in many respects similar to that of blizzard conditions, as agriculture and property are both often seriously damaged by hail. However, the damage caused by hail is most often in the form of crop

destruction, with some damage to buildings and automobiles, broken glass and the like. Hailstorms rarely cause fatalities. Hailstorms are particularly damaging as they tend to coincide with the time period at which agricultural crops are at their most vulnerable.

It Happened Here…

On June 13, 2020, a hailstorm pounded Calgary and the surrounding area, as chunks of ice the size of tennis balls ricocheted out of the sky. Wind-driven hailstones shattered windows and windshields, peeled the siding off homes and businesses, and coated the ground several inches thick. caused almost $1.2 billion in insured damage. The Insurance Bureau of Canada said the hail, rain and wind that hit Calgary, Airdrie and Rocky View County on June 13 were part of the costliest hailstorm and the fourth most expensive insured natural disaster in Canadian history.

In the summer of 2010, the Calgary area was hit with hailstones nearly four centimetres wide that dented cars and damaged homes. At the time, the storm shattered records, becoming the most expensive hailstorm in Canada, with damages costing around $400 million.

On June 9, 2008, a severe storm ripped through Chatham-Kent, pummeling wheat, corn and soybeans, and pock-marking hundreds of vehicles with golf-ball sized hail. Aluminum siding and roofs also took a beating. Just two weeks later, the same communities were slammed again.

On July 22 2008, a brief but severe thunderstorm hailed down on areas around Grimsby and Winona in the Niagara-St. Catharines region. At one orchard, 80 per cent of the peaches and pears were lost.

Hail insurance payouts to Saskatchewan growers in 2008 were the highest in history, at approximately $228 million. Nearly 21,000 claims were filed – 7,000 more than the previous year. The acreage affected was also a record. On virtually every day in July, hail occurred somewhere in Saskatchewan. Massive storms on July 9 and 10 pounded many of the same areas. Claims from those two days alone were estimated at $80 million.

In August 2007, a destructive hailstorm in Dauphin, Manitoba, for example, was only one of 279 ‘hailers’ that affected the Prairies in 2007. Crop-hail losses approached $200 million.

In 1995, several hailstorms struck southern Alberta, resulting in insured losses $200M in crop damage and $50M in home and vehicle damages. The small, rural community of Cereal, Alberta (population 126) was among the many affected by the hailstorms.

Hailstorms - Natural

Hazard Rating	High Risk ☐	Low Risk ☐	Need More Info ☐	Not Applicable ☐

Yes	No	Need More Info	Not Applicable	FACTORS
☐	☐	☐	☐	Hailstorms can be expected to occur where they have occurred in the past. Have hailstorms occurred previously in or near to your community?
☐	☐	☐	☐	Hailstorms may occur in the same regions that experience thunderstorms. Does your community experience thunderstorms, or meet most/all of the indicators for thunderstorms? (see section on Lightning and Thunderstorms further below)
☐	☐	☐	☐	Have Traditional Knowledge holders identified noticeable changes in the frequency and intensity of hailstorms in the community?
☐	☐	☐	☐	Hailstorms do not commonly occur in polar regions. Is your community located in one of the provinces?

Heat Waves and Heat Domes - Natural and Human-caused

Definition

A heat wave can take a number of forms. Such events can be characterized by temperatures significantly above the mean for an extended period; or by a combination of high temperatures with high humidity and a lack of air motion.

A heat dome happens when strong, high-pressure atmospheric conditions combine with influences from trade winds (La Niña) are even stronger than usual, which pushes more warm water toward Asia and brings cold, nutrient-rich water to the surface of the Pacific Ocean. This, in turn, pushes the jet stream northwards and when there are big changes in ocean temperatures from west to east during the previous winter, it can create large areas of excessive heat that get trapped under the high-pressure "dome."

Discussion

Of all of the atmospheric hazards, heat waves are perhaps the most difficult to quantify. Impacts of heat waves can range from crop losses, to forest fires, to high mortality due to heat prostration, or the aggravation of existing conditions such as high blood pressure or heart disease. Extended heat waves with drought conditions can increase potential for brush and forest fires, sometimes sparked by lightning strikes/or human caused such as by careless smokers or by sparks from trains or equipment.

Heat waves and domes also lead to situations where excessive power demands are made to run HVAC systems and air conditioners which can lead to power blackouts or brownouts. In addition excessive heat can result in damage to infrastructure such as submarine cables.

The effects of heat waves on physical health include heatstroke, heat exhaustion, heat syncope (fainting), and heat cramps. Heat stroke occurs when the internal temperature of the body reaches to more than 105 degrees Fahrenheit. Those affected by heatstroke are typically delirious or comatose, and it can lead to sustained neurological damage or even death. Heat exhaustion is a less severe condition with those affected experiencing dizziness, nausea,

disorientation, and excessive fatigue. Heat exhaustion is rarely fatal, and is easily redressed through rehydration and electrolyte balancing. Sodium and potassium salts help replenish the body's water and electrolyte levels after dehydration. Sodium is the main electrolyte found in extracellular fluid and is involved in fluid balance and blood pressure control.

Groups at high risk of the health impacts of heat waves include the very young, less than five years, and the elderly. Children are vulnerable as their internal temperature control mechanisms are immature and highly susceptible to variation; and the elderly are often not as cognizant of temperature variation, and may undertake high levels of activity, even during heat wave events, leading to as much as a 35 percent increase in deaths in this age group during heat waves.

It Happened Here…

In June 2021, a heat dome began in British Columbia and was gradually pushed east towards Alberta and the prairies. Temperature records were broken day after day, with the hottest ever recorded temperature in Canada, 49.6 C, occurring in Lytton, BC on June 29. Fifty-nine temperature all-time records were broken in a single day. Over 500 deaths are being attributed to the heat dome in B.C.

The heat dome also led to possible damage to the submarine power cable from the B.C. Mainland to Vancouver Island, where monitoring picked up a bulge and oil leak that was suspected as a result of the extreme heat and excessive demands on electricity during this period. The cable had to be taken out of service and alternate power sources had to be set up.

The Northwest Territories and Yukon broke 20 daily temperature records with a high of 38.1 C in Nahanni Butte, N.W.T., the highest temperature ever recorded in the region. As the heat dome spread east, Alberta broke 38 daily temperature records with a high of 41.5 C in the Grande Prairie area. Similarly, Saskatchewan and most of Manitoba were under a heat warning.

At the end of April and in early May 2013, temperatures over the southern third of Quebec were exceptionally warm, peaking at 29.8°C on May 6 at La Tuque – some 10 to 15 degrees warmer than normal. The early onset of warmth rapidly accelerated the snowmelt in regions further north. The heat also hastened field drying, enabling farmers to begin seeding earlier than usual and raising the forest fire threat.

Canada's North experienced record heat during the first half of August in 2013. Temperatures in Nunavut were particularly warm with Kugluktuk reaching 29.3°C on August 12 and 13, setting records for six consecutive days. Normal daily highs in the hamlet are about 13°C.

In 2012 alone, winter, spring and summer were among the top 10 hottest for their respective seasons. Incredibly, each of July, August and September tied or exceeded any previous year for the warmest on record. July through September were the warmest of any three-month period in Canada in 65 years. From January to November inclusive, 2012 was the fourth warmest since 1948 when record-keeping began on a nationwide basis.

In 2012 the Prairie provinces experienced temperatures more than 6°C above normal for the third warmest on record and the driest ever. For millions of Canadians in the East it was the second warmest winter on record. The unprecedented mildness led to the cancellation of winter carnivals, dogsled races, ice fishing derbies, pond hockey tournaments, and left snow too soggy for sculpting. Across Alberta and Saskatchewan, grass fires occurred with fire crews hosing down wildfires. Prevailing southerly winds brought in pollutants, triggering both extreme heat and smog alerts. Some Ontario cities had 15 to 20 days with smog advisories compared to one or two days in 2011.

On July 5, 1937, southeastern Saskatchewan experienced the hottest recorded temperature in Canada: 45°C was measured in the small, rural municipality of Yellow Grass (population 422).

Heat Waves and Heat Domes - Natural and Human-caused

Hazard Rating	High Risk ☐	Low Risk ☐	Need More Info ☐	Not Applicable ☐

Yes	No	Need More Info	Not Applicable	FACTORS
☐	☐	☐	☐	Extreme hot weather is more likely to occur where it has occurred in the past. Has your community previously experienced periods of extreme heat in the summer?
☐	☐	☐	☐	Very hot weather is more likely in deserts or arid areas. Is your community located in or near a desert or area with less than 25 cm./10 inches of rain a year?
☐	☐	☐	☐	Oceans can be a modifier of temperature. Is your community located inland?
☐	☐	☐	☐	Climate change is linked to increased risk of heat waves and heat domes. Is your community experiencing changes in weather related to climate change?
☐	☐	☐	☐	Have Traditional Knowledge holders identified noticeable increases in temperature?
☐	☐	☐	☐	Scientists have noted that temperatures in many communities in Canada are increasing and thus there is an increased likelihood communities in Canada will experience a heat wave. Have average maximum temperatures in your community been increasing?

Hurricanes and Post-Tropical Storms - Natural

Definition

Hurricanesare storms with winds of greater than 110 kilometres per hour. Hurricanes are extensive storms, often over 600 kilometres in diameter.

Post-tropical storms, (named extratropical cyclones in the USA), are large-scale weather systems that measure hundreds of kilometres across. They form and develop outside of the tropics and gather energy from the temperature and moisture differences where different air masses come together. They usually keep enough moisture and circulation higher up in the atmosphere to significantly energize the resulting (or even new) event into something more intense than would have otherwise occurred.

Discussion

The impact of hurricanes is three-fold: first, the high winds can cause extensive damage and injury; secondly, heavy and rapid rainfall causes flooding; and third, winds and low barometric pressure and high tides create high seas and major coastal flooding. Storm surges have been known to flood inland areas up to 100 kilometres inshore.

Post-tropical storms originate just below and above the equator. Two-thirds of them occur in the northern hemisphere, and most, 50 % occur in the western Pacific.

There have been over 600 deaths due to hurricanes reaching Canada since 1900. A hurricane typically forms from a cloud mass with a diameter of at least 40 kilometres, over a part of the ocean where surface temperatures exceed a threshold of 26 to 27 degrees Celsius. The warm surface temperature creates a rapidly rising column of warm air which creates the forward and rotating (always clockwise in the Northern hemisphere) motion of the hurricane. The typical

hurricane bears some resemblance to a tornado, in that both assume a funnel-like appearance as they develop and mature. However, while the base of the funnel of the tornado may be only several hundred metres wide, the base of a hurricane may exceed 100 kilometres.

It Happened Here…

On September 23, 2020 the former hurricane Teddy arrived in Nova Scotia as a post-tropical storm on Wednesday morning, bringing plenty of wind and rain for the province but paling in comparison to infamous past storms. Grand Etang received the strongest wind gusts at 132 km/h and Ingonish Beach received the most rain with 131 millimetres. Sydney got 44 millimetres of rain with wind gusts up to 87 km/h, while Halifax received between 65 to 92 millimetres.

On September 7, 2019 Hurricane Dorian, downgraded to a post-tropical cyclone, hit Nova Scotia and New Brunswick. It left around 400,000 Nova Scotia Power customers without power, and in New Brunswick, more than 64,000 households and businesses lost power, most in the southern reaches of the province. The winds caused damage, uprooting trees, blowing off part of a roof and causing a construction crane to collapse.

On September 6, 2010, Hurricane Igor wreaked havoc on Newfoundland, with tremendous rainfall of more than 200 millimetres in one day in some areas. Bridges were washed out, houses were flooded, roofs were damaged and power was knocked out.

In September 2003, a category 2 hurricane Juan tore through many communities in Nova Scotia, New Brunswick, Newfoundland and Quebec, including the small town of Annapolis Royal (population 444) in Nova Scotia. The hurricane caused 8 deaths and several million dollars in damages. Ocean waves reached heights of 14 meters and winds were measured at 135 km/h.

Post-tropical storms can have winds nearing 110 kilometers per hour. For example, in 2014, Hurricane Arthur was downgraded to post-tropical storm Arthur by the time it collided with a cold front over eastern Canada. This resulted in major power outages, localized flooding, extensive tree and crop damage, and damage to property Arthur made landfall near Metaghan, N.S. and moved northeastward to the Fundy coast before crossing into western P.E.I., bringing heavy rains of as much as 150 mm. The remnants of Arthur also affected the Gaspésie region of Quebec where soaking rains topped 80 mm and lashing winds reached 100 km/h. The town of Carleton-sur-Mer in Chaleur Bay was especially hard hit with power outages, uprooted trees, damaged houses and capsized sailboats. In Marsoui, near Sainte-Anne-des-Monts, the river burst its banks, flooding roads and highways and inundating 20 homes. In New Brunswick, Arthur's winds topped 100 km/h and it rained hard. Along the Fundy shoreline in St. Stephen it rained so hard (over 150 mm) that you couldn't see three metres ahead. In Nova Scotia, Greenwood was hit worst with wind gusts close to 140 km/h. On the province's southwestern and eastern shores, five- to seven-metre waves pounded with a huge surf that set off rip currents. At the storm's peak in Nova Scotia, it toppled trees and knocked out power for more than 144,000 homes and businesses; some lost services for up to eight days. In New Brunswick, the storm took out power for 140,000 NB Power customers − more than 60 per cent of the utility's clientele. It took as much as 18 days to reconnect power to all households and businesses.

Newfoundland has been subjected to numerous post-tropical storms. In August 2007, Chantal brought flooding rains of approximately 150 mm of rain and washed-out roads and caused extensive damage. In 2006, Florence brought hurricane-force winds, and in 2001; Gabrielle brought flooding rains to the Avalon Peninsula of Newfoundland.

On October 12, 1962 Typhoon Freda hit BC's Lower Mainland causing seven deaths and over $10 million of damage. A portion of Stanley Park was flattened as a result of the typhoon and in Victoria winds reached up to speeds of 90 km/h with gusts up to 145 km/h.

Hurricanes and Post-Tropical Storms - Natural

Hazard Rating	High Risk ☐	Low Risk ☐	Need More Info ☐	Not Applicable ☐

Yes	No	Need More Info	Not Applicable	FACTORS
☐	☐	☐	☐	Hurricanes and post-tropical storms generally occur in the same regions from year to year. Has your community previously experienced hurricanes or post-tropical storms?
☐	☐	☐	☐	**In Canada hurricanes occur mostly in the Atlantic Provinces. Is your community located in the Atlantic region of Canada?
☐	☐	☐	☐	Hurricanes and post-tropical storms are more likely and more forceful closer to the ocean. Is your community located in proximity to the ocean?
☐	☐	☐	☐	Have Traditional Knowledge holders identified noticeable changes in the number, frequency and intensity of hurricanes affecting your community?

Ice Fogs, Ice Storms and Freezing rain - Natural

Definition

An ice storm combines high wind, freezing temperature and freezing rain or drizzle. An ice fog combines very cold temperatures, and a source of warm moisture. Ice fog is composed of small ice particles that occurs in very low temperatures (typically minus 30°C/ -22°F or below) under clear, calm conditions in the polar latitudes.

Ice pellets are translucent pellets of ice, 5 mm (2 in) or less in diameter. Ice pellets may be spheres or irregularly shaped. Ice pellets will usually bounce on impacting a hard surface, often with an audible sound. Ice pellets may be called either sleet or small hail.

Freezing rain occurs when the air in an upper–air layer has an above-freezing temperature while the temperature at the surface is below freezing. The snow that falls, melts in the warmer layer; as a result, it is rain – not snow – that lands on the surface. But since the temperature is below 0°C, rain drops freeze on contact and turn into a smooth layer of ice spreading on the ground or any other object like trees or power lines.

Discussion

It is the combination of high wind and freezing precipitation which causes damage during an ice storm, as the amount of precipitation is frequently low enough that damage from it alone would be minimal. High winds cause freezing precipitation to form a glaze of ice on structures, leading to eventual failure.

Severe damage to hydro lines causing a loss of power for heat and light, along with a disruption of telephone systems, can have very serious and potentially fatal consequences. The disruption of transportation systems, communications, and hydro service can affect thousands of people. Schools close, businesses are unable to operate, highways and local roads become treacherous, and police and emergency services have difficulty performing their day-to-day tasks.

In both urban and rural places, wood burning emits high levels of particulate pollution and moisture to the atmosphere. A little of it can be dangerous, a lot can be catastrophic and can cause downed power and telecommunication cables and lead to major motor vehicle accidents.

The impact of ice storms is greatest in those areas of high population density and automobile concentration. As well, in some towns in the recent past, ice fog has wreaked havoc on local transportation and infrastructure. Freezing precipitation can have severe economic impacts, particularly on agricultural production.

It Happened Here…

On December 22, 2013 the Toronto area of Ontario was impacted by an ice and snow storm leaving 350,000 without power in Ontario, tens of thousands in Quebec, thousands in N.B.; some outages could last until Christmas. The storm, was suspected to have played some factor in four fatal highway accidents in Quebec and another in Ontario.

An ice storm, lasting from January 5-9, 1998, affected many parts of Ontario, Quebec and New Brunswick, including the small ville of Barkmere, Quebec (population 87). The intensity and duration of freezing rain were unprecedented, according to meteorologists. The Montreal region of Quebec, which includes Barkmere, received over 80mm of freezing rain over 96 hours. The storm resulted in 28 deaths and 945 injuries. Insured losses totaled more than $1 billion by June 1998.

In December 2008, an ice storm affected most of Prince Edward Island, including the small municipality of Georgetown (population 634). Almost 95% of residents were left without power, as 300 utility poles were damaged. Electric infrastructure damages were over $3M. Freezing rain damaged roofs, winds uprooted trees and transmission lines were disrupted.

Ice Fogs, Ice Storms and Freezing rain - Natural

Hazard Rating	High Risk ☐	Low Risk ☐	Need More Info ☐	Not Applicable ☐

Yes	No	Need More Info	Not Applicable	FACTORS
☐	☐	☐	☐	Ice fog and ice storms are most likely to occur where it has occurred in the past. Have ice fog and ice storms previously occurred in your community?
☐	☐	☐	☐	Ice fog occurs during very cold temperatures. Does your community experience winter temperatures below -30^{0}C or is your community located in the Yukon, Northwest Territories, or Nunavut?
☐	☐	☐	☐	Ice storms can occur when warm air overtops cold air (temperature inversions). Do you commonly experience wintertime temperature inversions in your community?
☐	☐	☐	☐	Ice storms occur most frequently with winds coming from the east and northeast. Does your community experience east and northeast winds?
☐	☐	☐	☐	Ice storms are more likely in, or near to hilly/mountainous terrain. Are you located in a region with hills or mountains?
☐	☐	☐	☐	Have Traditional Knowledge holders identified noticeable increases in ice fogs and ice storms in your community?
☐	☐	☐	☐	Ice storms can occur when cold air masses/cold fronts mix with warm air masses/warm fronts. Do cold and warm air masses meet in your region? (Check Risk Analysis Resources – Air Masses)

Lake-Effect Storms - Natural

Definition

Lake-effect storms occur along a stretch of shoreline of a lake or downwind some distance from the shore and are caused by the modification of cold, subfreezing air by the relatively warmer lake water. Lake effect snow storms may also occur as a result of the cold air movement.

Discussion

The intensity of the lake-effect storm depends upon several factors: the temperature contrast between the lake surface and the air passing over it, the over-water distance the air has traversed (the fetch), and the regional weather situation. Wind direction is a key component in terms of determining which areas may receive lake effect snow, as will the geography of the terrain and water.

It Happened Here…

On March 1, 2020, a storm generated an extreme Lake Effect snow system and blanketed the eastern shore of Lake Ontario and dumped up to 4 ft of snow in portions of Tug Hill. As well, blizzard-like conditions hit towns like Carthage and Copenhagen while the super-saturated shoreline near Ramona Beach gave way to swollen creeks feeding into Lake Ontario and surrounded seasonal and year-round residents' homes.

In late September, 2018, a passing cold front moved through Manitoba and triggered lake-effect showers and flurries across Lake Manitoba and Winnipeg. While heavy snow was not a factor, gusty winds up to 40-50 km/h could create reduced visibility on the roads and some minor accumulations around the lakes.

On October 27, 2010, a storm came through the small rural municipality of Victoria Beach, Manitoba (population 227). The storm originated in the United States' Midwest, and is connected to thunderstorms, rain, 282 damaging wind reports and 24 tornadoes throughout the region. No deaths or injuries were recorded. At Victoria Beach, 30 feet of shoreline vegetation was destroyed and winds were recorded at 90 km/h.

In 2014, strong cold winds and relatively warm waters off the Great Lakes combined to produce intense snow squalls on November 19-20. The strongest affected regions were near Georgian Bay where the weather system remained nearly stationary for several hours, dumping snow amounts of 90 cm near Parry Sound, 40 cm in Huntsville, and 20 cm in Bracebridge and Barrie. While the numbers were impressive, close to 200+ cm fell in similar lake-effect storms over Buffalo, New York. In Ontario, multiple collisions on Highway 400 north of Toronto blocked north-south lanes south of Barrie, causing lengthy delays.

Lake-Effect Storms - Natural

Hazard Rating	High Risk ☐	Low Risk ☐	Need More Info ☐	Not Applicable ☐

Yes	No	Need More Info	Not Applicable	FACTORS
☐	☐	☐	☐	Cool winds moving across large bodies of water can cause lake-effect storms. Is your community located near a large body of water?
☐	☐	☐	☐	Have Traditional Knowledge holders identified noticeable changes in numbers, frequency and intensity of lake-effect storms?
☐	☐	☐	☐	Lake-effect storms generally occur in conjunction with cold fronts. Is your community affected by cold fronts? (Check Risk Analysis Resources – Air Masses)

Lightning and Thunderstorms - Natural

Definition

Lightning is defined as all forms of visible electrical discharges moving through the atmosphere, usually eminating from tall cumulus and cumulonimbus clouds during thunderstorms. Lightning is often categorized for the way in which it is visible to the observer: streak lightning, forked lightning, sheet lightning, heat lightning.

Discussion

Lightning is caused by the union of three factors: moisture-laden air, the instability of existing weather systems and a triggering agent which causes air near the ground to rise. This triggering agent may be a mountain range where surface heating creates upward thermal currents; or a frontal lift system. Thunderclouds or storms, often spatially dispersed yet still dense cloud complexes, are the source of the lightning.

As thunderstorms are the result of the meeting of two weather systems of differential pressure, low and high, there is often a degree of separation between the two air masses and typically there are only a very few active electrical `cells' which emit lightning. These cells have a lifespan of approximately thirty minutes, during which there may be one flash per minute to as many as ten per minute. The electrical energy is caused by a buildup of differentially charged areas within the cloud mass and these positive and negative regions within the thundercloud give rise to the lightning flash. The flash may occur within the cloud mass, in a vertical or horizontal movement, or it may reach from cloud to ground.

Lightning strikes have clear seasonal and day/night time patterns. Seasonally, most lightning occurs during the summer and early fall months, as temperature, humidity and wind variations can provide the trigger mechanisms required for lightning. The change from day to night may cause sufficient temperature and wind variation to cause the uplift of air masses and subsequent thunderstorm activity.

Lightning strikes can be fatal or can cause severe injuries to people, including serious burns, loss of consciousness, and death from the disruption of respiratory functions. As well, there have been a number of airplane crashes caused by lightning and of course, lightning, is a major cause of forest fires.

It Happened Here…

On March 26, 2021, a man died after a lightning strike and house fire in the Halifax area Friday evening.

On June 26, 2008, lightning strikes are believed to have caused four fires near Old Crow, Yukon (population 299). No injuries or deaths were reported.

Lightning struck a beach in Wasaga Provincial Park in Ontario early in the afternoon on July 20, 2006 killing a 26-year-old woman and burning two others.

On August 7, 2001 a thunderstorm occurred in the region including Burks Falls (population 893), Ontario. Lightning struck a man standing outdoors resulting in one death.

Lightning and Thunderstorms

Hazard Rating	High Risk ☐	Low Risk ☐	Need More Info ☐	Not Applicable ☐

Yes	No	Need More Info	Not Applicable	FACTORS
☐	☐	☐	☐	Thunderstorms and lightning generally happen in the same location from year to year. Does your community regularly experience thunderstorms and lightning?
☐	☐	☐	☐	Thunderstorms occur in Canadian provinces and are unlikely in territories. Is your community in a province?
☐	☐	☐	☐	Thunderstorms generally occur in the presence of warm, humid weather. Does your community experience this type of weather in the summer?
☐	☐	☐	☐	Hills or mountains (topography) provide a primary source for the formation of thunderstorms. Is your community located in a mountainous or hilly region?
☐	☐	☐	☐	Thunderstorms occur most frequently on the windward (generally west) side of mountain ranges. Is your community located on the windward side of a range of mountains or hills?
☐	☐	☐	☐	Have Traditional Knowledge holders identified noticeable increases, intensity or frequency of thunderstorms?
☐	☐	☐	☐	Thunderstorms occur when cold and warm air masses meet. Is your community located in an area where polar and tropical masses meet? (Check Risk Analysis Resources – Air Masses)

Microbursts - Natural and Human-caused

Definition

Microbursts include surface winds in excess of 62 km/hr (39 mph) caused by a small-scale downdraft from the base of a convective cloud (formed by verticial movements of air). Downbursts occur in regions of a severe thunderstorm where the air is accelerated downward when exceptionally strong evaporative cooling occurs (a dry downburst) or by very heavy rain which drags dry air down with it (a wet downburst). When the rapidly descending air strikes the ground, it spreads outward in all directions in a circle, like a fast-running faucet hitting the sink bottom.

Discussion

A microburst initially develops as the downdraft begins its descent from cloud base. The downdraft accelerates and within minutes, reaches the ground (contact stage). It is during the contact stage that the highest winds are observed. During the outburst stage, the wind "curls" as the cold air of the microburst moves away from the point of impact with the ground. During the cushion stage, winds about the curl continue to accelerate, posing a great threat to nearby aircraft. (see Figure 1).

A downburst is a strong downdraft which includes an outburst of potentially damaging winds on or near the ground. If the diameter of the downburst is less than 2.5 miles, it is called a microburst.

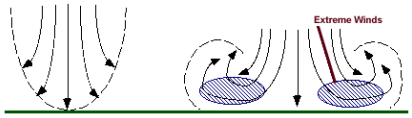


Figure 2 Microbursts

It Happened Here…

On June 16, 2016 citizens experienced heavy rainfall, strong winds and some tree damage was reported in several areas. Environment Canada confirmed two microbursts touched down during the storms -- one 10 km north of Stirling that destroyed a silo with a peak gust near 160 km/h, and one in the Bellmont Lake area, in Peterborough County.

On June 29, 2010, a microburst occurred in Goldsmith, Leamington, Ontario (population 1,333). The microburst winds reached 120 - 150km/h, caused hail, damaged a barn and uprooted trees.

Just after noon on July 3, 2011, winds gusting up to 100 km/h blasted through Calgary, downing power lines, toppling trees, swamping sailboats and stirring up a wall of dust. Outside the city, the wind felled a brick firewall next to a theatre in Strathmore. Experts referred to the sudden and swift wind blast as a “dry microburst”. On the Glenmore Reservoir, rescue teams pulled a few boats back to shore after violent winds created some of the biggest waves ever seen there.

On September 13, 2011, three squall lines preceding the passage of a strong cold front swept through southern Quebec in a southeasterly direction. Regions around Montréal, in Montérégie, the lower Laurentians, the Eastern Townships, and Beauce experienced torrential rainfalls up to 50 mm in less than two hours. Accompanying the heavy rains were strong gusty winds, frequent lightning and, in some places, cherry-sized hail. Microbursts generating winds between 100 and 120 km/h hit Saint-Colomban (Lower Laurentians) and Saint-Prosper (Beauce). Powerful winds brought down thousands of trees on vehicles, houses and hydro lines.

On July 4, 1996, a powerful outbreak of thunderstorms led to numerous reported tornadoes and microbursts near Saskatoon, Maymont and Osler, Saskatchewan. Winds in Saskatoon gusted between 120 and 140 km/h, causing damage to homes on the east side of the city and a drive-in theatre.

Microbursts

Hazard Rating	High Risk ☐	Low Risk ☐	Need More Info ☐	Not Applicable ☐

Yes	No	Need More Info	Not Applicable	FACTORS
☐	☐	☐	☐	Are there areas in your community with an extremely dry environment? These areas are at increased risk of a dry microburst.
☐	☐	☐	☐	Are there areas in your community with an extremely wet environment (i.e., heavy rain)? These areas are at increased risk of a wet microburst.
☐	☐	☐	☐	Scientists have noted that with climate change there are areas which are receiving lesser amounts of rain and become more arid or dry. Has your community been experienced increased temperatures and decreased rainfall over the past several years?
☐	☐	☐	☐	Have Traditional Knowledge holders identified noticeable changes in the number, frequency or intensity of microbursts?
☐	☐	☐	☐	Scientists have noted that with climate change there are changes in increased amounts of rainfalls over much of North America, which could result in saturated soils. Has your community been experiencing increased rainfall amounts over the past several years?

Sea Storms and Storm Surges - Natural and Human-caused

Definition

A sea storm is a storm with winds between 48 knots (88.89 kilometres) per hour and 63 knots (116.67 kilometres) per hour. Storm surges are described as increases in water levels which exceed levels normally associated with regular tides. Storm surges are caused by winds driving waters shoreward and are often coupled with low pressure systems, which in turn often cause increased sea levels at the same time.

Storm surge is a very complex component of a strong storm over water, though in simplest terms, it is water pushed toward the shore by the wind forces of a storm. Storm surge can form on any large body of water, but the most impressive and deadliest storm surges are similar to the strength of a hurricane. The height of a storm surge is dependent on the nature of the storm — its wind speed, the storm's speed and direction, and its central pressure — as well as oceanographic, geological and planetary influences defining its height and speed. These include the depth of the water, the submarine topography beneath the surge, the shoreline and beach characteristics, and the astronomical tides.

If your community is located away from the coastline you can you can safely state that “This couldn’t happen here.”

Discussion

A fall in atmospheric pressure over the sea surface will cause a rise in sea water. The rise in sea level from storm surges is approximately equal to the water equivalent of the drop in atmospheric pressure or about a one centimetre sea level rise for a one millibar drop in atmospheric pressure.

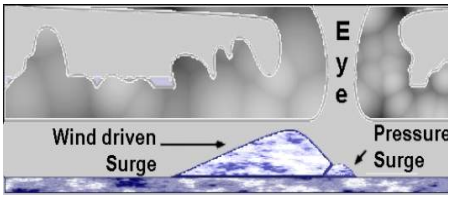


Figure 3 Wind and Pressure Storm

Both the effect of the wind and the structure of the sea bed can influence a sea surge. The combination of a strong onshore wind and a high tide can lead to large net increases in sea levels (several metres in height) which may extend over hundreds of kilometres of coastline. The angle and speed at which the storm approaches the coast will also affect the height of the surge. Basically, the greater the forward speed and more perpendicular the track to the coast, the higher the surge. (see Figures 2 and 3)

The wind shear effect which acts to push water inland is particularly potent in shallow water areas because the wind can act on the full depth of the water; whereas, in deep water the surface layers are pushed onshore but return seaward at depth. In addition, the force of a strong wind raising coastal water levels may be exacerbated in bays and shoaling areas.

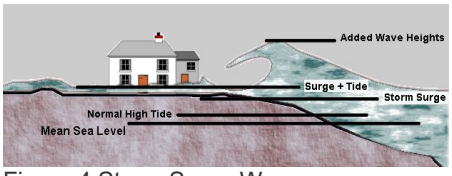


Figure 4 Storm Surge Wave

It Happened Here…

On November 15, 2020, a severe storm off the Great Lakes left thousands without power, shoreline communities flooded, and wind damage across the southwestern Ontario. The flooding was from a storm surge and water surged inland for up to 500 metres and also hit Port Ryerse, Long Point, and there was extensive flooding in Chatham-Kent.

On March 16, 2005 a storm surge pushed 10-meter waves, rocks and tonnes of ice along the east coast of Newfoundland. The small town of Baie Verte (population 1275) was among the communities affected. The storm caused millions of dollars in damages.

A sea storm hit the shores of Prince Edward Island in late December 2010, eroding 30 feet of shoreline and damaging fishing equipment and wharfs. The small town of North Rustico (population 637) was among the many communities affected. Rain and gale force winds were measured up to 120 km/h on the north shore.

In 2003, Halifax experienced the highest winds in Hurricane Juan, the highest storm surge and highest waves – they combined to arrive at the coastline at same time, making the Halifax waterfront flooding problem even worse. Together, with the already high tidal levels, a record water level of 290 cm (above the tidal benchmark known as, "chart datum") was recorded in Halifax. This value is greater than all Halifax water level data since 1961. It took the harbour waters 5 hours to rise 2 metres (6.7 feet) with the incoming tide and surge. The hurricane force east-southeast winds acted to dam the water up in the harbour, preventing it from draining back into the Atlantic as it normally does with the ebb tide. Had Juan arrived only 2 hours earlier, the peak surge in Halifax Harbour would have coincided exactly with the high tide, possibly resulting in an additional 45 cm of elevated water.

Sea Storms and Storm Surges

Hazard Rating	High Risk ☐	Low Risk ☐	Need More Info ☐	Not Applicable ☐

Yes	No	Need More Info	Not Applicable	FACTORS
☐	☐	☐	☐	Are there areas in your community at or near a coastline?
☐	☐	☐	☐	Are there areas in your community of low-lying lands on the coast?
☐	☐	☐	☐	Are there areas in your community with a coastline of shallow waters? In these places, the wind can affect the water at its entire depth.
☐	☐	☐	☐	Dykes prevent the natural process of marshes adjusting to rising tides, where the tide naturally brings in the below-surface mud. Are there coastal areas in your community that are separated from the sea by a network of aging dikes?
☐	☐	☐	☐	Are there areas in your community with a combination of extreme high tides, high winds (at high speeds) and low pressure (cloudy or stormy weather)?
☐	☐	☐	☐	Scientists have observed that with climate changes there are increased numbers of intense storms and possible changes as a result of El Ninõ which will result in increased numbers of storm surges. El Niño can be distinguished when the surface waters in the eastern tropical Pacific extending westward from Ecuador become warmer than average. The changing pattern of the Pacific Ocean causes a shift in atmospheric circulation, which then impacts weather patterns across much of the earth. El Niño events appear approximately every two to seven years. They typically last 12 to 18 months. Has your community noticed increased numbers of storm surges?
☐	☐	☐	☐	Are there areas in your community where the coast is characterized by sandy layers? This usually indicates storms have frequently occurred in the past and so the area is more at risk for future sea storms.
☐	☐	☐	☐	Are there coastal areas in your community with frequent high winds? These areas are at greater risk for ocean and coastal waves caused by sea storms.
☐	☐	☐	☐	More winters with reduced sea ice in the Gulf of St. Lawrence have resulted in more open water during the winter storm season, which will lead to an increase in the average number of storm-wave events per year, further accelerating coastal erosion. Is your community along the Gulf of St. Lawrence?
☐	☐	☐	☐	Have Traditional Knowledge holders identified noticeable changes in the number, frequency or intensity of sea storms and storm surges?
☐	☐	☐	☐	Communities which have implemented coastal zone adaptation plans and policies are more likely to prevent coastal erosion, storm surges, and flooding. Does your community not have a coastal zone adaptation plan or policy?

Seiche - Natural and Human-caused

Definition

Seiches are caused by atmospheric disturbances passing over the waters of a lake. Most often, persistent strong winds blowing along the lake axis initiate the formation of seiches when they cease blowing, but a fast-moving squall line with a strong pressure jumps and downdraft winds can also induce a seiche as it passes over a lake. (Seiches should not be confused with storm surges that form when lake waters are blown toward and pile up on the shore but do not slosh between the opposing shores.) It can be compared to the the sloshing of the water in your swimming pool, or any body of water, and may be also caused by the ground shaking in an earthquake. It may continue for a few moments, hours, or days, long after the generating force is gone.

Discussion

When the wind crosses the surface, waters are pushed to the downwind lakeshore. When the winds die or the squall line passes, the water accumulated along the downwind coast flows back across the basin and begins sloshing within the lake. This causes rising and falling water levels on both sides of the basin. With each circuit, the seiche diminishes in height eventually damping out into the background lake motions. Like the striking of a bell, it takes only one disturbance event to begin the wave action of a seiche. Once begun, a seiche can continue for days after the forces that created it cease.

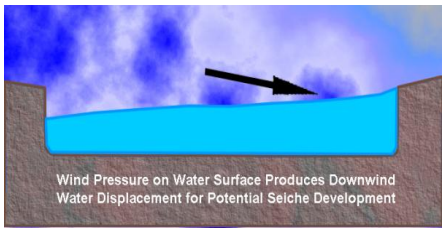


Figure 5 Seiche Development

Multiple seiches may arise when strong winds pulse over a lake or when a series of squall lines moves across the waters. Strong winds frequently produce seiches on large lakes, but most are rather small in size — less than 30 cm (a foot) high — and go unnoticed amidst the general surface wave motions. However, during severe storm conditions, water-level differences greater than 5 metres (16 feet) have been observed between opposing lakeshores.

Occasionally seiches can be triggered by wind conditions (see Figure 4) and when a large amount of water is displaced as a result of a landslide in an enclosed lake or inlet.

It Happened Here…

On November 16, 2020, A powerful storm system blasted the Midwest and East with damaging winds and generated a sloshing of Lake Erie known as a seiche. This storm system pushed a strong cold front across the region that was accompanied by lines of thunderstorms. Winds gusted as high as 82 mph at Port Colborne, Ontario, located on the northeast shore of Lake Erie across from Buffalo, New York. The storm also produced extensive damage to trees and structures across several U.S. states and Ontario, Canada. Over 1 million people.

On July 13, 1995, a metre high seiche occurred in Lake Superior, Ontario. It lasted about fifteen minutes and stranded moored boats when the water retreated. It affected the town of Rossport, Ontario (population 66).

St. John’s is known to have a harbour seiche with a period of about 20 minutes and amplitude that can reach 15 cm. This can be seen in the plot for Hurricane Luis in 1995.

During Hurricane Gustav in 2002, there was a 2-3-hour seiche in Sydney Harbour which shows up clearly in the water level and storm surge profiles.

Seiche

Hazard Rating	High Risk ☐	Low Risk ☐	Need More Info ☐	Not Applicable ☐

Yes	No	Need More Info	Not Applicable	FACTORS
☐	☐	☐	☐	Are there areas in your community near a fully or partially enclosed body of water such as a lake or harbour?
☐	☐	☐	☐	Are there areas in your community near a fully or partially enclosed body of water such as a lake or harbour where high winds are common?
☐	☐	☐	☐	Are there areas in your community near a fully or partially enclosed body of water such as a lake or harbour on or near a fault line (where earthquakes are likely to occur)?
☐	☐	☐	☐	Are there areas in your community near a fully or partially enclosed body of water such as a lake or harbour at risk for landslides and avalanches?
☐	☐	☐	☐	Are there areas in your community near a fully or partially enclosed body of water such as a lake or harbour where the weather changes quickly and often (changing air pressure)?
☐	☐	☐	☐	Have Traditional Knowledge holders identified areas where there have been previous seiches?
☐	☐	☐	☐	Are there areas in your community at risk for landslides and avalanches?

Snowstorms - Natural

Definition

Snow storms vary from light sprinkles of snow to accumulations of several metres of snow. Similar to the effects of blizzards, snowstorms are, however, not always associated with high winds.

Discussion

Figure 6 Snowstorm

Snow storms have serious impacts on highways, local roads, buildings and on infrastructure such as hydro-electric transmission lines and communications networks. The failure or collapse of towers and lines is caused by the rapid accumulation of snow. The combination of poor traction and inexperienced drivers on highways and local roads can also lead to extensive problems, injuries and death.

Heavy snowstorms can also have impacts on agricultural activities, most often the raising of cattle. Heavy accumulations of snow prevent ranchers from gaining access to their stock to feed and protect them.

It Happened Here…

On May 24, 2018 Gander set a new record as central and parts of eastern Newfoundland experienced a late-season snowstorm. Snowfall measured over 32 cm.

On February 19 and 20, 2004, Nova Scotia and Prince Edward Island were hit with a major snow storm. Among many cities, Oxford, Nova Scotia (population 1178) was affected by the storm. Over three feet of snow accumulated and winds reached 100km/hr. Transportation was halted, power was cut and schools and businesses closed. Nova Scotia issued a "Code Black" emergency for the first time in history.

On December 28, 1996, high wind speeds, heavy snowfall (70 cm/2 days) occurred on southern Vancouver Island. Houses, public buildings and vehicles were damaged. Boats were destroyed by boathouse collapses, highways were closed and over 1,000 travellers were stranded. Power failures affected over 50,000. Many greenhouses were destroyed and there were serious economic losses to those in the horticulture sector.

On September 7, 2014, in the midst of a sunny 25°C afternoon – Calgarians learned the next day's forecast called for freezing temperatures and upwards of 10 cm of snow, with snowfall warnings in effect for a large swath of southern Alberta. And snow it did! For the next three days, Calgary was battered by foul wintry weather that swapped sweat for slush as a 25-degree drop in temperature took hold. At Calgary International Airport, the three-day snowfall totalled 28.2 cm with amounts between 40 and 45 cm occurring over western portions of the city. The storm's snowfall was the highest September deposit before the autumn equinox in the last 130 years. The heavy wet snow created huge traffic problems for drivers and inflicted extensive property damage.

Snowstorms

Hazard Rating	High Risk ☐	Low Risk ☐	Need More Info ☐	Not Applicable ☐

Yes	No	Need More Info	Not Applicable	FACTORS
☐	☐	☐	☐	Snowstorms tend to occur where they have occurred in the past. Has your community experienced previous heavy snowfall events?
☐	☐	☐	☐	Snowstorms occur in below-freezing temperatures. Does your community experience cold winters?
☐	☐	☐	☐	A nearby source of moisture can increase precipitation of a snowstorm. Is your community located near large bodies of water that remain unfrozen in the winter?
☐	☐	☐	☐	In western Canada heavy snowfall can occur on the windward (west) side of mountain ranges. Is your community located on the windward side of a range of mountains or hills?
☐	☐	☐	☐	Snowstorms can occur when cold polar air masses/cold fronts mix with warm tropical air masses/warm fronts. Is your community located in an area where cold and warm air masses meet? (Check Risk Analysis Resources – Air Masses)
☐	☐	☐	☐	Scientists have noted that one of the effects of climate change in Canada is an increased amount of precipitation during the winter months. Has your community experienced increases in snowfalls over the past several years?
☐	☐	☐	☐	Have Traditional Knowledge holders identified noticeable changes in the number, frequency or intensity of snowstorms?
☐	☐	☐	☐	**Snowfall increases to its maximum in the Rocky Mountains and in the Gulf of St. Lawrence due to frequent winter storms. Is your community in these areas?

Tornadoes and Waterspouts- Natural

Definition

A tornado is a very rapidly rotating air funnel hanging from a cumulonimbus cloud (a cumulonimbus cloud is a dense towering vertical cloud associated with thunderstorms and atmospheric instability) and is observed as a funnel-shaped cloud. Among the many vortex weather features common in the world (those with rotary motion), the tornado is the smallest in size, the fastest, and frequently the most mobile; often covering vast distances before dissipating its force. The tornado is not considered to be the weather formation itself, but is rather a secondary formation of vortex activity in a higher cloud layer.

The waterspout is observed as a funnel which contains an intense vortex, sometimes destructive, of small horizontal extent and which occurs over a body of water. Waterspouts fall within the class of atmospheric phenomena known as convective vortices that includes tornadoes, dust-devils, landspouts, and hurricanes. These are circulations driven by, or associated with, either dry or moist convection. A true waterspout forms over the water and is not usually accompanied by a strong storm as is the tornadic waterspout. They commonly develop beneath lines of rapidly growing cumulus congestus clouds. The waterspout funnel forms in the rising air just ahead of any rainfall from these clouds in association with warm water temperatures and high humidity in the lowest kilometre of the atmosphere.

Discussion

The formation of the tornado is much like that of a hurricane: a thermal column of warm air rises from the surface of the earth, creating a large mass of tornado clouds, moving in a rotational, clockwise manner. It is these clouds which then spawn the characteristic funnel of the tornado.

The parent cloud formation of tornadoes is often a dark, heavy thunderstorm cloud, often moving rapidly into previously clear areas of sky. The parent tornado cloud is typically small, five to ten kilometres in length and four to five kilometres high. These clouds form quite close to the ground, and this leads to the disastrous impacts of a tornado funnel when it touches down to the earth's surface.

The vortex or funnel of a waterspout usually develops at the water surface and builds skyward. While the thin-columned waterspouts appear to be sucking water up from the water surface, what is actually seen is the condensation of water vapour in the rotating vortex air. As the column rotates, the highly humid air is cooled by expansion to its condensation point. When the water vapour in the vortex condenses, it makes the whirling mass visible. At the surface, the vortex winds stir the water into mushroom-shaped water sprays at the funnel base.

EF Rating	Wind Speeds Km/ph
0	90-130
1	135-175
2	180-220
3	225-265
4	270-310
5	315 +

In Canada, since 2013, tornadoes are rated by Environment and Climate Change Canada using the Enhanced Fujita Scale Damage Indicators.

	NT	BC	AB	SK	MB	ON	QC	NB	Total
2010	0	0	3	7	3	5	5	0	23
2011	0	0	1	1	0	14	3	0	19
2012	0	0	7	33	3	9	6	0	58
2013	0	0	4	13	5	22	4	1	49
2014	0	0	3	6	4	29	7	0	49
2015	0	0	7	0	6	8	1	0	22
2016	0	0	12	13	15	11	4	0	55
2017	0	0	8	9	1	12	14	0	44
2018	0	0	2	16	5	9	4	0	36
2019	1	0	13	12	4	4	1	0	35
2020	0	2	11	7	7	42	8	0	77
	1	**2**	**71**	**117**	**53**	**165**	**57**	**1**	**467**

In Canada, since 2020 the numbers of tornadoes are seeing a consistent increase, although the numbers vary considerably from year to year.

Over this time period the majority of tornadoes have been experienced in Ontario and Saskatchewan. By far the greatest number of tornadoes were rated at EF 0, reaching up to a maximum of EF 3 over this timeframe.

It Happened Here…

On July 15, 2021 a tornado left a path of destruction about five km long and up to 100 m wide at some points in Barrie, Ontario. This was the second devastating tornado to hit Barrie, the earlier tornado in 1985 (see below). Environment Canada gave the tornado a rating of EF-2 with winds of up to 210 km/h. Ten people were injured, none with life-threatening injuries, over a hundred people displaced and over 150 homes were damaged with dozens unsafe to enter.

On August 8, 2020, two people were killed and one person injured when a tornado touched down in a rural area of Manitoba, Canada, flipping cars and destroying structures on a farm.

On July 20, 2016, an EF 1 tornado tore through the Long Plain First Nation overall a trail of at least 8 km., leaving over 200 residents homeless and uprooting trees, taking off roofs and damaging the Dakota Ojibway Police Service's communications equipment. The accompanying storm left more than 18,000 Hydro customers across the province without power. Of that number, 6,500 were in the area that includes Portage la Prairie and Long Plain.

On August 21, 2011, the most powerful tornado to hit the province in years swept through the southwestern Ontario town of Goderich Sunday afternoon, killing one person and devastating community on the shores of Lake Huron. Downtown businesses, century-old buildings and several churches lost their roofs and upper floors as the twister ripped through the town.

On July 7, 2011, west-central Alberta could best be described as a “thunderstorm nursery” when it spawned a series of severe thunderstorms featuring four separate tornadoes. A funnel cloud first touched down southwest of Bergen about 4:40 p.m., followed an hour later by a tornado hitting 15 km southwest of Olds. Two twisters touched down near Sundre. Classic tornado signs were all there: noisy hail, a greenish sky and inky-black, rotating clouds. Property damage included downed trees, granaries, power lines and damaged homes.

In 2007, Canada experienced its first F5 tornado in recorded history. At 300 metres wide, travelling near Elie, Manitoba. at speeds between 420 to 510 kilometres per hour, the tornado ripped across 5.5 kilometres for around 35 minutes. While utility poles and trees were damaged and a house was carried off the ground and exploded in the air, no one died from the event.

In the summer of 2006, 23 tornadoes struck the province of Ontario - more than the normal 14. A major storm hop-scotched through hundreds of kilometres of cottage country on August 2-3 leaving properties in shambles. At Combermere, north of Bancroft, an F2 category tornado packing winds between 180 km/h to 240 km/h inflicted extensive damage. Its twisting winds tossed docks on shore and pushed cottages off their foundations. Once-towering, century-old pines were reduced to stumps and de-barked. In Gravenhurst, the storm peeled back the roof of the local curling rink. Environment and Climate Change Canada confirmed that the weather system on August 2 triggered 17 tornadoes, including two F2 touchdowns. It was the highest number of tornadoes for a single event ever in the province and represented what Ontario normally sees in one year.

In July 2000, the small, rural community of Delburne, Alberta (population 765) near Pine Lake was affected by a tornado. The tornado resulted from a thunderstorm on the eastern Canadian Rockies. Twelve people died and 140 were injured during the event.

The July 31, 1987 Edmonton Tornado, remains as Canada’s second deadliest tornado, leaving 27 dead.

On May 31, 1985 a series of tornadoes hit southern Ontario leaving 12 dead and hundreds homeless. Most severely impacted was Barrie, Ontario with 8 persons dead, but another tornado impacted the towns of Grand Valley leaving two dead and left two dead at nearby Tottenham.

Tornadoes and Waterspouts

Hazard Rating	High Risk ☐	Low Risk ☐	Need More Info ☐	Not Applicable ☐

Yes	No	Need More Info	Not Applicable	FACTORS
☐	☐	☐	☐	Tornadoes generally occur in the same regions from year to year. Have tornadoes occurred in or near your community in the past?
☐	☐	☐	☐	Tornadoes are known to occur in the same location as thunderstorms and hailstorms. Are thunder/hailstorms prevalent in your region?
☐	☐	☐	☐	Most tornadoes in Canada occur in southern Ontario and Saskatchewan. Is your community in one of these areas?
☐	☐	☐	☐	Tornadoes can occur when cold polar air masses/cold fronts meet warm tropical air masses/warm fronts. Is your community located in an area where cold and warm air masses meet? (Check Risk Analysis Resources – Air Masses)
☐	☐	☐	☐	Have Traditional Knowledge holders identified noticeable changes in the number, frequency or intensity of tornadoes?

Windstorms - Natural

Definition

Windstorms are a result of air in motion relative to the surface of the earth. Because the vertical (up/down) component of wind is generally small compared to the horizontal component, wind generally refers to the horizontal wind. When the vertical component is discussed, vertical wind is commonly used. There are different types of windstorms.

Wind squalls can be defined as:

- A strong wind which arrives suddenly, lasts minutes and ends with a sudden decrease in speed.
- A severe local storm with strong, gusty winds and usually precipitation, may be accompanied by thunder and lightning.

Discussion

In Canada, severe winds has caused significant damage. Speeds of 70-90 km/h are associated with broken tree branches, power outages and objects blown over. Speeds of 90-100 km/h are associated with limbs of trees and sometimes entire trees breaking, power outages and damaged signs. Speeds of 100-120 km/h are associated with significant tree branches and entire tree breakage, damage to roofs and power outages. Speeds of 120-140 km/h are associated with more tree damage and uprooting, sign damage, breaking glass as well as power outages over greater areas. Speeds of 140 km/h or more are associated with severe damage to trees, roofs (may be blown entirely off) and power outages will occur over greater areas.

It Happened Here…

On January 13, 2021, over 220,000 people in southern British Columbia were left without power. The wind at one point topped 100 km/h in Victoria and the eastern Fraser Valley. Environment

Canada said gusts hit 128 km/h across Metro Vancouver, Vancouver Island and the Fraser Valley.

On November 15, 2020, a wind storm that swept through swaths of southern and central Ontario has left hundreds of thousands of residents without power. Hydro One said it was working to restore electricity to more than 200,000 clients, while Toronto Hydro reported an outage affecting thousands more.

On December 21, 2018, winds were clocked at 144 km/h on a small island near Tofino. One woman was killed when a tree fell on her tent in Duncan, on Vancouver Island, just before 11:30 a.m. A statement posted Friday said four other people were also inside the tent. Two of them were injured and hospitalized. The 457 metre White Rock pier was closed until further notice after several boats broke away from their moorings and battered the middle of the pier, eventually collapsing a 30-metre section. A washout on Highway 4 between Port Alberni and Tofino occurred in one of the most severe storms to hit B.C. in years.

On September 20, 2007, central and coastal Newfoundland and Labrador experienced a severe wind storm. Among many communities, the small town of Cartwright (population 629) was affected. Winds were measured at 117 km/h and caused power outage, roof damage and uprooted hundreds of trees. No injuries or deaths were recorded.

December 15, 2006 was when winds reached a speed of 100 km/h. In Victoria, winds reached 124 km/h. About 250,000 residents lost power in the aftermath. The storm, known as “BC’s Stanley Park Windstorm” got its name by blowing down thousands of trees and forcing the closure of the park. More than $100 million of damage was done to throughout the region.

Windstorms

Hazard Rating	High Risk ☐	Low Risk ☐	Need More Info ☐	Not Applicable ☐

Yes	No	Need More Info	Not Applicable	FACTORS
☐	☐	☐	☐	Windstorms are more likely to occur where high winds have occurred in the past. Has your community previously experienced windstorms?
☐	☐	☐	☐	Windstorms may occur in conjunction with thunderstorms. Are thunderstorms known to occur in or near your community?
☐	☐	☐	☐	Windstorms are likely to occur in flat, wide-open areas. Is your community located in a prairie or plain landscape?
☐	☐	☐	☐	Scientists have observed that while the overall number of windstorms around the Eastern Seaboard have slightly decreased, the frequency of intense storms has increased. Is your community along the Eastern Seaboard?
☐	☐	☐	☐	Have Traditional Knowledge holders identified noticeable changes in the number, frequency or intensity of windstorms?

Risk Analysis Resources

Air Masses

An air mass is a large body of air with generally uniform temperature and humidity, which originates from a source region such as the arctic or an ocean. Fronts are the boundaries between two air masses. A cold front is the transition zone where a cold air mass replaces a warmer air mass. A warm front is the transition zone where a warmer air mass replaces a cold air mass. Air masses typically clash in the middle latitudes, and most weather occurs along these fronts. Warm maritime air masses generally develop over subtropical oceans and transport heat and moisture northwards into Canada. Cold polar or continental air masses originate over northern Canada, and transport cold and dry air southwards into the Provinces. Where these air masses meet, we tend to see storms develop.

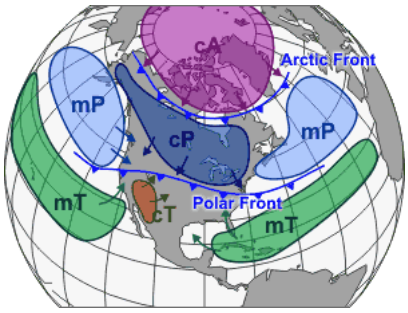


Figure 7 Air Masses

"...in winter an arctic air mass (very cold and dry air) can move over the ocean, picking up some warmth and moisture from the warmer ocean and becoming a maritime polar air mass (mP) - one that is still fairly cold but contains moisture. If that same polar air mass moves south … it will pick up some of the warmth of the ground, but due to lack of moisture it remains very dry. This is called a continental polar air mass (cP)… Continental tropical (cT) air is dry air pumped north, off of the Mexican Plateau. If it becomes stagnant over the Midwest, a drought may result. Maritime tropical (mT) air is air from the tropics which has moved north over cooler water." (See Figure 6)

Climate Change

Resource
Natural Resources Canada's "The Atlas of Canada" provides a lot of information about climate change. It includes information on some of the human activities (e.g., greenhouse gases) that are thought to influence climate change and some maps with projections of how climate change may influence water levels and numbers of forest fires. Atlas of Canada Canada maps The Geogratis web site GeoGratis is a web portal that provides access to a wide collection of Canadian geospatial data, maps, images, and publications at no cost and without restrictions. Keywords: Natural Resources of Canada, Atlas of Canada, Climate Change

Environment and Climate Change Canada provides information on climate change and gas emissions.

Keywords: Environment and Climate Change Canada, Climate Change

NASA's Earth Observatory has a lot of information related to climate change, including global maps of sea temperature and carbon monoxide changes.

Earth Observatory

Keywords: NASA Earth Observatory, Climate Change

The International Panel on Climate Change (IPCC) prepares comprehensive Assessment Reports about knowledge on climate change, its causes, potential impacts and response options. The IPCC also produces Special Reports, which are an assessment on a specific issue and Methodology Reports, which provide practical guidelines for the preparation of greenhouse gas inventories.

IPCC 5th and 6th and Special Reports

Keywords: Intergovernmental Panel on Climate Change, Assessment Report

UN International Strategy for Disaster Risk Reduction provides a toolkit for communities, including 10 Essentials (a self-assessment tool) for disaster risk reduction.

Making Cities Resilient: My City's Getting Ready

Keywords: United Nations International Strategy for Disaster Risk Reduction, toolkit, disaster risk reduction

Cold Front - Transition Zone From Warm Air to Cold Air

A cold front is defined as the transition zone where a cold air mass is replacing a warmer air mass. Cold fronts generally move from northwest to southeast. 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 Celsius within the first hour.

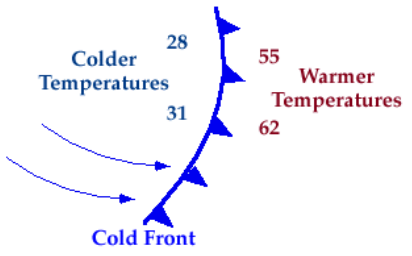


Figure 8 Cold Front

Symbolically, a cold front is represented by a solid line with triangles along the front pointing towards the warmer air and in the direction of movement. On colored weather maps, a cold front is drawn with a solid blue line. (see Figure 7)

If colder air is replacing warmer air, then the front is a cold front. On the other hand, if warmer air is replacing cold air, then the front is a warm front. On colored weather maps, a warm front is drawn with a solid red line with triangles along the front pointing towards the cold air and in the direction of movement.

Drought

The Canadian Drought Monitor (CDM) is Canada's official source for the monitoring and reporting of drought in Canada.

Keywords: Agriculture and Agri-Food Canada, drought

Hailstorms

Environment and Climate Change Canada provides a lot of information about major hailstorms and when they have occurred in Canada.

Natural Resources Canada provides information on the subject of hailstorms. Historical data/maps can be searched on GeoGratis.

Keywords: Environment and Climate Change Canada, hailstorms

Hurricanes

Environment and Climate Change Canada also provides information on hurricanes as does the Canadian Hurricane Center.

Natural Resources Canada provides information about hurricanes and when they have occurred in Canada. Historical data/maps can be searched on GeoGratis.

Keywords: Natural Resources Canada, GeoGratis, hurricanes, Environment and Climate Change Canada, Canadian Hurricane Centre, hurricanes

Permafrost

Environment and Climate Change Canada provides a lot of information about permafrost and when it has occurred in Canada.

Natural Resources Canada provides information on the subject of permafrost. Historical data/maps can be searched on GeoGratis.

Keywords: Natural Resources Canada, GeoGratis, permafrost

Storm Surges

Natural Resources Canada provides information about storm surges including the frequency and severity of past storm surges.

Keywords: Natural Resources Canada, GeoGratis, storm surges

Tornadoes

Natural Resources Canada provides information about tornadoes including historical data. Historical data/maps can be searched on GeoGratis.

Keywords: Natural Resources Canada, GeoGratis, tornadoes

Environment and Climate Change Canada provides information about tornadoes including historical data.

Keywords: Environment and Climate Change Canada, Spring and Summer Storms, GeoGratis, tornadoes

Weather Related Resources

The National Oceanic and Atmospheric Administration (NOAA) website has all kinds of information from weather warnings to climate change.

Keywords: National Oceanic and Atmospheric Administration, weather warning, climate change

The Institute for Catastrophic Loss Reduction (ICLR) has a lot of information about a number of natural hazards:

- Climate Extremes
- Hurricanes
- Tornadoes
- Winter Storms

Keywords: Institute for Catastrophic Loss Reduction, natural hazards

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