ICE STORMS: AN IN-DEPTH LOOK AT THE CAUSES, EFFECTS, AND CONSEQUENCES

W. Patrick Dryer, Jackie E. Ebert & Nicholas E. King

Abstract

Ice Storms are very remarkable and fascinating environmental events. Many factors must be just so in order for these amazing natural occurrences to form. Air temperature, pressure, humidity, as well as prevailing winds and air mass movements are all important in the creation of these potentially damaging hazards. An ice storm’s duration can last from a few hours to several days. This project looks into the delicate formation, impacts, and general response to ice storms—specifically with the 1998 ice storm which took place from January 5th to January 10th in a large part of eastern Ontario, southwest Quebec, and the north eastern United States.

Formation

The formation of an ice storm relies entirely on the storms ability to create conditions which produce freezing rain. These conditions are very precise and if not just so, the freezing rain will alter its molecular state into something more common, such as snow, sleet or simply rain.

This delicate dance between air temperature and moisture begins with the advancement of moist, warm air in the form of a warm front. As this warm front moves in, it creates into a mass of cold air. It produces a classic vertical temperature inversion with warm air above cold air. If the warm air rises over the cold air it begins to cool and condense. When this condensed air reaches the upper levels of the atmosphere it has now reached temperatures well below freezing (Figure 1), forming crystallized ice which quickly grow into snowflakes. The snowflakes, too heavy to stay in the atmosphere, fall to earth. At this point, if the temperature of the air remains consistently below freezing, the snow will fall to earth as snow. Nevertheless, if there is a warm enough and deep enough layer of air the snow will melt and continue to the ground as rain. For the raindrops to reach the ground as freezing rain they must be supercooled—where the temperature of a water droplet must drop below 0 C (32 F) without freezing. This temperature not constant, but is specific for each droplets size and particulate matter content. The thickness and temperature, as with the warm air mass, is critical in the cold air mass for the formation of freezing rain (Figure 2). If the cold air mass is too thick or too cold it could alter the rain droplets to sleet or ice pellets. If the cold air mass is too warm or too thin the rain could continue to the ground as rain, and remain that way unless it comes in contact with a surface temperature well below freezing.

For freezing rain to occur, warm air must be lifted, cooled and crystallized into snowflakes. These snowflakes then fall to earth, but not before experiencing two more temporal changes. The snowflakes then fall to earth, but not before experiencing two more temporal changes. The flakes will pass through a warm layer of air that will melt them into rain droplets, then finally pass through a cold layer of air that will need to cool the droplets to freezing 0 C (32 F) without freezing them (Figure 3). Then and only then is freezing rain produced. This fragile coordination of air temperatures and moisture is critical for the creation of an ice storm.

Consequences

Figure 12-Ice Effect on Powerlines. The heavy ice can cause powerlines to fail over.

Figure 11-Ice Effect on Powerlines. Infrastructure damage due to freezing rain is one of the largest concerns for communities prone to frequent ice storms. Overhead lines are conceivably hit the hardest by ice storms (Figures 11&12). Hanging wires can collect up to a 5 centimeter coating adding up to 20 pounds per foot of extra weight. This extra weight is what causes infrastructure failure. The combined forces of ice, wind and weight cause failure in power lines at weak points as well as cause towers to collapse to the ground under the added stresses (Figure 13).

Animals active in the winter months are also quite vulnerable to ice storms (Figure 14). Starvation is a large problem because animals, specifically deer and cattle, cannot get to food that has been covered with ice. Birds who cannot find shelter during an ice storm might find their feet frozen to whatever surface they perch on. Bird’s wings also get covered in ice making flight an impossibility. Ground bound animals may also see certain death because frozen drifts enclose opening for escape.

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For six days in January of 1998, freezing rain covered an extensive area including Ontario, Quebec, New Brunswick, and parts of New York and England. According to Environment Canada, more than 80 hours of freezing rain totaling more than four inches in some areas more than doubled the annual average rain fall. The storm affected nearly 4 million people, leaving them without power for more than a day, and 700,000 people remained without power three weeks after the storm. Conserves estimates of damage costs exceed one-half billion dollars from this storm. The ice storm of 1998 directly affected more people in Canada than any other previous weather event in recorded history.

The Storm of 1998

Figure 8- Shows Quebec’s transmission power grid before the storm.

Figure 9- Shows Quebec’s transmission power grid after the storm. Red areas show damaged power lines.

More than three million people in four states and two Canadian provinces were with.  The combined forces of ice, wind and weight add stresses (Figure 13).

Conclusion

Figure 16-Iced Deciduous. Deciduous trees, on the other hand, are quite vulnerable to ice storms due to their multiple large branches and non-evolutionary assistance (Figure 16). Icing can also saplate plants by sealing leaves from air with ice sheets.