THE 1998 ICE STORM: 10-YEAR RETROSPECTIVE

RMS Special Report

EXECUTIVE SUMMARY

The Ice Storm of 1998 hit the Canadian provinces of Ontario and Québec and portions of the northeastern United States from January 4 through January 10, 1998. Unusually long in duration and large in geographical extent, this storm triggered extensive power outages across the impacted region and is widely acknowledged to be Canada's costliest natural disaster.

Due to the collapse of power lines and supporting structures from ice accumulation, over 4.7 million people in Canada and another 500,000 in the United States lost power during the storm. The Canadian utility company Hydro-Québec was particularly hard hit, with over 1,850 miles (3,000 km) of power network impacted by the storm. Nearly 800,000 insurance claims were filed in Canada with another 140,000 in the United States, causing a total insured loss at the time of US$1.3 billion across both countries. The event also triggered a class action lawsuit against a group of Canadian insurers for additional living expenses (ALE) due to evacuation as a result of power outages.

Ten years following the 1998 event, this report chronicles the unique meteorological features of the storm and the potential insurance impacts of a repeat of the event in 2008, in the context of the current RMS understanding of winter storm risk throughout North America. RMS estimates that if the Ice Storm of 1998 were to recur in 2008, given the modifications in insurance industry practices, local disaster management, and improving the resilience of the electrical supply system, the insured loss would result in payments between US$1.0 and US$3.0 billion.

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INTRODUCTION

In early January 1998, a series of storms produced large amounts of freezing rain from northern New York State through the St. Lawrence River Valley region, with some locations receiving over 3.1 in (80 mm) of freezing rain, including Ottawa and Cornwall, Ontario, and Montreal, Québec. This series of storm systems from January 4 through January 10, dubbed the "1998 Ice Storm," devastated the Canadian provinces of Ontario and Québec, as well as portions of the northeastern United States. The event is widely acknowledged to be Canada's costliest natural disaster and was the most severe ice storm to hit the region since at least the 1920s.

Freezing rain is not an uncommon occurrence during the winter months in southern Ontario and Québec and in the northeastern United States, all of which receive an average of 30 to 50 hours of freezing rain a year (Cortinas, Jr. et al., 2004). What made the 1998 Ice Storm unique was its long duration, large geographical extent, and extraordinary freezing rain precipitation totals.

The storm caused considerable damage and disruption across the affected region, with a total of 45 deaths attributable to the storm. Extensive power outages were caused by the significant ice accumulation on power lines (Figure 1), as well as by trees bringing down power lines and transmission towers. Over 4.7 million people in Canada lost power during the storm, along with another 500,000 in the United States. The collapse of the power distribution system meant that more than 400,000 Canadians were still without power nearly two weeks after the storm. The widespread power outages and lengthy repair delays brought significant political pressure and public hostility upon the Canadian utility company Hydro-Québec, which provides almost all of the electricity consumed in Québec Province. Nearly 800,000 insurance claims were filed in Canada and an additional 140,000 in the United States, totaling insured losses at the time of C$1.6 billion in Canada and US$200 million in the United States. However, much of the loss was uninsured and some of the businesses worst affected were dairy farms, the maple syrup industry, and timber companies. According to the National Climatic Data Center (NCDC), the total economic loss at the time was approximately US$4.4 billion, with US$3 billion in Canada alone (National Climatic Data Center, 1999).

Ten years after the event, this report chronicles the unique meteorological features of the 1998 Ice Storm and how the event compares to past ice storms and potential future events in the region. The loss from the storm has also been reconstructed by RMS based on the property values and exposures in 2008, and placed in the context of our latest understanding of the risk from all classes of winter storms in both Canada and the United States.

Figure 1: Ice accumulation on power lines (Source: NOAA)

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THE 1998 ICE STORM

Storm Origin and Atmospheric Structure

The freezing rain of the 1998 Ice Storm was associated with a series of storm systems that originated over the Gulf of Mexico and the Gulf Stream in the subtropical Atlantic Ocean. As these low-pressure systems tracked northward toward the northeastern United States and southeastern Canada, they encountered an inverted, thermally stratified atmospheric structure ideal for the development of freezing rain. Normally, warmer air is situated near the surface of the Earth, with colder air above. However, during the storm a persistent and large-scale thermal stratification developed, sandwiching a warm, moist layer of air several thousand feet above the ground between a below-freezing layer of air in the upper atmosphere and a below-freezing layer near the ground (Figure 2).

This atmospheric thermal inversion developed several days prior to January 4, when a nearly stationary high-pressure system over northern Canada sent extremely cold Arctic air southward. At the same time, a storm system over Texas sent warm, moist air streaming northward. Since warm air is less dense than cold air, the warm air did not displace the cold air near the ground, but instead ascended through it, creating the thermally stratified atmospheric structure.

As snow from the storm systems fell from the upper atmosphere through the deep, warm, and moist layer, the snow melted into rain. Continuing to fall through the atmosphere, these raindrops encountered the shallow, cold layer where the temperature was below freezing, and the rain became supercooled liquid drops (Figure 2). Since the near-surface cold layer was thin, the supercooled raindrops froze instantly once they hit a surface, such as a branch, wire, or the ground.

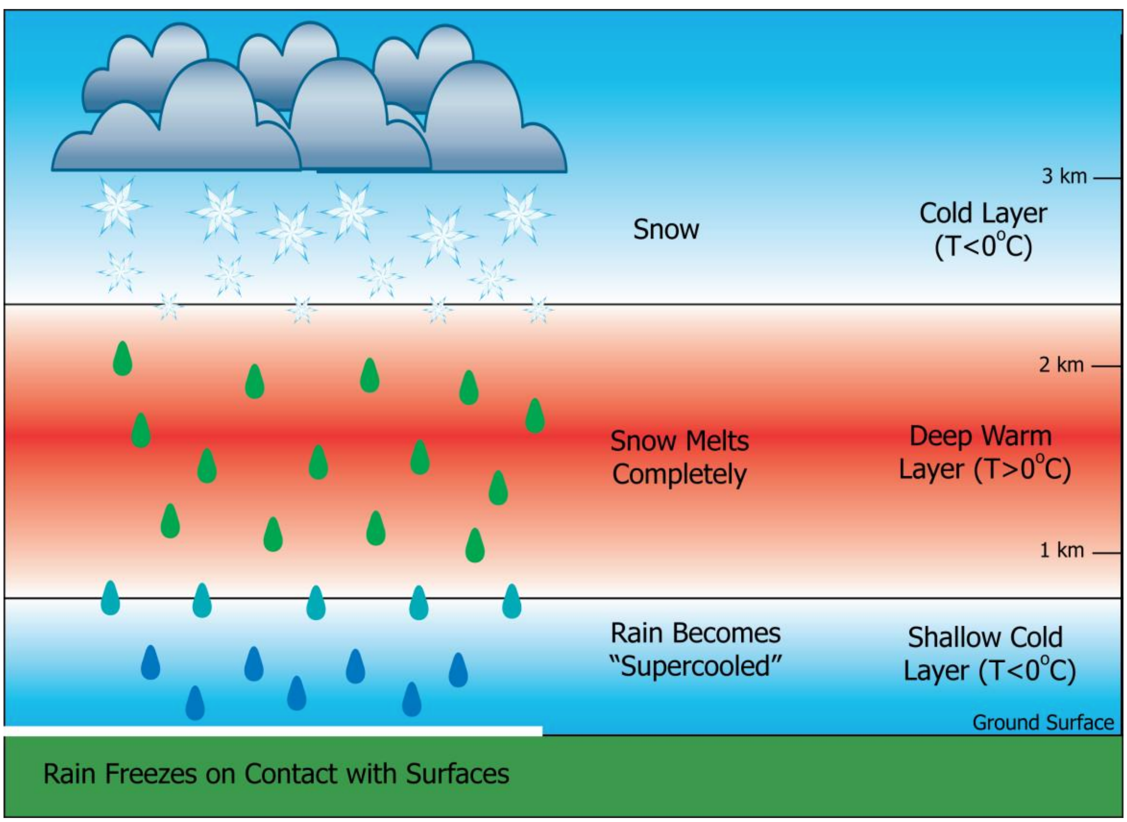

Figure 2: Illustration of the atmospheric thermal inversion needed for the development of freezing rain

Synopsis of the 1998 Ice Storm[1]

At 12:00 UTC on January 4, 1998, a strong, high-pressure system with a central pressure of 1038 millibars (mb) located near Hudson Bay ushered cold Arctic air southward into southern Ontario, Québec, and into the northeastern United States. The front associated with this cold Arctic air mass stalled over northern New England and became the focal point of freezing rain. At the same time, a stationary storm system centered near the panhandle of Texas sent warm, moist, Gulf of Mexico air northward. Where these two contrasting air masses met, a stationary front extended from the far northeastern United States southward toward the storm system centered over Texas. Over the course of several days and into the early morning hours of January 10, these two major synoptic weather features remained almost stationary, blocked by another large, high-pressure system over the Atlantic Ocean near Bermuda that retarded the eastward progression of the storm in Texas. A series of storm systems traveled northward along this stationary front, replenishing the precipitation, before the entire system finally moved off the East Coast of the United States on January 10, 1998.

The first wave of low pressure that originated over the Gulf of Mexico propagated northward along the stationary front at 00:00 UTC on January 5. Light freezing rain was initially reported in eastern Ontario, southwestern Québec, and northern New York State, while more intense precipitation began at 06:00 UTC on January 5 and continued for the next 24 hours. At 12:00 UTC on January 7, the low-pressure system in the southeastern United States slowly migrated toward Louisiana with a central pressure of 998 mb. The nearly stationary front formerly located across the northeastern United States now sagged southward near the New York and Pennsylvania border. The majority of freezing rain had dissipated across southeastern Ontario and southern Québec.

Twelve hours later, at 00:00 UTC on January 8, freezing rain began to fall again across parts of the Ontario, Québec, and New Brunswick provinces, as well as the states of New York and Maine, as a wave of low pressure traveled along the stationary front (Figure 3). This second bout of freezing rain continued for the remainder of the day before a more intense wave of low pressure arrived on January 9.

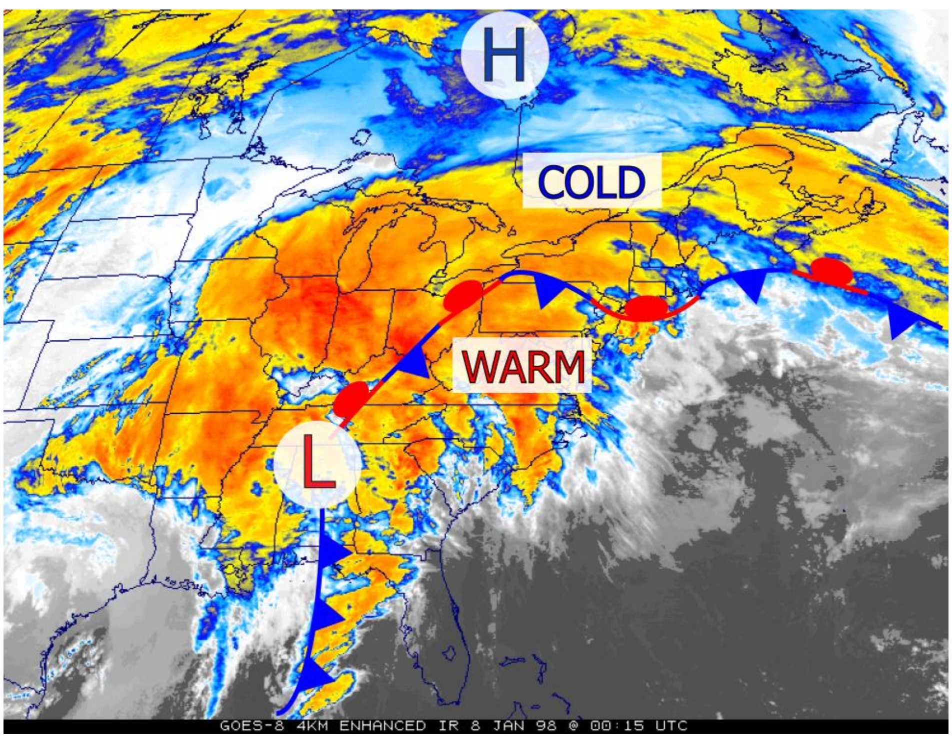

Figure 3: Satellite image and surface weather map of the 1998 Ice Storm on January 8, 1998 (Satellite image source: National Oceanic and Atmospheric Administration)

[1] The synopsis of events is taken primarily from Gyakum and Roebber, 2001, and National Weather Service, 1998.

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The last round of freezing rain began around 12:00 UTC on January 9 as the synoptic pattern finally began to break down. The low-pressure system over New York State continued to stream warm, moist air from the Gulf of Mexico and the Gulf Stream off the Atlantic Ocean to the affected region before finally dissipating in the early morning hours of January 10. After six days of intermittent freezing rain, impressive amounts of precipitation were recorded across the region. An accumulation of freezing rain greater than 3.1 in (80 mm) thick stretched from southeastern Ontario and northern New York State into southwestern Québec (Figure 4).

Within the generally flat terrain of the St. Lawrence and Champlain valleys, ice thicknesses were fairly uniform, but in the mountainous areas of Vermont and New Hampshire, ice thicknesses varied markedly. Many valleys in Vermont and New Hampshire remained above freezing, resulting in little ice accumulation. Elevations above 4,000 feet remained in the warm layer of the atmosphere, also resulting in low accumulation totals.

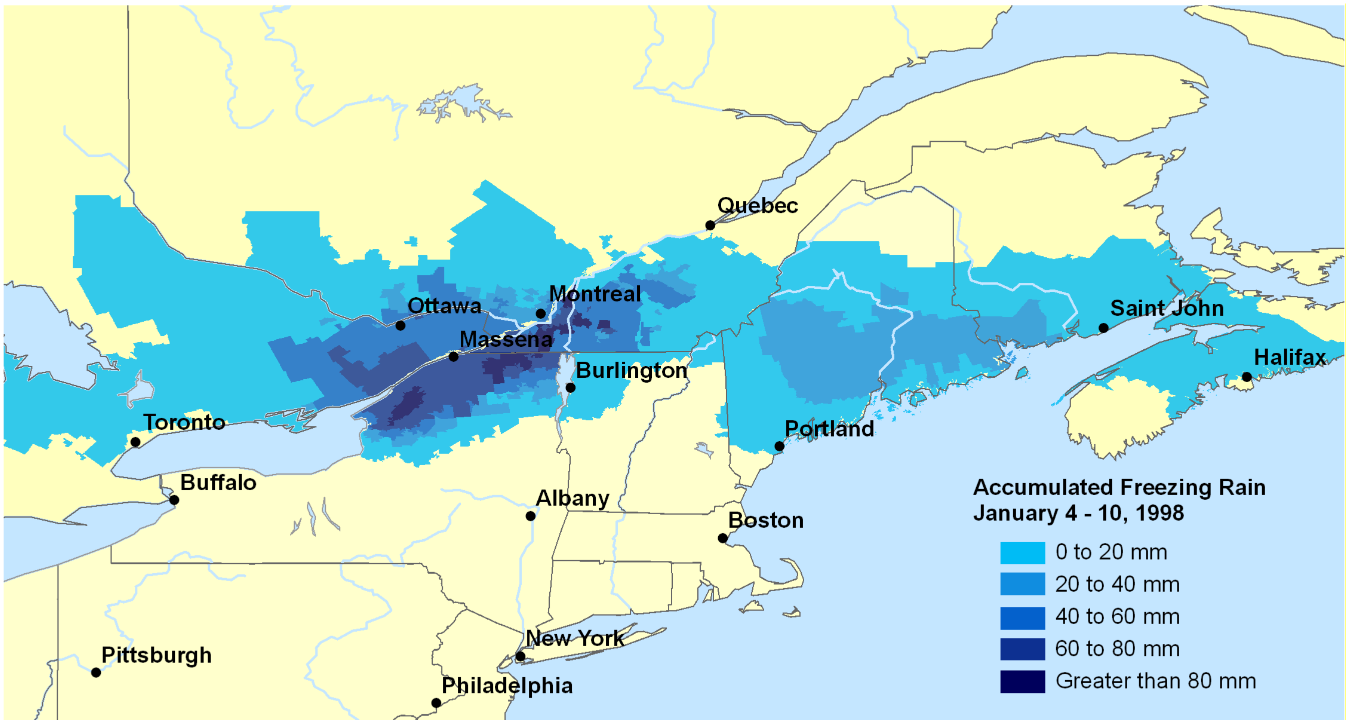

Figure 4: Total ice accumulation due to the 1998 Ice Storm in Canada and the United States

Climatic Perspective of the 1998 Ice Storm

There are several remarkable features of the 1998 Ice Storm related to the storm's unusual persistence and the way in which both precipitation and Arctic air were resupplied during the storm. These factors contributed to the extraordinary ice accumulation, the long duration of the event, and the large spatial extent of the storm.

The 1998 Ice Storm occurred in the midst of a strong El Niño event, with very warm sea surface temperatures across the eastern equatorial Pacific Ocean. A number of previous studies have theorized that the El Niño contributed to the large-scale atmospheric flows and the resupply of warm, moist air from the Gulf of Mexico, generating the ice storm's prolonged precipitation with an area of pronounced river flooding to the south of the area of ice accumulation. For example, Barsugli et al. (1999) used a forecasting model developed by the National Centers for Environmental Prediction to show a statistical correlation between El Niño and the 1998 storm. Moreover, according to Higuchi et al. (2000), an apparent connection exists between a positive phase of the North Atlantic Oscillation (i.e., when pressures in Iceland are much lower than in the Azores) and a persistent high-pressure system in northern Québec, as evidenced by three out of the four major freezing rain events since 1961, including the 1998 Ice Storm.

While Ottawa and Montreal sustain, on average, over 40 hours of freezing rain a year, the 1998 Ice Storm resulted in 80 hours of freezing rain and drizzle with 3.9 in (100 mm) of accumulation in Montreal. By this standard, the 1998 storm was the worst event to hit Canada in recent years. Moreover, comparing major storms in southeastern Canada, the December 1986 storm in Ottawa and the February 1961 storm in Montreal each deposited between 1.2 and 1.6 in (30 and 40 mm) of ice, which is less than half the ice thickness of freezing rain that occurred in the 1998 storm in these two Canadian cities (Meteorological Service of Canada, 1998).

Within the U.S. digital meteorological record, which began in 1948, the magnitude of the 1998 Ice Storm was unprecedented (DeGaetano, 2000). The 1998 event caused freezing rain to fall for 115 hours in Massena, New York, approximately twice as long as any storm in the previous fifty years. The freezing rain precipitation totals from the 1998 storm at Massena, New York (3.5 in or 90 mm) and Burlington, Vermont (2.2 in or 57 mm) were the highest ever recorded during this same time period. Prior to 1948, meteorological records become less reliable and it is more difficult to make precise comparisons with past ice storms. However, from the available information, it is clear that the 1998 Ice Storm was the most severe ice storm to hit the region since the 1921 Great New England Ice Storm or the Ice Storm of 1929.

The 1921 Great New England Ice Storm impacted a large region to the southeast of the 1998 storm footprint that included eastern Massachusetts, southern New Hampshire, Rhode Island, and Connecticut (DeGaetano, 2000). Millions of dollars in damages to telephone and electrical wire systems were reported, with additional extensive damage to fruit and shade trees. Ice accumulation measuring 2.0 in (50 mm) in diameter was observed on wires throughout the impacted area. The cities of Concord and Lawrence, Massachusetts reported the highest freezing rain totals with nearly 3.9 in (98 mm) and 3.1 in (78 mm), respectively.

The Ice Storm of 1929 impacted a similar region to that of the 1998 Ice Storm and produced similar ice loads (Jones and Mulherin, 1998). Freezing rain was reported across a large geographical area extending from Buffalo, New York through southeastern Ontario and southern Québec into the state of Maine. Strong winds up to 50 miles per hour (22 m/s) followed the freezing rain, causing extensive damage to ice-laden trees as well as electrical, telephone, and telegraph lines.

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DAMAGE AND LOSS FROM THE 1998 ICE STORM

Impact on Canada

Southeastern Ontario and southern Québec provinces suffered the most extensive damage and disruption from the 1998 storm, including 28 deaths linked to the event, primarily due to trauma or hypothermia associated with the loss of electrical power. Over 100 people were treated in emergency rooms for the effects of carbon monoxide poisoning from indoor generator use and improper ventilation. Structurally, the principal cause of damage was the weight of the ice accumulating on branches and wires, which led to failure of the branches and collapse of the wires or their supporting poles and pylons. Tree branches also fell onto wires, causing further breakages, and onto buildings, cars, or other structures. Transportation was severely disrupted across the region due to fallen tree branches and electrical wires across roadways, along with numerous automobile accidents caused by the ice. The loss of power meant that businesses could not function and many homes could not be heated. Around 600,000 people moved out of their homes, with 100,000 taking residence in temporary shelters to escape the cold. The loss of transmission towers due to both interrupted power and collapse from ice loading further disrupted communications (Figure 5).

Figure 5: Collapse of Hydro-Québec pylon during the 1998 Ice Storm (Source: http://www.vancouverislandpowerline.com/quebec_ice_storm.html)

The storm caused extensive power outages, impacting more than 4.7 million people, or 16 percent of the Canadian population. More than 400,000 residents in Québec were still without power two weeks after the ice storm and it took almost a month to fully restore power (Lecomte et al., 1998). According to McCreedy (2004), more than 1,850 miles (3,000 km) of Hydro-Québec's power network was impacted by the ice storm, with more than 24,000 poles, 4,000 transformers, and 1,000 steel pylons in need of repair. The province of Ontario had to repair over 11,000 poles, 1,000 transformers, and 300 steel towers. The cost of repairing the Hydro-Québec and Ontario Hydro power systems was C$1 billion (Lecomte et al., 1998).

The 1998 Ice Storm was also notable for its effect on Canadian forests. Statistics Canada (1998) estimates that nearly one million trees were damaged by the prolonged freezing rain. The Ontario Ministry of Natural Resources conducted aerial surveys and found widely scattered damage dependent upon tree species, with hardwood species suffering the most damage (e.g., poplar, soft maple, and white birch).

Potential homeowner's insurance damages from the storm fell into three classes: direct physical damage from falling branches and poles, indirect compensation for additional living expenses (ALE) associated with vacating properties that lacked electrical power, and damage associated with the loss of power itself — in particular

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related to pumps and freezers. While damage that fell into the first category was uncontroversial, there was uncertainty as to how contract wordings should be interpreted for the second and third categories.

On January 8, the Insurance Bureau of Canada (IBC) announced that additional living expenses would not be compensated without an evacuation order from civil authorities. On January 13, the premier of Québec, Lucien Bouchard, announced that citizens without auxiliary heating should leave their homes, but there was no legislative action to support his announcement. However, on January 22, the IBC acknowledged that this constituted an evacuation order for claims processing. Unfortunately, a large portion of homeowners believed that they were not fully compensated for their loss and in January 2000, a lawsuit was filed against ten Canadian insurers for ALE coverage. In 2005, the January 2000 lawsuit was substituted by a class action lawsuit filed against 19 insurance companies operating in Québec. The 2005 lawsuit, which is still ongoing in 2008, claims additional living expenses of C$75 per day for all those who were told to evacuate as a result of power outages caused by the storm, as well as C$250 exemplary damages. The case is not expected to be settled until at least 2009[2]. Finding for the plaintiffs could add nearly C$1 billion to the insurance loss from the storm (Gambrill, 2007).

While many grocers and restaurants purchase coverage for freezer contents spoilage, it is not a standard part of a homeowner's policy. However, evidence suggests that freezer contents losses were widely paid by insurers on the basis that the loss of power was associated with a weather catastrophe. As the value of the spoiled food could not be independently verified, claim exaggerations were likely to have occurred, to which stories concerning the extraordinary quantity of lobster residing in Montreal freezers may attest.

According to the IBC, the final bill paid by the insurance industry was nearly C$1.6 billion at the time of the event, with nearly 800,000 insurance claims reported. The storm caused significant economic loss to the manufacturing, transportation, retail, and agricultural sectors. The maple syrup industry sustained losses of C$25 million caused by the widespread tree damage in the region. As a result of the power outages, 5,500 Canadian dairy producers were forced to dump 13.5 million liters of milk worth C$7.8 million (McCready, 2004).

Impact on the United States

The northeastern United States also suffered extensive damage and disruption, although the greatest ice accumulation generally affected the less populated areas of northern New York, Vermont, New Hampshire, and Maine. The storm was linked to 17 deaths, 10 of which occurred in northern New York State. According to the Property Claims Services (PCS), more than 120,000 claims were submitted, resulting in total insurance losses of US$200 million. As in Canada, the widespread and prolonged power outages had a significant impact, with more than 500,000 people losing electricity. A week after the storm, 50,000 rural customers were still without power and it took nearly three weeks for power to be fully restored. According to DeGaetano (2000), 20 main transmission lines, 13,000 utility poles, 100 high-voltage structures, and 5,000 transformers needed to be replaced by the two largest utility companies servicing the impacted region, resulting in a repair bill of US$175 million.

Since the ice storm mainly impacted rural areas in the United States, dairy farms, the maple syrup industry, and forests were particularly hard hit. Power outages prevented the operation of milking machines and milk storage vehicles causing a loss of milk worth US$12.7 million (Lecomte et al., 1998). DeGaetano (2000) reported that approximately US$15 million was lost in the United States maple syrup industry from damaged trees and collection equipment with over US$9 million in New York State alone. As in Canada, about 70 percent of the forests in the region were damaged, totaling 17.5 million acres. The widespread forest damage greatly impacted loggers, sawmill owners, and other businesses that service the timber industry (Figure 6).

[2] For more information, see http://www.option-consommateurs.org/avocats/recours_collectifs/41/

Figure 6: Heavy stem and branch damage in northern Vermont due to the 1998 Ice Storm (Source: Forest Service, United States Department of Agriculture http://www.na.fs.fed.us/fhp/ice/durham/photo_g/photos.shtm)

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THE STORM IN PERSPECTIVE

For the 10th anniversary of the 1998 Ice Storm, RMS evaluated the issues involved in modeling this historic event, as well as the potential insurance impacts of a repeat of the event in 2008.

Modeling the 1998 Ice Storm in 2008

The 1998 Ice Storm is one of several thousands of events available in the 2008 RMS® North America Winter Storm Model. All major sources of damage associated with winter storms are explicitly modeled in the stochastic event set, including snow, ice, freezing temperatures, and extra-tropical winds. The 1998 storm and other similar events were developed through an innovative hybrid approach that uses statistical and numerical weather prediction techniques. Large-scale atmospheric fields are simulated using a Global Circulation Model (GCM) and refined by a regional mesoscale model and statistical methods. For events where the atmospheric temperature profile is conducive to freezing rain at the ground surface, such as in the 1998 Ice Storm, the accumulated ice thickness is computed from the precipitation and surface wind fields.

The vulnerability of the built environment to ice storms is a function of the ice thickness and wind speeds during the storm, and is captured in the model as direct damage from falling tree limbs and indirect damage resulting from power outages. For insurance losses, direct structural and non-structural damage to buildings and appurtenant structures (i.e., garages, carports, awnings, etc.) are modeled. For instance, small tree limbs falling onto a roof could damage the roof cover. A large branch could damage the roof cover as well as some roof structural elements, and may even damage windows and gutters. A collapsing tree could damage a substantial part of the roof and walls of a building. In addition to these types of damage, contents damage could occur as a consequence of substantial structural damage to the building envelope.

The damage associated with ice storms can be greatly increased by relatively high winds that occur during the period of icing or shortly after, while trees and wires are heavily loaded but before melting occurs. Higher wind speeds can increase the severity of the event directly through increased ice loading or indirectly through an increase in water flux due to the horizontal velocity of the raindrops (DeGaetano, 2000). Wind speeds in the 1998 Ice Storm were relatively low, with wind speeds ranging from 10 to 20 mph (5 to 9 m/s). In comparison, the 1962 Ice Storm that impacted western New York had maximum freezing rain accumulations of about 2.9 in (74 mm), less than the 1998 Ice Storm. However, wind gusts from this storm were as high as 70 mph (31 m/s) following the event, which greatly increased the damage from the storm.

During an ice storm, the weight of accumulated ice on transmission wires and towers could lead to substantial damage or collapse. In addition, falling limbs or leaning trees could damage the distribution network. The resulting power outages can cause indirect structural damage in the form of frozen pipes, malfunctioning heating systems, and broken electrical equipment. Moreover, inoperable sump pumps can lead to flooded basements. Contents damage can also be induced by power outages, such as in the loss of refrigerator and freezer contents. The presence of a strengthened transmission and distribution network or the possession of backup electricity generators reduces the potential of indirect damage to structures and their contents. These factors can be captured in the model.

Business interruption (BI) losses and additional living expenses (ALE) are calculated from the damage to the property or facility, as well as the impact of infrastructure (i.e., power, roads, telecommunications, etc.) through the use of time-dependent recovery models. The principal driver of additional living expenses to homeowners is evacuation caused by prolonged power outages if heat is not working and backup generators are not readily available. Business interruption losses to commercial and industrial properties are largely due to infrastructure downtime and disruption of normal business practice.

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The Cost of the 1998 Ice Storm in 2008

There are two ways of estimating the cost of a repeat of the 1998 Ice Storm in 2008. The most straightforward method is to assume that the 1998 event had not happened and trend forward the insured losses for both Canada and the United States to 2008 dollars in response to changes attributable to inflation, wealth, and population within the affected areas. Alternatively, the expected cost of a repeat of the event can be explored in the context of all of the changes that were triggered by the catastrophe, in particular those related to modifications in insurance industry practices, local disaster management, and improving the resilience of the electrical supply system.

Following the exercise outlined by Pielke and Landsea (2006), the insured losses from the 1998 Ice Storm can be trended forward to 2008 dollars to account for changes in inflation, wealth, and population in the affected areas. For example, using information from Statistics Canada and the Bank of Canada, and estimating the population within the ice accumulation footprint, factors for inflation, wealth, and population increase the Canadian loss by close to 95%. As previously discussed, the insured losses from the 1998 Ice Storm were C$1.6 billion in Canada and US$200 million in the United States. Combining all three factors, had the 1998 Ice Storm not occurred and instead hit the region in January 2008, it would result in an insured loss of C$3.1 billion in Canada and US$400 million in the United States. As the exchange rate between Canadian and U.S. dollars is almost one-to-one in January 1998, this yields a total insured loss of approximately US$3.5 billion across the impacted region.

A different loss estimate is obtained if one analyzes a recurrence of the event in 2008 in the same region as occurred in 1998 considering all the changes that were made in response to the storm. As already discussed, potential insurance losses fall into three categories: direct physical damage to automobile and property insurance coverages, additional living expenses where applicable, and as a result of the prolonged loss of power, refrigerator and freezer contents as covered. In terms of direct physical damage, it is assumed that the a repeat of the event would lead to similar levels of damage to trees and the vulnerability of lightweight infrastructure in the region has not changed significantly since 1998. Therefore, property damage can be expected to scale according to the greater concentration of properties and values in the affected area.

However, the remainder of the potential losses is a consequence of the extent of any interruption in electricity supply and the way that insurance coverages are applied. In terms of the resilience of the electrical power supply system, the Nicolet Commission, which investigated the impact of the 1998 Ice Storm, urged Hydro-Québec to reinforce its grid and introduce measures to limit the scope of future blackouts. Beyond the cost of the immediate repairs, the utility has taken steps to replant and reinforce wooden utility poles, reinforce major pylons, and bury a few electrical lines. A new high-voltage power line has also been added to the Montreal power grid to reduce the potential for a total loss of power to the city. While the utility has stated that the grid is significantly improved, an ice storm of the magnitude of the 1998 event would still cause significant and lengthy power outages, but would likely result in lower secondary insured losses because of the improvements made to the electrical system.

Given the publicity that has followed the class action litigation associated with additional living expenses and the enforced evacuation in Québec, in a repeat of the storm there would be little possibility of ambiguity over the legislated ordering of an evacuation. An evacuation order would likely be issued within 24 hours in areas of prolonged power outages in recognition of the threat to life posed by hypothermia. The Québec government has also set up a scheme of payments for evacuations lasting more than three days (averaging around C$40 per household), but this is not expected to replace claims for insurance recovery under ALE, especially until the class action litigation is resolved. For those householders that experienced the lengthy power outages of 1998, the immediate response was to purchase generators and non-electrical stoves and heaters to ensure they could stay in their homes for several days without electrical power. However, as years pass and the collective memory of the 1998 Ice Storm fades, a decreasing proportion of households will have invested in and maintained all the necessary secondary power and heating equipment to survive for many days without electricity.

While bursting pipes that result from the loss of power are expected to be paid under an insurance contract, freezer contents are not expected to be covered as a result of loss of offsite power. Since 1998, insurers have

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repeatedly emphasized and clarified in their contract wordings that this coverage would not be included unless a separate endorsement was purchased. Therefore, fewer freezer contents claims would be expected if the 1998 Ice Storm occurred in 2008. However, a greater proportion of restaurant owners and food merchants are likely to have the coverage than in 1998.

Therefore, if the 1998 Ice Storm recurred in January 2008, there would be fewer overall power outages, especially in urban centers, although the number of people with long-lasting outages in rural areas could be expected to be comparable to 1998. A greater proportion of people would also be able to stay in homes without power because of their backup heat and generator systems. While there would be a reduction in the numbers displaced, insurers could still expect many ALE claims, but would likely attempt to pay far fewer claims for freezer contents than in 1998. Combining all of these factors, and including the proportion of the loss associated with ALE and freezer contents claims in 1998, a recurrence of the storm would today leave a total insurance payment of between US$1.0 and US$3.0 billion. This range reflects the uncertainty in the behavior of the insurers, electricity supply industry, and disaster management officials, as much as uncertainty about the impacts of the event.

Implications of the 1998 Ice Storm for the Insurance Market

The 1998 Ice Storm highlights a number of features of complex catastrophic losses, as are also found in events such as the 2001 World Trade Center attacks, or Hurricane Katrina in 2005. These include the way in which insurance losses associated with direct damage from the event comprise only a minor proportion of the overall insurance loss — something that is typically associated with Super Catastrophe events. Disruptions to infrastructure lead to evacuations, which in turn become a principal driver of the overall insurance loss. The event also highlights key elements of loss amplification from claims inflation and coverage expansion associated with insurers paying parts of claims for which the terms of coverage may have been ambiguous. In the 1998 Ice Storm, this involves additional living expenses and freezer contents coverages for which the actual losses could not be verified. Also, the class action suit currently proceeding in Québec that aims to expand the liabilities of insurers has the potential to be settled following other future catastrophes, making it more difficult to resolve the final losses.

While, as argued in this report, changes have been made to the electricity supply infrastructure, as well as to disaster management procedures in the areas directly affected by the 1998 Ice Storm, in other regions prone to intense ice storms, the level of preparedness today will be little different than that which prevailed in southern Québec in 1998. The 1998 event surprised insurers and reinsurers with the magnitude of losses that could be associated with a winter storm in this region. Increases in the numbers and values of properties across the northern parts of the United States and southern Canada can be expected to bring far larger winter storm losses in the future.

Modeling of the Winter Storm Peril for Risk Management

Winter storms in North America are frequent events, causing nearly US$2 billion of insured losses annually, and with several historical incidences of losses exceeding US$2 billion (in 2008 dollars) such as the 1998 Ice Storm, the 1993 Storm of the Century, and the 1983 Freeze Outbreak. As such, winter storm losses form a significant part of the US$25 billion average annual loss from wind-related perils in North America, with the other major contributors coming from hurricanes and related damage (US$14.2 billion) and severe convective storms (US$8.5 billion). With the explicit modeling of each of the winter storm related modes of damage (snow, ice, freezing temperatures, and extra-tropical winds), and the modeling of straight-line winds, tornadoes, and hail in the RMS® North America Severe Convective Storms Model, together with U.S. hurricane and storm surge modeling, RMS offers a comprehensive capability for modeling natural peril related losses to wind and fire policies across North America.

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REFERENCES

Barsugli, J.J., Whitaker, J.S., Loughe, A.F., Sardeshmukh, P.D., and Toth, Z., 1999. "The Effect of the 1997/98 El Niño on Individual Large-Scale Weather Events." *Bulletin of the American Meteorological Society* 80: 1399-1411.

Cortinas Jr., J.V., Bernstein, B.C., Robbins, C.C. and Strapp, J.W., 2004. "An Analysis of Freezing Rain, Freezing Drizzle, and Ice Pellets across the United States and Canada: 1976–90." *Weather Forecasting* 19: 377–390.

DeGaetano A. T., 2000. "Climatic perspective and impacts of the 1998 northern New York and New England ice storm." *Bulletin of the American Meteorological Society* 81: 237–254.

Gambrill, D., 2007. "Slipping into Chaos." Claims Canada, April/May 2007. http://claimscanada.ca/issues_CLC/ISarticle.asp?id=186511&story_id=20546154214&issue=04022007&PC=CLC

Gyakum, J.R. and Roebber, P.J., 2001. "The 1998 Ice Storm–Analysis of a Planetary-Scale Event." Monthly Weather Review 129(12): 2983–2997.

Higuchi, K., Yuen, C.W., and Shabbar, A., 2000. "Ice Storm '98 in Southcentral Canada and northeastern United States: A climatological perspective." *Theoretical and applied climatology* 66: 61-79.

Jones, K.F., and Mulherin, N.D., 1998. "An Evaluation of the Severity of the January 1998 Ice Storm in Northern New England: Report for FEMA Region 1." U.S. Army Cold Regions Research and Engineering Laboratory, April 1998.

Lecomte, E. L., Pang, A.W., and Russell, J.W., 1998. "Ice Storm '98." Institute for Catastrophic Loss Reduction: ICLR Research Paper Series – No. 1.

McCreedy, J., 2004. "Ice storm 1998: Lessons Learned." 6th Canadian Urban Forest Conference, October 19 - 23, 2004, Kelowna, British Columbia.

Meteorological Service of Canada 1998. "Ice Storm '98: Worst Ice Storm in Canadian History." Meteorological Service of Canada, January 28, 1998. http://www.msc-smc.ec.gc.ca/events/icestorm98/icestorm98_the_worst_e.html

National Climatic Data Center, 1999. "Eastern U.S. Flooding and Ice Storm." National Climatic Data Center Report, April 12, 1999. http://www.ncdc.noaa.gov/oa/reports/janstorm/janstorm.html

National Weather Service, 1998. "Service Assessment: The Ice Storm and Flood of January 1998." National Weather Service Report, June 1998. http://www.nws.noaa.gov/om/assessments/pdfs/iceflood.pdf

Pielke, Jr., R. A. and Landsea, C.W. 1998. "Normalized Hurricane Damages in the United States: 1925-1995." *Weather and Forecasting* 13: 621-631.

Statistics Canada, 1998. "The St. Lawrence River Valley 1998 Ice Storm: Maps and Facts." Catalogue no. 16F0021XIB. http://www.statcan.ca/english/freepub/16F0021XIB/storm.pdf

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