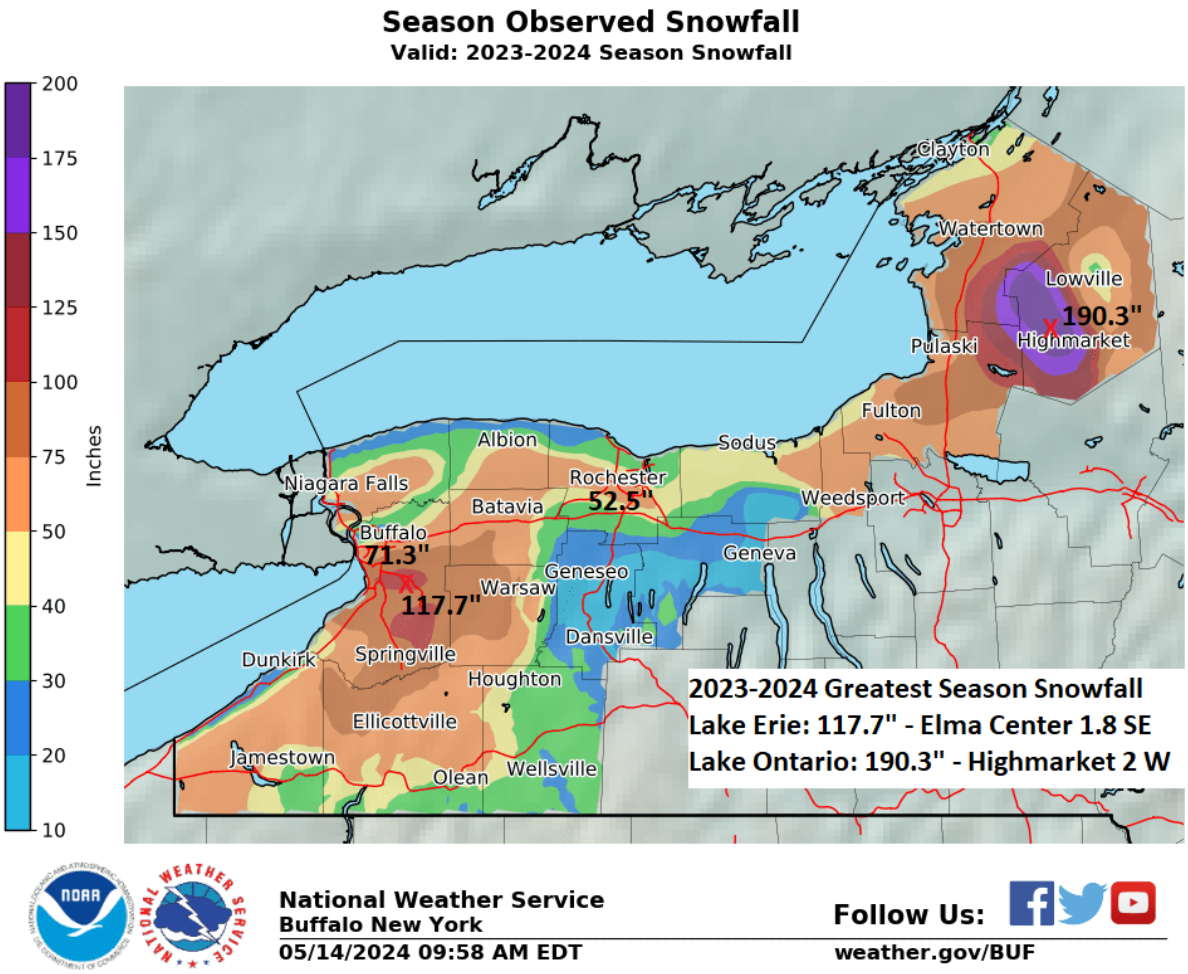

Winter Season Summary 2023-2024

After three consecutive years of La Niña, the winter of 2023-24 featured a return to El Niño. As this El Niño event increased in strength a mild winter was anticipated.

Off the western South American coastline a pool of warmer water, which only deviated from the climatological normal by a few degrees, had significant global impacts on the jet stream, keeping a fast zonal flow in the upper levels that aided in locking up colder air well to our north. This allowed for milder air from the south to continually flood the eastern Great Lakes region. Long term climate stations for the meteorological winter months of December, January and February finished either near or at the top for the warmest winter on record.

There was periodic weakening of the zonal flow across North America, allowing for cold air that was bottled up to the north to drop southward across the eastern Great Lakes. This breakdown lasted about a week and noticeably occurred twice this past winter,

once in the middle of January, and a second time towards the end of March. Combined these two weeks of arctic air accounted for more than half of the snow for the winter.

There were just 5 lake effect snow events this winter, one in November, and two each in the months of January and February. Synoptic snow events were also few, and there were little in the way of sleet or freezing rain events this winter. The snowpack that developed as a result of any snow event was short-lived as milder air soon after ablated the snowpack and returned the region to green grass.

The short bouts of winter's cold allowed for shallow ice thickness on area creeks and streams, with little impacts from ice jams during mild warm-ups. Lake Erie never completely froze this winter, with just periods of shore ice. This is the tenth time overall in nearly 100 years of measurements, and seventh time this century that Lake Erie has not frozen over.

Snowfall

Snowfall for the winter of 2023-24 was well below normal across all of our snow measuring sites through Western and North Central New York. Only the months of November and January saw a fair amount of stations with above normal snowfall. While the region was below normal, portions of the Genesee Valley and Finger Lakes region were well below normal with several long-standing stations receiving their least amount of snow on record (Geneva, Oswego).

Just 5 lake effect snow events occurred this winter, well below the average of 10 events. The first event occurred a week after Thanksgiving, dropping 2 feet of snow east of Lake Erie across the hills, and 3.5 feet of snow on the southern Tug Hill Plateau east of Lake Ontario. Two lake effect events, in close proximity to each other occurred in January, greatly affecting the Buffalo metro area. A long lasting, but minor impact lake effect event occurred just before Presidents Day in February, and the last lake effect snow event occurred during the final days of February.

For our two main climate sites of Buffalo and Rochester, Buffalo received more snowfall owing to significant southwest flow lake effect snow events off Lake Erie, whereas Rochester, which is typically not greatly impacted by the southwest flow events, also lacked much snowfall on a northwest flow off Lake Ontario. Snowfall for Buffalo was about 2 feet below normal, while Rochester was just over four feet below normal.

Temperatures

Temperatures for the winter of 2023-24 were above normal for all three climate locations. The only month that finished with a below normal temperature was November. Otherwise, all three meteorological months, and even the early spring months of March and April were well above normal. December, February and March all finished within the top ten warmest months for their respective month. Not only was it a mild winter, but when the arctic air arrived it was not that cold. For the season, Buffalo

had just 18 days drop below 20°F, the fewest on record. Rochester had just 21 days drop below 20°F, second fewest on record. Our coldest climate site in Watertown had just 16 days drop into the single digits, 5 days fewer than the previous record.

Winter Statistics for Buffalo, Rochester and Watertown

Buffalo

Average Temperature, November – March: 36.9F (5.3F above normal, 3rd warmest)

Snowfall: 71.3” (45th least snowiest)

Days with 1.0” or more of snowfall accumulation: 18 (21st fewest)

Days with 1” or more snow on ground: 33 (tied 4th fewest)

Rochester

Average Temperature, November – March: 37.3F (4.8F above normal, 2nd warmest)

Snowfall: 52.5” (13th least snowiest)

Days with 1.0” or more of snowfall accumulation: 17 (15th fewest)

Days with 1” or more snow on ground: 38 (tied 3rd fewest)

Watertown

Average Temperature, November – March: 33.5F (5.8F above normal 2nd warmest)

Below are tables for records set at the climate locations for the winter of 2023-2024.

Buffalo

Type	Date	New Record	Old Date	Old Record
Warm Minimum	December 9th	51°F	December 9, 1946	50°F
Warm Minimum	December 17th	46°F	December 17, 1921	43°F
Warm Minimum	December 27th	48°F	December 27, 1907	45°F
Warm Minimum	December 28th	42°F	December 28, 1940	40°F

Snow	January 14th	8.6”	January 14, 1963	7.8”
Snow	January 18th	7.9”	January 18, 1958	5.5”
Warm Minimum	February 9th	42°F	February 9, 1898	39°F
Warm Maximum	February 27th	68°F	February 27, 2000	64°F
Warm Minimum	February 27th	45°F	February 27, 1881	40°F
Warm Maximum	February 28th	64°F	February 28, 1954	64°F
Warm Minimum	March 3rd	42°F	March 3, 1874	39°F
Warm Maximum	March 4th	72°F	March 4, 1974	63°F
Warm Maximum	March 5th	72°F	March 5, 2004	68°F
Warm Minimum	March 5th	52°F	March 5, 1894	47°F
Warm Maximum	March 8th	66°F	March 8, 1921	65°F

Rochester

Type	Date	New Record	Old Date	Old Record
Warm Maximum	December 9th	63°F	December 9, 1966	63°F
Warm Minimum	December 9th	51°F	December 9, 1946	50°F
Warm Minimum	December 15th	42°F	December 15, 2011	41°F
Warm Minimum	December 17th	47°F	December 17, 2012	44°F
Warm Minimum	December 28th	42°F	December 28, 2018	42°F
Precipitation	January 26th	1.16”	January 26, 1978	0.78”
Warm Maximum	February 9th	62°F	February 9, 2001	62°F
Warm Maximum	February 10th	58°F	February 10, 1881	57°F
Warm Maximum	February 27th	73°F	February 27, 2000	66°F
Warm Maximum	February 28th	66°F	February 28, 2018	64°F
Warm Minimum	March 3rd	44°F	March 3, 1874	41°F

Warm Maximum	March 4th	72°F	March 4, 1974	69°F
Warm Maximum	March 5th	72°F	March 5, 2004	67°F
Warm Minimum	March 5th	53°F	March 5, 1894	48°F

Watertown

Type	Date	New Record	Old Date	Old Record
Precipitation	November 21th	0.91”	November 21, 1954	0.75”
Warm Minimum	December 9th	44°F	December 9, 1966	44°F
Warm Minimum	December 17th	45°F	December 17, 2012	42°F
Warm Maximum	December 18th	52°F	December 18, 1990	51°F
Warm Minimum	December 18th	39°F	December 18, 2012	35°F
Warm Minimum	December 27th	46°F	December 27, 2014	40°F
Precipitation	January 26th	0.61”	January 26, 1965	0.60”
Warm Maximum	February 8th	54°F	February 8, 2019	52°F
Warm Maximum	February 9th	57°F	February 9, 2023	52°F
Warm Minimum	February 9th	45°F	February 9, 1990	40°F
Warm Maximum	February 10th	56°F	February 10, 2001	52°F
Warm Maximum	February 27th	69°F	February 27, 2000	63°F
Warm Maximum	February 28th	62°F	February 28, 2018	60°F
Warm Minimum	March 2nd	41°F	March 2, 1991	41°F
Warm Minimum	March 3rd	41°F	March 3, 2004	34°F
Warm Maximum	March 4th	67°F	March 4, 1974	56°F
Warm Minimum	March 4th	43°F	March 4, 1979	39°F
Warm Minimum	March 5th	44°F	March 5, 2011	39°F

Warm Minimum	March 6th	39°F	March 6, 2022	38°F
Warm Maximum	March 13th	62°F	March 13, 2012	62°F

Monthly Highlights

November

November was relatively quiet this month with the bulk of the precipitation for the region occurring within three events. The first two events were rain events, while the third event was a lake effect snow event, one that had the only measurable snowfall for Buffalo and Rochester the final days of the month. This first major lake effect snow event of the year occurred the final days of the month, with snowfall totals of a foot to a foot and a half east of Lake Erie and around three feet east of Lake Ontario on the southern Tug Hill.

The month began damp with scattered light showers around the region through the first 9 days. November also began chilly with the first day of the month about 10 degrees or more below normal. The cool start was short-lived, with days in the 50s and 60s returning by the 3rd. Ahead of a southward dropping cold front, winds quickly and briefly became gusty, especially right off Lake Erie where a gust to 57 miles per hour came off the Lake late in the evening. A nice stretch of weather occurred from the 10th to the 16th, where a full week of days without precipitation occurred along with a good deal of sunshine for November standards. On the 17th a cold front slowly passed across the region, with a lengthy period of rain across Western and North Central New York. The next all-day rain event was not far behind with the 21st featuring over an inch of precipitation across Western New York, and nearly an inch east of Lake Ontario. The rain became lighter on the 22nd as it ended, leaving Thanksgiving the 23rd, dry with a mix of clouds and some sunshine. The first major lake effect snow event of the season occurred the 27th through the 29th. First, impacts were south of Buffalo and Watertown, but by the 29th the band lifted northward across the Buffalo Metro area, snarling the morning rush hour despite only producing a few inches of snow.

December

A strong El Niño signal in the equatorial Pacific region enhanced the strong west to east flow across the Pacific Ocean and continental United States, locking cold air well to our north and making for remarkable warmth through the month of December. Just a handful of days finished with below daily normal temperatures. This mild month also featured very little snowfall and of what snow that did accumulate was melted quickly in the warmth.

December began wet for Western New York as several storm systems approached the region from the south. Another storm passed by to the south of New York State on the 5th, and brought a little light snow to the region. A warm front from the west brought several inches of snow to Western New York on the 7th, but mild air behind the front quickly melted what snow fell. It was a sunny day on the 12th, but ahead of a cold front winds gusted to 40 to around 50 mph northeast of the Lakes through the afternoon hours. The combination of widespread, and later, lake effect snow brought additional snow to the Buffalo metro area on the 18th-19th. From this event, close to a foot of snow fell over the hills south of Buffalo, while several inches of snow fell

around Buffalo. Notable lower amounts fell east of Lake Ontario, with just a few inches of snow accumulating on the Tug Hill. Mild air temperatures melted the snow well before Christmas Day for the region, with no Cooperative Observers measuring any snow depth for Christmas morning. A mild airmass on Christmas Day brought a warm Christmas Day, with many locations having a top 5 or top 10 warmest Christmas temperature on record. Rain, drizzle and fog remained around the region on the 28th-30th, with a few wet snowflakes early on the 30th.

January

The mild start to winter continued into the first half of January with near or above normal temperatures recorded through the 13th. There were two relatively close wind events this month that produced widespread wind damage. Both events featured strong southeasterly damaging wind gusts, not the common southwest wind direction for many of our high wind events across the Lake Plain. The first event, on the 9th and 10th of the month was followed by the second event on the 13th and 14th of the month. Southwest winds behind a cold front on the 14th produced a seiche on Lake Erie of 7.4 feet. This cold front also brought the beginning of an 8-day stretch of more typical winter chill. Lake effect snow on the 13th began near the Buffalo metro area before settling southward briefly. This band of snow lifted back towards the airport early on the 14th, and across Niagara County during the early morning hours of the 14th. By later in the morning this band settled back southward across the Buffalo Southtowns, where it largely remained through the morning of the 15th. Later, this snowband lifted back northward across the Buffalo Northtowns and Niagara County where it diminished to flurries. Several feet of snow fell during this event across the Buffalo Southtowns, with heavy impacts across the county of Erie with travel bans and a football playoff game date shifted. East of Lake Ontario snowfall amounts were not as great, with a foot or two of snow across Jefferson and northern Lewis counties where the snow band resided much of the time. After a synoptic wave of low pressure passed across the region with a light general snowfall, another band of heavy lake effect snow formed across the Buffalo Southtowns late on the 16th. This band of snow again oscillated across Erie County through the 18th. Several feet of snow accumulated with this event across the Buffalo Southtowns and provided a weekly total of six feet to several Buffalo Southtown communities. This time snowfall amounts were greater east of Lake Ontario with three to four feet of snow accumulating on the northern Tug Hill. After synoptic snow departed eastward on the 16th, a band of heavy lake effect snow was uncovered near Oswego County and the southern Tug Hill. This band of snow lifted northward, and at times split into two separate bands. Snowfall rates up to 4 inches an hour occurred on the 17th east of Lake Ontario, leading to the nearly four feet of accumulation.

Another storm system brought light synoptic snows to Western New York on the 19th. Northerly flow behind this system brought lake snows now concentrated to the south of Lake Erie and Ontario, with day to day accumulations on the 19th through the 21st adding up to around a foot of snow south of Lake Ontario. Winter's brief appearance ended on the 24th when temperatures warmed into the lower 40s with widespread rainfall. This rain ripened the snowpack, such that the inch of rainfall on the 26th melted the snowpack producing poor drainage flooding. While ice jams occurred on a few Western New York creeks their impacts were manageable due to thin ice thickness. Several creeks and rivers rose to near or beyond bankfull during this warm stretch, including the Ellicott Creek and Tonawanda Creek. A little light rain and snow ended the month with little impact.

February

Mild air flowed across Western New York for the month of February. Buffalo had their warmest February on record, Rochester their second warmest and Watertown their third warmest February on climate record. Around a third of the month featured warmth of more than 10 degrees above their daily normal for our region. This mild flow also contributed to very little snowfall for the month.

It was a very dry start to the month, with very little precipitation measured through the first half of February. There was dense fog on the 4th and 5th across parts of the region with a saturated lower atmosphere. By the 8th milder air began shifting northward, with record breaking warmth at a few climate locations on the 9th and 10th. The one cool period this month occurred on the 17th through the 19th. Light lake effect snow on the 17th became heavier on the 18th with a southwest flow broad lake effect snow band. Snow east of Lake Ontario was a bit more pronounced with upwards of a foot of snow in oscillating bands of snow across the North Country. This cold period was brief, and by the 20th temperatures again went above normal. A few cold fronts the final days of the month brought brief cold periods and some snow. The final cold front on the 28th ushered in strong winds with isolated tree damage west of the Genesee River, with more widespread tree damage east of the Genesee River. Behind this cold front the last lake effect snow event of the year occurred. Gusty northwest flow brought lake effect snow to the southern and southeastern shoreline of Lake Ontario, with just over a foot of snow accumulating in a narrow band.

March

Record warmth that ended February took a brief pause the first few days of March, with temperatures in the 40s and 50s the first 3 days of the month, which were still well above normal. As a deep trough carved its way through the Rockies, warm air surged northward across the Great Lakes region, starting on the 4th when temperatures rose to record levels at a few climate stations, and continuing into the 5th with additional record high temperatures. Several cold frontal passages the 5th through the 11th brought light precipitation to Western and North Central New York, while taking the edge off the warmth. Temperatures remained above normal through the 17th.

The 18th through the 24th brought a brief period of winter's cold, complete with lake effect snow, graupel and then under a slow moving upper level low, upslope snow. The 19th through the 21st brought day to day snow, with greatest amounts found at higher elevations. Snow added up to around a foot and a half on the peaks of the Boston Hills, with around 3 inches of snow accumulating at lower elevations of Buffalo and Rochester. East of Lake Ontario, a foot to foot and a half of snow fell over this 3 day time period. A synoptic low passed across the region on Thursday and Friday the 21st and 22nd with a half a foot of widespread snow across Western and North Central New York. Increasing amounts of bright sunshine and cold temperatures on the 23rd maintained this snow into the start of the weekend, one last gasp of outdoor winter fun in this overall mild winter. This snow did not last long as temperatures in the lower 60s on the 25th rapidly depleted leftover snow.

April

A few snow showers occurred the first week of April with minor amounts of snow. This proved to be the final snow of the season for most areas, with just some hill tops having wet snow mix in with rain mid-month.

Hemispheric Discussion

It came as no surprise to many in the meteorological community that the winter of 2023-2024 was one of the warmest in the Great Lakes region in many years. In fact, “meteorological winter”, defined as the three month period from December through February, was the WARMEST on record for Rochester and the second warmest for Buffalo.

The blame for the significant positive temperature anomalies can be largely placed on the broad shoulders of an unusually strong and prolonged El Nino, one that was well forecast by climatologists. During stronger El Nino events, there is notably less amplitude with the overall jet stream pattern over North America. Not only are the winds at jet stream level more zonal (west to east) in nature, but the two main jets (Arctic and sub-tropical) are stronger and displaced further to the north. The more apparent of the two was the sub-tropical jet that was quite strong across the far southern states for the bulk of the winter. This helped to support very active weather, especially in California where plumes of deep tropical moisture (“Pineapple Express”) frequently fed very heavy precipitation events.

For our weather here in the Lower Great Lakes region, it is typically a persistent, northerly displacement of the Arctic jet that marks an unusually warm winter. This was certainly the case this past winter, particularly during the months of December and February when the axis of the arctic jet was centered in the vicinity of 60 degrees north latitude. The intensity, orientation, and overall position of this jet not only worked against cold air being allowed to “build” across the higher Canadian latitudes, but prevented frequent southerly intrusions of Arctic air into the Lower 48. At the same time, a strong positive NAO pattern supported stronger than normal jet stream winds over the Atlantic. This only further helped to block a scenario where any significant cold air, including a notorious cross polar flow, could develop over North America. The general absence of the polar vortex on this side of the Pole is probably one of the better ways to describe the result of the combined strong El Nino and pronounced positive NAO during large portions of this particular winter.

An examination of 850mb temperatures revealed significant positive departures across Canada and the northern half of the United States, particularly during the early and late stages of the 2023-24 winter. Again, this is likely the result of the aforementioned combination of the overlying El Nino and NAO jet level anomalies. This mirrored the overlying height departures which depicted strong ridging over the same areas. Near surface temperatures averaged well above normal from December through March as a result of these significant anomalies with some sites experiencing monthly averages that were nearly a full 10 degrees F above 30 year averages. During the heart of winter (Dec thru Feb), most areas had near or FEWER than five days each month where the mercury averaged below normal. Buffalo, for example, only had TWO days during the month of December where colder than normal weather was experienced!

Another way to show the extent of the warmth was to look at the Lake Erie surface temperatures. While it was somewhat impressive too that very little ice was ever able to form during the Winter of 2023-2024, it may be more eye opening to realize that virtually two thirds (64 out of 90) of the days experienced record high water temperatures. The only time that this dominant pattern broke down was during a ten day stretch in the

middle of January, when the jet stream pattern finally amplified across the country. While a robust El Nino was still in place over the Equatorial Pacific during the month of January, a ridge strengthened along the West Coast, while a mid-level block developed over Greenland. This coupled +PNA / -NAO pattern usually provides colder than normal weather to the eastern half of the country, and this case was no different. The resulting amplification of the jet level flow over North America allowed the polar vortex to drift away from the Arctic region where it had been anchored up to that point. In fact, this brief window of time was the only period where the polar vortex made its way as far south as Hudson Bay. While 850mb temperatures only averaged in the minus teens C, this was some of the coldest air of the season and it ended up being directed southwards to the center of the country and into the Great Lakes region. This period of very cold air also supported some of the most significant lake snows of the winter throughout the Great Lakes region. Buffalo, for example, received half of their total snowfall for the entire winter during this ten day stretch. On the flip side of that, some areas outside of the lake snowbelts (ie. Finger Lakes region) picked up less than twenty five percent of their typical seasonal snowfall with amounts totaling a foot or less with snowfall departures as great as six feet for parts of the western Southern Tier.