# A CATASTROPHIC LAKE EFFECT SNOW STORM OVER BUFFALO, NY OCTOBER 12-13, 2006

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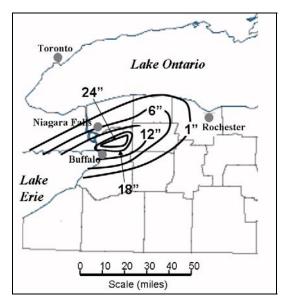
### 1. INTRODUCTION

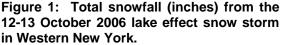
On October 12-13, 2006, an intense, localized, early season snowstorm hit Buffalo, New York and its immediate suburbs. The storm was comprised of a narrow band of very heavy wet snow which developed off the warm 17°C waters of Lake Erie, producing as much as two feet of snow in a little over twelve hours (Fig 1). The areal extent of the snowfall was on a very small scale, covering a width of no more than 25 miles and a length of approximately 40 miles. However, that narrow swath covered the most heavily populated metropolitan area of upstate New York with over 1,000,000 people directly impacted by the storm.

While lake effect snowfalls of a foot or more are not uncommon for the Buffalo metropolitan area from mid-November through January, snowfall of this magnitude so early in the season is certainly a rare event for Western New York. The explosive mid-October convection over Lake Erie dropping a heavy wet snow on fully foliated trees had catastrophic results.

# 2. SYNOPSIS

On the morning of October 12, 2006, an anomalously deep upper-level low centered over Northwestern Ontario circulated unseasonably cold air across





the Upper Great Lakes and Midwest. The well stacked surface to 500-hPa low pressure system resulted in a deep cyclonic flow over Lake Erie (Fig 2). The associated cold front swept across Western New York during the morning hours with light rain in its wake. During the course of the day colder air wrapped around the base of the deep trough and moved up the length of Lake Erie. As the cold air deepened over the warm waters of Lake Erie, light rain over the Buffalo area became mixed with graupel.

Mixed rain and graupel inland from lake Erie between 1500 and 1700 UTC quickly changed to all snow by 1800 UTC. This occurred at a time when a

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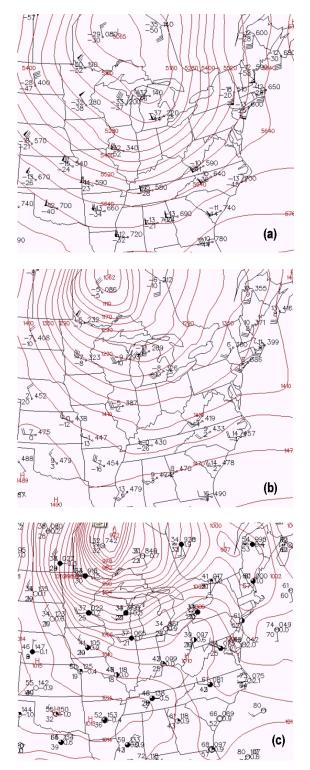


Figure 2: Synoptic maps from 0000UTC 13 October, 2006. (a) 500-hPa height and station plot, (b) 850-hPa height and station plot, (c) Surface pressure and station plot.

special upper air sounding at Buffalo showed fairly pronounced cooling between 3000 and 6000 ft, which was just below a very favorable snow crystal growth area. By 1900 UTC, cloud to ground lightning strikes were noted on the National Lightning Detection Network (NLDN) and reported by NWS Buffalo snow spotters. While thundersnows themselves are very uncommon (Curran, 1971), those that do occur typically only last up to 5 hours (Market, 2001). The NLDN depicted an average of fifteen cloud to ground strikes per hour between 0000 and 0900 UTC on Oct 13 with fourteen nonconsecutive hours of lightning being reported at BUF (Fig 3).

The lightning was an indication that there was enough mixed precipitation within the convective elements of the lake effect precipitation to initiate an electrical charge, and that there was also a very deep boundary layer present to allow for sufficient charge separation (Schultz, 1979). The 1800 UTC KBUF sounding verified that there was a lack of any capping through at least 18,000 feet, and the NAM/WRF model sounding depicted that an even more impressive 22,000 foot deep boundary layer was in place. This was nearly twice the thickness of most heavy lake effect thundersnow environments found over Western New York (Niziol, 1982).

While the Lake Erie surface water temperature averaged 17°C, the air temperature at 850mb was -6°C. The corresponding lake to 850mb delta T of 22°C resulted in a very unstable boundary layer. A unidirectional surface to 700mb flow aided in the development of a lake effect band of mixed precipitation. In addition. surface temperatures along both shores of Lake Erie were generally between 4°C and 6°C during the bulk of the daylight hours on Oct 12, but dew points of -3°C to -8°C indicated a very dry surface environment. Some of this drier air would have likely become part of the convergent low-level flow that fed into the lake band over the center of the lake. The influx of this very dry air in the low levels would have aided in evaporative cooling of the column, which upper air soundings showed to be just below freezing in the lowest few thousand feet.



Figure 3: 0100 UTC KBUF WSR-88D composite reflectivity image and National Lightning Detection Network one-hour lightning display.

Other microphysical processes may have played a role in changing the mixed precipitation to snow. The heavy precipitation rates that developed within the convective band may have dynamically cooled the column of air as colder air aloft was brought down to the surface in strong downdrafts. Lackman (2002) showed through case studies and equations that latent heat of melting during heavy precipitation rates at the early stages of an event can supply enough cooling to change mixed rain and graupel to snow. This scenario was supported by a report from a Buffalo television meteorologist who reported a brief changeover back to light rain as the heart of the lake effect snow band temporarily lifted north of his location (Parker, 2006, Personal Communications).

The most likely reason for the quick changeover from rain to snow was that the airmass simply became cold enough due to the advection of colder air aloft across the region late that day. Numerical guidance from the previous day forecasted 850mb temperatures to be in the vicinity of  $-4^{\circ}$ C to  $-6^{\circ}$ C during the afternoon and evening of Oct 12. In actuality, upper air soundings showed that temperatures at that level were between  $-6^{\circ}$ C and  $-8^{\circ}$ C.

Typically during the early Fall the diurnal effect of higher daytime surface temperatures over land tends to limit band organization. Even so, a well defined band of lake effect precipitation had developed by late in the day. During the night, colder land temperatures combined with further deepening of the cold air to intensify the lake effect band.

The favorable microphysics were also accompanied by equally favorable shear parameters common to single band lake effect events (Niziol, 1995). Overnight KBUF VAD wind data showed an extremely well aligned, low sheared southwesterly flow below 10,000 feet. The southwest flow up the full fetch of Lake Erie also allowed for maximum heat and moisture fluxes from the lake surface to be incorporated into the band, and focused the fifteen mile wide heavy snow band directly on the Buffalo Metropolitan area (Niziol, 1987).

The lake snow, being the product of a 'warm' early season and favorable snow microphysics, resulted in a snowfall that featured unusually low snow to water ratios. During the first half of the event 6:1 ratios were measured at the NWS office at the Buffalo International Airport. As the cold air deepened overnight, this ratio increased to about 12:1.

By 1200 UTC on the morning of Oct 13, the unidirectional southwesterly flow that had targeted Buffalo during the overnight hours had begun to back to more of a southerly component. This shifted the lake band north of Buffalo, and as the morning progressed, the band was displaced off the lake and weakened over the Niagara Peninsula of Southern Ontario. Precipitation changed to light rain and drizzle during this time.

Total snow fall from the event ranged from 24 inches across the eastern suburbs of Buffalo and 15 inches in downtown Buffalo, to 6 to 12 inches across the southern suburbs. Neighboring Niagara Falls escaped with only an inch or two of accumulation.

### 3. IMPACTS

The lake effect snowstorm of Oct 12-13, 2006 was a catastrophic storm for Buffalo, NY and parts of the surrounding counties. A very heavy, water laden snowfall of up to two feet crippled the region by destroying thousands of trees, knocking out power, and bringing travel

to a standstill. The storm was also at least partially to blame for at least four deaths and damage totaling over \$160 million.

The bulk of the damage was inflicted upon the area trees and electrical grid. After just a couple hours of moderate to heavy wet snow across the northern suburbs of Buffalo, there were reports of trees being damaged under the weight of just 2 to 3 inches of snow. The still fully foliated trees of mid-October proved to be very efficient snow collectors, and this proved devastating to trees in many cases due to the extremely wet and heavy nature of the sticky snowfall. Broken tree limbs were followed by whole trees being crushed to the ground by the oppressive weight of the snow. The fallen trees and limbs brought down power lines, which impacted homes and businesses on the north side of Buffalo even before nightfall Another contributing factor to the came. downed trees was the antecedent conditions that included a nearly saturated ground surface from a prolonged wet period that led up to the storm. The wet ground prior to the event made it easier for shallow rooted trees to fail.

The lake snow band intensified and drifted south across the heart of Buffalo and its populous eastern suburbs as the night began. Tens of thousands of damaged or fallen trees brought down power lines which caused massive and prolonged damage to a large portion of the area electrical grid. Upwards of 400.000 households lost power as this process continued unabated during the overnight Seventy percent of the homes in hours. Buffalo lost power, while over ninety percent of homes lost power across the northern and eastern suburbs. In the words of one utility spokesman, the damage to the electrical grid was 'unprecedented' in the Buffalo area. Fairly mild daytime temperatures in the 50s were experienced in the days following the event which helped utility workers in their restoration efforts. However, some residents were without power for up to two weeks.

The record snowfall created huge travel problems as well. The New York State Thruway between Rochester and Dunkirk, a stretch of 105 miles, was closed for nearly twelve hours. The Buffalo International Airport was also shut down, both because of the snow clogged runways and because power was lost to its supporting facilities. In comparison to the problems posed by the severely damaged electrical grid, the travel problems were alleviated relatively quickly. Both surface and air travel through the region was back to near normal within 24 to 36 hours after the storm.

There were several deaths that occurred as a result of the storm. Only one was directly attributed to the storm when a man clearing debris in his yard was struck by a falling limb. Three deaths were from carbon monoxide poisoning. Along with the fatalities, over 200 people were treated at area hospitals for carbon monoxide related problems. The relatively mild weather that followed the storm probably kept both those figures from being any higher.

New York Governor George Pataki declared a State Disaster Emergency for four Western New York counties, including Erie, Genesee, Niagara and Orleans. This enabled state aid to be funneled into the region, including the use of the National Guard which assisted in the massive clean up of the damage. These four Western New York counties were then later listed under a major disaster declaration by President Bush.

The 22.6 inches of snow measured by the National Weather Service at the Buffalo International Airport was only the sixth highest 24 hour snowfall on record, but it far outpaced any snowfall for the month of October at that location. The massive damage inflicted to the tens of thousands of trees will change the look and landscape for some neighborhoods in the region for generations to come.

# 4. CLIMATOLOGY

The lake effect snowstorm of Oct 12-13, 2006, was the worst October storm that Buffalo had ever received and could easily be argued to be the most destructive of all time. While the storm had devastating effects on the region, it was not the first time that the region had been severely impacted by early season lake effect snow.

On September 29, 1895, deep low pressure crossed to the north of Lake Erie. Telegraphed information about this storm and its earlier effects on Chicago were received by weather forecasters in Buffalo, and as a result they accurately forecasted a change to much colder weather with gusty winds. The marine centric weather forecasts of that time paid particular attention to wind threats to Great Lakes shipping with the public forecast playing a secondary role. This may have explained the importance given to the winds, which proved to be quite destructive. Gale force winds stranded nearly two dozen vessels and sank several others; all despite a fairly accurate wind forecast.

Along with gale force winds on Lake Erie, nearly six inches of snow fell in the Buffalo area. This brought down countless trees, with the greatest damage being inflicted to apple orchards that were yet to be harvested. According to historical newspaper accounts, this was the main public impact. Any problem relating to ground travel was left unmentioned.

A very important technological breakthrough occurred in Buffalo at the turn of the 20<sup>th</sup> century, as the invention of electricity resulted in power lines being strung across all of Buffalo. The city became one of the first in the country to take full advantage of electricity, and because of this Buffalo became known as "The City of Light". This led Buffalo to host the 1901 Pan American Exposition, during which time it showcased its modern electrically lit city (Grant, 2001).

The newly hung electric lines throughout Buffalo were then put to the test on October 10, 1906, when another early season storm crossed the Great Lakes region. The large storm brought a general coating of snow from the Upper Midwest to New England while lake effect snow buried portions of Western New York. Areas just south and east of Buffalo picked up over a foot of heavy wet snow. The weight of this snow brought down electric, telegraph, and telephone wires leaving Buffalo 'floundering' (Buffalo Enquirer, 1906).

Not only did this storm produce more snow than the 1895 event, it also had a much greater impact. Newspaper accounts went to great length and described in detail how 'communication with the outside' was difficult and how downed electric wires made travel dangerous. Widespread power outages near the Buffalo Metropolitan area were noted along with the tremendous damage to area trees and apple orchards. Unlike the 1895 event when the greatest impact was dealt to trees and Great Lakes shipping, the 1906 event was noted for its destruction to the various Buffalo "wire services".

An even greater lake effect snowstorm affected the Buffalo Metropolitan area on Oct 18, 1930 (Wiggin, 1950). One to two feet of heavy wet snow 'crippled' the southern suburbs of Buffalo, where power lines were torn and thousands of trees were either severely damaged or destroyed. Travel throughout the region was severely affected, and perishables that were now shipped into and out of the region were spoiled on snow clogged roadways (Fig 4). The greatest impacts from this event included loss of electrical and telephone services along with a much more noticeable effect on area travel.



Figure 4:Headline from the BuffaloEvening News edition on October 20, 1930.

There were several less significant early season lake effect snows since the last major one in 1930, but a clear history can be traced to show that these events have had a major impact on the lives of Buffalonians.

# 5. SUMMARY

The lake effect snow storm of Oct 12-13, 2006, was arguably the most destructive storm in Buffalo's history. Despite its crippling impact, the storm was extremely difficult to forecast. Not only did consecutive numerical guidance packages have varying solutions of precipitation type, but with a lake surface temperatures of 16°C Buffalo meteorologists with decades of lake effect snow experience had never witnessed anything like it. Only after extensive research in local newspaper archives did the history of such events come to light.

There was a preconceived notion that a significant lake effect snowfall could not take

place with a lake surface temperature of 17°C and 850mb forecast temperatures of -4°C to

-6°C. Strong pattern recognition by forecasters a week prior to the event was tempered by a calendar that read early October. This established a strong bias in thinking that heavy snow could not develop and most likely tainted a more objective analyses of the available guidance. The run to run model inconsistency and disagreement within the various models themselves only added to the mind set that developed among local meteorologists. Had the event taken place a month later in November, the mind set would have been altered by the knowledge that such events had taken place in the past.

With regards to the impacts of such a storm, research indicates that there have been other major early season lake effect snow storms that have affected the Buffalo Metropolitan area over the past 100 years. While the intensity of these events can be discussed by examining snowfall amounts, wind speeds and even the exact timing of the snowfall (day vs. night, day or the week), the severity can also be gauged by its impact on the affected communities. Likewise, the degree of impact can be measured against the social and technological advances of the period.

Historical records suggest that as time has passed, early season lake effect snow storms have had a greater and greater impact on the population of Buffalo and its surrounding communities. Part of the reason for this can be tied to the introduction of electricity at the turn of the century and to societies increasing dependence upon it.

Electricity was initially a luxury that was used hand in hand with other forms of energy, such as horse power and carbon based (wood and coal) burning appliances. As the 20<sup>th</sup> century progressed, electricity became more and more widespread. It replaced the older technology and fed the growing appetite for an easier lifestyle offered by modern electrically run appliances. This has led to a greater dependency on electricity for everything from home heating to conveniences such as refrigerators and televisions. Significant early season lake effect snow storms, especially with their high water content, are very effective at cutting off this power supply through downed tree limbs and power lines.

There are two other technological advances that have helped to increase the impact of early season lake effect snows.

Replacing horse power with the automobile has also made society much more mobile. Not only has society become more mobile, but it has become more reliant on the shipment of goods for day to day living. Locally grown food has increasingly given way to perishables that are being shipped from greater distances. While early season lake effect snows may be just as cumbersome to remove as those from midwinter, the machinery is not always available during earlier dates. With regards to the Oct 12, 2006 event, municipalities commented about the lack of "truck readiness".

Along with electricity and mobility. communication has changed tremendously with time. The lake effect events from the late 1800s and early 1900s started to have a very detrimental effect on local telephone and telegraph lines. During major events, heavy water laden snowfalls more easily bring down tree limbs and power lines, and at times this has effectively isolated areas in terms of communication. This remained a problem through much of the 20<sup>th</sup> century. Unlike electricity and transportation though, the advent of cell phones has now dramatically reduced the adverse impact on communications.

Early season lake effect snow storms have occurred in the past and will continue to take place in the future. In the same way that increased population in hurricane prone coastal areas have led to increased property loss, will the trend of increased impact to the Buffalo area continue as we become more and more dependent on technology?

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